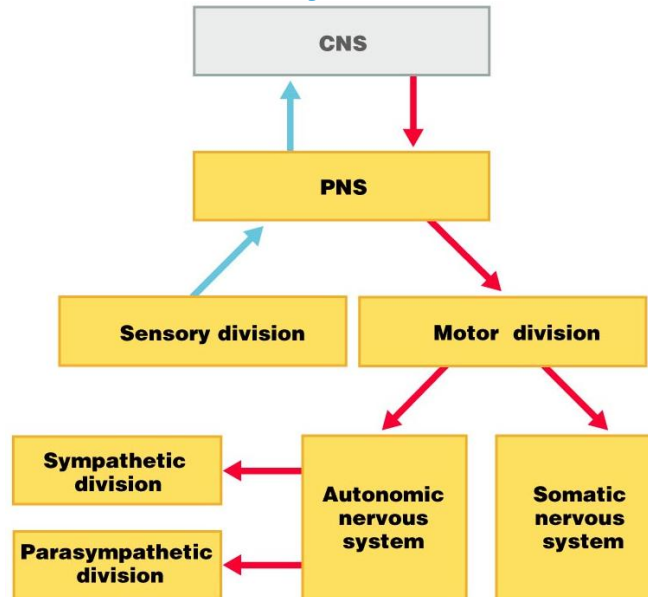


The Peripheral Nervous System (PNS)

PNS in the Nervous System



Peripheral Nervous System (PNS)

- PNS – all neural structures outside the brain and spinal cord
- Includes sensory receptors, peripheral nerves, associated ganglia, and motor endings
- Provides links to and from the external environment

PNS in the Nervous System

Sensory Receptors

- Structures specialized to respond to stimuli
- Activation of sensory receptors results in depolarizations that trigger impulses to the CNS
- The realization of these stimuli, sensation and perception, occur in the brain

Receptor Classification by Stimulus Type

- **Mechanoreceptors** – respond to touch, pressure, vibration, stretch, and itch
- **Thermoreceptors** – sensitive to changes in temperature
- **Photoreceptors** – respond to light energy (e.g., retina)
- **Chemoreceptors** – respond to chemicals (e.g., smell, taste, changes in blood chemistry)
- **Nociceptors** – sensitive to pain-causing stimuli

Receptor Class by Location: Exteroceptors

- Respond to stimuli arising outside the body
- Found near the body surface
- Sensitive to touch, pressure, pain, and temperature
- Include the special sense organs

Receptor Class by Location: Interoceptors

- Respond to stimuli arising within the body
- Found in internal viscera and blood vessels
- Sensitive to chemical changes, stretch, and temperature changes

Receptor Class by Location: Proprioceptors

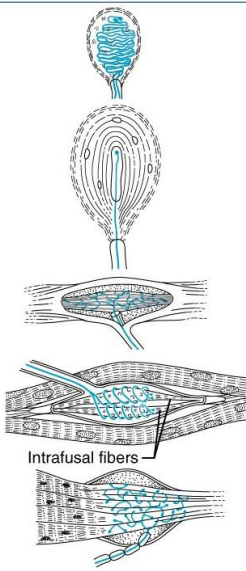
- Respond to degree of stretch of the organs they occupy
- Found in skeletal muscles, tendons, joints, ligaments, and connective tissue coverings of bones and muscles
- Constantly “advise” the brain of one’s movements

Receptor Classification by Structural Complexity

- Receptors are structurally classified as either simple or complex
- Most receptors are simple and include encapsulated and unencapsulated varieties
- Complex receptors are special sense organs

Simple Receptors: Encapsulated

TABLE 13.1 General Sensory Receptors Classified by Structure and Function (continued)

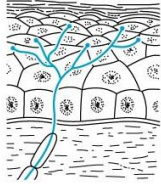
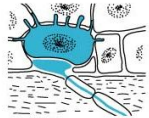
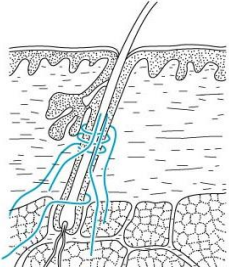
STRUCTURAL CLASS	ILLUSTRATION	FUNCTIONAL CLASSES ACCORDING TO LOCATION (L) AND STIMULUS TYPE (S)	BODY LOCATION
ENCAPSULATED			
Meissner's corpuscles (tactile corpuscles)		L: Exteroceptors S: Mechanoreceptors (light pressure, discriminative touch, vibration of low frequency); rapidly adapting	Dermal papillae of hairless skin, particularly nipples, external genitalia, fingertips, soles of feet, eyelids
Pacinian corpuscles (lamellated corpuscles)		L: Exteroceptors, interoceptors, and some proprioceptors S: Mechanoreceptors (deep pressure, stretch, vibration of high frequency); rapidly adapting	Dermis and hypodermis; periosteum, mesentery, tendons, ligaments, joint capsules; most abundant on fingers, soles of feet, external genitalia, nipples
Ruffini endings		L: Exteroceptors and proprioceptors S: Mechanoreceptors (deep pressure and stretch); slowly or nonadapting	Deep in dermis, hypodermis, and joint capsules
Muscle spindles		L: Proprioceptors S: Mechanoreceptors (muscle stretch, length)	Skeletal muscles, particularly those of the extremities
Golgi tendon organs		L: Proprioceptors S: Mechanoreceptors (tendon stretch, tension)	Tendons
Joint kinesthetic receptors		L: Proprioceptors S: Mechanoreceptors and nociceptors	Joint capsules of synovial joints

Simple Receptors: Unencapsulated

- Free dendritic nerve endings
 - Respond chiefly to temperature and pain
- Merkel (tactile) discs
- Hair follicle receptors
- Meissner's corpuscles (tactile corpuscles)
- Pacinian corpuscles (lamellated corpuscles)
- Muscle spindles, Golgi tendon organs, and Ruffini's corpuscles
- Joint kinesthetic receptors

Simple Receptors: Unencapsulated

TABLE 13.1 General Sensory Receptors Classified by Structure and Function

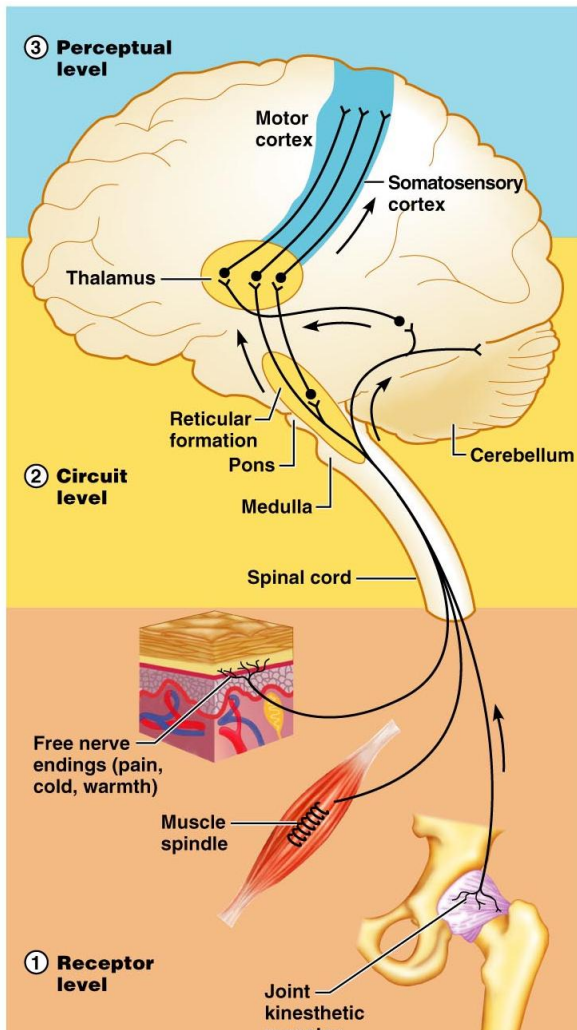
STRUCTURAL CLASS	ILLUSTRATION	FUNCTIONAL CLASSES ACCORDING TO LOCATION (L) AND STIMULUS TYPE (S)	BODY LOCATION
UNENCAPSULATED			
Free nerve endings of sensory neurons		L: Exteroceptors, interoceptors, and proprioceptors S: Thermoreceptors (warm and cool), chemoreceptors (itch, pH, etc.), mechanoreceptors (pressure), nociceptors (pain, hot, cold, pinch, and chemicals)	Most body tissues; most dense in connective tissues (ligaments, tendons, dermis, joint capsules, periosteum) and epithelia (epidermis, cornea, mucosae, and glands)
Modified free nerve endings: Merkel discs (tactile discs)		L: Exteroceptors S: Mechanoreceptors (light pressure); slowly adapting	Basal layer of epidermis of skin
Hair follicle receptors		L: Exteroceptors S: Mechanoreceptors (hair deflection); rapidly adapting	In and surrounding hair follicles

From Sensation to Perception

- Survival depends upon sensation and perception
- Sensation is the awareness of changes in the internal and external environment
- Perception is the conscious interpretation of those stimuli

Organization of the Somatosensory System

- Input comes from exteroceptors, proprioceptors, and interoceptors
- The three main levels of neural integration in the somatosensory system are:
 - Receptor level – the sensor receptors
 - Circuit level – ascending pathways
 - Perceptual level – neuronal circuits in the cerebral cortex



Processing at the Receptor Level

- The receptor must have specificity for the stimulus energy
- The receptor's receptive field must be stimulated
- Stimulus energy must be converted into a graded potential
- A generator potential in the associated sensory neuron must reach threshold

Adaptation of Sensory Receptors

- Adaptation occurs when sensory receptors are subjected to an unchanging stimulus
 - Receptor membranes become less responsive
 - Receptor potentials decline in frequency or stop

Adaptation of Sensory Receptors

- Receptors responding to pressure, touch, and smell adapt quickly
- Receptors responding slowly include Merkel's discs, Ruffini's corpuscles, and interoceptors that respond to chemical levels in the blood
- Pain receptors and proprioceptors do not exhibit adaptation

Processing at the Circuit Level

- Chains of three neurons conduct sensory impulses upward to the brain
- First-order neurons – soma reside in dorsal root or cranial ganglia, and conduct impulses from the skin to the spinal cord or brain stem
- Second-order neurons – soma reside in the dorsal horn of the spinal cord or medullary nuclei and transmit impulses to the thalamus or cerebellum
- Third-order neurons – located in the thalamus and conduct impulses to the somatosensory cortex of the

cerebrum

- The thalamus projects fibers to:
 - The somatosensory cortex
 - Sensory association areas
- First one modality is sent, then those considering more than one
- The result is an internal, conscious image of the stimulus

Main Aspects of Sensory Perception

- Perceptual detection – detecting that a stimulus has occurred and requires summation
- Magnitude estimation – how much of a stimulus is acting
- Spatial discrimination – identifying the site or pattern of the stimulus
- Feature abstraction – used to identify a substance that has specific texture or shape
- Quality discrimination – the ability to identify submodalities of a sensation (e.g., sweet or sour tastes)
- Pattern recognition – ability to recognize patterns in stimuli (e.g., melody, familiar face)

Structure of a Nerve

- Nerve – cordlike organ of the PNS consisting of peripheral axons enclosed by connective tissue
- Connective tissue coverings include:
 - Endoneurium – loose connective tissue that surrounds axons
 - Perineurium – coarse connective tissue that bundles fibers into fascicles
 - Epineurium – tough fibrous sheath around a nerve

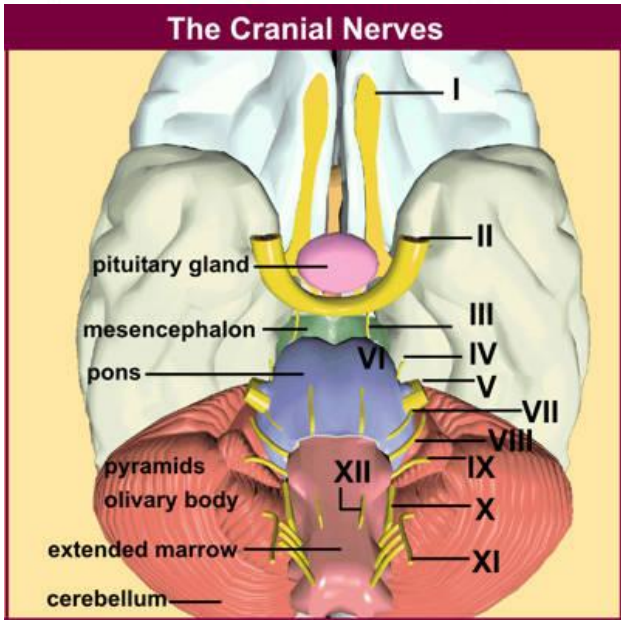
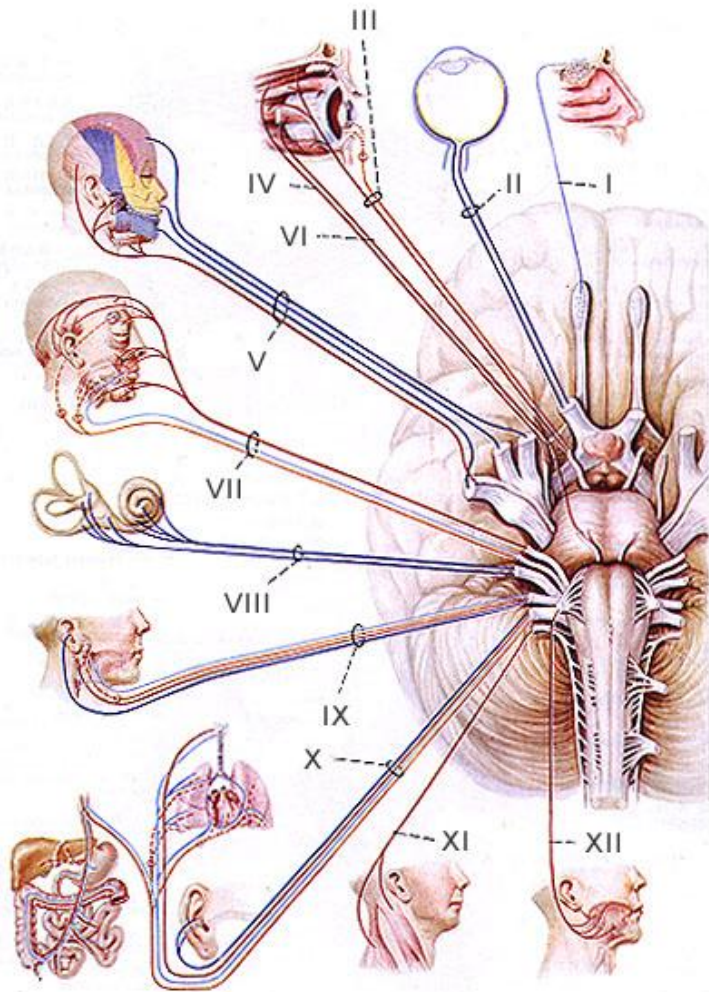
Classification of Nerves

- Sensory and motor divisions
- Sensory (afferent) – carry impulse to the CNS
- Motor (efferent) – carry impulses from CNS
- Mixed – sensory and motor fibers carry impulses to and from CNS; most common type of nerve
- Mixed nerves – carry somatic and autonomic (visceral) impulses
- The four types of mixed nerves are:
 - Somatic afferent and somatic efferent
 - Visceral afferent and visceral efferent
- Peripheral nerves originate from the brain or spinal column

Regeneration of Nerve Fibers

- Damage to nerve tissue is serious because mature neurons are amitotic
- If the soma of a damaged nerve remains intact, damage can be repaired
- Regeneration involves coordinated activity among:
 - Macrophages – remove debris
 - Schwann cells – form regeneration tube and secrete growth factors
 - Axons – regenerate damaged part

Cranial Nerves



Cranial Nerve:	Major Functions:
I Olfactory	<ul style="list-style-type: none"> • smell
II Optic	<ul style="list-style-type: none"> • vision

III Oculomotor	<ul style="list-style-type: none"> • eyelid and eyeball movement
IV Trochlear	<ul style="list-style-type: none"> • innervates superior oblique • turns eye downward and laterally
V Trigeminal	<ul style="list-style-type: none"> • chewing • face & mouth touch & pain
VI Abducens	<ul style="list-style-type: none"> • turns eye laterally
VII Facial	<ul style="list-style-type: none"> • controls most facial expressions • secretion of tears & saliva • taste
VIII Vestibulocochlear (auditory)	<ul style="list-style-type: none"> • hearing • equilibrium sensation
IX Glossopharyngeal	<ul style="list-style-type: none"> • taste • senses carotid blood pressure
X Vagus	<ul style="list-style-type: none"> • senses aortic blood pressure • slows heart rate • stimulates digestive organs • taste
XI Spinal Accessory	<ul style="list-style-type: none"> • controls trapezius & sternocleidomastoid • controls swallowing movements
XII Hypoglossal	<ul style="list-style-type: none"> • controls tongue movements

Nerves in Order	Modality	Function
Olfactory	Special Sensory	Smell
Optic	Special Sensory	Vision
Oculomotor	Somatic Motor Visceral Motor	Levator palpebrae, superioris, superior, medial & inferior recti muscles Parasympathetic to ciliary & pupillary constrictor muscles
Trochlear	Somatic Motor	Superior oblique muscle
Trigeminal	Branchial Motor	Muscles of mastication

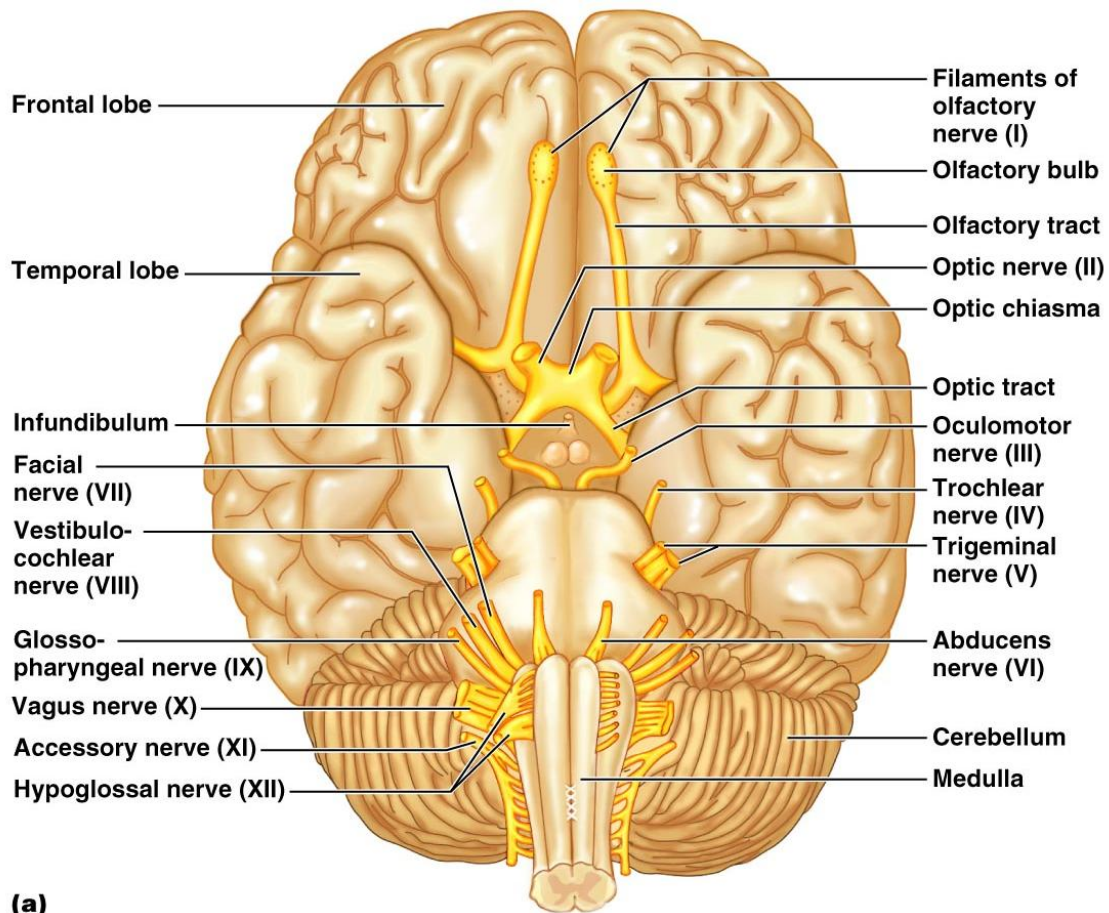
	General Sensory	Sensory for head/neck, sinuses, meninges, & external surface of tympanic membrane
Abducens	Somatic Motor	Lateral rectus muscle
Facial	Branchial Motor	Muscles of facial expression
	Visceral Motor	Parasympathetic to all glands of head except the parotid
	General Sensory	Sensory for ear and tympanic membrane
	Special Sensory	Taste anterior two-thirds of tongue
Vestibulocochlear	Special Sensory	Hearing and Balance
Glossopharyngeal	Branchial Motor	Stylopharyngeus muscle
	Visceral Motor	Parotid Gland
	Visceral Sensory	Carotid Body
	General Sensory	Sensation posterior one-third tongue & internal surface of tympanic membrane.
	Special Sensory	Taste posterior one-third tongue
Vagus	Branchial Motor	Muscles pharynx & larynx
	Visceral Motor	Parasympathetic to neck, thorax, & abdomen
	Visceral Sensory	Sensory from pharynx, larynx & viscera
	Special Sensory	Sensory from external ear
Spinal Accessory	Branchial Motor	Trapezius & sternocleidomastoid muscles
Hypoglossal	Somatic Motor	Tongue muscles except palatoglossal

Cranial Nerves

- Twelve pairs of cranial nerves arise from the brain
- They have sensory, motor, or both sensory and motor functions
- Each nerve is identified by a number (I through XII) and a name
- Four cranial nerves carry parasympathetic fibers that serve muscles and glands

"On Old Olympic Towering Tops A Finn And German Viewed Some Hops"

Cranial Nerves



(a)

Summary of Function of Cranial Nerves

Summary of Function of Cranial Nerves

Cranial nerves I - VI	Sensory function	Motor function	PS* fibers
I Olfactory	Yes (smell)	No	No
II Optic	Yes (vision)	No	No
III Oculomotor	No	Yes	Yes
IV Trochlear	No	Yes	No
V Trigeminal	Yes (general sensation)	Yes	No
VI Abducens	No	Yes	No

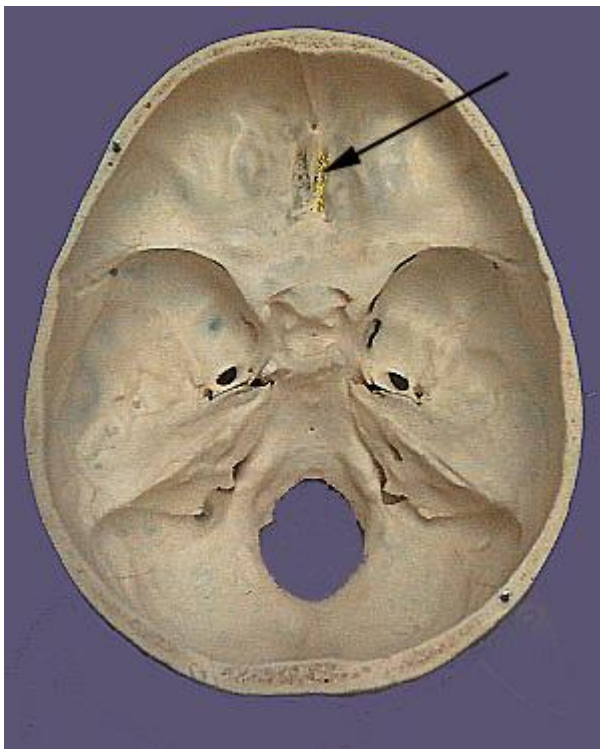
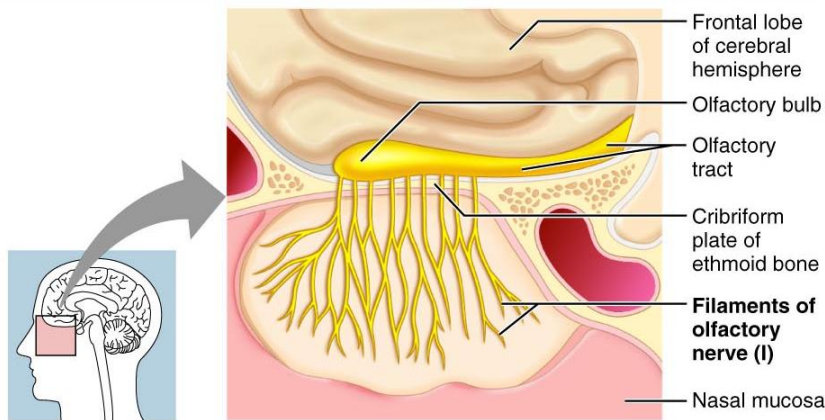
Cranial nerves VII - XII	Sensory function	Motor function	PS* fibers
VII Facial	Yes (taste)	Yes	Yes
VIII Vestibulocochlear	Yes (hearing and balance)	Some	No
IX Glossopharyngeal	Yes (taste)	Yes	Yes
X Vagus	Yes (taste)	Yes	Yes
XI Accessory	No	Yes	No
XII Hypoglossal	No	Yes	No

(b) *PS = parasympathetic

Cranial Nerve I: Olfactory

- Arises from the olfactory epithelium
- Passes through the cribriform plate of the ethmoid bone
- Fibers run through the olfactory bulb and terminate in the primary olfactory cortex
- Functions solely by carrying afferent impulses for the sense of smell

Cranial Nerve I: Olfactory



Olfactory Epithelium

The olfactory epithelium is located in the roof, superior conchae, and septum of the nasal cavity.

The epithelium is kept moist by the secretions of olfactory glands.

Olfactory receptor cells are bipolar nerve cells with a peripherally directed dendrite which terminates in a knob from which project numerous cilia.

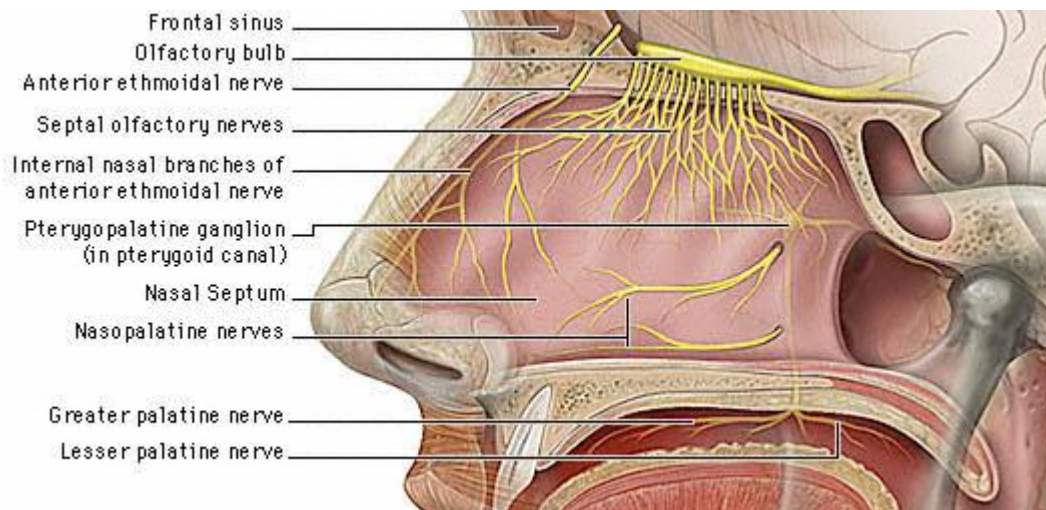
The olfactory chemoreceptors are located on these cilia.

Sensory Transduction and Peripheral Course of the Olfactory Nerve

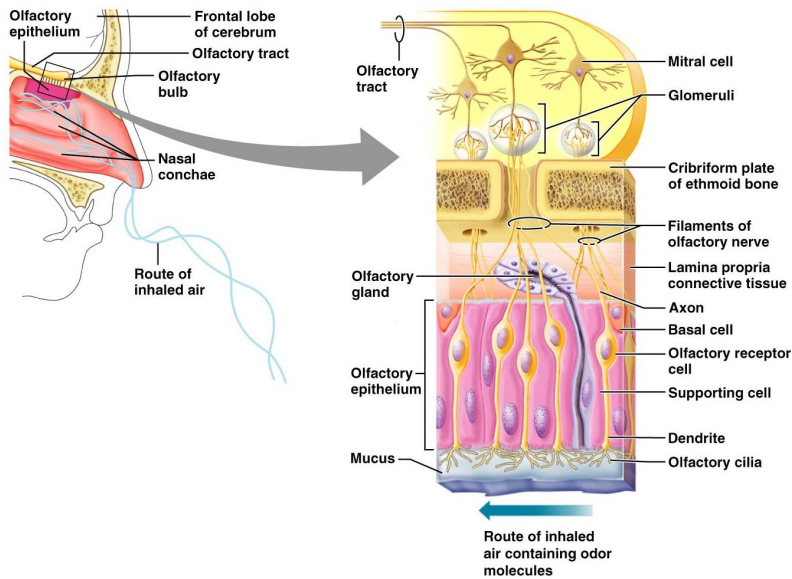
Inhaled aromatic molecules dissolve in the moisture lining the **olfactory epithelium** and stimulate its chemoreceptors.

Olfactory receptor cells initiate action potentials in response to these chemical stimuli. Intracellular studies show the presence of a slow rising receptor (generator) potential followed by a spike discharge from the receptor cell.

The peripheral processes of the receptor cells assemble into small bundles and pass through the cribriform plate of the ethmoid bone to synapse on secondary sensory neurons in the **olfactory bulb**.



Olfactory Receptors

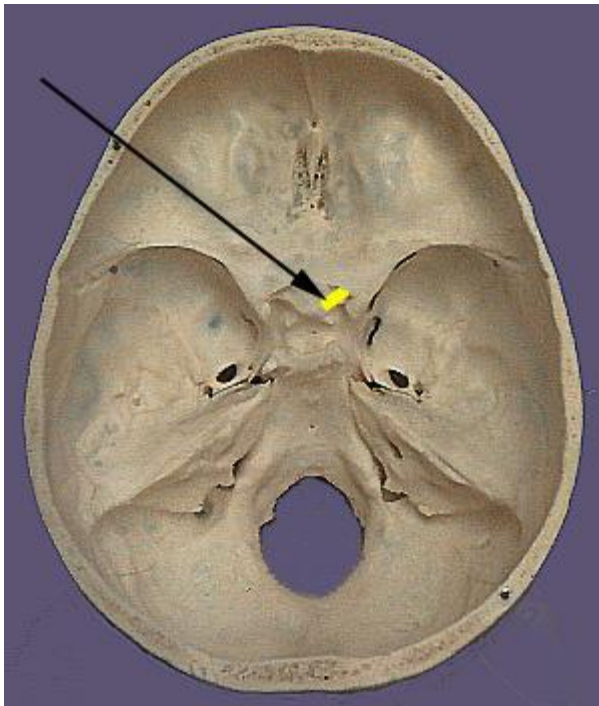


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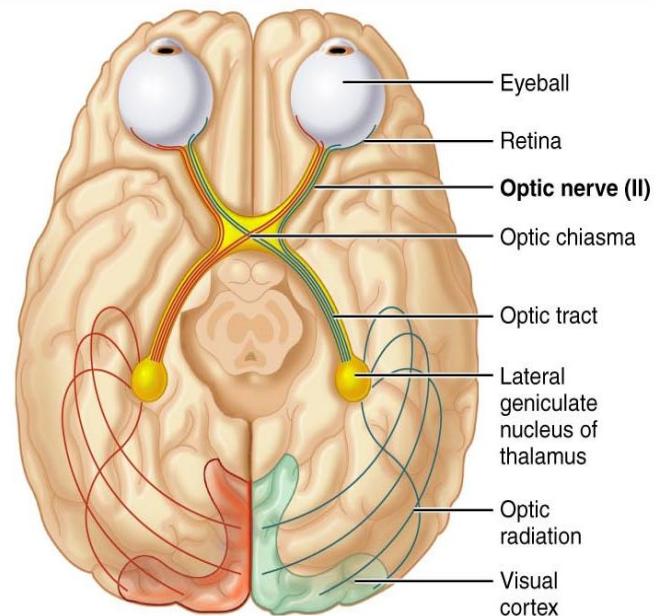
Figure 15.21

Cranial Nerve II: Optic

- Arises from the retina of the eye
- Optic nerves pass through the optic canals and converge at the optic chiasm
- They continue to the thalamus where they synapse
- From there, the optic radiation fibers run to the visual cortex
- Functions solely by carrying afferent impulses for vision



Cranial Nerve II: Optic



Sensory Transduction

Light passing through the cornea and aqueous humor and entering the pupil travels through the lens and

vitreous body to reach the retina at the back of the eye.

The process of converting photons of light into electrical signals occurs in a deep layer of the retina which contains the photoreceptor cells - the rods and cones.

Rods and cones are specialized cells which have stacks of plasma membrane associated with visual pigments making them sensitive to light.

The differences between the rod system and the cone system are described in the table below:

Rod system	Cone system
High sensitivity, specialized for night vision	Lower sensitivity, specialized for day vision
Saturate in daylight	Saturate only in intense light
Achromatic	Chromatic, mediate color vision
Low acuity	High acuity
Not present in central fovea	Concentrated in central fovea
Present in larger number than cones	Present in smaller number than rods

Sensory Transduction

Light incident on the photoreceptor cells triggers a series of chemical reactions which alter plasma membrane permeability resulting in a hyperpolarization of the rod or cone.

This hyperpolarization of the photoreceptor cell can produce either an excitatory (depolarization) or inhibitory (hyperpolarization) response by the bipolar cell dependent on the nature of the synapse between the two cells.

The bipolar cells are the primary sensory neurons of the visual pathway. They synapse with and either excite or inhibit the action potential firing rate of the secondary sensory neurons - the ganglion cells.

The axons of the ganglion cells converge at the optic disc near the center of the retina to exit the eye as the optic nerve.

At the optic chiasm approximately 1/2 of the fibers from each optic nerve cross the midline and exit the chiasm in the opposite optic tract.

The fibers of the optic tracts continue posteriorly around the cerebral peduncles of the midbrain with most synapsing in the lateral geniculate nucleus of their respective thalamus. A small portion of the fibers enter the pretectal region of the midbrain and participate in the pupillary light reflex.

Cells of the lateral geniculate nuclei are tertiary sensory neurons which project to the primary visual cortex in the occipital lobe via the optic radiation (geniculocalcarine tract). Note that the axons of the

optic radiation fan out to pass above and lateral to the inferior horn of the lateral ventricles enroute to the visual cortex. The fibers that course anteriorly toward the pole of the temporal lobe before turning posteriorly are referred to as Meyer's loop.

Central course

The entire area seen by an eye when it is focused on a central point is called the visual field of that eye.

Because rays of light reach the retina by converging and passing through the small opening of the pupil, the image of the entire visual field is projected onto the retina upside-down and reversed.

Therefore:

- The right half of the retina receives stimuli from the left visual field.
- The left half of the retina receives stimuli from the right half of the visual field.
- The upper half of the retina receives stimuli from the lower half of the visual field.
- The lower half of the retina receives stimuli from the upper half of the visual field.

Retinal Projections to the Primary Visual Cortex

Because fibers from different quadrants of the retina project to the primary visual cortex via predictable portions of the optic nerves, chiasm, and tracts it is convenient and clinically useful to divide the retina (and therefore the visual field) of each eye into nasal and temporal halves as well as superior and inferior halves yielding four quadrants.

The regions of the retina are referenced to the midline. The nasal hemiretina lies medial to the fovea, while the temporal hemiretina lies lateral to the fovea. The superior and inferior halves of the retina are also referenced to the fovea.

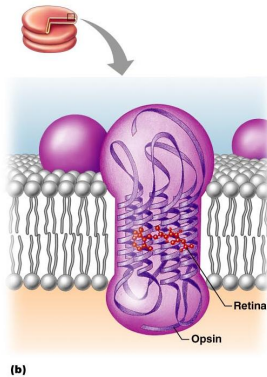
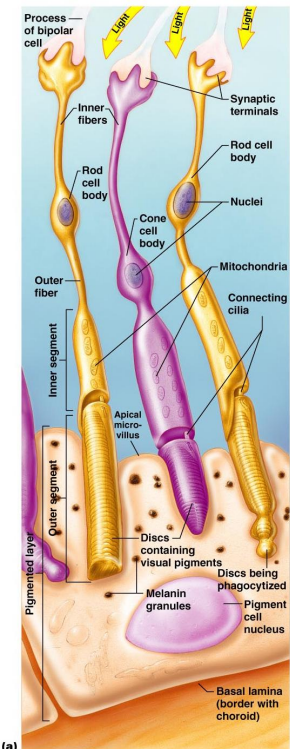
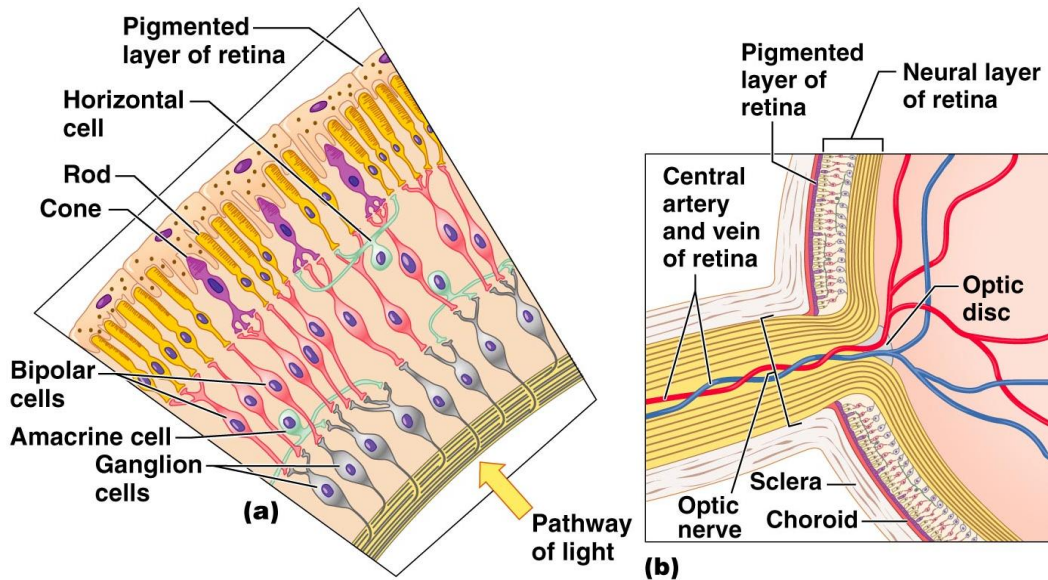
Axons of ganglion cells from the **nasal hemiretina** (lateral visual field) decussate at the optic chiasm and project to the contralateral lateral geniculate nucleus and midbrain.

Axons from the **temporal hemiretina** (medial visual field) remain ipsilateral throughout their course.

Axons from the **inferior half** of the retina (upper visual field) project via the Meyer's loop/temporal lobe portion of the optic radiation to the primary visual cortex below the calcarine fissure.

Axons from the **superior half** of the retina (lower visual field) project via the parietal lobe portion of the optic radiation to the primary visual cortex above the calcarine fissure.

Ganglion cells from the **center of the retina** (fovea) project to the tip of the occipital pole.



Clinical Correlation - Visual Deficits & Damage to the

Retina

Visual Deficits

Armed with knowledge of the anatomy of the visual system, one can predict the deficits associated with a lesion at a particular point in the central visual pathway.

Damage to the retina

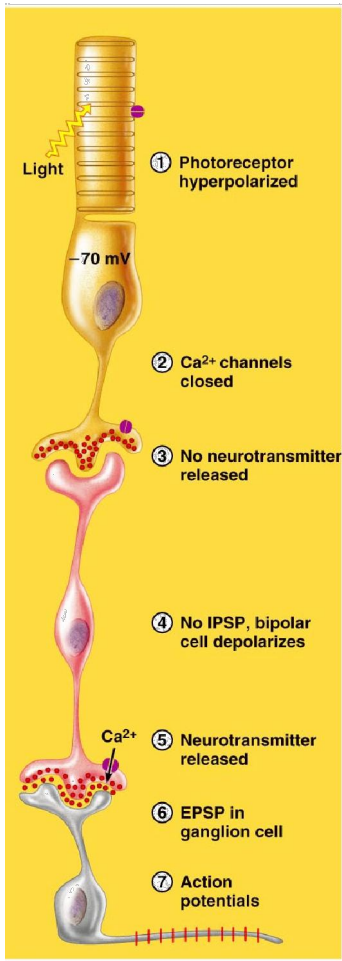
Results in a loss of input from the affected portion of the retina leading to a monocular field deficit.

Since axons of the ganglion cells converge toward the optic disc, damage to a portion of the retina closer to the optic disc will affect a greater number of neurons than would the same amount of damage in the peripheral retina leading to a larger visual field defect in that eye.

Since the cones are concentrated in the fovea, damage to the fovea results in a greater visual handicap than

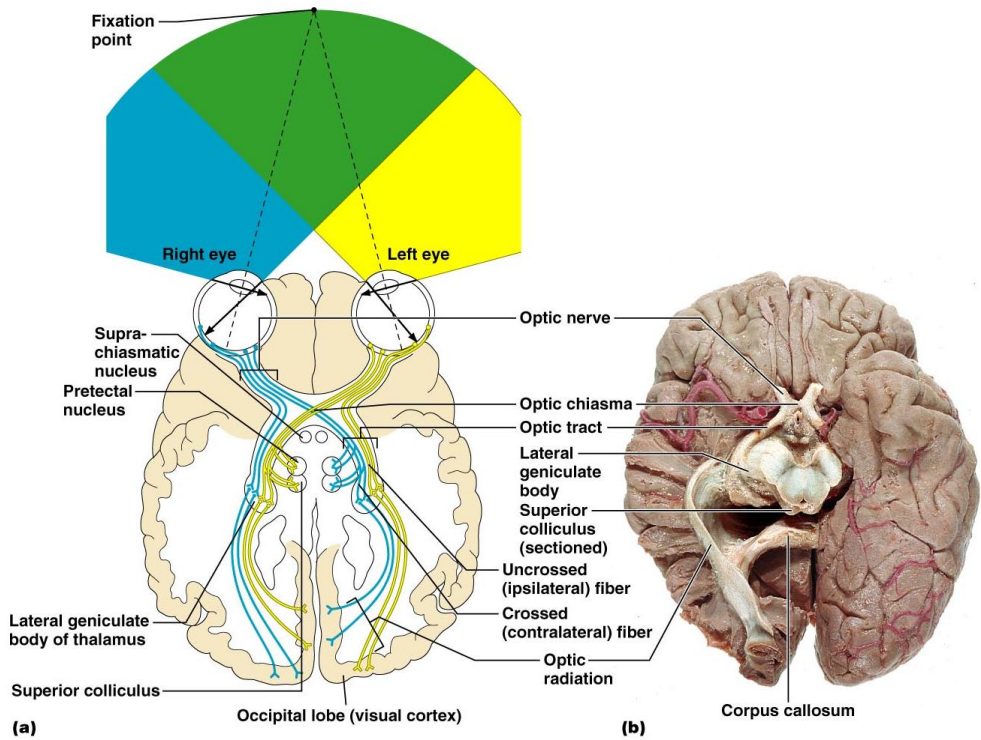
damage to peripheral regions of the retina.

Damage to the optic nerve will also result in a monocular visual defect due to loss of input from the ipsilateral eye. The patient will complain of blindness in that eye.



b)

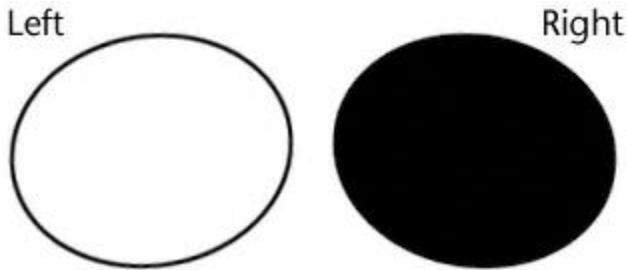
Visual Pathways



damage to the optic nerve

Damage to the optic nerve will also result in a monocular visual defect due to loss of input from the ipsilateral eye. The patient will complain of blindness in that eye.

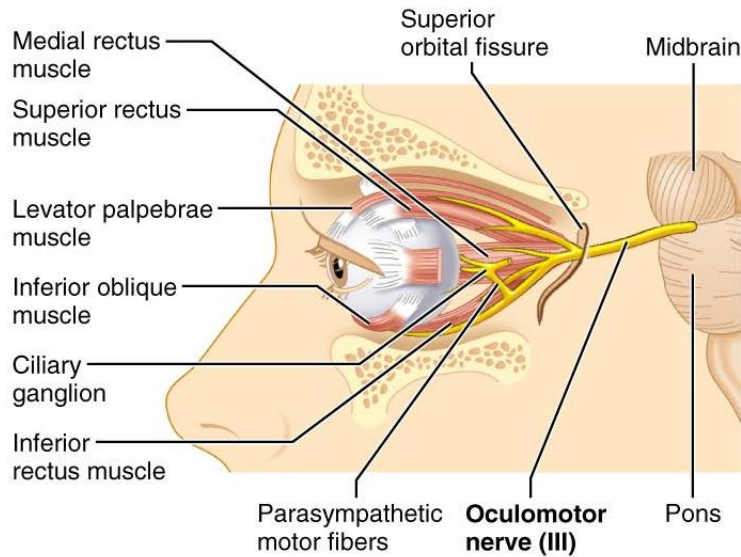
Damage to the optic nerve - ipsilateral blindness.



Cranial Nerve III: Oculomotor

- Fibers extend from the ventral midbrain, pass through the superior orbital fissure, and go to the extrinsic eye muscles
- Functions in raising the eyelid, directing the eyeball, constricting the iris, and controlling lens shape
- Parasympathetic cell bodies are in the ciliary ganglia

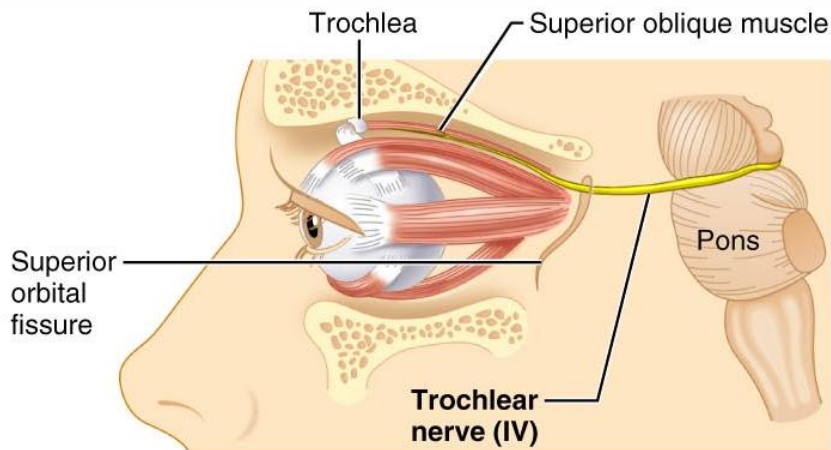
Cranial Nerve III: Oculomotor



Cranial Nerve IV: Trochlear

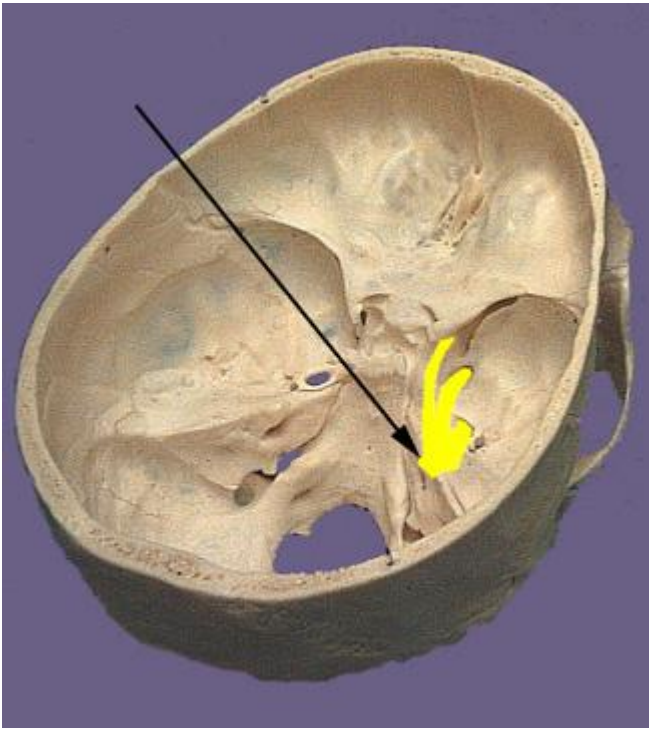
- Fibers emerge from the dorsal midbrain and enter the orbits via the superior orbital fissures; innervate the superior oblique muscle
- Primarily a motor nerve that directs the eyeball

Cranial Nerve IV: Trochlear

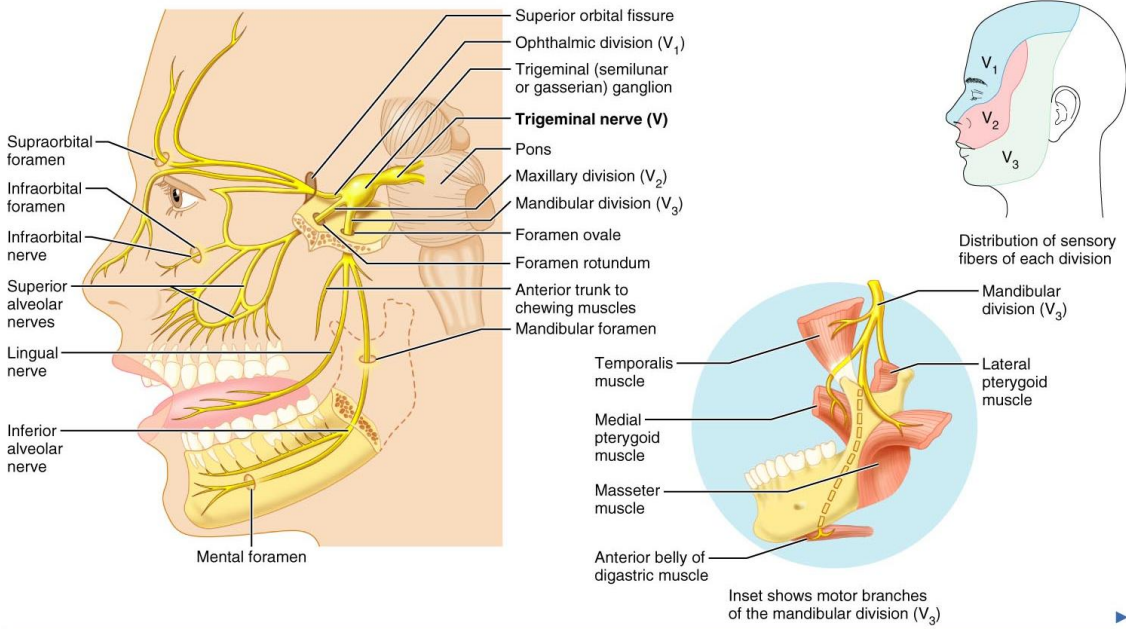


Cranial Nerve V: Trigeminal

- Three divisions: ophthalmic (V_1), maxillary (V_2), and mandibular (V_3)
- Fibers run from the face to the pons via the superior orbital fissure (V_1), the foramen rotundum (V_2), and the foramen ovale (V_3)
- Conveys sensory impulses from various areas of the face (V_1) and (V_2), and supplies motor fibers (V_3) for mastication



Cranial Nerve V: Trigeminal



- The trigeminal nerve as the name indicates is composed of three large branches.
- They are the [ophthalmic](#) (V₁, sensory), [maxillary](#) (V₂, sensory) and [mandibular](#) (V₃, motor and sensory) branches.
- The large sensory root and smaller motor root leave the brainstem at the midlateral surface of pons.
- The sensory root terminates in the largest of the cranial nerve nuclei which extends from the pons all the way down into the second cervical level of the spinal cord. The sensory root joins the trigeminal or semilunar ganglion between the layers of the dura mater in a depression on the floor of the middle crania fossa.
- This depression is the location of the so called Meckle's cave.
- The motor root originates from cells located in the masticator motor nucleus of trigeminal nerve located in the midpons of the brainstem.
- The motor root passes through the trigeminal ganglion and combines with the corresponding sensory root to become the mandibular nerve. It is distributed to the muscles of mastication, the mylohyoid muscle and the anterior belly of the digastric.
- The mandibular nerve also innervates the tensor veli palatini and tensor tympani muscles.
- The three sensory branches of the trigeminal nerve emanate from the ganglia to form the three branches of the trigeminal nerve.
- The ophthalmic and maxillary branches travel in the wall of the cavernous sinus just prior to leaving the cranium.
- The ophthalmic branch travels through the superior orbital fissure and passes through the orbit to reach the skin of the forehead and top of the head.
- The maxillary nerve enters the cranium through the foramen rotundum via the pterygopalatine fossa.

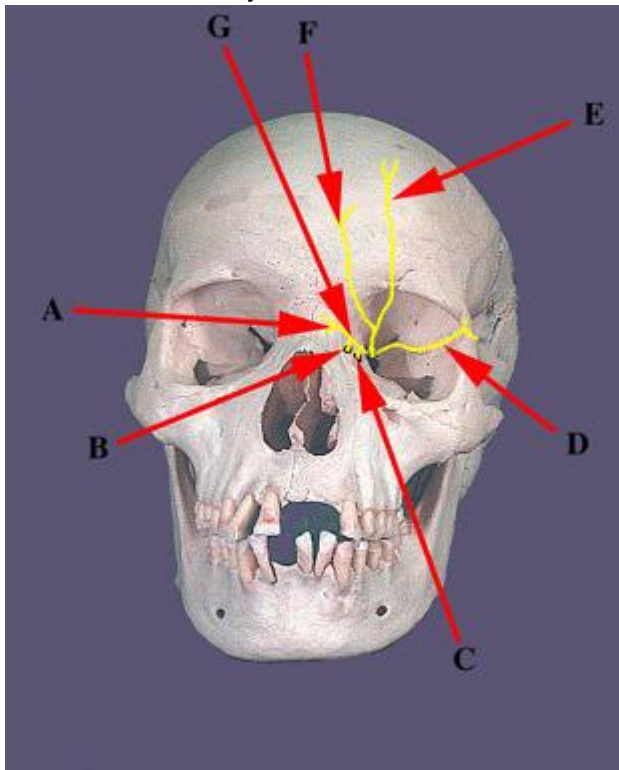
fossa via the inferior orbital fissure (face, cheek and upper
ard palate, nasal cavity and pharynx).

that enter the trigeminal ganglion within the cranium.

composed of branches that carry general sensory
the mouth and cheek, anterior two-thirds of the tongue,
head and scalp and meninges of the anterior and middle

OPHTHALMIC BRANCH

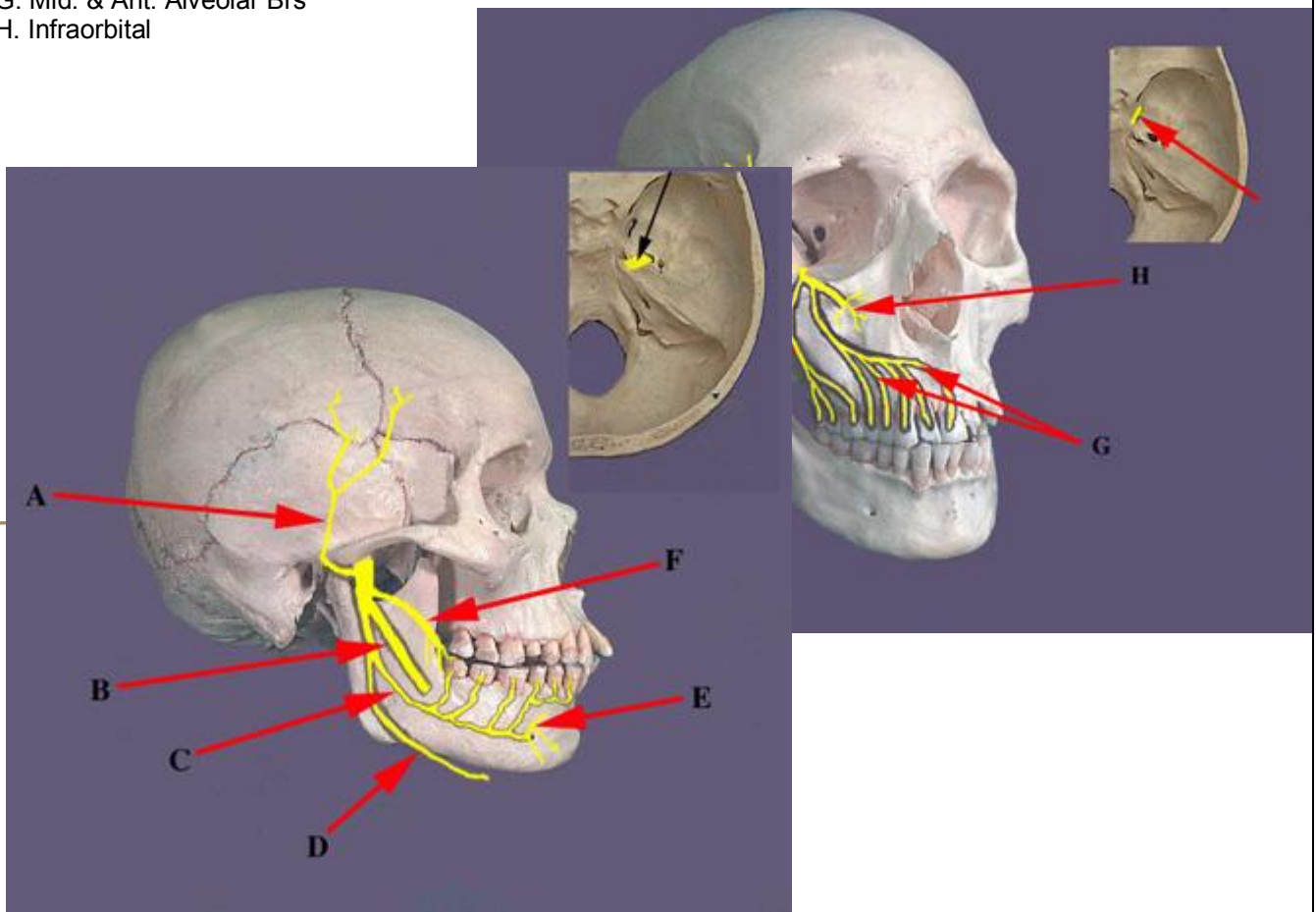
- A. Infratrochlear
- B. Anterior Ethmoid
- C. Posterior Ethmoid
- D. Lacrimal
- E. Supraorbital
- F. Supratrochlear



G. Nasociliary

Maxillary Nerve Branches

- A. Zygomaticotemporal
- B. Zygomaticofacial
- C. Post. Sup. Alveolar Brs
- D. Nasopalatine
- E. Greater Palatine
- F. Lesser Palatine
- G. Mid. & Ant. Alveolar Brs
- H. Infraorbital



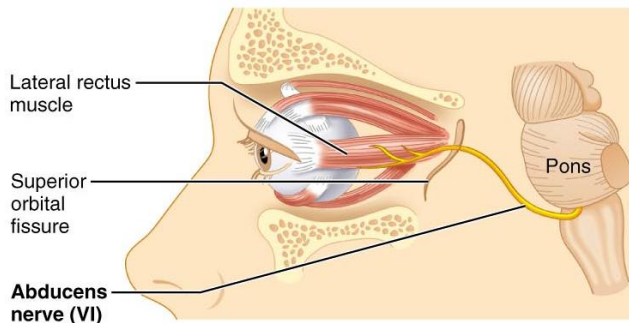
- A. Auriculotemporal
- B. Lingual
- C. Inferior Alveolar
- D. N. to the Mylohyoid
- E. Mental
- F. Buccal

Cranial Nerve VI: Abducens

- Fibers leave the inferior pons and enter the orbit via the superior orbital fissure
- Primarily a motor nerve innervating the lateral rectus muscle

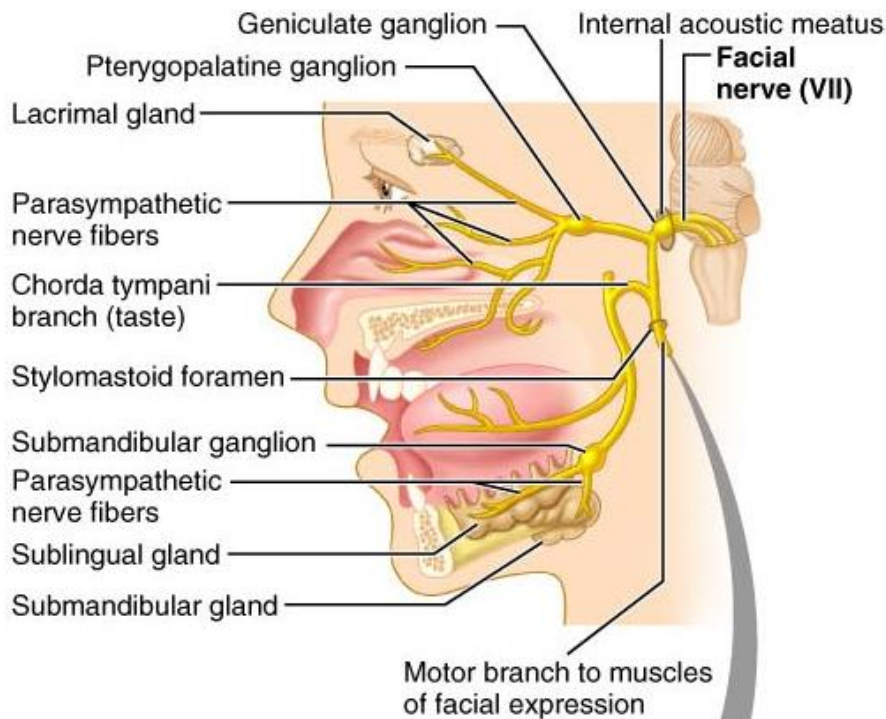
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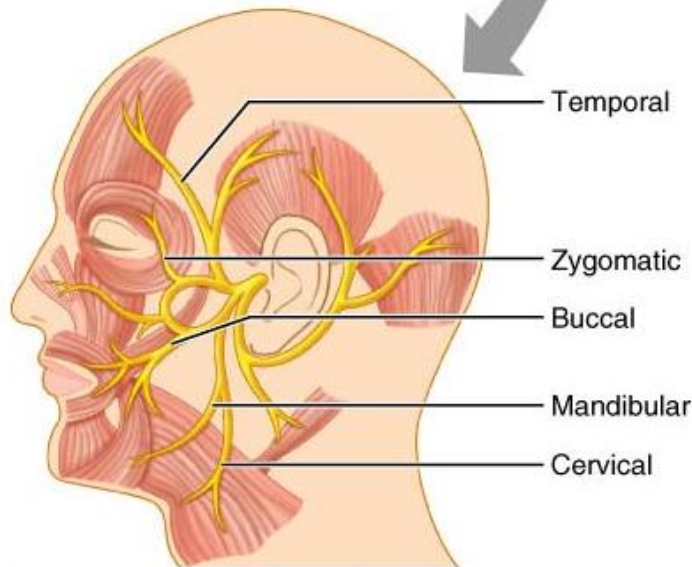


Cranial Nerve VII: Facial

- Fibers leave the pons, travel through the internal acoustic meatus, and emerge through the stylomastoid foramen to the lateral aspect of the face
- Mixed nerve with five major branches
- Motor functions include facial expression, and the transmittal of autonomic impulses to lacrimal and salivary glands
- Sensory function is taste from the anterior two-thirds of the tongue



(a) Parasympathetic efferents and sensory afferents



(b) Motor branches to muscles of facial expression and scalp muscles

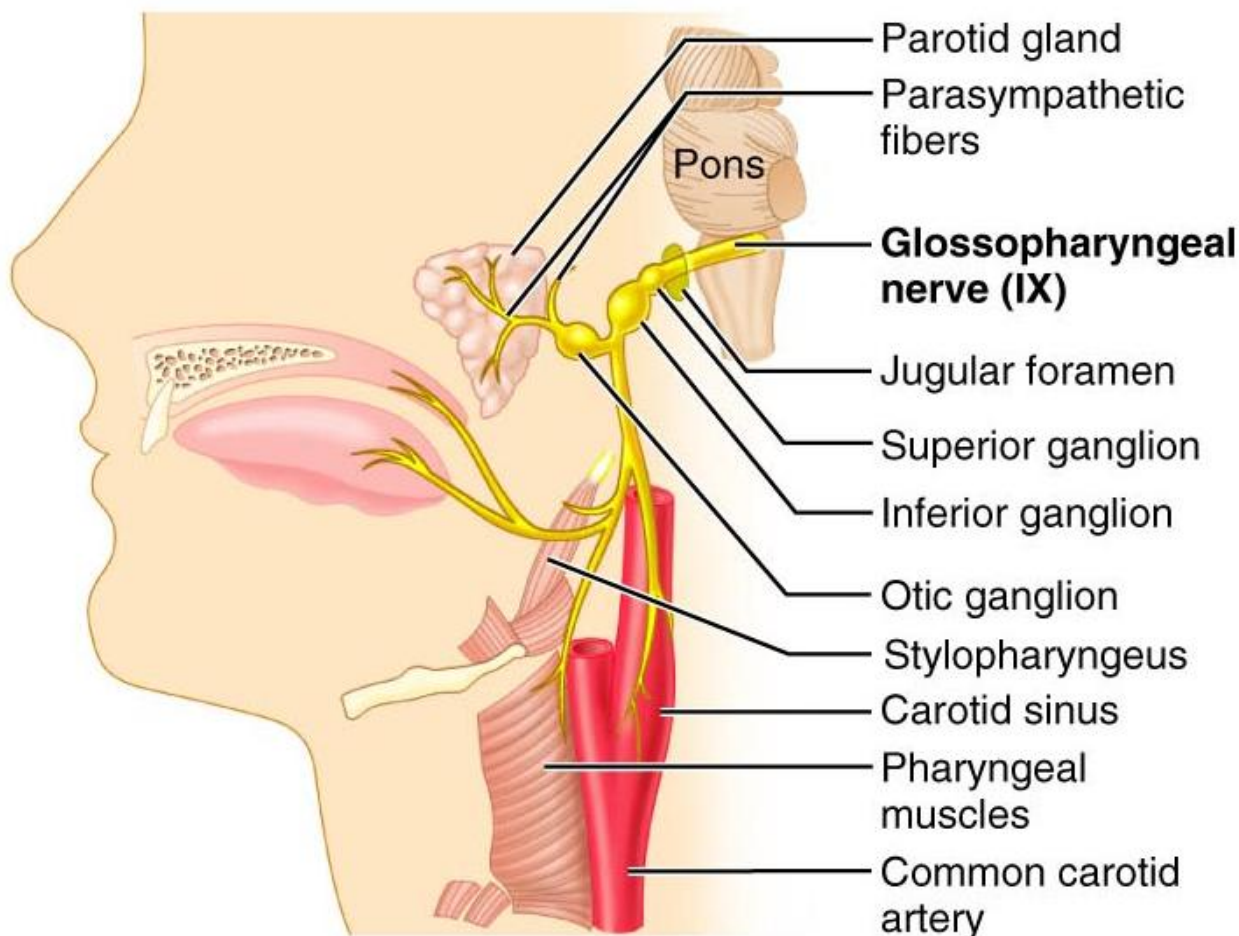
Cranial Nerve VIII: Vestibulocochlear

- Fibers arise from the hearing and equilibrium apparatus of the inner ear, pass through the internal acoustic meatus, and enter the brainstem at the pons-medulla border
- Two divisions – cochlear (hearing) and vestibular (balance)
- Functions are solely sensory – equilibrium and hearing

Cranial Nerve IX: Glossopharyngeal

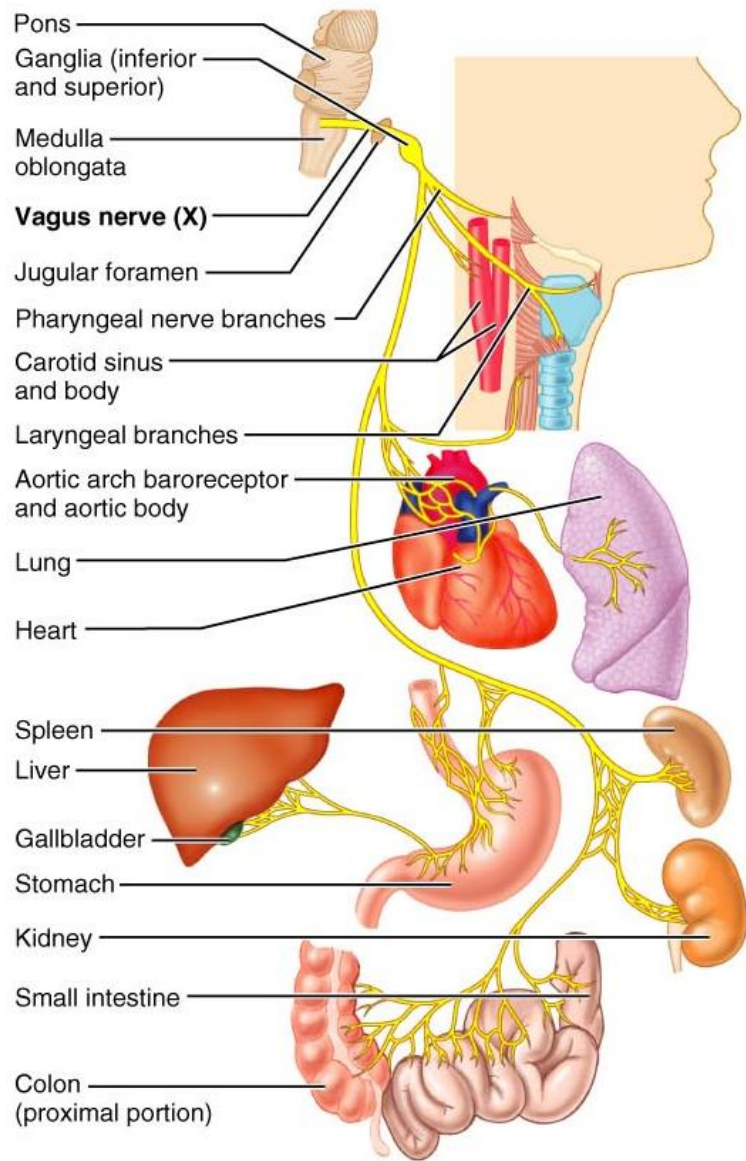
- Fibers emerge from the medulla, leave the skull via the jugular foramen, and run to the throat

- Nerve IX is a mixed nerve with motor and sensory functions
- Motor – innervates part of the tongue and pharynx, and provides motor fibers to the parotid salivary gland
- Sensory – fibers conduct taste and general sensory impulses from the tongue and pharynx



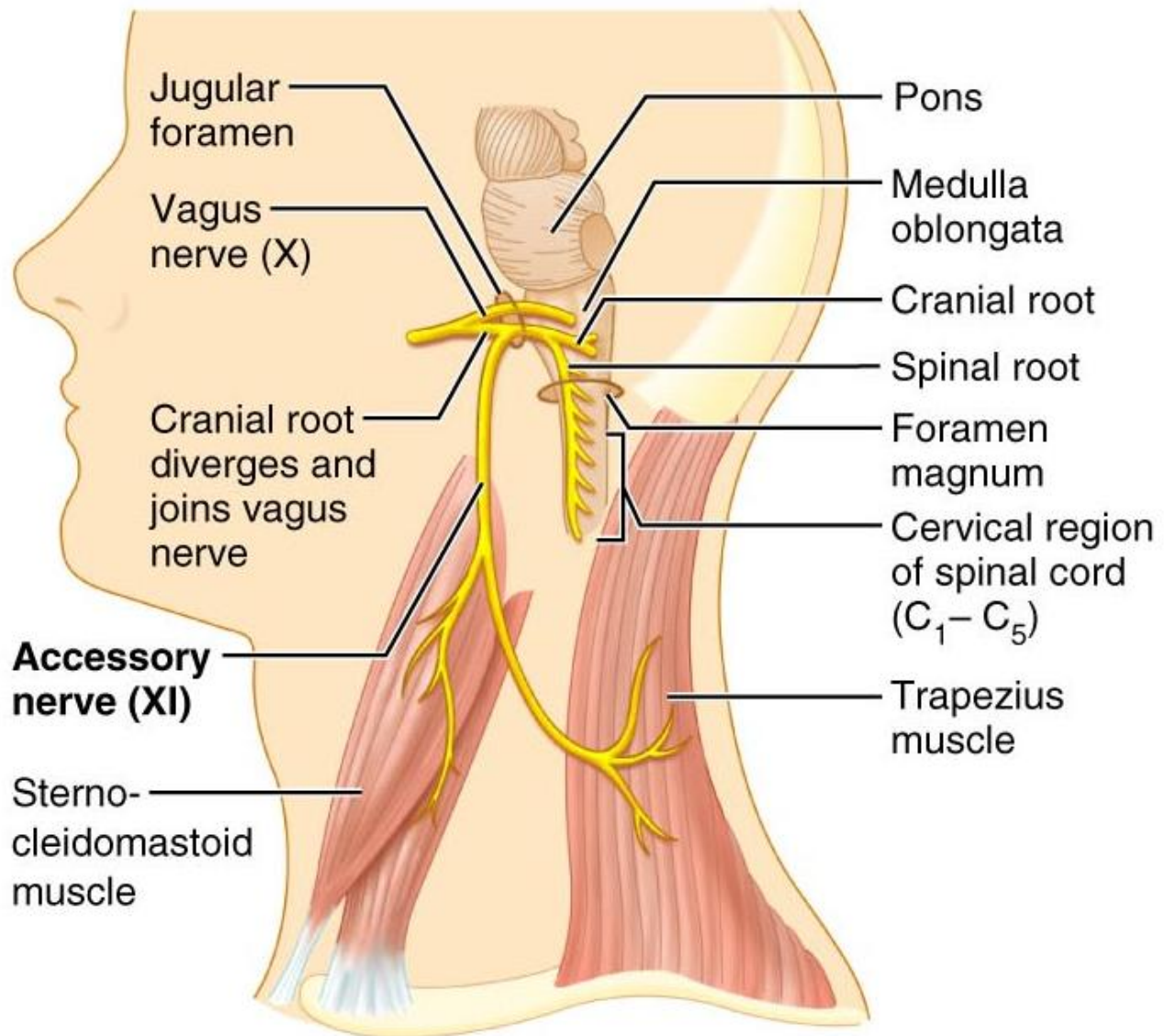
Cranial Nerve X: Vagus

- The only cranial nerve that extends beyond the head and neck
- Fibers emerge from the medulla via the jugular foramen
- The vagus is a mixed nerve
- Most motor fibers are parasympathetic fibers to the heart, lungs, and visceral organs
- Its sensory function is in taste



Cranial Nerve XI: Accessory

- Formed from a cranial root emerging from the medulla and a spinal root arising from the superior region of the spinal cord
- The spinal root passes upward into the cranium via the foramen magnum
- The accessory nerve leaves the cranium via the jugular foramen
- Primarily a motor nerve
 - Supplies fibers to the larynx, pharynx, and soft palate
 - Innervates the trapezius and sternocleidomastoid, which move the head and neck



Cranial Nerve XII: Hypoglossal

- Fibers arise from the medulla and exit the skull via the hypoglossal canal
- Innervates both extrinsic and intrinsic muscles of the tongue, which contribute to swallowing and speech

