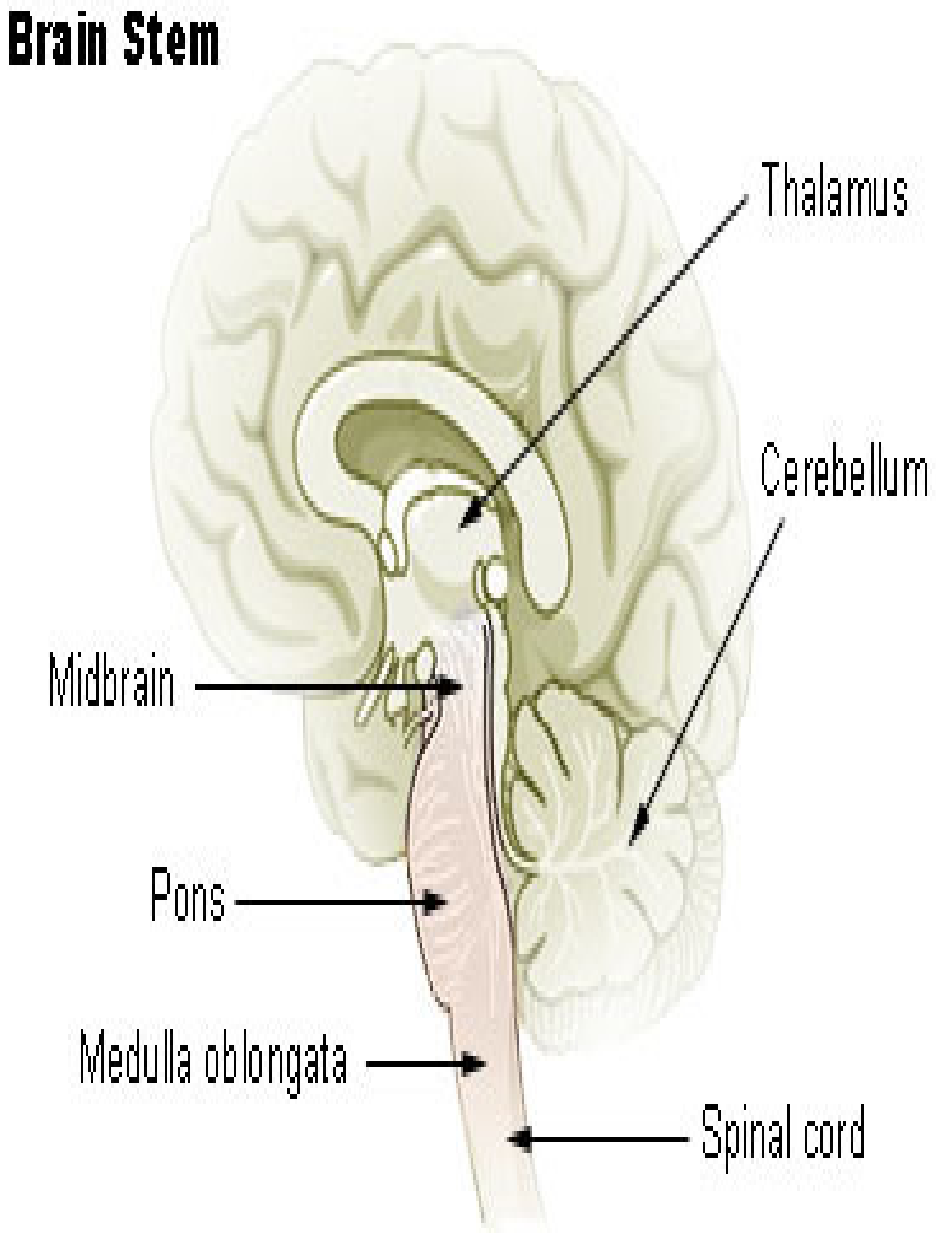
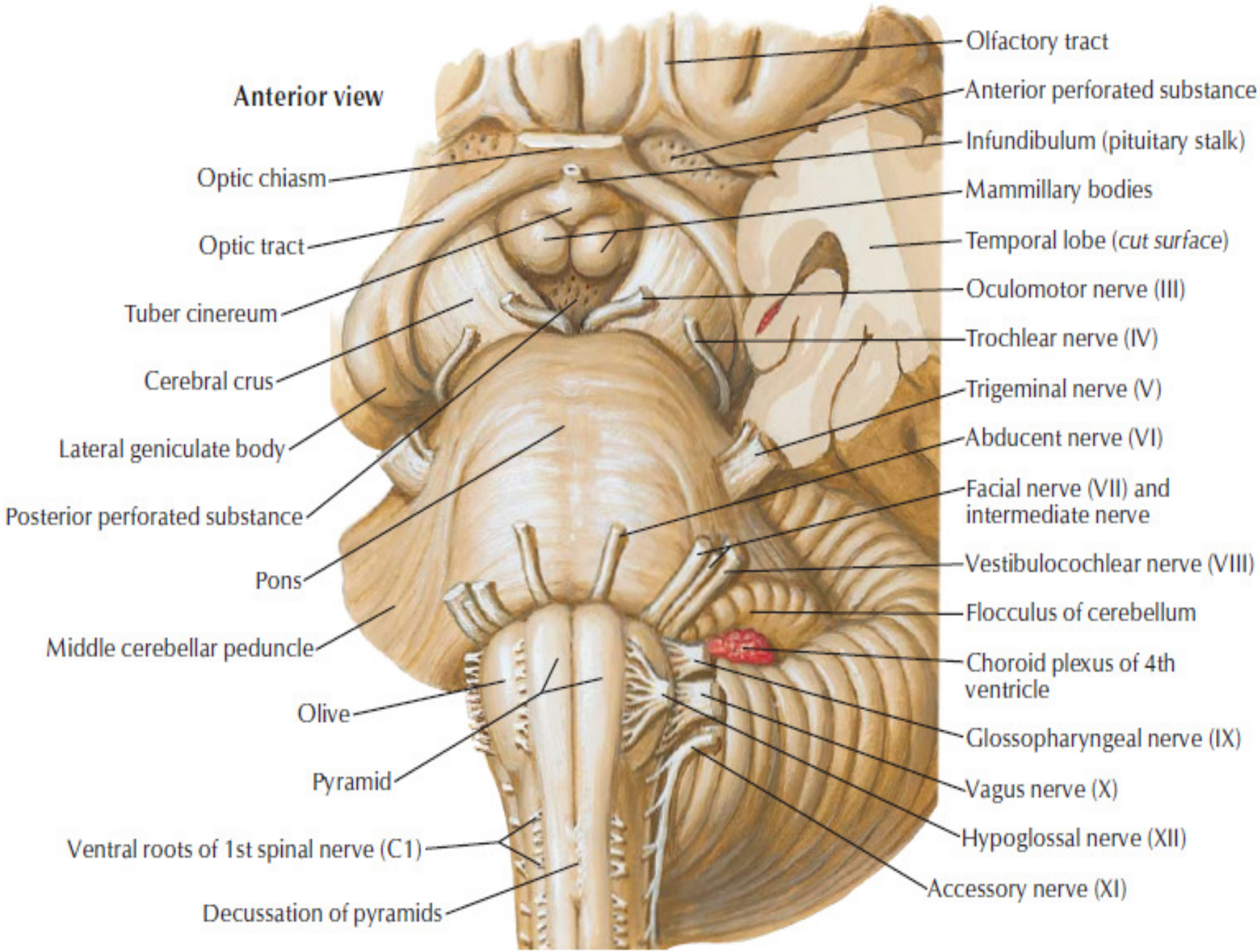
Brain stem

- Stalk like in shape
- Connects spinal cord forebrain

Parts:

1. Medulla oblongata
2. Pons
3. Midbrain



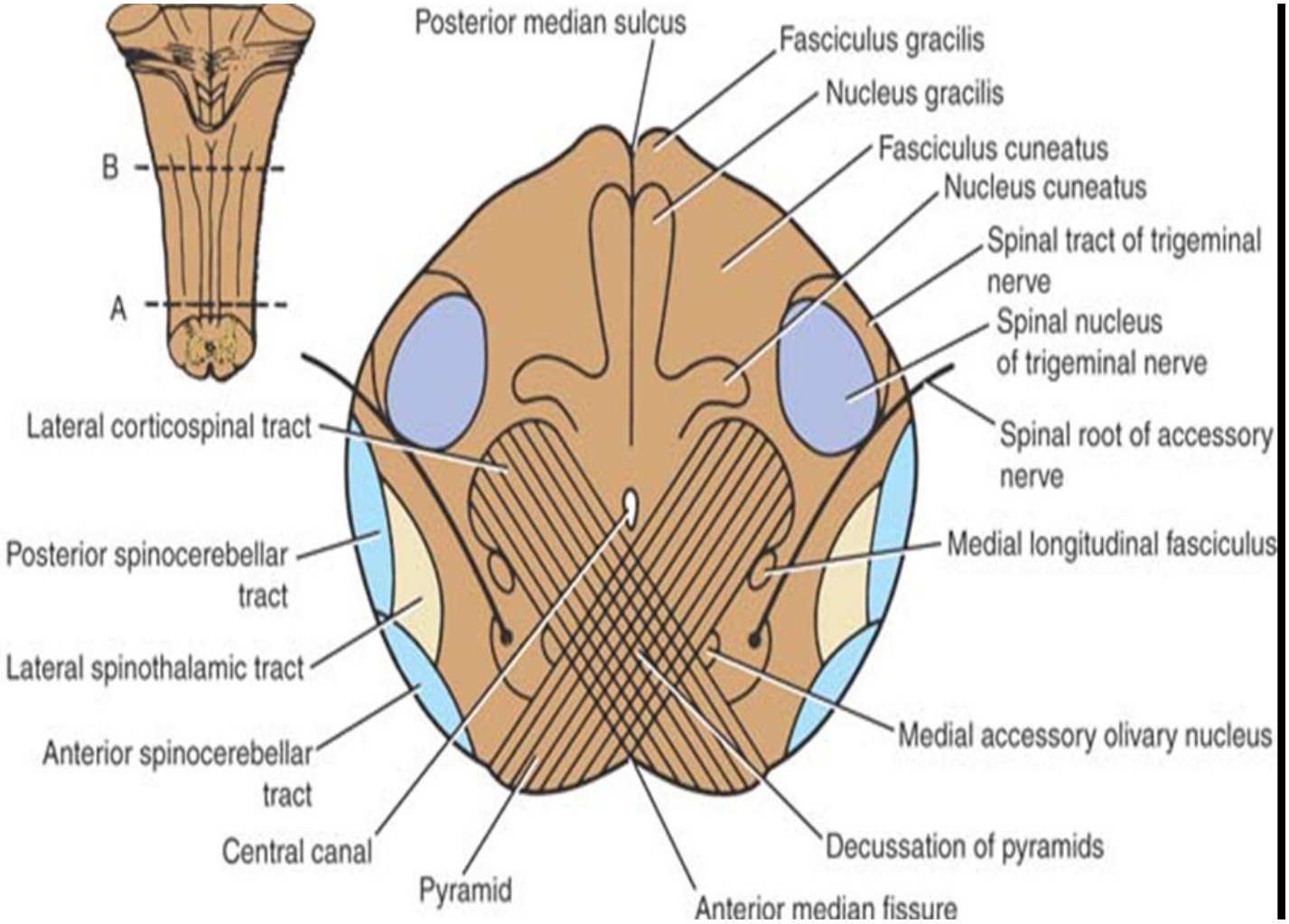

Anterior view
Optic chiasm
Optic tract
Tuber cinereum
Cerebral crus
Lateral geniculate body
Posterior perforated substance
Pons
Middle cerebellar peduncle
Olive
Pyramid
Ventral roots of 1st spinal nerve (C1)
Decussation of pyramids
Olfactory tract
Anterior perforated substance
Infundibulum (pituitary stalk)
Mammillary bodies
Temporal lobe (cut surface)
Oculomotor nerve (III)
Trochlear nerve (IV)
Trigeminal nerve (V)
Abducent nerve (VI)
Facial nerve (VII) and intermediate nerve
Vestibulocochlear nerve (VIII)
Flocculus of cerebellum
Choroid plexus of 4th ventricle
Glossopharyngeal nerve (IX)
Vagus nerve (X)
Hypoglossal nerve (XII)
Accessory nerve (XI)

Internal structure of medulla

1. Level of decussation of pyramids(motor / close medulla)
2. Level of decussation of leminisci (sensory/ close medulla)
3. Level of olives (open medulla)
4. Level Just Inferior to the Pons

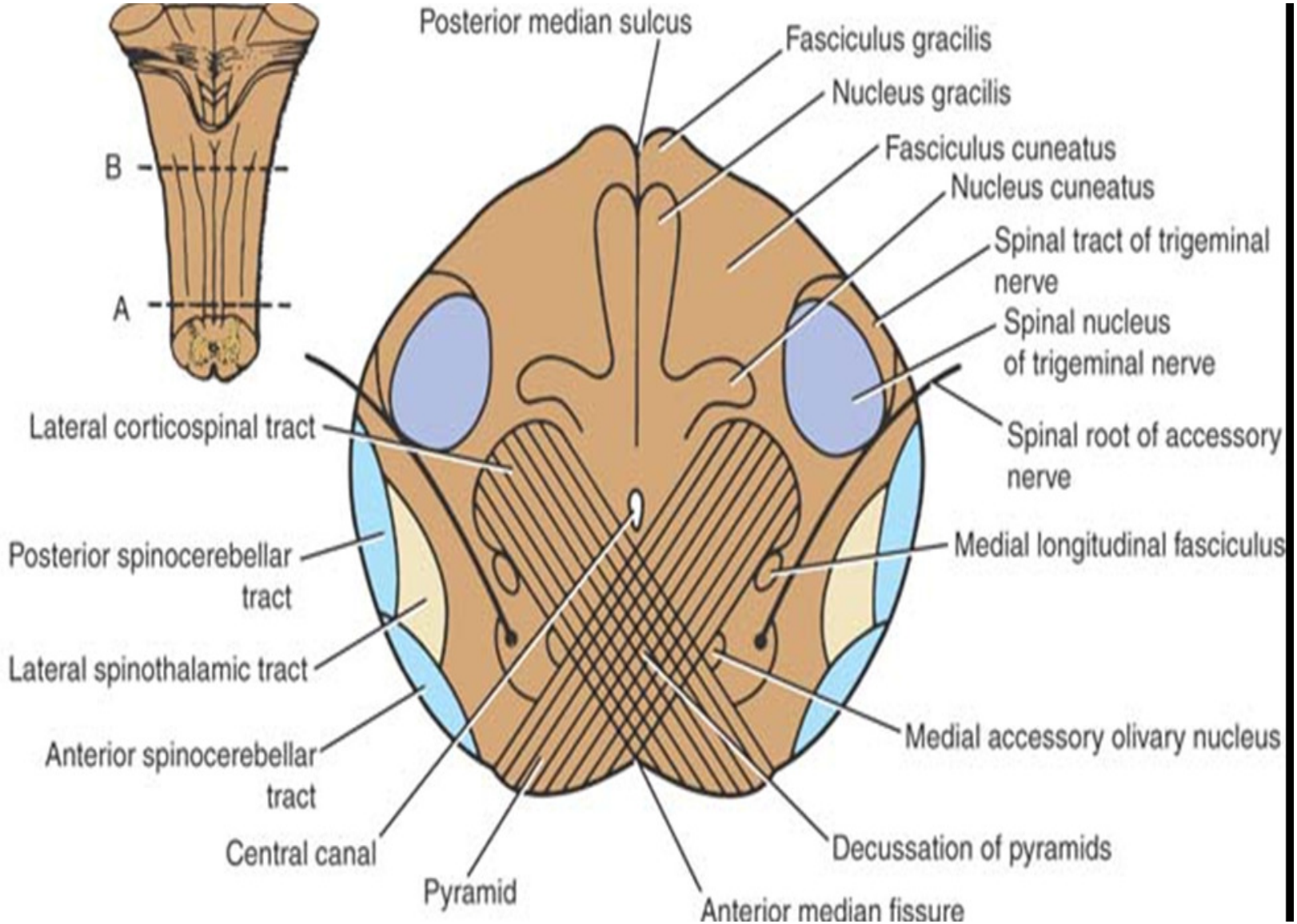
Level of decussation of pyramids

- Decussation of pyramids
- Fasciculus gracilis and the fasciculus cuneatus
- nucleus gracilis and the nucleus cuneatus (posterior to the central gray matter)
- Spinal nucleus of the trigeminal nerve
- Central canal



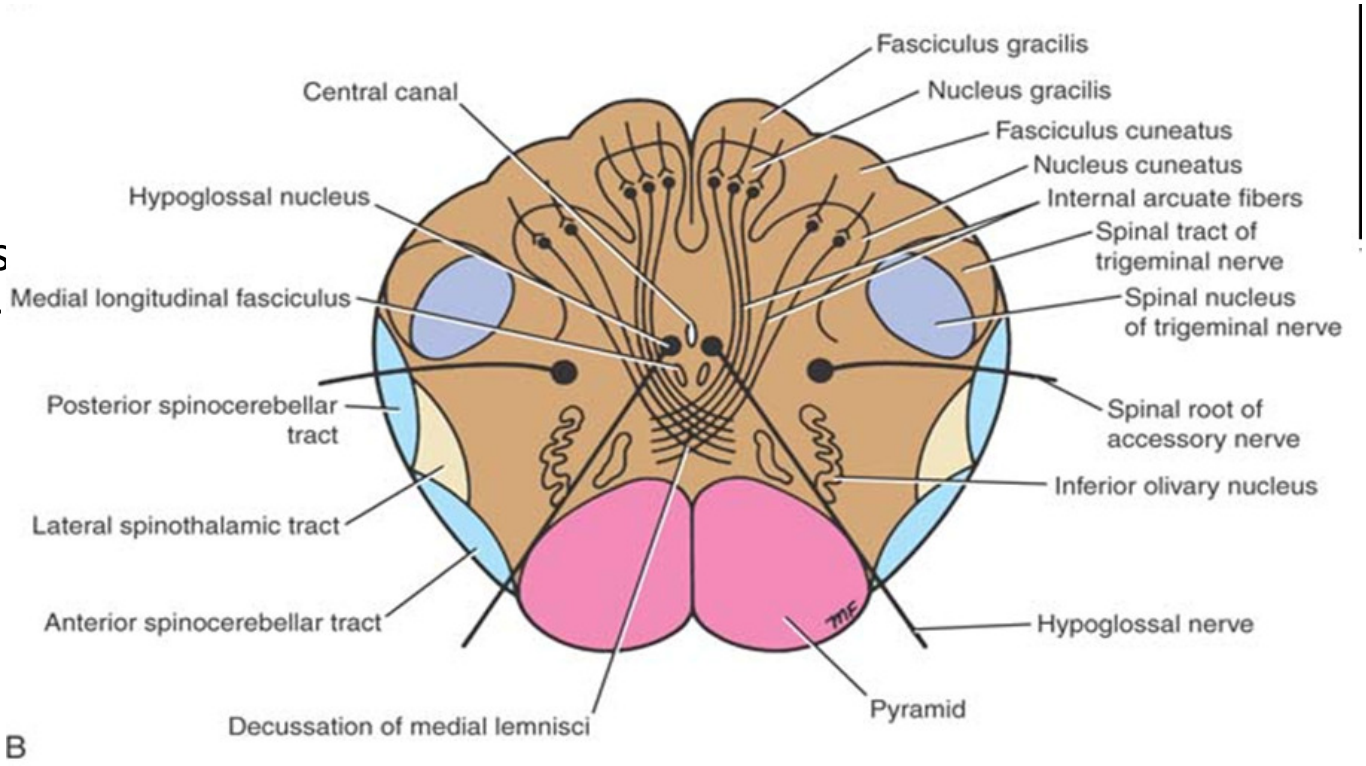
- The lateral and anterior white columns of the spinal cord is unchanged

Level of decussation of pyramids



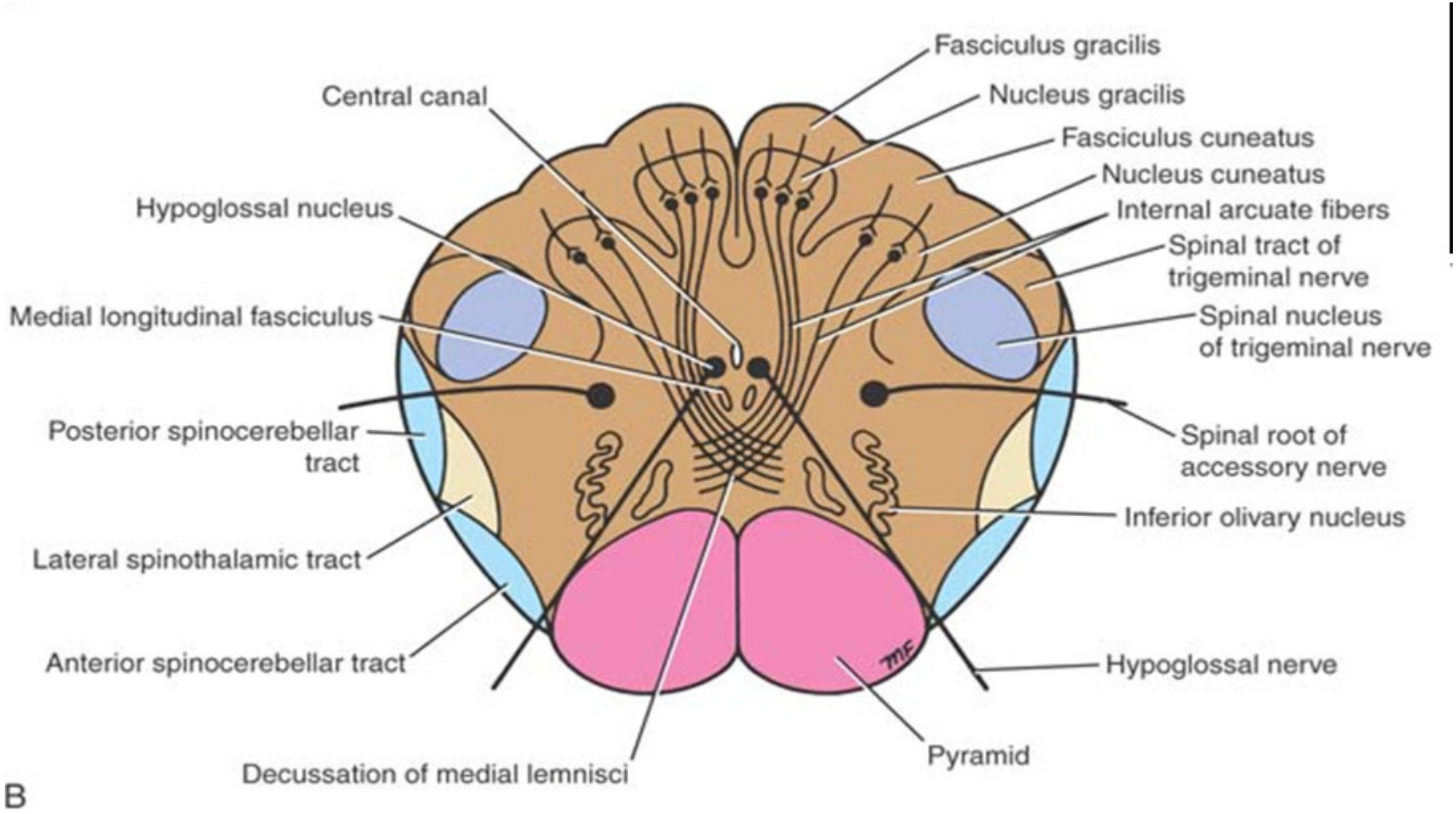
Level of decussation of leminsci

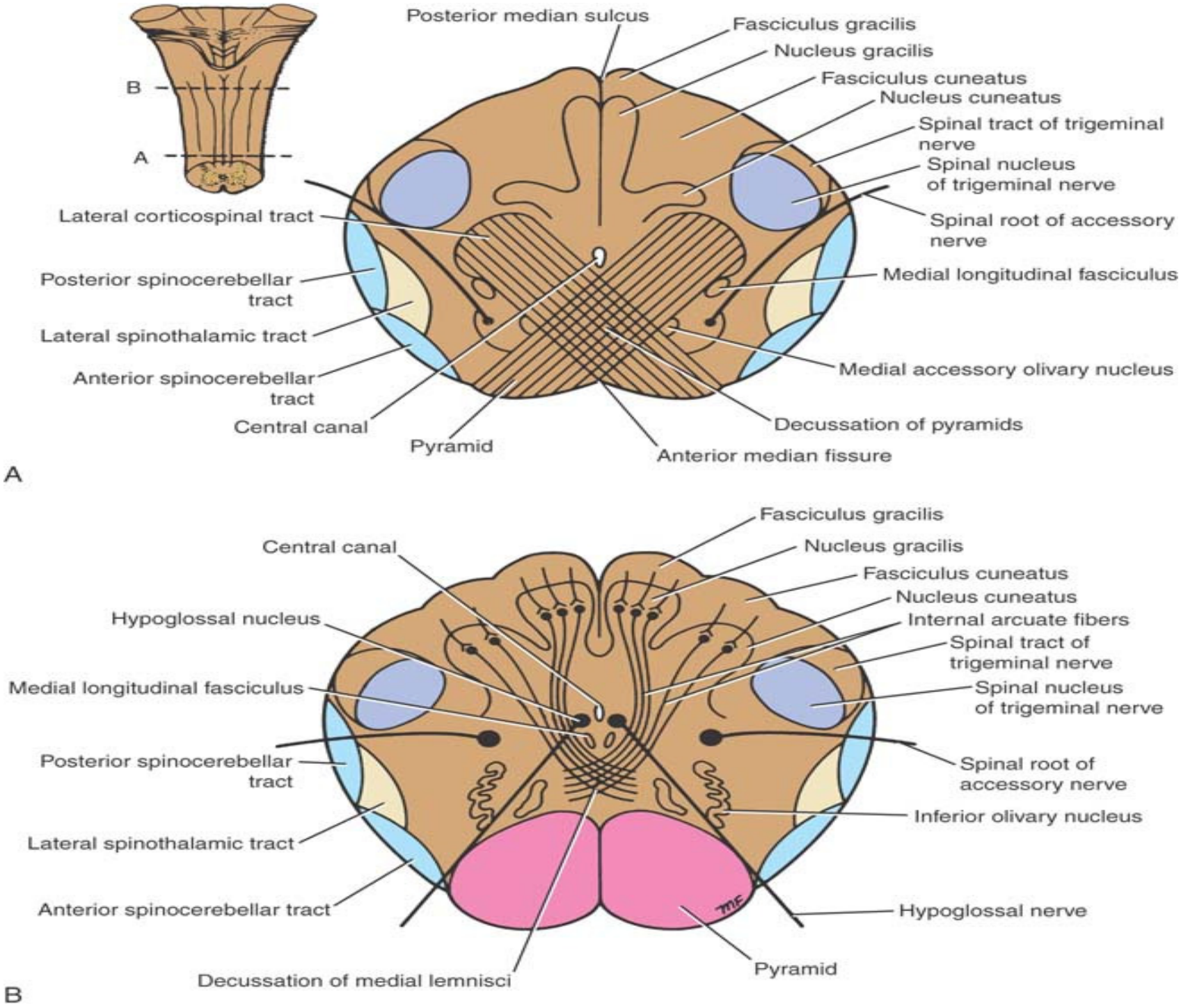
- Sensory decussation
- Leminisci are formed by internal arcuate fibers
- internal arcuate fibers emerge from anterior aspect of nucleus gracilis and nucleus cuneatus
- Decussation takes place posterior to pyramids
- Spinal nucleus of the trigeminal nerve (lateral to the internal arcuate fibers)
- spinal lemniscus lateral to the decussation of the lemnisci



- The spinocerebellar vestibulospinal, and the rubrospinal tracts (anterolateral)
- Central canal

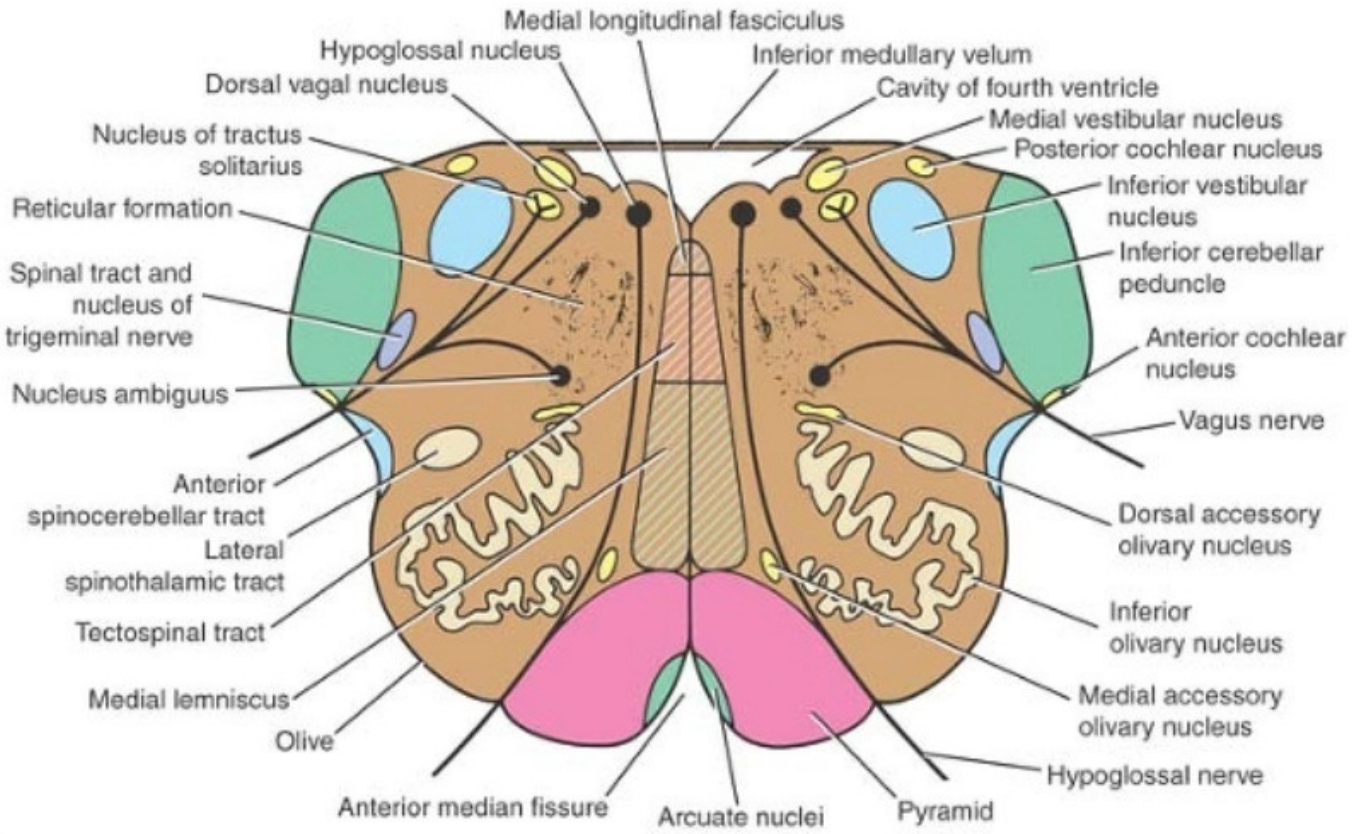
Level of sensory decussation




B
A
Posterior median sulcus
Fasciculus gracilis
Nucleus gracilis
Fasciculus cuneatus
Nucleus cuneatus
Spinal tract of trigeminal nerve
Spinal nucleus of trigeminal nerve
Spinal root of accessory nerve
Medial longitudinal fasciculus
Medial accessory olivary nucleus
Decussation of pyramids
Anterior median fissure
Pyramid
Central canal
Anterior spinocerebellar tract
Lateral spinothalamic tract
Posterior spinocerebellar tract
Lateral corticospinal tract
A
Fasciculus gracilis
Nucleus gracilis
Fasciculus cuneatus
Nucleus cuneatus
Internal arcuate fibers
Spinal tract of trigeminal nerve
Spinal nucleus of trigeminal nerve
Spinal root of accessory nerve
Inferior olivary nucleus
Hypoglossal nerve
Pyramid
Decussation of medial lemnisci
Anterior spinocerebellar tract
Lateral spinothalamic tract
Posterior spinocerebellar tract
Medial longitudinal fasciculus
Hypoglossal nucleus
Central canal
B

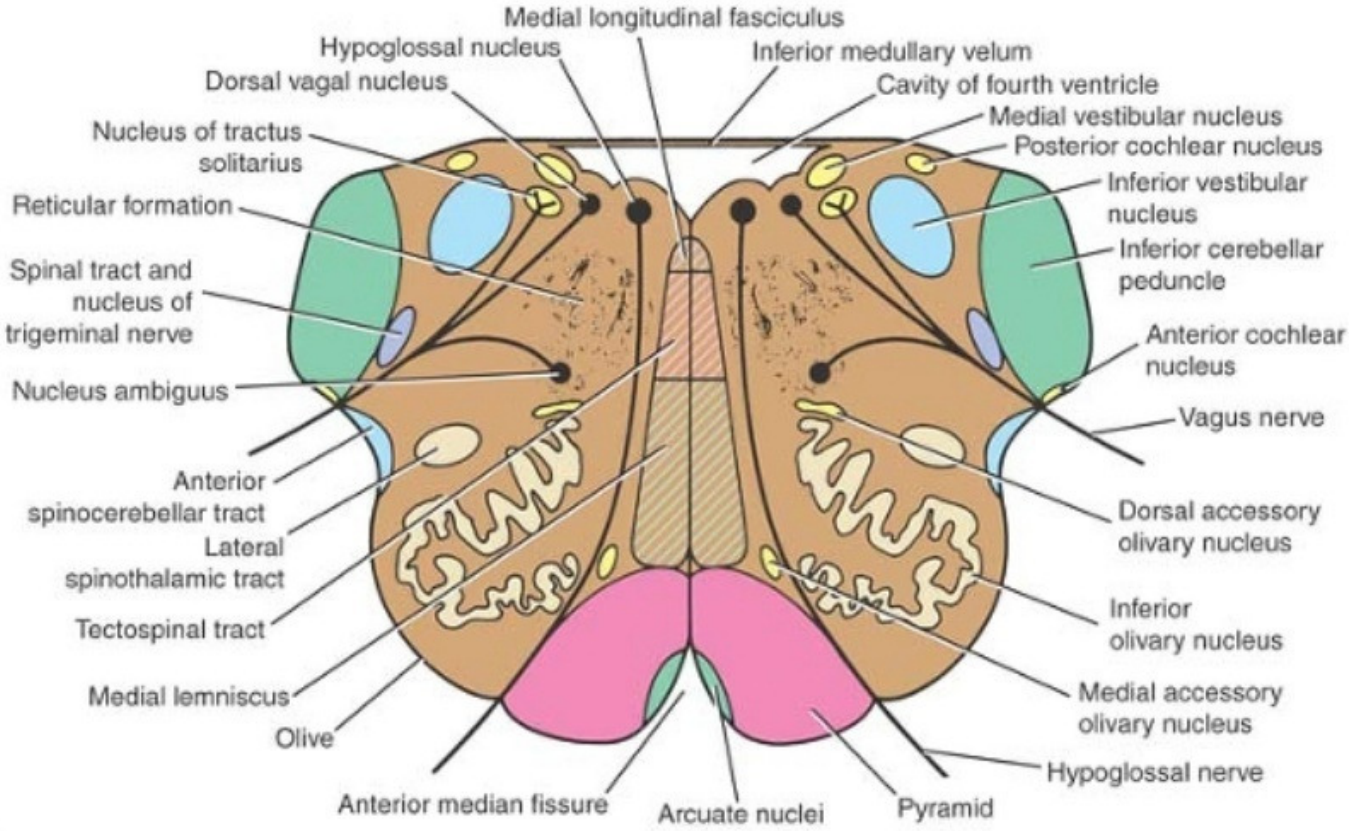
Level of olives (open medulla)

- inferior part of 4th ventricle
- Pyramids
- ICP (posterolateral corner)
- Medial leminiscus
- RF
- Spinal nucleus of trigeminal and its tract (anteriomedial to ICP)
- Nuclei of 12th 11th 10th & 9th
- Inf Olivary nucleus
- Medial longitudinal fasciculus



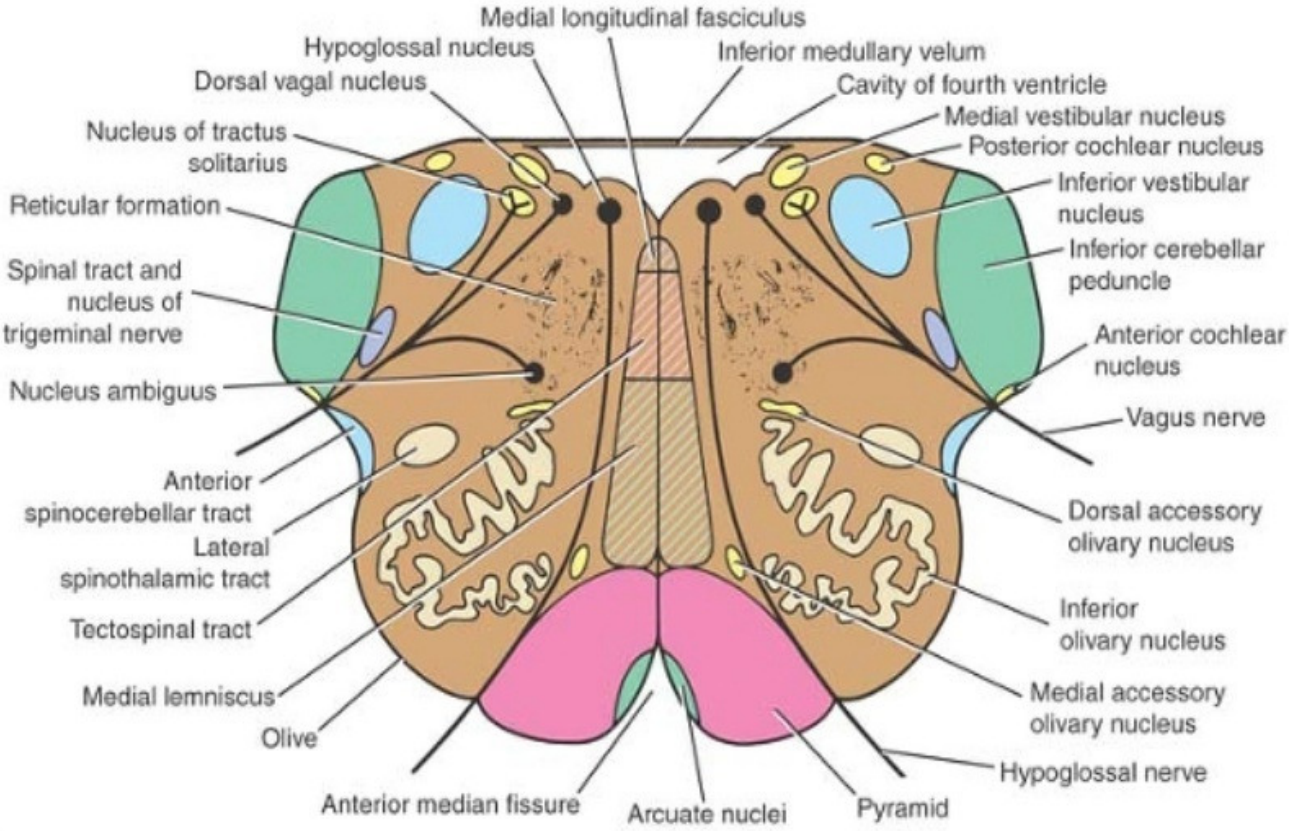
Olivary nuclear complex

- Mainly Inf. Olivary nucleus
- Gray matter is shaped like a crumpled bag with its mouth directed medially
- Responsible of the elevation olive
- Has communications with spinal cord, cerebellum & cortex
- Function is associated with voluntary muscle movement



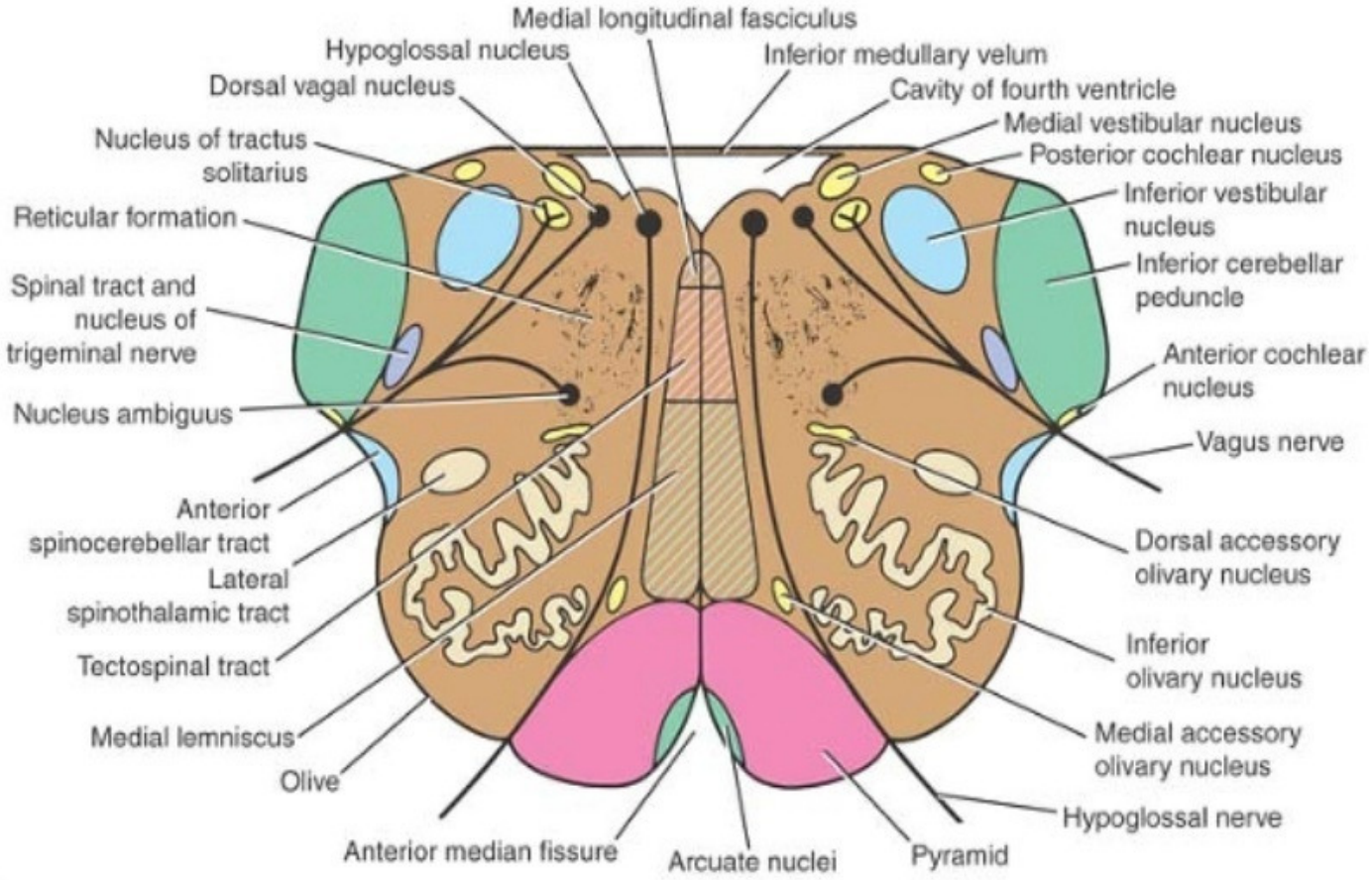
Nucleus ambiguus

- Large motor neurons
- Situated deep in RF
- Emerging fibers join 9th, 10th and 11th (cranial root of accessory)
- An elongated nucleus in the medulla oblongata that gives rise to the motor fibers of the glossopharyngeal, vagus, and accessory (cranial) nerves supplying striated muscle of the larynx and pharynx and soft palat



Medial longitudinal fasciculus

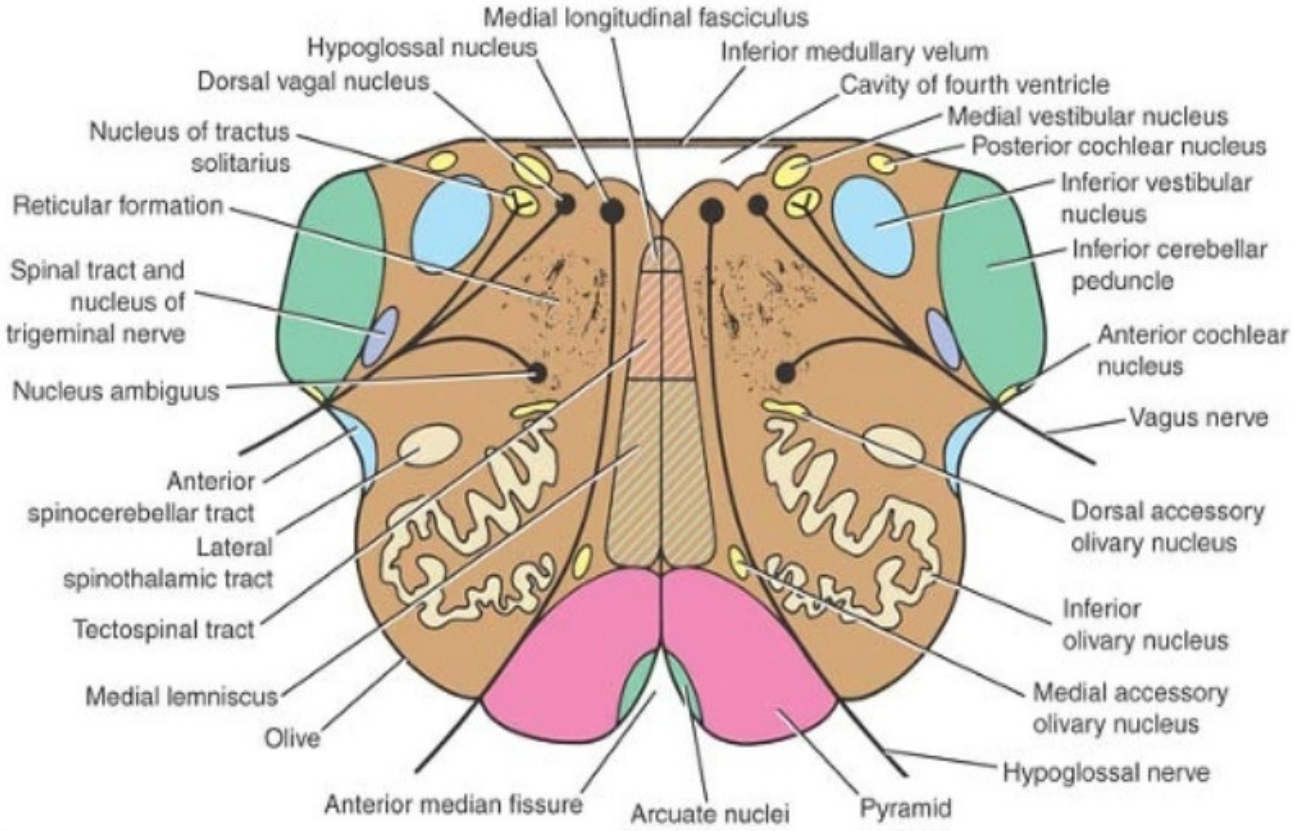
- Small tract of nerve fibers
- situated on each side of the midline
- Posterior to med. Leminiscus
- Anterior to 12th nucleus
- It is composed largely of ascending fibers from the vestibular nuclei and cochlear nuclei ascending to the motor nuclei (third, fourth and sixth)



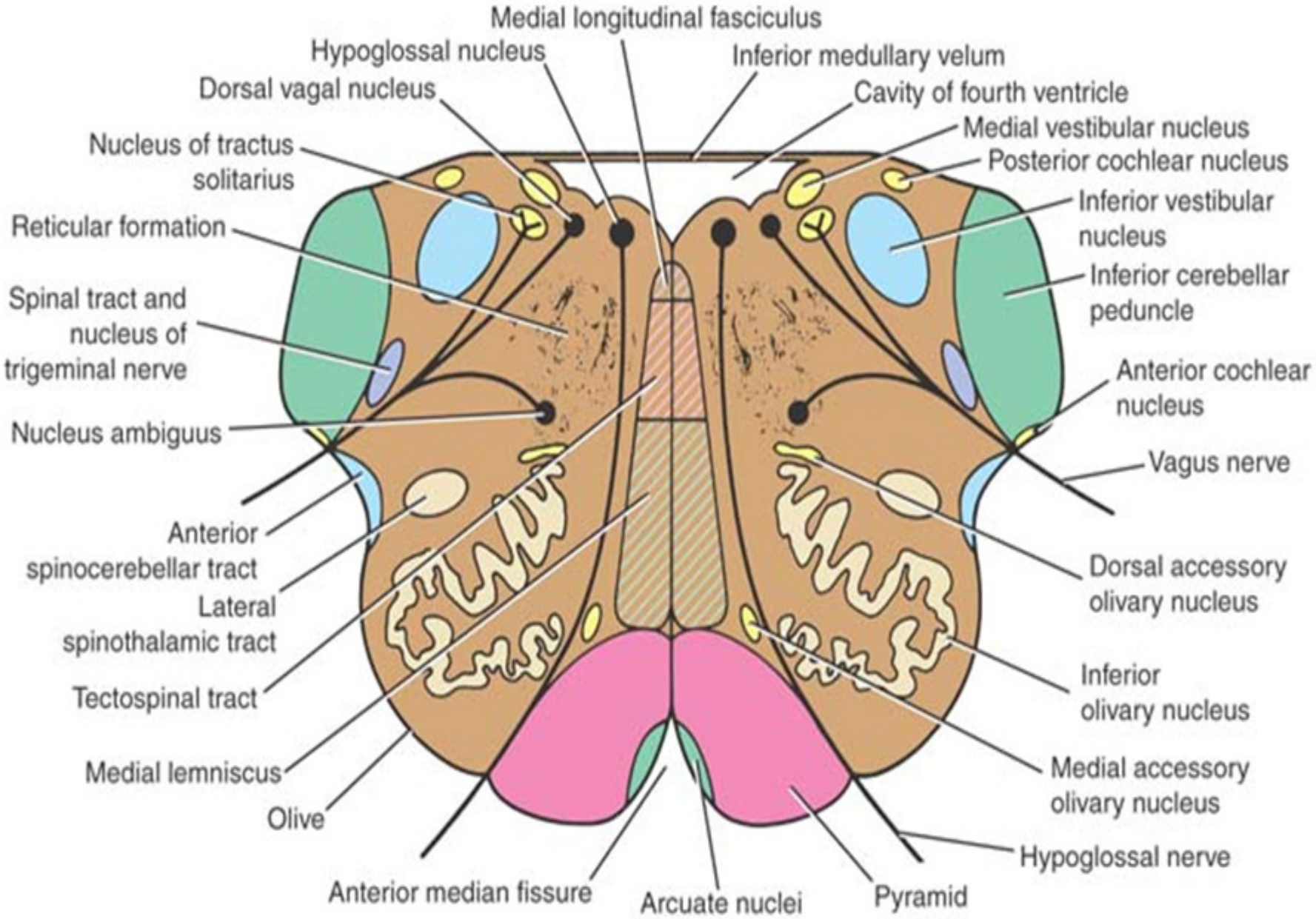
Central gray matter

- Lies beneath the floor of 4th ventricle
- Passing from M to L:

1. Hypoglossal nucleus
2. Dorsal nucleus of vagus
3. Solitary nucleus
4. Vestibular nuclei (medial and inferior)

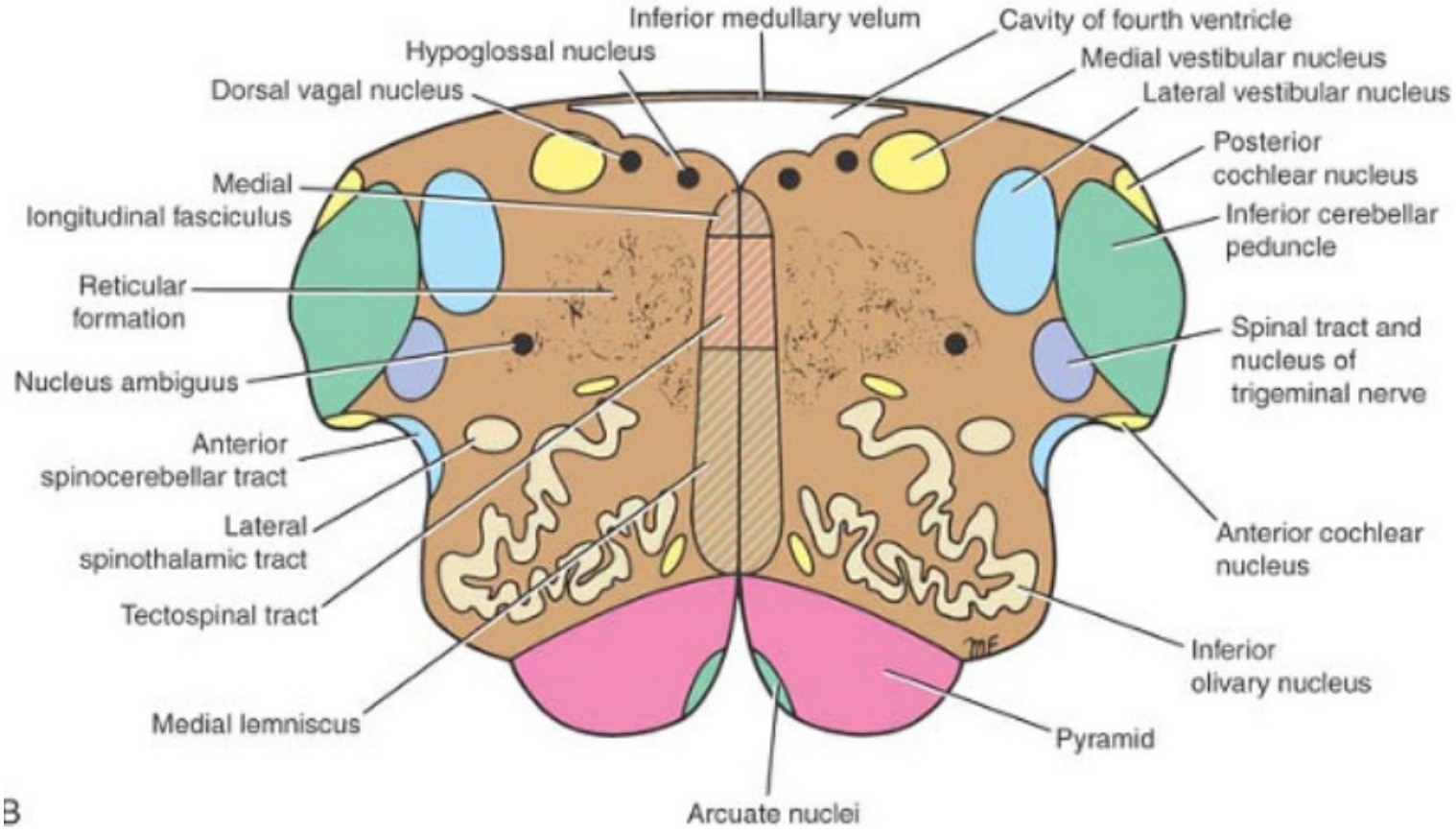


Medulla oblongata at the level of olives



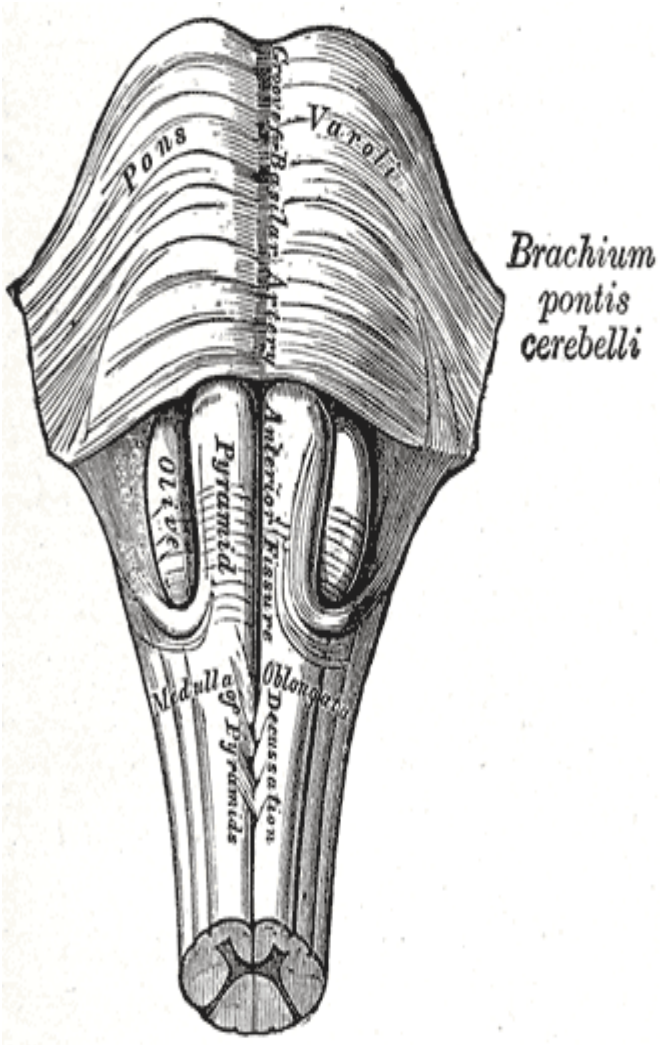
Level Just Inferior to the Pons

- No major changes
- **Lateral vestibular nucleus** replaced the inferior vestibular nucleus
- **Cochlear nuclei** visible on the anterior and posterior surfaces of the inferior cerebellar peduncle.



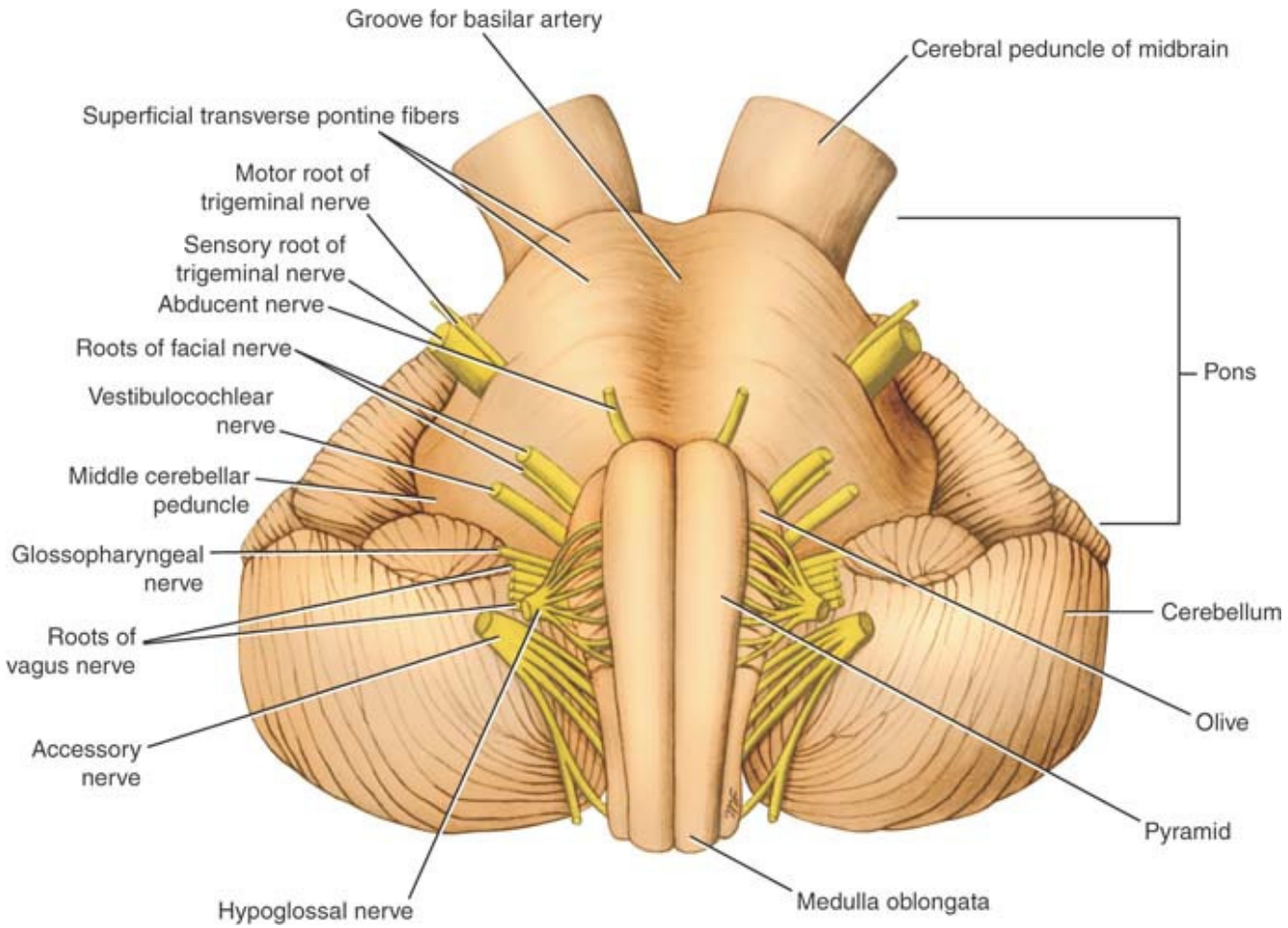
Pons

- Located anterior to cerebellum
- 1 inch long
- Anterior surface is convex & shows transverse fibers that converge on each side to form middle cerebellar peduncle
- Located between the midbrain and medulla oblongata
- Contains the nuclei of cranial nerves V, VI, VII and VIII

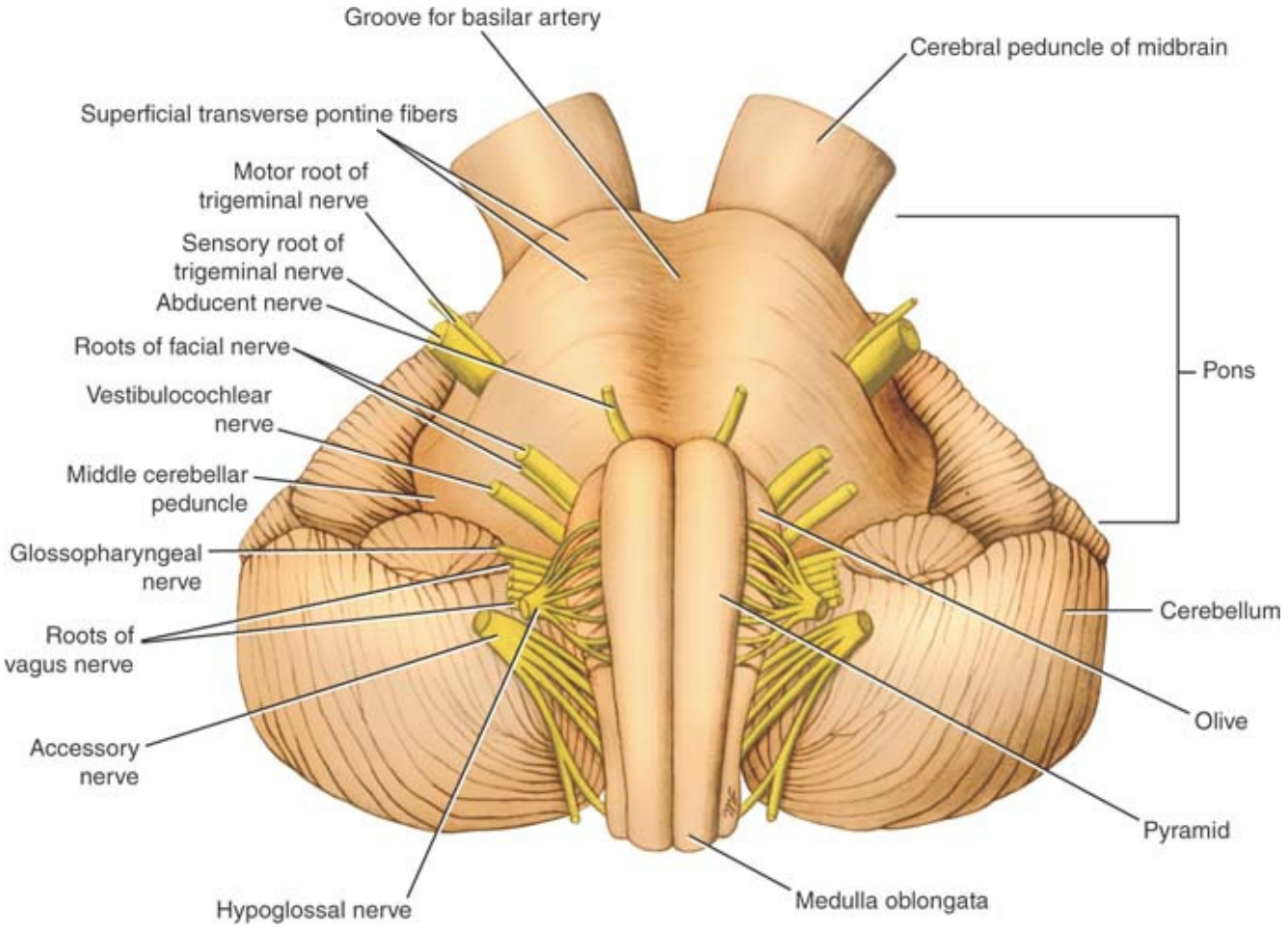


Gross appearance (anterior surface)

- Basilar groove (midline)..lodges basilar artery
- 5th nerve emerges from anterolateral surface (small motor (medial) and large sensory (lateral)
- 6th 7th & 8th emerges at pontomedullary junction M→L

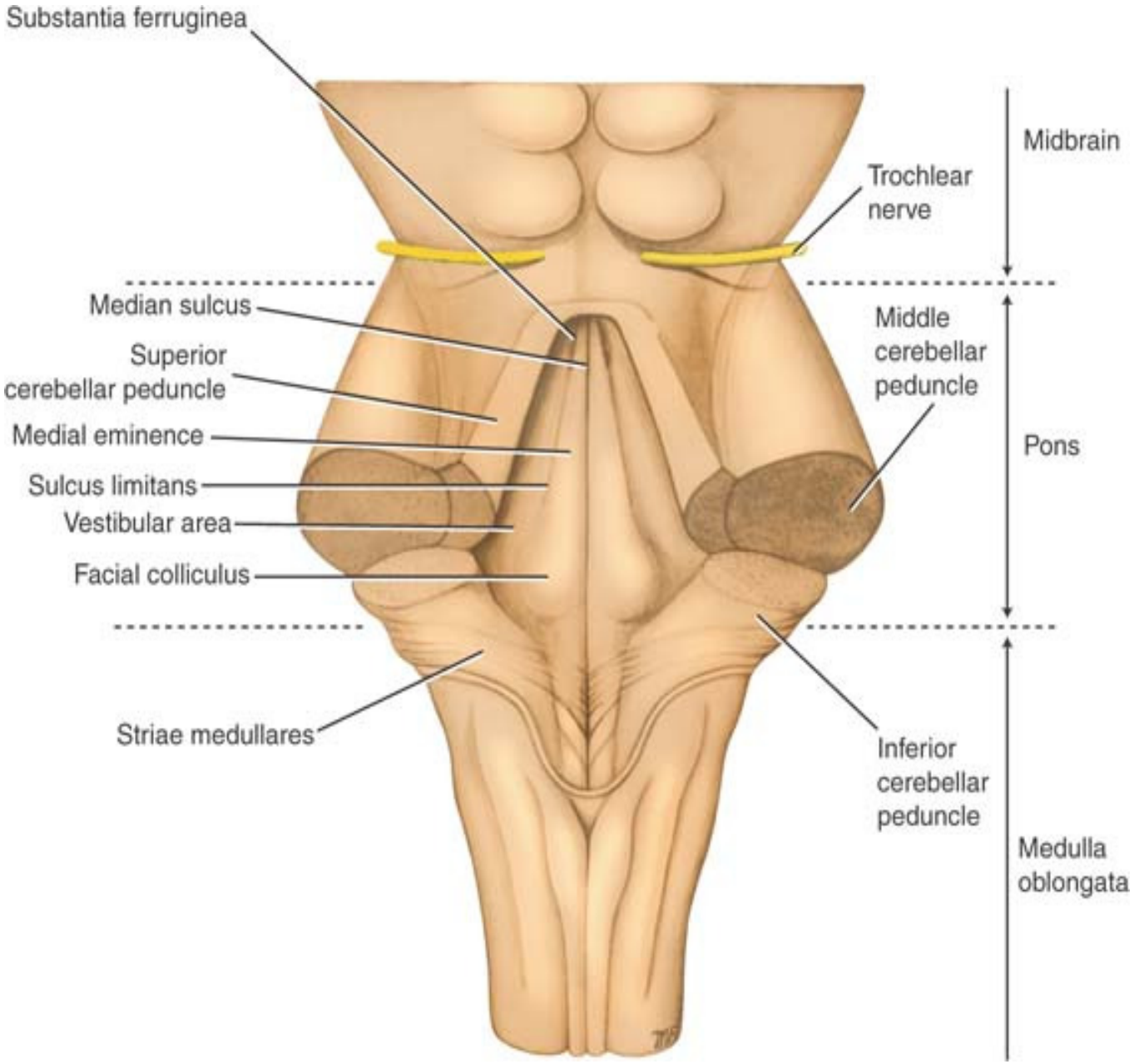


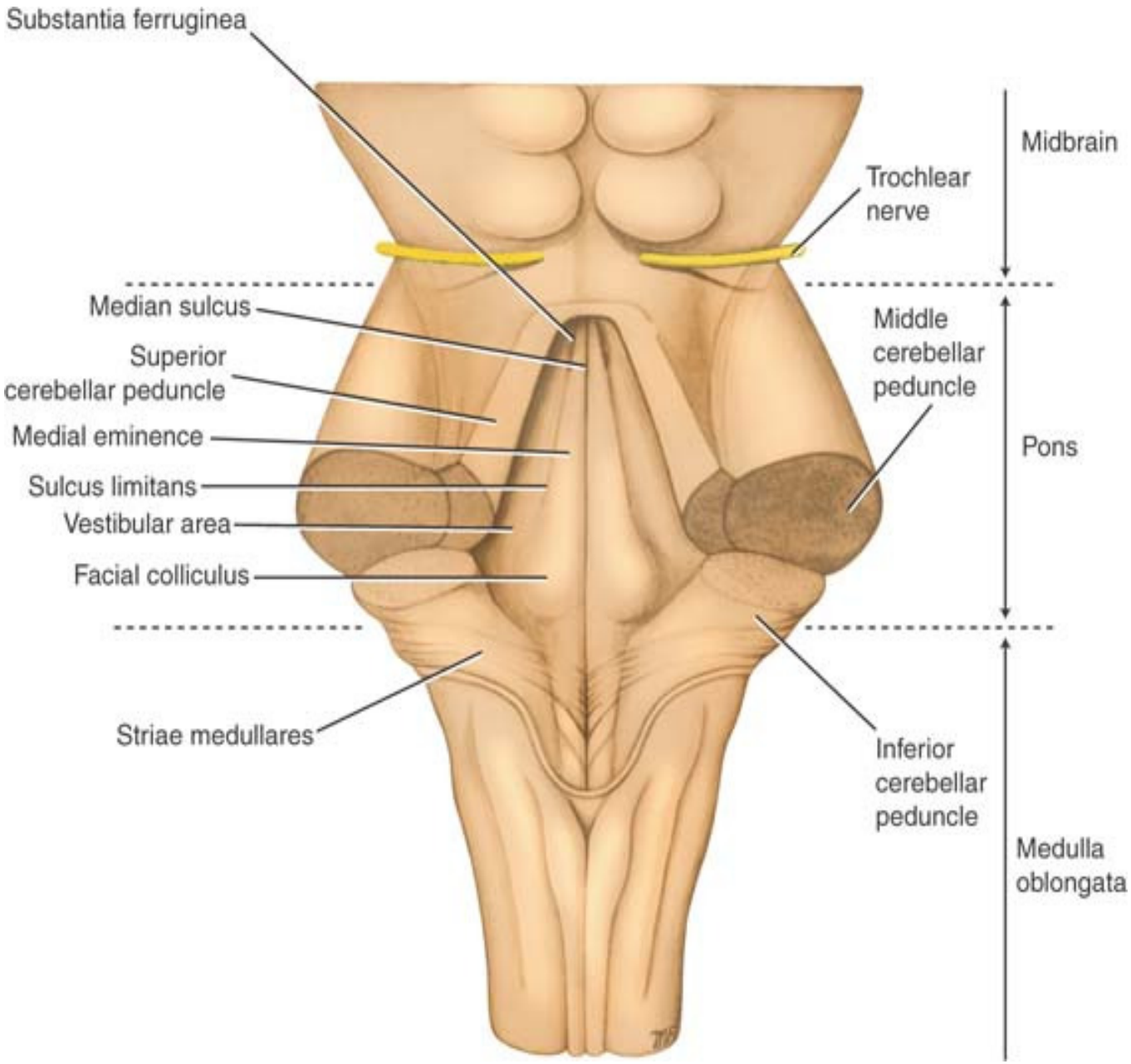
Pons – anterior view



Pons (posterior view)

- Its hidden by from view by cerebellum
- Forms the upper half of floor of 4th ventricle
- Triangular in shape
- Median sulcus
- Medial eminence
- Sulcus limitans
- Facial colliculus (inf end of medial eminence)
- Area vestibuli (Lateral to sulcus limitans)

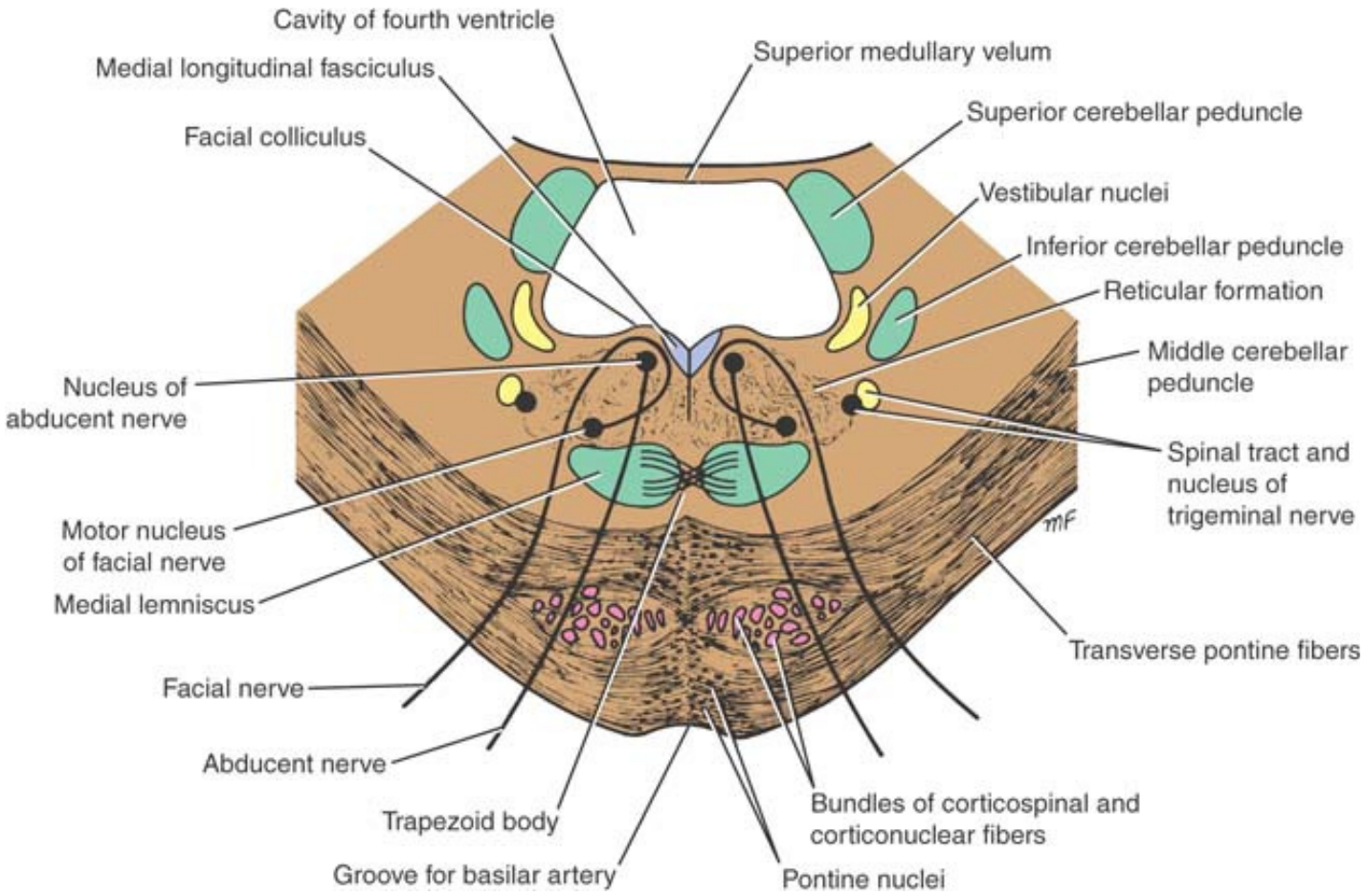



Substantia ferruginea
Trochlear nerve
Midbrain
Median sulcus
Superior cerebellar peduncle
Middle cerebellar peduncle
Medial eminence
Pons
Sulcus limitans
Vestibular area
Facial colliculus
Striae medullares
Inferior cerebellar peduncle
Medulla oblongata

Internal structure of pons

- Its divided by transversely running fibers of trapezoid body into:

1. Tegmentum (post part)
2. Basal part (ant part)

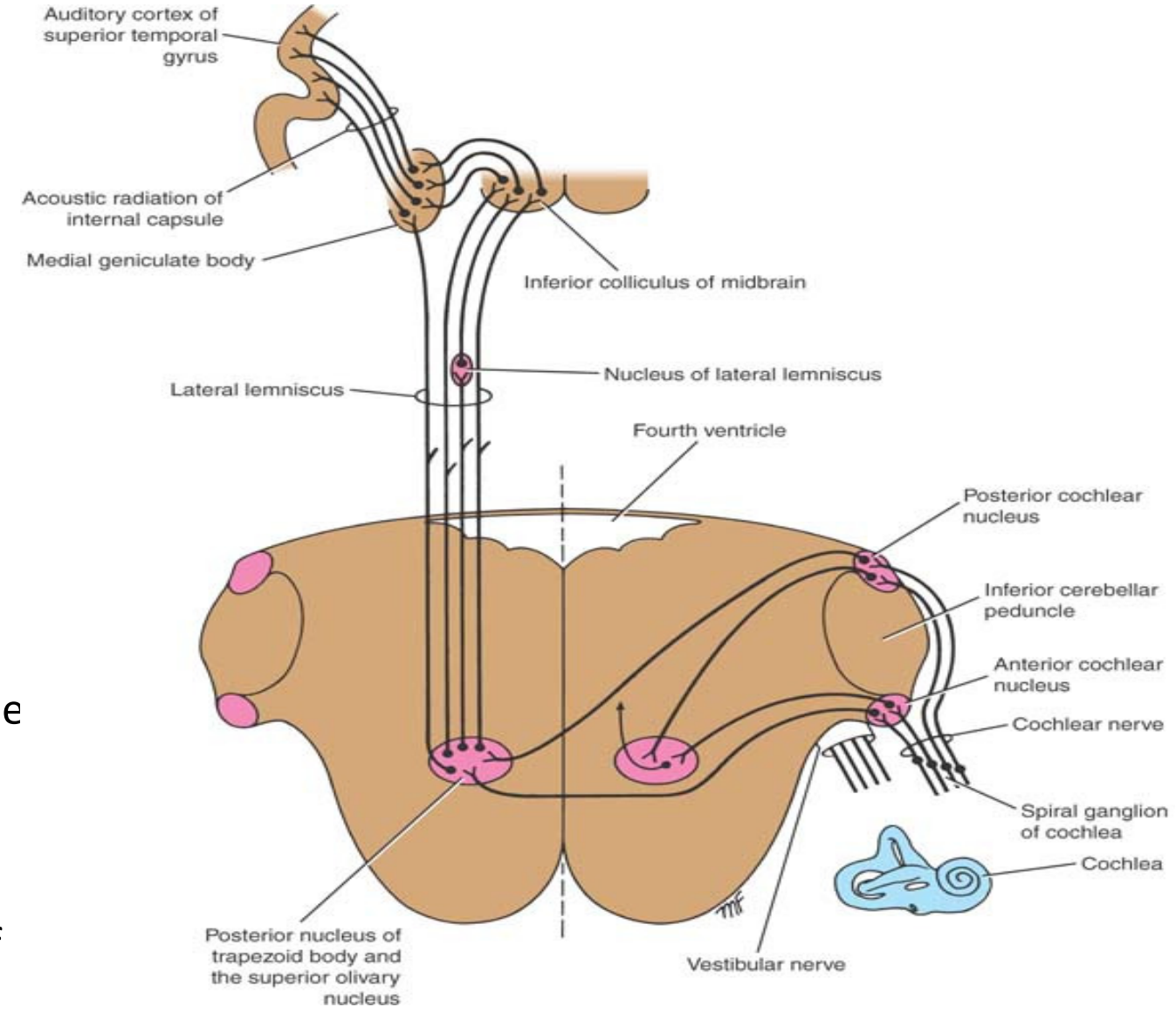


levels

- Level through caudal part (facial colliculus)
- Level through cranial part (trigeminal nuclei)

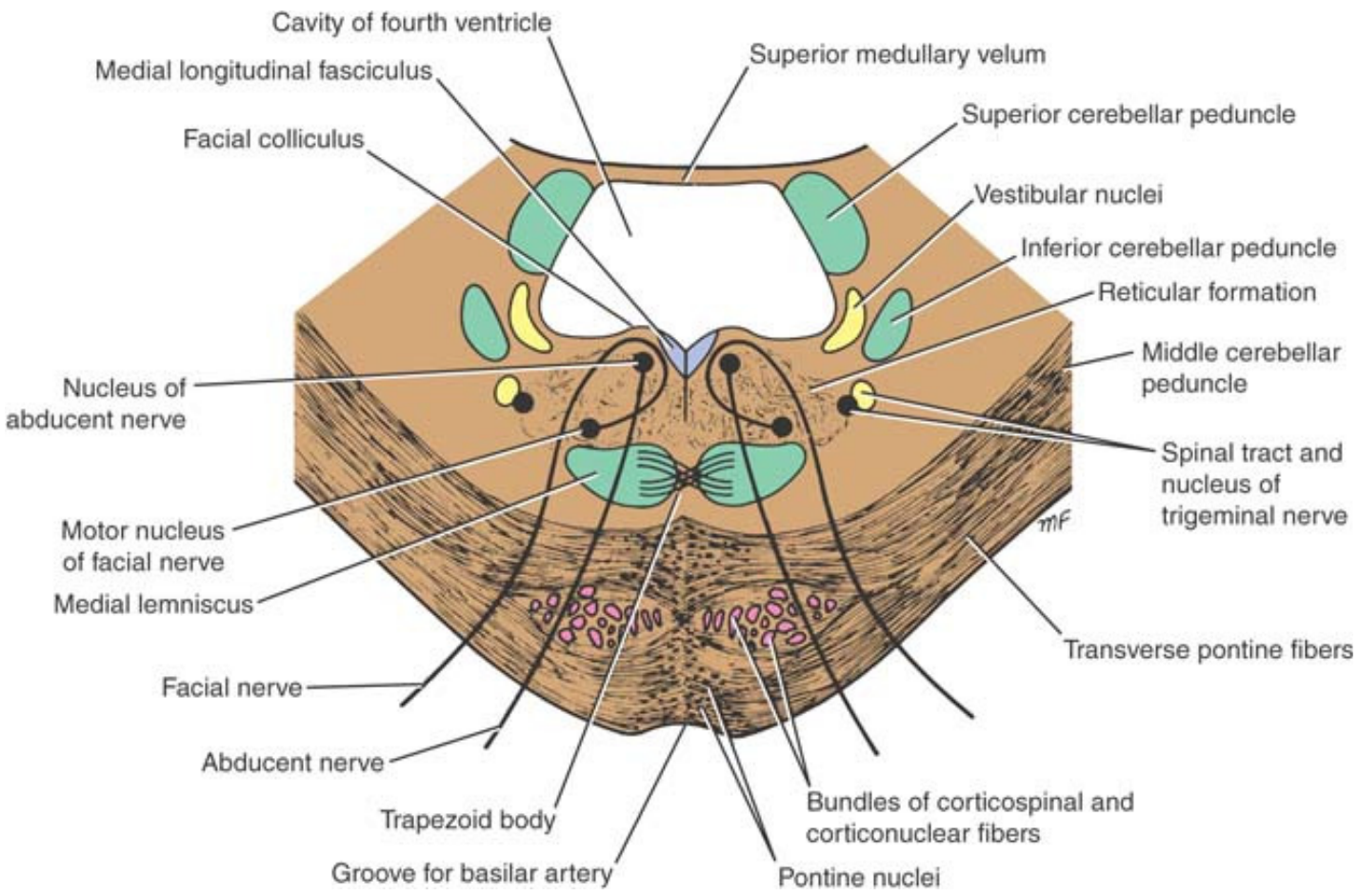
The trapezoid body

- is part of the acoustic pathway
- Made up of fibers derived from cochlear nuclei
- **lateral lemniscus**: tract of axons in the brainstem that carries information about sound from the cochlear nucleus to the contralateral inferior colliculus of the midbrain
- Cochlear nuclei---- trapezoid body---- lateral lemniscus----inf colliculus-----medial geniculate body----- auditory cortex



Level through caudal part (facial colliculus)

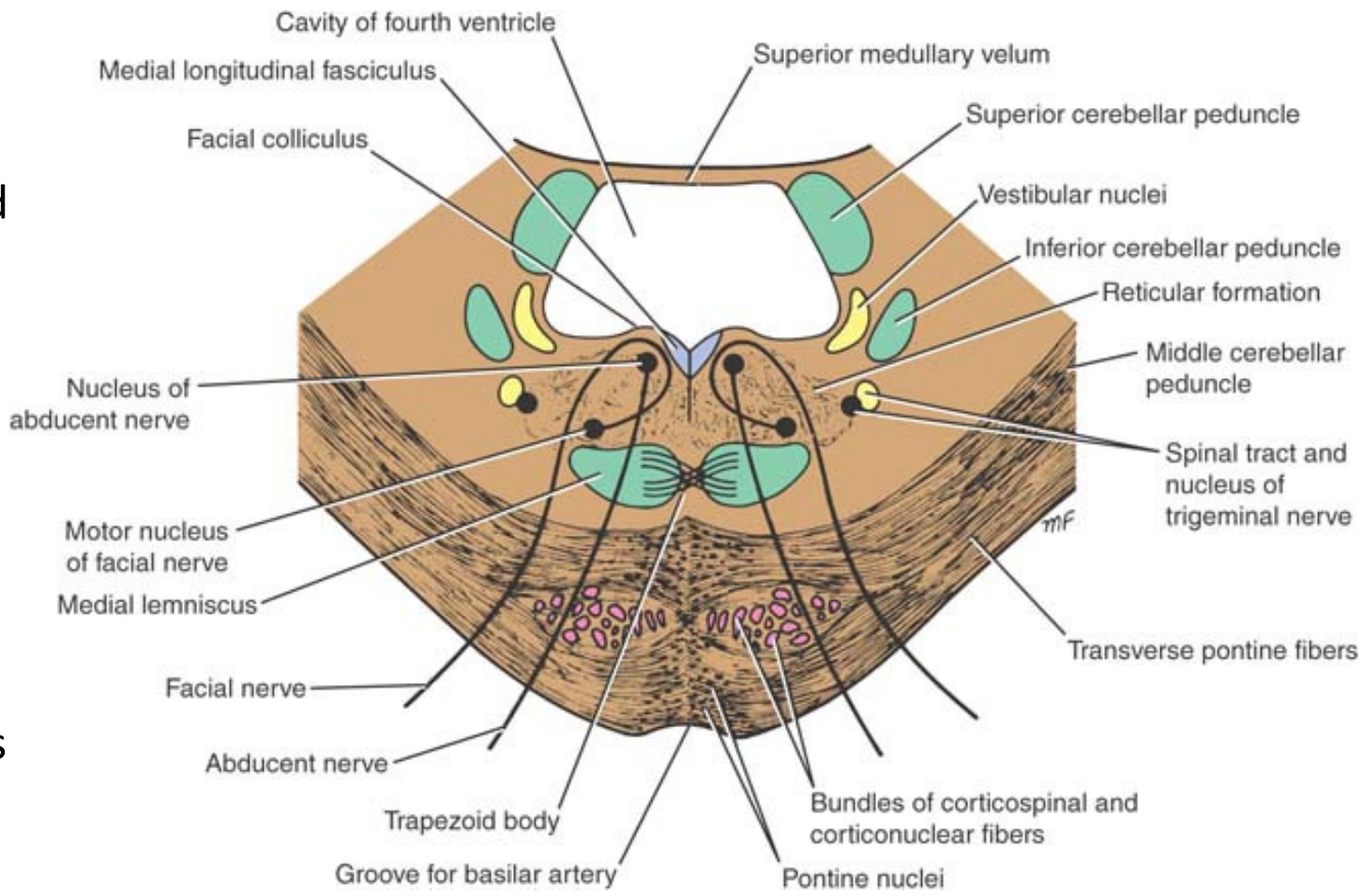
- **Medial lemniscus** most anterior part of the tegmentum, long axis running transversely
- **Facial nucleus** posterior to the lateral part of the medial lemniscus
- **MLF**: beneath the floor of the fourth ventricle on either side of the midline



- **Abducent nucleus:** beneath the floor of the upper part of the fourth
- **Spinal nucleus** of trigeminal and its tract: anteromedial aspect of ICP
- **Medial vestibular nucleus:** lateral to the abducent nucleus

Level through caudal part (facial colliculus)

- Basilar part of pons contain small masses of nerve cells called pontine nuclei
- Corticopontine fibers terminate in pontine nuclei
- Axons of these cells give origin to transverse fibers of the pons which cross the midline and intersect the corticospinal & corticonuclear tracts, breaking them into small bundles



- Transverse fibers enter MCP to cerebellum
- This connection is the main pathway linking cerebellum to cerebral cortex

Facial Nerve Nuclei

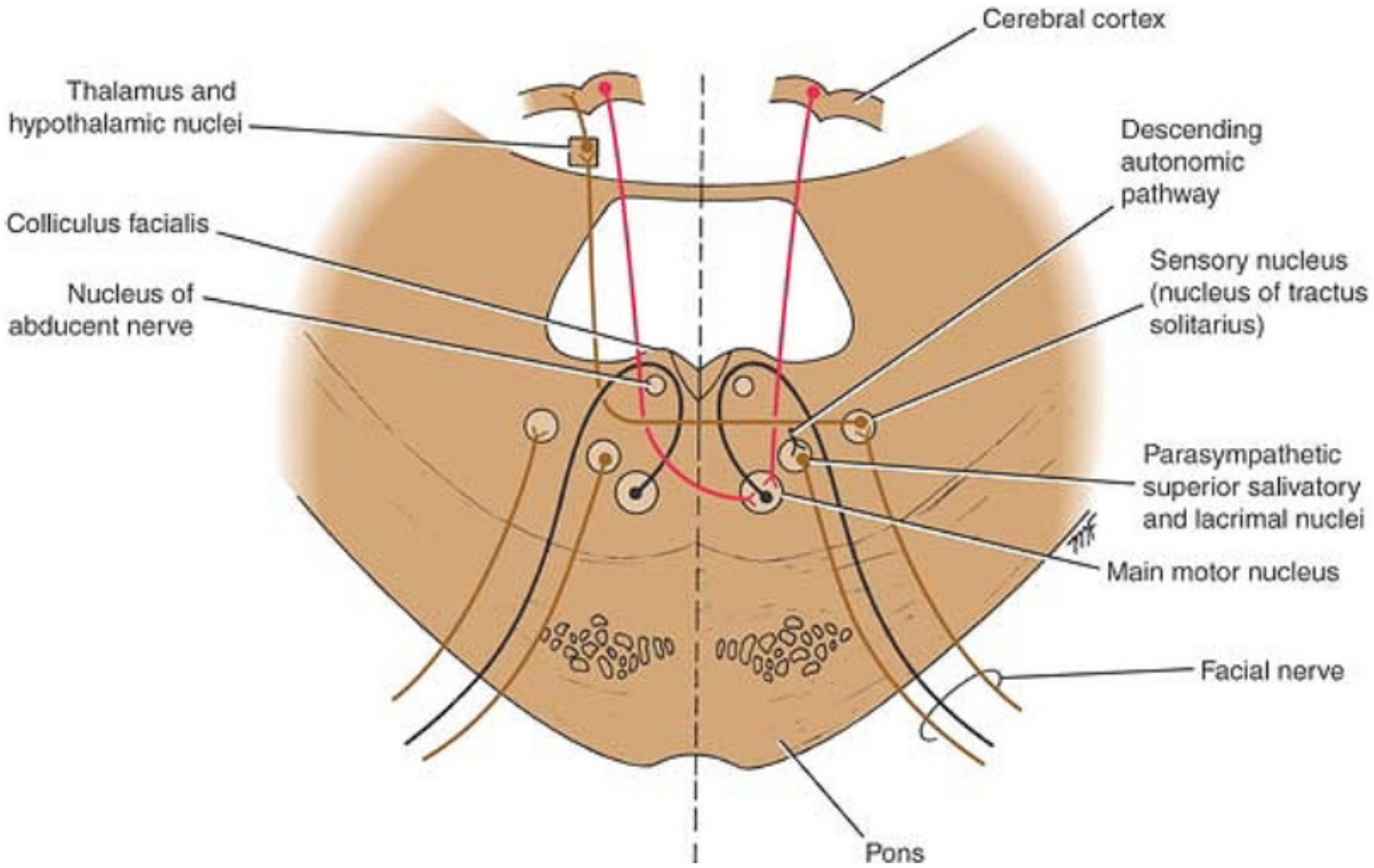
Parasympathetic Nuclei:

- **Location**: Posterolateral to the main motor nucleus

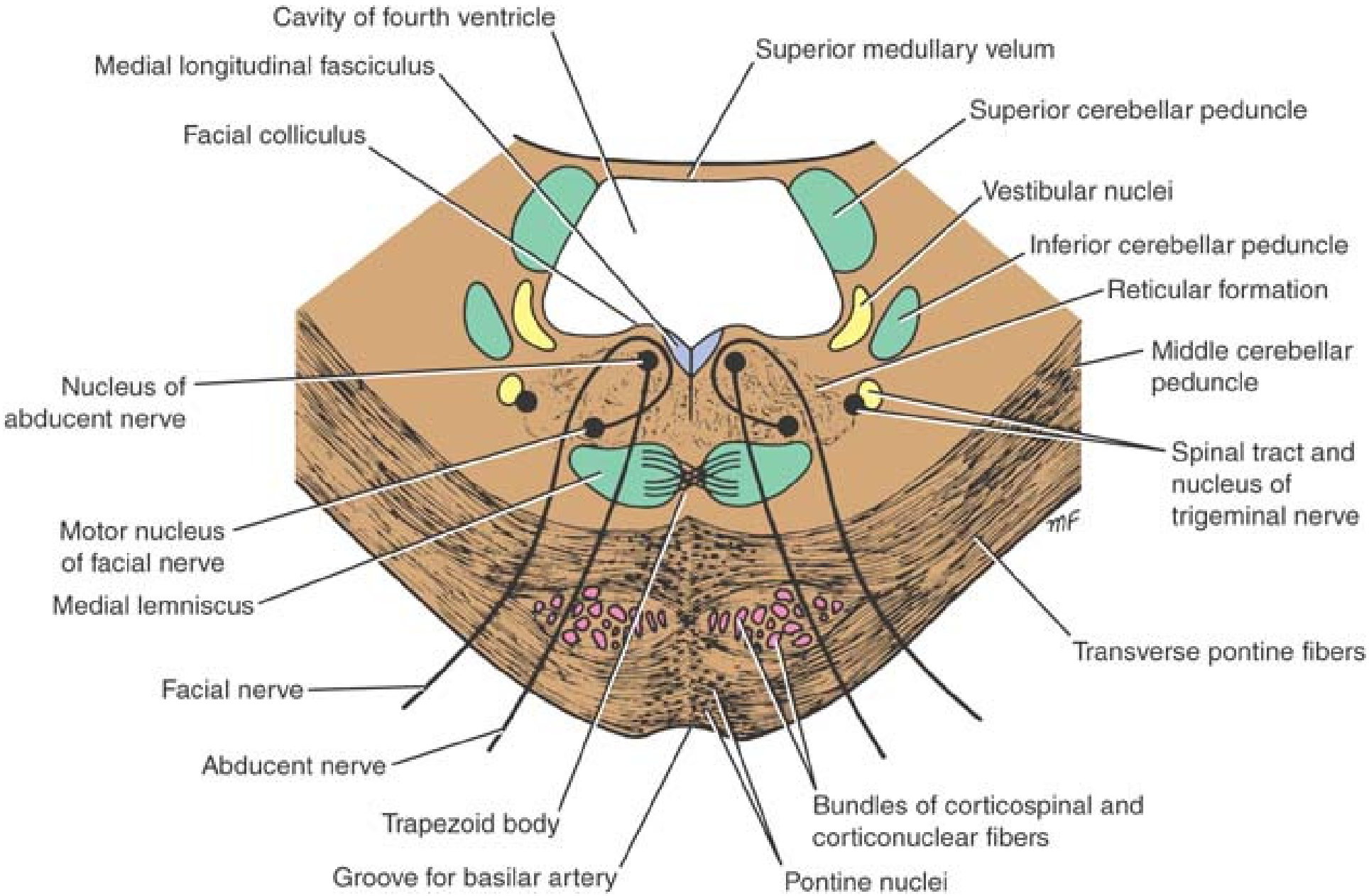
- superior salivatory: receives from the hypothalamus

- Lacrimal nucleus: receives from

  - hypothalamus (Emotional)
  - sensory nuclei of the trigeminal (reflex)

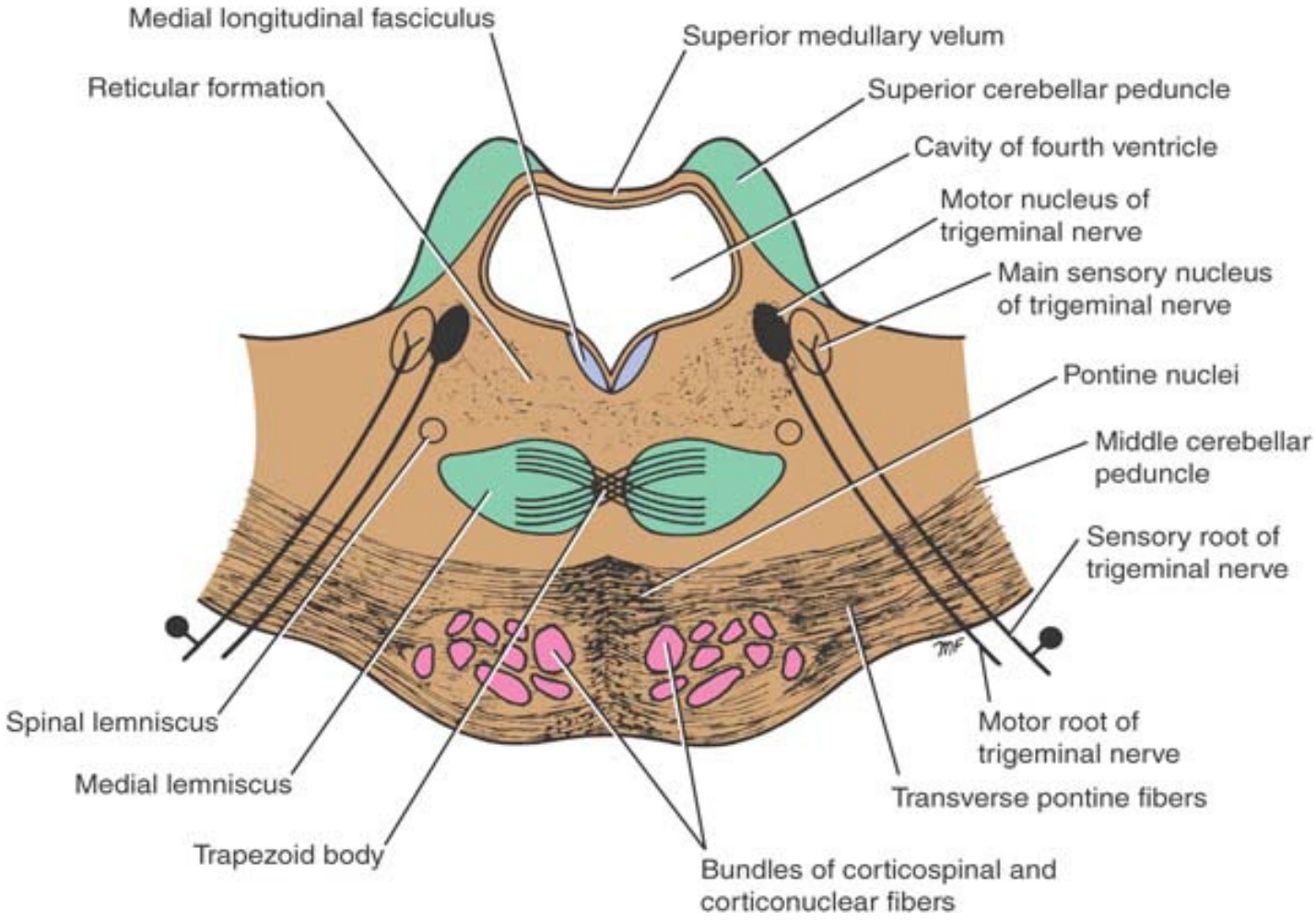


Level through caudal part (facial colliculus)

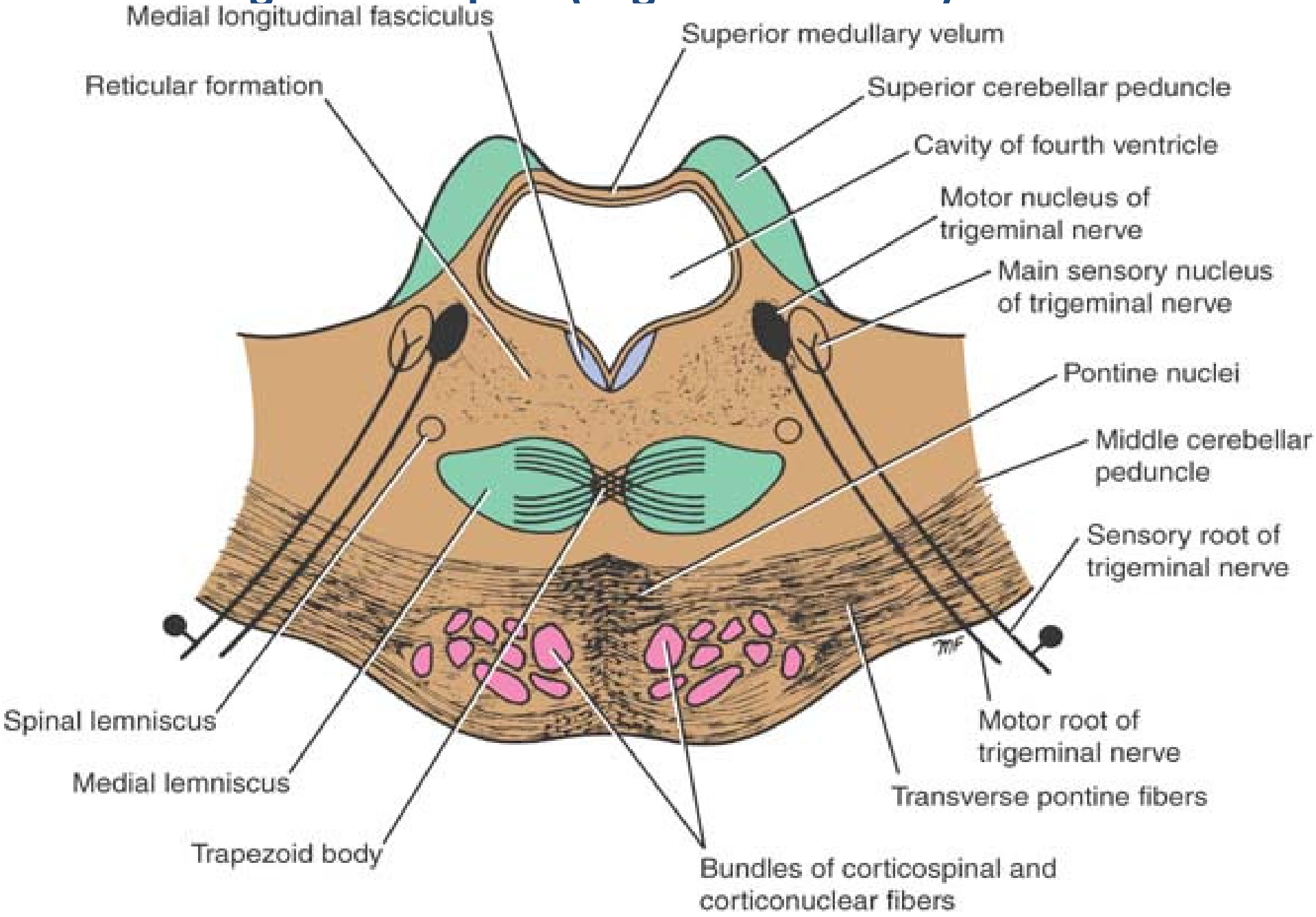


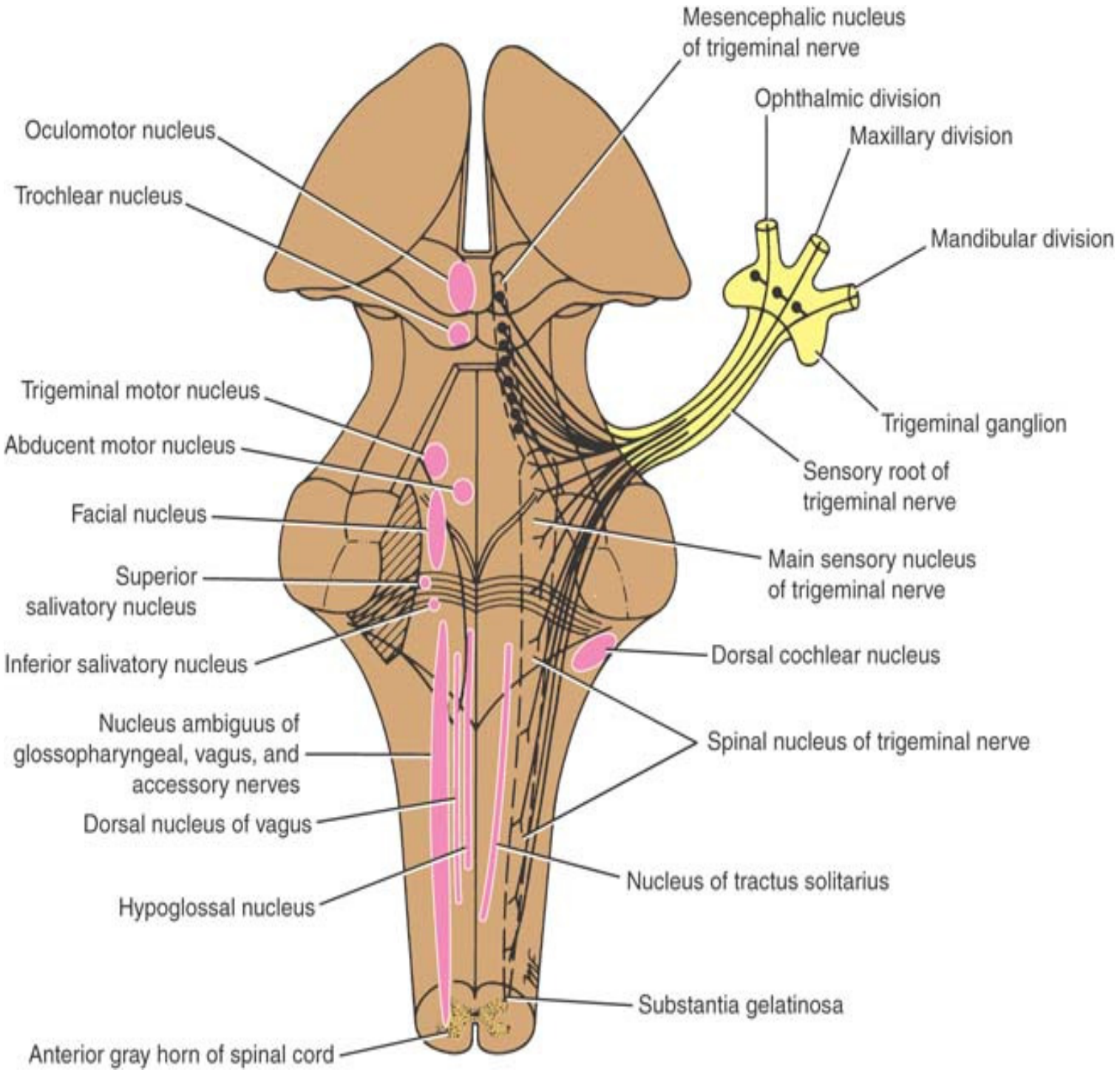
Level through cranial part (trigeminal nuclei)

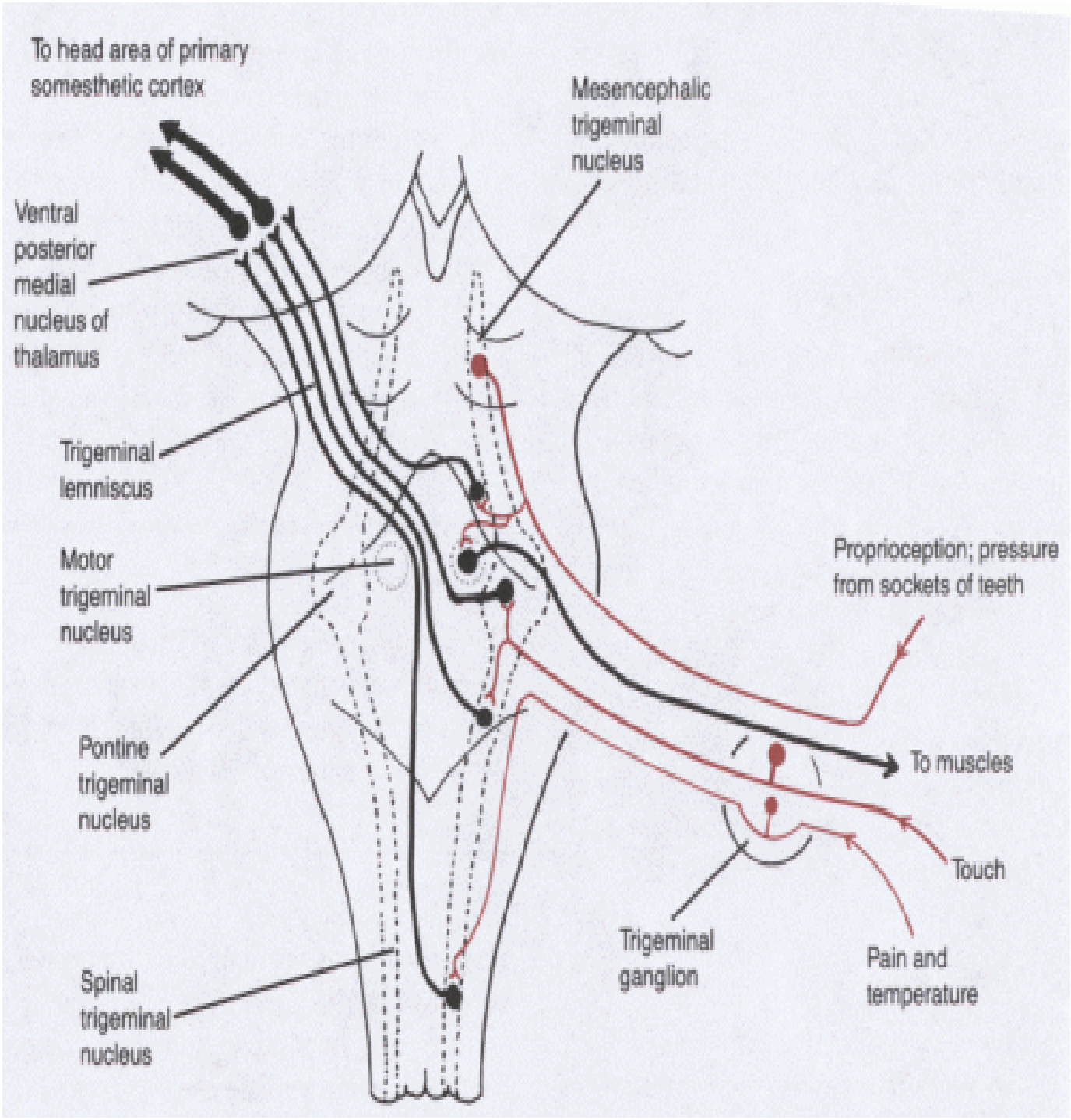
- **Motor nucleus** of trigeminal n: beneath the lateral part of thefourth ventricle within the reticular formation
- **Main Sensory** nucleus of trigeminal n (*lateral*)
- **SCP:** posterolateral to the motor nucleus of V
- **Trapezoid body**
- **Medial leminiscus**
- **Lateral leminiscus, Spinal leminiscus**: lateral extremity of the medial lemniscus



Level through cranial part (trigeminal nuclei)

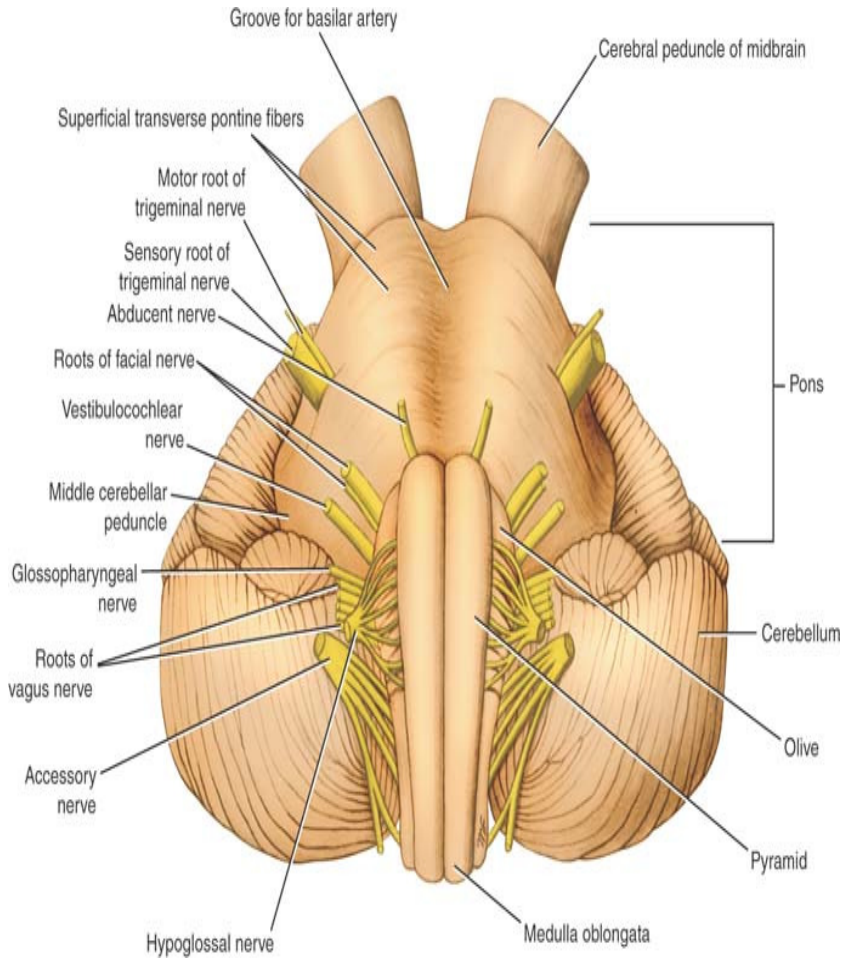



Mesencephalic nucleus of trigeminal nerve
Ophthalmic division
Maxillary division
Mandibular division
Oculomotor nucleus
Trochlear nucleus
Trigeminal motor nucleus
Abducent motor nucleus
Facial nucleus
Superior salivatory nucleus
Inferior salivatory nucleus
Nucleus ambiguus of glossopharyngeal, vagus, and accessory nerves
Dorsal nucleus of vagus
Hypoglossal nucleus
Anterior gray horn of spinal cord
Trigeminal ganglion
Sensory root of trigeminal nerve
Main sensory nucleus of trigeminal nerve
Dorsal cochlear nucleus
Spinal nucleus of trigeminal nerve
Nucleus of tractus solitarius
Substantia gelatinosa

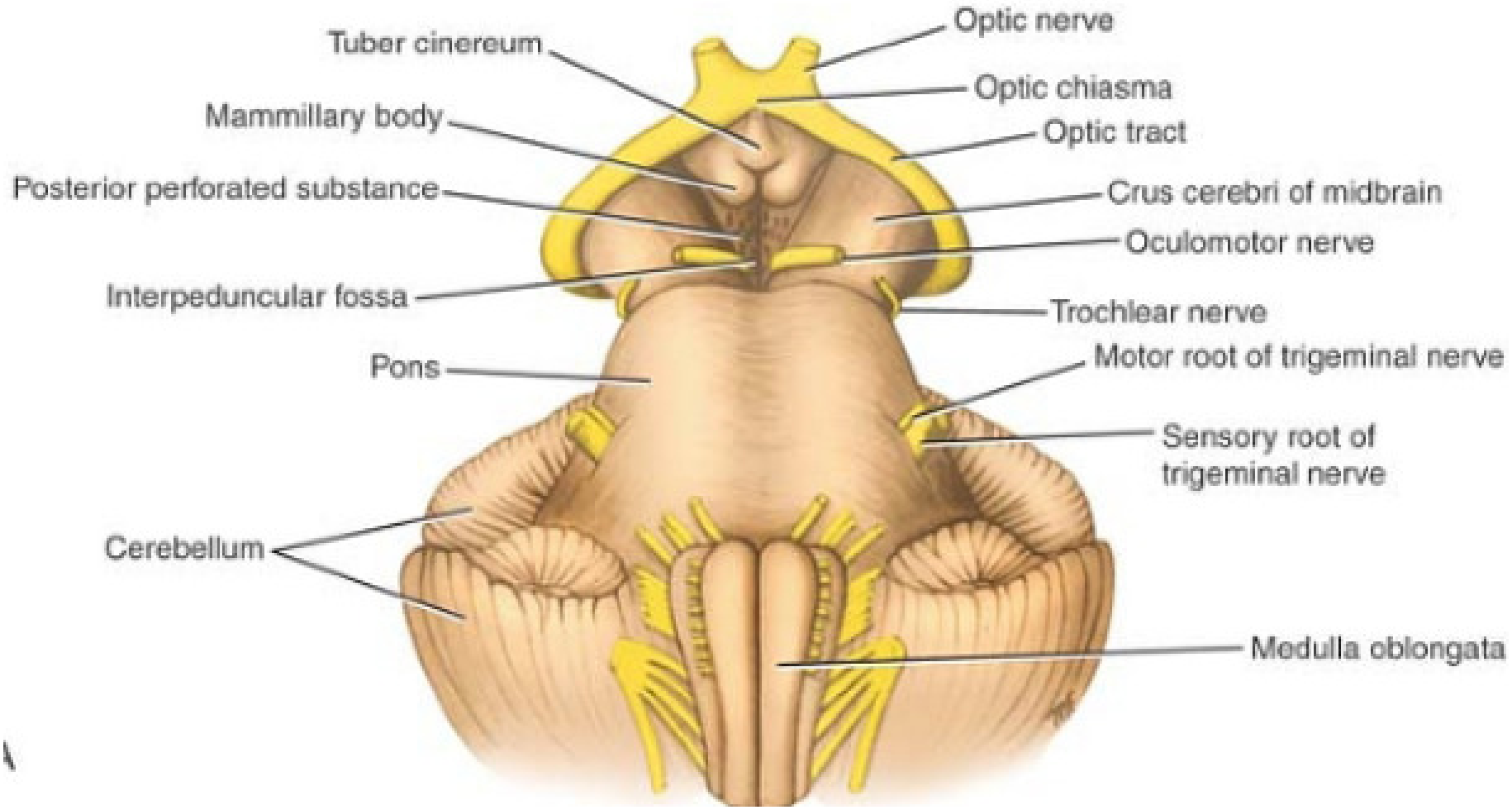

To head area of primary somesthetic cortex
Mesencephalic trigeminal nucleus
Ventral posterior medial nucleus of thalamus
Trigeminal lemniscus
Motor trigeminal nucleus
Pontine trigeminal nucleus
Spinal trigeminal nucleus
Proprioception; pressure from sockets of teeth
To muscles
Touch
Trigeminal ganglion
Pain and temperature

The Brain Stem – The Midbrain

- Lies between the diencephalon and the pons
- Central cavity – the **cerebral aqueduct**
- Cerebral peduncles located on the ventral surface of the brain divided by the **substantia nigra** into**:**
- **Crus cerebri: Anterior**
- **Tegmentum: Posterior**
  - Contain pyramidal (corticospinal) tracts
- Superior cerebellar peduncles
  - Connect midbrain to the cerebellum



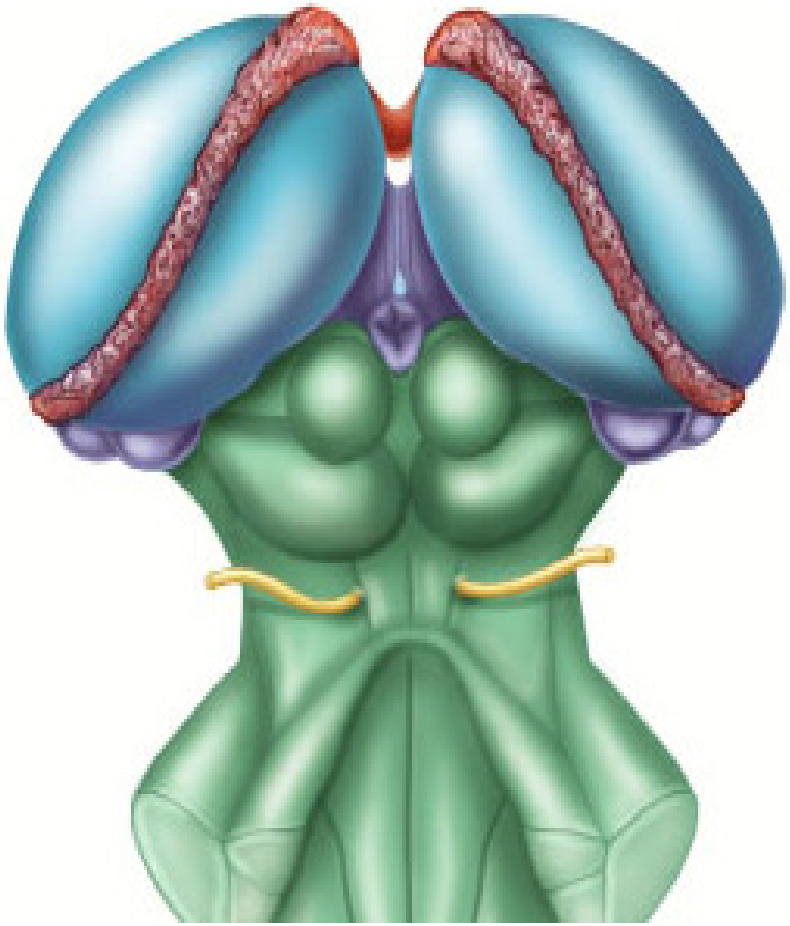
Midbrain ant. View



- Interpeduncular fossa
- Crus cerebri
- 3rd nerve emerges from medial side of crus cerebri in the interpeduncular fossa

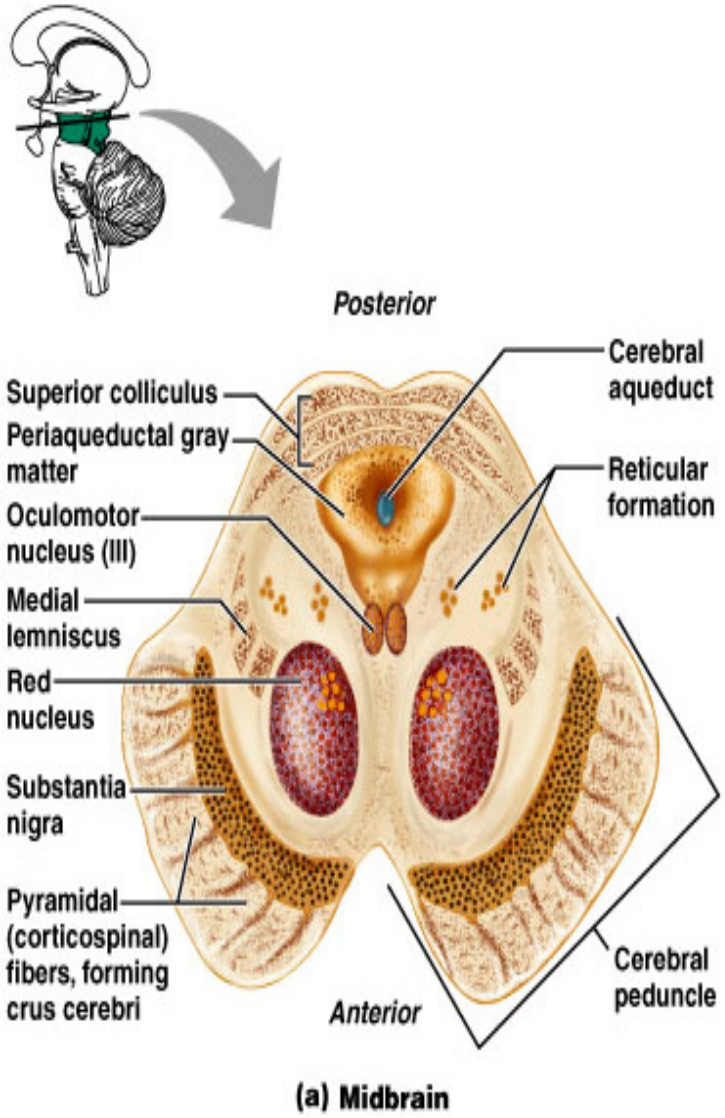
The Midbrain-posterior view

- Corpora quadrigemina – the largest nuclei
  - Divided into the superior and inferior colliculi
    - Superior colliculi – nuclei that act in visual reflexes
    - Inferior colliculi – nuclei that act in auditory reflexes
- Trochlear nerve emerges below the level of inf. Colliculus (from posterior surface)
- Occulomotor nerve emerges at the level of sup. colliculus
- Sup.brachium (to lateral geniculate body)
- Inf. Brachium (to medial geniculate body)
- 4^{th} emerges



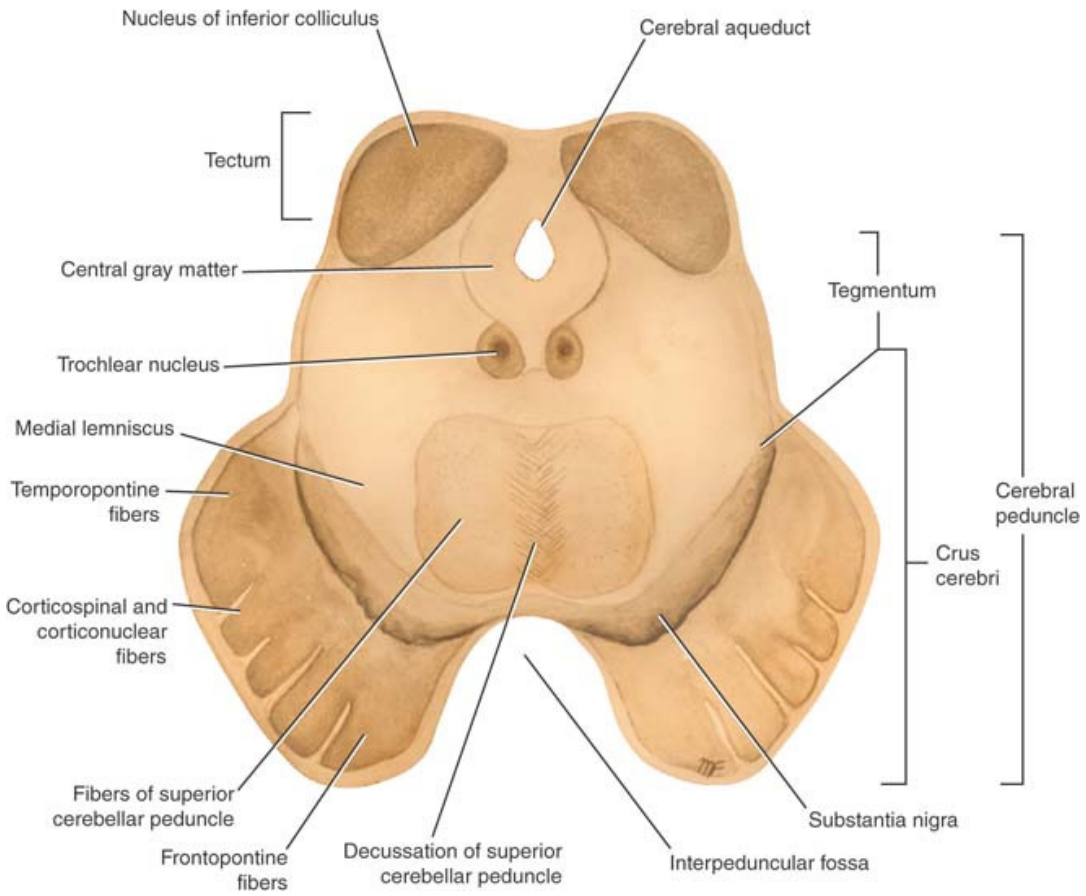
The Brain Stem – The Midbrain

- Imbedded in the white matter of the midbrain
  - Two pigmented nuclei
  - Substantia nigra – neuronal cell bodies contain melanin
    - Functionally linked to the basal nuclei
  - Red nucleus – lies deep to the substantia nigra
    - Largest nucleus of the reticular formation



Cerebral peduncle is divided into crus cerebri (ant) & tegmentum (post)

Tectum is post to cerebral aqueduct

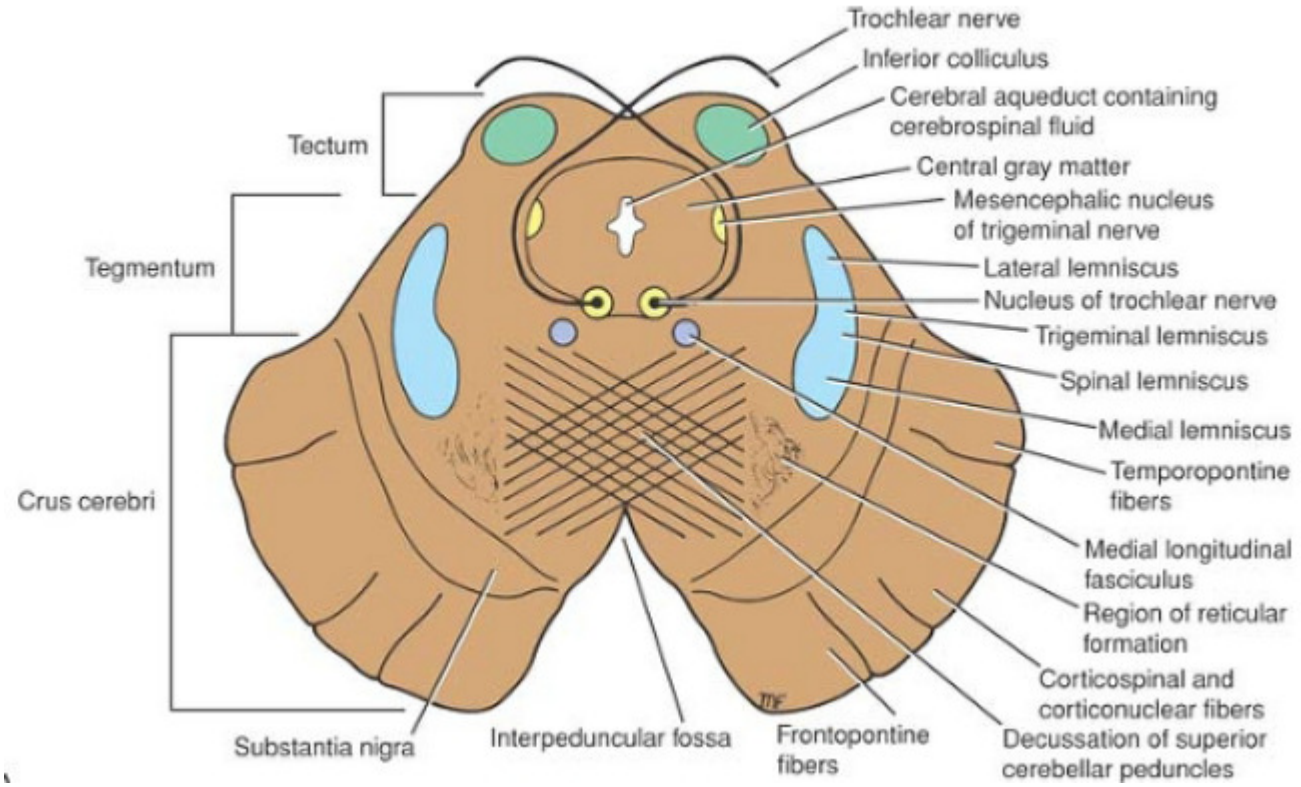


Substantia nigra is situated between the tegmentum and crus cerebri

- Trochlear nucleus lies close to midline in the central gray matter (posterior to MLF)
- Trochlear nerves decussate in the superior medullary velum

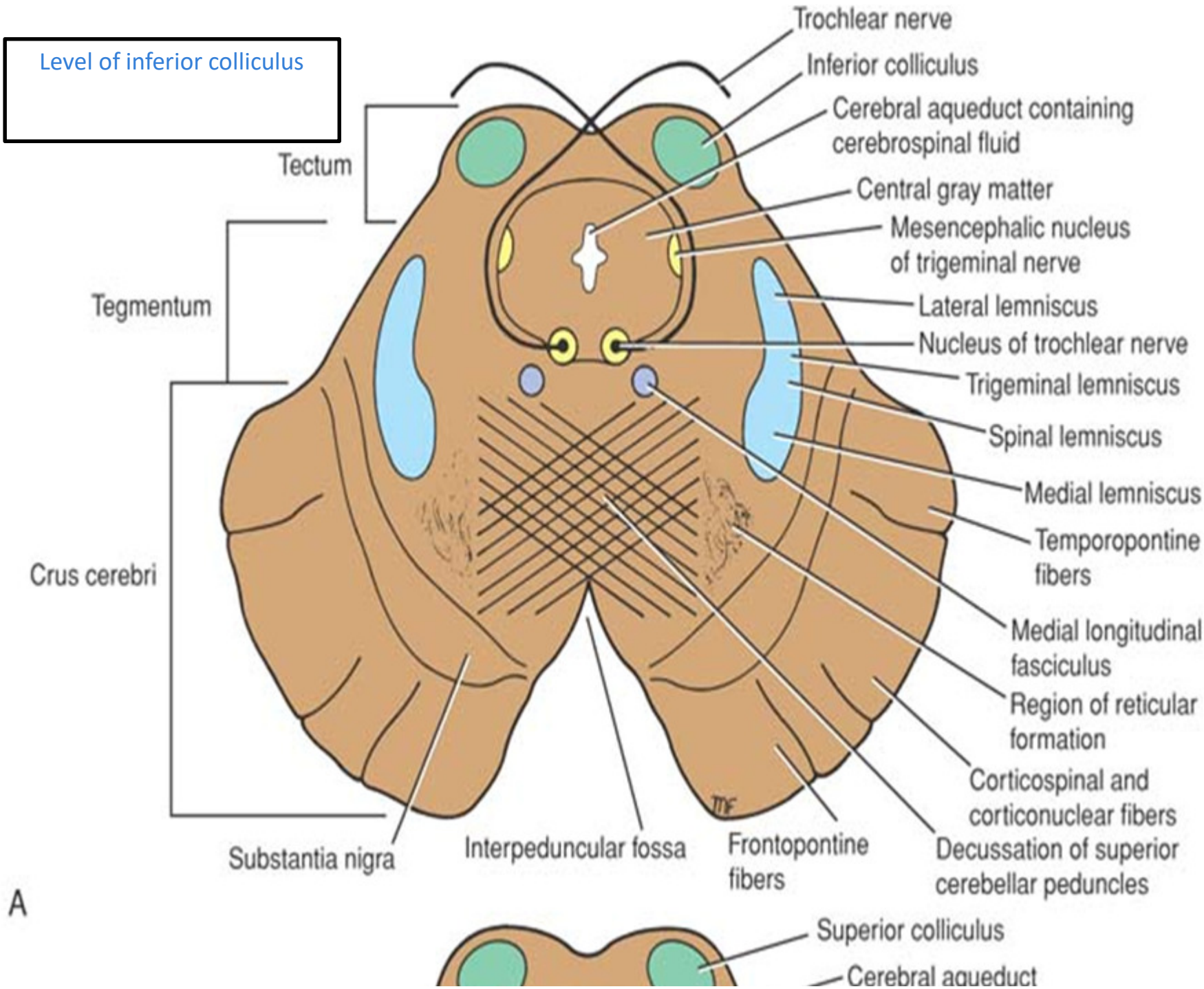
- Decussation of sup. cerebellar peduncles (central part of the tegmentum anterior to the cerebral aqueduct)
  - RF is lateral to decussation
  - Medial, spinal ,trigeminal & lateral leminisci (Posterior to Substantia nigra)

Level of inf. colliculus



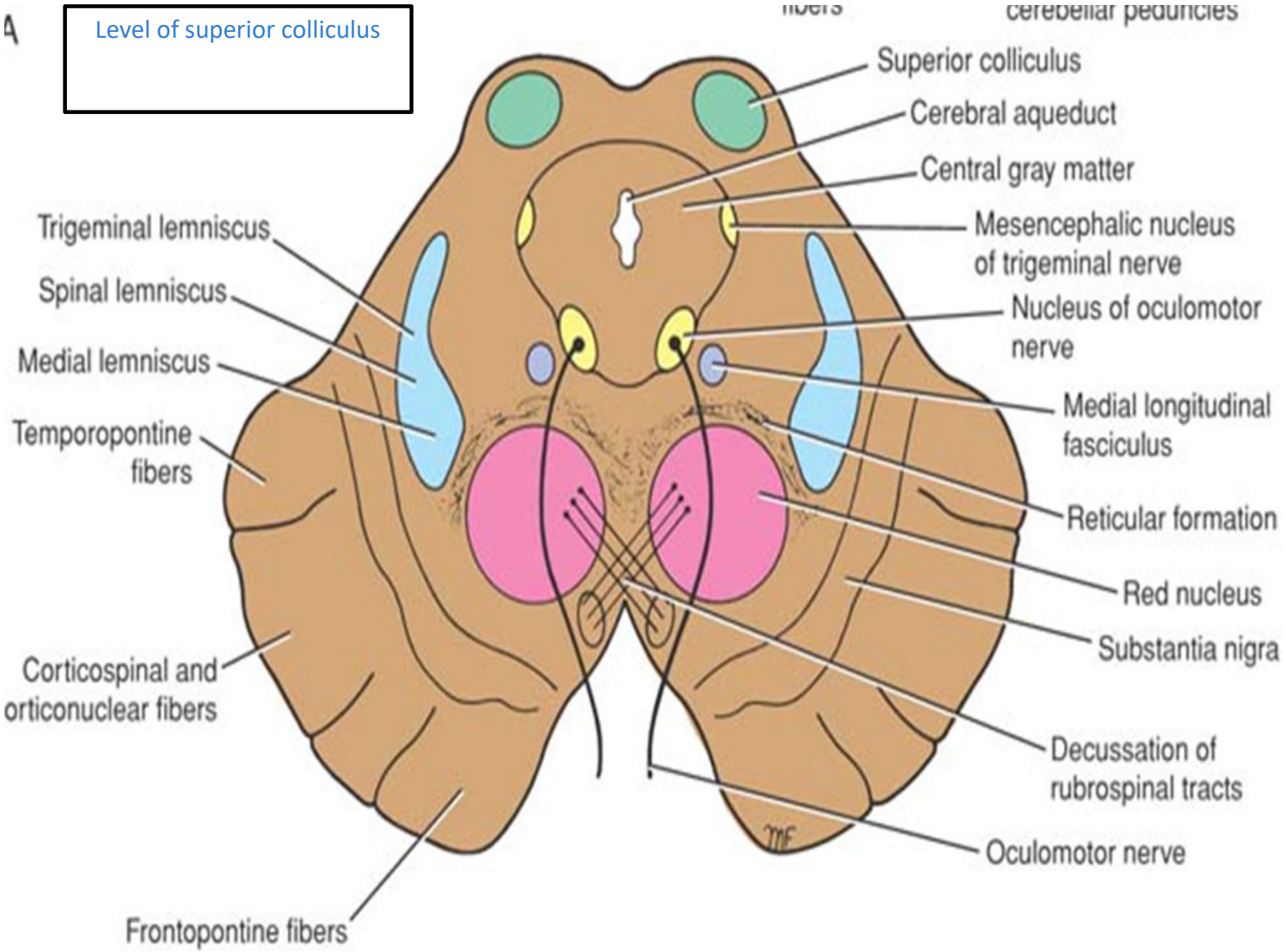
- Substantia nigra
- Crus cerebri
- Mesencephalic nucleus of trigeminal *(lateral to cerebral aqueduct)*
- MLF

Level of inferior colliculus

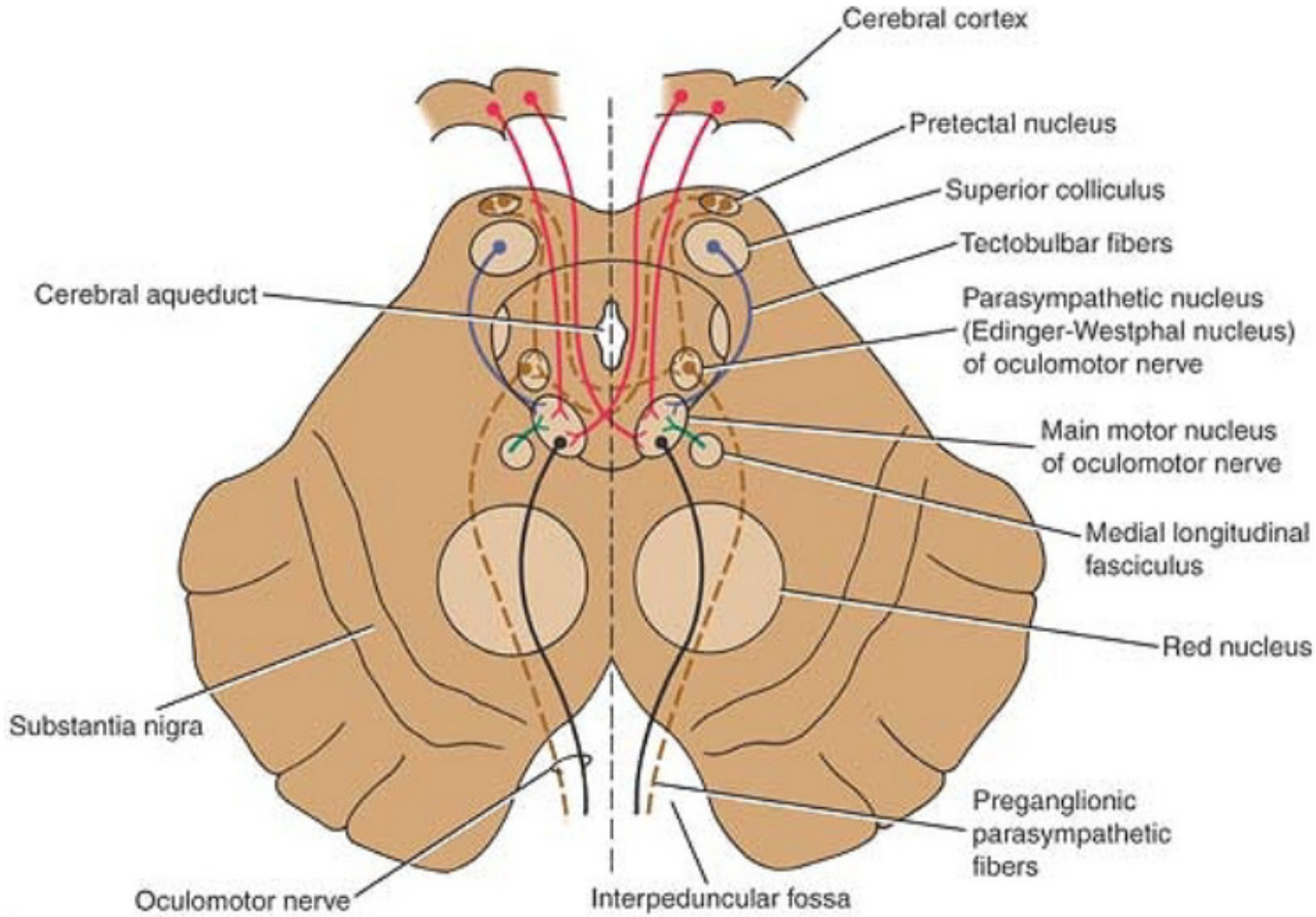


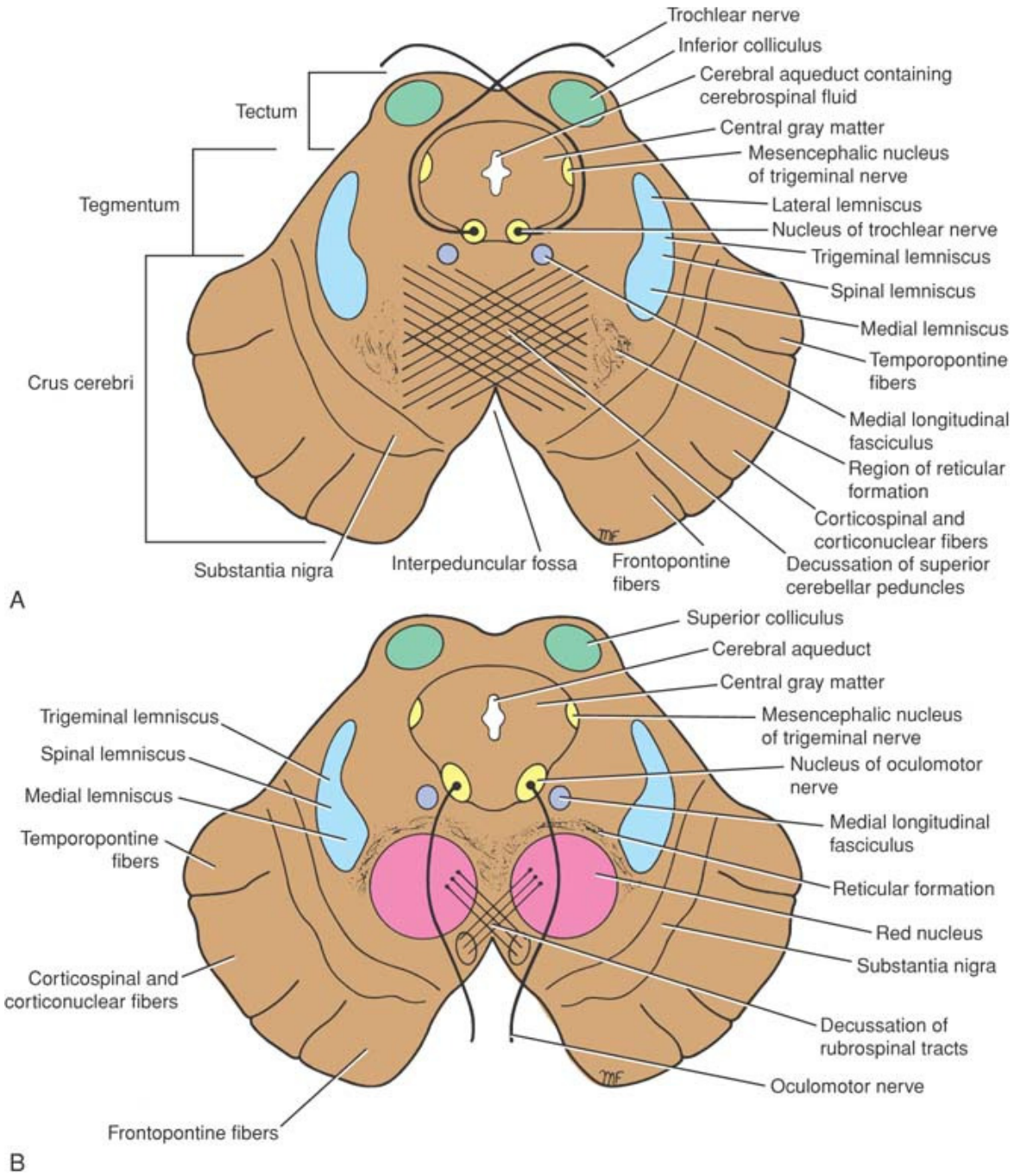
A

Level of superior colliculus



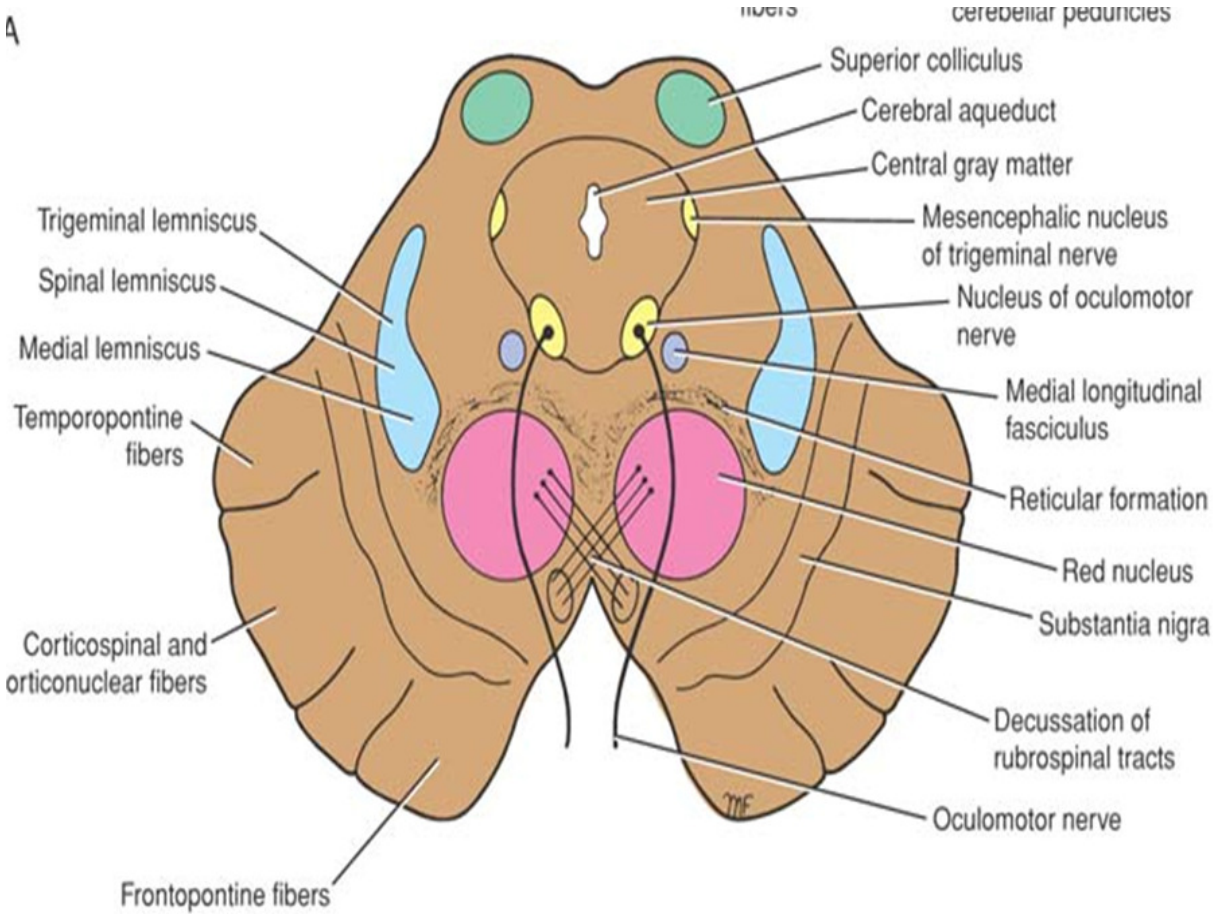
- Edinger-Westphal nucleus
- **pretectal nucleus:** close to the lateral part of the superior colliculus.




Trochlear nerve
Inferior colliculus
Cerebral aqueduct containing cerebrospinal fluid
Tectum
Central gray matter
Mesencephalic nucleus of trigeminal nerve
Tegmentum
Lateral lemniscus
Nucleus of trochlear nerve
Trigeminal lemniscus
Spinal lemniscus
Medial lemniscus
Temporopontine fibers
Crus cerebri
Medial longitudinal fasciculus
Region of reticular formation
Corticospinal and corticonuclear fibers
Decussation of superior cerebellar peduncles
Substantia nigra
Interpeduncular fossa
Frontopontine fibers
A
Superior colliculus
Cerebral aqueduct
Central gray matter
Trigeminal lemniscus
Mesencephalic nucleus of trigeminal nerve
Spinal lemniscus
Nucleus of oculomotor nerve
Medial lemniscus
Medial longitudinal fasciculus
Temporopontine fibers
Reticular formation
Red nucleus
Substantia nigra
Corticospinal and corticonuclear fibers
Decussation of rubrospinal tracts
Oculomotor nerve
Frontopontine fibers
B

Red nucleus

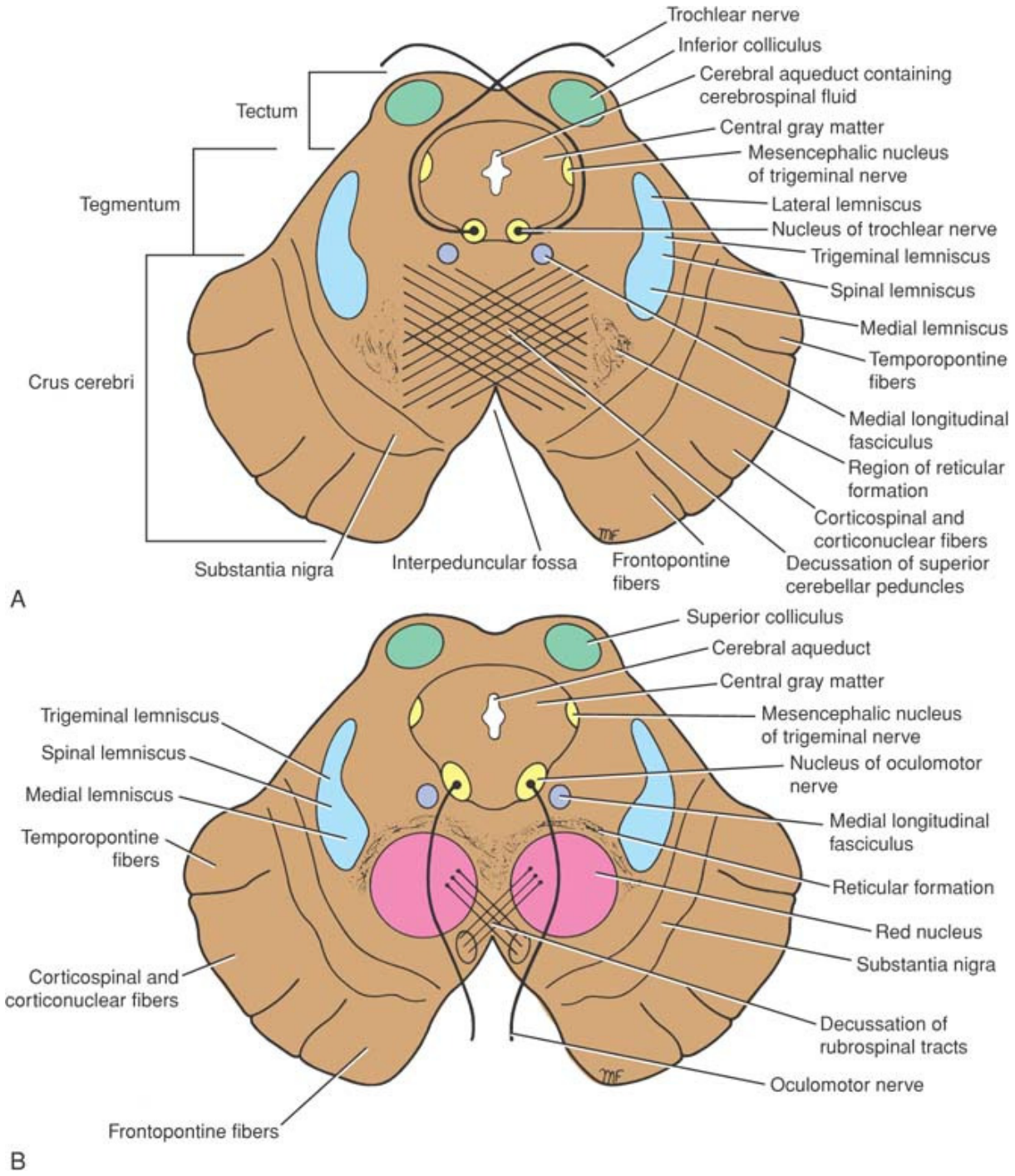
- Rounded mass of gray matter
- Situated bt cerebral aqueduct and substantia nigra
- Reddish blue(vascularity & iron containing pigment)
- Afferents from: cerebral cortex,cerebellum,substantia nigra, thalamic nuclei, spinal cord
- Efferent to: spinal cord, reticular formation. thalamus and substantia nigra
- involved in motor coordination.



Crus cerebri

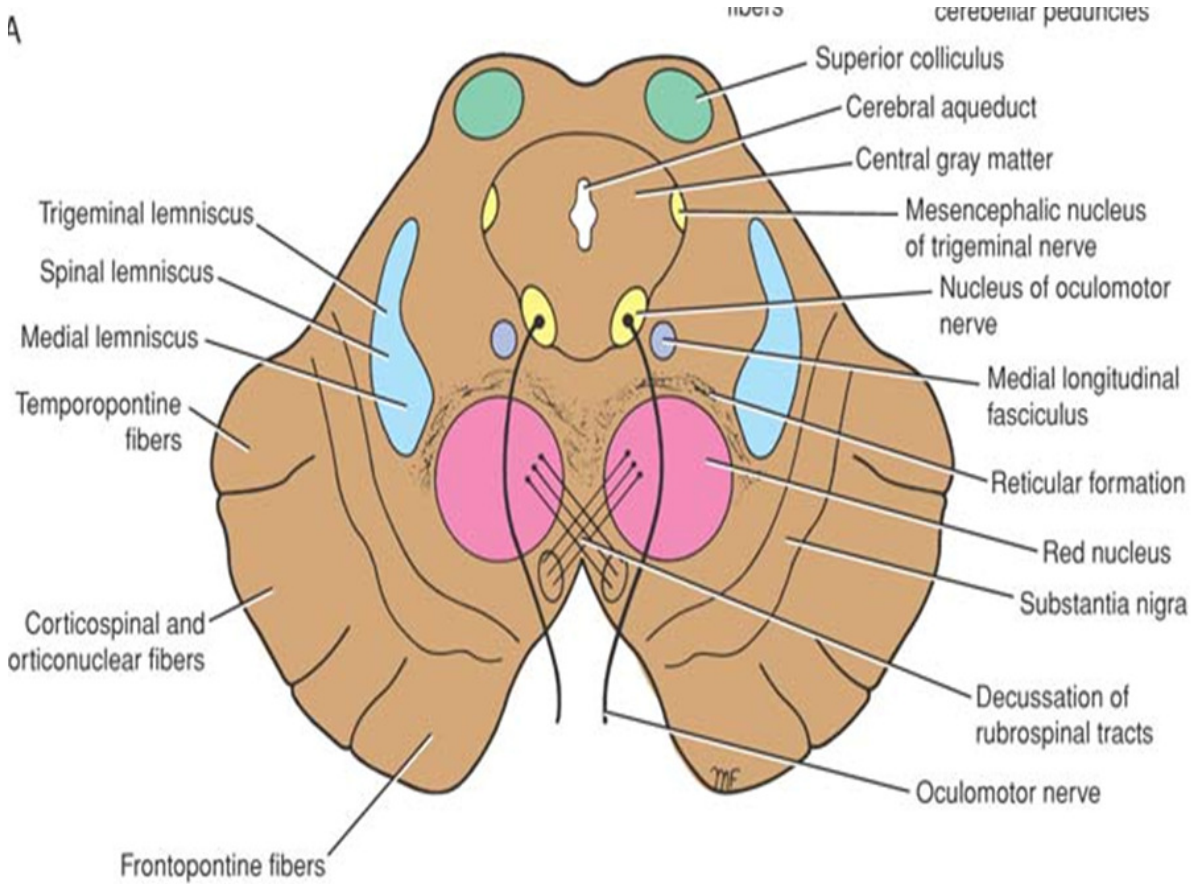
- Corticospinal & corticonuclear fibers (middle)
- Frontopontine fibers (medial)
- Temporopontine fibers (lateral)

these descending tracts connect the cerebral cortex with spinal cord, cranial nerves nuclei, pons & cerebellum



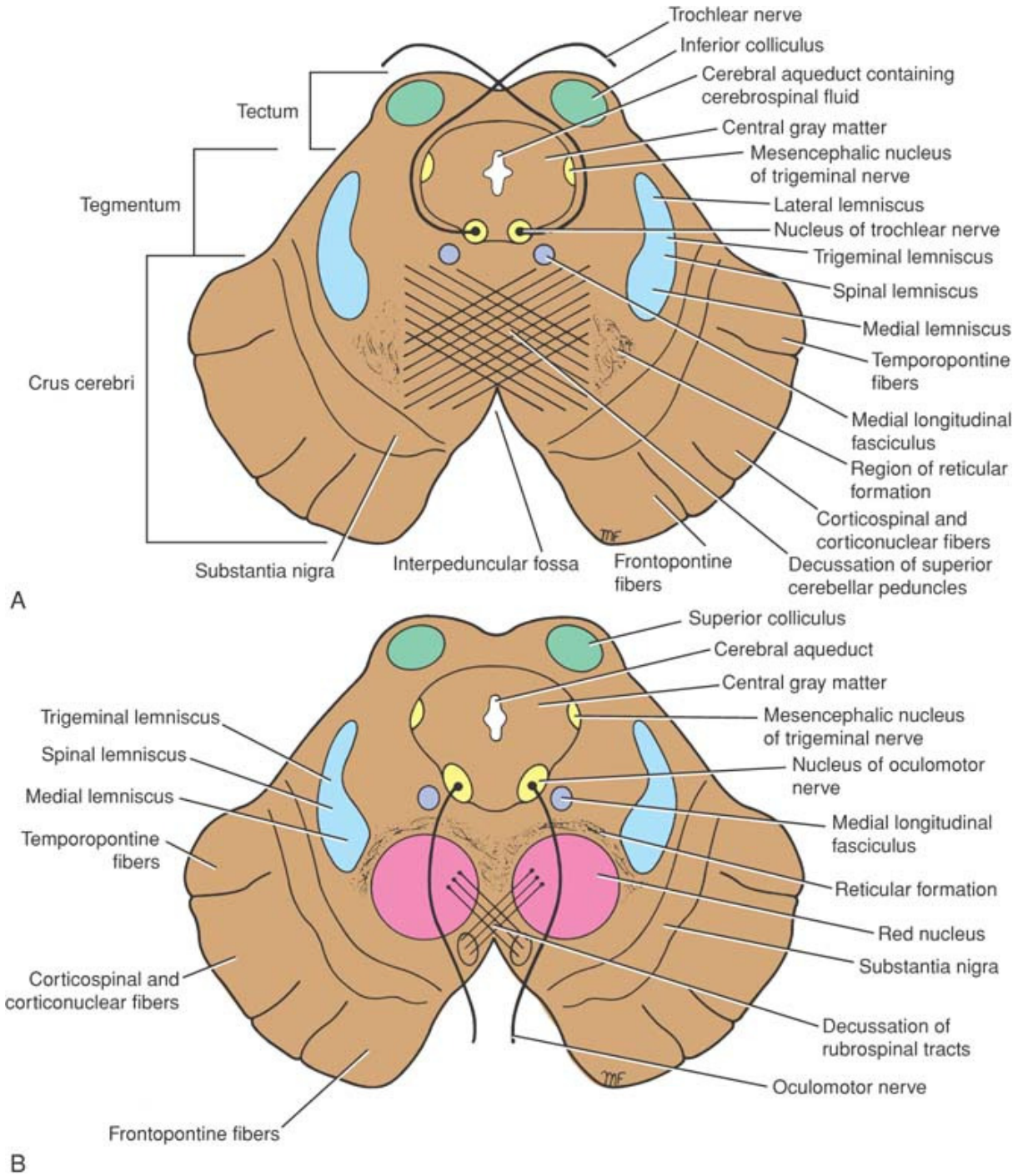
Level at superior colliculus

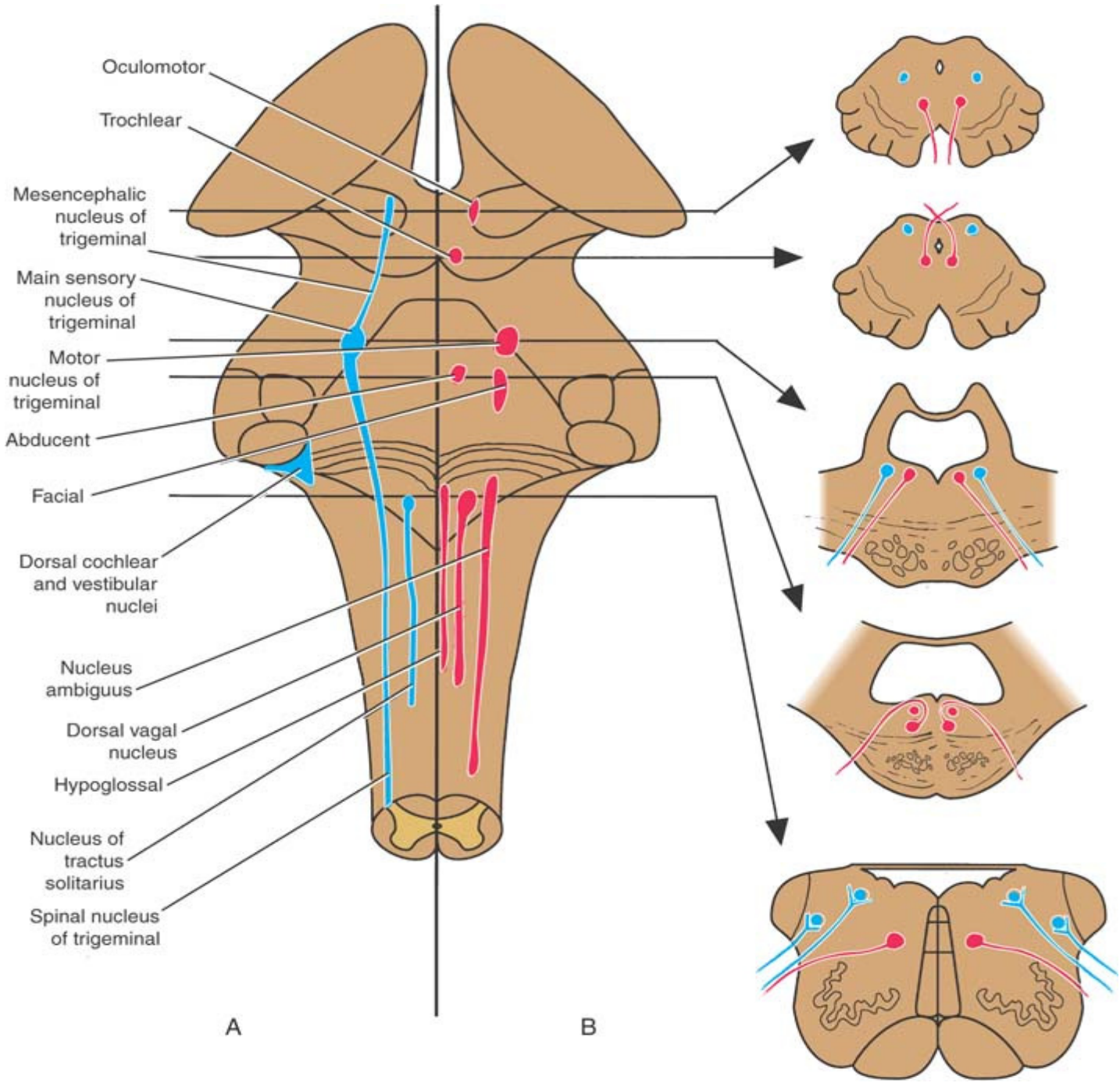
- Superior colliculus
- Occulomotor nucleus (posterior to MLF)
- Occulomotor n emerges through red nucleus
- Edinger-Westphal nucleus
- **pretectal nucleus:** close to the lateral part of the superior colliculus.
- MLF
- Medial , trigeminal, spinal leminiscus (**no** lateral leminiscus)
- Red nucleus
- Substantia nigra
- Crus cerebri
- RF



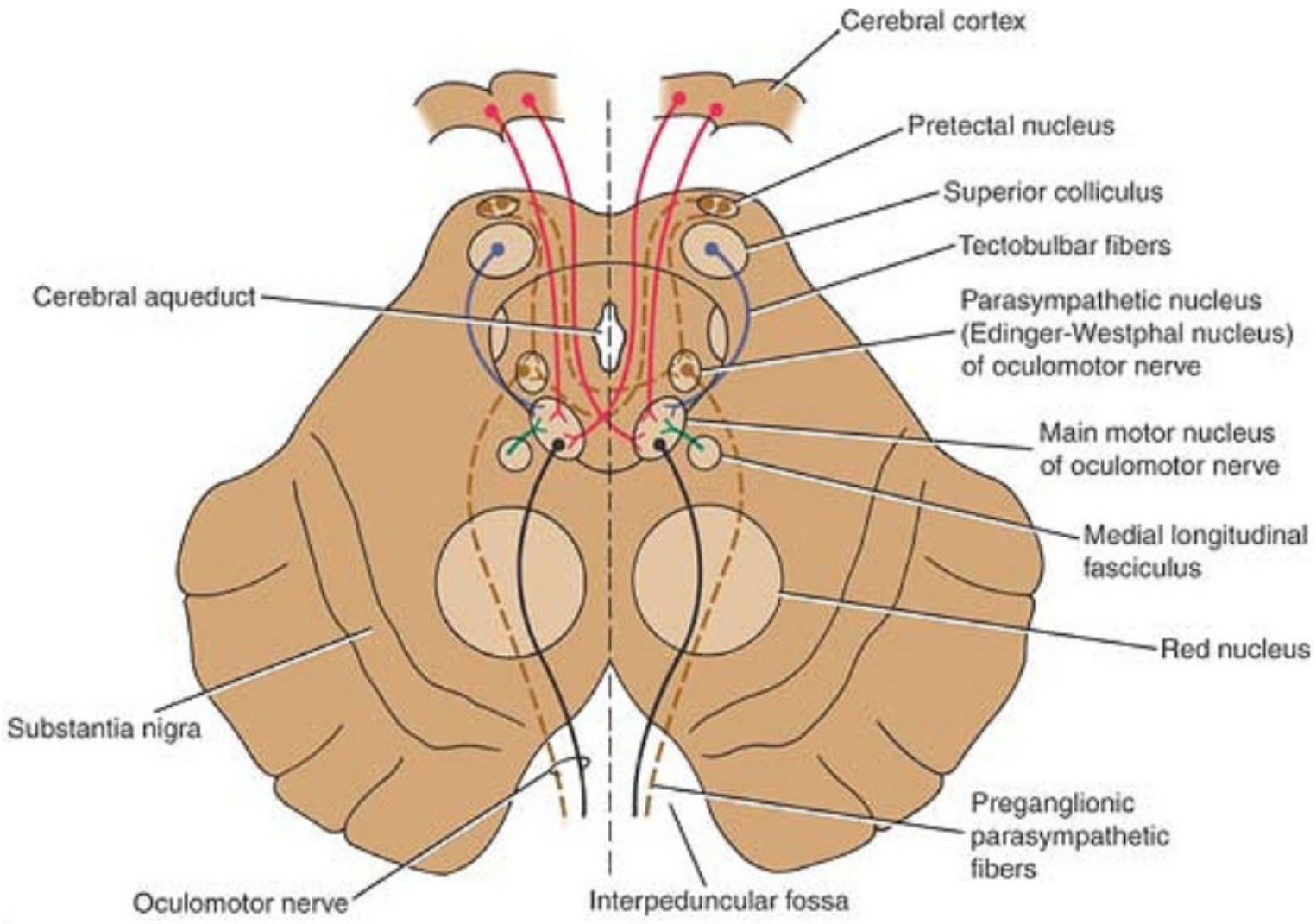
Substantia nigra

- Large motor nucleus
- is a brain structure located in the midbrain
- plays an important role in reward, addiction, and movement.
- *Substantia nigra* is Latin for "black substance" due to high levels of melanin
- has connections with basal ganglia ,cerebral cortex
- Concerned with muscle tone
- Parkinson's disease is caused by the death of neurons in the substantia nigra

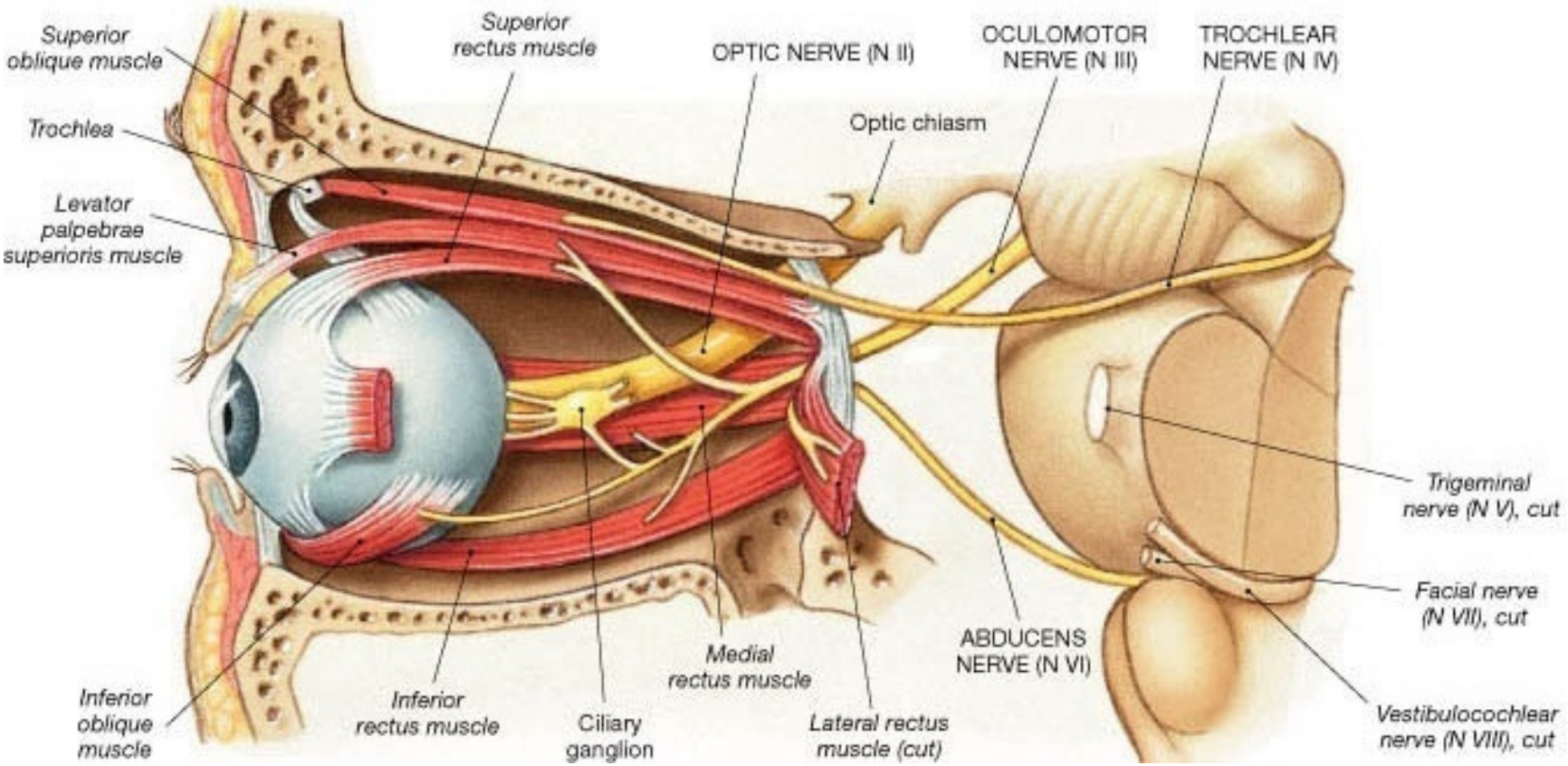



Oculomotor
Trochlear
Mesencephalic nucleus of trigeminal
Main sensory nucleus of trigeminal
Motor nucleus of trigeminal
Abducent
Facial
Dorsal cochlear and vestibular nuclei
Nucleus ambiguus
Dorsal vagal nucleus
Hypoglossal
Nucleus of tractus solitarius
Spinal nucleus of trigeminal
A
B

Oculomotor Nerve (III)



- **Main oculomotor nucleus**
- **Accessory parasympathetic nucleus (Edinger-Westphal nucleus)**

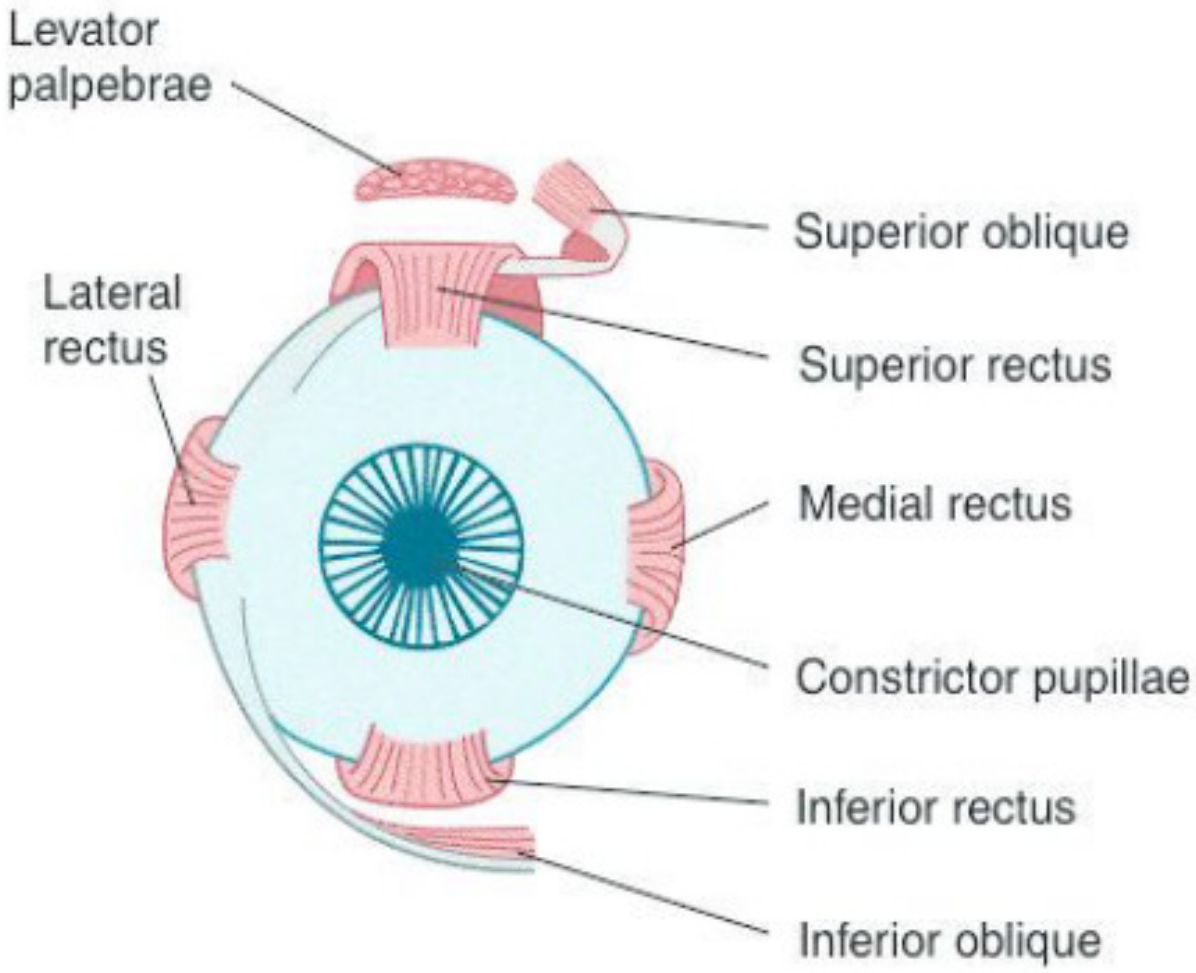


Course of occulomotor nerve

- Red nucleus
- Interpeduncular fossa
- Middle cranial fossa in the lateral wall of the cavernous sinus (Two rami)
- superior orbital fissure

Oculomotor Nerve (III)

- **Extrinsic muscles:**
  - The levator palpebrae superioris, superior rectus, medial rectus, inferior rectus, and inferior oblique
- **Intrinsic muscles:**
  - The constrictor pupillae of the iris and ciliary muscles



- **Action:**
  - Lifting the upper eyelid; turning the eye upward, downward, and medially; constricting the pupil; and accommodating the eye

Oculomotor Nerve injury

- **Complete lesion**
  - All of the muscles are paralyzed except lateral rectus and superior oblique
  - Symptoms:
    - External strabismus
    - Diplopia
    - Ptosis: drooping of the upper eyelid.
    - The pupil is widely dilated and nonreactive to light
    - Accommodation of the eye is paralyzed.
- **Incomplete lesions:**
  - **Internal ophthalmoplegia:** loss of the autonomic innervation of the sphincter pupillae and ciliary muscle
  - **External ophthalmoplegia.:** paralysis of the extraocular muscles

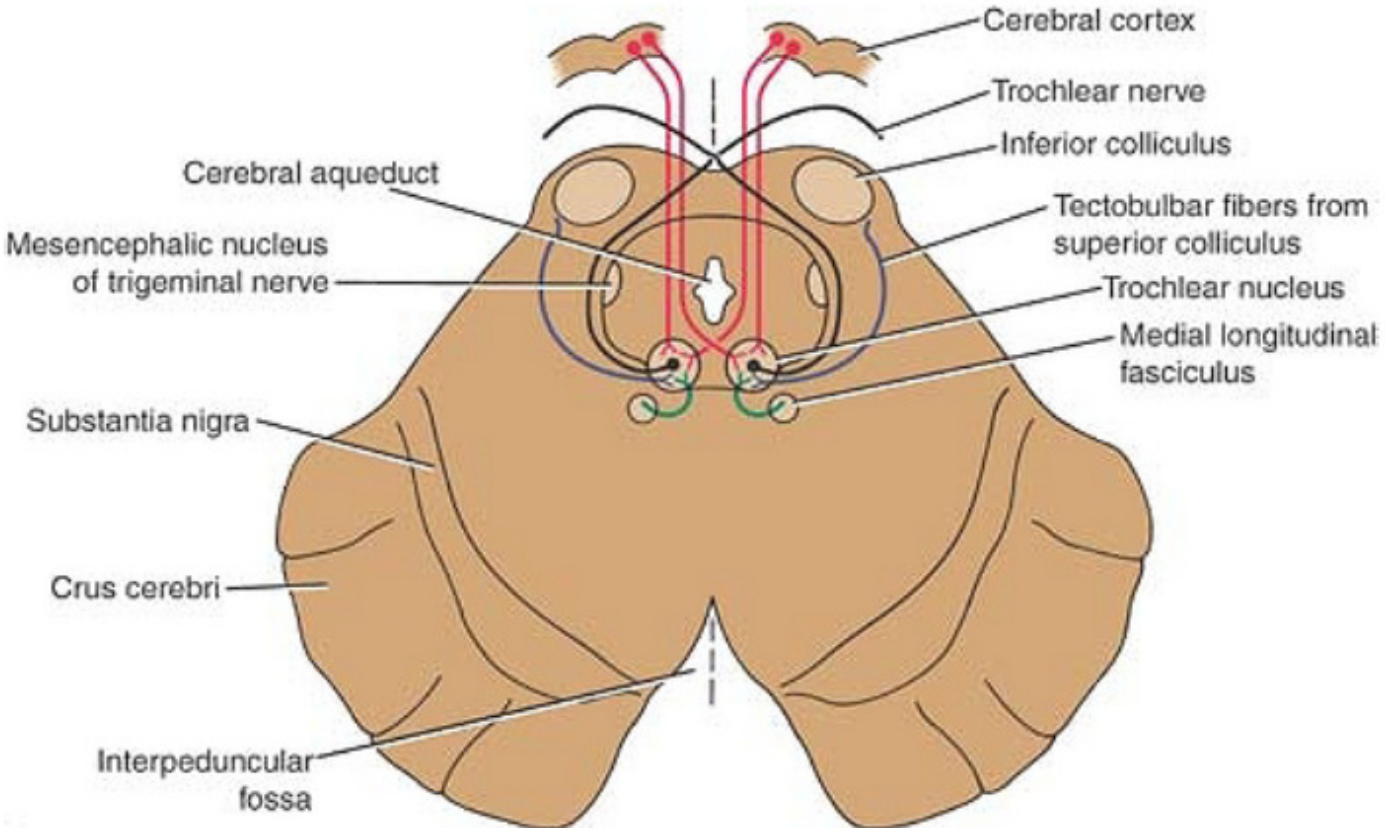
Double Vision

In cases of (diabetic neuropathy), the autonomic fibers are unaffected, whereas the nerves to the extraocular muscles are paralyzed.

Trochlear Nerve

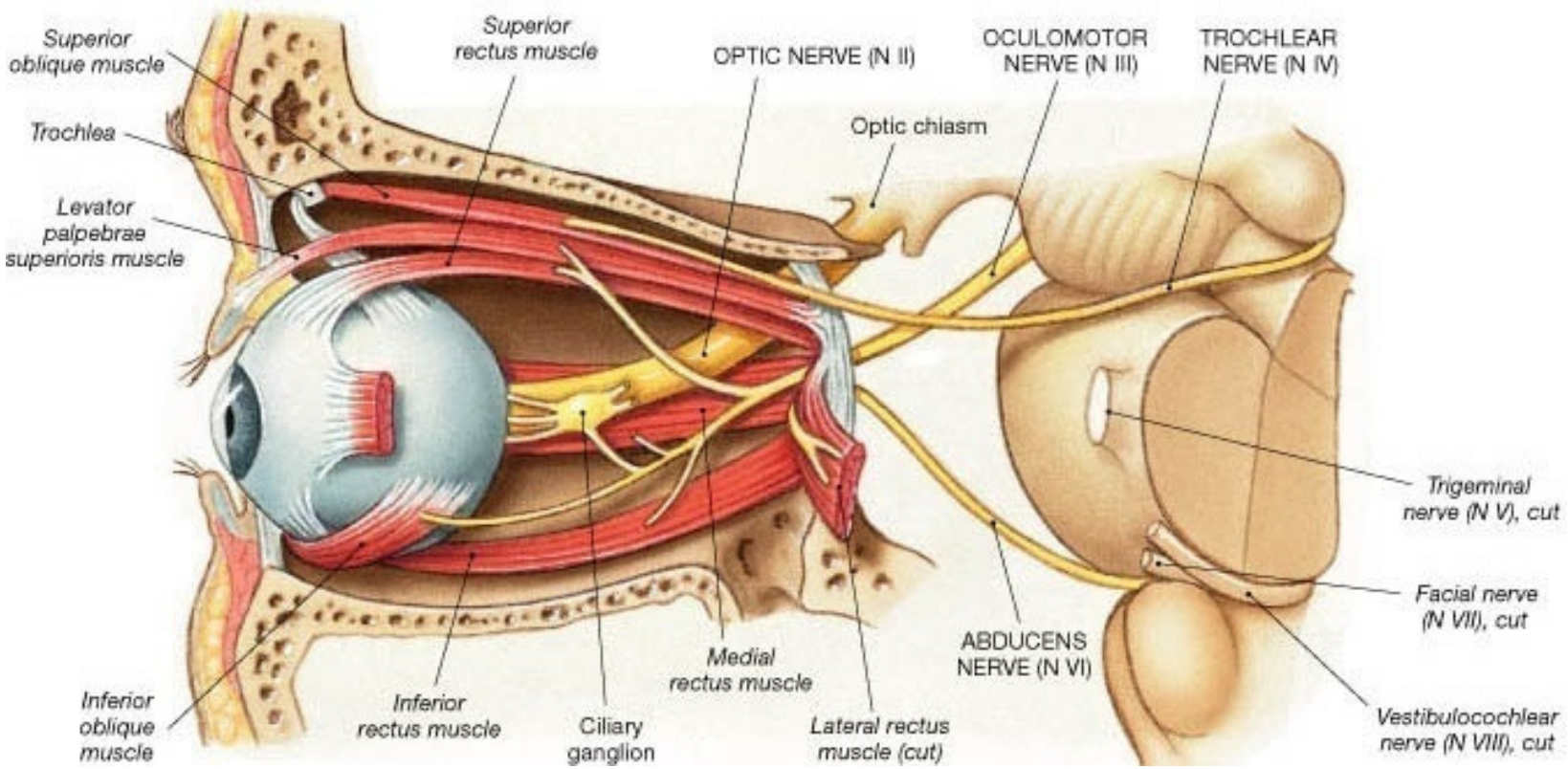
Nucleus

- **Location**

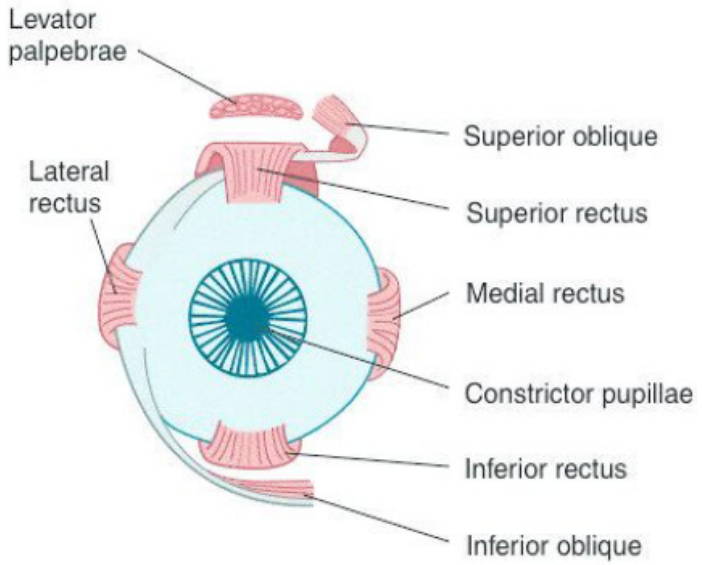


- Pass **posteriorly** around the central gray matter
- Immediately decussates

Trochlear Nerve



- **Supplies**: superior oblique muscle
- **Action:** turning the eye downward and laterally



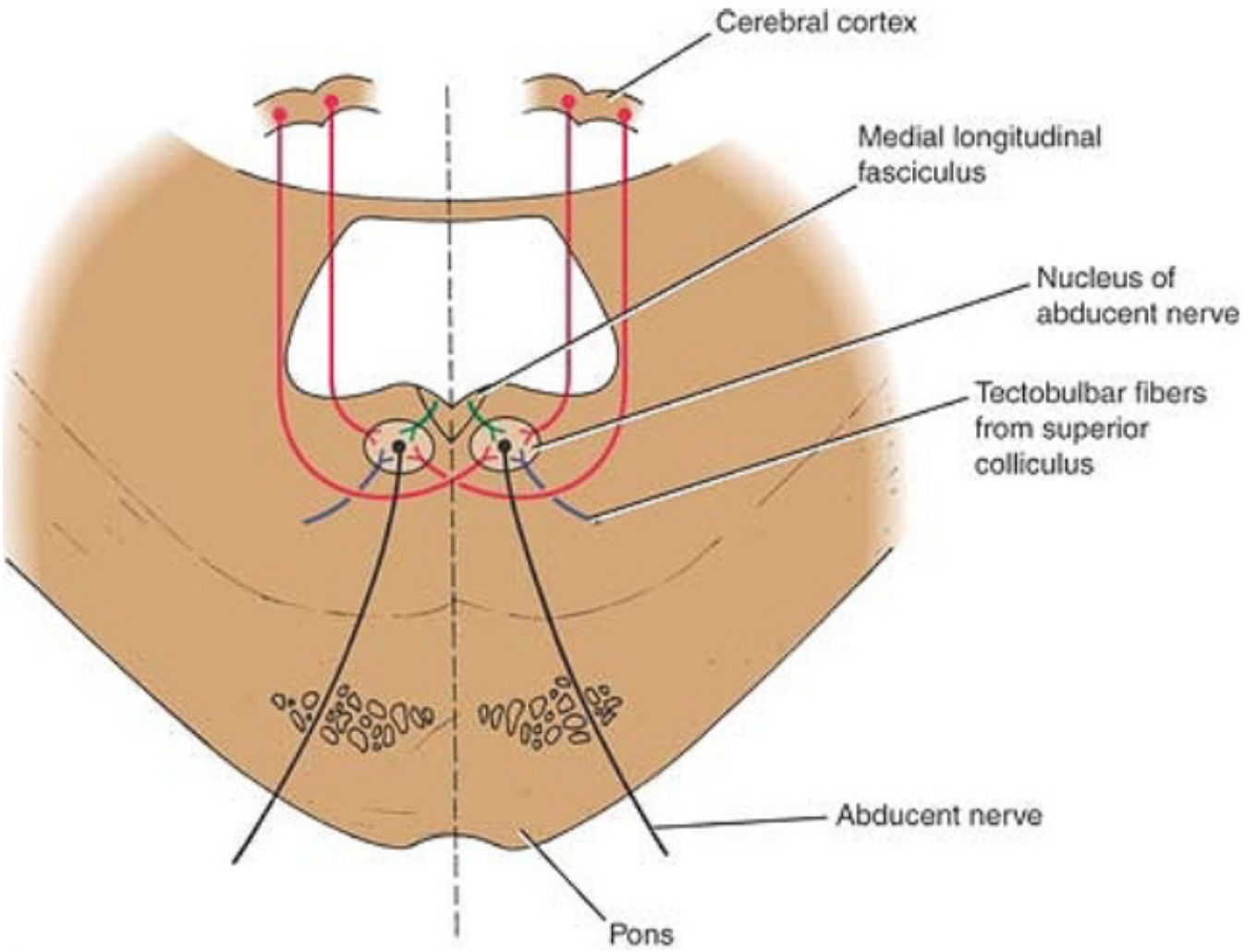
Trochlear Nerve injury

- Symptoms:
  - Diplopia
  - Difficulty in turning the eye downward and laterally.
  - Difficulty in descending stairs
  - Head tilt to the side opposite the paralsied eye (compensatory adjustment)

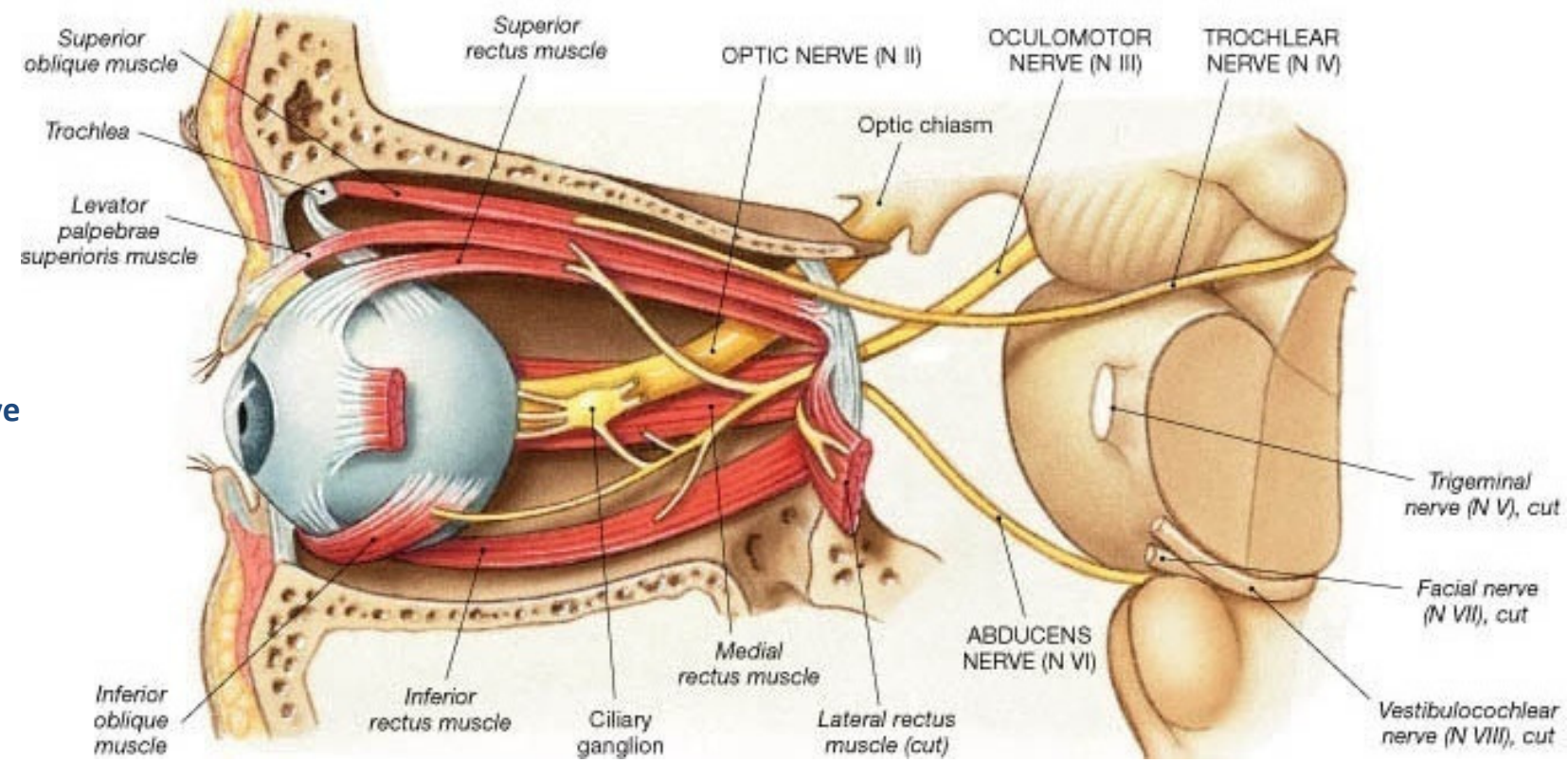
Abducent Nerve

Nucleus

- **Location:** beneath the floor of the upper part of the fourth ventricle, close to the midline



Course of
Abducent nerve



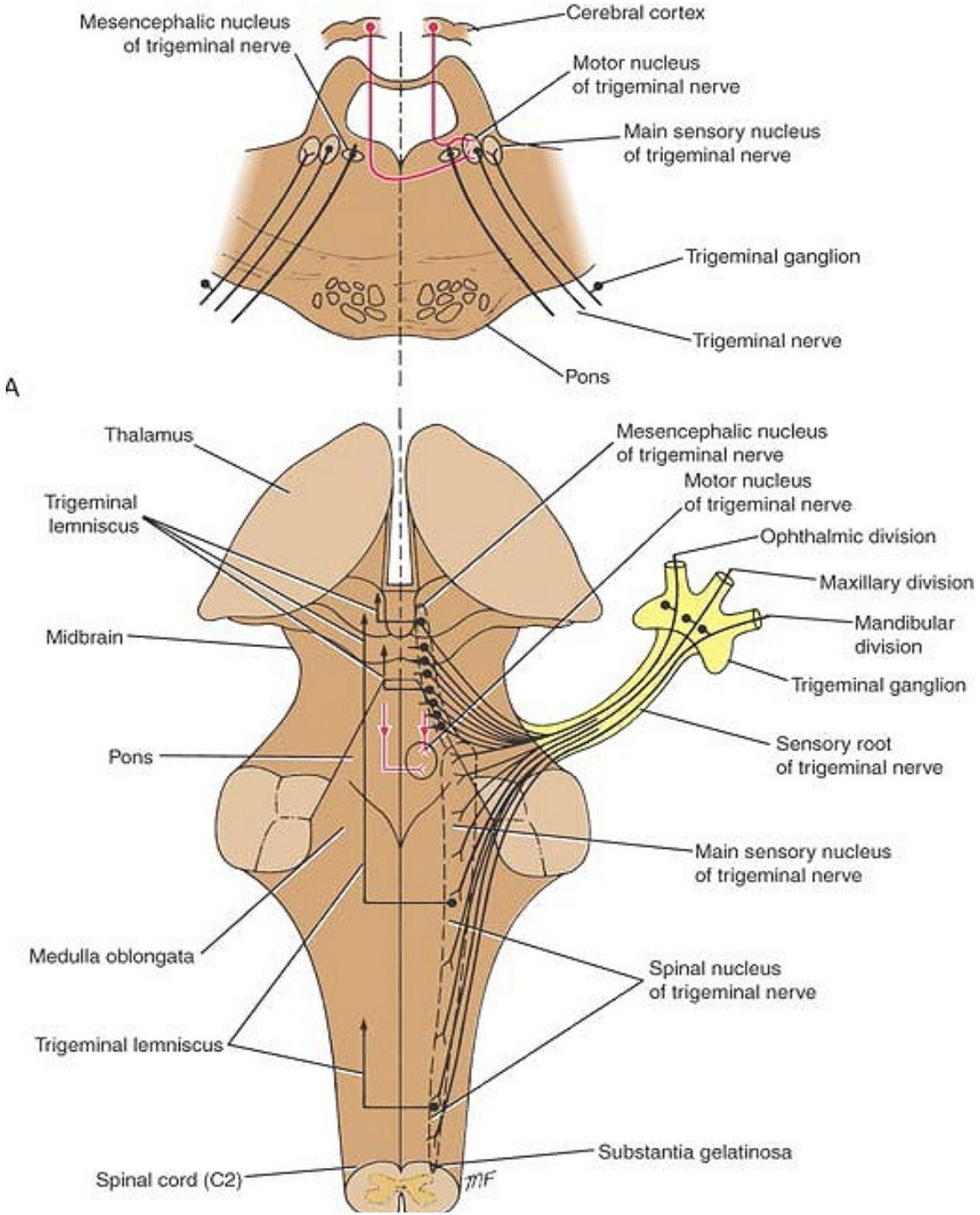
- Passes anteriorly: groove between the lower border of the pons and the medulla oblongata
- Through the cavernous sinus, below and lateral to the internal carotid artery
- Superior orbital fissure
- Supplies the lateral rectus: turning the eye laterally

Abducent Nerve injury

- Symptoms:
  - Diplopia
  - Difficulty in turning the eye laterally.
  - **internal strabismus.** unopposed medial rectus pulls the eyeball medially

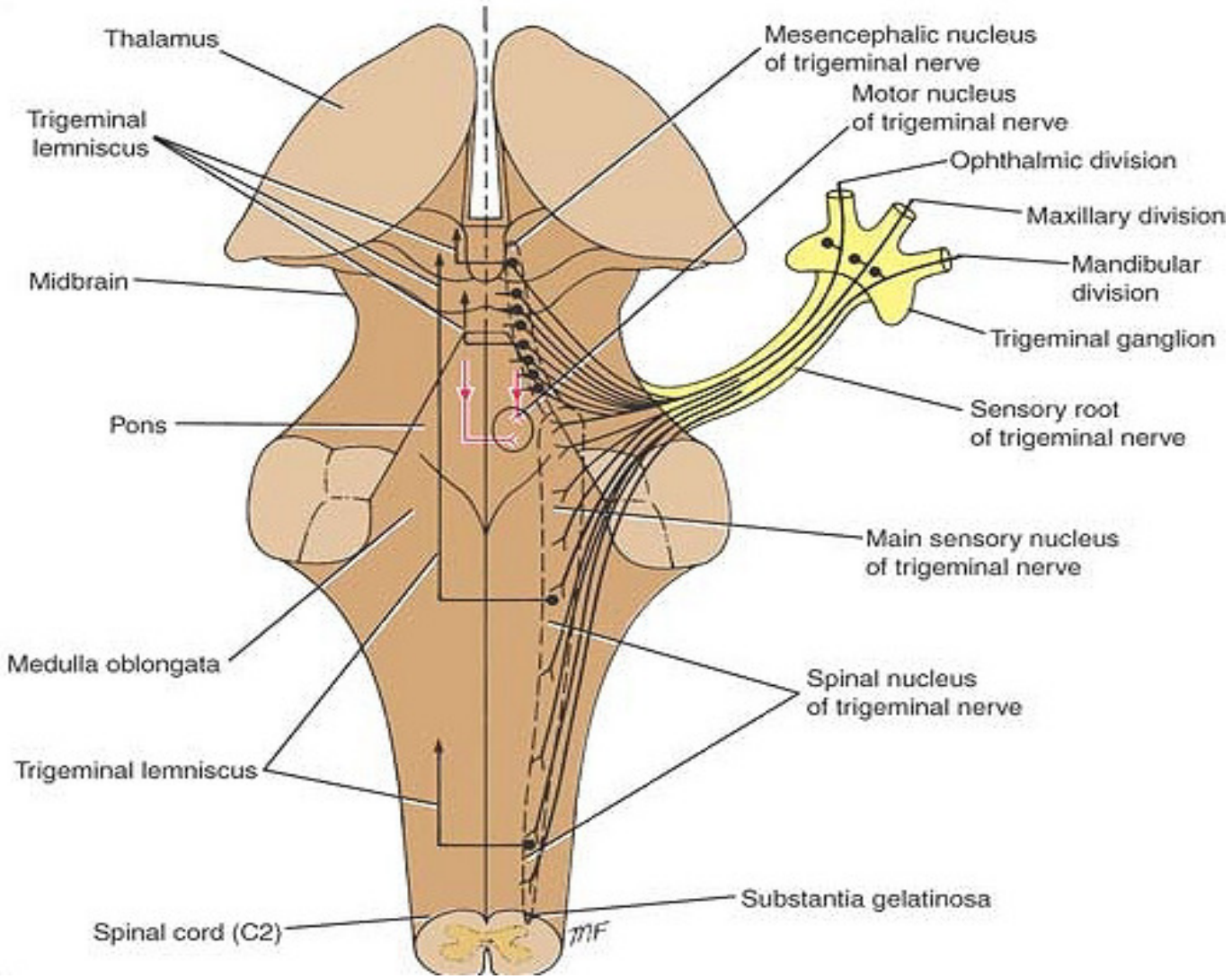
Trigeminal Nerve Nuclei

- **Main sensory nucleus**
  - Posterior part of the pons (lateral)
- **Motor nucleus**
  - Posterior part of the pons (Medial)
- **Spinal nucleus**
  - Superiorly: main sensory nucleus
  - Inferiorly: C2 segment
- **Mesencephalic nucleus**
  - Lateral part of the gray matter around the cerebral aqueduct
  - Inferiorly main sensory nucleus

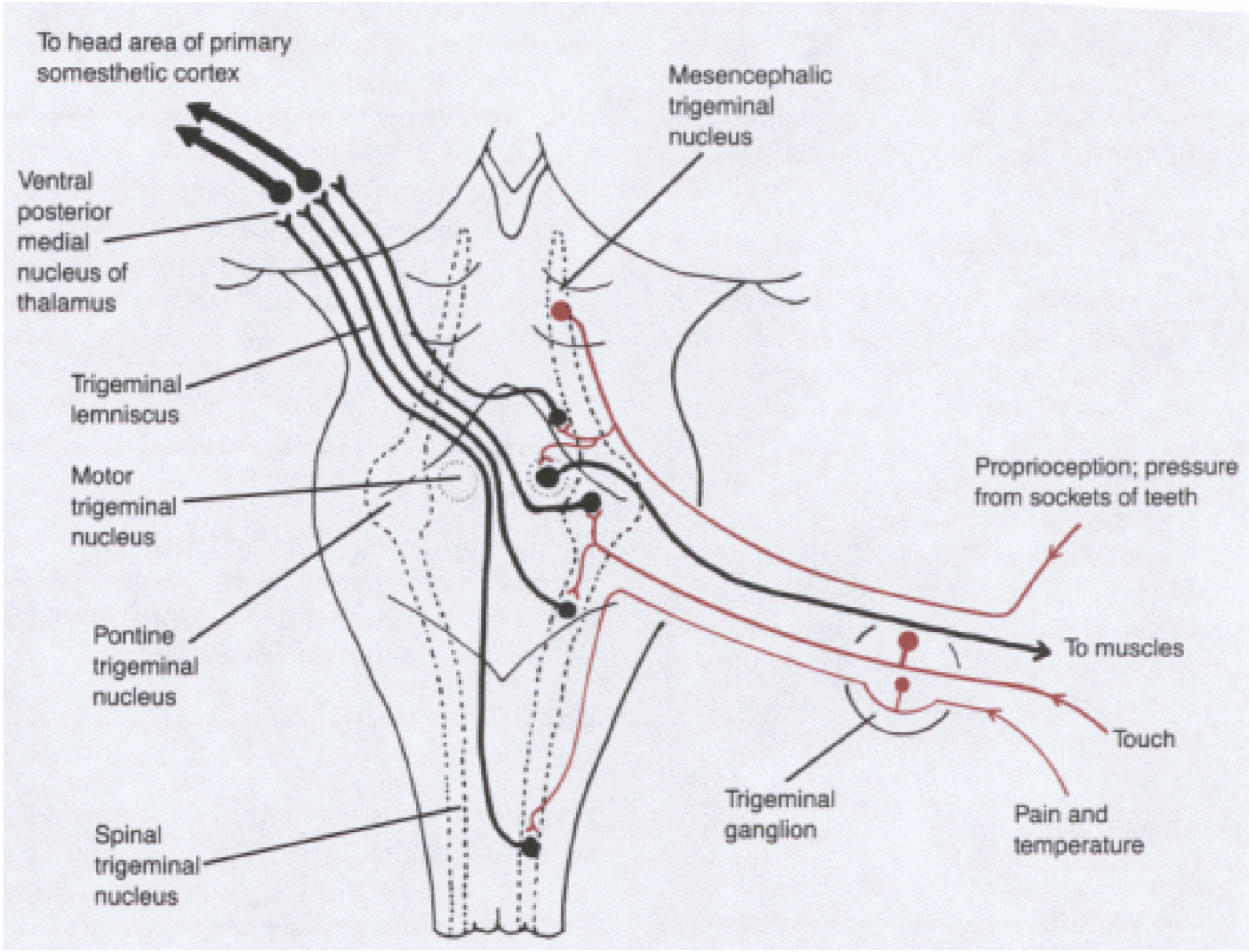


Sensory Components

- Trigeminal sensory ganglion: (Cell bodies)
- Ascending branches: main sensory nucleus
- Descending branches: spinal nucleus
- Division:
  - ophthalmic inferior part of SN
  - Maxillary: middle part of SN
  - Mandibular: superior part of SN

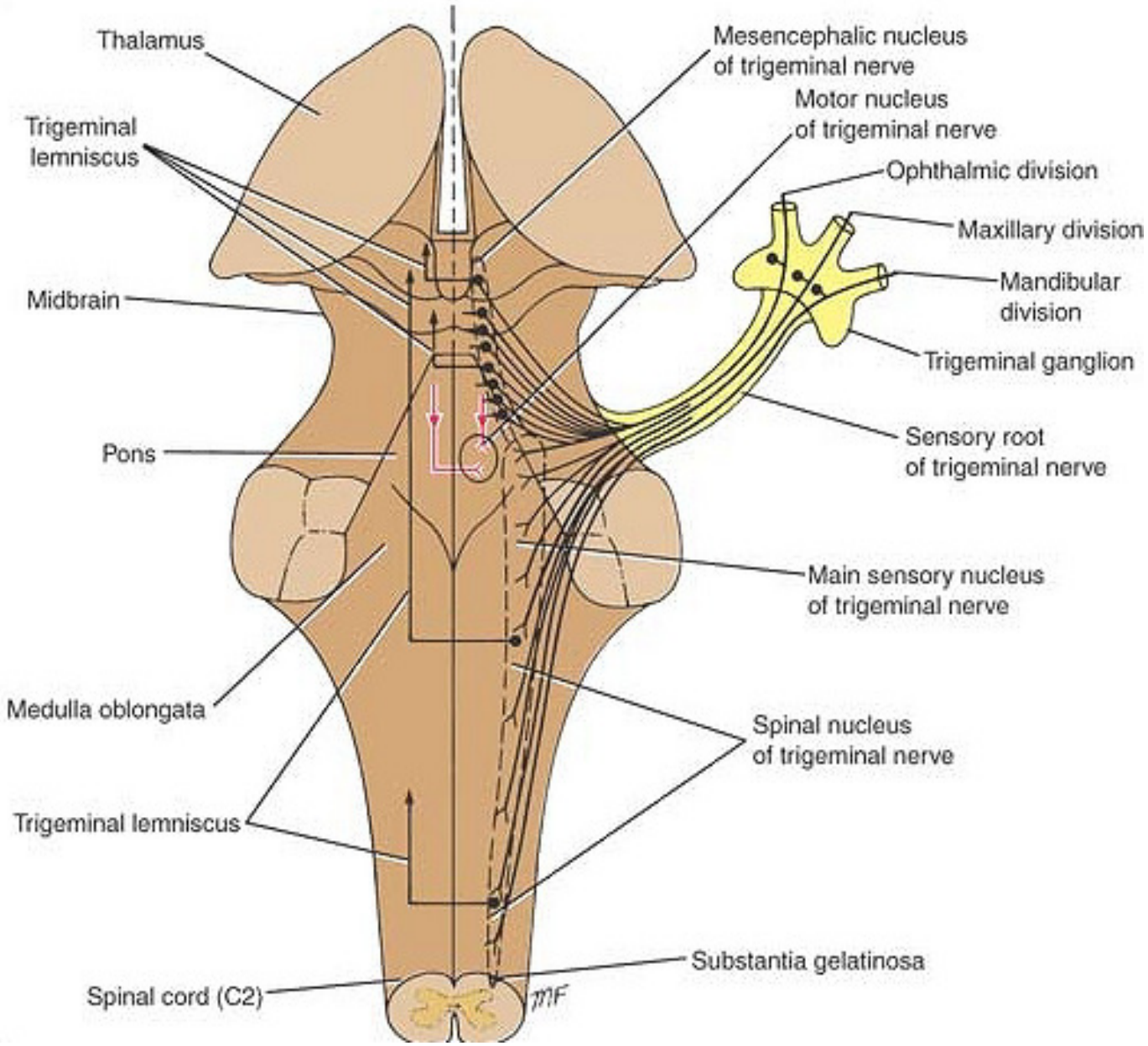


- Main sensory nucleus: discriminative and light touch of the face as well as conscious proprioception, (similar to PCML)
- Spinal nucleus: crude touch, pain, and temperature (similar to ALS)
- Mesencephalic nucleus: reflex proprioception of the periodontal ligament and of the muscles of mastication in the jaw


To head area of primary somesthetic cortex
Mesencephalic trigeminal nucleus
Ventral posterior medial nucleus of thalamus
Trigeminal lemniscus
Motor trigeminal nucleus
Pontine trigeminal nucleus
Spinal trigeminal nucleus
Proprioception; pressure from sockets of teeth
To muscles
Touch
Trigeminal ganglion
Pain and temperature

Motor Components

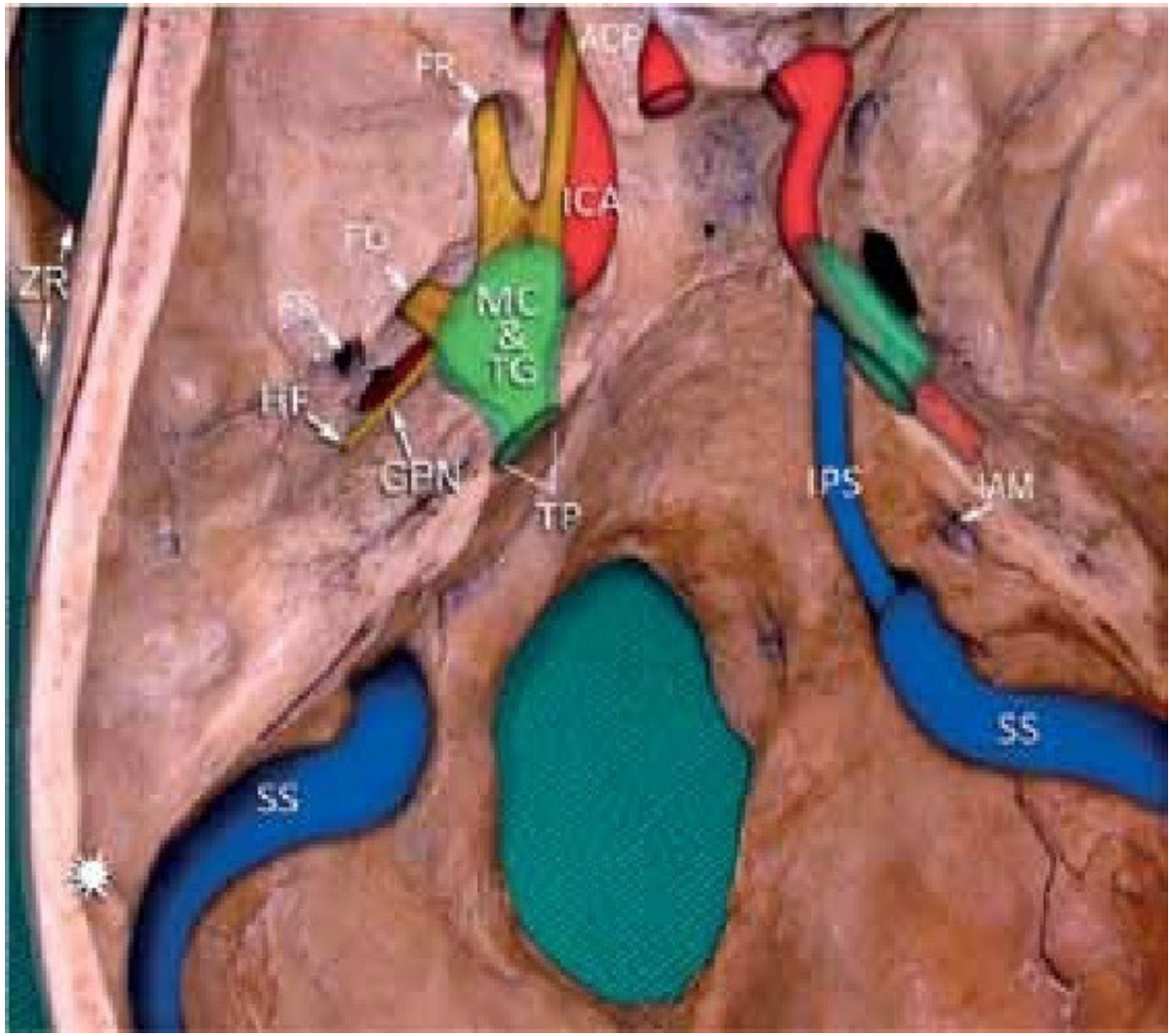
- Motor nucleus receives
  - Corticonuclear fibers
  - Red nucleus
  - Reticular formation
  - Tectum

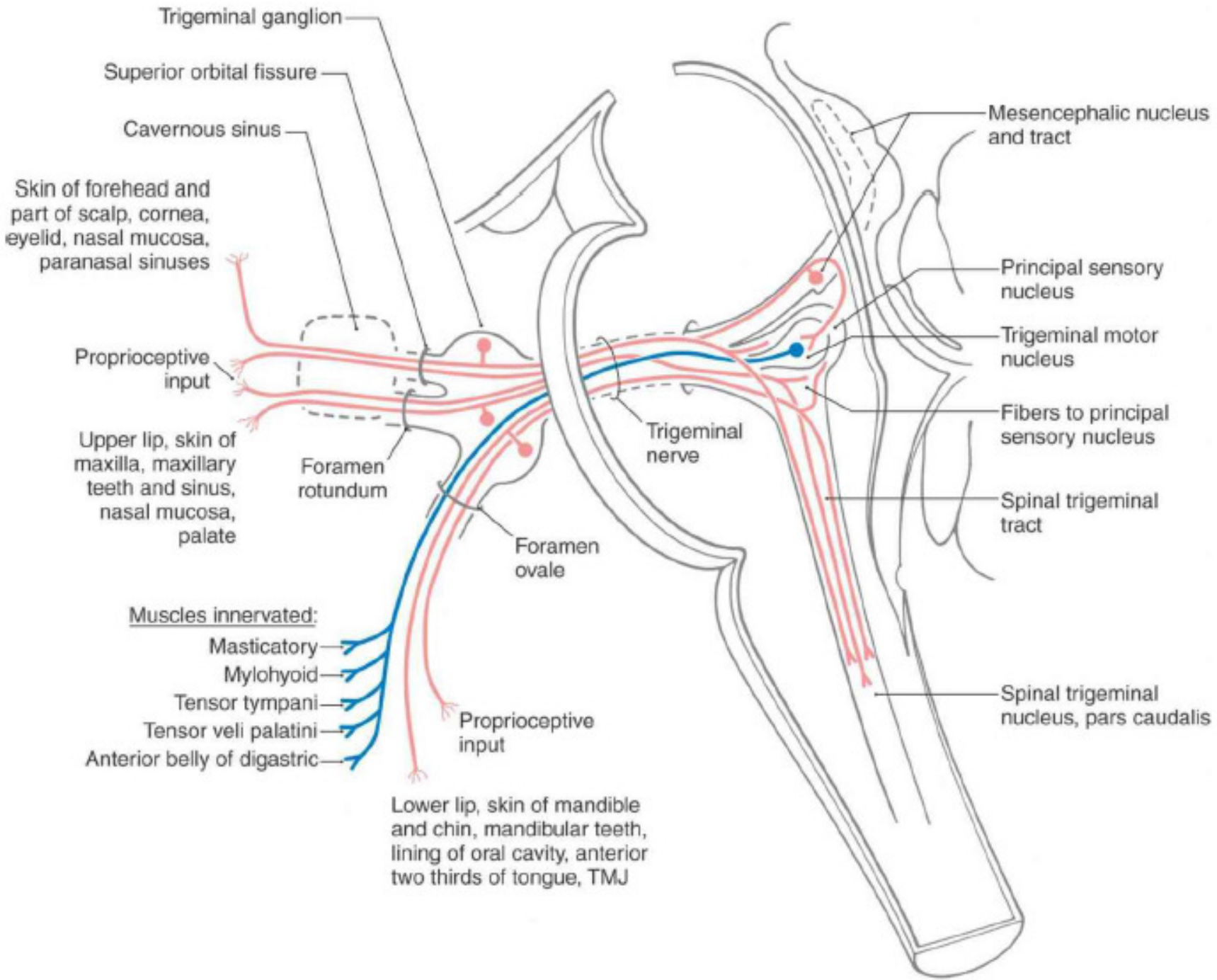


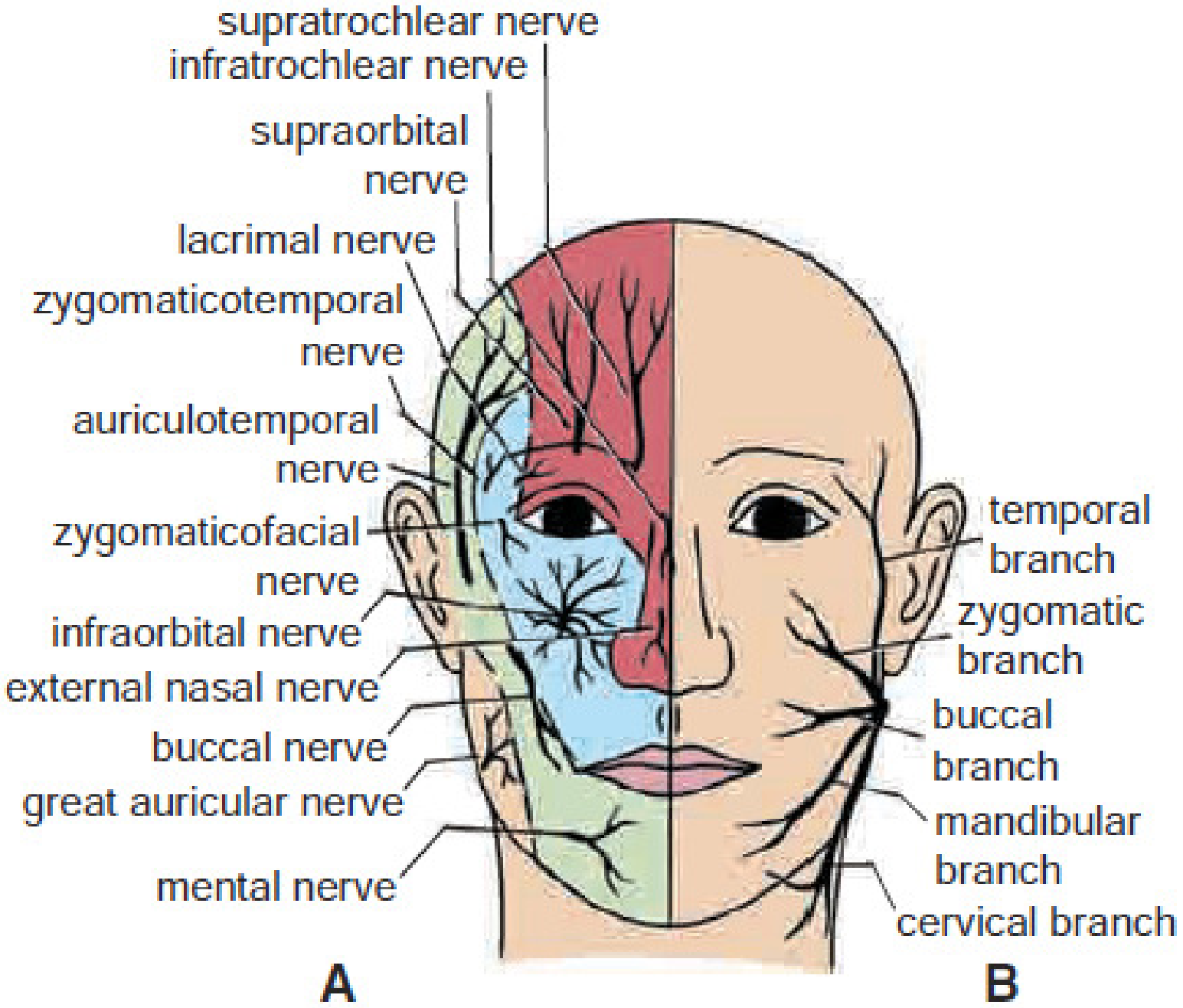
- Supplies
  - Muscles of mastication
  - Tensor tympani
    - Tensor veli palatini
    - Mylohyoid
    - Anterior belly of the digastric muscle

Course of V

- Anterior aspect of the pons
- Upper surface of the apex of the petrous bone
- Trigeminal ganglion: in **Meckel cave:** pouch of dura mater
- Divisions:
  - Ophthalmic: superior orbital fissure
  - Maxillary: foramen rotundum
  - Mandibular: foramen ovale




Trigeminal ganglion
Superior orbital fissure
Cavernous sinus
Skin of forehead and part of scalp, cornea, eyelid, nasal mucosa, paranasal sinuses
Proprioceptive input
Upper lip, skin of maxilla, maxillary teeth and sinus, nasal mucosa, palate
Foramen rotundum
Trigeminal nerve
Foramen ovale
Muscles innervated:
Masticatory
Mylohyoid
Tensor tympani
Tensor veli palatini
Anterior belly of digastric
Proprioceptive input
Lower lip, skin of mandible and chin, mandibular teeth, lining of oral cavity, anterior two thirds of tongue, TMJ
Mesencephalic nucleus and tract
Principal sensory nucleus
Trigeminal motor nucleus
Fibers to principal sensory nucleus
Spinal trigeminal tract
Spinal trigeminal nucleus, pars caudalis


supratrochlear nerve
infratrochlear nerve
supraorbital nerve
lacrimal nerve
zygomaticotemporal nerve
auriculotemporal nerve
zygomaticofacial nerve
infraorbital nerve
external nasal nerve
buccal nerve
great auricular nerve
mental nerve
temporal branch
zygomatic branch
buccal branch
mandibular branch
cervical branch
A
B