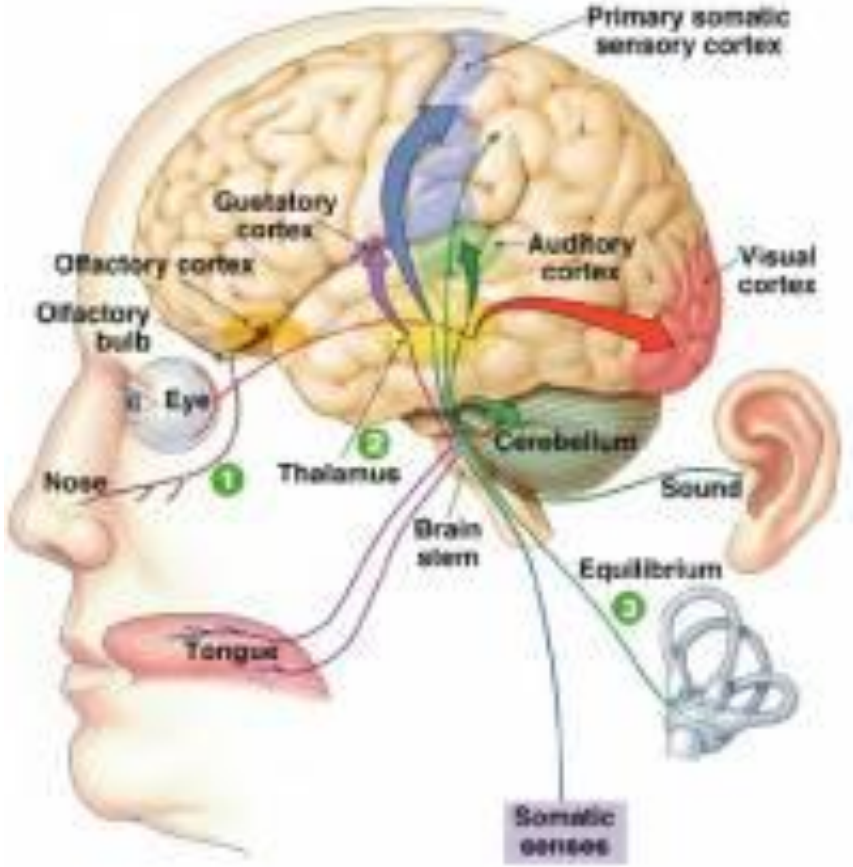
Sensory Systems Anatomy

- Vision
- Hearing
- Balance
- Taste
- Smell
- Touch
- Pain
- Proprioception
- Interoception

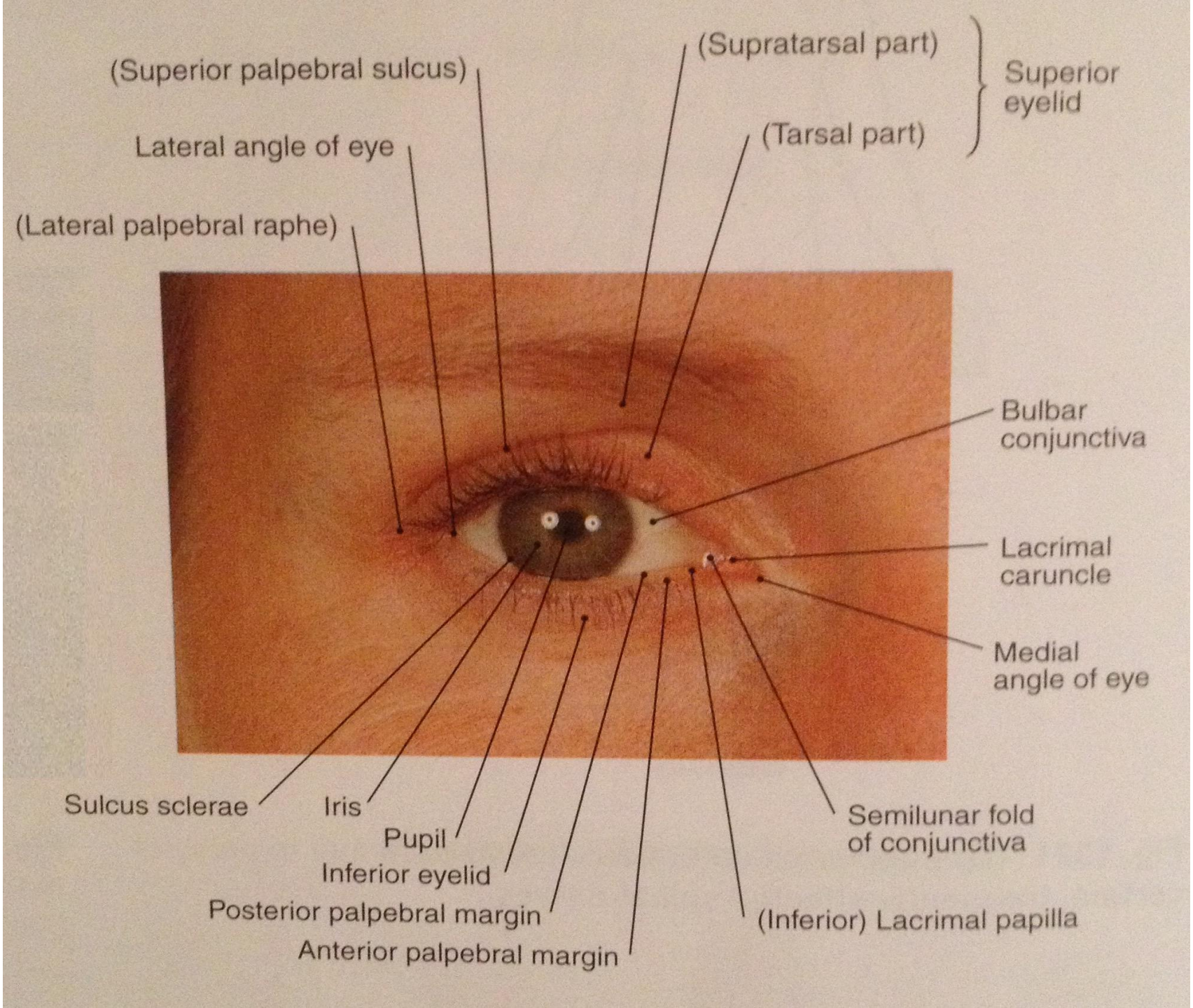


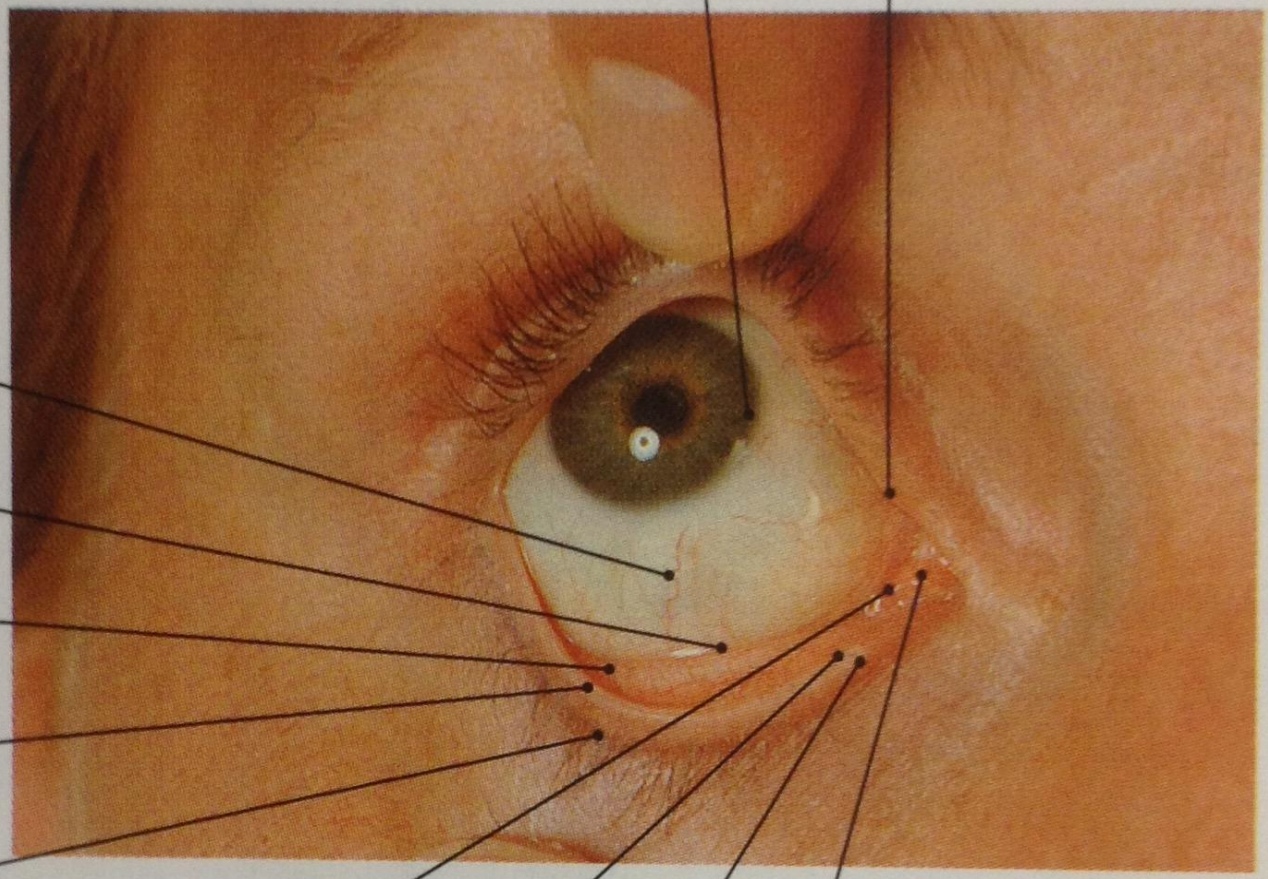
MUDr. Azzat Al-Redouan

Sensory receptors

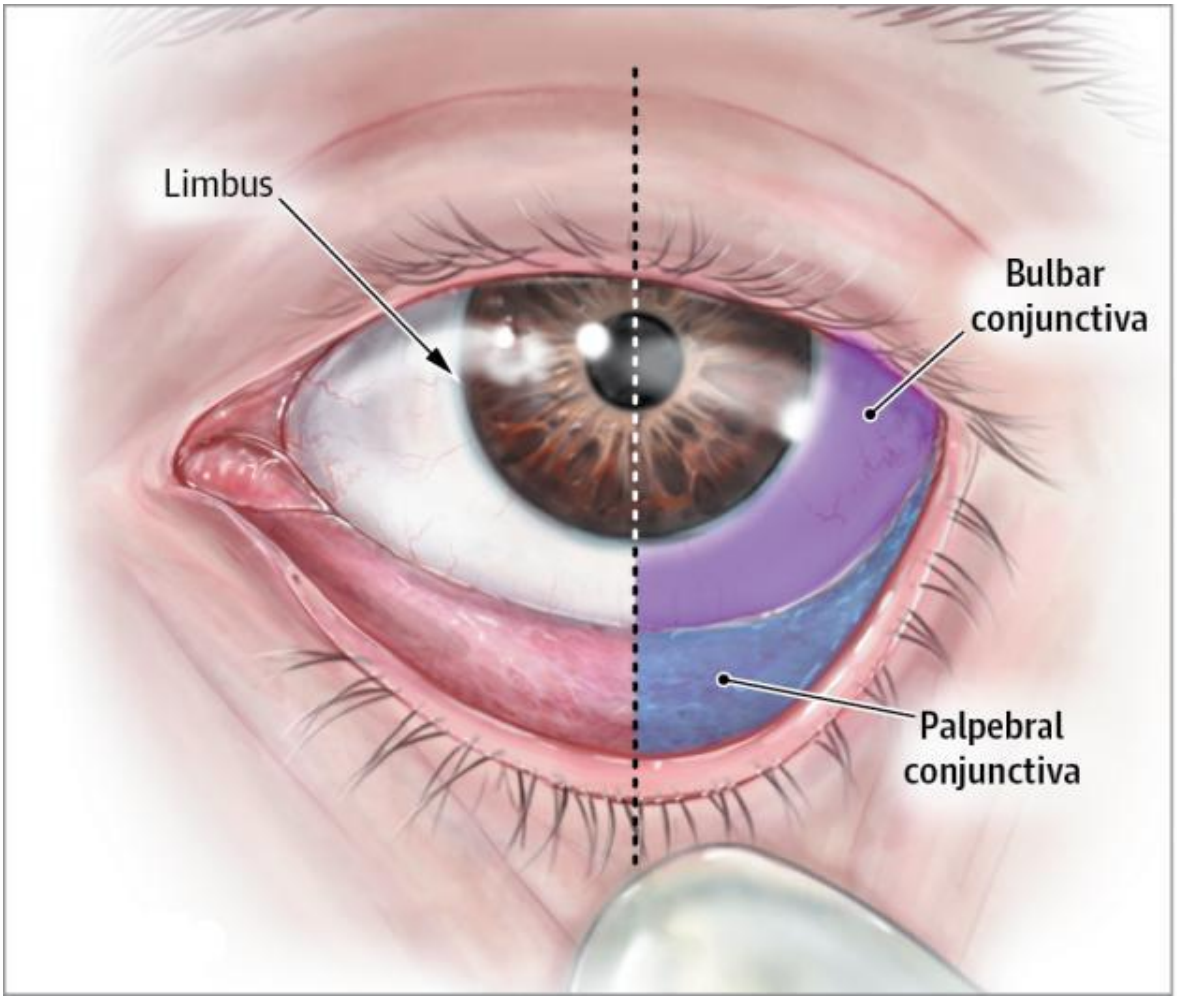
- Vision — Light
- Taste, Smell — Chemical
- Hearing, Touch — Mechanical

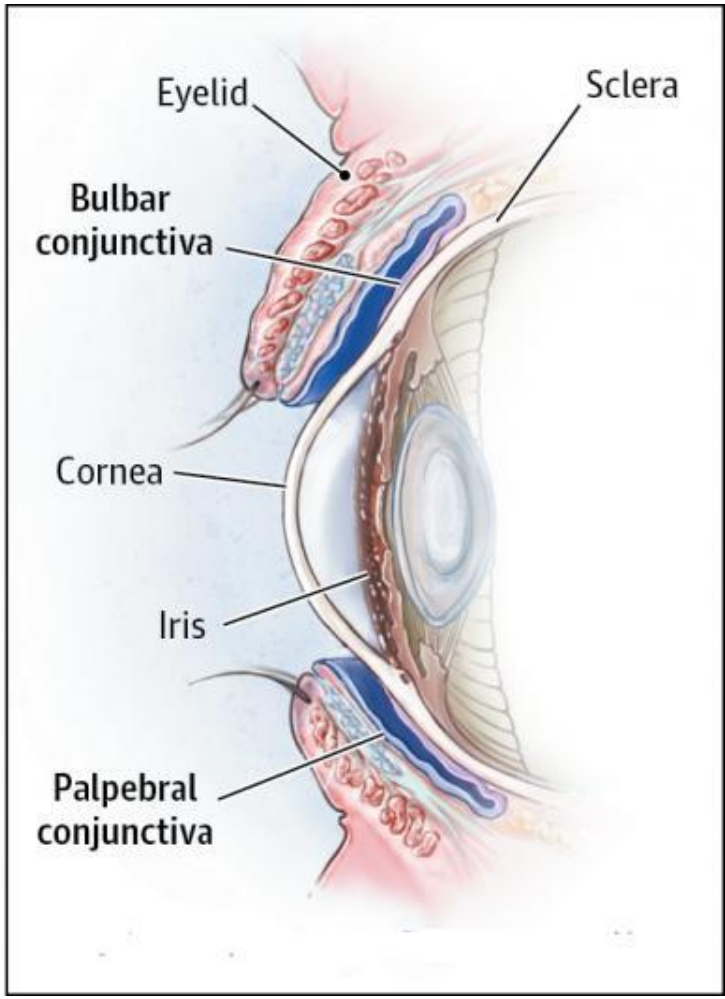
- Internal
  - Baroreceptors - blood pressure
  - Osmoreceptors - osmolarity
  - Chemoreceptors – chemical concentration


(Superior palpebral sulcus)
(Supratarsal part)
Superior eyelid
Lateral angle of eye
(Tarsal part)
(Lateral palpebral raphe)
Bulbar conjunctiva
Lacrimal caruncle
Medial angle of eye
Sulcus sclerae
Iris
Pupil
Inferior eyelid
Posterior palpebral margin
Anterior palpebral margin
Semilunar fold of conjunctiva
(Inferior) Lacrimal papilla

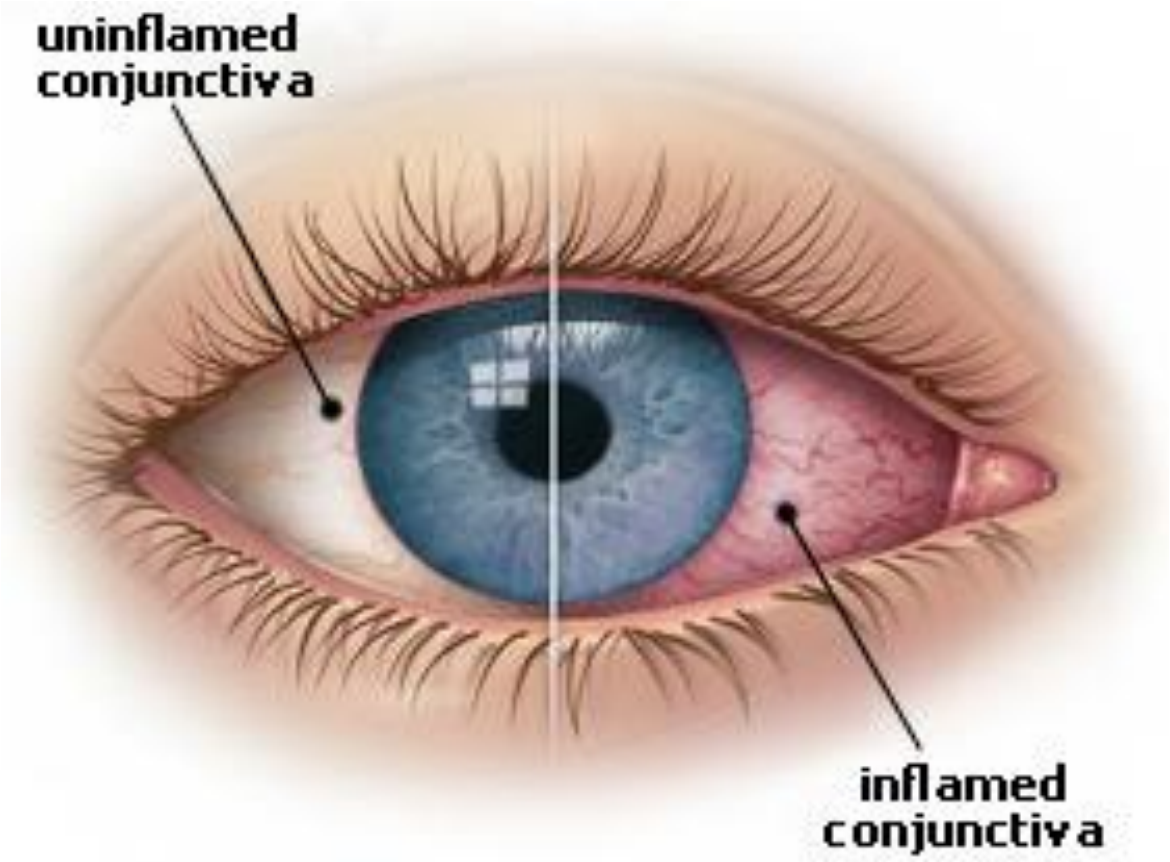

Sulcus sclerae
(Superior) Lacrimal papilla
Bulbar conjunctiva
Inferior conjunctival fornix
Palpebral conjunctiva
Posterior palpebral margin
Anterior palpebral margin
Semilunar fold of conjunctiva
Lacrimal punctum
(Inferior) Lacrimal papilla
Lacrimal caruncle

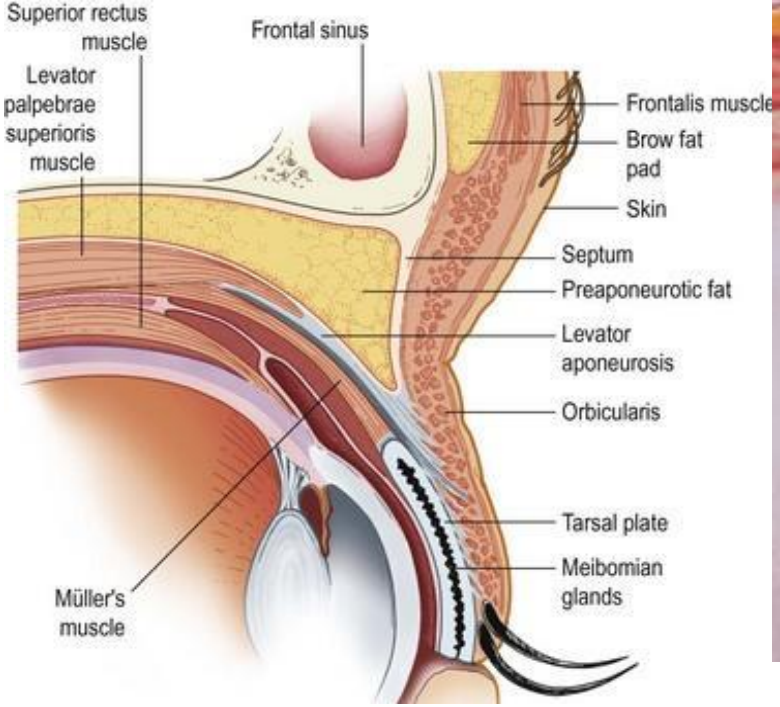
Conjunctiva

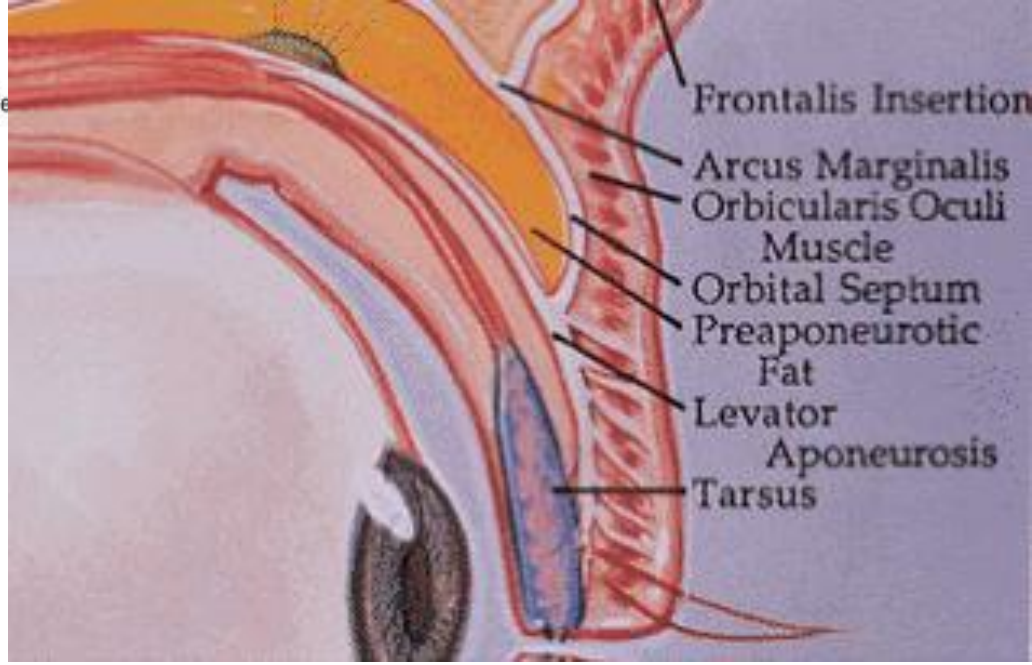


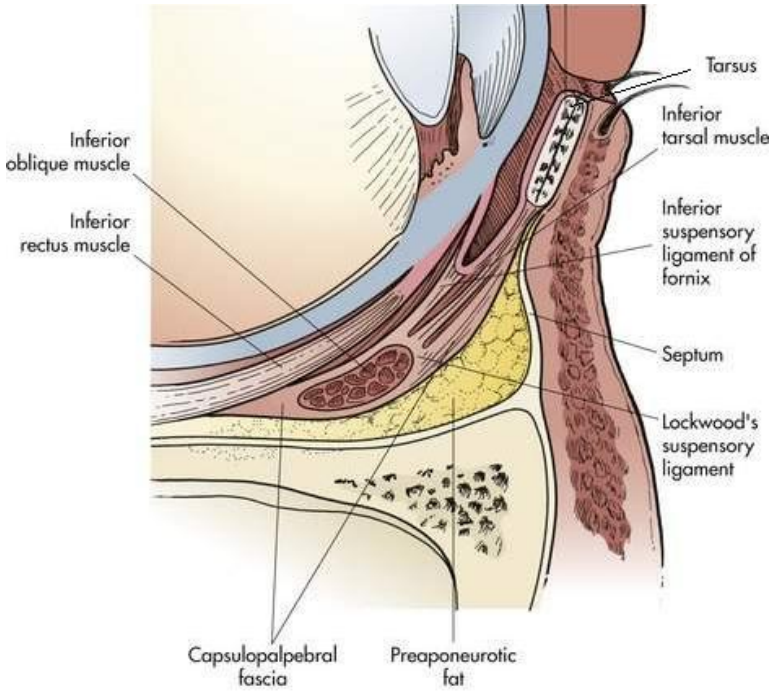


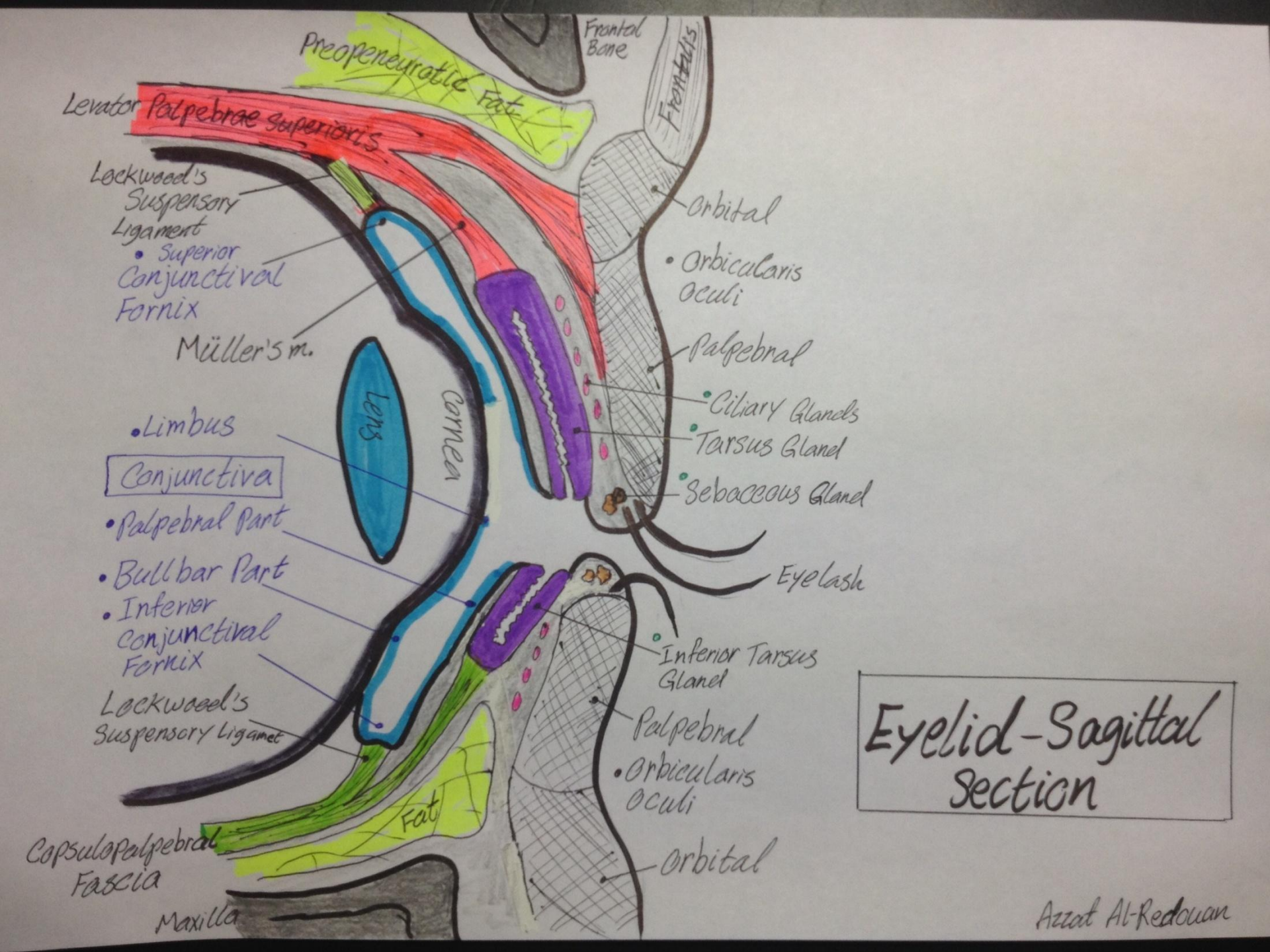
Conjunctivitis




Superior rectus muscle
Frontal sinus
Levator palpebrae superioris muscle
Frontalis muscle
Brow fat pad
Skin
Septum
Preaponeurotic fat
Levator aponeurosis
Orbicularis
Tarsal plate
Meibomian glands
Müller's muscle


Frontalis Insertion
Arcus Marginalis
Orbicularis Oculi Muscle
Orbital Septum
Preaponeurotic Fat
Levator Aponeurosis
Tarsus


Tarsus
Inferior tarsal muscle
Inferior oblique muscle
Inferior rectus muscle
Inferior suspensory ligament of fornix
Septum
Lockwood's suspensory ligament
Capsulopalpebral fascia
Preaponeurotic fat

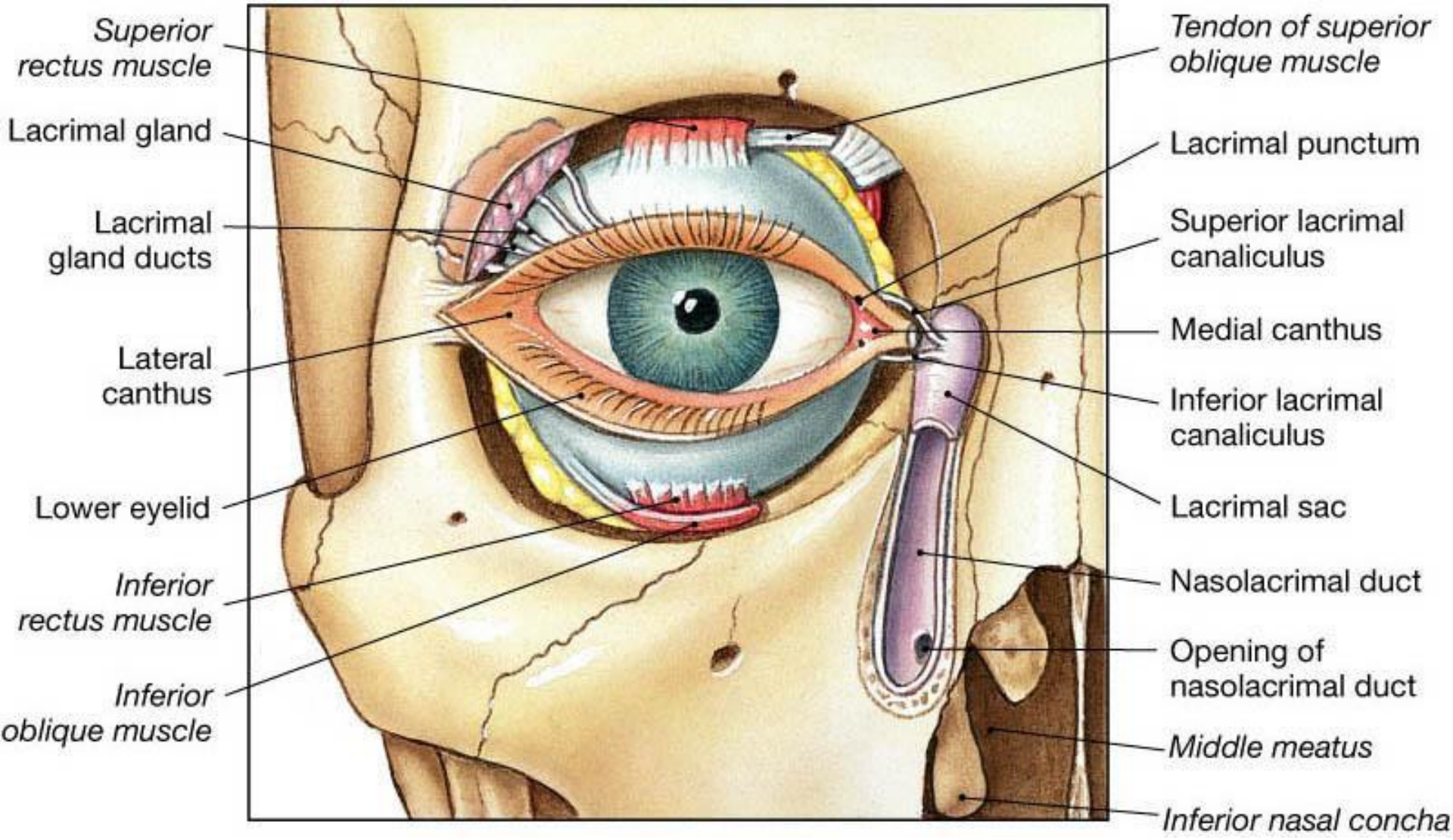

Frontal Bone
Frontalis
Preaponeurotic Fat
Levator Palpebrae Superioris
Lockwood's Suspensory Ligament
• Superior Conjunctival Fornix
Müller's m.
Orbital
• Orbicularis Oculi
Palpebral
Ciliary Glands
Tarsus Gland
Sebaceous Gland
Eyelash
Lens
Cornea
• Limbus
Conjunctiva
• Palpebral Part
• Bulbar Part
• Inferior Conjunctival Fornix
Lockwood's Suspensory Ligament
Inferior Tarsus Gland
Palpebral
• Orbicularis Oculi
Orbital
Fat
Capsulopalpebral Fascia
Maxilla
Eyelid - Sagittal Section
Azzat Al-Redouan

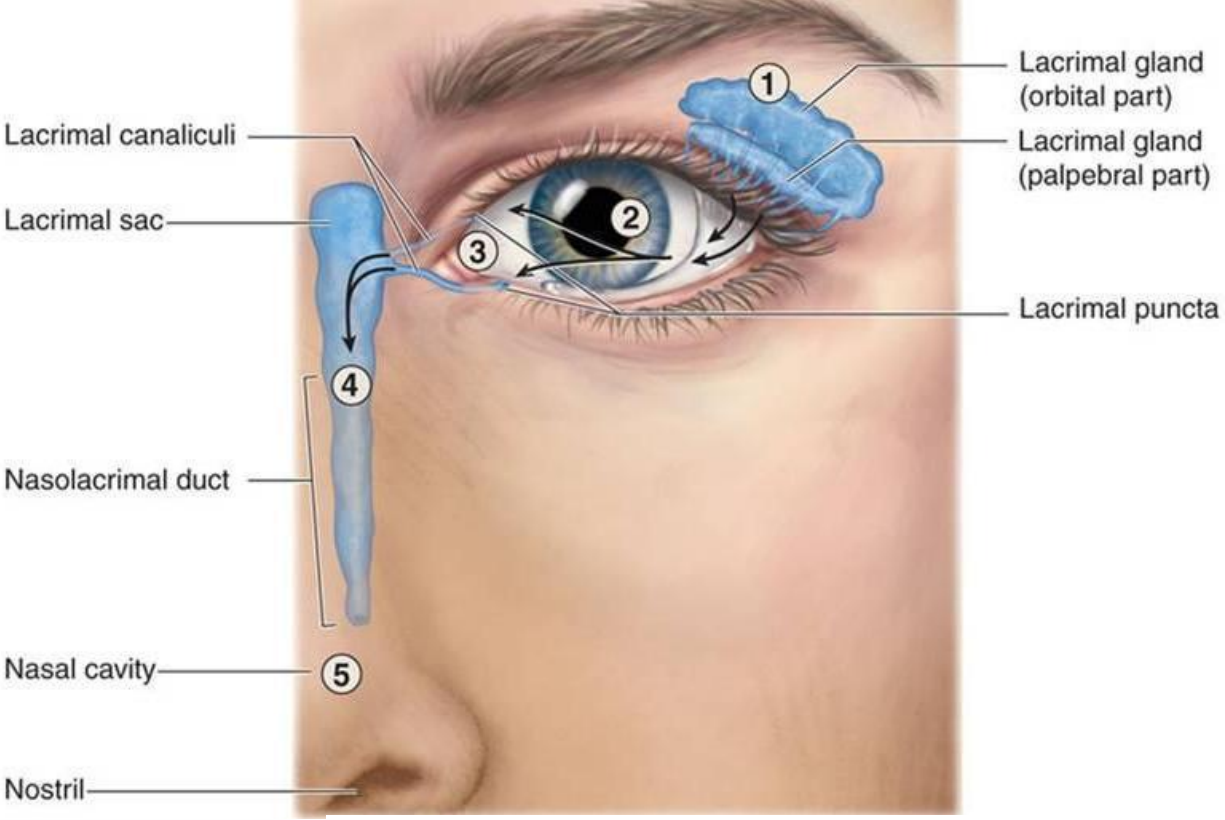
Exophthalmos

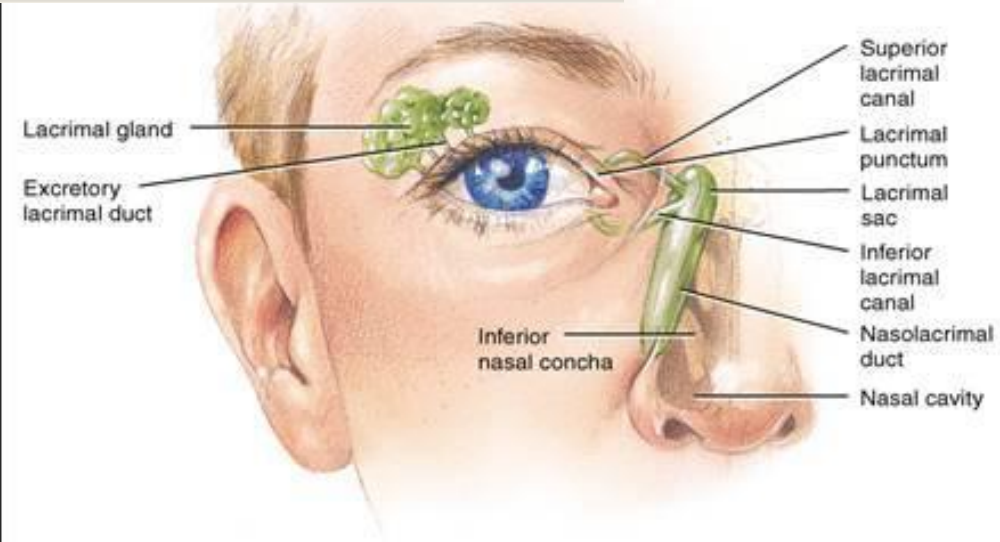
Periorbital Edema

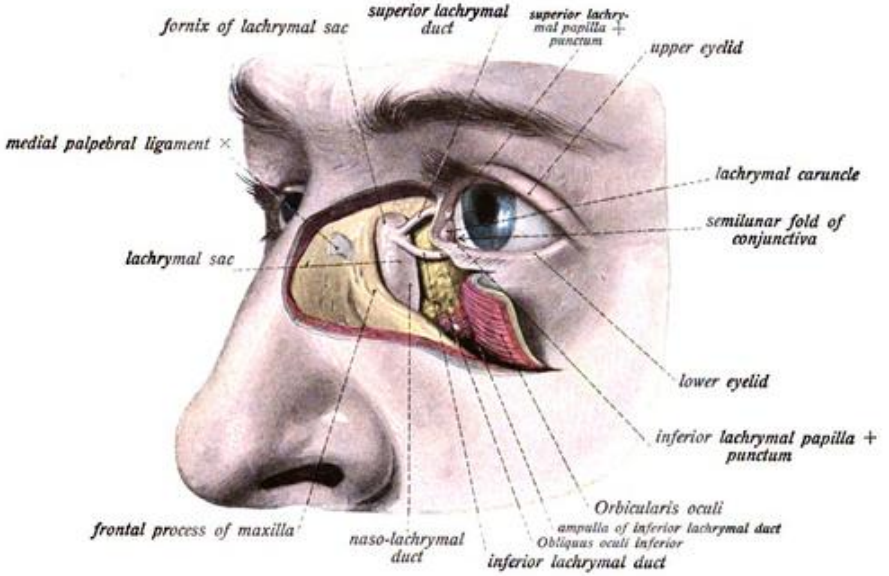
Palbepral Inflammation

Lacrimal Apparatus

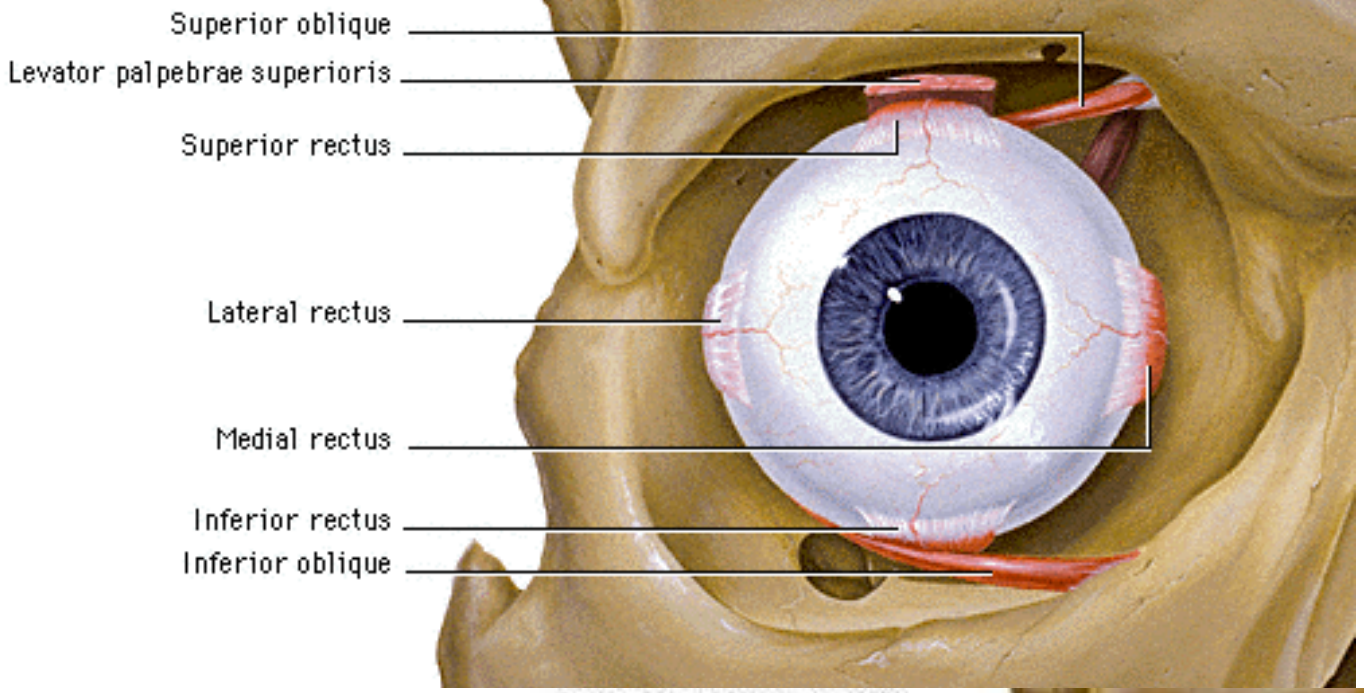


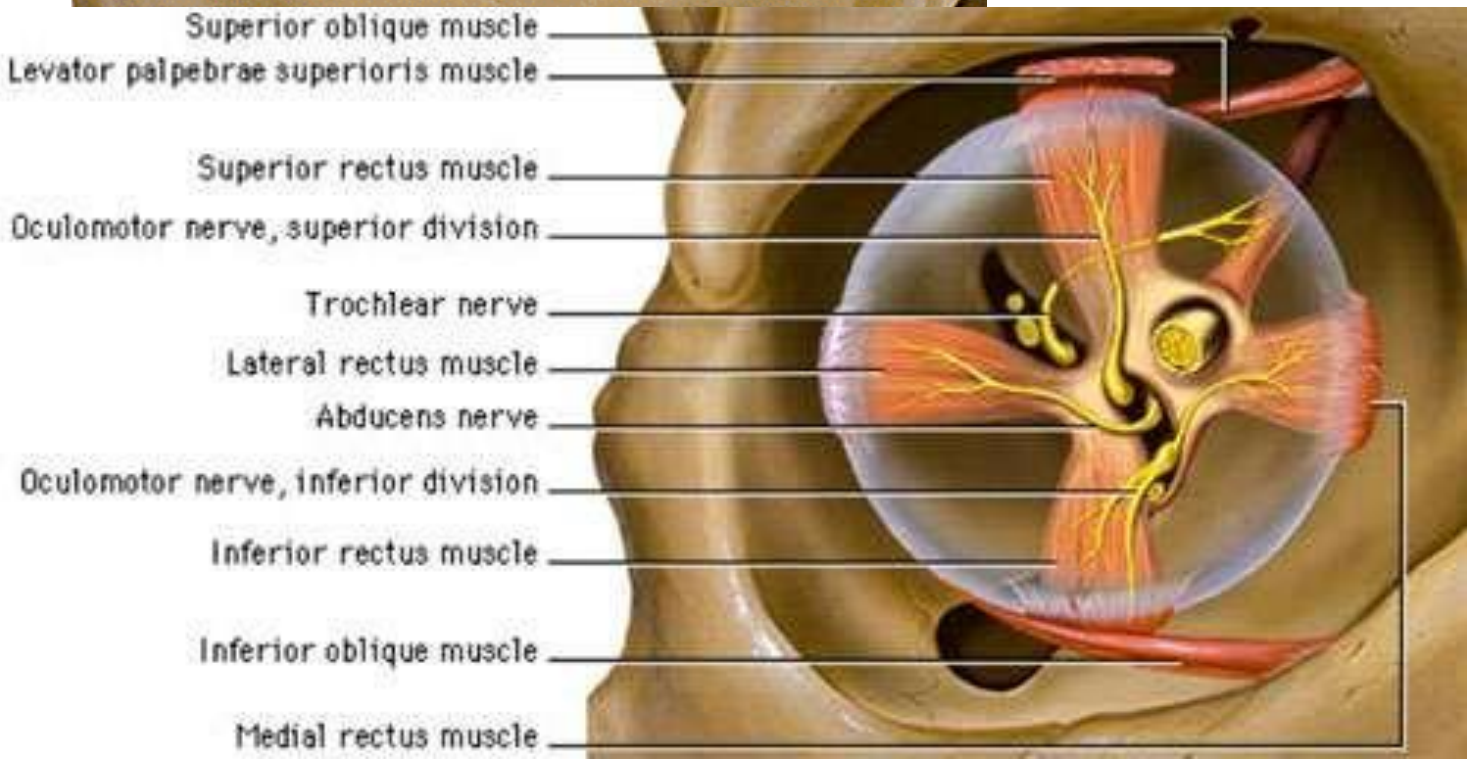

Lacrimal canaliculi
Lacrimal sac
Nasolacrimal duct
Nasal cavity
Nostril
1
2
3
4
5
Lacrimal gland (orbital part)
Lacrimal gland (palpebral part)
Lacrimal puncta

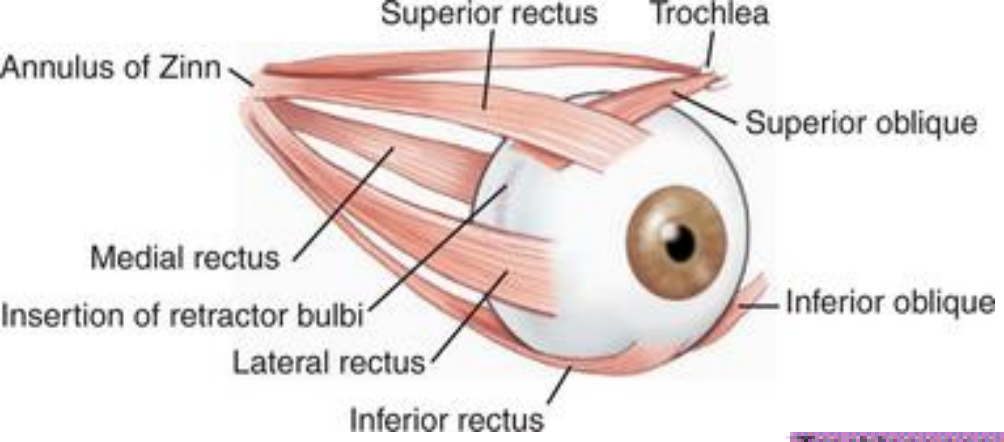

Lacrimal gland
Excretory lacrimal duct
Superior lacrimal canal
Lacrimal punctum
Lacrimal sac
Inferior lacrimal canal
Nasolacrimal duct
Nasal cavity
Inferior nasal concha

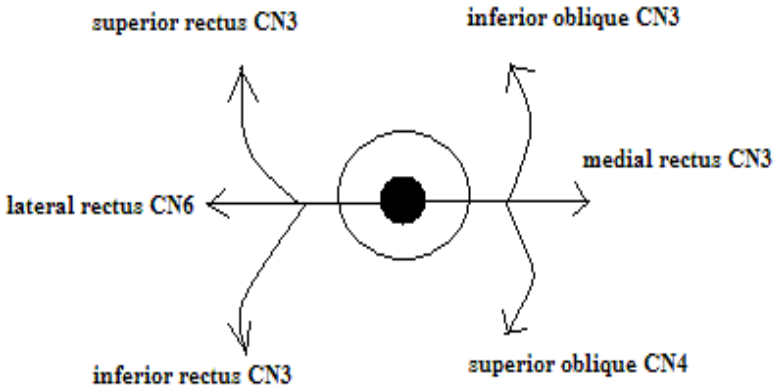

fornix of lachrymal sac
superior lachrymal duct
superior lachrymal papilla + punctum
upper eyelid
medial palpebral ligament
lachrymal caruncle
semilunar fold of conjunctiva
lachrymal sac
lower eyelid
inferior lachrymal papilla + punctum
Orbicularis oculi
ampulla of inferior lachrymal duct
Obliquus oculi inferior
frontal process of maxilla
naso-lachrymal duct
inferior lachrymal duct

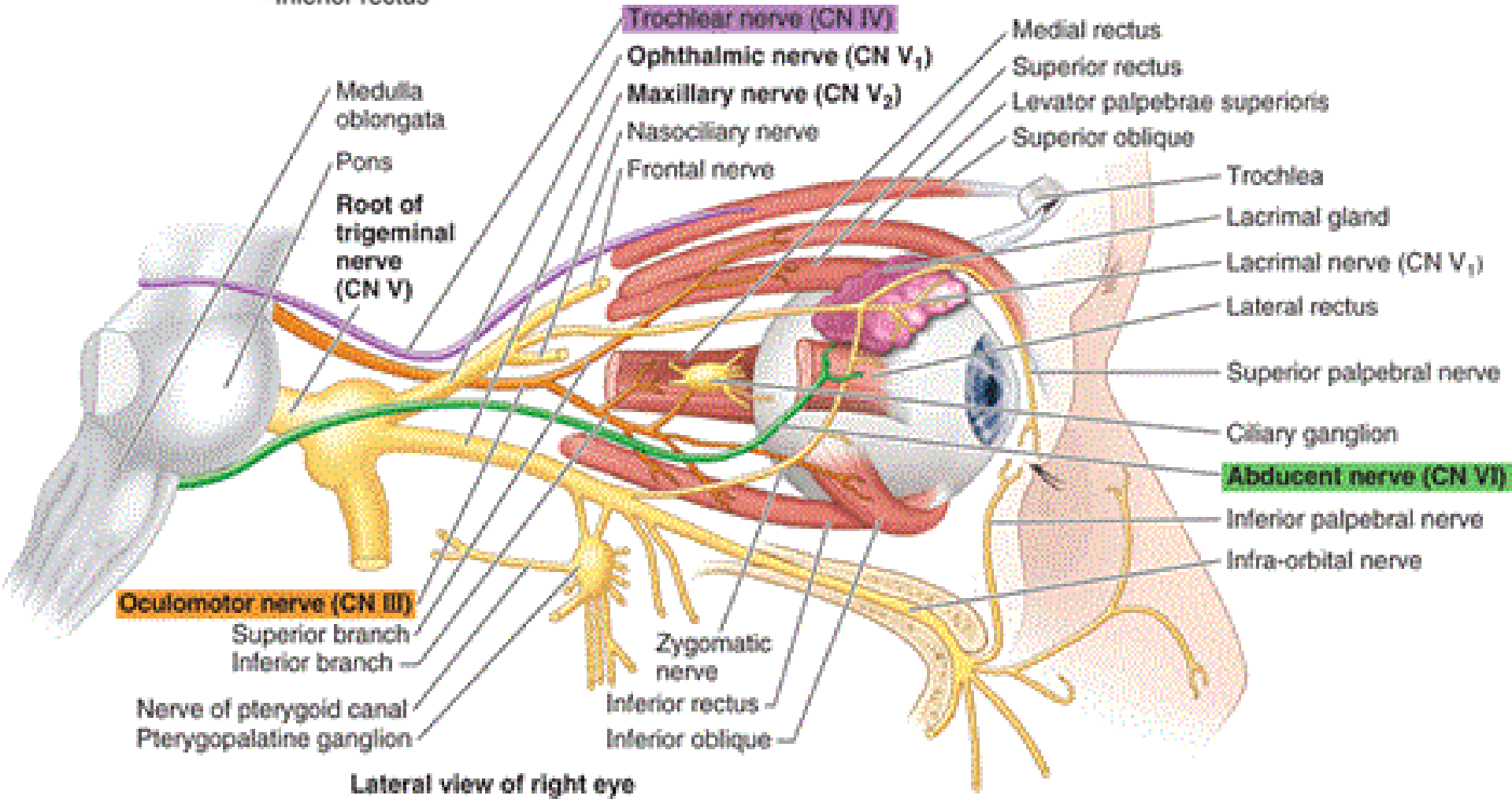
Lacrimal Canaliculi Obstruction


Superior oblique
Levator palpebrae superioris
Superior rectus
Lateral rectus
Medial rectus
Inferior rectus
Inferior oblique

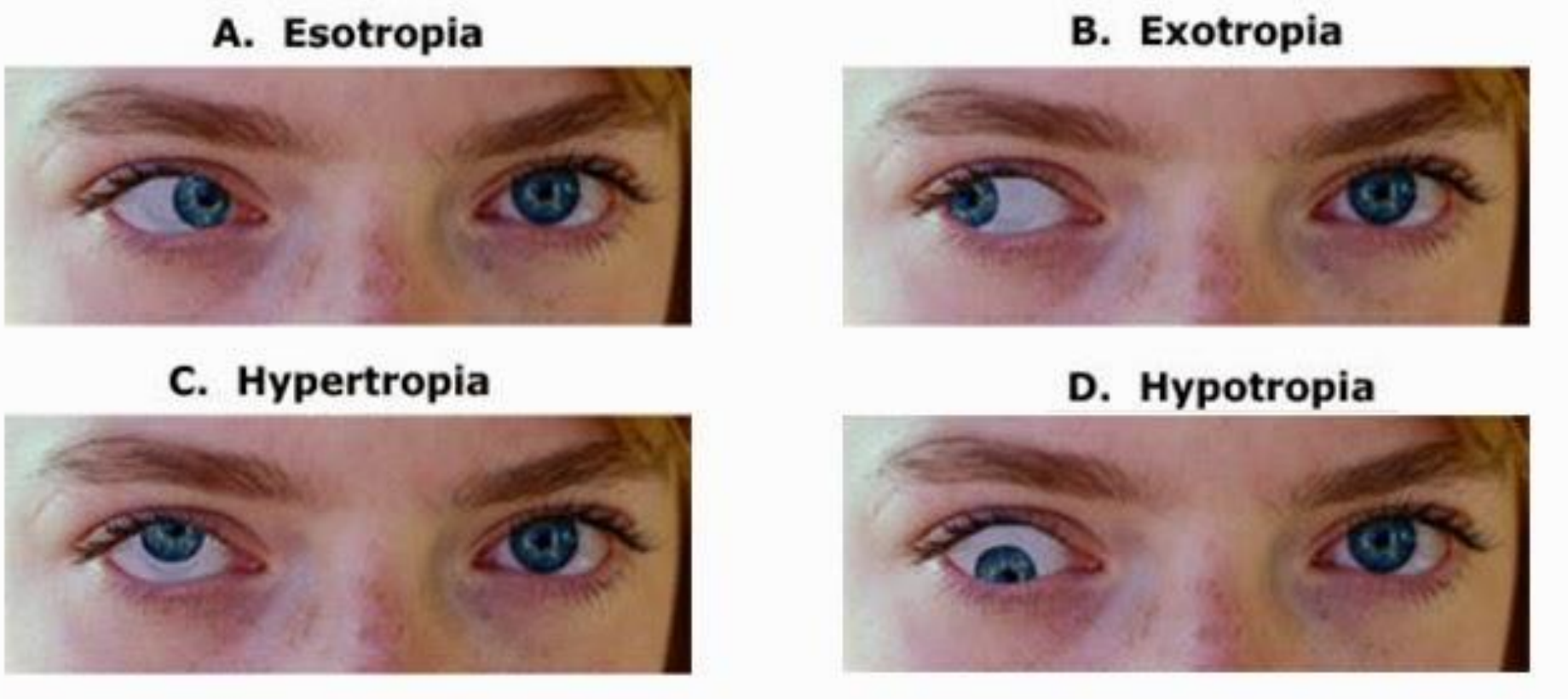

Superior oblique muscle
Levator palpebrae superioris muscle
Superior rectus muscle
Oculomotor nerve, superior division
Trochlear nerve
Lateral rectus muscle
Abducens nerve
Oculomotor nerve, inferior division
Inferior rectus muscle
Inferior oblique muscle
Medial rectus muscle

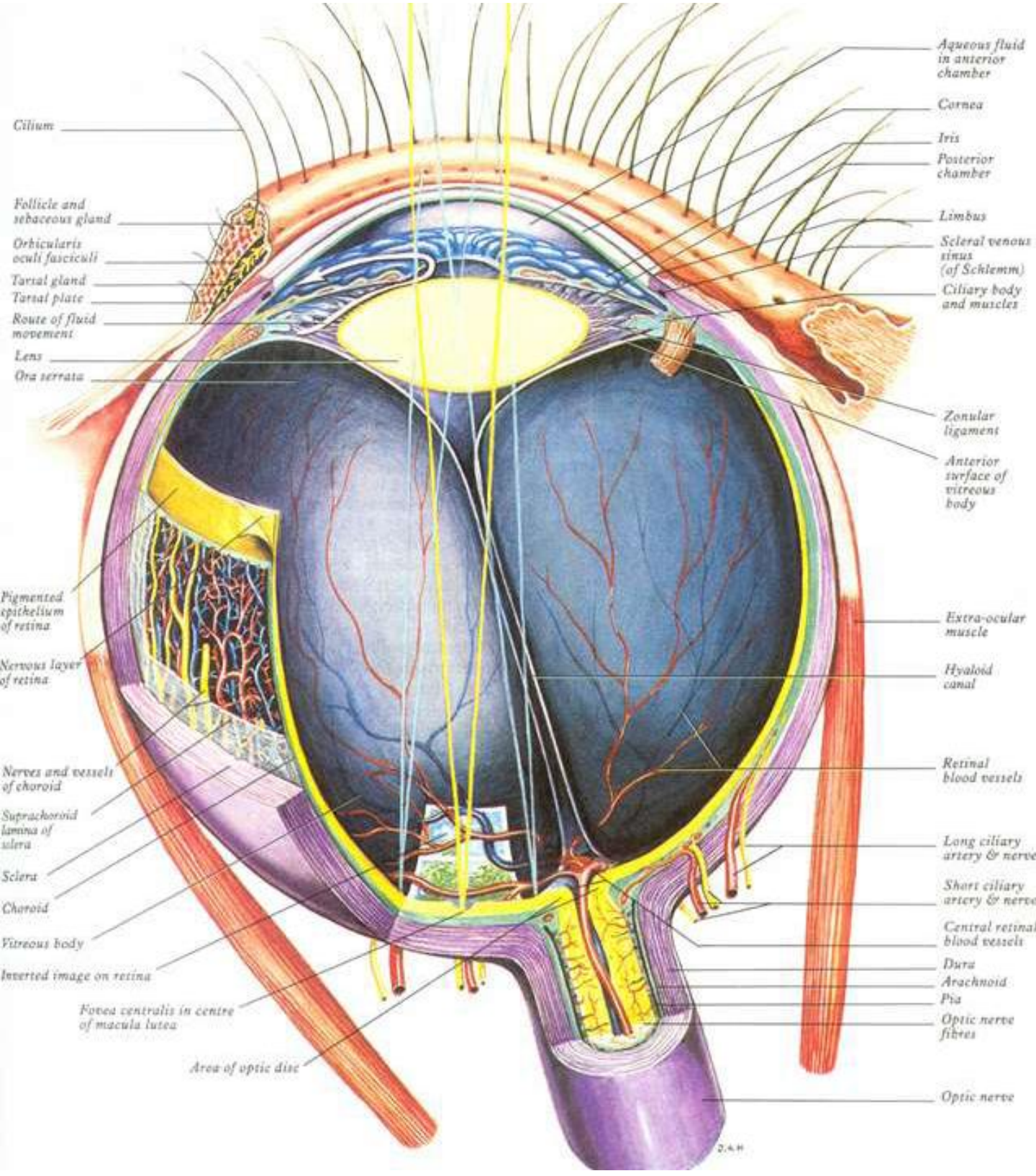

Superior rectus
Trochlea
Annulus of Zinn
Superior oblique
Medial rectus
Insertion of retractor bulbi
Inferior oblique
Lateral rectus
Inferior rectus

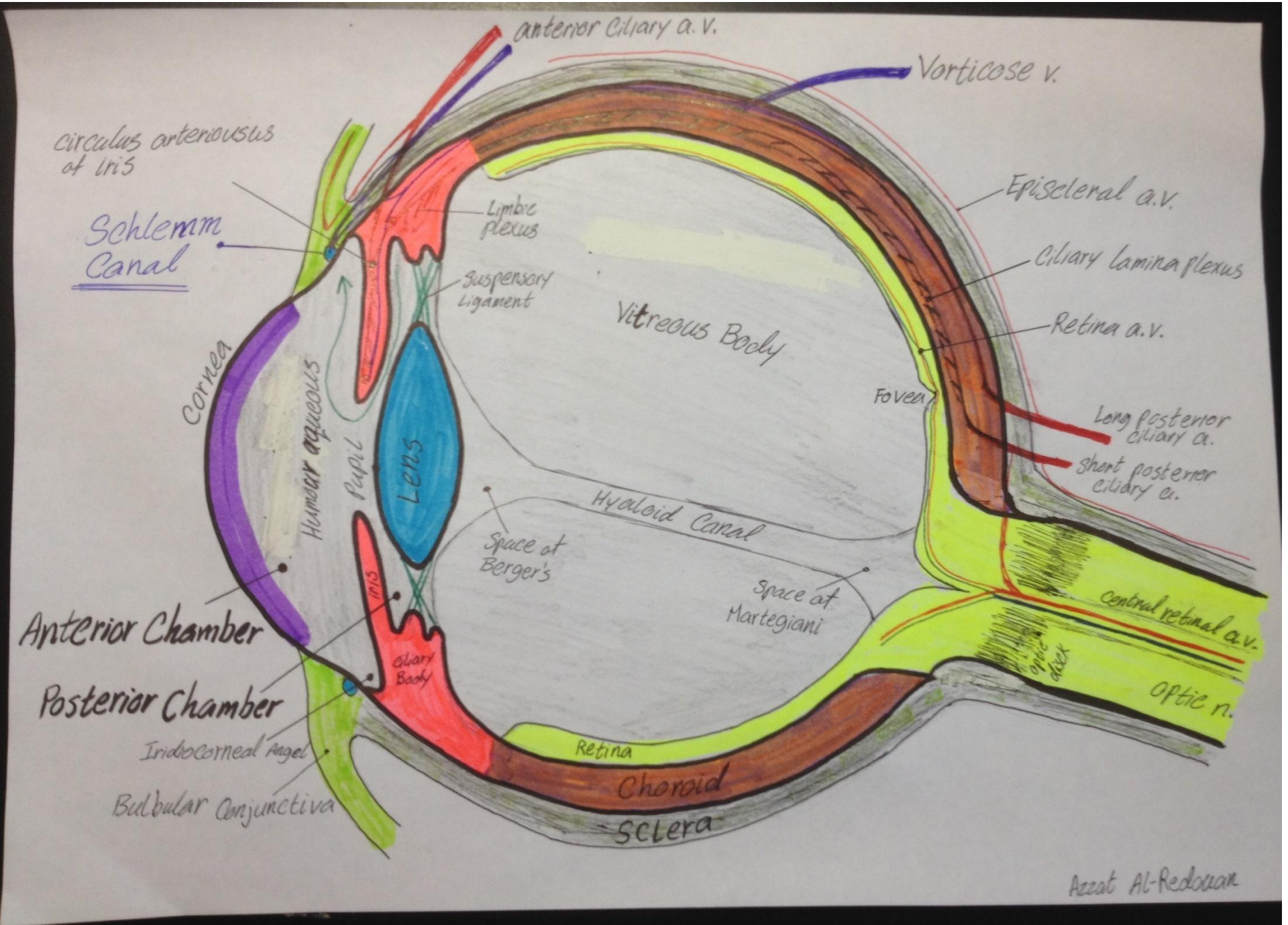

superior rectus CN3
inferior oblique CN3
medial rectus CN3
lateral rectus CN6
inferior rectus CN3
superior oblique CN4

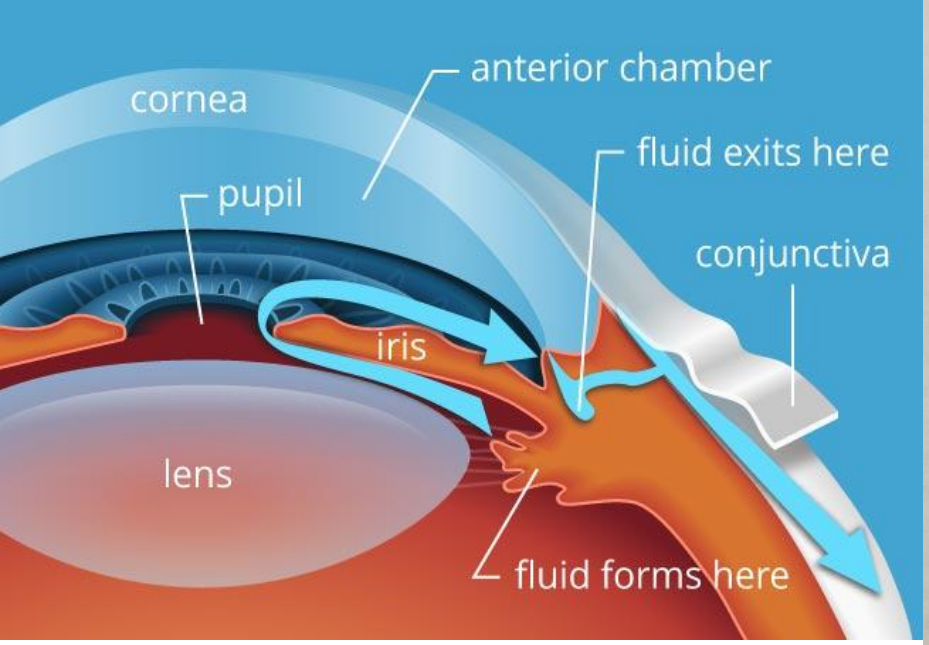

Trochlear nerve (CN IV)
Ophthalmic nerve (CN V1)
Maxillary nerve (CN V2)
Nasociliary nerve
Frontal nerve
Medulla oblongata
Pons
Root of trigeminal nerve (CN V)
Medial rectus
Superior rectus
Levator palpebrae superioris
Superior oblique
Trochlea
Lacrimal gland
Lacrimal nerve (CN V1)
Lateral rectus
Superior palpebral nerve
Ciliary ganglion
Abducent nerve (CN VI)
Inferior palpebral nerve
Infra-orbital nerve
Oculomotor nerve (CN III)
Superior branch
Inferior branch
Nerve of pterygoid canal
Pterygopalatine ganglion
Zygomatic nerve
Inferior rectus
Inferior oblique
Lateral view of right eye

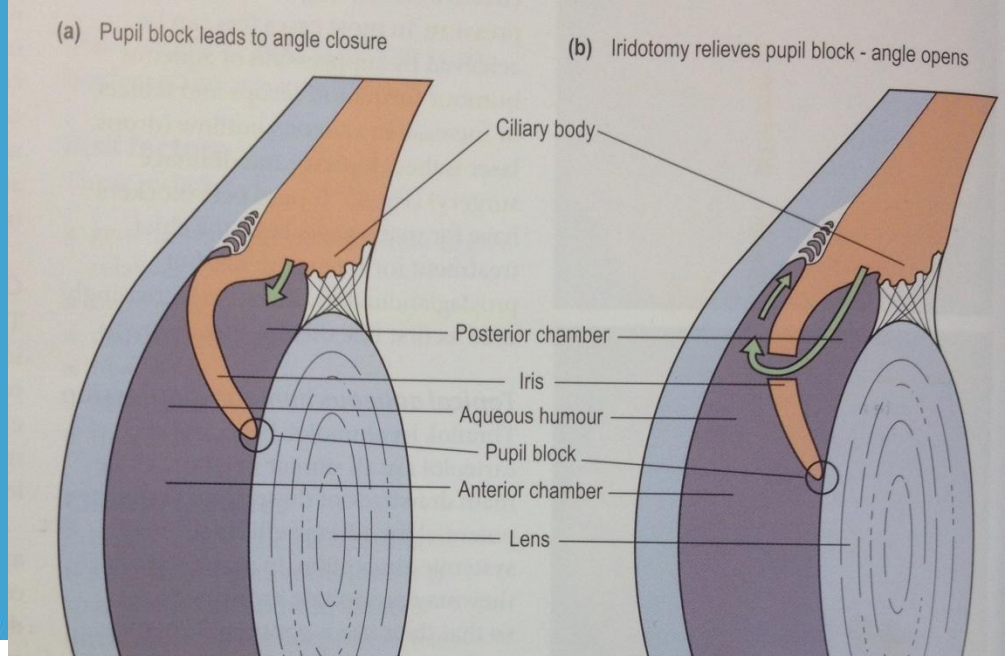
Strabismus (Misalignment of eyeballs)




Aqueous fluid in anterior chamber
Cornea
Iris
Posterior chamber
Limbus
Scleral venous sinus (of Schlemm)
Ciliary body and muscles
Zonular ligament
Anterior surface of vitreous body
Extra-ocular muscle
Hyaloid canal
Retinal blood vessels
Long ciliary artery & nerve
Short ciliary artery & nerve
Central retinal blood vessels
Dura
Arachnoid
Pia
Optic nerve fibres
Optic nerve
Cilium
Follicle and sebaceous gland
Orbicularis oculi fasciculi
Tarsal gland
Tarsal plate
Route of fluid movement
Lens
Ora serrata
Pigmented epithelium of retina
Nervous layer of retina
Nerves and vessels of choroid
Suprachoroid lamina of sclera
Sclera
Choroid
Vitreous body
Inverted image on retina
Fovea centralis in centre of macula lutea
Area of optic disc


anterior Ciliary a.v.
Vorticose v.
circulus arteriosus of Iris
Schlemm Canal
Episcleral a.v.
Limbic plexus
Ciliary lamina plexus
Suspensory Ligament
Vitreous Body
Retina a.v.
Cornea
Fovea
Long posterior ciliary a.
Short posterior ciliary a.
Lens
Hyaloid Canal
Space of Berger's
Space of Martegiani
Central retinal a.v.
Anterior Chamber
Iris
Ciliary Body
Optic disc
Optic n.
Posterior Chamber
Iridocorneal Angel
Retina
Choroid
Bulbular Conjunctiva
Sclera
Assat Al-Redouan





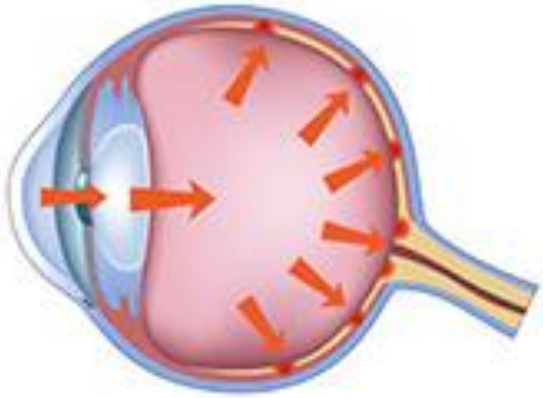
Development of Glaucoma

Healthy Eye

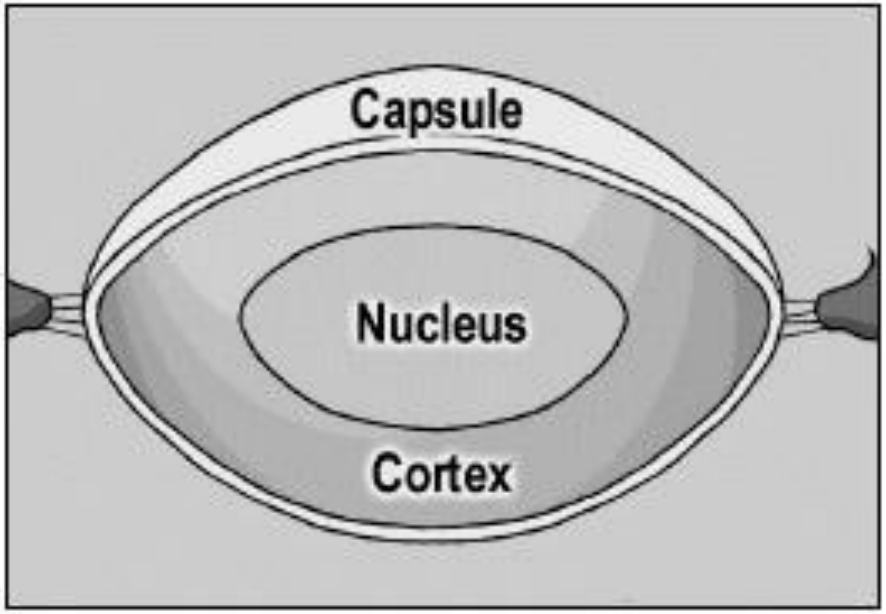
Flow of aqueous humour through the drainage canal.

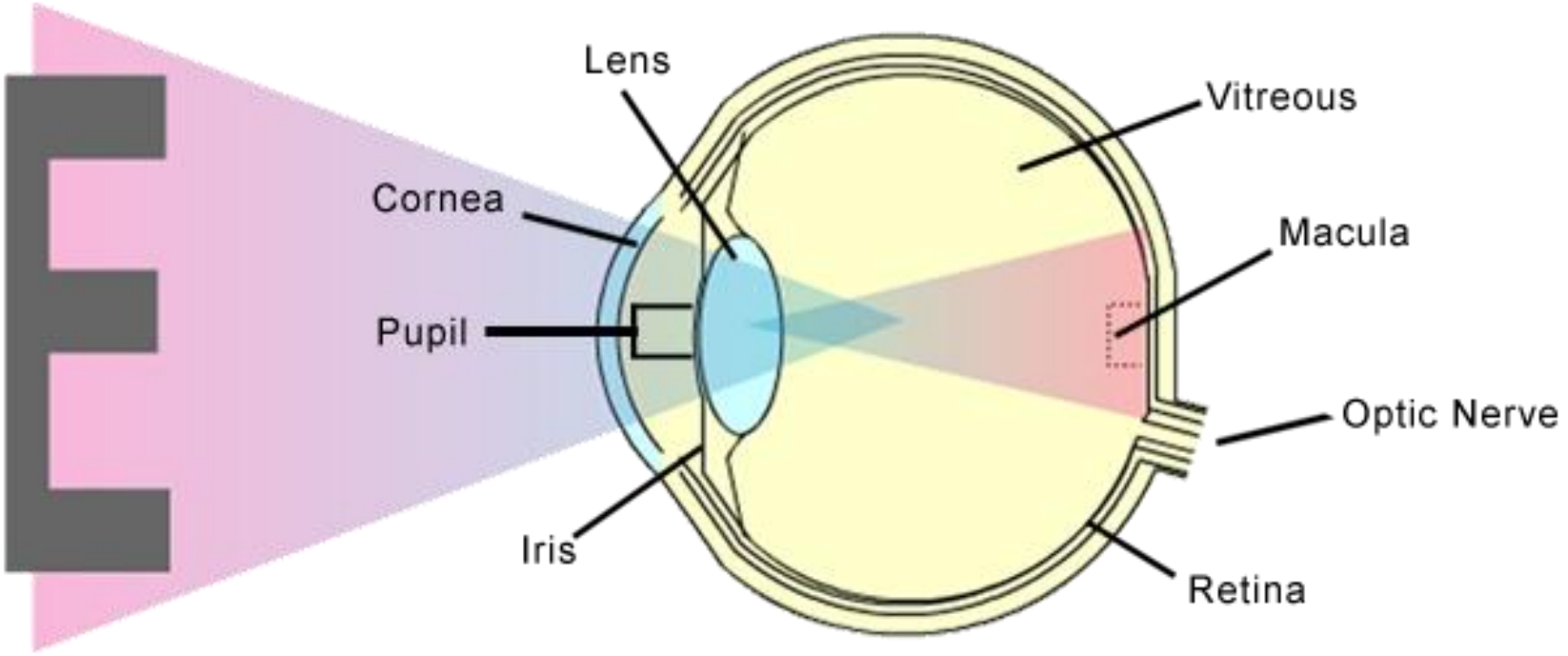
Glaucoma

1. Drainage canal blocked; build up of fluid.

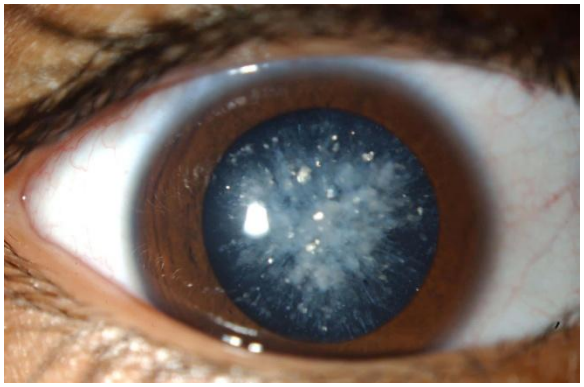


2. Increased pressure damages blood vessels and optic nerve.

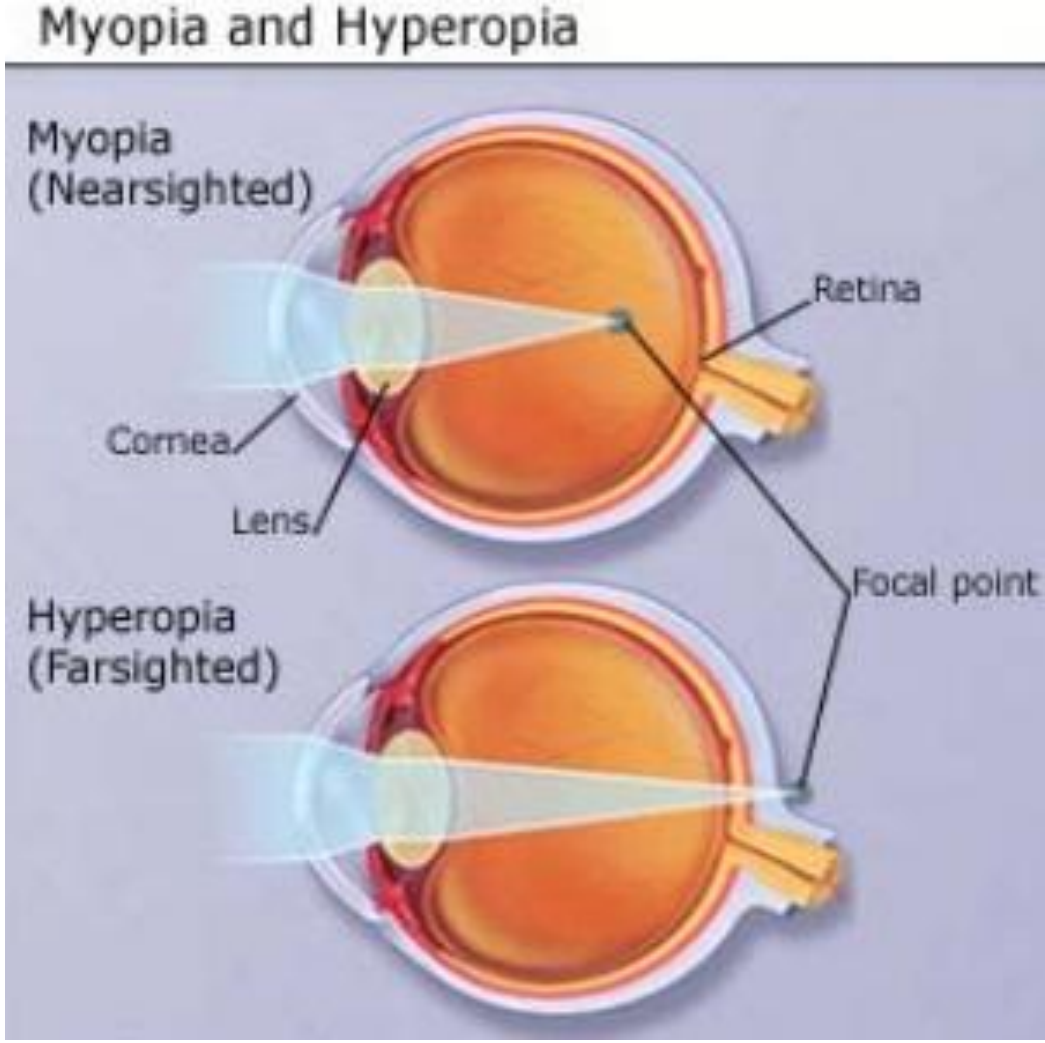

Capsule
Nucleus
Cortex


Lens
Vitreous
Cornea
Macula
Pupil
Optic Nerve
Iris
Retina

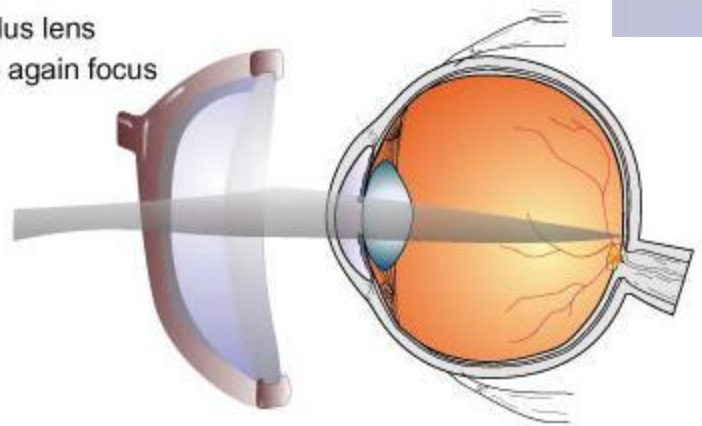
Cataract



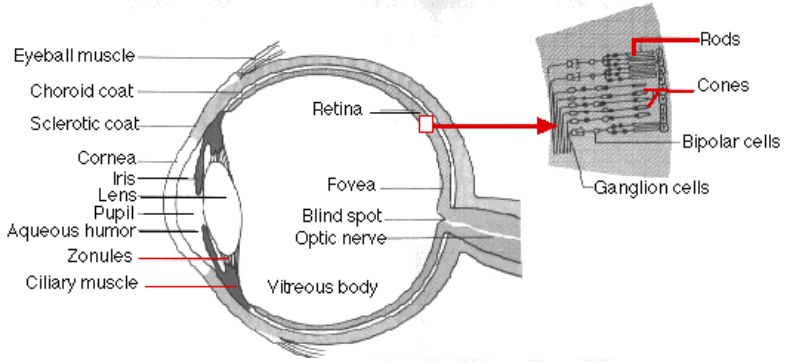
Refraction Errors

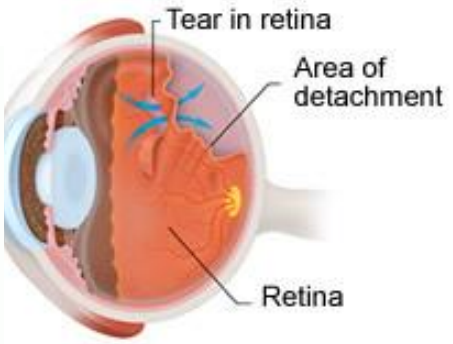


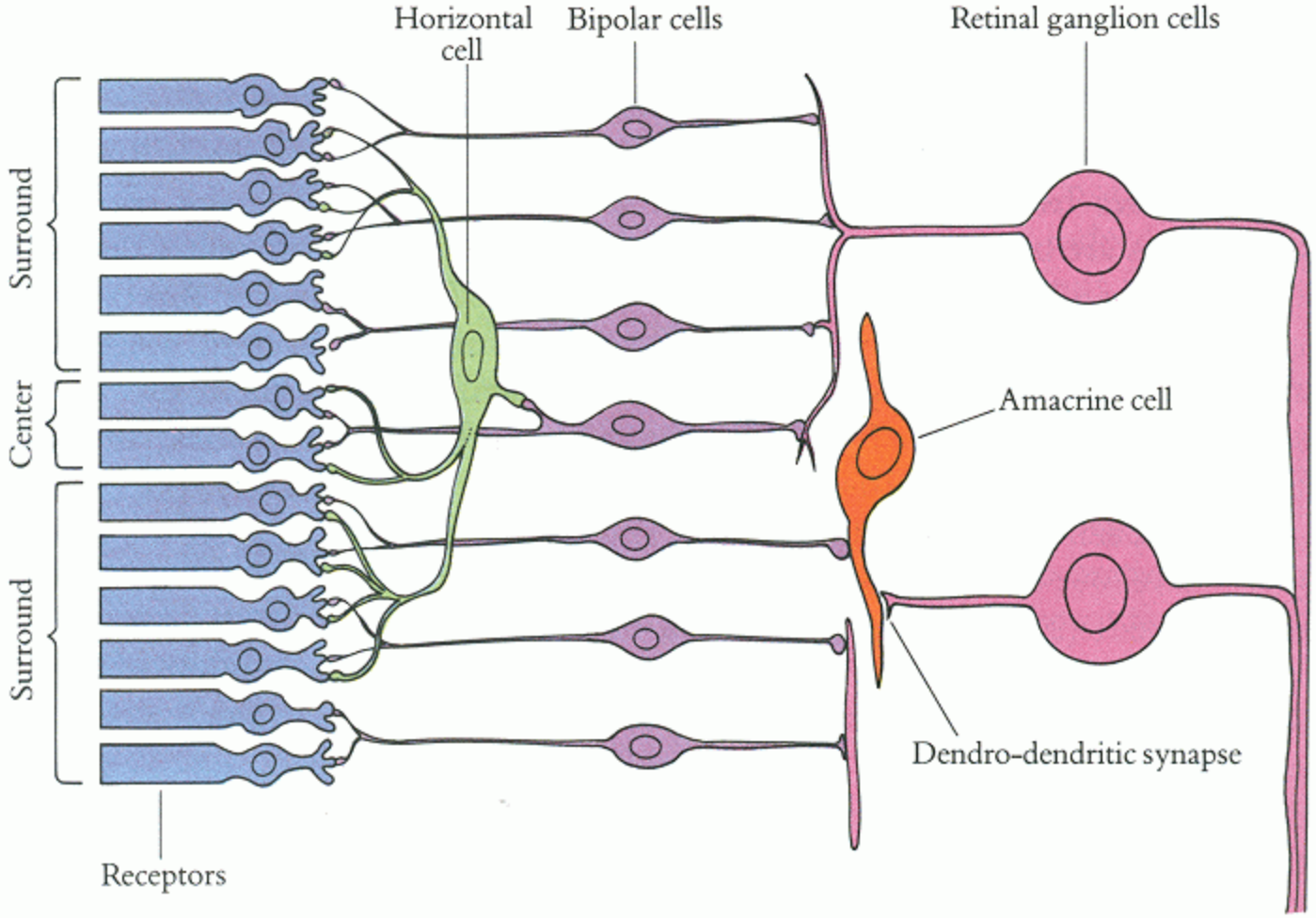
Correction with a plus lens allows light to once again focus on the retina.



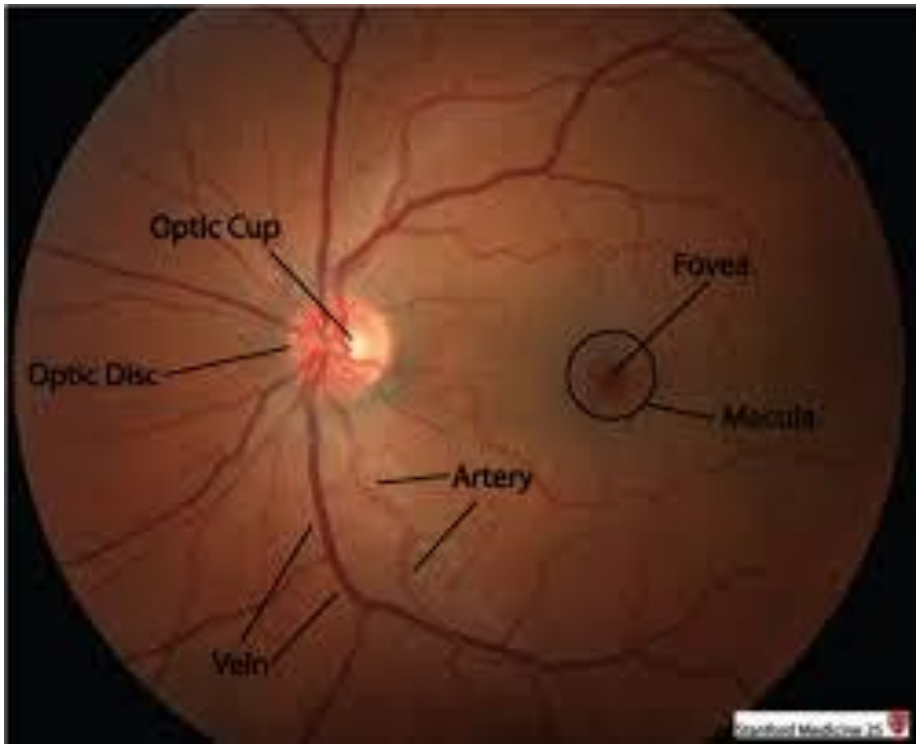
Retina

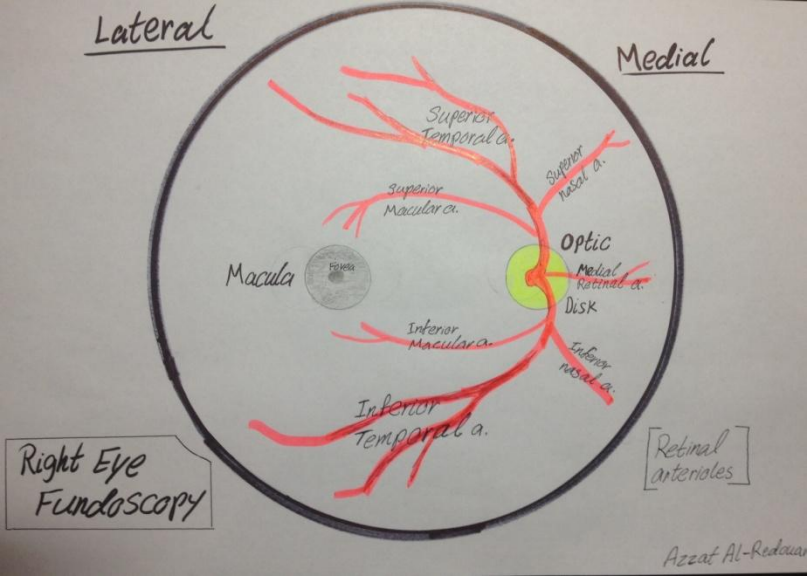

Eyeball muscle
Choroid coat
Sclerotic coat
Cornea
Iris
Lens
Pupil
Aqueous humor
Zonules
Ciliary muscle
Retina
Fovea
Blind spot
Optic nerve
Vitreous body
Rods
Cones
Bipolar cells
Ganglion cells

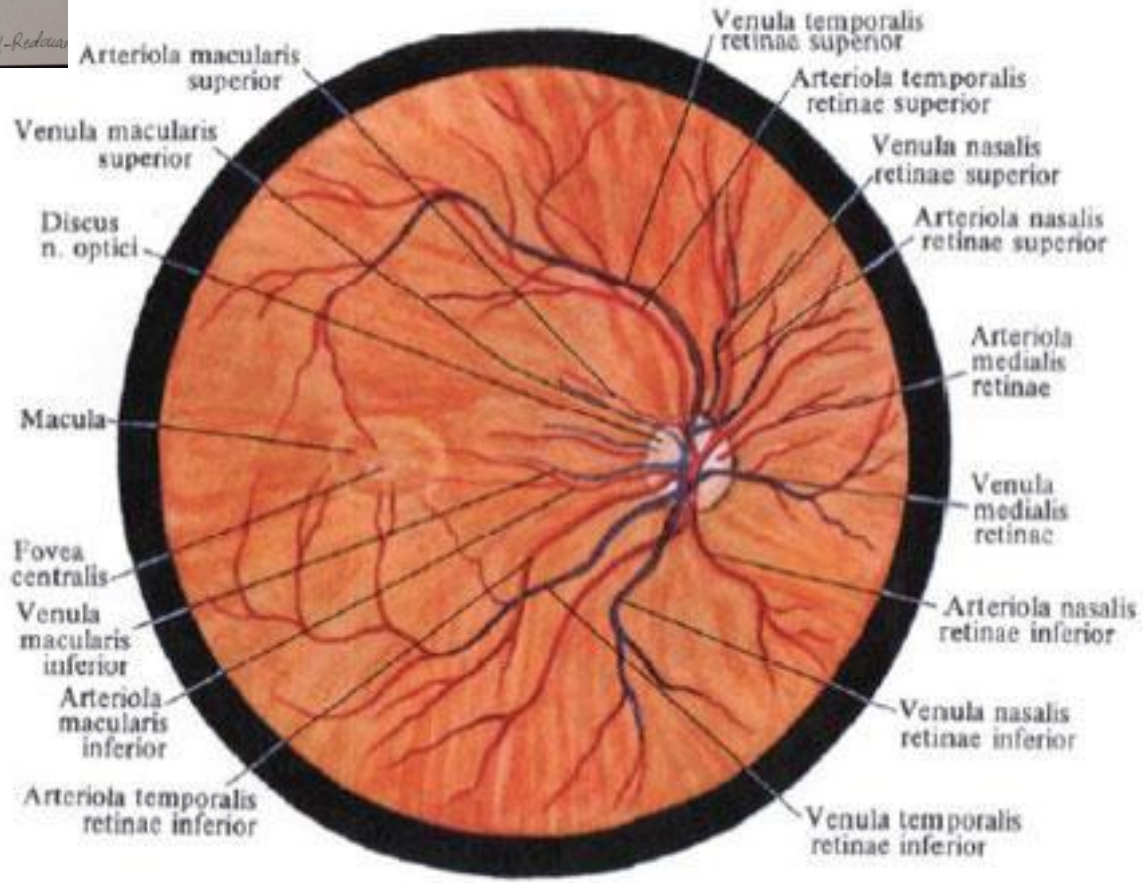

Tear in retina
Area of detachment
Retina


Horizontal cell
Bipolar cells
Retinal ganglion cells
Surround
Center
Surround
Amacrine cell
Dendro-dendritic synapse
Receptors

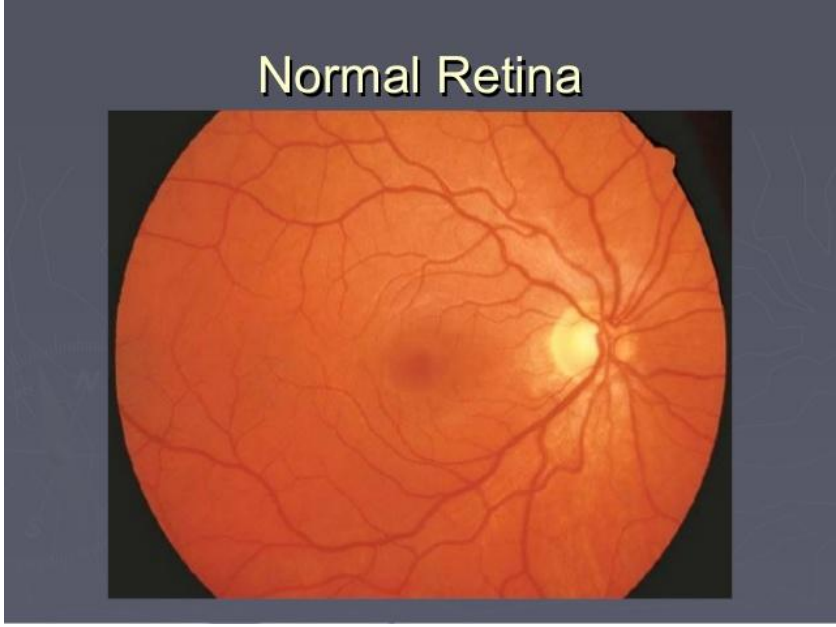
Fundoscopy



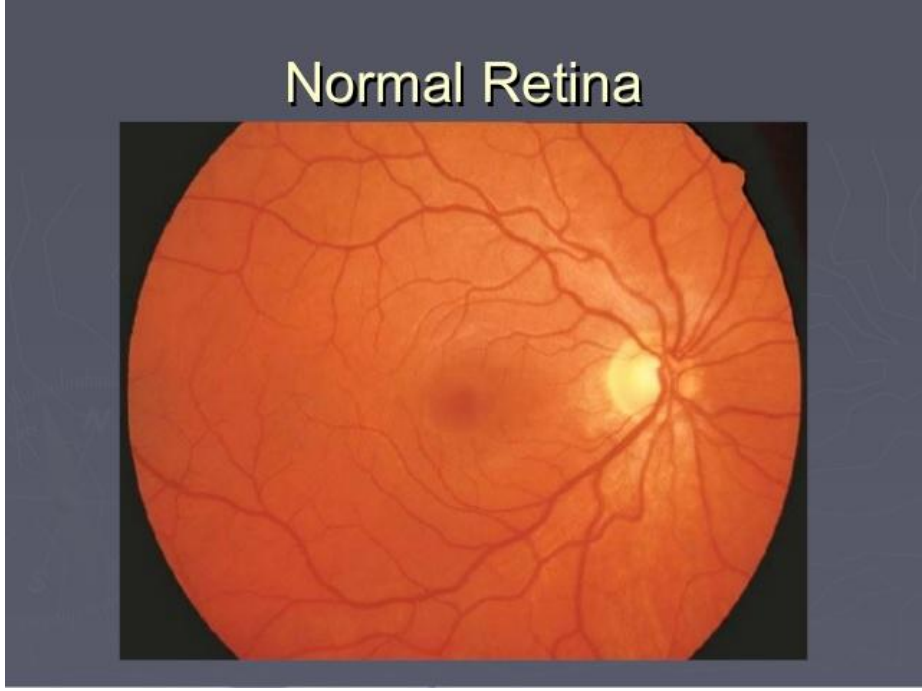

Lateral
Medial
Superior Temporal a.
Superior nasal a.
Superior Macular a.
Optic
Macula
Fovea
Medial Retinal a.
Disk
Inferior Macular a.
Inferior nasal a.
Inferior Temporal a.
Retinal arteriales
Right Eye Fundoscopy
Azzat Al-Redaw

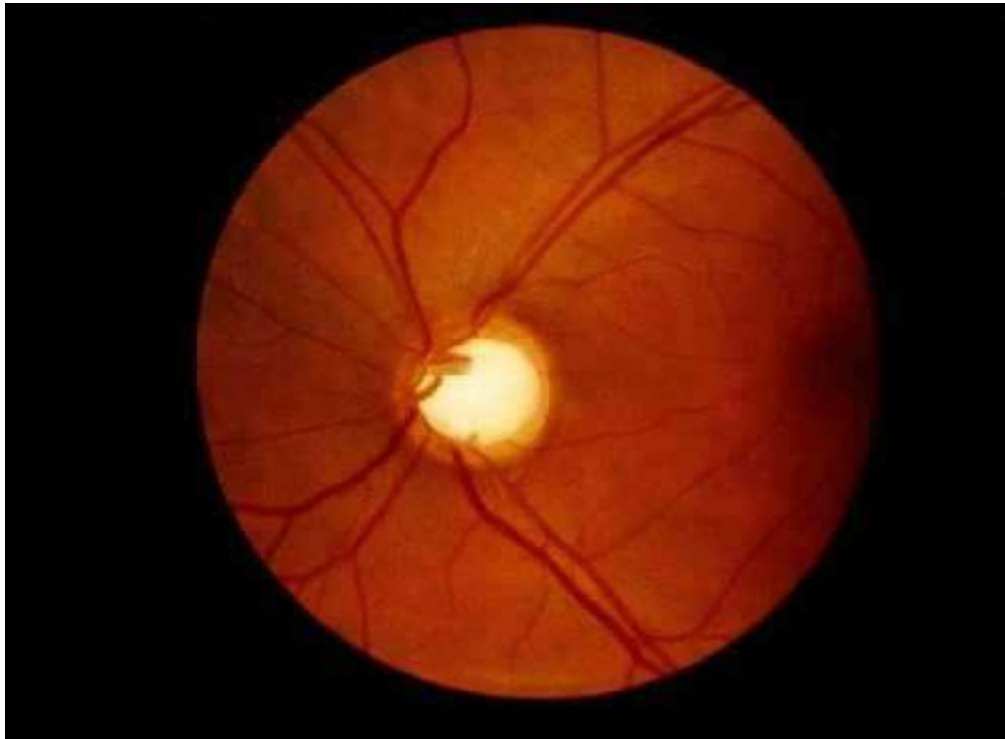

Arteriola macularis superior
Venula temporalis retinae superior
Arteriola temporalis retinae superior
Venula macularis superior
Venula nasalis retinae superior
Discus n. optici
Arteriola nasalis retinae superior
Arteriola medialis retinae
Macula
Venula medialis retinae
Fovea centralis
Arteriola nasalis retinae inferior
Venula macularis inferior
Arteriola macularis inferior
Venula nasalis retinae inferior
Arteriola temporalis retinae inferior
Venula temporalis retinae inferior

macular degeneration

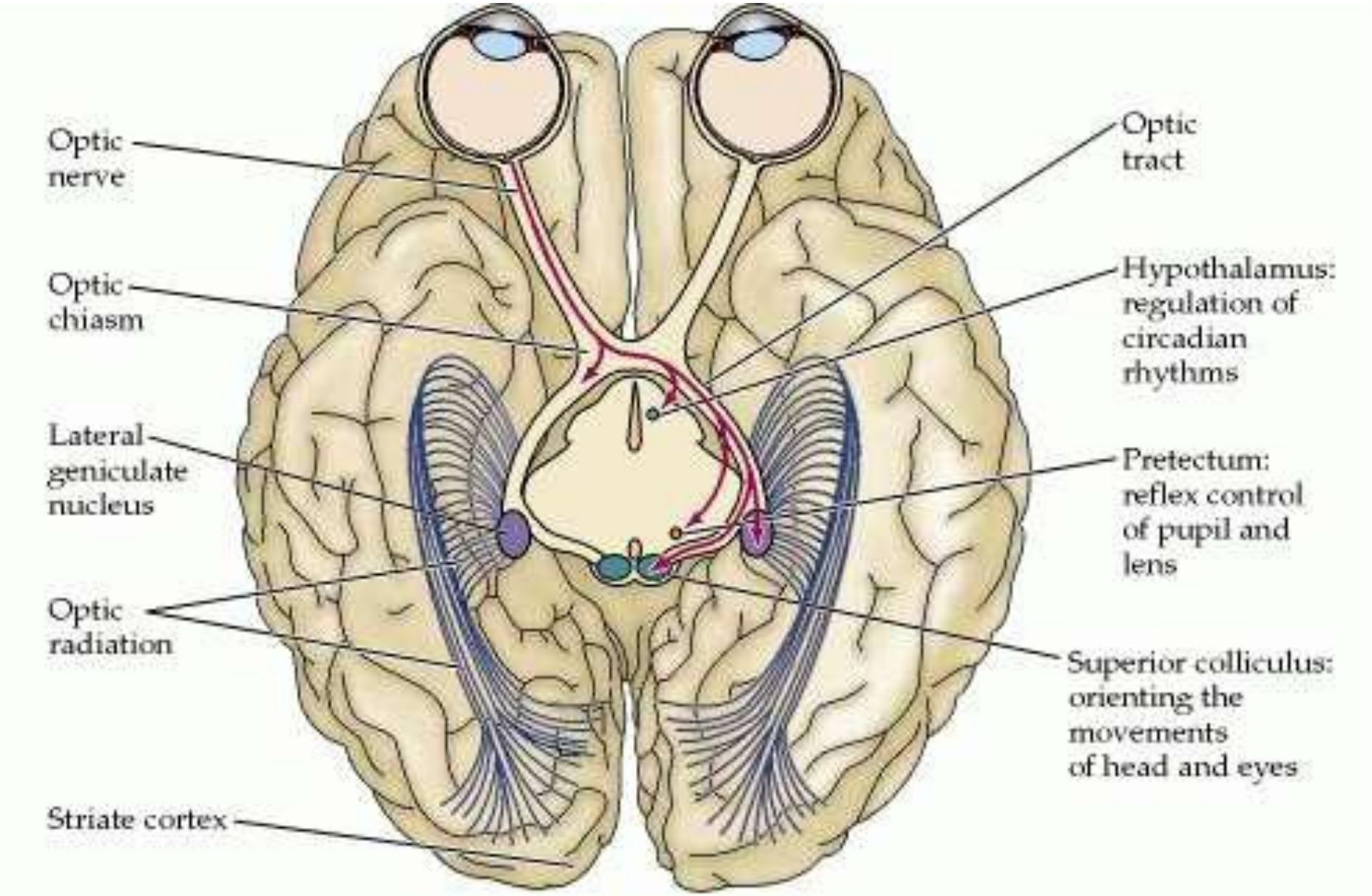


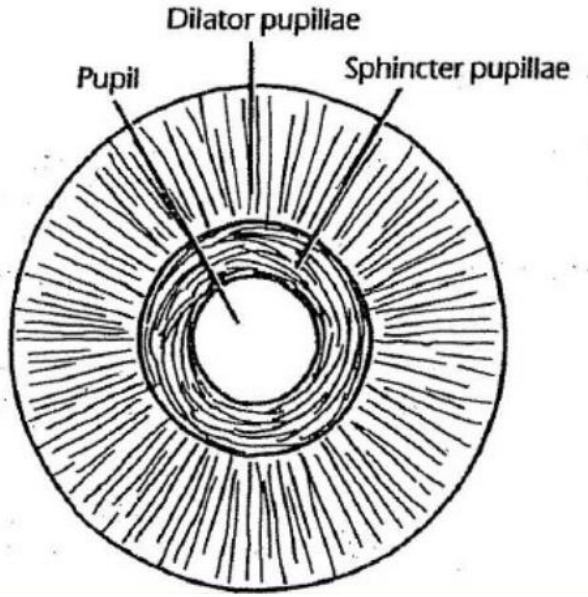
Glaucoma

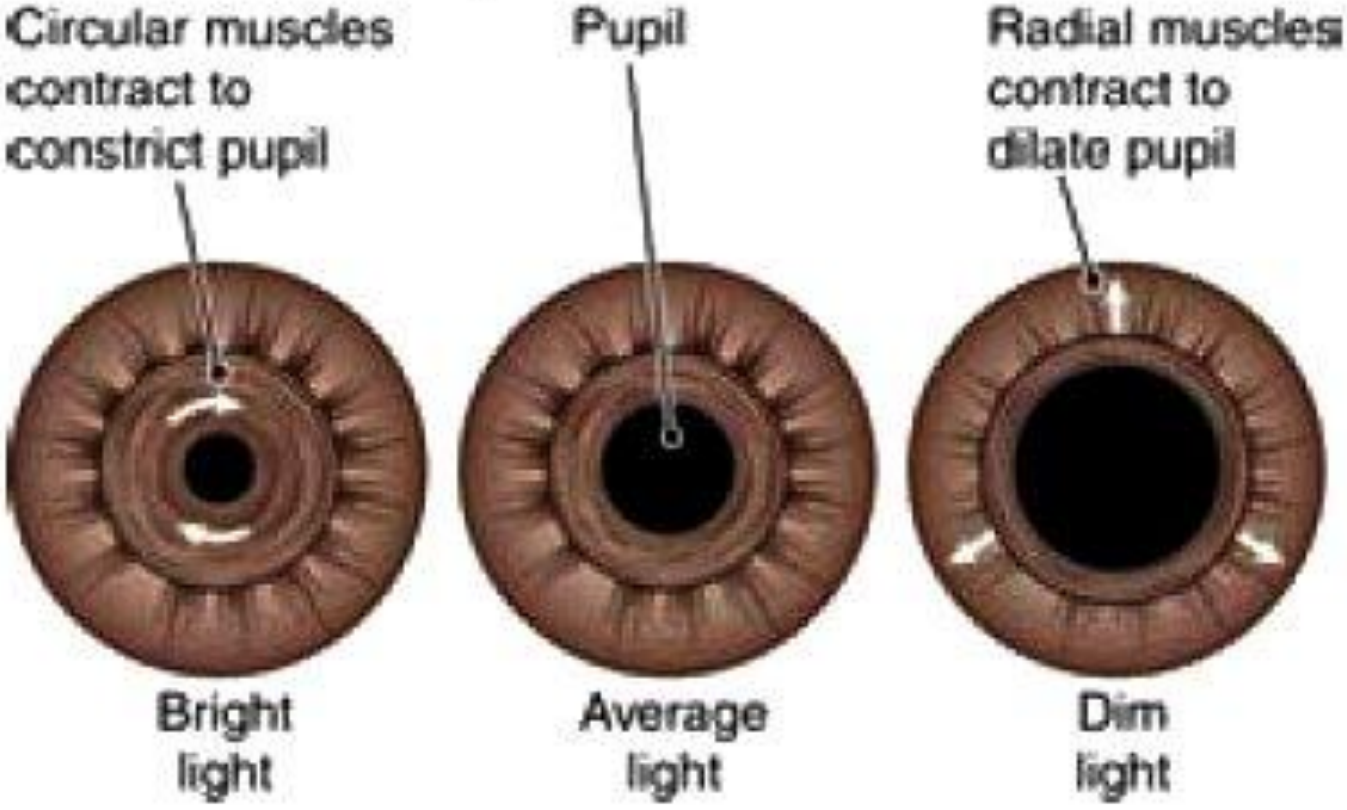




Visual Pathway

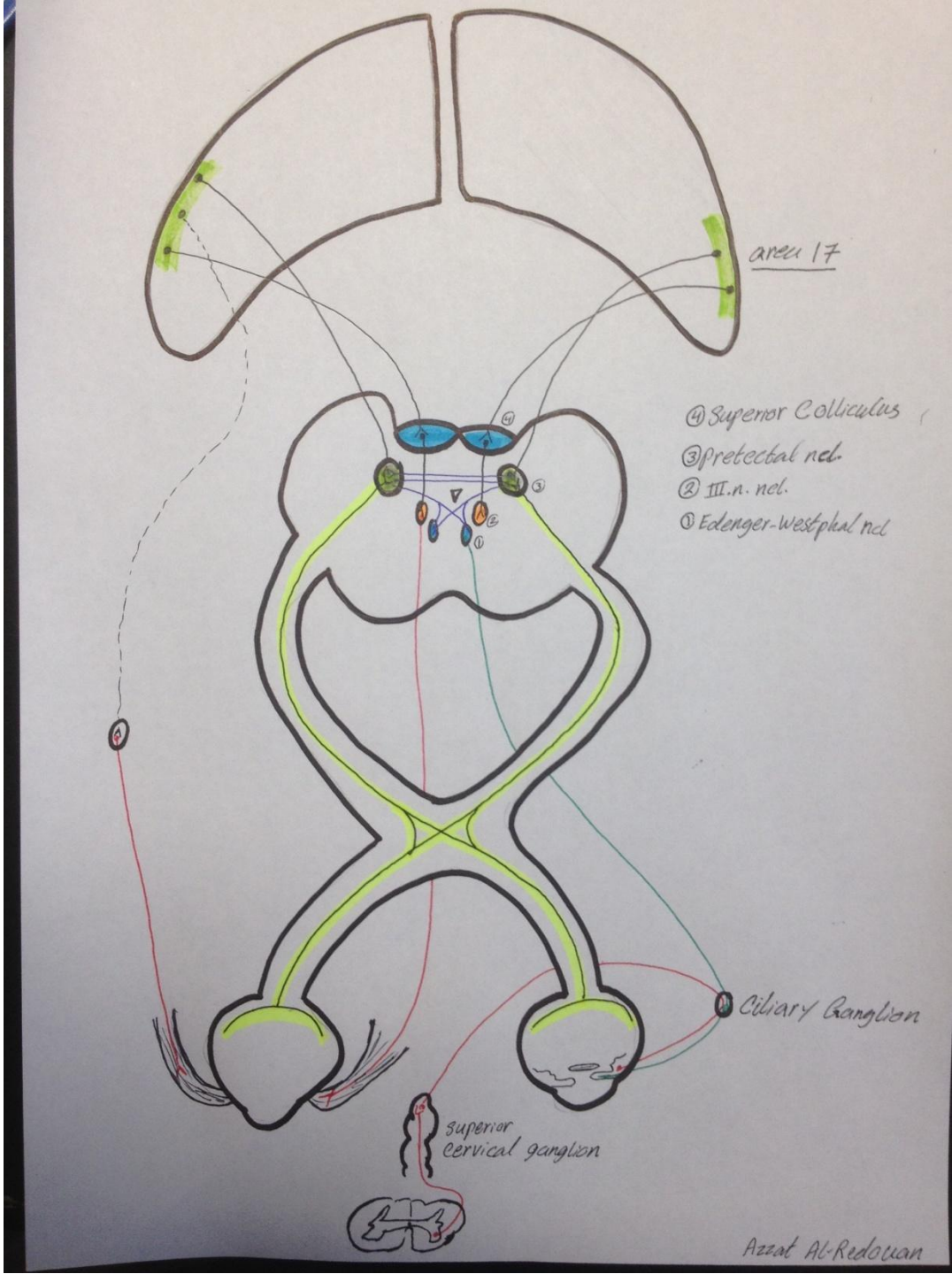


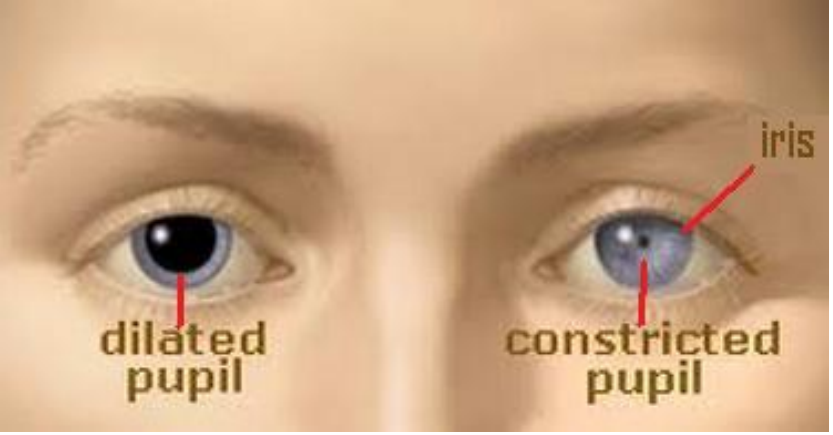

Dilator pupillae
Pupil
Sphincter pupillae


Circular muscles contract to constrict pupil
Pupil
Radial muscles contract to dilate pupil
Bright light
Average light
Dim light

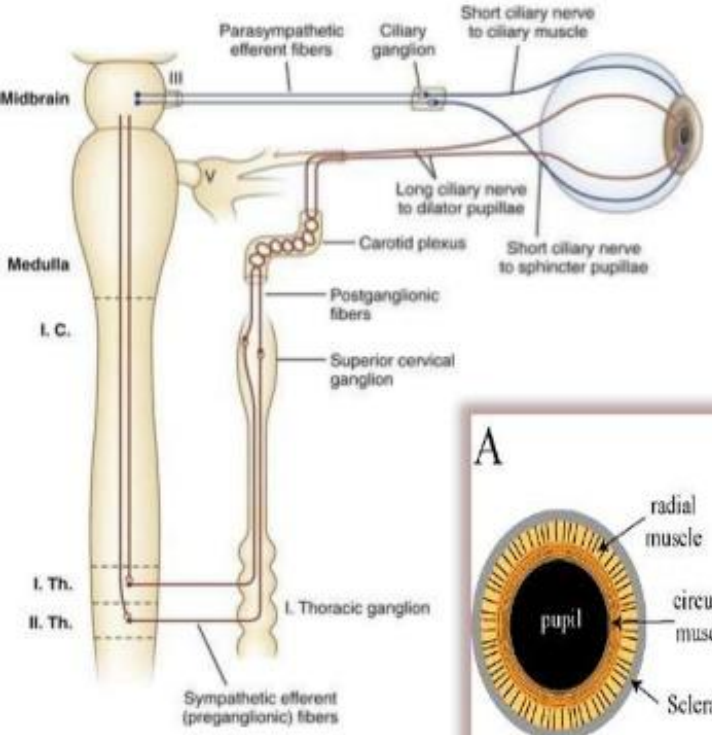
Iris

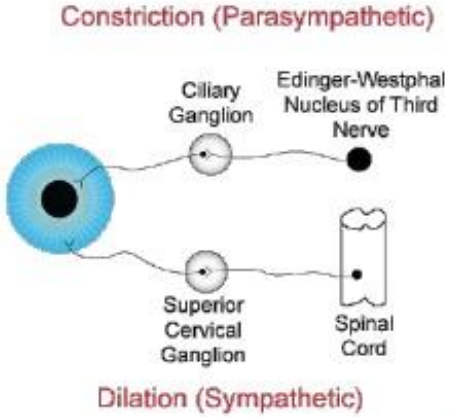
Papillary Reflex Pathway

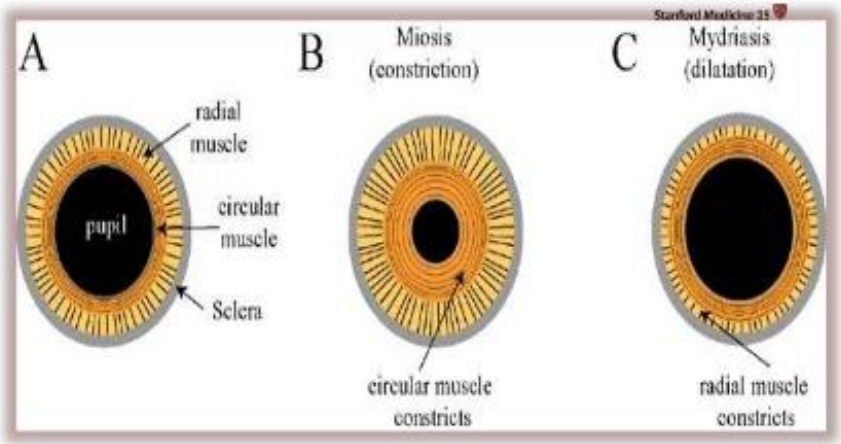


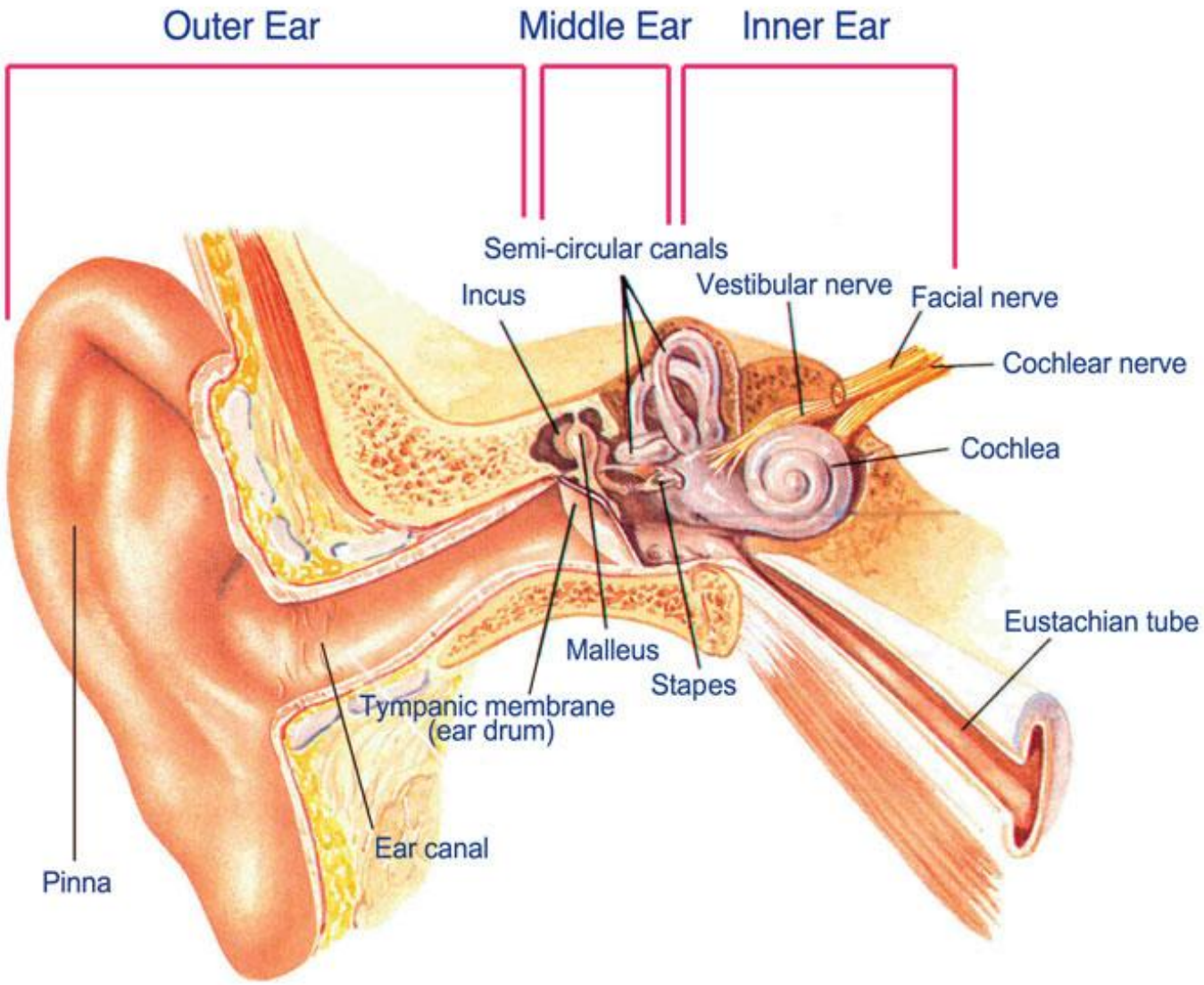


Nerve Pathway & Muscles

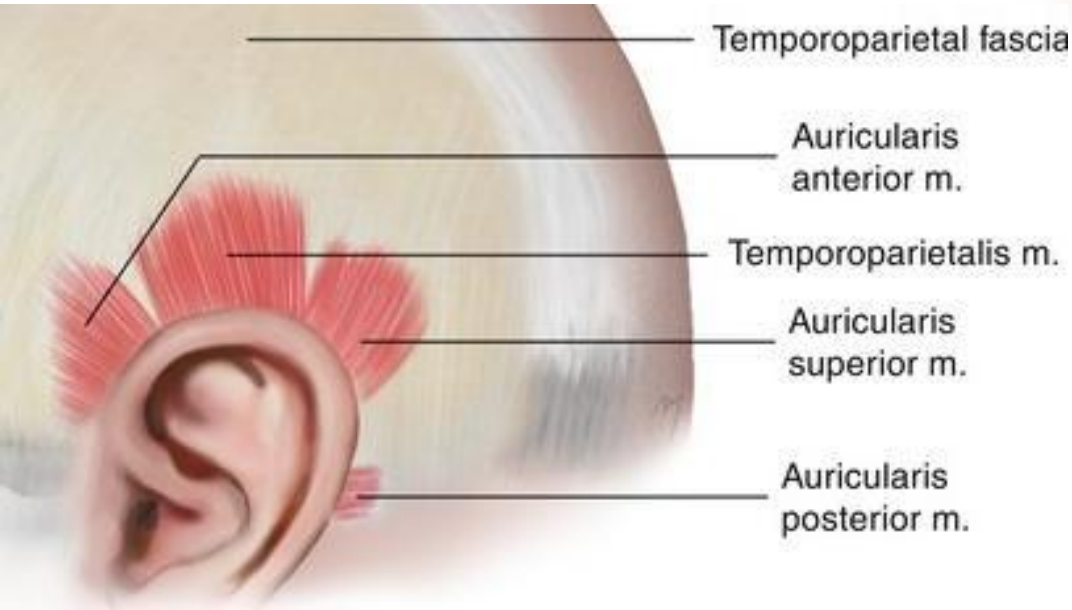


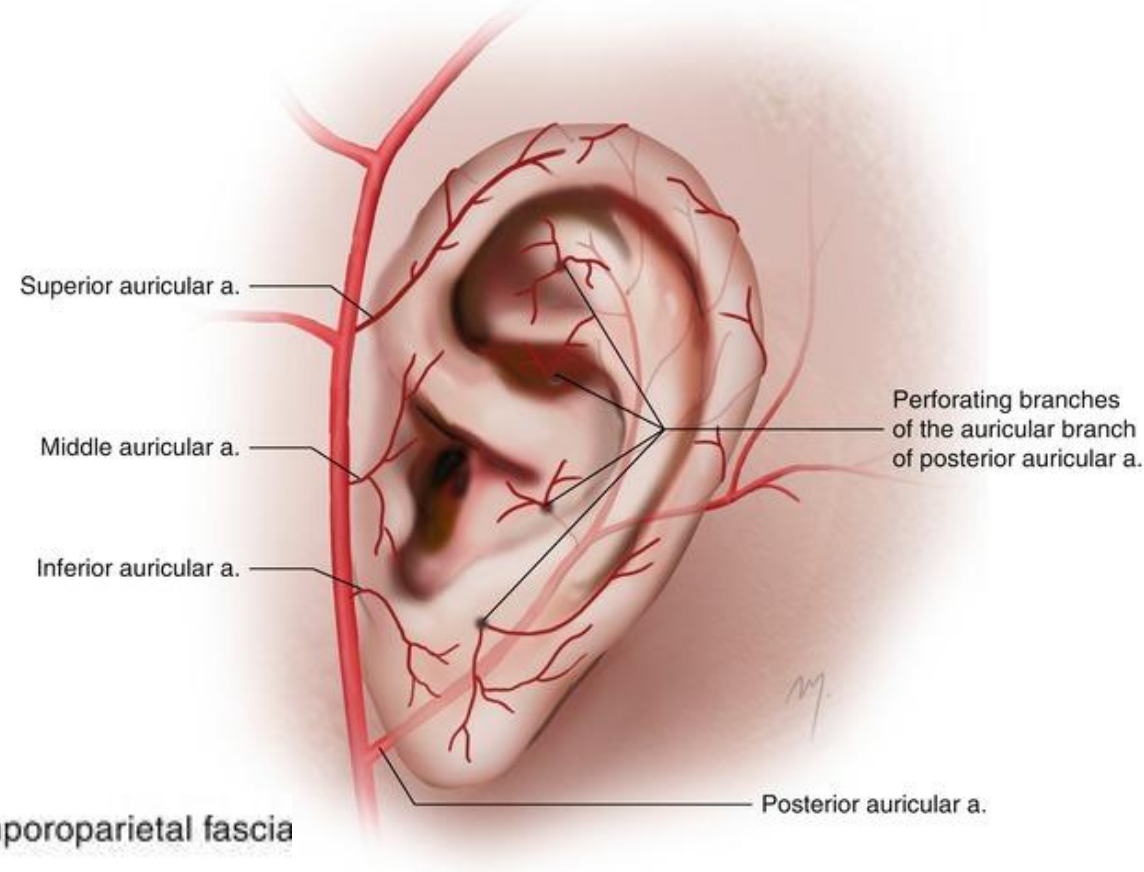





Outer Ear
Middle Ear
Inner Ear
Semi-circular canals
Incus
Vestibular nerve
Facial nerve
Cochlear nerve
Cochlea
Eustachian tube
Malleus
Stapes
Tympanic membrane
(ear drum)
Ear canal
Pinna


helix
triangular fossae
antihelix
helix crus
anterior notch
concha
tragus
interagic notch
antitragus
helix tail
earlobe


Temporoparietal fascia
Auricularis anterior m.
Temporoparietalis m.
Auricularis superior m.
Auricularis posterior m.


Superior auricular a.
Middle auricular a.
Inferior auricular a.
Perforating branches of the auricular branch of posterior auricular a.
Posterior auricular a.

Grade I Microtia

Grade II Microtia

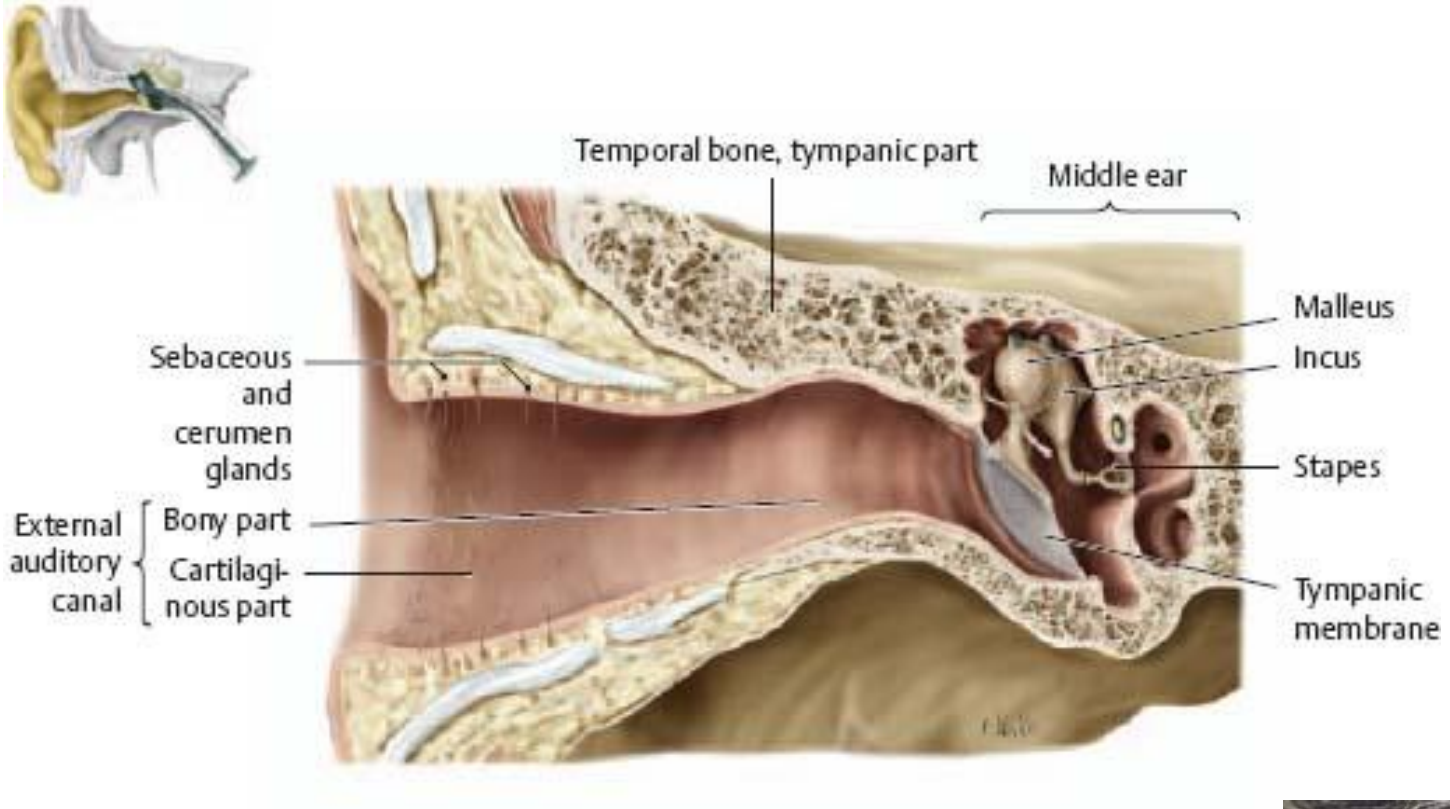
Grade III Microtia

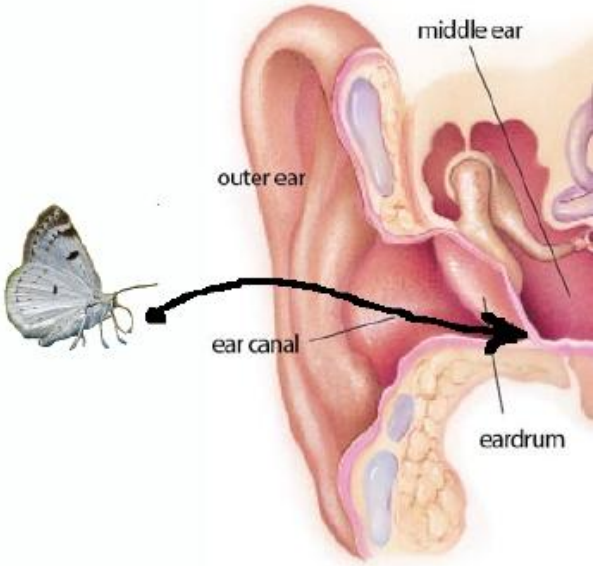
Grade IV Microtia

Cauliflower Ear

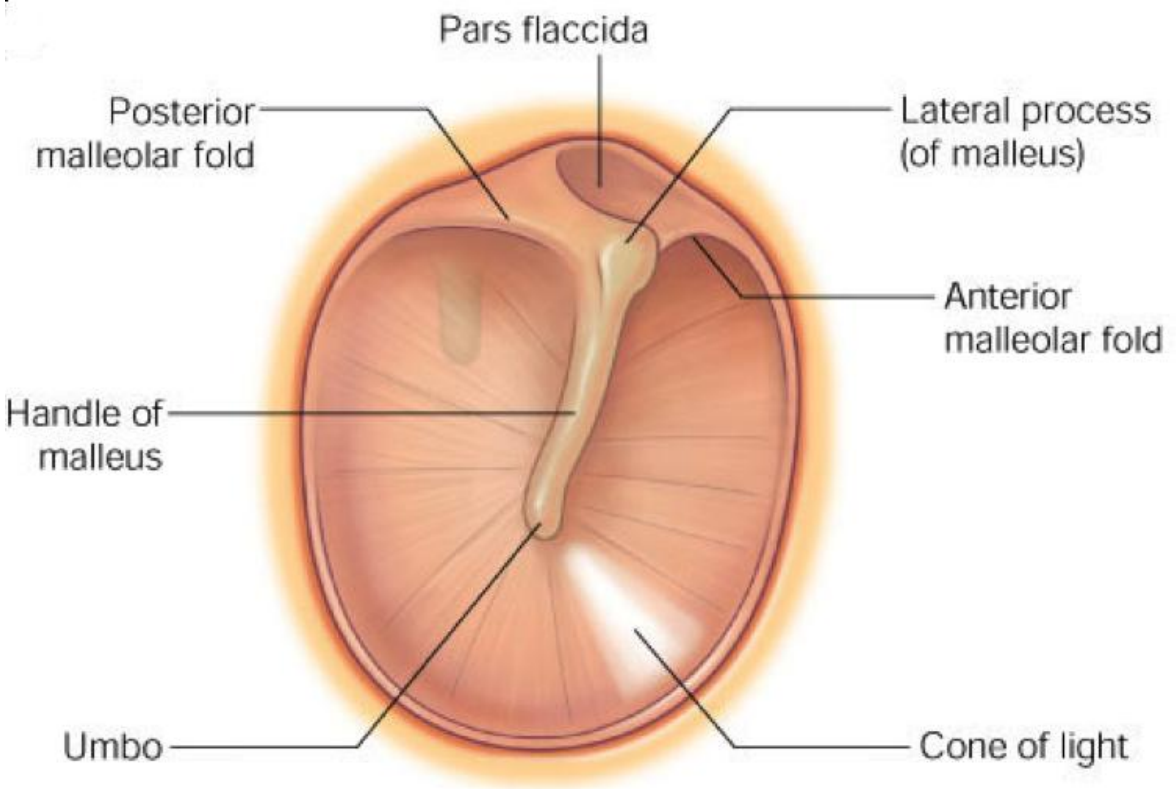
Trauma

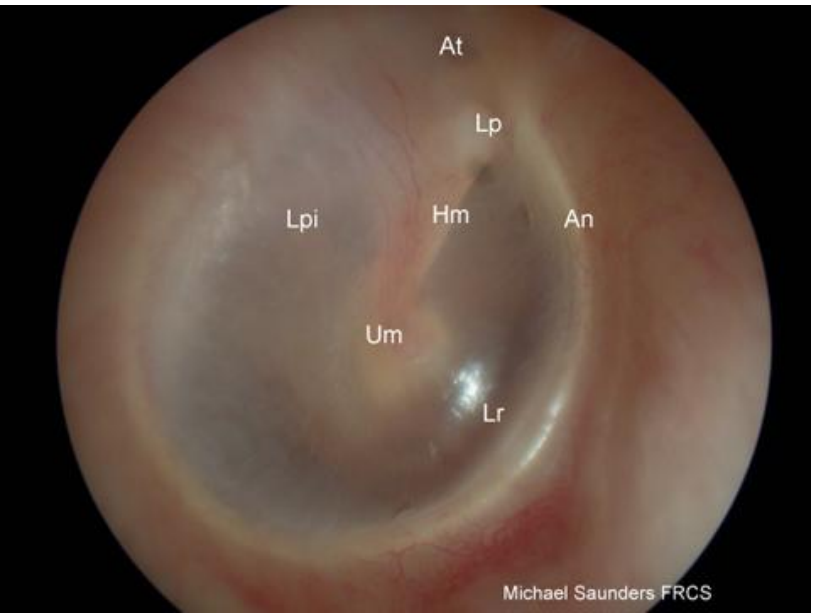
Preauricular Fistula

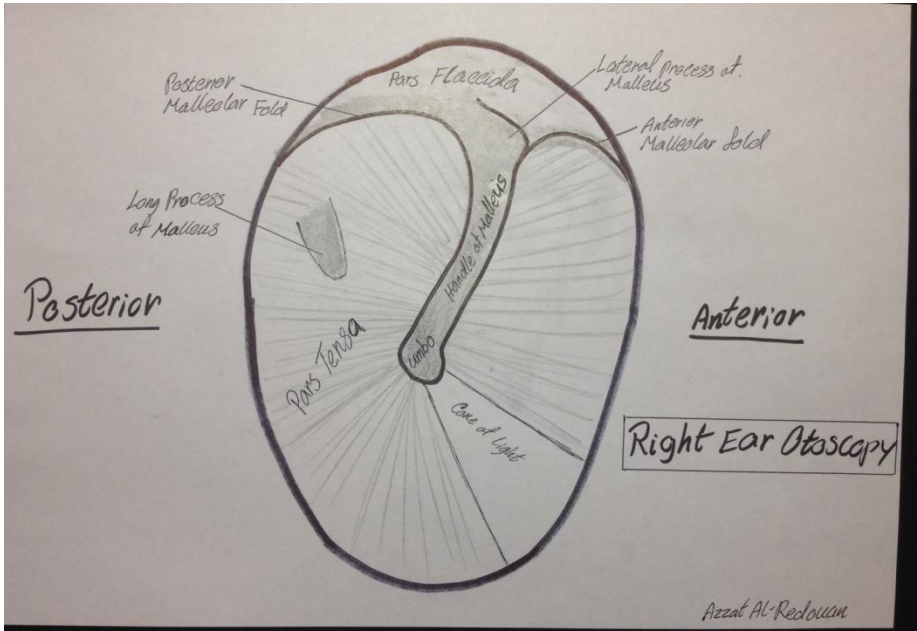

Temporal bone, tympanic part
Middle ear
Malleus
Incus
Stapes
Tympanic membrane
Sebaceous and cerumen glands
External auditory canal
Bony part
Cartilagi-nous part

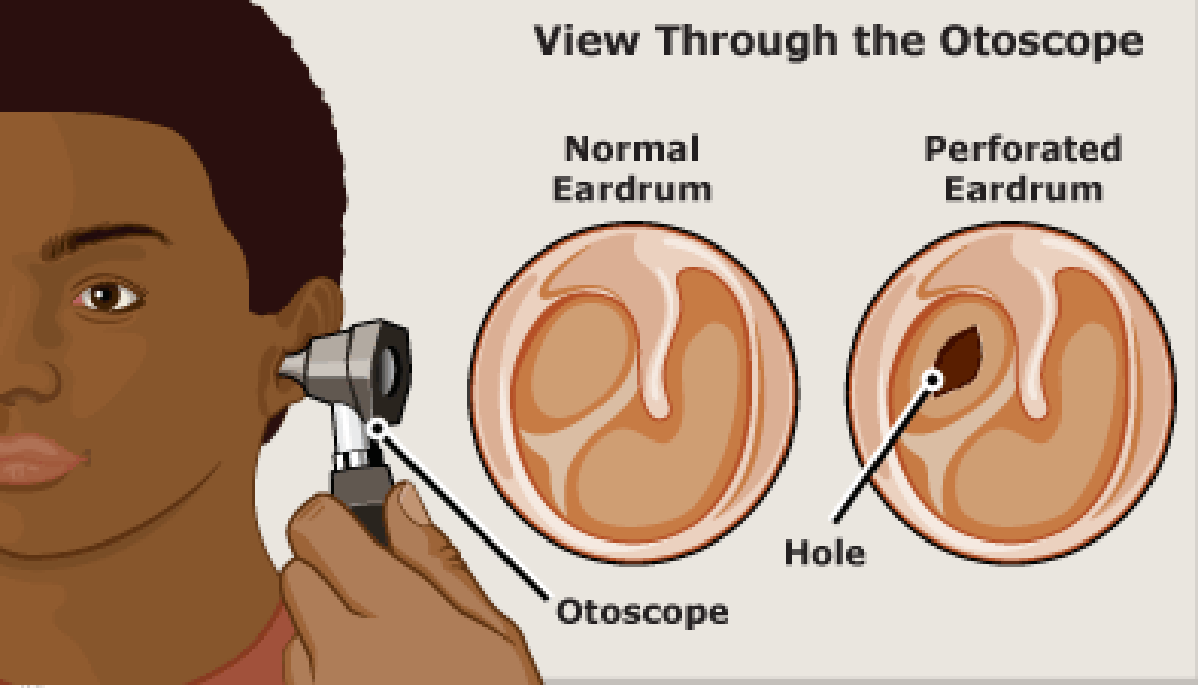

middle ear
outer ear
ear canal
eardrum

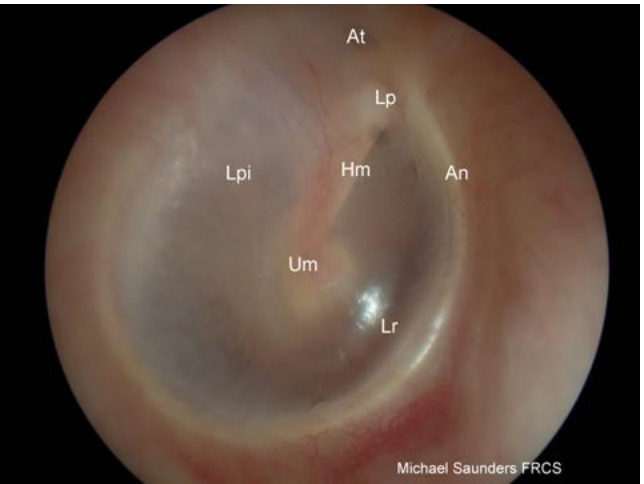
Otoscopy

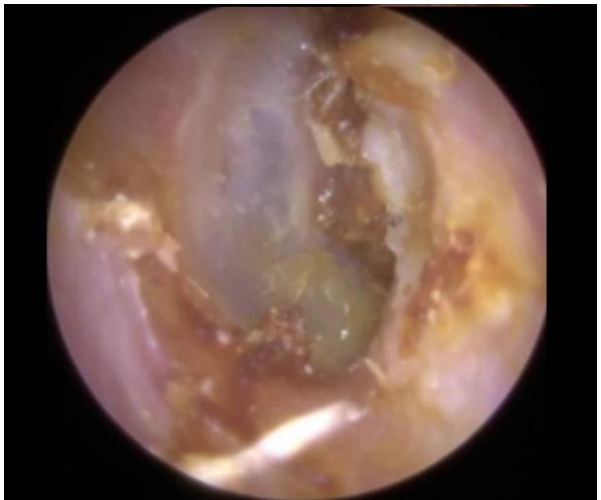

Pars flaccida
Posterior malleolar fold
Lateral process (of malleus)
Anterior malleolar fold
Handle of malleus
Umbo
Cone of light

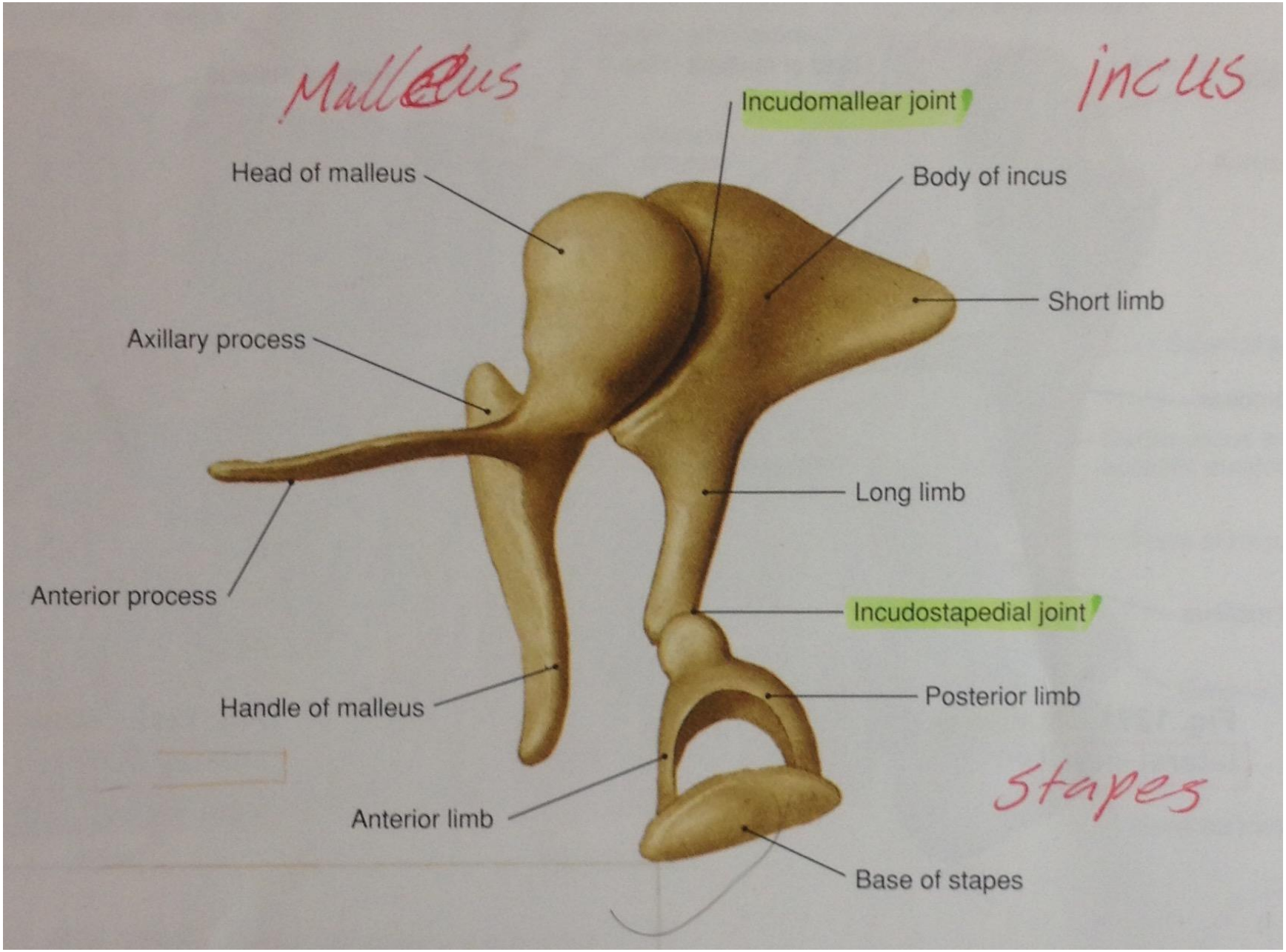

At
Lp
Lpi
Hm
An
Um
Lr
Michael Saunders FRCS

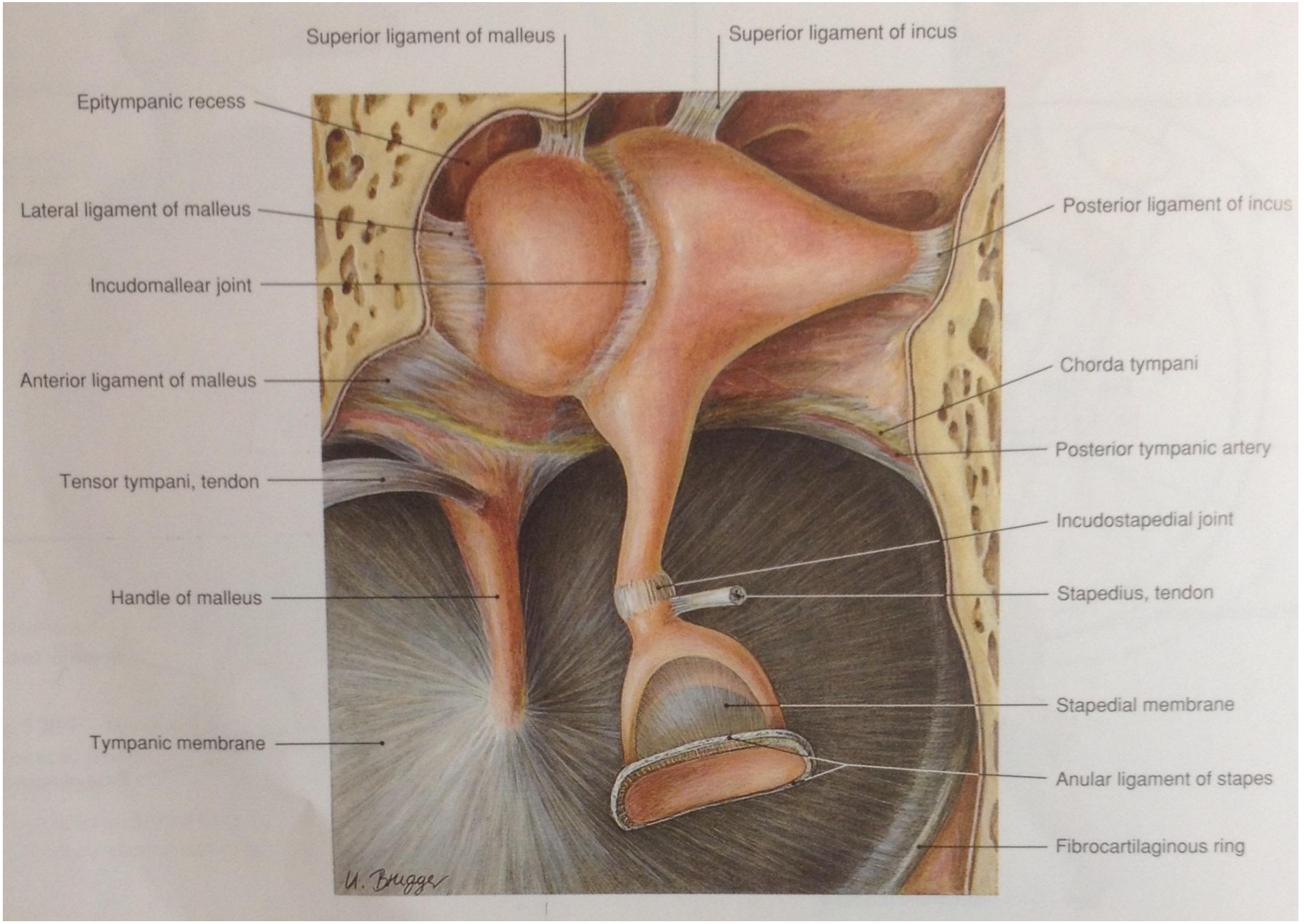

Posterior Malleolar Fold
Pars Flaccida
Lateral process of Malleus
Anterior Malleolar fold
Long Process of Malleus
Handle of Malleus
Posterior
Anterior
Pars Tensa
Umbo
Cone of Light
Right Ear Otoscopy
Azzat Al-Rechaan

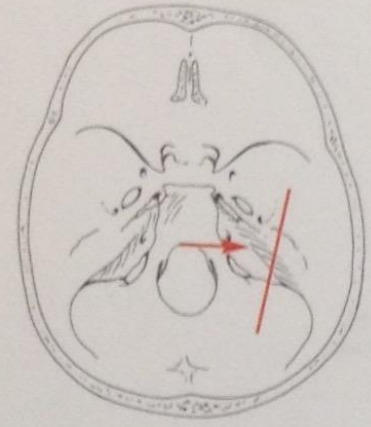

View Through the Otoscope
Normal Eardrum
Perforated Eardrum
Hole
Otoscope

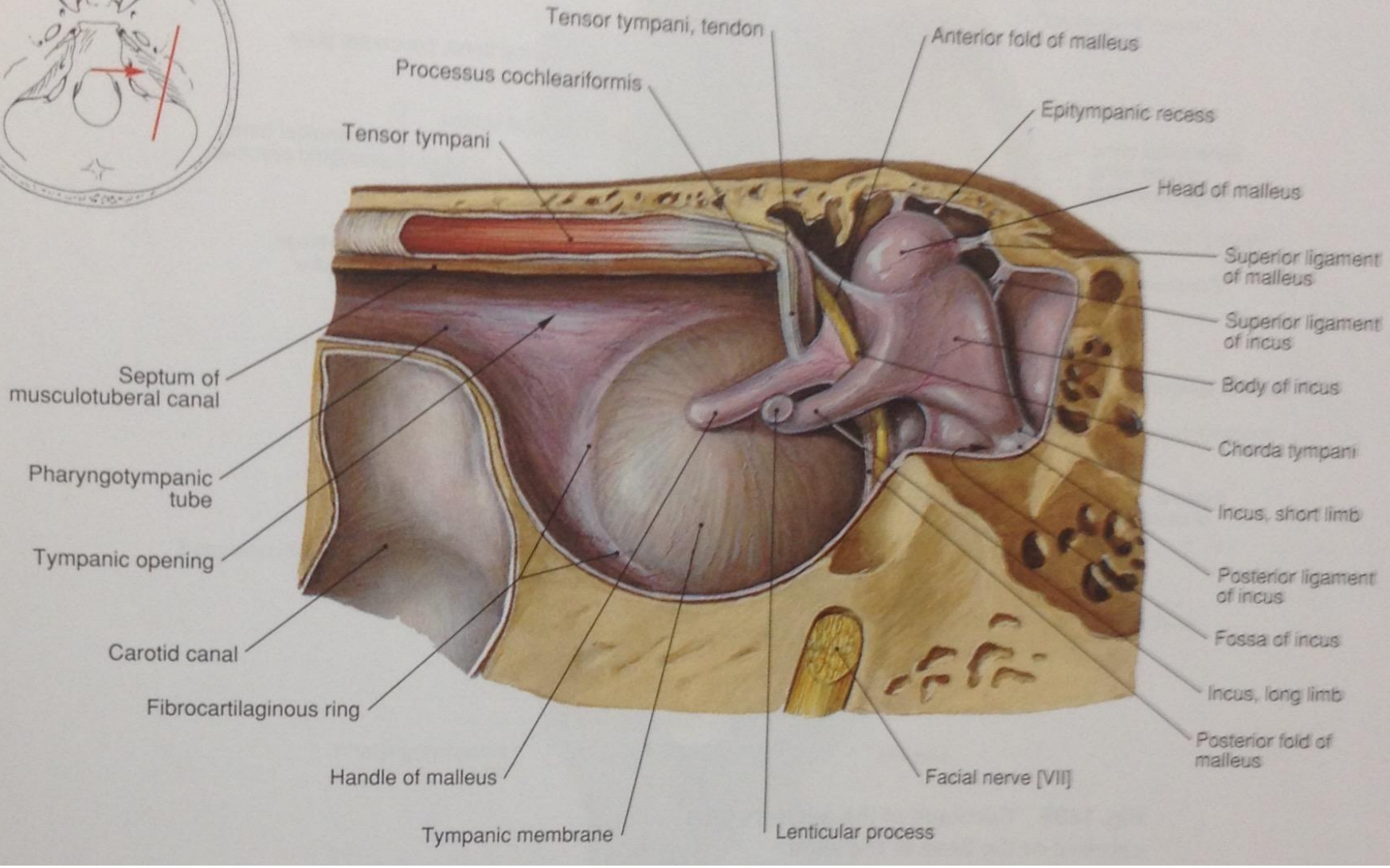

At
Lp
Lpi
Hm
An
Um
Lr
Michael Saunders FRCS

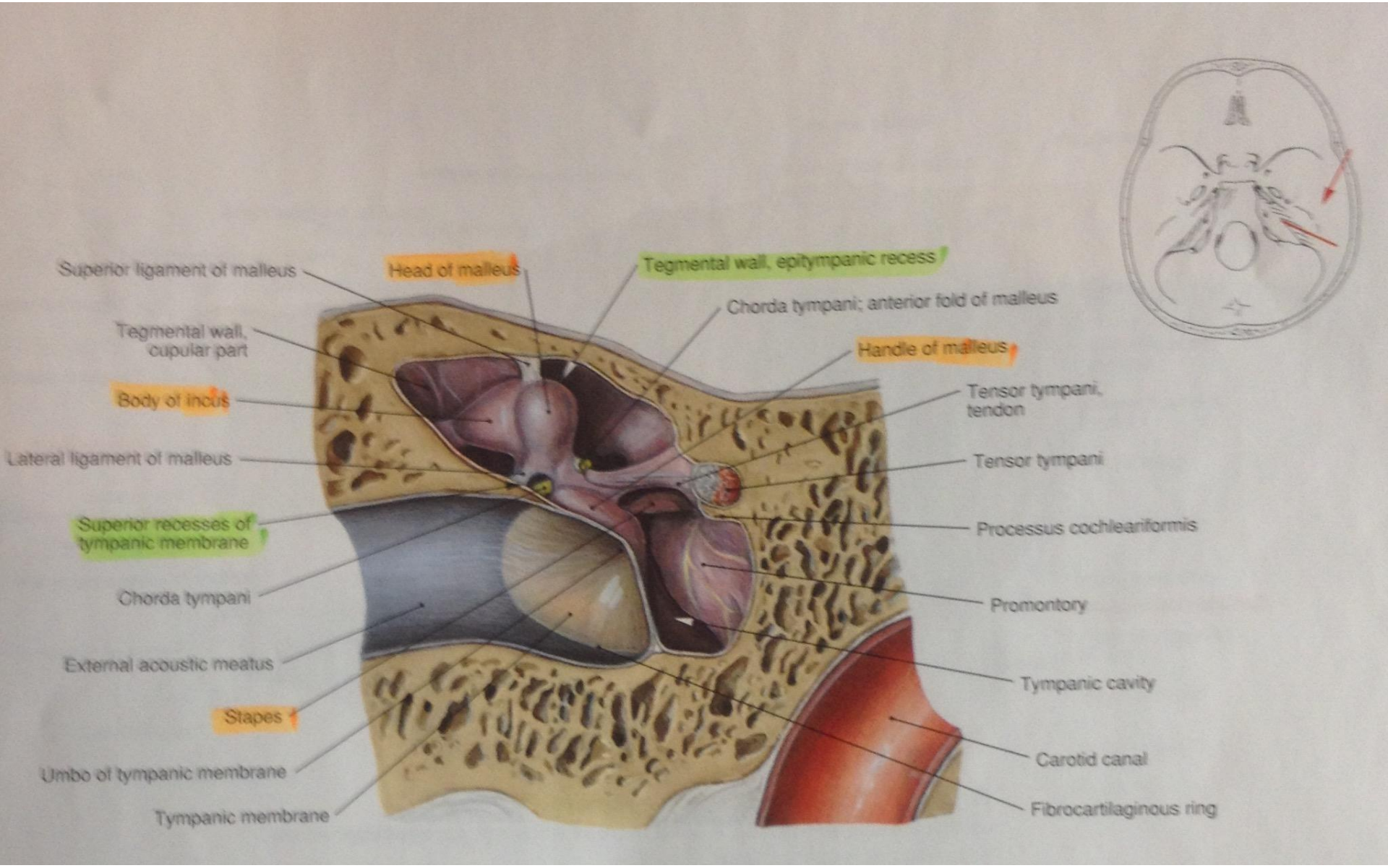



Malleus
Incudomallear joint
Incus
Head of malleus
Body of incus
Short limb
Axillary process
Long limb
Anterior process
Incudostapedial joint
Handle of malleus
Posterior limb
Stapes
Anterior limb
Base of stapes

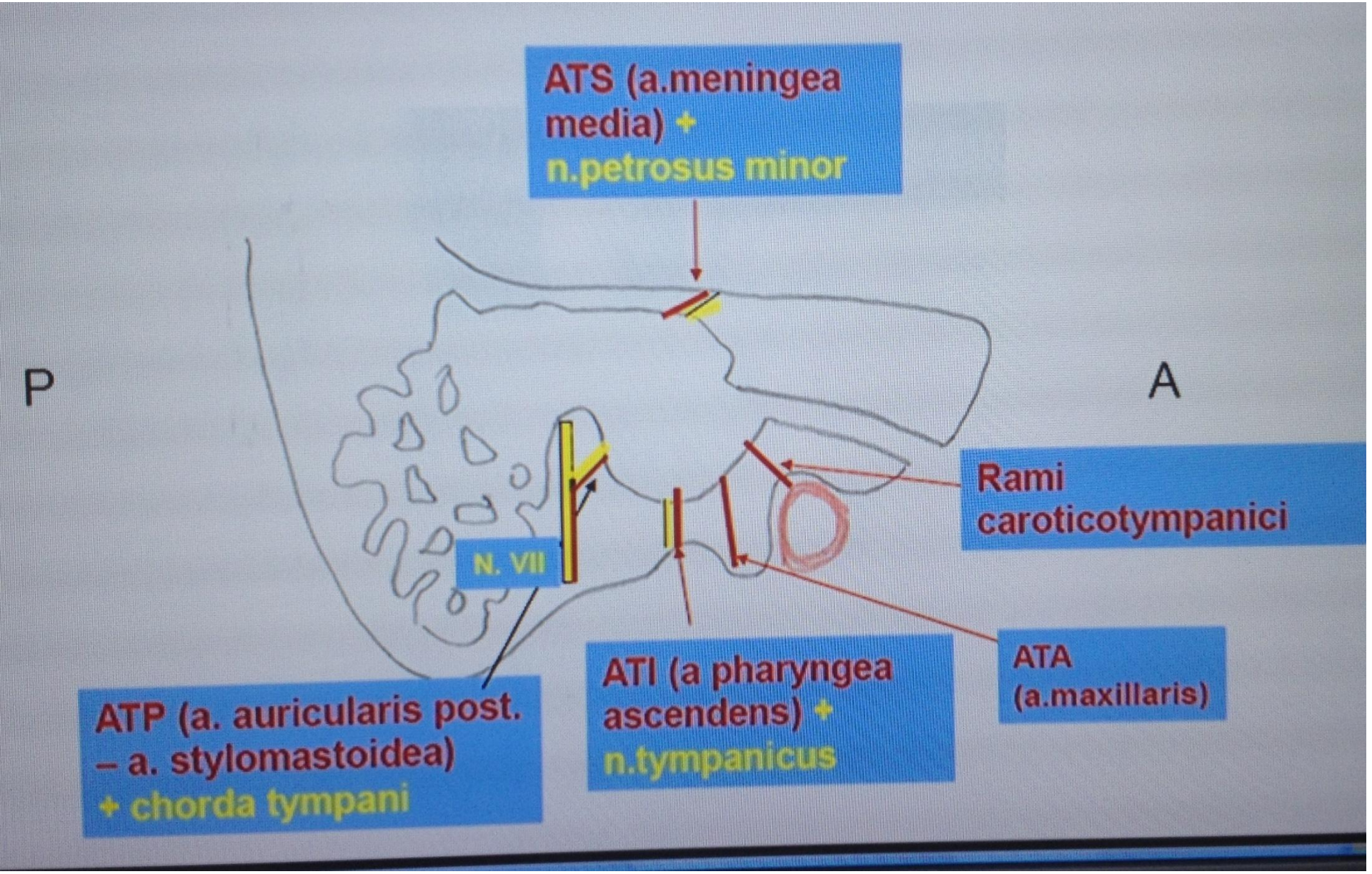

Superior ligament of malleus
Superior ligament of incus
Epitympanic recess
Lateral ligament of malleus
Incudomallear joint
Anterior ligament of malleus
Tensor tympani, tendon
Handle of malleus
Tympanic membrane
Posterior ligament of incus
Chorda tympani
Posterior tympanic artery
Incudostapedial joint
Stapedius, tendon
Stapedial membrane
Anular ligament of stapes
Fibrocartilaginous ring
U. Brugger



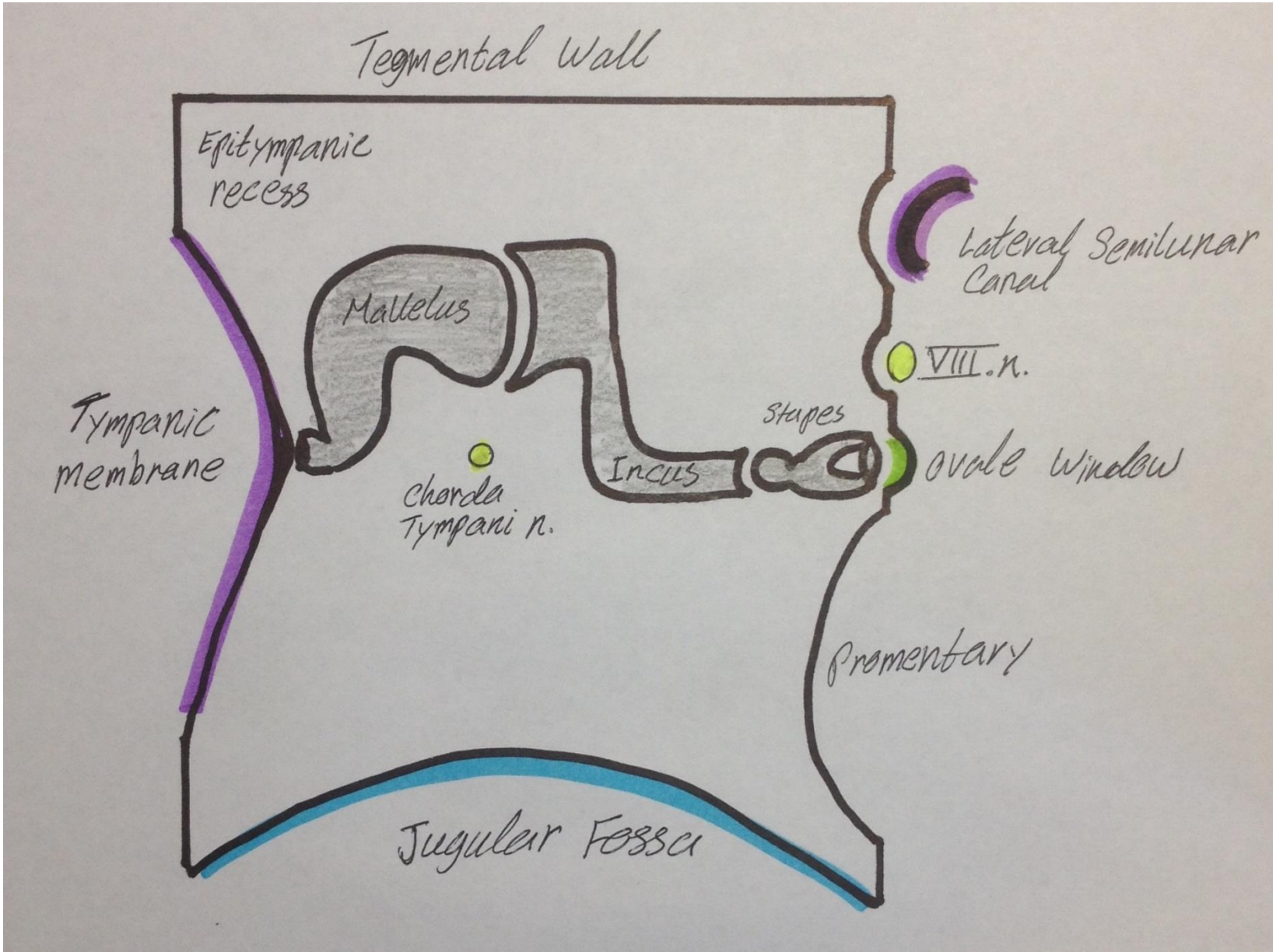

Tensor tympani, tendon
Anterior fold of malleus
Processus cochleariformis
Epitympanic recess
Tensor tympani
Head of malleus
Superior ligament of malleus
Superior ligament of incus
Septum of musculotuberal canal
Body of incus
Chorda tympani
Pharyngotympanic tube
Incus, short limb
Posterior ligament of incus
Tympanic opening
Fossa of incus
Carotid canal
Incus, long limb
Posterior fold of malleus
Fibrocartilaginous ring
Handle of malleus
Facial nerve [VII]
Tympanic membrane
Lenticular process

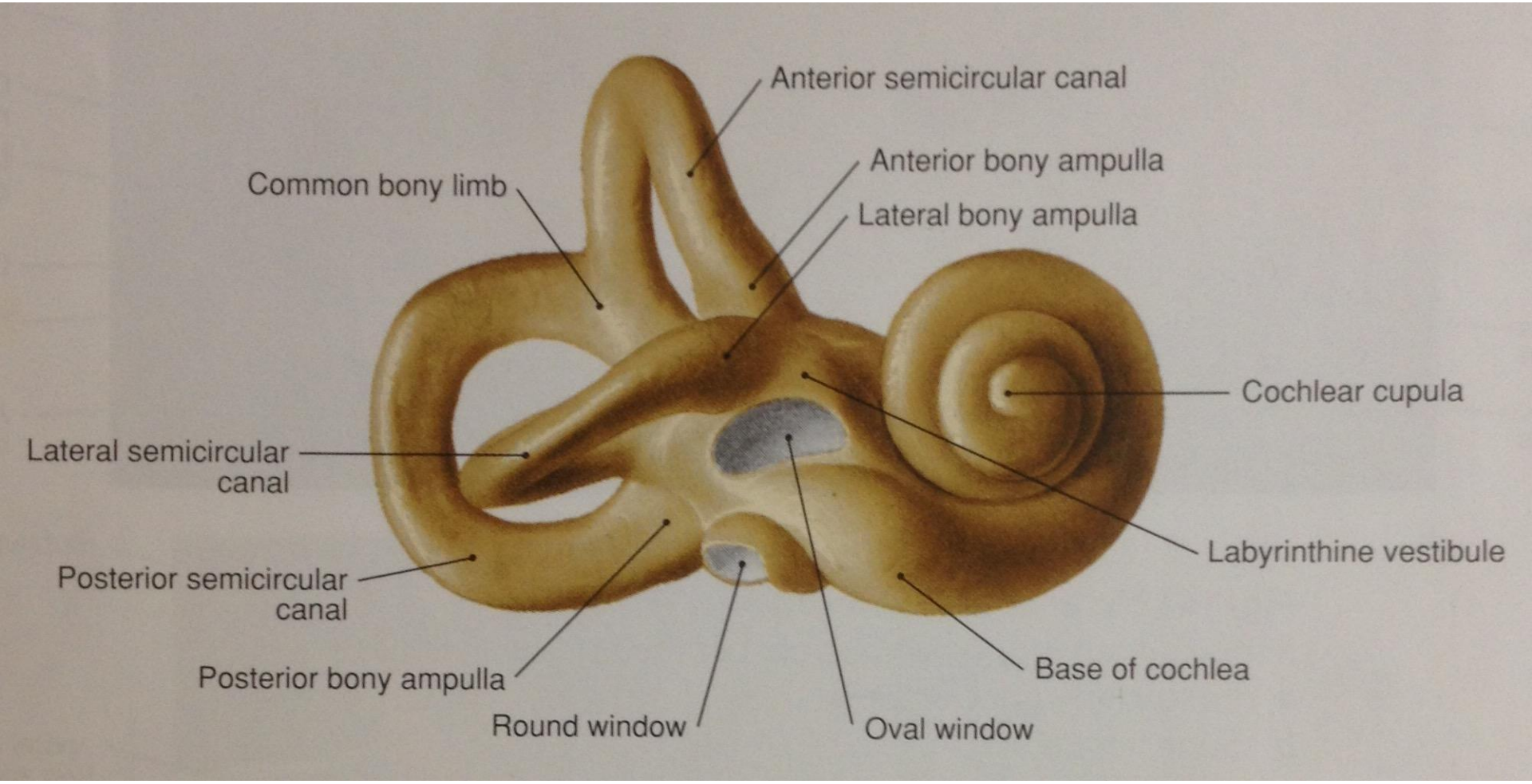

Superior ligament of malleus
Head of malleus
Tegmental wall, epitympanic recess
Chorda tympani; anterior fold of malleus
Tegmental wall, cupular part
Handle of malleus
Body of incus
Tensor tympani, tendon
Lateral ligament of malleus
Tensor tympani
Superior recesses of tympanic membrane
Processus cochleariformis
Chorda tympani
Promontory
External acoustic meatus
Tympanic cavity
Stapes
Carotid canal
Umbo of tympanic membrane
Tympanic membrane
Fibrocartilaginous ring

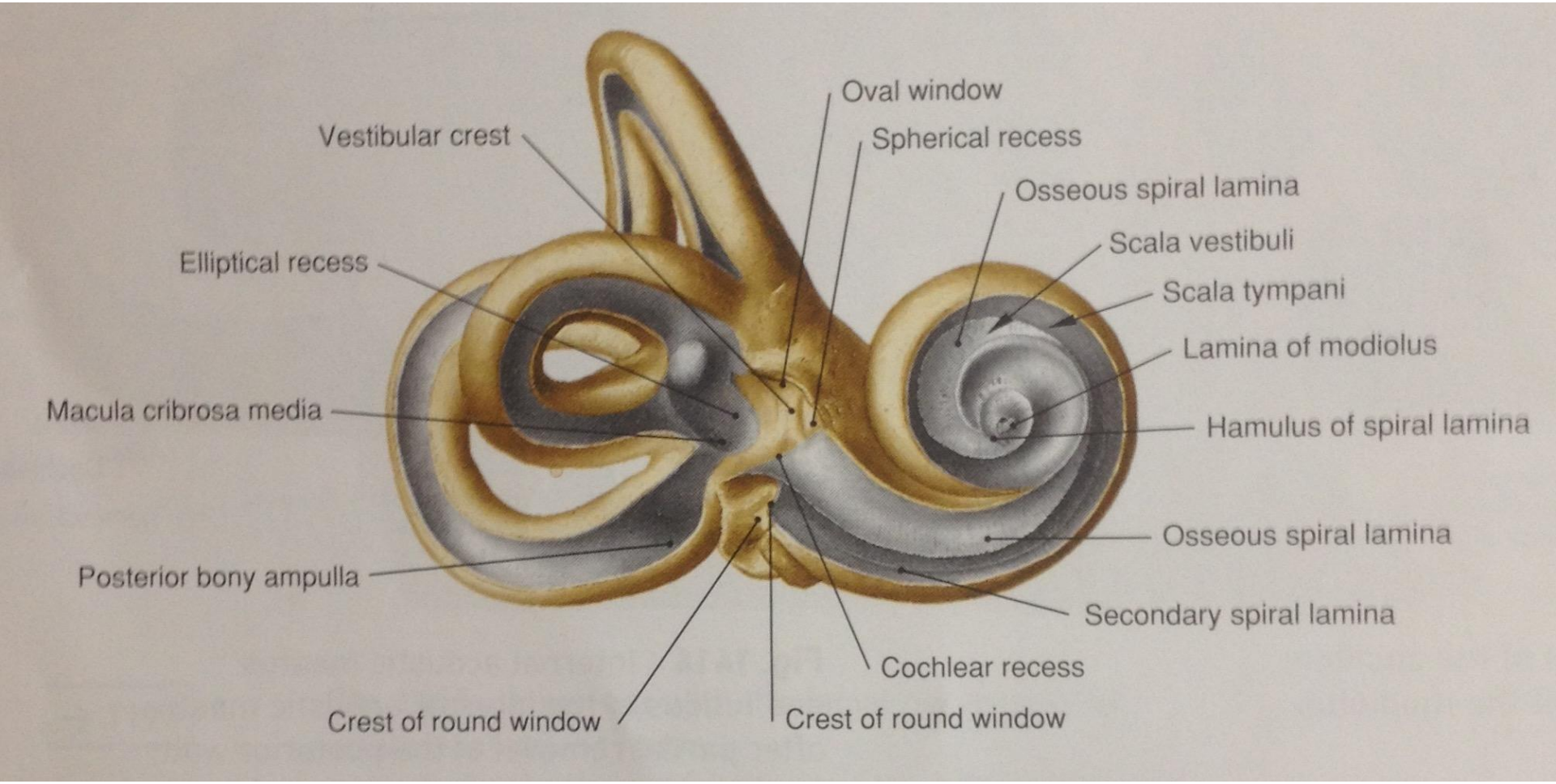
Middle Ear Blood Supply

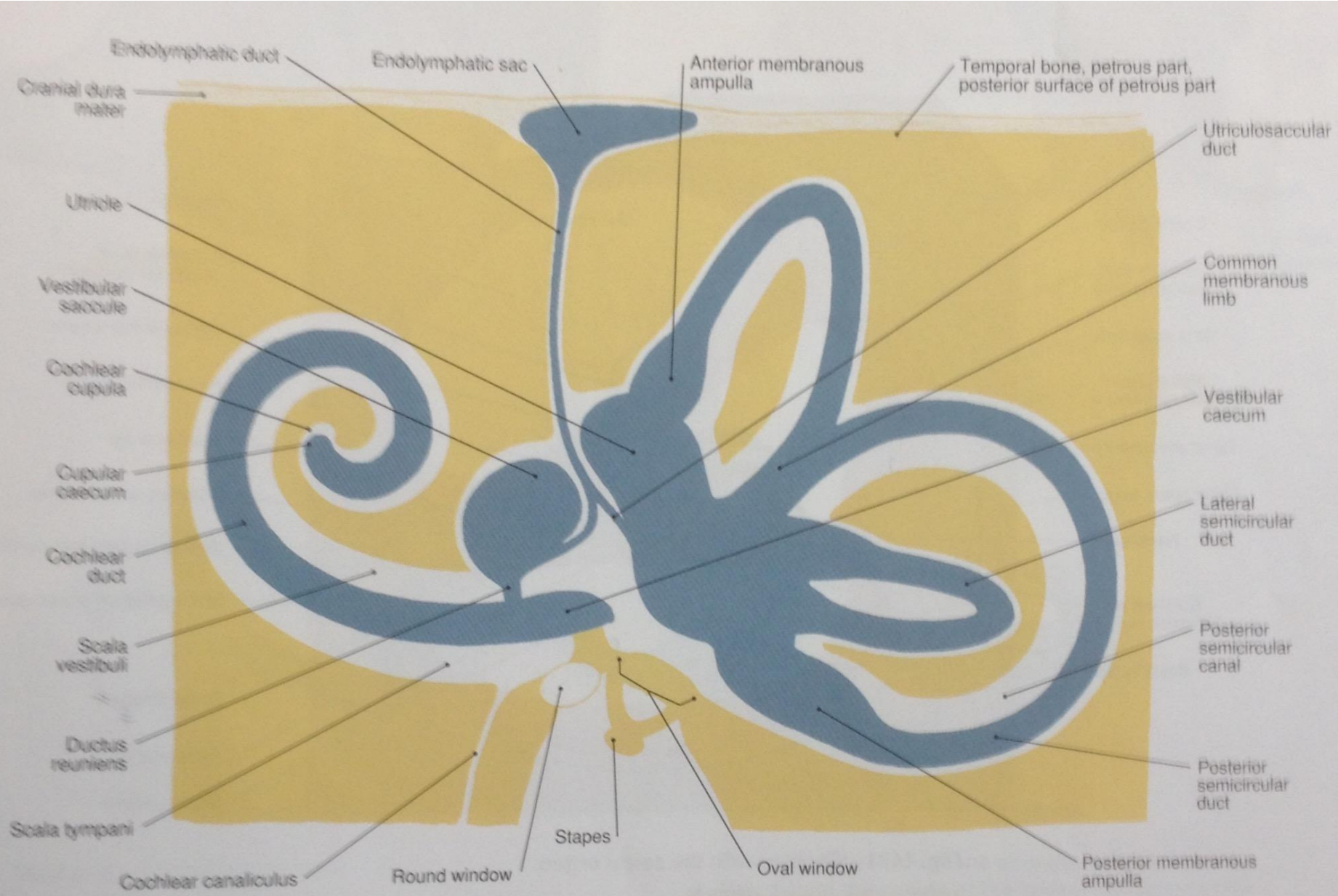


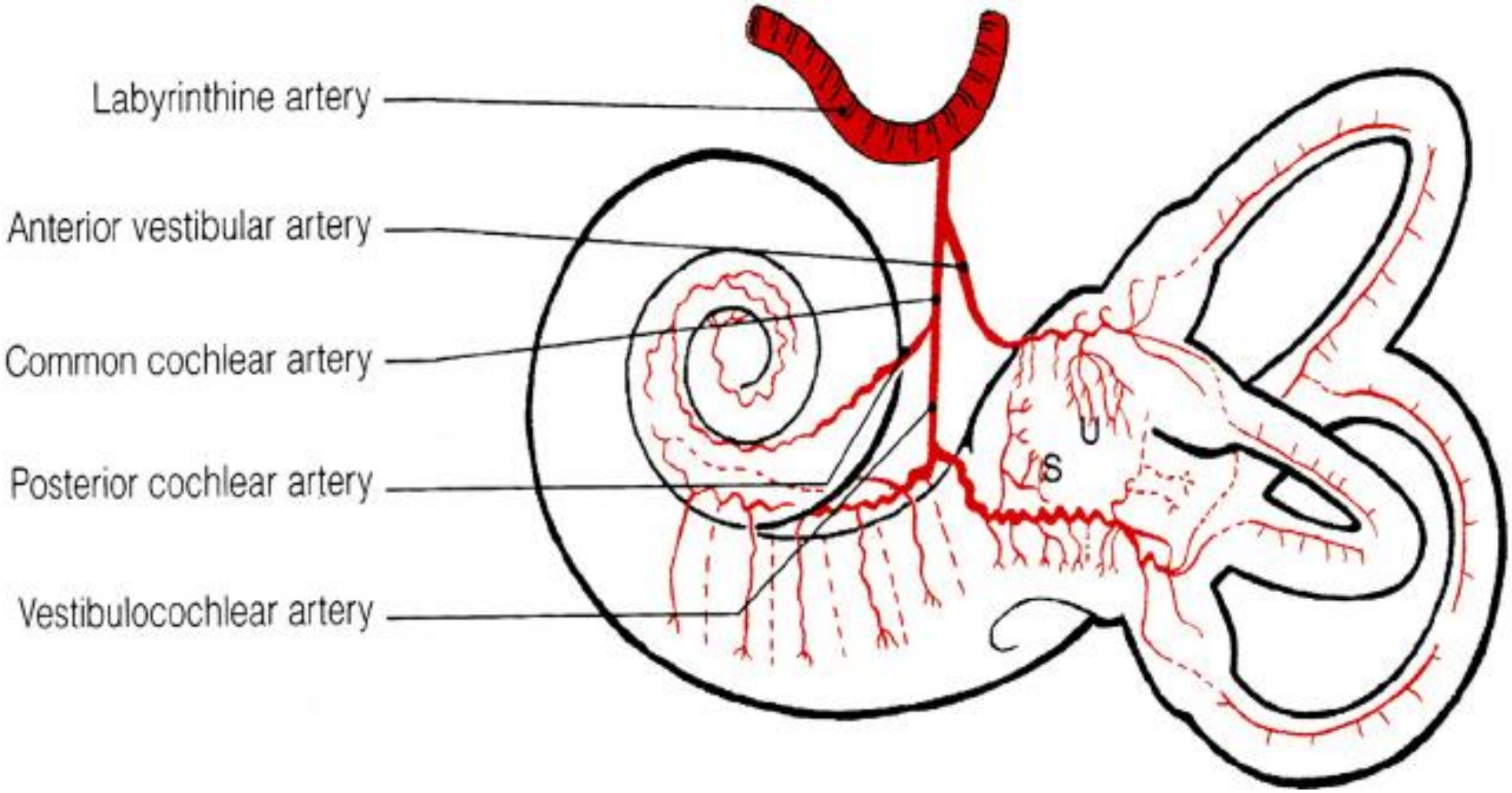
Middle Ear Walls

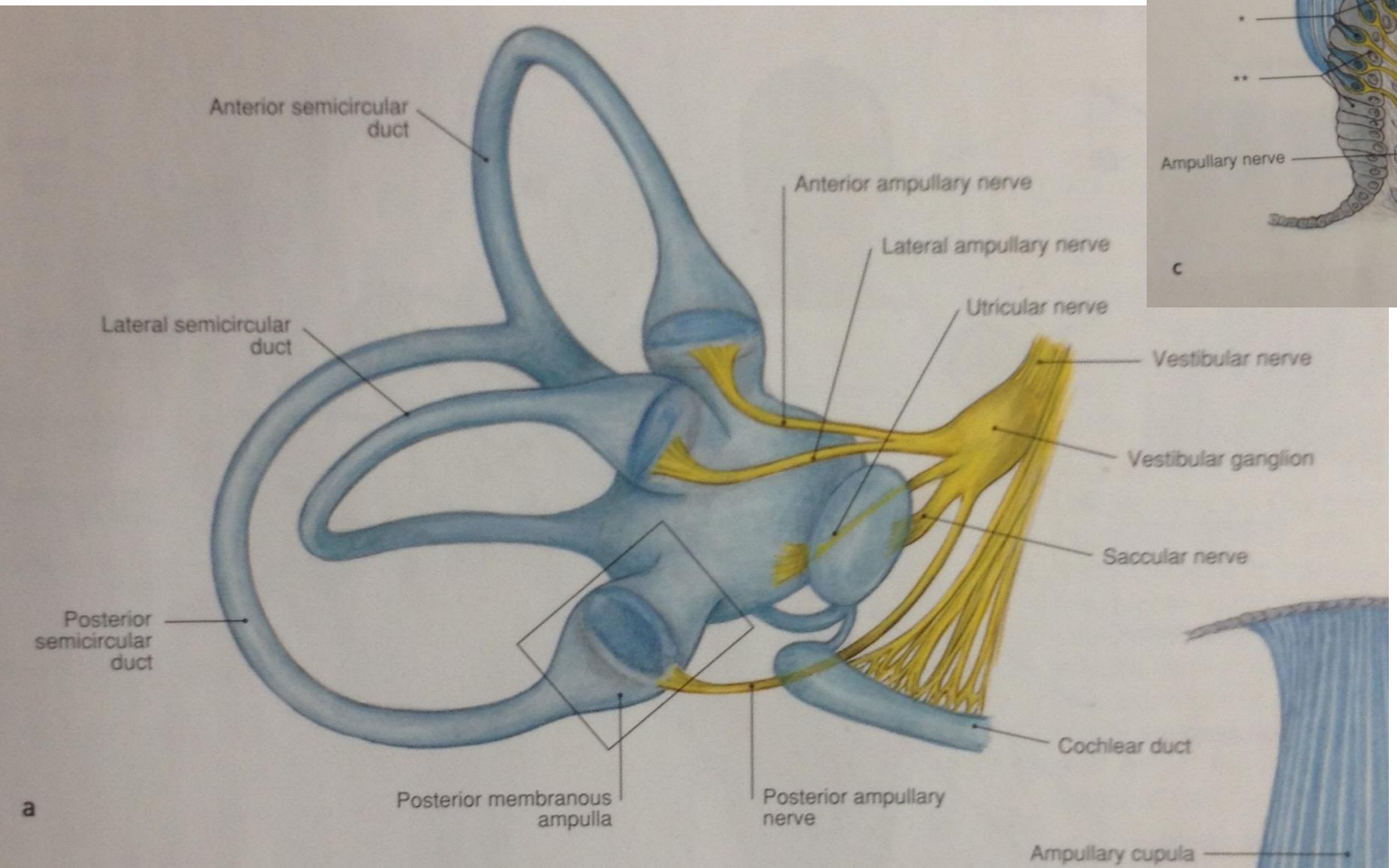


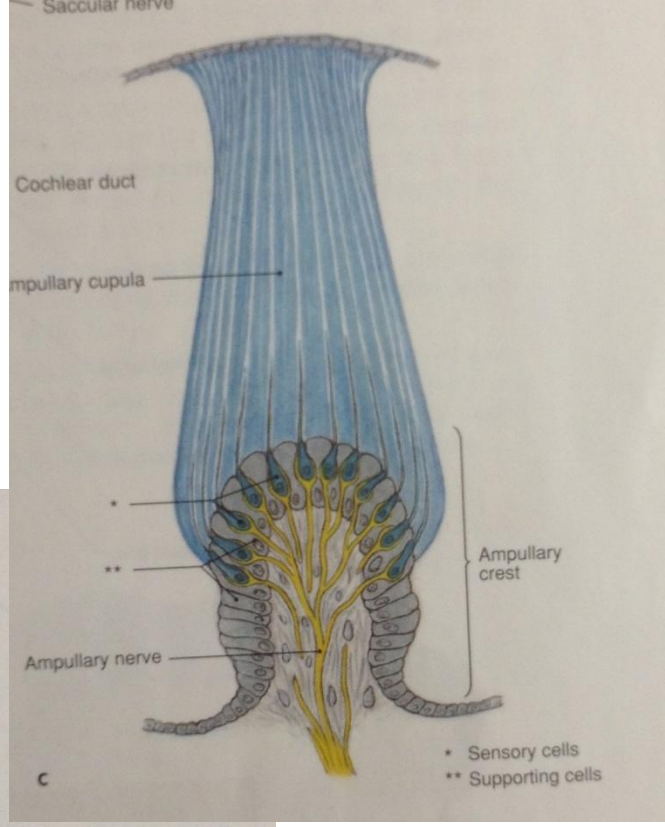

Anterior semicircular canal
Anterior bony ampulla
Common bony limb
Lateral bony ampulla
Cochlear cupula
Lateral semicircular canal
Labyrinthine vestibule
Posterior semicircular canal
Base of cochlea
Posterior bony ampulla
Round window
Oval window


Oval window
Vestibular crest
Spherical recess
Osseous spiral lamina
Scala vestibuli
Elliptical recess
Scala tympani
Lamina of modiolus
Macula cribrosa media
Hamulus of spiral lamina
Osseous spiral lamina
Posterior bony ampulla
Secondary spiral lamina
Cochlear recess
Crest of round window
Crest of round window

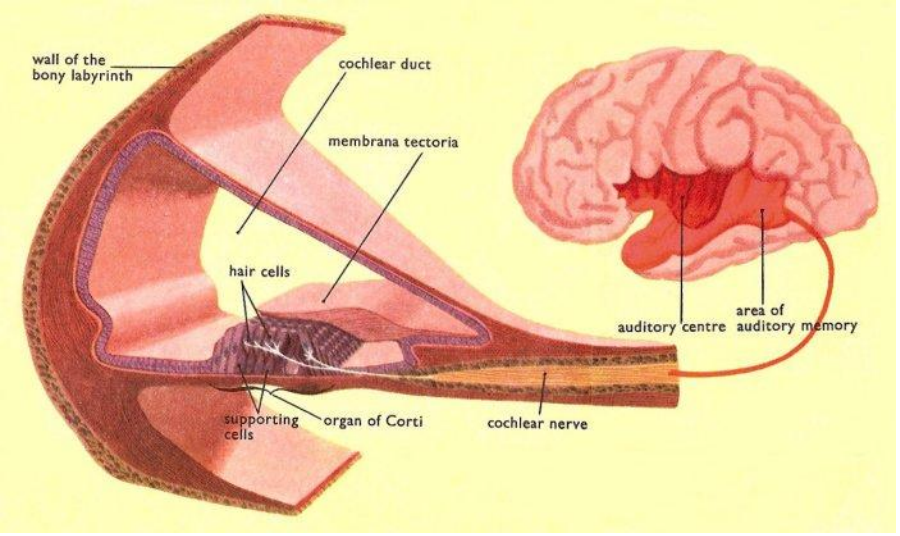

Endolymphatic duct
Endolymphatic sac
Anterior membranous ampulla
Temporal bone, petrous part, posterior surface of petrous part
Cranial dura mater
Utriculosaccular duct
Utricle
Common membranous limb
Vestibular saccule
Cochlear cupula
Vestibular caecum
Cupular caecum
Lateral semicircular duct
Cochlear duct
Scala vestibuli
Posterior semicircular canal
Ductus reuniens
Posterior semicircular duct
Scala tympani
Stapes
Cochlear canaliculus
Round window
Oval window
Posterior membranous ampulla

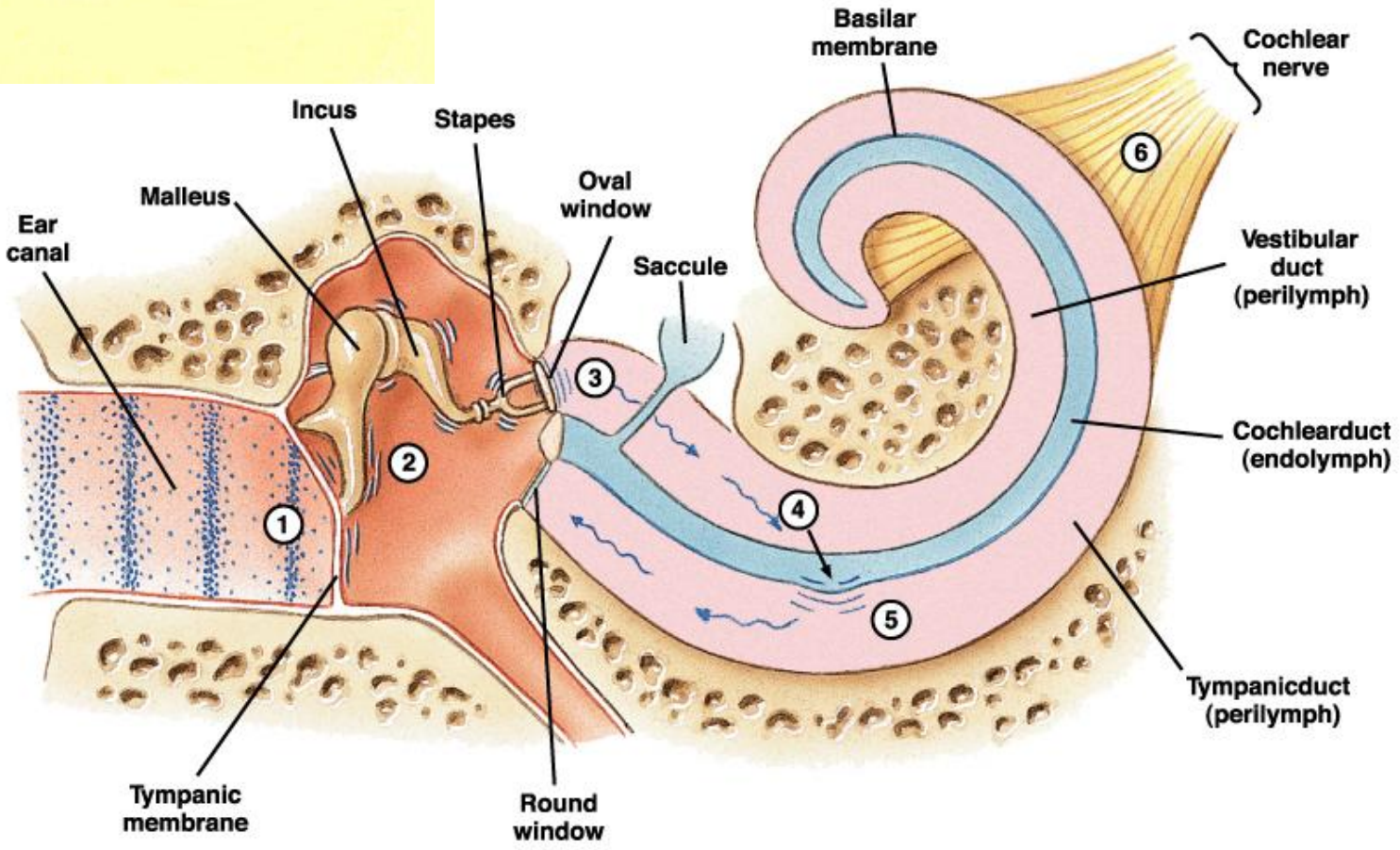

Labyrinthine artery
Anterior vestibular artery
Common cochlear artery
Posterior cochlear artery
Vestibulocochlear artery
U
S

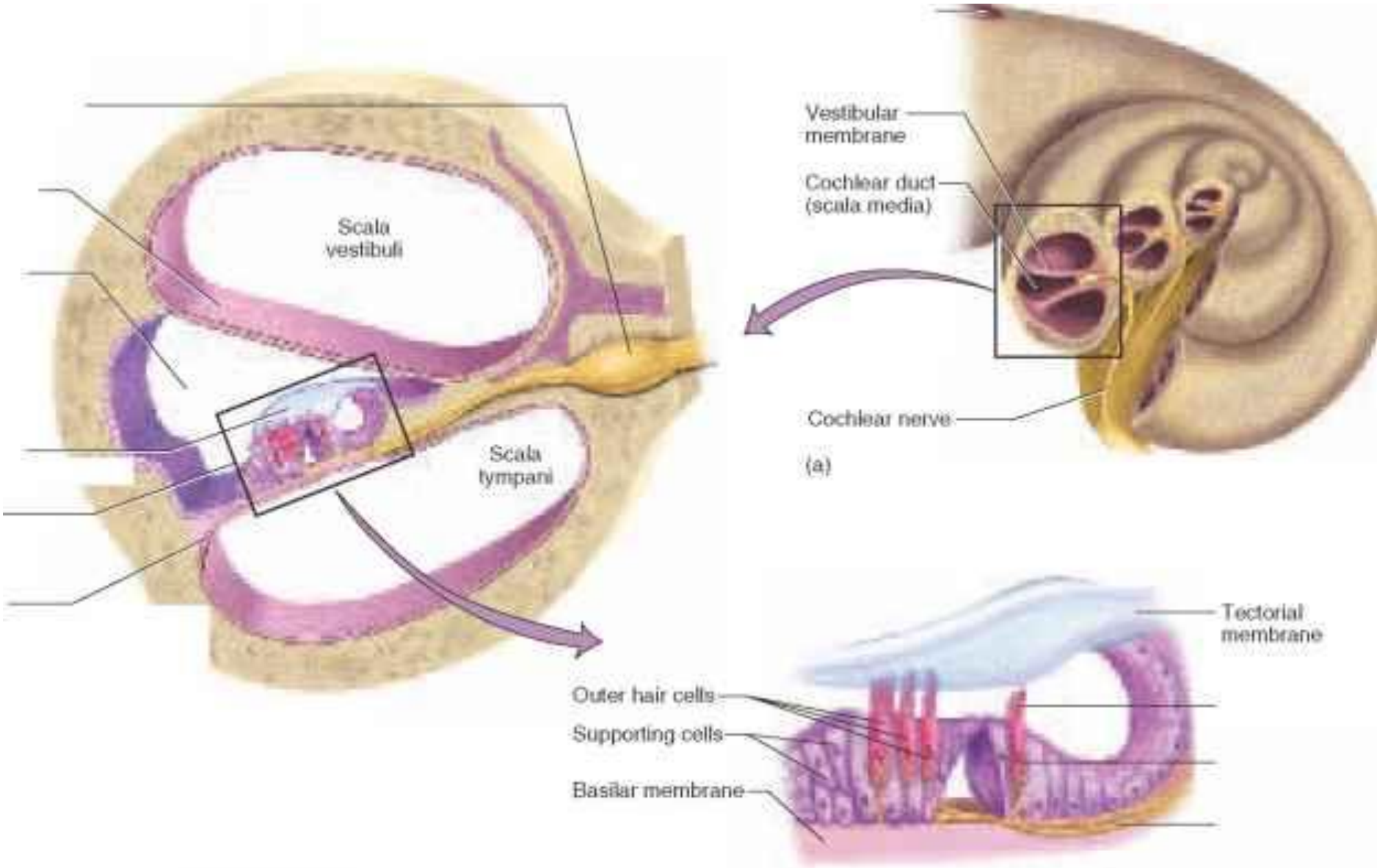

Anterior semicircular duct
Anterior ampullary nerve
Lateral ampullary nerve
Utricular nerve
Lateral semicircular duct
Vestibular nerve
Vestibular ganglion
Saccular nerve
Posterior semicircular duct
Cochlear duct
Posterior membranous ampulla
Posterior ampullary nerve
a

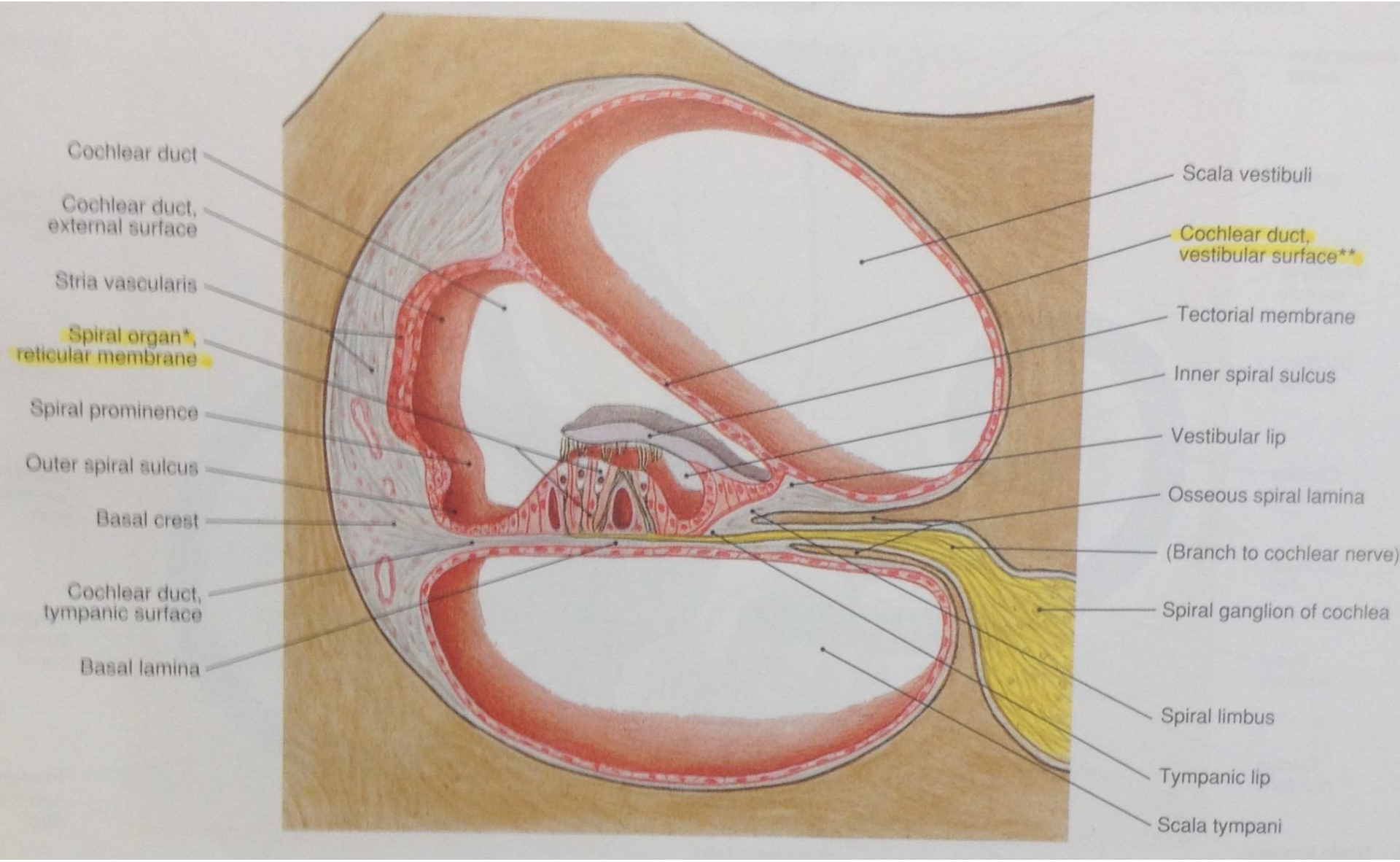

Saccular nerve
Cochlear duct
mpullary cupula
Ampullary crest
Ampullary nerve
* Sensory cells
** Supporting cells
c

Ampullary cupula

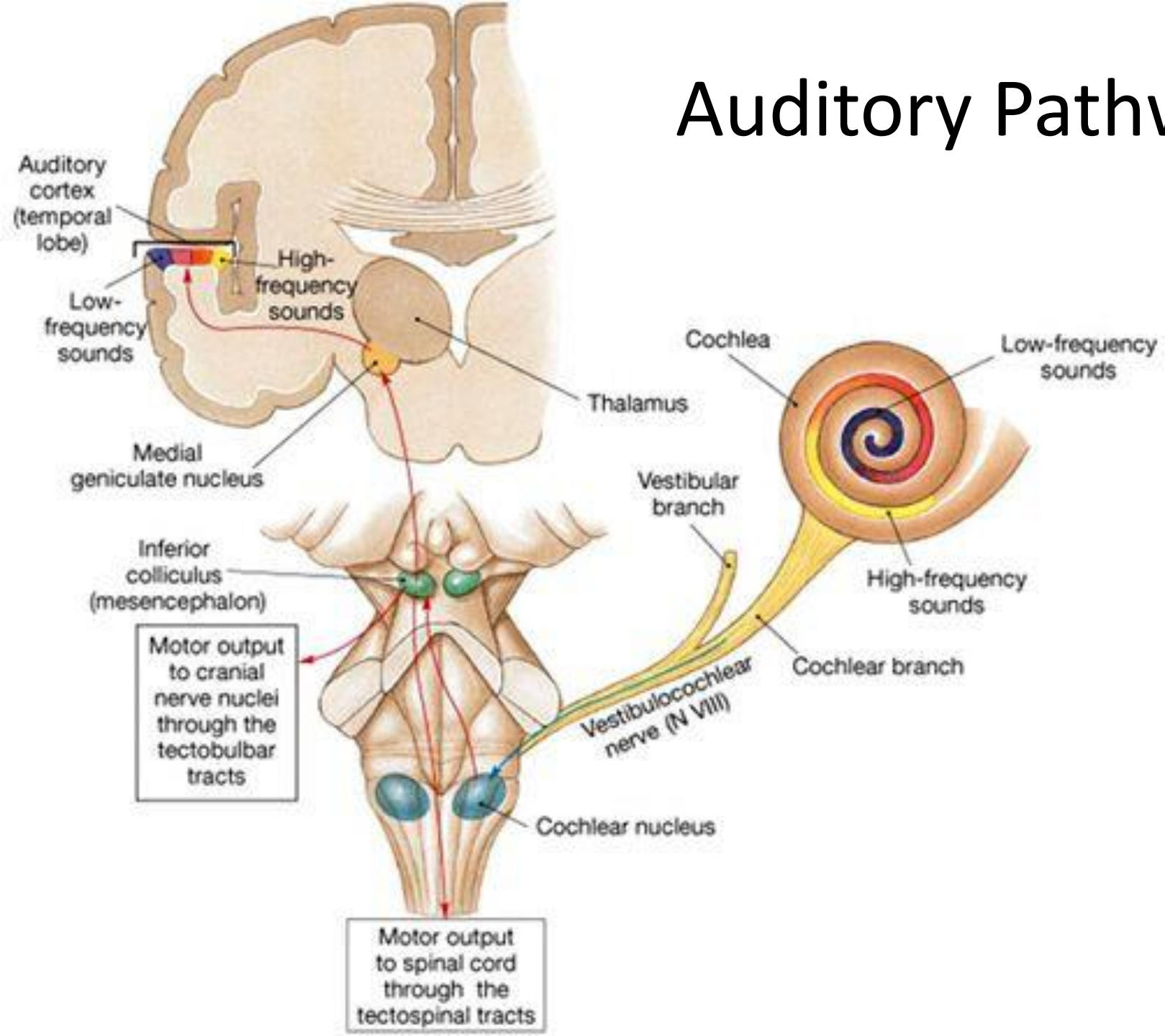

wall of the bony labyrinth
cochlear duct
membrana tectoria
hair cells
auditory centre
area of auditory memory
supporting cells
organ of Corti
cochlear nerve


Basilar membrane
Cochlear nerve
Incus
Stapes
Malleus
Oval window
Ear canal
Saccule
Vestibular duct (perilymph)
Cochlearduct (endolymph)
Tympanicduct (perilymph)
Tympanic membrane
Round window
1
2
3
4
5
6

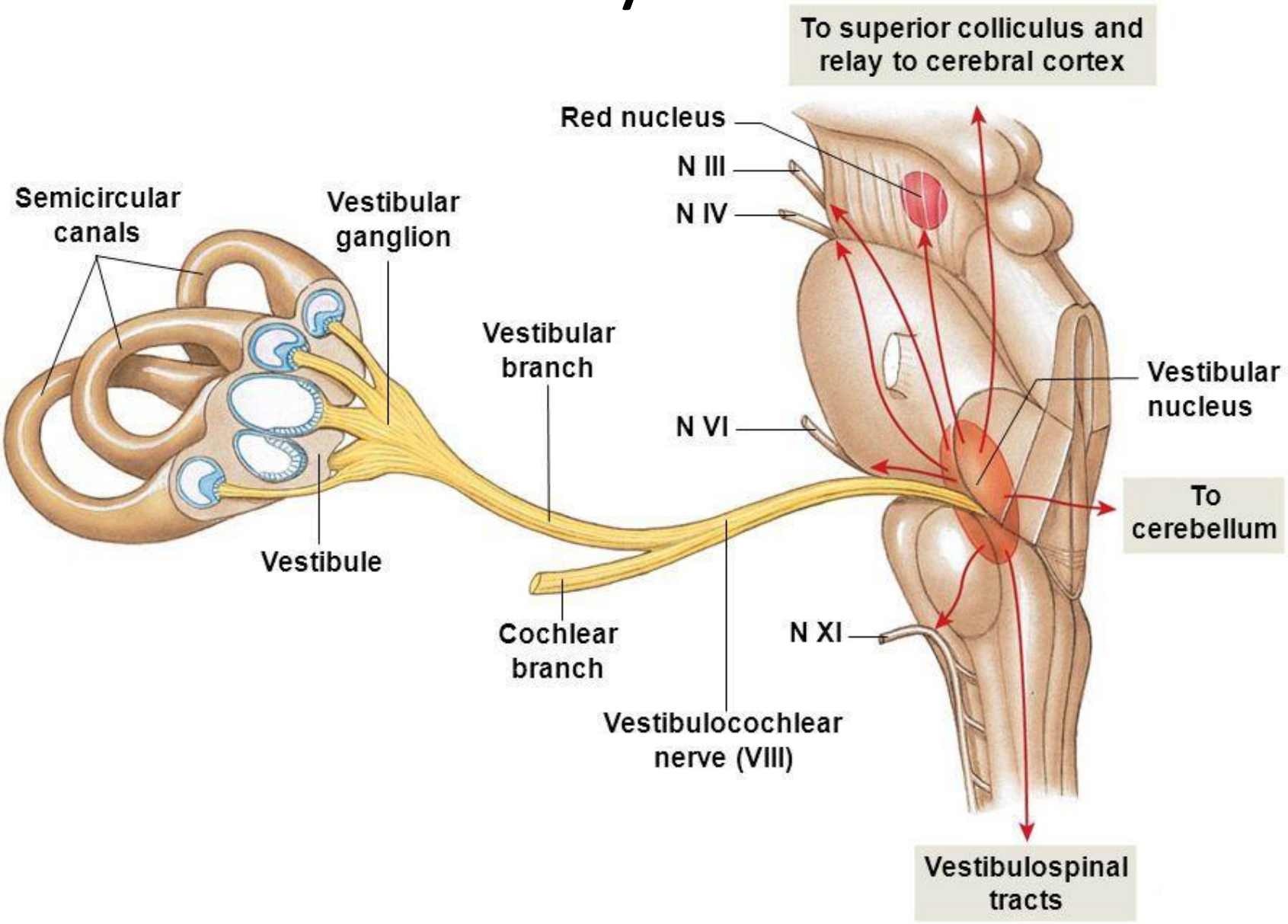

Scala vestibuli
Scala tympani
Vestibular membrane
Cochlear duct (scala media)
Cochlear nerve
(a)
Tectorial membrane
Outer hair cells
Supporting cells
Basilar membrane


Cochlear duct
Cochlear duct, external surface
Stria vascularis
Spiral organ*, reticular membrane
Spiral prominence
Outer spiral sulcus
Basal crest
Cochlear duct, tympanic surface
Basal lamina
Scala vestibuli
Cochlear duct, vestibular surface**
Tectorial membrane
Inner spiral sulcus
Vestibular lip
Osseous spiral lamina
(Branch to cochlear nerve)
Spiral ganglion of cochlea
Spiral limbus
Tympanic lip
Scala tympani

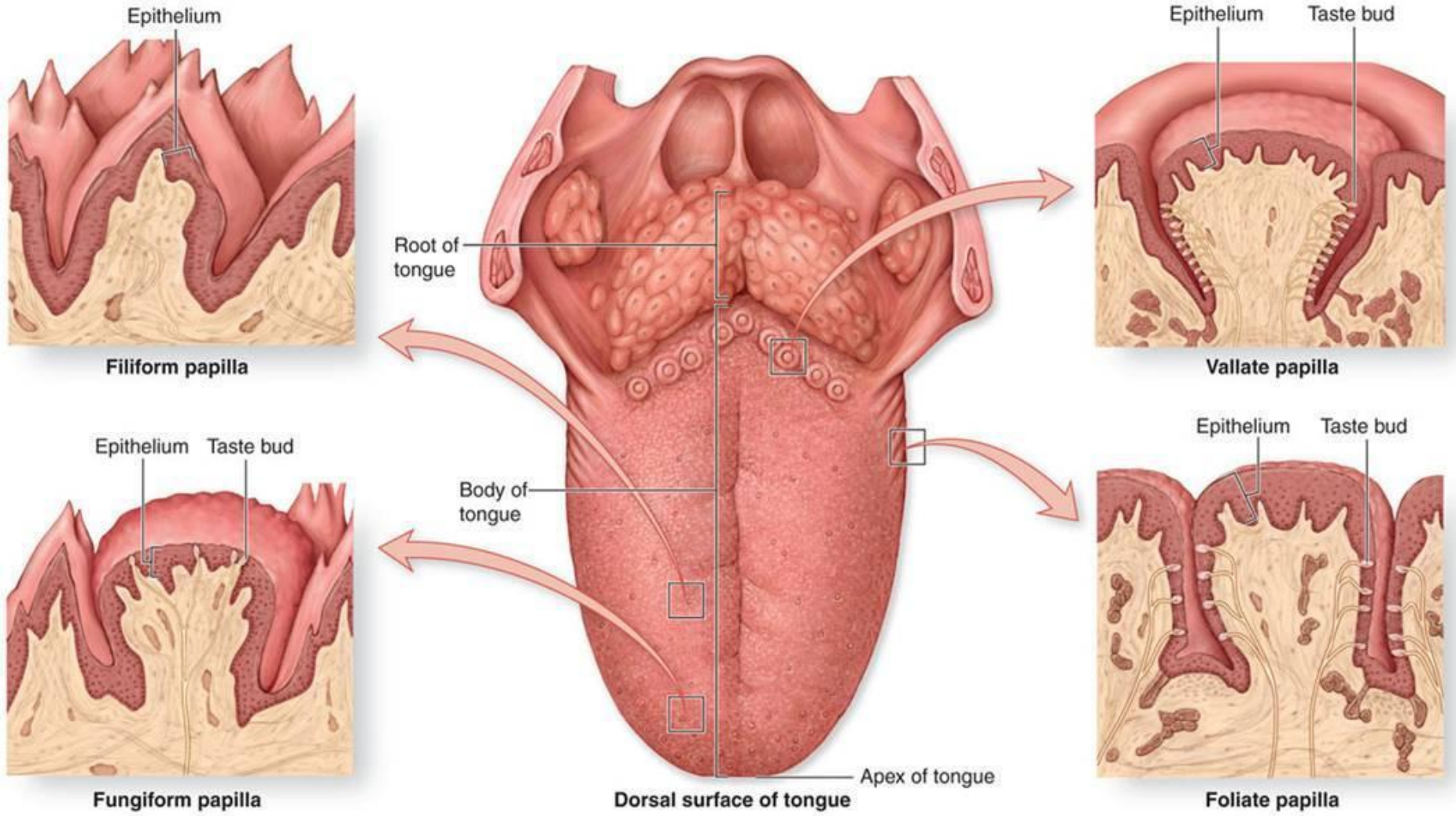
Auditory Pathway



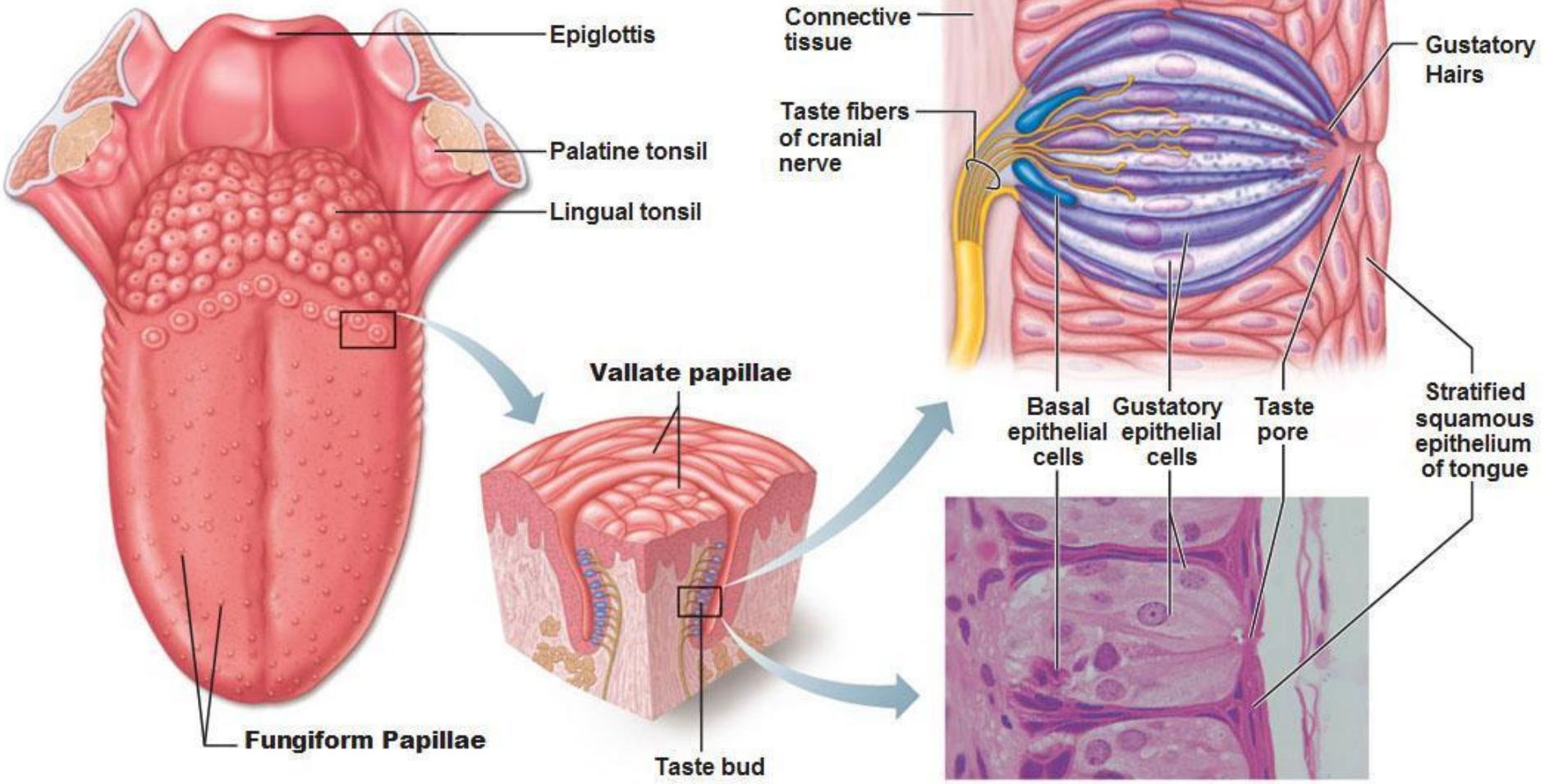
Vestibular Pathway



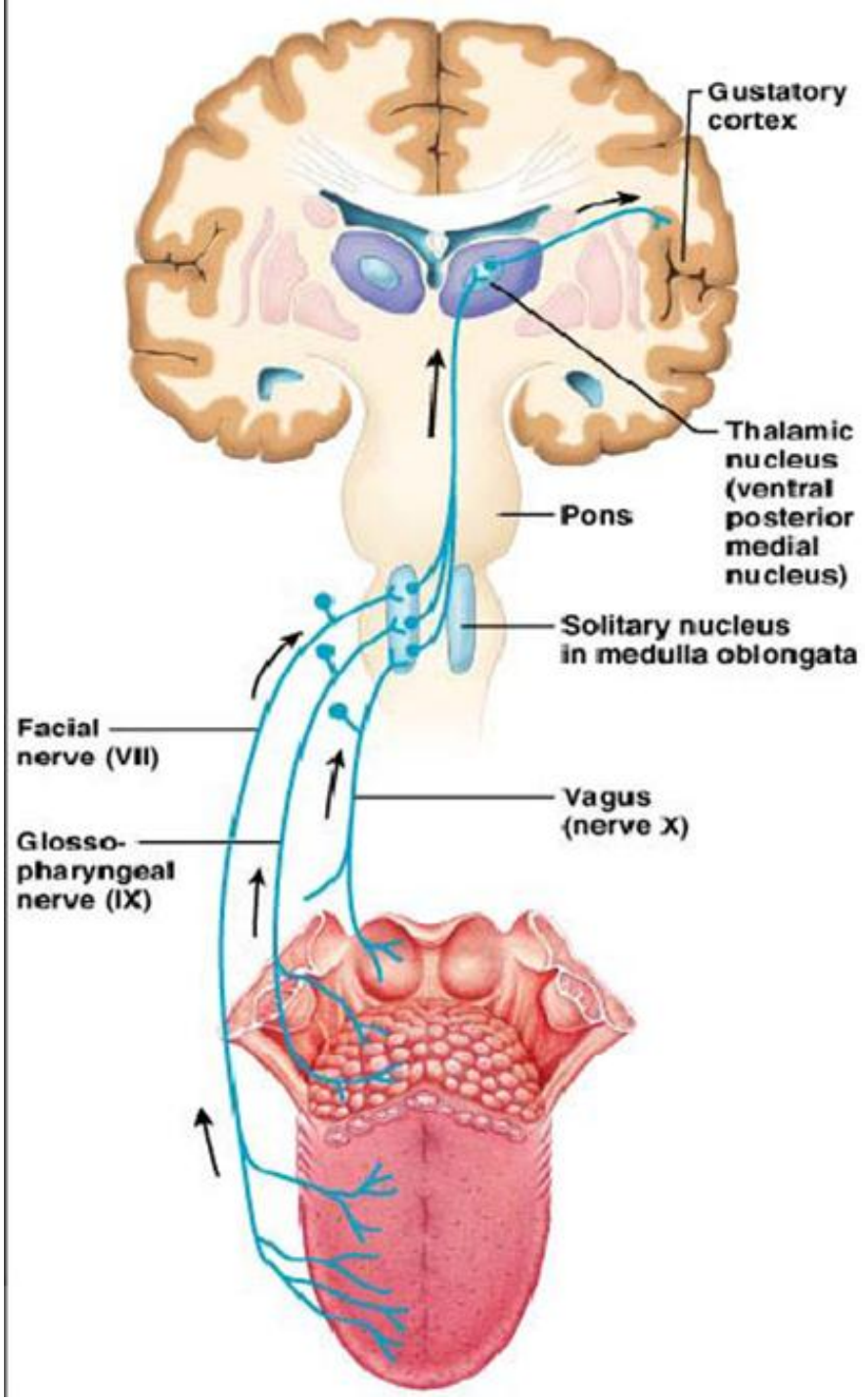
Taste Buds Types & localization



Taste Buds

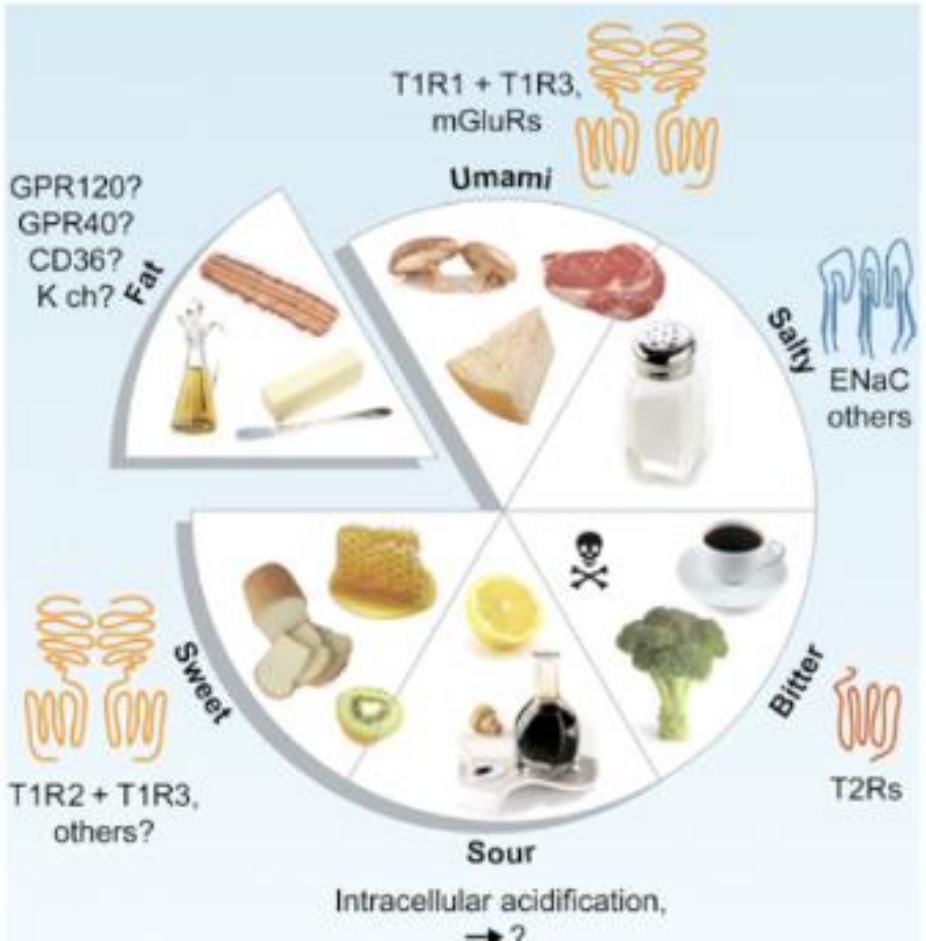

Epiglottis
Palatine tonsil
Lingual tonsil
Fungiform Papillae
Vallate papillae
Taste bud
Connective tissue
Taste fibers of cranial nerve
Gustatory Hairs
Basal epithelial cells
Gustatory epithelial cells
Taste pore
Stratified squamous epithelium of tongue

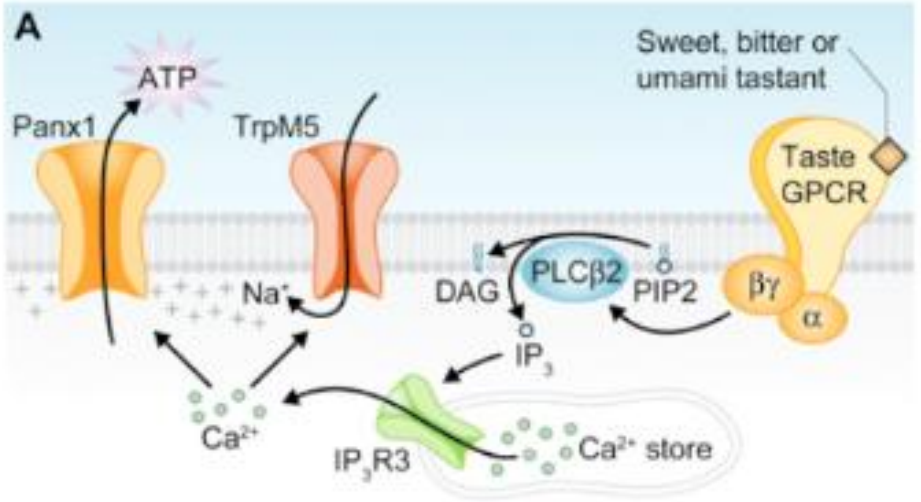
Gustatory Pathway

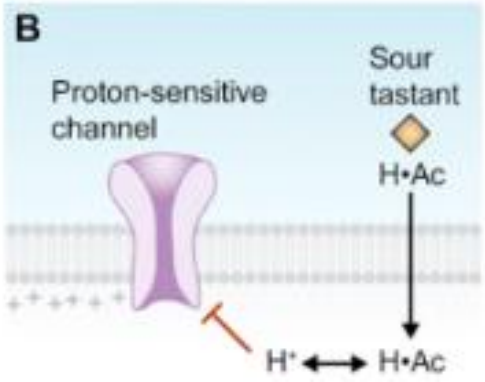


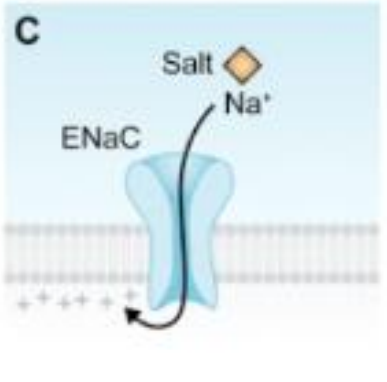
Taste Sensation:

. Sweet
. Bitter
. Sour
. Salty
. Umami
. Water (Even though some still don't agree)
. Toxic ? (It could be grouped under extreme bitterness)









ANKYLOGLOSSIA

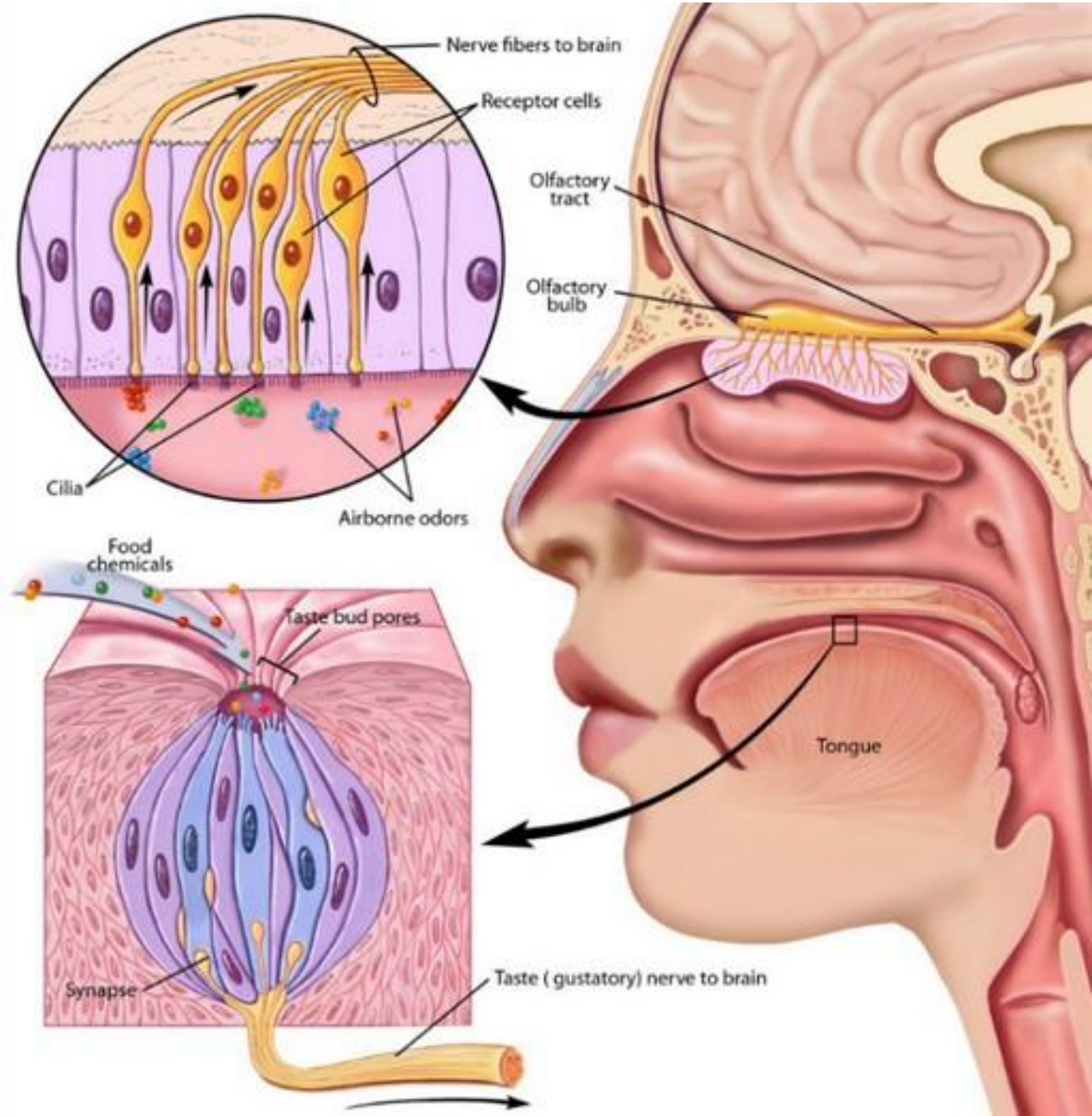
Tongue Blisters

Coating Fungal Infection

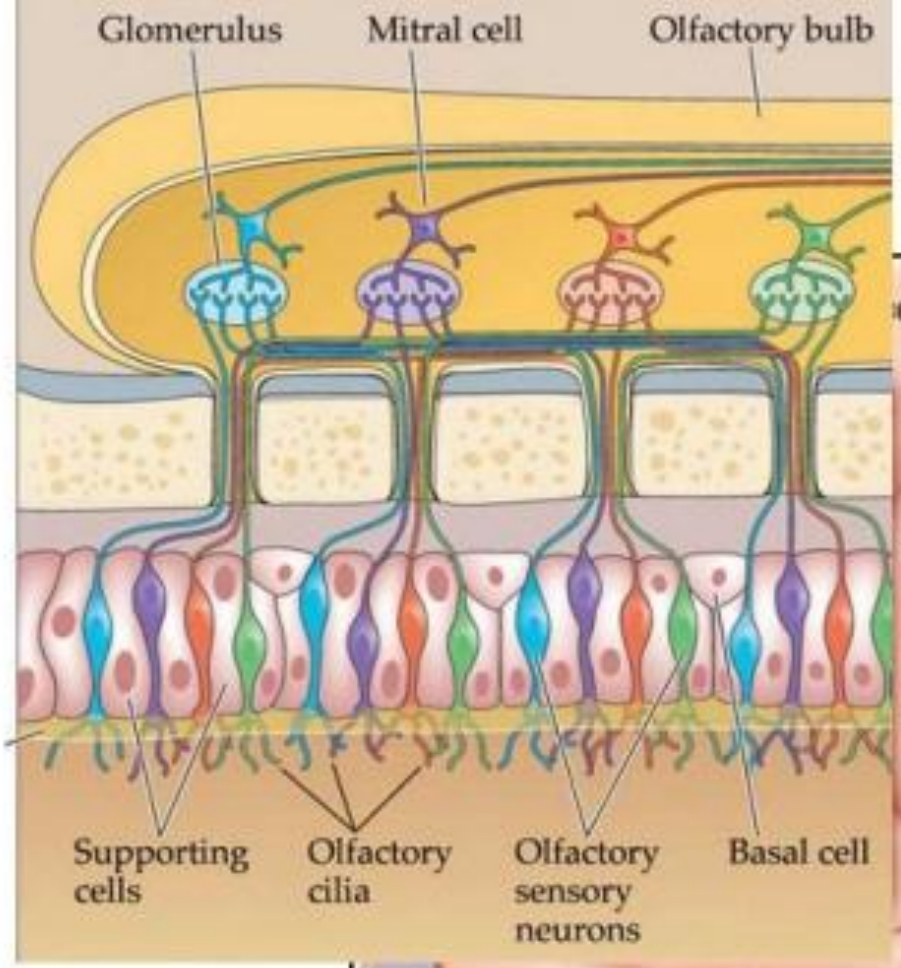
Fissured Tongue

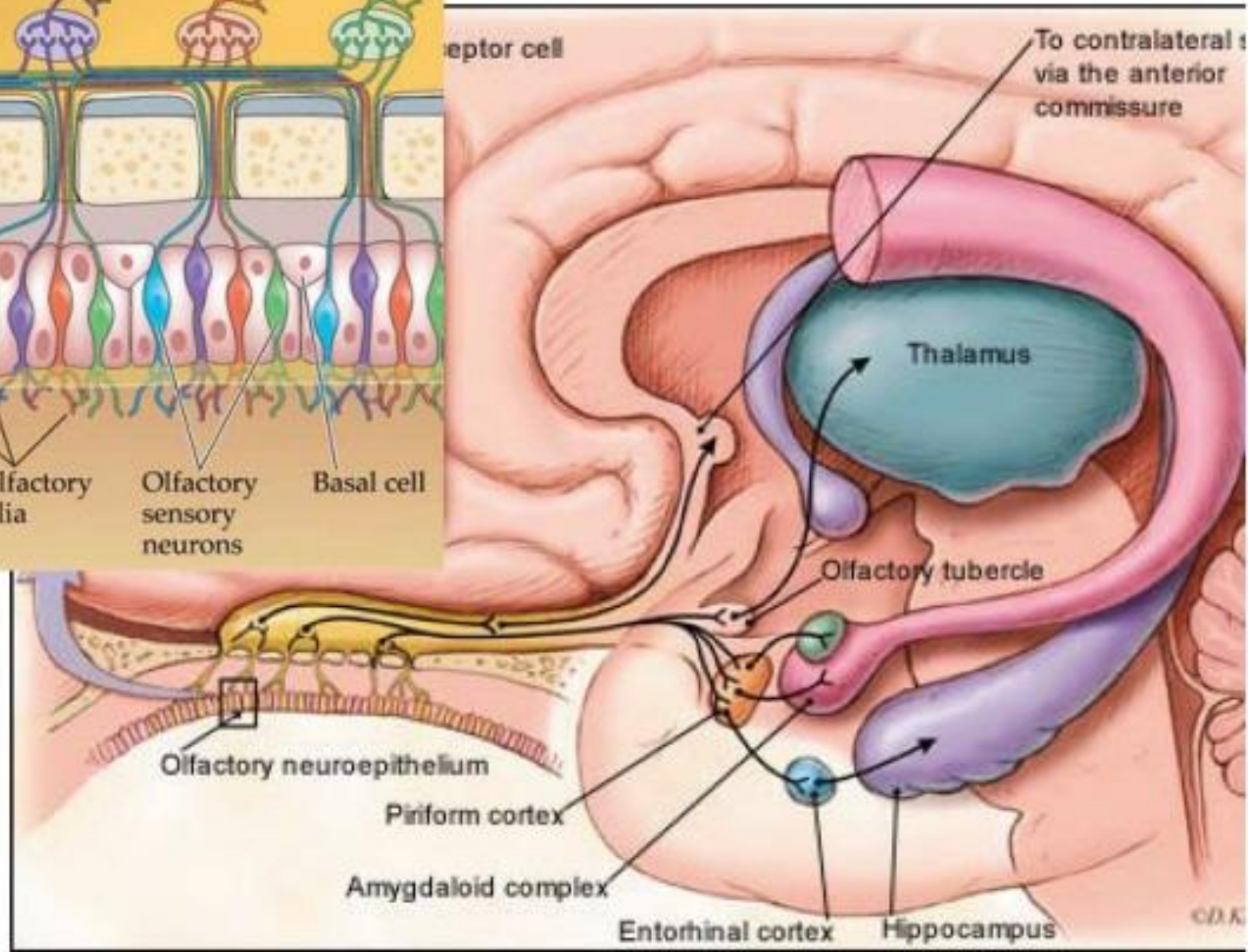
Bifid Tongue

Olfaction


Nerve fibers to brain
Receptor cells
Olfactory tract
Olfactory bulb
Cilia
Airborne odors
Food chemicals
Taste bud pores
Tongue
Synapse
Taste (gustatory) nerve to brain

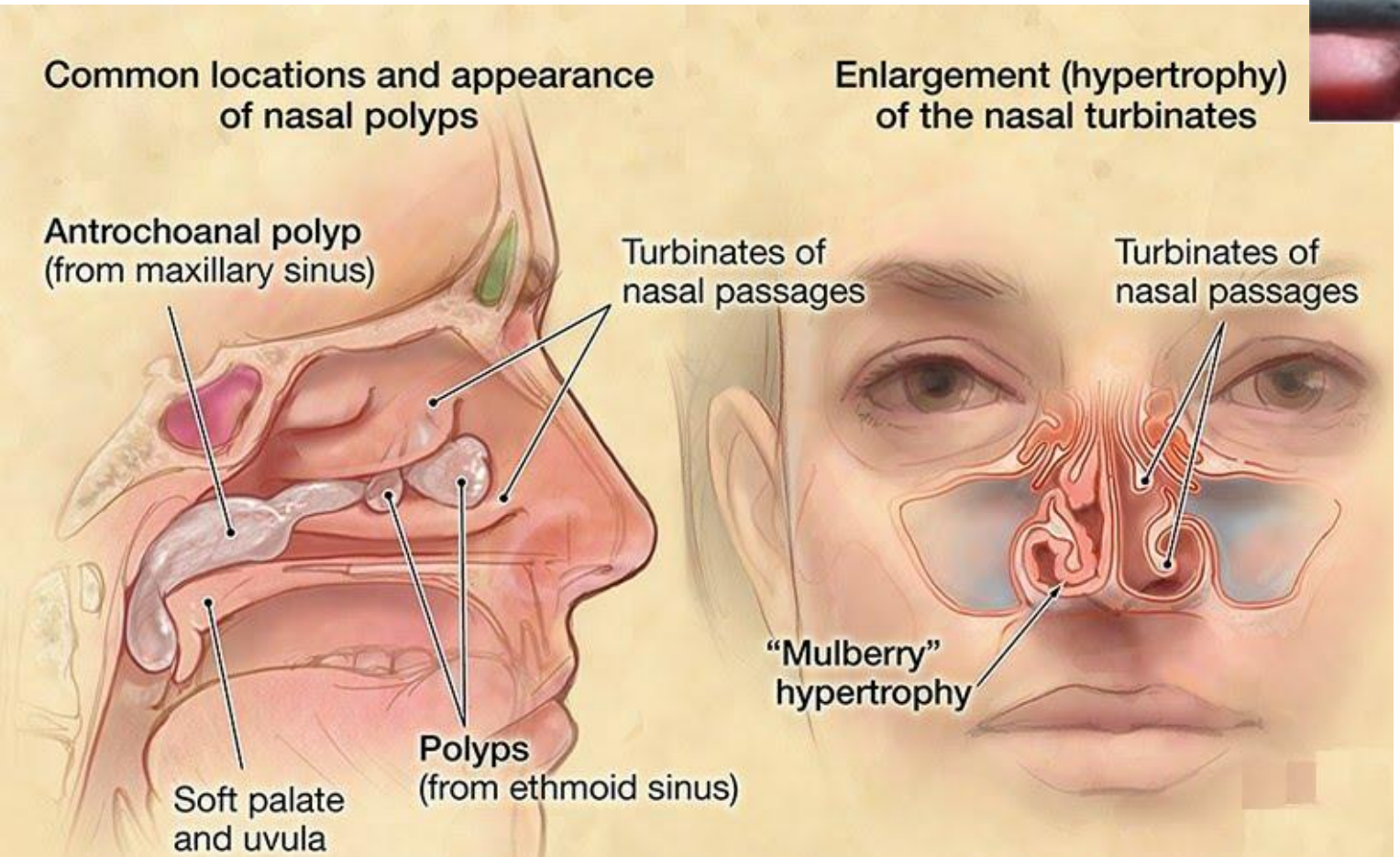
Olfactory Pathway





Example of Anatomical related disorder interfering with olfaction quality:

Nasal Polyp



Pain: Evolutionary mechanism initiating neurophysiologic process toward stimuli disturbing haemostasis (damage) → Protection

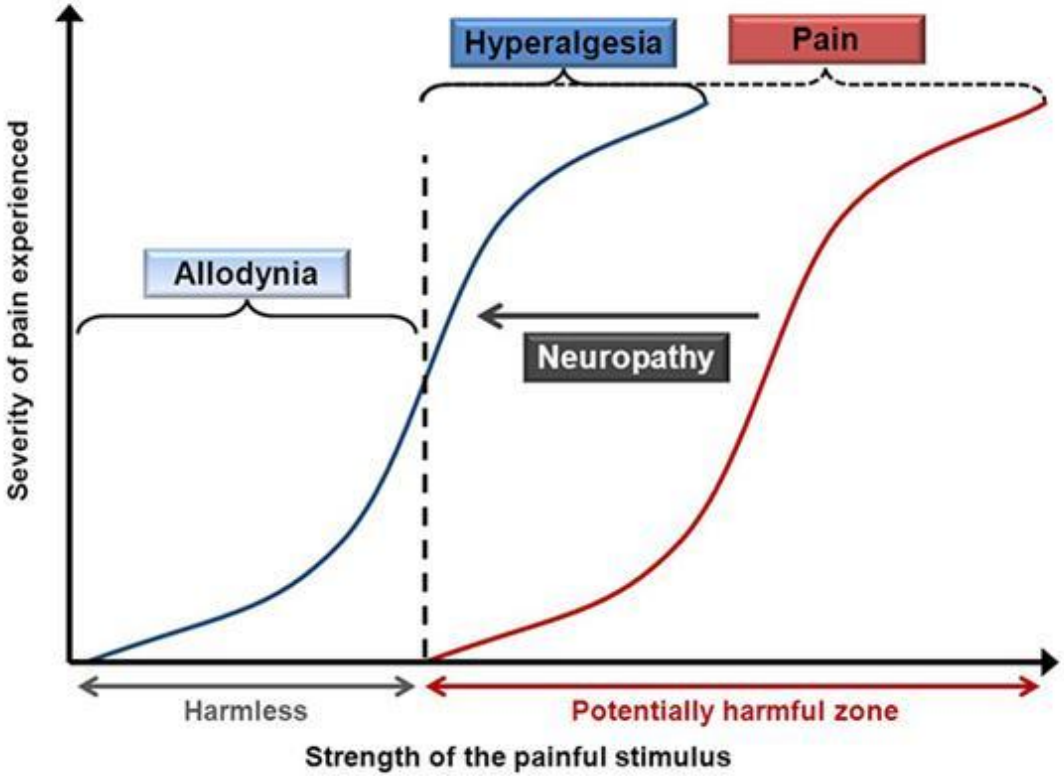
a) Repulsion away from harmful triggers

b) Awareness of harmful sources

*When a stimuli is NOT sensed → SIELNT HARM

e.g. Diabetic foot (Delayed awareness of bleeding and infection during stepping injuries)

Pain types	Nociceptive	Neuropathic
Definition	Pain caused by physiological activation of pain receptors	Pain caused by lesion or dysfunction of the somatosensory system, especially the nociceptive pathway
Mechanism	Natural physiological transduction	Ectopic impulse generation, among others
Localization	Local + referred pain	Confined to innervation territory of the lesioned nervous structure
Quality of symptoms	Ordinary painful sensation (good verbal descriptors)	New strange sensations (poor verbal descriptors)
Treatment	Good response	Poor-moderate response



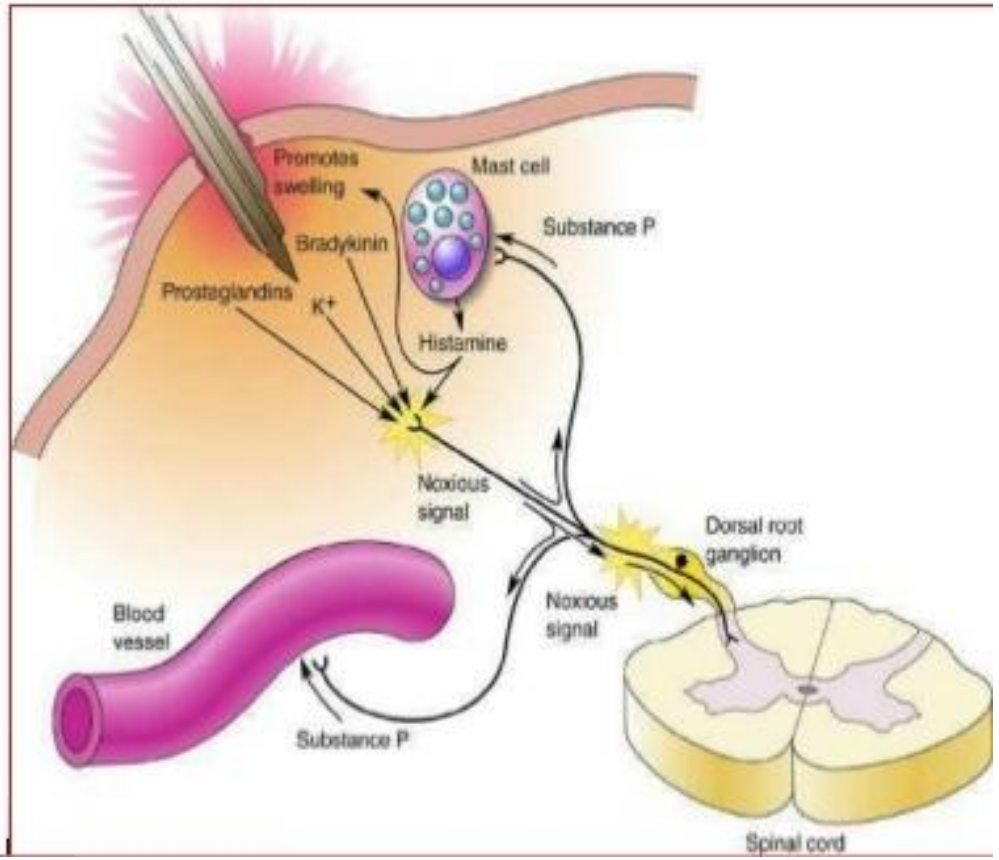
Classification of pain b

- pain
  - Based on etiology
    - Nociceptive pain
      - Somatic pain
      - Visceral pain
    - Neuropathic pain
      - Peripheral neuropathic pain
      - Central neuropathic pain

Pain

Nociceptors

- Nociceptors are special receptors that respond only to **noxious** stimuli and generate nerve impulses which the brain interprets as "pain"
- Free nerve endings
- Tissue damage

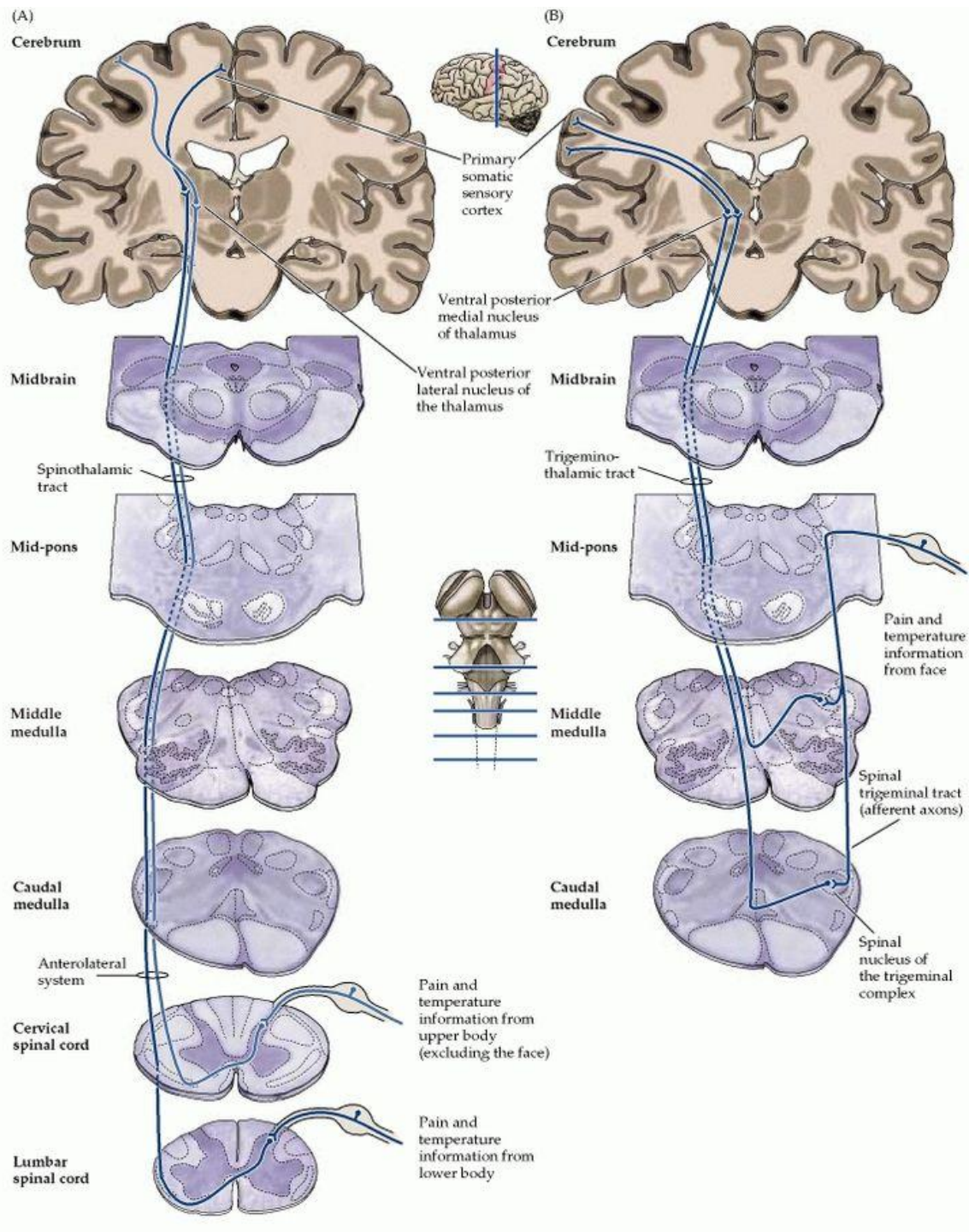


Nociceptors

- Free nerve endings that respond to intense stimuli
- Types:
  - **Mechanical**
    - Strong pressure, sharp objects
  - **Thermal**
    - Burning heat (>45ºC)
    - Noxious cold (variable)
  - **Chemical**
    - pH extremes
    - Environmental irritants
    - Internal neuroactive substances
  - **Polymodal**
- Sensations mediated by Aδ fibers (sharp, intense pain) and C fibers (persistent, dull pain).

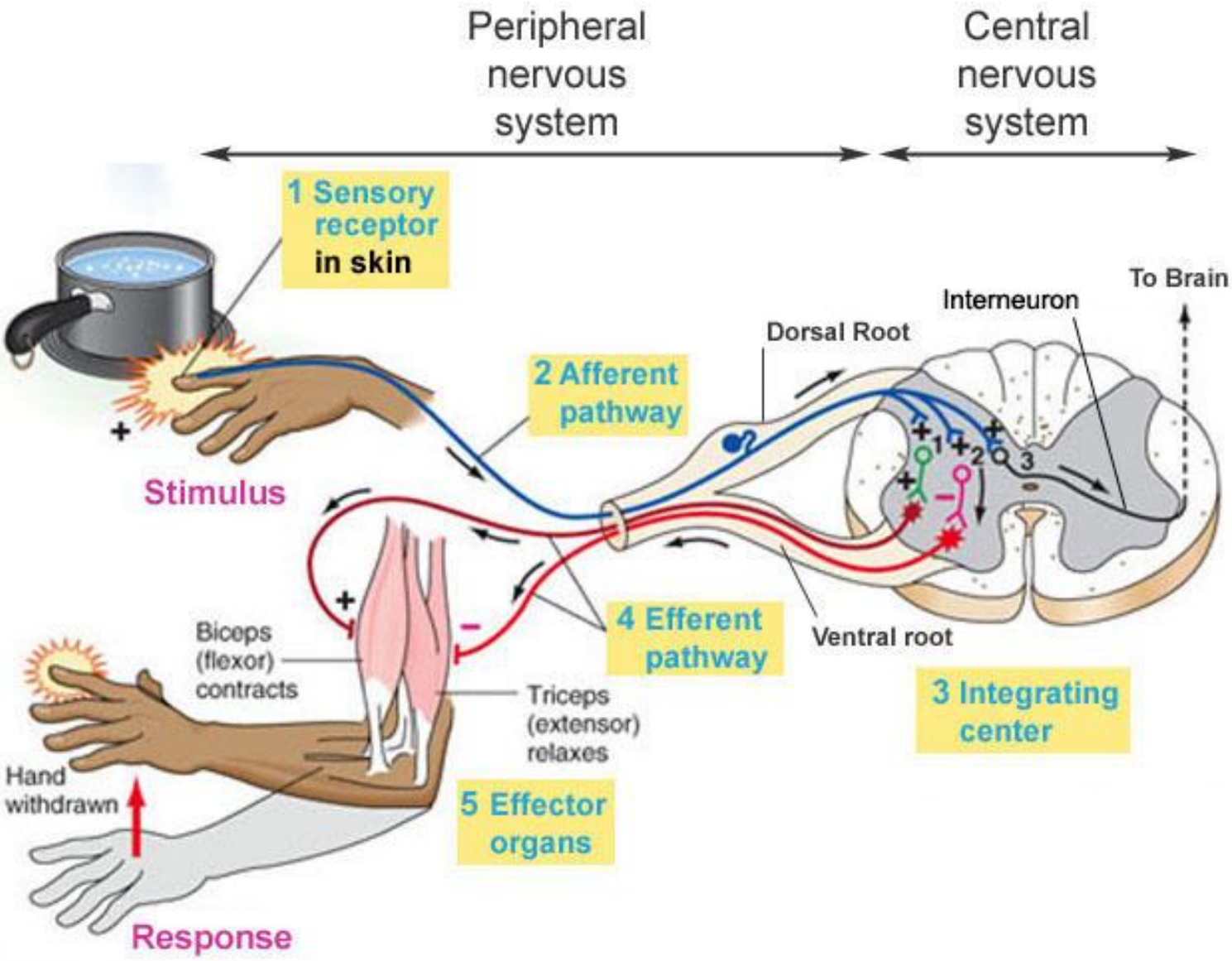
Pain Pathways:

A) From Body (Left)
B) From Face (Right)



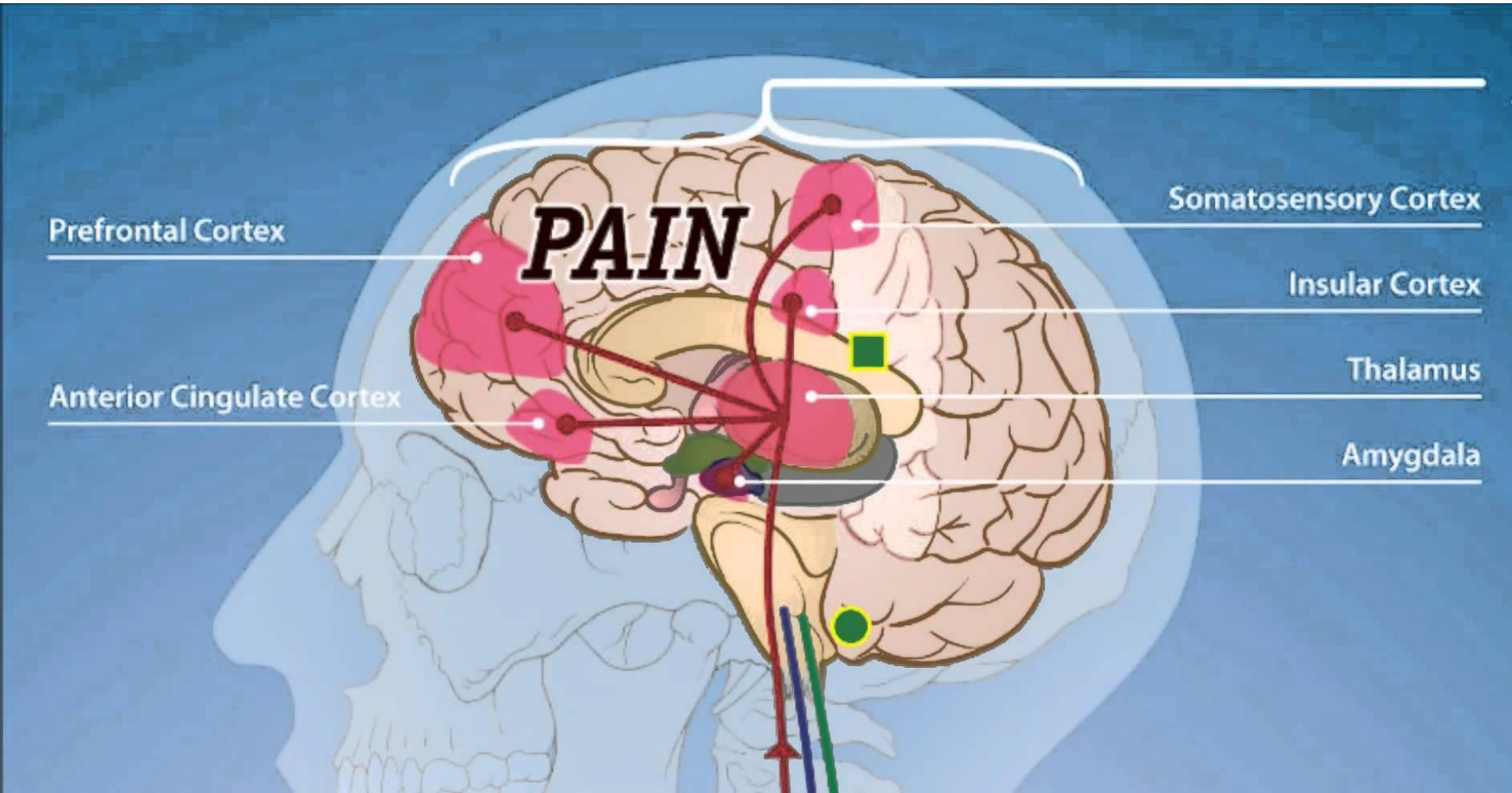
1st Respond – Spinal Arch Reflex

*Immediate & fast before signal had reached the brain → repulse from pain stimuli without thinking!

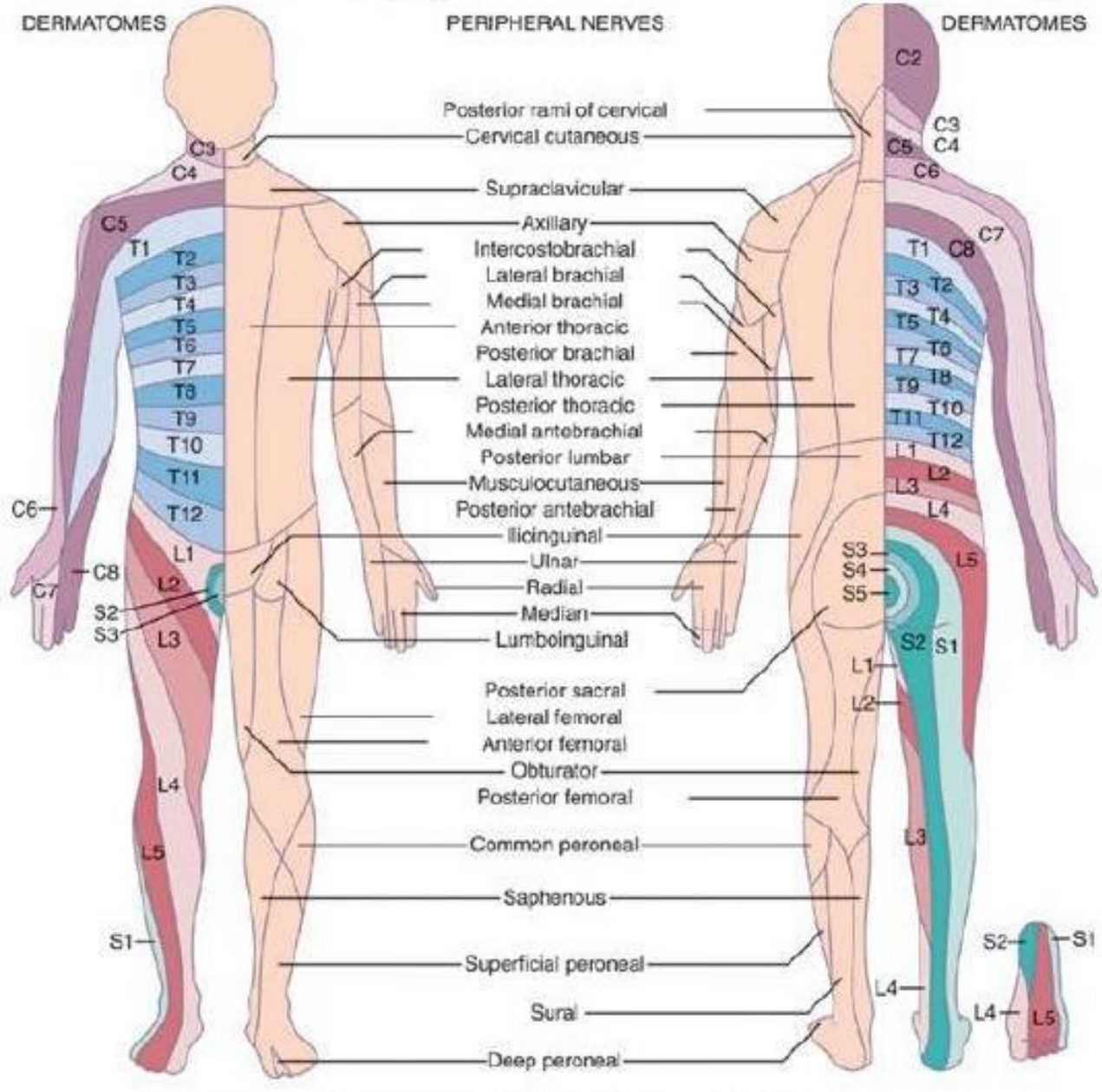


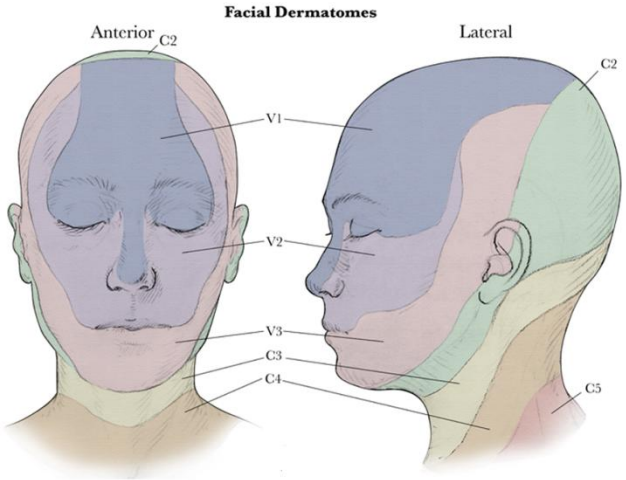
2nd Respond – Cortical modulation

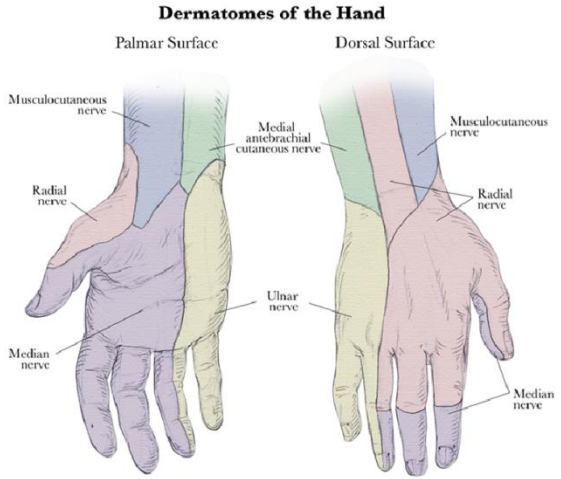
*Delayed & speed varies → Thinking of how to deal with the situation
*Repetitive or Long term stimulation lead to adaptability
*Establish memory → a. Influence future responses b. Mechanism in psychological Trauma



Coetaneous Pain Source → Dermatomes

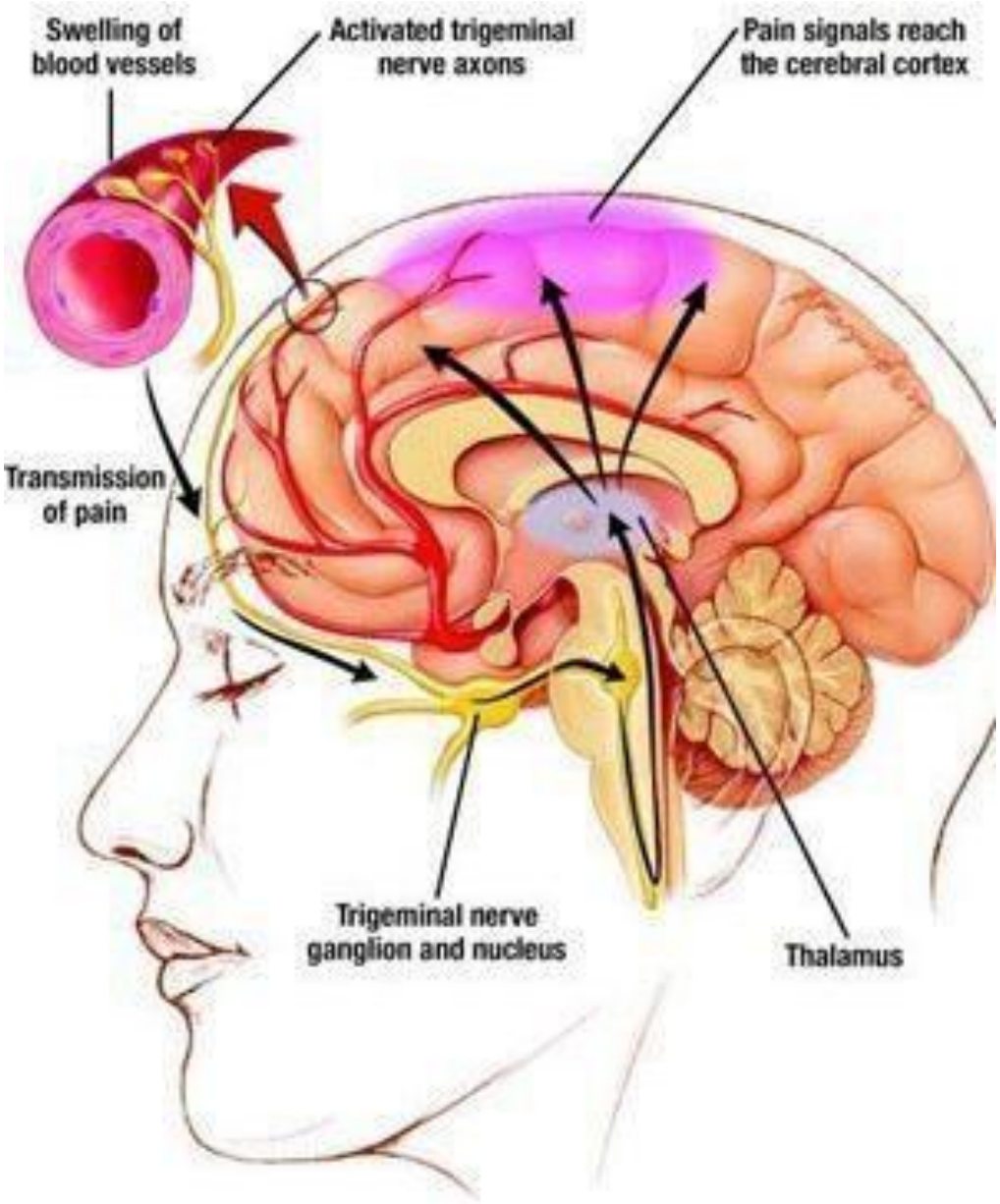






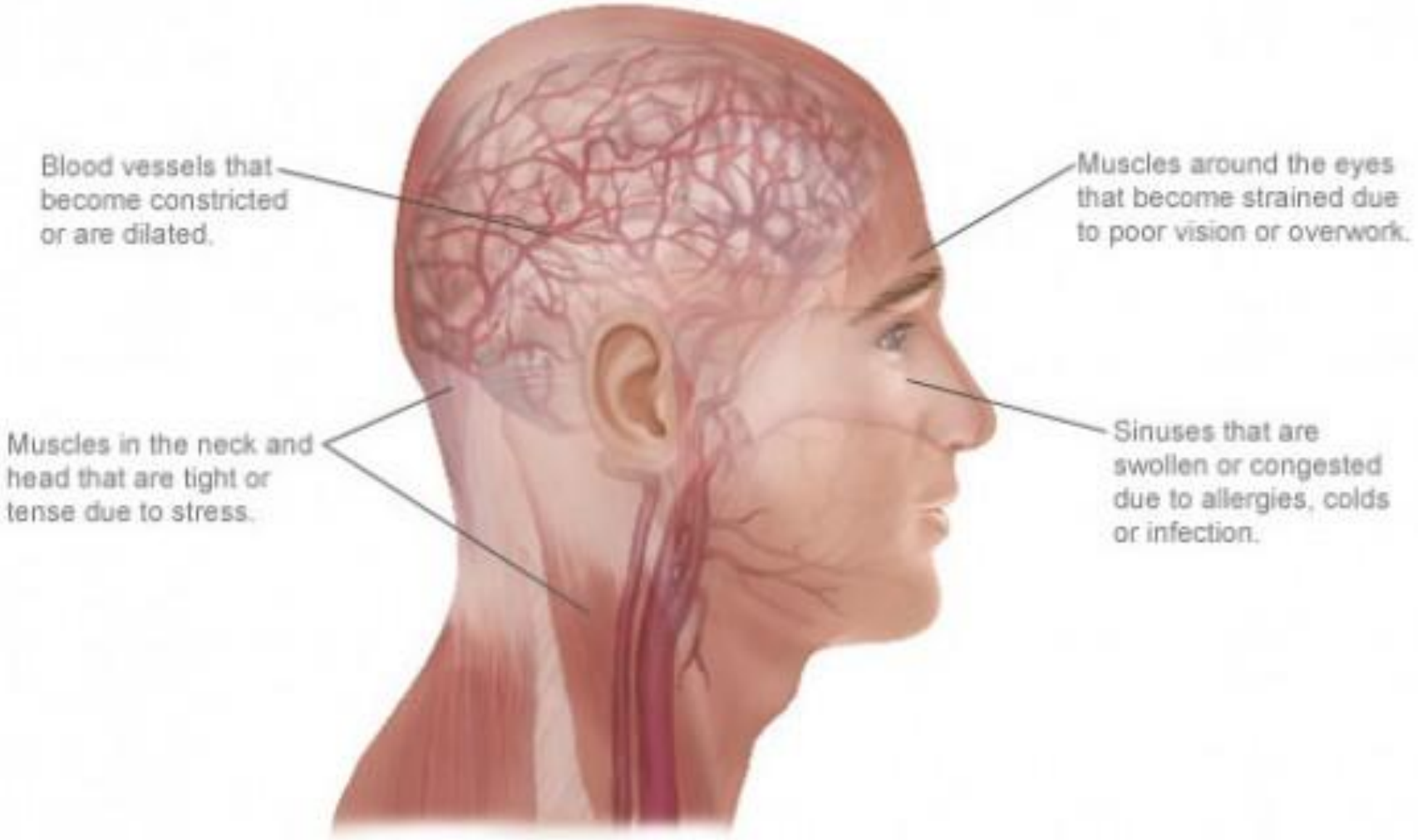
Headache???

*Source: Vessels, Meanings, Surrounding tissues
*NOT the Brain itself



Common Headache Causes

A headache is defined as a pain in the head that is located above or around the eyes or ears, at the back of the head or in the upper area of the neck. Headaches have many causes, including:



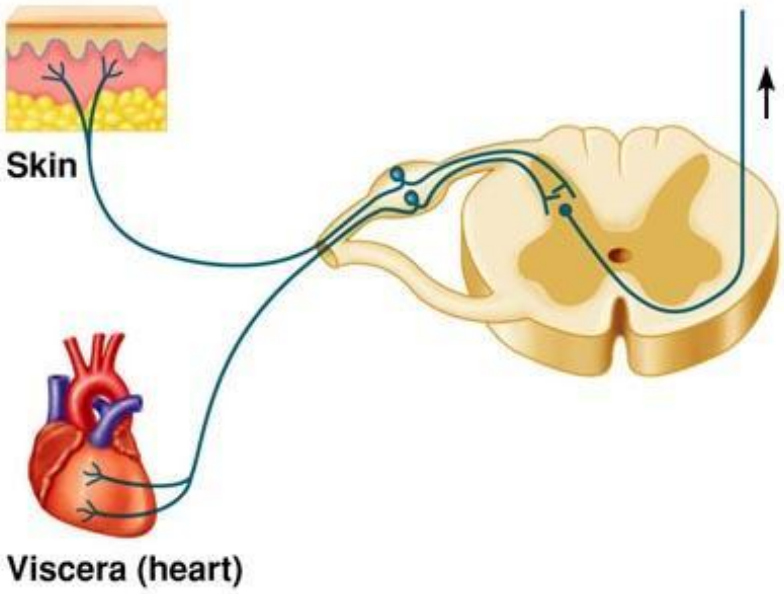
Refereed Pain

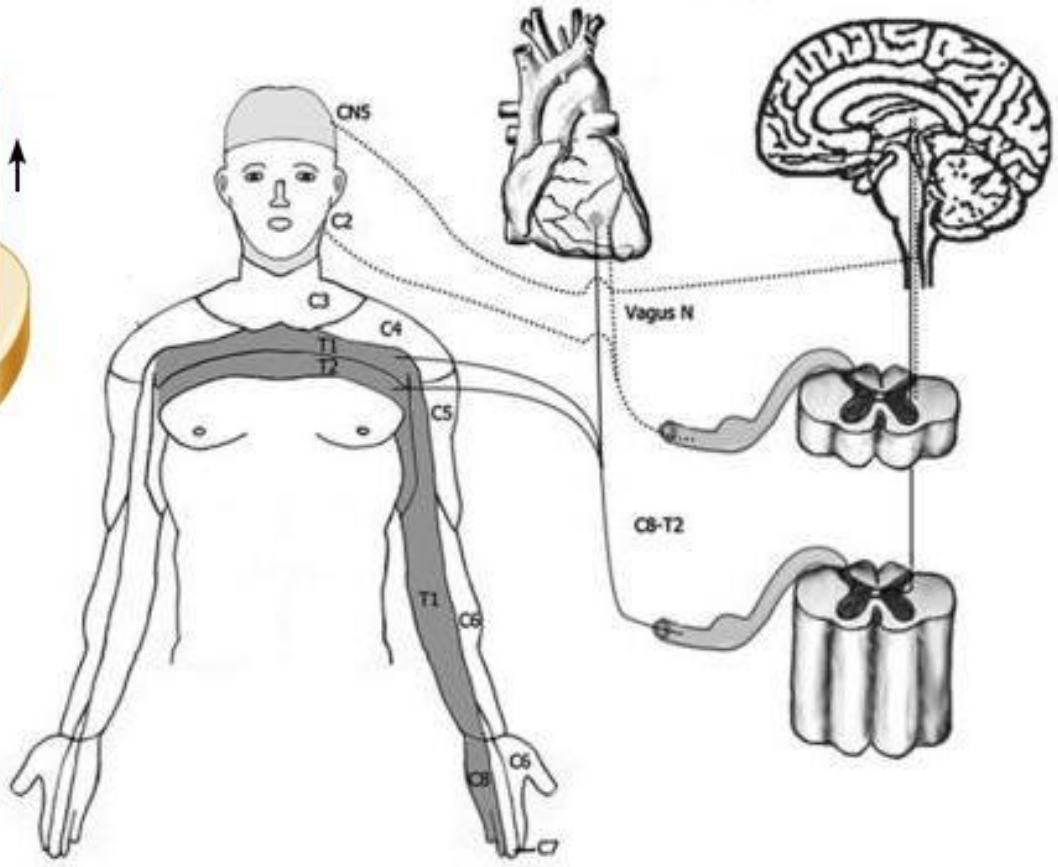
Visceral pain perceived on a distal dermatome

*Brain misinterpret signal due to common segmental innervations.

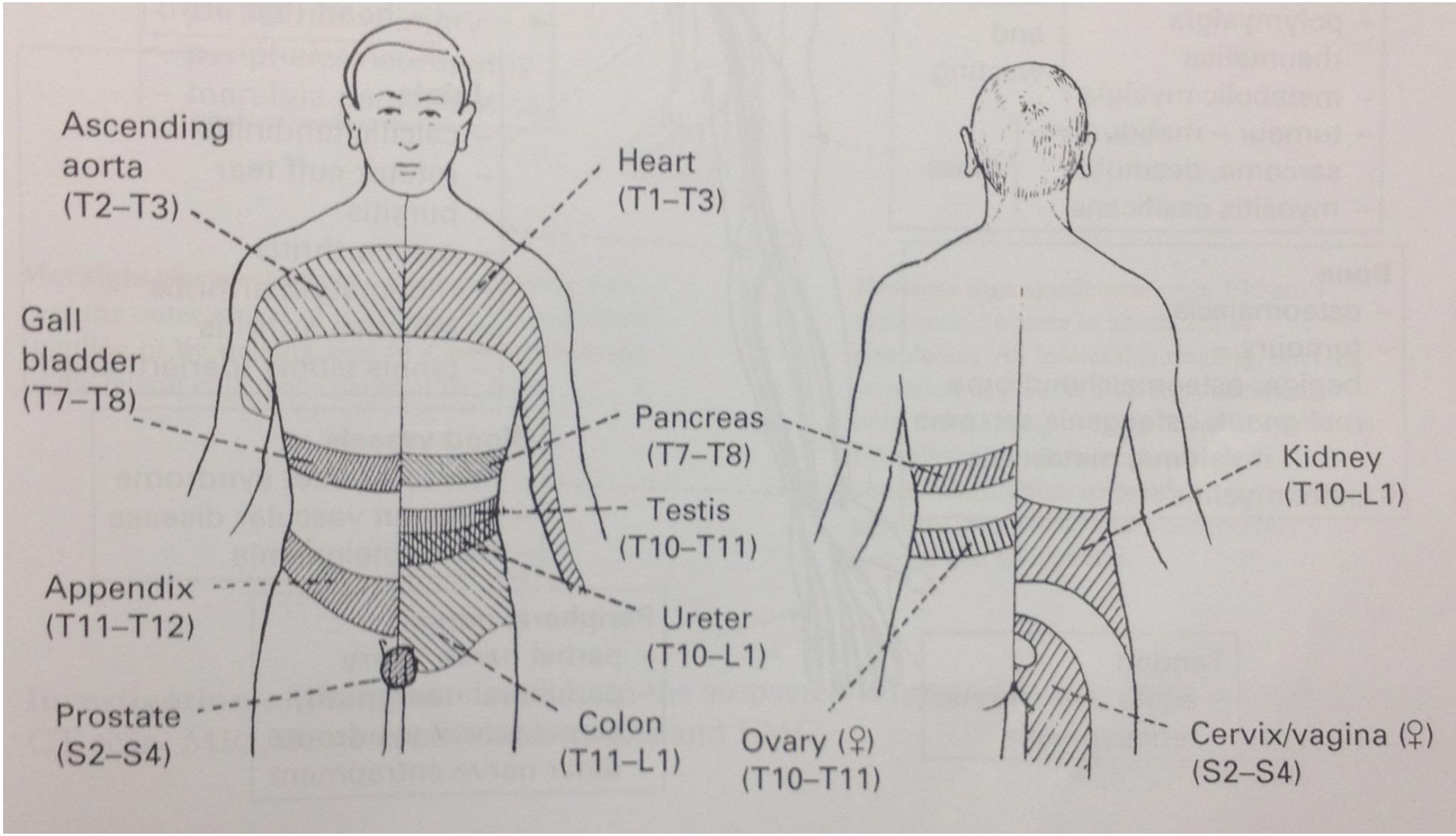
*Useful in understanding <u>patients subjective pain complain.</u>

*Multiple hypothesized mechanisms – subject of research

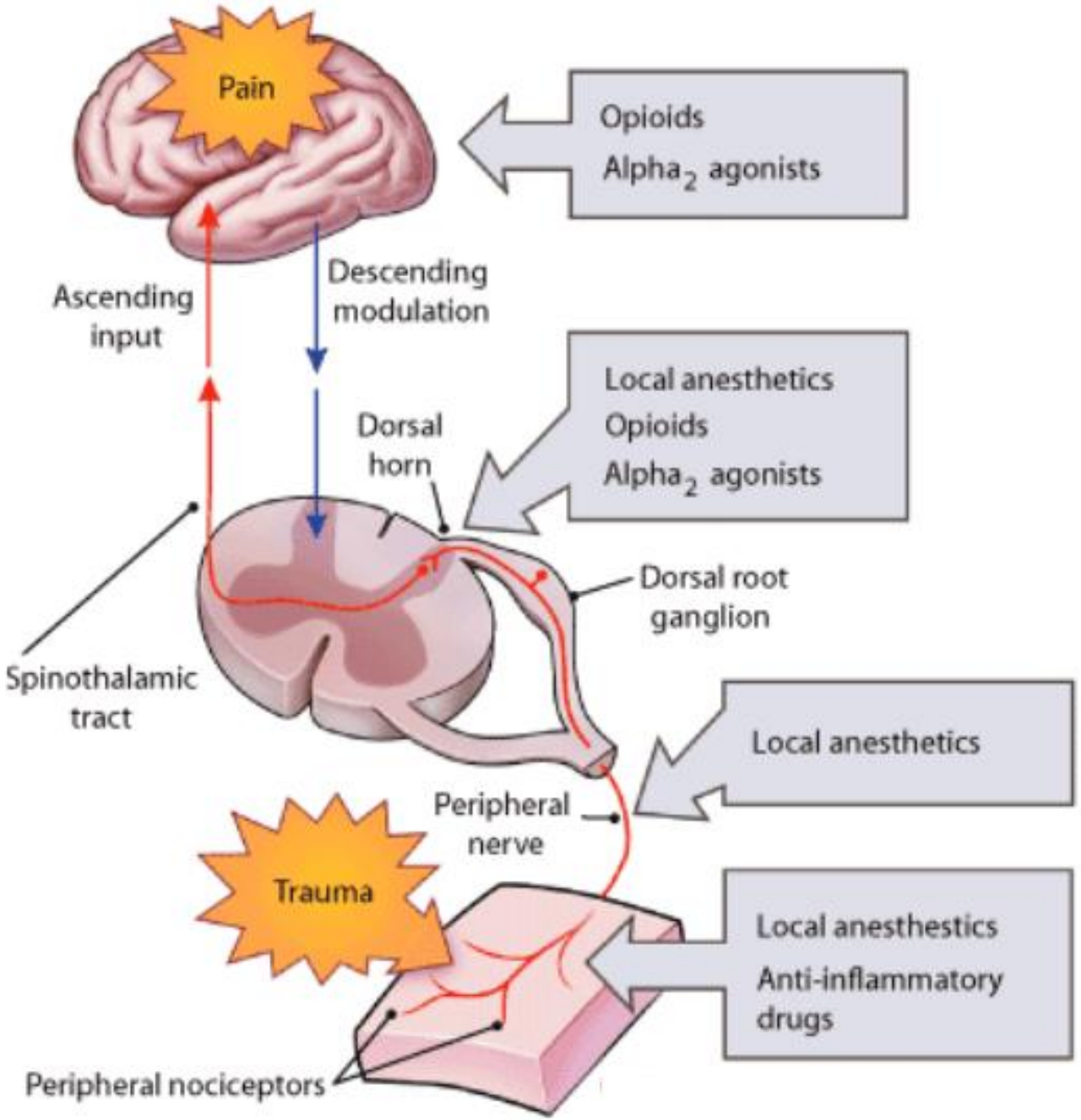




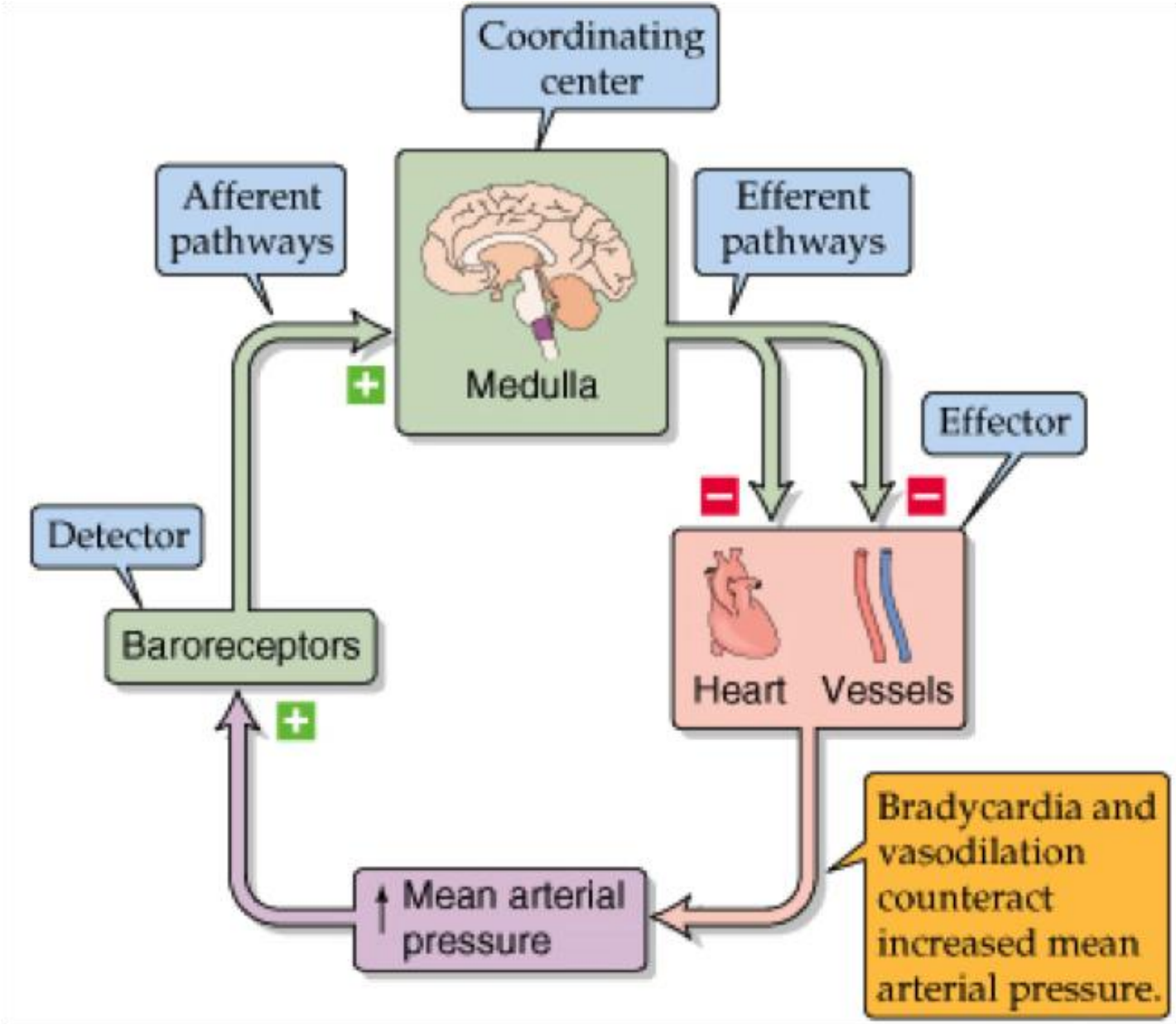
Refereed Pain



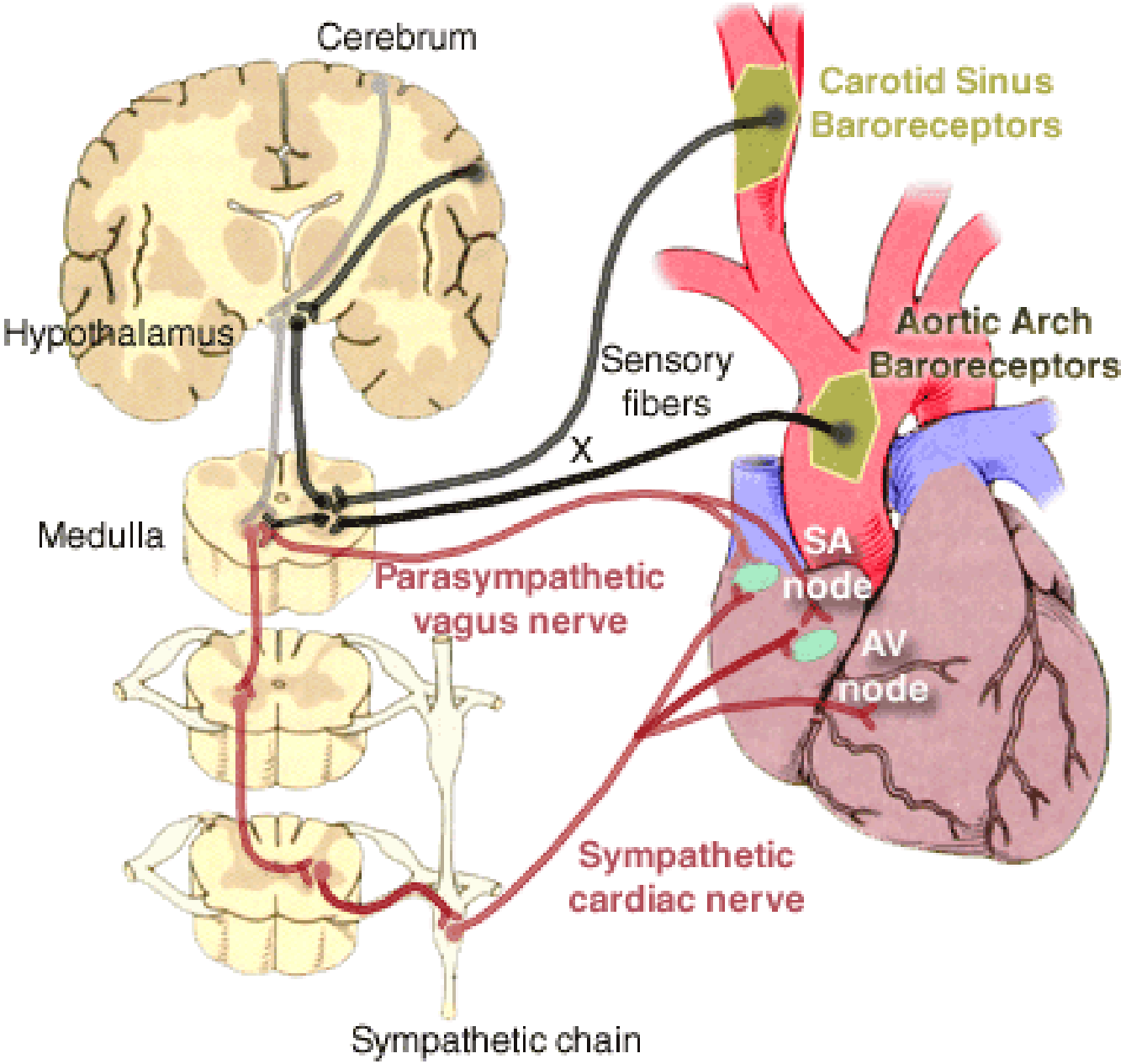
Sites Where Pharmaceutical Pain Blockers Exert their Mechanism Of Action



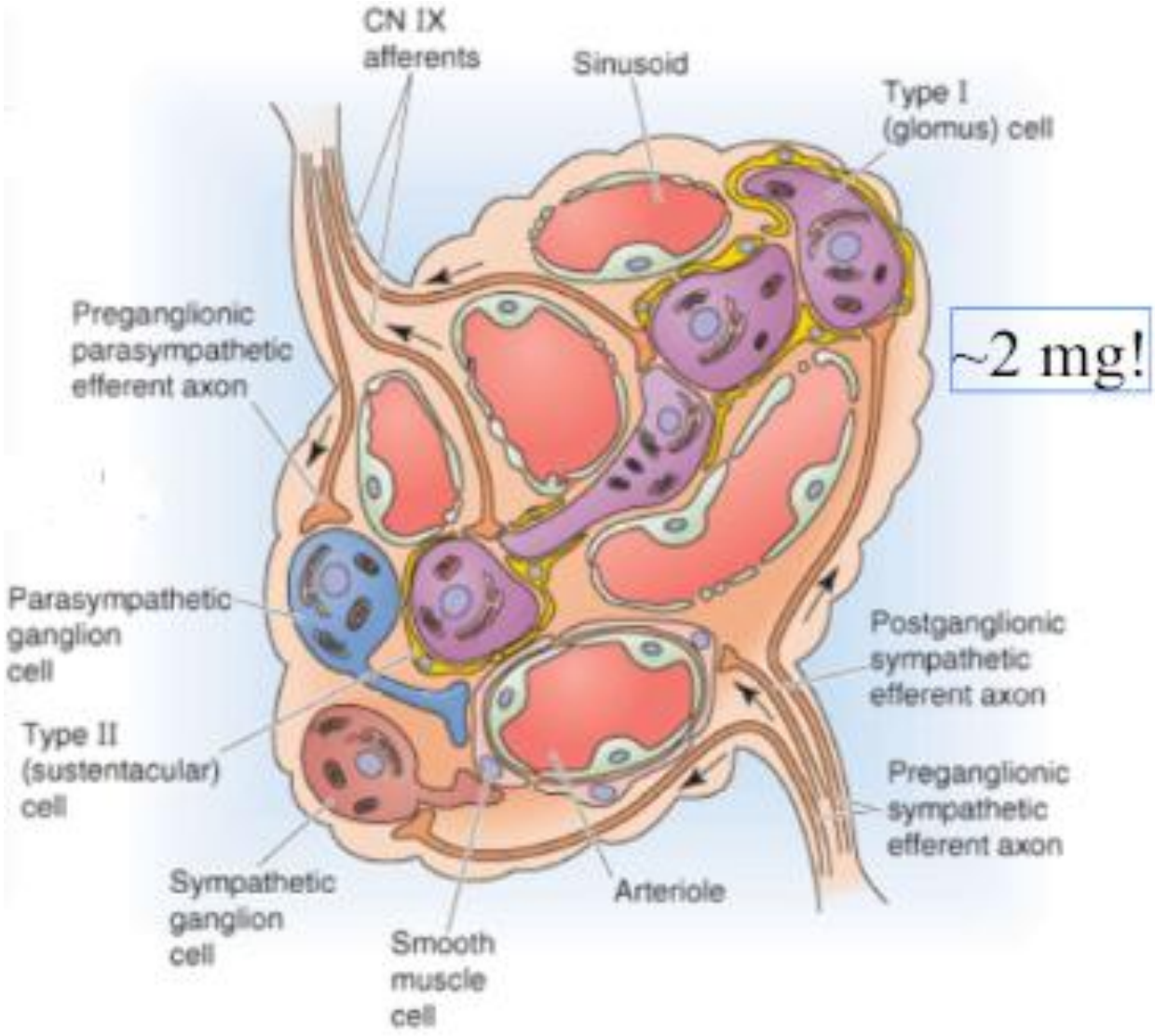
Interoception – Baroreceptors

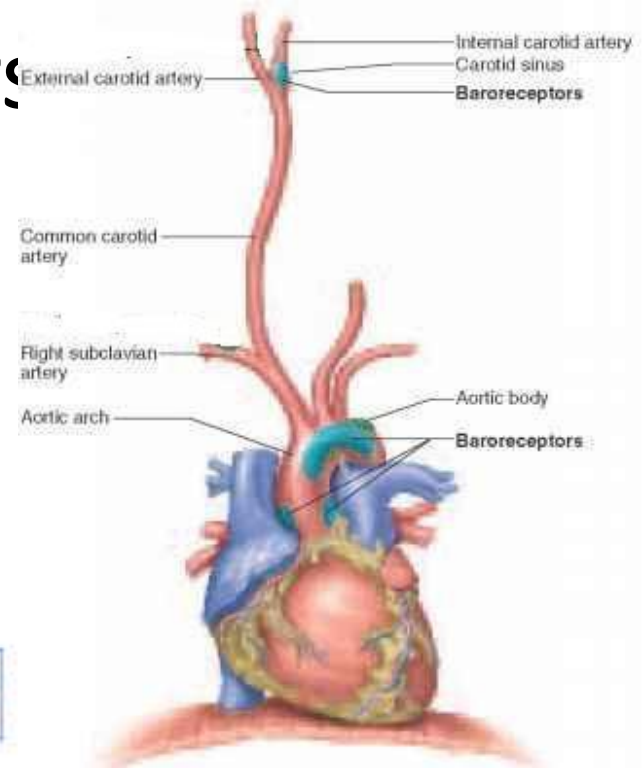


Interoception – Barororeflex arch

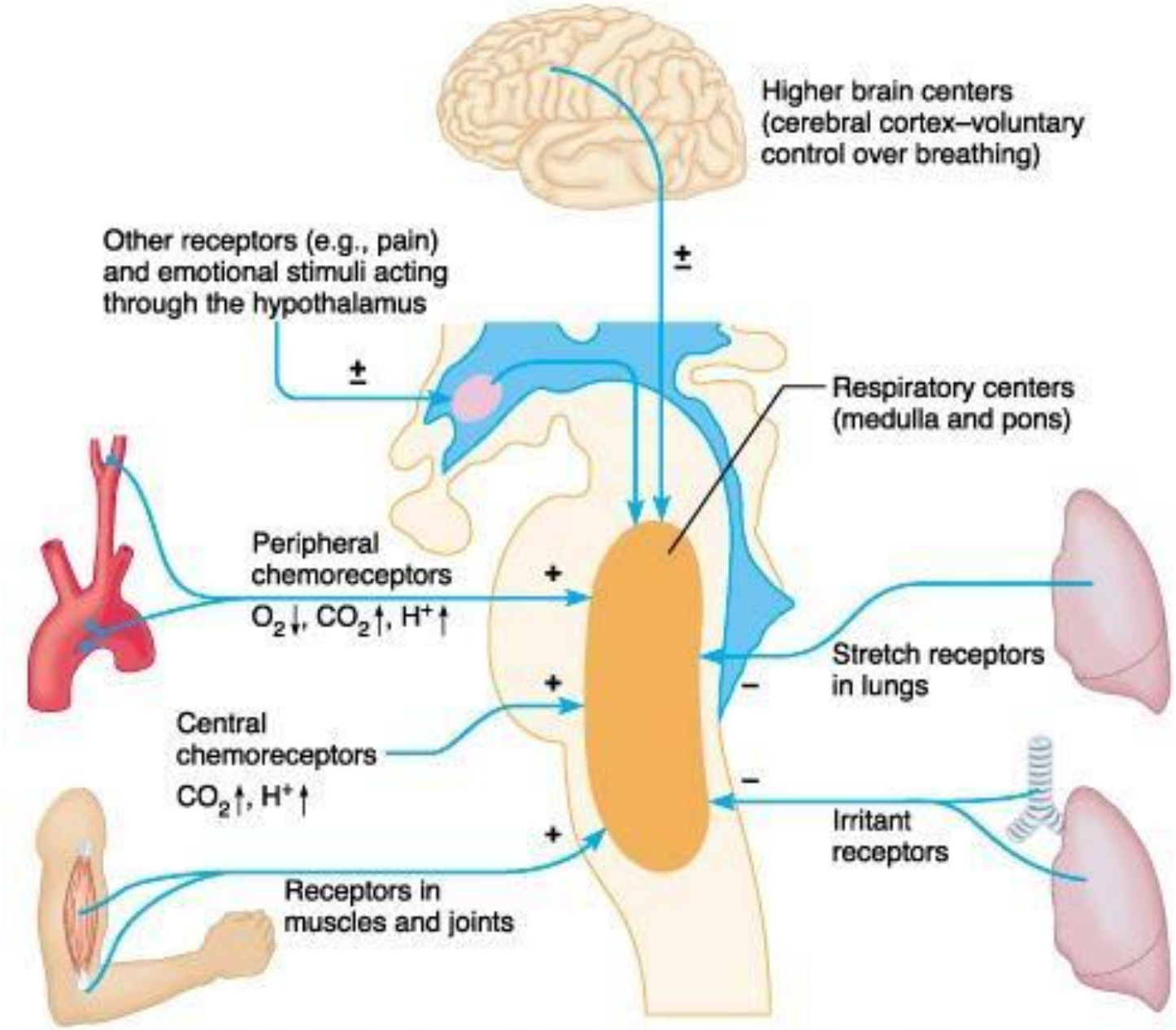


Interoception – Baroreceptors

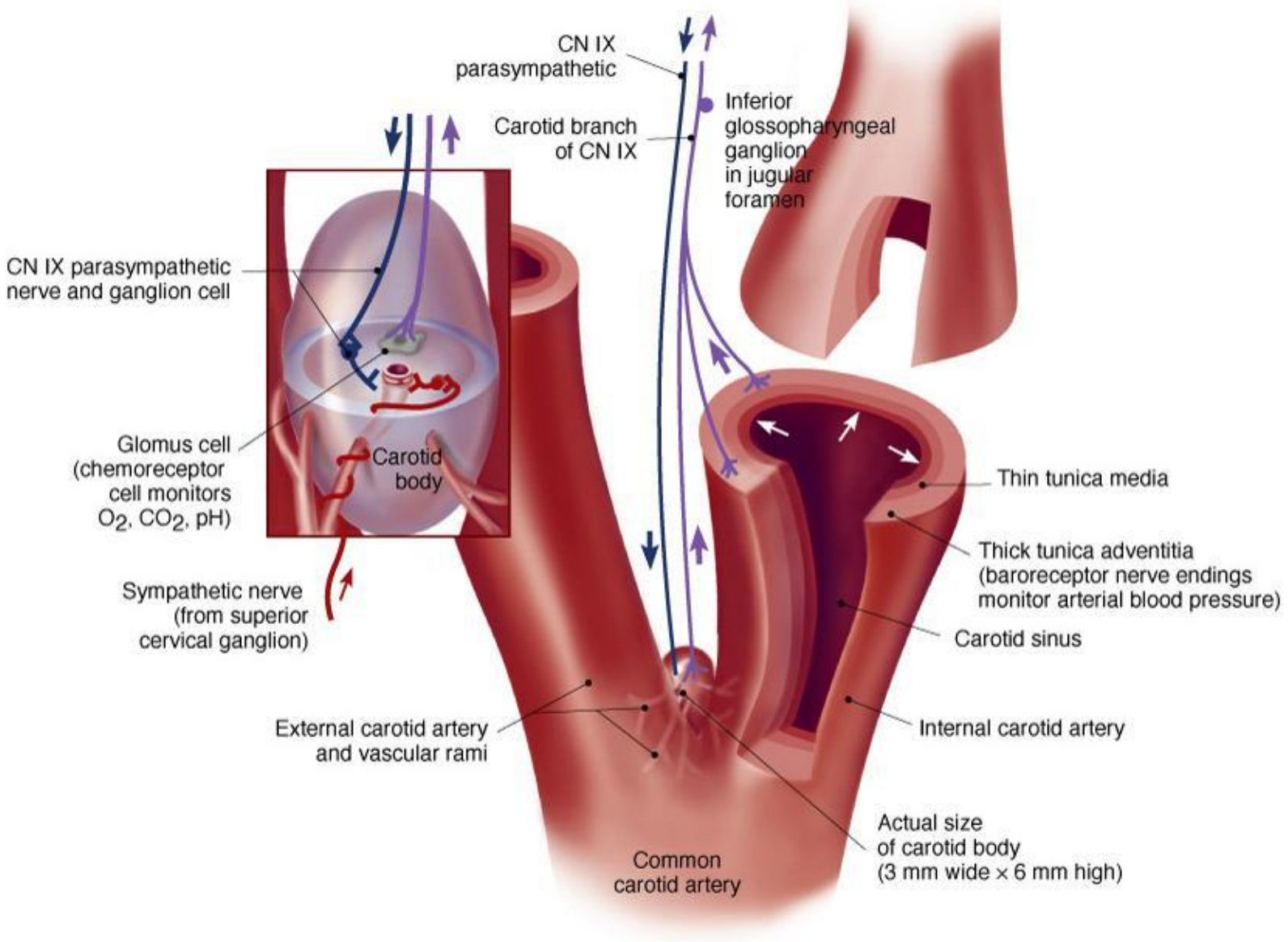




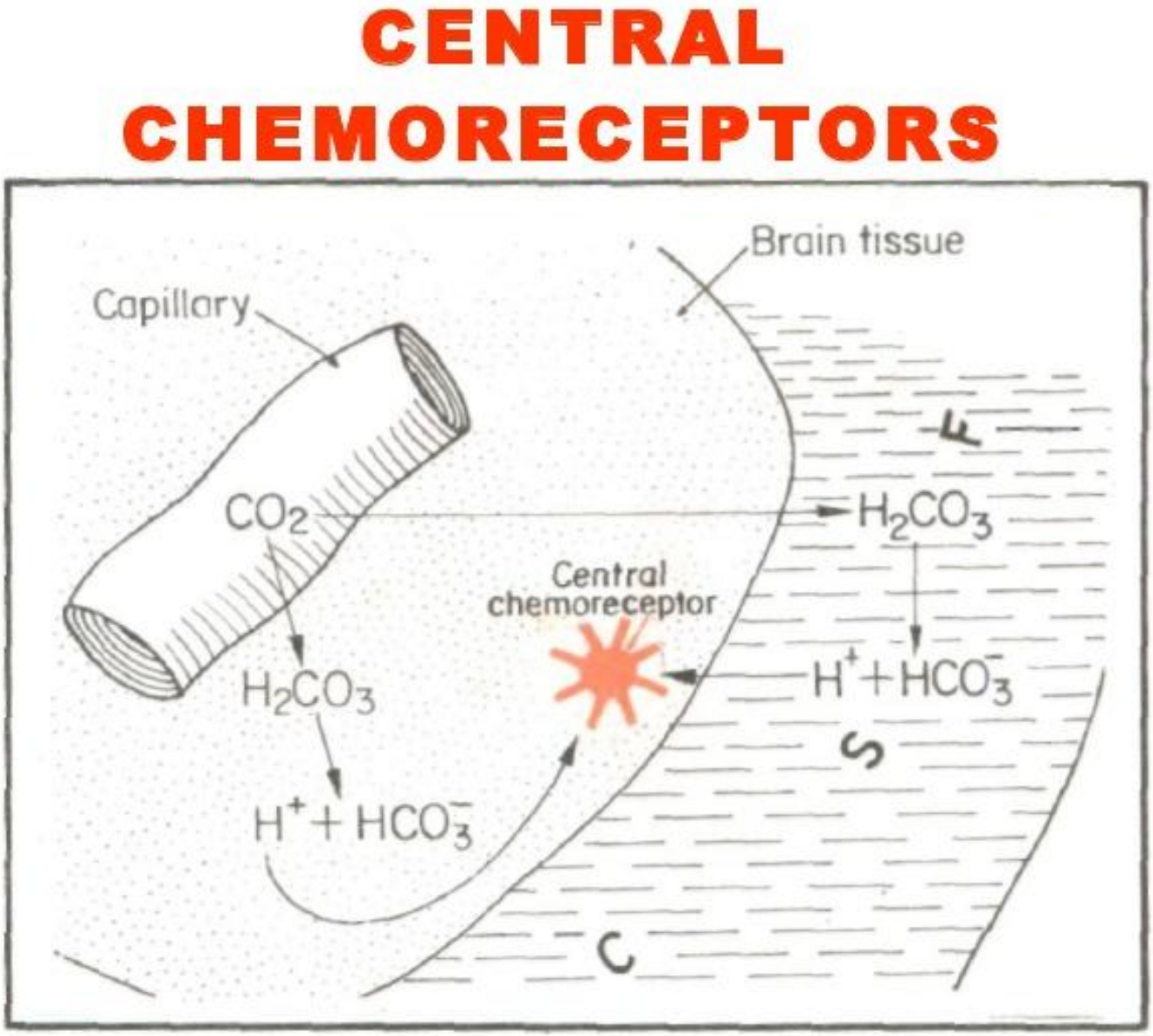
Interoception – Chemoreceptors



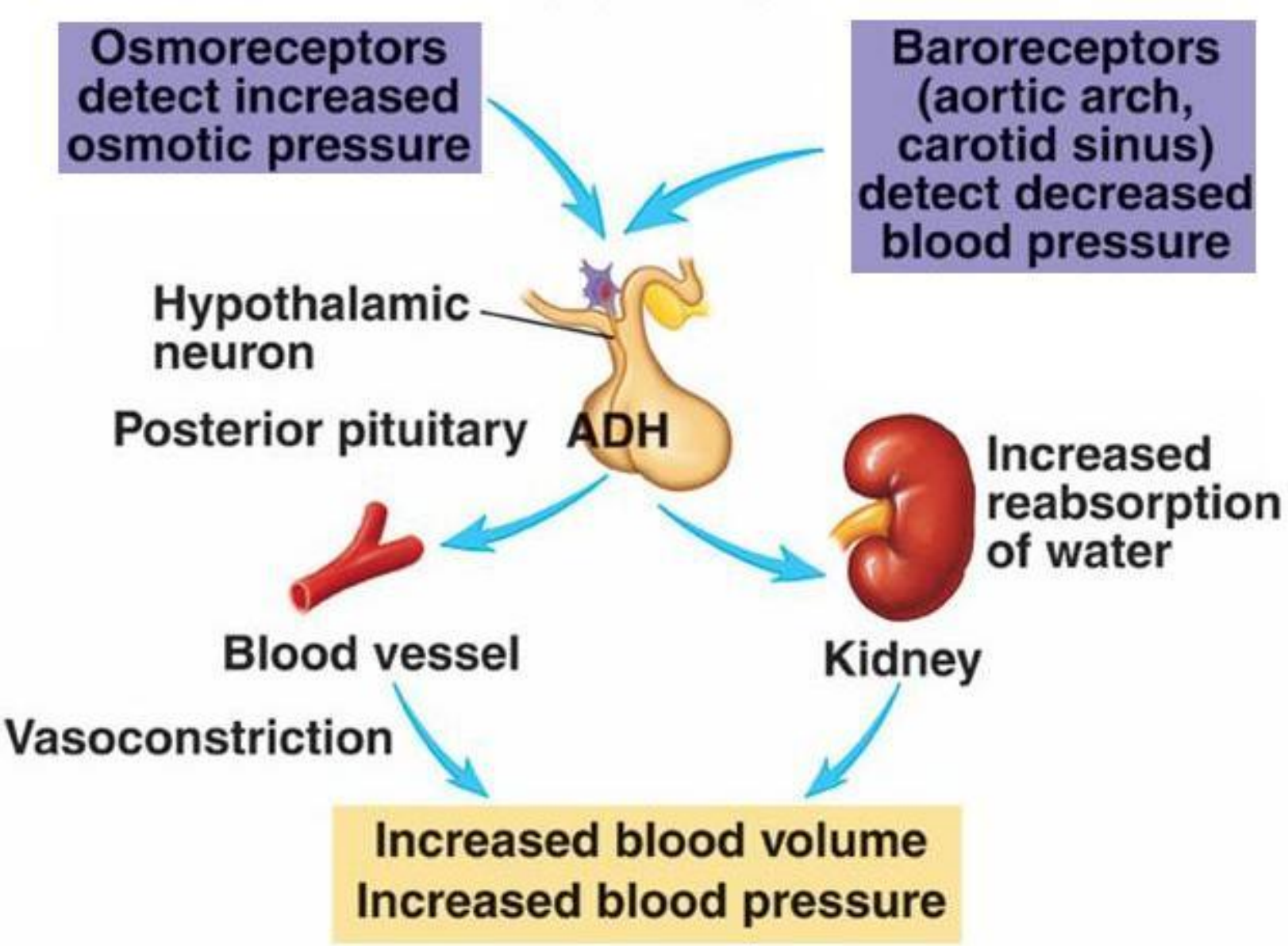
Interoception – Chemoreceptors



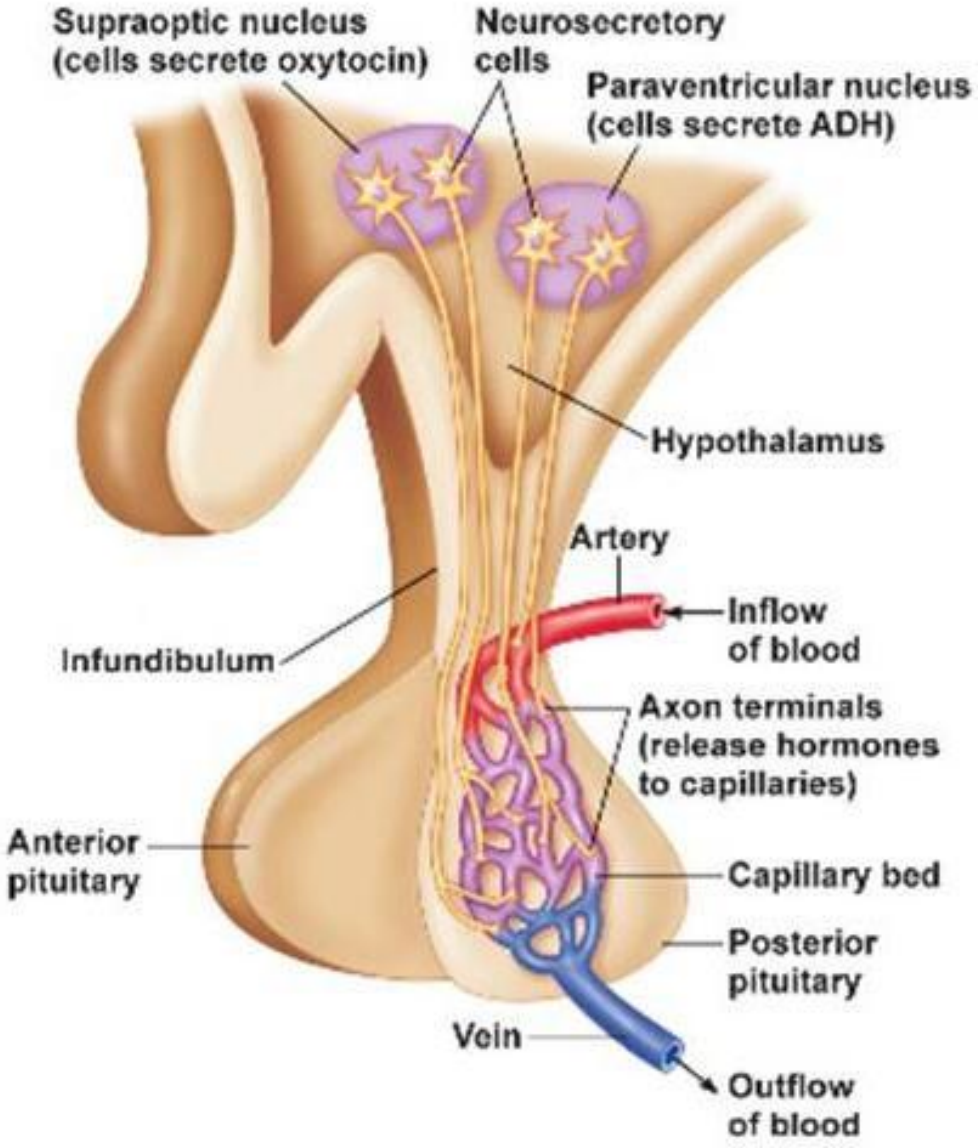
Interoception – Chemoreceptors

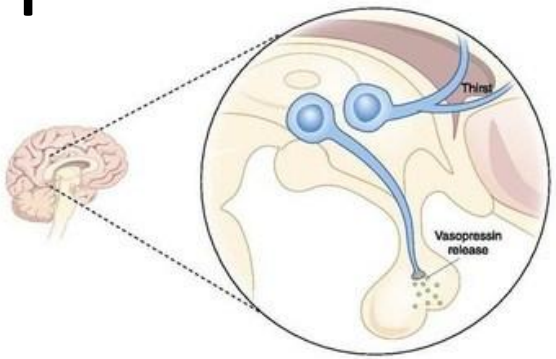


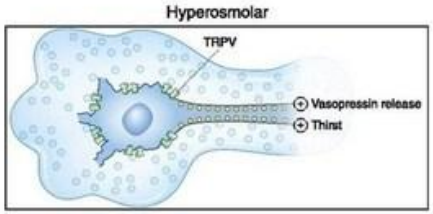
Interoception – Osmoreceptors

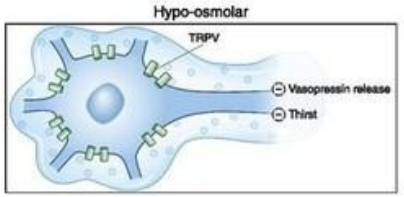


Interoception – Osmoreceptors





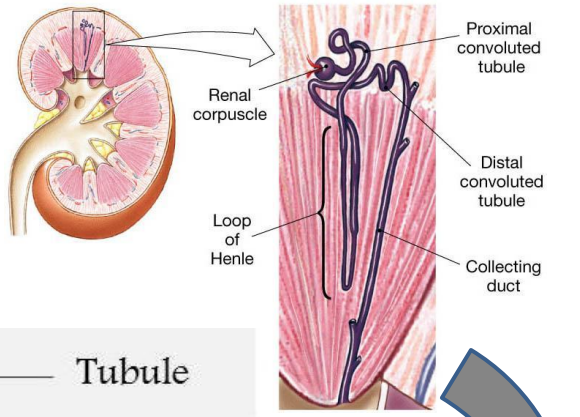


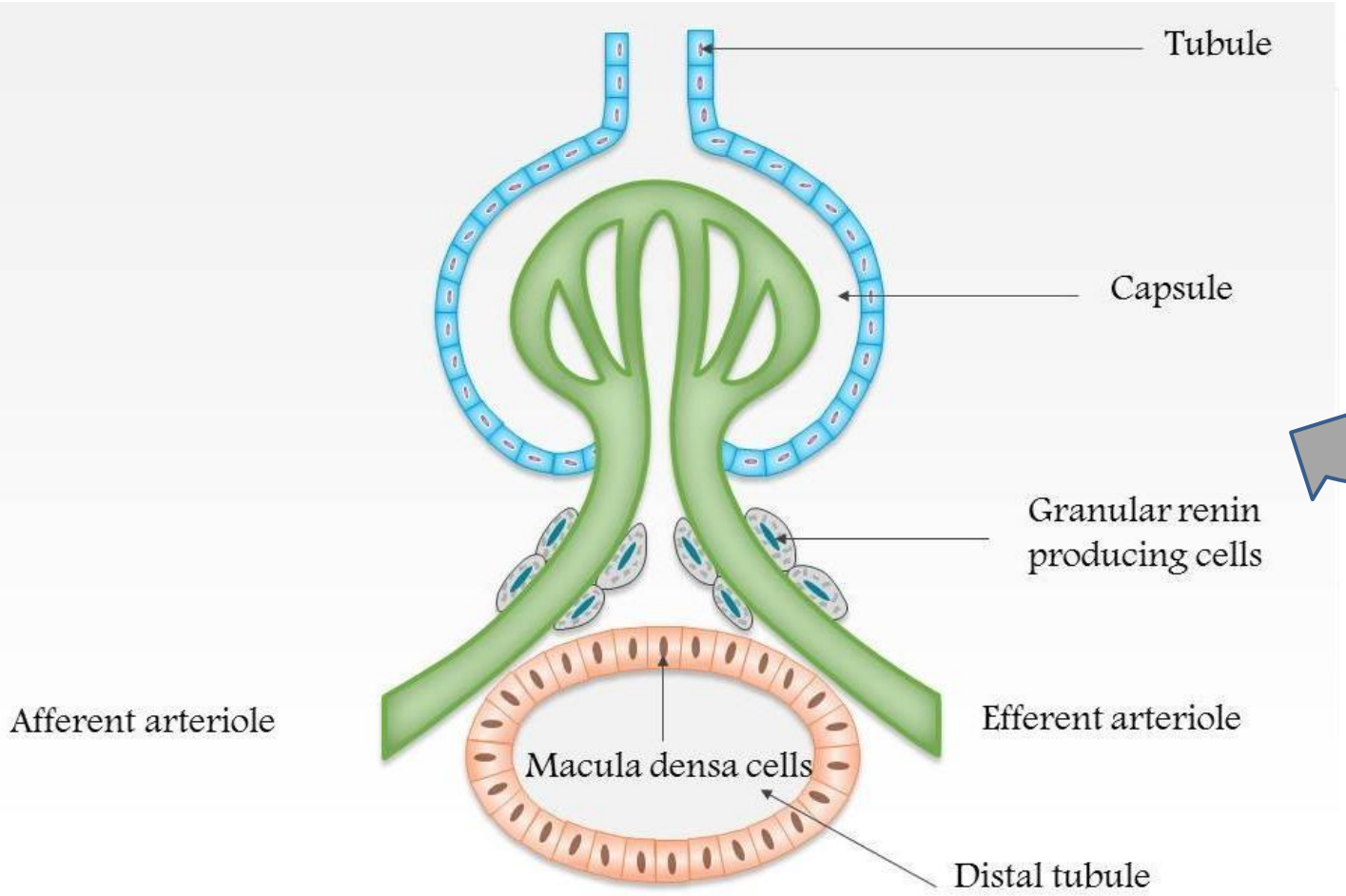


Hypothalmic nuclei

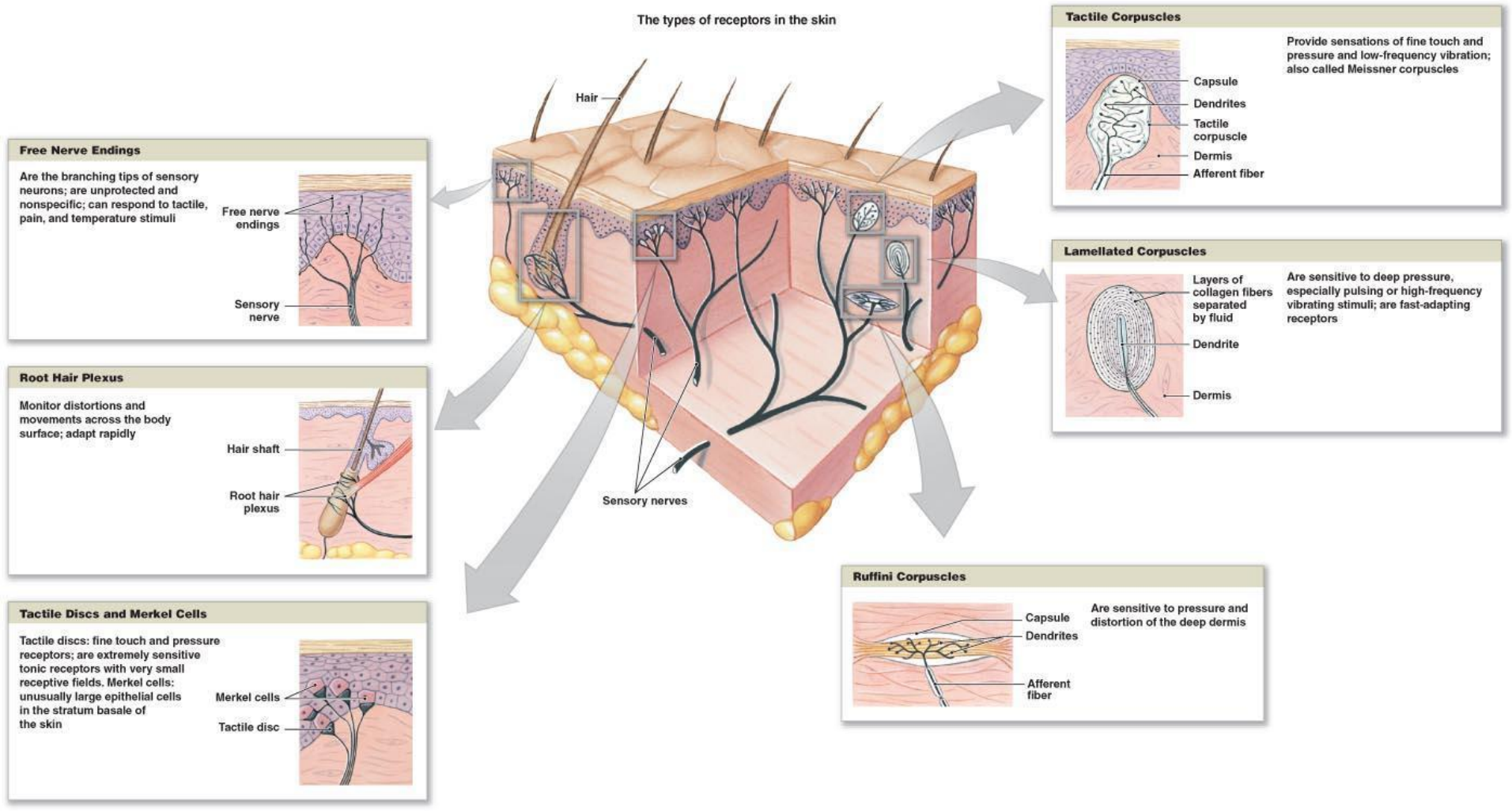
Interoception – Osmoreceptors

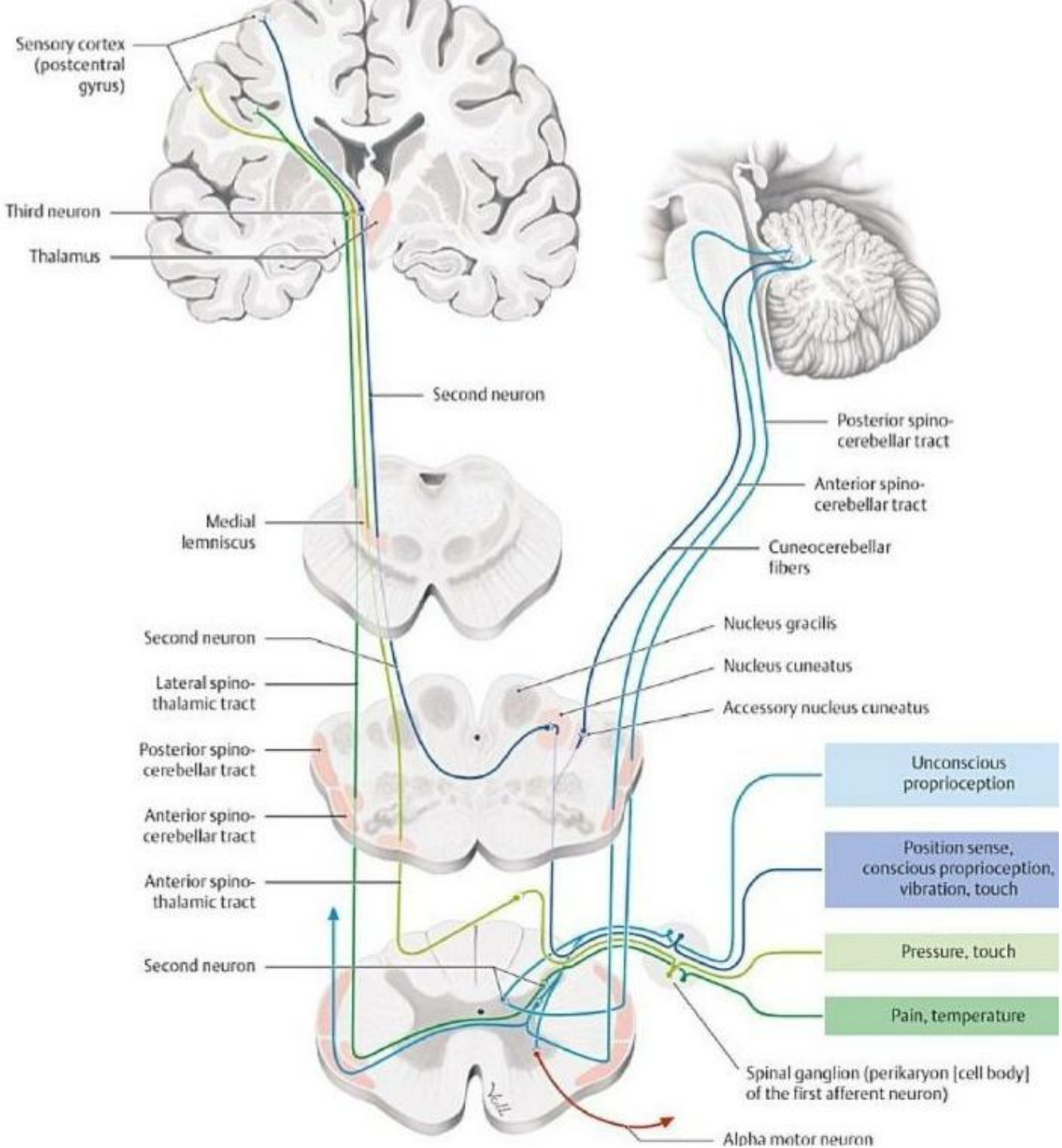
juxtaglomerular apparatus



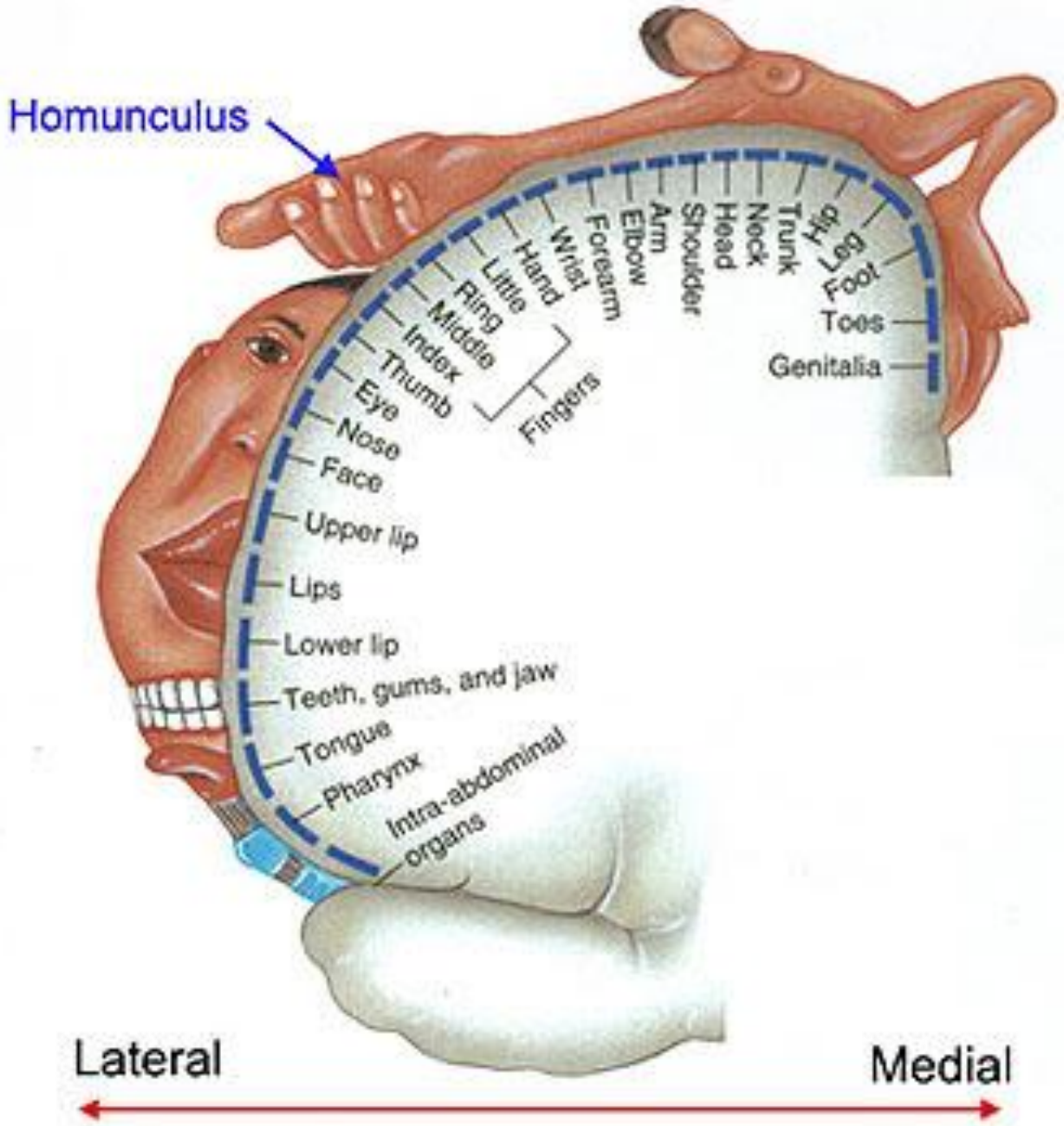


Type Of Cutaneous Receptors




Sensory cortex (postcentral gyrus)
Third neuron
Thalamus
Second neuron
Medial lemniscus
Second neuron
Lateral spino-thalamic tract
Posterior spino-cerebellar tract
Anterior spino-cerebellar tract
Anterior spino-thalamic tract
Second neuron
Posterior spino-cerebellar tract
Anterior spino-cerebellar tract
Cuneocerebellar fibers
Nucleus gracilis
Nucleus cuneatus
Accessory nucleus cuneatus
Unconscious proprioception
Position sense, conscious proprioception, vibration, touch
Pressure, touch
Pain, temperature
Spinal ganglion (perikaryon [cell body] of the first afferent neuron)
Alpha motor neuron

Somatosensory Map



KEEP UP THE HARD WORK...!