**Cranial nerves**

- There are 12 pairs of the cranial nerves, out of which the first two pairs arise from the **forebrain** and the next 10 pairs arise from the **brainstem**.
- They are numbered 1 to 12 in the craniocaudal sequence of their attachment on the brain. The cranial nerves are generally designated by Roman numerals.

The 12 pairs of nerves are:

I Olfactory
II Optic
III Oculomotor
IV Trochlear
V Trigeminal
VI Abducent
VII Facial
VIII Vestibulo-cochlear
IX Glossopharyngea
X Vagus
XI Accessory
XII Hypoglossal (VS)

**Superficial Attachments of the Cranial Nerves**

- All the 12 pairs of cranial nerves are attached on the ventral aspect of the brain ***except*** **the 4th pair** (trochlear nerves) which are attached on the dorsal aspect. Tese nerves have the longest intracranial nerve path of all the 12 paires
- Each cranial nerve enters or leaves the brain surface at its **superficial attachment** and the fibres which it contains either arise from (efferent or motor fibres) or terminate in (afferent or sensory fibres) motor and sensory nuclei within the brain, respectively.

***Olfactory nerves-*** about 20 olfactory nerves (on each side) **emerging from the olfactory epithelium of nasal cavity** and the passing through the cribriform plate of ethmoid and ending in in the olfactory bulb

***Optic nerve***-it **emerge from the retina** and joins the anterolateral angle of the optic chiasma.

***Oculomotor nerve*** - **It emerges** from the groove on the medial aspect of the cerebral peduncle in the posterior part of the interpeduncular fossa

***Trochlear nerve***-**it emerges** on the dorsal aspect of the **midbrain,** lateral to the median plane. It winds round the lateral aspect of the midbrain toward the interpeduncular fossa, immediately superior to the pons

***Trigeminal nerve***=the largest of the cranial nerves **emerging from the** area of junction of the pons and middle cerebellar peduncle with two roots: a **large lateral sensory root and a small medial motor root.**

***Abducent nerve***-**It emerges** at the **inferior border of the pons**

***Facial nerve***-**It emerges at the inferior border of pons** lateral to the abducent nerve by two roots: a thick medial motor root and a slender lateral sensory root called *nervus intermedius.*

***Vestibulocochlear nerve***=consists of two nerves: vestibular and cochlear **emerging from the** area corresponding to the **cerebello-pontine angle**. The cochlear nerve lies posterior to the inferior cerebellar peduncle and vestibular lies anterior to it.

***Glossopharyngeal nerve***-**It emerges** by a number of rootlets from a **groove between the olive and inferior cerebellar peduncle.**

***Vagus nerve***=**It also emerges by a number of rootlets from a groove between the olive and inferior cerebellar peduncle below** the rootlets of the glossopharyngeal nerve.
***Accessory nerve***-It has two roots: cranial and spinal. **The cranial root emerges** by a number of rootlets **from the medulla** below the rootlets of the vagus nerve and it is joined by the **spinal root**, which emerges by a number of rootlets from the **upper five cervical spinal segments.**
***Hypoglossal nerve***-It emerge by a row of rootlets from a **groove between the pyramid and olive.**

**OLFACTORY NERVE**
Olfactory nerve is -the 1st cranial nerve.
-purely sensory
-carries the sense of smell from nasal cavity.
**Unique Features**
1. The primary sensory neurons of olfactory nerve lie on the body surface in the epithelial lining of the nasal cavity and their dendrites lie free in the mucous film.
2. The primary sensory neurons of olfactory nerve (olfactory neurons) undergo continuous turnover, i.e.,they are continuously replaced by stem cells in the olfactory neuroepithelium.
**Functional Components**
**Special somatic afferent fibres**: They carry special sensations of smell from the olfactory region of the nasal cavity and terminate in the olfactory bulb.
**Course, Relations, and Distribution**
Each olfactory nerve consists of about 20 bundles of non-myelinated nerve fibres. They arise from primary receptor neurons (modified bipolar neurons) of the olfactory epithelium of nasal cavity, pass through foramina in the cribriform plate of the ethmoid to enter the anterior cranial fossa, where they terminate in the olfactory bulb.
In the olfactory bulb, they synapse with the mitral cells. The bundles of olfactory nerves are surrounded by three meninges (namely pia mater, arachnoid mater, and dura mater) near the cribriform plate. This provides a potential communication between the subarachnoid space and lymphatics of the nasal mucosa. Thus, infection from nose can spread into the meninges of the brain.
*Distribution:* **olfactory region of the nasal cavity**

**OPTIC NERVE**
Optic nerve is the 2nd cranial nerve. It is purely sensory and responsible for vision; hence, it is also called the **nerve of sight**.
**Unique Features**
The optic nerve is not a true peripheral (cranial) nerve. It is actually a tract of brain for it develops as an outgrowth of diencephalon during embryonic life. Hence, it presents the following unique features:
1. It consists of second-order sensory neurons.
2. Its fibres are myelinated by oligodendrocytes.
3. It is surrounded by meninges.
4. Its fibres cannot regenerate if cut/damaged.
**Functional Component**
**Special somatic afferent fibres**: They **carry sense of sight** from the visual field of the corresponding eye.
**Course and Relations**
The fibres of optic nerve arise from ganglion cells in the neural layer of the retina of the eyeball, converge toward the optic disc at the posterior pole of the eyeball, pierce the outer layer of retina, choroid, and sclera to leave the eyeball.

Immediately after emerging from the eyeball, the fibres unite to form the optic nerve, which passes posteromedially through the posterior half of the orbit and enters the middle cranial fossa through the optic canal.
In the middle cranial fossa, optic nerves of two sides unite to form the **optic chiasma**. The midregion of optic chiasma is composed of crossed fibres from the medial/nasal halves of the retina of both eyes, while the lateral region is made up of fibres from the lateral/temporal half of the retina of the ipsilateral eye.
Diverging from the chiasma are the optic tracts. Most of the fibres of the optic tract relay in the lateral geniculate body.
The third-order neurons arise in the lateral geniculate body, run in the retrolenticular part of the internal capsule, and form optic radiations. The fibres of optic radiation terminate in and around the calcarine sulcus of the **occipital lobe (visual cortex).**
Some of the fibres from the lateral geniculate body reach the pretectal area of the midbrain and form a part of the pathway for **light reflex**.
Thus, **visual pathway** consists of the following components in craniocaudal order:
**Retina → optic nerve → optic tract → lateral geniculate body → optic radiation → visual cortex**.
The optic nerve is 4 cm in length. It is divided into three parts: (a) intraorbital part, (b) canalicular part, and (c) intracranial part. It is enclosed by three meninges of the brain.

**OPTIC NERVE (CN II)**
**Function:** Special sensory (special somatic afferent)—that is, the special sense of vision.
Although officially nerves by convention, the **optic nerves** (CN II) develop in a completely different manner from the other cranial nerves. The structures involved in receiving and transmitting optical stimuli (the optical fibers and neural retina, together with the pigmented epithelium of the eyeball) develop as evaginations of the diencephalon.
The optic nerves are paired, anterior extensions of the forebrain (diencephalon) and are therefore actually CNS fiber tracts formed by axons of **retinal ganglion cells**. In other words, they are third order neurons, with their cell bodies located in the retina.
The optic nerves are surrounded by extensions of the cranial meninges and subarachnoid space, which is filled with cerebrospinal fluid (CSF). The meninges extend all the way to the eyeball.
The central artery and vein of the retina traverse the meningeal layers and course in the anterior part of the optic nerve. Cranial nerve II begins where the unmyelinated axons of retinal ganglion cells pierce the sclera (the opaque part of the external fibrous coat of the eyeball) and become myelin ated, deep to the *optic disc.*
The nerve passes posteromedially in the orbit, exiting through the *optic canal* to enter the middle cranial fossa, where it forms the **optic chiasm**. Here, fibers from the nasal (medial) half of each retina decussate in the chiasm and join uncrossed fi bers from the temporal (lateral) half of the retina to form the **optic tract.**
The partial crossing of optic nerve fibers in the chiasm is a requirement for binocular vision, allowing depth-of-field perception (three-dimensional vision). Thus fibers from the right halves of both retinas form the right optic tract. The decussation of nerve fi bers in the chiasm results in the right optic tract conveying impulses from the left visual field and vice versa.
The **visual field** is what is seen by a person who has both eyes wide open and who is looking straight ahead.

Most fibers in the optic tracts terminate in the **lateral geniculate bodies** of the thalamus. From these nuclei, axons are relayed to the visual cortices of the occipital lobes of the brain.

## OCULOMOTOR NERVE (CN III)

**Functions:** Somatic motor (general somatic efferent) and visceral motor (general visceral efferent–parasympathetic).

**Nuclei:** There are two oculomotor nuclei, each serving one of the functional components of the nerve. The somatic **motor nucleus of the oculomotor nerve** is in the midbrain and the visceral motor (parasympathetic) **accessory (Edinger-Westphal) nucleus of the oculomotor nerve** lies dorsal to the rostral two thirds of the somatic motor nucleus (Haines, 2006).(moore)

The oculomotor nerve (CN III) provides the following

Motor to the striated muscle of four of the six extra-ocular muscles (*superior, medial,* and *inferior recti* and *inferior oblique*) and superior eyelid (L. *levator palpebrae superioris*);hence the nerve's name.

Parasympathetic through the ciliary ganglion to the smooth muscle of the sphincter pupillae, which causes constriction of the pupil and ciliary muscle, which produces accommodation (allowing the lens to become more rounded) for near vision. (moore)

*CN III is the chief motor nerve to the ocular and extra-ocular muscles.* It emerges from the midbrain, pierces the dura mater lateral to the sellar diaphragm roofing over the hypophysis, and then runs through the roof and lateral wall of the *cavernous sinus.*

CN III leaves the cranial cavity and enters the orbit through the *superior orbital fissure.* Within this fi ssure, CN III divides into a **superior division** (which supplies the superior rectus and levator palpebrae superioris) and an ***inferior division*** *(which supplies the inferior and medial rectus and inferior oblique*).

The inferior division also carries presynaptic parasympathetic (visceral efferent) fibers to the *ciliary ganglion,* where they synapse. Postsynaptic fibers from this ganglion pass to the eyeball in the *short ciliary nerves* to innervate the ciliary body and sphincter pupillae .(moore)

## TROCHLEAR NERVE

Trochlear nerve is the 4th cranial nerve. It is purely motor and supplies only one muscle—the superior oblique muscle of the eyeball.

### Unique Features

1. It is the only cranial nerve which emerges on the dorsal aspect of the brain.
2. It is the most slender of all the cranial nerves.
3. It is the smallest cranial nerve.
4. It is the only cranial nerve whose nuclear fibres decussate before emerging on the surface of the brain.
5. Its nucleus receives only ipsilateral corticonuclear fibres.
6. Phylogenetically, it is the nerve of 3rd eye.

**Functional Components and Nuclei General somatic efferent fibres**: They arise from the trochlear nucleus in the midbrain and supply the superior oblique muscle of the eyeball.

### Course, Relations, and Distribution

The trochlear nerves arise from the dorsal aspect of the midbrain, one on either side of **frenulum veli**. After emerging from the brain, the nerve winds round the superior cerebellar peduncle and cerebral peduncle just above the pons. It then passes between the posterior cerebral and superior cerebellar arteries to appear ventrally. It lies medial to and below the free margin to tentorium cerebelli. The nerve enters the cavernous sinus by piercing the posterior corner of its roof.

In the cavernous sinus, it runs forward in its lateral wall between the oculomotor and ophthalmic nerves. In the anterior part of the sinus, it crosses over the oculomotor nerve and becomes lateral to it. The nerve enters the orbit through the superior orbital fissure superolateral to the tendinous ring. It runs medially above the levator palpebrae superioris to enter the orbital surface of the superior oblique which it supplies.

## ABDUCENT NERVE

Abducent nerve is the 6th cranial nerve. It is purely motor and supplies only one muscle—the **lateral rectus of the eyeball.**
It is so named because it abducts the eye. It is also called **lover's nerve**, because in ancient times (non-verbal era between the teenager girls and boys), the boy used to call the girls from a gathering by sending signal through the action of this muscle.

**Unique Feature**

It is most susceptible to damage of all the cranial nerves during increased intracranial pressure.

**Functional Components and Nuclei**

1. **General somatic efferent fibres.** They arise from the abducent nucleus in the pons and supply the lateral rectus muscle of the eyeball.
2. **General somatic afferent fibres.** They carry proprioceptive sensations from the lateral rectus and terminate in the mesencephalic nucleus of the trigeminal nerve

**Course, Relations, and Distribution**

The abducent nerve arises at the lower border of the pons opposite the pyramid of the medulla. The nerve runs upward, forward, and laterally dorsal to the anterior cerebellar artery and pierces the dura mater over the clivus inferolateral to the dorsum sellae. It then passes through the medial wall of the inferior petrosal sinus and arches forward directly over the sharp ridge of the petrous temporal bone, under the **petroclinoid ligament** and enters the fibro-osseous canal (**Dorello's canal**) formed by the apex of the petrous temporal bone and petroclinoid ligament (**Gruber's ligament**).

The nerve then enters the cavernous sinus by piercing the posterior wall close to the floor of the sinus. In the cavernous sinus, it runs forward inferolateral to the internal carotid artery.

The nerve enters the orbit through the superior orbital fissure within the tendinous ring **lateral to two divisions of oculomotor and nasociliary nerves**. In the orbit, it runs forward, toward the lateral side to enter the orbital surface of the lateral rectus muscle which it supplies.

## TRIGEMINAL NERVE

Trigeminal nerve is the 5th cranial nerve. It is a mixed nerve containing both the motor and sensory fibres but predominantly it is sensory. It consists of three large nerves: **ophthalmic, maxillary,** and **mandibular**, hence the name trigeminal nerve (L. *trigeminus* = triplet). It is a motor nerve to the muscles of mastication and several small muscles and the principal sensory nerve of the head and face.

**Unique Features**

1. It is the largest cranial nerve.
2. Its sensory ganglion (largest in the body) is located within the cranial cavity (cf. all the sensory ganglia are located outside the cranial cavity).

**Nuclei**

There are **three sensory and one motor nuclei**. The **sensory nuclei** are arranged in a column which spans from the midbrain through the pons and medulla and into the upper cervical cord.

mesencephalic nucleus: proprioceptive fibers for muscles of the face, orbit, mastication, and tongue

main sensory nucleus: located in the upper pons, lateral to the motor nucleus is responsible for touch sensation for all three trigeminal divisions

spinal nucleus: lower pons to upper cervical cord is responsible for pain and temperature; additionally it receives afferent fibers from the glossopharyngeal nerve and vagus nerve.

The **motor nucleus** is located in the upper pons and gives off the smaller motor root which bypasses the trigeminal ganglion and innervates the muscles of mastication as well as mylohyoid and tensor palatini.

**Functional Components and Nuclei**

1. **Special visceral efferent fibres.** They arise from motor the nucleus of the trigeminal nerve in the pons and supply the muscles derived from the 1st pharyngeal arch, *viz.* the muscles of mastication, mylohyoid, anterior belly of digastric, tensor palati, and tensor tympani.
2. **General somatic afferent fibres**:

1.(a) They carry *exteroceptive sensations* (i.e., **pain, touch, and temperature**) from skin of head and face, mucous membrane of mouth, nasal cavity, meninges, etc. and terminate in the **main sensory nucleus and spinal nucleus of the trigeminal nerve.**

2. (b) They also carry ***proprioceptive sensations*** from the **muscles of mastication,** temporomandibular joint, and teeth and terminate in the **mesencephalic nucleus of the trigeminal nerve** and the reticular formation of brainstem.
3. The exteroceptive neurons are pseudounipolar and their cell bodies are located in the **trigeminal ganglion**.The proprioceptive neurons are unipolar and their cell bodies are located in the **mesencephalic nucleus of the trigeminal nerve.** *The mesencephalic nucleus is the only site in the CNS which contains unipolar neurons/first-order sensory neurons.*

**Course, Relations, and Distribution**

The trigeminal nerve **arises by two roots** (a smaller medial motor root and a larger lateral sensory root) from the ventrolateral aspect of the pons at its junction with the middle cerebellar peduncle.

The sensory root passes forward and laterally over the apex of the petrous temporal bone to enter the middle cranial fossa. Here it exhibits a rounded enlargement, the **trigeminal (gasserian) ganglion**.

The ganglion occupies adural invagination in a shallow fossa on the anterior surface of the petrous temporal bone.The subarachnoid expansion over this portion of trigeminal nerve is called **Meckel's cave** The sensory root may be cut here in order to relieve the pain of trigeminal neuralgia.

The convex distal surface of ganglion gives origin to three large divisions of the trigeminal nerve—ophthalmic, maxillary, and mandibular:

1. The **ophthalmic nerve** (purely sensory) arises from the anterolateral aspect of the ganglion and enters the lateral wall of the cavernous sinus where it lies below the trochlear nerve.

In the cavernous sinus, it divides into three branches: nasociliary, lacrimal, and frontal. All these branches enter the orbit through the superior orbital fissure

2. The **maxillary nerve** (purely sensory) arises from the ganglion and enters the lateral wall of the cavernous sinus where it occupies the lowest position and leaves the cavernous sinus to enter the **pterygopalatine fossa** through the **foramen rotundum**.

3. The **mandibular nerve** (the largest division) arises from the trigeminal ganglion and immediately enters the infratemporal fossa through the foramen ovale.
The **motor root** of the trigeminal nerve after emerging from the pons passes forward and laterally deep to the sensory root and trigeminal ganglion and enters the infratemporal fossa through the foramen ovale. After emerging from the foramen ovale, it immediately joins the mandibular nerve and thus the mandibular nerve contains both the motor and sensory fibres

- **Ophthalmic division / nerve (V1 or Va)**
  Courses anteriorly in the lateral wall of the cavernous sinus inferior to trochlear nerve. Just before entering the orbit, the tentorial nerve arises and ascends to supply a large portion of the falx and supratentorial dura. The ophthalmic division then divides into 3 terminal branches before each passes through the superior orbital fissure separately:

1. frontal nerve (superior orbital fissure outside the tendinous ring)
   - supraorbital nerve (supraorbital notch)
   - supratrochlear nerve (supratrochlear notch)
2. lacrimal nerve (superior orbital fissure outside the tendinous ring)

3.nasociliary nerve (superior orbital fissure though the tendinous ring) with braches:

-small communicating branch

-to the ciliary ganglion

-short ciliary nerves

-long ciliary nerves

-infratrochlear nerve

-posterior ethmoidal nerve (posterior ethmoidal foramen)

-anterior ethmoidal nerve (anterior ethmoidal foramen then the cribriform plate)

- **Maxillary division / nerve (V2 or Vb)**
  Courses anteriorly low in the lateral wall of the cavernous sinus inferior to trochlear nerve. Just before exiting the skull it runs along the floor of the middle cranial fossa and gives off the middle meningeal nerve which ascends to supply the anterior dura of the middle cranial fossa. It then passes through the foramen rotunda in the greater wing of the sphenoid bone to exit skull and enter the superior aspect of the pterygopalatine fossa. It gives branches to pterygopalatine ganglion but also receives parasympathetic nerves from the ganglion via the greater petrosal nerve.

It then divides into the:

- zygomatic nerve (inferior orbital fissure)
  - zygomaticotemporal nerve (zygomaticotemporal foramen)
  - zygomaticofacial nerve (zygomaticofacial foramen)
- infraorbital nerve (inferior orbital fissure then infraorbital foramen)
  - posterior superior alveolar nerve (pterygomaxillary fissure)
  - middle superior alveolar nerve

- anterior superior alveolar nerve

- nasopalatine nerve (sphenopalatine foramen)
- posterior superior nasal nerves (sphenopalatine foramen)
- greater palatine nerve (greater palatine foramen)
  - lateral posterior inferior nasal nerve (un-named foramina)
- lesser palatine nerve (lesser palatine foramen)
- pharyngeal nerve (palatovaginal canal)

- **Mandibular division / nerve (V3 or Vc)**

Courses inferiorly through the foramen ovale to enter the infratemporal fossa, hence does not pass through the cavernous sinus. It consists of a sensory root and a smaller motor root, the later which bypasses the trigeminal ganglion inferiorly. These roots pass through the foramen ovale separately and then unite just below the foramen. It immediately gives off nervus spinosus and nerve to medial pterygoid from the main trunk. It then descends in the infratemporal fossa passing between the tensor veli palatini and lateral pterygoid muscles before dividing into anterior and posterior divisons:

anterior division (4 branches, all motor except one)

- deep temporal nerves
- lateral pterygoid nerves
- masseteric nerve
- buccal nerve(sensitive)
-

posterior division (3 branches, all sensory except one)

- auriculotemporal nerve
- lingual nerve
- inferior alveolar nerve (also motor)
- nerve to mylohyoid
- incisive nerve
- mental nerve

**FACIAL NERVE**

Facial nerve is the 7th cranial nerve. It is a mixed (i.e., motor and sensory) nerve, but predominantly it is motor. It is named facial nerve because it supplies the muscles of facial expression. *It is the most frequently paralyzed of all the peripheral nerves of the body.*

**Functional Components and Nuclei**

1. **Special visceral efferent fibres (SVA)**. They arise from the motor nucleus of the facial nerve in the pons and supply the muscles of facial expression.
2. **General visceral efferent fibres.** These are preganglionic parasympathetic fibres which arise from lacrimatory and superior salivatory nuclei in the brainstem. They supply the secretomotor fibres to lacrimal, submandibular, and sublingual glands.

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**Course and Relations**

This nerve consists of two distinct roots: (a) a large medial motor root (the *facial nerve proper*) and (b) a small lateral sensory root (the *nervous intermedius*). The two roots arise from the **pontomedullary junction** lateral to the superior end of the olive of the medulla. The sensory root lies between the motor root of facial medially and the vestibulocochlear nerve laterally. After emerging from the brainstem, the roots of the facial nerve pass laterally and forward in the cerebellopontine angle, along with the vestibulocochlear and labyrinthine artery. All these structures then enter the internal acoustic meatus. In the meatus, the motor root is lodged in a groove on the vestibulocochlear nerve, while the sensory root remains separate. At the **lateral end (bottom) of the internal acoustic meatus, two roots unite to form the trunk of the facial nerve.** (Here it is important to note that the bottom or fundus of the internal acoustic meatus forms the medial wall of the bony labyrinth of the internal ear.) The facial nerve enters the facial canal in the petrous temporal bone through its opening in the fundus of the internal acoustic meatus.

The facial canals divide into three segments: labyrinthine, tympanic, and mastoid.
The **labyrinthine segment** of the facial canal lies above the vestibule of bony labyrinth and bends to reach the anterosuperior part of the medial wall of the middle ear (tympanum) near the processus cochleariformis. Here the canal bends sharply backward. The facial nerve coursing through the labyrinthine segment of canal also makes a sharp bend called the **external genu of the facial nerve** which **possesses the geniculate ganglion.**

The **tympanic segment** of the facial canal runs horizontally backward in the medial wall of the middle ear till it reaches the junction of the medial and posterior wall of the middle ear.
The bulge of the tympanic segment of the facial canal is seen in the medial wall of the middle ear above the promontory and fenestra vestibuli and below the bulge produced by the lateral semicircular canal.

The **mastoid segment** begins at the junction of the medial and posterior wall of the middle ear and passes vertically downward in the posterior wall of the middle ear till it reaches the stylomastoid foramen at the base of the skull.
The facial nerve comes out of cranial cavity through the stylomastoid foramen.

**Branches and Distribution**

1. **Greater petrosal nerve—**arises from the geniculate ganglion. It consists of preganglionic parasympathetic fibres which relay in the pterygopalatine ganglion and supply the secretomotor fibres to the lacrimal gland and the mucous glands of nasal cavity and palate.
2. **Nerve to stapedius—**arises from the vertical part of the facial nerve opposite the pyramidal eminence, runs forward through a short canal within it to reach the stapedius muscle to supply it.

3. **Chorda tympani nerve—**arises from the vertical part of the facial nerve about 6 mm above the stylomastoid foramen, and enters the middle ear through the *posterior canaliculus* (on the posterior wall of the middle ear), runs across its lateral wall of the middle ear (pars flaccida of the tympanic membrane); passing between the long process of incus and the handle of malleus, and leaves the middle ear by entering the *anterior canaliculus* (on the anterior wall of the middle ear). It then traverses through the bony canaliculus and enters the inferotemporal fossa through the medial end of *petrotympanic fissure*. After emerging from the petrotympanic fissure, it runs medially forward and downward, crossing the medial aspect of the spine of sphenoid, to join the posterior aspect of the lingual nerve.
The chorda tympani nerve consists of two types of fibres:

(a) *Preganglionic parasympathetic (GVE) fibres*, which provide secretomotor supply to the submandibularand sublingual glands.
(b) *Special visceral afferent fibres*, which carry taste sensations from anterior two-third of the tongue
4. **Posterior auricular nerve—**supplies the occipital belly of occipitofrontalis.
5. **Nerve to the posterior belly of digastric—**supplies the concerned muscle.
6. **Nerve to stylohyoid—**supplies the concerned muscle.
7. **Five terminal branches** (temporal, zygomatic, buccal,
    - ⦿ marginal, mandibular, and cervical)—supply the muscles
    - ⦿ of facial expression.

## VESTIBULOCOCHLEAR NERVE

Vestibulocochlear nerve is the 8th cranial nerve. It consists of two distinct parts: (a) a vestibular part, called the **vestibular nerve,** and (b) a cochlear part, called the **cochlear nerve** . The vestibular nerve is concerned with the maintenance of **equilibrium**, while the cochlear nerve is concerned with **hearing**.

**Functional Component and Nuclei**

**Special somatic afferent fibres:** They carry sensory information necessary for the maintenance of equilibrium and hearing from the membranous labyrinth of the internal ear.
The fibres carrying the sensory information for equilibrium terminate in the vestibular nuclei within the brainstem.
The fibres carrying the sensory information for hearing terminate in the dorsal and ventral cochlear nuclei, located respectively on the dorsal and ventral aspects of the inferior cerebellar peduncle.

**Course and Relations**

The ***vestibular nerve*** arises from the lateral aspect of the pontomedullary junction, passes through the pontocerebellar angle and enters the internal acoustic meatus along with the facial nerve and labyrinthine vessels.
The ***vestibular ganglion*** (also called **Scarpa's ganglion**) is located on the vestibular nerve in the lateral part of the internal acoustic meatus. It consists of bipolar sensory neurons.
In the lateral part of the internal acoustic meatus, the nerve divides into **three** distinct branches: **superior and inferior divisions and singular nerve**. These branches pass through the foramina in the fundus of the meatus and innervate the sensory receptors for equilibrium (cristae ampullaris and maculae) in the membranous labyrinth of the internal ear.
The **cochlear nerve** also arises from the lateral aspect of the pontomedullary junction and takes a similar course to enter the internal acoustic meatus. At the medial end of the internal acoustic meatus, it enters into bony labyrinth of the middle ear through ***tractus spiralis foraminosus*** in the fundus of the meatus and reaches the modiolus of the internal ear. In the modiolus, the cochlear nerve possesses a sensory ganglion called the *spiral ganglion* made of bipolar neurons. The peripheral process of these neurons innervates the sensory receptor of hearing—the *organ of Corti*.

The last four cranial nerves are the nerves of the neck and closely related to each other, hence described together. The last four cranial nerves leave the skull close together, the glossopharyngeal, vagus, and accessory through the jugular foramen, and the hypoglossal nerve through the hypoglossal canal.
At first, they lie between the internal jugular vein and the internal carotid artery, where the cranial root of the accessory nerve joins the vagus nerve and is distributed through it.

Glossopharyngeal nerve is the 9th cranial nerve. It is a mixed nerve, i.e., composed of both the motor and sensory fibres, but predominantly it is sensory. It derives its name from the fact that it provides sensory innervation to the tongue and pharynx.

**Functional Components and Nuclei**

1. **Special visceral efferent fibres:** They supply the stylopharyngeus muscle. They arise from *nucleus ambiguus.*
2. **General visceral efferent fibres:** They supply the secretomotor fibres to the parotid gland. They are preganglionic parasympathetic fibres and arise from the *inferior salivatory nucleus.*
3. **Special visceral afferent fibres:** They carry taste sensations from the posterior one-third of tongue including vallate papillae and terminate in the *nucleus tractus solitarius*.
4. **General visceral afferent fibres:** They carry general sensations of pain, touch, and temperature from the mucous membrane of the pharynx, tonsil, soft palate, and the posterior one-third of tongue and terminate in the dorsal nucleus of the vagus.

5. **General somatic afferent fibres:** They carry proprioceptive sensations from the stylopharyngeus and skin of the auricle and terminate in the *nucleus of the spinal tract of 5th nerve*.

**Course**

The glossopharyngeal nerve arises from the upper part of the lateral aspect of the medulla between the olive and the inferior cerebellar peduncle by three or four rootlets. The rootlets unite to form a single trunk which runs forward and laterally to leave the cranial cavity by passing through the intermediate compartment of the jugular foramen enclosed in a separate sheath of dura mater.

The **superior** and **inferior sensory ganglia** are located on the nerve as it passes through the jugular foramen.

The **smaller superior ganglion** lies within the jugular foramen and is considered the detached part of the inferior ganglion.

The **larger inferior ganglion** lies just below the jugular foramen and contains the cell bodies of most of the sensory fibres of the nerve.

**Branches and Distribution**

The glossopharyngeal nerve gives the following important branches:

1. **Tympanic branch (Jacobson's nerve):** It leaves the inferior ganglion and enters the middle ear through the tympanic canaliculus situated at the bony edge between the jugular foramen and carotid canal. It forms the tympanic plexus over the promontory of the middle ear.
    - **The tympanic plexus gives off:**
    - (a) the lesser petrosal nerve and
    - (b) twigs to tympanic cavity, auditory tube, and mastoid air cells.
    - The lesser petrosal nerve carries the preganglionic parasympathetic fibres which relay in the otic ganglion. The postganglionic fibres from the ganglion supply the parotid gland.
2. **Carotid nerve (nerve of Herring):** It is a branch to carotid sinus and carotid body. It serves as an afferent limb for pressoreceptor and chemoreceptor reflexes from the carotid sinus and carotid body to regulate the heart rate and respiration, respectively.
3. **Pharyngeal branch:** It joins the pharyngeal branches of the vagus and the cervical sympathetic chain to form the *pharyngeal plexus* on the middle constrictor of the pharynx.
4. **Branch to stylopharyngeus:** It arises as the nerve, winds round the stylopharyngeus muscle. *It is the only motor branch of the glossopharyngeal nerve.*
5. **Tonsillar branches:** They supply the mucous membrane of tonsil, fauces, and palate.
6. **Lingual branches**: They supply the posterior one-third of the tongue and vallate papillae and convey taste and general sensations.

## VAGUS NERVE

Vagus nerve is the 10th cranial nerve. It is a mixed nerve, i.e., composed of both the motor and sensory fibres but predominantly it is motor. It is the longest and most widely distributed cranial nerve. It is so called because of its extensive vague course and distribution. Its field of distribution extends beyond the head and neck—to the thorax and abdomen. It conveys most of the efferent fibres of the cranial part of the parasympathetic outflow and distributes the fibres of an cranial part of the accessory nerve.

### Functional Components and Nuclei

1. **Special visceral efferent fibres:** supply the muscles of palate, pharynx, and larynx. They arise from *nucleus ambiguus*.
2. **General visceral efferent fibres:** arise from the *dorsal nucleus of vagus*, and provide parasympathetic innervation to heart, bronchial tree, and most of the GIT.
3. **Special visceral afferent fibres:** carry taste sensations from the posteriormost part of the tongue and epiglottis and terminate in the *nucleus tractus solitarius*.
4. **General visceral afferent fibres:** carry general sensations from the mucous membrane of pharynx, larynx, trachea, esophagus, and thoracic and abdominal viscera and terminate in the **nucleus tractus solitarius and some in the *dorsal nucleus of the vagus*.**
5. **General somatic afferent fibres:** carry general sensations from skin of the auricle and terminate in the ***nucleus of the spinal tract of the trigeminal nerve***

### Course and Relations

The vagus nerve arises from the lateral aspect of the medulla between the olive and inferior cerebellar peduncle by about 10 rootlets below and in line of the rootlets of the glossopharyngeal nerve. These nerve rootlets unite to form the nerve trunk which runs laterally, crosses the jugular tubercle, and leaves the cranial cavity by passing through the middle part of the jugular foramen enclosed in the common dural sheath with the 11th nerve.

The superior and inferior sensory ganglia are located on the nerve as it passes through the jugular foramen:

1. A smaller **superior ganglion** lies within the jugular foramen.
2. The **larger inferior (nodose) ganglion** lies just below the jugular foramen. Both the ganglia contain the cell bodies of the sensory fibres of the vagus nerve. The *superior ganglion* contains the cell bodies of GSA fibres, whereas the inferior ganglion contains the cell bodies of visceral afferent fibres.
3. The cranial root of the accessory (11th) nerve unites with the vagus nerve just below its inferior ganglion and thus transfers all its fibres to the vagus nerve for distribution.

After coming out of the cranial cavity through the jugular foramen, the nerve runs vertically downward within the carotid sheath in the neck first between the internal jugular vein laterally and the internal carotid artery medially and then between the internal jugular vein (laterally) and the common carotid artery (medially). At the root of the neck, the nerve enters the thorax.

The **right vagus nerve** enters the thorax by crossing in front of the right subclavian artery, whereas the **left vagus nerve** enters the thorax by passing between the left common carotid and left subclavian arteries.

### Branches and Distribution

The branches and distribution of the vagus nerve in the region of head and neck are as follows:

1. **Meningeal branch:** It arises from the *superior ganglion,* takes a recurrent course, and enters the cranial cavity through the jugular foramen to supply the dura mater of the posterior cranial fossa.
2. **Auricular branch (Arnold's nerve or Alderman's nerve):**

It arises from the *superior ganglion*, enters the *mastoid canaliculus* on the lateral wall of the jugular fossa, and emerges through the tympanomastoid fissure just behind the external auditory meatus to supply the skin on the back of the meatus and adjoining

part of the auricle. Then it enters the meatus between its bony and cartilaginous parts to supply the floor of the meatus and the tympanic membrane.
Stimulation of this nerve, as in syringing of the ear, may cause reflex coughing **(ear cough)**, vomiting, and even cardiac arrest.
3. **Pharyngeal branch:** It arises from the *inferior ganglion*, passes forward between the internal and external carotid arteries, and takes part in the formation of pharyngeal plexus. It supplies:
(a) all the muscles of pharynx *except* the stylopharyngeus, which is supplied by the glossopharyngeal nerve, and
(b) all the muscles of soft palate *except* the tensor palati which is supplied by the mandibular nerve (through the nerve to medial pterygoid).
4. **Branches to carotid body:** It arises from the inferior ganglion.
5. **Superior laryngeal nerve (nerve of 4th arch):** It arises from the *inferior ganglion*, passes downward and forward deep to the internal carotid artery to reach the middle constrictor where it divides into external and internal laryngeal nerves:
(a) The *external laryngeal nerve (motor)* runs downward in company with superior thyroid vessels and supplies cricothyroid muscle. It also gives twigs to the inferior constrictor and pharyngeal plexus.
(b) The *internal laryngeal nerve (sensory)* passes downward and forward toward the gap between the middle and inferior constrictors. It pierces the thyrohyoid membrane to enter the larynx. It supplies the:(i) mucous membrane of larynx above the vocal cords, and (ii) mucous membrane of the pharynx, epiglottis, vallecula, and the posteriormost part of the tongue.
6. **Superior and inferior cervical cardiac branches:** The *superior cardiac branch* arises in the upper part of the neck and the inferior cardiac branch in the lower part of the neck. They enter the thorax through the thoracic inlet. They carry preganglionic parasympathetic fibres to the heart and are cardio-inhibitory. The *inferior cervical cardiac branch* of the left vagus nerve joins the *superficial cardiac plexus*. The remaining cervical cardiac branches of both the vagus nerves join the *deep cardiac plexus.*
7. **Recurrent laryngeal nerve (nerve of 6th arch):**
(a) *On the right side*, it arises in the root of the neck from the vagus nerve as it crosses in front of the subclavian artery, winds around the first part of the subclavian artery, and then ascends up (in a recurrent direction) in the tracheoesophageal groove.
(b) *On the left side,* it arises in the superior mediastinum from the vagus nerve as it crosses the arch of the aorta (lateral aspect). It hooks below the arch of the aorta on the left side of *ligamentum arteriosum* behind the arch of aorta on its way to the tracheoesophageal groove.
The recurrent laryngeal nerve provides motor innervation to all the intrinsic muscles of the larynx (*except* the cricothyroid which is supplied by the external laryngeal nerve) and sensory innervation to the mucous membrane of laryngeal cavity up to the vocal cord.
Each recurrent laryngeal nerve passes deep to the inferior constrictor muscle to enter the laryngeal cavity deep to the cricothyroid joint. Now it is called the *inferior laryngeal nerve*.

## ACCESSORY NERVE

Accessory nerve is the 11th cranial nerve. It is purely motor.
It consists of two roots: cranial and spinal.
the **cranial root** is accessory to the vagus and its fibres are distributed through the vagus nerve.
The **spinal root** has an independent course and is generally regarded as **spinal accessory nerve,** or simply as **accessory nerve**.

### Functional Components and Nuclei

1. **Special visceral efferent fibres:** provide motor supply to the muscles of soft palate, pharynx, and larynx. They arise from the *nucleus ambiguus* and form the cranial root.
2. **General somatic efferent fibres:** provide motor supply to the sternocleidomastoid and trapezius muscles. They arise from the *spinal nucleus of accessory nerve*, in the ventral horns of the upper five spinal segments and form the spinal root.

### Course and Relations

The **cranial root** arises by four or five rootlets from the posterolateral sulcus of the medulla between the olive and inferior cerebellar peduncle. The rootlets are attached in line with the rootlets of the vagus nerve above. These rootlets unite together to form a single trunk which runs laterally along with the 9th and 10th cranial nerves to reach the jugular foramen where it is joined by the spinal root.

The spinal accessory nerve communicates with the C2, C3, and C4 spinal nerves. The C2 and C3 spinal nerves carry proprioceptive fibres from the sternocleidomastoid while C3 and C4 carry proprioceptive fibres from the trapezius muscle.

**Distribution**

The **cranial root** of the accessory nerve via the vagus nerve and pharyngeal plexus of nerves supplies:

All the muscles of the palate *except* the tensor palati and tensor tympani which are supplied by the mandibular nerve (nerve to medial pterygoid):

(a) All the muscles of the pharynx *except* the stylopharyngeus which is supplied by the glossopharyngeal nerve.

(b) All the intrinsic muscles of larynx.

The **spinal root** of the accessory nerve supplies the following two muscles:

1. Sternocleidomastoid muscle along with C2 and C3 spinal nerves.
2. Trapezius muscle along with C3 and C4 spinal nerves.

## HYPOGLOSSAL NERVE

Hypoglossal nerve is the 12th cranial nerve. It is purely a motor nerve.

**Functional Components and Nuclei**

**General somatic efferent fibres:** These fibres arise from the hypoglossal nucleus and supply all the muscles of the tongue (extrinsic and intrinsic) which develop from occipital myotomes.

**Course and Relations**

The hypoglossal nerve arises on the ventral aspect of the medulla from the anterolateral sulcus between the pyramid and the olive by 10–15 rootlets.

The rootlets of the hypoglossal nerve are attached in line with the rootlets of the ventral root of the 1st cervical spinal nerve.

**Branches and Distribution**

The hypoglossal nerve gives the following branches:

1. **Branches of the hypoglossal proper:** They supply all the muscles of the tongue *except* palatoglossus which is supplied by the cranial root of accessory via the pharyngeal plexus.
2. **Branches of the hypoglossal nerve containing C1 fibres:**

These are as follows:

(a) *Meningeal branch:* It arises from the nerve as it comes out through the hypoglossal canal taking a recurrent course, enters the cranial cavity through the hypoglossal canal, and supplies the dura mater of the posterior cranial fossa.

(b) *Descendens hypoglossi* or *upper root of ansa cervicalis:* It arises as the nerve crosses in front of the internal carotid artery. It runs downward to join the inferior root of ansa cervicalis at the level of cricoid cartilage.

(c) *Nerve to thyrohyoid:* It crosses the greater cornu of the hyoid bone to reach the muscle.

(d) *Nerve to geniohyoid:* It arises from above the hyoid bone.

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**Development of the Nervous System**

-The first embryonic trace of the central nervous system appears early in the third week of development.
-A dorsal streak called the *neuroectoderm* appears along the length of the embryo and thickens to form a **neural plate.**
-This is destined to give rise to all neurons and glial cells **except microglia, which come from mesoderm**.
-As development progresses, the neural plate sinks and the edges of it thicken, thus forming a **neural groove** with a raised **neural fold** along each side.
-The neural folds then fuse along the midline, somewhat like a closing zipper, beginning in the cervical(neck) region of the neural groove and progressing rostrally (toward the head) and caudally (toward the tail).By 4 weeks, this process creates a hollow channel called the **neural tube.** For a period of time , the neural tube is open to the amniotic fluid at the rostral and caudal ends. These openings close at 25 and 27 days, respectively.The lumen of the neural tube becomes a fluid-filled space that later constitutes the *central canal* of the spinal cord and *ventricles* of the brain.
Following closure, the neural tube separates from the overlying ectoderm, sinks a little deeper, and grows lateral processes that later give rise to motor nerve fibers.
Some ectodermal cells that originally lay along the margin of the neural groove separate from the rest and form a longitudinal column on each side called the **neural crest.**Some neural crest cells become sensory neurons,while others migrate to other locations and give rise to sympathetic neurons, ganglia, Schwann cells, and the *adrenal medulla,* a gland.By the fourth week, the neural tube exhibits three anterior dilations, or *primary vesicles,* called the **forebrain** (*prosencephalon*), **midbrain** (*mesencephalon*), and **hindbrain** (*rhombencephalon*).While these vesicles develop, the neural tube bends at the junction of the hindbrain and spinal cord to form the **cervical flexure,** and in the midbrain region to form the **cephalic flexure.** (saladin)
By the fifth week, the neural tube undergoes further flexion and subdivides into five *secondary vesicles.* the forebrain divides into two of them, the **telencephalon** and **diencephalon**;the midbrain remains undividedand retains the name **mesencephalon;** the hindbrain dividesdivides into two vesicles, the **metencephalon** and **myelencephalon**.
-the telencephalon has a pair of lateral outgrowths that later become the *cerebral hemispheres,*and the diencephalon exhibits a pair of small cuplike *optic vesicles* that become the retinas of the eyes.
-In week 14, Schwann cells and oligodendrocytes begin spiraling around the nerve fibers, laying down layers of myelin and giving the fibers a white appearance. Yet very little myelin is present in the brain at birth, and there is little visible distinction between the *gray matter* and *white matter* of the newborn brain.Myelination proceeds rapidly in infancy and it is this, far more than the multiplication or enlargement of neurons, that accounts for most postnatal brain growth. Myelination is not completed until late adolescence.Since myelin has such a high lipid content, dietary fat is important to early nervous system development.Well-meaning parents can do their children significant harm by giving them the sort of low-fat diets (skimmed milk, etc.) that may be beneficial to an adult.In the third month of development, the spinal cord extends for the full length of the embryo. As the vertebrae develop, *spinal nerves* arise from the cord and pass straight laterally to emerge between the vertebrae, through the intervertebral foramina. Subsequently, however, the vertebral column grows faster than the spinal cord. By birth, the cord ends in the vertebral canal of the third lumbar vertebra (L3), and by adulthood, it ends at the level of L1 to L2.As the vertebral column elongates, the spinal nerve roots elongate, so they still emerge between the same vertebrae but the lower vertebral canal is occupied by a bundle of nerve roots instead of spinal cord.
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