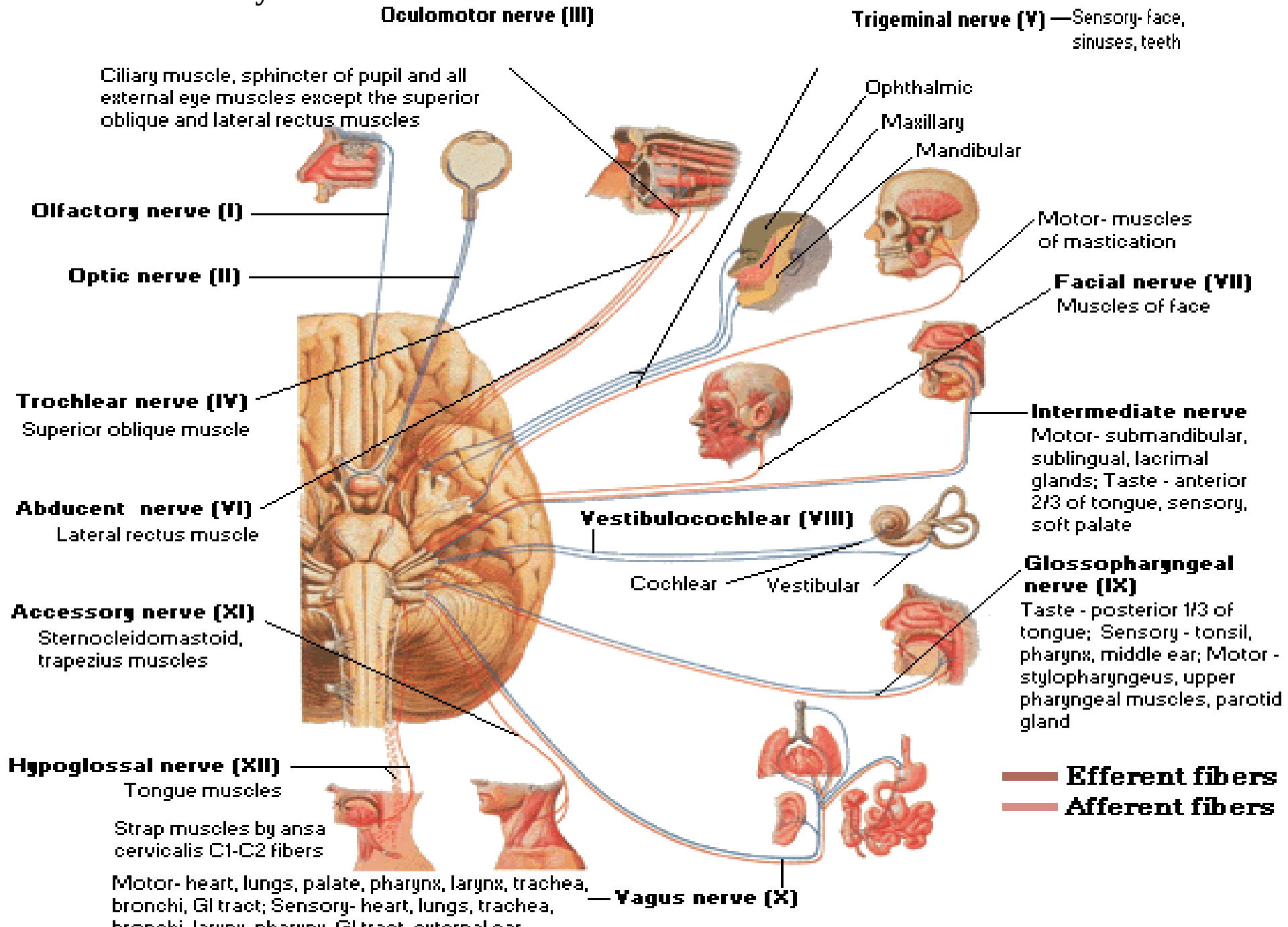
Cranial Nerves

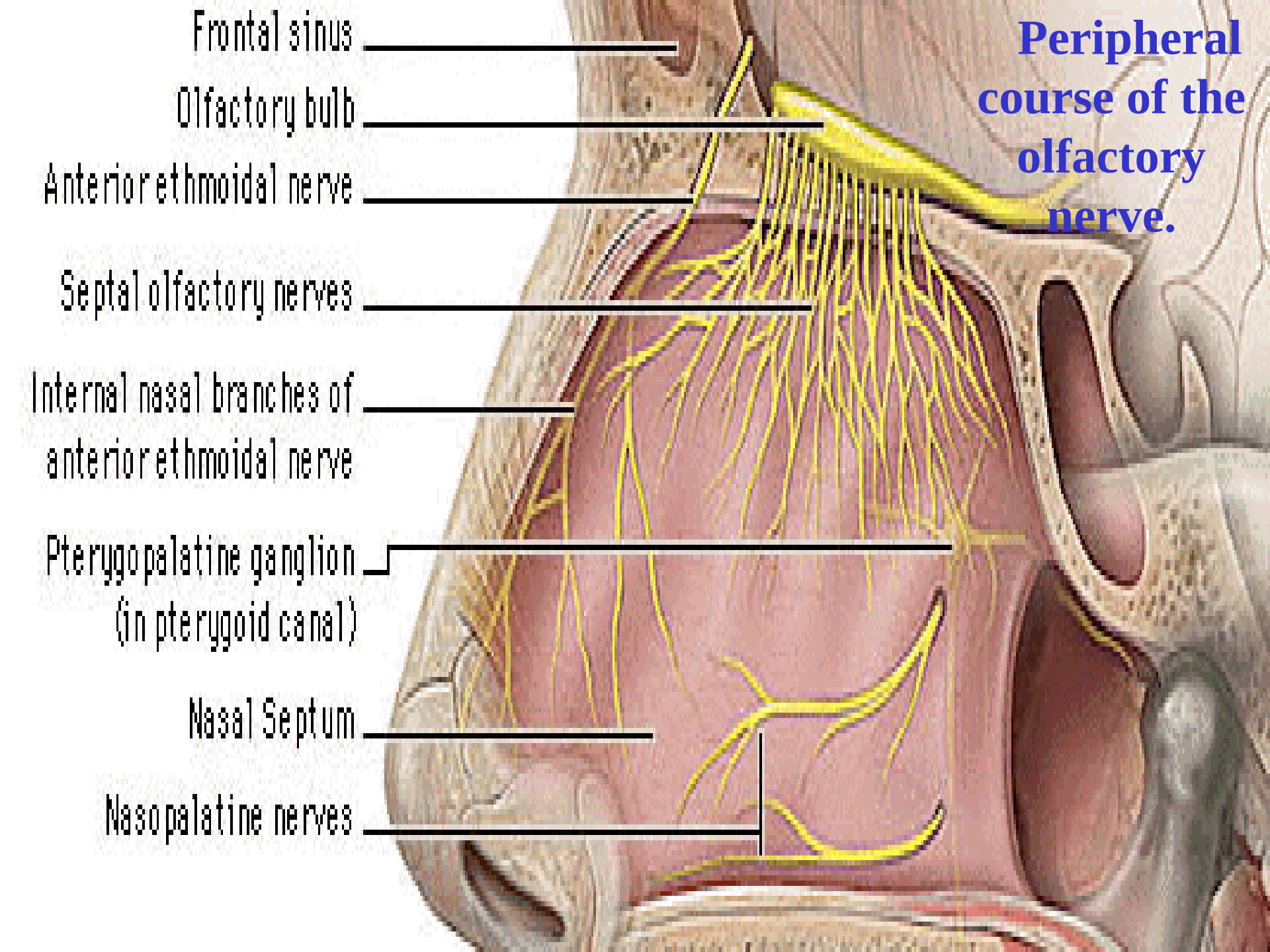
Motor and sensory distribution of cranial nerves.



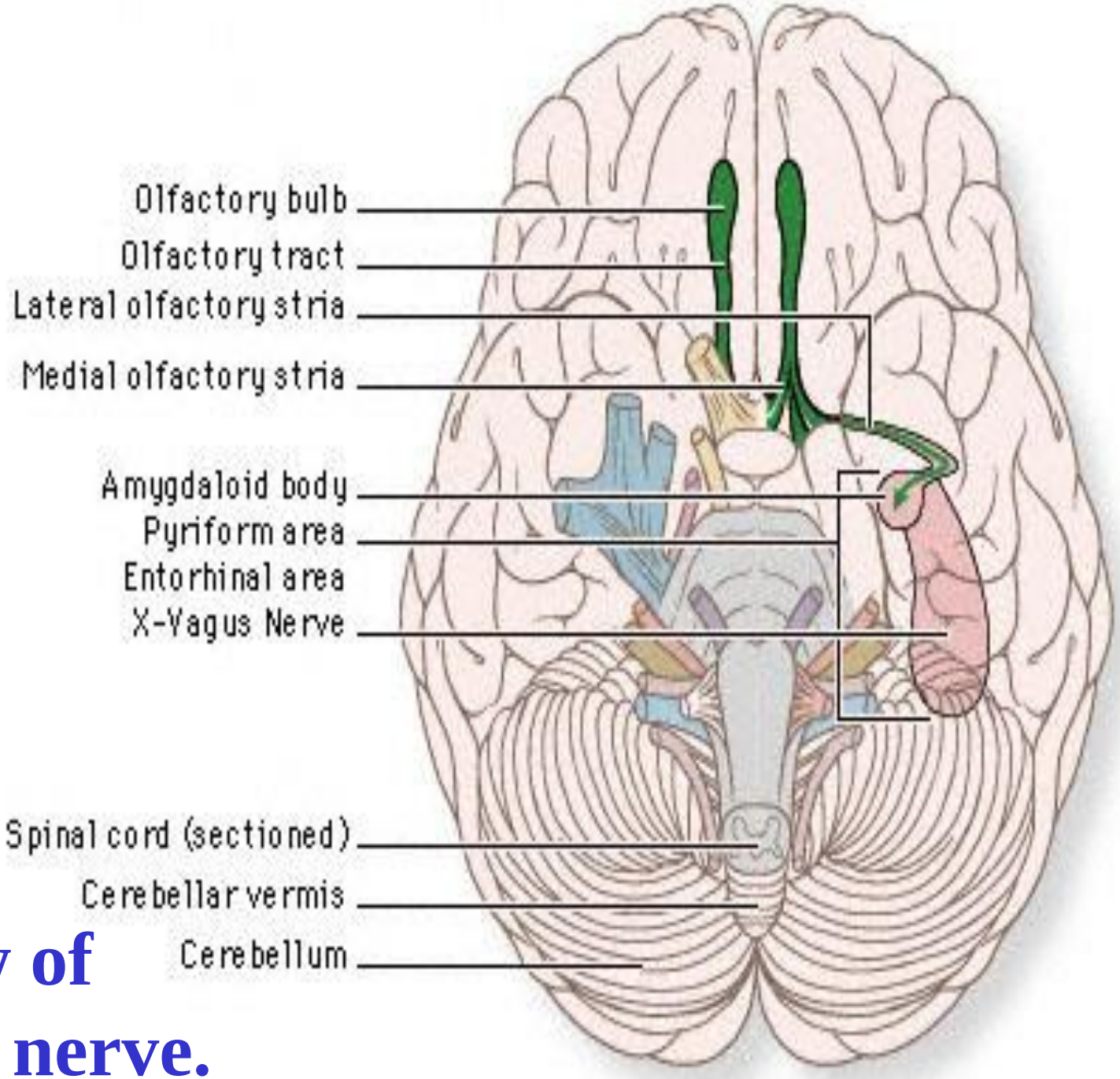
Somatic impulses are of two types:

1. **Extroceptive** = Initiated by changes in the external environment and give rise to the sensations like; touch, pressure, heat, cold and pain.
   Proprioceptive = Information regarding the position and movement of the different parts of the body like; muscles, ligaments, tendons and joints.
2. **Enteroceptive**= Initiated by changes in the internal organs and give rise to the sensations like; pain in the stomach, kidney, intestine-- etc.

I. **Olfactory nerve:** The olfactory system consists of the olfactory epithelium, bulbs and tracts along with olfactory areas of the brain collectively known as the **rhinencephalon.**

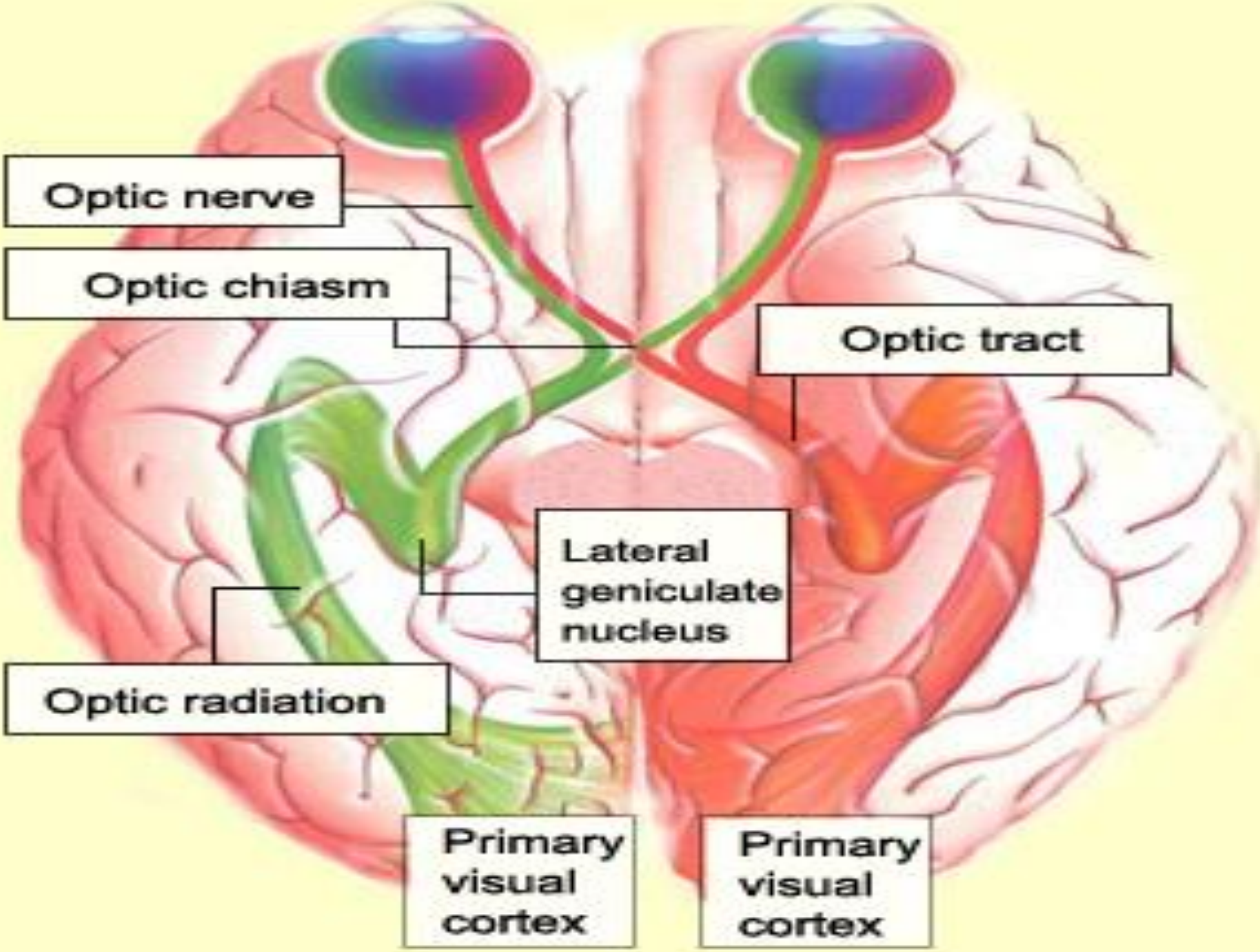


Peripheral course of the olfactory nerve.



Over view of Olfactory nerve.

II. Optic nerve: Comes from the **retina** and emerge as two optic nerves then decussate in **optic chiasma** to form **optic tracts** then go to the **visual cortex in the occipital lobes.**

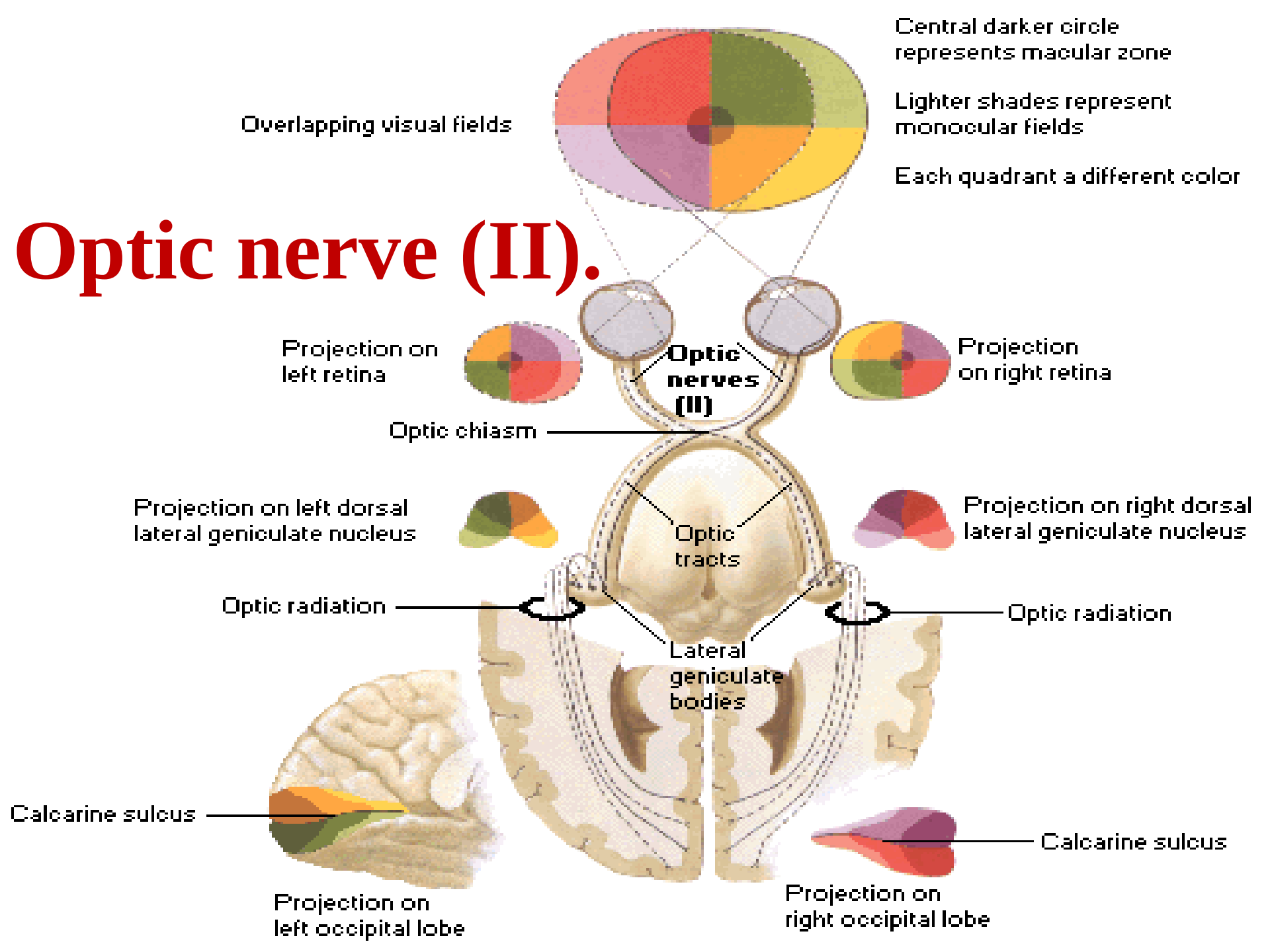

Optic nerve
Optic chiasm
Optic tract
Lateral geniculate nucleus
Optic radiation
Primary visual cortex
Primary visual cortex

The **lateral geniculate nucleus (LGN)** (also called the **lateral geniculate body** or **lateral geniculate complex**) is a relay center in the thalamus for the visual pathway. It receives a major sensory input from the retina. It is the main central connection for the optic nerve to the occipital lobe. It has six layers of neurons (grey matter) alternating with optic fibers (white matter). **LGN** is a small, ovoid, ventral projection at the termination of **optic tract** on each side of the brain. The **LGN** and the **medial geniculate nucleus (MGN)** which deals with auditory information are both thalamic nuclei and so are present in both hemispheres.

LGN receives information directly from the ascending retinal ganglion cells via the optic tract and from the reticular activating system. Neurons of the LGN send their axons through the optic radiation, a direct pathway to the primary visual cortex.

LGN receives also many strong feedback connections from the primary visual cortex. In humans as well as other mammals, the two strongest pathways linking the eye to the brain are those projecting to the dorsal part of the **LGN** in the thalamus, and to the superior colliculus.

Optic nerve (II).



III. Oculomotor nerve: Consists predominantly from somatic efferent fibers **(motor** to superior, medial, and inferior recti muscles and the inferior oblique and levator palpebrae superioris muscles.

The **extrinsic muscles** of the eye are **six** in number **attached to the eyeball** (superior, inferior, medial and lateral recti muscles and the superior and inferior oblique muscles. One **Levator palpebrae superioris** is **not attached** to the eyeball. It arises from the undersurface of lesser wing of sphenoid infront of optic foramen and inserted to the orbicularis oculi muscle, upper eyelid, medial and lateral palpebral ligaments. The common **tendinous ring**, from which four recti muscles arise, is attached medially and superiorly to sphenoid bone above optic foramen.

1. **Superior rectus** muscle arises from the upper part of common tendinous ring, passes forward and laterally below levator palpebrae superioris.
2. **Inferior rectus** muscle arises from the common tendinous ring, below optic foramen, passes forward and laterally on the floor of the orbit.
3. **Medial rectus** muscle is the largest of the ocular muscles arises from the common tendinous ring, passes forward and medially below the superior oblique muscle.
4. **Lateral rectus** muscle arises from the common tendinous ring passes forward and laterally.

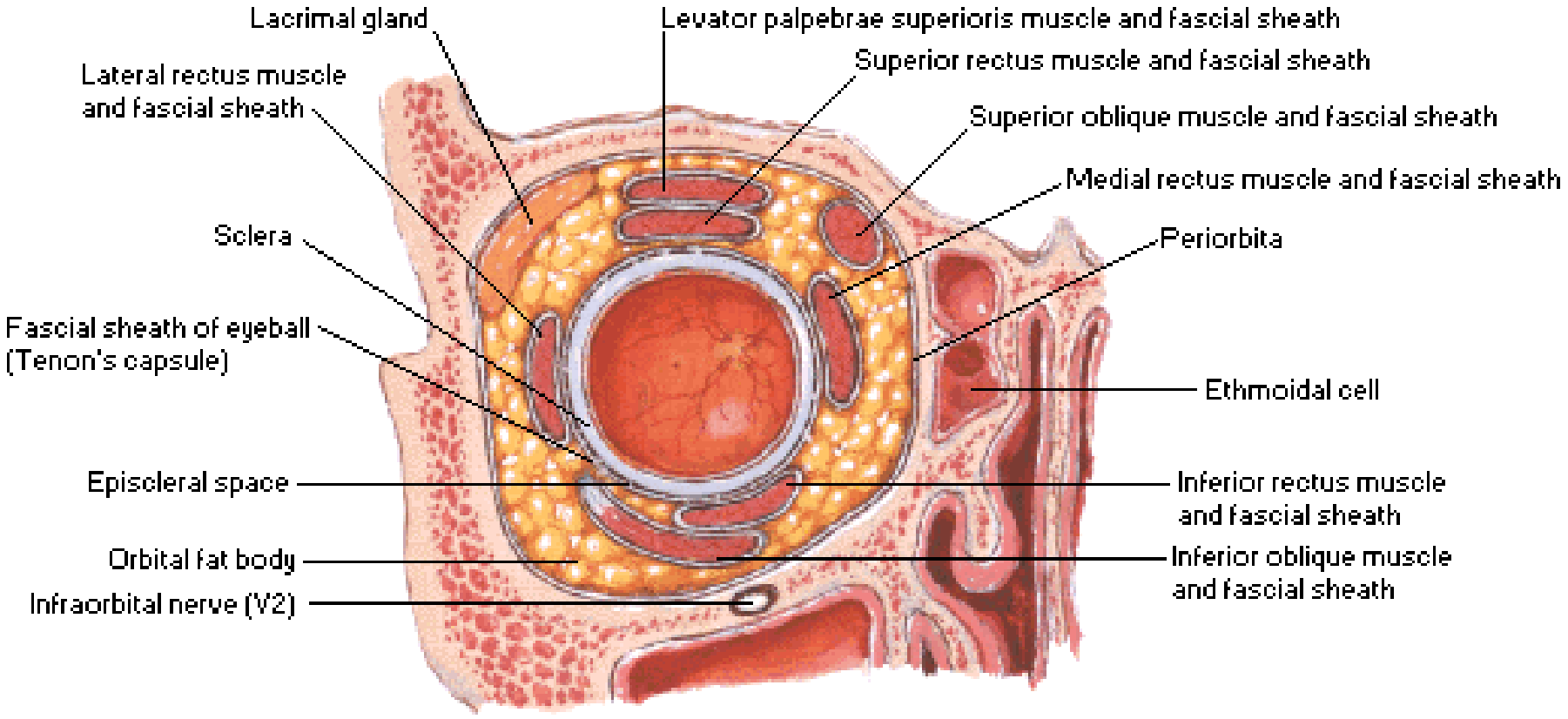
5. **Superior oblique** muscle arises from area above and medial to optic foramen by a narrow tendon. This muscle passes forward at the junction of the roof and medial wall of the orbit to the trochlear pully where it again becomes tendinous. The tendon passes round the pully back wards and laterally below superior rectus muscle.
6. **Inferior oblique** muscle arises from the maxilla, lateral to the opening of nasolacrimal canal. The fibers pass back wards and laterally.

Nerve supply of:

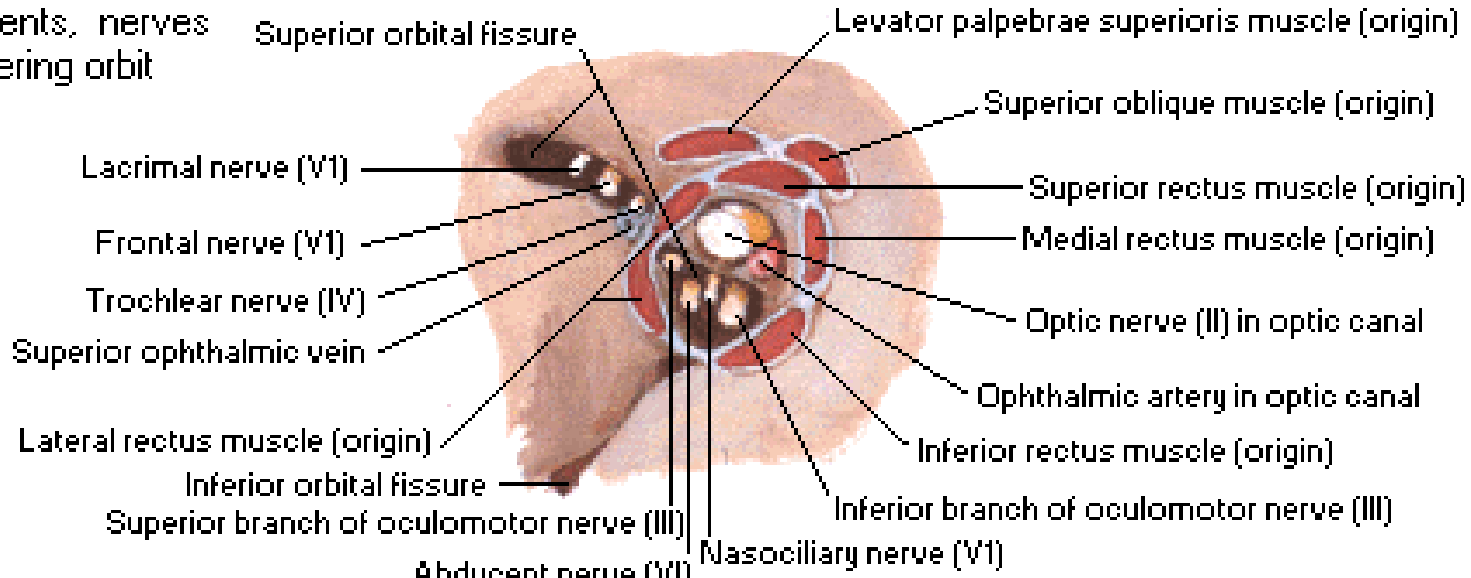
1. Levator palpebrae superioris and superior rectus muscles = **Superior division of III.**
2. Medial and Inferior recti muscles and Inferior oblique muscle = **Inferior division of III.**
3. Superior oblique muscle = **IV nerve** (which contains also postganglionic sympathetic which come from internal carotid plexus, and properioceptive belong to V)**.**
4. Lateral rectus muscle = **VI nerve** (which contains also postganglionic sympathetic which come from internal carotid plexus, and properioceptive belong to V)**.**

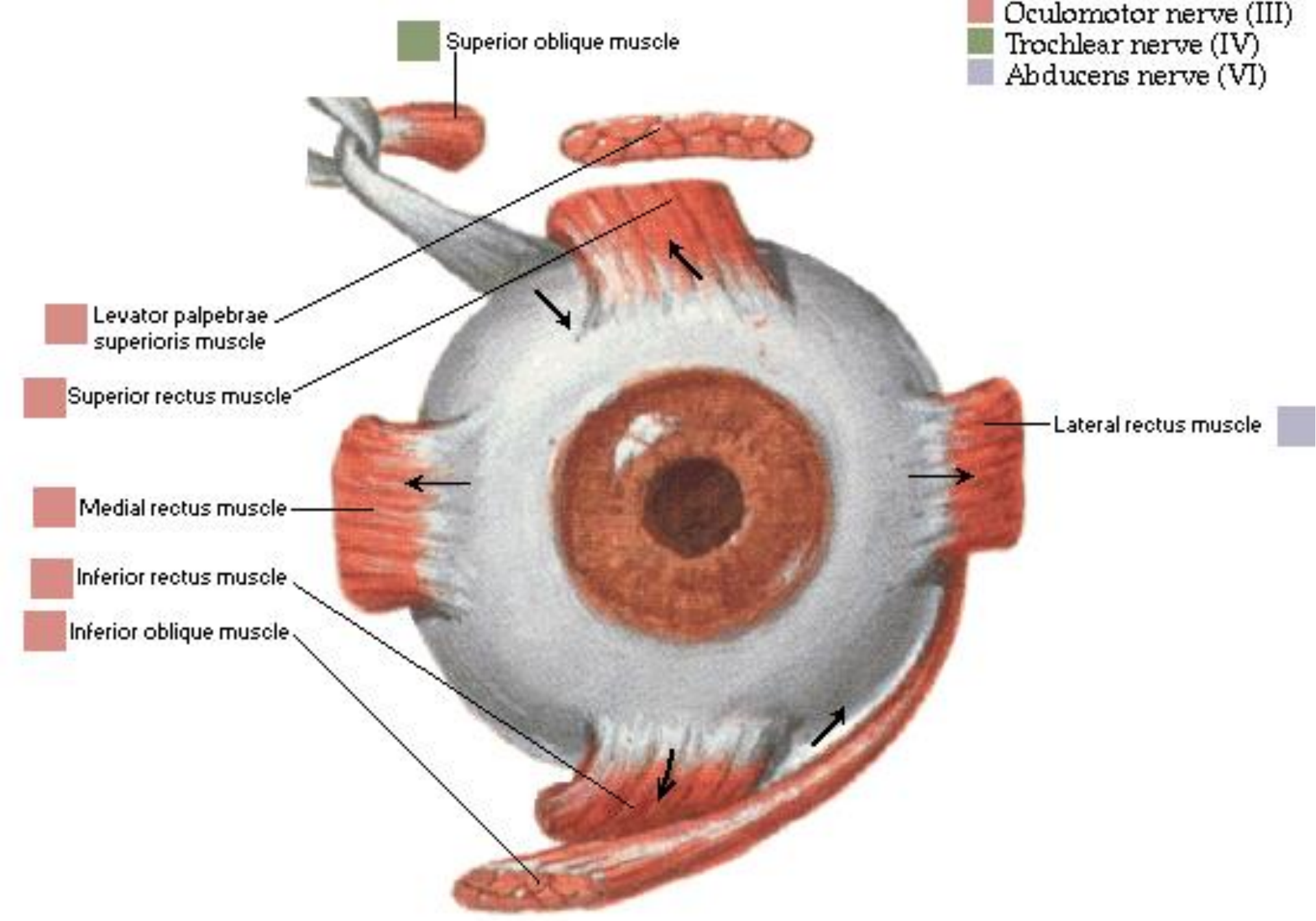
Actions of the muscles:

- Superior rectus = Rotate the eyeball **upwards and medially**.
- Inferior rectus =Rotate the eyeball **downwards and medially**.
- Medial rectus = Rotate the eyeball **medially**.
- Lateral rectus = Rotate the eyeball **laterally**.
- Superior oblique=Rotate the eyeball **downwards and outwards**.
- Inferior oblique = Rotate the eyeball **upwards and outwards**.



Muscle attachments, nerves and vessels entering orbit





Note: arrows indicate direction of eye movement produced by each muscle

V. Trigeminal nerve: Has **small motor root** and **large sensory root.**

***This nerve has a flattened and plexiform ganglion rather than compact and ovoid like dorsal root ganglion. The V has three divisions:

1. **Ophthalmic division:** It contains **general somatic afferent** fibers to the skin and mucous membrane. **Postganglionic sympathetic, which** come from internal carotid plexus. It divides into: **Nasociliary, lacrimal and frontal** nerves that enter the orbit through superior orbital fissure.

A. The **nasociliary** gives: Branches to nasal septum, lateral wall of the nose. **B. internal nasal** branches to mucous membrane of septal and lateral walls and terminates as **external nasal** nerve in the skin of lower part of nose.

C. **Infratrochlear nerve** leaves the orbit beneath the pully of superior oblique muscle; it goes to the lacrimal sac, conjunctiva, skin of medial eyelids and the root of the nose.

D. **Short ciliary** (12 or more fine filaments) contain: Sensory, **postganglionic sympathetic** to the blood vessels of eyeball and **postganglionic parasympathetic** for **sphincter pupilae.**

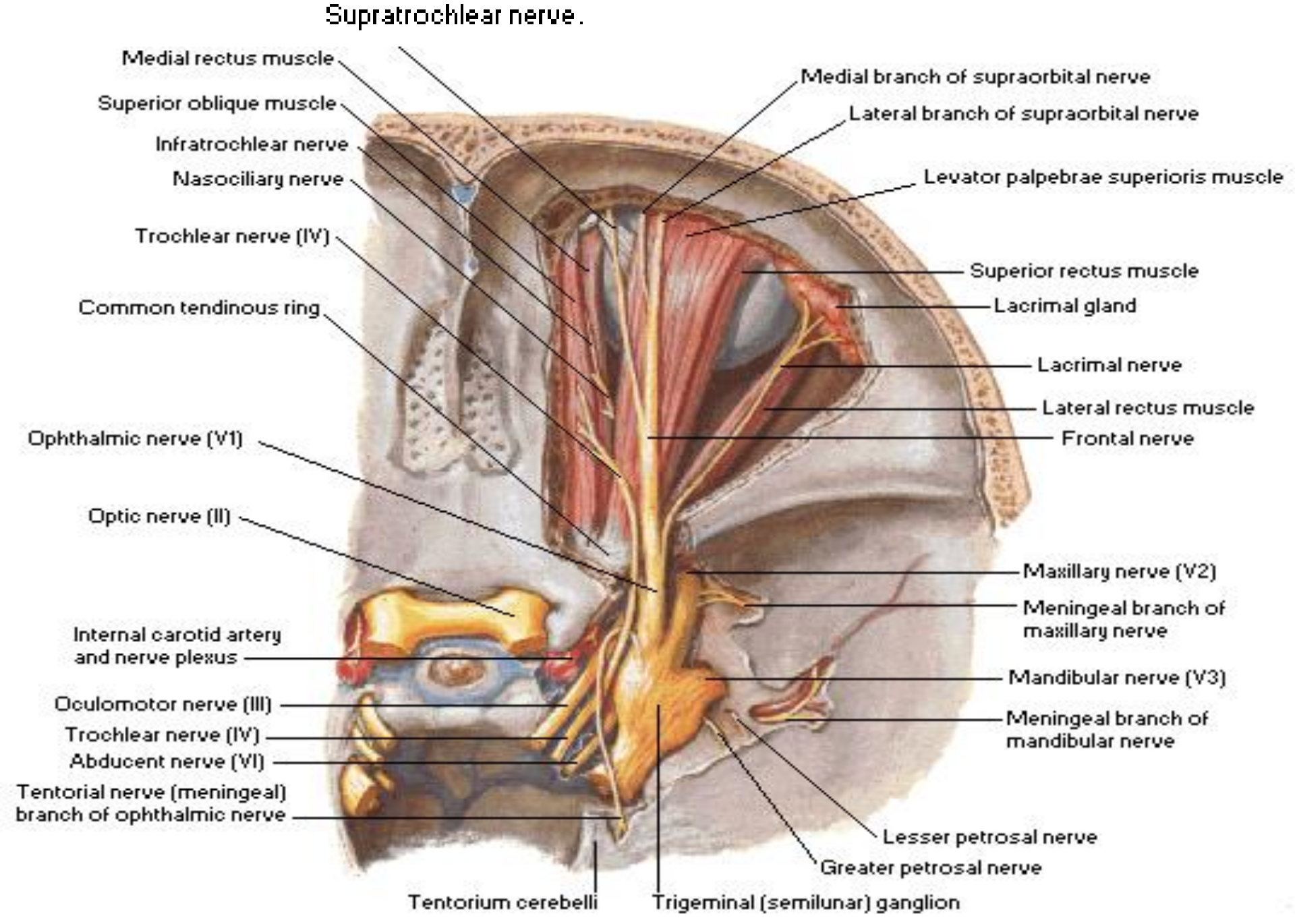
E. **Long ciliary** nerves (two or three in number), contain **sensory** to the iris and **postganglionic sympathetic** fibers for **dilator pupilae** muscle and blood vessels.

F. **Posterior ethmoidal** to supply the ethmoidal and sphenoidal air sinuses.

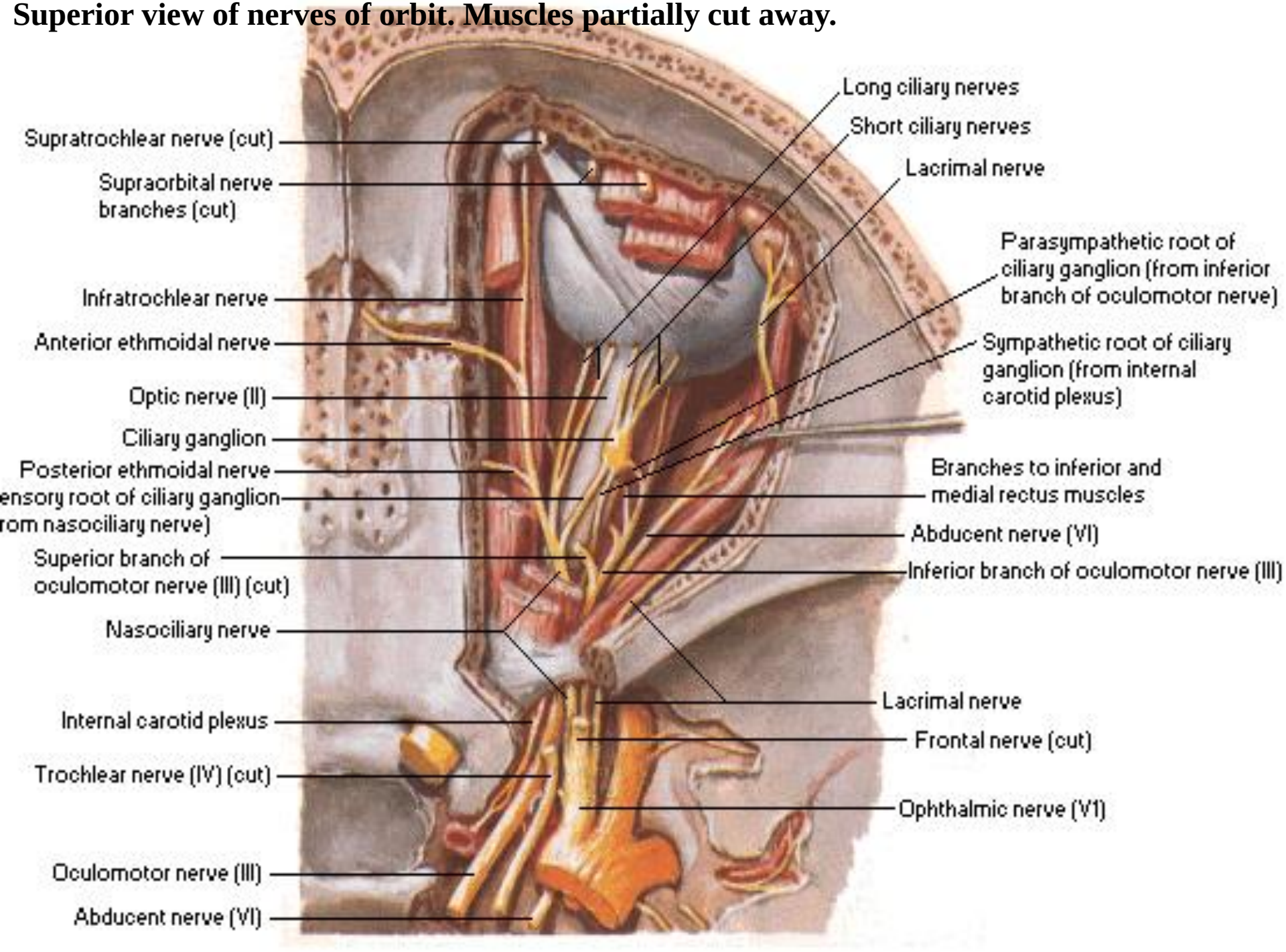
2. The **frontal nerve** is the largest branch of ophthalmic division of V, enters the orbit through the superior orbital fissure lateral to tendinous ring. It divides into larger lateral **supraorbital** and smaller **supratrochlear** to supply the skin of upper eyelid, the forehead and anterior part of the scalp and vertex of cranium.

3. The **lacrimal nerve** enters through superior orbital fissure and passes forwards on the lateral orbital wall to supply the lateral part of conjunctiva and the skin of lateral part of upper eyelid and adjacent part of the face. It receives a communication from **zygomatic** branch of **maxillary division of V**, which conveys secretomotor (**postganglionic parasympathetic**) fibers from **pterygopalatine ganglion** to the lacrimal gland.

Superior view of nerves of orbit.



Superior view of nerves of orbit. Muscles partially cut away.



2. Maxillary division of V (somatic afferent fibers) is larger than ophthalmic and smaller than mandibular.It has the following branches:

* **Infraorbital nerve.**
* **Posterior superior alveolar nerve.**
- **Middle superior alveolar** nerve (to reinforce both).
- **Zygomatic nerve.**
- **Two large pterygopalatine nerves** leave maxillary nerve to **pterygopalatine ganglion.** These nerves contain **sensory** (somatic afferent), **postganglionic sympathetic** (from superior cervical ganglion), **postganglionic parasympathetic** from ganglion its self.

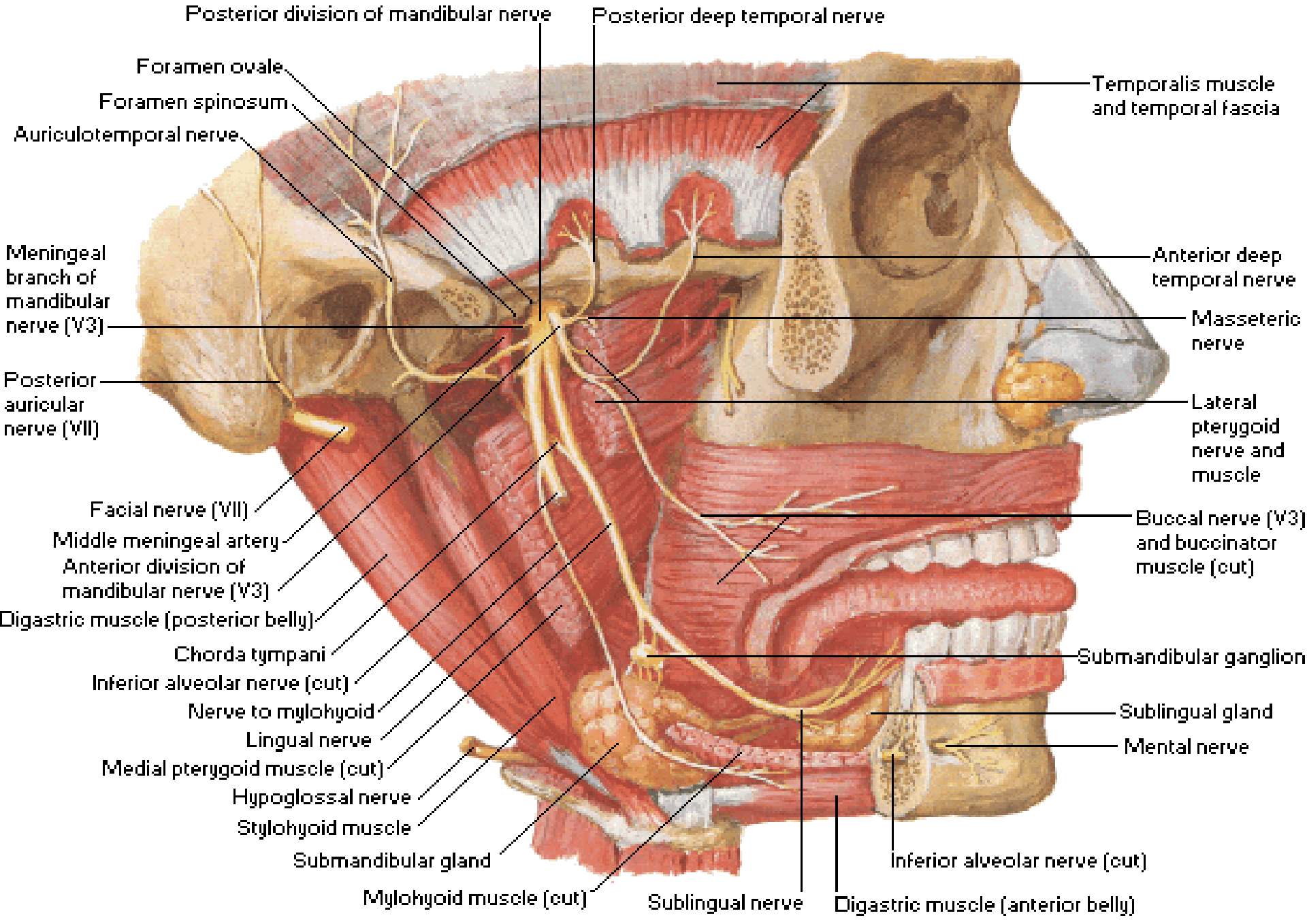
3. **Mandibular division of V** is the largest division formed by the junction of motor root and lateral branch of V ganglion. . After a short course, during which **meningeal branch (nervous spinosus)** to the dura and nerve to **medial pterygoid, tenser palati and tensor tympani (tenses the tympanic membrane, increases its medial convexity &restrict its freedom of movement to prevent wide excursions of the ear ossicles = damage of inner ear in loud sounds) muscles.**

It divides into anterior and posterior divisions.

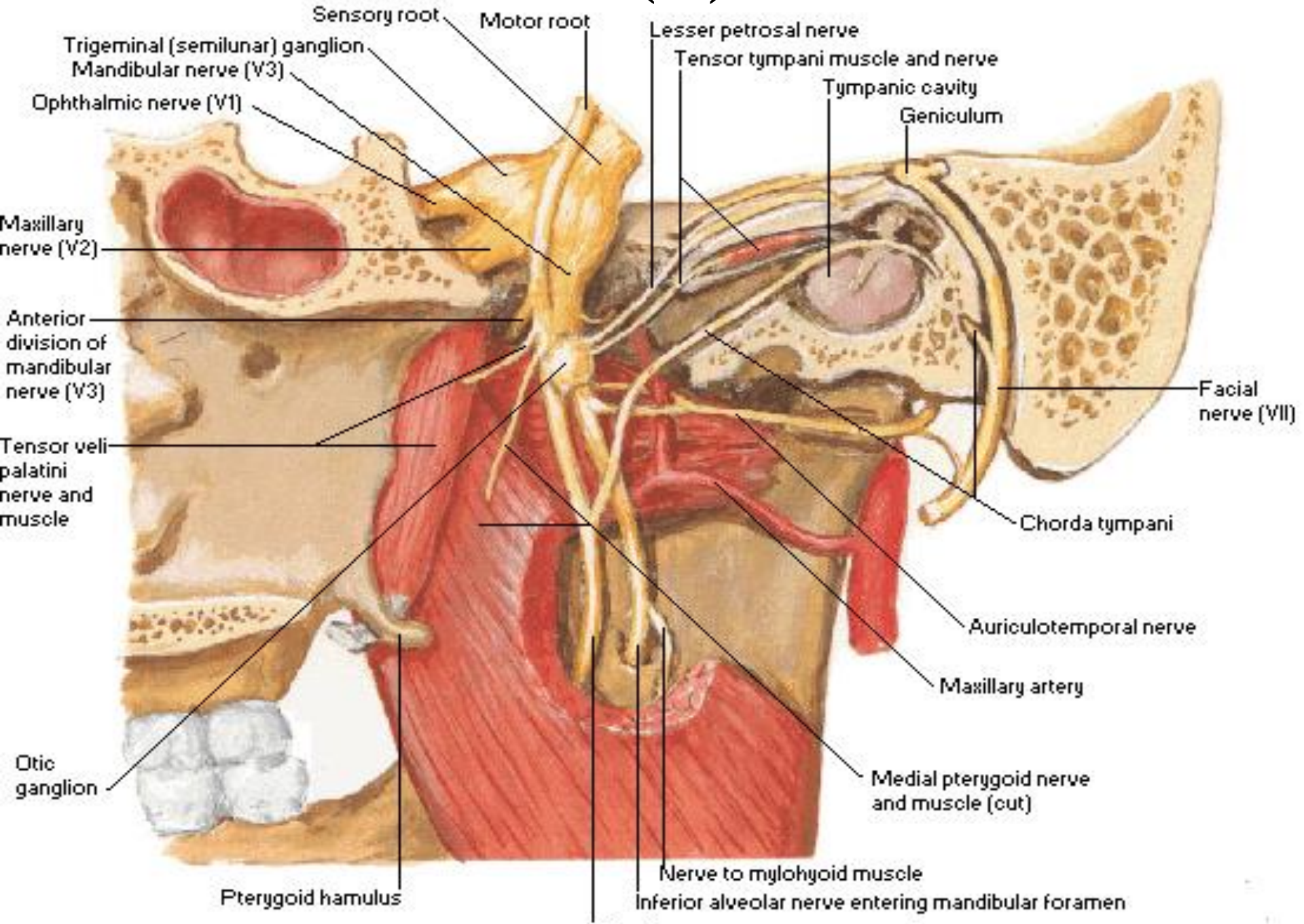
A. The anterior division (mainly motor) supplies lateral pterygoid, temporalis and masseter muscles and buccal nerve (sensory) to the skin of the angle of the mouth and corresponding area of mucous membrane lining the cheek.

B. The **posterior division (mainly sensory**) via inferior alveolar, lingual and auriculotemporal nerves.

Lateral view of mandibular nerve (V3).



Medial view of mandibular nerve (V3).



VII. Facial nerve: Contains **larger motor root** as branchiomotor to supply muscles of facial expression, and **smaller sensory root** (nervus intermedius) which contains **somatic afferent** from external auditory meatus, tympanic membrane, and small area behind the auricle.

-**Special sensation (taste)** to the anterior 2/3 of the tongue via chorda tympani to the lingual nerve. Both roots of VII unite to form a single trunk, enter internal auditory meatus along with VIII and internal auditory vessels.

-Then VII enters the **facial canal,** (a narrow canal runs through petrous temporal bone) and ends at the **stylomastoid foramen**.

-Pierces the parotid gland and ends at the anterior border of it as terminal branches.

It has the following branches:

A. Greater petrosal nerve arises at **geniculate ganglion** of VII and carries taste fibers to the palate and **preganglionic parasympathetic fibers** to the **pterygopalatine ganglion**.The **greater petrosal nerve** and **deep petrosal nerve** (**postganglionic sympathetic**) unite to form **nerve of pterygoid canal (vidian nerve)** to the **pterygopalatine ganglion**.

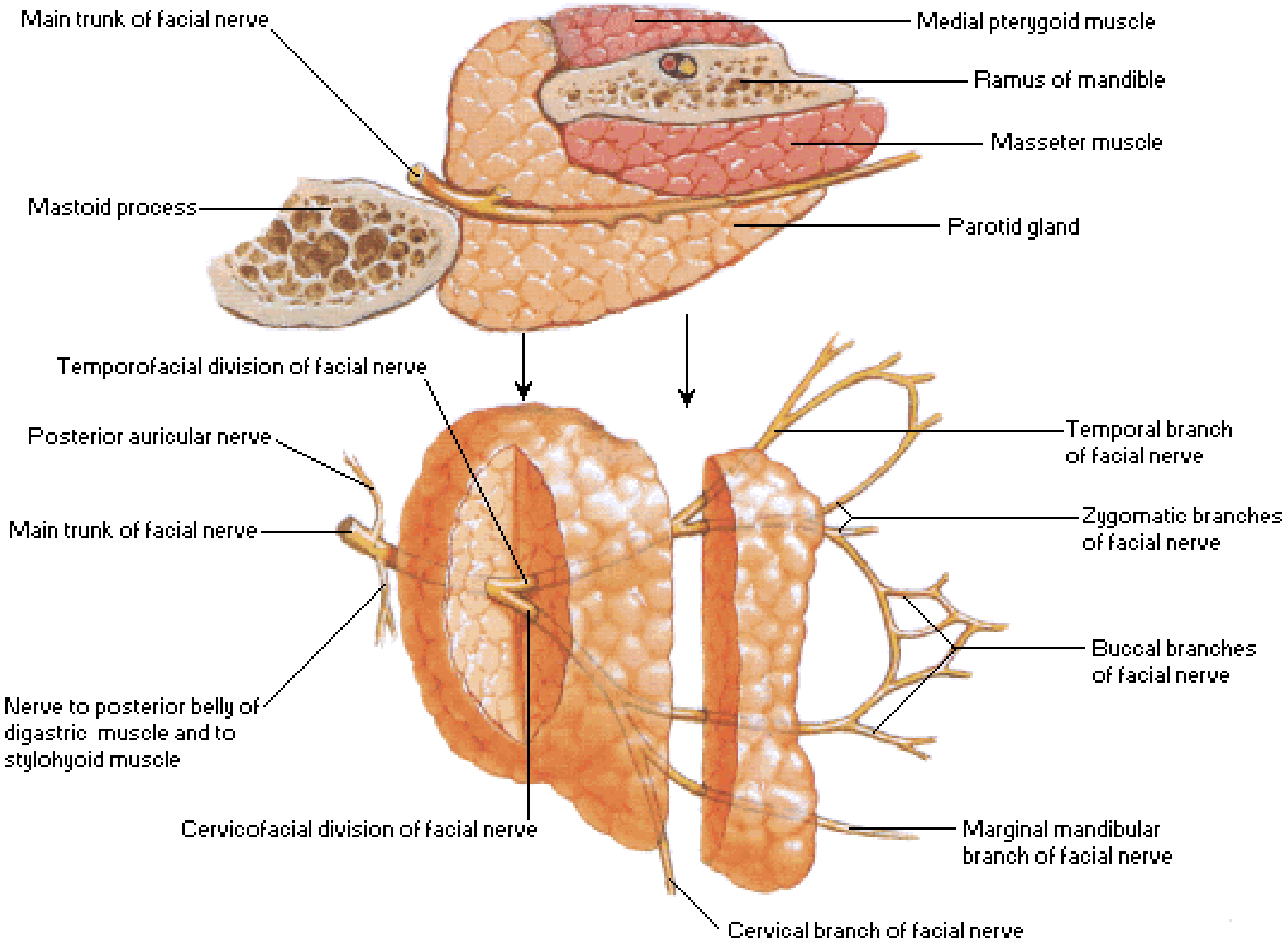
B. Digastric branch to supply posterior belly of digastric and stylohyoid muscles.

C. Posterior auricular nerve to supply occipitalis bellies and posterior auricular.

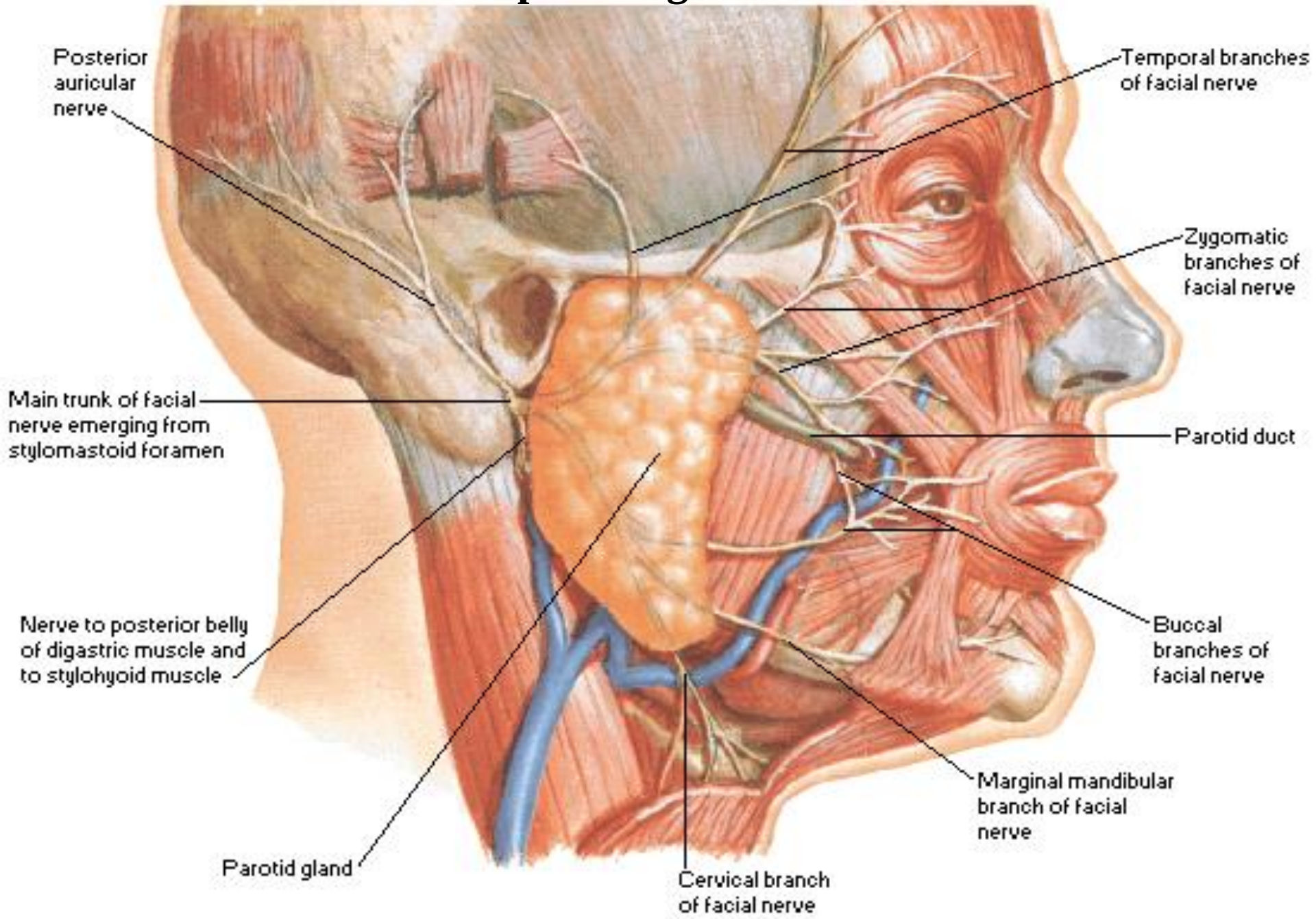
D. Nerve to stapedius muscle (prevent excessive movements of the stapes, its paralysis=excessive acuteness of hearing (hyperacusia).

E. Chorda tympani.

F. Terminal branches: Temporal, zygomatic, maxillary, buccal, mandibular, and cervical nerves.


Main trunk of facial nerve
Medial pterygoid muscle
Ramus of mandible
Masseter muscle
Mastoid process
Parotid gland
Temporofacial division of facial nerve
Posterior auricular nerve
Temporal branch of facial nerve
Main trunk of facial nerve
Zygomatic branches of facial nerve
Buccal branches of facial nerve
Nerve to posterior belly of digastric muscle and to stylohyoid muscle
Cervicofacial division of facial nerve
Marginal mandibular branch of facial nerve
Cervical branch of facial nerve

Facial nerve branches and parotid gland in situ.

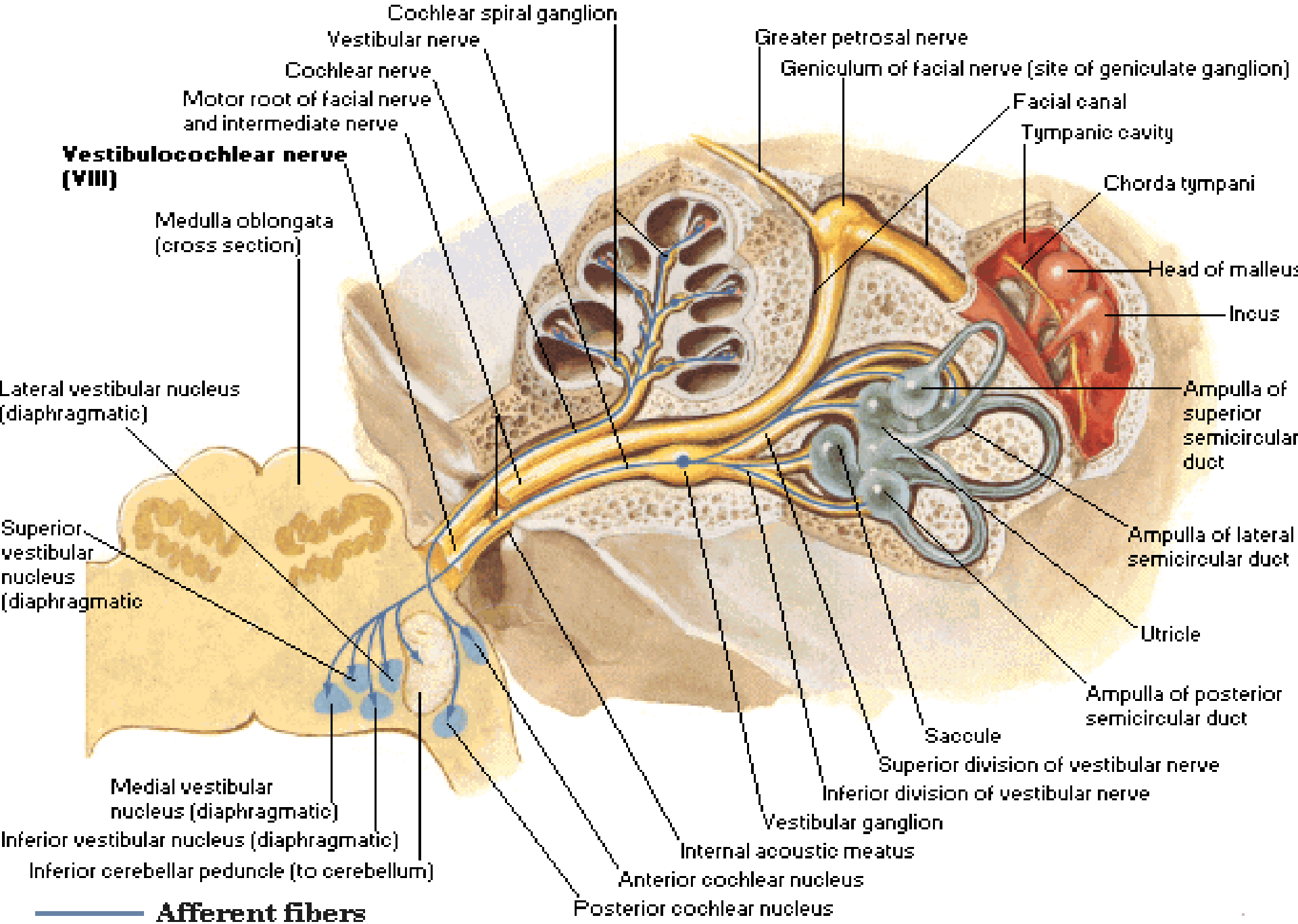


VIII. Vestibulocochlear nerve: Consists of two sets of sensory fibers:

A – Vestibular that originates from the **vestibular ganglion (vestibule),** which present in outer part of internal acoustic meatus and semicircular canals. It responsible for sense of position and movement of head.

B – Cochlear that originates from **spiral ganglion (cochlea)** of internal ear and it concerned with hearing. Both divisions enter the skull with VII nerve through internal acoustic meatus, cross posterior cranial fossa to the brain between pons and medulla oblongata.

Vestibulocochlear nerve (VIII).



IX. Glossopharyngeal nerve: Arises from retroolivary sulcus of medulla oblongata in line with VII, X, XI nerves because all of these nerves contain branchiomotor fibers. IX nerve has two ganglions:

A. Superior ganglion is sensory contains cell bodies of **general somatic afferent** which are distributed to the **mucous membrane of middle ear.**

B. Inferior sensory that is large and important and contains cell bodies of other sensory fibers in the nerve. IX nerve passes through jugular foramen to become infront of internal carotid artery (superficial to stylopharyngeus muscle) deep to the hyoglossus muscle at the back of the tongue.

IX nerve has the following branches:

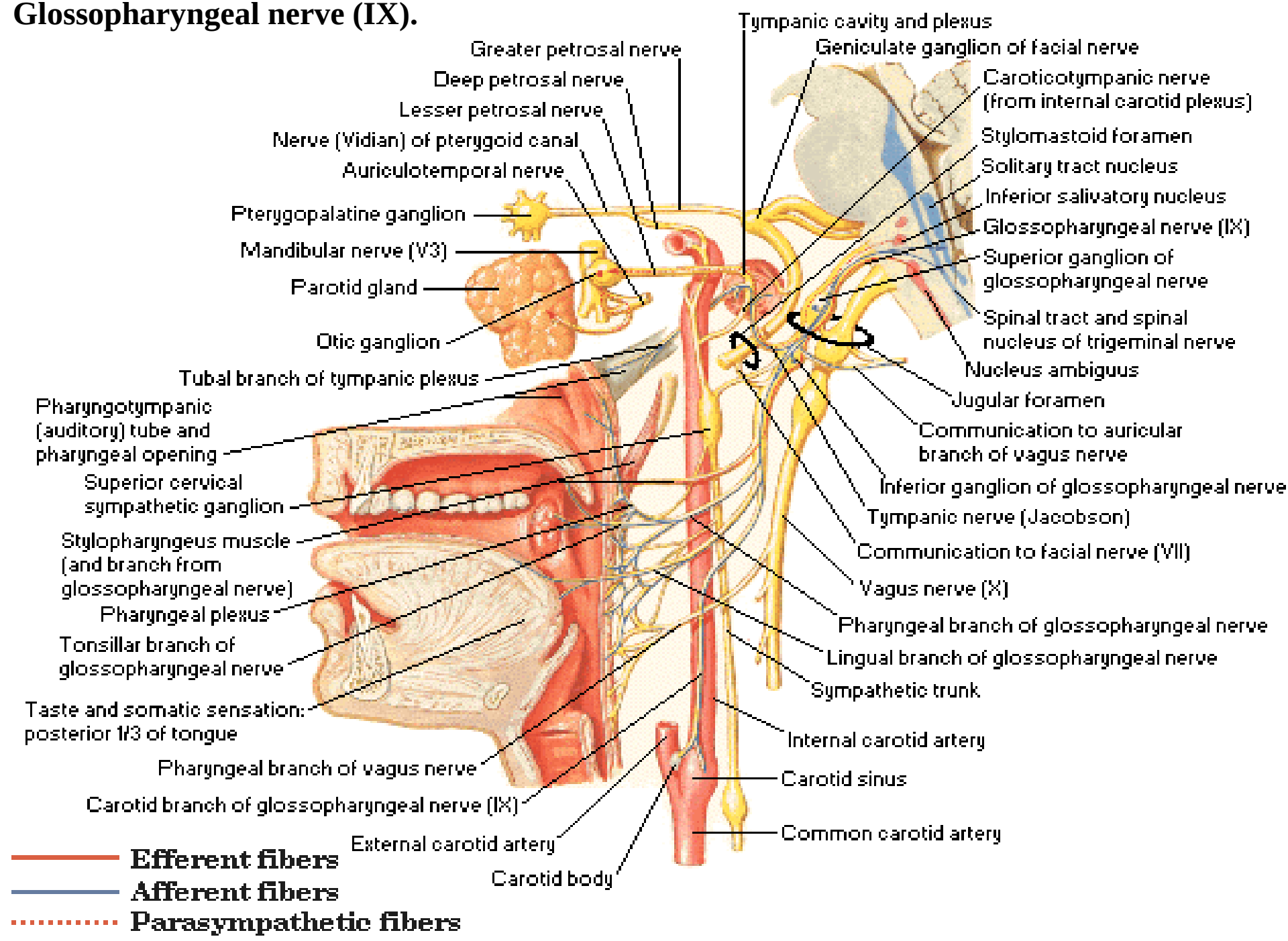
- **Tympanic nerve:** To the tympanic plexus, the sensory fibers supply the mucous membrane of middle ear and its pre ganglionic parasympathetic fibers travel in **lesser petrosal nerve to otic ganglion**. Post ganglionic parasympathetic fibers goes to parotid gland via auriculotemporal nerve.
- **Carotid nerve:** Carries afferent fibers from **baroceptors** of carotid **sinus** and **chemoreceptors** of carotid **body.**

- **Pharyngeal nerve:** To the pharyngeal plexus (together with X, and cervical sympathetic trunk). Through this plexus, IX contributes sensory fibers to the pharyngeal mucosa and motor fibers to constrictor muscles of the pharynx.

- **Muscular nerve:** supplies stylopharyngeus muscle.

- **Tonsillar nerve:** Sensory to mucosa over palatine tonsil, adjacent parts of soft palate and palatine arches.

Glossopharyngeal nerve (IX).



X. Vagus nerve: It contains the following functional classes of fibers:

1. **General visceral efferent (pre ganglionic parasympathetic):** To the heart, smooth muscles and glands in a large part of alimentary tract and lungs.
2. **General visceral afferent:** Includes visceral reflexes and sensibility.
3. **Special visceral efferent (branchiomotor):** To the muscles of fourth and sixth pharyngeal arches.
4. **Special visceral afferent:** To the taste buds on epiglottis and most posterior part of the tongue.
5. **General somatic afferent:** To the dura mater of posterior cranial fossa and small area of the skin in external auditory meatus.

•X nerve passes through jugular foramen, it has two ganglions: **Small superior ganglion (general somatic afferent)** lies in the foramen**. Larger inferior ganglion (general and special visceral afferent)** lies below the exit of the nerve from the foramen.

• The cranial part of XI nerve join X nerve at the level of inferior ganglion and distributed through X nerve to give motor supply to pharyngeal and palatal muscles **except tensor palate** which supplied by mandibular division of V nerve.

• It has the following branches:

1. **Meningeal nerve** to the dura mater of posterior cranial fossa.

2. Auricular nerve to supply the skin on the cranial surface of auricle and posterior wall of external auditory meatus and lower part of tympanic membrane.

3. Pharyngeal nerve from the cranial part of XI nerve passes between internal and external carotid arteries to form pharyngeal plexus (together with IX, and cervical sympathetic trunk) and provides the main motor supply of pharyngeal muscles.

4. **Superior laryngeal nerve** is divided into **smaller external laryngeal nerve** to cricothyoid muscle (the only intrinsic muscle of larynx that **not** supplied by recurrent laryngeal nerve). **Larger internal laryngeal nerve (sensory branch)** which pierces thyrohyoid membrane to mucous membrane of the pharynx and larynx from dorsum of the tongue to the level of vocal folds.

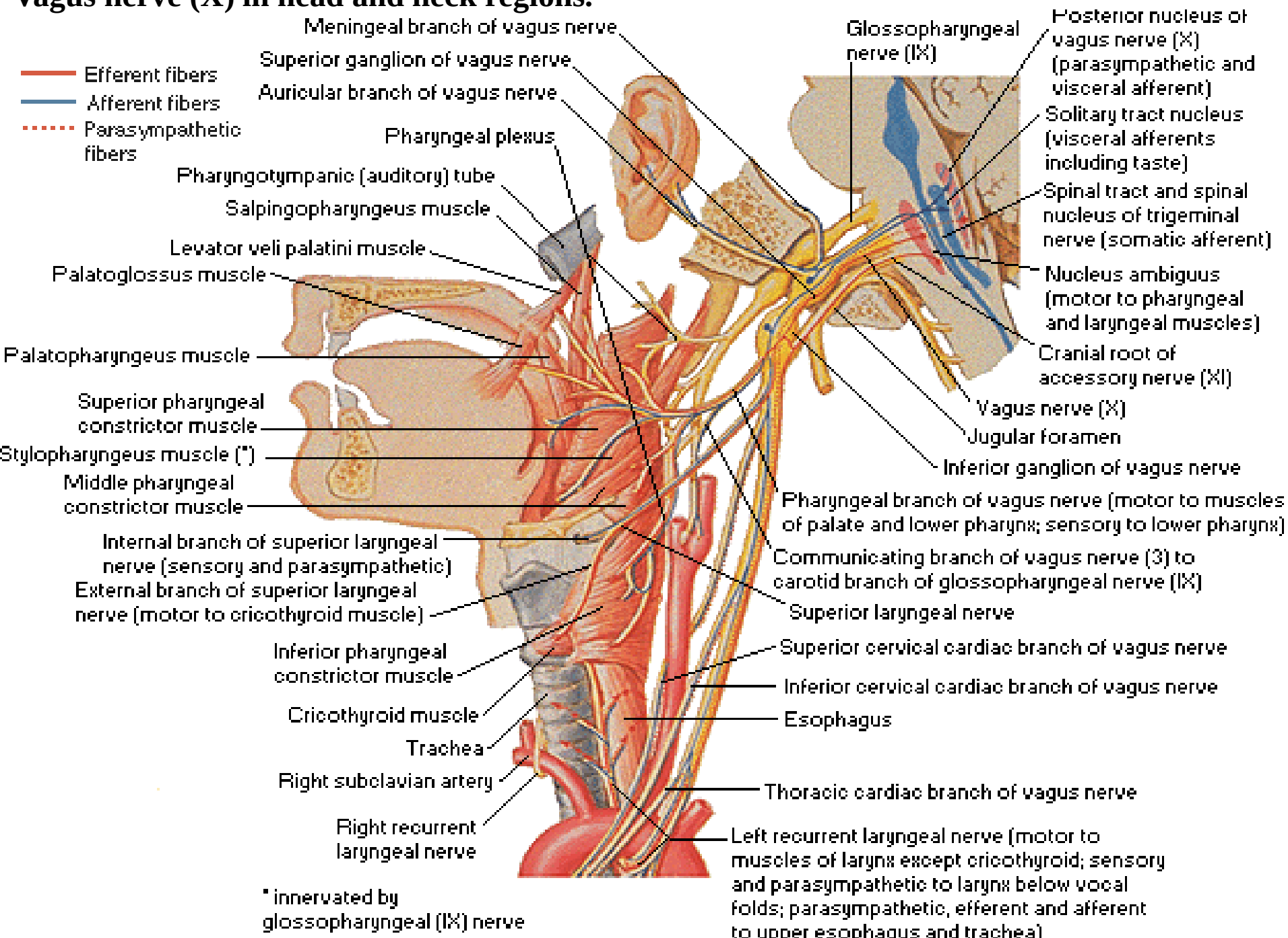
5. **Cardiac nerve** that divides into upper and lower nerves, arise in the neck. On the **right side**, both of them go behind subclavian artery to the deep cardiac plexus**.** On the **left side**, the upper nerve is medial to aorta and goes to the deep cardiac plexus**,** while the lower nerve is lateral to aortic arch and goes to the superficial cardiac plexus**.**

6. Recurrent laryngeal nerve is situated between trachea and esophagus and closely related to the inferior thyroid artery that may damage in operation of thyroid gland. Each nerve supplies all intrinsic muscles of its own side of larynx **except** cricothyoid muscle and mucous membrane of pharynx and larynx below vocal fold.

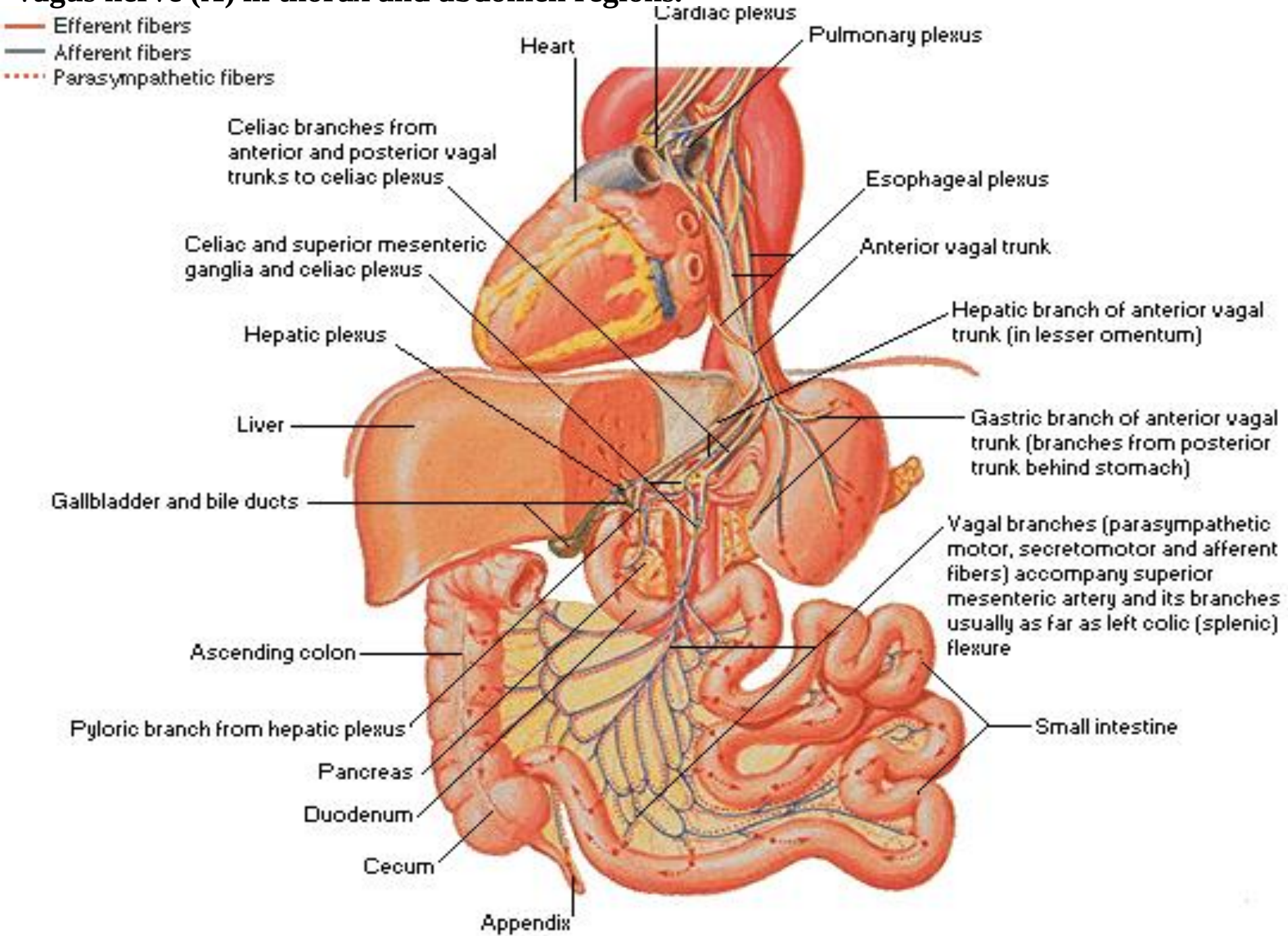
7. Bronchial and pulmonary nerves to the pulmonary plexus at the root of the lung which contains also sympathetic to the smooth muscle glands of bronchial tree, smooth muscles of pulmonary blood vessels and to mediastinal and visceral pleura. **8. Esophageal nerve** as motor, sensory and sympathetic. **9. Branches to aorta, brachiocephalic and right subclavian arteries** to the pressure and chemoreceptors.

10. Abdominal branches to the stomach, intestine, liver, spleen, pancreas, kidney and suprarenal glands.

Vagus nerve (X) in head and neck regions.

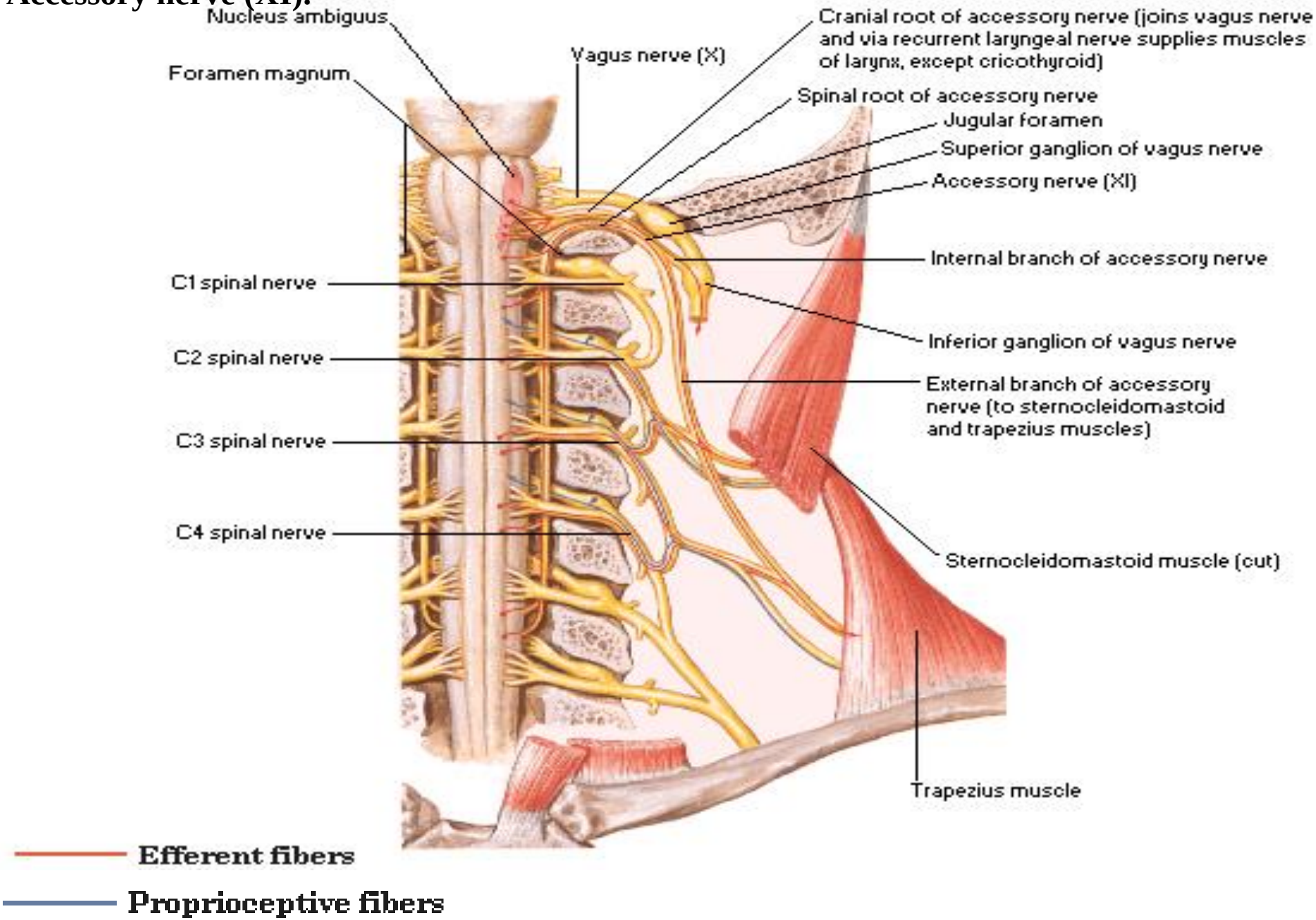


Vagus nerve (X) in thorax and abdomen regions.



XI. Acessory nerve: Consists of **cranial** and **spinal** roots. The cranial (branchiomotor) joins X nerve to the muscles of pharynx and larynx, while the spinal arises from upper five or six cervical segments of spinal cord, passes through foramen magnum and join the cranial root **(without intermingling of the fibers of the two roots)** in the jugular foramen to supply sternocleidomastoid and trapezius muscles. It communicates with 2, 3, and 4 ventral rami of cervical spinal nerves as **properioceptive** to the same muscles.

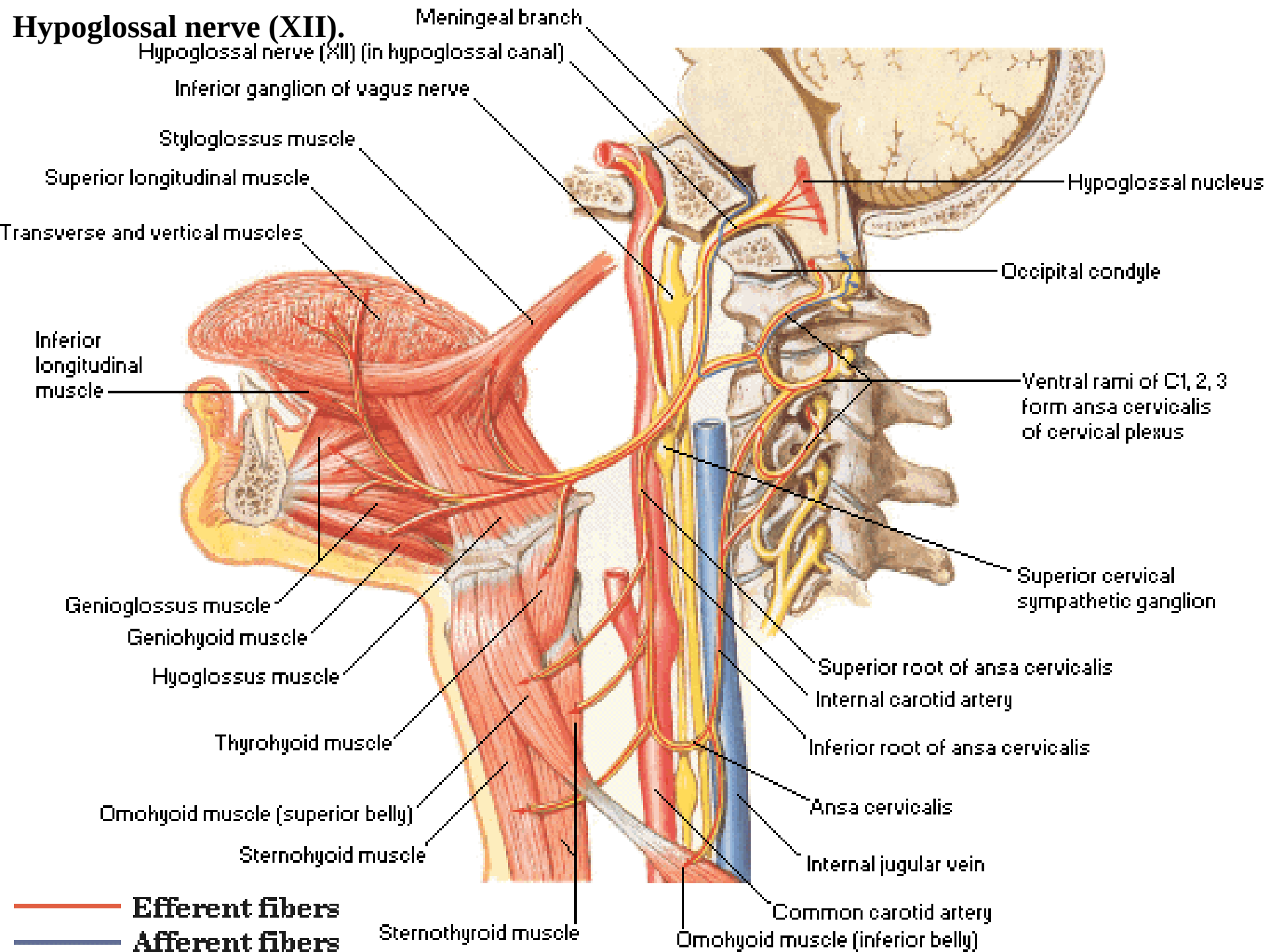
Accessory nerve (XI).



XII. Hypoglossal nerve is **motor** to all intrinsic and extrinsic muscles of the tongue **except** palatoglossus muscle. It also serves as a route whereby some fibers from ventral primary ramus of 1^{st}, 2^{nd} and 3^{rd} cervical spinal nerves to supply geniohyoid, and infrahyoid muscles **(ansa cervicalis).** It also contains **postganglionic sympathetic** as vasoconstrictor fibers of the arterioles of tongue. **No sensory** fibers in XII nerve but the sensory innervations to the muscle spindles of the tongue are transmitted via **lingual nerve**.

Section of XII nerve leads to degeneration of the muscles that supplied, atrophy and wrinkled tongue of that side. When the tongue protruded, the tip is deviated to paralyze side by unopposed action of the muscles of normal side (principally genioglossus).

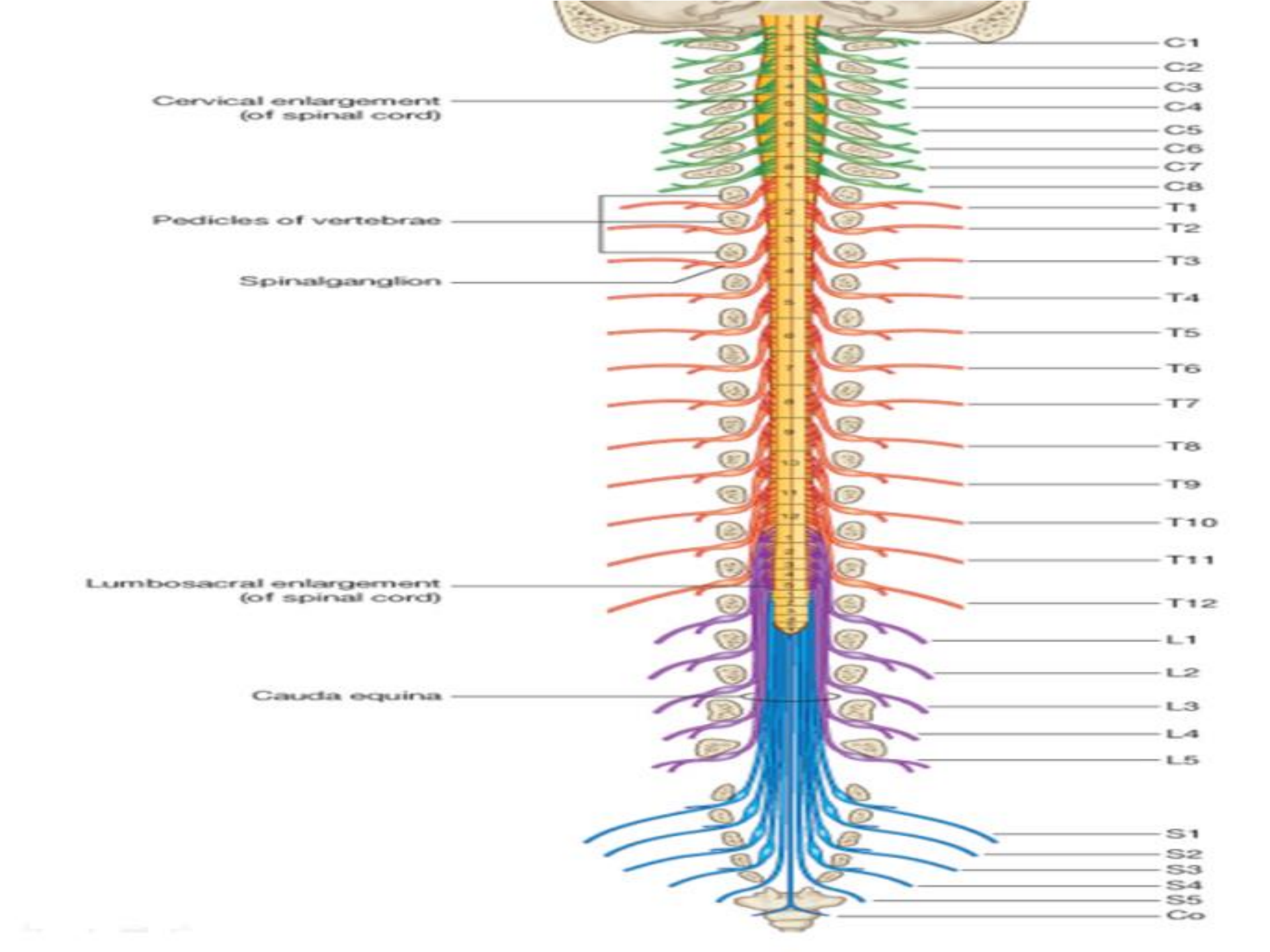
Hypoglossal nerve (XII).



2. Spinal Cord

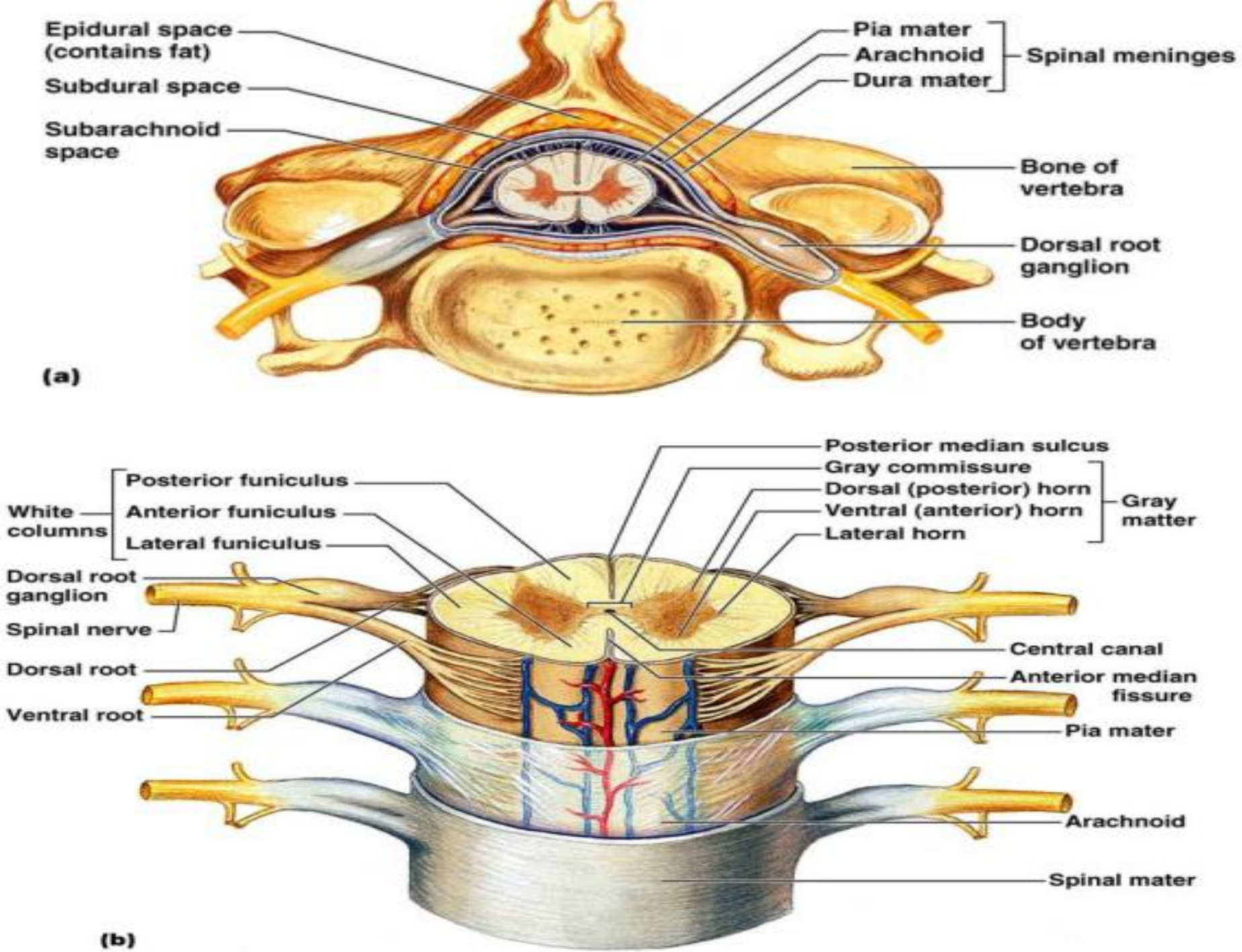
- Is a cylindrical, grayish white structure (**because** of the tracts of myelinated nerve fibers**)** extends down the vertebral canal from the level of foramen magnum, where it is continuous with the medulla oblongata of the brain, to the lower border of the body of 1st lumbar vertebra or the upper border of the body of 2nd lumbar vertebra.

- Its length varies with the height of individual and is on average about 45 cm.
- In mid – thoracic region, it is cylindrical and relatively slender. In cervical region where it gives origin to **brachial plexus** and in lower thoracic and lumber levels where it gives origin to **lumbosacral plexus**, there are fusiform swellings (**cervical and lumbar enlargements**).
- If the spinal cord is stripped of its membranous coverings, it is found to be marked down the midline posteriorly by a **shallow** furrow (**posterior median sulcus**) while along the midline anteriorly is a **deep** fissure (**anterior median fissure**).


Cervical enlargement
(of spinal cord)
Pedicles of vertebrae
Spinalganglion
Lumbosacral enlargement
(of spinal cord)
Cauda equina
C1
C2
C3
C4
C5
C6
C7
C8
T1
T2
T3
T4
T5
T6
T7
T8
T9
T10
T11
T12
L1
L2
L3
L4
L5
S1
S2
S3
S4
S5
Co

*At the whole length of cord, the **spinal nerves** (31 pairs) are attached by **dorsal** (**sensory**) and **ventral (motor) roots**. The **dorsal nerve root** contains sensory axons (with cell bodies situated in the **dorsal root ganglion**) that carry afferent signals. These extend to the posterior horn where they synapse with interneurons and neurons of the spinal tracts. Further synapses occur with other interneurons or motor neurons with cell bodies situated in the **ventral horn**.

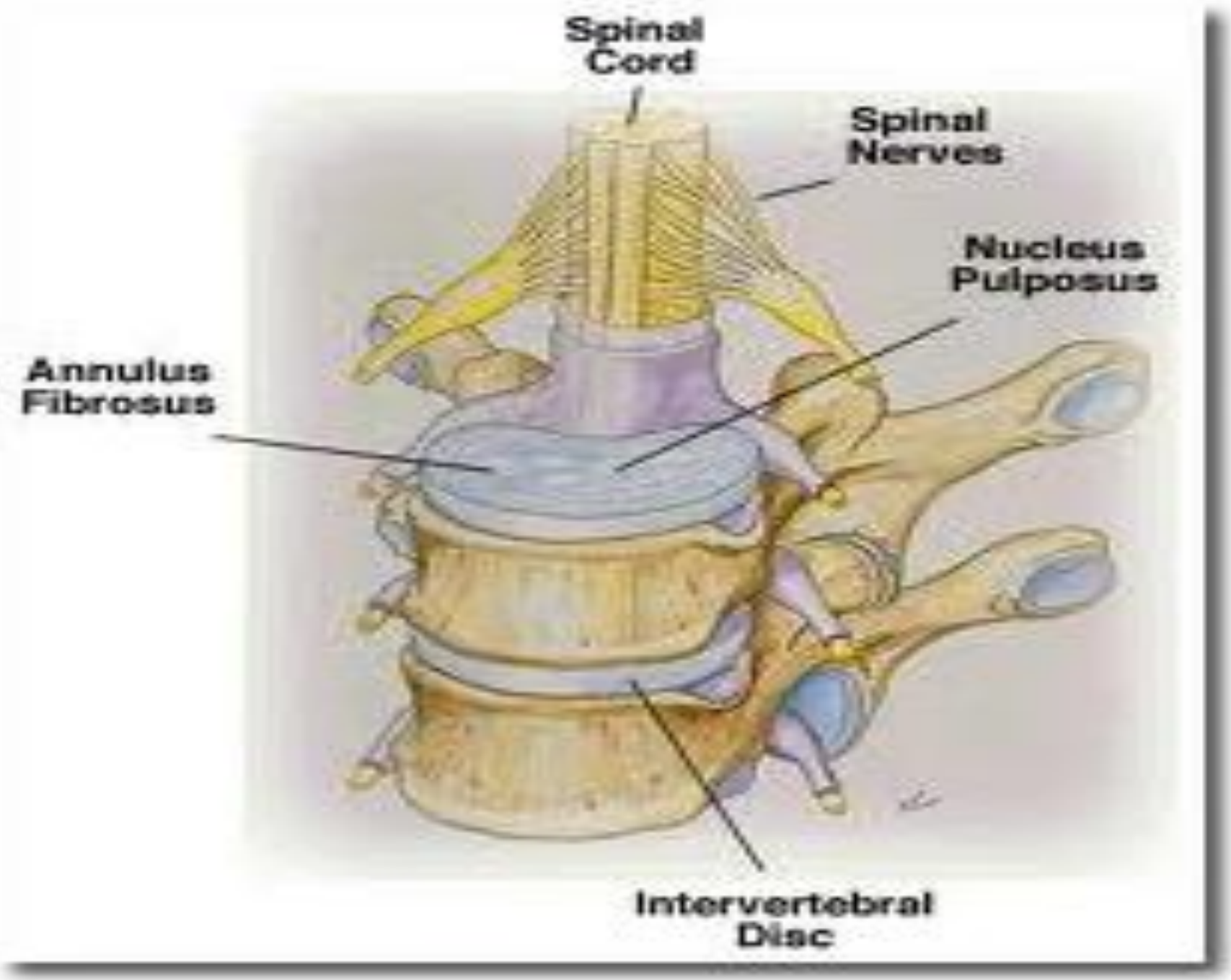
*The **ventral nerve root** contains motor neurons carrying efferent signals that synapse with interneurons previously mentioned. The **lateral horn** is a collection of grey matter lying between the anterior and posterior horns in the thoracic and upper lumbar areas of the spinal cord represent the **origin of sympathetic fibers** that pass with ventral horn.


Epidural space (contains fat)
Subdural space
Subarachnoid space
Pia mater
Arachnoid
Dura mater
Spinal meninges
Bone of vertebra
Dorsal root ganglion
Body of vertebra
(a)
Posterior median sulcus
Gray commissure
Dorsal (posterior) horn
Ventral (anterior) horn
Lateral horn
Gray matter
White columns
Posterior funiculus
Anterior funiculus
Lateral funiculus
Dorsal root ganglion
Spinal nerve
Dorsal root
Ventral root
Central canal
Anterior median fissure
Pia mater
Arachnoid
Spinal mater
(b)

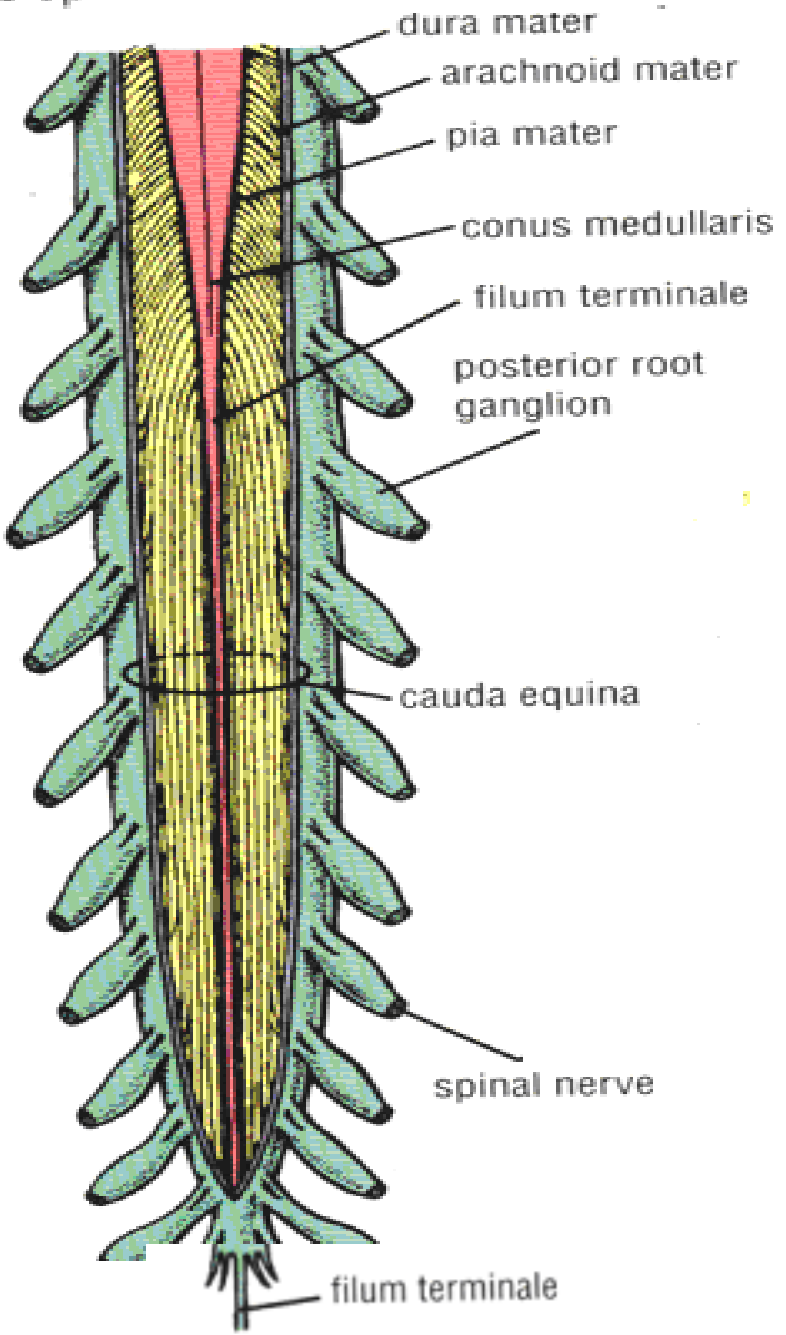
*The spinal nerve roots pass laterally from each spinal cord segment to the level of their respective **intervertebral foramina,** where they unite to form a **spinal nerve** which is made up of a mixture of motor and sensory fibers. After emergence from the **intervertebral foramina**, each spinal nerve immediately divides into a large anterior ramus and a smaller posterior ramus that contain both motor and sensory fibers.

- The lower nerve roots together are called **cauda equine (lumbar**, sacral and cocceygeal nerves descend vertically as a leash of dorsal and ventral roots in subarachnoid space inferior to the end of spinal medulla)**.**
- The spinal cord and cauda equine below it, are enclosed in a tubular sheath of tough inelastic fibrous tissue (**dura matter**).
- It is separated from the walls of the canal by **extradural (epidural) space** containing loose areolar tissue and plexuses of veins.
- In pia mater run blood vessels that vascularize the cord.

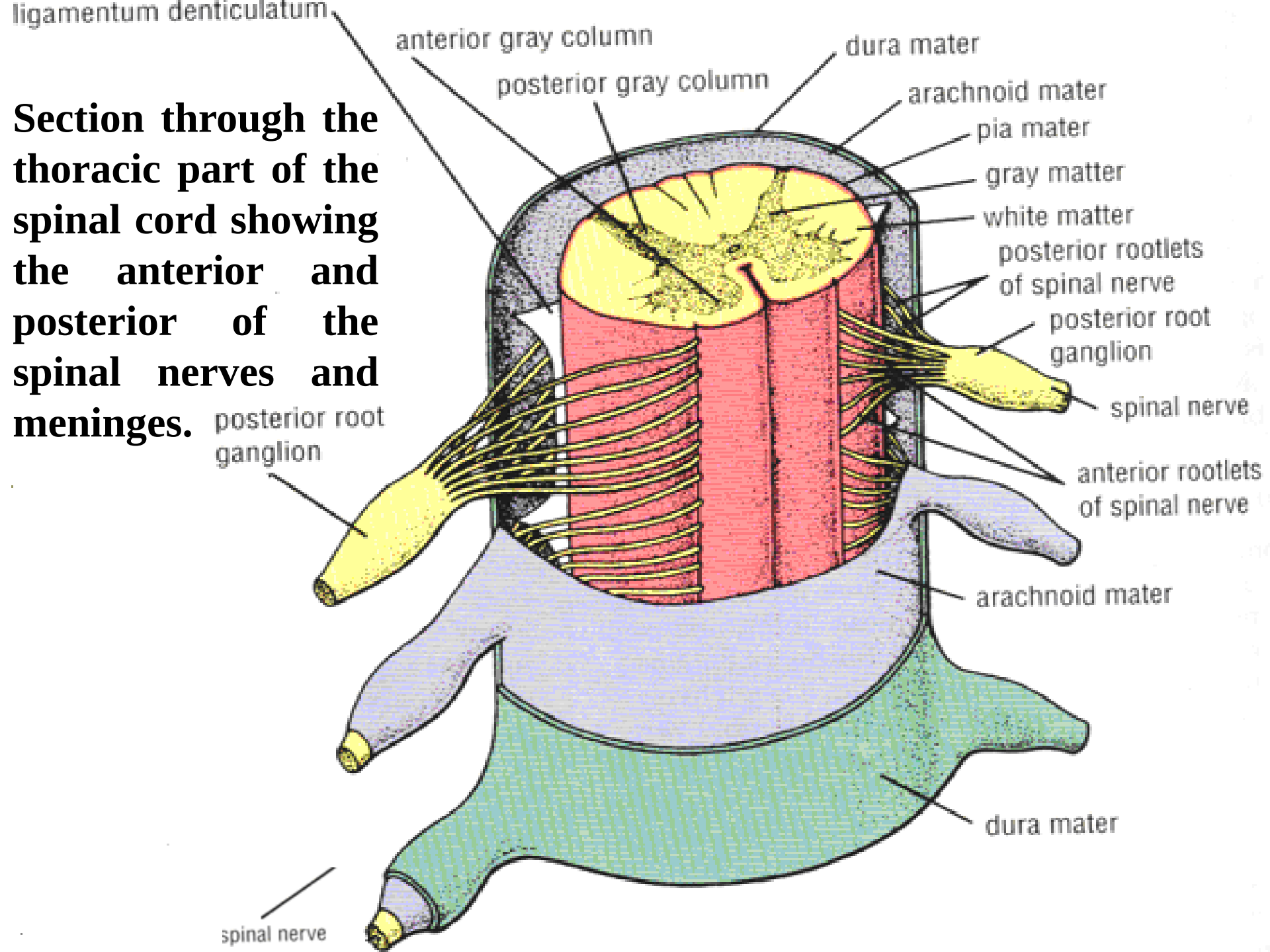
- The cord is suspended in the middle of its dural sheath by a membranous expansion of pia mater which is attached along lateral aspect of cord, midway between ventral and dorsal spinal nerve roots **ligamentum denticulatum**) which is attached firmly to inner surface of dura mater and arachnoid by a series of pointed processes which project out between adjacent nerve roots. The lower end of spinal cord forms a blunt tapering extremity (**conus medullaris that contains terminal ventricle**) and from this a fine strand of fibrous tissue (**filum terminale**) extends downwards in midst of cauda equine, finally to reach back of coccyx where it is firmly attached by blending with periosteum.


Spinal Cord
Spinal Nerves
Nucleus Pulposus
Annulus Fibrosus
Intervertebral Disc

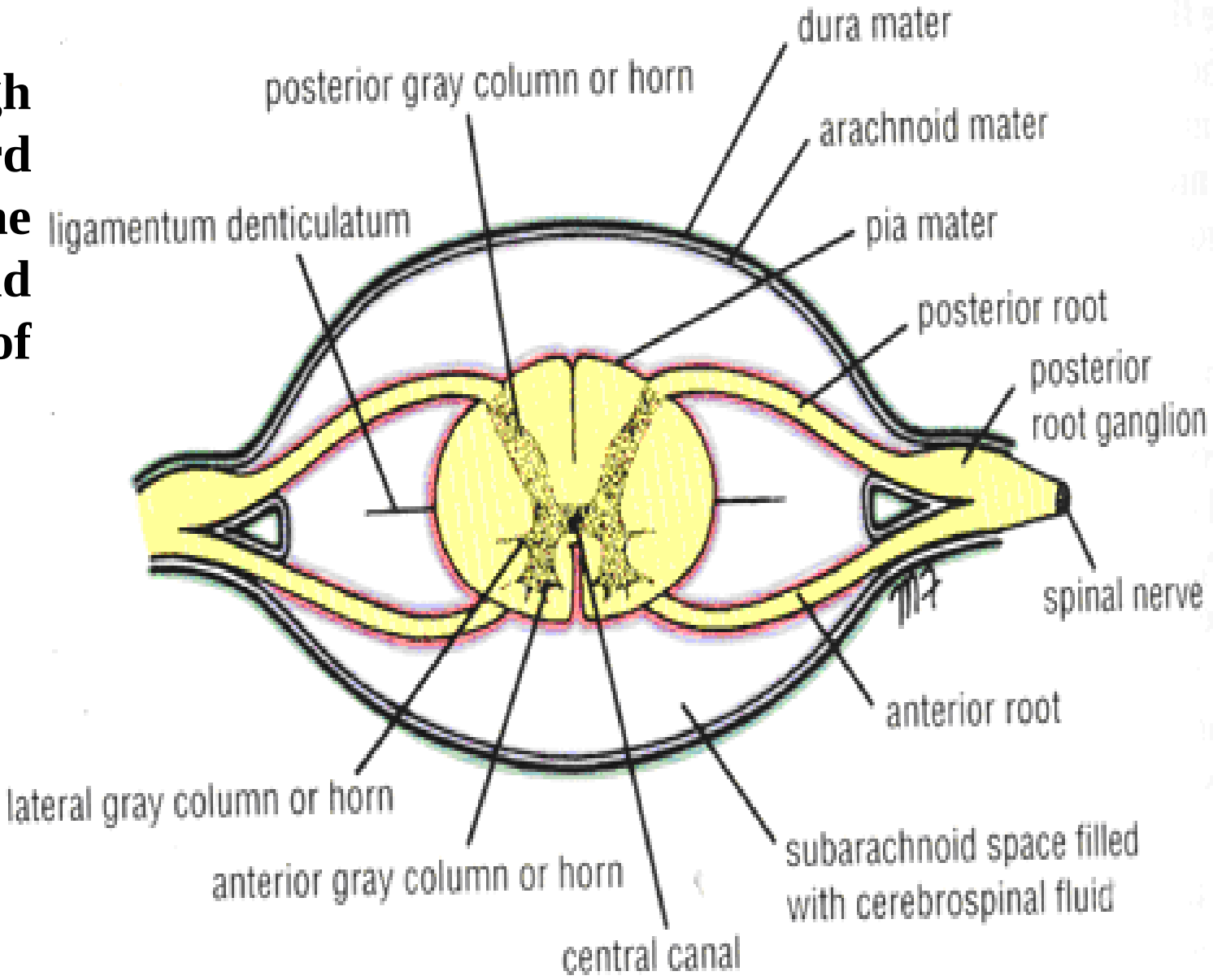
Lower end of the spinal cord and the cauda equina.



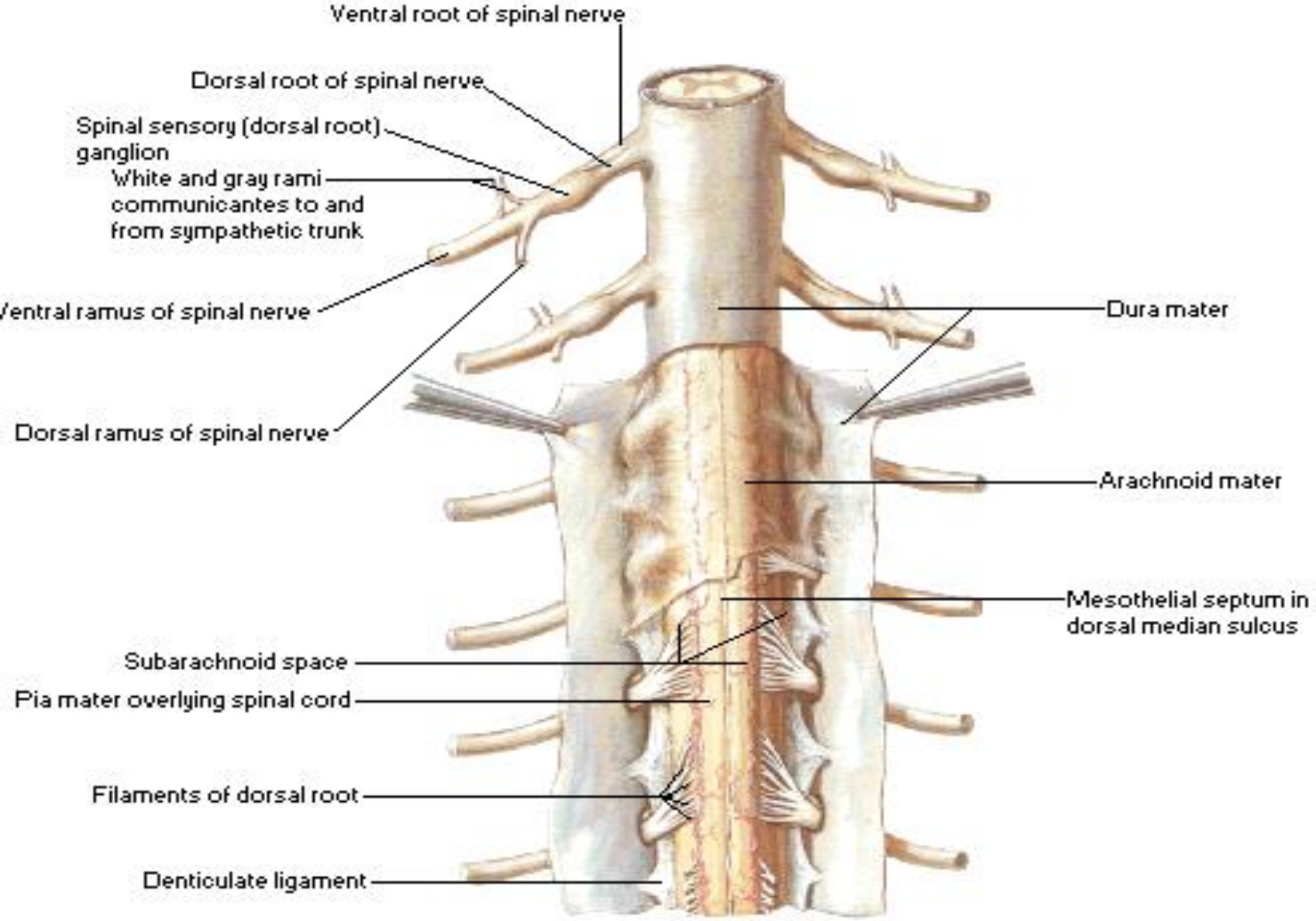
Section through the thoracic part of the spinal cord showing the anterior and posterior of the spinal nerves and meninges.



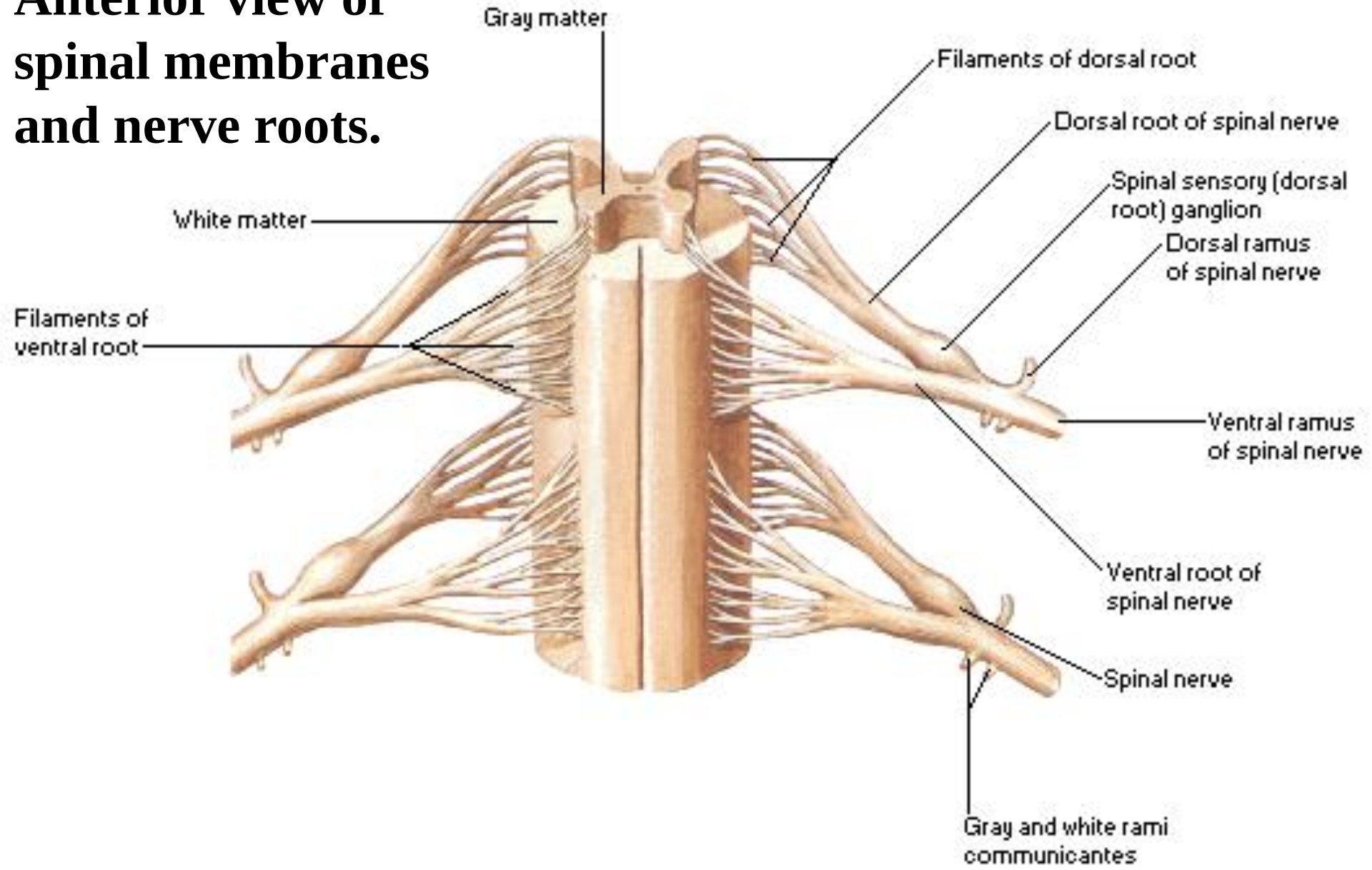
Transverse section through the spinal cord showing the meninges and the position of the CSF.



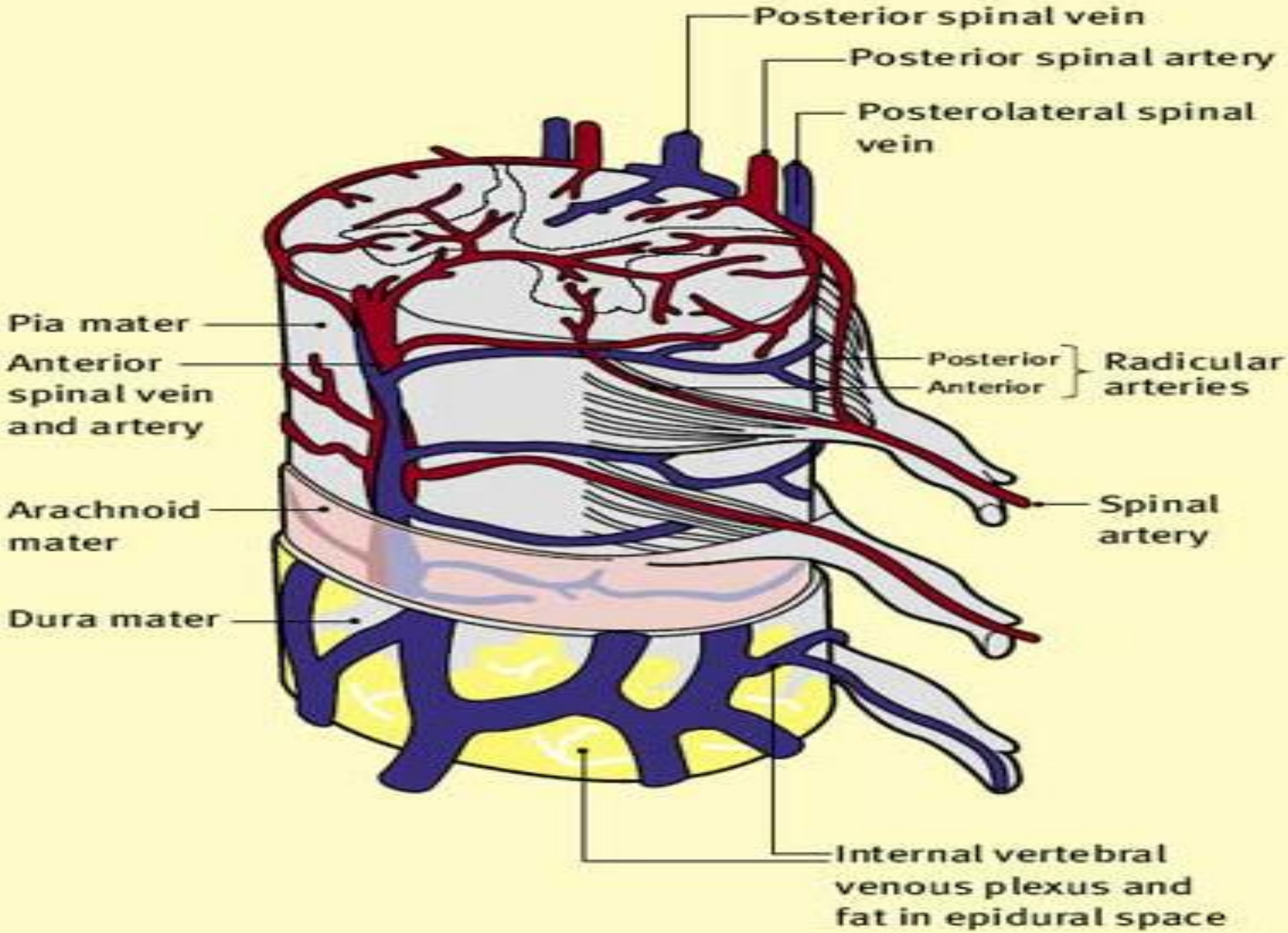
Posterior view of spinal membranes and nerve roots.



Anterior view of spinal membranes and nerve roots.



Arterial supply and venous drainage of the spinal cord



Good Luck With Best Wishes