

Cranial Nerve Innervation of Ocular Structures

S.Karmakar

T H E N E R V O U S S Y S T E M

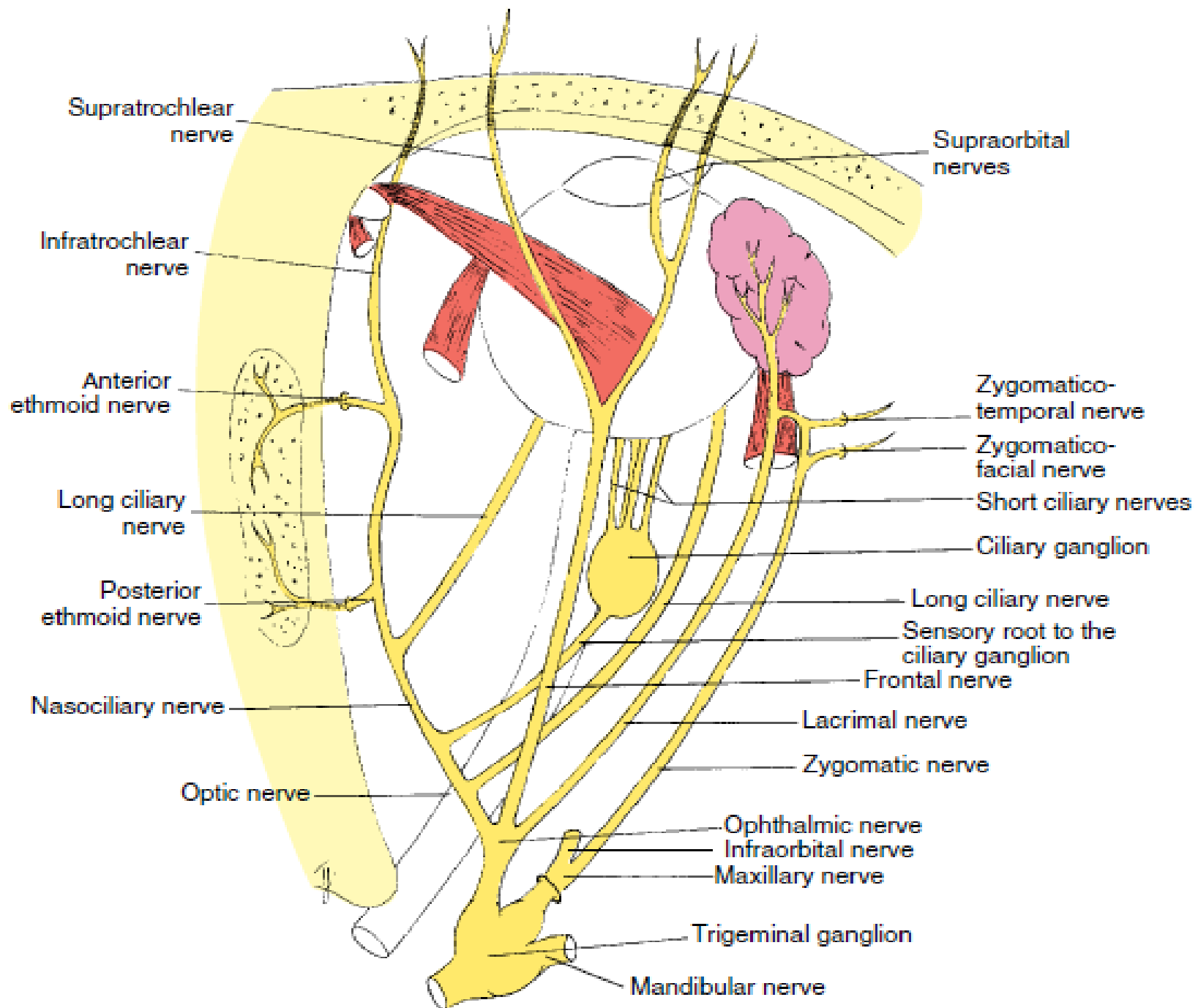
- Information comes into the central nervous system (CNS) via afferent fibers. Afferent sensory fibers usually have specialized nerve endings that respond to such sensations as touch, pressure, temperature, and pain.
- Information processing occurs within the brain or spinal cord and involves communication between different areas of the CNS through fiber tracts.
- Efferent fibers, either somatic or autonomic, carry information from the CNS to the target structures: muscles, organs, or glands. The efferent pathway in the somatic system generally consists of a fiber that runs the distance from the CNS to the target muscle.

AFFERENT PATHWAY: ORBITAL SENSORY INNERVATION

- The eye is richly supplied with sensory nerves that carry sensations of touch, pressure, warmth, cold, and pain.
- Sensations from the cornea, iris, conjunctiva, and sclera consist primarily of pain; even light touching of the cornea is registered as irritation or pain

TRIGEMINAL NERVE

- The fibers of the trigeminal nerve (CN V) serving ocular structures are sensory and originate in the innervated structures.
- the nerves as they join to become larger nerves, come together in the ganglion of the fifth cranial nerve, and then exit the ganglion and enter the pons.



Ophthalmic Division of Trigeminal Nerve

A) Nasociliary Nerve

- Sensory fibers from the structures of the medial canthal area—caruncle, canaliculi, lacrimal sac, medial aspect of the eyelids, and skin at the side of the nose —join to form the infratrochlear nerve. This nerve penetrates the orbital septum, enters the orbit below the trochlea, and runs along the upper border of the medial rectus muscle.
- Sensory fibers from the skin along the center of the nose, the nasal mucosa, and the ethmoid sinuses form the anterior ethmoid nerve;

- Corneal sensory innervation is dense, estimated to be 400 times as dense as other epithelial tissue innervation.
- Three networks of nerves are formed.
 - 1) located in the corneal epithelium,
 - 2) (the subepithelial plexus) is in the anterior stroma,
 - 3) the stromal plexus, is in the middle of the stroma
- No nerves are found in posterior stroma, Descemet's membrane, or endothelium

long ciliary nerves

- These long ciliary nerves, **one on the lateral side** and **one on the medial side of the globe**, course **between the choroid and sclera** to the back of the eye, where they leave the globe at points approximately 3 mm on each side of the optic nerve

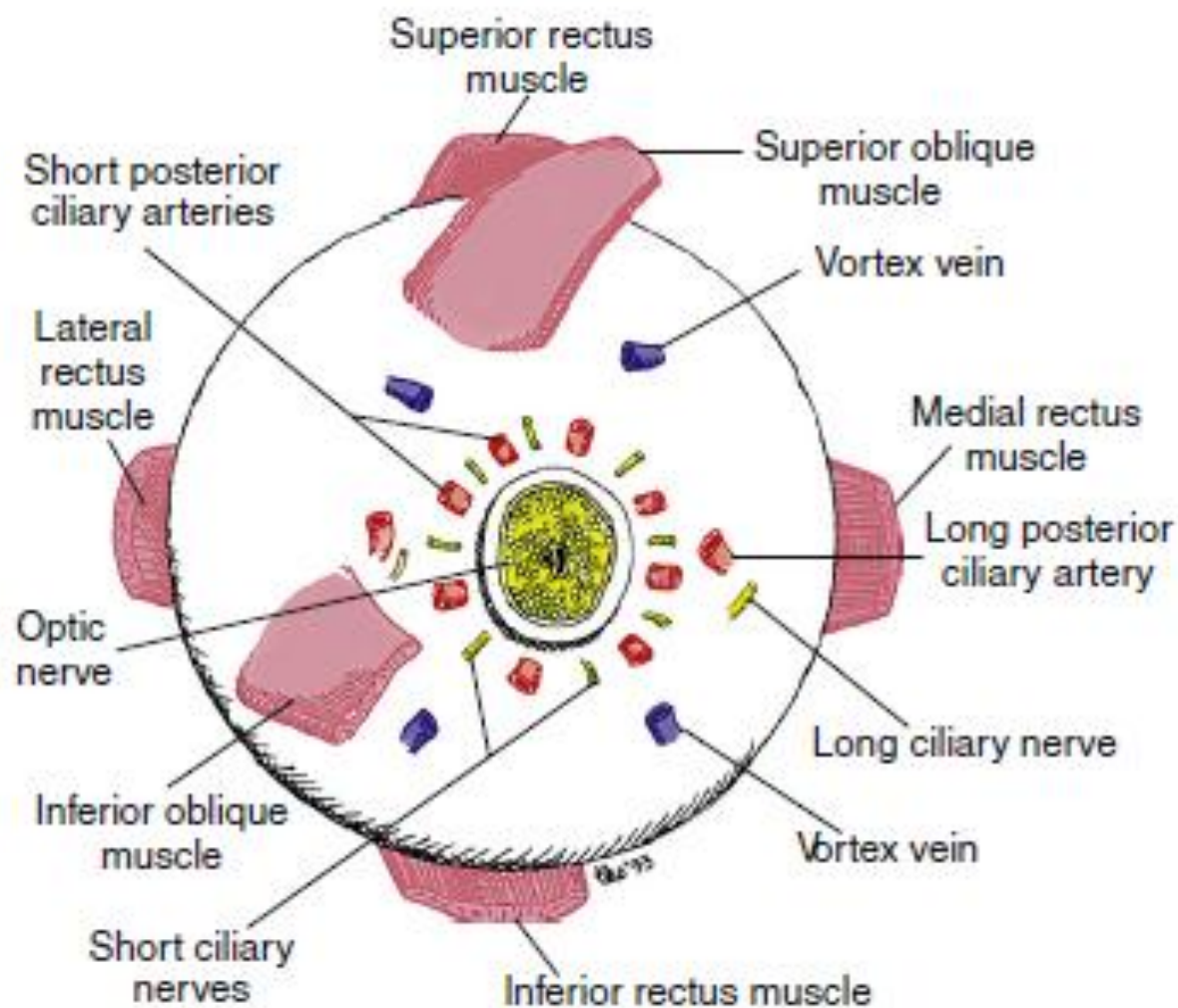
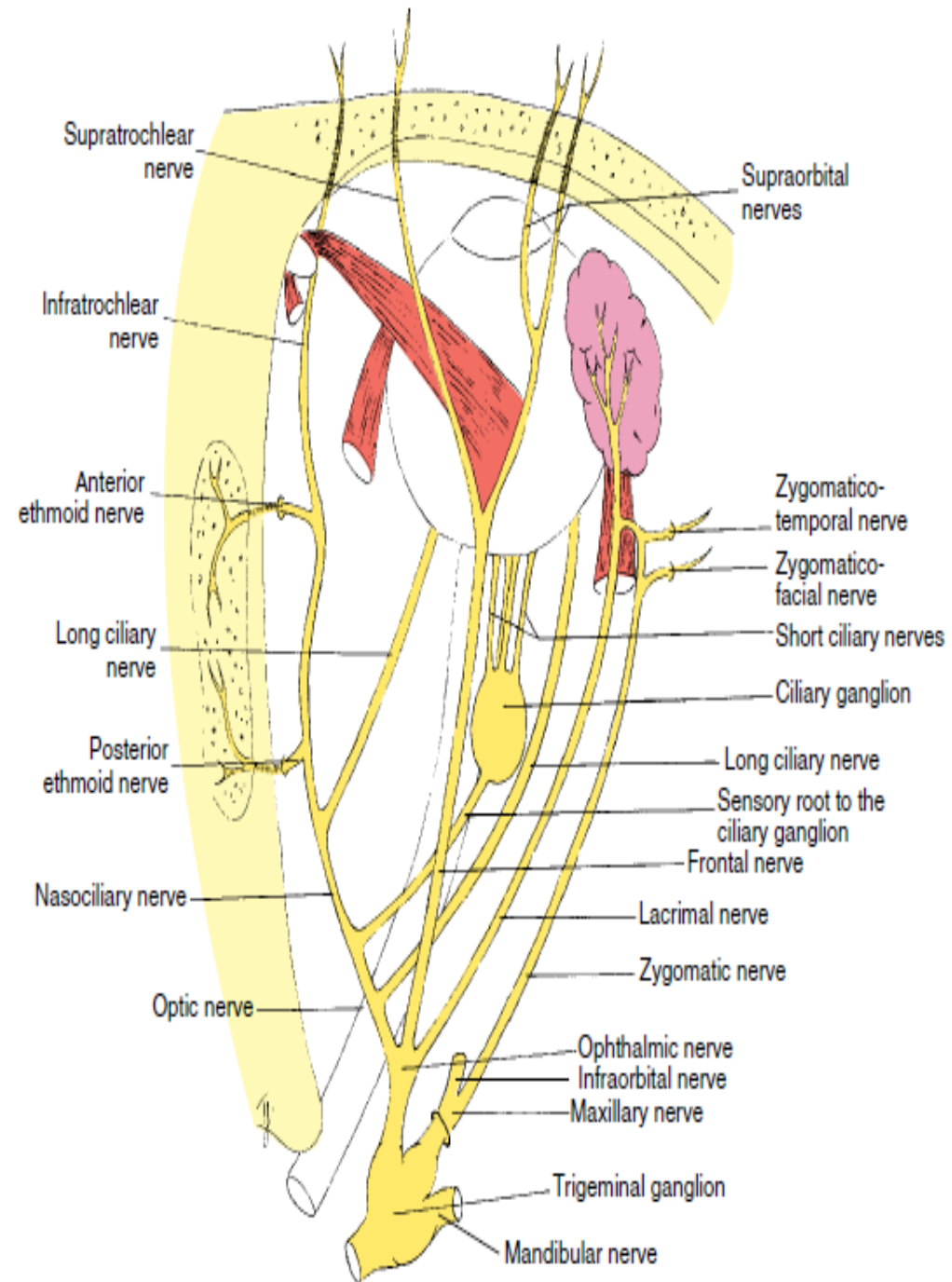


FIGURE 12-3

Posterior sclera. Posterior portion of globe showing optic nerve passing through posterior scleral foramen; long and short ciliary arteries and nerves passing through posterior apertures; and vortex veins passing through middle apertures.

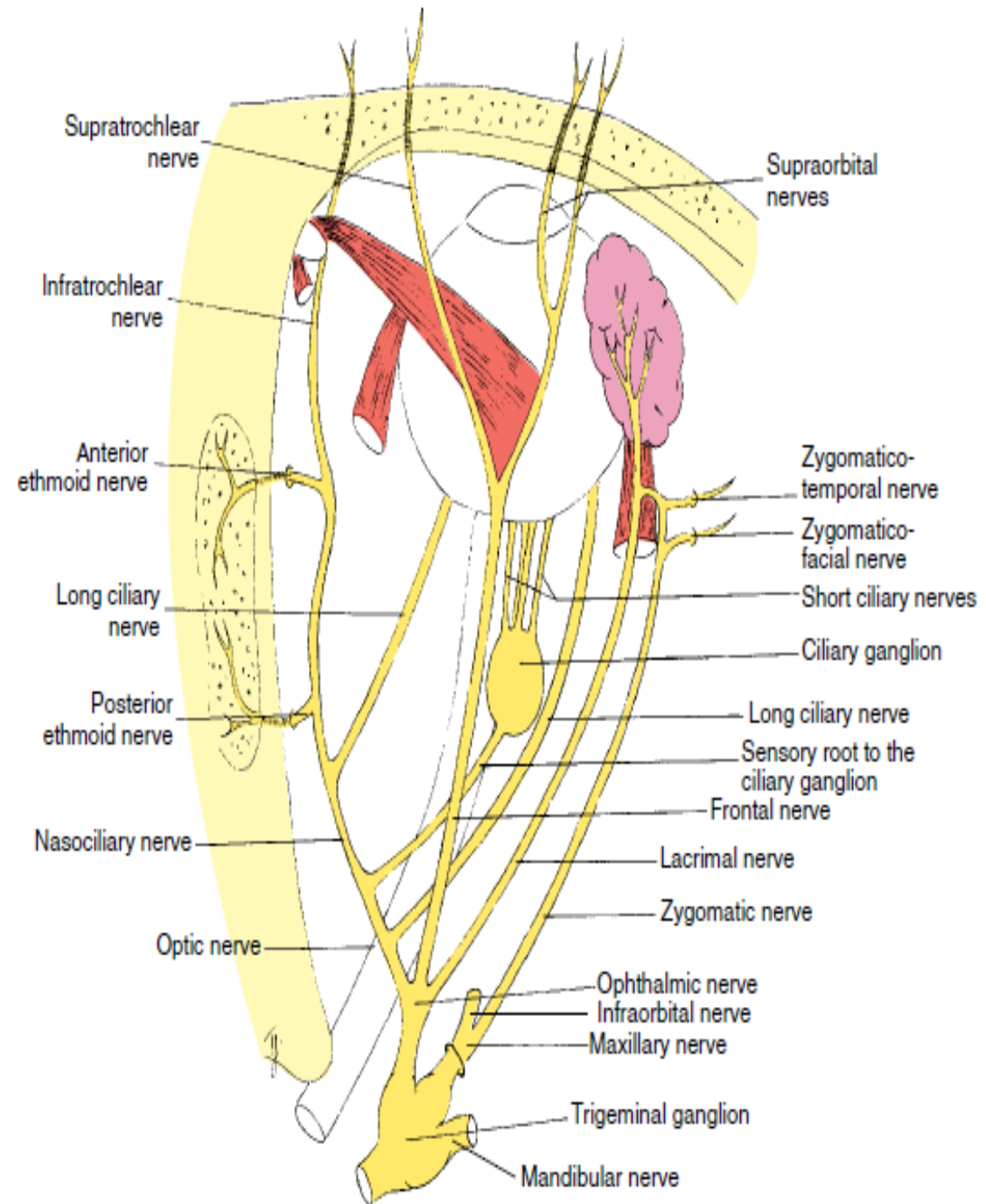
short ciliary nerves

- The short ciliary nerves exit the sclera in a ring around the optic nerve in company with the short posterior ciliary arteries and enter the ciliary ganglion.
- The sensory fibers do not synapse but pass through the ganglion, leaving as the sensory root of the ciliary ganglion, which then joins the nasociliary nerve.



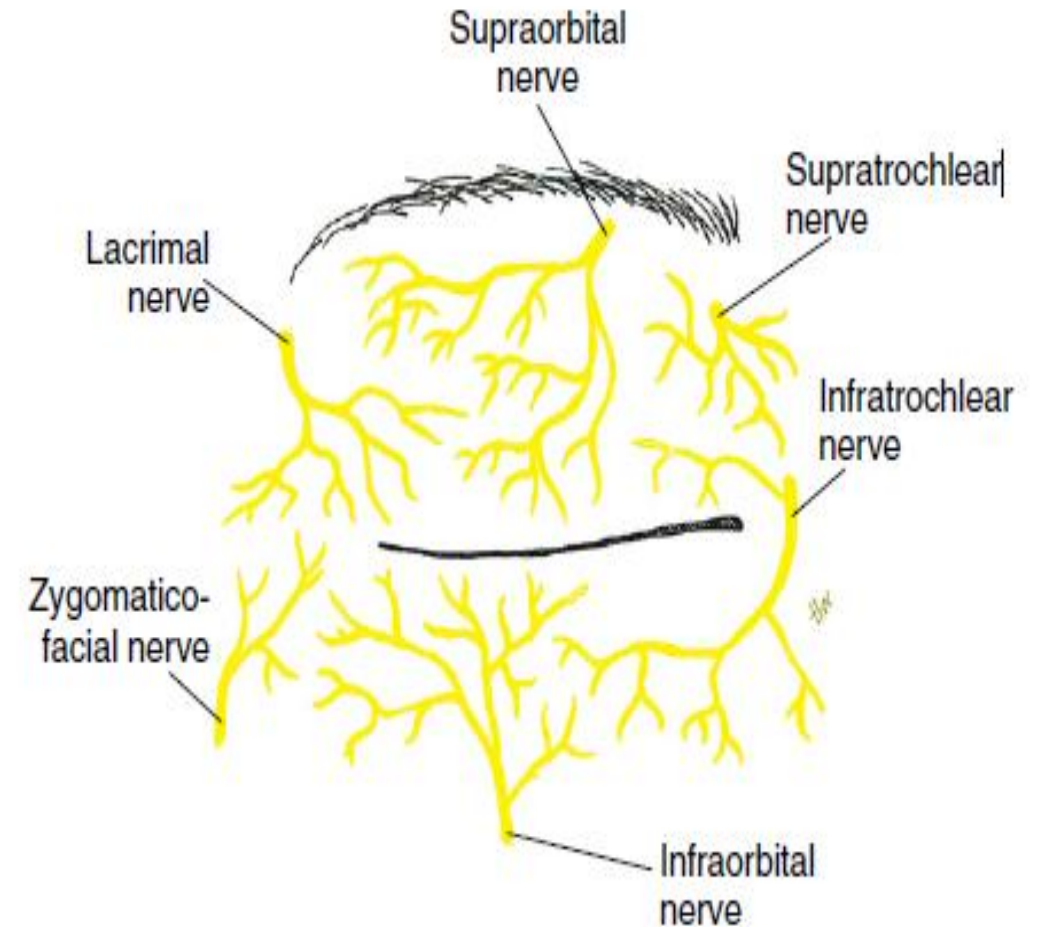
nasociliary nerve

- formed by the joining of the infratrochlear nerve, the anterior and posterior ethmoid nerves, the long ciliary nerves, and the sensory root of the ciliary ganglion
- The nasociliary nerve exits the orbit by passing through the oculomotor foramen *within* the common tendinous ring and the superior orbital fissure into the cranial cavity.



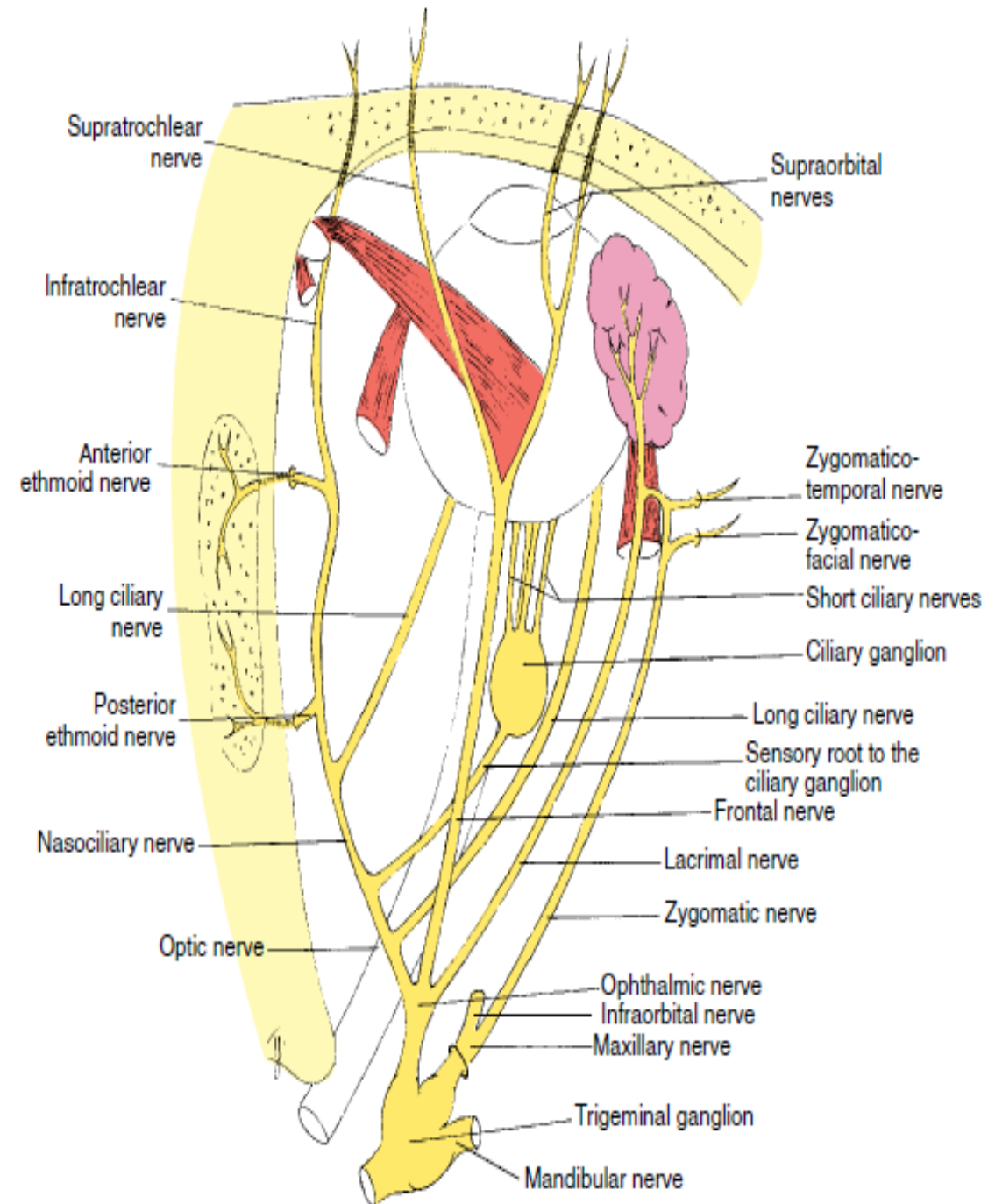
Frontal Nerve

- Sensory fibers from the skin and muscles of the forehead and upper eyelid come together and form the supratrochlear nerve. This nerve enters the orbit by piercing the superior medial corner of the orbital septum.
- Sensory fibers from the skin and muscles of the forehead and upper eyelid form a second nerve, the supraorbital nerve, lateral to the supratrochlear nerve.
- The supraorbital nerve joins the supratrochlear nerve midway in the orbit and forms the frontal nerve



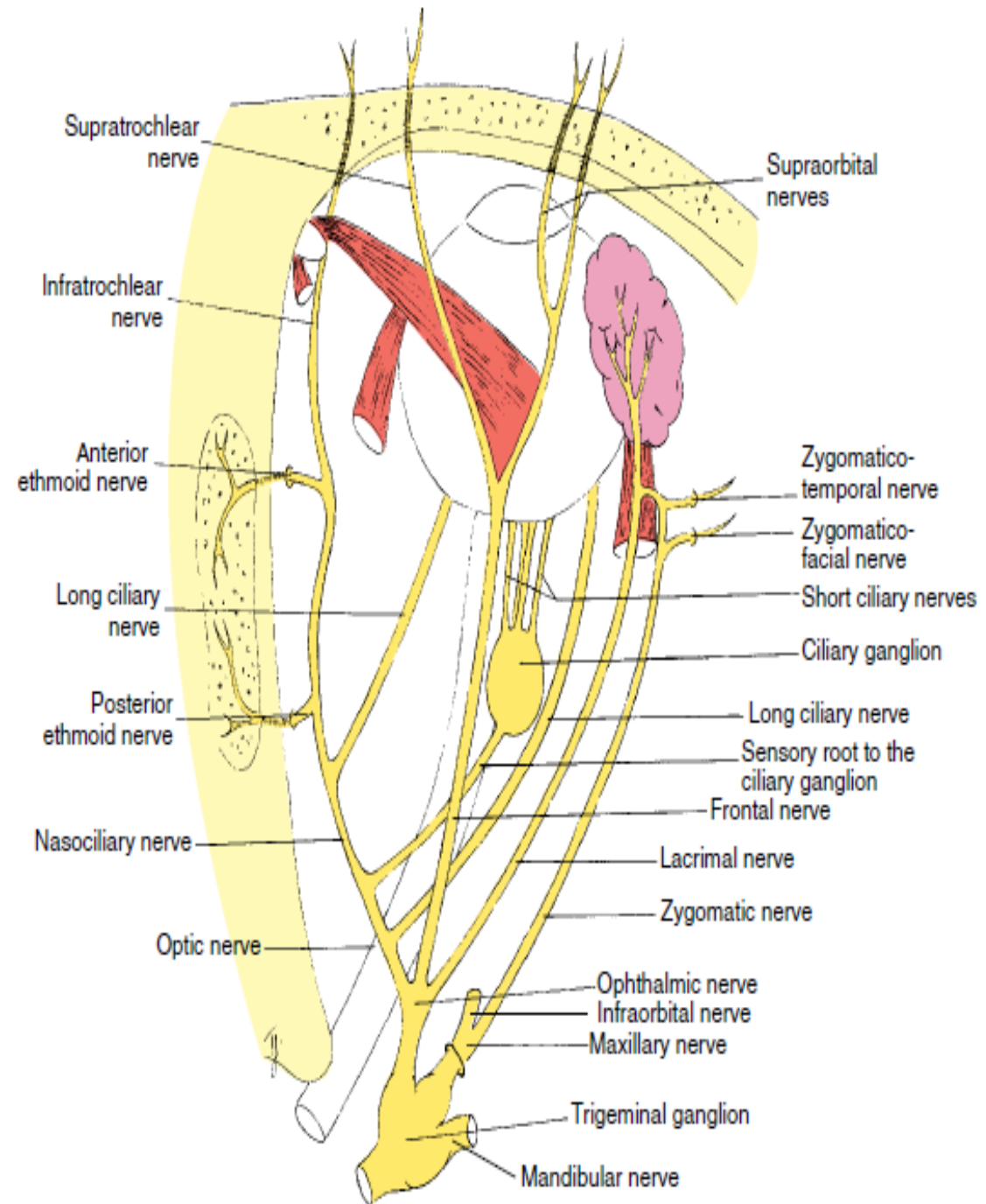
Lacrimal Nerve

- Sensory fibers from the lateral aspect of the upper eyelid and temple area come together and enter the lacrimal gland; they join the sensory fibers that serve the gland itself to form the lacrimal nerve. The lacrimal nerve leaves the gland and runs posteriorly along the upper border of the lateral rectus muscle.



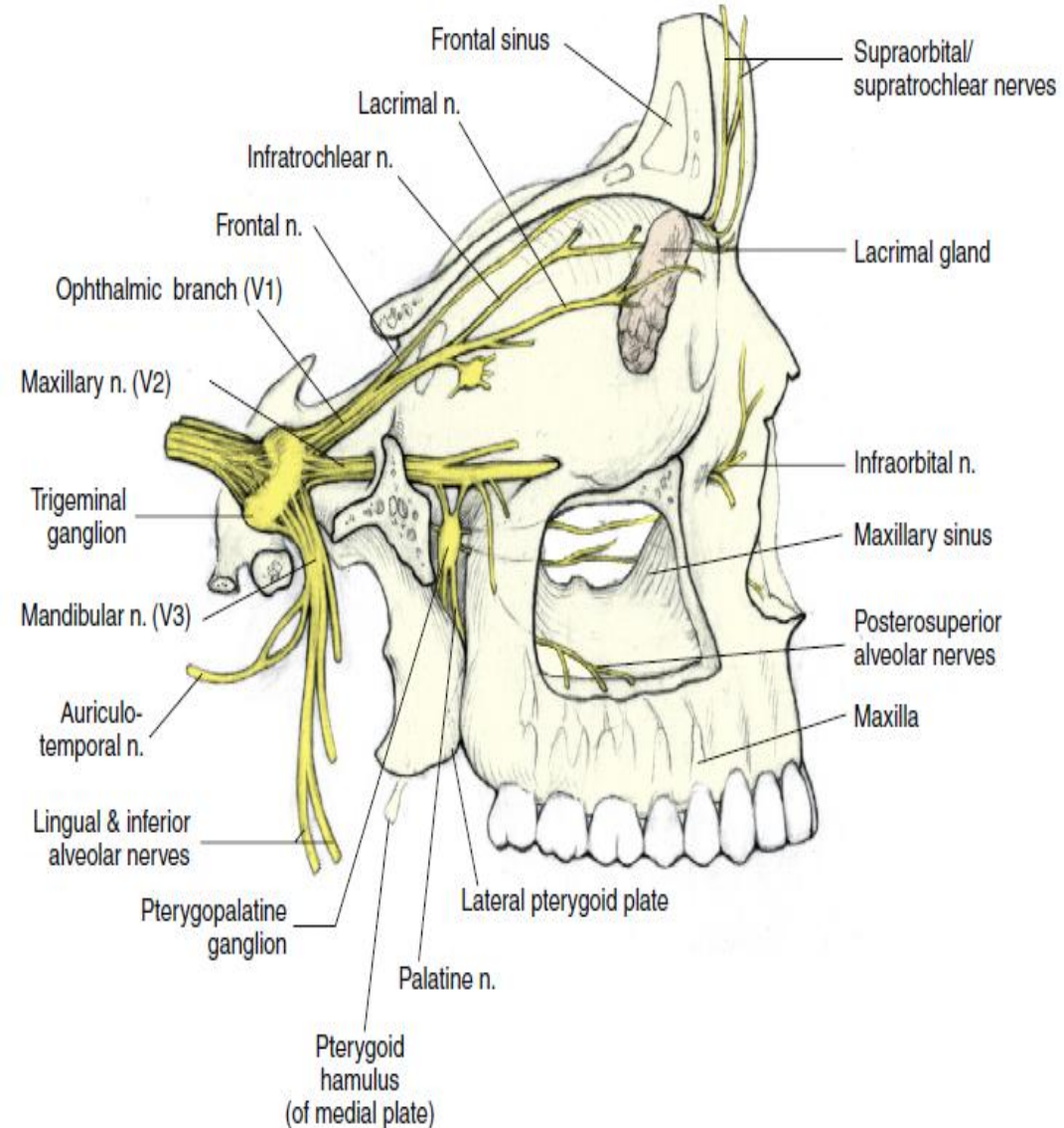
Ophthalmic Nerve Format

- After exiting the orbit, the nasociliary nerve, the lacrimal nerve, and the frontal nerve join and form the ophthalmic division of the trigeminal nerve. The ophthalmic nerve then enters the lateral wall of the cavernous sinus, coursing between the two dural layers.
- While in the wall of the sinus the nerve receives sensory fibers from the oculomotor, trochlear, and abducens nerves.
- Carry proprioceptive information from the extraocular muscles.



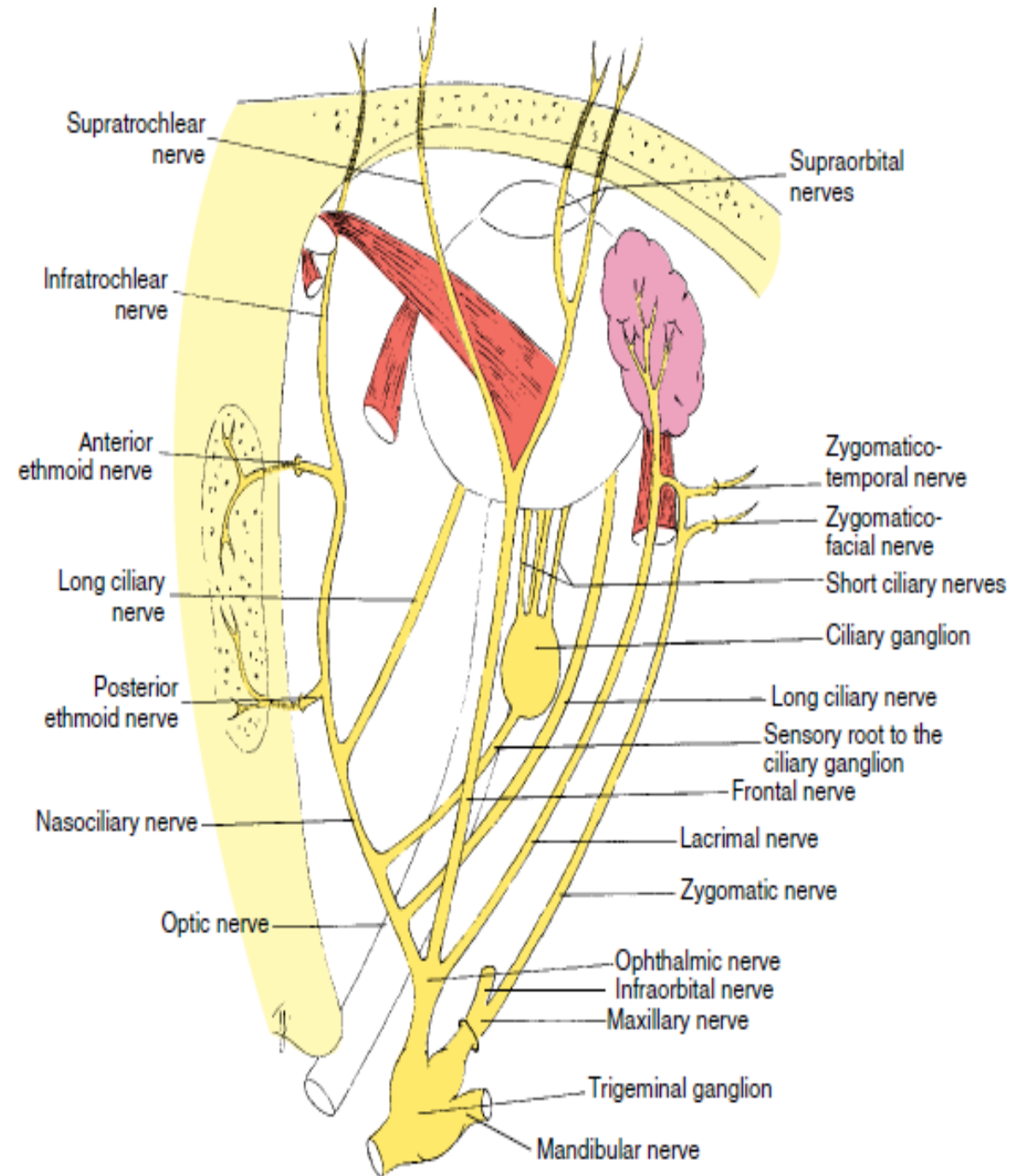
Maxillary Division of Trigeminal Nerve

- **Infraorbital Nerve:** The infraorbital nerve, formed by sensory fibers from the cheek, upper lip, and lower eyelid, enters the maxillary bone through the infraorbital foramen.
- It runs posteriorly through the infraorbital canal and groove; while it is in the maxillary bone, branches join from the upper teeth and maxillary sinus.
- As the nerve leaves the infraorbital groove it exits the orbit through the inferior orbital fissure and joins other fibers in forming the maxillary nerve.



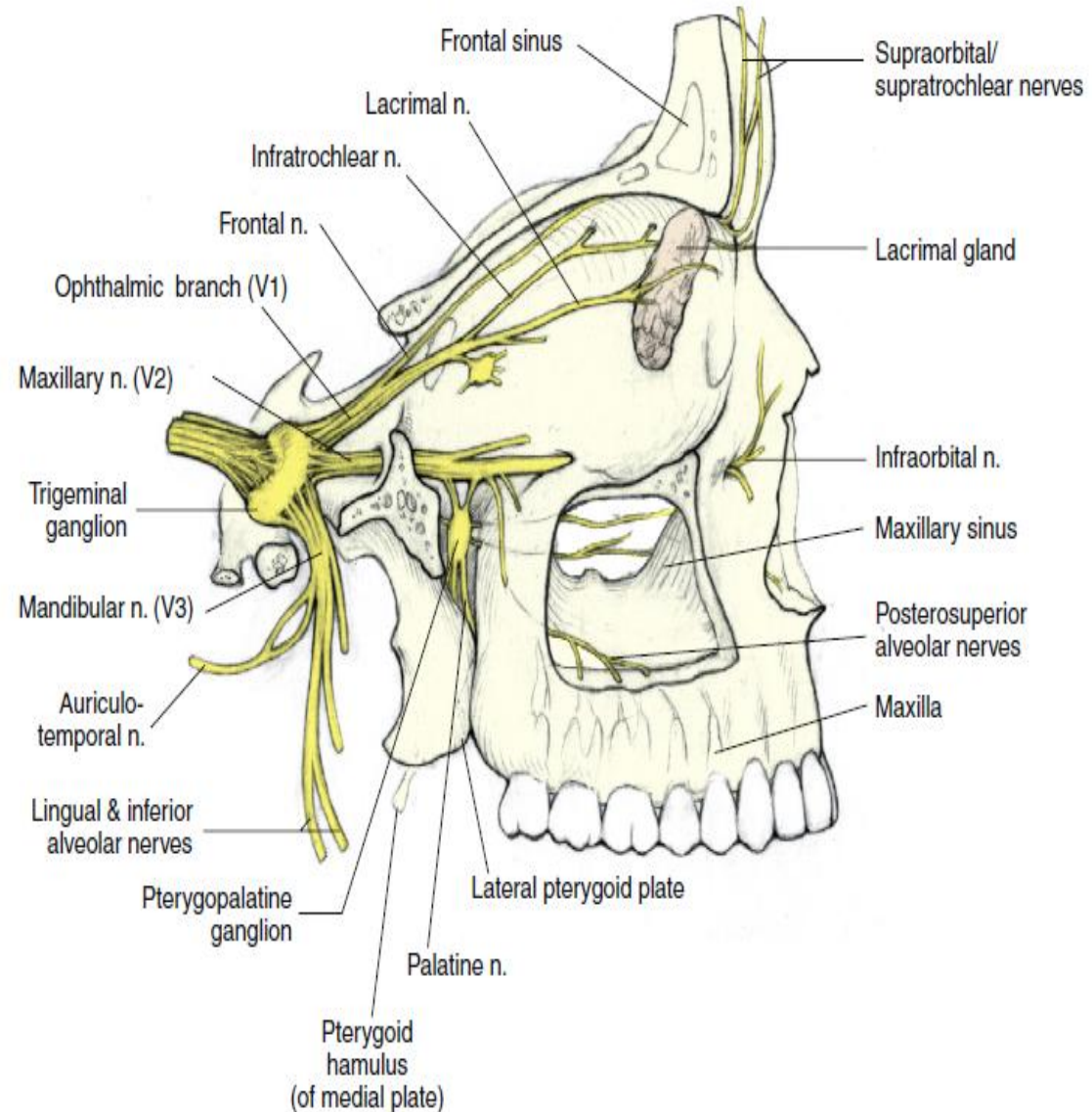
Zygomatic Nerve

- Sensory fibers from the lateral aspect of the forehead enter the orbit through a foramen in the zygomatic bone as the zygomaticotemporal nerve.
- Fibers from the lateral aspect of the cheek and lower eyelid enter the orbit through a foramen in the zygomatic bone as the zygomaticofacial nerve. These two nerves join to become the zygomatic nerve and course along the lateral orbital wall, exiting the orbit through the inferior orbital fissure and joining with the maxillary nerve.



Maxillary Nerve Formation

- Having been formed by the joining of the infraorbital nerve, the zygomatic nerve, and nerves from the roof of the mouth, upper teeth and gums, and mucous membranes of the cheek, the maxillary nerve traverses the area between the maxilla and the sphenoid bone.
- As it passes near the pterygopalatine fossa, it receives some autonomic fibers from the pterygopalatine ganglion



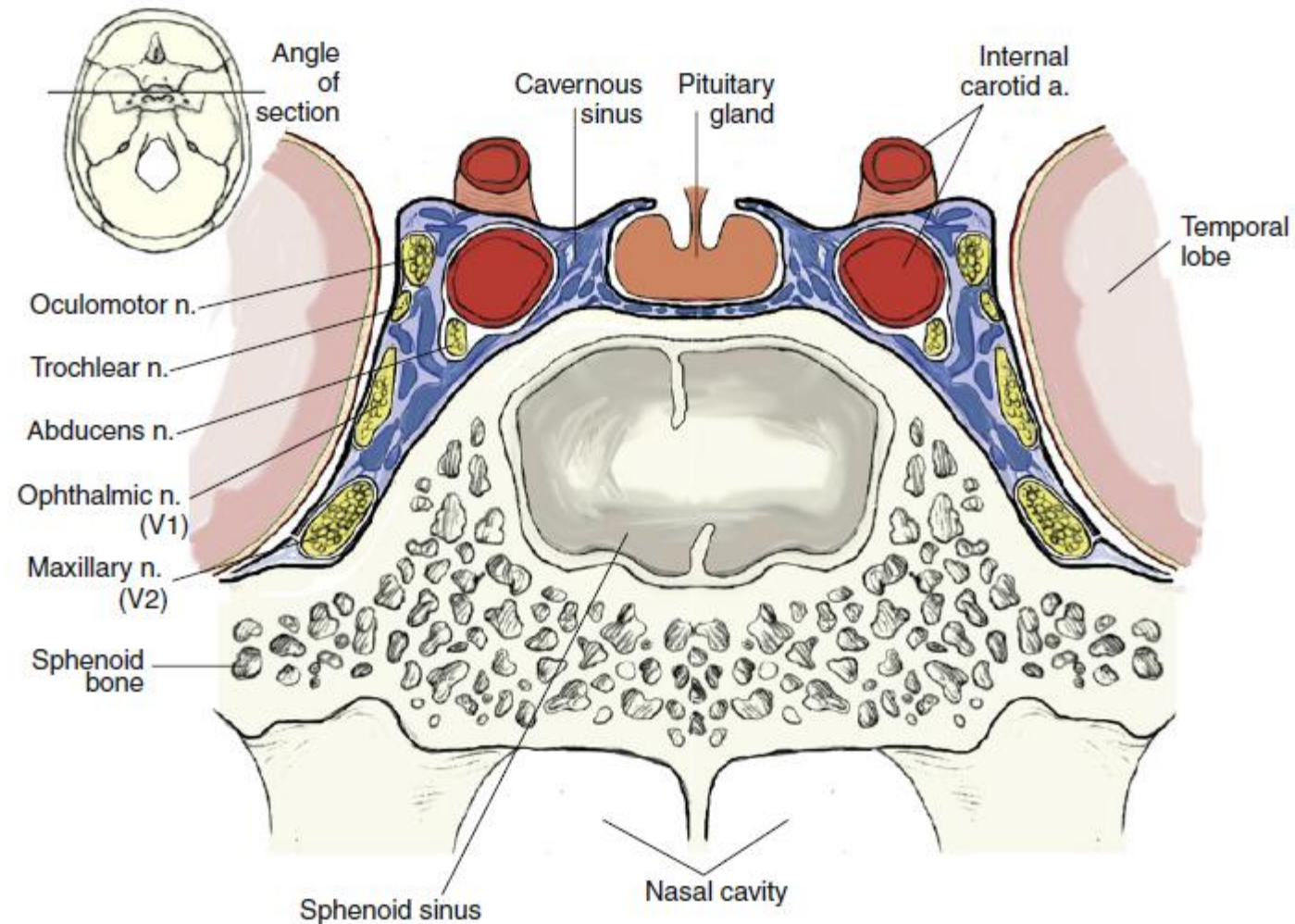
Mandibular Division of Trigeminal Nerve

- The mandibular nerve innervates the lower face and contains both sensory and motor fibers. It enters the skull via the foramen ovale.

TRIGEMINAL NERVE FORMATION

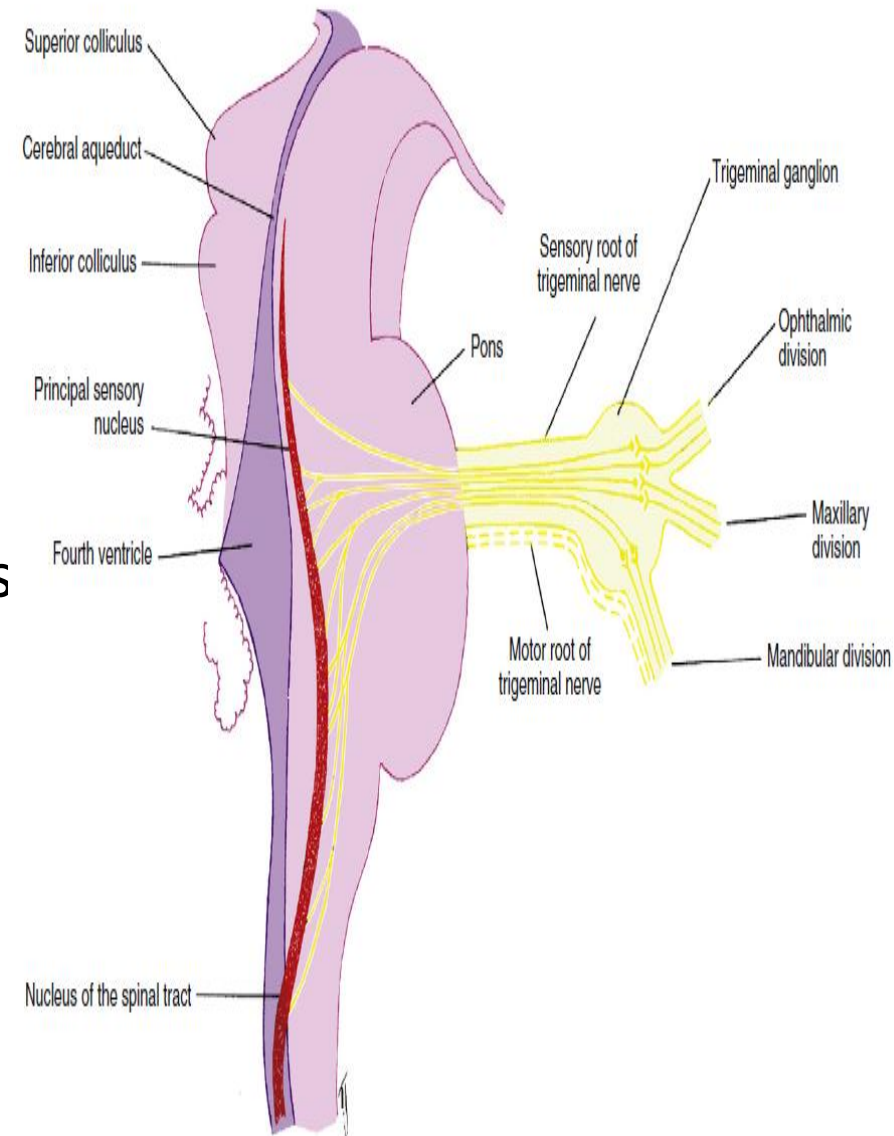
- As the ophthalmic and maxillary divisions enter the skull, they run posteriorly within the lateral wall of the cavernous sinus. The mandibular division lies just below the cavernous sinus.
- The sensory fibers from the three divisions enter the trigeminal ganglion (gasserian ganglion, semilunar ganglion), where they synapse.

cross section of cavernous sinus.



TRIGEMINAL NERVE FORMATION

- The motor fibers of the mandibular division, which innervate the muscles of mastication, pass along the lower edge of the ganglion. Only the sensory fibers synapse within the ganglion.
- The fibers leave the trigeminal ganglion and enter the lateral aspect of the pons as either the sensory root or the motor root of the trigeminal nerve.
- The sensory root carries information from the structures of the face and head, including all orbital structures. After entering the brain stem, these fibers form an ascending and a descending tract, both terminating in sensory nuclei of the trigeminal nerve
- The ascending tract terminates in the principal sensory nucleus in the pons; it registers the sensations of touch and pressure



TRIGEMINAL NERVE FORMATION

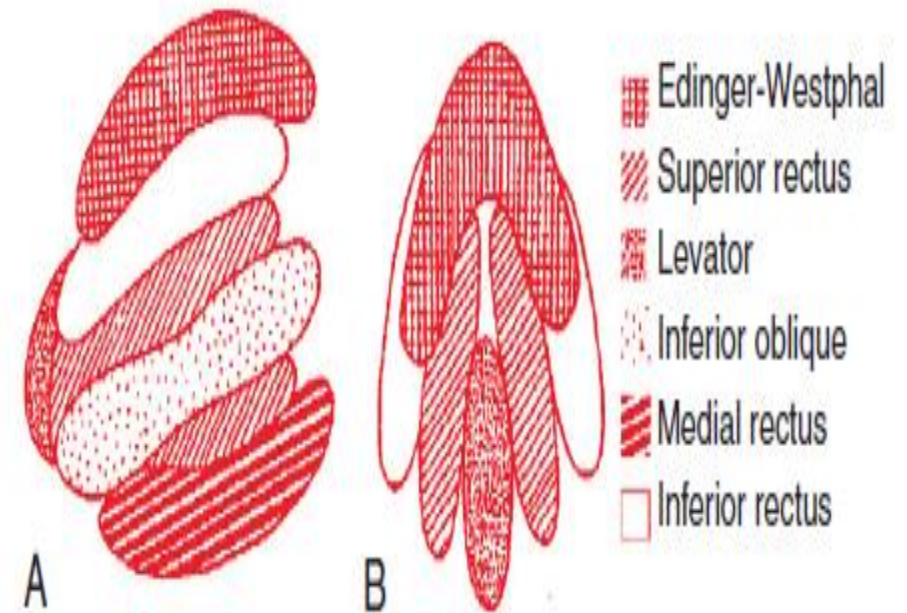
- The descending tract, which carries pain and temperature sensations, courses through the pons and medulla to the elongated nucleus of the spinal tract.
- The tract extends into the second cervical segment of the spinal cord.
- Information from the trigeminal nuclei is relayed to the thalamus.

EFFERENT PATHWAY: MOTOR NERVES

- The cranial nerves that supply striated muscles of the orbit and adnexa are the oculomotor nerve, the trochlear nerve, the abducens nerve, and the facial nerve.

OCULOMOTOR NERVE: CRANIAL NERVE III

- The oculomotor nerve innervates the superior rectus, medial rectus, inferior rectus, inferior oblique, and superior palpebral levator muscles.
- It also provides a route along which the autonomic fibers travel to innervate the iris sphincter muscle, the ciliary muscle, and the smooth muscles of the eyelid.



Oculomotor Nucleus

- The oculomotor nucleus is located in the midbrain, at the level of the superior colliculus, ventral to the cerebral aqueduct, and dorsal to the medial longitudinal fasciculus.
- It extends in a column from the posterior edge of the floor of the third ventricle to the trochlear nucleus.
- A definitive area or subnucleus within the oculomotor nucleus controls each muscle.
- Fibers to the inferior rectus, inferior oblique, and medial rectus muscles supply the *ipsilateral eye*; fibers innervating the superior rectus muscle decussate and supply the *contralateral eye*.

Oculomotor Nucleus

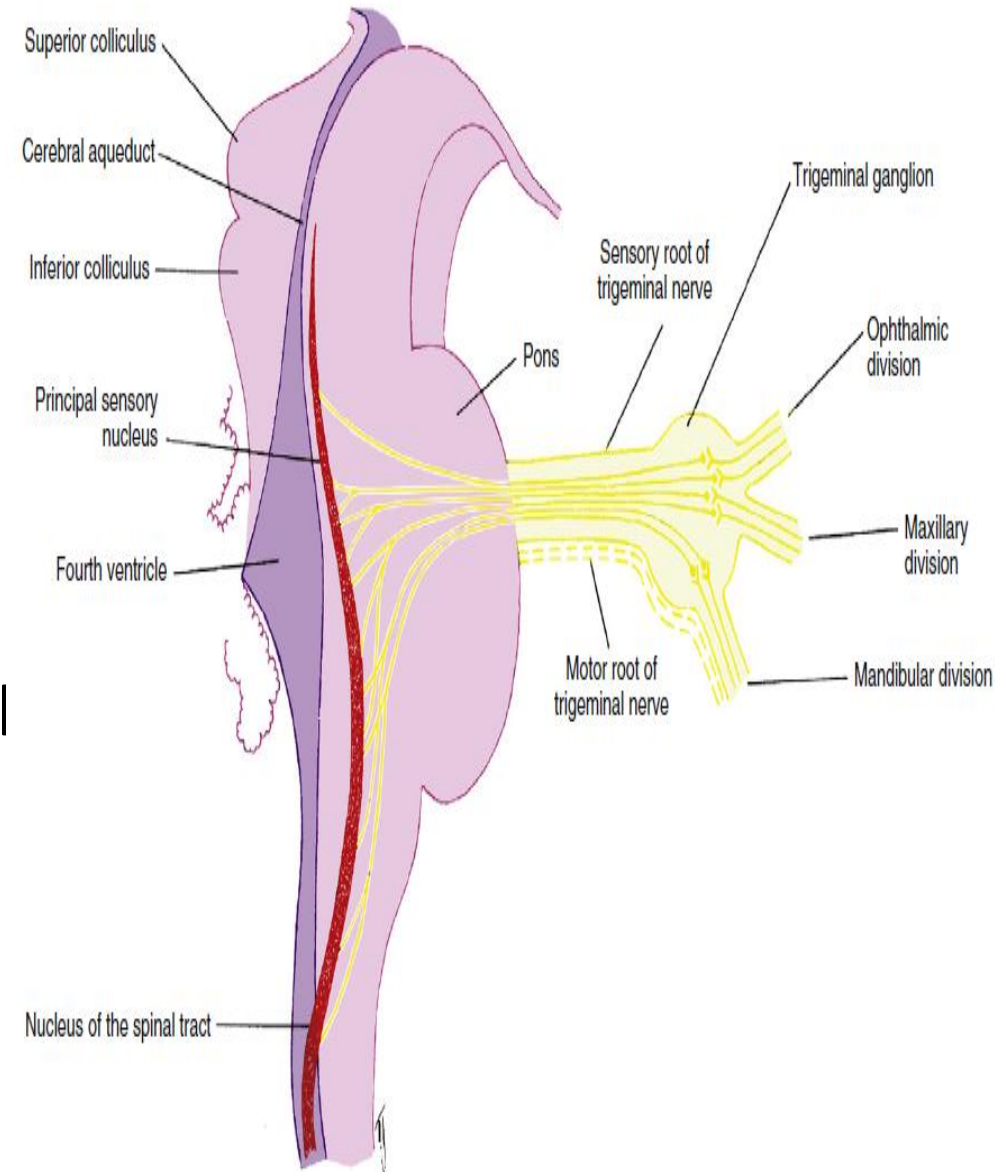
- An autonomic nucleus, the accessory third nerve nucleus (Edinger-Westphal nucleus), supplies parasympathetic innervation to the ciliary and iris sphincter muscles.
- It is located in the rostral, ventral portion of the oculomotor nucleus

TROCHLEAR NERVE: CRANIAL NERVE IV

- The trochlear nerve innervates the superior oblique muscle.

Trochlear Nucleus

- The trochlear nucleus is located in the midbrain, at the level of the inferior colliculus, anterior to the cerebral aqueduct, dorsal to the medial longitudinal fasciculus, and below the oculomotor nucleus

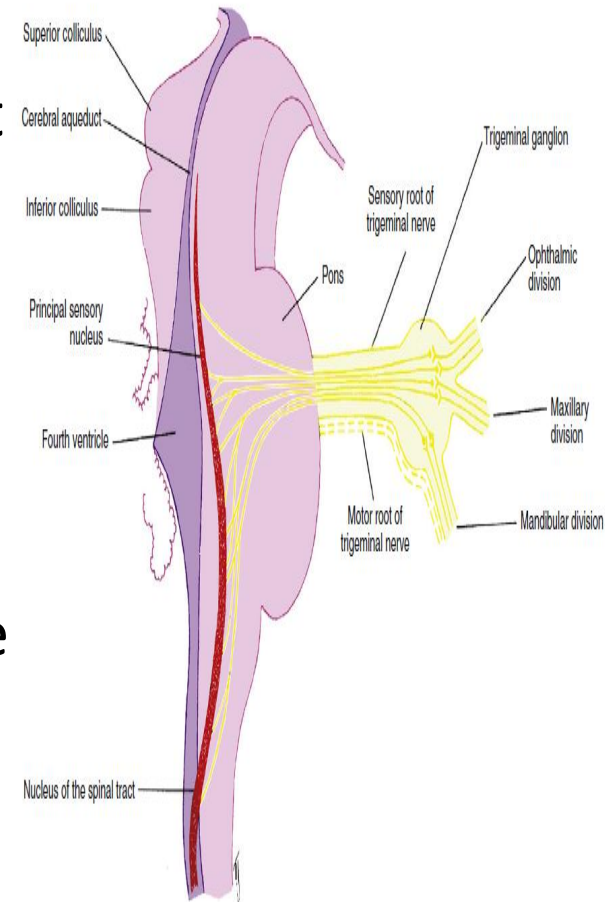


ABDUCENS NERVE: CRANIAL NERVE VI

- The abducens nerve innervates the lateral rectus muscle.
- The abducens nucleus is located near the inferior dorsal midline of the pons beside the floor of the fourth ventricle.

Abducens Nucleus

- The fibers from the nucleus pass through the pons and lie adjacent to the corticospinal tract for part of their path; they exit in the groove between the pons and the medulla oblongata.
- The abducens nucleus also contains *internuclear neurons that communicate with the nucleus for the contralateral medial rectus muscle in the oculomotor complex* via the medial longitudinal fasciculus.
- Thus coordinated movement of the ipsilateral lateral rectus muscle and the contralateral medial rectus muscle results in conjugate horizontal eye movement



SUPERIOR ORBITAL FISSURE

- The trochlear, frontal, and lacrimal nerves as well as the superior ophthalmic vein are located in the superior orbital fissure *above the muscle cone*.
- *The superior and inferior* divisions of the oculomotor nerve, the abducens nerve, and the nasociliary nerve are located *within the superior orbital fissure and the common tendinous ring*.
- The inferior ophthalmic vein lies *below the fissure and the tendinous ring*

CONTROL OF EYE MOVEMENTS

- Communication among areas of the CNS is necessary to produce controlled and coordinated eye movements.
- The corticonuclear tract contains fibers that travel from the cerebral hemispheres to the nuclei of CNs III, IV, and VI;
- The tectobulbar tract connects the superior colliculus to the CN III, IV, and VI nuclei.
- The medial longitudinal fasciculus extends from the midbrain into the spinal cord and connects the vestibular nucleus, the oculomotor nucleus, the abducens nucleus, and the trochlear nucleus, providing a connection between eye movement control and the vestibular apparatus

FACIAL NERVE: CRANIAL NERVE VII

- The facial nerve has two roots: the large motor root innervates the facial muscles, and the smaller root contains sensory and parasympathetic fibers.
- The sensory fibers carry taste sensations from the tongue.
- The parasympathetic nerves supply secretomotor fibers to various glands of the face; those supplying the lacrimal gland

Facial Nucleus

- The motor nucleus of the facial nerve is located in the reticular formation of the pons.
- The upper segment of the nucleus supplies the frontalis, procerus, corrugator superciliaris, and orbicularis muscles, and the lower segment supplies the remaining facial muscles

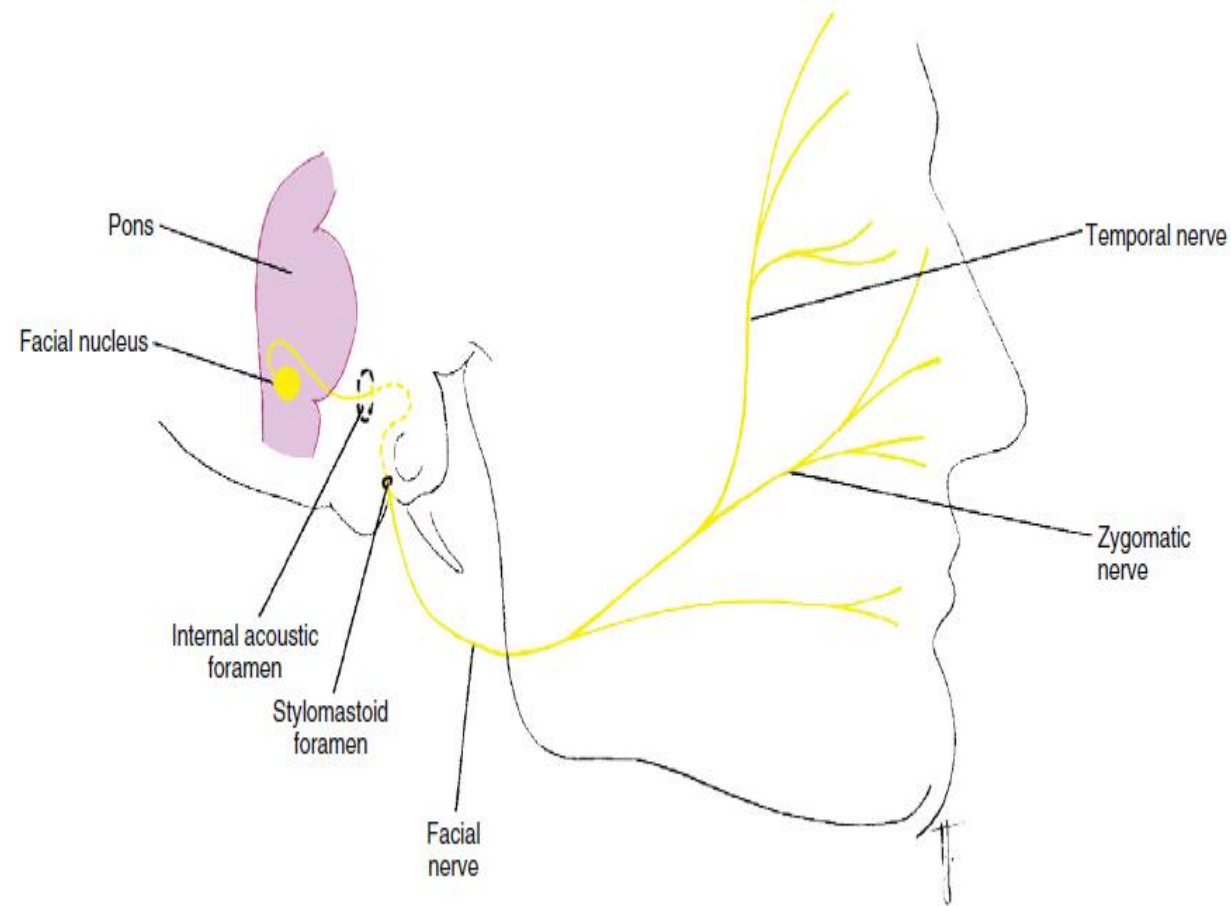


FIGURE 12-12

Facial nerve pathway. Motor pathway of facial nerve to facial muscles of orbit.

Cranial Nerve Damage

- *Injury to sensory cranial nerve fibers results in anesthesia, a loss of sensation in the innervated area.*
- *Injury to a cranial motor nerve causes either a partial loss (paresis) or a total loss (paralysis) of muscle function.*
- *Paresis or paralysis of an extraocular muscle can result in diplopia if the involvement is acquired; in congenital involvement, diplopia usually is not a complaint because the brain has learned to disregard the double image, resulting in suppression.*

CONTINUE...

- *Nerve fibers can be ischemic, damaged by a compromised blood supply caused by vascular diseases (e.g., hypertension, atherosclerosis, diabetes mellitus) or by space-occupying lesions (e.g., aneurysms, hemorrhages, tumors) that exert pressure on the nerve fibers.*
- *A number of clinical signs and symptoms accompany damage to the motor nerves that innervate the extraocular muscles.*
- *In acquired extraocular muscle impairment, a patient often attempts to minimize diplopia by carrying the head in a compensatory position.*
- *If a horizontal deviation is present, the head will be turned to the right or left.*
- *With a vertical deviation, the head is raised or lowered, and if a torsional deviation occurs the head is tilted toward the shoulder usually away from the involved side.*
- *With right superior oblique involvement the head may be turned to the left, positioned down, and tilted toward the left shoulder*

Patient tilts head toward the left shoulder and turns head to the left and down, resulting from right superior oblique dysfunction.



Clinical Comment: Oculomotor Damage

1. MIDBRAIN INVOLVEMENT: *A lesion in the midbrain can affect the entire oculomotor nucleus or selectively affect only some subnucle.*
 - *If the lesion affects the entire oculomotor nucleus, the muscles involved are the ipsilateral medial rectus, inferior rectus, and inferior oblique, contralateral superior rectus, and both levators.*
 - *The contralateral eye would be unable to elevate in abduction and unable to depress in adduction.*

2. INTRACRANIAL INVOLVEMENT:

- *The oculomotor nerve lies near several blood vessels in its intracranial path and frequently is affected by an aneurysm of the posterior communicating artery.*
- *Damage to the nerve results in ptosis because of levator muscle paralysis*
- *Third nerve palsies that include a dilated pupil are highly suspicious of a compressive lesion.*
- *Incomplete lesions of the oculomotor nerve are possible.*
- *If injury involves the cerebral peduncles, a contralateral hemiparesis will be present.*
- *In paralysis of the iris sphincter and ciliary muscle, the pupil will be dilated, and accommodation will not occur.*

3. CAVERNOUS SINUS INVOLVEMENT

- *The lateral wall of the cavernous sinus contains the oculomotor nerve as well as the trochlear, ophthalmic, and maxillary nerves.*
- *A lesion that affects all these nerves would leave only the lateral rectus muscle still functioning.*
- *The eye would be positioned out in primary gaze and could move only from the lateral position to the midline.*

4. *ORBITAL INVOLVEMENT: Both divisions of the oculomotor nerve are located within the muscle cone, together with the abducens and nasociliary nerves. A retrobulbar tumor or inflammation involving these nerves would leave only the superior oblique muscle functional.*

- *In primary position, the eye would be positioned downward and outward slightly and would be fairly immobile.*

Clinical Comment: Trochlear Damage

- *When the superior oblique muscle is affected by trochlear nerve damage, the eye is elevated in primary gaze and is unable to move down in the adducted position.*
 - *The head may be tilted toward the opposite shoulder to compensate for the unopposed extorsion of the inferior oblique muscle.*
1. *MIDBRAIN INVOLVEMENT: Damage to the trochlear nucleus will affect the contralateral superior oblique muscle.*
 2. *INTRACRANIAL INVOLVEMENT: Damage to the trochlear nerve affects the ipsilateral superior oblique muscle, causing the eye to be elevated in primary gaze and unable to move down in the adducted position*



Clinical Comment: Abducens Damage

- *Damage to the abducens nerve results in paralysis of the lateral rectus muscle; because of the unopposed action by the medial rectus muscle, a convergent strabismus is evident.*
- *The eye will be unable to abduct.*
- *The patient might try to compensate for the diplopia by turning the face toward the paralyzed side*
- *1. PONS INVOLVEMENT: Damage here could affect the lateral rectus and the muscles of the forehead and the orbicularis.*
- *Symptoms might include the inability to abduct the eye and lagophthalmos.*

Sixth nerve palsy OS.

A, Primary position, left eye positioned in. B, Unable to abduct; C, Normal adduction.



2. INTRACRANIAL INVOLVEMENT

- *The course of the abducens nerve renders it particularly susceptible to increased intracranial pressure, which causes the brain stem to be displaced posteriorly, stretching the nerve over the bony prominence of the temporal bone.*
- *Fractures of the base of the skull and aneurysms of the basilar and carotid arteries can affect the abducens nerve.*

3. CAVERNOUS SINUS INVOLVEMENT:

- *The abducens nerve is located near the internal carotid artery within the cavernous sinus.*
- *Often, it is the first nerve affected with an aneurysm of this vessel. A lateral rectus muscle palsy with Horner's syndrome on the same side*