



Sheet no.16

Lecture date: 16/3/2021

Lecture title: General Sensory Pathways of the Face Area, Taste & Hearing Pathways

Written by: Aseel Qandeel

Edited by : Ruaa Mrayat

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دعاء لزميلنا رشيد

اللهم اغفر له و ارحمه و اعف عنه و اكرم منزله". "اللهم ابدله داراً خيراً من داره و أهلاً خيراً من أهله
و ذرية خيراً من ذريته و زوجاً خيراً من زوجة".

Lecture Objectives

- Describe pathways for general sensations (pain, temperature, touch and proprioception) from the face area.
- Describe taste pathways.
- Describe hearing pathways

⚠ The doctor uploaded a chapter on Teams , it will be our reference regarding cranial nerves topic ,make sure to check it out!

<https://teams.microsoft.com/l/file/5815E0CC-2D06-4265-BB1F-23AC4B152B2E?tenantId=c7142531-dd68-4a6f-b036-039ec52d6bd1&fileType=pdf&objectUrl=https%3A%2F%2Fbauniversity.sharepoint.com%2Fsites%2FNeuroscience20202021%2FShared%20Documents%2FAnatomy%2FCranial%20Nerves.pdf&baseUrl=https%3A%2F%2Fbauniversity.sharepoint.com%2Fsites%2FNeuroscience20202021&serviceName=teams&threadId=19:f1f6be9f5c1745fda95b610049bc896e@tread.tacv2&groupId=76e81d1e-4127-42a8-b917-63228beb96c9>

Sensory Innervation of Head

- **Most of the sensory innervation of the head region is supplied by some cranial nerves:**
 - 1- **Trigeminal n.** (The most important one; Most of the sensory innervation of the head is supplied by it)
 - 2- Facial n.
 - 3- Glossopharyngeal n.
 - 4- Vagus n. (which also carries sensory information from visceral organs in the thoracic and abdominal regions)
- **Spinal nerves (C1-C3) participate in the sensory innervation of the head**
 - ✓ Recap , we've mentioned before that the innervation of the dura mater below the tentorium cerebelli is through spinal nerves (C1-C3)
 - ✓ Also the posterior part of the scalp is innervated by the spinal nerves

Cranial Nerves Innervating Head ---Sensory Innervation: Modalities and Territories

Trigeminal nerve (V)

1- GSA (general somatic afferent)

- We are mainly talking here about the sensation coming from the skin, so we're excluding sensation coming from visceral organs, taste and special senses.
- **GSA is the only modality for the trigeminal nerve.**

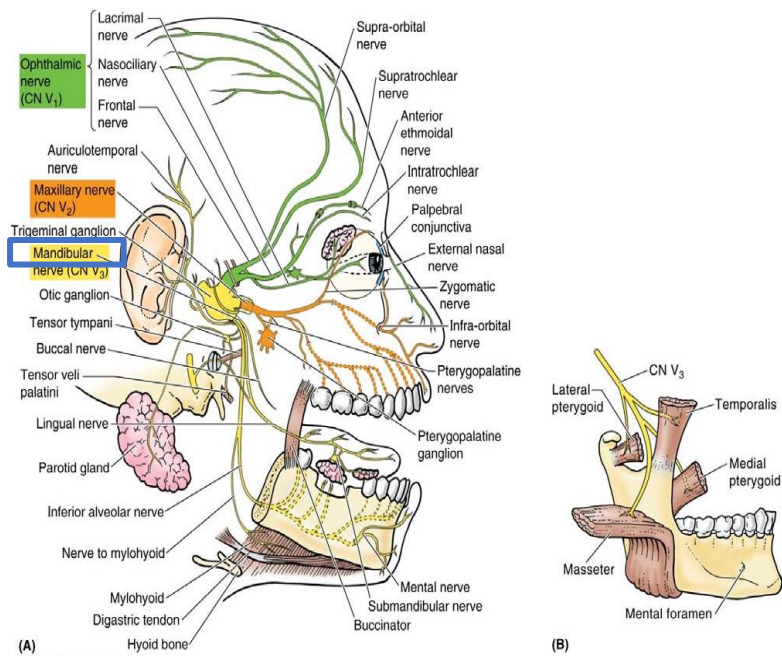
✦ Carries information from :

1- Skin of face and head

- With 2 exceptions :
 - A. The posterior part of the scalp.
 - B. Dura mater below tentorium cerebelli.

2- Mucus membrane

- Nasal cavity



- Oral cavity
- Paranasal sinuses
 - All mucous membranes in the head except → mastoid air cells

3- Eye

- General sensation of eye ball not vision

4- External ear

- Middle ear is considered a visceral organ innervated by general visceral afferents

5- Dura matter (Above the tentorium cerebelli)

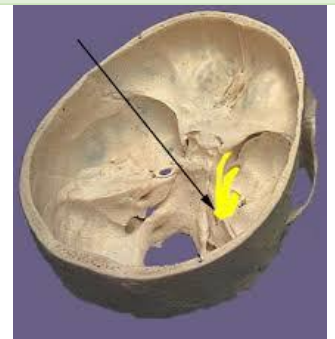
6- TMJ

7- Teeth (upper and lower teeth)

✦ Trigeminal ganglion

- Where 1st order neurons of the trigeminal n. are located.
- We're talking about sensory fibers, so we expect their cell bodies to be outside the CNS in a ganglion.
- Trigeminal ganglion is not part of the CNS , **but It's within the cranial cavity**, specifically within the middle cranial fossa

Additional ,Trigeminal ganglion

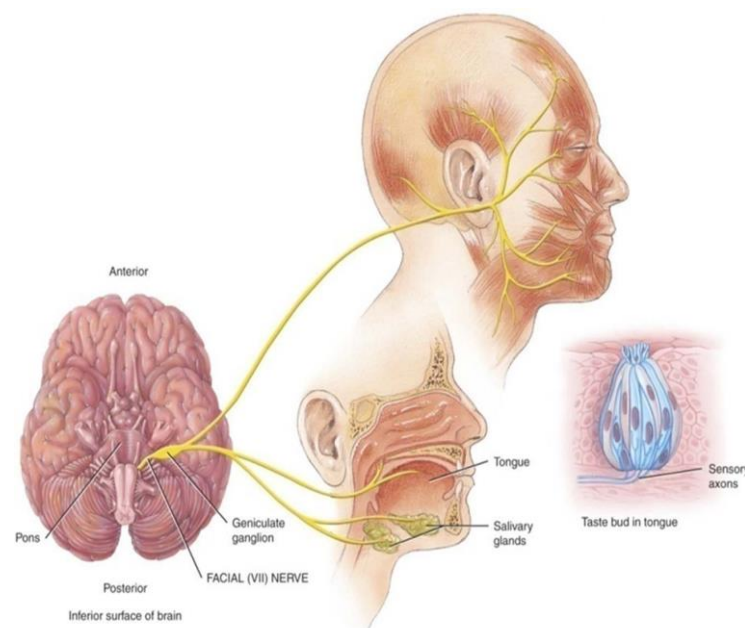


Facial Nerve (VII)

1- GSA(general somatic efferent)

A. External ear

- It's innervated by the 4 Cranial nerves mainly by the trigeminal nerve and also by the facial, glossopharyngeal and vagus nerves but to lower extent
- External auditory meatus is the meeting point for all pharyngeal arches and each arch is innervated by a specific cranial nerve, so this is why all of the 4 nerves innervate external auditory meatus.



B. Mastoid (mastoid air cells)

2- SVA(special visceral afferent)

- Taste from tongue (anterior $\frac{2}{3}$)

3- GVA(general visceral afferent)

- A. Soft palate (some consider it as a visceral organ)
- B. Floor of the mouth
- C. Pharynx (controversial)

✦ **Geniculate ganglion** → mostly found in the facial canal within the middle ear

Glossopharyngeal nerve (IX)

1- GSA

- External ear (very small area)

2- SVA

- Taste from tongue (posterior $\frac{1}{3}$)

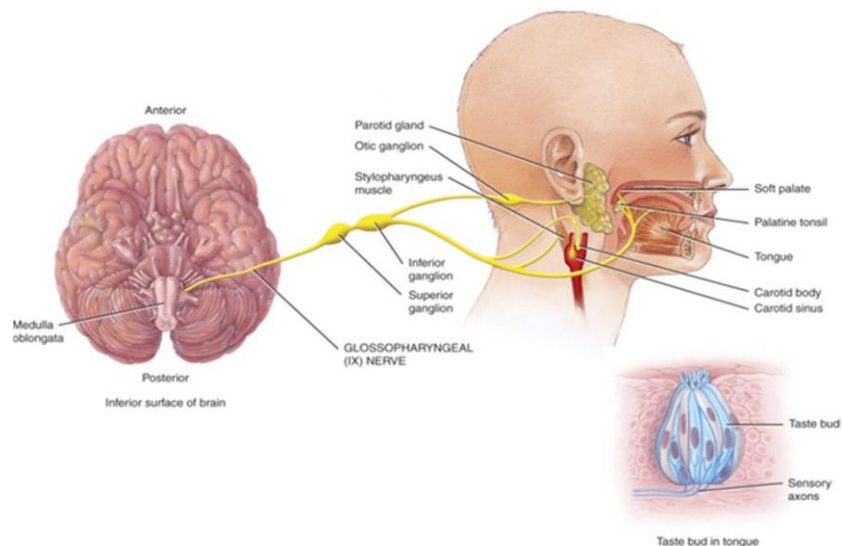
3- GVA

- 1- Tongue (posterior $\frac{1}{3}$)
- 2- Fauces
- 3- Pharynx (we're talking about the oropharynx)
- 4- Middle ear
- 5- Carotid sinus baroreceptors
- 6- Carotid body chemoreceptors

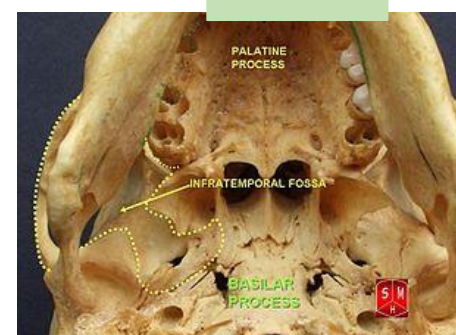
✦ 2 Ganglia :

- 1- Superior ganglion , contains cells bodies of GSA
- 2- Inferior ganglion , contains cells bodies of other modalities (SVA and GVA)

✦ Glossopharyngeal n. leaves the cranial cavity through jugular foramen



Additional



- ✦ Both superior and inferior ganglia are found just below the jugular foramen, in the infratemporal fossa.
- ✦ Superior ganglion contains the cell bodies of GSA while the inferior ganglion contains the cell bodies of the other modalities (SVA and GVA)

Vagus Nerve (X)

1- GSA

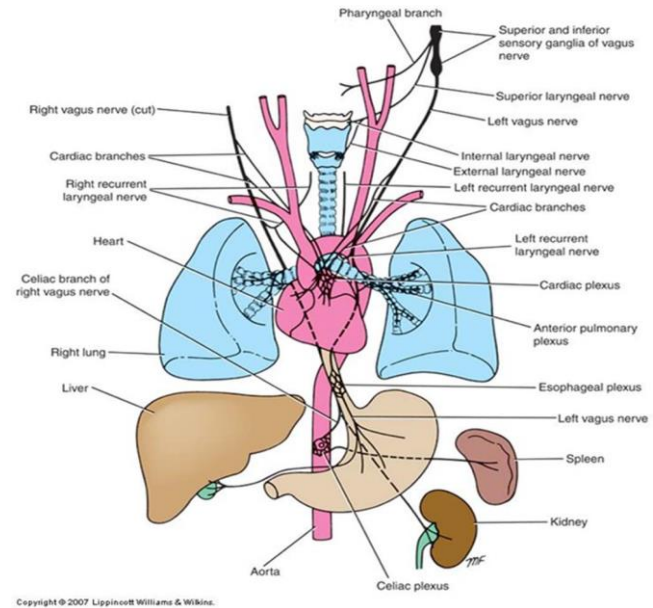
- External ear (small area)

2- SVA

- Taste (epiglottis & base of tongue)

3- GVA-mainly the parasympathetic part(?)

1. Pharynx (laryngopharynx)
2. Larynx
3. Other viscera (in the thoracic and abdominal regions)



✦ 2 ganglia:

- 1- Superior jugular ganglion , contains cell bodies of **GSA**
- 2- Inferior nodose ganglion, contains cell bodies of other modalities (**SVA&GVA**)

- ✦ They are located close to each other; they are located below the jugular foramen; in the infratemporal fossa like the glossopharyngeal nerve.

Sensory innervation of head – Summary

	Territories innervated by GSA	Territories innervated by SVA	Territories innervated by GVA	1st order neurons
Trigeminal n.	<ol style="list-style-type: none"> 1. Skin of face and head - except posterior part of the scalp and dura mater below tentorium cerebelli 2. Mucous membranes except mastoid air cells 	No SVA	No GVA	Trigeminal ganglion (V)-GSA
Facial n.	<ol style="list-style-type: none"> 1-External ear 2-Mastoid (mastoid air cells) 	taste from tongue (anterior $\frac{2}{3}$)	<ol style="list-style-type: none"> 1-Soft palate 2-Floor of the mouth 3-Pharynx 	Geniculate ganglion (VII) – GSA, GVA, SVA
Glossopharyngeal n.	External ear	Taste from tongue (posterior 1/3)	<ol style="list-style-type: none"> 1-Tongue (posterior 1/3) 2-Fauces 3-Pharynx 4-Middle ear 	<ol style="list-style-type: none"> 1. Superior ganglion (IX) – GSA 2. Inferior ganglion (IX) – SVA, GVA
Vagus n.	External ear	Taste epiglottis & base of tongue)	<ol style="list-style-type: none"> 1-pharynx (laryngopharynx) 2-Larynx 3-Other viscera 	<ol style="list-style-type: none"> 1- Superior jugular ganglion (V) – GSA 2- Inferior nodose ganglion (V) – GVA, SVA
Spinal nerves (C2-C3)	<ol style="list-style-type: none"> 1-Posterior part of the scalp 2-Dura mater (below tentorium cerebelli) 	—	—	Dorsal root ganglion (C1-C3)

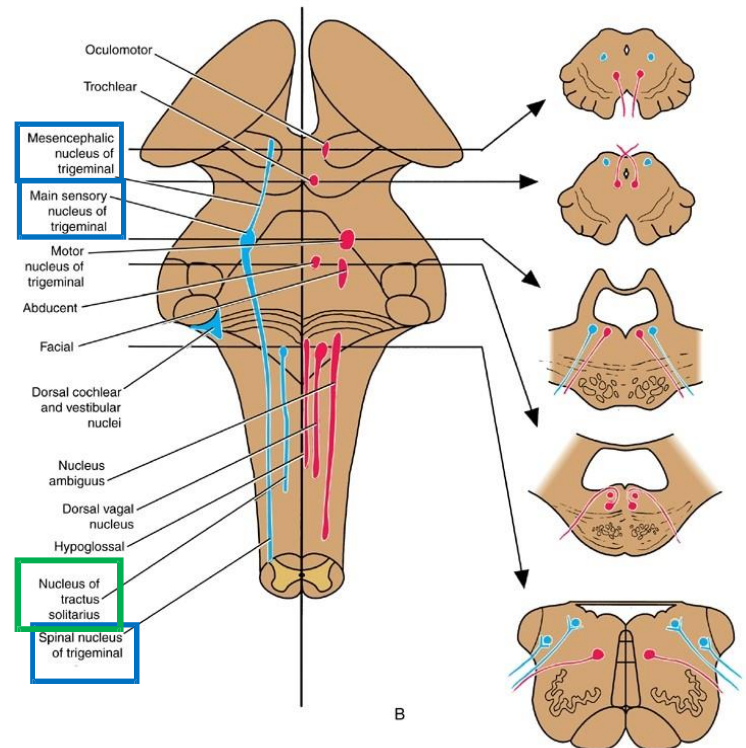
Cranial Nerve Innervating Head -Central Sensory Component

Brainstem sensory nuclei

- These sensory nuclei receive information from 1st order neurons of (V,VII,IX and X nerves) we talked about earlier.

1- Nucleus of tractus solitarius

- Contains (GVA, SVA)
- The Most medially located among sensory nuclei of the brainstem
- Located in the medulla oblongata and reaches the beginning of pons
- **Some may divide this nucleus into regions where:**
 - The upper part (closer to the pons) is related to facial n.
 - Middle part is related to glossopharyngeal n.
 - The Lower part is related to vagus n.
- GVA & SVA of 1st order neurons of the nerves (VII, IX & X), will be connected with the nucleus solitarius once they enter the brainstem.



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2- Trigeminal sensory complex (GSA)

- GSA of 1st order neurons will be connected with the trigeminal sensory complex once they enter the brainstem
- Trigeminal sensory complex starts from upper part of the spinal cord (C2)and continues up to the midbrain (all over the brainstem)

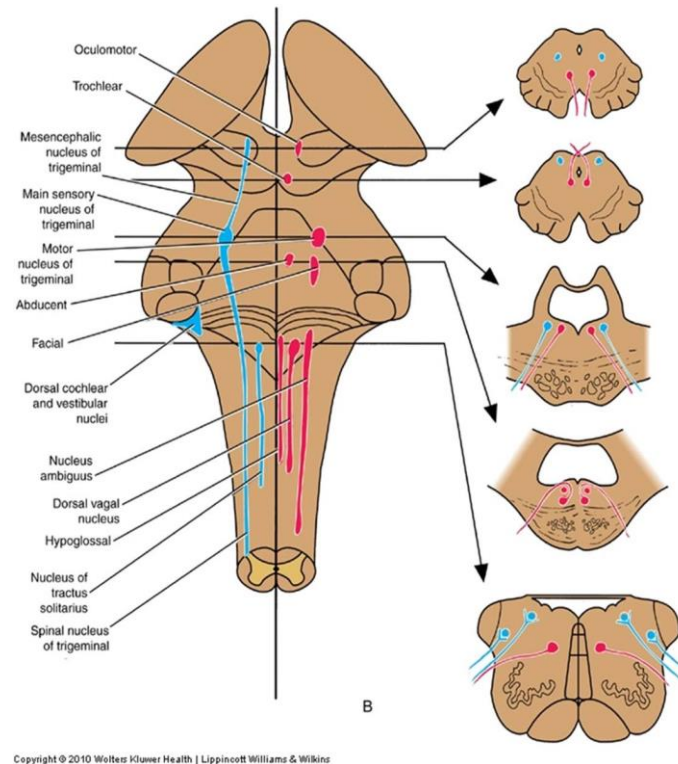
★ Parts:

- Spinal nucleus (C2 up to the middle of the pons)
- Main sensory nucleus (within the pons , near motor nucleus of trigeminal nerve)
- Mesencephalic nucleus (the rest of the pons and midbrain)

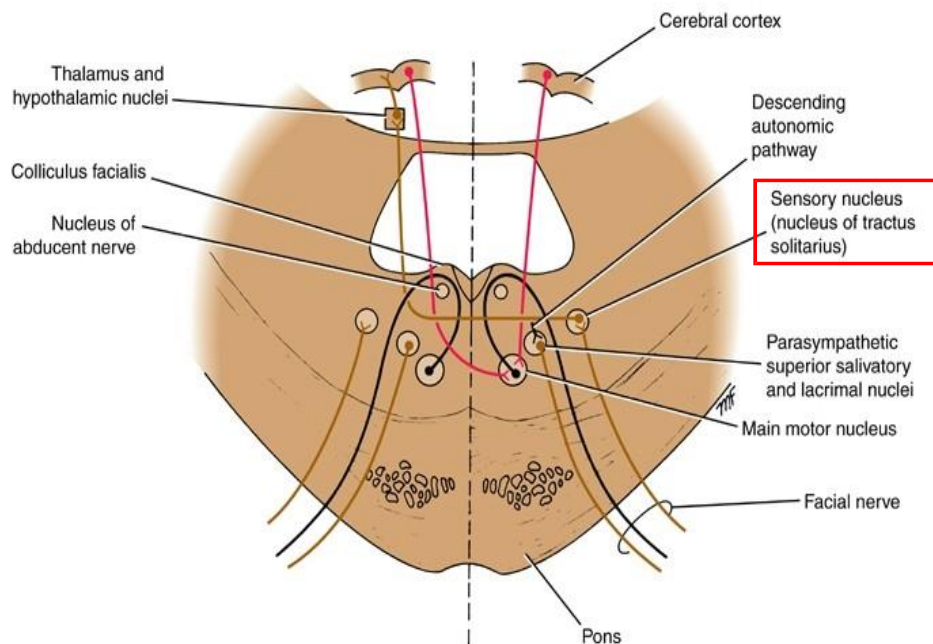
- Trigeminal sensory complex receives GSA from all sensory nerves (VII,X,IX and V) not only the trigeminal nerve

Nucleus of Tractus Solitarius

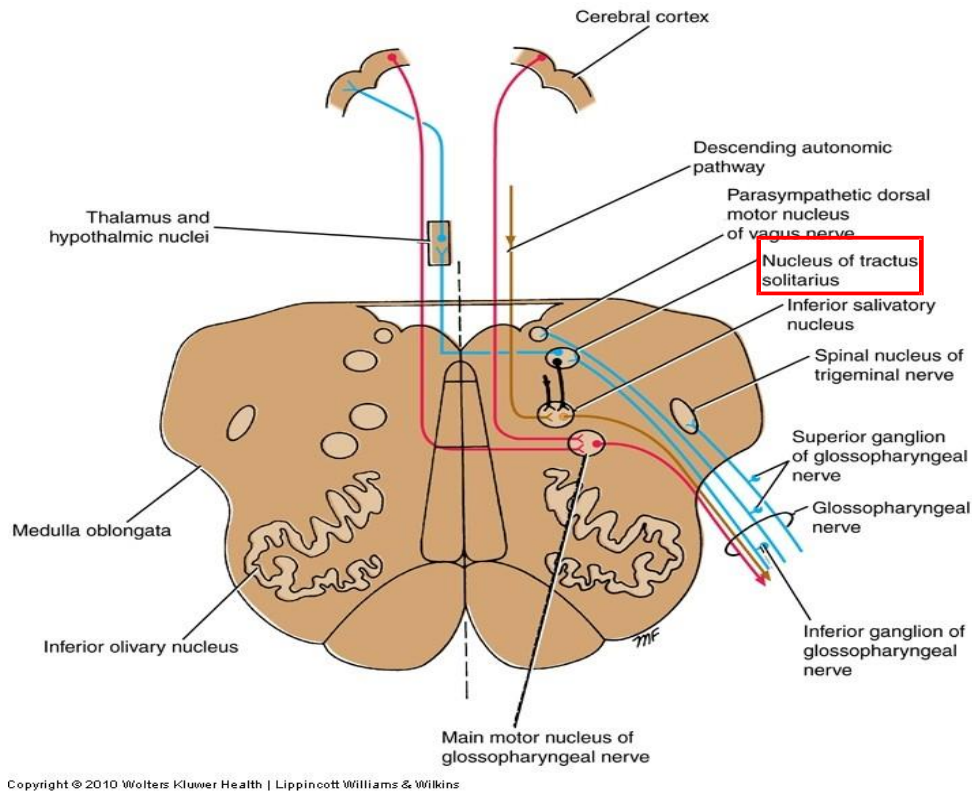
- Deals with GVA and SVA
- Sensory nucleus for
 1. Facial nerve
 2. Glossopharyngeal nerve
 3. Vagus nerve
- Contains 2nd order neurons for GVA & SVA
- Axons which leave nucleus of tractus solitarius cross midline and moves toward the Posterior-ventromedial nucleus (PVM) of thalamus , where the 3rd order neurons are located
- Axons from thalamus → internal capsule → corona radiata → cortex (postcentral gyrus)



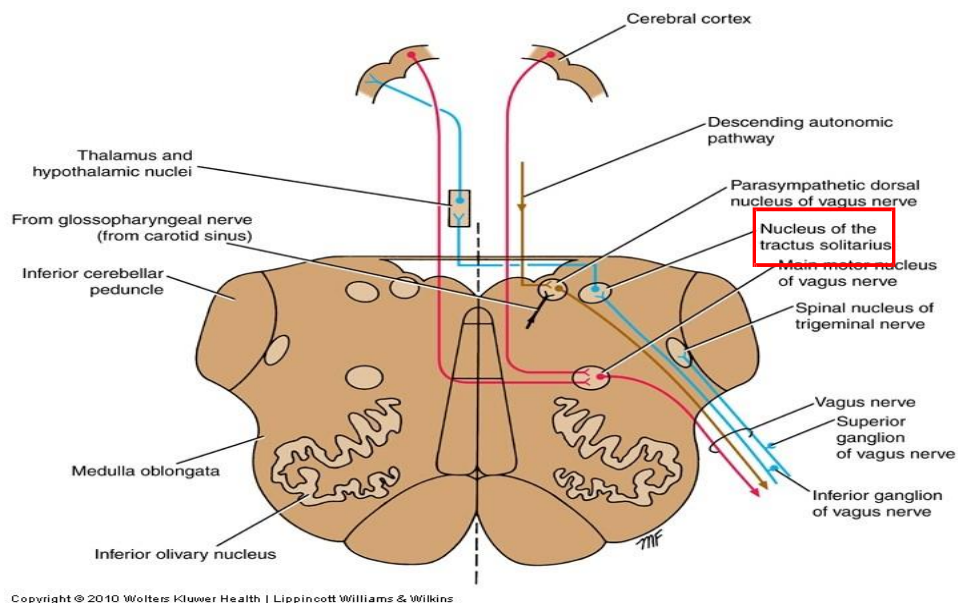
Sensory nucleus of tractus solitarius receives inputs from facial nerve



- The middle of nucleus of tractus solitarius receives input from Glossopharyngeal Nerve
- Medial to spinal nucleus of trigeminal nerve



- The lower part of nucleus of tractus solitarius receives input from Vagus Nerve
- Nucleus of tractus solitarius is considered an important part of Cardiovascular and respiratory centers because it contains the GVA which comes from heart and lungs



Trigeminal System

- Most of the sensory information from head are carried by the trigeminal nerve
 - Face, oral & nasal cavities, cornea, meninges and cranial blood vessels
- Small sensory components (GSA) of cranial nerve VII, IX, X
- All GSA information is processed by trigeminal nuclei (where the 2nd order neurons are located)

Trigeminal Nerve Sensory Nuclei

- Located in the tegmentum
- Lateral to the nucleus of tractus solitarius

1- Mesencephalic nucleus (GSA)

✦ Modalities :

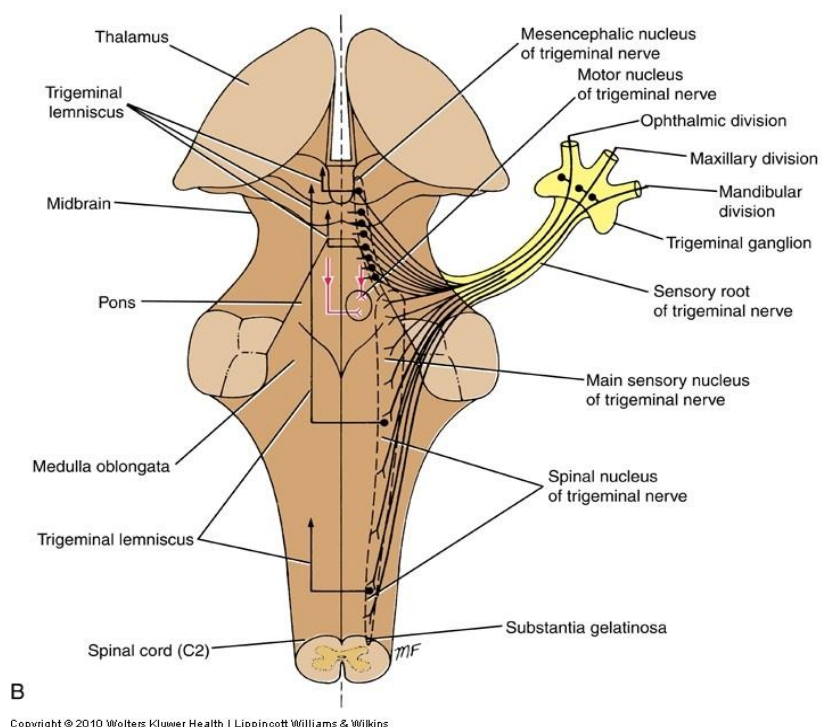
- Unconscious proprioception, the same as spinocerebellar tract
- Location, Extension

2- Main sensory nucleus (GSA)

- Touch & pressure

3- Spinal nucleus* (GSA)

- The caudal one
- Pain & temperature
- Extensions
 - C2 -medulla and to the beginning of pons
- Somatotopic organization (within the trigeminal nerve itself)
 - Ophthalmic branch – most caudal
 - Maxillary branch – in the middle
 - Mandibular branch – most rostral



- Spinal nucleus receives GSA from V, IX, and X.

Trigeminal Nerve Sensory Nuclei

Spinal nucleus parts

1. Pars caudalis

- The most caudal part.
- From C2 up to pyramidal decussation.
- Responsible for Pain & temperature.
- Receives fibers from:
 - 1- C1-C3
 - 2- GSA from IIV, IX,
 - 3- cerebral blood vessels
 - 4- Dura mater

2. Pars interpolaris (Middle part)

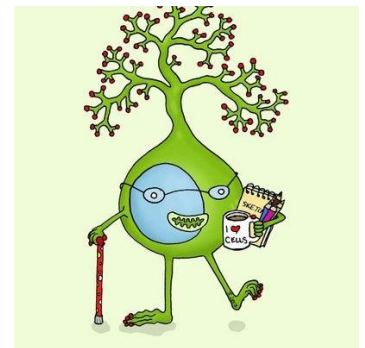
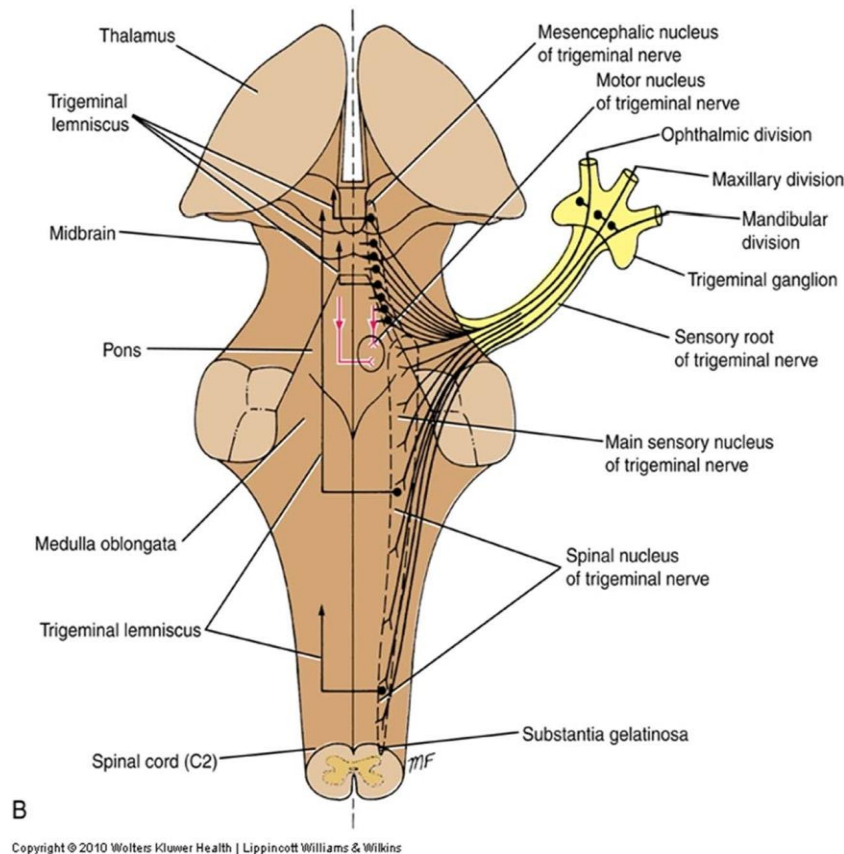
- Between the lower part of pyramidal decussation up to the area below rostral third of the inferior olivary nucleus.
- Receives
 1. Pain sensation from teeth.
 2. Light touch.

3. Pars oralis (Upper part)

- Near the main sensory nucleus, there's an interference between both of them in function
- ✦ Modalities:
 1. Light touch
 2. Discriminative touch

Main sensory nucleus

- Light touch
- Discriminative touch



Trigeminal nerve sensory nuclei

- 1st order neurons are located within Trigeminal ganglion
- 2nd order neurons are Located within Trigeminal nerve sensory nuclei
- Except mesencephalic nucleus (which deals with information related to unconscious proprioception) contains 1st order neurons.
- This is an exception to the rule that suggests that cell bodies of sensory neurons are outside the CNS
- Central axons of 2nd order neurons cross midline and Form trigeminal lemniscus which travel toward Ventral posterio-medial (VPM) nucleus of thalamus , where the 3rd order neurons are located
- Axons of 3rd order neurons travel toward Internal capsule → Corona radiate → Other parts of cerebral cortex.

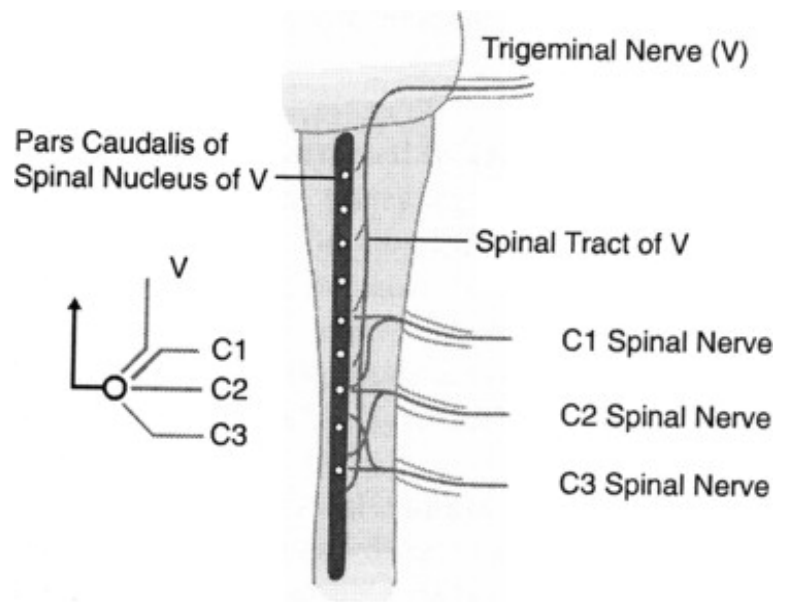
Trigemino-cervical Complex

- Upper cervical afferents (C1-C3) converge (with the fibers coming from the trigeminal nerve itself) to the pars caudalis of spinal trigeminal nucleus

Cervical headache (cervicogenic headache)

- Pain referred from cervical origin to the head structures
- These headaches may seem that they are originated from the head when in fact they are originated from the neck

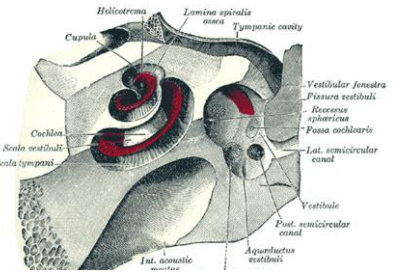
but How? Upper parts of the spinal nerve converge with the trigeminal n.(which innervates areas of the Head) in the pars caudalis of spinal trigeminal nucleus



- The cell bodies of 1st order neurons related to Hearing are located in the spiral ganglion (refer to the picture)
- Spiral ganglion are located in an area called spiral lamina of the cochlea
- Central axons (which are bipolar axons) form the cochlear nerve
- Cochlear nerve enter the cranial cavity through Internal acoustic meatus to reach cochlear nuclei (in the medulla) where the 2nd order neurons are located

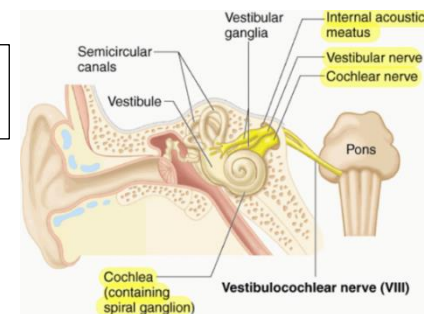
Additional

The osseous **spiral lamina** is a bony shelf or ledge which projects from the modiolus (chiasma of facial muscles) into the interior of the



- if damaged deafness or tinnitus (ringing) is produced

This picture may help →

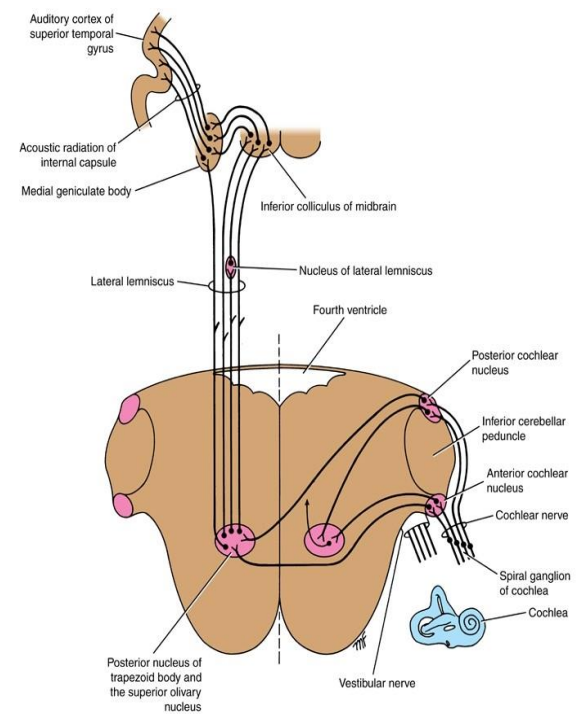


Auditory Nuclei/Pathway

- **1st order neuron** – in spiral ganglion
- **2nd order neurons** within Cochlear nuclei
 - 2 cochlear nuclei , Anterior & posterior
 - Location
 - Relations – surrounding inferior cerebellar peduncles
 - The anterior nucleus is anterior to inferior cerebellar peduncles and the posterior one is posterior to it.
 - Some of the axons coming out of these nuclei cross the midline and some of them uncross the midline and stay in the same side.

▪ **3rd order neurons**

- Posterior nucleus of trapezoid body (near olivary nucleus) & superior olivary nucleus (superior to the inferior olivary nucleus)
- Axons of 3rd neurons form lateral lemniscus which travel toward inferior colliculus → medial geniculate , or directly toward medial geniculate without passing the inferior colliculus



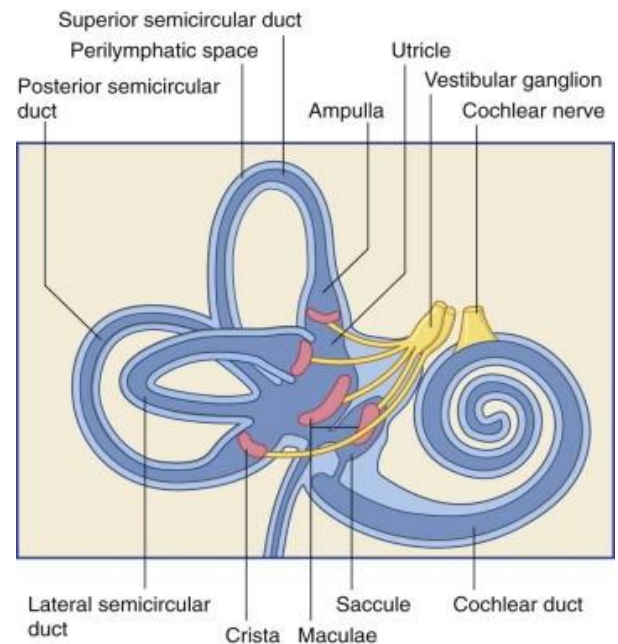
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- **4th order neurons**

- Inferior colliculus
- Medial geniculate body (5th) (part of the thalamus) → internal capsule → auditory cortex (superior temporal gyrus)

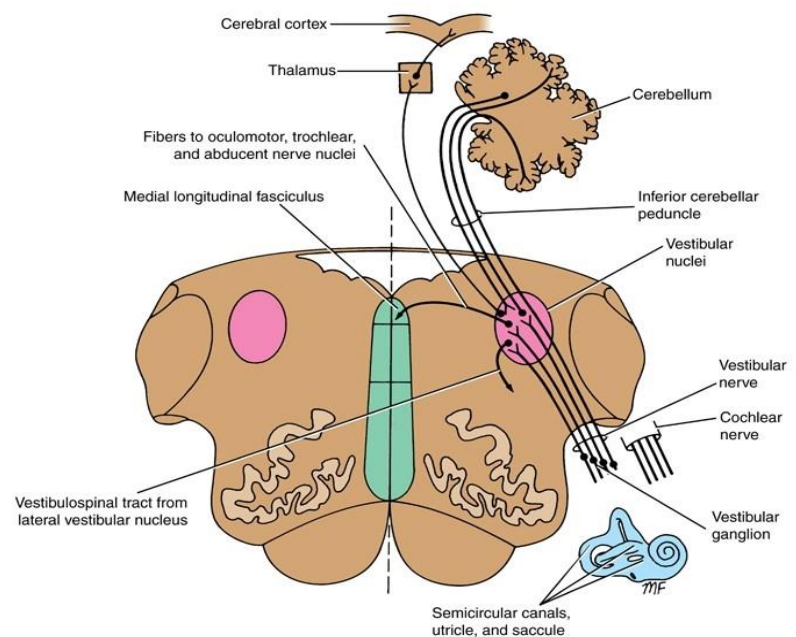
2-Vestibular branch

- Associated with **equilibrium**
- Receptors in the semicircular canals, saccule, and utricle
- The cell bodies of bipolar neurons in **vestibular ganglion**
- Axons travel to nuclei in the thalamus; some fibers also travel to the cerebellum
- Lesion results in **disequilibrium, vertigo, nystagmus, ataxia**



The Vestibular Nuclei/Pathway

- Location – 4th ventricle
- Vestibular nuclei (2nd order neurons) in the brainstem
 - Lateral → gives vestibulospinal tract
 - Superior
 - Medial
 - Inferior
- The rest receives Inputs from cerebellum
- Axons



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- To spinal cord
- To nuclei of eye muscles nerves (III, IV, VI)
- To thalamus (VP) → vestibular area in cerebral cortex (postcentral gyrus)

