Cranial Nerves and Special Senses

All 12 Pairs

Introduction

- I = Olfactory
- Test with tobacco, coffee, cloves, peppermint, cinnamon

- II = Optic
- Test with appropriate tests for vision

- III = Oculomotor
- With complete paralysis, eyes deviate inferiorly oblique to the lateral

- IV = Trochlear
- Eye deviates superiorly when paralyzed

- V = Trigeminal

- Motor:
- bilateral paralysis, mouth will not close tightly
- Unilateral paralysis: mandible deviates TOWARDS the weak side when the mouth is open
- Sensory: test touch, pain, temp

- VI = Abducens

- Paralysis: eye[s] may converge – no lateral movement

- VII = Facial

- Motor paralysis: flaccidity = Bell's Palsy; unable to whistle or puff out cheeks

- Sensory paralysis: test taste (anterior $^{2}/_{3}$)

VIII = Acoustic or Auditory or Vestibulocochlear -- Cochlear Portion: Tests for Hearing

- Weber's Test: vibrating tuning fork in skull mid-line
- Lateralization of sound to one side means bone conduction loss on that side

- Rinne's Test: vibrating tuning fork on mastoid process. After sound not heard, place fork by ear and listen. Tones here are normally heard 2X as long as on the mastoid – test for air conduction.

Application: Hearing

- Rinne's test: place a vibrating tuning fork on the mastoid process and time it until the person doesn't hear it there; place in front of ear and time until person doesn't hear any more.
- Normal: person hears it twice as long in front of the ear as on the mastoid process.

VIII = Acoustic or Auditory or Vestibulocochlear – Vestibular Portion

- Balance tests – spin on stool

IX and X – Glossopharyngeal and Vagus

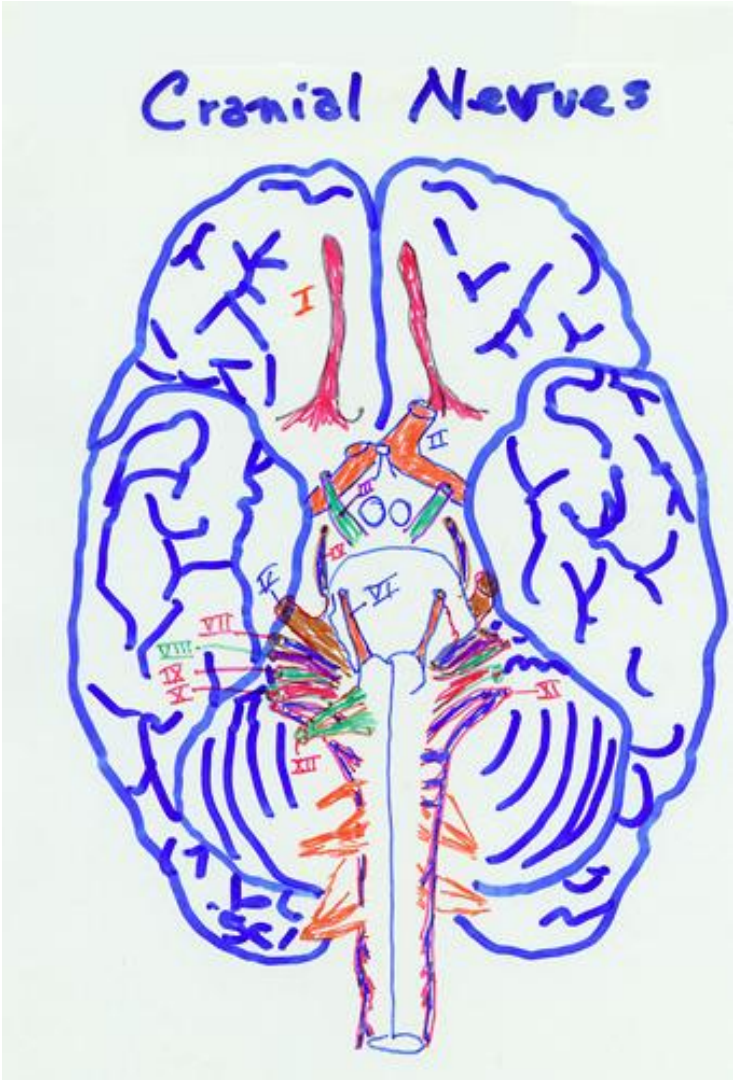
- Tested together

- Open mouth and say “Ahhhhhh”
  - If uvula doesn’t elevate, bilateral paralysis
  - Unilateral elevation: uvula deviates to strong side (away from side of lesion)
- Gag reflex – present or absent

- XI = Spinal Accessory
- Raise shoulders against resistance – check for tense trapezius
- Turn head back to midline against resistance – check for tense SCM

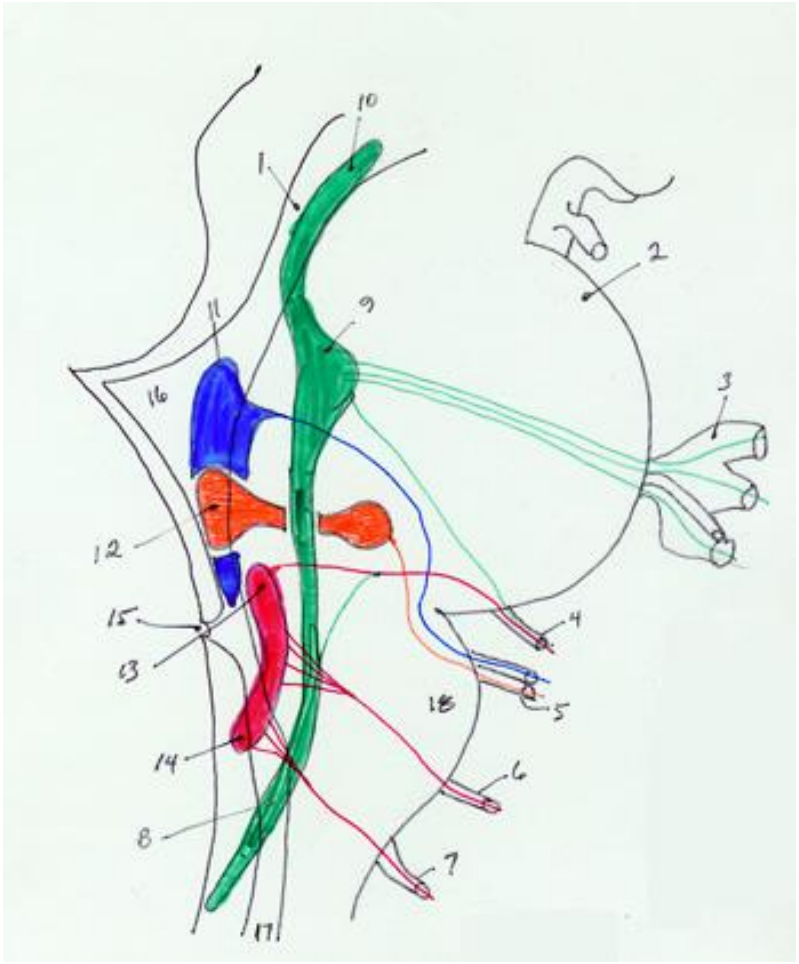
- XII = Hypoglossal
- Stick out tongue – if paralyzed, tongue deviates to weak side
- Test lingual speech: “round the rugged rock the ragged rascal ran”

Cranial Nerves – Basilar View



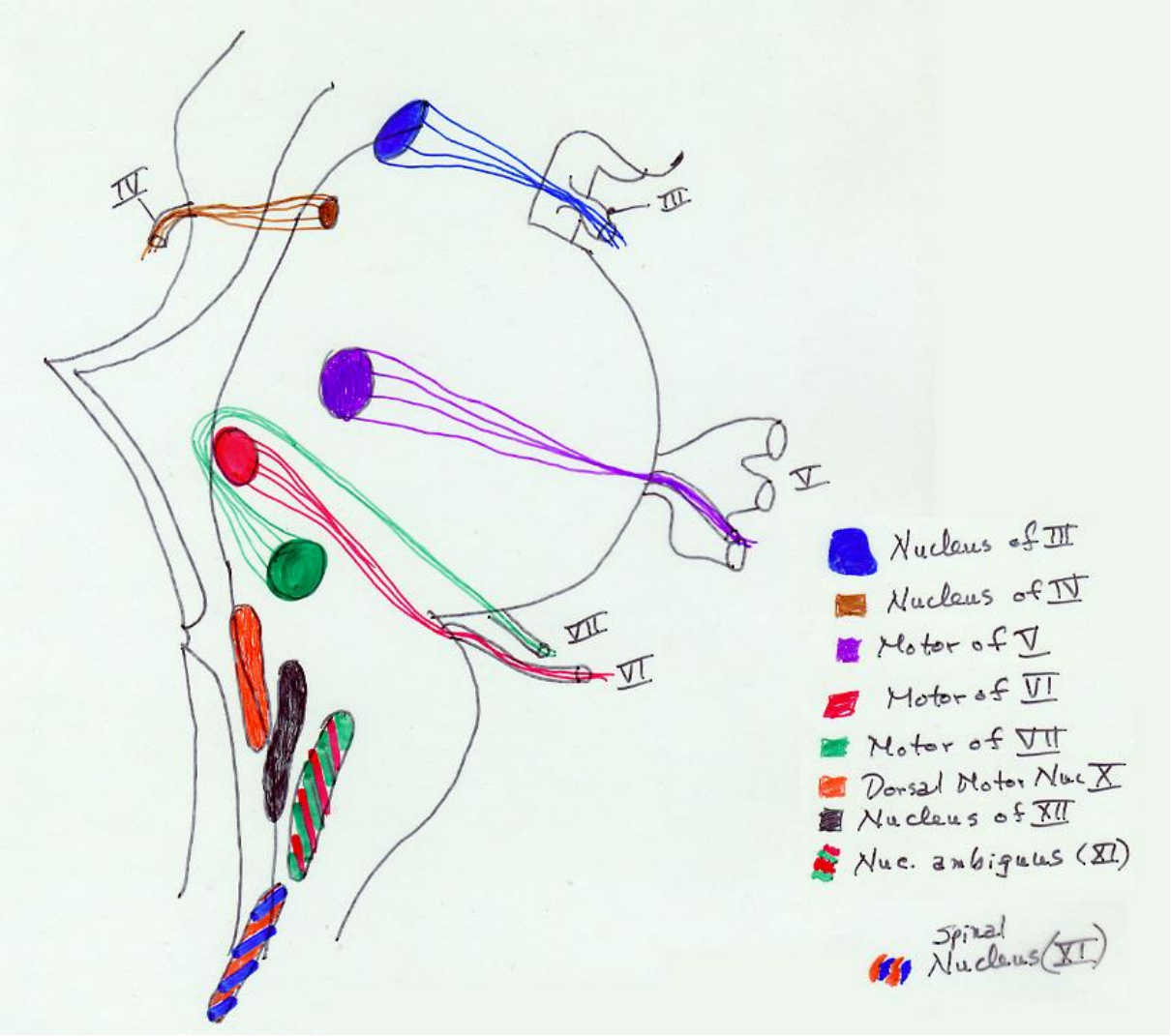
	Cranial Nerve	Mnemonic	
	Olfactory	On	
	Optic	Old	
	Oculomotor	Olympus'	
	Trochlear	Tiny	
	Trigeminal	·Tops	
	Abducens	A	
	Facial	Finn	
	Acoustic	And	
	Glossopharyngeal	German	
	Vagus	Viewed	
	Spinal Accessory	Some	
	Hypoglossal	Hops	

Sensory Nuclei

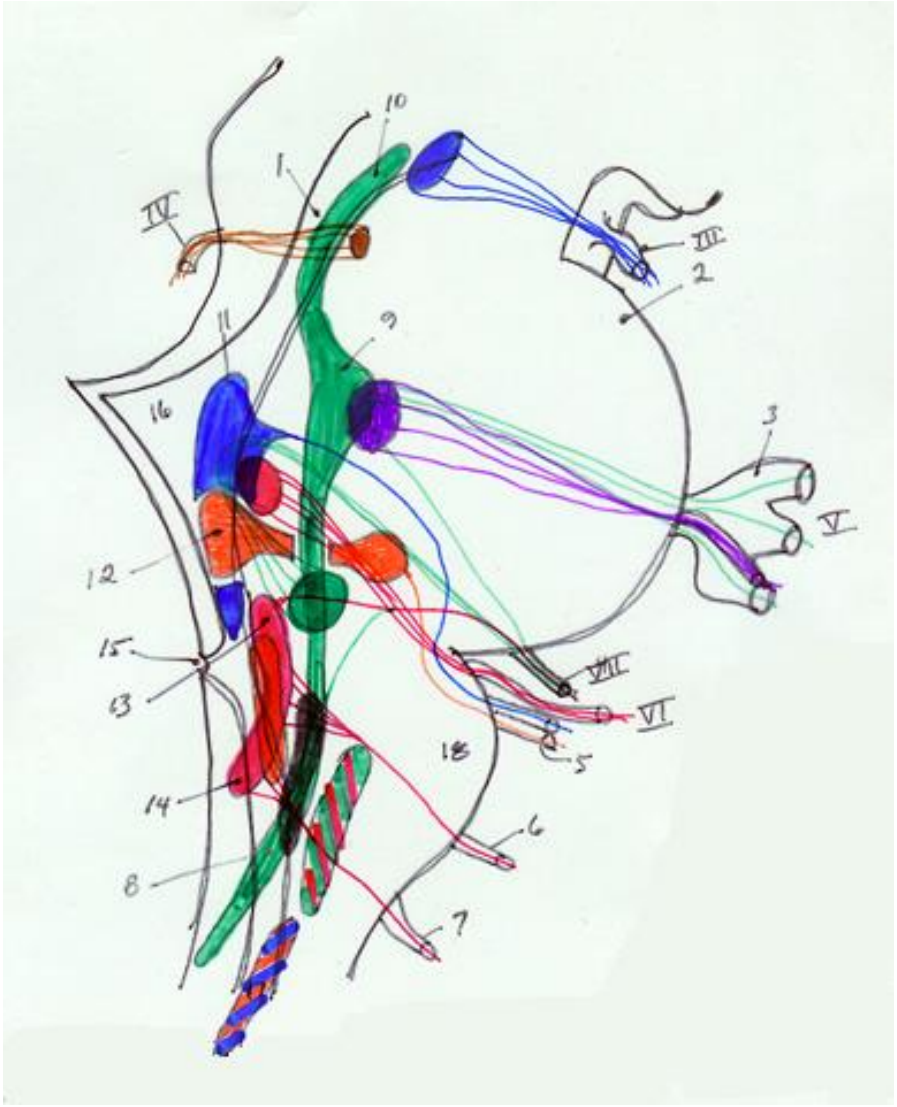


- 1-Aqueduct of Sylvius
- 2-Pons
- 3-V
- 4-VII
- 5-VIII
- 6-IX
- 7-X
- 8-Spinal nucleus of V
- 9-Primary Sensory nucleus of V
- 10-Mesencephalic Nucleus of V
- 11-Vestibular nucleus
- 12-Cochlear nucleus
- 13-Nucleus of Tractus solitarius
- 14-Commissural Nucleus
- 15-Foramen of Magendie
- 16-4th ventricle
- 17-Central canal
- 18-Medulla

Motor Nuclei

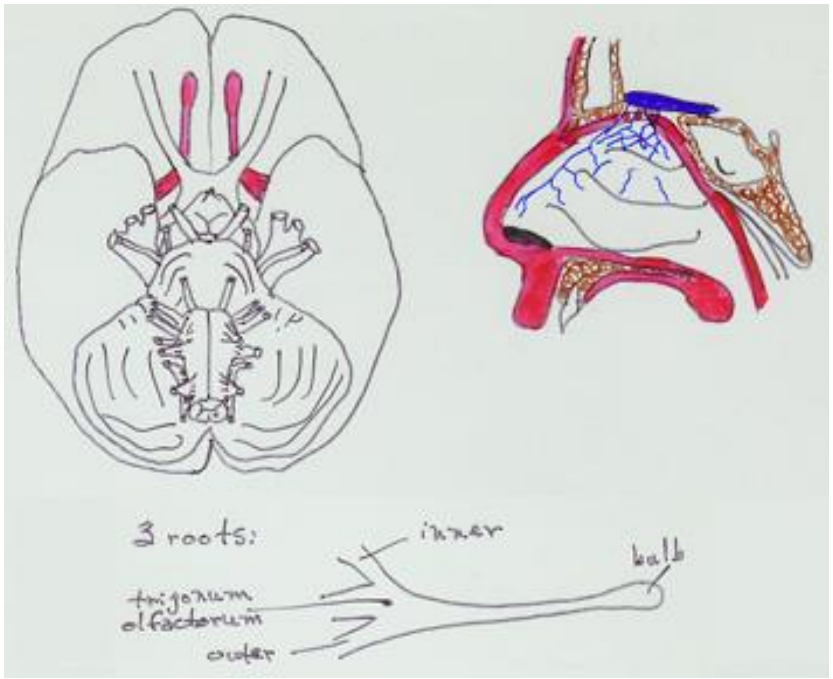


Motor over Sensory Nuclei



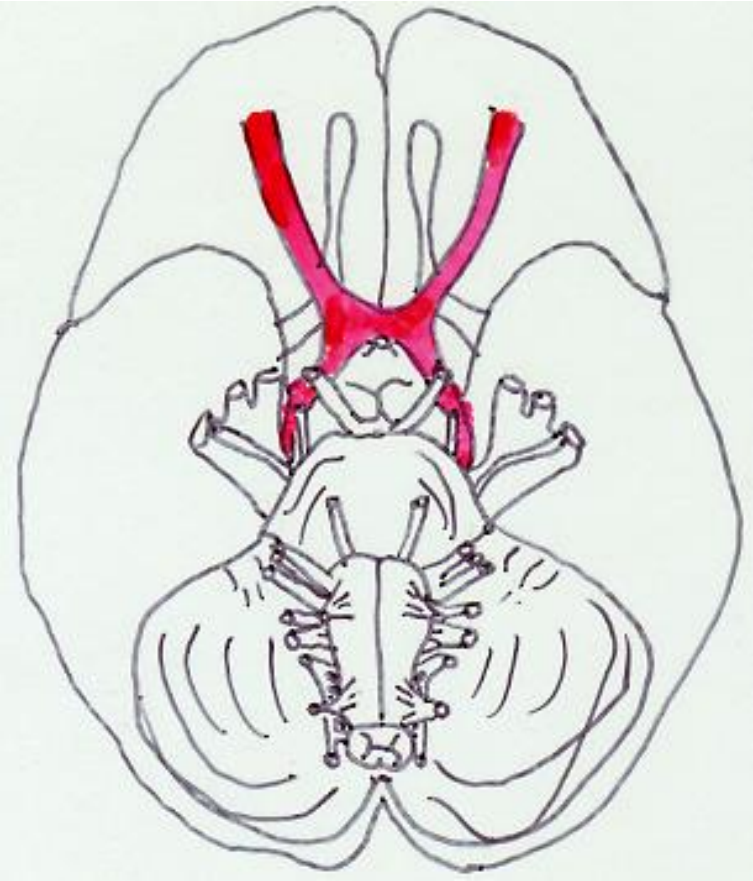
Cranial Nerve Description			Mnemonic
I	Olfactory	Sensory	Silly
II	Optic	Sensory	Sally's
III	Oculomotor	Motor	Mother
IV	Trochlear	Motor	Makes
V	Trigeminal	Both	Big
VI	Abducens	Motor	Maroon
VII	Facial	Both	Balls
VIII	Acoustic	Sensory	Sail
IX	Glossopharyngeal	Both	By
X	Vagus	Both	Bob's
XI	Spinal Accessory	Both	Blue
XII	Hypoglossal	Motor	Mercedes

Olfactory Nerve: I – Sensory: Smell



- Exits skull via cribriform plate
- Terminates in temporal lobe
- ~20 fibers spread over the nose:
  - inner group of fibers over the upper third of septum
  - outer group of fibers over superior turbinate and surface of ethmoid
- Anomaly: Loss of smell with secondary loss of taste

Optic Nerve: II – Sensory: Sight

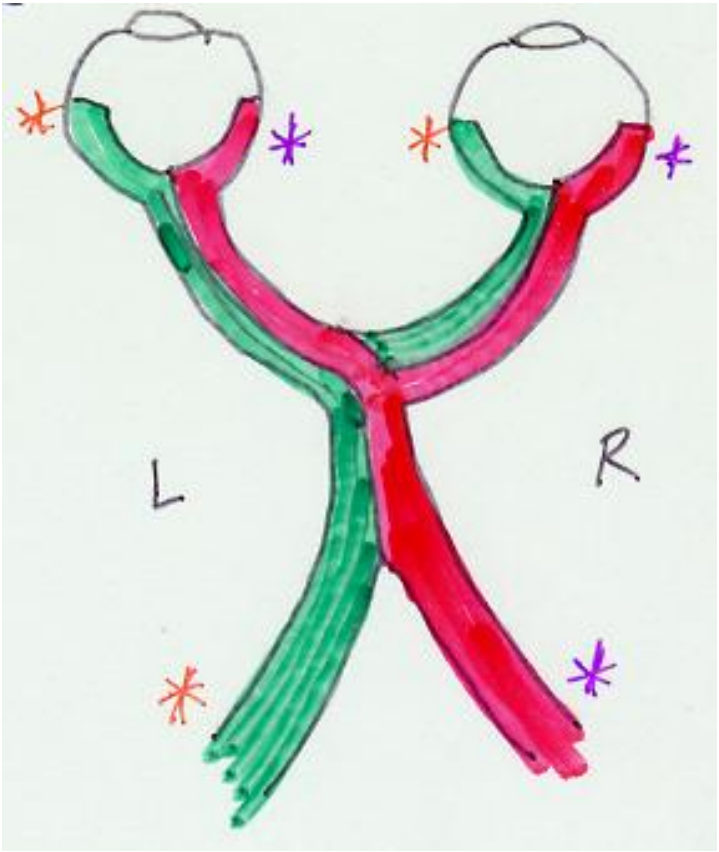


- Exits skull via optic foramen; terminates in occipital lobe
- Optic tract exits brain in 2 bands
- Optic tract crosses at optic chiasm with 2 sets of fibers
- Anomaly = blindness – complete or incomplete

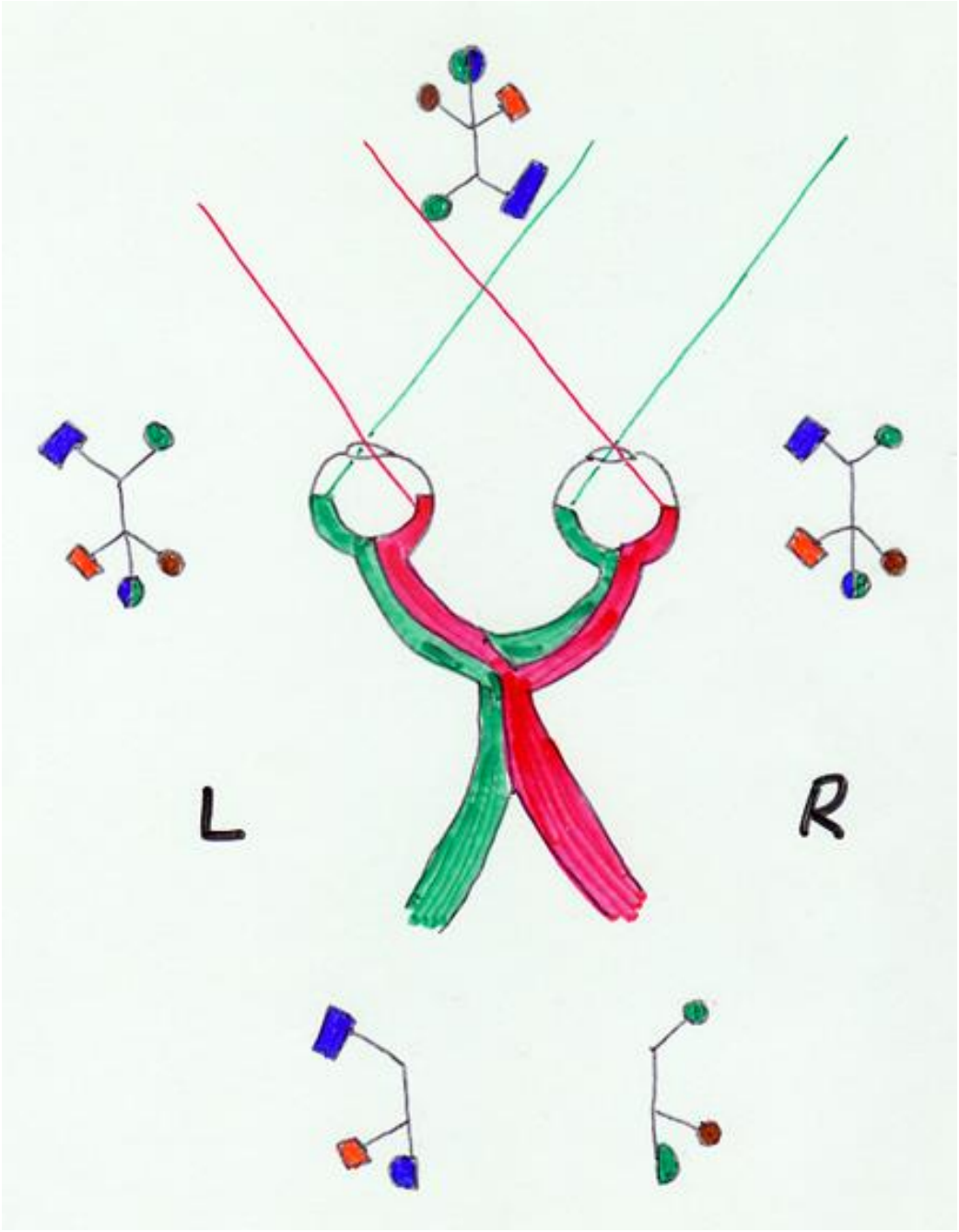
II, Cont'd
Optic tract exits brain in 2 bands

- External Band
  - Partly continuous with superior colliculi
  - Coordinates movement of eyeball and head, regulates focusing, adjusts size of pupils
- Internal Band
  - Partly continuous with inferior colliculus
  - Coordinates movement of head and trunk due to audio stimulus

II – Cont'd

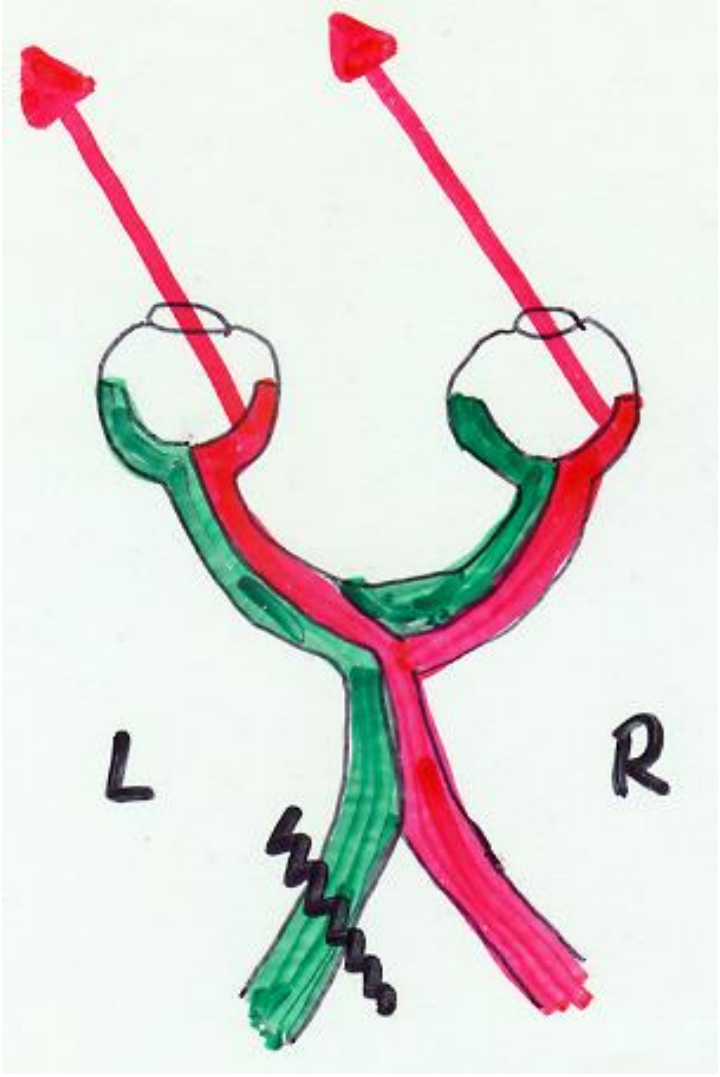


- 2 sets of fibers cross at chiasm
  - Crossed in greatest numbers
  - Left crosses right and right crosses left
- Uncrossed
  - Left stays left and right stays right
- Right tract supplies right half of EACH eye; left tract supplies left half of EACH eye



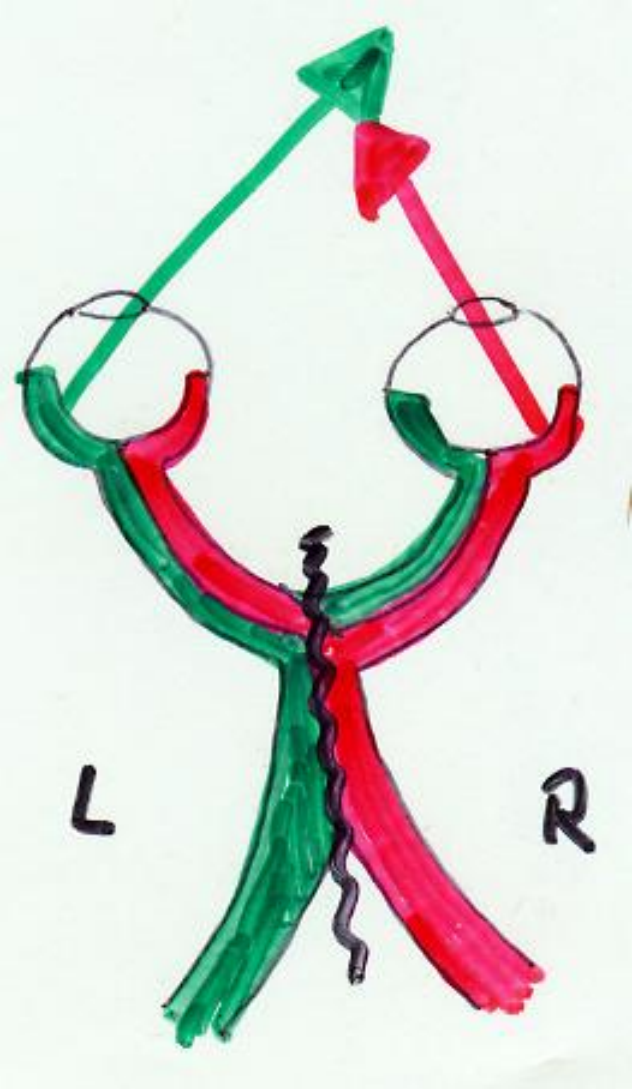
- Flip it upside down
- Rotate it horizontally 180°
- Split it vertically

Nerve Anomaly #1



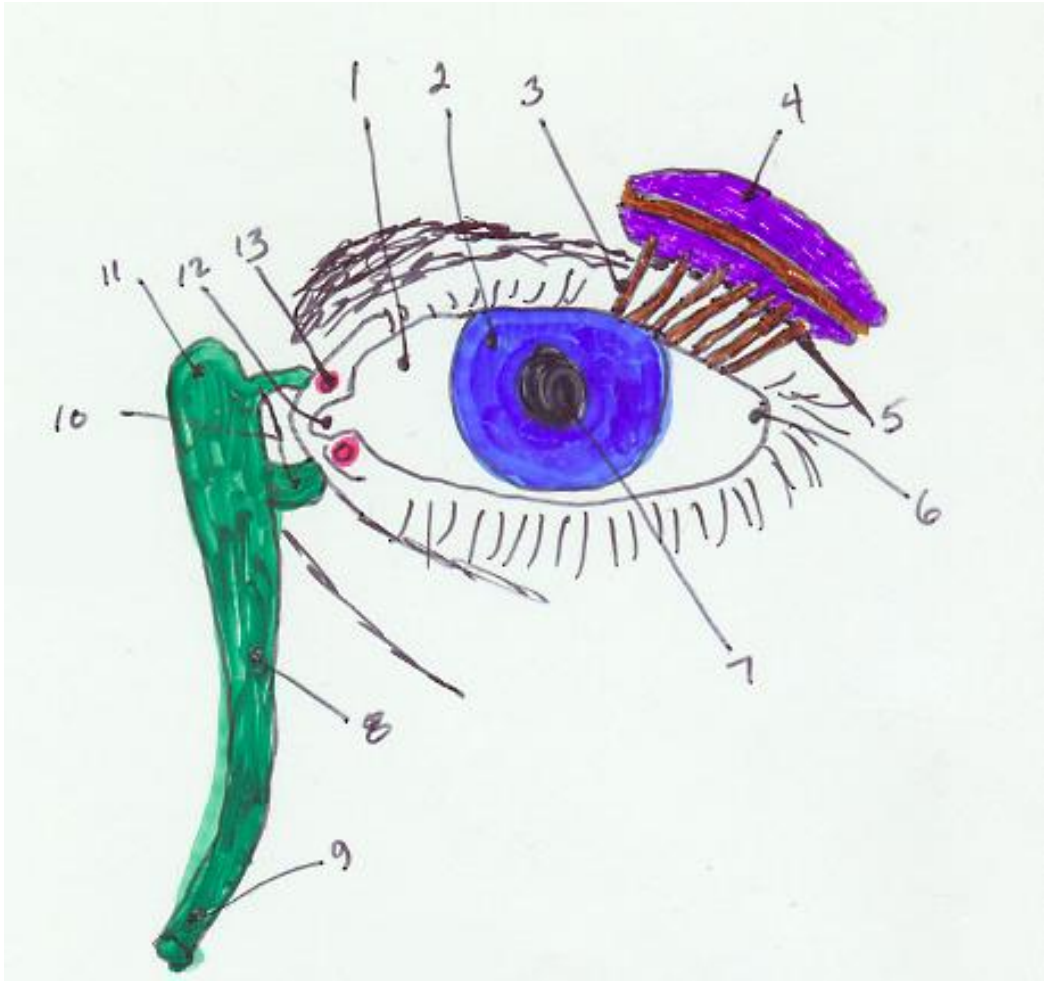
- Tract lesion
  - Have half central vision
  - Leaves left peripheral vision

Nerve Anomaly #2



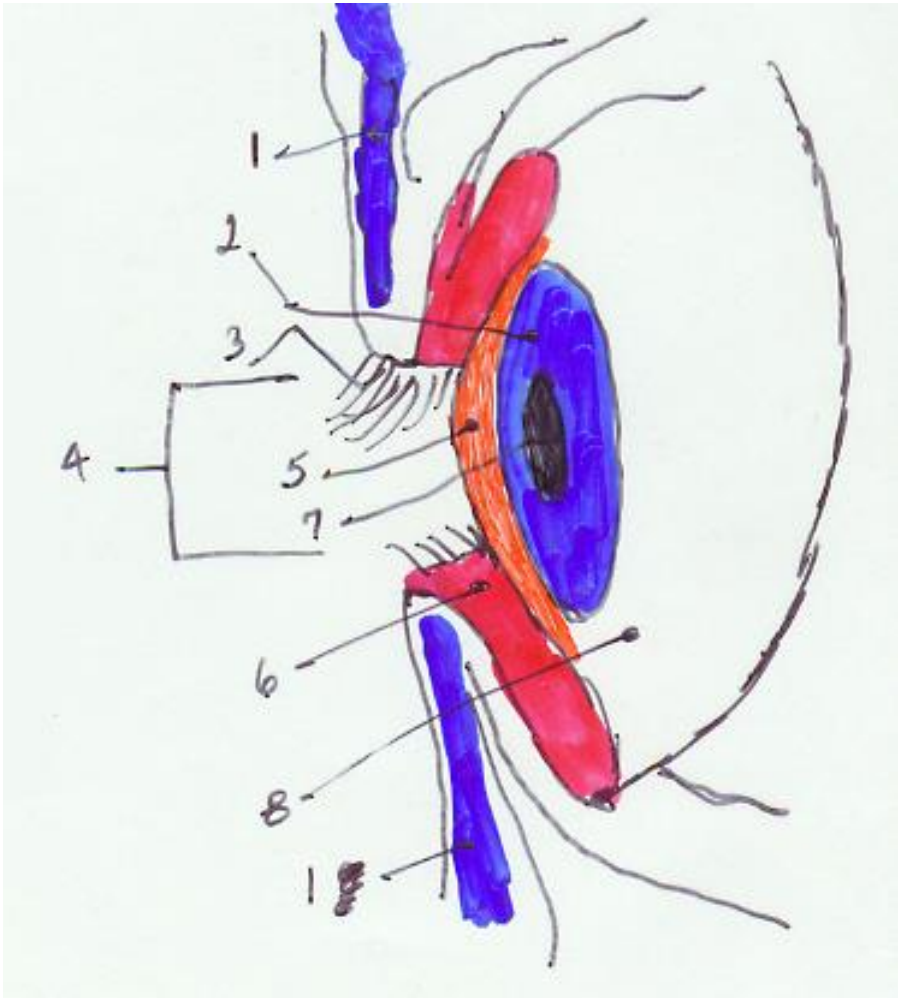
- Chiasm Lesion
- Left all central vision
- No peripheral vision

External Eye -- Anterior



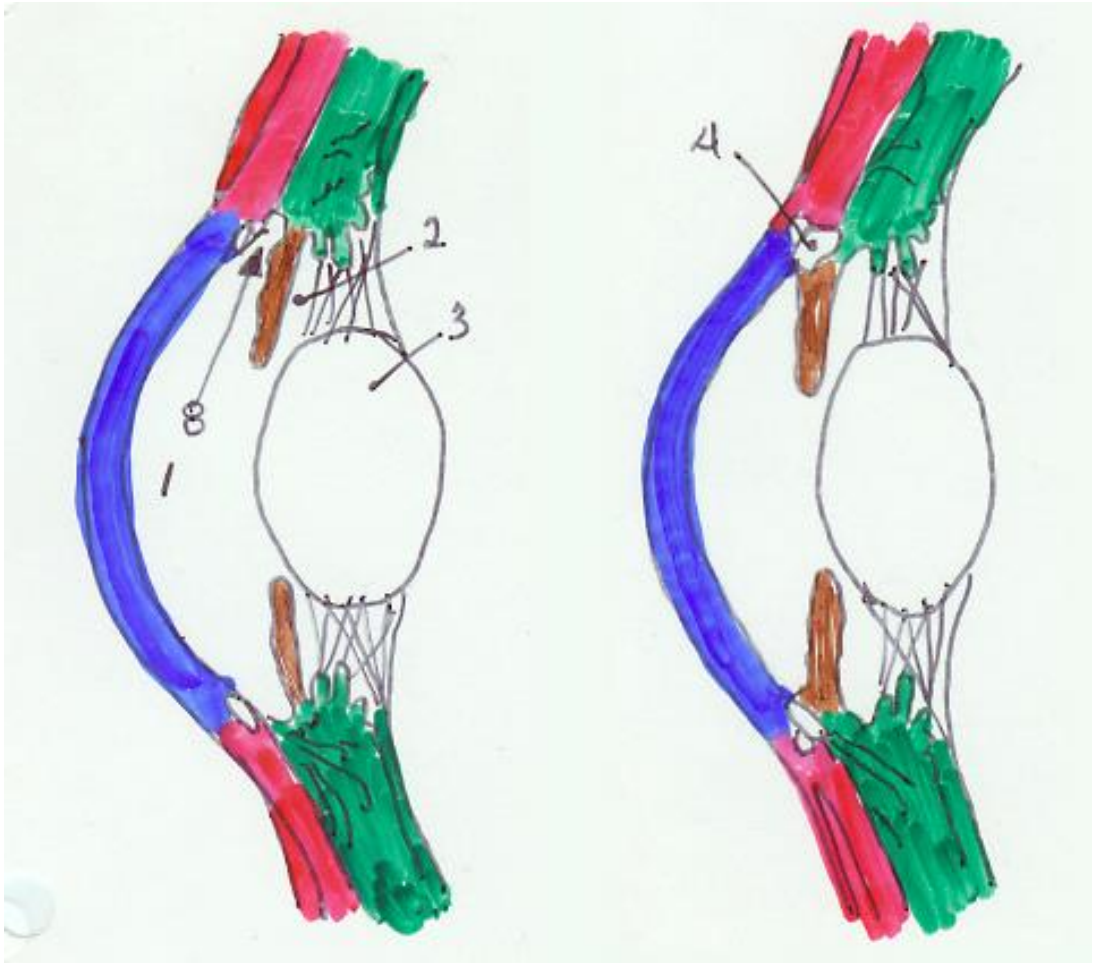
1. Sclera
2. Iris
3. Lacrimal ducts
4. Lacrimal gland
5. Eye lid
6. Outer canthus
7. Pupil
8. Nasolacrimal duct
9. Inferior meatus in nose
10. Lacrimal canals
11. Lacrimal sac
12. Inner canthus
13. Lacrimal puncta

External Eye -- Lateral



1. Orbicularis oculi
2. Iris
3. Eyelashes
4. Palpebral fissure
5. Cornea
6. Palpebral conjunctiva
7. Pupil
8. Ocular conjunctiva

Internal Eye -- Anterior

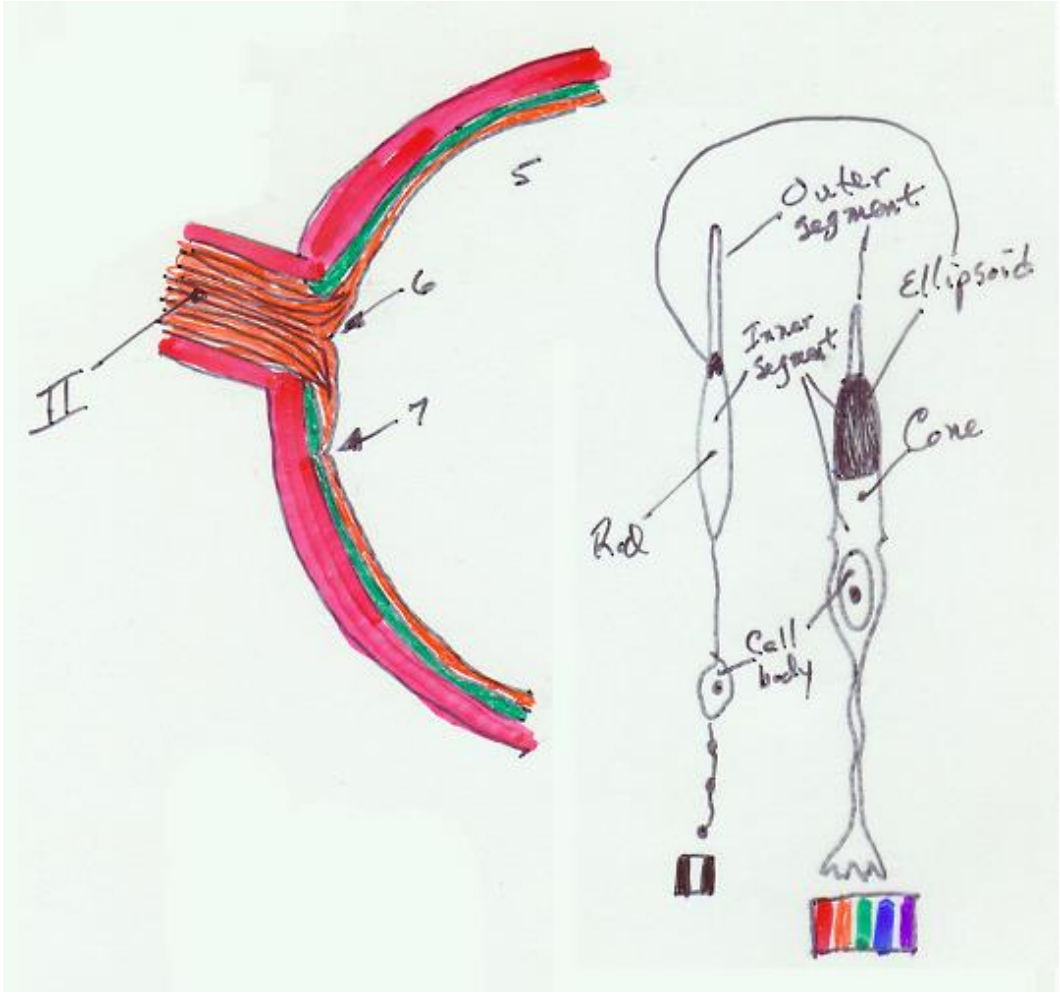


1. Anterior chamber
2. Posterior chamber angle
3. Lens
4. Angle closure (closed angle glaucoma = tunnel vision)
8. Anterior chamber angle

- Anterior cavity filled with aqueous humor
- Anterior cavity = 1 & 2
- Suspensory ligaments attached to ciliary muscles/body
- Canal of Schlemm at #8 filters/drains to veins

- Sclera
- Cornea
- Choroid
- Iris

Interior Eye -- Posterior

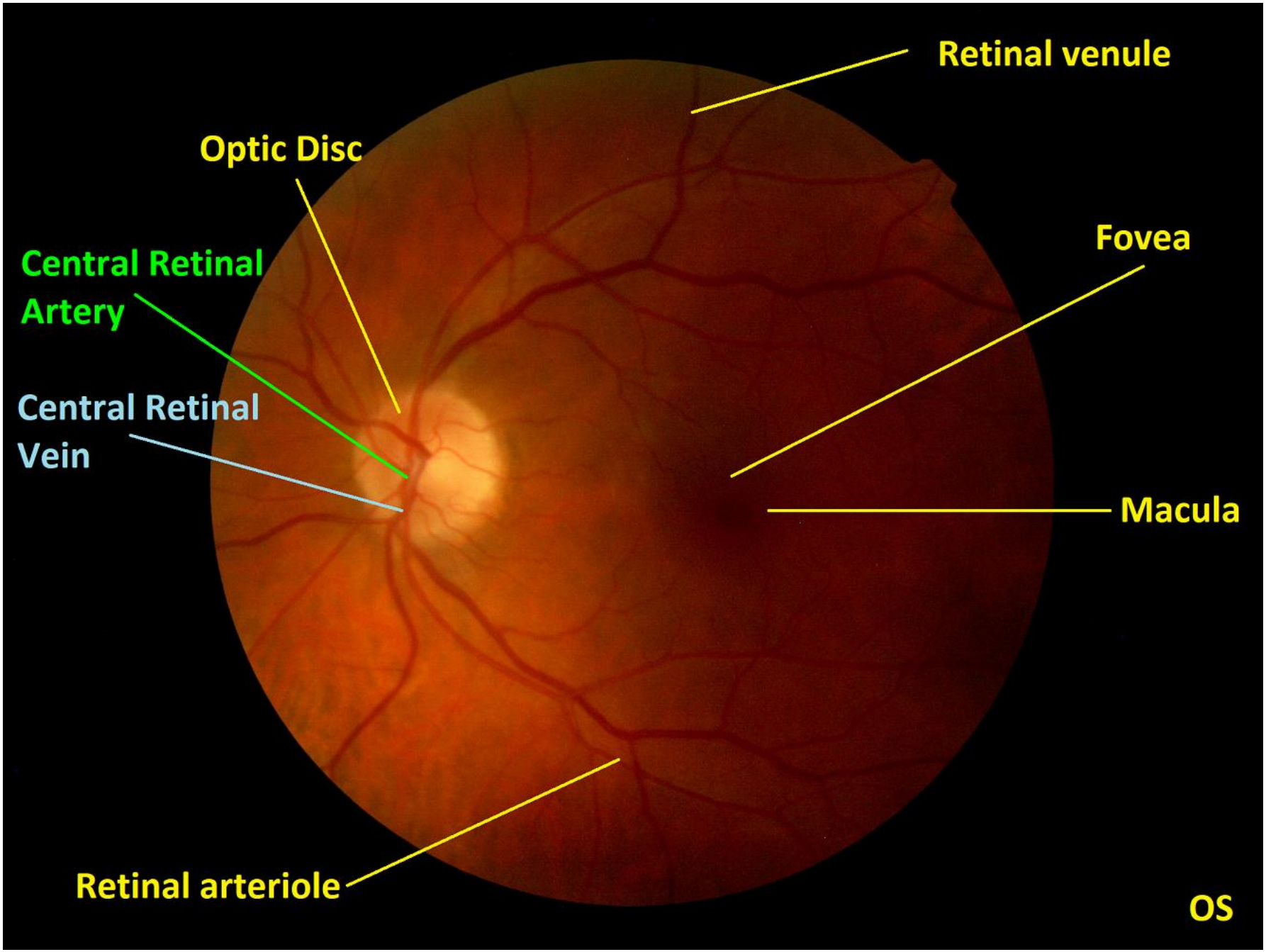


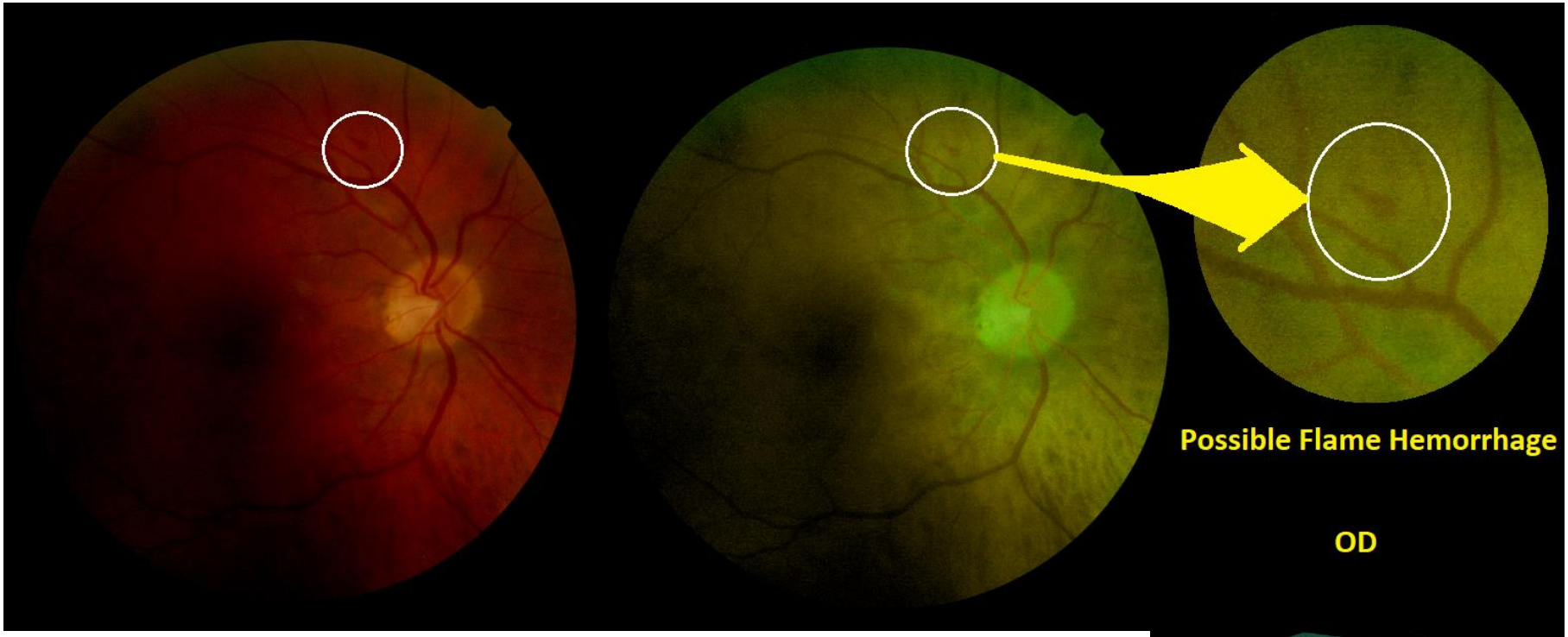
5. Posterior cavity (filled with vitreous humor)
6. Optic disk (blind spot)
7. Fovea centralis (sharpest vision)

Retina

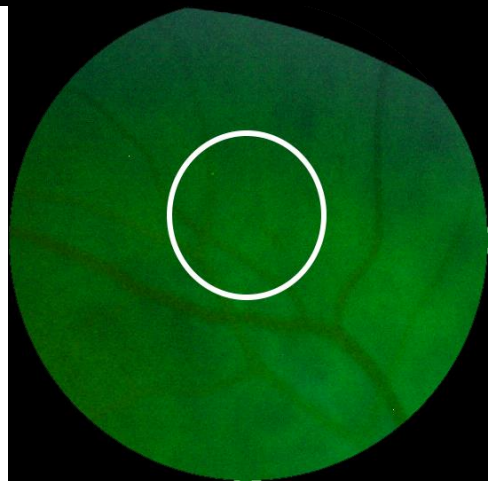
Choroid

Sclera

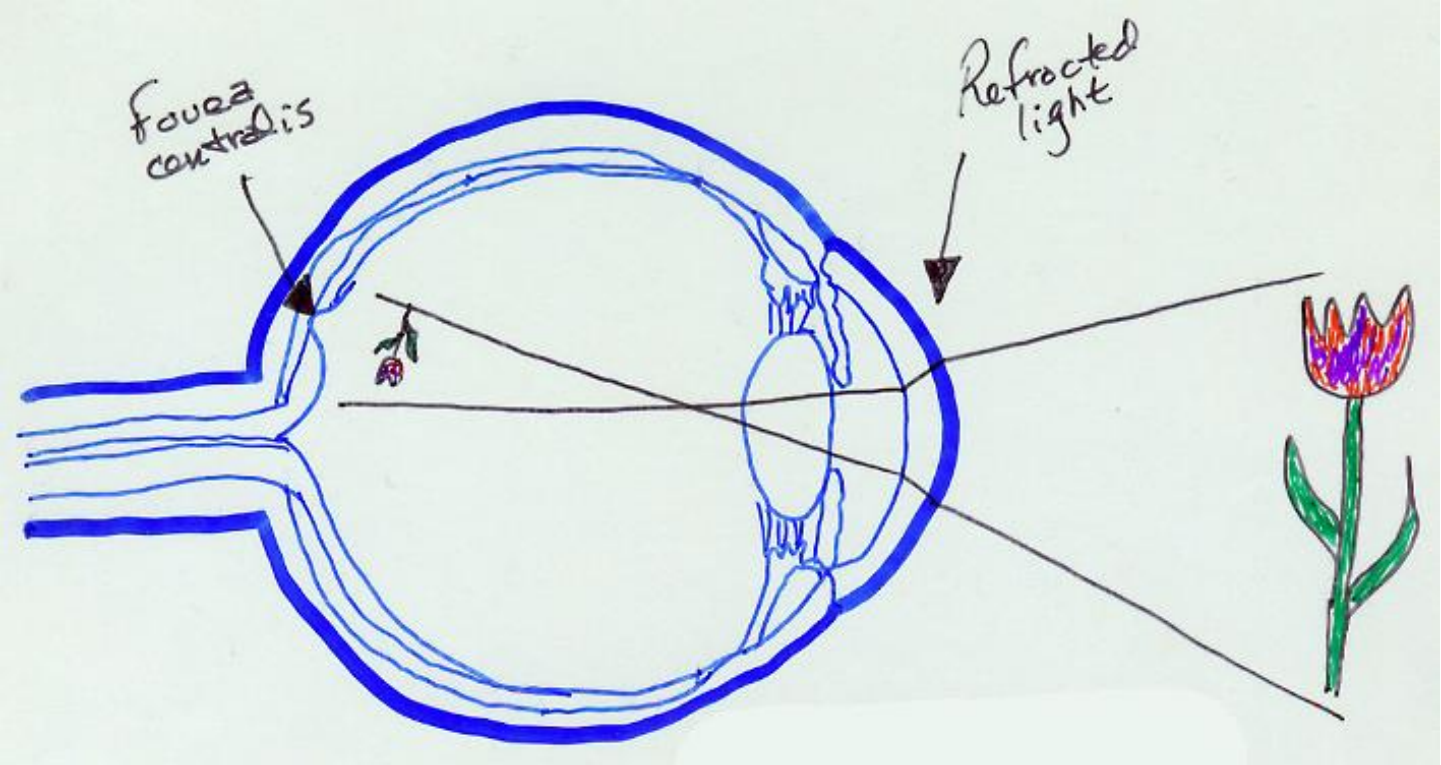

Retinal venule
Optic Disc
Fovea
Central Retinal Artery
Central Retinal Vein
Macula
Retinal arteriole
OS



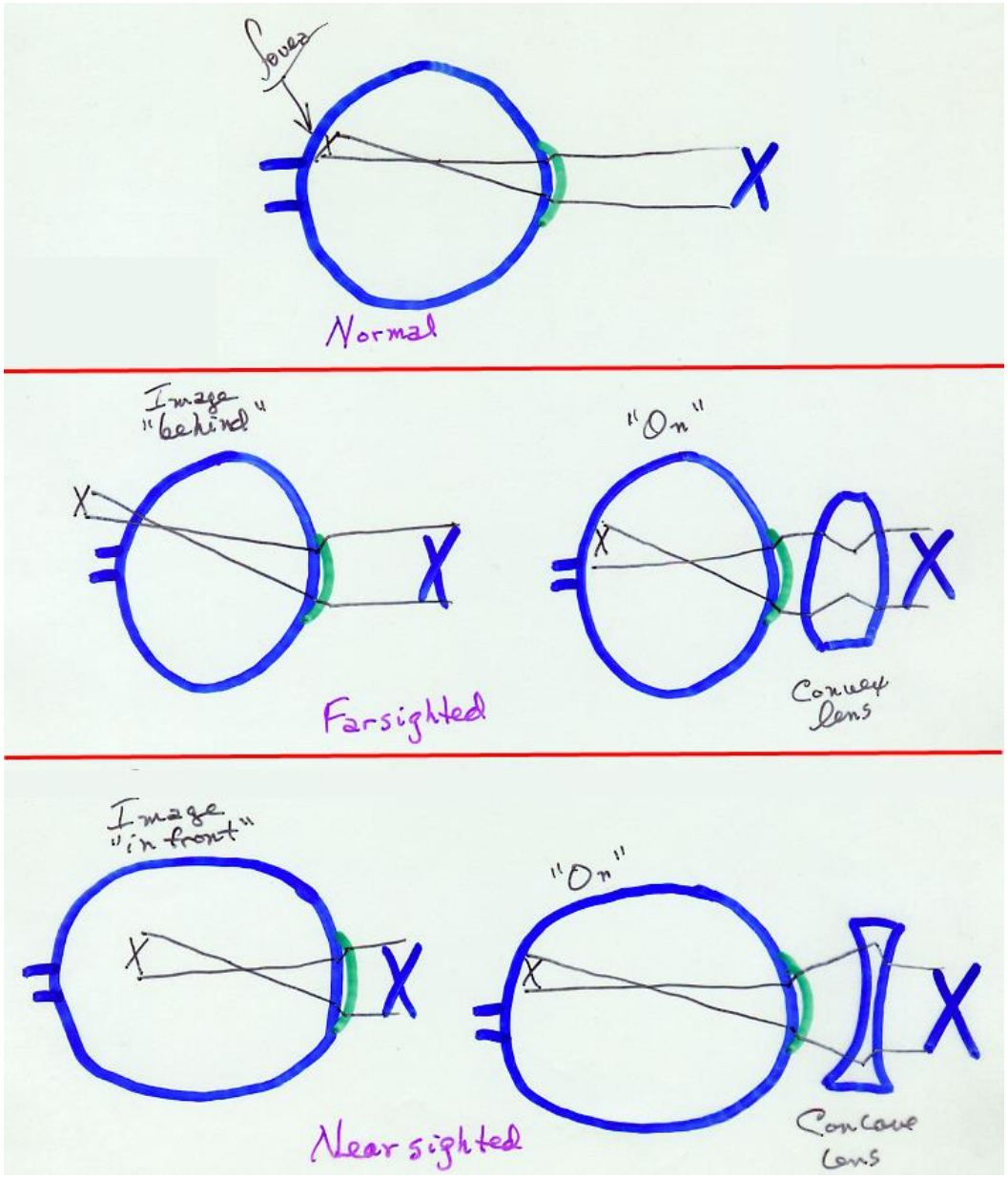
6 weeks later – typical course of events



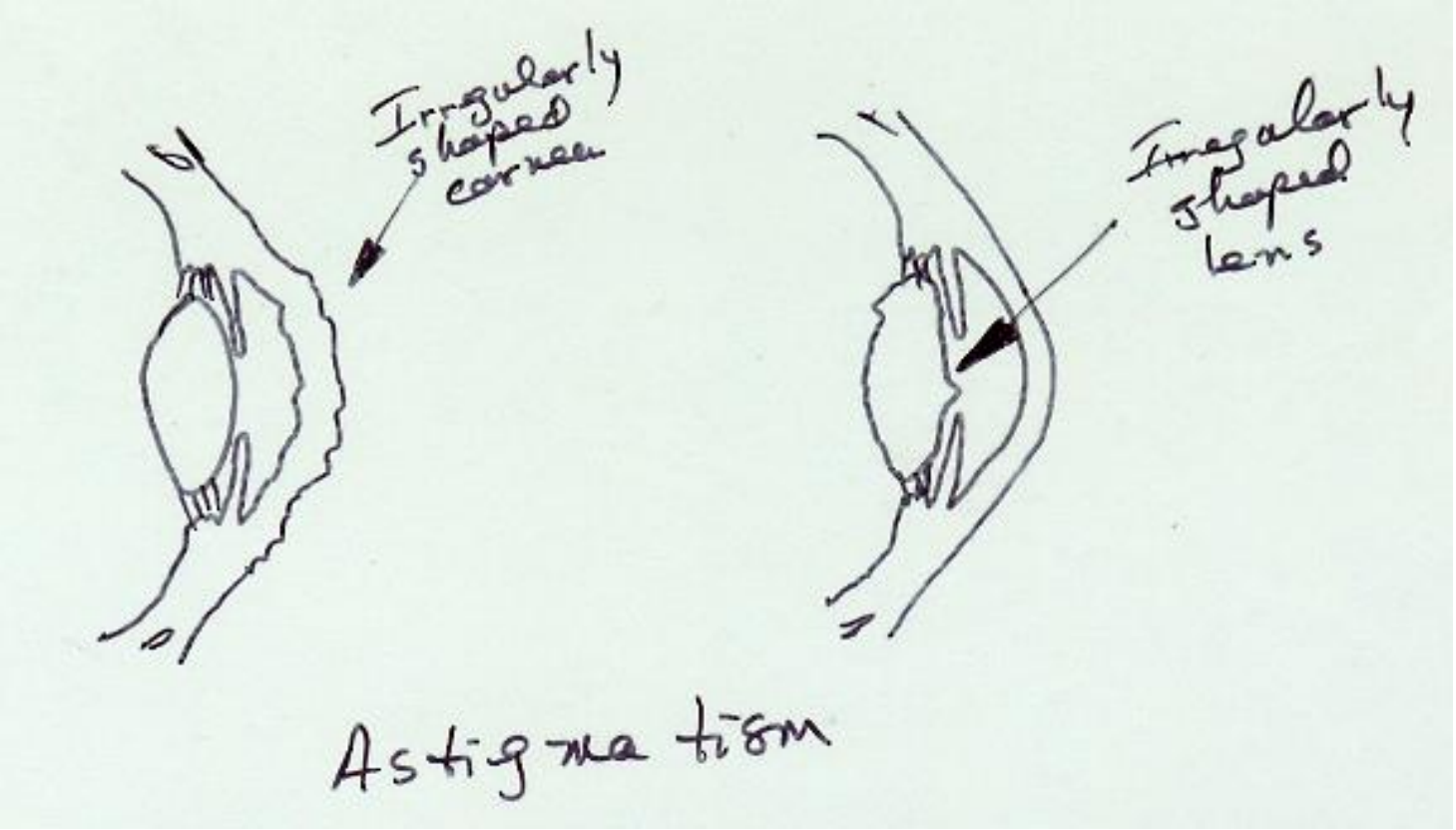
Vision – Normal: image projected onto the fovea



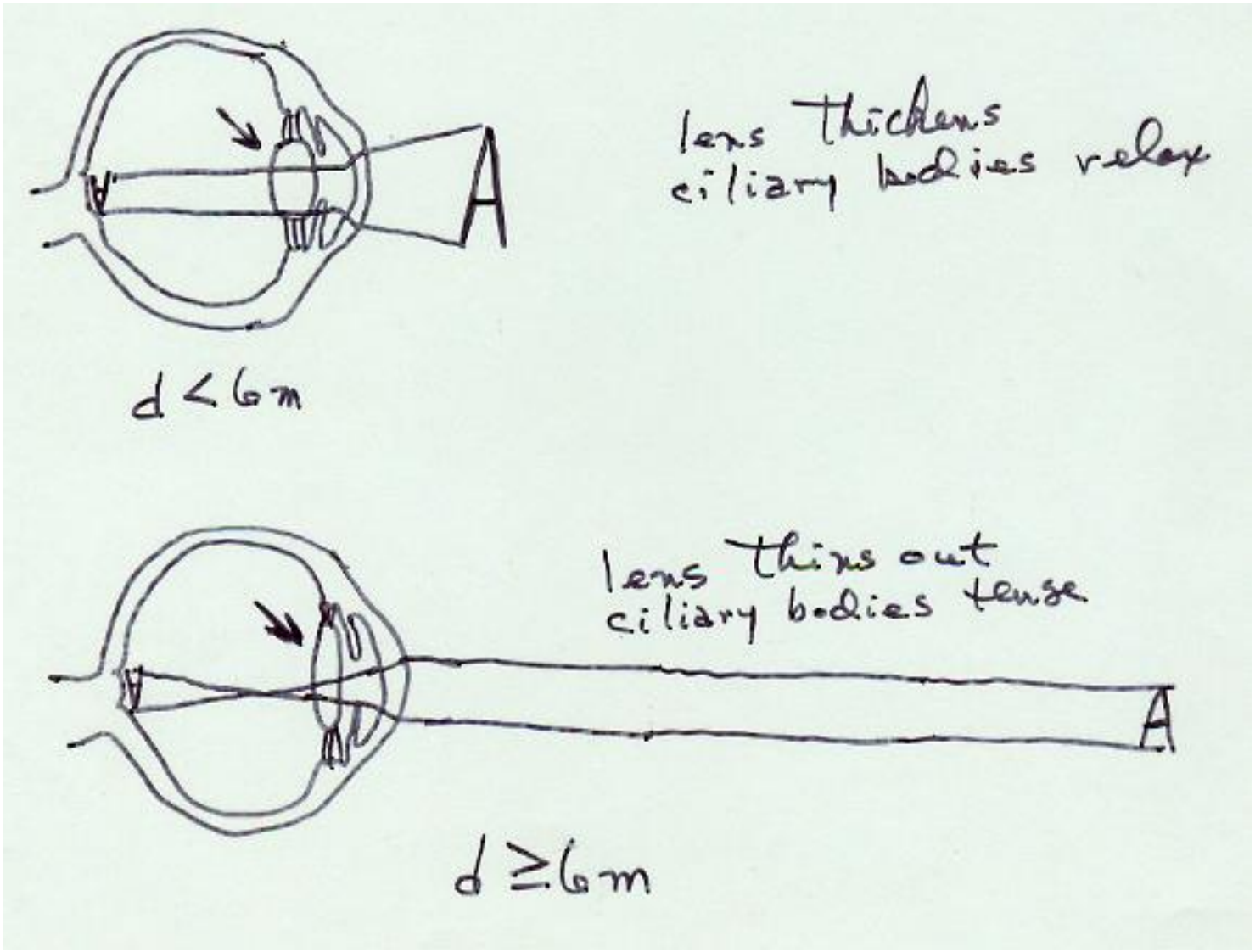
- Myopia = near sighted
- Hypermetropia = far sighted
- Presbyopia = “old age” trombone syndrome

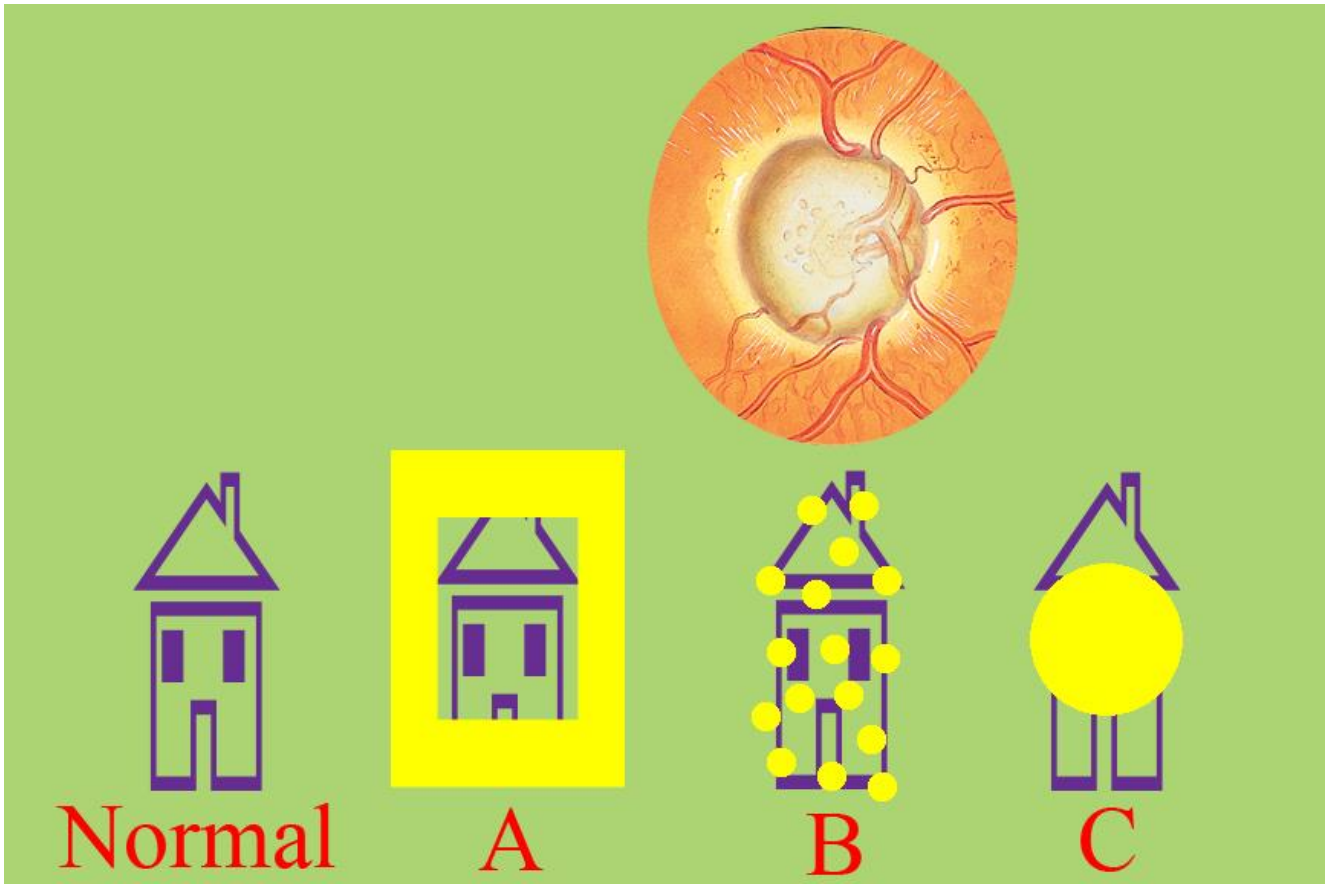

Rays
Normal
Image "behind"
"On"
Farsighted
Convex lens
Image "in front"
"On"
Nearsighted
Concave Lens

Astigmatism

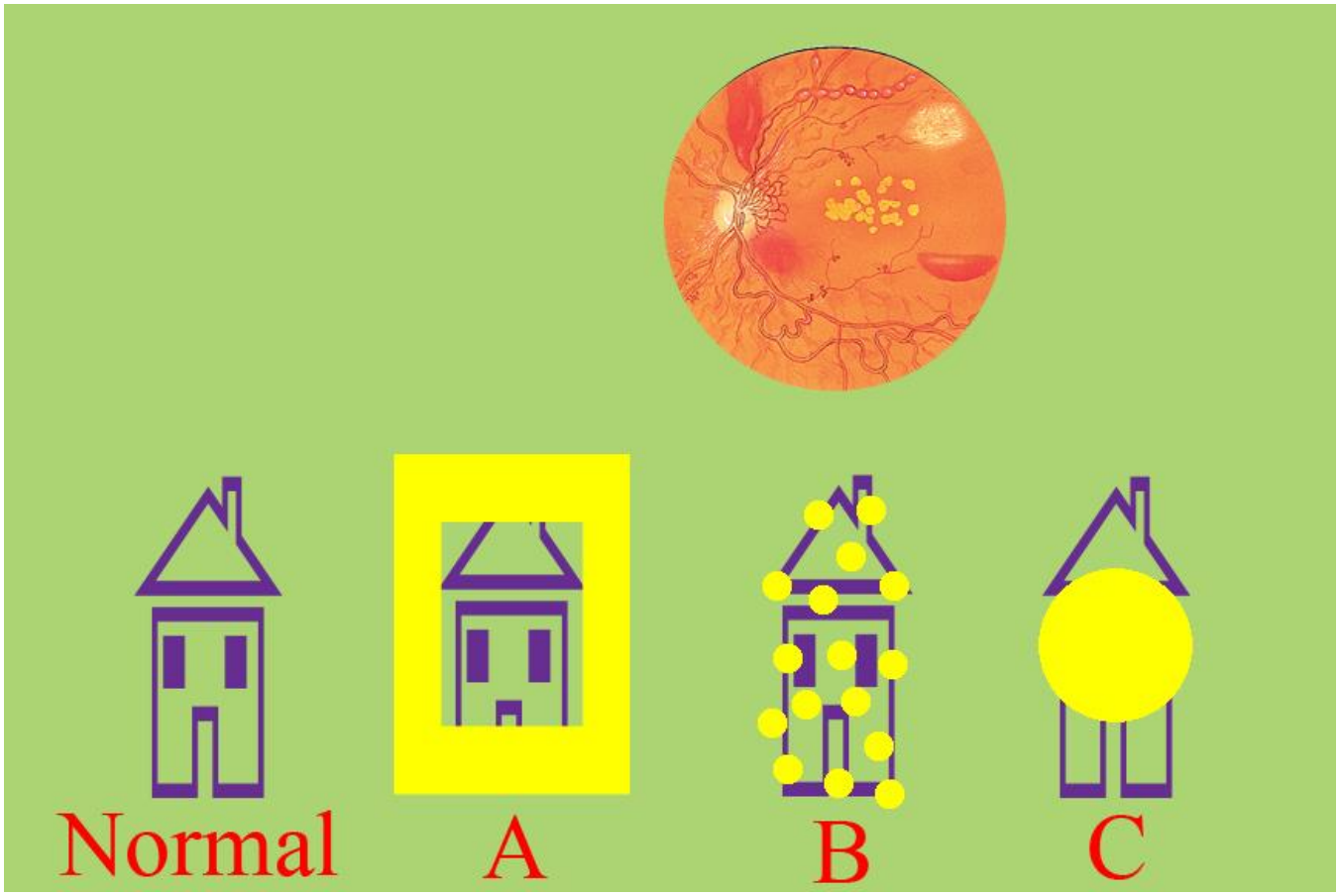


Accomodation

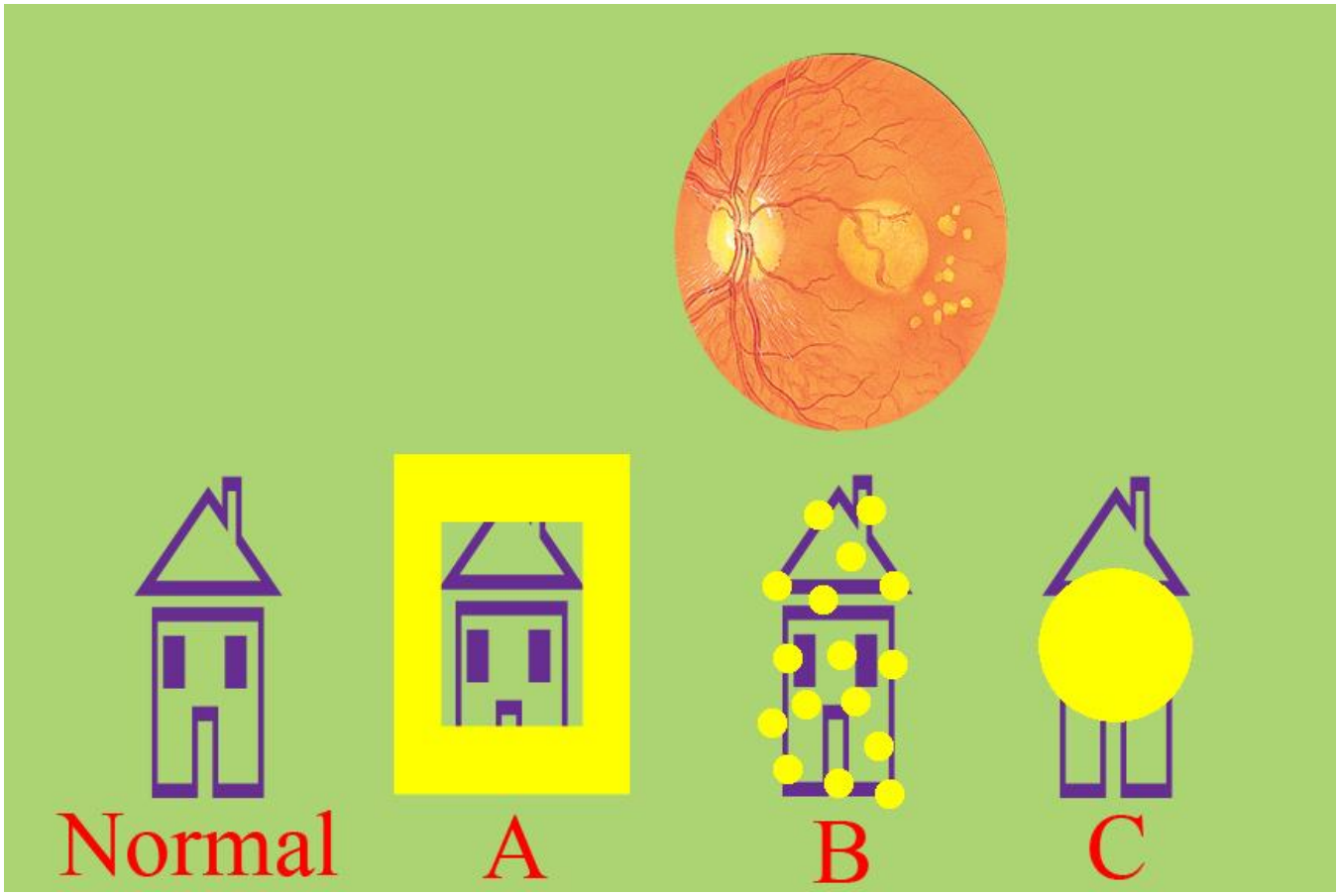




The very top image represents a view of the retina from a person with glaucoma. This vision loss pathology causes people to develop tunnel vision.



The very top image represents a view of the retina from a person with diabetic retinopathy. This vision loss pathology causes people to have a “shot-gun patterned view” of the world.



The very top image represents a view of the retina from a person with macular degeneration. This vision loss pathology causes people to lose their central vision.

Oculomotor Nerve: III – Motor: Movement of Eye

- Exits skull via superior orbital fissure
- The deep origin is beneath the floor of the Aqueduct of Sylvius (connects 3^{d} and 4th ventricles)
- The nerve bifurcates

- Superior bifurcation innervates the levator palpebrae and superior rectus
- Inferior bifurcation innervates medial rectus, rectus inferior, inferior oblique; ciliary muscle and iris sphincter

Terms

- Levator palpebrae: raises upper eyelid

- Ciliary muscle and Iris sphincter: permits accommodation (adjusting the eye to the vision of near objects via ciliary muscle) and allows the anterior surface of the lens to become more convex with slight pupillary contraction (iris sphincter)

- Anomalies

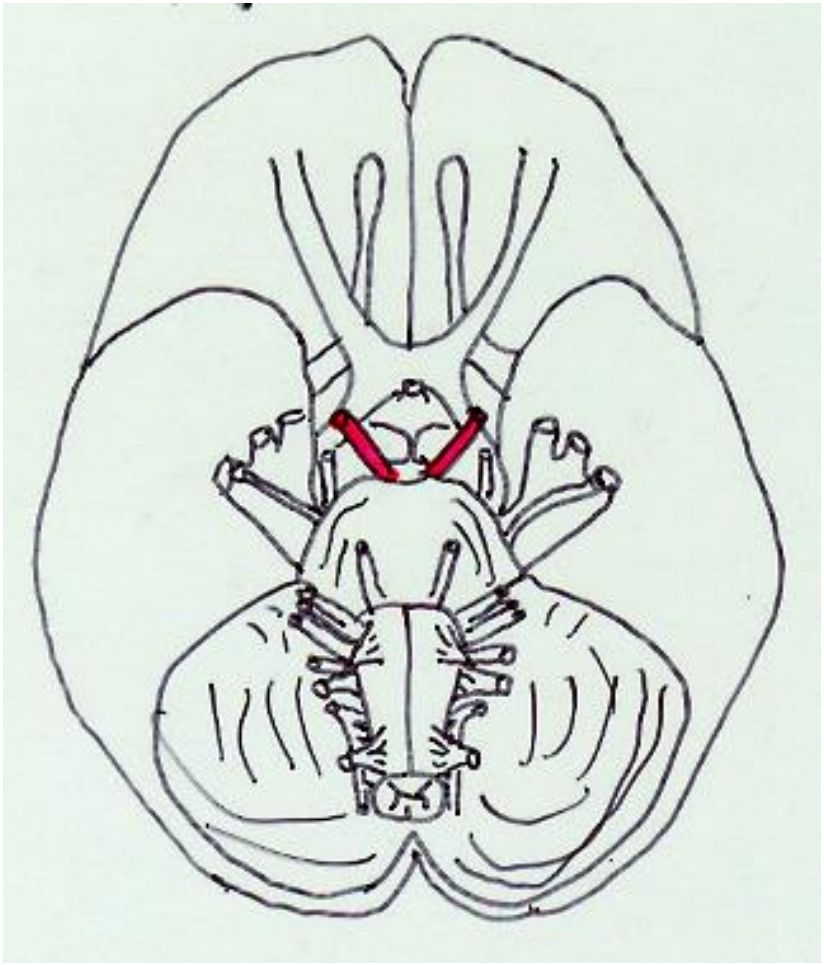
- Ptosis: paralysis of levator palpebrae

- External strabismus due to no innervation of external rectus by III

- Pupillary dilation due to sphincter (iris) paralysis

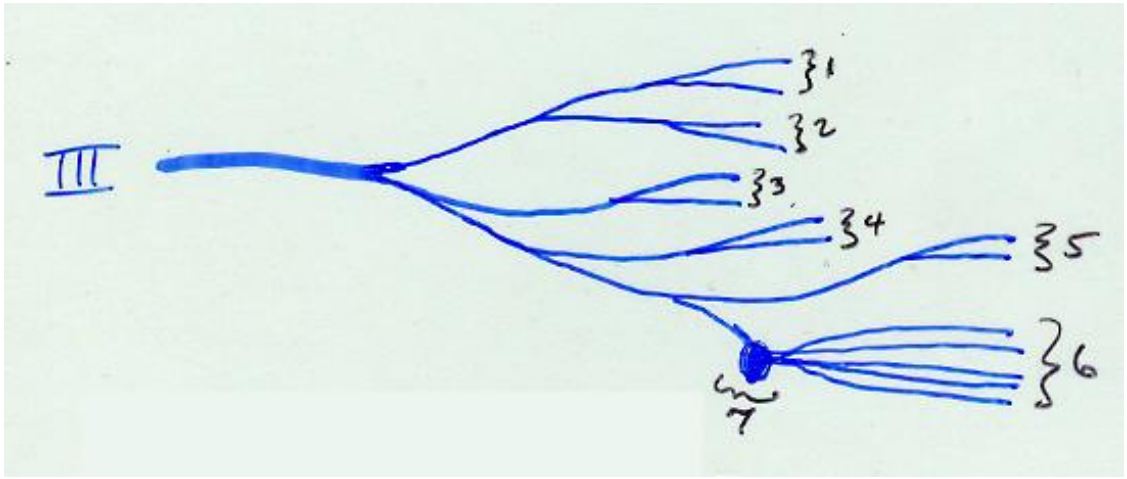
- Loss of accommodation

III, Cont'd



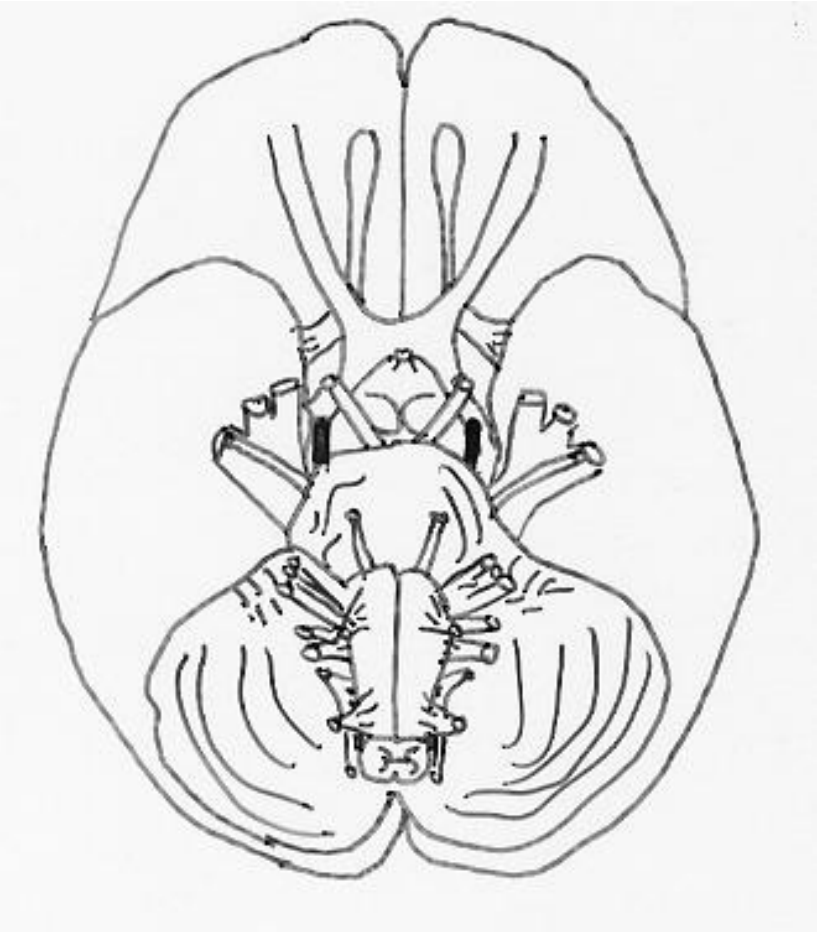
- Motor functions: accommodation, raise the upper eyelid, pupil dilation/constriction, eyeball movement in all directions EXCEPT inferiorly laterally and laterally.

III, Cont'd – Wiring Diagram



1. To levator palpebrae
2. To superior rectus
3. To rectus medialis
4. Rectus inferioris
5. Inferior oblique
6. To ciliary muscle and iris
7. Lenticular ganglion

Trochlear Nerve: IV – Motor: Inferolateral Movement of Eyeball



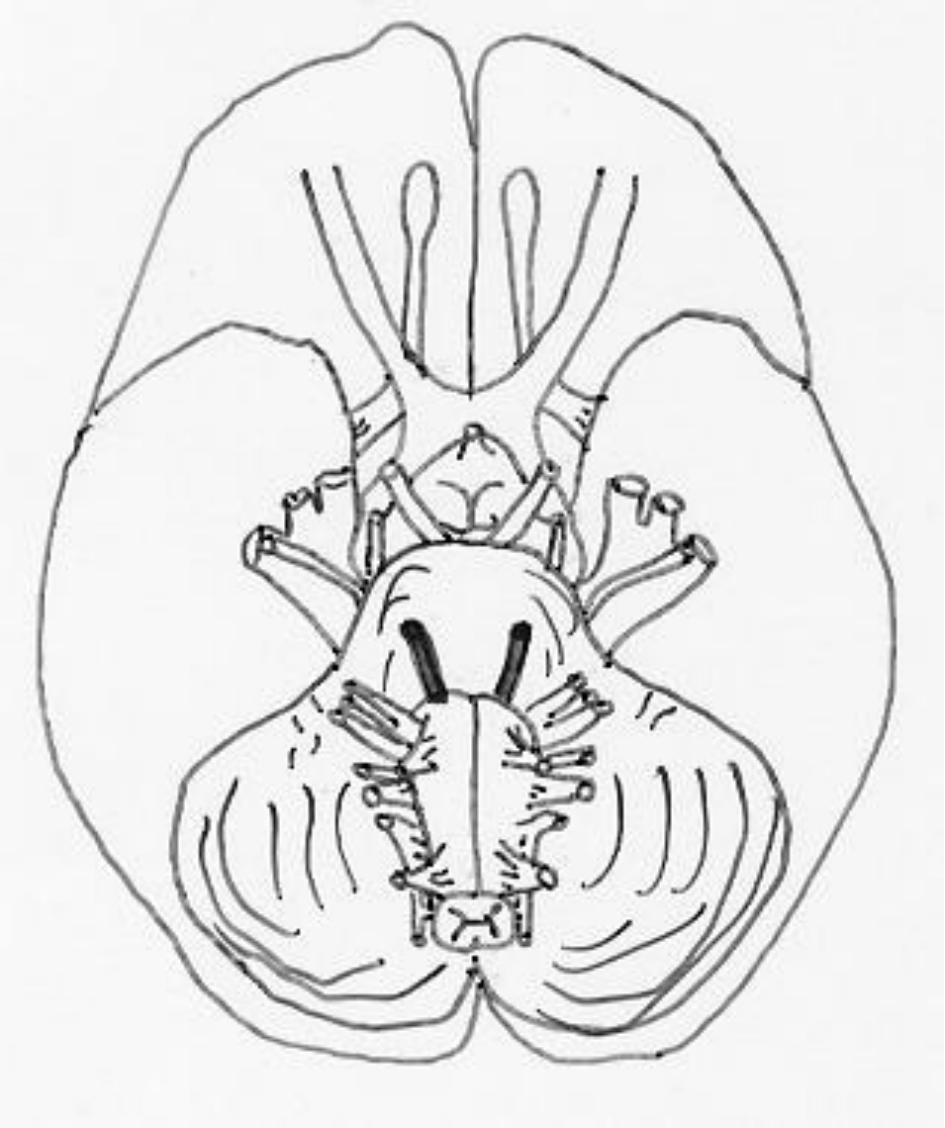
- Exits skull via sphenoidal fissure
- Apparent origin behind corpora quadrigemina
- Deep origin in floor of Aqueduct of Sylvius beneath 3^{d} nerve (& continuous with)
- Supplies/enters orbital surface of superior oblique
  - Trochlea = pulley
- Smallest of the cranial nerves

- Anomaly: unable to turn eye down and out due to superior oblique paralysis and leads to diplopia

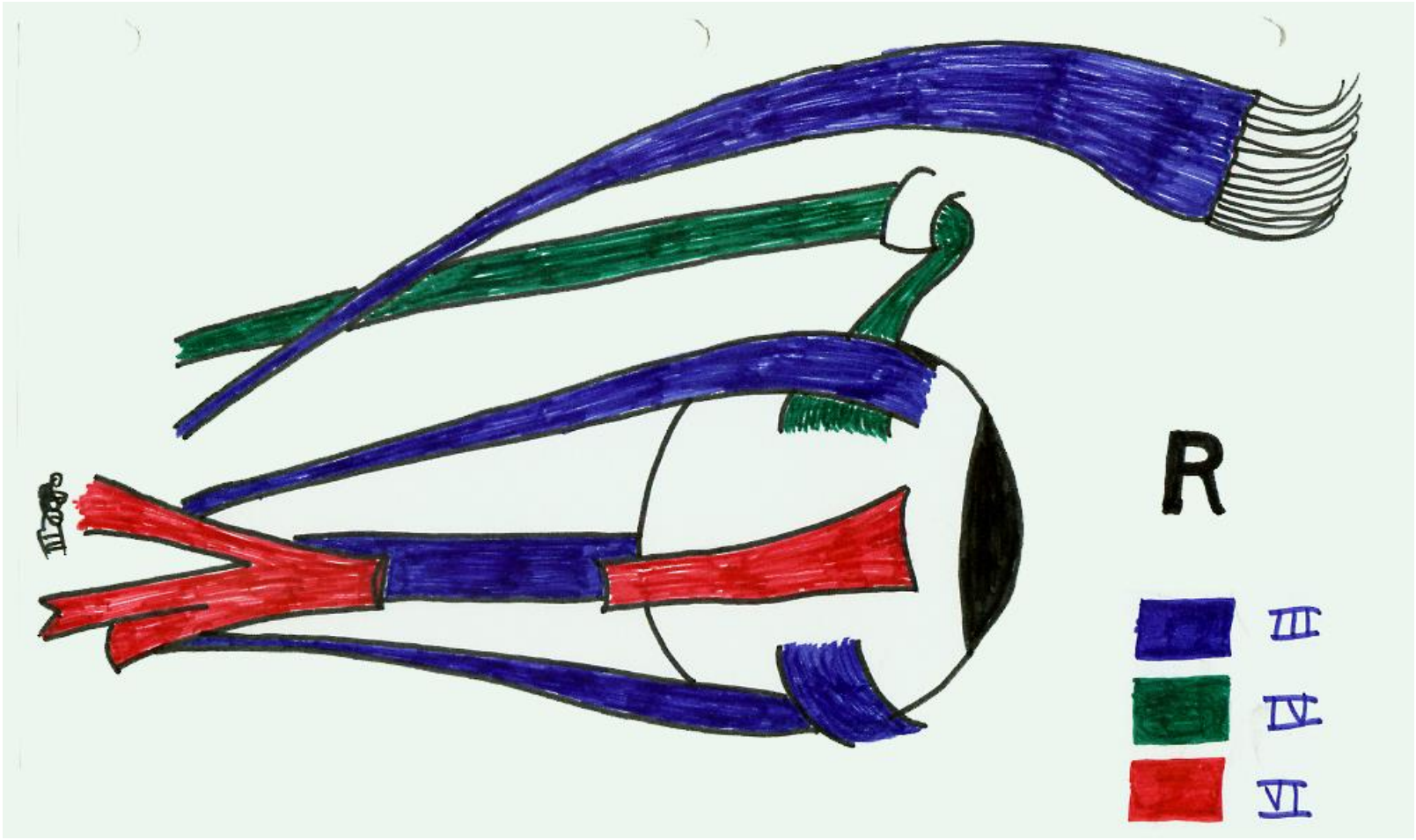
Abducens Nerve: VI – Motor: Lateral Eye Motion

- Exits skull via superior orbital fissure
- Superficial origin close to pons;
- Deep origin upper part of the floor of the 4th ventricle
- Passes into the 3d nerve
- Supplies external rectus (rectus lateralis)

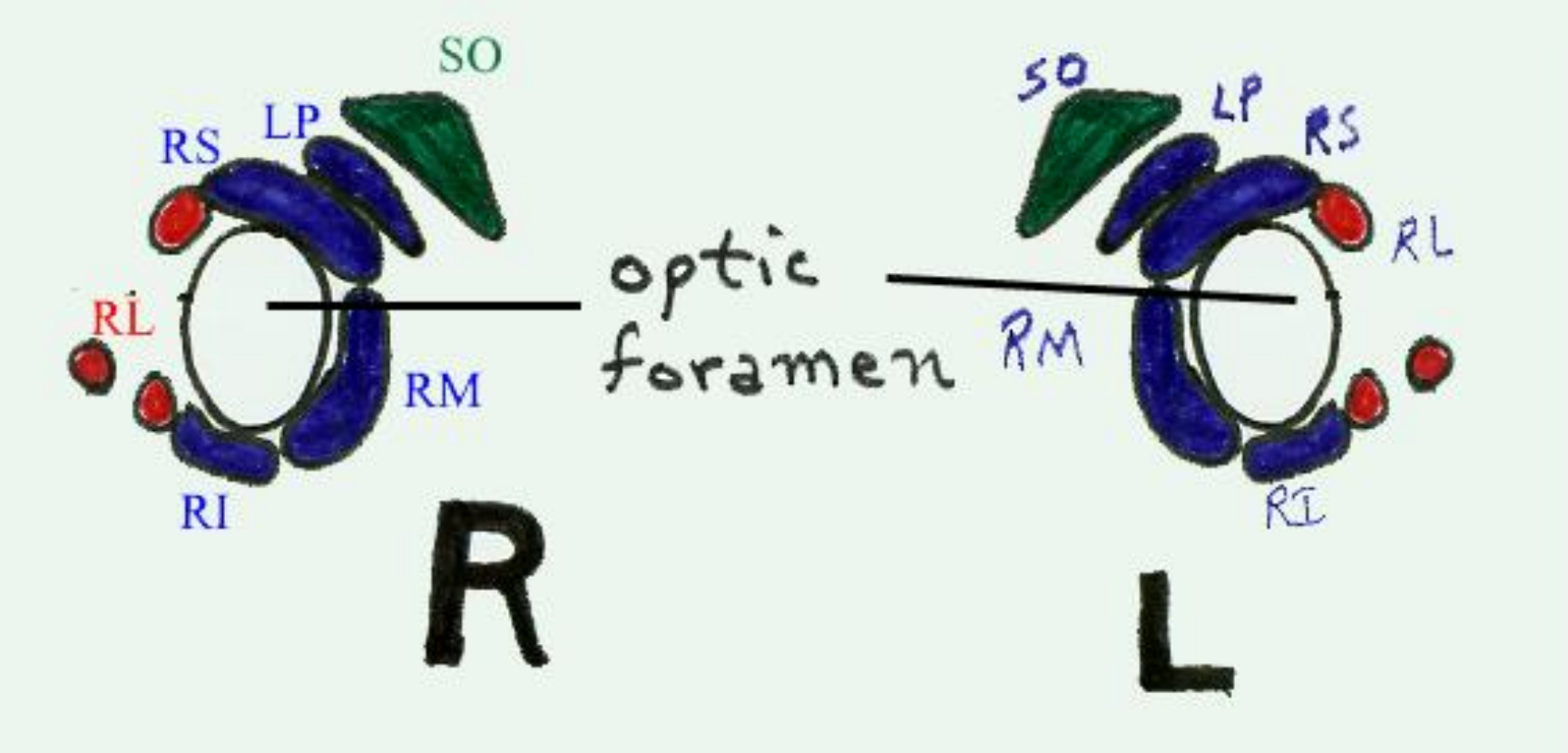
- Anomalies: this nerve has the highest frequency of involvement in basilar fractures than any other cranial nerve; result is convergent squint; also leads to secondary pupillary contraction because of other fibers passing with VI: III



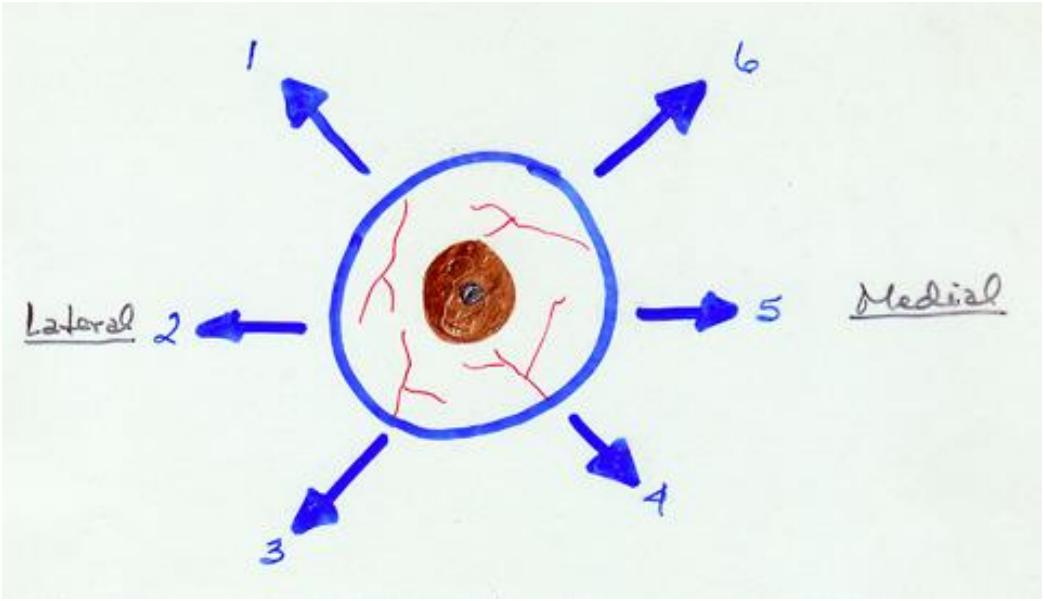
Extraocular Muscles



Extraocular Muscles: Origins



Cardinal Eye Movements



1. Inferior oblique (III)
2. Rectus lateralis (VI)
3. Superior oblique (IV)
4. Rectus inferioris (III)
5. Medial rectus (III)
6. Rectus superioris (III)

Trigeminal Nerve: V – Motor and Sensory

- Superficial origin in the anterolateral pons
- Deep origin of sensory long tract in medulla
- Deep origin of motor upper part of floor of 4th ventricle and side of aqueduct of Sylvius

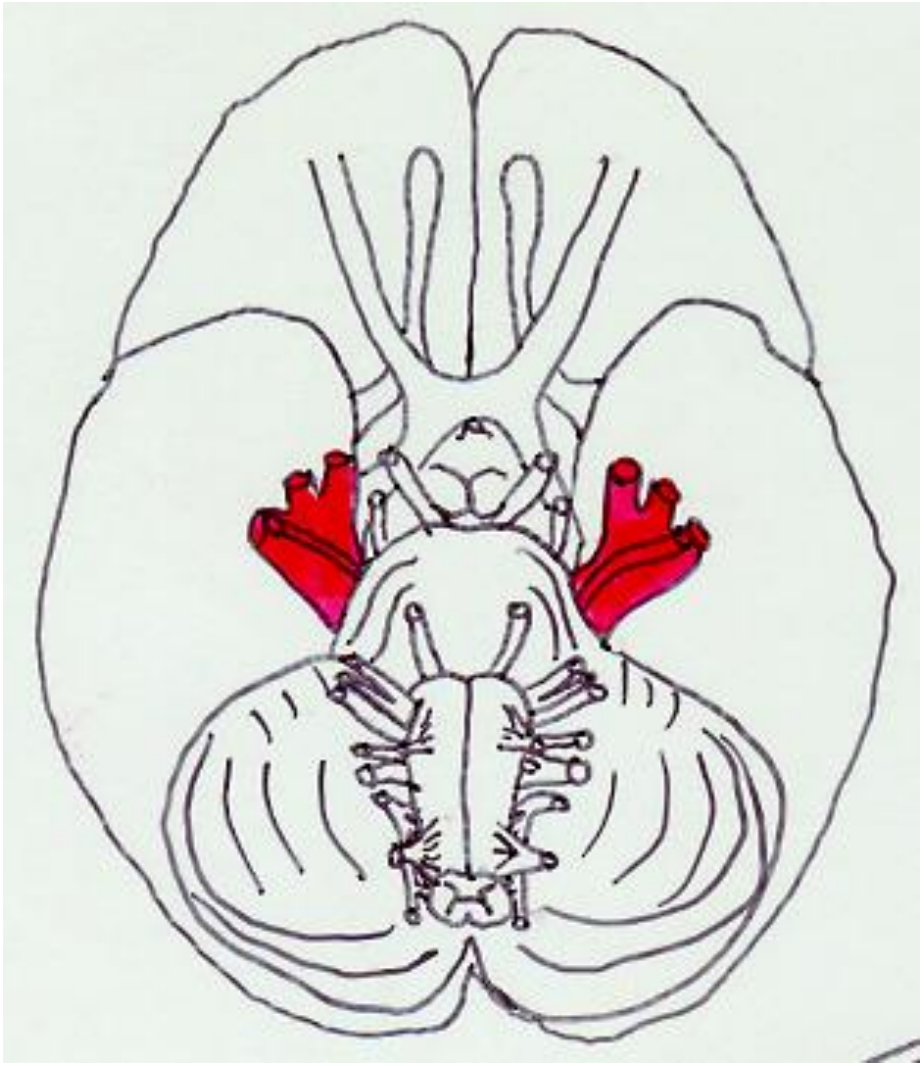
- Three branches (hence "tri"):
  - Ophthalmic – pure sensory
  - Maxillary – pure sensory
  - Mandibular – sensory and motor

- Ophthalmic Branch
  - Exits via sphenoidal fissure
  - Supplies eyeball, lacrimal gland, conjunctiva, nasal mucosa and skin of eyebrow, forehead and nose
  - Smallest of the 3 subdivisions

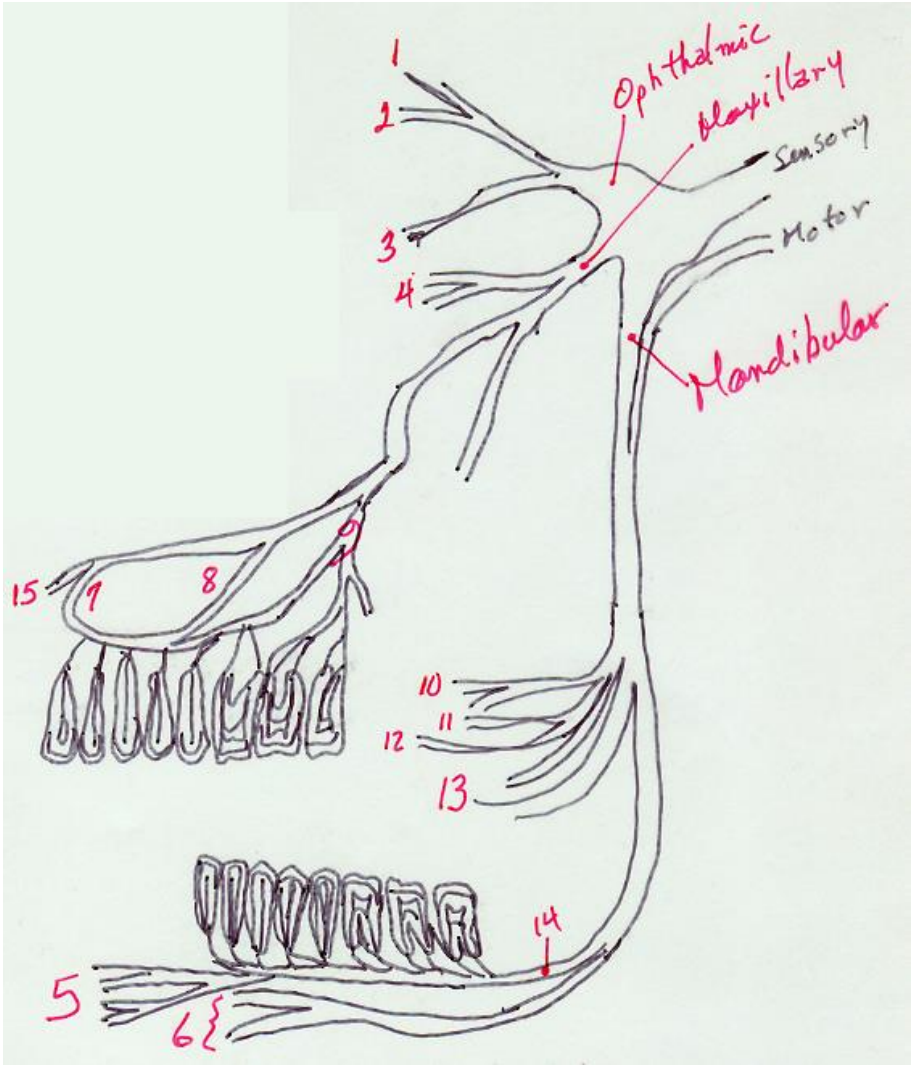
- Maxillary Branch
  - Exits via foramen rotundum
  - Enters orbit and traverses sub-orbital canal exiting at infraorbital foramen
  - Supplies temple, side of forehead, malar cheek skin, maxillary teeth (individual branches to each tooth), skin and conjunctiva of lower eyelid with sensation, skin of side of nose, upper lip and mucous membrane of mouth

- Mandibular Branch
- Exits via foramen ovale
- Has two roots: large (sensory) and small (motor)
- Supplies teeth and gums of mandible, skin of temple and external ear, lower face and lower lip, muscles of mastication, submandibular and sublingual salivary glands and tongue (anterior $^{2}/_{3}$)

Trigeminal Nerve: V



Wiring Diagram: V



1. To forehead/scalp
2. To lacrimal gland
3. To nose tip/septum and ciliary body and iris
4. To temple/cheek
5. To chin/lower lip
6. Mylo-hyoid and anterior digastricus
7. Anterior dental
8. Mid-dental
9. Posterior dental
10. To masseter
11. To external pterygoid
12. Buccinator
13. To internal pterygoid
14. Inferior dental
15. Labial

V: Anomalies

- Sensory
  - Anesthesia to half of face (except over parotid)
  - Destructive inflammation of cornea
  - Dry nose, decreased secretion of lacrimal/salivary glands
- Motor
  - Paralysis of muscles of mastication

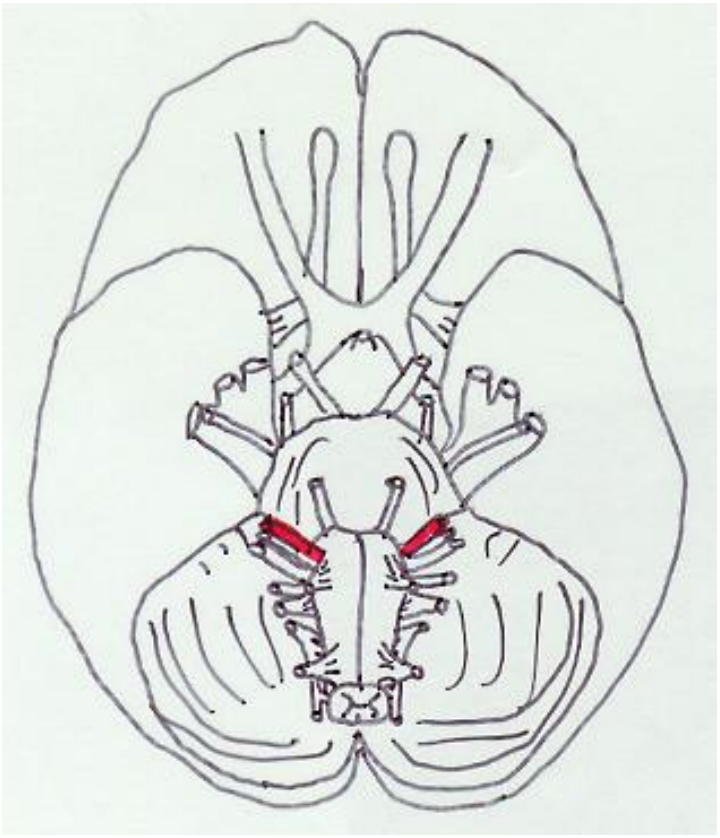
Facial Nerve: VII – Motor and Sensory

- Motor nerve of all muscles of expression in the face
- Nerve of taste for anterior $^2/_3$ of tongue
- Vasodilator nerve for submandibular and sublingual glands
- Supplies muscles of facial expression, platysma and buccinator, external ear, posterior belly of digastricus and stylohyoid, anterior $^2/_3$ of tongue, “sub” salivary glands
- Exits skull via internal auditory meatus through petrous portion of temporal bone to stylo-mastoid foramen
- Superficial origin is upper end of medulla
- Deep origin lower part of pons anterolateral to VI

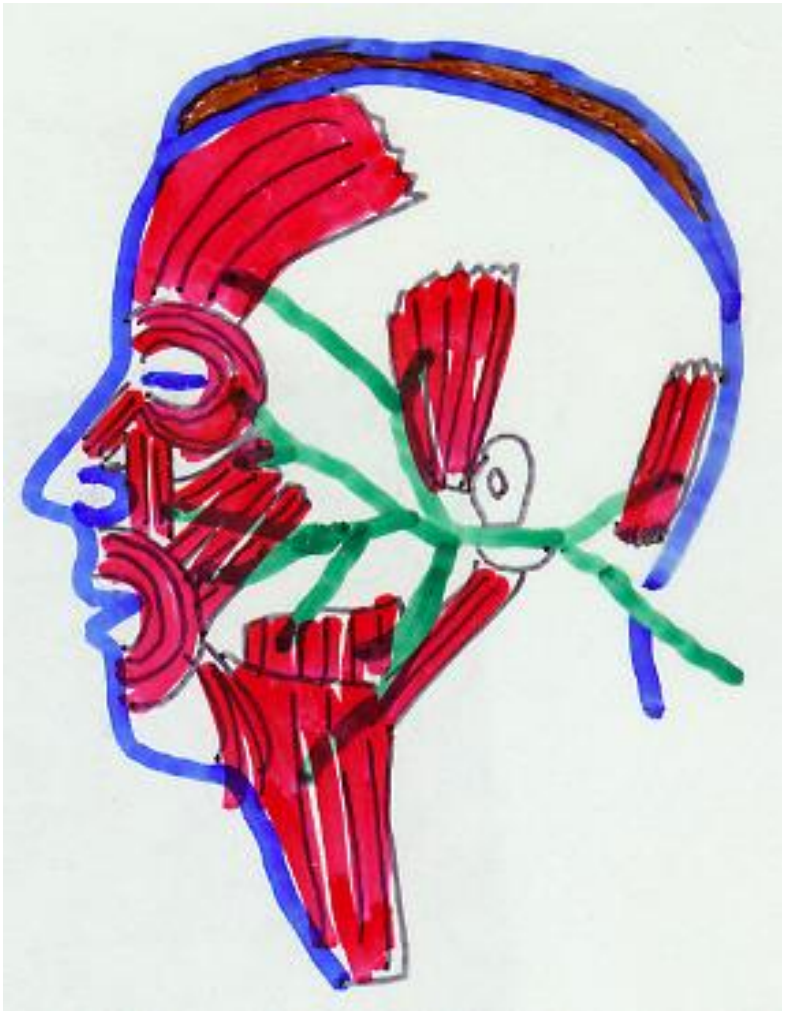
VII, Cont'd – Anomalies -- More frequently paralyzed than any of the other cranial nerves

- Paralysis depends on
  - Central causes (clot, tumor which increases pressure on nerve before it enters internal auditory meatus)
  - In the petrous bone due to middle ear disease or fracture (loss of taste – patient unable to differentiate between bitters and sweets, acids and salines – mouth dry because of no salivary flow)
  - At or after exit from the stylo-mastoid foramen (after exit from stylomastoid foramen all muscles of expression are paralyzed = smooth forehead; patient unable to frown, ptosis, tears run down cheek constantly; nostril can not be dilated; mouth is drawn to the healthy side; effected corner of mouth sags; unable to whistle; partial loss of taste; called Bell's palsy – may be idiopathic; may clear up spontaneously

VII



Temporal
Zygomatic
Buccal
Mandibular
Cervical



Acoustic, Auditory or Vestibulocochlear Nerve: VIII -- Sensory

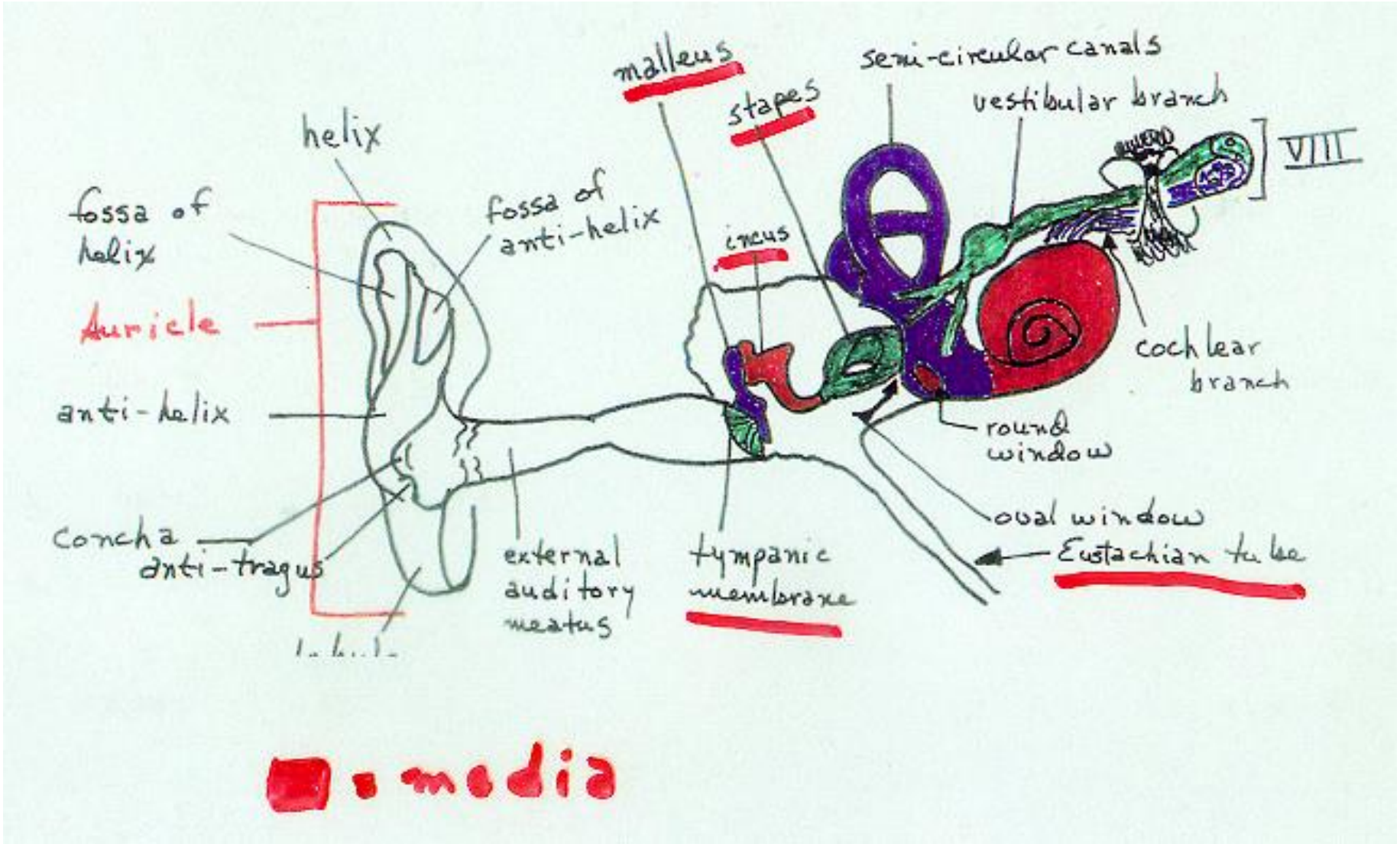
- For hearing and balance
- This nerve for balance and hearing
- Has a few fibers from the inferior colliculi
- Exclusive to the inner ear – has 2 roots
  - Vestibular – enters medulla from semi-circular canals
  - Cochlear – external to vestibular root at medulla

- Anomalies:
  - If torn due to fx, deafness PERMANENT
  - If bruised or pressed on by blood, deafness temporary
  - Loud explosions cause deafness due to compression ("soft" nerve)

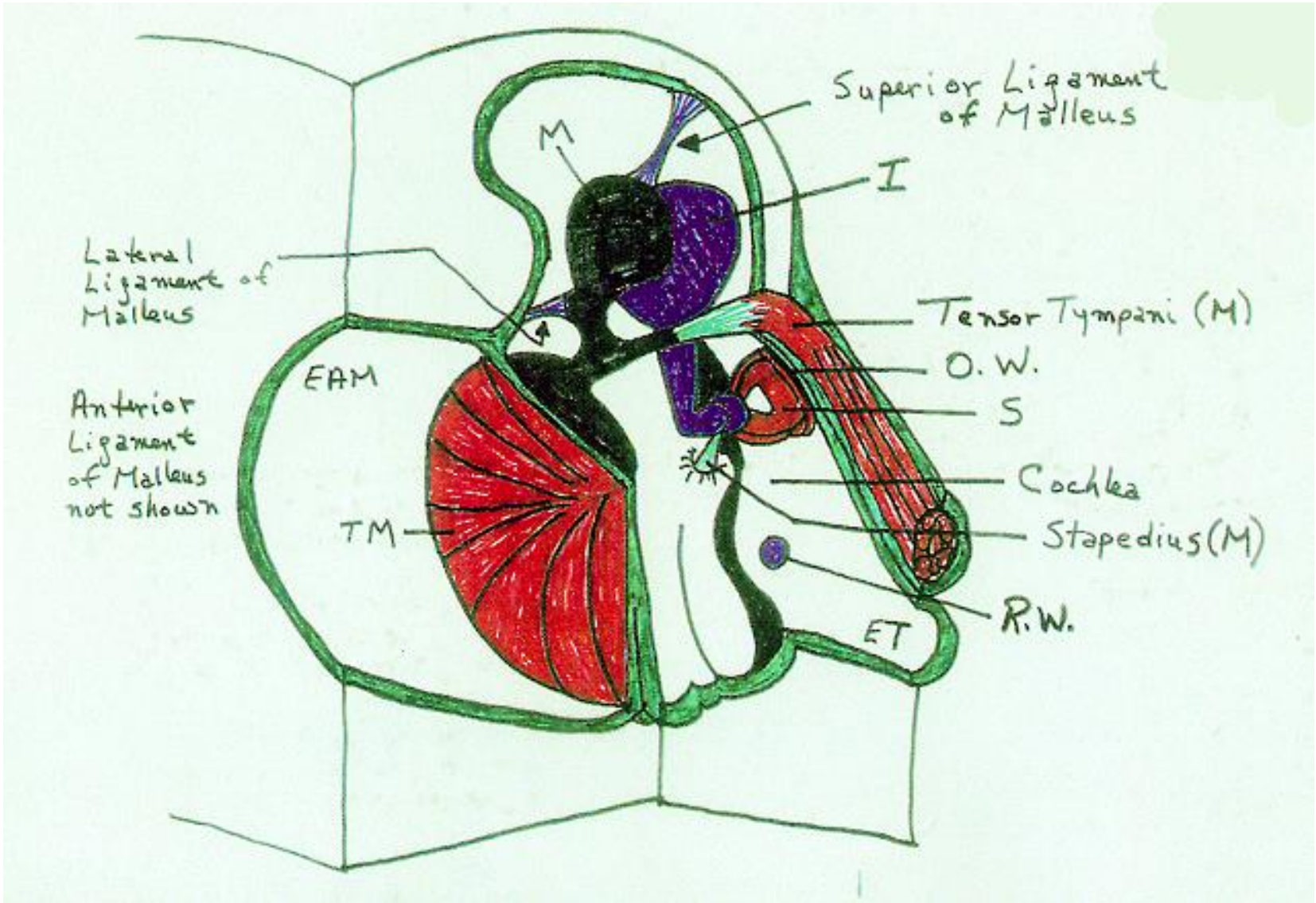
Ultrasound

- Wavelengths greater than 20,000 Hz are called ultrasound.
- These sounds can not be heard by humans.
- Cool mist nebulizers are to be used with caution around newborns – “crush” VIII
- Application: Pulmosonic

The Ear


malleus
stapes
semi-circular canals
vestibular branch
VIII
helix
fossa of helix
fossa of anti-helix
incus
Auricle
anti-helix
cochlear branch
round window
oval window
Eustachian tube
concha
anti-tragus
external auditory meatus
tympanic membrane
media

Middle Ear Structures



Middle Ear Muscles

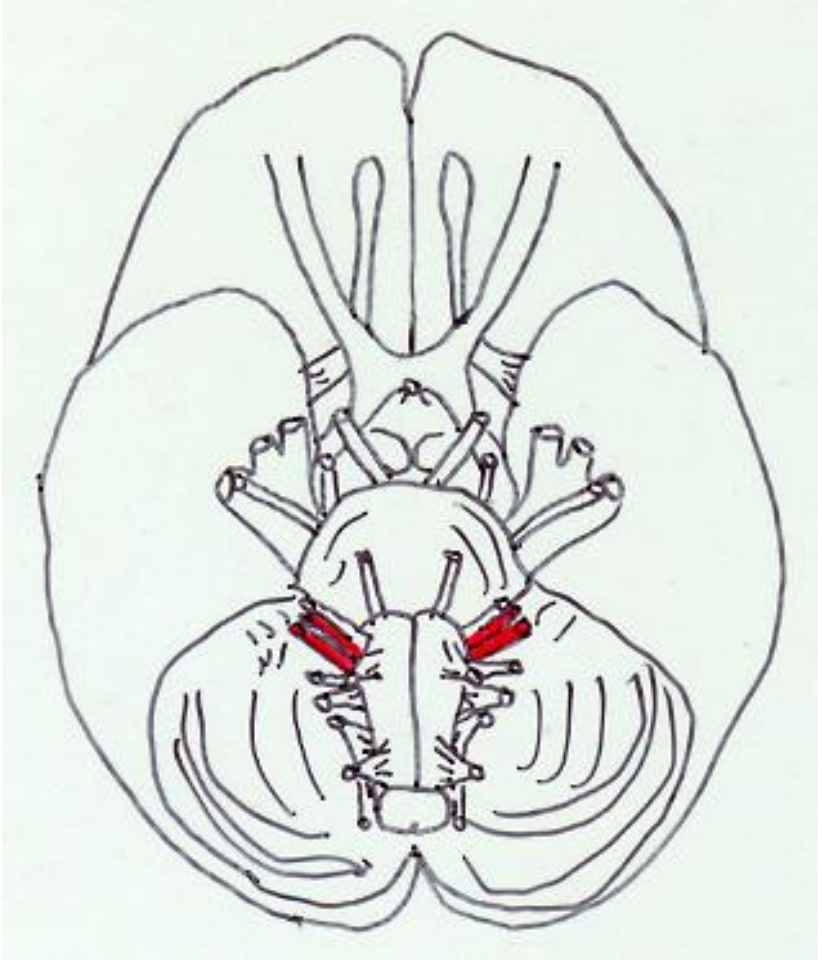
- Tensor tympani
- Insertion: medial malleus
- Origin: cartilaginous wall of auditory tube
- Action: malleus pulled inward
- Paralysis: leads to difficulty hearing because the TM gets “floppy”

- Stapedius
- Insertion: posterior stapes
- Origin: inner wall of tympanic cavity (~2 mL, BTW)
- Action: stapes pulled outward
- Paralysis: results in hyperacusia – abnormally sensitive hearing

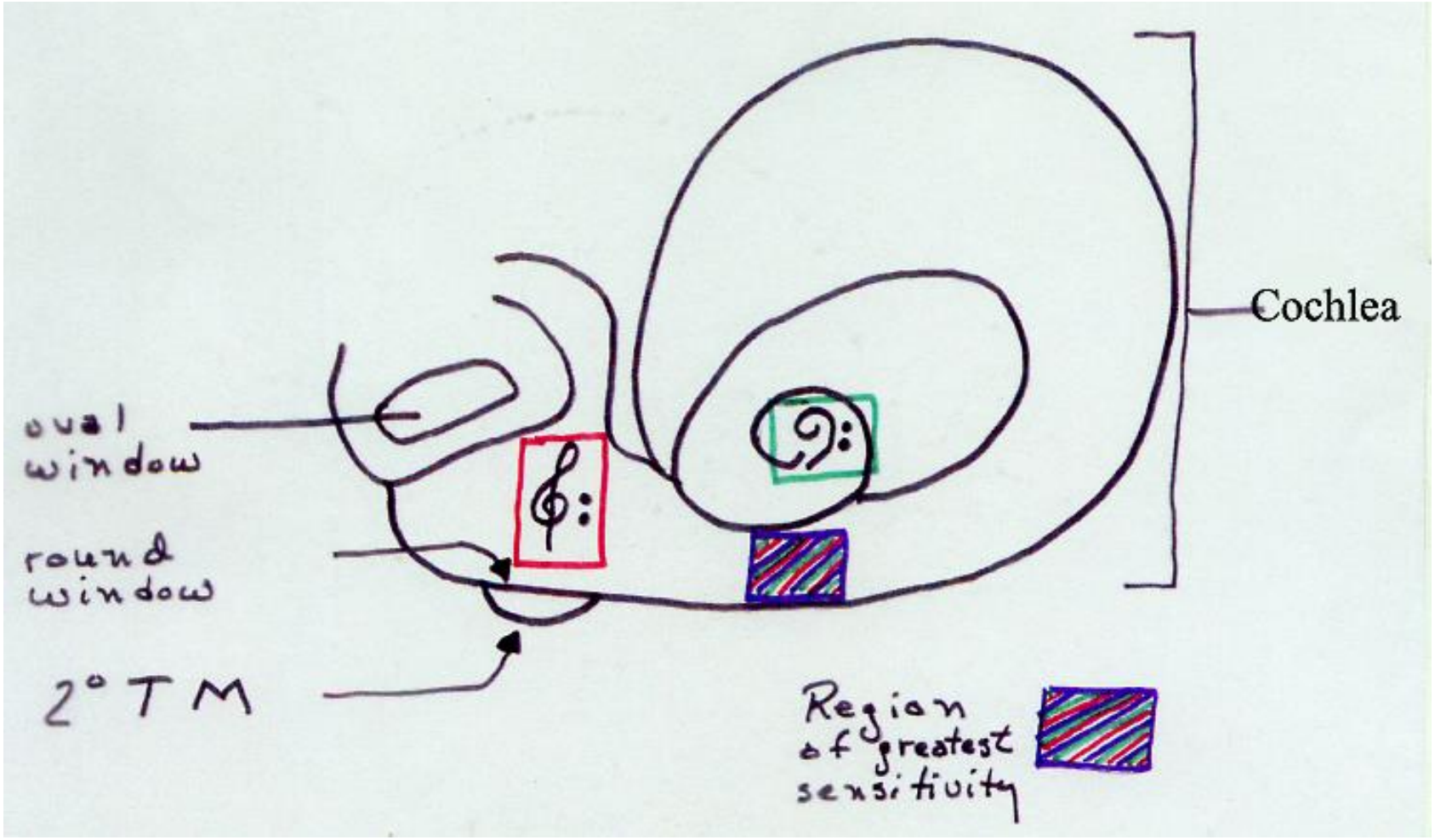
Tympanic Reflex

- Protective mechanism that reduces pressure from loud sounds – these loud sounds would damage hearing receptors otherwise
- Works with contraction of both T. tympani and stapedius and leads to a rigid bridge of auditory ossicles which results in a 2° loss of effectiveness of vibratory transmission, aka “damping”
- Elicited in about 0.1 seconds following a loud external sound
- Rapid noises such as a gunshot are too fast
- Slow noise like the roar of thunder elicit this reflex
- Also elicited by people singing or speaking
- Muffles the lower frequencies of these sounds and improves the hearing of the higher frequency sound (common in human voices)

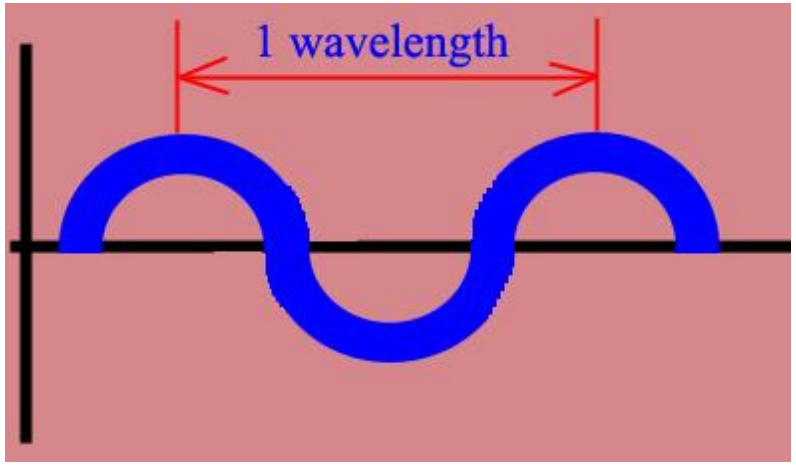
VIII



Inner Ear Structures – Light Physiology



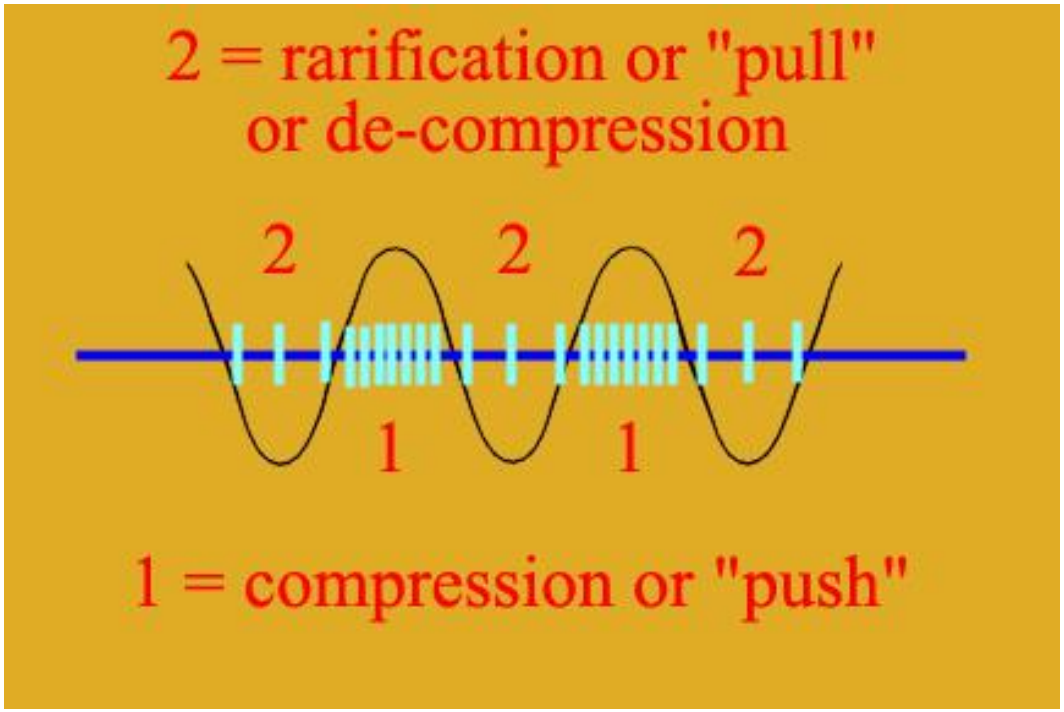
Sound Waves



$$\frac{1\lambda}{\text{sec}} = 1Hz = 1cps$$

- A wavelength is the distance from the top or bottom of one wave to the top or bottom of the next
- Amplitude is the height of a wave's crest above the average level (black line)
- Frequency equals the number of wavelengths/time

Sound



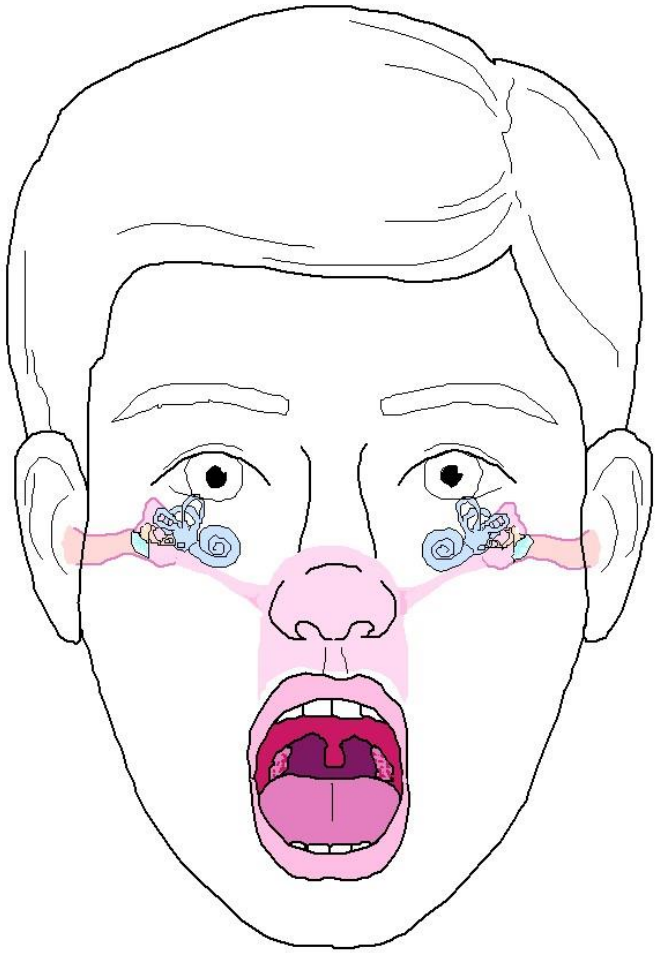
- In order to transmit sound waves through air, it must be condensed and rarified:
  - Condensed = compresses air in front of sound wave (pushes ear drum in)
  - Rarified = thins the air behind the sound wave (“pulls” ear drum out); vacuum or decompression

Terms: Sound

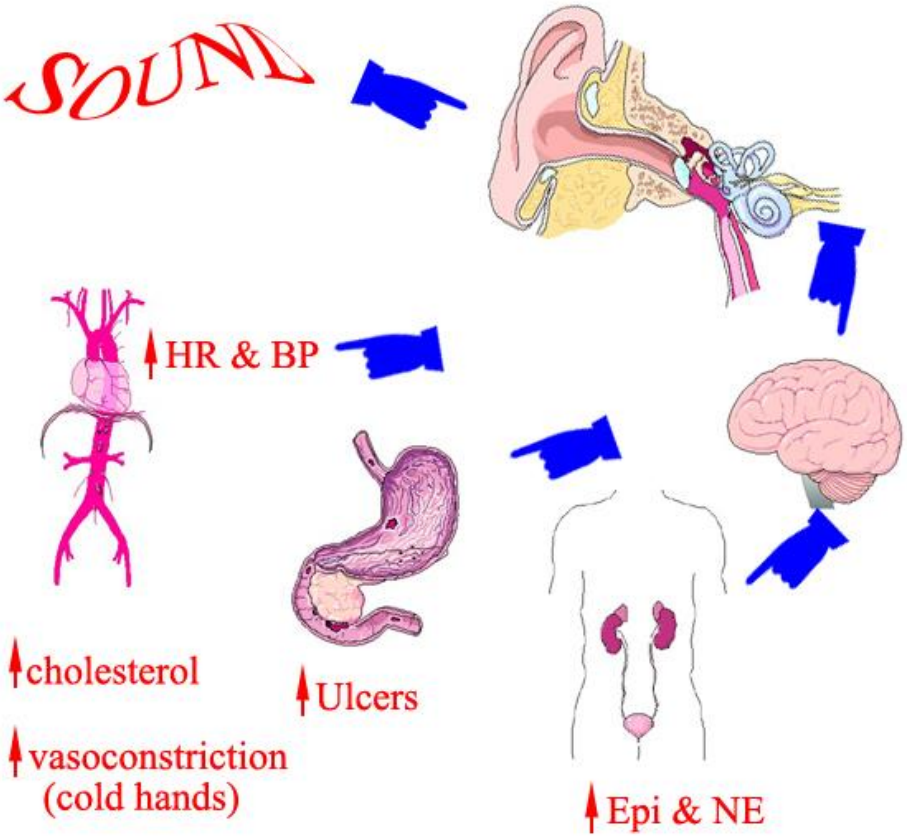
- Pitch = frequency
- The higher the pitch the higher the frequency
- The lower the pitch, the lower the frequency

- Highest pitch on the right of a piano and is about 8300 Hz
- Lowest pitch on the left of a piano and is about 28 Hz

Different Perspective on Closed Tube



Sounds – Physiological Effects



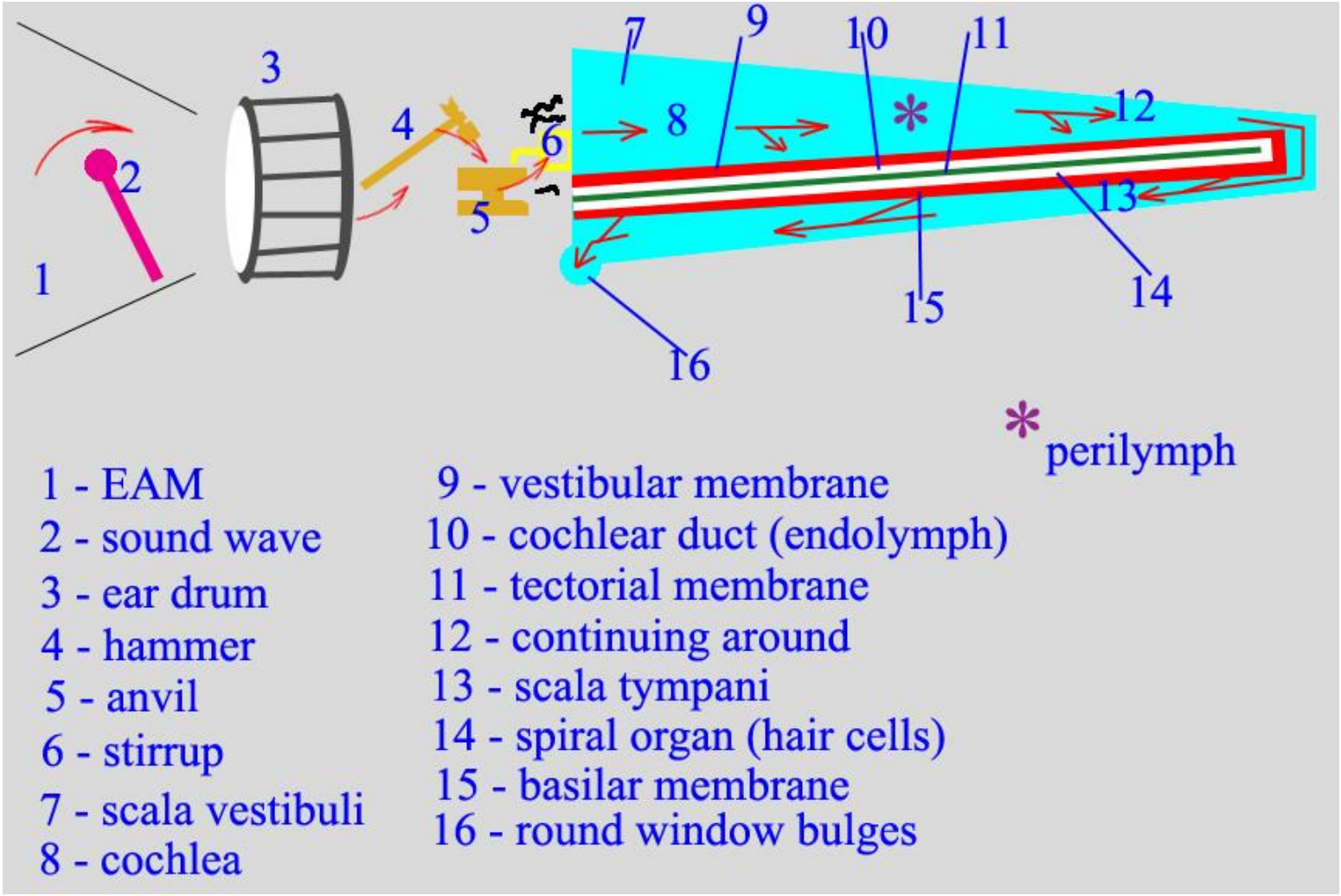
Decibel Scale

A scale based on multiples of 10		
Source	Intensity (dB)	# times > TOH
TOH	0	10^0
Whisper	20	10^2
Normal Talking	60	10^6
Vacuum Cleaner	80	10^8
Walkman max'd out	100	10^{10}
Pain threshold	130	10^{13}
F-14 taking off	140	10^{14}
Instantly perforate TM	160	10^{16}

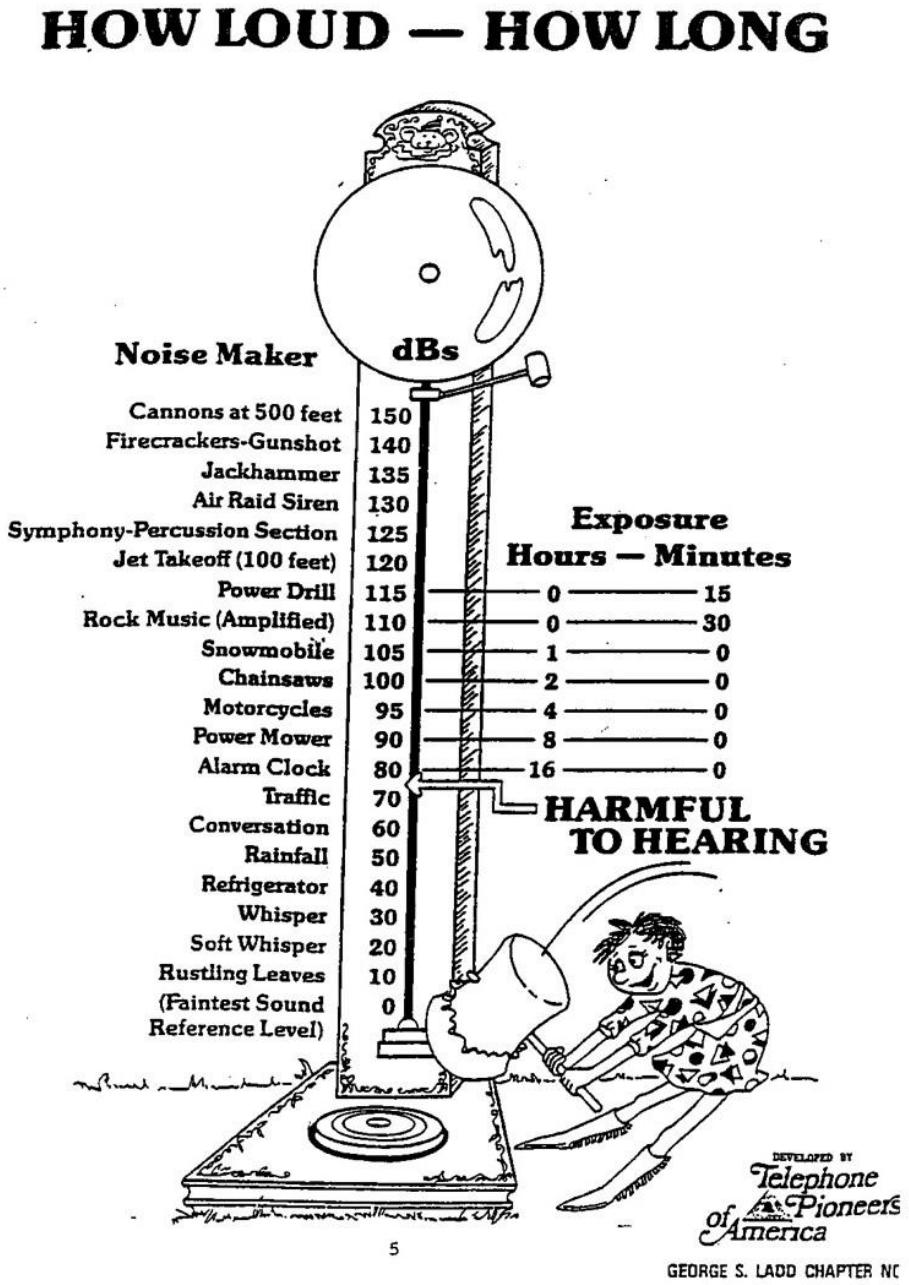
Decibels, again

- If one sound is 10^x times more intense than another sound, then it has a sound level $10 \cdot x$ more decibels than the less intense sound.

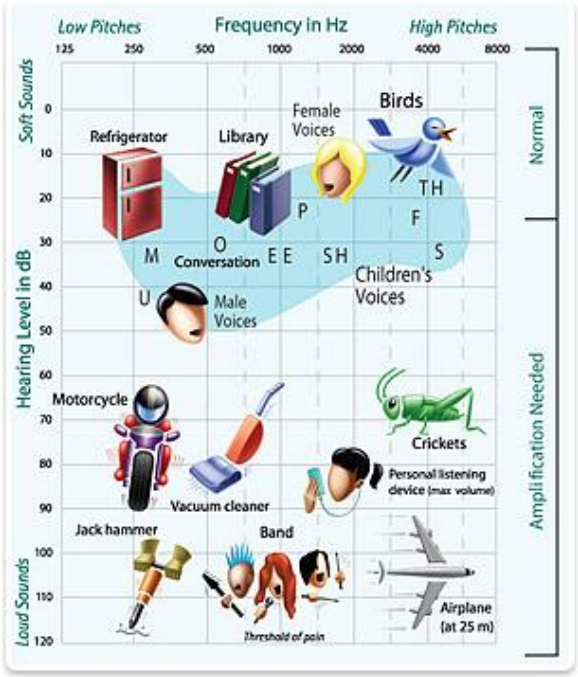
The Ear -- Hearing

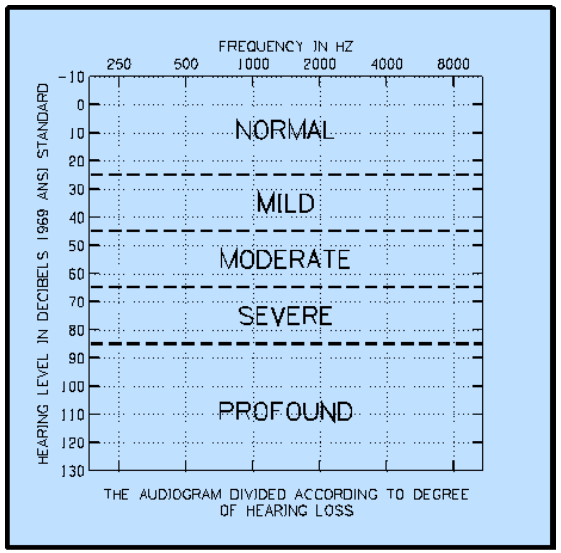


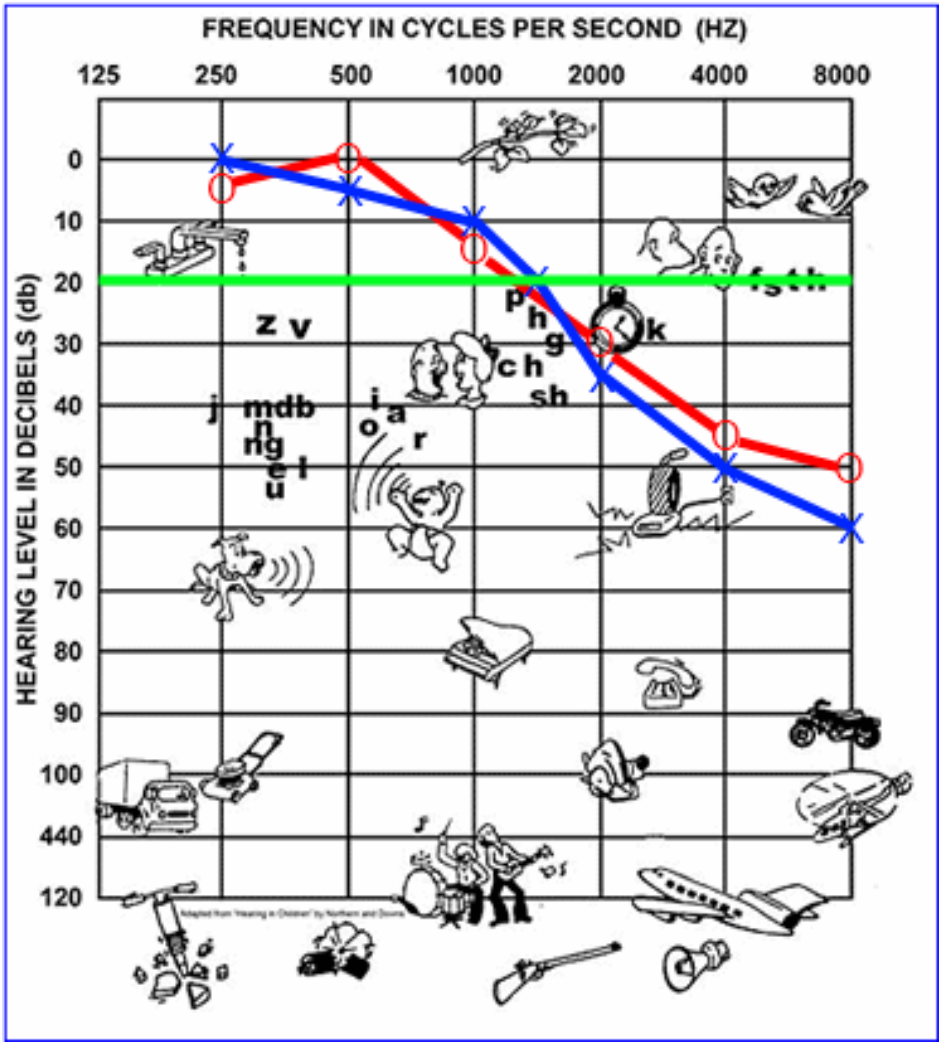
Time to Hearing Loss



Audiograms


Low Pitches
Frequency in Hz
High Pitches
125 250 500 1000 2000 4000 8000
Soft Sounds
Loud Sounds
Hearing Level in dB
0 10 20 30 40 50 60 70 80 90 100 110 120
Refrigerator
Library
Female Voices
Birds
TH
F
P
M
O
Conversation
E E
SH
S
Children's Voices
U
Male Voices
Motorcycle
Crickets
Personal listening device (max volume)
Vacuum cleaner
Jack hammer
Band
Airplane (at 25 m)
Threshold of pain
Normal
Amplification Needed


FREQUENCY IN HZ
250 500 1000 2000 4000 8000
HEARING LEVEL IN DECIBELS 1969 ANSI STANDARD
-10 0 10 20 30 40 50 60 70 80 90 100 110 120 130
NORMAL
MILD
MODERATE
SEVERE
PROFOUND
THE AUDIOGRAM DIVIDED ACCORDING TO DEGREE OF HEARING LOSS

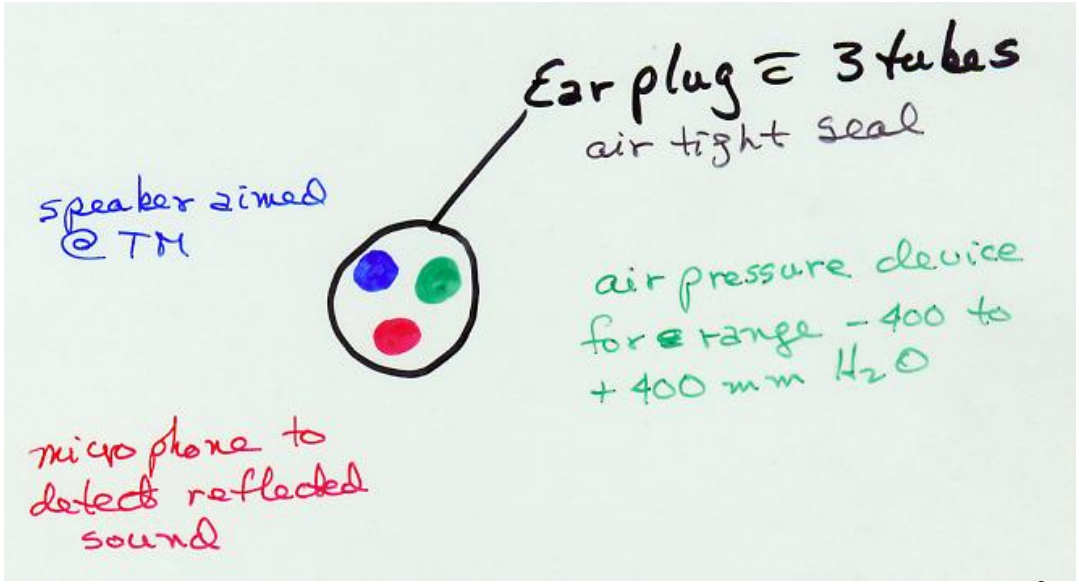

FREQUENCY IN CYCLES PER SECOND (HZ)
125 250 500 1000 2000 4000 8000
HEARING LEVEL IN DECIBELS (db)
0 10 20 30 40 50 60 70 80 90 100 440 120
z v
j
m d b
n
ng
e
l
u
i
a
o
r
p
h
g
k
c h
sh
f s th

Tympanometry: Impedance Audiometry

- TM compliance is inversely proportional to the impedance
- Compliance = property to alter size and shape due to an applying force, wt or release from an applied force; in electricity = conductance

- Impedance = acoustically: resistance to sound wave transmission; in electricity = resistance to electron flow
- Compliance is measured as mL or cc change

How Audiometry "works" -- sorta



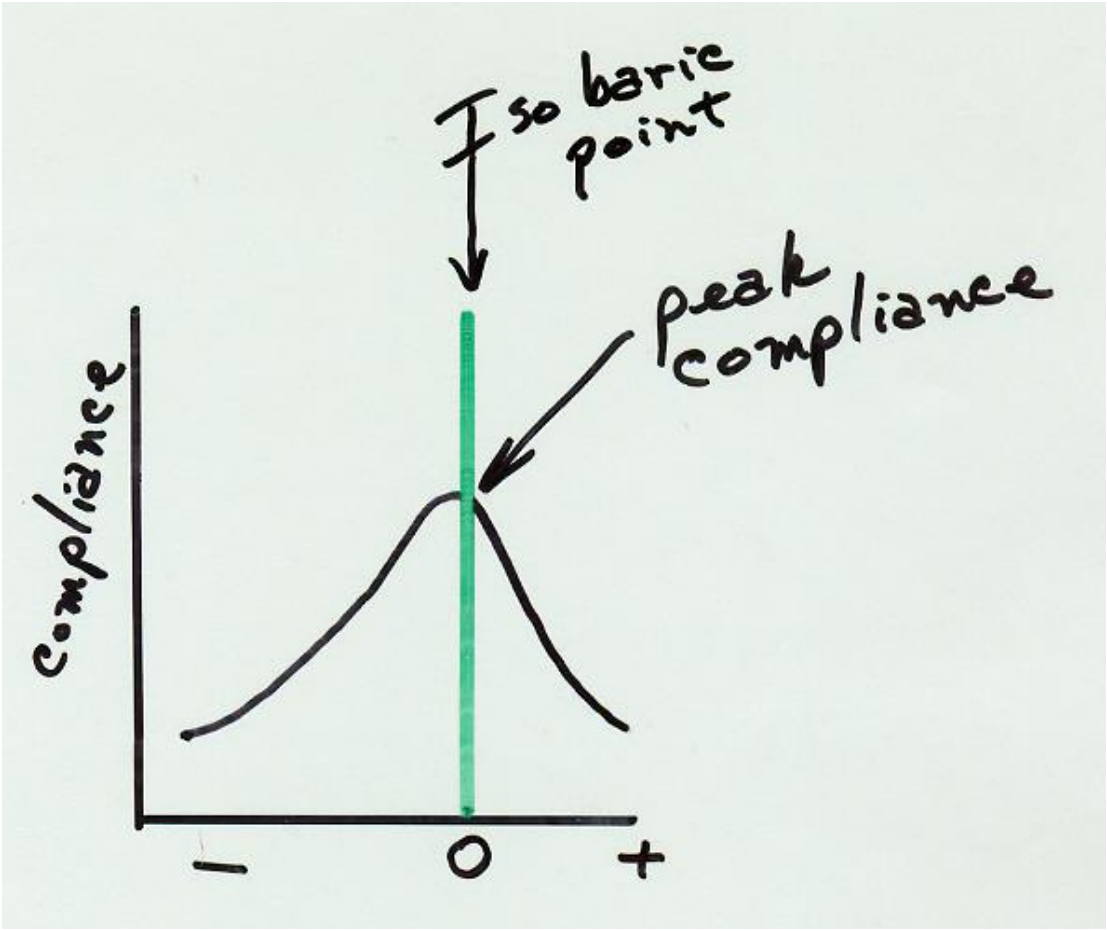
- Give a 220 Hz tone from a probe towards the TM and vary the pressure from -400 mm H_2O to +400 mm H_2O and record the reflected energy

Is very reliable with the young due to being easy, non-invasive, automatic, painless

- With bulging TM due to effusion, conduction mechanism stiff and reflects sound

Mid-ear bones disconnected = sound absorbed

Type A Tympanogram

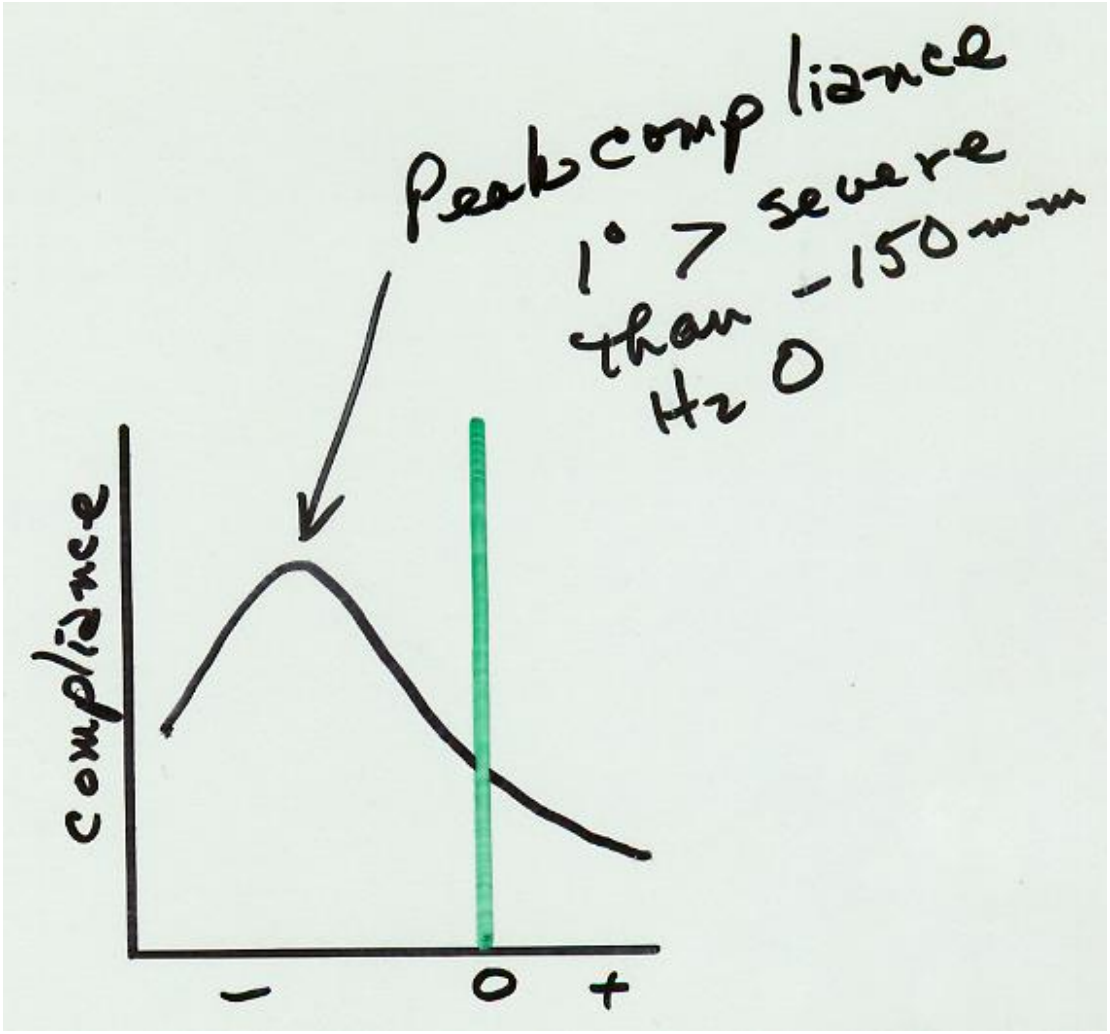


- Normal
- Good Eustachian tube function
- Absence of effusion

Type B Tympanogram

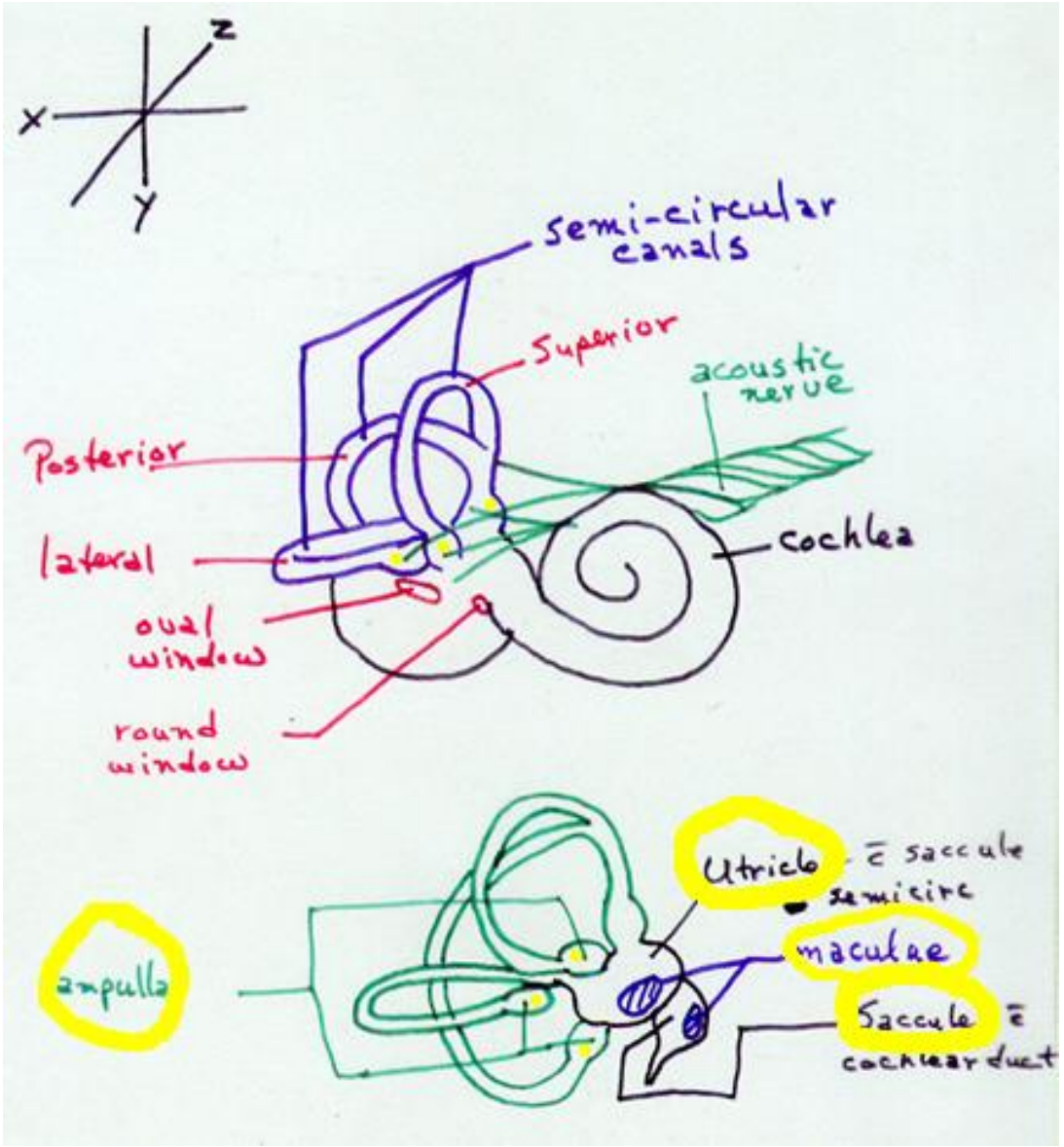
- Middle ear effusion
- Non-mobile TM
- Hard-packed cerumen
- Perforated TM
- Patent tubes

Type C Tympanogram



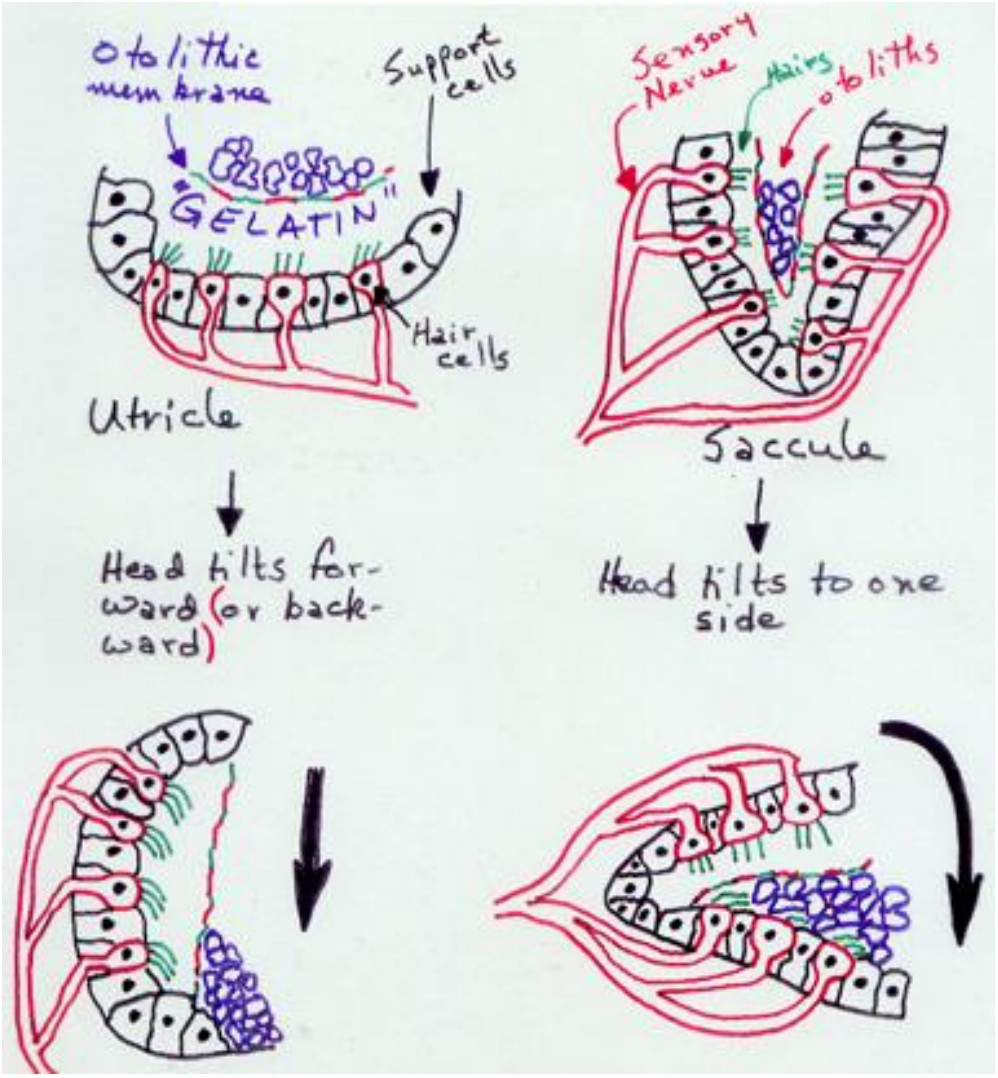
- Primarily associated with retracted TM with or without effusion
- Eustachian tube obstruction
- 1 in 5 present with effusion
- Goes with bronchitis, too – even recovery phase

Semi-Circular Canals



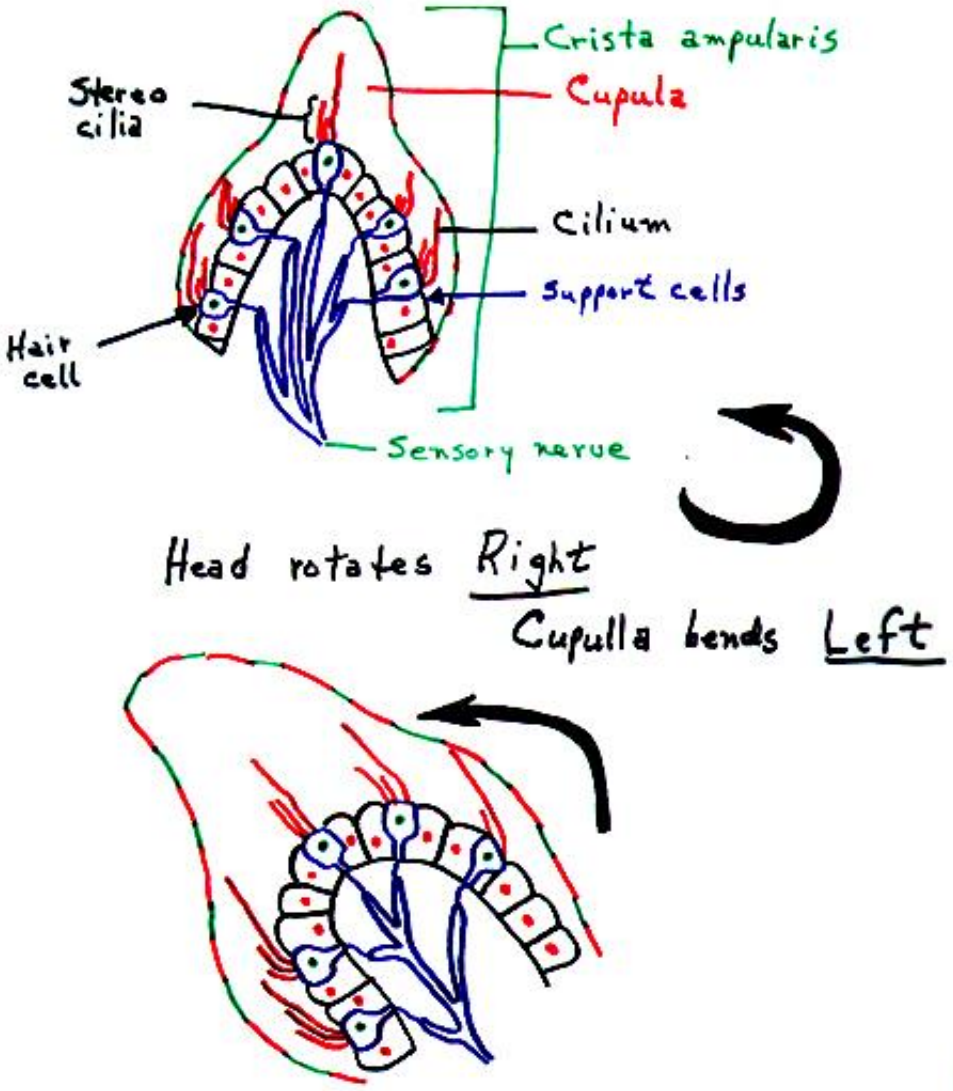
The macula of utricle allows a person to perceive changes in longitudinal acceleration as well as effects of gravity.

Static Equilibrium: Macular



- Maintains balance and posture
- Relaxes/contracts skeletal muscles when head and body are motionless
- Stabilizer

Dynamic Equilibrium: Ampullar



- Maintains balance when
- Head is suddenly moved or rotated, or
- Body is suddenly moved or rotated

Glossopharyngeal Nerve: IX – Motor and Sensory

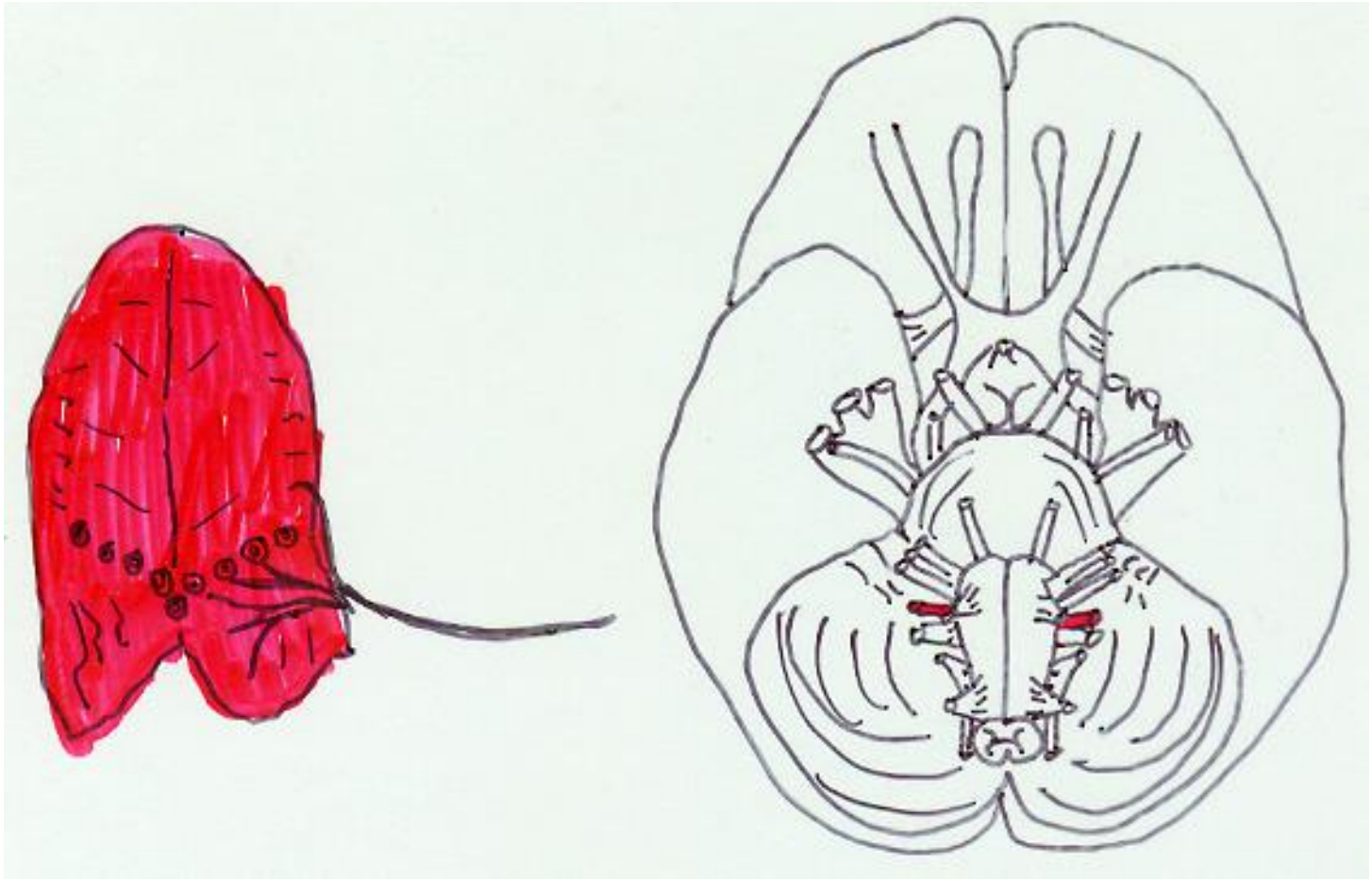
- Exits skull via jugular foramen
- Superficial origin is upper part of the medulla
- Deep origin is lower floor of 4^{th} ventricle and lower part of medulla

- Nerve is distributed to posterior $^{1}/_{3}$ of tongue (taste for here)
- Nerve of sensation to mucous membranes of pharynx, fauces and tonsils and uvula
- Sensory to pressure receptors in carotid artery

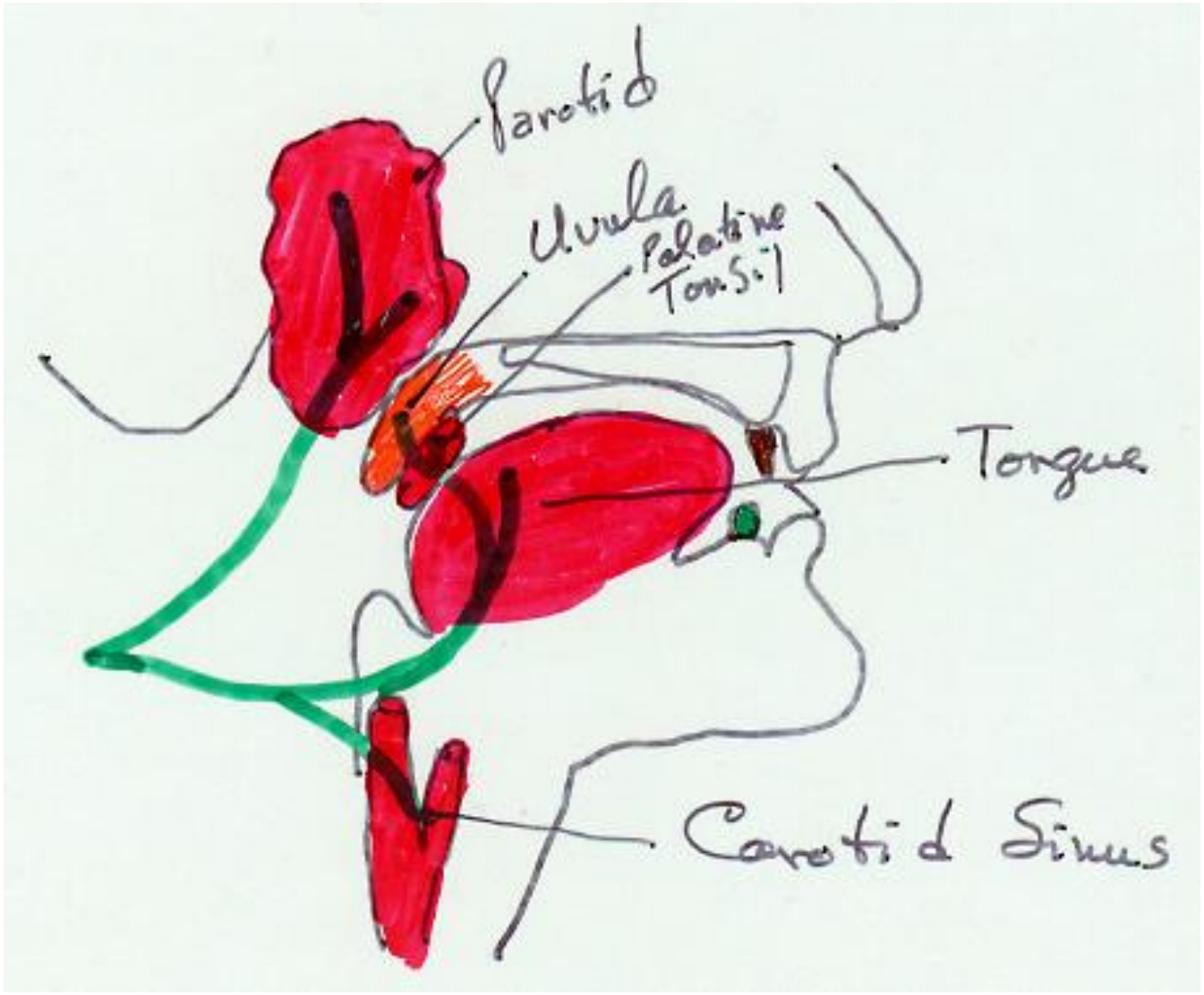
IX, Cont'd -- Anomalies

- Injury and/or inflammation causes impairment of swallowing and taste – specifically of sour and bitter (primarily the latter)

IX, Cont'd



IX, Cont'd

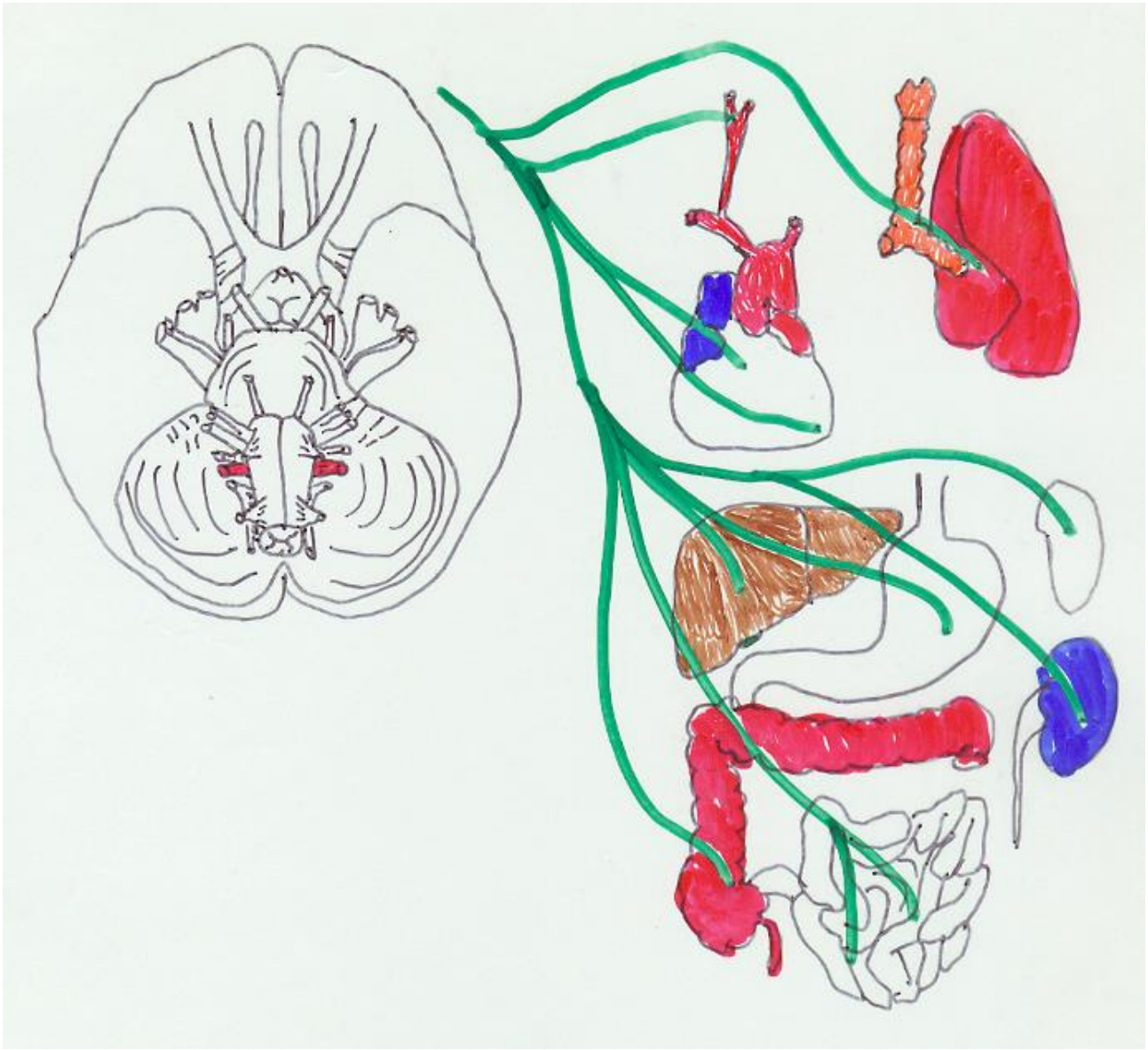


Vagus (Pneumogastric) Nerve: X – Motor and Sensory

- Pneumogastric and cardiac innervation
- Exits skull at jugular foramen accompanying IX
- Superficial origin below IX
- Deep origin lower part of floor of 4th ventricle
- 11 branches to the body
- Motor and sensory to organs of voice and respiration
- Motor to pharynx, esophagus, stomach and heart

- Anomalies
- Sensory
  - Superior laryngeal trunk pressed upon (goiter or aneurism) causes a particularly dry, brassy cough; when paralyzed, patient has a deep, hoarse voice
- Motor
  - When inferior laryngeal trunk paralyzed, the voice is altered and weak due to same side paralysis and strong side vocal cord compensation crossing over the mid-line of the glottis

X, Cont'd



Spinal Accessory Nerve: XI – Motor and Sensory

- Accessory to X;
  - SCM and trapezius innervation, as well
- Enters the skull via foramen magnum then exits the skull via the jugular foramen

- Two Parts:

1. Accessory to Vagus

- Superficial origin side of medulla below vagus roots
- Deep origin traced to back of medulla
- Distributed to pharyngeal and superior laryngeal branches of X

2. Spinal

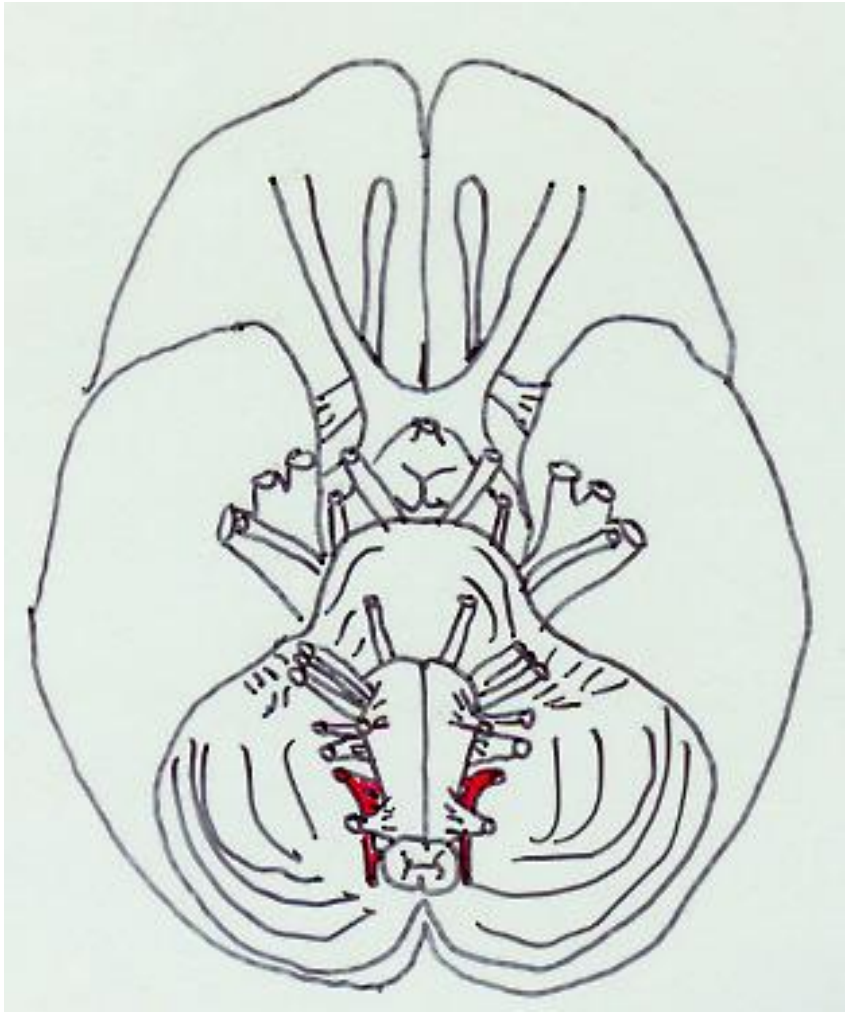
- Superficial origin lateral tract of cord as far down as C6
- Deep origin is gray matter of cord
- Pierces SCM and deep surface of trapezius

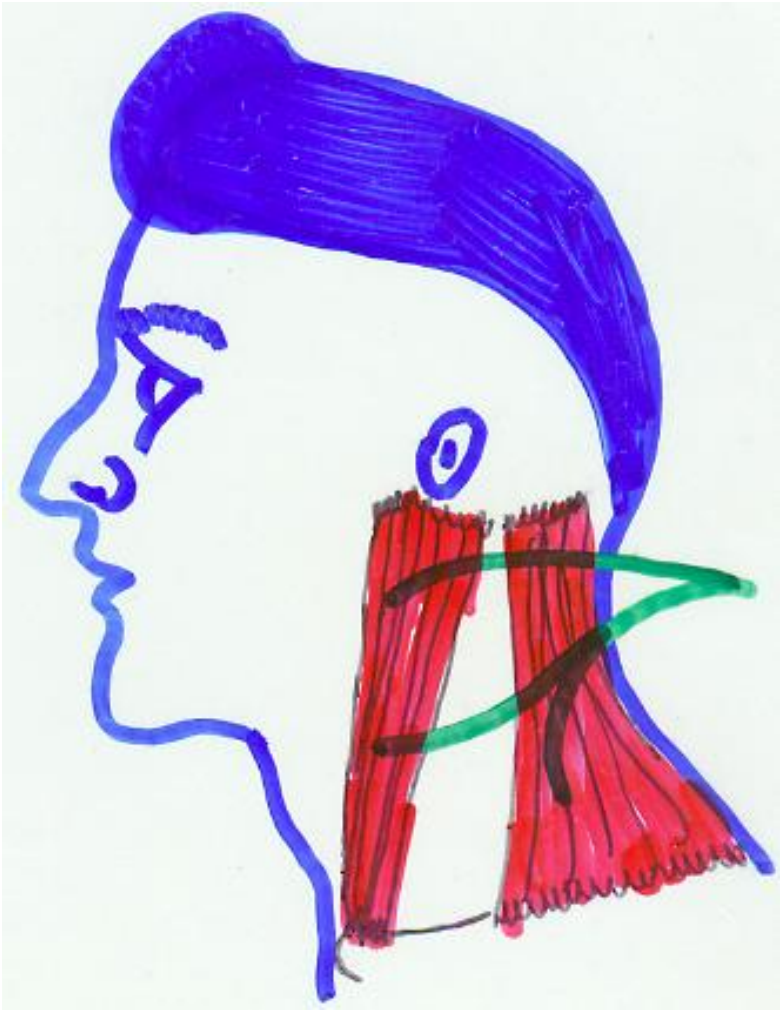
XI, Cont'd -- Anomalies

Motor

- Hyperactive XI causes spasmodic torticollis (wry neck)
- To treat torticollis requires excision or division of a portion to correct

XI, Cont'd





Hypoglossal Nerve: XII – Motor Nerve of Tongue

- Exits skull via anterior condyloid canal (hypoglossal canal)
- Superficial origin 10-15 filaments off of medulla
- Deep origin is a nucleus of grey matter on floor of 4th ventricle
- Passes into tongue all the way to the tip

- Anomalies
- When paralyzed unilaterally, tongue is twisted to weak side

XII, Cont'd