

11

Cranial Nerve Nuclei

CHAPTER OBJECTIVES

- To learn the basic information regarding the motor and sensory nuclei of the cranial nerves, including their locations and central connections
- Understand the functional ramifications of lesions to cranial nerve nuclei versus damage of the cranial nerve proper

A 49-year-old man wakes up one morning to find the right side of his face paralyzed. When examined by his local medical practitioner, he is found to have complete paralysis of the entire right side of the face. He is also found to have severe hypertension. The patient talks with slightly slurred speech. The physician tells the patient that he has suffered a mild stroke, and he is admitted to the hospital.

The patient is later seen by a neurologist who disagrees with the diagnosis. The original physician grouped together the facial paralysis, the slurred speech, and the hypertension and, in the absence of other findings, made the incorrect diagnosis of cerebral hemorrhage. A lesion of the corticonuclear fibers on one side of the brain

will cause paralysis only of the muscles of the lower part of the opposite side of the face. This patient has complete paralysis of the entire right side of the face, which could only be caused by a lesion of the lower motor neuron. The correct diagnosis was Bell palsy, an inflammation of the connective tissue sheath of the facial nerve, which temporarily interfered with the functions of the axons of the right facial nerve. This case provides a good example of how knowledge of the central connections of a cranial nerve enables a physician to make the correct diagnosis.

The cranial nerves are commonly damaged by trauma or disease, and testing for their integrity forms part of every physical examination.

CRANIAL NERVES

The 12 pairs of cranial nerves (CNs) leave the brain and pass through foramina and fissures in the skull. All the nerves are distributed in the head and neck, except CN X, which also supplies structures in the thorax and abdomen. The CNs are named as follows:

1. Olfactory
2. Optic
3. Oculomotor
4. Trochlear
5. Trigeminal
6. Abducens
7. Facial
8. Vestibulocochlear
9. Glossopharyngeal
10. Vagus
11. Accessory
12. Hypoglossal

See Atlas Plates 1, 6, and 8.

CRANIAL NERVE ORGANIZATION

The olfactory, optic, and vestibulocochlear nerves are entirely sensory. The oculomotor, trochlear, abducens, accessory, and hypoglossal nerves are entirely motor. The trigeminal, facial, glossopharyngeal, and vagus nerves are both sensory and motor nerves. The letter symbols commonly used to indicate the functional components of each cranial nerve are shown in Table 11-1. The cranial nerves have central motor and/or sensory nuclei within the brain and peripheral nerve fibers that emerge from the brain and exit from the skull to reach their effector or sensory organs.

The different components of the cranial nerves, their functions, and the openings in the skull through which the nerves leave the cranial cavity are summarized in Table 11-2.

Cranial Nerve Motor Nuclei

The motor nuclei of the cranial nerves receive impulses from the cerebral cortex through the corticonuclear

Table 11-1 The Letter Symbols Commonly Used to Indicate the Functional Components of Each Cranial Nerve

Component	Function	Letter Symbols
Afferent Fibers	Sensory	
General somatic afferent	General sensations	GSA
Special somatic afferent	Hearing, balance, vision	SSA
General visceral afferent	Viscera	GVA
Special visceral afferent	Smell, taste	SVA
Efferent Fibers		
General somatic efferent	Somatic striated muscles	GSE
General visceral efferent	Glands and smooth muscles (parasympathetic innervation)	GVE
Special visceral efferent	Branchial arch striated muscles	SVE

Table 11-2 Cranial Nerves

Number	Name	Components ^a	Function	Opening in Skull
I	Olfactory	Sensory (SVA)	Smell	Openings in cribriform plate of ethmoid
II	Optic	Sensory (SSA)	Vision	Optic canal
III	Oculomotor	Motor (GSE, GVE)	Raises upper eyelid, turns eyeball upward, downward, and medially; constricts pupil; accommodates eye	Superior orbital fissure
IV	Trochlear	Motor (GSE)	Assists in turning eyeball downward and laterally	Superior orbital fissure
V	Trigeminal ^b			
	Ophthalmic division	Sensory (GSA)	Cornea, skin of forehead, scalp, eyelids, and nose; also mucous membrane of paranasal sinuses and nasal cavity	Superior orbital fissure
	Maxillary division	Sensory (GSA)	Skin of face over maxilla; teeth of upper jaw; mucous membrane of nose, the maxillary sinus, and palate	Foramen rotundum
	Mandibular division	Motor (SVE)	Muscles of mastication, mylohyoid, anterior belly of digastric, tensor veli palatini, and tensor tympani	Foramen ovale
		Sensory (GSA)	Skin of cheek, skin over mandible and side of head, teeth of lower jaw and temporomandibular joint; mucous membrane of mouth and anterior part of tongue	
VI	Abducent	Motor (GSE)	Lateral rectus muscle turns eyeball laterally	Superior orbital fissure
VII	Facial	Motor (SVE)	Muscles of face and scalp, stapedius muscle, posterior belly of digastric, and stylohyoid muscles	Internal acoustic meatus, facial canal, stylomastoid foramen
		Sensory (SVA)	Taste from anterior two-thirds of tongue, from floor of mouth and palate	
		Secretomotor (GVE) parasympathetic	Submandibular and sublingual salivary glands, the lacrimal gland, and glands of nose and palate	

(continued)

Table 11-2 Cranial Nerves (*Continued*)

Number	Name	Components ^a	Function	Opening in Skull
VIII	Vestibulocochlear			
	Vestibular	Sensory (SSA)	From utricle and saccule and semicircular canals—position and movement of head	Internal acoustic meatus
	Cochlear	Sensory (SSA)	Organ of Corti—hearing	
IX	Glossopharyngeal	Motor (SVE)	Stylopharyngeus muscle—assists swallowing	Jugular foramen
		Secretomotor (GVE) parasympathetic	Parotid salivary gland	
		Sensory (GVA, SVA, GSA)	General sensation and taste from posterior third of tongue and pharynx; carotid sinus (baroreceptor); and carotid body (chemoreceptor)	
X	Vagus	Motor (GVE, SVE) Sensory (GVA, SVA, GSA)	Heart and great thoracic blood vessels; larynx, trachea, bronchi, and lungs; alimentary tract from pharynx to splenic flexure of colon; liver, kidneys, and pancreas	Jugular foramen
XI	Accessory			
	Cranial root	Motor (SVE)	Muscles of soft palate (except tensor veli palatini), pharynx (except stylopharyngeus), and larynx (except cricothyroid) in branches of vagus	Jugular foramen
	Spinal root	Motor (SVE)	Sternocleidomastoid and trapezius muscles	
XII	Hypoglossal	Motor (GSE)	Muscles of tongue (except palatoglossus) controlling its shape and movement	Hypoglossal canal

^aThe letter symbols are explained in Table 11-1.

^bThe trigeminal nerve also carries proprioceptive impulses from the muscles of mastication and the facial and extraocular muscles.

(corticobulbar) fibers. These fibers originate from the pyramidal cells in the inferior part of the precentral gyrus (area 4) and from the adjacent part of the postcentral gyrus. The corticonuclear fibers descend through the **corona radiata** and the **genu of the internal capsule**. They pass through the midbrain just medial to the corticospinal fibers in the **basis pedunculi** and end by synapsing either directly with the lower motor neurons within the cranial nerve nuclei or indirectly through the **internuncial neurons**. The corticonuclear fibers thus constitute the **first-order neuron** of the descending pathway, the internuncial neuron constitutes the **second-order neuron**, and the lower motor neuron constitutes the **third-order neuron**.

The majority of the corticonuclear fibers to the motor cranial nerve nuclei cross the median plane before reaching the nuclei. Bilateral connections are present for all the cranial motor nuclei except for part of the facial nucleus that supplies the muscles of the lower part of the face and a part of the hypoglossal nucleus that supplies the genioglossus muscle.

Somatic Motor and Branchiomotor Nuclei

The somatic motor and branchiomotor nerve fibers of a cranial nerve are the axons of nerve cells situated within

the brain. These nerve cell groups form motor nuclei and innervate striated muscle. Each nerve cell with its processes is referred to as a **lower motor neuron**. Such a nerve cell is, therefore, equivalent to the motor cells in the anterior gray columns of the spinal cord.

General Visceral Motor Nuclei

The general visceral motor nuclei form the cranial outflow of the parasympathetic portion of the autonomic nervous system. They are the **Edinger–Westphal nucleus** of the oculomotor nerve, the **superior salivatory** and **lacrimal nuclei** of the facial nerve, the **inferior salivatory nucleus** of the glossopharyngeal nerve, and the **dorsal motor nucleus** of the vagus. These nuclei receive numerous afferent fibers, including descending pathways from the hypothalamus.

Cranial Nerve Sensory Nuclei

Sensory nuclei of the cranial nerves include somatic and visceral afferent nuclei. The sensory or afferent parts of a cranial nerve are the axons of nerve cells outside the brain and are situated in ganglia on the nerve trunks (equivalent to posterior root ganglion of a spinal nerve) or may be situated in a sensory organ, such as the nose, eye, or ear. These cells and their processes

form the **first-order neuron**. The central processes of these cells enter the brain and terminate by synapsing with cells forming the sensory nuclei. These cells and their processes form the **second-order neuron**. Axons from these nuclear cells now cross the midline and ascend to other sensory nuclei, such as the thalamus, where they synapse. The nerve cells of these nuclei form the **third-order neuron**, and their axons terminate in the cerebral cortex.

OLFACTORY NERVES (CRANIAL NERVE I)

The olfactory nerves arise from the olfactory receptor nerve cells in the olfactory mucous membrane located in the upper part of the nasal cavity above the level of the superior concha (Fig. 11-1). The **olfactory receptor cells** are scattered among supporting cells. Each receptor cell consists of a small bipolar nerve cell with

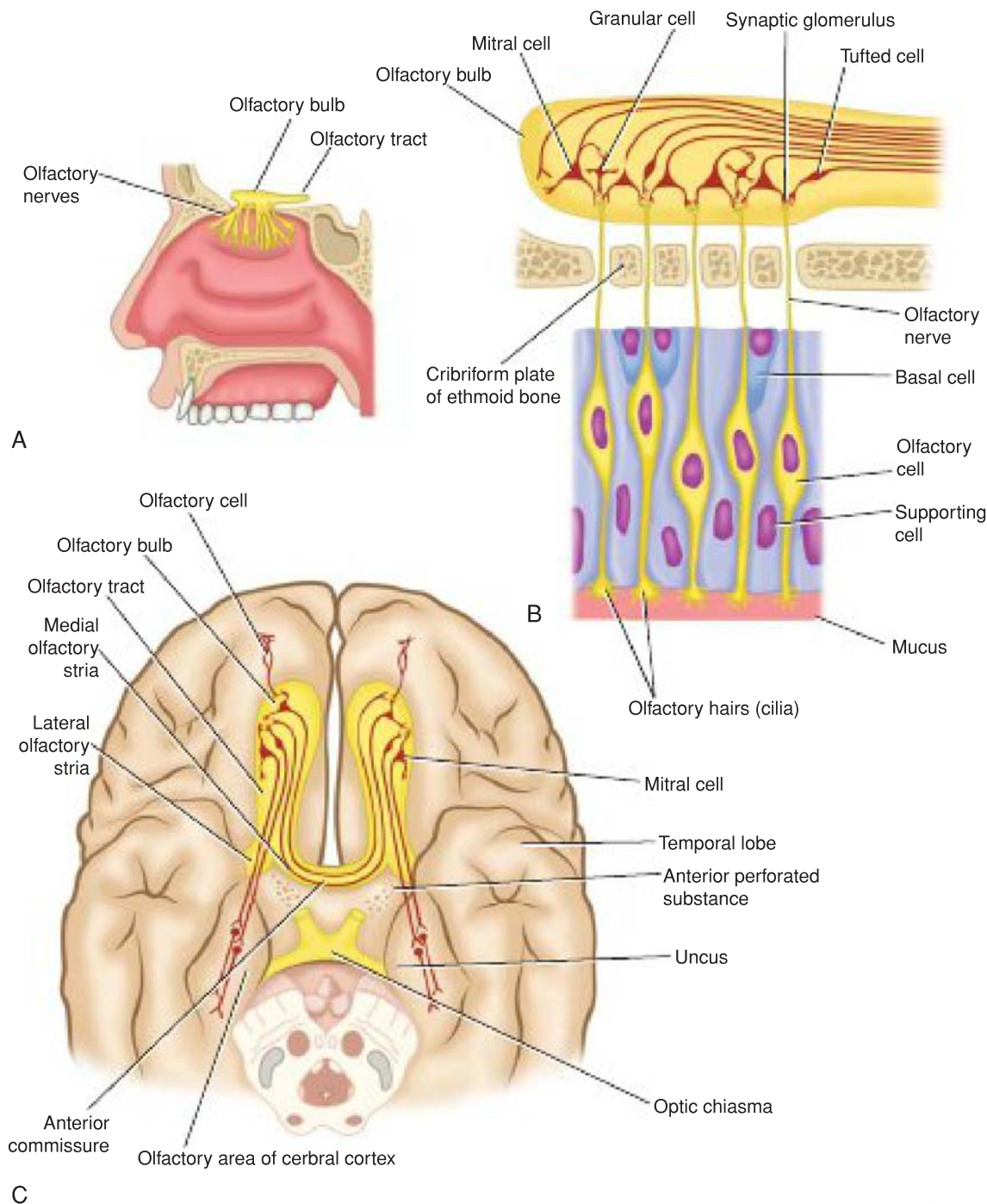


Figure 11-1 **A:** Distribution of olfactory nerves on the lateral wall of the nose. **B:** Connections between the olfactory cells and the neurons of the olfactory bulb. **C:** Connections between the olfactory cell and the rest of the olfactory system.

a coarse peripheral process that passes to the surface of the membrane and a fine central process. From the coarse peripheral process, a number of short cilia arise, the **olfactory hairs**, which project into the mucus covering the surface of the mucous membrane. These projecting hairs react to odors in the air and stimulate the olfactory cells.

The fine central processes form the **olfactory nerve fibers** (see Fig. 11-1A,B). Bundles of these nerve fibers pass through the openings of the cribriform plate of the ethmoid bone to enter the olfactory bulb. The olfactory nerve fibers are unmyelinated and are covered with Schwann cells.

Olfactory Bulb

This ovoid structure possesses several types of nerve cells, the largest of which is the **mitral cell** (see Fig. 11-1C). The incoming olfactory nerve fibers synapse with the dendrites of the mitral cells and form rounded areas known as **synaptic glomeruli**. Smaller nerve cells, called **tufted cells** and **granular cells**, also synapse with the mitral cells. The olfactory bulb, in addition, receives axons from the contralateral olfactory bulb through the olfactory tract.

Olfactory Tract

This narrow band of white matter runs from the posterior end of the olfactory bulb beneath the inferior surface of the frontal lobe of the brain (see Fig. 11-1B). It consists of the axons of the mitral and tufted cells of the bulb and some centrifugal fibers from the opposite olfactory bulb.

As the olfactory tract reaches the **anterior perforated substance**, it divides into **medial** and **lateral olfactory striae**. The lateral stria carries the axons to the **olfactory area of the cerebral cortex**, namely, the **periamygdaloid** and **prepiriform areas** (see Fig. 11-1C). The medial olfactory stria carries the fibers that cross the median plane in the anterior commissure to pass to the olfactory bulb of the opposite side.

The periamygdaloid and prepiriform areas of the cerebral cortex are often known as the **primary olfactory cortex**. The **entorhinal area (area 28)** of the parahippocampal gyrus, which receives numerous connections from the primary olfactory cortex, is called the **secondary olfactory cortex**. These areas of the cortex are responsible for the appreciation of olfactory sensations. Note that in contrast to all other sensory pathways, the olfactory afferent pathway has only two neurons and reaches the cerebral cortex without synapsing in one of the thalamic nuclei.

The primary olfactory cortex sends nerve fibers to many other centers within the brain to establish connections for emotional and autonomic responses to olfactory sensations.

OPTIC NERVE (CRANIAL NERVE II)

The fibers of the optic nerve are the axons of the cells in the **ganglionic layer** of the retina. They converge on

the **optic disc** and exit from the eye, about 3 or 4 mm to the nasal side of its center, as the optic nerve (Fig. 11-2). The fibers of the optic nerve are myelinated, but the sheaths are formed from oligodendrocytes rather than Schwann cells, since the optic nerve is comparable to a tract within the central nervous system.

The optic nerve leaves the orbital cavity through the optic canal and unites with the optic nerve of the opposite side to form the **optic chiasma**.

Optic Chiasma

The optic chiasma is situated at the junction of the anterior wall and floor of the third ventricle. Its antero-lateral angles are continuous with the optic nerves, and the posterolateral angles are continuous with the optic tracts. In the chiasma, the fibers from the nasal (medial) half of each retina, including the nasal half of the **macula**, cross the midline and enter the optic tract of the opposite side, while the fibers from the temporal (lateral) half of each retina, including the temporal half of the **macula**, pass posteriorly in the optic tract of the same side.

Optic Tract

The optic tract emerges from the optic chiasma and passes posterolaterally around the cerebral peduncle. Most of the fibers now terminate by synapsing with nerve cells in the **lateral geniculate body**, which is a small projection from the posterior part of the thalamus. A few of the fibers pass to the **pretectal nucleus** and the **superior colliculus** of the midbrain and are concerned with light reflexes (Fig. 11-3).

Lateral Geniculate Body

The lateral geniculate body is a small, oval swelling projecting from the **pulvinar of the thalamus**. It consists of six layers of cells, on which synapse the axons from the optic tract. The axons of the nerve cells within the geniculate body leave it to form the **optic radiation** (see Fig. 11-2).

Optic Radiation

The fibers of the optic radiation are the axons of the nerve cells of the lateral geniculate body. The tract passes posteriorly through the retrolenticular part of the **internal capsule** and terminates in the **visual cortex (area 17)**, which occupies the upper and lower lips of the calcarine sulcus on the medial surface of the cerebral hemisphere. The visual association cortex (areas 18 and 19) is responsible for recognition of objects and perception of color.

Visual Pathway and Binocular Vision Neurons

Four neurons conduct visual impulses to the visual cortex: (1) **rods** and **cones**, which are specialized receptor neurons in the retina; (2) **bipolar neurons**, which connect the rods and cones to the ganglion cells; (3) **ganglion**

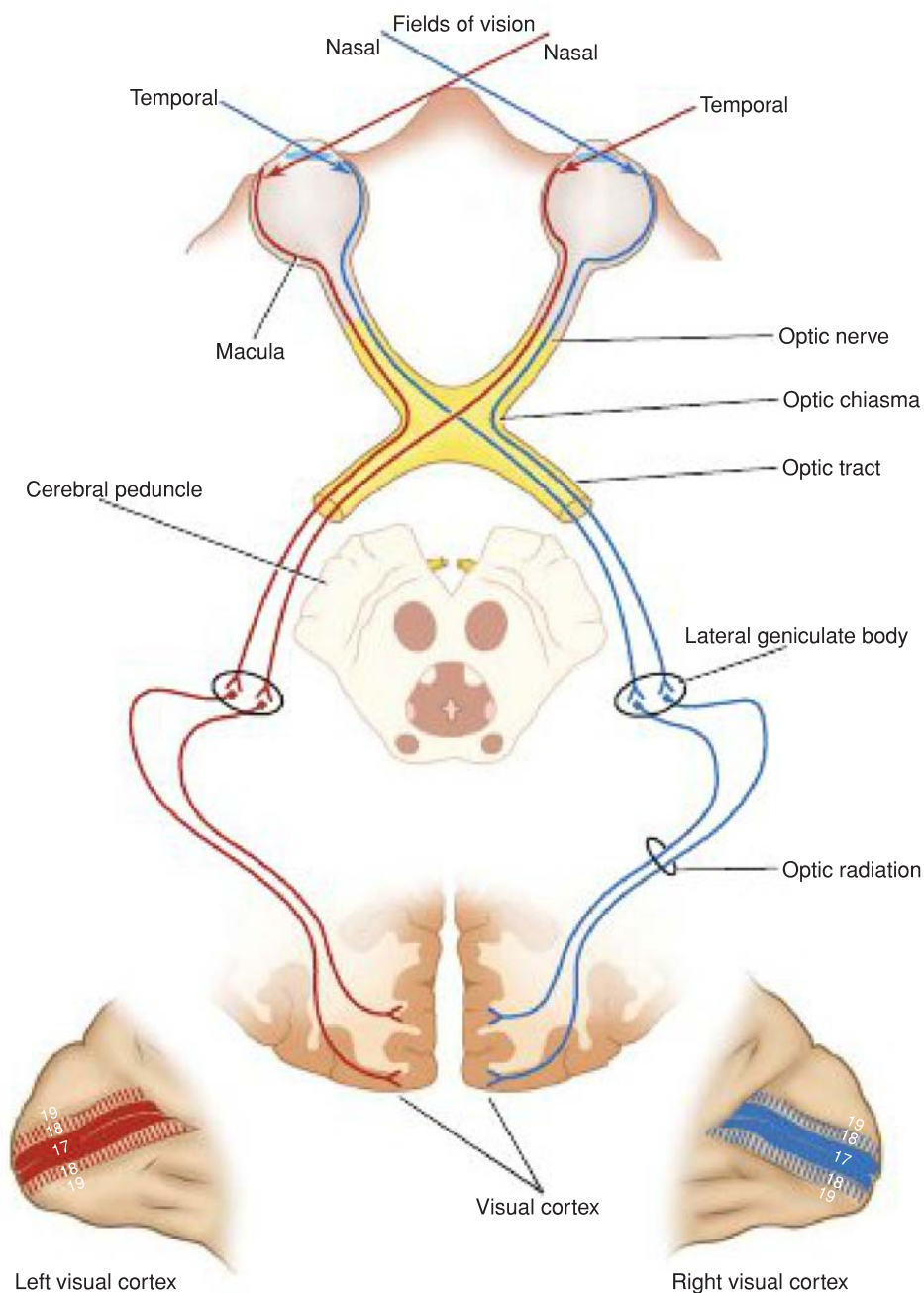


Figure 11-2 Optic pathway.

cells, whose axons pass to the lateral geniculate body; and (4) **neurons of the lateral geniculate body**, whose axons pass to the cerebral cortex.

In binocular vision, the right and left fields of vision are projected on portions of both retinæ. The image of an object in the right field of vision is projected on the nasal half of the right retina and the temporal half of the left retina. In the optic chiasma, the axons from these two retinal halves are combined to form the left optic tract. The lateral geniculate body neurons now project the complete right field of vision on the visual cortex of the left hemisphere and the left visual field on the visual cortex of the right hemisphere. The lower retinal quadrants (upper field of vision) project on the lower wall of the calcarine sulcus, while the upper

retinal quadrants (lower field of vision) project on the upper wall of the sulcus. Note also that the **macula lutea** is represented on the posterior part of area 17, and the periphery of the retina is represented anteriorly.

Visual Reflexes

Several unique neuronal pathways exert involuntary control over our vision for optimal visual function, protection, and cognitive processing.

Direct and Consensual Light Reflexes

If a light is shone into one eye, the pupils of both eyes normally constrict. The constriction of the pupil on which the light is shone is called the **direct light reflex**;

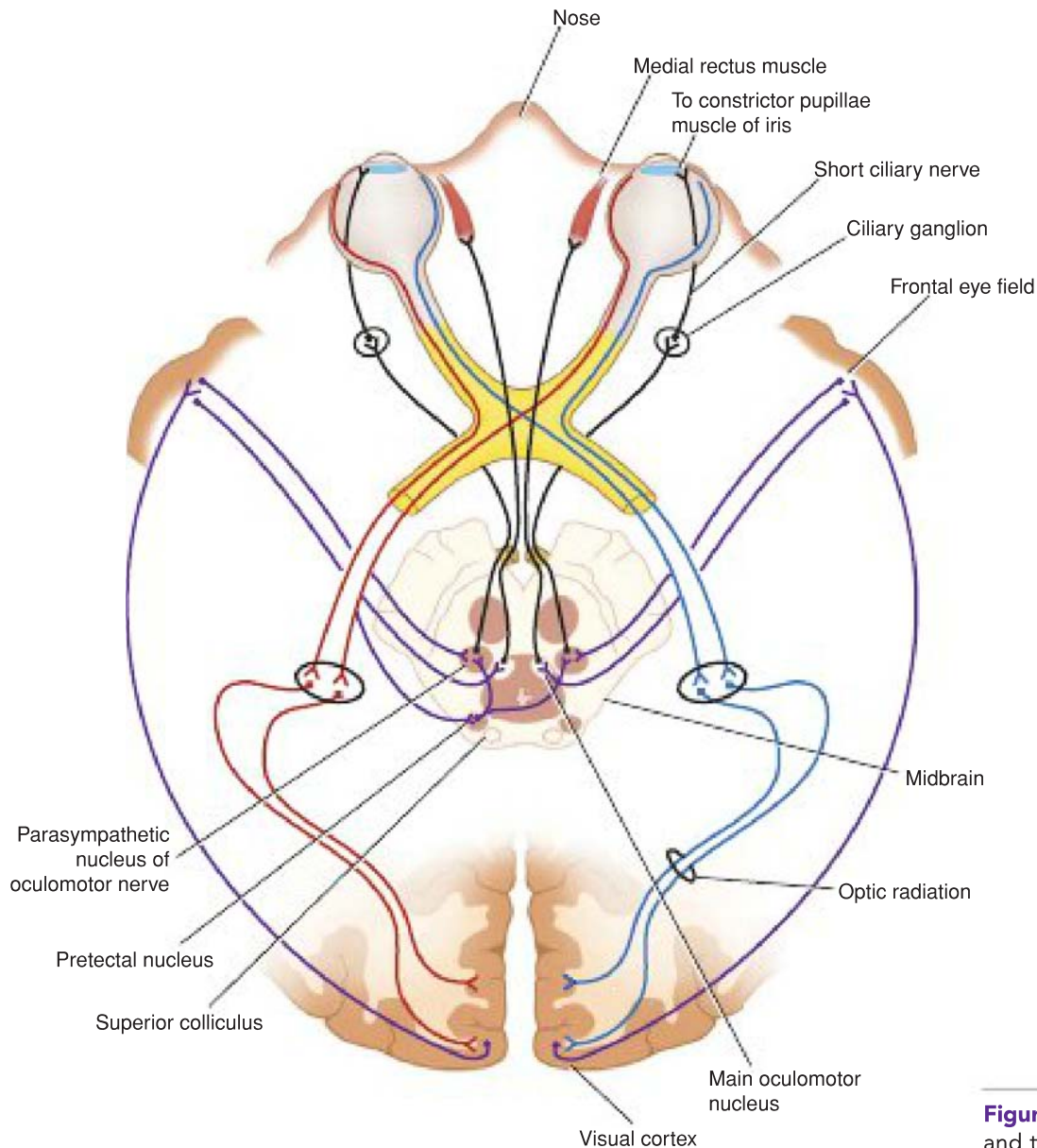


Figure 11-3 Optic pathway and the visual reflexes.

the constriction of the opposite pupil, even though no light fell on that eye, is called the **consensual light reflex** (see Fig. 11-3).

The afferent impulses travel through the optic nerve, optic chiasma, and optic tract. Here, a small number of fibers leave the optic tract and synapse on nerve cells in the **pretectal nucleus**, which lies close to the superior colliculus. The impulses are passed by axons of the pretectal nerve cells to the parasympathetic nuclei (**Edinger–Westphal nuclei**) of the third cranial nerve on **both sides**. Here, the fibers synapse and the parasympathetic nerves travel through the third cranial nerve to the **ciliary ganglion** in the orbit. Finally, post-ganglionic parasympathetic fibers pass through the **short ciliary nerves** to the eyeball and the **constrictor pupillae muscle** of the iris. Both pupils constrict in the consensual light reflex because the pretectal nucleus sends fibers to the parasympathetic nuclei on both

sides of the midbrain. The fibers that cross the median plane do so close to the cerebral aqueduct in the posterior commissure.

Accommodation Reflex

When the eyes are directed from a distant to a near object, contraction of the medial recti brings about convergence of the ocular axes; the lens thickens to increase its refractive power by contraction of the ciliary muscle; and the pupils constrict to restrict the light waves to the thickest central part of the lens. The afferent impulses travel through the optic nerve, the optic chiasma, the optic tract, the lateral geniculate body, and the optic radiation to the visual cortex. The visual cortex is connected to the eye field of the frontal cortex. From here, cortical fibers descend through the internal capsule to the oculomotor nuclei in the midbrain. The oculomotor

nerve travels to the medial recti muscles. Some of the descending cortical fibers synapse with the parasympathetic nuclei (Edinger–Westphal nuclei) of the third cranial nerve on **both sides**. Here, the fibers synapse, and the parasympathetic nerves travel through the third cranial nerve to the ciliary ganglion in the orbit. Finally, postganglionic parasympathetic fibers pass through the short ciliary nerves to the **ciliary muscle** and the **constrictor pupillae muscle** of the iris.

Corneal Reflex

Light touching of the cornea or conjunctiva results in blinking of the eyelids. Afferent impulses from the

cornea or conjunctiva travel through the ophthalmic division of the trigeminal nerve to the sensory nucleus of the trigeminal nerve (Fig. 11-4A). Internuncial neurons connect with the motor nucleus of the facial nerve on both sides through the medial longitudinal fasciculus. The facial nerve and its branches supply the orbicularis oculi muscle, which causes closure of the eyelids.

Visual Body Reflexes

The automatic scanning movements of the eyes and head that are made when reading, the automatic movement of the eyes, head, and neck toward the source of

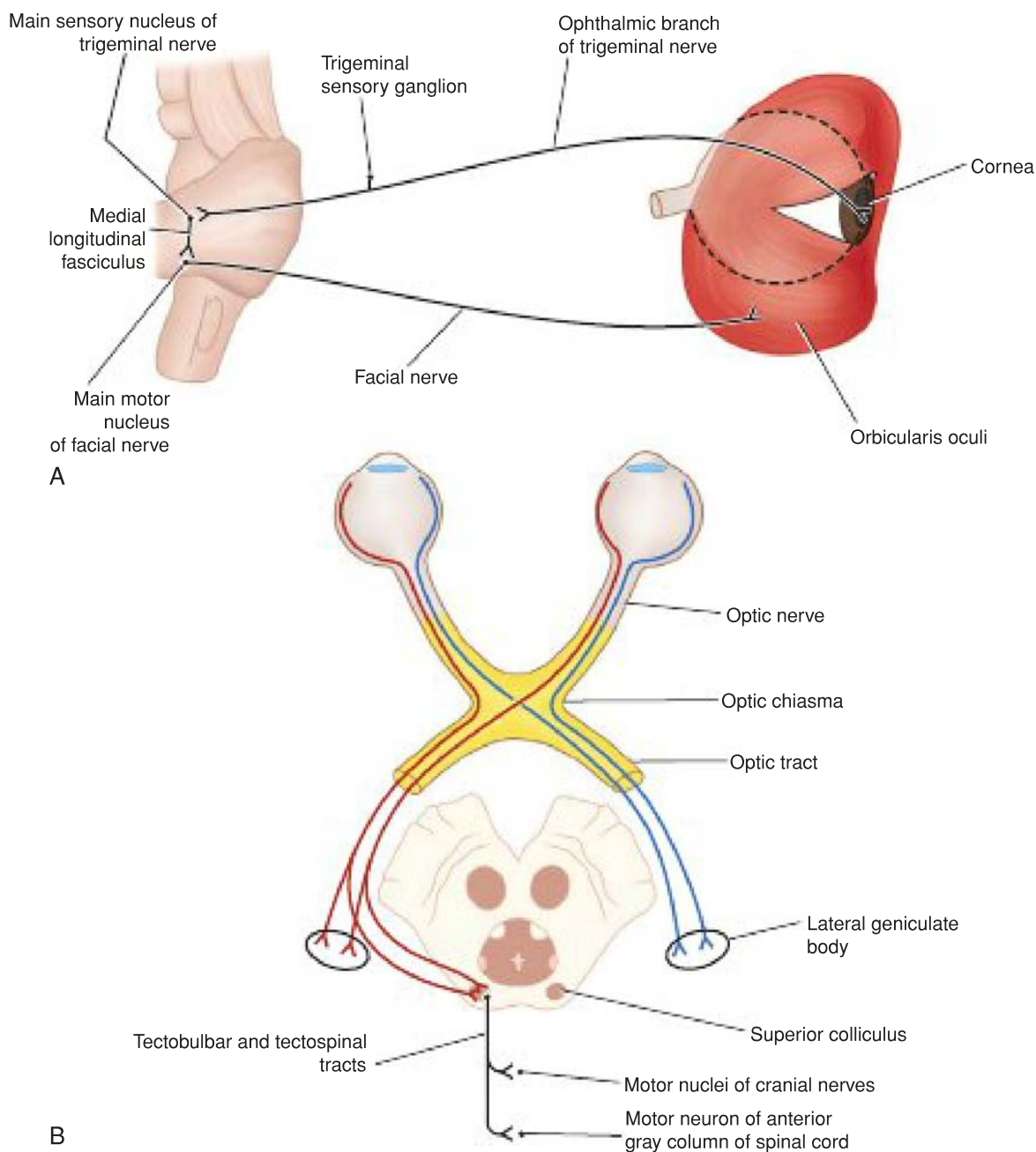


Figure 11-4 **A:** Corneal reflex. **B:** Visual body reflex.

the visual stimulus, and the protective closing of the eyes and even the raising of the arm for protection are reflex actions that involve the following reflex arcs (see Fig. 11-4B). The visual impulses follow the optic nerves, optic chiasma, and optic tracts to the superior colliculi. Here, the impulses are relayed to the tectospinal and tectobulbar (tectonuclear) tracts and to the neurons of the anterior gray columns of the spinal cord and cranial motor nuclei.

Pupillary Skin Reflex

The pupil will dilate if the skin is painfully stimulated by pinching. The afferent sensory fibers are believed to have connections with the efferent preganglionic sympathetic neurons in the lateral gray columns of the first and second thoracic segments of the spinal cord. The **white rami communicantes** of these segments pass to the sympathetic trunk, and the preganglionic fibers ascend to the superior **cervical sympathetic ganglion**. The postganglionic fibers pass through the **internal carotid plexus**, **long ciliary nerves**, and **short ciliary nerves** to the dilator pupillae muscle of the iris.

OCULOMOTOR NERVE (CRANIAL NERVE III)

The oculomotor nerve is entirely motor in function.

Oculomotor Nerve Nuclei

The oculomotor nerve has two motor nuclei: (1) the main motor nucleus and (2) the accessory parasympathetic nucleus.

The **main oculomotor nucleus** is situated in the anterior part of the gray matter that surrounds the **cerebral aqueduct of the midbrain** (Fig. 11-5). It lies at the level of the **superior colliculus**. The nucleus consists of groups of nerve cells that supply all the extrinsic muscles of the eye except the superior oblique and the lateral rectus. The outgoing nerve fibers pass anteriorly through the red nucleus and emerge on the anterior surface of the midbrain in the **interpeduncular fossa**. The main oculomotor nucleus receives corticonuclear fibers from both cerebral hemispheres. It receives tectobulbar fibers from the superior colliculus and, through this route, receives information from the visual cortex. It also receives fibers from the medial longitudinal fasciculus, by which it is connected to the nuclei of the fourth, sixth, and eighth cranial nerves.

The **accessory parasympathetic nucleus (Edinger-Westphal nucleus)** is situated posterior to the main oculomotor nucleus (see Fig. 11-5A). The axons of the nerve cells, which are preganglionic, accompany the other oculomotor fibers to the orbit. Here, they synapse in the **ciliary ganglion**, and postganglionic fibers pass through the **short ciliary nerves** to the constrictor pupillae of the iris and the ciliary muscles. The accessory parasympathetic nucleus receives corticonuclear

fibers for the accommodation reflex, and fibers from the pretectal nucleus for the direct and consensual light reflexes (see Fig. 11-3).

Oculomotor Nerve Course

The oculomotor nerve emerges on the anterior surface of the midbrain (see Fig. 11-5A). It passes forward between the posterior cerebral and the 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 extrinsic muscles of the eye: the levator palpebrae superioris, superior rectus, medial rectus, inferior rectus, and inferior oblique. It also supplies, through its branch to the ciliary ganglion and the short ciliary nerves, parasympathetic nerve fibers to the following intrinsic muscles: the constrictor pupillae of the iris and ciliary muscles.

Therefore, the oculomotor nerve is entirely motor and is responsible for lifting the upper eyelid; turning the eye upward, downward, and medially; constricting the pupil; and accommodating the eye.

TROCHLEAR NERVE (CRANIAL NERVE IV)

The trochlear nerve is entirely motor in function.

Trochlear Nerve Nucleus

The trochlear nucleus is situated in the anterior part of the gray matter that surrounds the **cerebral aqueduct of the midbrain** (Fig. 11-6). It lies inferior to the oculomotor nucleus at the level of the **inferior colliculus**. The nerve fibers, after leaving the nucleus, pass posteriorly around the central gray matter to reach the posterior surface of the midbrain.

The trochlear nucleus receives corticonuclear fibers from both cerebral hemispheres. It receives the tectobulbar fibers, which connect it to the visual cortex through the superior colliculus (see Fig. 11-6A). It also receives fibers from the **medial longitudinal fasciculus**, by which it is connected to the nuclei of the third, sixth, and eighth cranial nerves.

Trochlear Nerve Course

The trochlear nerve, the most slender of the cranial nerves and the only one to leave the posterior surface of the brainstem, emerges from the midbrain and **immediately decussates with the nerve of the opposite side**. The trochlear nerve 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 nerve supplies the superior oblique muscle of the eyeball. The trochlear nerve is entirely

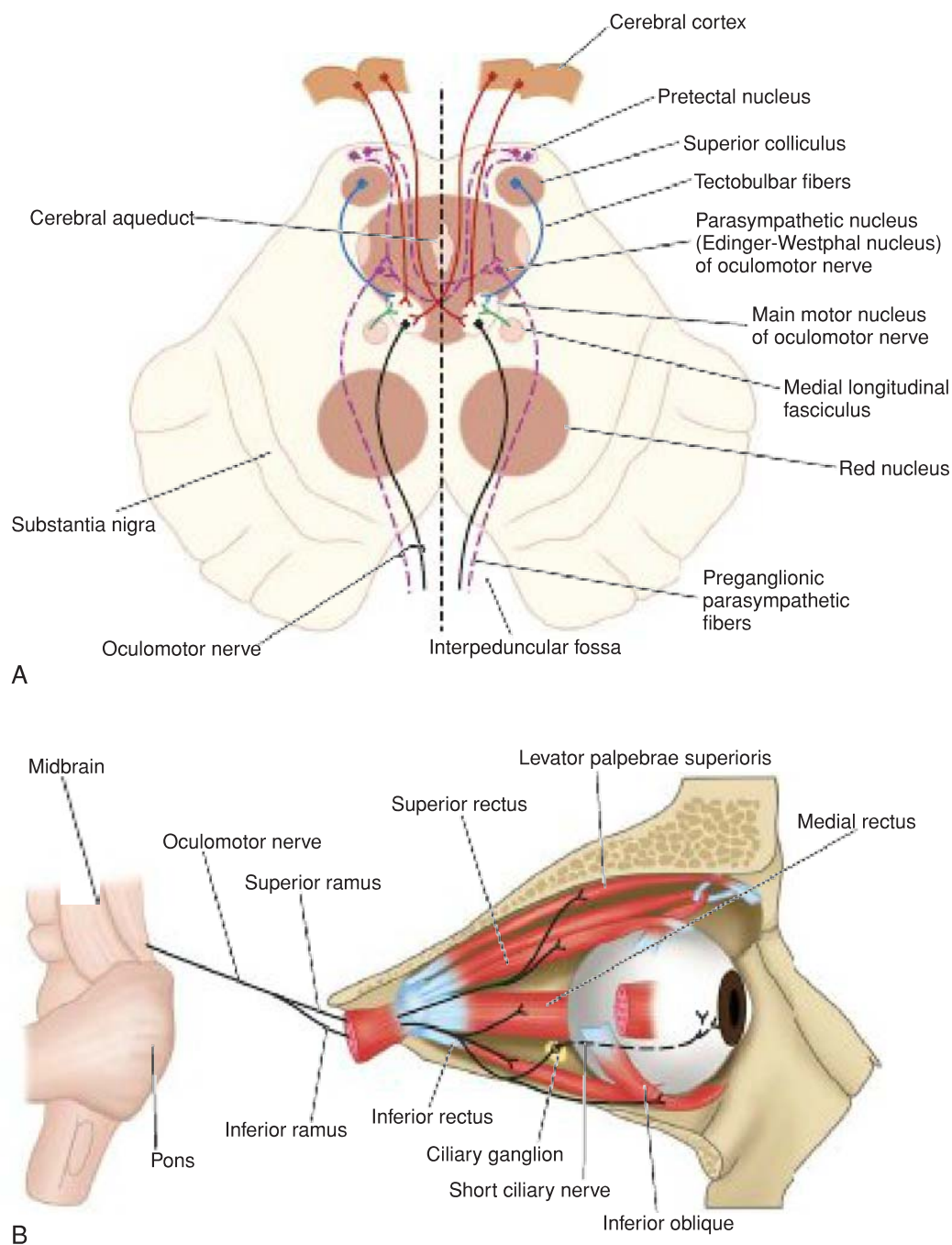


Figure 11-5 **A:** Oculomotor nerve nuclei and their central connections. **B:** The distribution of the oculomotor nerve.

motor and assists in turning the eye downward and laterally.

TRIGEMINAL NERVE (CRANIAL NERVE V)

The trigeminal nerve is the largest cranial nerve and contains both sensory and motor fibers (Fig. 11-7). It is the sensory nerve to the greater part of the head and the motor nerve to several muscles, including the muscles of mastication.

Trigeminal Nerve Nuclei

The trigeminal nerve has four nuclei: (1) the main sensory nucleus, (2) the spinal nucleus, (3) the mesencephalic nucleus, and (4) the motor nucleus.

Main Sensory Nucleus

The main sensory nucleus lies in the posterior part of the pons, lateral to the motor nucleus (see Fig. 11-7A). It is continuous below with the spinal nucleus.

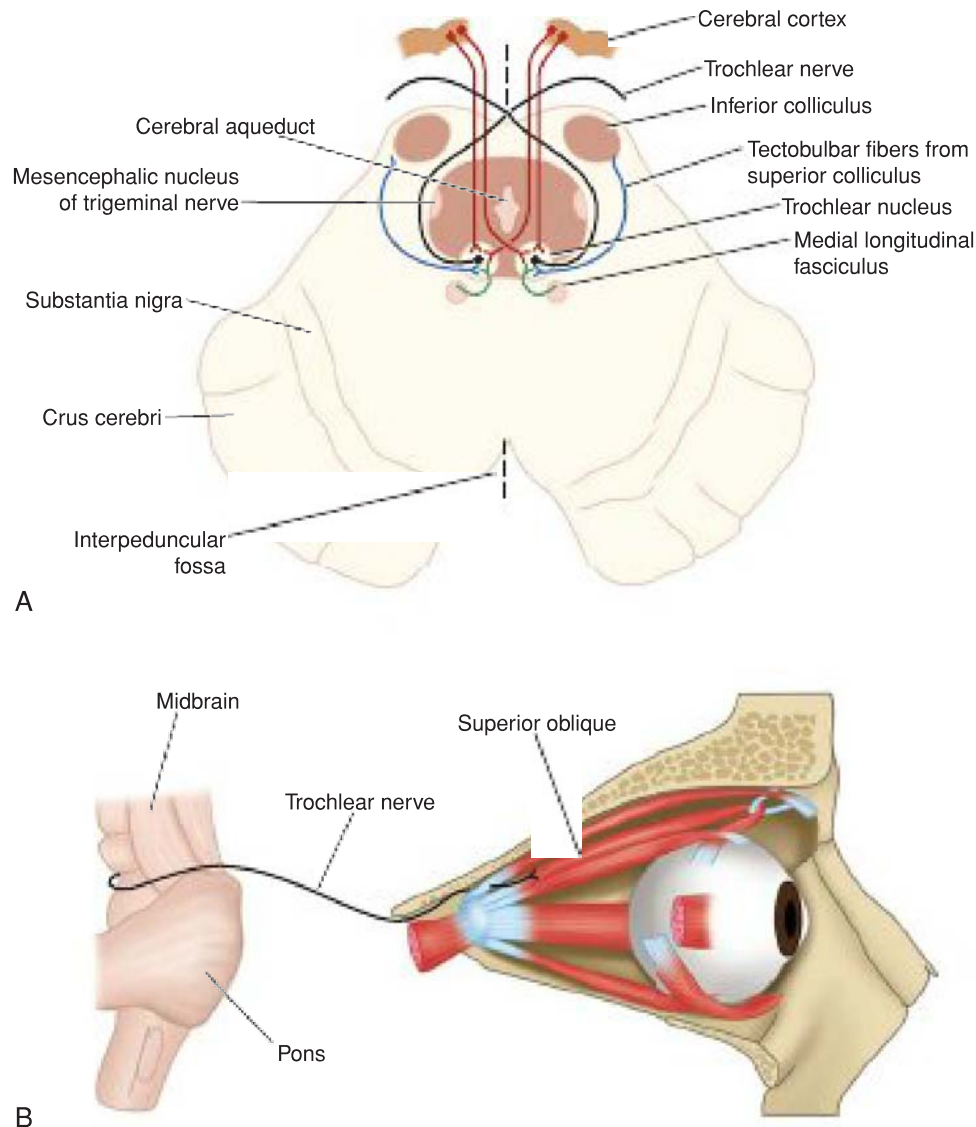


Figure 11-6 **A:** Trochlear nerve nucleus and its central connections. **B:** Distribution of the trochlear nerve.

Spinal Nucleus

The spinal nucleus is continuous superiorly with the main sensory nucleus in the pons and extends inferiorly through the whole length of the medulla oblongata and into the upper part of the spinal cord as far as the second cervical segment (see Fig. 11-7B).

Mesencephalic Nucleus

The mesencephalic nucleus is composed of a column of unipolar nerve cells situated in the lateral part of the gray matter around the cerebral aqueduct. It extends inferiorly into the pons as far as the main sensory nucleus (see Fig. 11-7).

Motor Nucleus

The motor nucleus is situated in the pons, medial to the main sensory nucleus (see Fig. 11-7).

Trigeminal Nerve Sensory Components

The sensations of pain, temperature, touch, and pressure from the skin of the face and mucous membranes travel along axons whose cell bodies are situated in the **semilunar** or **trigeminal** sensory ganglion (see Fig. 11-7B). The central processes of these cells form the large sensory root of the trigeminal nerve. About half the fibers divide into ascending and descending branches when they enter the pons; the remainder ascend or descend without division. The ascending branches terminate in the main sensory nucleus, and the descending branches terminate in the spinal nucleus. The sensations of touch and pressure are conveyed by nerve fibers that terminate in the main sensory nucleus. The sensations of pain and temperature pass to the spinal nucleus. The sensory fibers from the ophthalmic division of the trigeminal nerve terminate in the inferior part of the spinal nucleus;

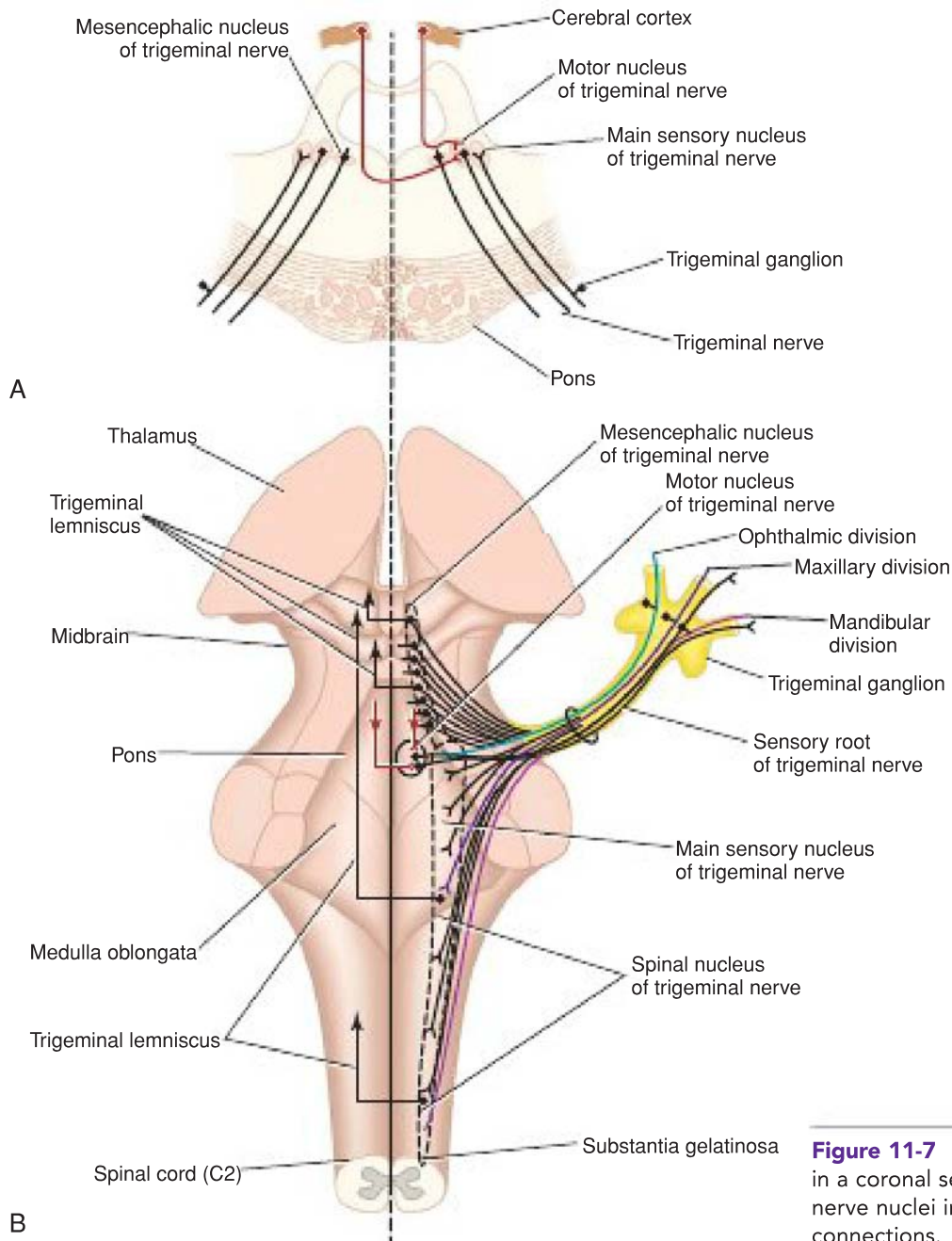


Figure 11-7 **A:** Trigeminal nerve nuclei seen in a coronal section of the pons. **B:** Trigeminal nerve nuclei in the brainstem and their central connections.

fibers from the maxillary division terminate in the middle of the spinal nucleus; and fibers from the mandibular division end in the superior part of the spinal nucleus.

Proprioceptive impulses from the muscles of mastication and from the facial and extraocular muscles are carried by fibers in the sensory root of the trigeminal nerve that have bypassed the semilunar or trigeminal ganglion. The fibers' cells of origin are the unipolar cells of the mesencephalic nucleus.

The axons of the neurons in the main sensory and spinal nuclei and the central processes of the cells in the mesencephalic nucleus now cross the median plane and ascend as the trigeminal lemniscus to terminate on

the nerve cells of the ventral posteromedial nucleus of the thalamus. The axons of these cells now travel through the internal capsule to the postcentral gyrus (areas 3, 1, and 2) of the cerebral cortex.

Trigeminal Nerve Motor Component

The motor nucleus receives corticonuclear fibers from both cerebral hemispheres (see Fig. 11-7). It also receives fibers from the reticular formation, the red nucleus, the tectum, and the medial longitudinal fasciculus. In addition, it receives fibers from the mesencephalic nucleus, thereby forming a monosynaptic reflex arc.

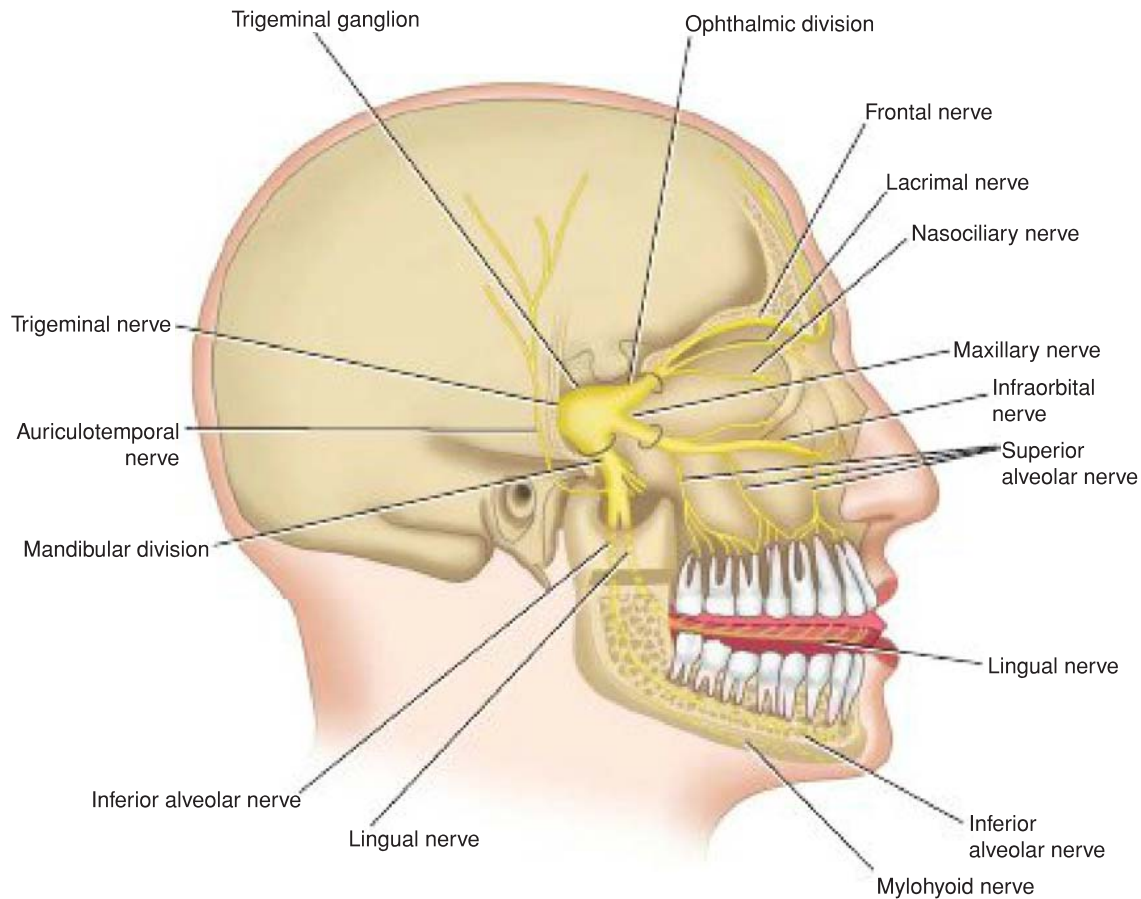


Figure 11-8 Distribution of the trigeminal nerve.

The cells of the motor nucleus give rise to the axons that form the motor root. The motor nucleus supplies the **muscles of mastication**, the **tensor tympani**, the **tensor veli palatini**, and the **mylohyoid** and the **anterior belly of the digastric muscle**.

Trigeminal Nerve Course

The trigeminal nerve leaves the anterior aspect of the pons as a small motor root and a large sensory root. The nerve passes forward out of the posterior cranial fossa and rests on the upper surface of the apex of the petrous part of the temporal bone in the middle cranial fossa. The large sensory root now expands to form the crescent-shaped **trigeminal ganglion**, which lies within a pouch of dura mater called the **trigeminal** or **Meckel cave**. The ophthalmic, maxillary, and mandibular nerves arise from the anterior border of the ganglion (Fig. 11-8). The ophthalmic nerve (V_1) contains only sensory fibers and leaves the skull through the superior orbital fissure to enter the orbital cavity. The maxillary nerve (V_2) also contains only sensory fibers and leaves the skull through the foramen rotundum. The mandibular nerve (V_3) contains both sensory and motor fibers and leaves the skull through the foramen ovale.

The sensory fibers to the skin of the face from each division supply a distinct zone (Fig. 11-9), there being

little or no overlap of the dermatomes (compared with the overlap of the dermatomes of the spinal nerves). As noted previously, the motor fibers in the mandibular division are mainly distributed to muscles of mastication.

ABDUCENS NERVE (CRANIAL NERVE VI)

The abducens nerve is a small motor nerve that supplies the **lateral rectus muscle** of the eyeball.

Abducens Nerve Nucleus

The small motor nucleus is situated beneath the floor of the upper part of the fourth ventricle, close to the midline and beneath the **colliculus facialis** (Fig. 11-10A). The nucleus receives afferent corticonuclear fibers from both cerebral hemispheres. It receives the tectobulbar tract from the superior colliculus, by which the visual cortex is connected to the nucleus. It also receives fibers from the medial longitudinal fasciculus, by which it is connected to the nuclei of the third, fourth, and eighth cranial nerves (see Fig. 11-9).

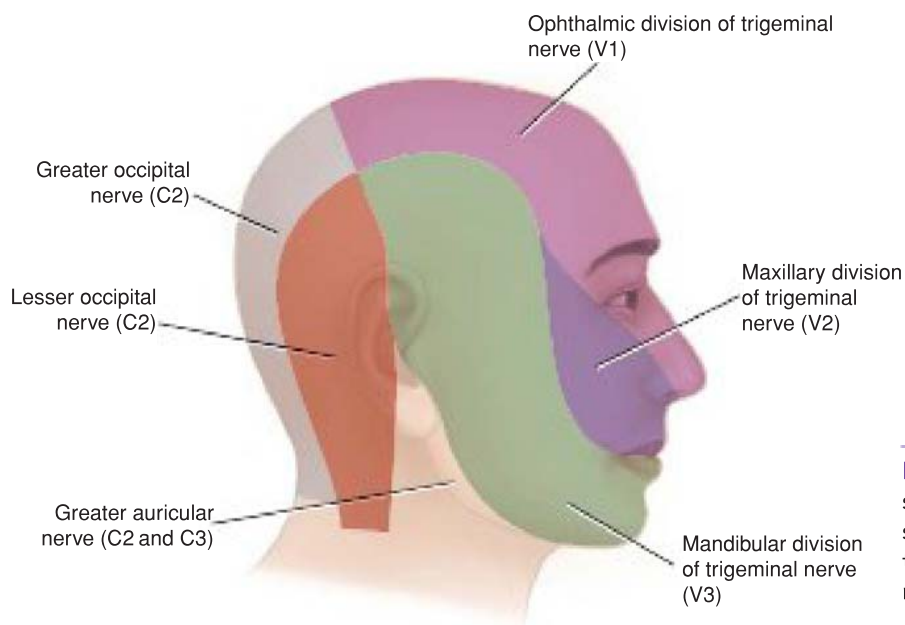


Figure 11-9 Sensory nerve supply to the skin of the head and neck. Note that the skin over the angle of the jaw is supplied by the great auricular nerve (C2 and C3) and not by branches of the trigeminal nerve.

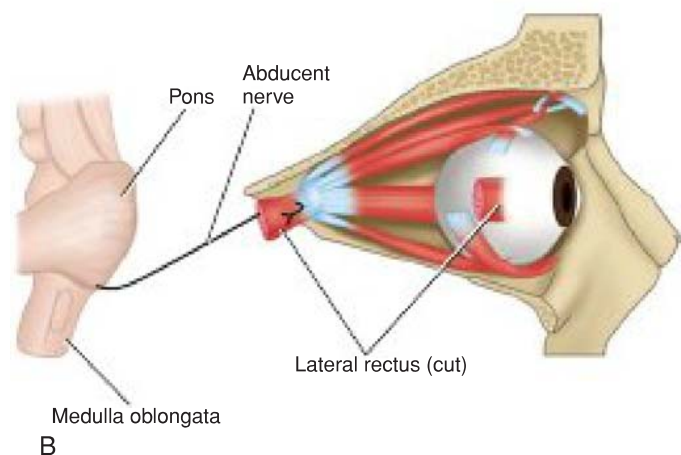
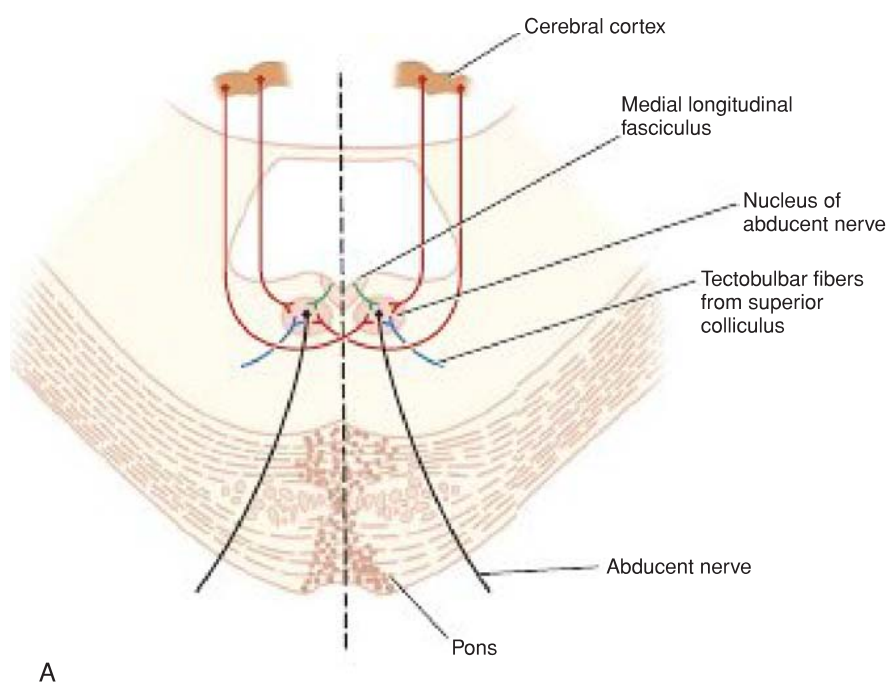


Figure 11-10 **A:** Abducens nerve nucleus and its central connections. **B:** Distribution of the abducens nerve.

Abducens Nerve Course

The fibers of the abducens nerve pass anteriorly through the pons and emerge in the groove between the lower border of the pons and the medulla oblongata (see Fig. 11-10B). It passes forward through the cavernous sinus, lying below and lateral to the internal carotid artery. The nerve then enters the orbit through the superior orbital fissure. The abducens nerve is entirely a motor nerve and supplies the lateral rectus muscle and, therefore, is responsible for turning the eye laterally.

FACIAL NERVE (CRANIAL NERVE VII)

The facial nerve is both a motor and a sensory nerve.

Facial Nerve Nuclei

The facial nerve has three nuclei: (1) the main motor nucleus, (2) the parasympathetic nuclei, and (3) the sensory nucleus.

Main Motor Nucleus

The main motor nucleus lies deep in the reticular formation of the lower part of the pons (Fig. 11-11). The part of the nucleus that supplies the muscles of the upper part of the face receives corticonuclear fibers from both cerebral hemispheres. The part of the nucleus that supplies the muscles of the lower part of the face receives only corticonuclear fibers from the opposite cerebral hemisphere.

These pathways explain the voluntary control of facial muscles. However, another involuntary pathway exists; it is separate and controls **mimetic** or **emotional changes in facial expression**. This other pathway forms part of the reticular formation (see p. 301).

Parasympathetic Nuclei

Parasympathetic nuclei lie posterolateral to the main motor nucleus. They are the **superior salivatory** and **lacrimal nuclei** (see Fig. 11-11). The superior salivatory nucleus receives afferent fibers from the hypothalamus through the **descending autonomic pathways**. Information concerning taste also is received from the **nucleus of the solitary tract** from the mouth cavity.

The lacrimal nucleus receives afferent fibers from the hypothalamus for emotional responses and from the sensory nuclei of the trigeminal nerve for reflex lacrimation secondary to irritation of the cornea or conjunctiva.

Sensory Nucleus

The sensory nucleus is the upper part of the **nucleus of the tractus solitarius** and lies close to the motor nucleus (see Fig. 11-11). Sensations of taste travel through the peripheral axons of nerve cells situated in the **geniculate ganglion** on the seventh cranial nerve. The central processes of these cells synapse on nerve cells in the nucleus. Efferent fibers cross the median plane and ascend to the ventral posteromedial nucleus of the opposite thalamus and to a number of hypothalamic nuclei. From the thalamus, the axons of the thalamic cells pass through the internal capsule and

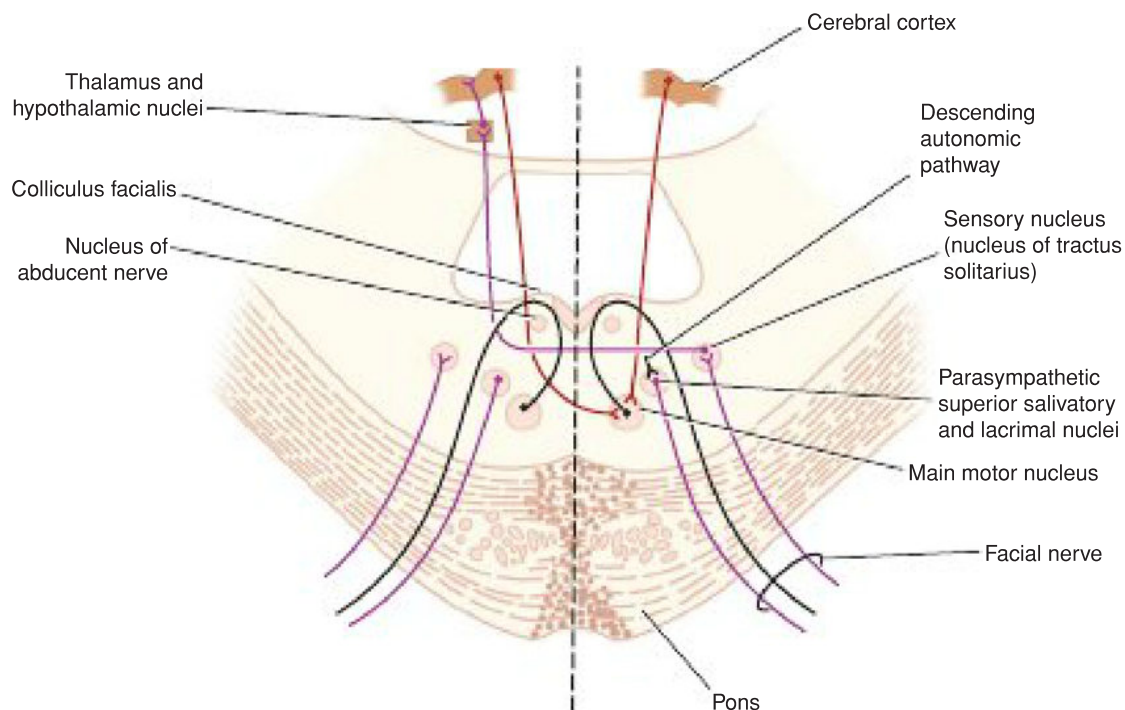


Figure 11-11 Facial nerve nuclei and their central connections.

corona radiata to end in the taste area of the cortex in the lower part of the postcentral gyrus.

Facial Nerve Course

The facial nerve consists of a motor and a sensory root. The fibers of the motor root first travel posteriorly around the medial side of the abducens nucleus (see Fig. 11-11). They then pass around the nucleus beneath the **colliculus facialis** in the floor of the fourth ventricle and, finally, pass anteriorly to emerge from the brainstem.

The sensory root (**nervus intermedius**) is formed of the central processes of the unipolar cells of the geniculate ganglion. It also contains the efferent preganglionic parasympathetic fibers from the parasympathetic nuclei.

The two roots of the facial nerve emerge from the anterior surface of the brain between the pons and the medulla oblongata. They 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 and runs laterally through the inner ear. On reaching the medial wall of the tympanic cavity, the nerve expands to form the sensory **geniculate ganglion** (Fig. 11-12) and turns sharply backward above the promontory. At the posterior wall of the tympanic cavity, the facial nerve turns downward on the medial side of the aditus to the mastoid antrum, descends behind the pyramid, and emerges from the stylomastoid foramen.

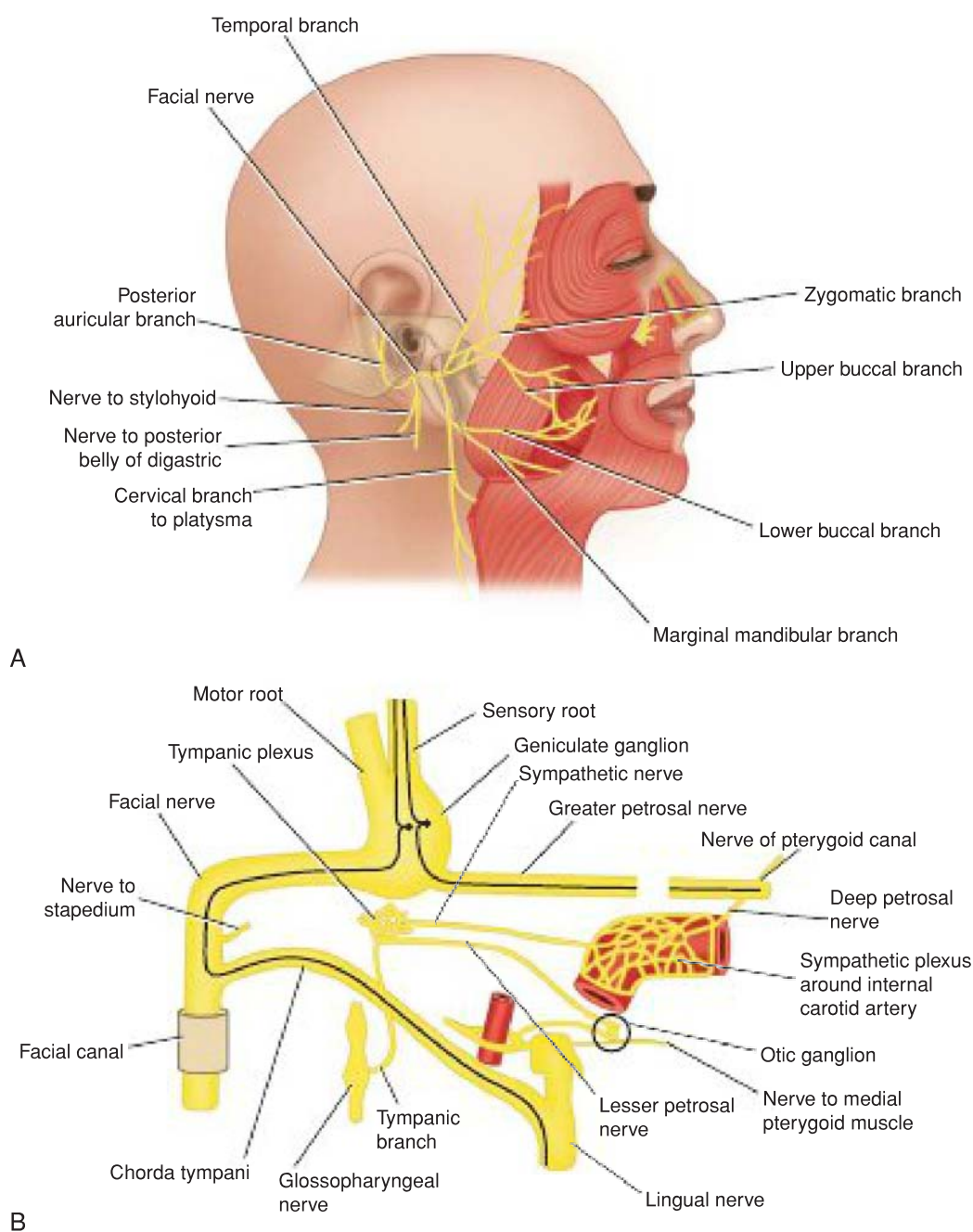


Figure 11-12 **A:** Distribution of the facial nerve. **B:** Branches of the facial nerve within the petrous part of the temporal bone; the taste fibers are shown in black. The glossopharyngeal nerve is also shown.

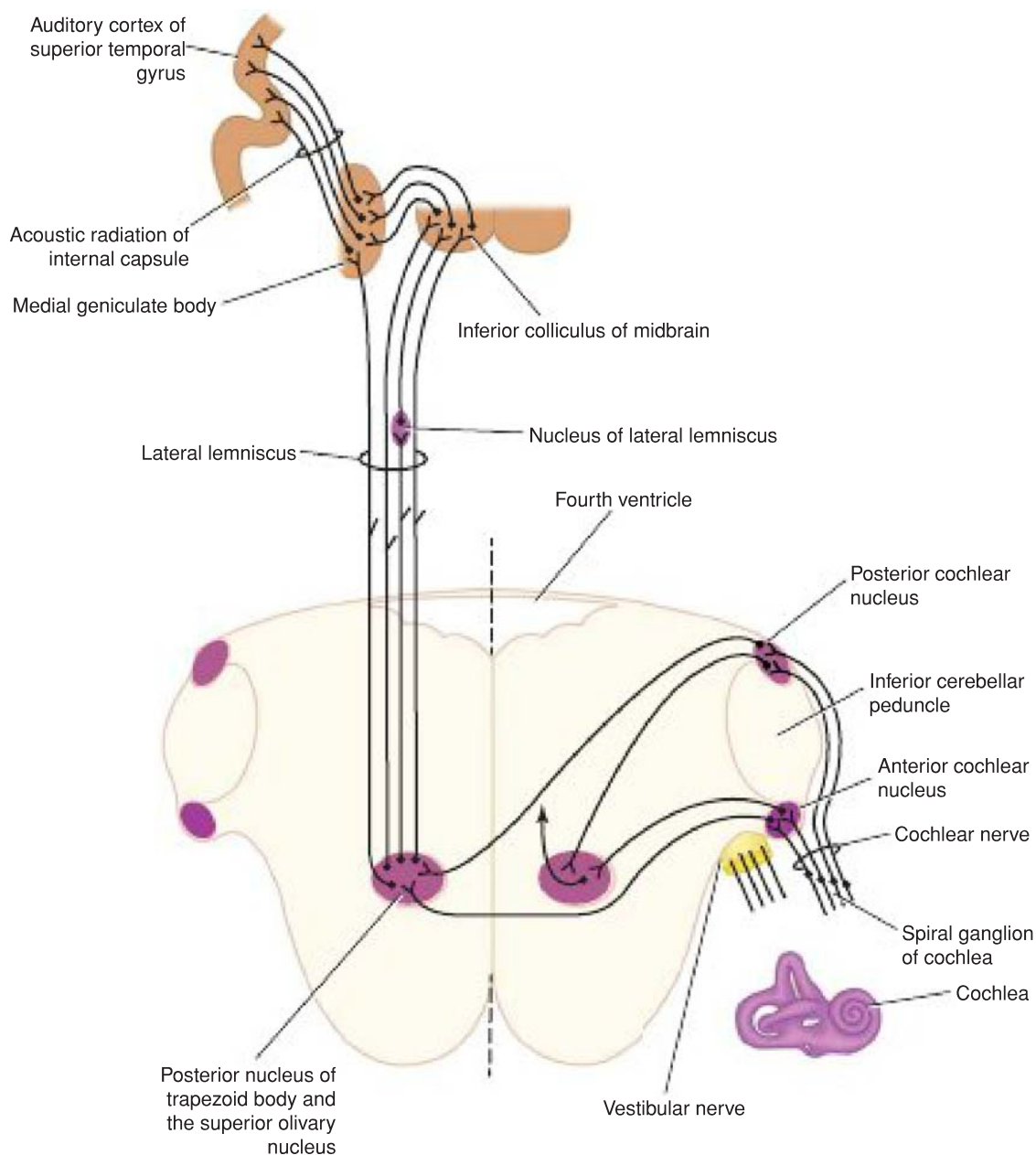


Figure 11-14 Cochlear nerve nuclei and their central connections. The descending pathways have been omitted.

cerebellum through the inferior cerebellar peduncle. Efferent fibers also descend uncrossed to the spinal cord from the lateral vestibular nucleus and form the **vestibulospinal tract**. In addition, efferent fibers pass to the nuclei of the oculomotor, trochlear, and abducens nerves through the medial longitudinal fasciculus.

These connections enable the movements of the head and the eyes to be coordinated so that visual fixation on an object can be maintained. In addition, information received from the internal ear can assist in maintaining balance by influencing the muscle tone of the limbs and trunk.

Ascending fibers also pass upward from the vestibular nuclei to the cerebral cortex, to the vestibular area

in the postcentral gyrus just above the lateral fissure. These fibers are thought to relay in the ventral posterior nuclei of the thalamus. The cerebral cortex probably serves to orient the individual consciously in space.

Cochlear Nerve

The cochlear nerve conducts nerve impulses concerned with sound from the organ of Corti in the cochlea. The fibers of the cochlear nerve are the central processes of nerve cells located in the **spiral ganglion of the cochlea** (Fig. 11-15). They enter the anterior surface of the brainstem at the lower border of the pons on the lateral side of the emerging facial nerve by the vestibular nerve

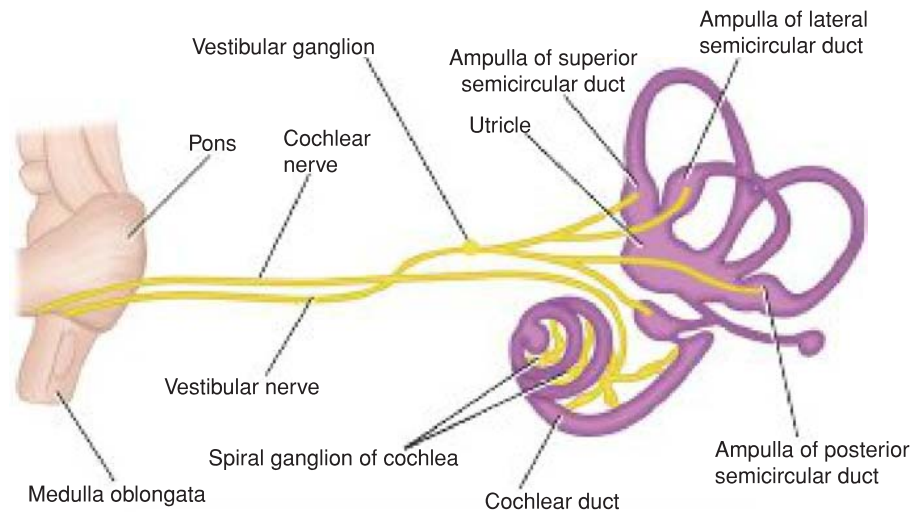


Figure 11-15 Distribution of the vestibulocochlear nerve.

(see Fig. 11-14). On entering the pons, the nerve fibers divide, with one branch entering the **posterior cochlear nucleus** and the other branch entering the **anterior cochlear nucleus**.

Cochlear Nuclei

The anterior and posterior cochlear nuclei are situated on the surface of the inferior cerebellar peduncle (see Fig. 11-14). They receive afferent fibers from the cochlea through the cochlear nerve. The cochlear nuclei send axons (second-order neuron fibers) that run medially through the pons to end in the **trapezoid body** and the olivary nucleus. Here, they are relayed in the **posterior nucleus of the trapezoid body** and the superior olivary nucleus on the same or the opposite side. The axons now ascend through the posterior part of the pons and midbrain and form a tract known as the **lateral lemniscus**. Each lateral lemniscus, therefore, consists of third-order neurons from both sides. As these fibers ascend, some of them relay in small groups of nerve cells, collectively known as the **nucleus of the lateral lemniscus**.

On reaching the midbrain, the fibers of the lateral lemniscus either terminate in the **nucleus of the inferior colliculus** or are relayed in the **medial geniculate body** and pass to the **auditory cortex** of the cerebral hemisphere through the **acoustic radiation of the internal capsule**.

The primary auditory cortex (areas 41 and 42) includes the gyrus of Heschl on the upper surface of the superior temporal gyrus. The recognition and interpretation of sounds, on the basis of past experience, take place in the secondary auditory area.

Nerve impulses from the ear are transmitted along auditory pathways on both sides of the brainstem, with more being projected along the contralateral pathway. Many collateral branches are given off to the reticular activating system of the brainstem (see p. 301). The tonotopic organization present in the organ of Corti is preserved within the cochlear nuclei, the inferior colliculi, and the primary auditory area.

Descending Auditory Pathways

Descending fibers originating in the auditory cortex and in other nuclei in the auditory pathway accompany the ascending pathway. These fibers are bilateral and end on nerve cells at different levels of the auditory pathway and on the hair cells of the organ of Corti. These fibers are believed to serve as a feedback mechanism and inhibit the reception of sound. They may also have a role in the process of auditory sharpening, suppressing some signals and enhancing others.

Vestibulocochlear Nerve Course

The vestibular and cochlear parts of the nerve leave the anterior surface of the brain between the lower border of the pons and the medulla oblongata (see Fig. 11-15). They run laterally in the posterior cranial fossa and enter the internal acoustic meatus with the facial nerve. The fibers are then distributed to the different parts of the internal ear.

GLOSSOPHARYNGEAL NERVE (CRANIAL NERVE IX)

The glossopharyngeal nerve is a motor and a sensory nerve.

Glossopharyngeal Nerve Nuclei

The glossopharyngeal nerve has three nuclei: (1) the main motor nucleus, (2) the parasympathetic nucleus, and (3) the sensory nucleus.

Main Motor Nucleus

The main motor nucleus lies deep in the reticular formation of the medulla oblongata and is formed by the superior end of the nucleus ambiguus (Fig. 11-16). It receives corticonuclear fibers from both cerebral

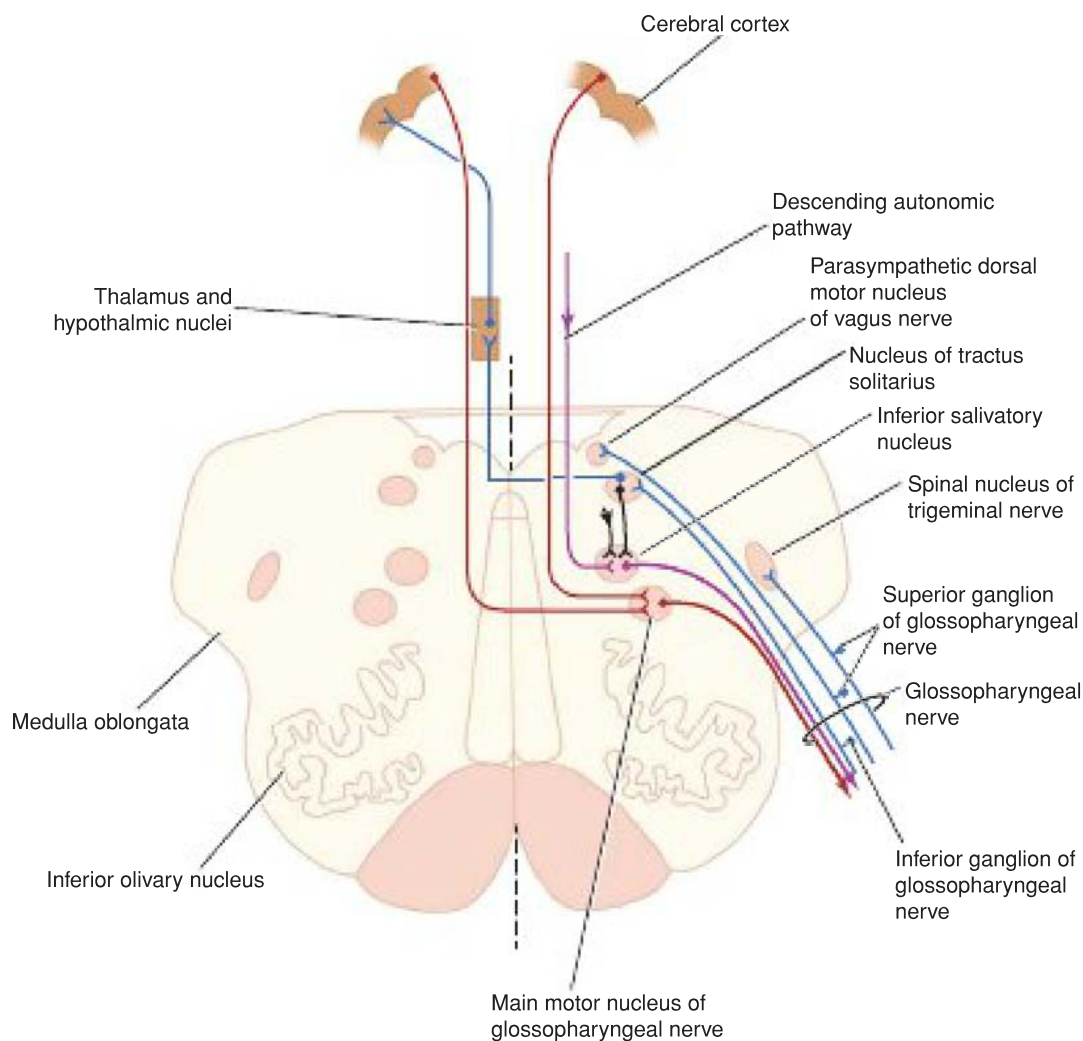


Figure 11-16 Glossopharyngeal nerve nuclei and their central connections.

hemispheres. The efferent fibers supply the **stylopharyngeus muscle**.

Parasympathetic Nucleus

The parasympathetic nucleus is also called the **inferior salivatory nucleus**. It receives afferent fibers from the hypothalamus through the **descending autonomic pathways**. It also is thought to receive information from the olfactory system through the reticular formation. Information concerning taste also is received from the nucleus of the solitary tract from the mouth cavity.

The efferent preganglionic parasympathetic fibers reach the otic ganglion through the **tympanic branch of the glossopharyngeal nerve**, the **tympanic plexus**, and the **lesser petrosal nerve** (Fig. 11-17). The postganglionic fibers pass to the **parotid salivary gland**.

Sensory Nucleus

The sensory nucleus is part of the **nucleus of the tractus solitarius** (see Fig. 11-16). Sensations of taste

travel through the peripheral axons of nerve cells situated in the **ganglion** on the glossopharyngeal nerve. The central processes of these cells synapse on nerve cells in the nucleus. Efferent fibers cross the median plane and ascend to the ventral group of nuclei of the opposite thalamus and a number of hypothalamic nuclei. From the thalamus, the axons of the thalamic cells pass through the internal capsule and corona radiata to end in the lower part of the postcentral gyrus.

Afferent information that concerns common sensation enters the brainstem through the superior ganglion of the glossopharyngeal nerve but ends in the **spinal nucleus of the trigeminal nerve**. Afferent impulses from the **carotid sinus**, a baroreceptor situated at the bifurcation of the common carotid artery, also travel with the glossopharyngeal nerve. They terminate in the **nucleus of the tractus solitarius** and are connected to the **dorsal motor nucleus of the vagus nerve**. The carotid sinus reflex that involves the glossopharyngeal and vagus nerves assists in the regulation of arterial blood pressure.

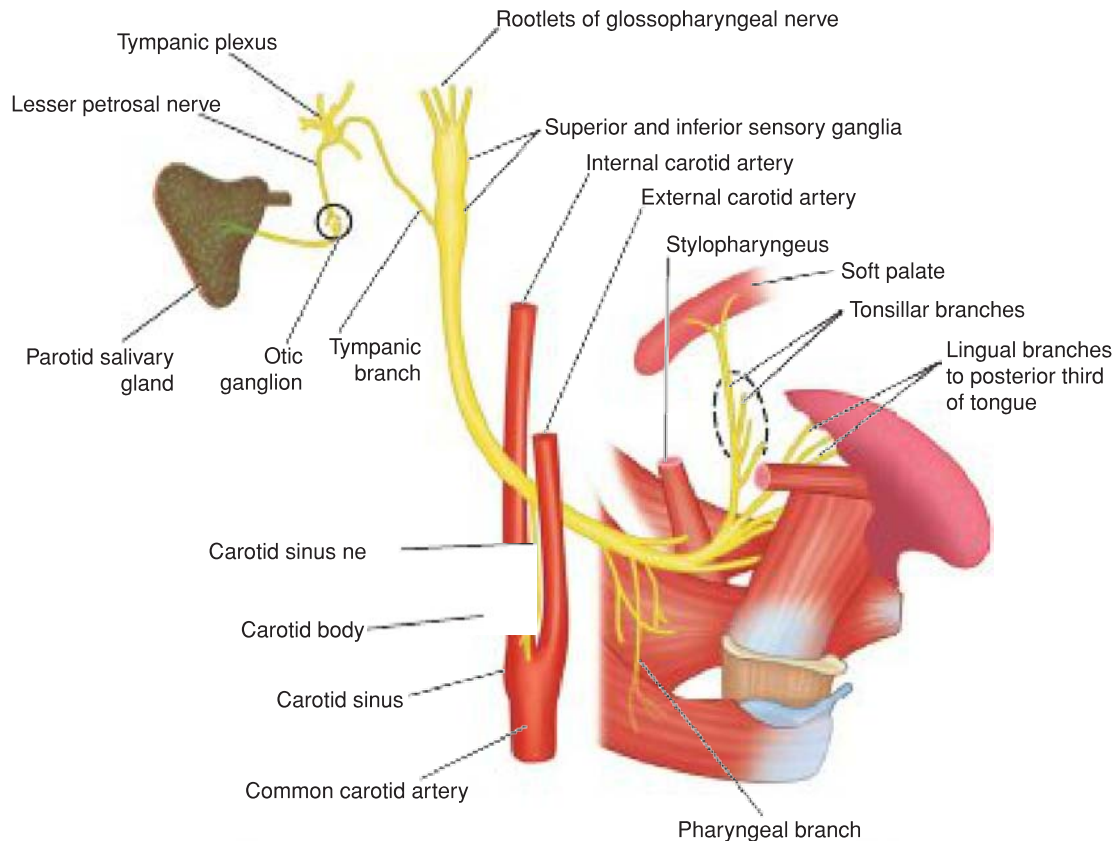


Figure 11-17 Distribution of the glossopharyngeal nerve.

Glossopharyngeal Nerve Course

The glossopharyngeal nerve leaves the anterolateral surface of the upper part of the medulla oblongata as a series of rootlets in a groove between the olive and the inferior cerebellar peduncle (see Fig. 11-16). It passes laterally in the posterior cranial fossa and leaves the skull through the jugular foramen. The superior and inferior glossopharyngeal sensory ganglia are situated on the nerve here. The nerve then descends through the upper part of the neck in company with the internal jugular vein and the internal carotid artery to reach the posterior border of the stylopharyngeus muscle, which it supplies. The nerve then passes forward between the superior and middle constrictor muscles of the pharynx to give sensory branches to the mucous membrane of the pharynx and the posterior third of the tongue (see Fig. 11-17).

VAGUS NERVE (CRANIAL NERVE X)

The vagus nerve is a motor and a sensory nerve.

Vagus Nerve Nuclei

The vagus nerve has three nuclei: (1) the main motor nucleus, (2) the parasympathetic nucleus, and (3) the sensory nucleus.

Main Motor Nucleus

The main motor nucleus lies deep in the reticular formation of the medulla oblongata and is formed by the nucleus ambiguus (Fig. 11-18). It receives corticonuclear fibers from both cerebral hemispheres. The efferent fibers supply the constrictor muscles of the pharynx and the intrinsic muscles of the larynx (Fig. 11-19).

Parasympathetic Nucleus

The parasympathetic nucleus forms the dorsal nucleus of the vagus and lies beneath the floor of the lower part of the fourth ventricle posterolateral to the hypoglossal nucleus (see Fig. 11-18). It receives afferent fibers from the hypothalamus through the descending autonomic pathways. It also receives other afferents, including those from the glossopharyngeal nerve (carotid sinus reflex). The efferent fibers are distributed to the involuntary muscle of the bronchi, heart, esophagus, stomach, small intestine, and large intestine as far as the distal third of the transverse colon (see Fig. 11-19).

Sensory Nucleus

The sensory nucleus is the lower part of the **nucleus of the tractus solitarius**. Sensations of taste travel through the peripheral axons of nerve cells situated in the **inferior ganglion on the vagus nerve**. The central

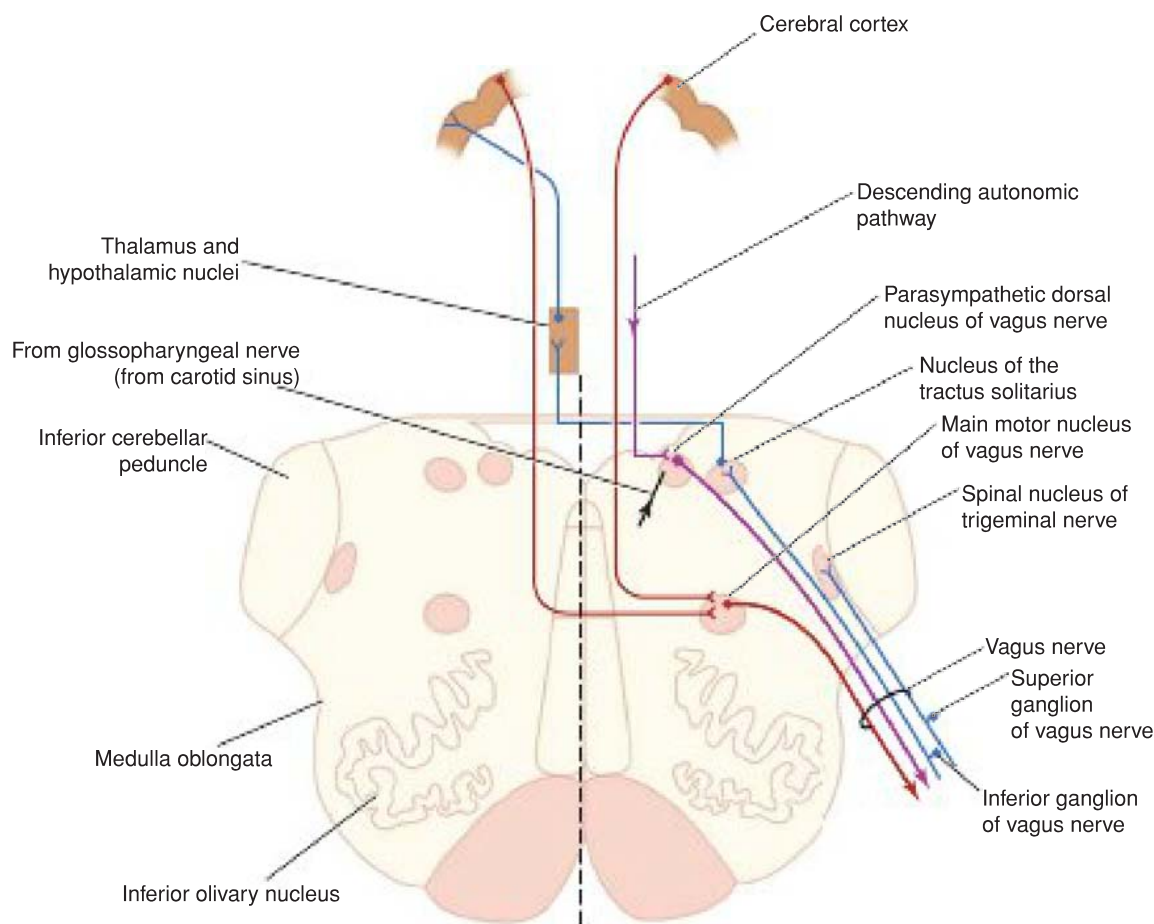


Figure 11-18 Vagus nerve nuclei and their central connections.

processes of those cells synapse on nerve cells in the nucleus (see Fig. 11-18). Efferent fibers cross the median plane and ascend to the ventral group of nuclei of the opposite thalamus as well as to a number of hypothalamic nuclei. From the thalamus, the axons of the thalamic cells pass through the internal capsule and corona radiata to end in the postcentral gyrus.

Afferent information concerning common sensation enters the brainstem through the superior ganglion of the vagus nerve but ends in the **spinal nucleus of the trigeminal nerve**.

Vagus Nerve Course

The vagus nerve leaves the anterolateral surface of the upper part of the medulla oblongata as a series of rootlets in a groove between the olive and the inferior cerebellar peduncle (see Fig. 11-18). The nerve passes laterally through the posterior cranial fossa and leaves the skull through the jugular foramen. The vagus nerve possesses two sensory ganglia, a rounded superior ganglion, situated on the nerve within the jugular foramen, and a cylindrical **inferior ganglion**, which lies on the nerve just below the foramen. 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 vertically in the neck within the carotid sheath with the internal jugular vein and the internal and common carotid arteries.

The **right vagus nerve** enters the thorax and passes posterior to the root of the right lung, contributing to the pulmonary plexus. It then passes on to the posterior surface of the esophagus and contributes to the **esophageal plexus**. It enters the abdomen through the esophageal opening of the diaphragm. The posterior vagal trunk (which is the name now given to the right vagus) is distributed to the posterior surface of the stomach and, by a large celiac branch, to the duodenum, liver, kidneys, and small and large intestines as far as the distal third of the transverse colon. This wide distribution is accomplished through the celiac, superior mesenteric, and renal plexuses.

The **left vagus nerve** enters the thorax and crosses the left side of the aortic arch and descends behind the root of the left lung, contributing to the **pulmonary plexus**. The left vagus then descends on the anterior surface of the esophagus, contributing to the **esophageal plexus**. It enters the abdomen through the esophageal opening of the diaphragm. The anterior vagal trunk (which is the

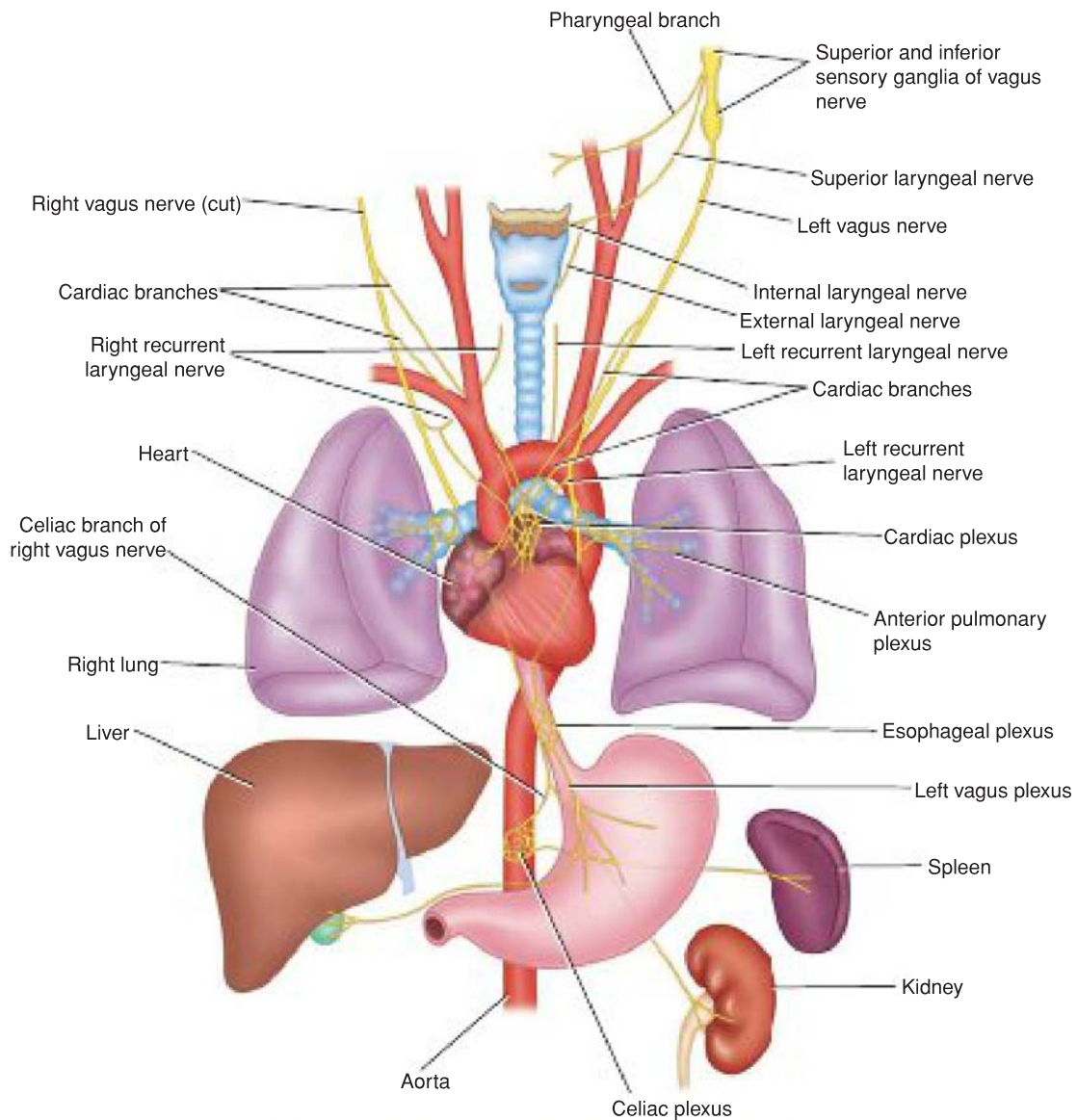


Figure 11-19 Distribution of the vagus nerve.

name now given to the left vagus) divides into several branches, which are distributed to the stomach, liver, upper part of the duodenum, and head of the pancreas.

ACCESSORY NERVE (CRANIAL NERVE XI)

The accessory nerve is a motor nerve that is formed by the union of a cranial and a spinal root.

Cranial Root

The cranial root (part) is formed from the axons of nerve cells of the nucleus ambiguus (Fig. 11-20). The nucleus receives corticonuclear fibers from both cerebral hemispheres. The efferent fibers of the nucleus emerge from

the anterior surface of the medulla oblongata between the olive and the inferior cerebellar peduncle.

Cranial Root Course

The nerve runs laterally in the posterior cranial fossa and joins the spinal root. The two roots unite and leave the skull through the jugular foramen. The roots then separate, and the cranial root joins the vagus nerve and is distributed in its pharyngeal and recurrent laryngeal branches to the muscles of the soft palate, pharynx, and larynx.

Spinal Root

The spinal root (part) is formed from axons of nerve cells in the **spinal nucleus**, which is situated in the anterior gray column of the spinal cord in the upper five

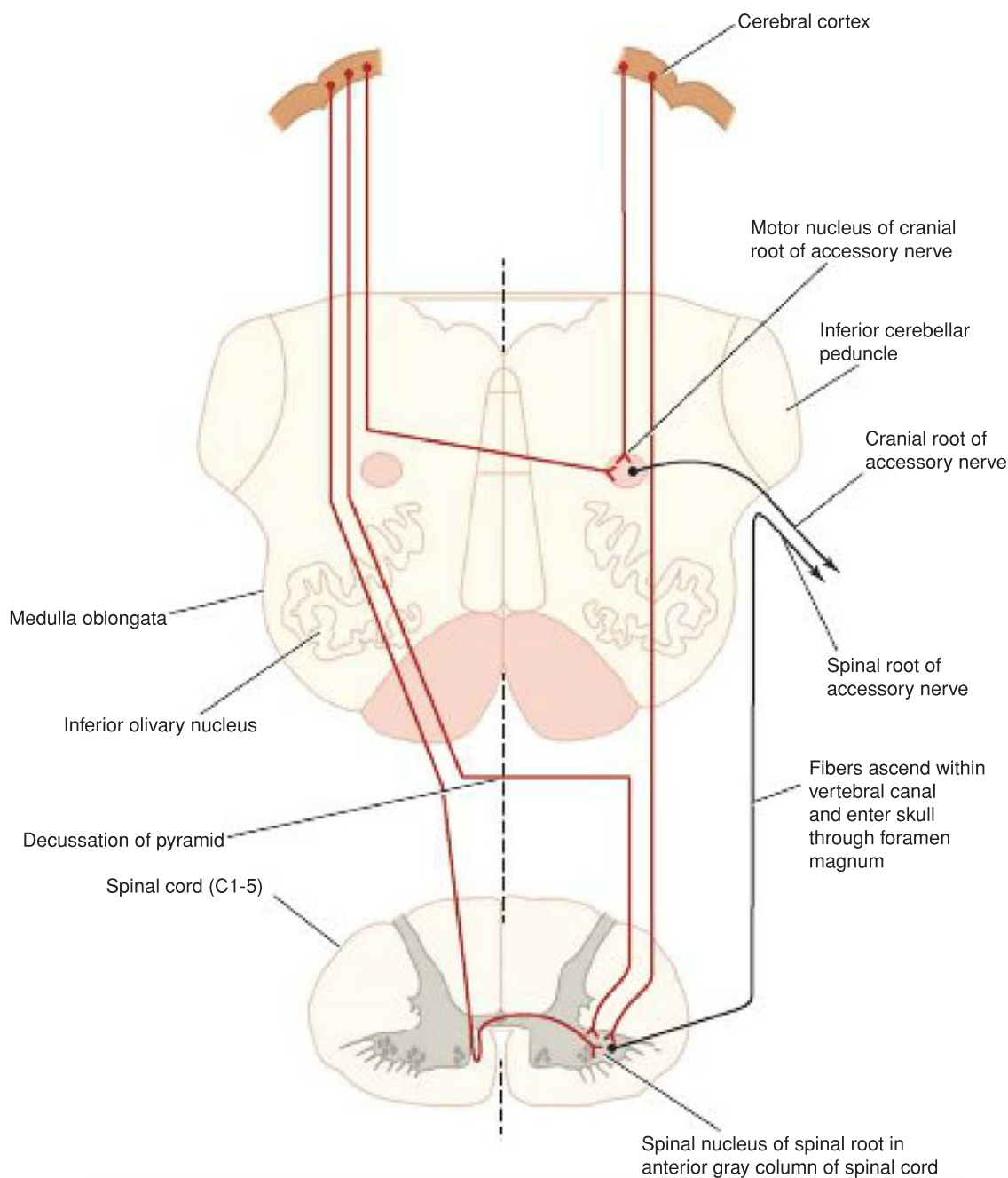


Figure 11-20 Cranial and spinal nuclei of the accessory nerve and their central connections.

cervical segments (see Fig. 11-20). The spinal nucleus is thought to receive corticospinal fibers from both cerebral hemispheres.

Spinal Root Course

The nerve fibers emerge from the spinal cord midway between the anterior and posterior nerve roots of the cervical spinal nerves. The fibers form a nerve trunk that ascends into the skull through the foramen magnum. The spinal root passes laterally and joins

the cranial root as they pass through the jugular foramen. After a short distance, the spinal root separates from the cranial root and runs downward and laterally and enters the deep surface of the sternocleidomastoid (SCM) muscle, which it supplies (Fig. 11-21). The nerve then crosses the posterior triangle of the neck and passes beneath the trapezius muscle, which it supplies.

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

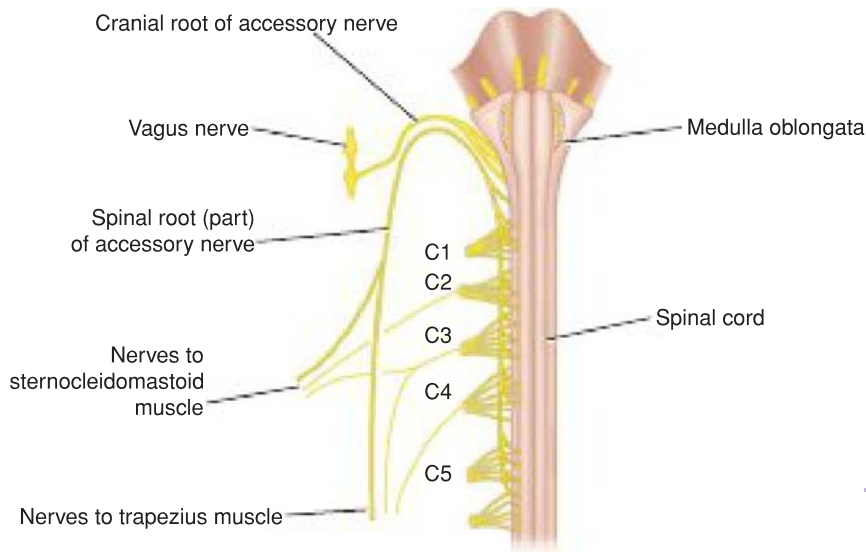


Figure 11-21 Distribution of the accessory nerve.

HYPOGLOSSAL NERVE (CRANIAL NERVE XII)

The hypoglossal nerve is a motor nerve that supplies all the intrinsic muscles of the tongue as well as the styloglossus, the hyoglossus, and the genioglossus muscles.

Hypoglossal Nucleus

The hypoglossal nucleus is situated close to the midline immediately beneath the floor of the lower part of the fourth ventricle (Fig. 11-22). It receives corticonuclear fibers from both cerebral hemispheres. However, the cells responsible for supplying the genioglossus muscle

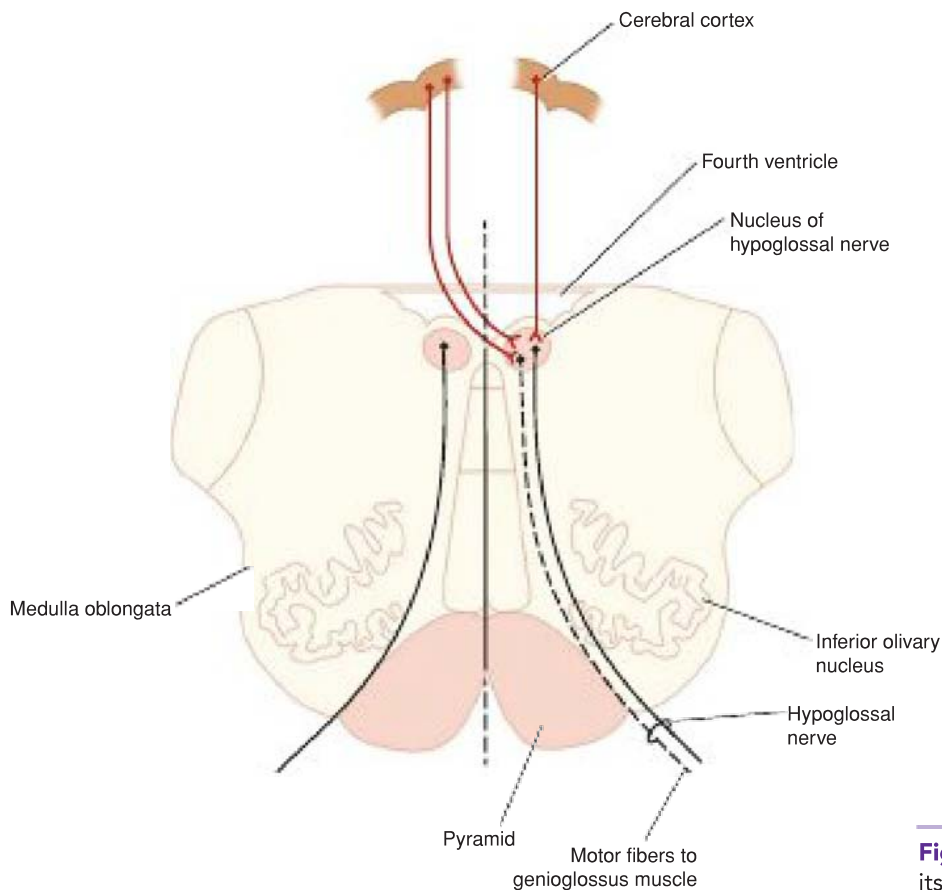


Figure 11-22 Hypoglossal nucleus and its central connections.

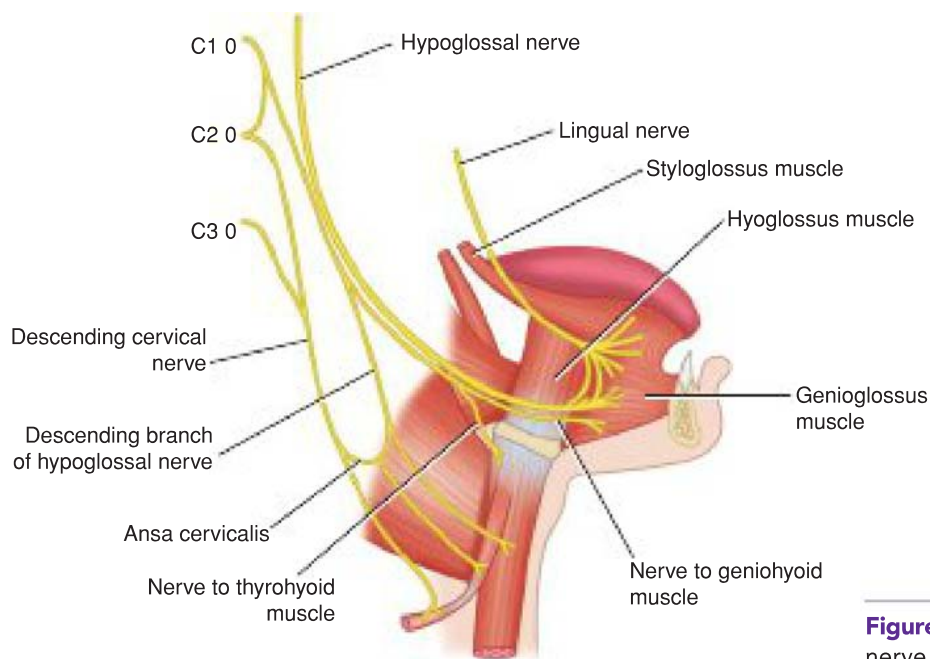


Figure 11-23 Distribution of the hypoglossal nerve.

(Fig. 11-23) only receive corticonuclear fibers from the opposite cerebral hemisphere.

The hypoglossal nerve fibers pass anteriorly through the medulla oblongata and emerge as a series of roots in the groove between the pyramid and the olive (see Fig. 11-22).

Hypoglossal Nerve Course

The hypoglossal nerve fibers emerge on the anterior surface of the medulla oblongata between the pyramid and the olive (see Fig. 11-22). The nerve crosses the posterior cranial fossa and leaves the skull through the hypoglossal canal. The nerve passes downward and forward in the neck between the internal carotid

artery and the internal jugular vein until it reaches the lower border of the posterior belly of the digastric muscle. Here, it turns forward and crosses the internal and external carotid arteries and the loop of the lingual artery. It passes deep to the posterior margin of the mylohyoid muscle lying on the lateral surface of the hyoglossus muscle. The nerve then sends branches to the muscles of the tongue (see Fig. 11-23).

In the upper part of its course, the hypoglossal nerve is joined by C1 fibers from the cervical plexus. The delicate cervical nerve fibers merely run with the hypoglossal nerve for support and later leave it to supply muscles in the neck.

Thus, the hypoglossal nerve controls the movements and shape of the tongue.



Clinical Notes

General Considerations

The 12 pairs of cranial nerves supply information to the brain from outlying receptor organs and bring about changes in peripheral effector organs by means of appropriate motor nerves. Unfortunately for the student, the nerve cells are not arranged simply, as in the spinal cord, but are grouped together to form **nuclei** that are found in different situations at different levels of the brainstem. Moreover, whereas spinal nerves possess afferent somatic fibers, afferent visceral fibers, efferent somatic fibers, and efferent visceral fibers, cranial nerves, in addition, possess special somatic afferent

fibers (e.g., visual and auditory) and special visceral afferent fibers (e.g., taste).

When the central connections of the different cranial nerve nuclei were discussed in the previous section, a simplified practical version was given, since many of the precise connections of the cranial nerve nuclei are still not known. Because the delicate movements of the eyes, the larynx, and the face require carefully integrated muscle action and the fine control of muscle tone, it must be assumed that the motor nuclei of the various cranial nerves receive input from the cerebellum, the red nucleus,

the reticular formation, and the corpus striatum in the same manner as the lower motor neurons of the spinal cord.

Three points of clinical value should be remembered:

1. Bilateral corticonuclear connections are present for all the cranial motor nuclei **except** that part of the facial nucleus that supplies the muscles of the lower part of the face and that part of the hypoglossal nucleus that supplies the genioglossus muscle.
2. The cranial nerves that possess afferent sensory fibers have cell bodies that are found in ganglia along the course of the nerves; these are equivalent to the posterior root ganglia. In the case of the olfactory nerves, the cells are the olfactory receptors.
3. In situations in which the cranial nerve nuclei are close together, it is very rare for a disease process to affect one nucleus only. For example, the cell groups of the nucleus ambiguus serve the glossopharyngeal, the vagus, and the cranial root of the accessory nerve, and functional loss involving all three nerves is a common finding.

Clinical Examination

The systematic examination of the 12 cranial nerves is an important part of the examination of every neurologic patient. It may reveal a lesion of a cranial nerve nucleus or its central connections, or it may show an interruption of the lower motor neurons.

Olfactory Nerve

First, determine that the nasal passages are clear. Then, apply some easily recognizable aromatic substance, such as oil of peppermint, oil of clove, or tobacco, to each nostril in turn. Ask the patient whether he or she can smell anything; if so, ask the patient to identify the smell. It should be remembered that food flavors depend on the sense of smell and not on the sense of taste.

Bilateral anosmia can be caused by disease of the olfactory mucous membrane, such as the common cold or allergic rhinitis. **Unilateral anosmia** can result from disease affecting the olfactory nerves, bulb, or tract. A lesion of the olfactory cortex on one side is unlikely to produce complete anosmia, because fibers from each olfactory tract travel to both cerebral hemispheres. Fractures of the anterior cranial fossa involving the cribriform plate of the ethmoid could tear the olfactory nerves. Cerebral tumors of the frontal lobes or meningiomas of the anterior cranial fossa can produce anosmia by pressing on the olfactory bulb or tract.

Optic Nerve

First, ask the patient whether he or she has noted any change in eyesight. **Visual acuity** should be tested for near and distant vision. Near vision is tested by asking the patient to read a card with a standard size of type. Each eye is tested in turn, with or without spectacles. Distant vision is tested by asking the patient to read Snellen type at a distance of 20 ft.

The **visual fields** should then be tested. The patient and the examiner sit facing each other at a distance of 2 ft. The patient is asked to cover the right eye, and the examiner covers his own left eye. The patient is asked to look into the pupil of the examiner's right eye. A small object is then moved in an arc around the periphery of the field of vision, and the patient is asked whether he or she can

see the object. The extent of the patient's field of vision is compared with the normal examiner's field. Then, the other eye is tested. The clinician must be careful not to miss loss or impairment of vision in the central area of the field (central scotoma).

VISUAL PATHWAY LESIONS

Lesions of the optic pathway may have many pathologic causes. Expanding tumors of the brain and neighboring structures, such as the pituitary gland and the meninges, and cerebrovascular accidents are commonly responsible. The most widespread effects on vision occur where the nerve fibers of the visual pathway are tightly packed together, such as in the optic nerve or the optic tract.

CIRCUMFERENTIAL BLINDNESS

Circumferential blindness may be caused by hysteria or optic neuritis (Fig. 11-24 [1]). Optic neuritis may occur following spread of infection from the sphenoid and ethmoid sinuses; the optic nerve is infected as it passes through the optic canal to enter the orbital cavity.

TOTAL BLINDNESS OF ONE EYE

Total blindness of one eye would follow complete section of one optic nerve (Fig. 11-24 [2]).

NASAL HEMIANOPIA

Nasal hemianopia would follow a partial lesion of the optic chiasma on its lateral side (Fig. 11-24 [3]).

BITEMPORAL HEMIANOPIA

Bitemporal hemianopia would follow a sagittal section of the optic chiasma (Fig. 11-24 [4]). This condition is most commonly produced by a tumor of the pituitary gland exerting pressure on the optic chiasma.

CONTRALATERAL HOMONYMOUS HEMIANOPIA

Contralateral homonymous hemianopia would follow division of the optic tract or optic radiation or destruction of the visual cortex on one side; the lesion would produce the same hemianopia for both eyes—that is, homonymous hemianopia (Fig. 11-24 [5–7]). If the right optic tract is divided, for example, a left temporal hemianopia and a right nasal hemianopia will occur.

FUNDUS EXAMINATION

The ocular fundus should be examined with an ophthalmoscope. The patient is asked to look at a distant object. When the right eye is examined, the physician should use his or her right eye and hold the ophthalmoscope in his or her right hand. The physician should systematically examine the fundus, looking first at the optic disc, then at the retina, then at the blood vessels, and finally at the macula.

The **optic disc** is creamy pink, and the lateral margin is seen clearly. The center of the disc is paler and hollowed out.

The **retina** is pinkish red, and there should be no hemorrhages or exudates.

The **blood vessels** should consist of four main arteries with their accompanying veins. Carefully examine the arteriovenous crossings. The veins should not be indented by the arteries.

The **macula** is examined by asking the patient to look directly at the light of the ophthalmoscope. It should look slightly darker than the surrounding retina.

EXTRAOCULAR MUSCLE EXAMINATION

To examine the extraocular muscles, the patient's head is fixed, and he or she is asked to move the eyes, in turn, to the

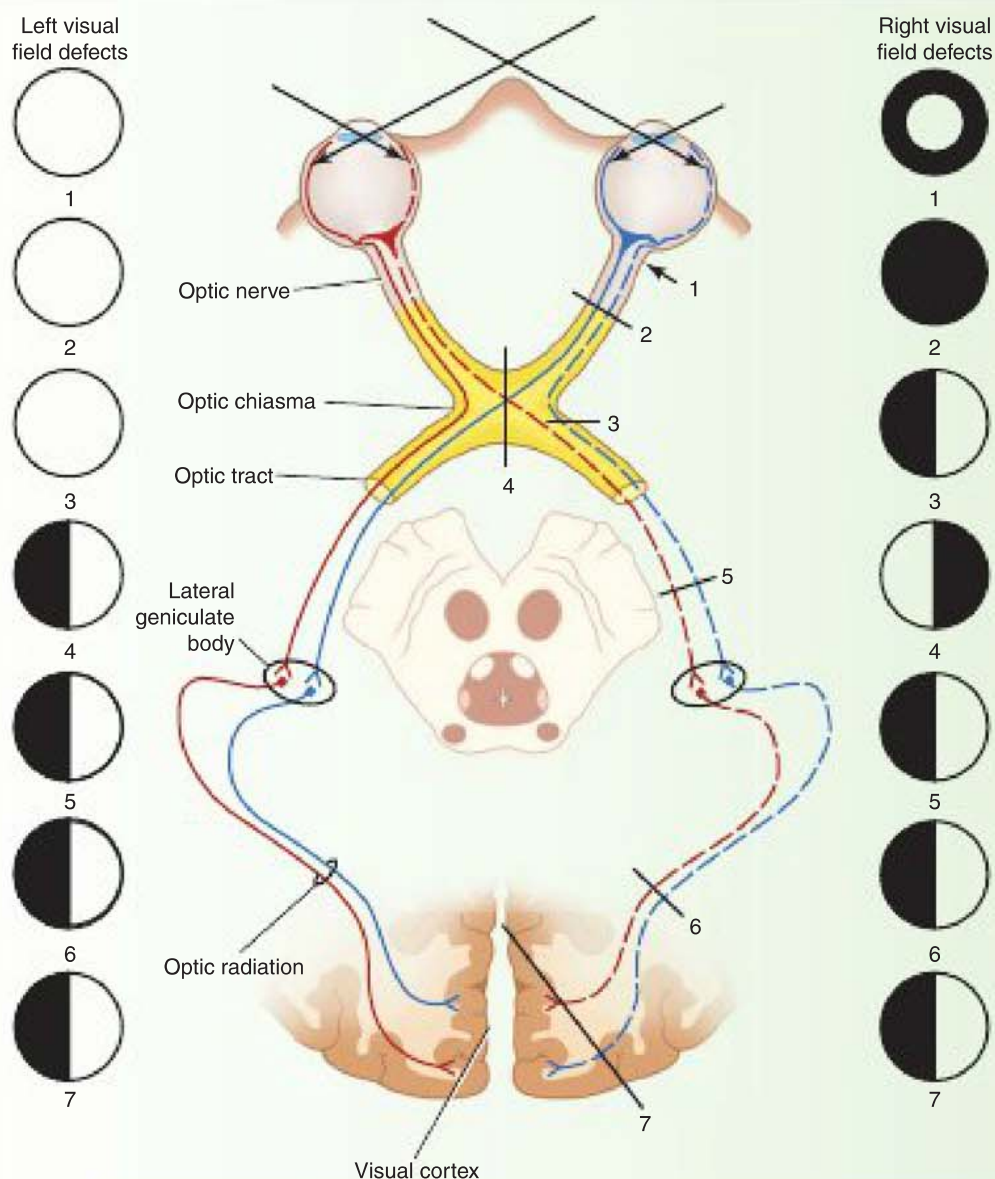


Figure 11-24 Visual field defects associated with lesions of the optic pathways. **1.** Right-sided circumferential blindness due to retrobulbar neuritis. **2.** Total blindness of the right eye due to division of the right optic nerve. **3.** Right nasal hemianopia due to a partial lesion of the right side of the optic chiasma. **4.** Bitemporal hemianopia due to a complete lesion of the optic chiasma. **5.** Left temporal hemianopia and right nasal hemianopia due to a lesion of the right optic tract. **6.** Left temporal and right nasal hemianopia due to a lesion of the right optic radiation. **7.** Left temporal and right nasal hemianopia due to a lesion of the right visual cortex.

left, to the right, upward, and downward, as far as possible in each direction. The patient should then be asked to look upward and laterally, upward and medially, downward and medially, and downward and laterally.

The pupillary reactions to convergence associated with accommodation and the direct and consensual pupillary reactions to light are tested. The nervous pathways involved in the pupillary reflexes are described on pages 328-329.

Oculomotor Nerve

The oculomotor nerve supplies all the extraocular muscles except the superior oblique and the lateral rectus. It also supplies the striated muscle of the levator palpebrae superioris and the smooth muscle concerned with accommodation, namely, the sphincter pupillae and the ciliary muscle.

In a complete lesion of the oculomotor nerve, the eye cannot be moved upward, downward, or inward. At rest, the eye looks laterally (external strabismus), owing to the

activity of the lateral rectus, and downward, owing to the activity of the superior oblique. The patient sees double (diplopia). The upper eyelid droops (ptosis) due to paralysis of the levator palpebrae superioris. The pupil is widely dilated and nonreactive to light, owing to paralysis of the sphincter pupillae and unopposed action of the dilator (supplied by the sympathetic). Accommodation of the eye is paralyzed.

Incomplete lesions of the oculomotor nerve are common and may spare the extraocular muscles or the intraocular muscles. The condition in which the innervation of the extraocular muscles is spared with selective loss of the autonomic innervation of the sphincter pupillae and ciliary muscle is called **internal ophthalmoplegia**. The condition in which the sphincter pupillae and the ciliary muscle are spared with paralysis of the extraocular muscles is called **external ophthalmoplegia**.

The possible explanation for the involvement of the autonomic nerves and the sparing of the remaining fibers is that the parasympathetic autonomic fibers are superficially placed within the oculomotor nerve and are likely to be first affected by compression. The nature of the disease also plays a role. For example, in cases of diabetes with impaired nerve conduction (diabetic neuropathy), the autonomic fibers are unaffected, whereas the nerves to the extraocular muscles are paralyzed.

The conditions most commonly affecting the oculomotor nerve are diabetes, aneurysm, tumor, trauma, inflammation, and vascular disease. See lesions of the oculomotor nerve in the midbrain (Benedikt syndrome) on page 217.

Trochlear Nerve

The trochlear nerve supplies the superior oblique muscle, which rotates the eye downward and laterally.

In lesions of the trochlear nerve, the patient complains of double vision on looking straight downward, because the images of the two eyes are tilted relative to each other. This is because the superior oblique is paralyzed, and the eye turns medially as well as downward. In fact, the patient has great difficulty in turning the eye downward and laterally.

The conditions most often affecting the trochlear nerve include stretching or bruising as a complication of head injuries (the nerve is long and slender), cavernous sinus thrombosis, aneurysm of the internal carotid artery, and vascular lesions of the dorsal part of the midbrain. See lesions of the trochlear nerve in the midbrain on page 217.

Abducens Nerve

The abducens nerve supplies the lateral rectus muscle, which rotates the eye laterally. In a lesion of the abducens nerve, the patient cannot turn the eye laterally. When the patient is looking straight ahead, the lateral rectus is paralyzed, and the unopposed medial rectus pulls the eyeball medially, causing **internal strabismus**. Diplopia is also seen.

Lesions of the abducens nerve include damage due to head injuries (the nerve is long and slender), cavernous sinus thrombosis or aneurysm of the internal carotid artery, and vascular lesions of the pons.

INTERNUCLEAR OPHTHALMOPLÉGIA

Lesions of the medial longitudinal fasciculus will disconnect the oculomotor nucleus that innervates the medial rectus muscle from the abducens nucleus that innervates the lateral rectus muscle. When the patient is asked to look

laterally to the right or left, the ipsilateral lateral rectus contracts, turning the eye laterally, but the contralateral medial rectus fails to contract, and the eye looks straight forward.

Bilateral internuclear ophthalmoplegia can occur with multiple sclerosis, occlusive vascular disease, trauma, or brainstem tumors. Unilateral internuclear ophthalmoplegia can follow an infarct of a small branch of the basilar artery.

Trigeminal Nerve

The trigeminal nerve has sensory and motor roots. The sensory root passes to the trigeminal ganglion, from which emerge the ophthalmic (V_1), maxillary (V_2), and mandibular (V_3) divisions. The motor root joins the mandibular division.

The sensory function may be tested by using cotton and a pin over each area of the face supplied by the divisions of the trigeminal nerve (see Fig. 11-9). Note that the dermatomes overlap very little and that the skin covering the angle of the jaw is innervated by branches from the cervical plexus (C2 and C3). In lesions of the ophthalmic division, the cornea and conjunctiva will be insensitive to touch.

The motor function may be tested by asking the patient to clench his or her teeth. The masseter and the temporalis muscles can be palpated and felt to harden as they contract.

TRIGEMINAL NEURALGIA

In trigeminal neuralgia, the severe, stabbing pain over the face is of unknown cause and involves the pain fibers of the trigeminal nerve. Pain is felt most commonly over the skin areas innervated by the mandibular and maxillary divisions of the trigeminal nerve; only rarely is pain felt in the area supplied by the ophthalmic division.

Facial Nerve

The facial nerve supplies the muscles of facial expression, supplies the anterior two-thirds of the tongue with taste fibers, and is secretomotor to the lacrimal, submandibular, and sublingual glands.

To test the facial nerve, the patient is asked to show the teeth by separating the lips with the teeth clenched. Normally, equal areas of the upper and lower teeth are revealed on both sides. If a lesion of the facial nerve is present on one side, the mouth is distorted. A greater area of teeth is revealed on the side of the intact nerve, since the mouth is pulled up on that side. Another useful test is to ask the patient to close both eyes firmly. The examiner then attempts to open the eyes by gently raising the patient's upper lids. On the side of the lesion, the orbicularis oculi is paralyzed so that the eyelid on that side is easily raised.

The sensation of taste on each half of the anterior two-thirds of the tongue can be tested by placing small amounts of sugar, salt, vinegar, and quinine on the tongue for the sweet, salty, sour, and bitter sensations.

FACIAL NERVE LESIONS

The facial nerve may be injured or may become dysfunctional anywhere along its long course from the brainstem to the face. Its anatomical relationship to other structures greatly assists in the localization of the lesion. If the abducens nerve (supplies the lateral rectus muscle) and the facial nerve are not functioning, this would suggest a lesion in the pons of the brain. If the vestibulocochlear nerve (for balance and hearing) and the facial nerve are not functioning, this suggests a lesion in the internal acoustic

meatus. If the patient is excessively sensitive to sound in one ear, the lesion probably involves the nerve to the stapedius muscle, which arises from the facial nerve in the facial canal.

Loss of taste over the anterior two-thirds of the tongue indicates that the facial nerve is damaged proximal to the point where it gives off the chorda tympani branch in the facial canal.

A firm swelling of the parotid salivary gland associated with impaired function of the facial nerve is strongly indicative of a cancer of the parotid gland with involvement of the nerve within the gland.

Deep lacerations of the face may involve branches of the facial nerve.

The part of the facial nucleus that controls the muscles of the upper part of the face receives corticonuclear fibers from both cerebral hemispheres. Therefore, it follows that with a lesion involving the upper motor neurons, only the muscles of the lower part of the face will be paralyzed (Fig. 11-25 [1]). However, in patients with a lesion of the facial nerve motor nucleus or the facial nerve itself—that is, a lower motor neuron lesion—all the muscles on the affected side of the face will be paralyzed (Fig. 11-25 [2]). The lower eyelid will droop, and the angle of the mouth will sag. Tears will flow over the lower eyelid, and saliva will dribble from the corner of the mouth. The patient will

be unable to close the eye and will be unable to expose the teeth fully on the affected side.

In patients with hemiplegia, the emotional movements of the face are usually preserved. This indicates that the upper motor neurons controlling these **mimetic** movements have a course separate from that of the main corticobulbar fibers. A lesion involving this separate pathway alone results in a loss of emotional movements, but voluntary movements are preserved. A more extensive lesion will produce both mimetic and voluntary facial paralysis.

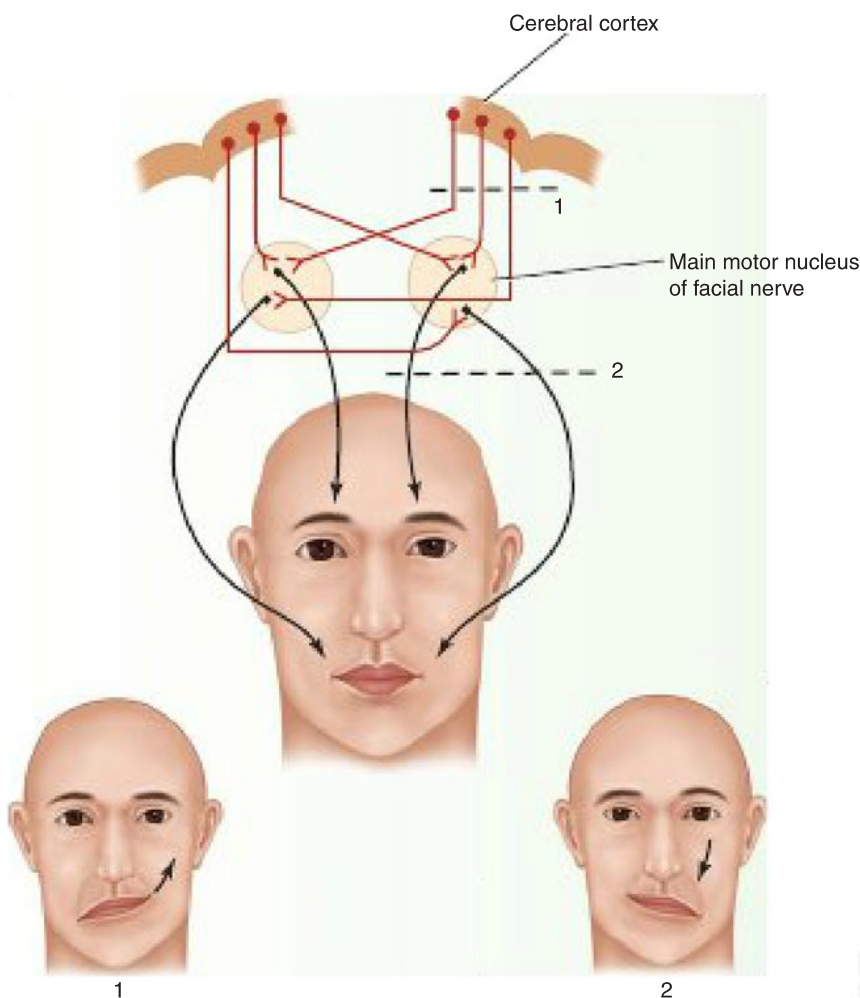
BELL Palsy

Bell palsy is a dysfunction of the facial nerve, as it lies within the facial canal; it is usually unilateral. The site of the dysfunction will determine the aspects of facial nerve function that do not work.

The swelling of the nerve within the bony canal causes pressure on the nerve fibers; this results in a temporary loss of function of the nerve, producing a lower motor neuron type of facial paralysis. The cause of Bell palsy is not known; it sometimes follows exposure of the face to a cold draft.

Vestibulocochlear Nerve

The vestibulocochlear nerve innervates the utricle and saccule, which are sensitive to static changes in equilibrium;



motor neurons (1) and lower motor neurons (2).

the semicircular canals, which are sensitive to changes in dynamic equilibrium; and the cochlea, which is sensitive to sound.

VESTIBULAR NERVE FUNCTION DISTURBANCE

Disturbances of vestibular nerve function include dizziness (**vertigo**) and **nystagmus** (see p. 242). Vestibular nystagmus is an uncontrollable rhythmic oscillation of the eyes, and the fast phase is away from the side of the lesion. This form of nystagmus is essentially a disturbance in the reflex control of the extraocular muscles, which is one of the functions of the semicircular canals. Normally, the nerve impulses pass reflexly from the canals through the vestibular nerve, the vestibular nuclei, and the medial longitudinal fasciculus, to the third, fourth, and sixth cranial nerve nuclei, which control the extraocular muscles; the cerebellum assists in coordinating the muscle movements.

Vestibular function can be investigated with **caloric tests**. These involve the raising and lowering of the temperature in the external auditory meatus, which induces convection currents in the endolymph of the semicircular canals (principally, the lateral semicircular canal) and stimulates the vestibular nerve endings.

The causes of vertigo include diseases of the labyrinth, such as Ménière disease. Lesions of the vestibular nerve, the vestibular nuclei, and the cerebellum can also be responsible. Multiple sclerosis, tumors, and vascular lesions of the brainstem also cause vertigo.

COCHLEAR NERVE FUNCTION DISTURBANCE

Disturbances of cochlear function are manifested as **deafness** and **tinnitus**. The patient's ability to hear a whispered voice or a vibrating tuning fork should be tested; each ear should be tested separately.

Loss of hearing may be due to a defect of the auditory-conducting mechanism in the middle ear, damage to the receptor cells in the spiral organ of Corti in the cochlea, a lesion of the cochlear nerve, a lesion of the central auditory pathways, or a lesion of the cortex of the temporal lobe.

Lesions of the internal ear include **Ménière disease**, **acute labyrinthitis**, and **trauma** following head injury. Lesions of the cochlear nerve include **tumor (acoustic neuroma)** and **trauma**. Lesions in the central nervous system include **tumors of the midbrain** and **multiple sclerosis**. Only bilateral temporal lobe lesions cause deafness.

Glossopharyngeal Nerve

The glossopharyngeal nerve supplies the stylopharyngeus muscle and sends secretomotor fibers to the parotid gland. Sensory fibers innervate the posterior third of the tongue for general sensation and taste.

The integrity of this nerve may be evaluated by testing the patient's general sensation and that of taste on the posterior third of the tongue.

Isolated lesions of the glossopharyngeal nerve are rare and usually also involve the vagus nerve.

Vagus Nerve

The vagus nerve innervates many important organs, but the examination of this nerve depends on testing the function of the branches to the pharynx, soft palate, and larynx. The **pharyngeal** or **gag reflex** may be tested by touching the lateral wall of the pharynx with a spatula. This should

immediately cause the patient to gag; that is, the pharyngeal muscles will contract. The afferent neuron of the pharyngeal reflex runs in the glossopharyngeal nerve, and the efferent neurons run in the glossopharyngeal (to the stylopharyngeus muscle) and vagus nerves (pharyngeal constrictor muscles). Unilateral lesions of the vagus will show little or no gag reflex on that side.

The innervation of the soft palate may be tested by asking the patient to say "ah." Normally, the soft palate rises and the uvula moves backward in the midline.

All the muscles of the larynx are supplied by the recurrent laryngeal branch of the vagus, except the cricothyroid muscle, which is supplied by the external laryngeal branch of the superior laryngeal branch of the vagus. Hoarseness or absence of the voice may occur as a symptom of vagal nerve palsy. The movements of the vocal cords may be tested by means of a laryngoscopic examination. Lesions involving the vagus nerve in the posterior cranial fossa commonly involve the glossopharyngeal, accessory, and hypoglossal nerves as well.

Accessory Nerve

The accessory nerve supplies the SCM and the trapezius muscles by means of its spinal root. The patient should be asked to rotate the head to one side against resistance, causing the SCM of the opposite side to come into action. Then, the patient should be asked to shrug the shoulders, causing the trapezius muscles to come into action.

Lesions of the spinal part of the accessory nerve will result in paralysis of the SCM and trapezius muscles. The SCM muscle will atrophy, causing weakness in turning the head to the opposite side. The trapezius muscle will also atrophy, causing the shoulder to droop on that side as well as weakness and difficulty in raising the arm above the horizontal.

Lesions of the spinal part of the accessory nerve may occur anywhere along its course and may result from tumors or trauma from stab or gunshot wounds in the neck.

Hypoglossal Nerve

The hypoglossal nerve supplies the intrinsic muscles of the tongue and the styloglossus, hyoglossus, and genioglossus muscles. To test the integrity of the nerve, the patient is asked to put out the tongue; in the setting of a lower motor neuron lesion, the tongue will be observed to deviate toward the paralyzed side. The tongue will be smaller on the side of the lesion, owing to muscle atrophy, and fasciculation may accompany or precede the atrophy. Remember that the greater part of the hypoglossal nucleus receives corticonuclear fibers from both cerebral hemispheres. However, the part of the nucleus that supplies the genioglossus receives corticonuclear fibers only from the opposite cerebral hemisphere. If a patient has a lesion of the corticonuclear fibers, there will be no atrophy or fibrillation of the tongue, and on protrusion, the tongue will deviate to the side opposite the lesion. (Note that the genioglossus is the muscle that pulls the tongue forward.)

Lesions of the hypoglossal nerve may occur anywhere along its course and may result from tumor, demyelinating diseases, syringomyelia, and vascular accidents. Injury of the nerve in the neck may also follow stab and gunshot wounds.

Key Concepts

Cranial Nerve Organization

- The 12 pairs of cranial nerves leave the brain or superior spinal cord and pass through foramina and fissures in the skull. All nerves are distributed in the head and neck except for cranial nerve X, which also supplies structures in the thorax and abdomen.
- Olfactory, optic, and vestibulocochlear nerves are entirely sensory. Oculomotor, trochlear, abducens, accessory, and hypoglossal are entirely motor. All others cranial nerves are both sensory and motor.

Cranial Nerve I

- The olfactory nerves are a series of bipolar cells located in the mucous membrane of the nasal cavity roof. The projecting olfactory hairs react to odors in the air, stimulating the olfactory nerves.
- Nerves are myelinated by Schwann cells and project through the cribriform plate to synapse on mitral and tufted cells located in the olfactory bulb.
- Axons from the mitral and tufted cells form the olfactory tract and project to the primary olfactory cortex, accomplishing the function of smell.
- Secondary connections throughout the cortex are responsible for appreciation or triggering of emotional and autonomic responses to the detected smell.

Cranial Nerve II

- Fibers of the optic nerve are the axons of ganglion cells from the retina. The optic nerve leaves the orbital cavity through the optic canal and unites with the nerve of the opposite side to form the optic chiasma.
- The optic tract arises from the optic chiasma, carrying axons from the complementary half of each eye (i.e., ipsilateral nasal with contralateral temporal).
- Most fibers of optic tract synapse in the lateral geniculate body of the thalamus, which projects to the primary visual cortex via the optic radiations.
- A smaller number of fibers do not synapse in the lateral geniculate nucleus, but instead, project to the pretectal nucleus and the superior colliculus, and are concerned with light reflexes.

Cranial Nerve III

- Oculomotor nerve carries somatic and visceral motor fibers from the main oculomotor and Edinger–Westphal nuclei, respectively.

- This nerve controls the movement of extraocular muscles and the smooth muscle of the iris and ciliary muscles for the actions of constriction and accommodation.
- The nerve fibers exit the midbrain in the interpeduncular fossa and exit the cranial cavity through the superior orbital fissure.

Cranial Nerve IV

- The motor fibers from the trochlear nucleus exit the midbrain posteriorly and immediately decussate with the nerve on the opposite side.
- The trochlear nerves pass anteriorly around the midbrain and exit the cranial cavity via the superior orbital fissure to innervate the superior oblique muscle of the eyeball.

Cranial Nerve V

- The trigeminal nerve is the largest cranial nerve, carrying sensation to the head and motor control to the muscles of mastication.
- The trigeminal nerve has four nuclei: main (sensory), spinal (sensory), mesencephalic (sensory), and motor.
- Pain, temperature, touch, and pressure travel along axons whose cell bodies are located in the semilunar or trigeminal sensory ganglion.
 - The sensations of touch and pressure are conveyed by fibers that synapse in the main sensory nucleus.
 - The sensations of pain and temperature are conveyed by fibers that synapse in the spinal nucleus.
 - Proprioceptive fibers from the muscles of the face, orbit, mouth, and mastication, synapse in the mesencephalic nucleus
- The trigeminal nerve is formed from three major nerves: ophthalmic (V_1), maxillary (V_2), and mandibular (V_3).

Cranial Nerve VI

- The motor fibers from the abducens nerve nucleus exit the brainstem at the junction of the pons and medulla oblongata.
- The abducens nerve exits the cranial cavity through the superior orbital fissure, to the orbit, where it innervates the lateral rectus muscle of the eyeball.

Cranial Nerve VII

- The fibers of the facial nerve originate from the main motor nucleus, superior salivatory (parasympathetic) and lacrimal (parasympathetic), and nucleus of the tractus solitarius (sensory).
- The motor fibers exit the cranial cavity through the internal acoustic meatus where they join the sensory root stemming from the geniculate ganglion.
- The fibers from the motor nucleus innervate the muscles of facial expression, the stapedius, the posterior belly of the digastric, and the stylohyoid muscles.
- Fibers from the superior salivatory nucleus supply the submandibular and sublingual salivary glands. The lacrimal nucleus supplies the lacrimal gland.
- The sensory nucleus receives taste fibers from the anterior two-thirds of the tongue.

Cranial Nerve VIII

- The vestibulocochlear nerve consists of two parts, vestibular nerve and cochlear nerve.
- The vestibular nerve conducts head positioning information from the utricle, saccule, and semicircular canals.
- The cell bodies of these fibers are positioned in the vestibular ganglion and project to the vestibular nuclear complex, a group of nuclei that transmit vestibular information to the cortex and spinal cord.
- The cochlear nerve consists of bipolar cell bodies in the spiral nucleus of the cochlear, with fibers conducting cochlear sensations to the anterior and posterior cochlear nuclei.
- Second-order neurons from the cochlear nuclei communicate with the posterior nucleus of the trapezoid body, which sends a bundle of third-order fibers, called the lateral lemniscus, to the inferior colliculus and medial geniculate body. From here, axons project to the primary auditory cortex of the superior temporal gyrus.

Cranial Nerve IX

- The glossopharyngeal nerve has three nuclei: the main motor, inferior salivatory (parasympathetic), spinal trigeminal (sensory), and nucleus of the tractus solitarius (sensory).
- The motor fibers innervate the stylopharyngeus muscles.
- The parasympathetic fibers innervate the parotid salivary gland.

- The sensory fibers from the pharynx and posterior third of the tongue synapse in the spinal trigeminal nucleus, while the taste and carotid sinus and body reflexes synapse in the nucleus solitarius.
- The glossopharyngeal nerve exits the cranial cavity through the jugular foramen.

Cranial Nerve X

- The vagus has four nuclei: nucleus ambiguus (motor), dorsal nucleus (parasympathetic), spinal trigeminal (sensory), and nucleus of the tractus solitarius (sensory).
- The motor fibers from the nucleus ambiguus innervate the constrictor muscles of the pharynx and the intrinsic muscles of the larynx.
- The sensory fibers conveying taste from the epiglottis and visceral afferents from the organs synapse in the nucleus solitarius. Sensation from the mucosa of the larynx ends in the spinal nucleus of the trigeminal.
- Parasympathetic fibers from the dorsal nucleus of the vagus are distributed to the involuntary muscle of the bronchi, heart, esophagus, stomach, small intestine, and up to a third of the transverse colon.
- The vagus nerve exits the cranial cavity through the jugular foramen.

Cranial Nerve XI

- The accessory nerve is a motor nerve that receives efferent fibers from the nucleus ambiguus and the anterior gray column of the first five segments of the spinal cord.
- The fibers originating in the gray columns bring about movement of the SCM and trapezius muscles.
- Fibers from the nucleus ambiguus run with the vagus nerve and are usually attributed to the functions of CN X.
- The accessory nerve exits the cranial cavity through the jugular foramen.

Cranial Nerve XII

- The hypoglossal nerve is a motor nerve that receives its efferent fibers from the hypoglossal nucleus and innervates the muscles of the tongue.
- The hypoglossal nerve exits the medulla oblongata between the pyramid and the olive and traverses the hypoglossal canal to exit the cranial cavity.