

Cranial Nerves

Organization of the Cranial Nerves

The cranial nerves are named as follows:

- I. Olfactory*
- II. Optic*
- III. Oculomotor*
- IV. Trochlear*
- V. Trigeminal*
- VI. Abducent*
- VII. Facial*
- VIII. Vestibulocochlear*
- IX. Glossopharyngeal*
- X. Vagus*
- XI. Accessory*
- XII. Hypoglossal*

The olfactory, optic, and vestibulocochlear nerves are entirely sensory; the oculomotor, trochlear, abducent, accessory, and hypoglossal nerves are entirely motor; and the remaining nerves are mixed. .

Olfactory Nerves

*The olfactory nerves arise from **olfactory receptor nerve cells** in the olfactory mucous membrane. The olfactory mucous membrane is situated in the upper part of the nasal cavity above the level of the superior concha. Bundles of these olfactory nerve fibers pass through the openings of the cribriform plate of the ethmoid bone to enter the **olfactory bulb** in the cranial cavity. The olfactory bulb is connected to the olfactory area of the cerebral cortex by the **olfactory tract**.*

Optic Nerve

*The optic nerve is composed of the axons of the cells of the **ganglionic layer** of the retina. The optic nerve emerges from the back of the eyeball and leaves the orbital cavity through the optic canal to enter the cranial cavity. The optic nerve then unites with the optic nerve of the opposite side to form the optic chiasma. In the chiasma, the fibers from the medial half of each retina cross the midline and enter the **optic tract** of the opposite side, whereas the fibers from the lateral half of each retina pass posteriorly in the optic tract of the same side. Most of the fibers of the optic tract terminate by synapsing with nerve cells in the **lateral geniculate body**. A few fibers pass to the pretectal nucleus and the superior colliculus and are concerned with light reflexes. The axons of the nerve cells of the lateral geniculate body pass posteriorly as the **optic radiation** and terminate in the **visual cortex** of the cerebral hemisphere (*

Oculomotor Nerve

*The oculomotor nerve emerges on the anterior surface of the midbrain . It passes forward between the posterior cerebral and superior cerebellar arteries .It then continues into the middle cranial fossa in the lateral wall of the cavernous sinus. Here, it divides into a **superior** and an **inferior ramus**, which enter the orbital cavity through the superior orbital fissure .The oculomotor nerve supplies the following:*

- **The extrinsic muscles of the eye:** the levator palpebrae superioris, superior rectus, medial rectus, inferior rectus, and inferior oblique .
- **The intrinsic muscles of the eye:** The constrictor papillae of the iris and the ciliary muscles are supplied by the parasympathetic component of the oculomotor nerve. These fibers synapse in the **ciliary ganglion** and reach the eyeball in the **short ciliary nerves**.The oculomotor nerve, therefore, is entirely motor. It is responsible for lifting the upper eyelid; turning the eye upward, downward, and medially; constricting the pupil; and accommodation of the eye.

Trochlear Nerve

The trochlear nerve is the most slender of the cranial nerves. Having crossed the nerve of the opposite side, it leaves the posterior surface of the midbrain .It then passes forward through the middle cranial fossa in the lateral wall of the cavernous sinus and enters the orbit through the superior orbital fissure .The trochlear nerve supplies: The superior oblique muscle of the eyeball (extrinsic muscle) The trochlear nerve is entirely motor and assists in turning the eye downward and laterally.

Trigeminal Nerve

*The trigeminal nerve is the largest cranial nerve .It leaves the anterior aspect of the pons as a small **motor root** and a large **sensory root**, and it passes forward, out of the posterior cranial fossa, to reach the apex of the petrous part of the temporal bone in the middle cranial fossa. Here, the large sensory root expands to form the **trigeminal ganglion** . The trigeminal ganglion lies within a pouch of dura mater called the **trigeminal cave**. The motor root of the trigeminal nerve is situated below the sensory ganglion and is completely separate from it. The ophthalmic (V1), maxillary (V2), and mandibular (V3) nerves arise from the anterior border of the ganglion*

Ophthalmic Nerve (V1)

The ophthalmic nerve is purely sensory . It runs forward in the lateral wall of the cavernous sinus in the middle cranial fossa and divides into three branches, the lacrimal, frontal, and nasociliary nerves, which enter the orbital cavity through the superior orbital fissure.

Branches

The **lacrimal nerve** runs forward on the upper border of the lateral rectus muscle. It is joined by the zygomaticotemporal branch of the maxillary nerve, which contains the parasympathetic secretomotor fibers to the lacrimal gland. The lacrimal nerve then enters the lacrimal gland and gives branches to the conjunctiva and the skin of the upper eyelid.

The **frontal nerve** runs forward on the upper surface of the levator palpebrae superioris muscle and divides into the **supraorbital** and **supratrochlear nerves**. These nerves leave the orbital cavity and supply the frontal air sinus and the skin of the forehead and the scalp. The **nasociliary nerve** crosses the optic nerve, runs forward on the upper border of the medial rectus muscle, and continues as the **anterior ethmoid nerve** through the anterior ethmoidal foramen to enter the cranial cavity. It then descends through a slit at the side of the crista galli to enter the nasal cavity. It gives off two **internal nasal branches** and it then supplies the skin of the tip of the nose with the **external nasal nerve**. Its branches include the following:

- **Sensory fibers** to the ciliary ganglion
- **Long ciliary nerves** that contain sympathetic fibers to the dilator pupillae muscle and sensory fibers to the cornea
- **Infratrochlear nerve** that supplies the skin of the eyelids
- **Posterior ethmoidal nerve** that is sensory to the ethmoid and sphenoid sinuses

Maxillary Nerve (V2)

The maxillary nerve arises from the trigeminal ganglion in the middle cranial fossa. It passes forward in the lateral wall of the cavernous sinus and leaves the skull through the foramen rotundum and crosses the pterygopalatine fossa to enter the orbit through the inferior orbital fissure. It then continues as the infraorbital nerve in the infraorbital groove, and it emerges on the face through the infraorbital foramen. It gives sensory fibers to the skin of the face and the side of the nose.

Branches

- **Meningeal branches**
- **Zygomatic branch**, which divides into the zygomaticotemporal and the zygomaticofacial nerves that supply the skin of the face. The zygomaticotemporal branch gives parasympathetic secretomotor fibers to the lacrimal gland via the lacrimal nerve.
- **Ganglionic branches**, which are two short nerves that

suspend the pterygopalatine ganglion in the pterygopalatine fossa . They contain sensory fibers that have passed through the ganglion from the nose, the palate, and the pharynx. They also contain postganglionic parasympathetic fibers that are going to the lacrimal gland.

■ ■ **Posterior superior alveolar nerve** , which supplies the maxillary sinus as well as the upper molar teeth and adjoining parts of the gum and the cheek

■ ■ **Middle superior alveolar nerve** , which supplies the maxillary sinus as well as the upper premolar teeth, the gums, and the cheek

■ ■ **Anterior superior alveolar nerve** , which supplies the maxillary sinus as well as the upper canine and the incisor teeth

Pterygopalatine Ganglion

The pterygopalatine ganglion is a parasympathetic ganglion, which is suspended from the maxillary nerve in the pterygopalatine fossa . It is secretomotor to the lacrimal and nasal glands .

Branches

■ ■ **Orbital branches**, which enter the orbit through the inferior orbital fissure

■ ■ **Greater and lesser palatine nerves** , which supply the palate, the tonsil, and the nasal cavity

■ ■ **Pharyngeal branch**, which supplies the roof of the nasopharynx

Mandibular Nerve (V3)

The mandibular nerve is both motor and sensory . The sensory root leaves the trigeminal ganglion and passes out of the skull through the foramen ovale to enter the infratemporal fossa. The motor root of the trigeminal nerve also leaves the skull through the foramen ovale and joins the sensory root to form the trunk of the mandibular nerve, and then divides into a small anterior and a large posterior division.

Branches from the Main Trunk of the Mandibular Nerve

■ ■ **Meningeal branch**

■ ■ **Nerve to the medial pterygoid muscle**, which supplies not only the medial pterygoid, but also the tensor veli palatini muscle.

Branches from the Anterior Division of the Mandibular Nerve

■ ■ **Masseteric nerve** to the masseter muscle

■ ■ **Deep temporal nerves** to the temporalis muscle

■ ■ **Nerve to the lateral pterygoid muscle**

■ ■ **Buccal nerve** to the skin and the mucous membrane of

*the cheek . The buccal nerve **does not supply the buccinator muscle** (which is supplied by the facial nerve), and it is the **only sensory branch** of the anterior division of the mandibular nerve.*

Branches from the Posterior Division of the Mandibular Nerve

■ **Auriculotemporal nerve**, which supplies the skin of the auricle , the external auditory meatus, the temporomandibular joint, and the scalp. This nerve also conveys postganglionic parasympathetic secretomotor fibers from the otic ganglion to the parotid salivary gland.

■ **Lingual nerve**, which descends in front of the inferior alveolar nerve and enters the mouth . It then runs forward on the side of the tongue and crosses the submandibular duct. In its course, it is joined by the **chorda tympani nerve** , and it supplies the mucous membrane of the anterior two thirds of the tongue and the floor of the mouth. It also gives off **preganglionic parasympathetic secretomotor fibers** to the submandibular ganglion.

■ **Inferior alveolar nerve** , which enters the mandibular canal to supply the teeth of the lower jaw and emerges through the mental foramen (mental nerve) to supply the skin of the chin . Before entering the canal, it gives off the **mylohyoid nerve** , which supplies the mylohyoid muscle and the anterior belly of the digastrics muscle.

■ **Communicating branch**, which frequently runs from the inferior alveolar nerve to the lingual nerve. The branches of the posterior division of the mandibular nerve are sensory (except the nerve to the mylohyoid muscle).

Injury to the Lingual Nerve

The lingual nerve passes forward into the submandibular region from the infratemporal fossa by running beneath the origin of the superior constrictor muscle, which is attached to the posterior border of the mylohyoid line on the mandible. Here, it is closely related to the last molar tooth and is liable to be damaged in cases of clumsy extraction of an impacted third molar.

Otic Ganglion

The otic ganglion is a parasympathetic ganglion that is located medial to the mandibular nerve just below the skull, and it is adherent to the nerve to the medial pterygoid muscle. The preganglionic fibers originate in the glossopharyngeal nerve, and they reach the ganglion via the

lesser petrosal nerve . The postganglionic secretomotor fibers reach the parotid salivary gland via the auriculotemporal nerve. **Submandibular Ganglion** The submandibular ganglion is a parasympathetic ganglion that lies deep to the submandibular salivary gland and is attached to the lingual nerve by small nerves . Preganglionic parasympathetic fibers reach the ganglion from the facial nerve via the chorda tympani and the lingual nerves. Postganglionic secretomotor fibers pass to the submandibular and the sublingual salivary gland.

The trigeminal nerve is thus the main sensory nerve of the head and innervates the muscles of mastication. It also tenses the soft palate and the tympanic membrane.

Abducent Nerve

This small nerve emerges from the anterior surface of the hindbrain between the pons and the medulla oblongata . It passes forward with the internal carotid artery through the cavernous sinus in the middle cranial fossa and enters the orbit through the superior orbital fissure. The abducent nerve supplies the lateral rectus muscle and is therefore responsible for turning the eye laterally.

Facial Nerve

The facial nerve has a motor root and a sensory root (**nervus intermedius**). The nerve emerges on the anterior surface of the hindbrain between the pons and the medulla oblongata. The roots pass laterally in the posterior cranial fossa with the vestibulocochlear nerve and enter the internal acoustic meatus in the petrous part of the temporal bone . At the bottom of the meatus, the nerve enters the facial canal that runs laterally through the inner ear. On reaching the medial wall of the middle ear (tympanic cavity), the nerve swells to form the sensory **geniculate ganglion** .

The nerve then bends sharply backward above the promontory and, at the posterior wall of the middle ear, bends down on the medial side of the aditus of the mastoid antrum . The nerve descends behind the pyramid and it emerges from the temporal bone through the stylomastoid foramen. The facial nerve now passes forward through the parotid gland to its distribution. **Important Branches of the Facial Nerve**

■ **Greater petrosal nerve** arises from the nerve at the geniculate ganglion . It contains preganglionic parasympathetic fibers that synapse in the pterygopalatine ganglion. The postganglionic fibers are secretomotor to the lacrimal gland and the glands of the nose and the palate. The greater petrosal nerve also contains taste fibers from the palate.

■ **Nerve to stapedius** supplies the stapedius muscle in the middle ear .

■ **Chorda tympani** arises from the facial nerve in the facial canal in the posterior wall of the middle ear . It runs forward over the medial surface of the upper part of the tympanic membrane and leaves the middle ear through the **petrotympanic fissure**, thus entering the infratemporal fossa and joining the lingual nerve. The chorda tympani contains preganglionic parasympathetic secretomotor fibers to the submandibular and the sublingual salivary glands. It also contains taste fibers from the anterior two thirds of the tongue and floor of the mouth.

■ **Posterior auricular**, the posterior belly of the digastric, and the stylohyoid nerves are **muscular branches given off by the facial nerve as it emerges from the stylomastoid foramen.** ■ **Five terminal branches to the muscles of facial expression.** These are the **temporal**, the **zygomatic**, the **buccal**, the **mandibular**, and the **cervical branches**. The facial nerve lies within the parotid salivary gland after leaving the stylomastoid foramen, and it is located between the superficial and the deep parts of the gland . Here, it gives off the terminal branches that emerge from the anterior border of the gland and pass to the muscles of the face and the scalp. **The buccal branch supplies the buccinator muscle, and the cervical branch supplies the platysma and the depressor anguli oris muscles.**

The facial nerve thus controls facial expression, salivation, and lacrimation and is a pathway for taste sensation from the anterior part of the tongue and floor of the mouth and from the palate.

Vestibulocochlear Nerve

The vestibulocochlear nerve is a sensory nerve that consists of two sets of fibers: **vestibular** and **cochlear**. They leave the anterior surface of the brain between the pons and the medulla oblongata . They cross the posterior cranial fossa and enter the internal acoustic meatus with the facial nerve . **Vestibular Fibers** The vestibular fibers are the central processes of the nerve cells of the vestibular ganglion situated in the internal acoustic meatus . The vestibular fibers originate from the vestibule and the semicircular canals; therefore, they are concerned with the sense of position and with movement of the head.

Cochlear Fibers

The cochlear fibers are the central processes of the nerve cells of the **spiral ganglion of the cochlea** . The cochlear fibers originate in the **spiral organ of Corti** and are therefore concerned with hearing.

Glossopharyngeal Nerve

*The glossopharyngeal nerve is a motor and sensory nerve . It emerges from the anterior surface of the medulla oblongata between the olive and the inferior cerebellar peduncle. It passes laterally in the posterior cranial fossa and leaves the skull by passing through the jugular foramen. The **superior and inferior sensory ganglia** are located on the nerve as it passes through the foramen. The glossopharyngeal nerve then descends through the upper part of the neck to the back of the tongue .*

Important Branches of the Glossopharyngeal Nerve

■ ■ **Tympanic branch** passes to the tympanic plexus in the middle ear . Preganglionic parasympathetic fibers for the parotid salivary gland now leave the plexus as the **lesser petrosal nerve**, and they synapse in the otic ganglion.

■ ■ **Carotid branch** contains sensory fibers from the carotid sinus (pressoreceptor mechanism for the regulation of blood pressure and the carotid body and chemoreceptor mechanism for the regulation of heart rate and respiration)

■ ■ **Nerve to the stylopharyngeus muscle**

■ ■ **Pharyngeal branches** run to the **pharyngeal plexus** and also receive branches from the vagus nerve and the sympathetic trunk.

■ ■ **Lingual branch** passes to the mucous membrane of the posterior third of the tongue (including the vallate papillae). The glossopharyngeal nerve thus assists swallowing and promotes salivation. It also conducts sensation from the pharynx and the back of the tongue and carries impulses, which influence the arterial blood pressure and respiration, from the carotid sinus and carotid body.

Vagus Nerve

*The vagus nerve is composed of motor and sensory fibers . It emerges from the anterior surface of the medulla oblongata between the olive and the inferior cerebellar peduncle. The nerve passes laterally through the posterior cranial fossa and leaves the skull through the jugular foramen. The vagus nerve has both **superior and inferior sensory ganglia**. Below the inferior ganglion, the **cranial root of the accessory nerve** joins the vagus nerve and is distributed mainly in its pharyngeal and recurrent laryngeal branches. The vagus nerve descends through the neck alongside the carotid arteries and internal jugular vein within the carotid sheath . It passes through the mediastinum of the thorax , passing behind the root of the lung, and enters the abdomen through the esophageal opening in the diaphragm.*

Important Branches of the Vagus Nerve in the Neck

■ ■ **Meningeal and auricular branches**

■ ■ **Pharyngeal branch** contains nerve fibers from the cranial part of the accessory nerve. This branch joins the pharyngeal plexus and supplies all the muscles of the pharynx (except the stylopharyngeus) and of the soft palate (except the tensor veli palatini).

■ ■ **Superior laryngeal nerve** divides into the internal and the external laryngeal nerves. The **internal laryngeal nerve** is sensory to the mucous membrane of the piriform fossa and the larynx down as far as the vocal cords. The **external laryngeal nerve** is motor and is located close to the superior thyroid artery; it supplies the cricothyroid muscle.

■ ■ **Recurrent laryngeal nerve**. On the right side, the nerve hooks around the **first part of the subclavian artery** and then ascends in the groove between the trachea and the esophagus. On the left side, the nerve hooks around the **arch of the aorta** and then ascends into the neck between the trachea and the esophagus. The nerve is closely related to the inferior thyroid artery, and it supplies all the muscles of the larynx, except the cricothyroid muscle, the mucous membrane of the larynx below the vocal cords, and the mucous membrane of the upper part of the trachea.

■ ■ **Cardiac branches** (two or three) arise in the neck, descend into the thorax, and end in the cardiac plexus. The vagus nerve thus innervates the heart and great vessels within the thorax; the larynx, trachea, bronchi, and lungs; and much of the alimentary tract from the pharynx to the splenic flexure of the colon. It also supplies glands associated with the alimentary tract, such as the liver and pancreas. The vagus nerve has the most extensive distribution of all the cranial nerves and supplies the aforementioned structures with afferent and efferent fibers.

Accessory Nerve

The accessory nerve is a motor nerve. It consists of a cranial root (part) and a spinal root (part).

Cranial Root

The cranial root emerges from the anterior surface of the medulla oblongata between the olive and the inferior cerebellar peduncle. The nerve runs laterally in the posterior cranial fossa and joins the spinal root.

Spinal Root

The spinal root arises from nerve cells in the anterior gray column (horn) of the upper five segments of the cervical part of the spinal cord. The nerve ascends alongside the spinal cord and enters the skull through the

foramen magnum. It then turns laterally to join the cranial root. The two roots unite and leave the skull through the jugular foramen. The roots then separate: The cranial root joins the vagus nerves and is distributed in its branches to the muscles of the soft palate and pharynx (via the pharyngeal plexus) and to the muscles of the larynx (except the cricothyroid muscle). The spinal root runs downward and laterally and enters the deep surface of the sternocleidomastoid muscle, which it supplies, and then crosses the posterior triangle of the neck to supply the trapezius muscle.

The accessory nerve thus brings about movements of the soft palate, pharynx, and larynx and controls the movements of the sternocleidomastoid and trapezius muscles, two large muscles in the neck.

Hypoglossal Nerve

The hypoglossal nerve is a motor nerve. It emerges on the anterior surface of the medulla oblongata between the pyramid and the olive, crosses the posterior cranial fossa, and leaves the skull through the hypoglossal canal. The nerve then passes downward and forward in the neck and crosses the internal and external carotid arteries to reach the tongue. In the upper part of its course, it is joined by C1 fibers from the cervical plexus.

Important Branches of the Hypoglossal Nerve

■ ■ **Meningeal branch**

■ ■ **Descending branch** (C1 fibers) passes downward and joins the **descending cervical nerve** (C2 and 3) to form the **ansa cervicalis**. Branches from this loop supply the omohyoid, the sternohyoid, and the sternothyroid muscles.

■ ■ **Nerve to the thyrohyoid muscle (C1)**

■ ■ **Muscular branches to all the muscles of the tongue** except the palatoglossus (pharyngeal plexus)

■ ■ **Nerve to the geniohyoid muscle (C1)**. The hypoglossal nerve thus innervates the muscles of the tongue (except the palatoglossus)