

Oculomotor (CN3)

Nuclei

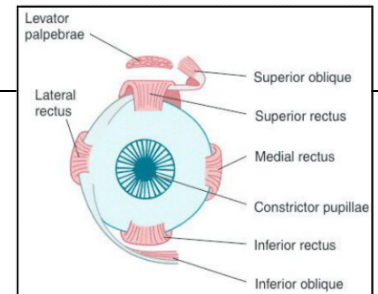
1- main motor nucleus

2- accessory parasympathetic nucleus (Edinger-Westphal nucleus), posterolateral to main nucleus.

Supplies

1- **extrinsic muscles** (levator palpebrae superioris, superior rectus, medial rectus, inferior rectus, inferior oblique (all eyeball muscles except the lateral rectus & superior oblique))

2- **intrinsic muscles** (constrictor pupillae of the iris, ciliary muscles)



Action of muscles

1- lifting upper eyelid

2- turning eye up, down, medially

3- constricting pupil

4- accommodating the eye

Course (bilateral tract)

1- fibers of two nuclei pass via red nucleus (no synapse)

2- pass via substantia nigra exiting through interpeduncular fossa

3- enter middle cranial fossa in lat. wall of cavernous sinus.

4- nerve leaves cranial cavity & enters orbital cavity via superior orbital fissure (bet. greater & lesser wing of sphenoid)

5- divides into two branches: sup. & inf. rami, which supply most extraocular muscles

Lesion

1- Complete lesion

All muscles are paralyzed except lat. rectus & sup. oblique. **Symptoms:**

- **External strabismus:** in resting position, affected eye turns laterally. (due to abduction by lateral rectus), & that causes diplopia.
- **Ptosis:** drooping of upper eyelid (paralysis of levator palpebrae superioris)
- **Mydriasis:** The pupil is widely dilated & nonreactive to light. Dilation is overriding.
- **Paralyzed accommodation**
- **Ophthalmoplegia:** paralysis of one or more of the eye muscles



1- Complete lesion

- **Internal ophthalmoplegia:** Loss of the autonomic innervation of sphincter pupillae & ciliary muscle. **Symptoms:** pupil widely dilated & nonreactive to light only (affects the autonomic (parasympathetic) part)
- **External ophthalmoplegia:** paralysis of the extraocular muscles due to paralysis of the motor part of the oculomotor nerve. **Symptoms** External strabismus, diplopia & ptosis only (affects the motor part)

notes

* cavernous sinus is one of the Dural sinuses located on either side of Sella turcica

* parasympathetic (preganglionic) fibers pass through inferior ramus & synapse in ciliary ganglion. Then come out as postganglionic through short ciliary nerve which will innervate intrinsic muscles of the eye

* Eye movement must be synchronized, oculomotor nerve complete lesion → no synchronization → Diplopia

* Diplopia: double vision

* parasympathetic fibers run superficial in the nerve. So, if there was pressure applied on the nerve, the parasympathetic will be affected without the motor component. (parasympathetic is more susceptible to injury).

* diabetic neuropathy affects the motor fiber only

Trochlear nerve (CN4)

Nuclei

one motor nucleus, anterior to cerebral aqueduct, at the level of inf. colliculi in midbrain

Supplies

superior oblique muscle (passes through a structure called the trochlea, a pulley-like structure)

Action of muscles (pulley-like system gives the superior oblique muscle its action)

- 1- depression of the eyeball (despite being inserted on its superior surface)
- 2- lateral rotation of eyeball (moves eye downward & lateral)

Course (bilateral tract)

- 1- Fibers go posteriorly around the cerebral aqueduct & mesencephalic nucleus
- 2- emerge from post. aspect of midbrain
- 3- turn around crus cerebri & move along the lat. wall of cavernous sinus (with oculomotor nerve) entering the orbit via sup. orbital fissure to innervate the superior oblique muscle

Lesion symptoms:

1- Diplopia

2- Difficulty in turning eye downward & laterally (at rest eye will go upward & medially)

3- Difficulty in descending stairs (normally when you are descending stairs, only your eyes move downward, but in the case of this injury, patient will tilt his head to the side opposite the paralyzed eye (compensatory adjustment) to look at the floor)

Notes

* nerves that pass through superior orbital fissure: CN3 + CN4+ CN6 & ophthalmic division of trigeminal



Abducent nerve (CN6)

Nuclei

one motor nucleus, underneath floor of 4th ventricle, at level of the facial colliculus (caudal part) of pons

Supplies

lateral rectus muscle of the eye.

Action of muscles

turns the eye laterally

Course (bilateral tract)

- 1- nerve leaves brainstem anteriorly at pontomedullary junction medial to facial nerve.
- 2- enters cavernous sinus below & lat. to ICA.
- 3- enters orbit through sup. orbital fissure & innervates lateral rectus muscle

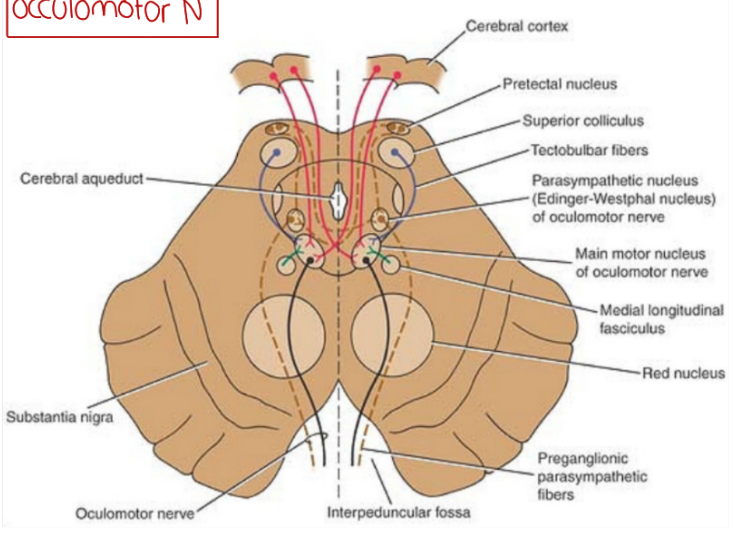
Lesion

1- Diplopia.

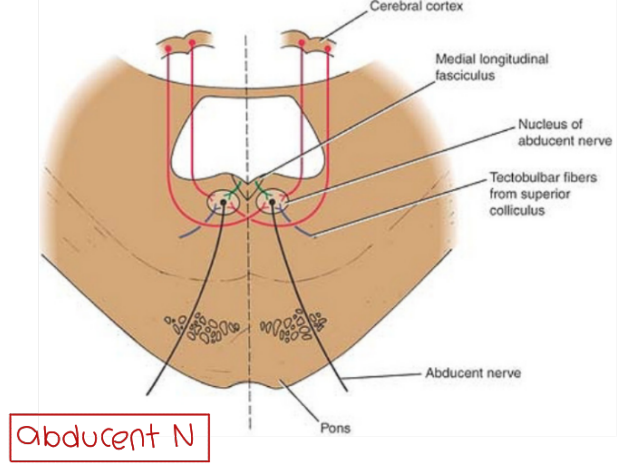
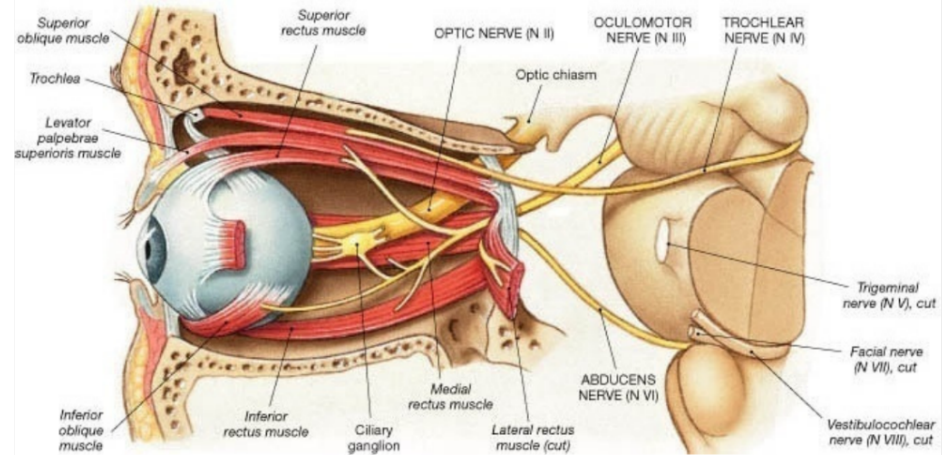
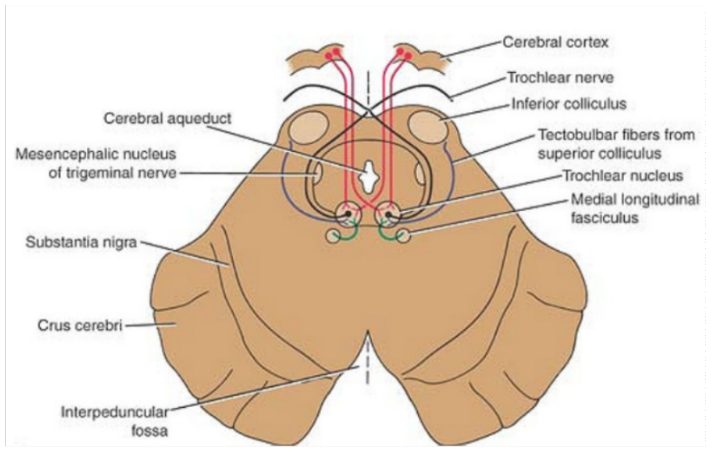
2- Internal strabismus: Difficulty in turning eye laterally (at rest eye is pulled medially by the overriding of medial rectus that is supplied by oculomotor)



Oculomotor N

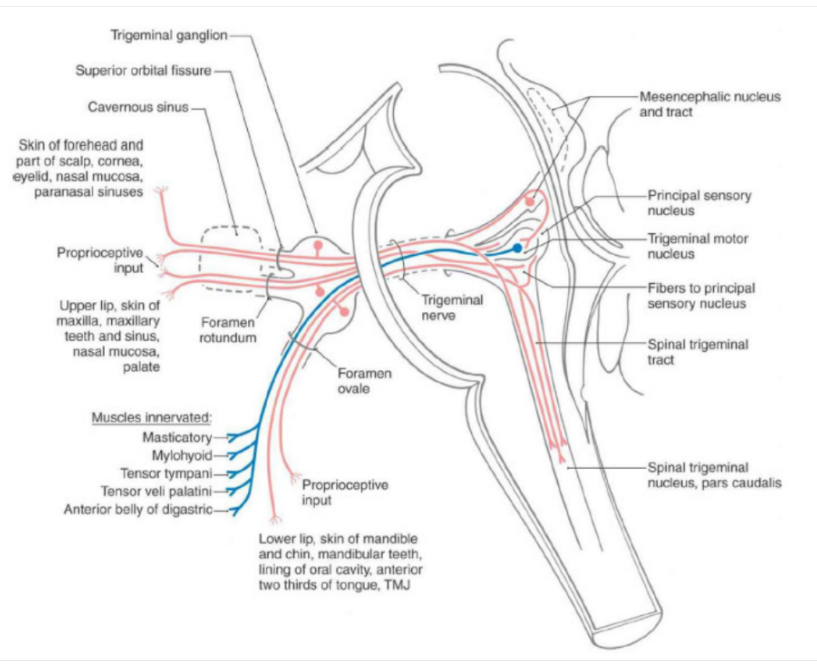
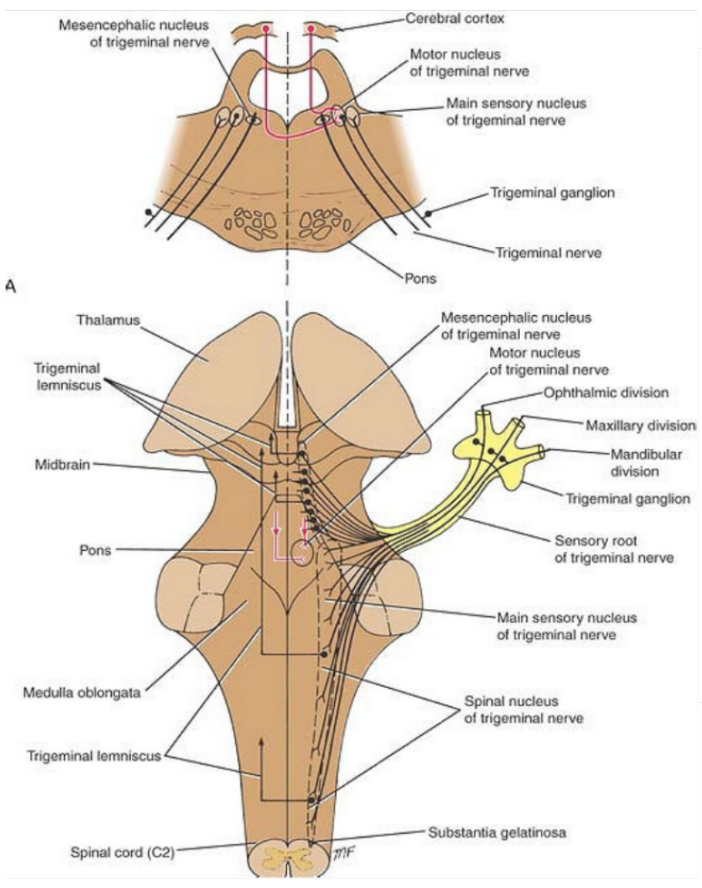


Trochlear N



Abducent N

trigeminal N



Trigeminal nerve (CN5)

Nuclei

Mixed cranial nerve + the biggest cranial nerve + It has 4 nuclei: **3 sensory and 1 motor**.

1- Motor nucleus (Posterior part of the pons (Medial))

2- Main sensory nucleus (Posterior part of the pons (lateral))

3- Spinal nucleus (Superiorly: main sensory nucleus. (ends at midpontine area), Inferiorly: C2 segment)

4- Mesencephalic nucleus: (Lateral part of gray matter around cerebral aqueduct, Inferiorly main sensory nucleus)

Supplies

1- receives sensations from all face except the angle of the mandible (supplied by great auricular nerve)

2- receives sensations from oral cavity, nasal cavity, paranasal sinuses.

3- For the mandibular division ONLY. It supplies:

- Muscles of mastication (masseter, temporalis, medial pterygoid, and lateral pterygoid)
- Tensor tympani
- Tensor veli palatini
- Mylohyoid
- Anterior belly of the digastric muscle.

Modality of each nucleus

1- Main sensory nucleus: Discriminative and light touch of the face as well as conscious proprioception. (similar to PCML)

2- Spinal nucleus: Crude touch, pain, and temperature (similar to ALS)

3- Mesencephalic nucleus: Reflex proprioception of the periodontal ligament and of the muscles of mastication in the jaw.

4- Motor nucleus: receives fibers from the corticonuclear tract, red nucleus, reticular formation, and the tectum.

Course (bilateral tract)

1- nerve originates from three sensory nuclei and one motor at the level of pons anteriorly.

2- The sensory nuclei merge to form a sensory root. The motor nucleus continues to form a motor root (motor runs inferior to sensory).

3- In the middle cranial fossa they expand into the trigeminal ganglion. (Trigeminal ganglion is located lateral to the cavernous sinus, in the upper surface of the apex of the petrous bone in a depression called Meckel's cave (which is a pouch in the dura mater))

4- The divisions of this nerve will go out through:

- Ophthalmic: through superior orbital fissure.
- Maxillary: through foramen rotundum to pterygopalatine fossa.
- Mandibular: through foramen ovale to infratemporal fossa.

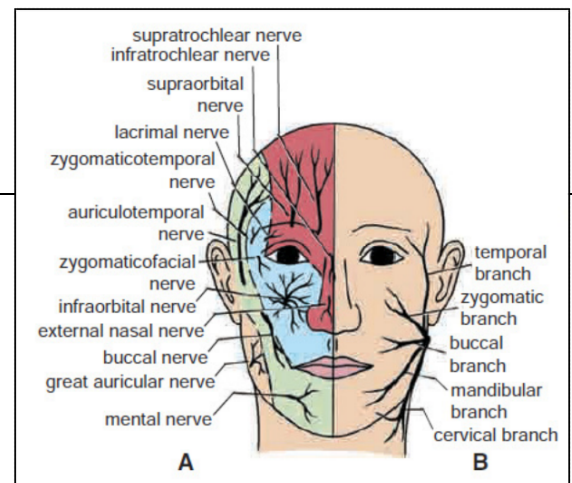
Notes:

* Sensory Components:

- Trigeminal sensory ganglion: (Cell bodies)
- Ascending branches: main sensory nucleus
- Descending branches: spinal nucleus

* Division of the trigeminal nerve:

- Ophthalmic branch: occupies inferior part of Spinal Nucleus.
- Maxillary branch: occupies middle part of SN
- Mandibular branch: occupies superior part of SN



Facial nerve (CN7):

Nuclei

Mixed nerve (motor, sensory, and parasympathetic)

1- Main motor nucleus, in the deep reticular formation of the lower part of the pons, then the motor fibers go posteriorly and curve around the abducens nucleus, and this curve forms a bulge in the fourth ventricle (facial colliculus), then the fibers go anteriorly to leave the brainstem. (The upper part of the face receives upper motor neurons from both hemispheres. The lower part only receives upper motor neurons from the contralateral hemisphere)

2- The parasympathetic nuclei (superior salivatory lacrimatory nucleus), posterolateral to motor nucleus

- **Superior salivatory**: receives from the hypothalamus, parasympathetic supply to submandibular and sublingual glands (salivatory) but NOT parotid gland.

- **Lacrimal nucleus**: receives from Hypothalamus (emotional) and sensory nuclei of the trigeminal (reflex), supplies the lacrimal gland (lacrimatory).

3- Sensory nucleus

- **Taste** of ant. 2/3 of the tongue: cell bodies of 1st order neurons are in the geniculate ganglia (from chorda tympani) → synapse with 2nd order neurons in the nucleus of tractus solitaries → ascends to VPM nucleus of thalamus then radiates to 1^o gustatory cortex (area 43) in the parietal lobe.

- **General** sensation from the skin of the external acoustic meatus is carried with the facial nerve (geniculate ganglion) into the spinal trigeminal nucleus.

Course

1- nerve emerges from the pontomedullary junction

2- enters the internal acoustic meatus in the petrous part of temporal bone

3- passes through facial canal first behind the medial wall of cavity of middle ear (tympanic cavity) where it curves and forms the geniculate ganglion (knee) then continues in the posterior wall of the tympanic cavity

4- gives two branches in the tympanic cavity:

- **Chorda tympani**: leaves middle ear through petrotympanic fissure & enters infratemporal fossa, then attaches to lingual nerve, it **carries two types of fibers**, preganglionic parasympathetic from salivatory lacrimatory nucleus (submandibular ganglia), and taste fibers from anterior 2/3 of tongue.

- **Greater petrosal**: Emerges from geniculate ganglion → passes through middle ear to enter middle cranial fossa through the greater petrosal foramen → passes over foramen lacerum and joins deep petrosal nerve (sympathetic fibers from the superior cervical ganglia) to form the **nerve to pterygoid canal** → passes through pterygoid canal to reach the pterygopalatine fossa → parasympathetic fibers synapse in pterygopalatine ganglia which is suspended by the maxillary nerve & leave with the zygomatic nerve till they reach the orbit where the fibers attach to the lacrimal nerve & ascend to innervate the lacrimal gland.

5- finally emerge from stylomastoid foramen.

Lesion

Location of the lesion

1. In the pons: Abducens and facial not working.
2. Internal acoustic meatus: Vestibulocochlear and facial
3. Chorda tympani: Loss of taste over the anterior two thirds of the tongue

Order of the neuron affected:

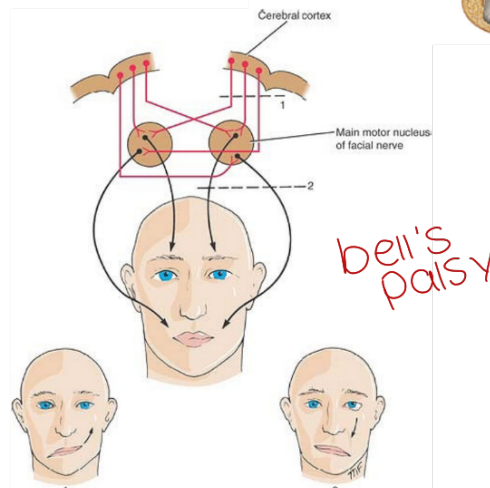
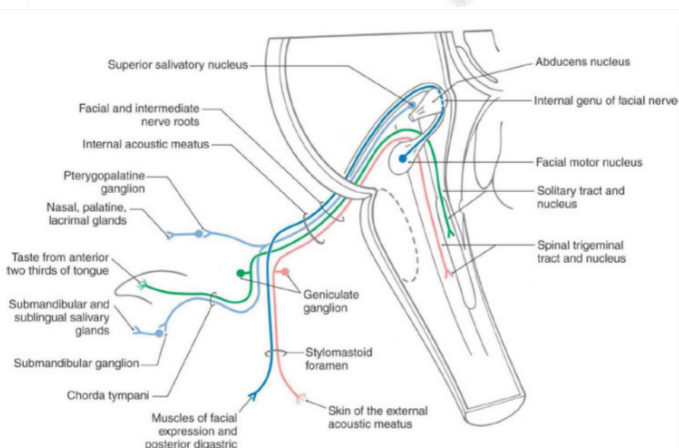
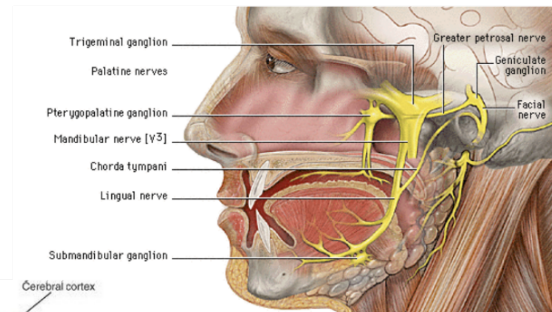
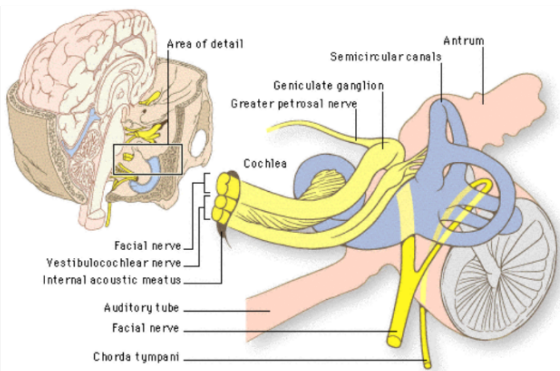
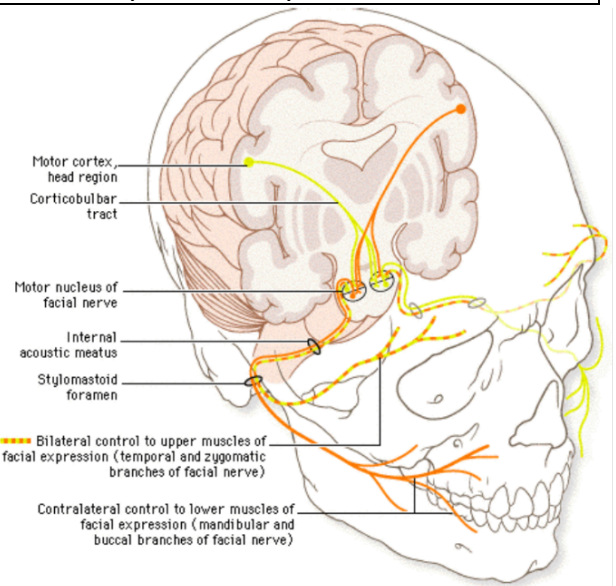
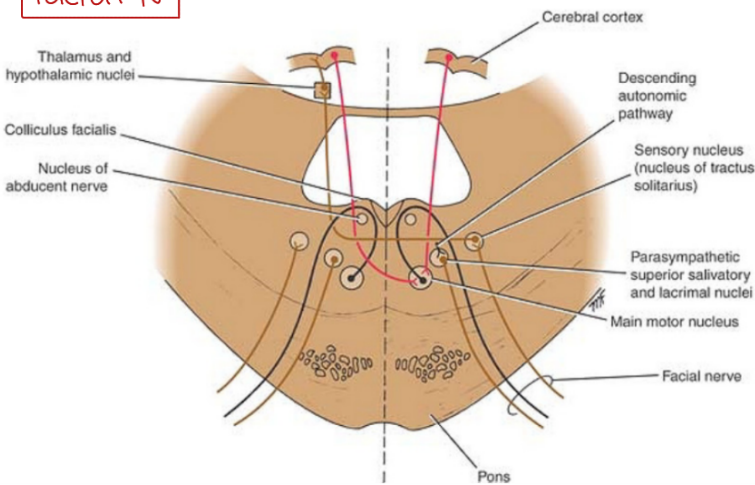
1. Lower motor neuron lesion → ipsilateral half paralysis
2. Upper motor neuron lesion → contralateral lower part paralysis (upper part of face is supplied bilaterally by upper motor neurons, so if there is a lesion on one side the other side will compensate)

Bell's palsy: Usually unilateral, lower motor neuron paralysis, the cause is still not known.

Notes

- * cranial nerves 6,7,8 emerge from the pontomedullary junction
- * Both the salivatory (for the sublingual and submandibular glands) and the lacrimatory (emotional tears) parts (of parasymp. nuclei) receive fibers from the hypothalamus (the hypothalamus is responsible of the ANS), the lacrimatory part also receives fibers from the trigeminal sensory nuclei (reflex tears for foreign bodies).
- * The greater petrosal carries preganglionic parasympathetic from the salivatory lacrimatory nucleus.

facial N



Glossopharyngeal nerve (CN9)

Nuclei

- 1. Motor nucleus**, deep in the reticular formation of medulla, arises from superior end of nucleus ambiguus
- 2. Parasympathetic nucleus** (inferior salivatory nucleus), posterior to nucleus ambiguus, receives from the hypothalamus (all autonomic from the hypothalamus) and passes to the otic ganglia
- 3. Sensory nucleus** (general, taste, and visceral sensation):
 - **Taste sensation** from posterior 1/3 of the tongue (cell bodies of 1st order neurons are in inf. ganglia (special & visceral sensory) → synapses with 2nd order neurons in nucleus tractus solitarius, → ascends to synapse in VPM of thalamus to reach 1^o gustatory cortex)
 - **Visceral sensation** from the carotid sinus (baroreceptor). (nerve passes bet. internal & external carotid in the neck → carries visceral sensation from the carotid sinus → Cell bodies of 1st order neurons are in the inferior ganglia → synapse in nucleus tractus solitarius which is connected to dorsal nucleus of vagus nerve (parasympathetic of the vagus) which induces the carotid sinus reflex that reduces the blood pressure)
 - **General sensation** from skin of auditory meatus, middle ear, auditory tube, pharynx except the nasopharynx (maxillary), and posterior 1/3 of the tongue (common sensation), (cell bodies are in superior ganglion → goes to spinal nucleus of trigeminal (it carries general sensation from many cranial nerves but primarily from trigeminal))

Supplies

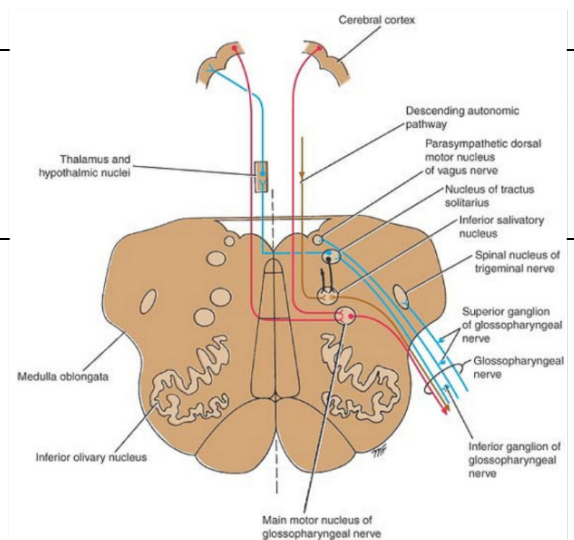
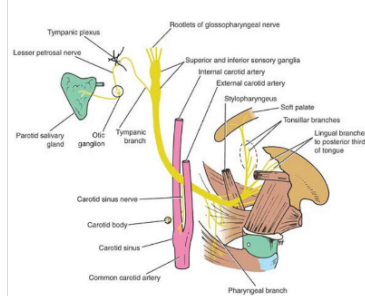
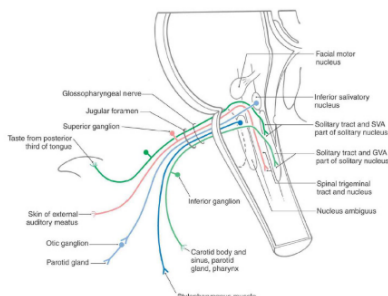
1. Motor nucleus → stylopharyngeus muscle
2. parasympathetic nucleus → parotid gland

Course

1. The glossopharyngeal nerve emerges from the groove between the olive and the inferior cerebellar peduncle.
2. Descends from jugular foramen to leave the skull and there it forms two ganglia (superior and inferior)
3. At the level of the inferior ganglia, it gives a branch called tympanic branch (preganglionic parasympathetic fibers)
4. It enters through the tympanic canaliculus to reach the tympanic cavity where it joins the tympanic plexus near the tympanic membrane (that's a lot of tympanic I know)
5. It leaves the tympanic cavity as the lesser petrosal nerve through the lesser petrosal hiatus to reach the middle cranial fossa.
6. From the middle cranial fossa, it descends through foramen ovale to the infratemporal fossa and synapses in the otic ganglia which is suspended by the mandibular nerve, and through the auriculotemporal it reaches the parotid gland.

Lesion

- Loss of the gag reflex (normally induces vomiting)
- Loss of the carotid sinus reflex
- Loss of taste from the posterior third of the tongue



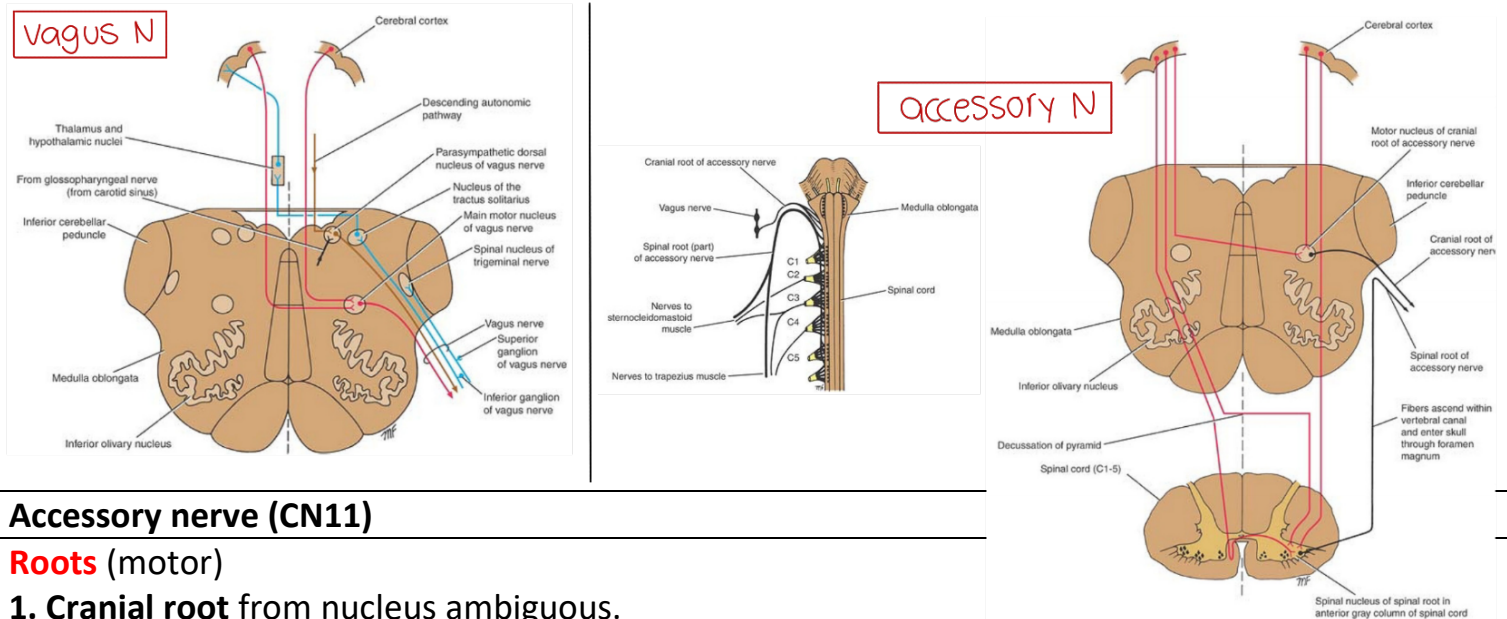
Vagus nerve (CN10)

Nuclei

- 1. Motor nucleus** (lower part of nucleus ambiguus). Supplies the constrictor muscles of the pharynx and the muscles of the larynx.
- 2. Dorsal nucleus (parasympathetic)**, anterior to floor of lower part of 4th ventricle, (receives afferents from hypothalamus and glossopharyngeal nerve (carotid sinus reflex). Efferent to involuntary muscles of the bronchi, heart, esophagus, stomach, small intestines, and large intestines as far as the distal 1/3 of the transverse colon)
- 3. Sensory nucleus:**
 - **Taste sensation** from the epiglottis (carried to lower part of nucleus tractus solitarius, cell bodies of 1st order neurons in inferior ganglia (don't confuse it with inferior ganglion of the glossopharyngeal, both have sup. and inf. ganglia))
 - **General sensation** from the outer ear, mucosa of the larynx, and the dura of posterior cranial fossa (cell bodies of 1st order neurons in superior ganglia, then to spinal nucleus of trigeminal)

Lesion

- Uvula deviates to the healthy side.
- Hoarseness of voice (paralysis in muscles of larynx)
- Dysphagia & nasal regurgitation (paralysis in muscles of pharynx)
- Arrhythmia in heart & irregularity in GI tract because (parasympathetic dysfunction)



Accessory nerve (CN11)

Roots (motor)

- 1. Cranial root** from nucleus ambiguus.
- 2. Spinal root** originates from the spinal cord (lamina IX from the upper 5 cervical segments).

Supplies

1. cranial root → thought to supply soft palate
2. spinal root → trapezius and sternocleidomastoid

Course

- 1- spinal root ascends to cranial cavity through foramen magnum to join the cranial root
- 2- they then move together (fibers of the two roots don't mix) & leave through jugular foramen.
- 3- they separate once more and the cranial root joins the vagus nerve & courses along with it, while the spinal descends by itself and supplies the trapezius and sternocleidomastoid..

Hypoglossal nerve (CN12)

Nuclei

one motor nucleus, Beneath the floor of the lower part of 4th ventricle

Supplies

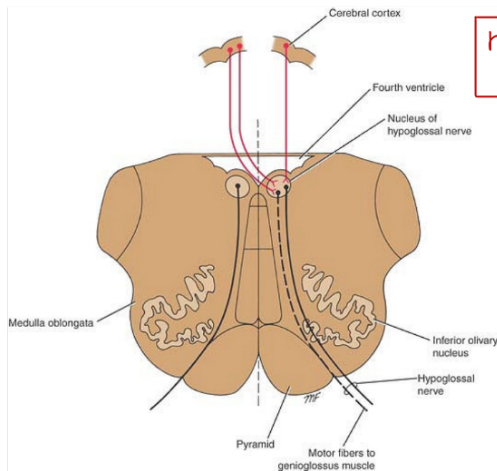
- 1- all the muscles of the tongue except palatoglossus (from the vagus)
- 2- Cells responsible for supplying genioglossus muscle receive from the opposite cerebral hemisphere (not bilateral).

Course

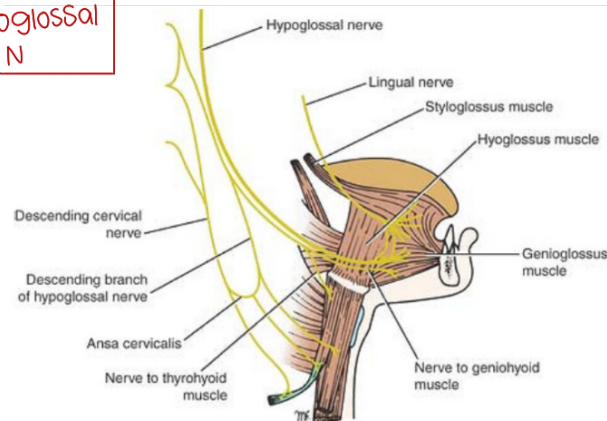
- 1- Emerges between olive & pyramid (the other medullary cranial nerves emerge bet. inferior cerebellar peduncle & olive).
- 2- Leaves the skull through the hypoglossal canal.
- 3- Courses between ICA and internal jugular V to reach the tongue, during its course it attaches to the C1 spinal nerve but doesn't mix with it.

Lesion

- 1- **Lower motor neuron lesion:** Tongue deviates toward paralyzed side during protrusion with muscle atrophy (ipsilateral)
- 2- **Upper motor neuron lesion:** On protrusion, tongue will deviate to the side opposite to lesion (genioglossus paralysis) with no atrophy.



hypoglossal N

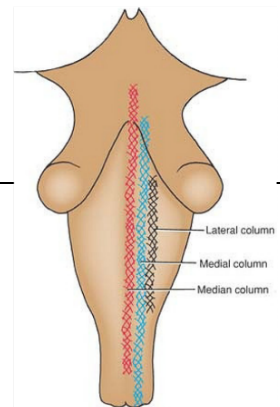


Reticular formation:

Deeply placed continuous network of nerve cells and fibers that extend from the spinal cord through the medulla, the pons, and the midbrain, it might reach some superior structures like the thalamus and subthalamus but it's mainly in the brainstem.

Columns (three longitudinal)

- Median column: intermediate-size neurons
- Medial column: large neurons
- Lateral column: small neurons



Function:

1. Control of skeletal muscle
2. Control of somatic and visceral sensations
3. Control of the autonomic nervous system (vital centers)
4. The reticular activating system (it switches the cortex on and off)