

Brainstem and its Associated Cranial Nerves

Anatomical and Physiological Review

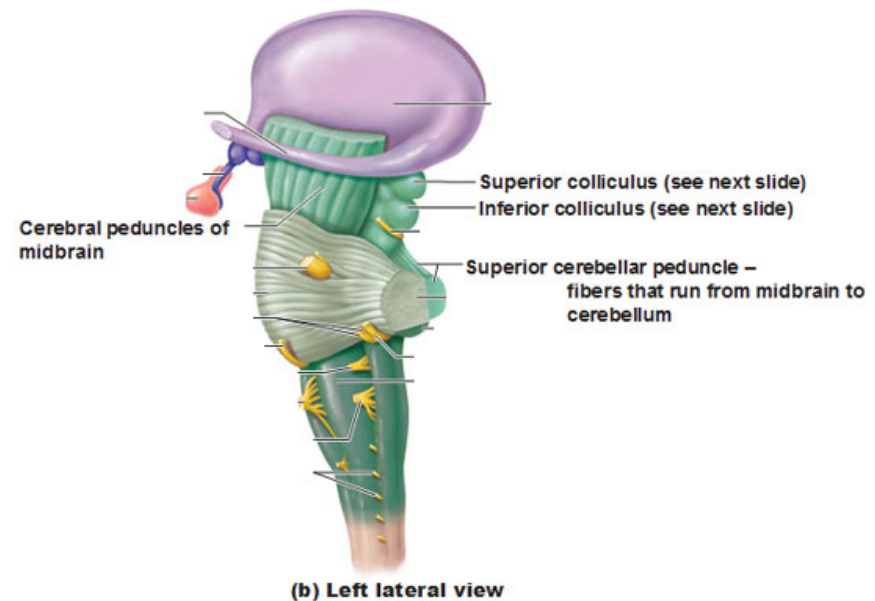
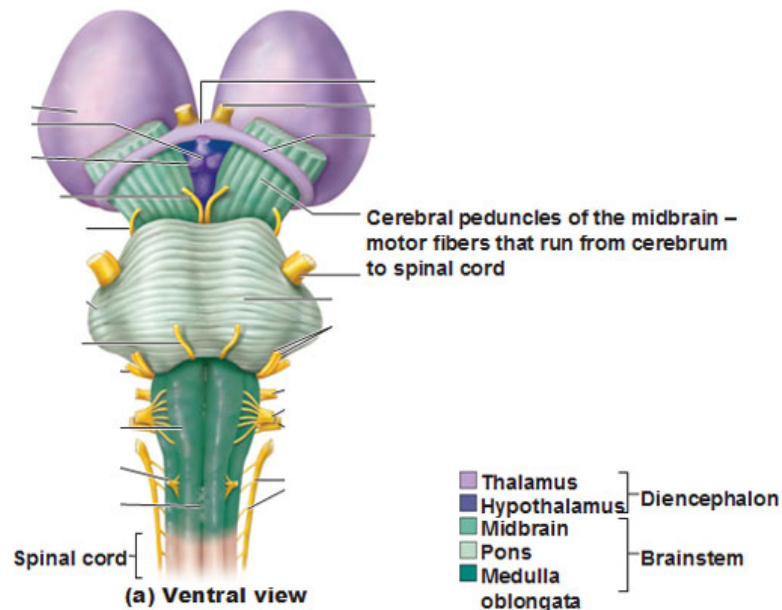
By Sara Alenezy

With appreciation to Noura AlTawil's significant efforts

Midbrain (Mesencephalon)

External Anatomy of Midbrain

<p style="text-align: center;">Ventral Surface</p>	<ol style="list-style-type: none"> 1. Crus Cerebri (Also known as Basis Pedunculi or Cerebral Peduncles): Large column of descending “Upper Motor Neuron” fibers that is responsible for movement coordination, which are: <ol style="list-style-type: none"> a. Frontopontine fibers b. Corticospinal fibers c. Corticobulbar fibers d. Temporo-pontine fibers 2. Interpeduncular Fossa: Separates the Crus Cerebri from the middle. 3. Nerve: 3rd Cranial Nerve (Oculomotor) emerges from the Interpeduncular fossa.
<p style="text-align: center;">Dorsal Surface</p>	<ol style="list-style-type: none"> 1. Superior Colliculus: Involved with <u>visual reflexes</u>. 2. Inferior Colliculus: Involved with <u>auditory reflexes</u>. 3. Nerve: 4th Cranial Nerve (Trochlear) emerges caudally to the Inferior Colliculus after decussating in the superior medullary velum.



Internal Anatomy of Midbrain

Level of Superior Colliculus	<ol style="list-style-type: none"> 1. Superior Colliculus: Nucleus of grey matter that is associated with the Tectospinal Tract (descending) and the Spinotectal Tract (ascending). <ol style="list-style-type: none"> a. <u>Tectospinal Pathway:</u> turning the head, neck and eyeballs in response to a <u>visual</u> stimuli.¹ b. <u>Spinotectal Pathway:</u> turning the head, neck and eyeballs in response to a <u>cutaneous</u> stimuli.² 2. Oculomotor Nucleus: Situated in the periaqueductal grey matter. 3. Red Nucleus: Red mass³ of grey matter situated centrally in the Tegmentum. Involved in motor control (Rubrospinal Tract).
Level of Inferior Colliculus	<ol style="list-style-type: none"> 1. Inferior Colliculus: Nucleus of grey matter that is associated with the Tectospinal Tract (descending) and the Spinotectal Tract (ascending). <u>Tectospinal Pathway:</u> turning the head, neck and eyeballs in response to a <u>auditory</u> stimuli. 2. Trochlear Nucleus: Situated in the periaqueductal grey matter. 3. Decussation of the Superior Cerebellar Peduncles. 4. Substantia Nigra: Pigmented melanin containing neurons that are situated ventrally in the Tegmentum. It is a part of Basal Ganglia, thus, responsible for motor function. It secretes dopamine. Its degeneration cause Parkinson's disease. 5. Ascending Lemnisci: composed of 1) Medial Lemniscus 2) Lateral Lemniscus 3) Spinal Lemniscus (Spinothalamic only) and 4) Trigeminal Lemniscus.

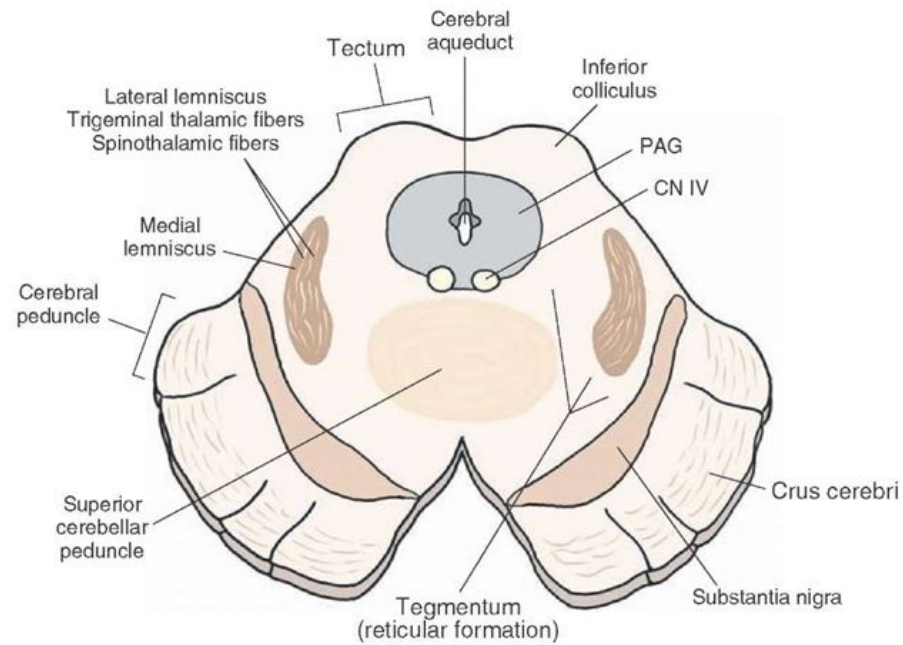
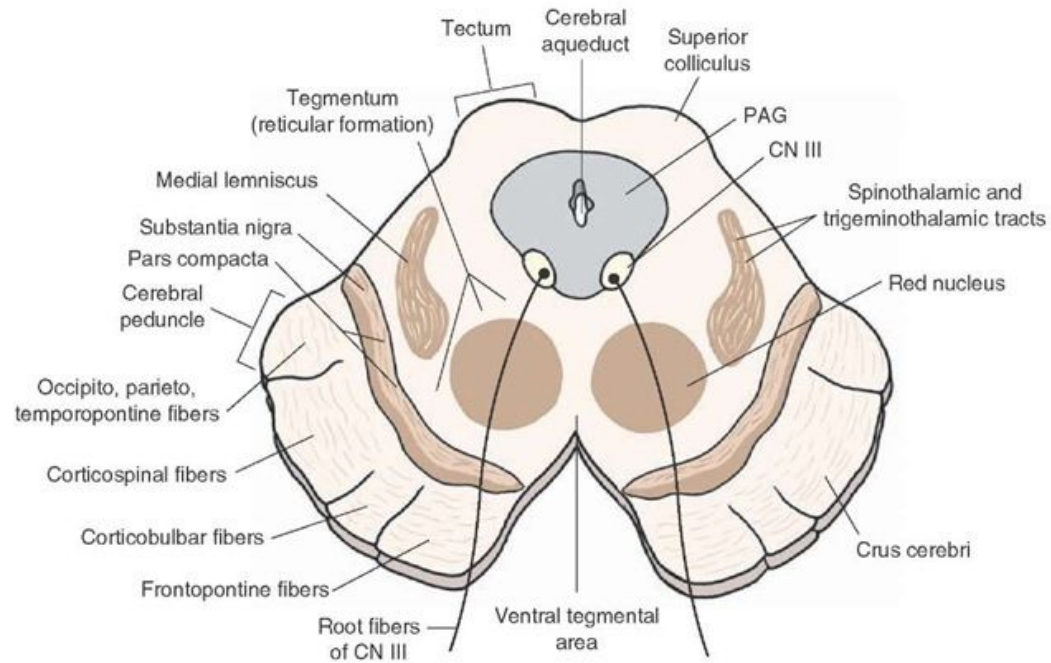
Nuclei of Midbrain

Nucleus	Type	Location	Fiber
Oculomotor Nucleus	Motor	Periaqueductal grey matter at the level of Superior Colliculus	General Somatic Efferent
Trochlear Nucleus	Motor	Periaqueductal grey matter at the level of Inferior Colliculus	General Somatic Efferent

¹ Superior Colliculus receives special sensation from the Retina (e.g. a ball aimed at your face), then, it sends it up to the Lateral Geniculate Body (Neuron) of the Thalamus, thus, to the Primary Visual Cortex (Area 17) and back, after that, it gives rise to a motor response via the spine (e.g. running away).

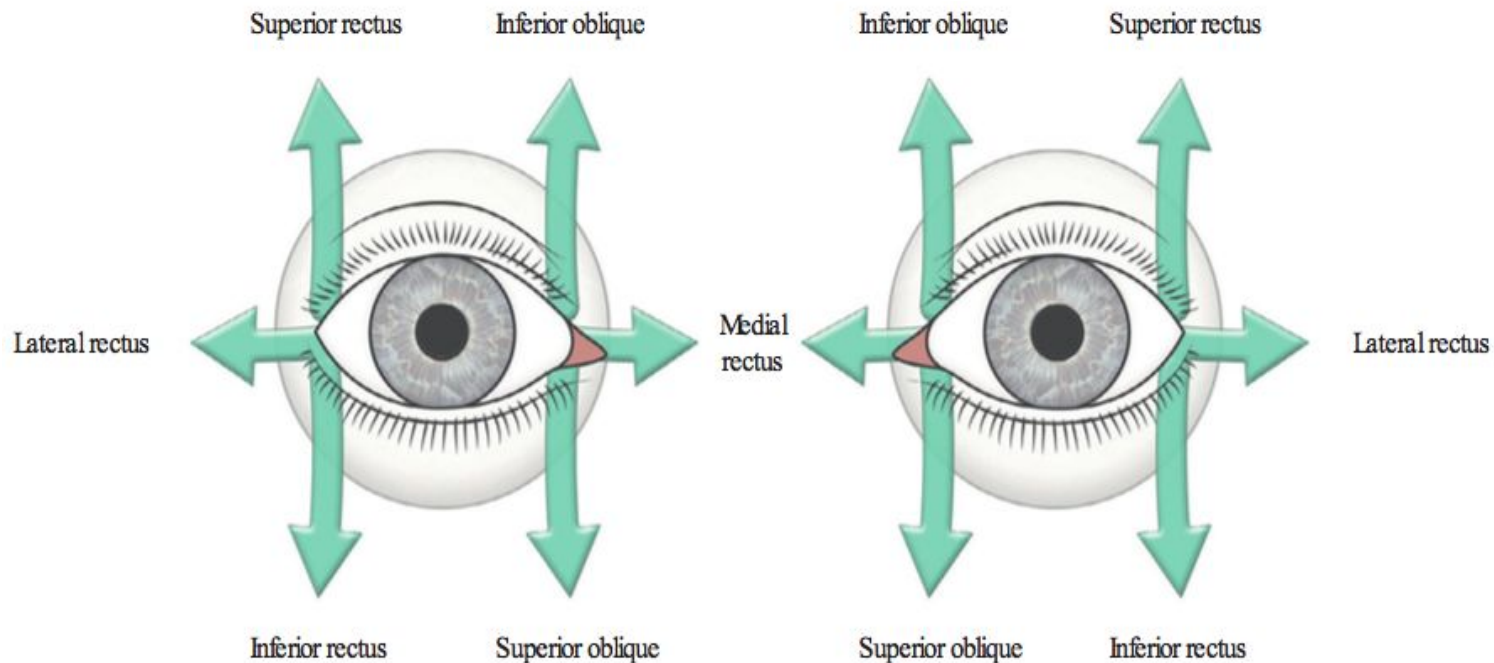
² Superior Colliculus receives general sensation from the skin (e.g. someone touching you from behind), then, it sends it up to the Lateral Geniculate Body (Neuron) of the Thalamus, thus, to the Primary Visual Cortex (Area 17) and back, after that, it gives rise to a motor response via the spine (e.g. turning your head towards the person).

³ Its red coloration is due to 1) its vascularity and 2) the presence of an iron containing pigment in the cytoplasm of its neurons.



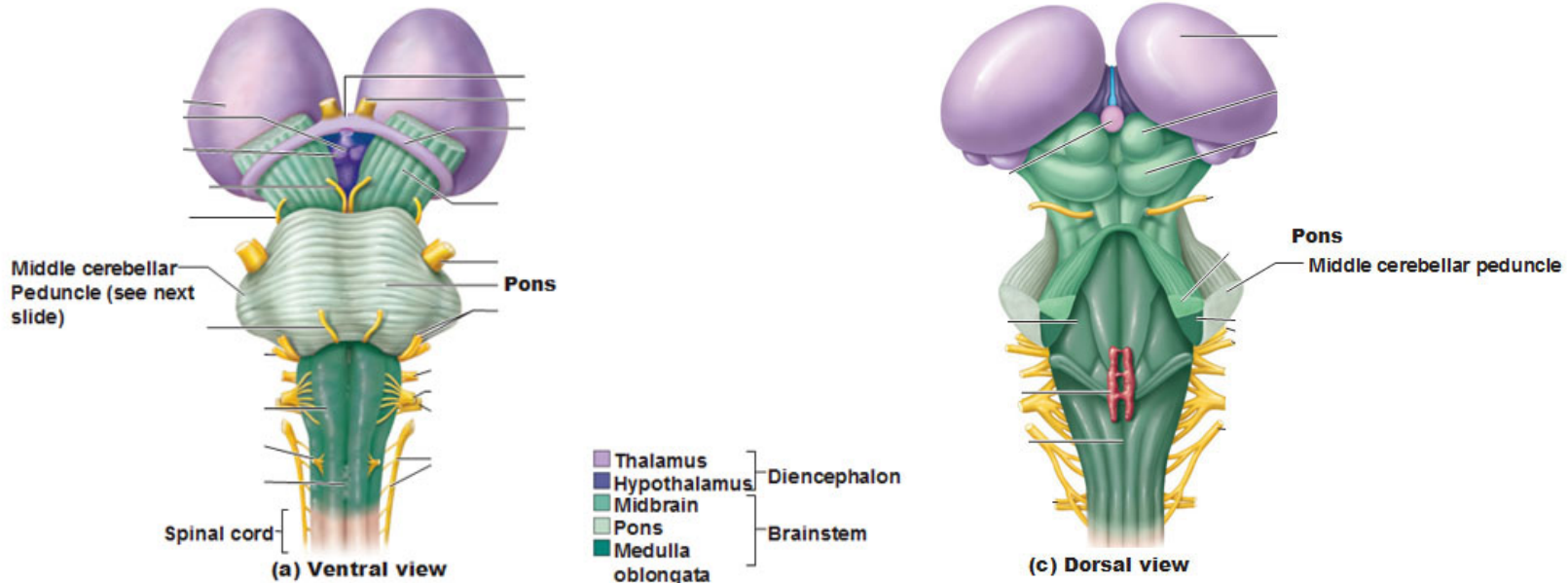
Cranial Nerves of Midbrain

Nerve	Type	Function	Nuclei	Fiber	Muscles	Route	Lesion
Oculomotor	Motor	Eyeball movement and elevation of upper eyelid	Oculomotor Nucleus	GSE	Most extraocular	Leaves the brainstem ventrally through the interpeduncular fossa □ Passes between Posterior Cerebral and Superior Cerebellar Arteries □ Enters the middle cranial fossa □ Runs through the lateral wall of the Cavernous Sinus □ Enter the Superior Orbital Fissure	Lateral squint, ptosis, diplopia, pupillary dilatation, and loss of accommodation. The eyeball is fully abducted and depressed (down and out).
		Pupil constriction and accommodation	Edinger-Westphal Nucleus	GVE	Ciliary and Constrictor Pupillae		
Trochlear	Motor	Eyeball movement	Trochlear Nucleus	GSE	Superior Oblique	Leaves the brainstem caudally to the Inferior Colliculus □ Enters the middle cranial fossa □ Runs through the lateral wall of the Cavernous Sinus □ Enter the Superior Orbital Fissure	Diplopia, inability to rotate the eyeball infero-laterally, deviation upward and slightly inward (medially) and difficulty in walking downstairs.



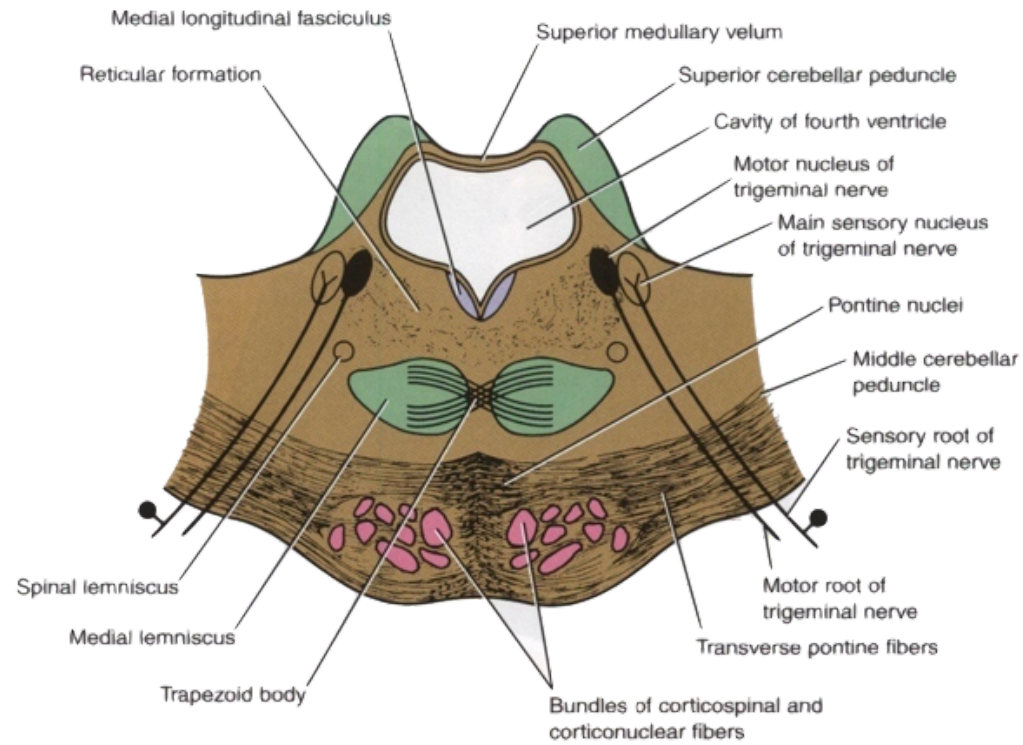
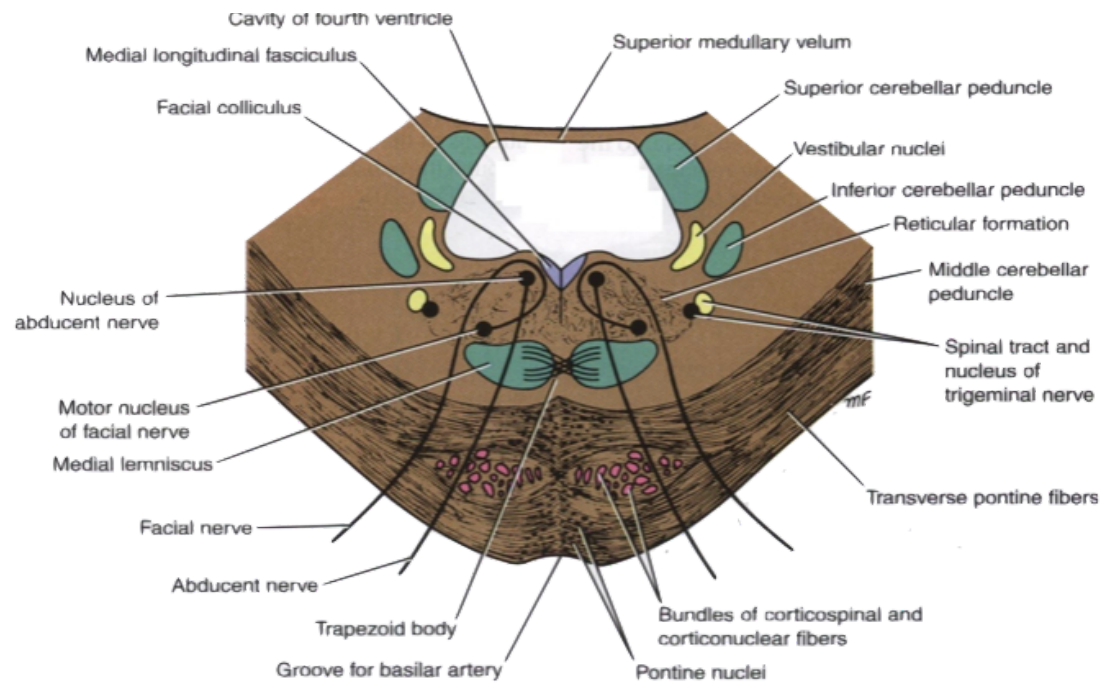
Pons

External Anatomy of Pons	
Ventral Surface	<ol style="list-style-type: none"> 1. Basilar Sulcus: occupied by the Basilar artery, divides Pons into two halves. 2. Transverse Pontine (Pontocerebellar) fibers: emerge from the Pontine Nucleus □ pass through the middle cerebellar peduncle □ terminate in the opposite hemisphere of cerebellum. 3. Nerves: <ol style="list-style-type: none"> a. 5th Cranial Nerve (Trigeminal) emerges from the middle of ponto-lateral aspect. b. 6th Cranial Nerve (Abducent) emerges from the sulcus between Pons and Pyramid. c. 7th Cranial Nerve (Facial) emerges from the cerebellopontine angle. d. 8th Cranial Nerve (Vestibulocochlear) emerges from the cerebellopontine angle.
Dorsal Surface	<ol style="list-style-type: none"> 1. Median Sulcus: divides Pons into two parts <ol style="list-style-type: none"> a. Medial Eminence and Facial Colliculus (covers Abducent Nucleus internally). b. Vestibular Area (covers Vestibular Nuclei Complex internally). 2. Upper Portion of 4th Ventricle. 3. Middle Cerebellar Peduncle.



Internal Anatomy of Pons	
Caudal Pons	<ol style="list-style-type: none"> 1. Trapezoid Body (Nucleus): divides caudal pons into a. Basis Pontis and b. Tegmentum. 2. Pontine Nucleus: give rise to pontocerebellar fibers, and is associated with motor coordination. 3. Middle Cerebellar Peduncle. 4. Corticospinal Tract. 5. Medial Lemniscus: horizontal with 90° rotation. 6. Spinal Sensory Nucleus of Trigeminal. 7. Abducent Nucleus. 8. Facial Motor Nucleus.
Middle Pons	<ol style="list-style-type: none"> 1. Main Motor Nucleus of Trigeminal. 2. Main Sensory Nucleus of Trigeminal. 3. Superior Cerebellar Peduncle of Midbrain. 4. Superior Medullary Velum.
Rostral Pons	<ol style="list-style-type: none"> 1. Corticospinal fibers: predominant. 2. Medial Longitudinal Fasciculus.

Nuclei of Pons			
Nucleus	Type	Location	Fiber
Pontine Nucleus	Motor	Ventral portion of Pons	-
Abducent Nucleus	Motor	Caudal Pons	General Somatic Efferent
Facial Nucleus	Motor	Caudal Pons	Special Visceral Efferent
Spinal Trigeminal Nucleus	Sensory	Along the brainstem, cervical spine and upper thoracic	General Somatic Afferent
Trigeminal Sensory Nucleus	Sensory	Middle and Rostral Pons	General Somatic Afferent
Trigeminal Motor Nucleus	Motor	Middle and Rostral Pons	Special Visceral Efferent



Cranial Nerves of Midbrain								
Nerve	Type	Function	Nuclei	Fiber	Ganglion	Route	Branches	Lesion
Trigeminal	Mixed	Proprioception of 1st Pharyngeal arch muscles ⁴	Mesencephalic	GSA	Occupies a depression in the middle cranial fossa	Emerges from the middle of ponto-lateral aspect by 2 roots <u>L</u> arge <u>L</u> ateral Sensory Root Small <u>M</u> edial <u>M</u> otor Root Divides into 3 divisions at the trigeminal ganglion	<u>Ophthalmic (Sensory)</u> Branches into Frontal ⁵ , Lacrimal ⁶ and Nasociliary ⁷	<u>Trigeminal Neuralgia:</u> recurring episodes of intense stabbing excruciating pain radiating from the angle of the jaw along a branches of the trigeminal nerve. Usually involves maxillary & mandibular branches, rarely in the ophthalmic division.
		Touch from face and scalp	Main Trigeminal Sensory				<u>Maxillary (Sensory)</u> Branches into Superior Alveolar ⁸ , Zygomaticofacial and Infraorbital ⁹	
		Pain and temperature from face and scalp	Spinal Sensory				<u>Mandibular (Mixed)</u> Branches into 1) <u>Sensory branches:</u> Lingual ¹⁰ , Inferior Alveolar ¹¹ , Buccal ¹² , Auriculotemporal ¹³ and 2) <u>Motor branches</u> ¹⁴ .	
		Supplying muscles of 1st Pharyngeal arch	Main Trigeminal Motor	SVE				

⁴ Four Muscles of mastication (Temporalis, Masseter, Medial & Lateral pterygoid). Other four muscles (Anterior Belly of Digastric, Mylohyoid, Tensor Palati and Tensor Tympani).

⁵ Supplies skin of face and scalp.

⁶ Supplies skin of face and lacrimal gland.

⁷ Supplies skin of face, nasal cavity and eyeball.

⁸ (Posterior, middle and anterior) Supplies Upper teeth, gums and maxillary air sinus.

⁹ Both supply the face.

¹⁰ Receives general sensations from anterior 2/3 the of tongue.

¹¹ Supplies lower teeth, gums and face.

¹² Supplies cheek on upper jaw.

¹³ Supplies auricle, temple, parotid gland and Templo-Mandibular Joint.

¹⁴ To 8 muscles (4 muscles of mastication & other 4 muscles).

CONT... Cranial Nerves of Midbrain

Nerve	Type	Function	Nuclei	Fiber	Muscle	Course	Branches	Lesion
Abducent	Motor	Abduction (lateral movement) of the eyeballs	Abducent Nucleus	GSE	Lateral Rectus	Emerges from the ventral aspect at the junction of Pons and the pyramid □ Passes inside the Cavernous Sinus, lying below the internal carotid artery □ Enters the orbit through the superior orbital fissure.	-	Inability to direct the affected eye laterally (medial squint). May also involve the facial nerve, causing paralysis of all facial muscles in the ipsilateral side.
Facial	Mixed	Taste sensation from anterior 2/3 of the tongue	Solitary Nucleus	SVA	-	Emerges from the cerebellopontine angle as 2 roots 1) Medial motor root and 2) Lateral root (nervous intermedius) containing parasympathetic and taste fibers. Passes through internal auditory meatus □ inner ear □ runs in facial canal □ emerges from the stylomastoid foramen □ enters the parotid gland where it ends.	<u>In Facial Canal:</u> Greater petrosal ¹⁵ , Chorda Tympani ¹⁶ and Nerve to Stapes ¹⁷ .	<u>Bell's Palsy:</u> Lower motor neuron lesion (whole face affected) causing paralysis of all facial expression muscles.
		Supplying muscles developed from the 2nd pharyngeal arch ¹⁸	Motor Nucleus of Facial	SVE			<u>Emerging from Stylomastoid foramen:</u> Posterior Auricular ¹⁹ and Muscular ²⁰	
		Supplying submandibular, sublingual, lacrimal, nasal and palatine glands	Superior Salivatory Nucleus	GVE			<u>Inside Parotid Gland:</u> Temporal, Zygomatic, Buccal, Mandibular and Cervical.	

¹⁵ Preganglionic parasympathetic fibers to lacrimal, nasal and palatine glands.

¹⁶ a) Preganglionic parasympathetic fibers to submandibular and sublingual glands. b) Taste fibers from anterior 2/3 of tongue.

¹⁷ Control the amplitude of sound waves from the external environment to the inner ear.

¹⁸ Muscles of face, auricle, posterior belly of digastric, stylohyoid, platysma (neck), stapedius, and occipitofrontalis (scalp).

¹⁹ Occipitofrontalis muscle.

²⁰ Posterior belly of digastric and stylohyoid.

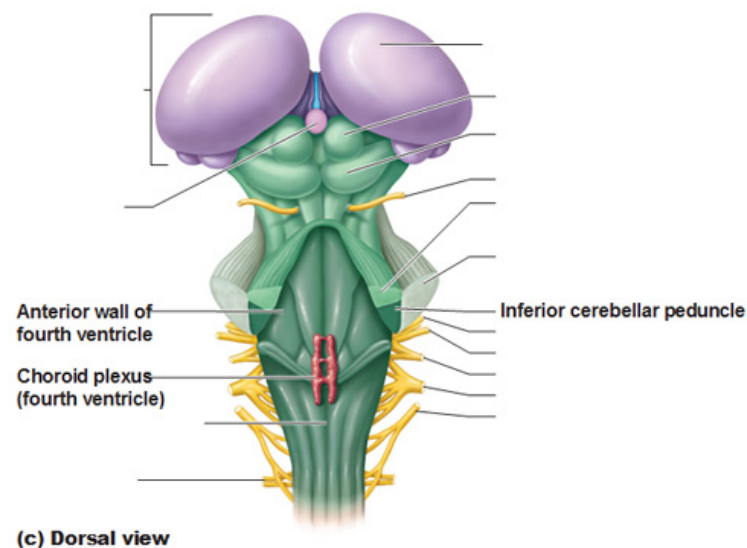
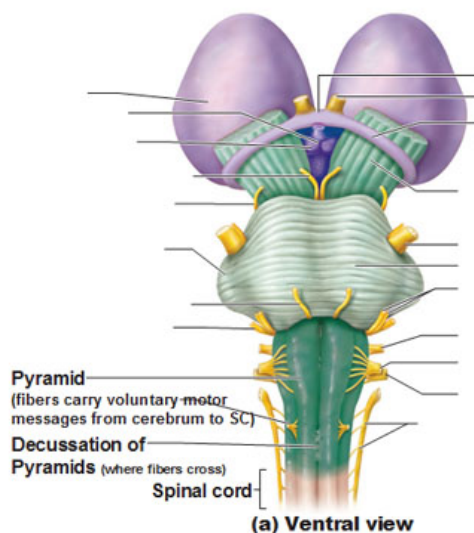
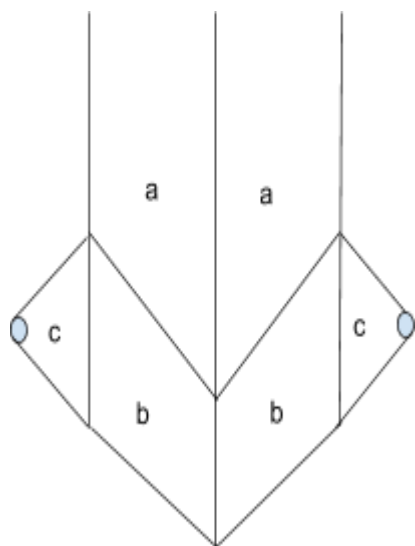
CONT... Cranial Nerves of Midbrain

Nerve	Type	Function	Nuclei	Fiber	Course	Projections	Neurons	Center
Vestibular	Sensory	Conveys impulses associated with body posture, balance and coordination of head and eye movement from inner ear to nervous system.	Vestibular Nuclei	SSA	Leave the ventral surface of brain stem through the cerebello-pontine angle lateral to facial nerve □ run laterally in posterior cranial fossa □ enter the internal acoustic meatus along with 7th nerve.	<p>1. <u>Vestibulo-Cerebellar Tract:</u> Ipsilateral flocculonodular lobe of cerebellum through inferior cerebellar peduncle.</p> <p>2. <u>Vestibulo-Ocular Tract:</u> Bilaterally to ventral posterior nucleus of thalamus, which in turn project to the cerebral cortex. Bilaterally to motor nuclei of cranial nerves through medial longitudinal fasciculus.</p> <p>3. <u>Vestibulospinal Tract:</u> To Motor neurons of the spinal cord as lateral (ipsilateral) directly & medial (bilateral) tracts through MLF, for control the posture.</p>	<p><u>1st order:</u> located in the vestibular ganglion.</p> <p><u>2nd order:</u> Located in the medial, inferior and superior vestibular nuclei at rostral medulla</p>	Vestibular Cortex, Located in the lower part of postcentral gyrus.
Cochlear	Sensory	Conveys impulses associated with hearing from inner ear to nervous system.	Cochlear Nucleus			-	<p><u>1st order:</u> at spiral ganglion at the organ of corti.</p> <p><u>2nd order:</u> at Cochlear nucleus</p> <p><u>3rd order:</u> at inferior colliculus</p> <p><u>4th order:</u> at Medial Geniculate Body</p>	<p>Primary Auditory Cortex (Areas 41 and 42)</p> <p>Auditory Association Cortex (Area 22)</p>

Medulla Oblongata

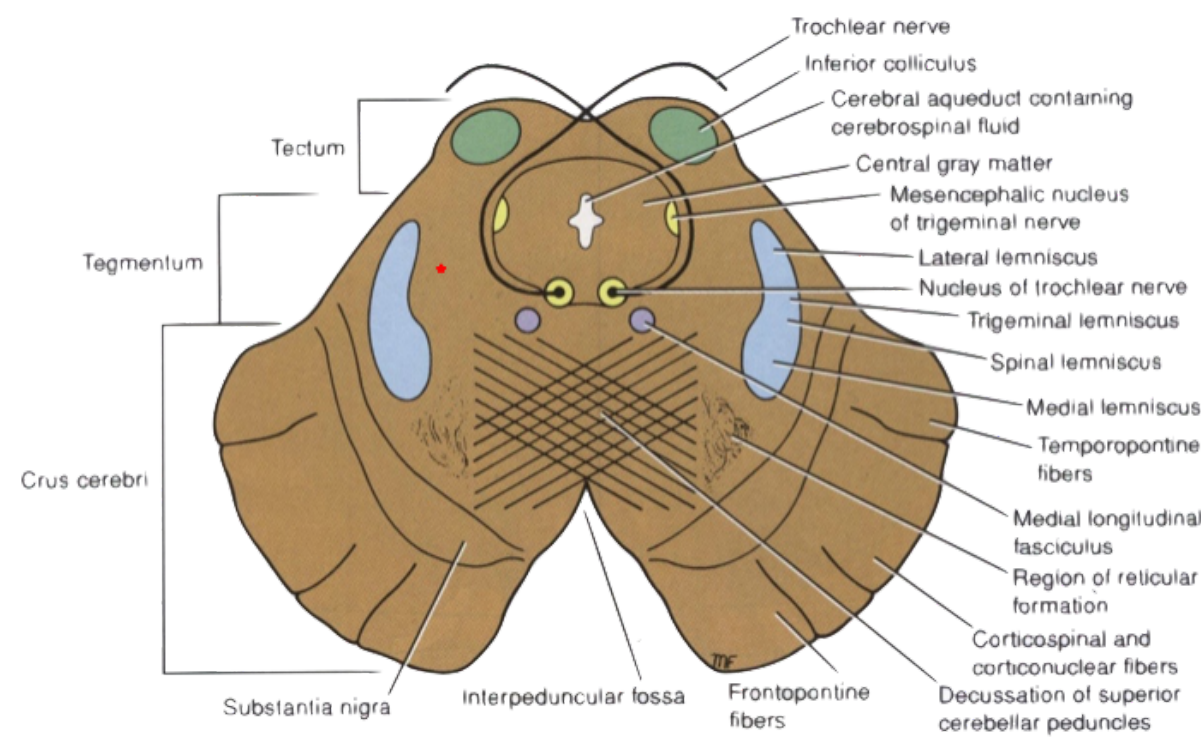
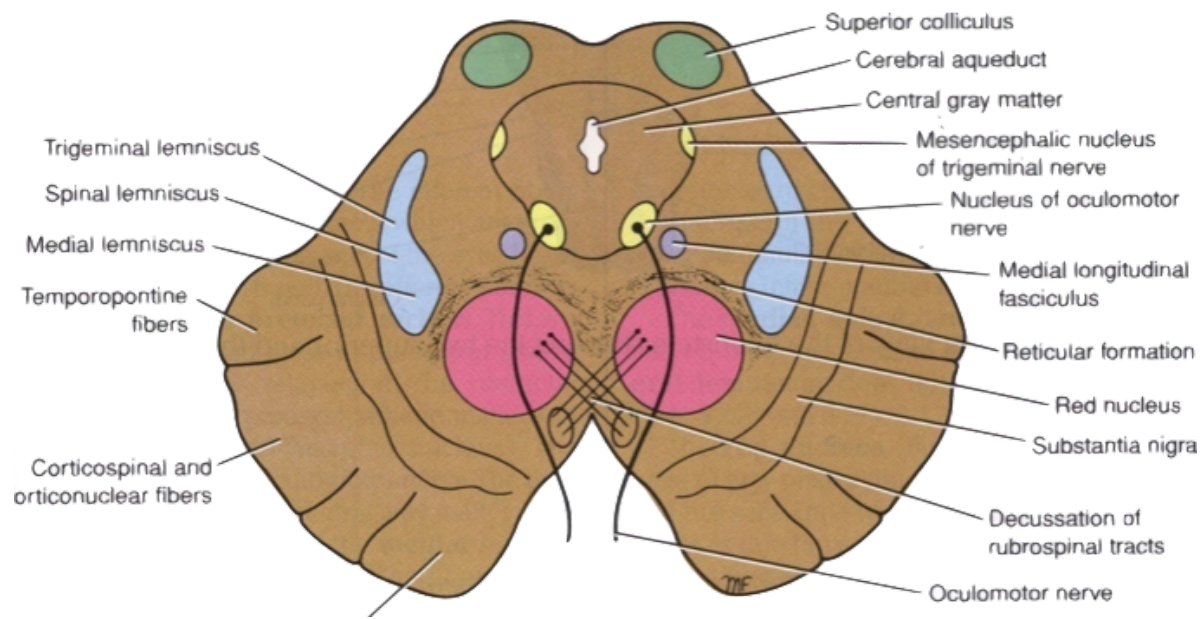
External Structures of Medulla		
Ventral Surface	<ol style="list-style-type: none"> Ventral Median Fissure: continuation of spinal cord's Ventral Median Fissure. Pyramid: produced by corticospinal (pyramidal) tracts. Olive: produced by Inferior Olivary Nucleus. Nerves: <ol style="list-style-type: none"> 12th Cranial Nerve emerges from the sulcus between Pyramid and Olive. 9th, 10th, 11th Cranial Nerves emerge from sulcus between Olive & Inferior Cerebellar Peduncle. 	
Dorsal Surface	Closed Medulla (Caudal)	Open Medulla (Rostral)
	<ol style="list-style-type: none"> Central canal. Fasciculus Gracilis and Cuneatus: ascending fibers of the dorsal column. Gracile and Cuneate tubercle: on the upper part of the each fasciculi marking their nuclei. 	<ol style="list-style-type: none"> Inferior portion of the 4th ventricle Inverted V shaped sulcus* that divides the area into (Medial → Lateral): <ol style="list-style-type: none"> Hypoglossal Triangle Vagal Triangle Vestibular Area Each area covers its own nucleus internally.

*



Internal Structures of Medulla			
Level	Closed Medulla “Motor Decussation”	Mid Medulla “Sensory Decussation”	Open Medulla “Mother of Nuclei”
Cavity	Central canal	Central canal	Inferior portion of the 4th ventricle
Structures	<ol style="list-style-type: none"> 1. Pyramidal (Motor) Decussation 2. Pyramids 3. Trigeminal Sensory Nucleus 4. Spinal Fibers 	<ol style="list-style-type: none"> 1. Gracile and Cuneate Nuclei. 2. Internal Arcuate Fibers: decussating axons of Gracile and Cuneate fibers. 3. Medial Lemniscus: Vertical in position, rotates at the level of Pons. 4. Pyramids. 	<ol style="list-style-type: none"> 1. Inferior Cerebellar Peduncles 2. Inferior Olivary Nucleus. 3. Pyramids. 4. Medial lemniscus. 5. Medial Longitudinal Fasciculus. 6. Hypoglossal Nucleus. 7. Dorsal Nucleus of Vagus. 8. Anterior & Posterior Cochlear Nuclei. 9. Vestibular Nuclei Complex. 10. Nucleus Ambiguus. 11. Solitary Nucleus. 12. Tectospinal Tracts

Nuclei of Pons			
Nucleus	Type	Location	Fiber
Hypoglossal Nucleus	Motor	Open Medulla	General Somatic Efferent
Nucleus Ambiguus	Motor	Open Medulla	Special Visceral Efferent
Cochlear Nuclei	Sensory	Open Medulla	Special Visceral Afferent
Solitary Nucleus	Sensory	Open Medulla	Special/General Visceral Afferent
Spinal Trigeminal Nucleus	Sensory	Along the brainstem, cervical spine and upper thoracic	General Somatic Afferent
Inferior Olivary Nucleus	Motor	Open Medulla	-
Vestibular Nuclei Complex	Sensory	Open Medulla	Special Somatic Afferent
Dorsal Motor Nuclei of Vagus	Motor	Open Medulla	General Visceral Efferent



Cranial Nerves of Medulla							
Nerve	Type	Function	Nuclei	Fiber	Course	Branches	Lesion
Hypoglossal	Motor	Motor supply of the tongue muscles ²¹	Hypoglossal Nuclei	GSE	Emerges from the sulcus between Pyramid and Olive emerges from the sulcus between Pyramid and Olive □ Leaves the cranial cavity from the hypoglossal canal □ Courses downwards with the neurovascular bundle (Internal Carotid Artery, Internal Jugular Vein, Vagus) □ Curves forward behind the mandible to supply the tongue	Ansa Cervicalis ²²	<p>One damaged: On protrusion the tongue will point to the side of the lesion.</p> <p>Both damaged: Protrusion cannot be performed</p>
Cranial Accessory	Motor	Supplies muscles of the pharynx, larynx, soft palate and esophagus.	Nucleus Ambiguus	SVE	Emerges caudal to the vagus nerve on the lateral aspect of the medulla □ Joins the spinal briefly □ Separates from the spinal root once it reaches the jugular foramen □ joins the vagus.	-	<p>Mistake: Commonly injured while removing posterior triangle lymphoma.</p> <p>Intention: Stab wound (due to its superficial position)</p> <p>Manifestation: Dropping shoulder, winged scapula, atrophy and weakness of trapezius, trouble swallowing and speech, inability to turn the head.</p>
Spinal Accessory		Supplies the Sternomastoid and Trapezius	Spinal Accessory Nucleus	-	Enters the cranial cavity via foramen magnum and joins the cranial root □ Separates from the cranial once it reaches the jugular foramen.	-	

²¹ Except the palatoglossus which is supplied by the vagus.

²² Supplies neck muscles & start at C1.

CONT... Cranial Nerves of Medulla

Nerve	Type	Function	Nuclei	Fiber	Course	Ganglia	Branches	Lesion
Vagus	Mixed	Parasympathetic innervation of cardiac muscle, smooth muscles and glands of viscera	Dorsal Nucleus of Vagus	GVE	Leaves the cranial cavity through the jugular foramen in the carotid sheath □ Runs between the internal jugular vein & internal / common carotid arteries □ As it descends down the neck it supplies prevertebral muscles and fascia the IJV is behind it & ICA+CCA are in front of it □ Enters the thorax through its inlet as right & left vagus. <u>Right vagus:</u> descends in front of the subclavian artery <u>Left vagus:</u> descends between the left common carotid & the subclavian	<p>Superior ganglion: in the jugular foramen with the:</p> <ol style="list-style-type: none"> Inferior ganglion of glossopharyngeal n. Superior cervical sympathetic ganglion Facial n. <p>Inferior ganglion: Just below the jugular foramen with the:</p> <ol style="list-style-type: none"> Cranial part of the accessory Hypoglossal Superior cervical sympathetic 1st cervical n. 	<p>1. Meningeal: sensations from the dura to the spinal trigeminal nucleus</p> <p>2. Auricular: sensations from the external acoustic meatus and tympanic membrane to the spinal trigeminal nucleus.</p> <p>3. Pharyngeal: Motor from nucleus ambiguus to the pharyngeal mucosa, superior and inferior constrictors and all the palate muscles <u>except</u> tensor palatini</p> <p>4. Nerve to carotid body: Vagus, as well as the glossopharyngeal, takes information from it and transfer it to the cardiorespiratory centers in the M.O.</p> <p>5. Superior laryngeal: divides into: Internal: Sensation from the hypopharynx, epiglottis, larynx above the vocal cords. External: Supplies the cricothyroid muscle.</p> <p>6. Recurrent laryngeal:</p> <ol style="list-style-type: none"> Around the subclavian from the right arch of the aorta on the left gives motor supply to all laryngeal muscles except cricothyroid Provides sensation to the larynx below the vocal cords. 	<p>Lateral Medullary Syndrome: Is a degenerative disease seen after age 50 due to thrombosis of inferior cerebellar artery.</p> <p>Tumors: compress the nerve</p> <p>Symptoms: Antagonistic to its anatomic function+ palatal pharyngeal and laryngeal paralysis</p>
		Motor action to the pharynx & larynx	Nucleus Ambiguus	SVE				
		Takes sensations from the viscera	Solitary Nucleus	GVA				
		Takes sensations from the auricles, external acoustic (auditory) meatus & cerebral dura mater	Spinal Trigeminal Nucleus	GSA				

CONT... Cranial Nerves of Medulla

Nerve	Type	Function	Nuclei	Fiber	Course	Ganglia	Branches	Lesion
Glossopharyngeal	Mixed	<p>1. Receives visceral sensations from mucosa of posterior 1/3 of tongue, pharynx, auditory tube, tympanic cavity and carotid sinus</p> <p>2. Tract receives sensation of taste on the post. 1/3 of the tongue.</p>	Solitary Nucleus	GVA and SVA	<p>Leaves the cranial cavity via jugular foramen</p> <p>□ Passes between the internal jugular & external carotid</p> <p>□ Lies deep to the styloid process</p> <p>□ Process through the posterior part of the stylopharyngeus and supplies it²³</p> <p>□ Breaks into branches at the level of Hyoglossus muscle.</p>	<p>Superior ganglion: Small, no branches, connected to the superior cervical sympathetic ganglion.</p> <p>Inferior ganglion: Large, carries general sensation from the pharynx, soft palate & tonsils. Connected to the auricular branch of the vagus.</p> <p>Trunk: Connected to the facial nerve at the stylomastoid foramen.</p>	<p>1. Tympanic: Secretomotor from the inferior salivatory nucleus to the otic ganglion then to the parotid gland.</p> <p>2. Nerve to stylopharyngeus: motor from the nucleus ambiguus to the stylopharyngeus m.</p> <p>3. Pharyngeal: From the pharyngeal mucosa to the solitary nucleus.</p> <p>4. Tonsillar: from the tonsils to the solitary nucleus</p> <p>5. Lingual: general & special (taste) sensation from the tongue to the solitary nucleus.</p> <p>6. Baro & Chemoreceptors: from the carotid sinus to solitary nucleus.</p>	<p>Difficulty swallowing, absent gag reflex, poor salivation (dry mouth), No taste on the posterior 1/3 of the tongue.</p>
		Motor supply to the Stylopharyngeus muscle.	Nucleus Ambiguus	SVE				
		Parasympathetic supply to otic ganglion	Inferior Salivatory Nucleus	GVE				

²³ All muscles are supplied via pharyngeal plexus except stylopharyngeus supplied directly via glossopharyngeal.