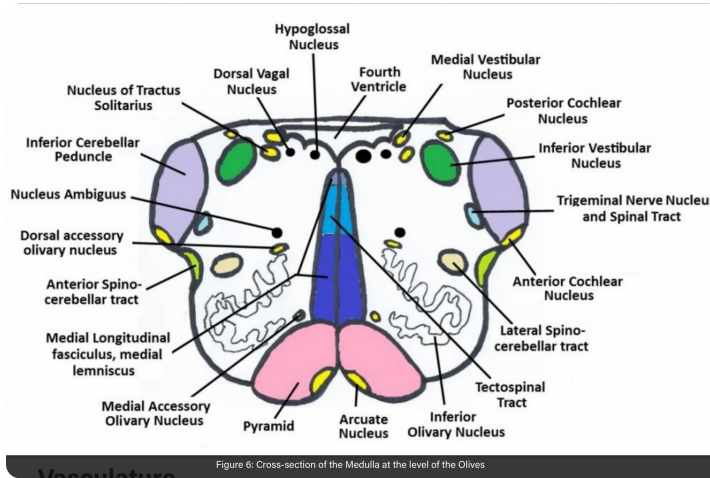


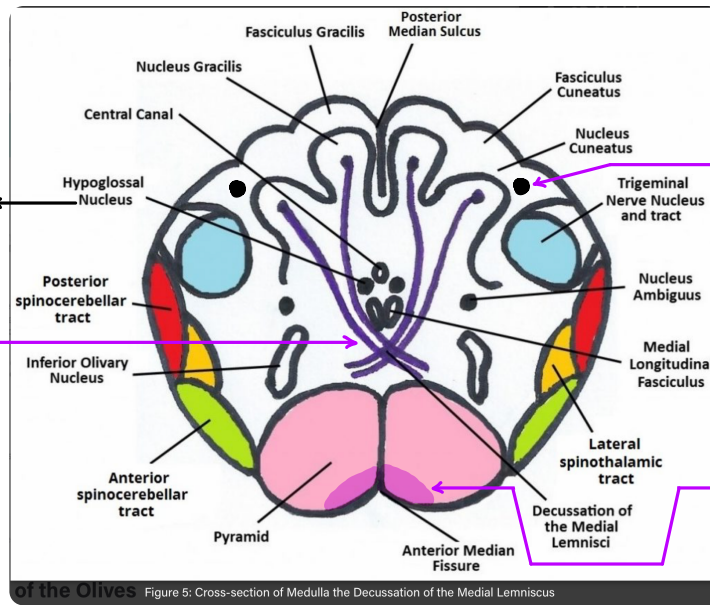
- 1) Medulla oblongata :- sections @
- i) Olives [Topmost]
  - ii) Sensory Decussation [Middle]
  - iii) Pyramidal Decussation [Lower]

→ Central canal opens up here to form the 4<sup>th</sup> ventricle



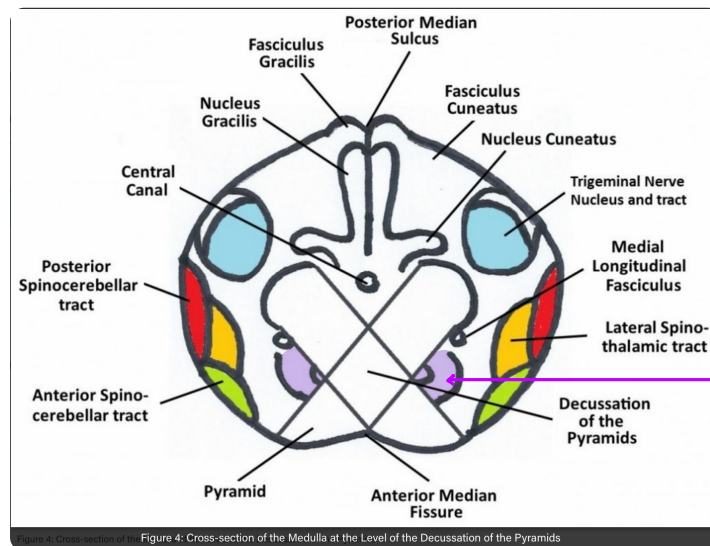
Nucleus of Tractus solitarius + Dorsal Nucleus of Vagus +

Internal arcuate fibres



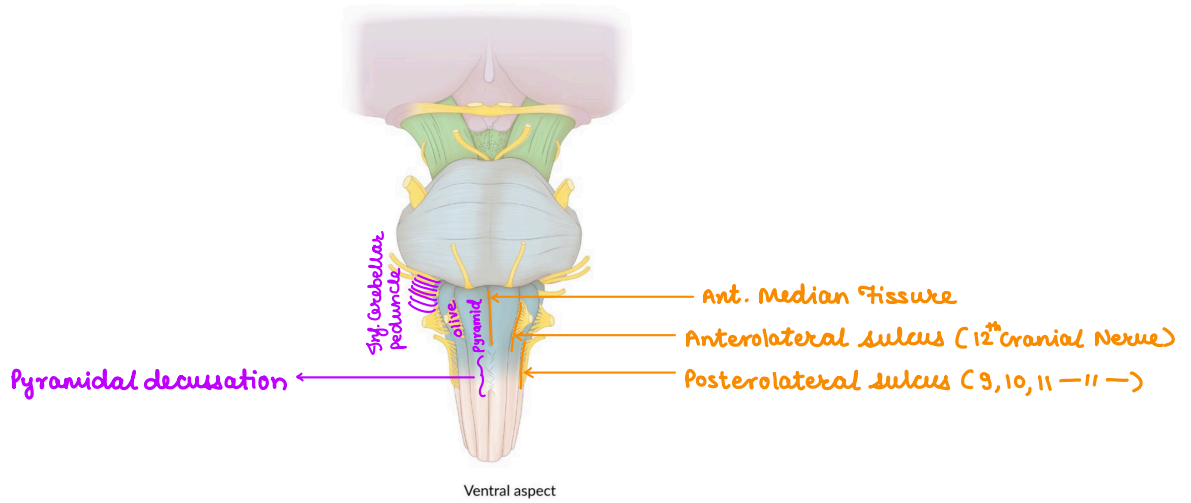
Accessory Cuneate Nucleus :- connects 2 same sided cerebellum via Post. External Arcuate fibres [Cuneocerebellar pathway] via Inferior Cerebellar Peduncle

Arcuate nuclei :- Pontine nuclei dropped in the medulla few corticopontine fibres reach here & cross to go to opposite sided cerebellum via Ant. External Arcuate fibres

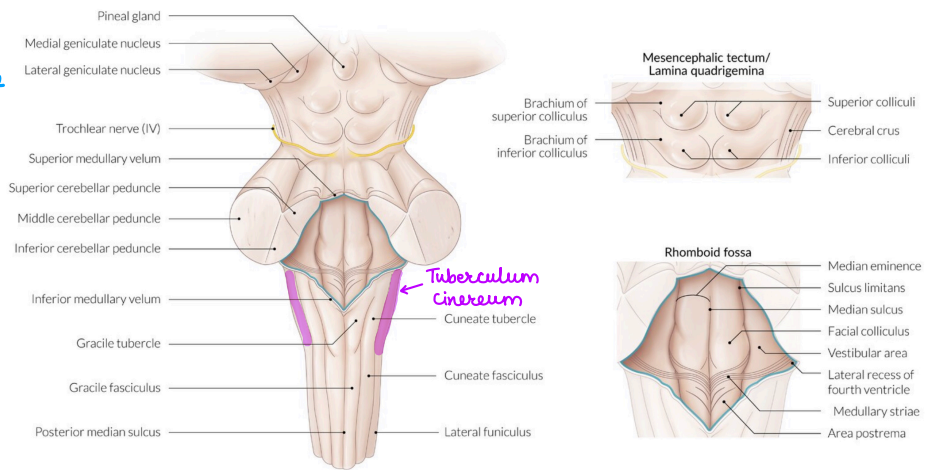
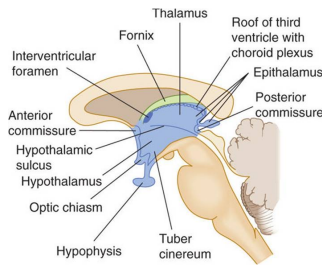


Gray matter cut by the crossing Pyramidal tract, remaining portion is spinal Nucleus of Accessory nerve & supraspinal nucleus of cervical Nerve

\*] External features of medulla oblongata :-



\*] **Tuberculum cinereum / Trigeminal tubercle :-**  
 elevation due to spinal tract of Trigeminal nerve  
 [Don't confuse with Tuberc cinereum which is in hypothalamus]



Throughout the medulla, the anterior spinal artery supplies a region beginning at the central canal (or anterior border of the fourth ventricle), and fans out to encompass the pyramids.

Below the level of the olives the posterior half of the medulla is supplied by the posterior spinal artery. No other regions are supplied by this vessel. The remaining portions are supplied by the posterior inferior cerebellar and vertebral arteries.

In cross section through the olives both the posterior inferior cerebellar and vertebral arteries take on greater territories posterolaterally and anterolaterally respectively. They continue to do so as the medulla ascends.

At the highest point in the medulla, the anterior inferior cerebellar artery supplies the outermost portions of the posterior region.

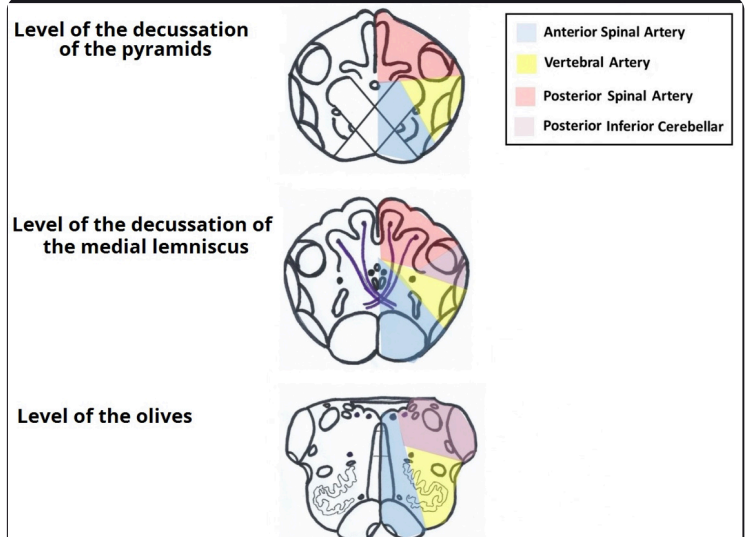
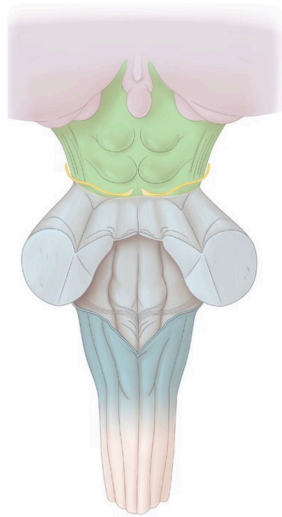


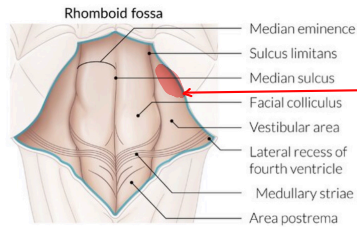
Figure 7: Blood Supply to the Medulla at: Decussation of Pyramids, Decussation of the Lemnisci, and at the level of the olives.

\*] Pons :-

\*] Ext. Surface :-



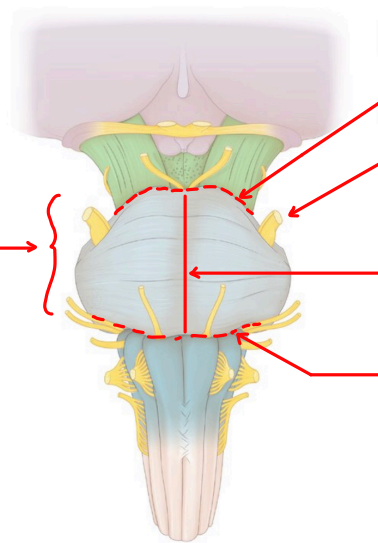
Dorsal aspect



**locus ceruleus** :- Bluish grey area  $\bar{E}$  Neurons rich in Melanin & Noradrenaline

**Floor of 4<sup>th</sup> Ventricle**  $\left\{ \begin{array}{l} \text{Upper } 1/2 \text{ :- Dorsal aspect of pons} \\ \text{Lower } 1/2 \text{ :- Dorsal aspect of medulla} \end{array} \right.$

Horizontal striations are due to corticopontine fibres



Ventral aspect

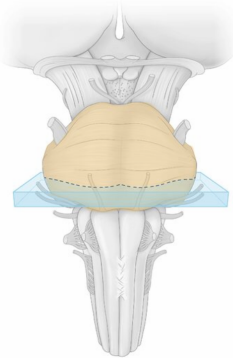
Superior Cerebellar art.

lateral larger part :- Sensory }  $\bar{V}$  CN  
medial smaller part :- Motor }

Basilar groove (Basilar art.)

Ant. Inferior Cerebellar art.

\*] Internal structure :- 2 sections  $\left\{ \begin{array}{l} \text{Upper pons (Trigeminal Nuc/ superior medullary velum closing the 4<sup>th</sup> Ventricle)} \\ \text{Lower pons (at facial colliculus)} \end{array} \right.$



\*] The Basilar portion of Pons (Ant. part) is same throughout the Pons while the Dorsal Tegmental area is different at both levels

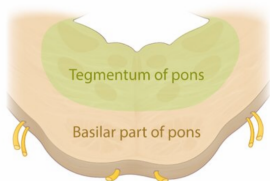
\*] Both Basilar & Tegmentum have Gray matter & white matter

$\Rightarrow$  Basilar portion  $\left\{ \begin{array}{l} \text{Gray} \rightarrow \text{Pontine nuclei} \\ \text{White} \left\{ \begin{array}{l} \text{Longitudinal tracts} \\ \text{Horizontal/Transverse tracts (Pontocerebellar fibres)} \end{array} \right. \end{array} \right.$

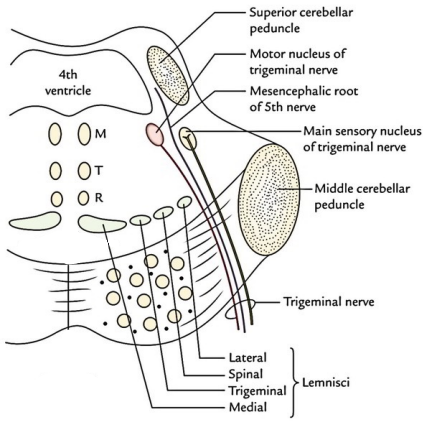
$\Rightarrow$  Longitudinal tract :- Coming from Cerebral peduncle i.e.:-

- i) Corticopontine tract  $\rightarrow$  Relays in Pontine nuclei & via Pontocerebellar fibres joins C/L cerebellum
- ii) Corticospinal tract  $\rightarrow$  Continue as pyramids in medulla
- iii) Corticonuclear tract  $\rightarrow$  Relays at C/L Motor Cranial nerve nuclei

\*] Only 5<sup>th</sup> Cranial nerve nuclei can be seen throughout the section of Brainstem

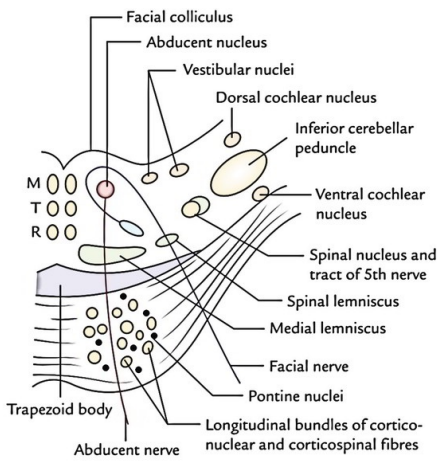


\*J Upper pons section :-



- \*Tegmentum
- Gray :- Only 5<sup>th</sup> Cranial nerve nuclei
  - White :-
    - i) MLF
    - ii) Tectospinal tract
    - iii) Rubrospinal tract
 } In the centre
  - iv) medial lemnisci :- Dorsal column tract
  - v) Trigeminal lemnisci
  - vi) Spinal lemnisci :- All spinothalamic tract
  - vii) lateral lemnisci :- Cochlear nuclei

\*Lower pons section :-



- \*Tegmentum
- Gray :- Cranial Nerve nuclei 5, 6, 7 & 8
  - White :-
    - i) MLF
    - ii) Tectospinal tract
    - iii) Rubrospinal tract
 } In the centre
  - iv) medial lemnisci
  - v) Spinal lemnisci
  - vi) Trapezoid body :- Decussation of Cochlear Nuclei fibres

\*The route of facial nerve nucleus around Abducent nerve forming facial colliculus to reach the motor nuclei of Trigeminal Nerve is called **Neurobiotaxis**

**Pontine vascular syndromes**

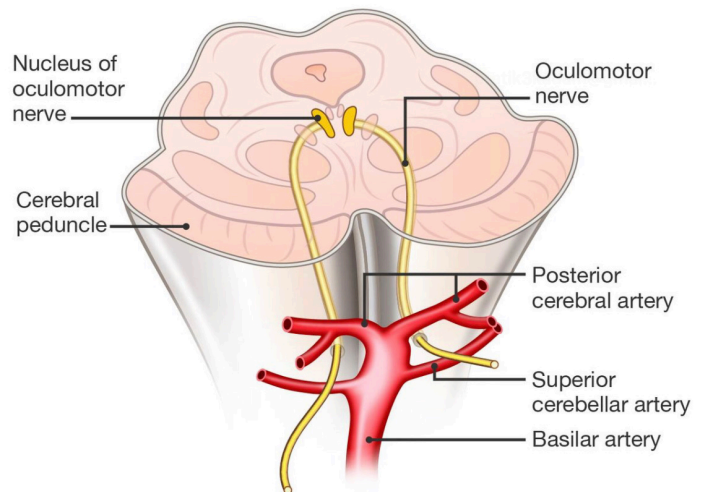
Vascular supply :

Anterior - Basilar artery.

Dorsal pontine - Superior cerebellar artery.

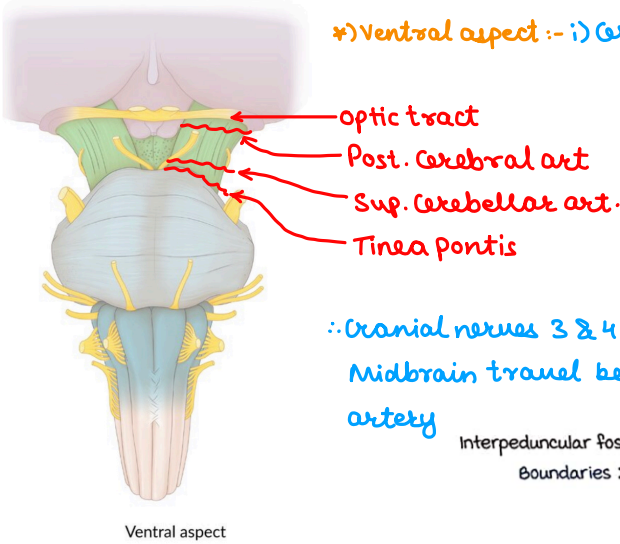
Lateral - Basilar and anterior inferior cerebellar artery.

Oculomotor nerve cranial nerves



\*) Midbrain :-

\*) Ventral aspect :- i) Cerebral Peduncles & Interpeduncular fossa is seen



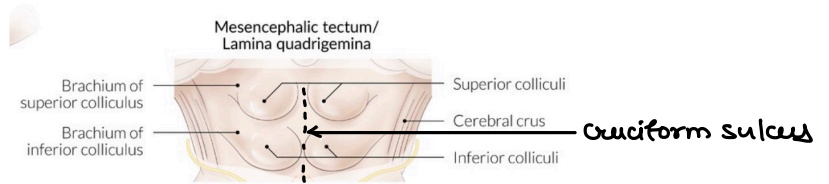
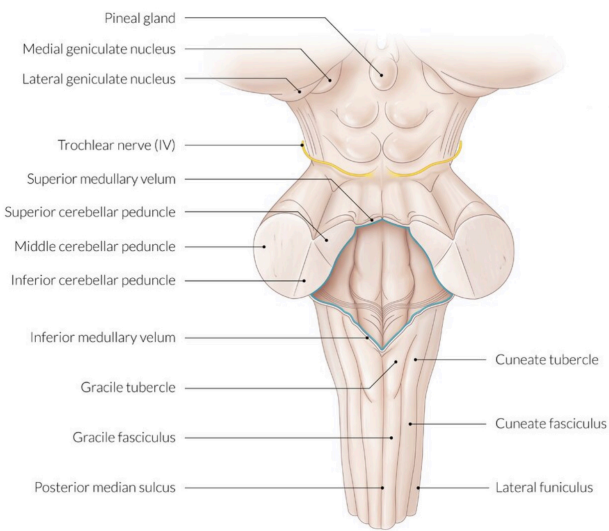
4 structures crossing the cerebral peduncle

∴ Cranial nerves 3 & 4 emerging from Midbrain travel bet<sup>n</sup> PCA & sup. Cerebellar artery

Interpeduncular fossa → In cerebral peduncle  
 Boundaries : Anteriorly → Optic chiasma  
 Base → Pons  
 Either sides → Cerebral peduncle

Contents → Same as floor of third ventricle

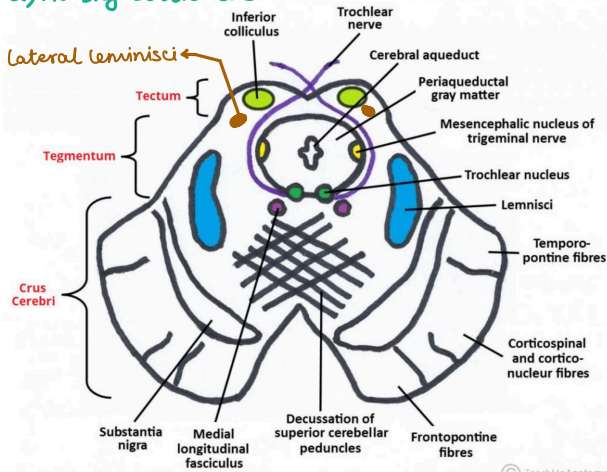
- |  |   |   |
|--|---|---|
| Contents of Interpeduncular fossa + Oculomotor nerve | } | 1. Optic chiasma (in third ventricle only)          |
|  |   | 2. Infundibulum                                     |
|  |   | 3. Pituitary  |
|  |   | 4. Tuber cinereum                                   |
|  |   | 5. Mammillary body                                  |
|  |   | 6. Posterior perforated substance                   |
|  |   | 7. Tegmentum of mid brain (in third ventricle only) |



\*) Dorsal aspect :- i) Corpora quadrigemina seen & their brachium  
 ii) Cruciform sulcus in bet<sup>n</sup> them ends up in Pineal body while down into the Tegmentum veli (sup. medullary velum)  
 ⇒ Superior Brachium connect sup. Colliculus to lateral geniculate B.  
 ⇒ Inferior Brachium connects Inf. Colliculus to medial geniculate B.

\*) Internal structure :- 2 sections → i) At Inferior Colliculus  
 ii) At Superior Colliculus

a) At Inf. Colliculus



i) The substantia nigra & crus cerebri are same throughout  
 ⇒ Subs. nigra :- Motor Nucleus rich in Dopamine & Iron → This dopamine is transported to Corpus striatum via its axons called Nigrostriatal pathway  
 ⇒ Crus cerebri :- i) Medial 1/5<sup>th</sup> :- Frontopontine fibres  
 ii) Middle 3/5<sup>th</sup> :- Corticospinal & Corticonuclear fibres  
 iii) Lateral 1/5<sup>th</sup> :- Parieto-P, Temporo-P & Occipito-Pontine fibres  
 ii) The lateral lemniscus communicates & Inf. colliculus (Auditory)

Figure 3 - Cross-section of the midbrain at the level of the inferior colliculi. NOTE: corticonuclear fibres are also known as corticobulbar.

## b) At Superior Colliculus :-

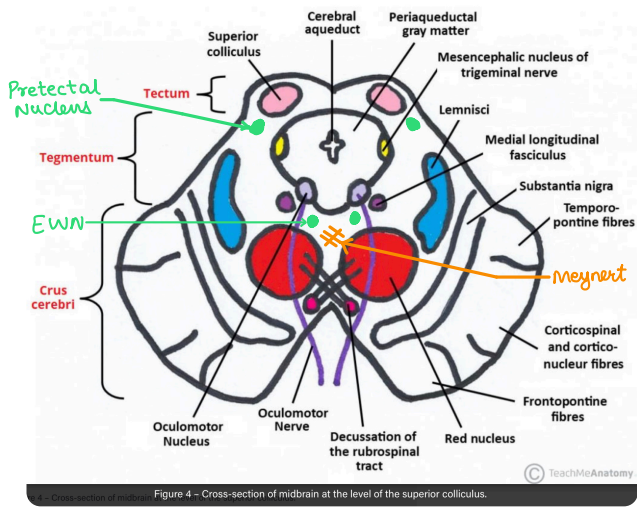
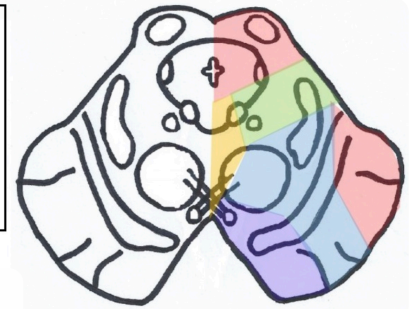
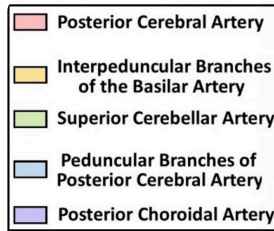


Figure 4 - Cross-section of midbrain at the level of the superior colliculus.

The supply to the area is derived from the **basilar artery** and its branches. The major suppliers are: the posterior cerebral artery and its peduncular branch, the superior cerebellar artery, the posterior choroidal artery, and the interpeduncular branches of the basilar artery.



In the rule of 4 there are 4 rules

1. There are **4 structures** in the 'midline' beginning with **M**
2. There are **4 structures** to the 'side' (lateral) beginning with **S**
3. There are **4 cranial nerves** in the **medulla**, 4 in the **pons** and 4 **above the pons** (2 in the midbrain)
4. There are **4 motor nuclei** that are in the **midline** are those that **divide equally into 12** except for 1 and 2, that is 3, 4, 6 and 12 (5, 7, 9 and 11 are in the lateral brainstem)

The **4 medial structures** and the associated deficits are:

1. **Motor pathway** (or corticospinal tract): contralateral weakness of the arm and leg
2. **Medial Lemniscus**: contralateral loss of vibration and proprioception in the arm and leg
3. **Medial longitudinal fasciculus**: ipsilateral internuclear ophthalmoplegia (failure of adduction of the ipsilateral eye towards the nose and nystagmus in the opposite eye as it looks laterally)
4. **Motor nucleus and nerve**: ipsilateral loss of the cranial nerve that is affected (3, 4, 6 or 12)

The **4 'side' (lateral) structures** and the associated deficits are:

1. **Spinocerebellar pathway**: ipsilateral ataxia of the arm and leg
2. **Spinothalamic pathway**: contralateral alteration of pain and temperature affecting the arm, leg and rarely the trunk
3. **Sensory nucleus of the 5th cranial nerve**: ipsilateral alteration of pain and temperature on the face in the distribution of the 5th cranial nerve (this nucleus is a long vertical structure that extends in the lateral aspect of the pons down into the medulla)
4. **Sympathetic pathway**: ipsilateral Horner's syndrome, that is partial ptosis and a small pupil (miosis)

The **4 cranial nerves in the medulla** are CN 9-12:

1. Glossopharyngeal (CN9): ipsilateral loss of pharyngeal sensation
2. Vagus (CN10): ipsilateral palatal weakness
3. Spinal accessory (CN11): ipsilateral weakness of the trapezius and sternocleidomastoid muscles
4. Hypoglossal (CN12): ipsilateral weakness of the tongue. The 12th cranial nerve is the motor nerve in the midline of the medulla. Although the 9th, 10th and 11th cranial nerves have motor components, they do not divide evenly into 12 (using our rule) and are thus not the medial motor nerves.

The **4 cranial nerves in the pons** are CN 5-8:

1. Trigeminal (CN5): ipsilateral alteration of pain, temperature and light touch on the face back as far as the anterior two-thirds of the scalp and sparing the angle of the jaw.
2. Abducent (CN6): ipsilateral weakness of abduction (lateral movement) of the eye (lateral rectus).
3. Facial (CN7): ipsilateral facial weakness.
4. Auditory (CN8): ipsilateral deafness. The 6th cranial nerve is the motor nerve in the medial pons. The 7th is a motor nerve but it also carries pathways of taste, and using the rule of 4 it does

The **4 cranial nerves in the pons** are CN 5-8:

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The **4 cranial nerves above the pons** are CN 1-4:

1. Olfactory (CN1): not in midbrain.
2. Optic (CN2): not in midbrain.
3. Oculomotor (CN3): impaired adduction, supraduction and infraduction of the ipsilateral eye with or without a dilated pupil. The eye is

The **4 cranial nerves above the pons** are CN 1-4:

1. Olfactory (CN1): not in midbrain.
2. Optic (CN2): not in midbrain.
3. Oculomotor (CN3): impaired adduction, supraduction and infraduction of the ipsilateral eye with or without a dilated pupil. The eye is turned out and slightly down.
4. Trochlear (CN4): eye unable to look down when the eye is looking in towards the nose (superior oblique). The 3rd and 4th cranial nerves are the motor nerves in the midbrain.

Thus a **medial brainstem syndrome** will consist of the 4 M's and the relevant motor cranial nerves, and a **lateral brainstem syndrome** will consist of the 4 S's and either the 9-11th cranial nerve if the lesion is in the medulla, or the 5th, 7th and 8th cranial nerve if the lesion is in the pons.

“ Handy tip: If there are signs of both a lateral and a medial (paramedian) brainstem syndrome, then one needs to consider a basilar artery problem, possibly an occlusion.

I'll let you mull over these rules until the next

i) Superior colliculus gets afferent fibres from :-

- i) Retina
- ii) Snf. Colliculus
- iii) Spinal cord
- iv) Frontal & occip. cortex

Efferent

→ spinal cord (Tectospinal tract)

- ii) Red nucleus acts as relay station for Cortico rubrospinal & cerebello rubro spinal fibres from cortex & cerebellum respectively
- iii) At this level only medial, Trigeminal & spinal lemnisci are present coz lateral lemnisci is fused = Snf. colliculus
- iv) 2 decussations → Dorsal decussation of Meynert (Tectospinal tract) → Ventral decussation of Forel (Rubrospinal tract)

- By Dr Peter Gates

I. 4 Cranial nerves → medulla 9, 10, 11, 12 4 Cranial nerves → Pons 5, 6, 7, 8 2 Cranial nerves → mid brain 3, 4	II. 3, 4, 6, 12 → medially located cranial nerves 5, 7, 9, 11 → Laterally located
III. 4m → medial motor nucleus 3, 4, 6, 12 motor system (Pyramid) medial lemniscus median longitudinal fasciculus	IV. 4S → (Side → Lateral) Spinothalamic tract Spino cerebellar tract Sensory nuclei (5) Sympathetic system

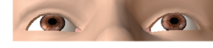
- - medial in medulla
- - lateral in medulla

## THE RULE OF 4 OF THE BRAINSTEM

HORNER'S SYNDROME: (IPSI LATERAL)

Left ptosis  
Left miosis  
Left anhidrosis

INTERNUCLEAR OPTHALMOPLEGIA: (IPSI LATERAL FAILURE TO ADDUCT)



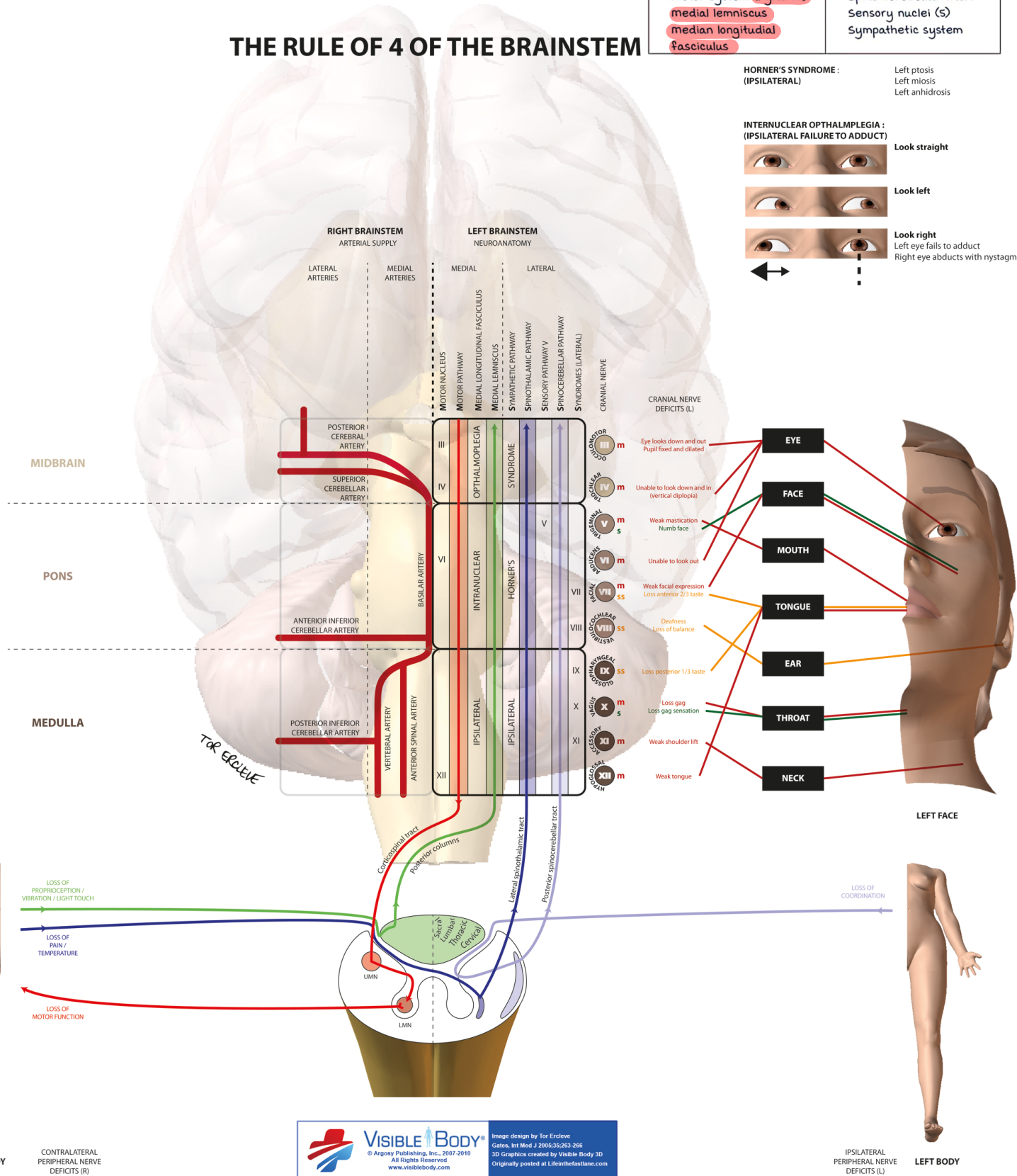
Look straight



Look left



Look right  
Left eye fails to adduct  
Right eye abducts with nystagmus



# MIDBRAIN

## \* → Ventral Midbrain :

i) Weber's syn :-  
[PCA]

Corticobulbar fibres  
Corticospinal fibres  
Substantia Niagra  
Oculomotor nerve

→ C/L lower face palsy (UMN type)  
C/L Facial & Hypoglossal nerve paralysis  
C/L Hemiplegia  
← U/L or Hemiparkinsonism  
Parkinsonian features (Rigidity, Tremor & Bradykinesia)  
S/L Ophthalmoplegia (Ptosis, Mydriasis, Down & Out eye, Cycloplegia)

ii) Claude syn :-

Red nucleus  
Dentato-Rubro-Thalamic tract  
Oculomotor Nerve

C/L Coarse Tremors  
C/L Hemiataxia  
S/L Ophthalmoplegia

iii) Benedikt's syn :-

Red nucleus  
Dentato-Rubro-Thalamic tract  
Oculomotor Nerve  
Medial Lemniscus  
Subthalamus

C/L Coarse Tremors  
C/L Hemiataxia  
S/L Ophthalmoplegia  
C/L loss of Proprioception, Vibration & 2 point discrimin<sup>n</sup>)  
C/L Hemiballismus

## \* → Dorsal Midbrain :

\* i) Parinaud syn :-

Pretectal nucleus connect<sup>n</sup>  
= Upgaze centre  
Unopposed down gaze  
Pretectal nucleus  
Loss of supranuclear inhibitory control over 3rd Nerve (overfires)

Upgaze palsy

Sun setting sign  
Light near dissociation i.e. Argyll Robertson pupil  
Convergence Retraction nystagmus [SR, IR & MR]  
Collier's sign [LPS]

ii) Nothnagel syn :-

Oculomotor Nerve  
Crossed sup. Cerebellar Peduncles  
(Dentato-Rubrothalamic tract)

S/L Ophthalmoplegia  
C/L Hemiataxia

# PONS - 6 & 7 CN

i) Latexal Pontine syn :-  
(Maxie-Foix syn)  
[AICA/Basilar art.]

Spinothalamic tract  
Corticospinal tract  
Middle Cerebellar Peduncle  
-----  
Vestibular Nuclei  
Descending Sympathetic tract  
Spinal Nucleus of Trigeminal nerve  
Facial nerve nuclei  
Cochlear nerve nuclei

C/L loss of Pain & Temperature  
C/L Hemiplegia  
S/L Hemiataxia  
Nystagmus, Vertigo, Nausea, Vomiting  
Horner's syndrome  
S/L loss of pain & temp. of face  
S/L facial droop & loss of Corneal reflex  
S/L deafness



ii) Ventral Pontine syn:-

\* a) Millard Gubler syn:-

[Basilar art.]

[FSH]

Corticospinal tract  
Abducent & Facial Nerve

C/L Hemiplegia

Crossed Hemiplegia

5<sup>th</sup> (diplopia) & 7<sup>th</sup> C 5/L Facial palsy, 5/L loss of corneal reflex)

\* b) Raymond syn:-

[Basilar art.]

[SH]

Corticospinal tract  
Abducent Nerve

C/L Hemiplegia

5<sup>th</sup> nerve palsy

iii) Dorsal Pontine syn:-

[Foville syn.]

[Sup. cerebell. art.]

Corticospinal tract  
Facial Nerve  
Parapontine Reticular "format"

C/L Hemiplegia

Crossed Hemiplegia

7<sup>th</sup> C 5/L Facial palsy)

5/L conjugate gaze palsy

\* iv) Locked In syn:-

[Pontine infarc<sup>n</sup>]

B/L Corticospinal & corticobulbar tracts

Quadriplegia ± Preserved consciousness (RAS) & vertical gaze (coz nuclei is in midbrain)

v) Top of Basilar Occlus<sup>n</sup>:-

**Medulla**

B/L P<sub>2</sub> occlusion (Medial Temporal lobe & Occipital lobe)  
Pretectal nucleus

Ataxia, Amnesia & altered behaviour

Vertical gaze palsy

Corticospinal tract NOT invol

\* i) Lateral Medullary Syndrome

[Vertebral art. > PICA]

[Wallenberg syn.]

crossed sensory loss

& Dissociative (dorsal

column preserved)

Persistent Hiccups\*

Spinal Nucleus of Trigeminal nerve  
7<sup>th</sup> Nerve (NTS)\*  
8<sup>th</sup> Nerve (Vestibulocerebellar)  
Nucleus ambiguus (9, 10, 11 CN)\*  
Descending sympathetic fibres  
Dorsal Nucleus of Vagus  
spinothalamic tract

5/L Numbness, loss of pain & temp. of face  
5/L loss of taste sensations from ant. 2/3<sup>rd</sup> of the tongue  
5/L Ataxia, giddiness, Vertigo, Nystag., Diplopia, Vomiting  
5/L Dysphagia, Nasal regurgitation, Hoarseness of voice  
Horner's syndrome  
5/L ANS symptoms  
C/L loss of pain, Crude Touch & Temperature

\* ii) Medial Medullary Syndrome :-

[ASA (br. of vertebral artery)]

[Dejerine syndrome]

Hypoglossal Nerve  
Corticospinal tract  
Medial Lemniscus

5/L Paralysis ± Atrophy of tongue, towards the side of lesion deviation  
C/L Hemiplegia  
C/L loss of fine touch, 2 point discriminat<sup>n</sup> & Proprioception

iii) Cruciate Paralysis :-

Rostral portion of the Pyramidal Decussation

Paralysis of one arm & opposite leg /  
Brachial diplegia (weakness of both arms ± relative sparing of legs)

iv) Avellis syndrome :-

[Tegmentum involved]

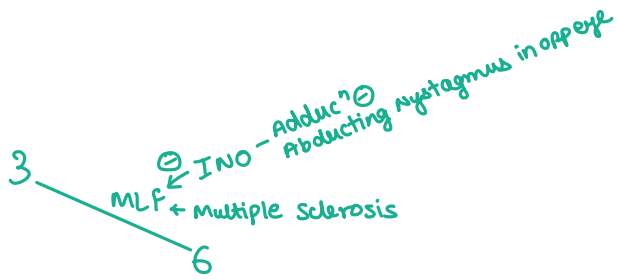
10<sup>th</sup> nerve  
spinothalamic tract  
Corticospinal tract

5/L 10<sup>th</sup> Nerve palsy  
C/L loss of pain & Temp.  
C/L Hemiplegia

v) Jackson syn:-  
[Avellis + 12<sup>th</sup> Nerve]

10<sup>th</sup> nerve  
Spinothalamic tract  
Corticospinal tract  
12<sup>th</sup> Nerve

3/L 10<sup>th</sup> Nerve palsy  
C/L loss of Pain & Temp.  
C/L Hemiplegia  
3/L Paralysis & Atrophy of Tongue



\* Dejerine rousy syn:- Thalamic lesion [VPL Nucleus] :- Hemisensory loss [Body + Face]