

# ORBIT

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I. **BONES OF ORBIT** - bones are rigidly linked together to form a stable socket to permit precise movements of eye.

## A. Boundaries

1. Roof - Frontal bone (anterior cranial fossa is superior to roof)
2. Floor - Maxillary bone (Maxillary sinus is inferior to floor).
3. Medial wall - Maxillary, Lacrimal, Ethmoid, Frontal and Sphenoid bones (nasal cavity is medial to medial wall of orbit).
4. Lateral wall - Zygomatic bone and sphenoid bone (greater wing).

B. Foramina - openings which transmit nerves and vessels to structures in orbit (eye, extraocular muscles and lacrimal gland (tears)); also **IMPORTANTLY**, orbit serves as passageway for nerves that are sensory to face, scalp and nasal cavity - see Foramina handout

C. Lining of orbit - periosteum of bones of orbit is called Periorbita.

II. **EYELIDS** - layered, moveable structures which protect eye, keep cornea (outermost layer) of eye moist.

## A. Layers

1. Skin - contains eyelashes (cilia), openings of sebaceous and sweat glands.
2. Subcutaneous layer - connective tissue containing sebaceous glands;

Clinical: **Obstruction of sebaceous glands in subcutaneous layer of eyelid called a stye (hordeolum).**

3. Orbicularis oculi muscle - skeletal muscle which surrounds eyelid; closes eyelids; innervated by Facial nerve (VII); damage to facial nerve paralyzes muscle; patient unable to close eyelids and spread tears over cornea; can result in corneal damage.

4. Orbital septum, tarsal plate and Levator Palpebrae Superioris muscle.

- a. Orbital septum - fascial layer inside eyelid, is continuous with connective tissue lining orbit (periorbita).

- b. Tarsal plate - dense fibrous connective tissue, located deep to orbital septum; forms 'skeleton' of eyelid; contains **tarsal glands**.

Clinical: Obstruction of **tarsal glands in eyelid called a chalazion.**

c. Levator palpebrae superioris muscle - muscle composed of both smooth and skeletal muscle components; origin - Tendinous ring (see below); insertion - skin and tarsal plate of upper lid; action - opens eyelids; **innervation - skeletal part by Oculomotor nerve (III), smooth part by Sympathetics.**

**Clinical – Ptosis = eyelid droop, important clinical sign; can result from damage to Oculomotor Nerve (III) or sympathetics.**

5. Conjunctiva - membrane covering inner side of eyelid; conjunctiva continues as a layer over sclera of eye and fuses to cornea; reflection of conjunctiva from eyelid to eye called Superior and Inferior fornices of conjunctiva; very sensitive.

III. **LACRIMAL APPARATUS** - tears are constantly produced in lacrimal gland, drain to nasal cavity via lacrimal duct.

A. Lacrimal gland - located in superolateral orbit; have numerous ducts (about 12) which open through conjunctiva; produce tears;

**Flow of tears:** circulate over conjunctiva and wash out dirt; drain through **lacrimal puncta** (openings) in medial part of upper and lower eyelids (you can see these on yourself in a mirror); puncta drain to **lacrimal sac** which drains via **Nasolacrimal duct** to **Inferior Meatus of nasal cavity** (this is why you blow your nose when you are crying)

B. Innervation of lacrimal gland - **Parasympathetics from Facial nerve (VII)** via a complicated pathway in which fibers hitch-hike with branches of the Trigeminal nerve (V) (more in future Cranial nerve lecture).

Clinical: **Obstructed Nasolacrimal Duct** - Nasolacrimal duct develops embryologically as a solid cord between maxillary and nasal processes; cord then becomes canalized; failure of canalization is Obstructed Nasolacrimal duct; tears flow onto face of neonate.

IV. **FASCIAL SHEATH OF EYEBALL** - thin fascial membrane surrounding eye (also called Tenon's capsule); thickenings of sheath attach to bones and form Medial and Lateral Check ligaments which prevent excess movement of eye.

## V. LAYERS OF EYE

A. Structure of eyeball - described as three layers

1. Fibrous layer



a. Sclera - tough, smooth fibroelastic layer surrounding eye (continuous anteriorly with cornea); functions to protect eye and maintain shape; provides attachment of extraocular muscles; pierced by nerves and vessels of eye.

b. Cornea - avascular, transparent layer covering anterior eye; important in focusing light; **Clinical: irregularities in cornea responsible for astigmatism.**

## 2. Vascular layer

Note: Blood supply to eye is derived from branches of **Ophthalmic artery** (from Internal Carotid Artery); major branches to eye: 1. Choroidal arteries (Anterior and Posterior) - to choroid; 2) Central Artery of Retina - to retina.

a. Choroid - highly vascular (Choroidal arteries and veins), pigmented membrane; provides nutrients and oxygen to other layers of eye.

b. Ciliary body - attaches to suspensory ligament of lens; hold lens taut; contains ciliary muscles.

i. Ciliary muscles - smooth muscles attached to suspensory ligaments of lens; **contraction of muscles produces relaxation of suspensory ligaments; causes lens to thicken for near vision (accommodation);** innervation - **Parasympathetics from Ciliary ganglion (nerve III)** cause contraction of ciliary muscles (parasympathetics travel in **Short Ciliary nerves**).

c. Iris - pigmented, contractile layer surround pupil (opening); controls amount of light entering eye; contains two muscles

i. Constrictor pupillae - circular smooth muscle which constricts iris, pupil; innervated by Parasympathetics (from Ciliary ganglion of III).

ii. Dilator pupillae - radial smooth muscle which dilates pupil; innervated by sympathetics.

3. Retina - contains photosensitive rods and cones and many neurons which process visual information; artery - **Central Artery of Retina** (branch of Ophthalmic artery), classically thought to have no anastomoses (occlusion results in blindness).

**New Anatomy:** imaging has shown that branches of Ciliary Arteries (**Cilioretinal arteries**) are present in about 20% of people; can provide partial sparing of retina in cases of **Central Retinal Artery Occlusion (CRAO)**.

Note: **Subarachnoid space** extends around optic nerve up to its junction with sclera in back of eyeball; optic nerve can be viewed in ophthalmoscope as optic disc; changes in

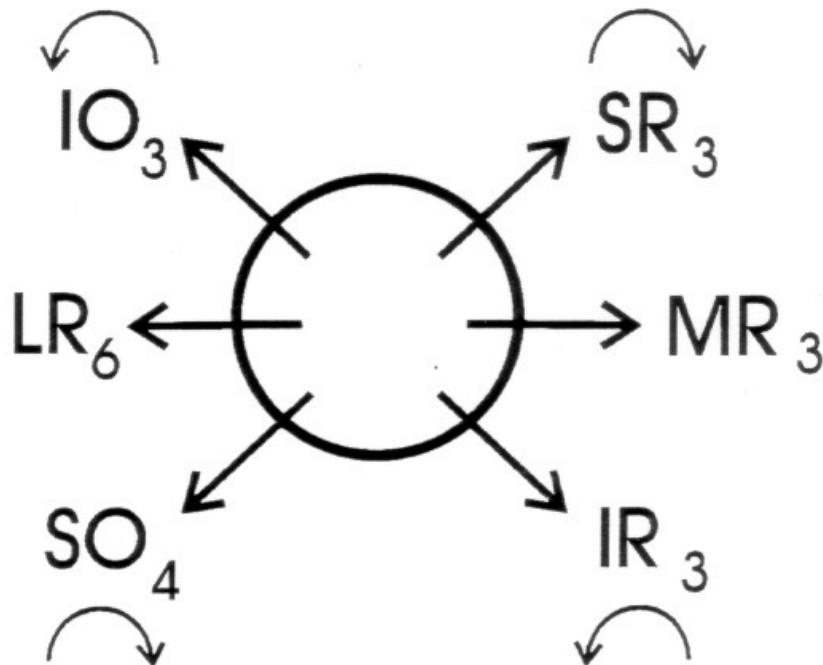
intracranial pressure (ex. hydrocephalus) can be diagnosed by viewing optic disc.

## VI. EXTRAOCULAR MUSCLES

A. Origins - all take origin from Tendinous ring (except Inferior Oblique which has origin on floor of orbit); Tendinous ring is ring of connective tissue surrounding opening of Optic canal and Superior Orbital Fissure.

### B. Actions and Innervation

Muscle	Nerve	Action
Medial rectus	III	Adduct eye
Lateral rectus	VI	Abduct eye
Inferior rectus	III	Adduct, lower and laterally rotate eye
Superior rectus	III	Adduct, raise and medially rotate eye
Superior oblique	IV	Abduct, lower and medially rotate eye
Inferior oblique	III	Abduct, raise and laterally rotate eye.



## VII. NERVE DAMAGE

A. **Abducens** nerve (VI) - damage causes **Medial Strabismus** (cross-eyed).

B. **Trochlear** nerve (IV) - damage results in **inability to turn eye down and out**;  
ALSO **Head Tilt**: at rest, **patient tilts head to opposite side (compensate for unilateral eye rotation)**

C. **Oculomotor** nerve (III) - damage causes **ptosis (drooping eyelid** from paralysis of skeletal component of Levator palpebrae superioris), **Lateral Strabismus** (wall-eyed, from damage to Medial rectus), **dilated pupil** (from paralysis of Constrictor pupillae) and **diplopia** (double vision)

## VIII. CILIARY GANGLION - parasympathetic ganglion of Oculomotor nerve (III)

A. Contains - parasympathetics for Ciliary muscles and Sphincter Pupillae; parasympathetics travel in Short Ciliary nerves.

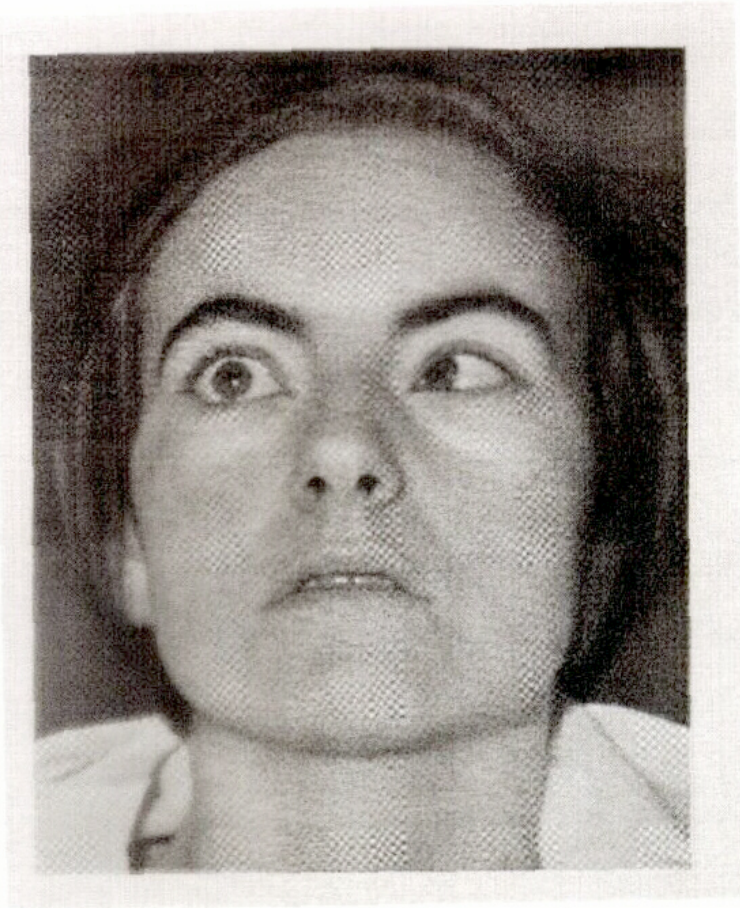
B. Nerves passing to back of eye (in addition to Optic Nerve)

1. Short Ciliary nerves - parasympathetics from III to Ciliary muscles and constrictor pupillae

2. Long ciliary nerves - sensory branches of Ophthalmic division (V1) of Trigeminal nerve which innervate cornea.

**Clinical: 'Blown' Pupil = Pupil Dilated (Mydriasis) - pupil unable to constrict in response to light; indicates catastrophe (stroke, herniation, etc.); Anisocoria – pupils of unequal size (can be normal or abnormal)**

# ORBIT



## OUTLINE

I. BONES OF ORBIT

II. EYELIDS

III. LACRIMAL APPARATUS

IV. FASCIAL SHEATH  
OF EYEBALL

V. STRUCTURE OF EYE

VI. EXTRAOCULAR MUSCLES/  
EYE MOVEMENTS

VII. CILIARY GANGLION

VIII. NERVE DAMAGE

- **VISION REQUIRES COORDINATED MOVEMENTS OF TWO EYES**
- **EYES/EYE MOVEMENTS USED DIAGNOSTICALLY**

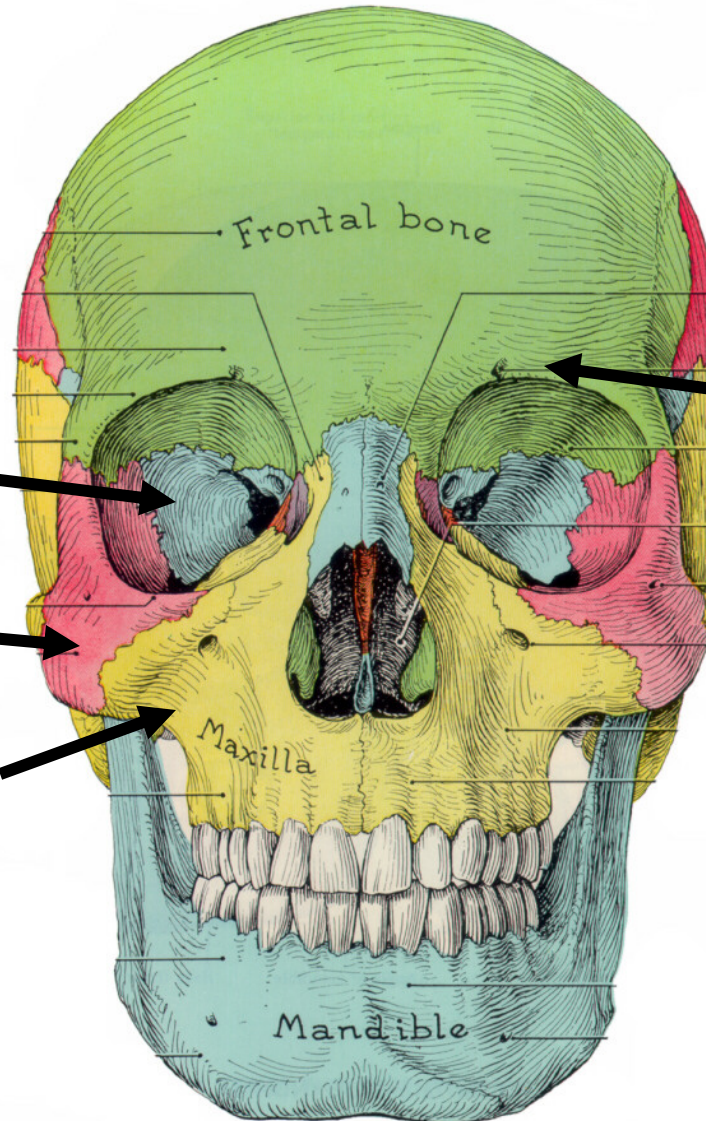
# I. BONES OF ORBIT

RIGIDLY LINKED  
FOR EYE  
MOVEMENTS

SPHENOID

ZYGOMATIC

MAXILLARY



## A. BOUNDARIES

1. ROOF  
FRONTAL

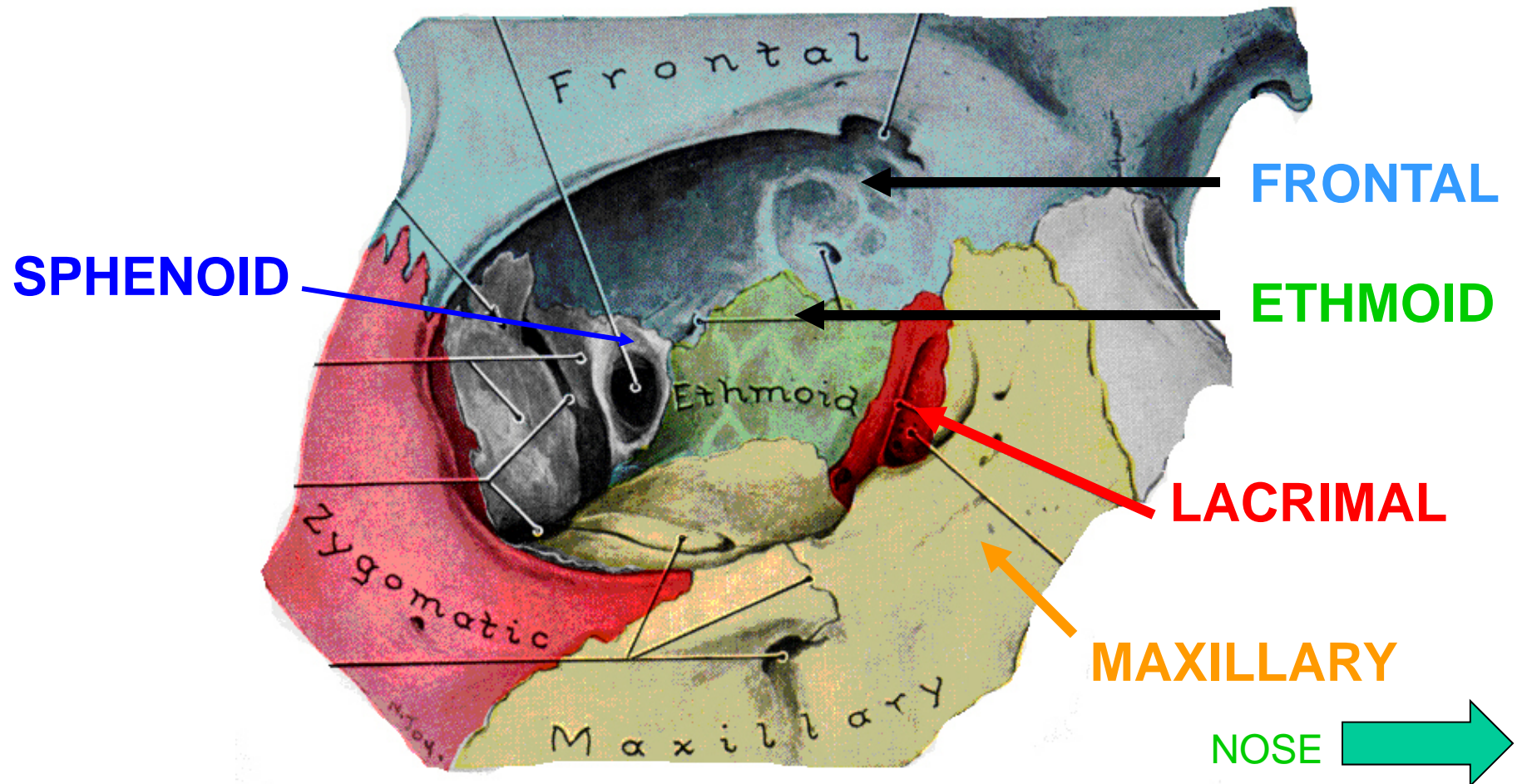
4. LATERAL  
WALL  
ZYGOMATIC  
SPHENOID

2. FLOOR  
MAXILLARY



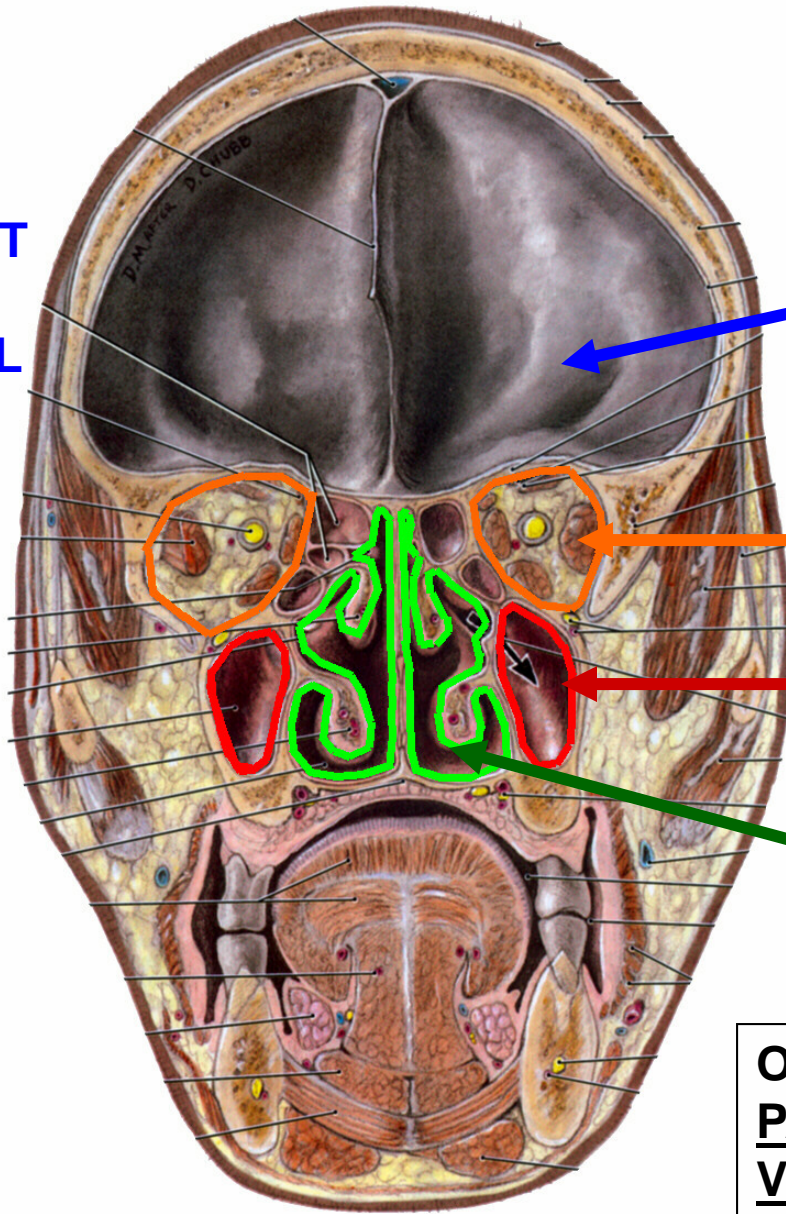
# BONES OF ORBIT

3. MEDIAL WALL - INCLUDES MAXILLARY, LACRIMAL, ETHMOID, FRONTAL AND SPHENOID BONES (NASAL CAVITY IS MEDIAL TO MEDIAL WALL OF ORBIT)



# BONES OF ORBIT

HEAD CUT  
IN  
CORONAL  
PLANE



## RELATIONS OF ORBIT

1) ANTERIOR CRANIAL FOSSA - SUPERIOR TO ROOF

ORBIT

2) MAXILLARY SINUS - INFERIOR TO FLOOR

3) NASAL CAVITY - MEDIAL TO MEDIAL WALL OF ORBIT

ORBIT - SERVES AS A PASSAGEWAY FOR NERVES, VESSELS TO FACE, SCALP AND NASAL CAVITY

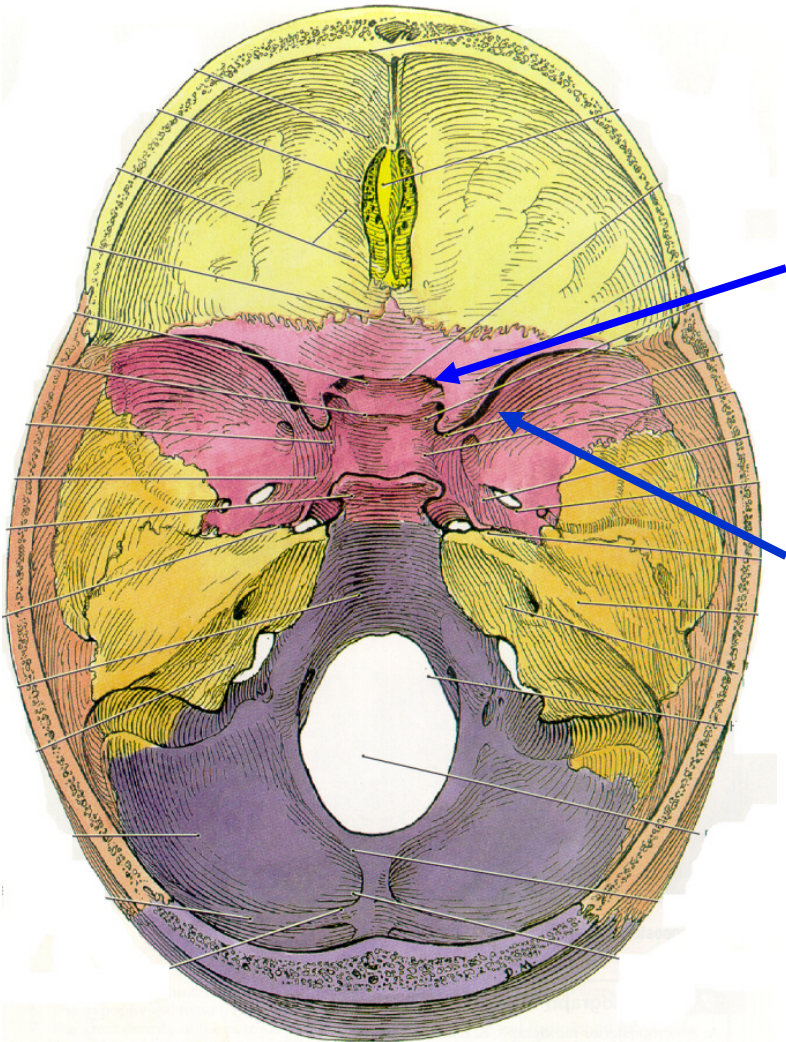


## B. FORAMINA OF ORBIT – structures entering orbit

FORAMINA- MOST STRUCTURES ENTER ORBIT FROM MIDDLE CRANIAL FOSSA

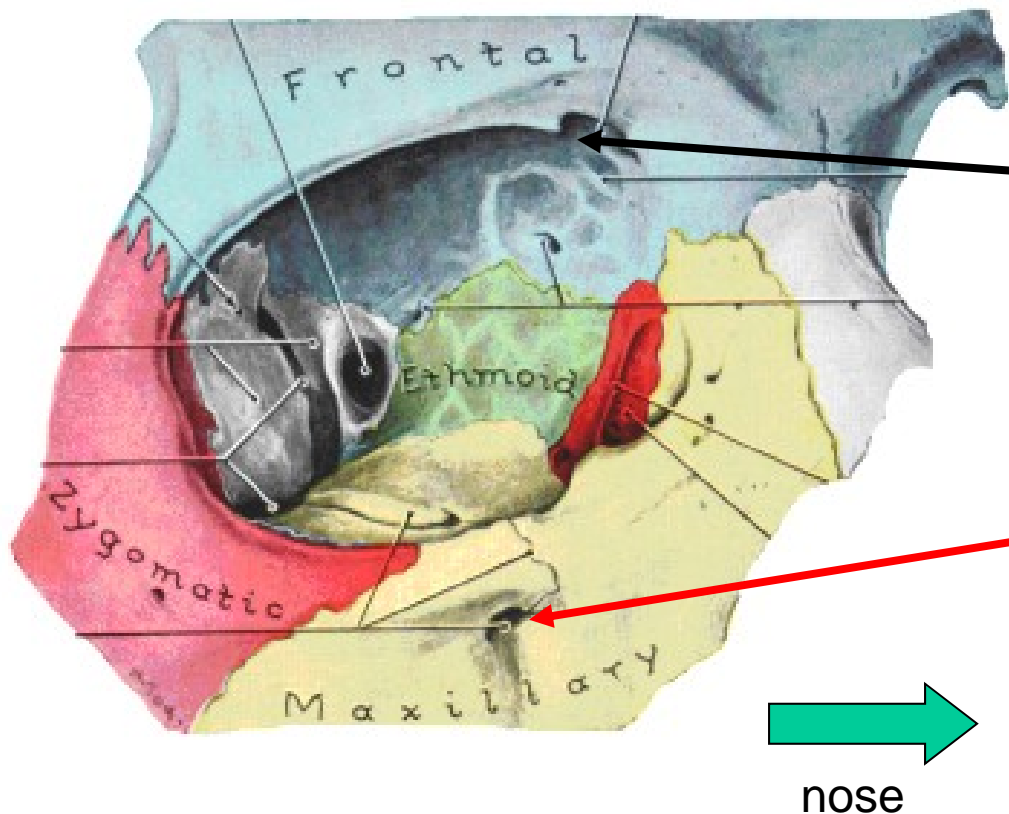
1) OPTIC CANAL- IN BASE OF LESSER WING OF SPHENOID BONE, CONTAINS OPTIC NERVE (II) and OPTHALMIC ARTERY

2) SUPERIOR ORBITAL FISSURE - BETWEEN GREATER AND LESSER WINGS OF SPHENOID, CONTAINS III, IV, V1, VI, OPTHALMIC VEINS





## B. FORAMINA OF ORBIT – pathways leaving orbit

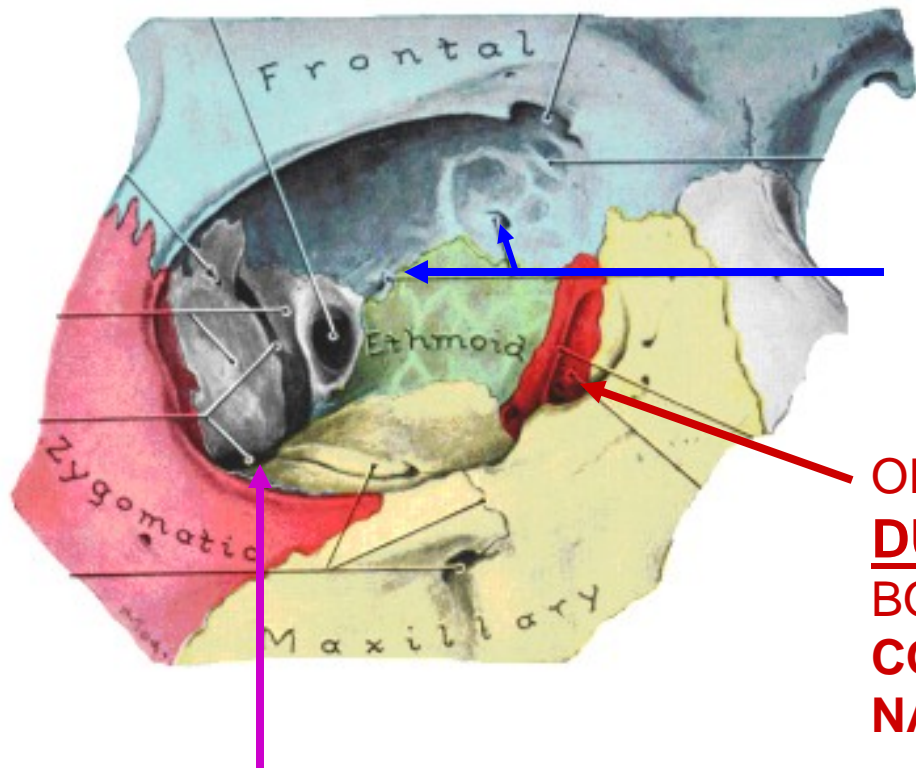


TO FACE, SCALP:

1) **SUPRAORBITAL NOTCH OR FORAMEN** - IN FRONTAL BONE CONTAINS SUPRAORBITAL N., A. and V. FROM V1, OPHTHALMIC artery and vein.

2) **INFRAORBITAL FORAMEN** - IN MAXILLARY BONE CONTAINS INFRAORBITAL N., A. and V. FROM V2 AND MAXILLARY artery.

## C. FORAMINA OF ORBIT - pathways to Nasal Cavity



**2) ANT. AND POST. ETHMOIDAL FORAMINA**- BETWEEN ETHMOID AND FRONTAL BONES; CONNECT ORBIT AND NASAL CAVITIES  
**CONTAINS: ANT. AND POST. ETHMOIDAL N., A. and V. (br. Of V1 and OPHTHALMIC artery, vein)**

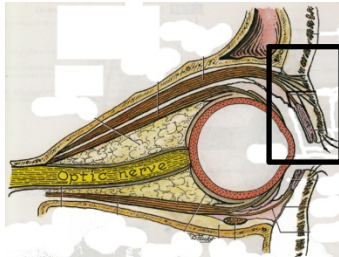
**OPENING OF 3) NASOLACRIMAL DUCT**- IN MAXILLARY, LACRIMAL BONES AND INF. NASAL CONCHA;  
**CONTAINS: MEMBRANEOUS NASOLACRIMAL DUCT AND TEARS**

**NOTE: INFERIOR ORBITAL FISSURE - KNOW FOR NEXT BLOCK IN JANUARY**

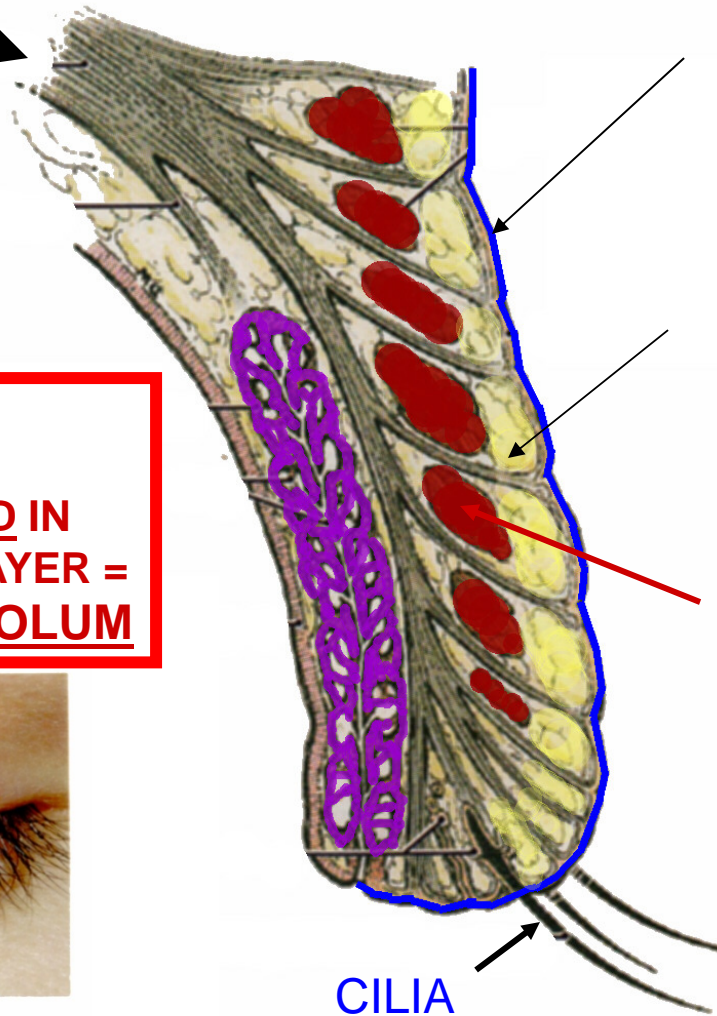


## II. EYELIDS = PALPEBRAE - LAYERED

EYELIDS PROTECT EYE, MOVEABLE, KEEP CORNEA MOIST



ORIENT - EYELID  
PARASAGITTAL  
SECTION



1. SKIN - CONTAINS EYELASHES (CILIA) AND OPENINGS OF SEBACEOUS, SWEAT GLANDS;

2. SUBCUTANEOUS LAYER - CONNECTIVE TISSUE CONTAINS SEBACEOUS GLANDS; OBSTRUCTION = STYE OR HORDE'OLUM

3. ORBICULARIS OCULI (PALPEBRAL PART) - SKELETAL MUSCLE CLOSES EYE, INNERVATED BY VII - PARALYZE ORBICULARIS OCULI - CAN DAMAGE CORNEA

## CLINICAL

OBSTRUCTION or INFECTION OF SEBACEOUS GLAND IN SUBCUTANEOUS LAYER = STYE OR HORDE'OLUM



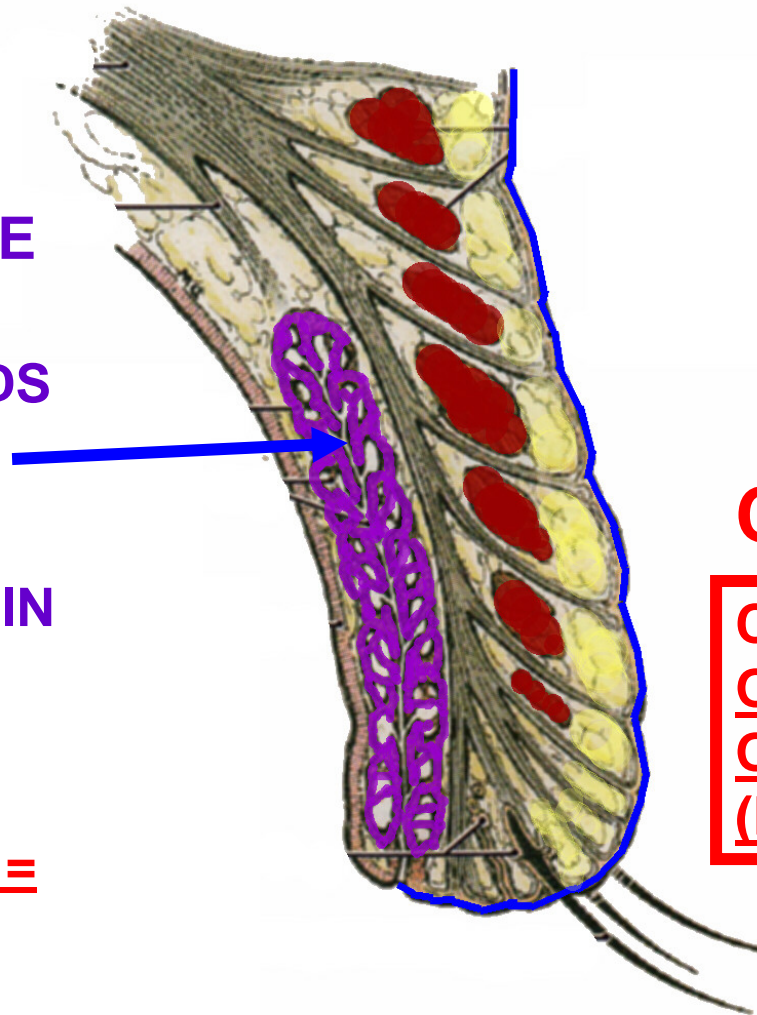
FIGURE 10-10  
Acute hordeolum of upper eyelid.  
From Palay, Krachmer, 1997.

# EYELIDS - LAYERS

4B. TARSAL PLATE - FIBROUS CT 'SKELETON' OF EYELID, DEEP TO ORBITAL SEPTUM

**TARSAL PLATE**  
- CONTAINS  
**TARSAL GLANDS**  
(Meibomian glands)

- KEEP TEARS IN EYE, PREVENT EVAPORATION OF TEARS -  
**OBSTRUCTION = CHALAZION**



**CHALAZION**



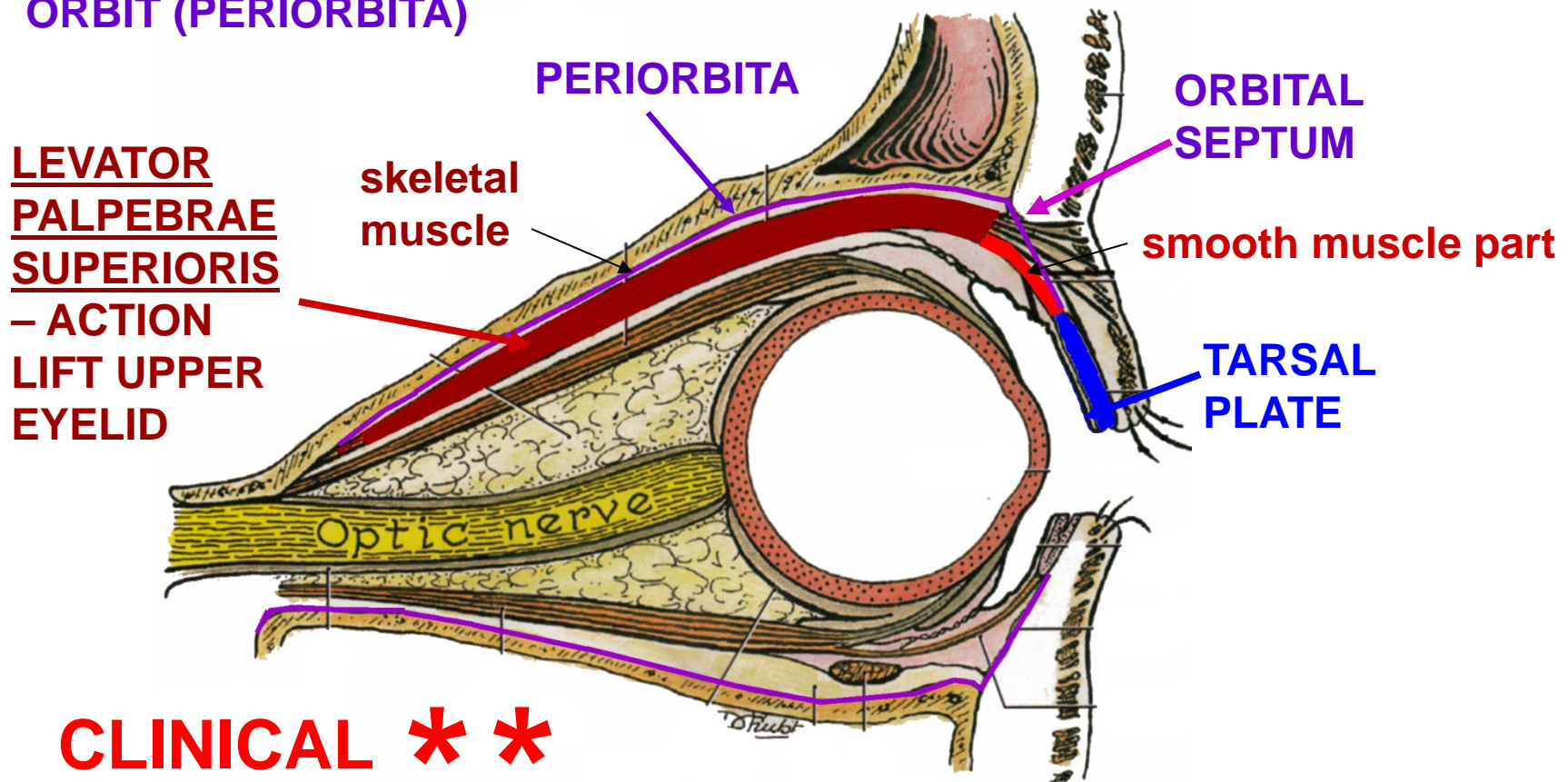
**CLINICAL**

**CHALAZION:**  
**OBSTRUCTION**  
**OF TARSAL**  
**(MEIBOMIAN) GLAND**



# EYELIDS - LAYERS

4A. ORBITAL SEPTUM - CT LAYER CONTINUOUS WITH PERIOSTEUM OF ORBIT (PERIORBITA)

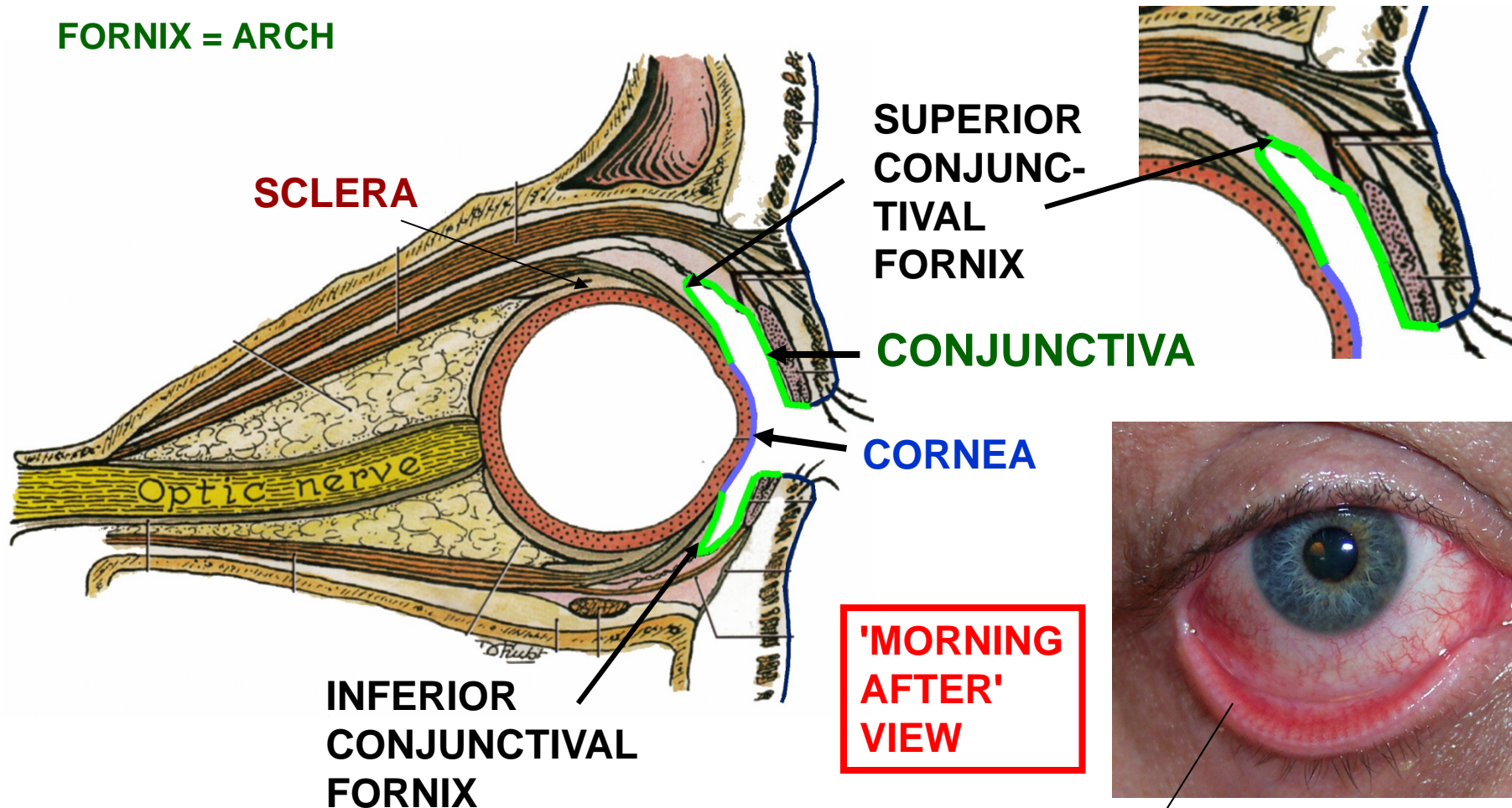


**CLINICAL \* \***

4C. LEVATOR PALPEBRAE SUPERIORIS MUSCLE - ORIGIN FROM TENDINOUS RING - COMPOSED OF SKELETAL (CN III) AND **SMOOTH (SYMPATHETICS)** MUSCLE PARTS - damage either part: **EYELID DROOP = PTOSIS- DAMAGE III OR SYMPATHETICS**

5) CONJUNCTIVA - CLEAR MEMBRANE COVERING INSIDE OF LID - FUSES TO SCLERA - REFLECTED TO CORNEA OF EYE AT FORNICES

FORNIX = ARCH

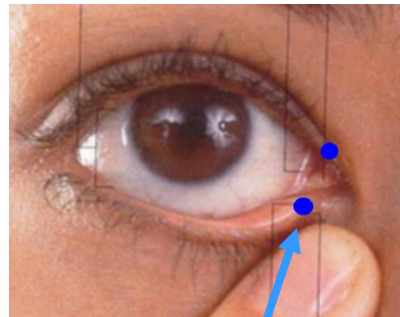
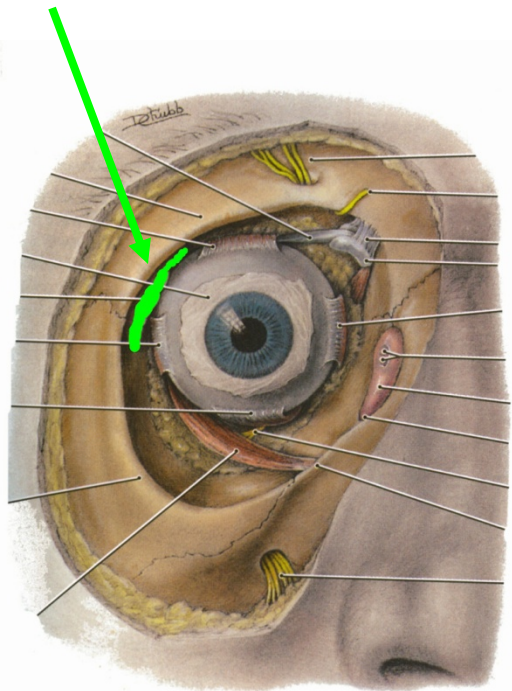


FORNIX = LATIN FOR ARCH, VAULT

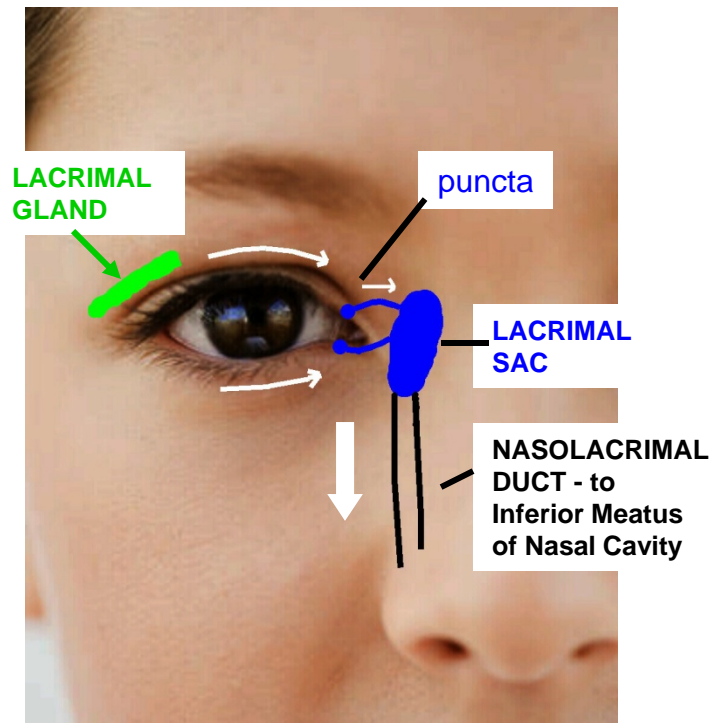
Conjunctivitis (Pinkeye) - inflammation of conjunctiva

### III. LACRIMAL APPARATUS

A. LACRIMAL GLAND - LOCATED IN SUPEROLATERAL ORBIT - OPENS BY DUCTS (~12) THROUGH CONJUNCTIVA TO SUPERIOR FORNIX - TEARS CONSTANTLY PRODUCED



LACRIMAL PUNCTA

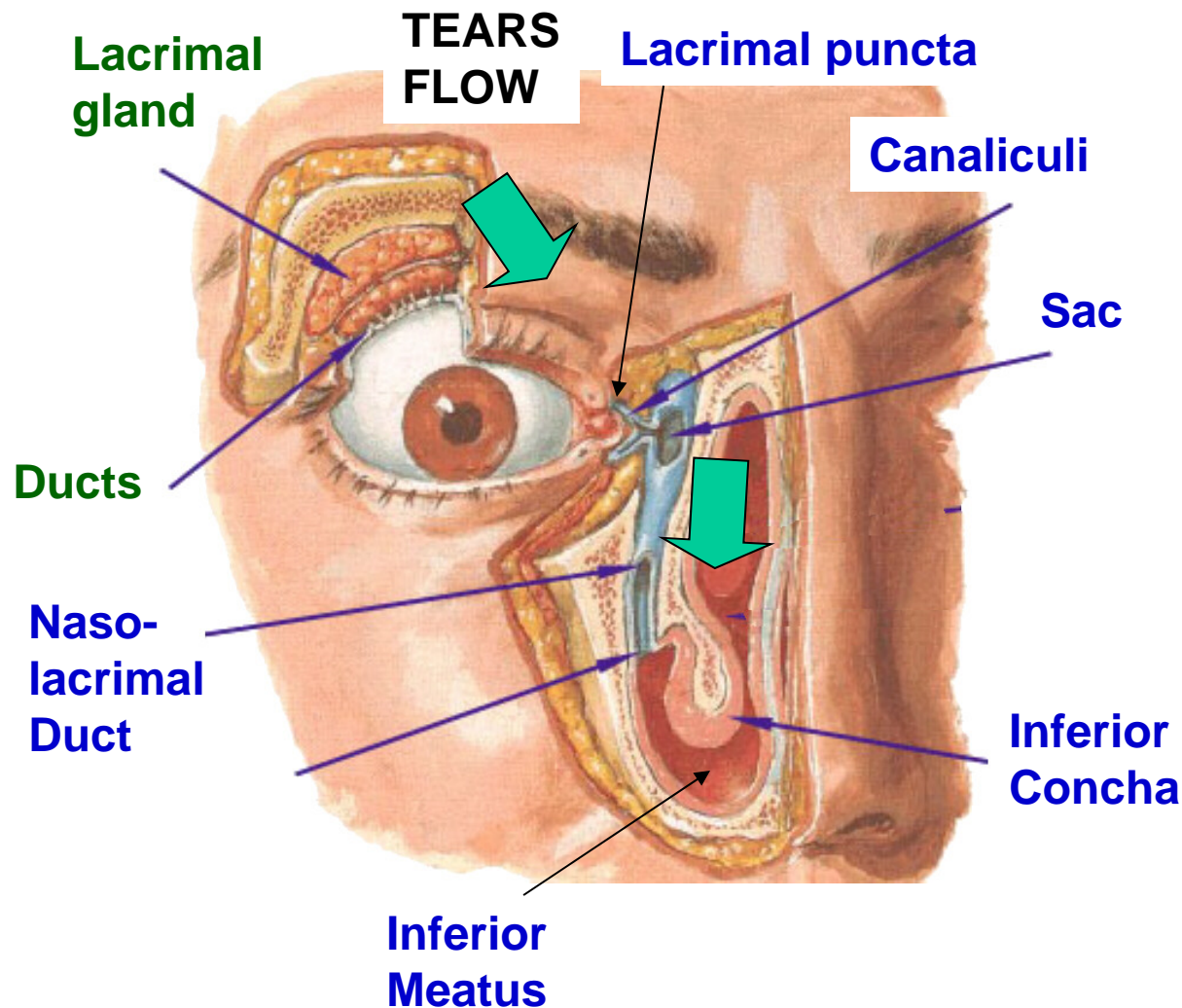


- TEARS DRAIN THROUGH LACRIMAL PUNCTA TO LACRIMAL SAC TO NASOLACRIMAL DUCT TO INFERIOR MEATUS OF NASAL CAVITY

B. LAC. GLAND INNERVATED BY VII - COMPLEX PATHWAY



# DRAINAGE OF TEARS

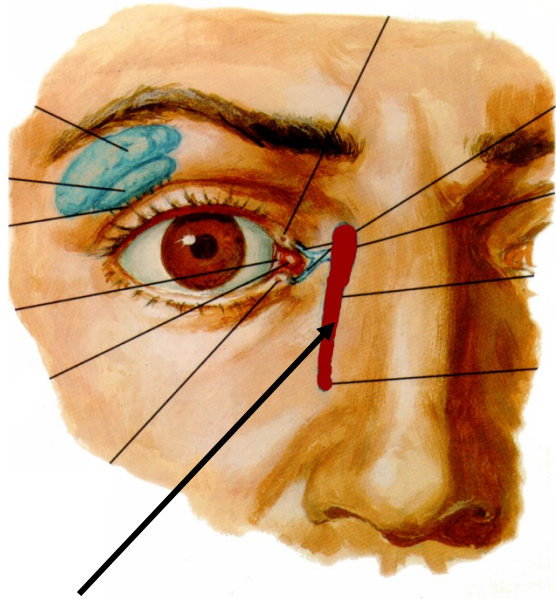


- TEARS FLOW ACROSS EYE TO LACRIMAL PUNCTA ON MEDIAL END OF EYELIDS (eyelids meet at MEDIAL CANTHUS);
- TEARS THEN PASS THROUGH LACRIMAL CANALICULI TO LACRIMAL SAC;
- SAC CONNECTS TO NASOLACRIMAL DUCT WHICH DRAINS TO INFERIOR MEATUS OF NASAL CAVITY

**LACRIMAL GLAND IS INNERVATED BY VII - FACIAL NERVE;**  
**BLOCK VII - DECREASE TEARS; PRESSURE/IRRITATION VII - EXCESSIVE TEARS**

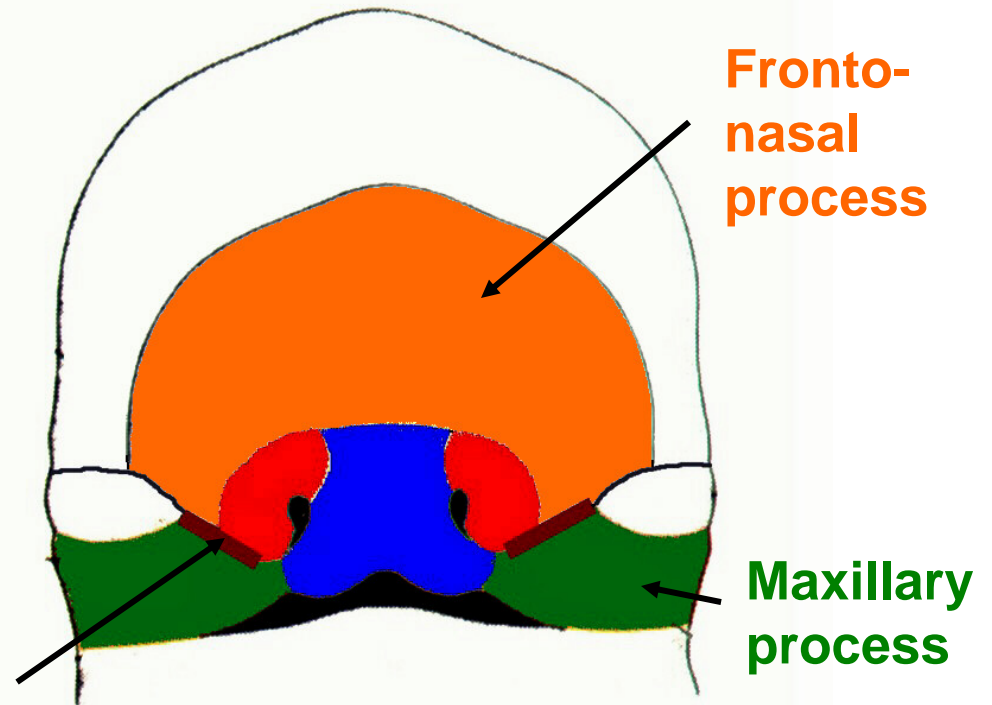


## DEVELOPMENT: OBSTRUCTED NASOLACRIMAL DUCT



### NASOLACRIMAL DUCT

- extends from Medial Canthus of eye to Inferior Meatus of nasal cavity

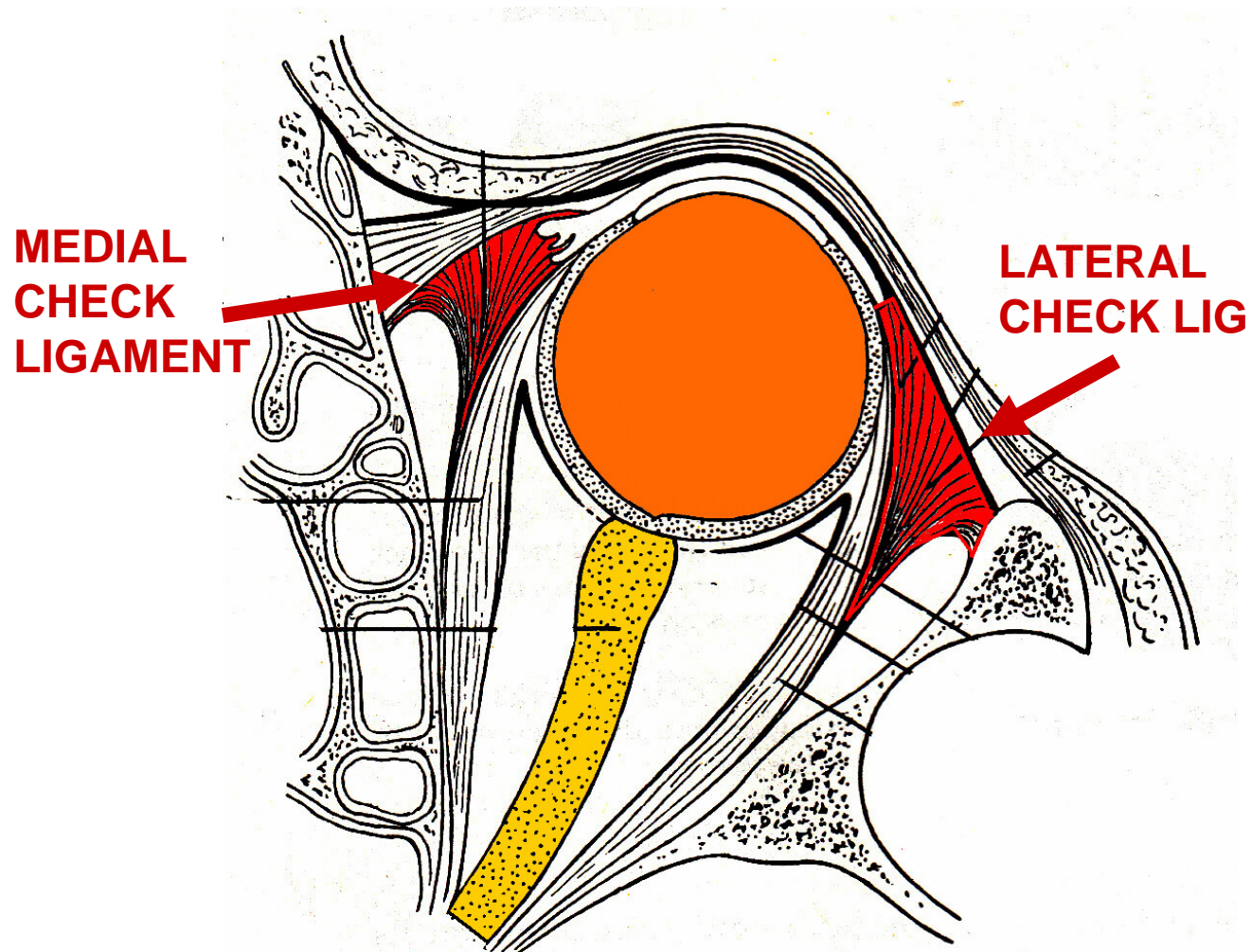


- Develops as a fold between maxillary process and frontonasal process  
- then forms a solid cord that becomes canalized.

**Obstructed Duct - failure of duct to canalize; tears drain over lower eyelid to face; opened surgically for tears to drain to nasal cavity**

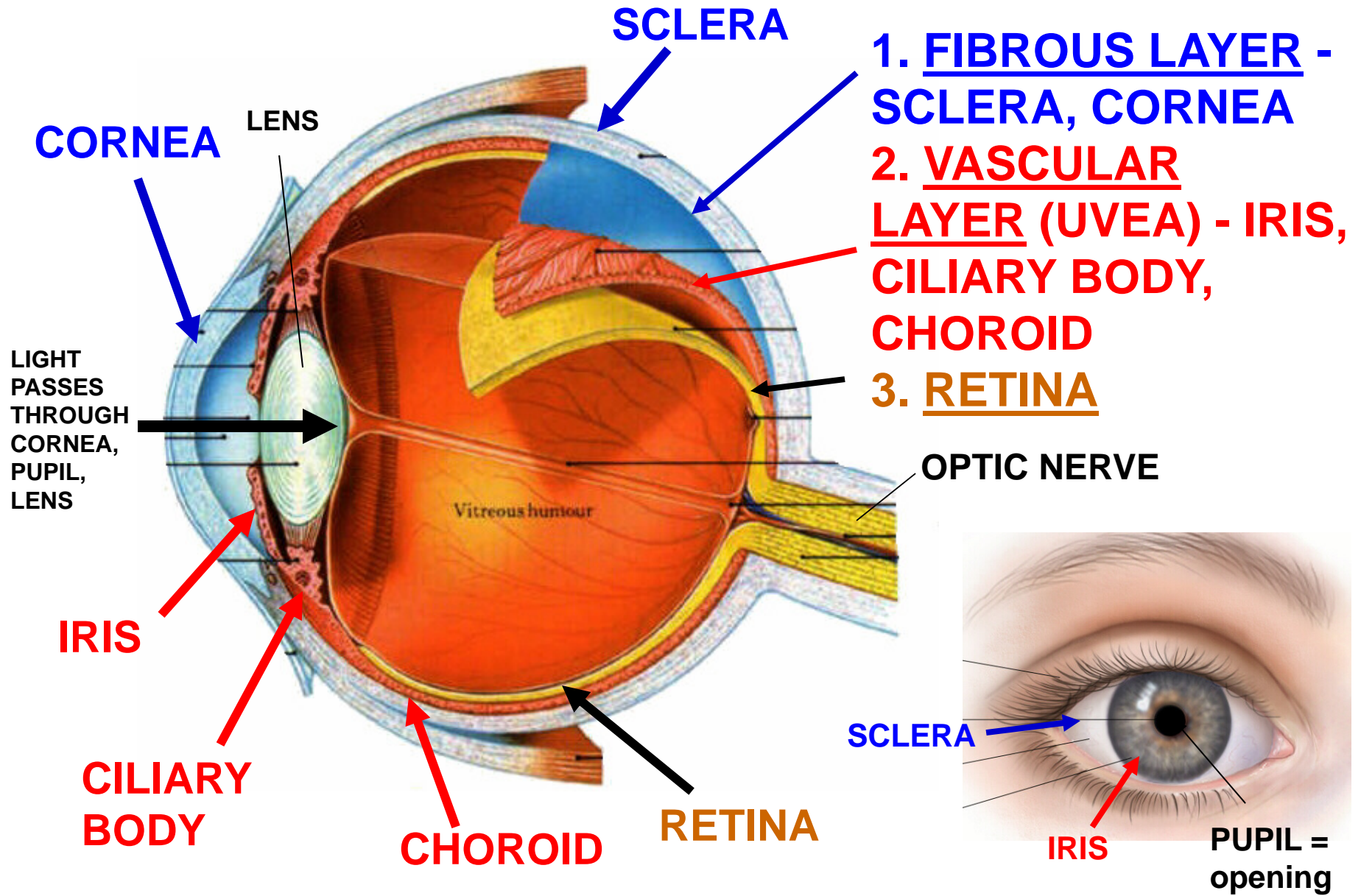
## IV. FASCIAL SHEATH OF EYE

NOSE



= TENON'S  
CAPSULE - THIN  
MEMBRANE  
SURROUNDS  
BACK OF EYE -  
THICKENINGS -  
MEDIAL AND  
LATERAL  
CHECK  
LIGAMENTS -  
PREVENT  
EXCESSIVE  
ROTATION

# V. STRUCTURE OF EYE - 3 LAYERS

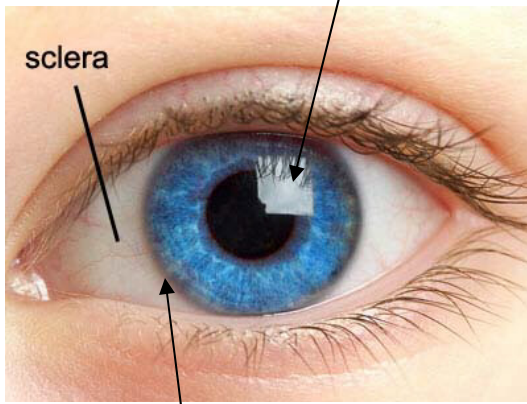




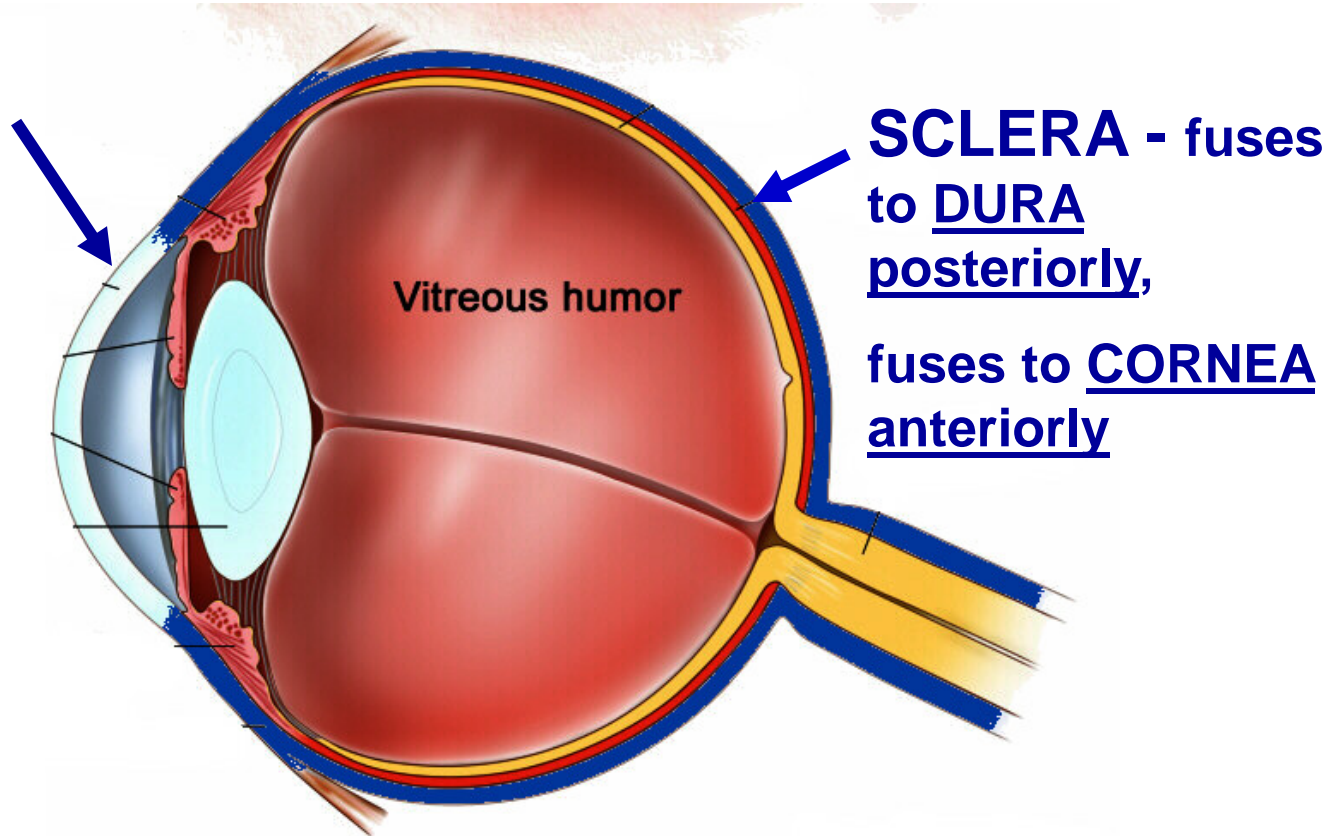
# EYE- STRUCTURE OF EYEBALL- FIBROUS LAYER

A) SCLERA - TOUGH, SMOOTH WHITE FIBROELASTIC CT LAYER; SURROUNDS EYE; PIERCED BY VESSELS AND NERVES; FUNCTIONS- MAINTAIN EYE SHAPE, ATTACHMENT OF MUSCLES

**CORNEA -  
clear layer**

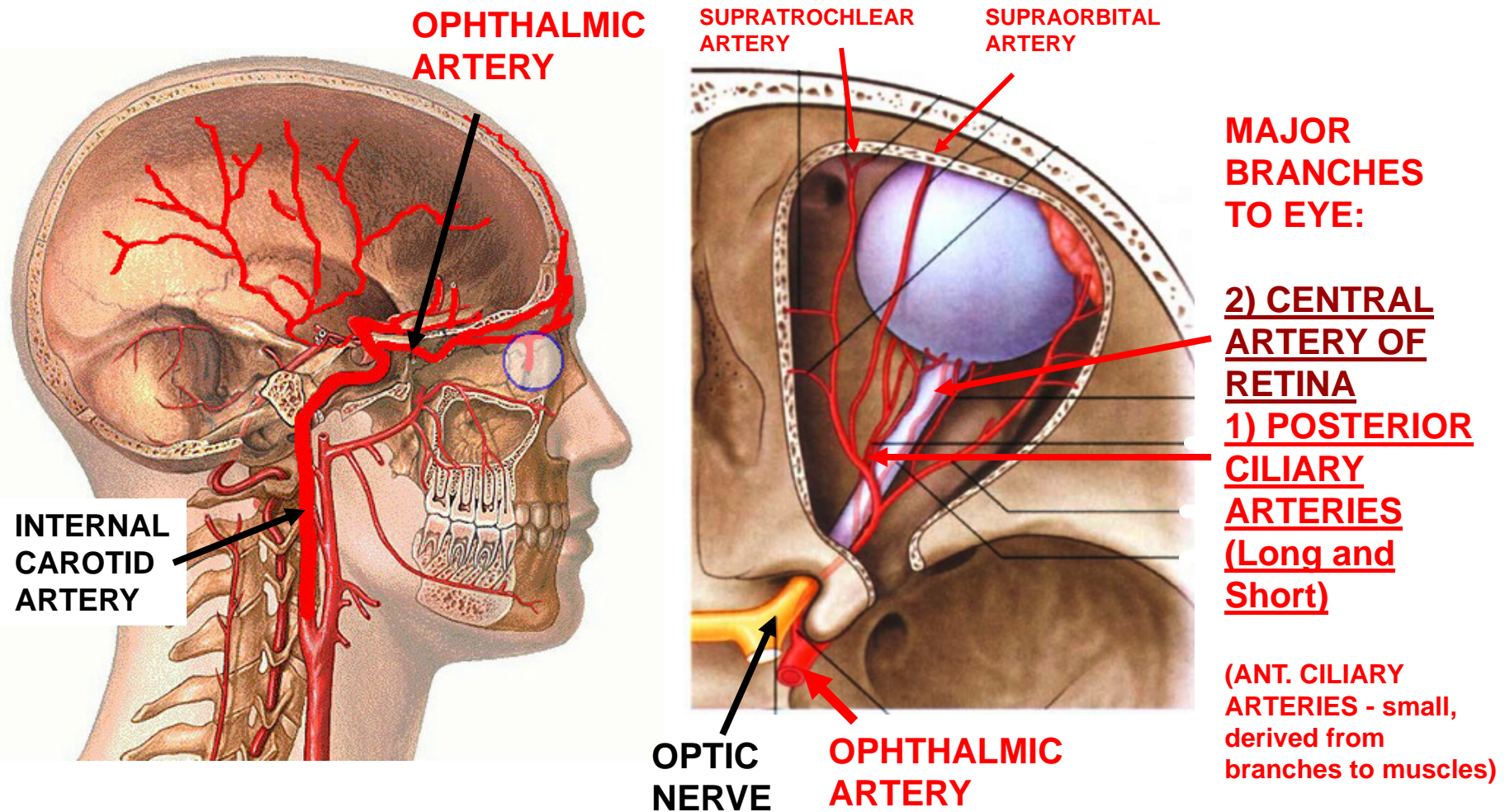


**LIMBUS - junction of  
sclera and cornea**



B) CORNEA - AVASCULAR, TRANSPARENT LAYER OVER ANTERIOR EYE - AIDS IN FOCUSSING LIGHT; **IRREGULARITIES - ASTIGMATISM**

# BLOOD SUPPLY TO ORBIT: OPHTHALMIC ARTERY



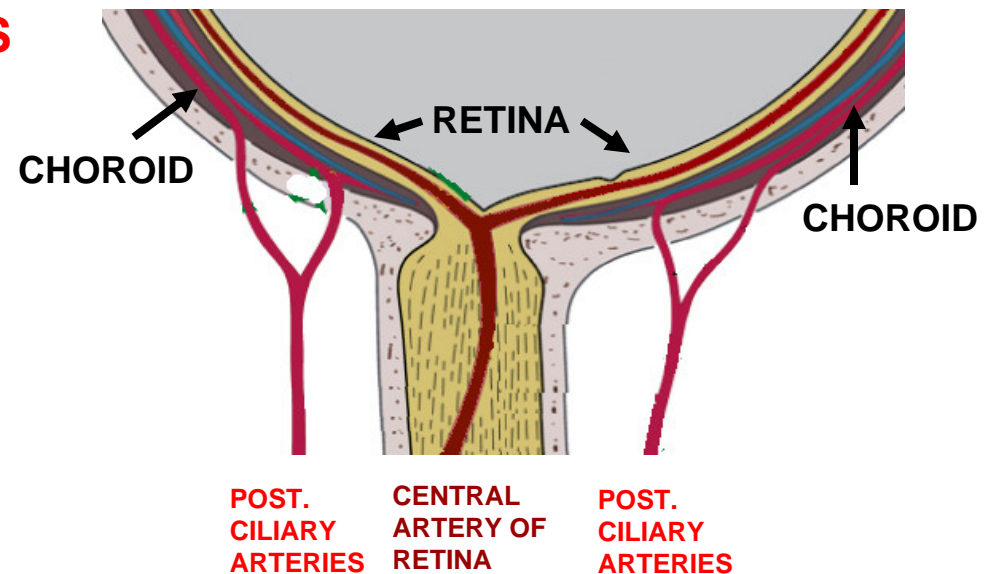
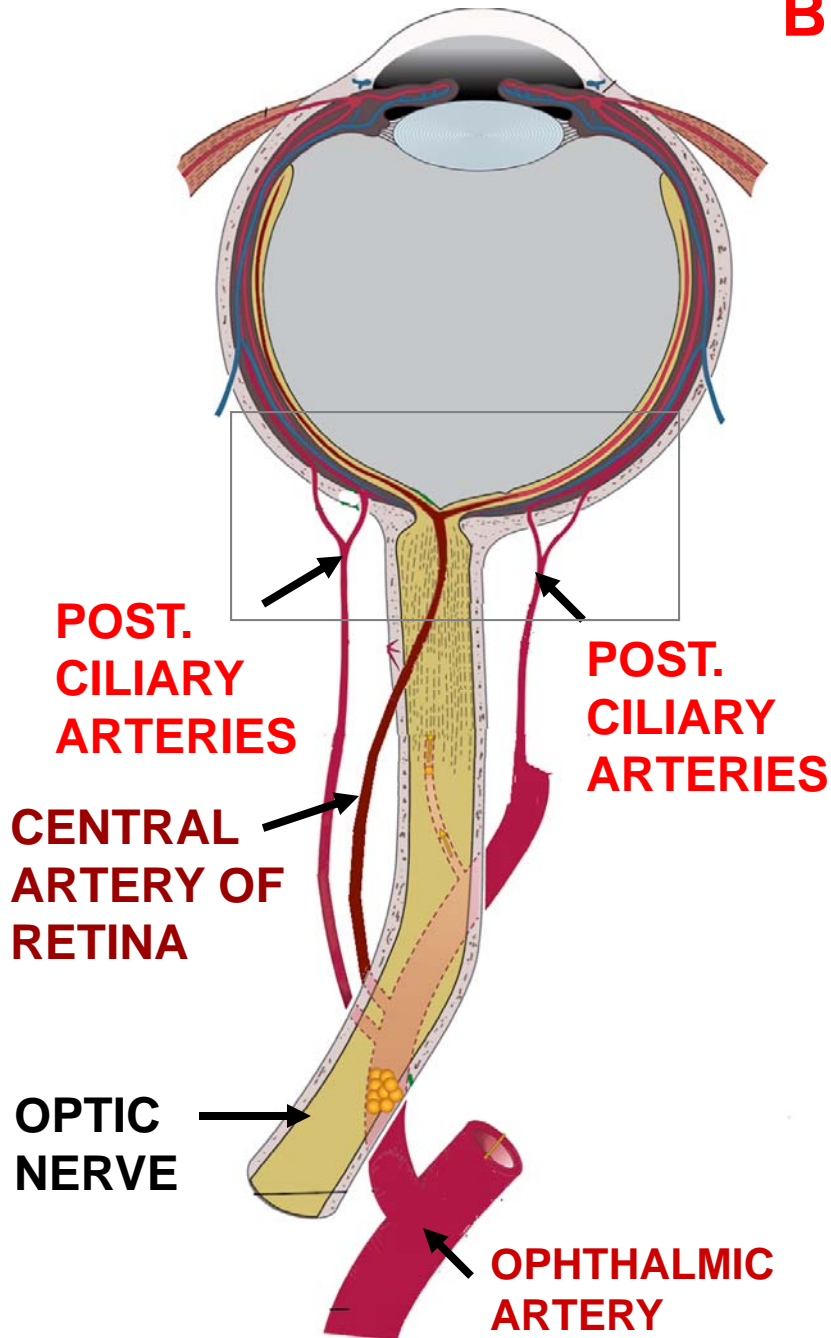
**Note: Branches of Ophthalmic Artery supply eye: Posterior Ciliary Arteries and Central Artery of Retina enter posterior side of Eyeball**

# BLOOD SUPPLY TO EYE

## BRANCHES TO EYE:

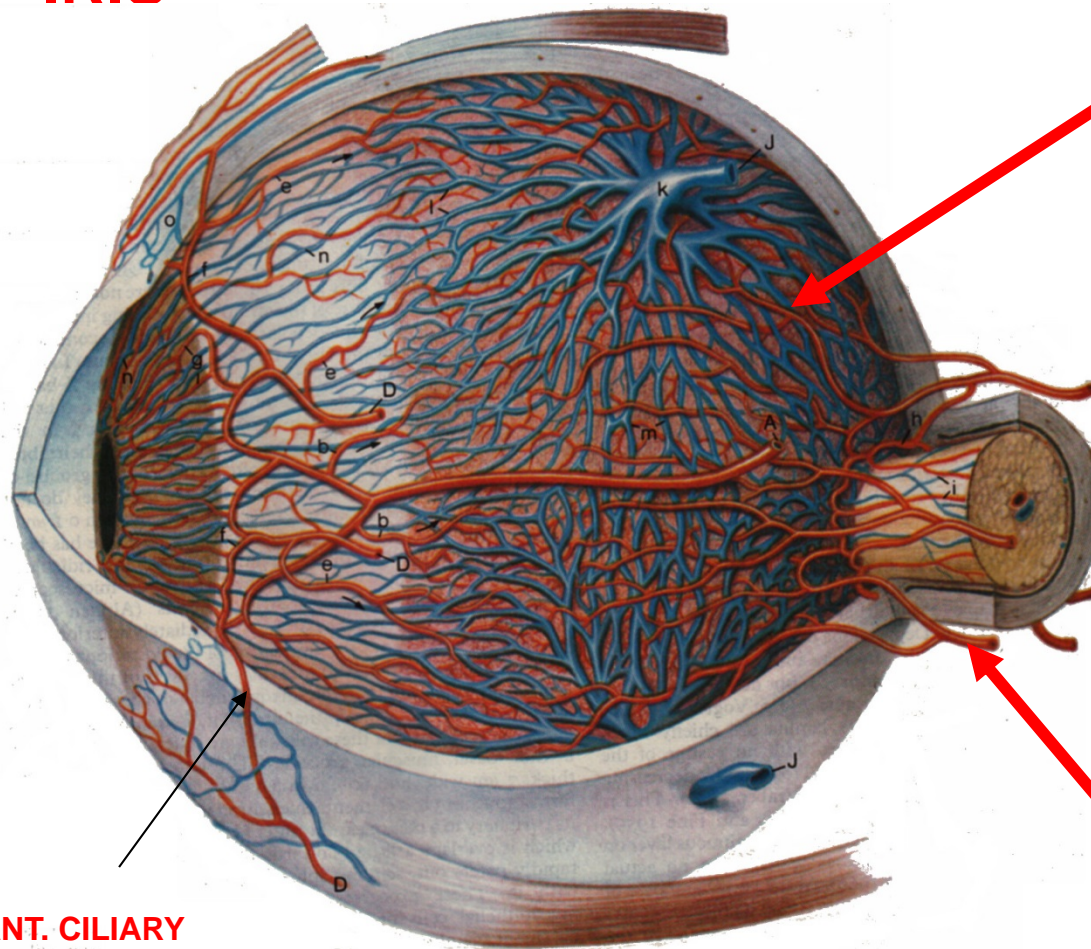
- 1) POSTERIOR CILIARY ARTERIES - pierce sclera; blood to choroid, photoreceptors
- 2) CENTRAL ARTERY OF RETINA - pierces Optic nerve; blood to neural retina

**CENTRAL ARTERY OF RETINA - end artery (no anastomosis)**





# EYE - STRUCTURE OF EYEBALL - VASCULAR LAYER = UVEAL TRACT (UVEA) = CHOROID, CILIARY BODY, IRIS



ANT. CILIARY ARTERIES - small

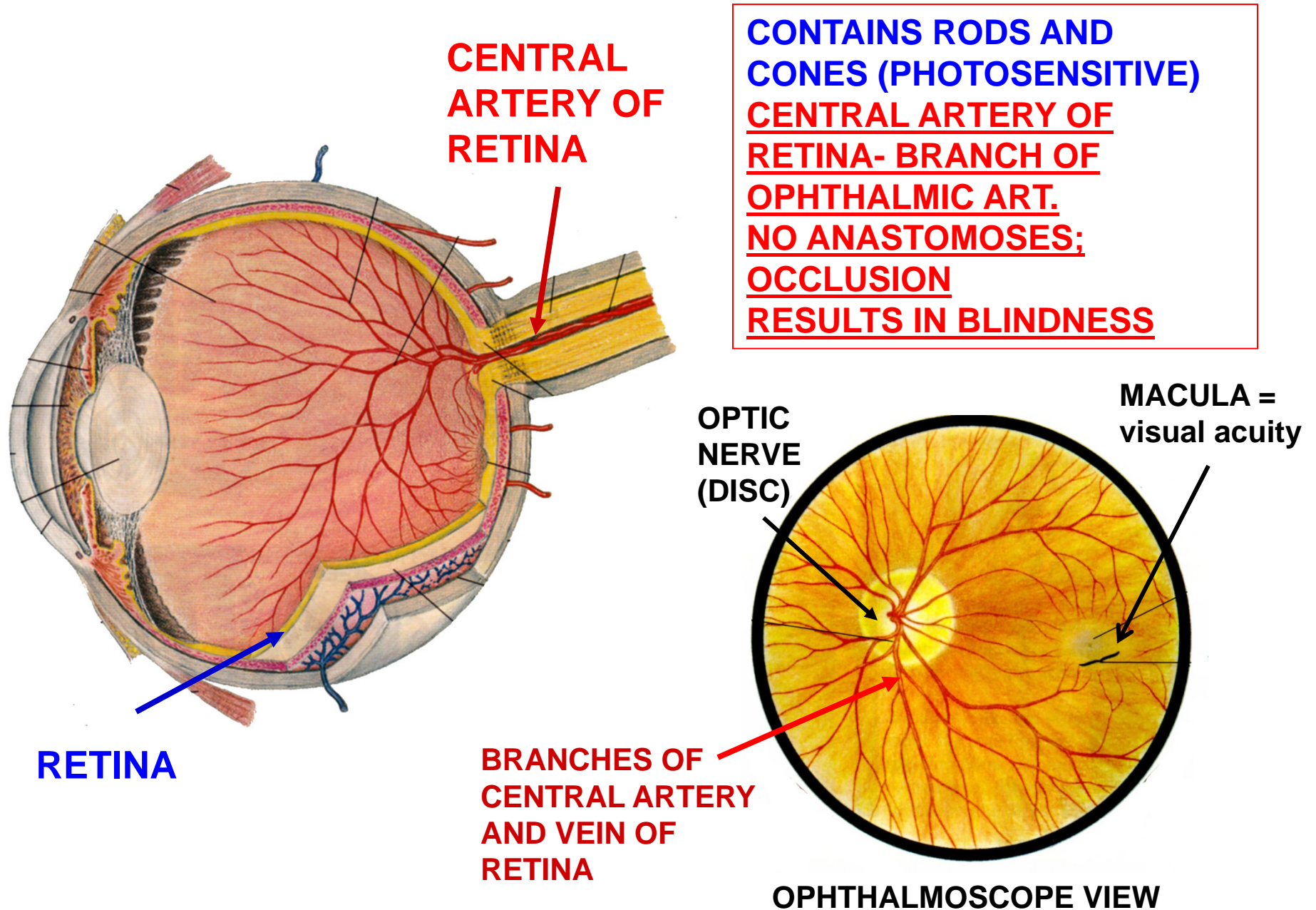
uva = L. grape

**A. CHOROID** -  
HIGHLY VASCULAR,  
PIGMENTED:  
FUNCTIONS:  
PROVIDE O<sub>2</sub>,  
NUTRIENTS TO  
PHOTORECEPTORS.

BUT NORMALLY  
DOES NOT SUPPLY  
GANGLION CELLS  
OF RETINA (THAT  
FORM OPTIC NERVE)

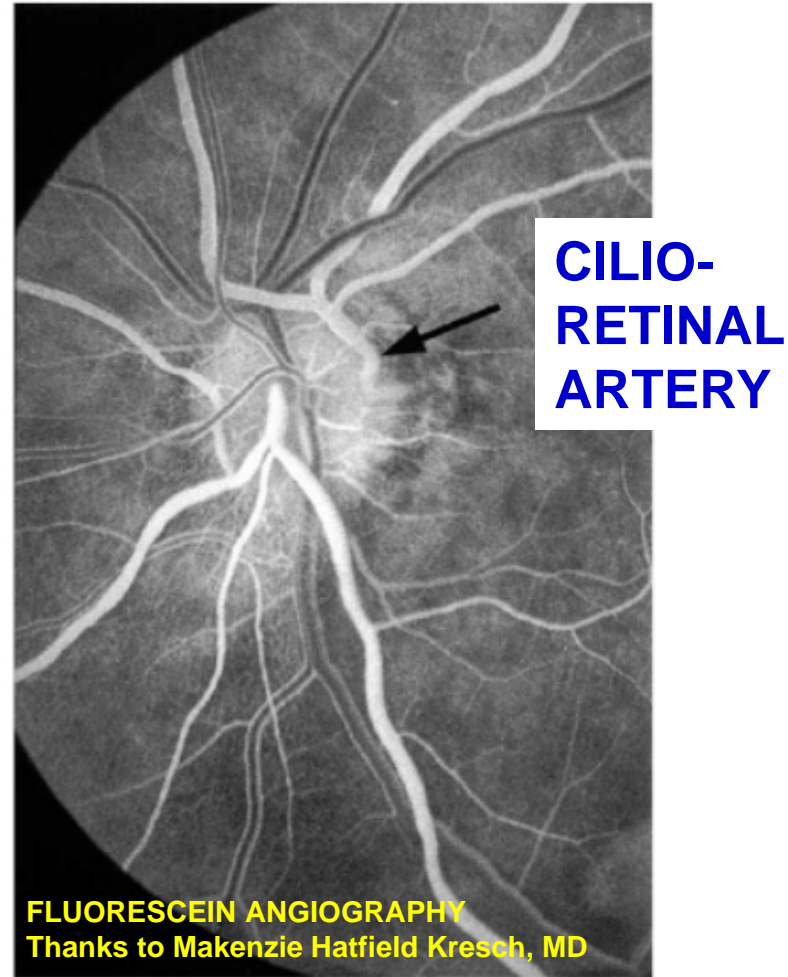
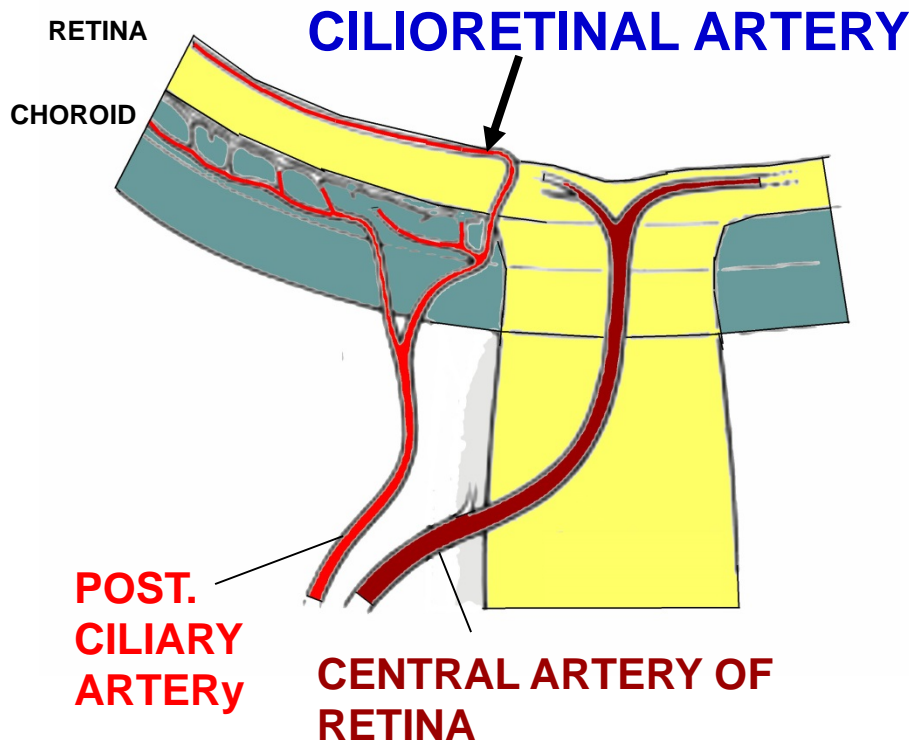
POSTERIOR CILIARY  
ARTERIES (LONG AND  
SHORT) -  
branches of  
Ophthalmic Artery

# EYE- STRUCTURE OF EYEBALL- RETINA



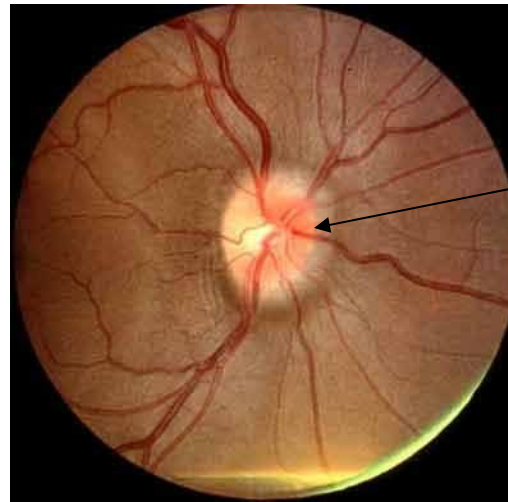
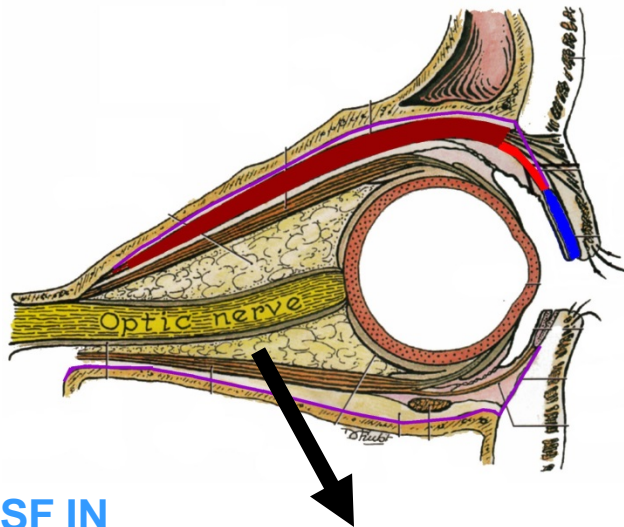


**CRAO - CENTRAL RETINAL ARTERY OCCLUSION - most common cause, Carotid Artery atherosclerosis; if complete: blind in one eye**



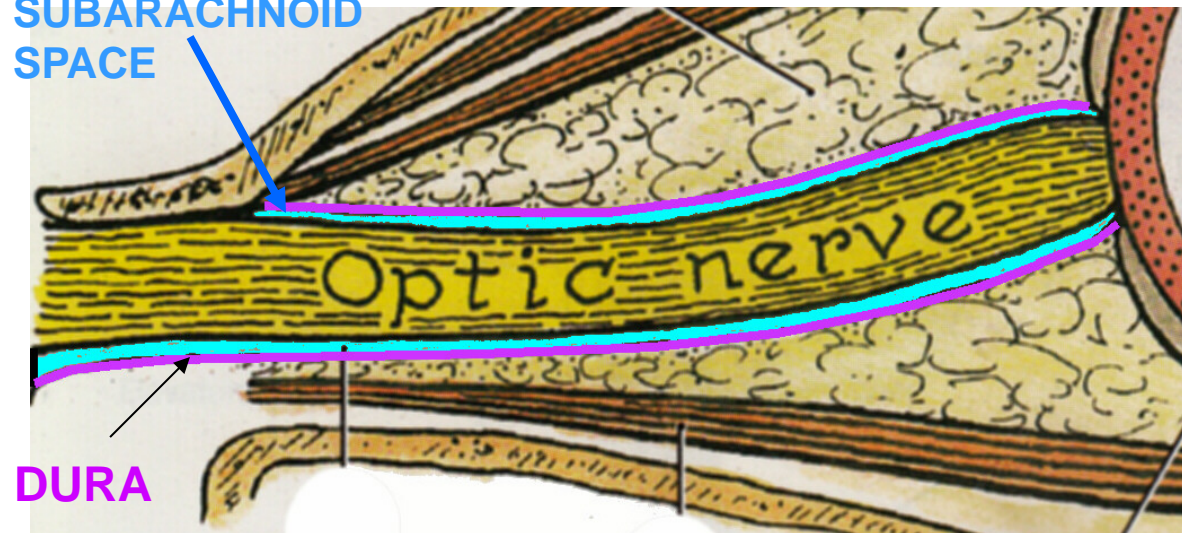
**New Anatomy: imaging has shown that branches of Ciliary Arteries (Cilioretinal arteries) can supply retina (20% of people); can provide partial sparing of retina in cases of Central Retinal Artery Occlusion**

# SUBARACHNOID SPACE EXTENDS TO BACK OF EYEBALL



**PAPILLEDEMA**  
- engorgement  
of retinal veins  
(correspond to  
branches of  
central artery)

CSF IN  
SUBARACHNOID  
SPACE



## CLINICAL

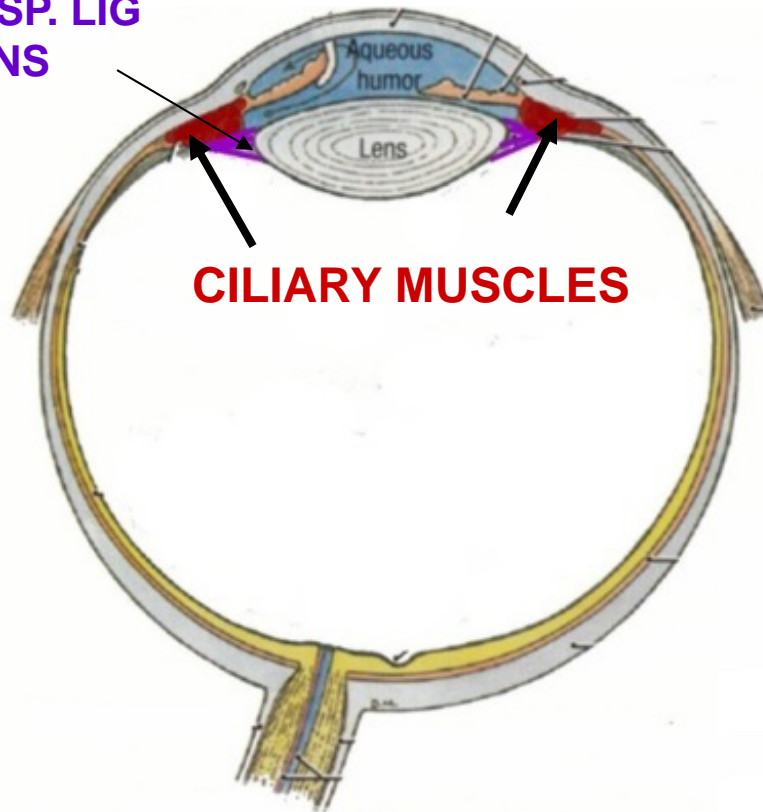
**DURA AND  
SUBARACHNOID SPACE  
(CSF) EXTEND AROUND  
OPTIC NERVE;  
INCREASE IN CSF  
(PRESSURE) CAN  
AFFECT VISION**

**PAPILLEDEMA = swelling of optic disc**

Clinical - slow onset;  
headaches

# EYE- STRUCTURE OF EYEBALL- VASCULAR LAYER

SUSP. LIG  
LENS

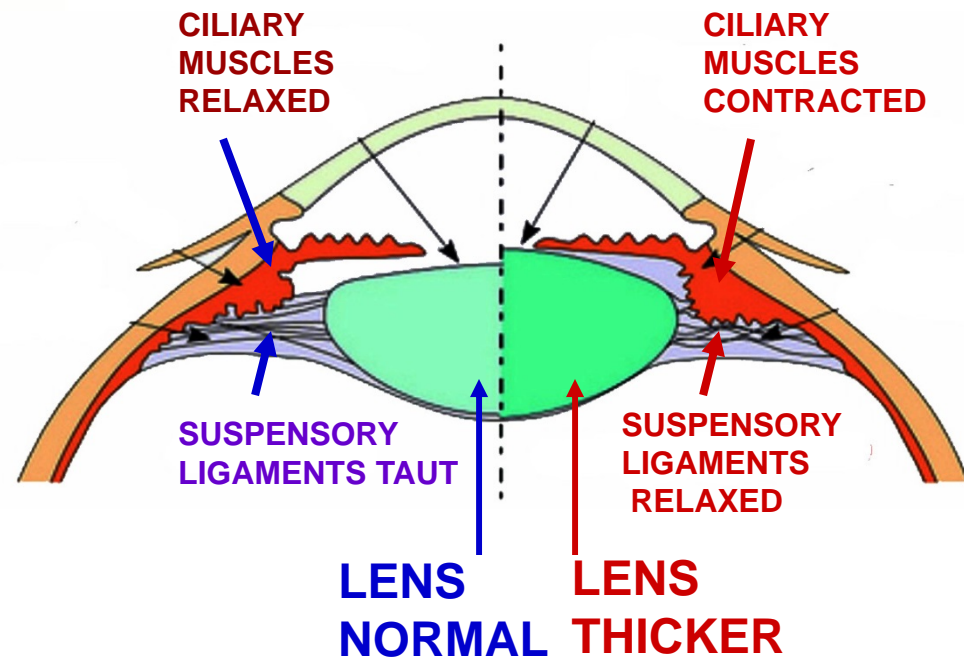


**CILIARY MUSCLES**

**B. CILIARY BODY- CILIARY MUSCLES- SMOOTH MUSCLES AT ATTACHMENTS OF SUSPENSORY LIGAMENTS OF LENS CONTROL THICKNESS OF LENS**

**NORMAL VISION**

**NEAR VISION**



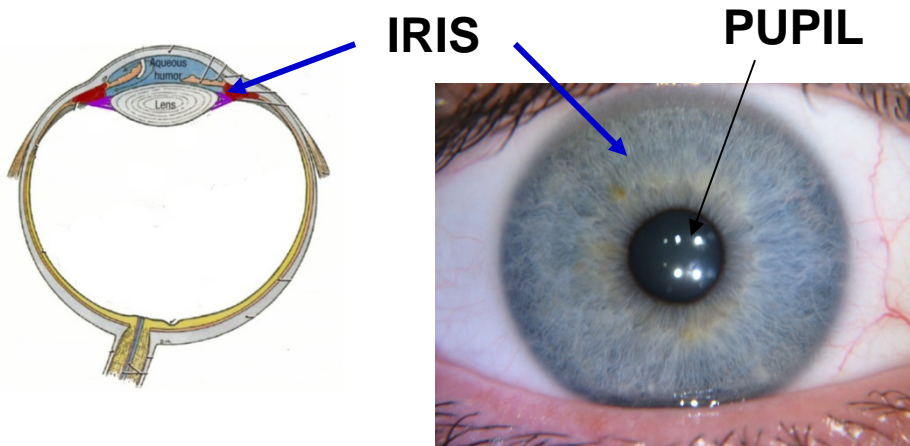
**ACCOMMODATION - THICKEN LENS FOR NEAR VISION (VIEWING OBJECTS CLOSE UP)**

**PARASYMPATHETIC CONTROL- III (Short ciliary nerves)**

**CILIARY MUSCLES CONTRACT - LENS THICKER**



# EYE - STRUCTURE OF EYEBALL- VASCULAR LAYER



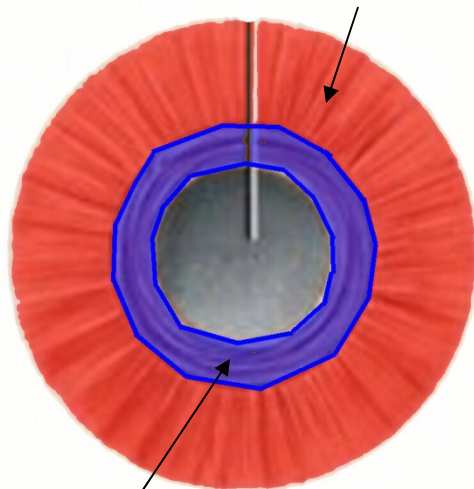
**C. IRIS - PIGMENTED, CONTRACTILE LAYER WITH SMOOTH MUSCLES SURROUNDING PUPIL**

**NORMAL**

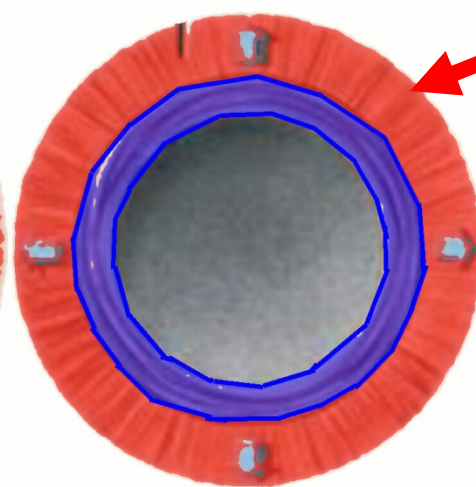
**DILATOR**

**BRIGHT LIGHT - PUPIL CONSTRICTED**

**DIM LIGHT - PUPIL DILATED**



**CONSTRUCTOR**



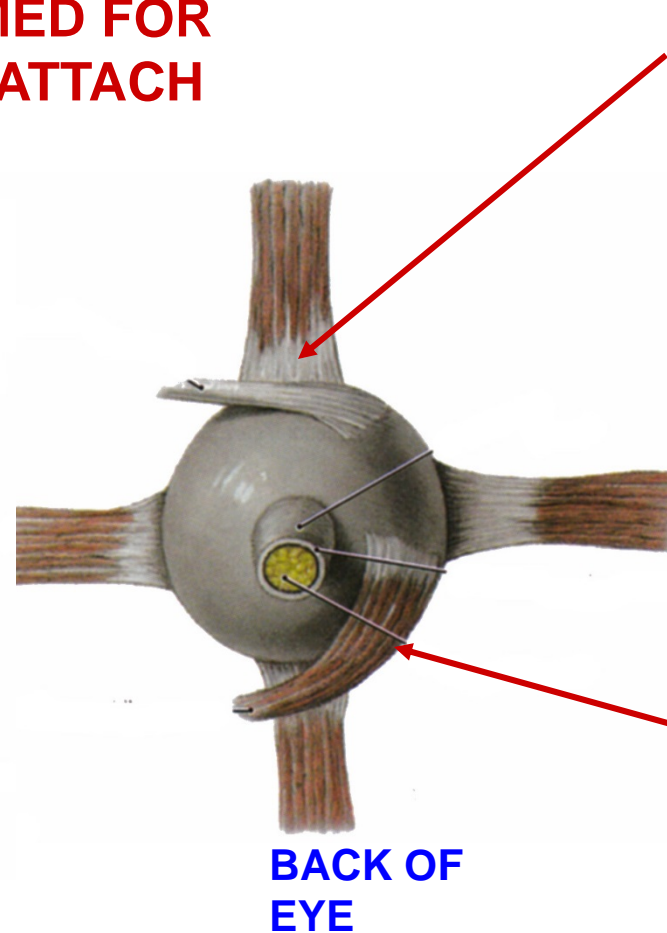
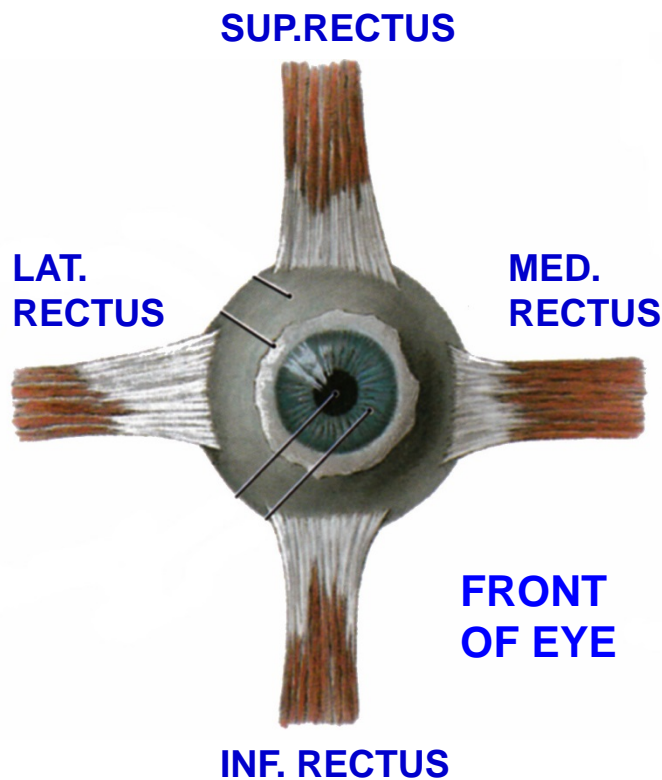
**DILATOR PUPIL- RADIAL SMOOTH MUSCLE; SYMPATHETICS**

**CONSTRUCTOR PUPIL- CIRCULAR SMOOTH MUSCLE; PARASYMPATHETICS (CN III)**

# V. EXTRAOCULAR MUSCLES

- VOLUNTARY SKELETAL MUSCLES WHICH MOVE EYEBALL

RECTI = STRAIGHT, NAMED FOR SIDES ON WHICH THEY ATTACH

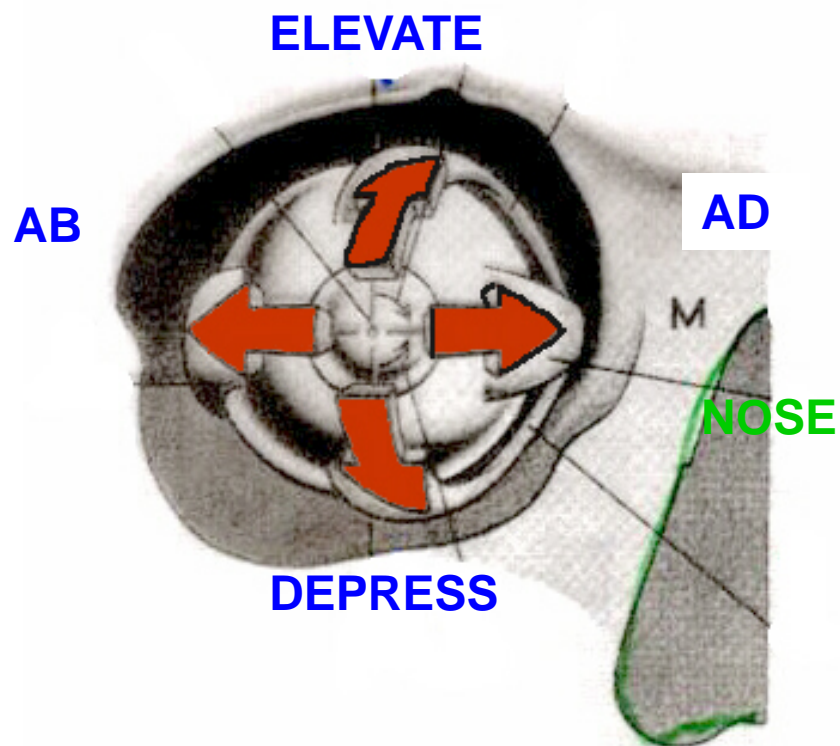


OBLIQUES - MORE COMPLICATED DEVIATED SUPERIOR OBLIQUE - ACTS THROUGH PULLEY (TROCHLEA); INFERIOR OBLIQUE - TO FLOOR OF ORBIT

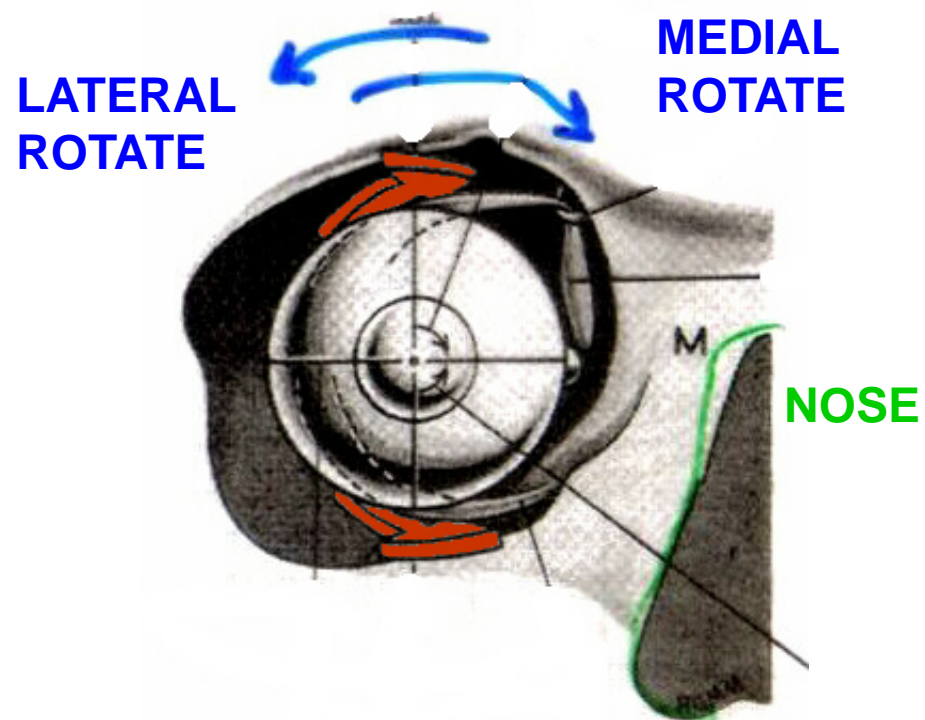
# EYE MOVEMENTS

## VOLUNTARY

ADDUCT - MOVE MEDIANLY  
ABDUCT - LATERALLY  
ELEVATE OR RAISE - SUPERIORLY  
DEPRESS OR LOWER - INFERIORLY

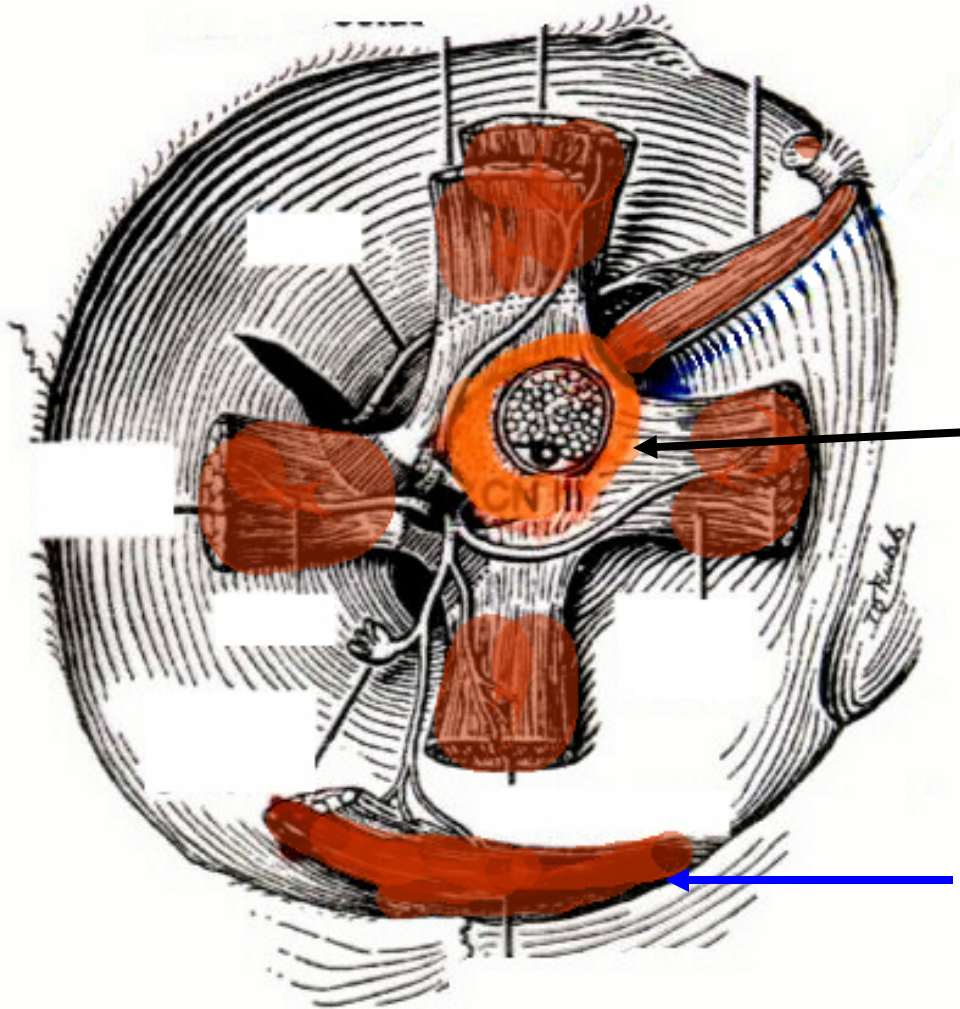


ROTATE- INVOLUNTARY WHEN TILT  
HEAD: MEDIAL ROTATE - INTORSION  
LATERAL ROTATE - EXTORSION





## A. ORIGINS OF EXTRAOCULAR MUSCLES



VIEW OF ENUCLEATED  
ORBIT- EYEBALL  
REMOVED; MOST  
MUSCLES TAKE ORIGIN  
FROM

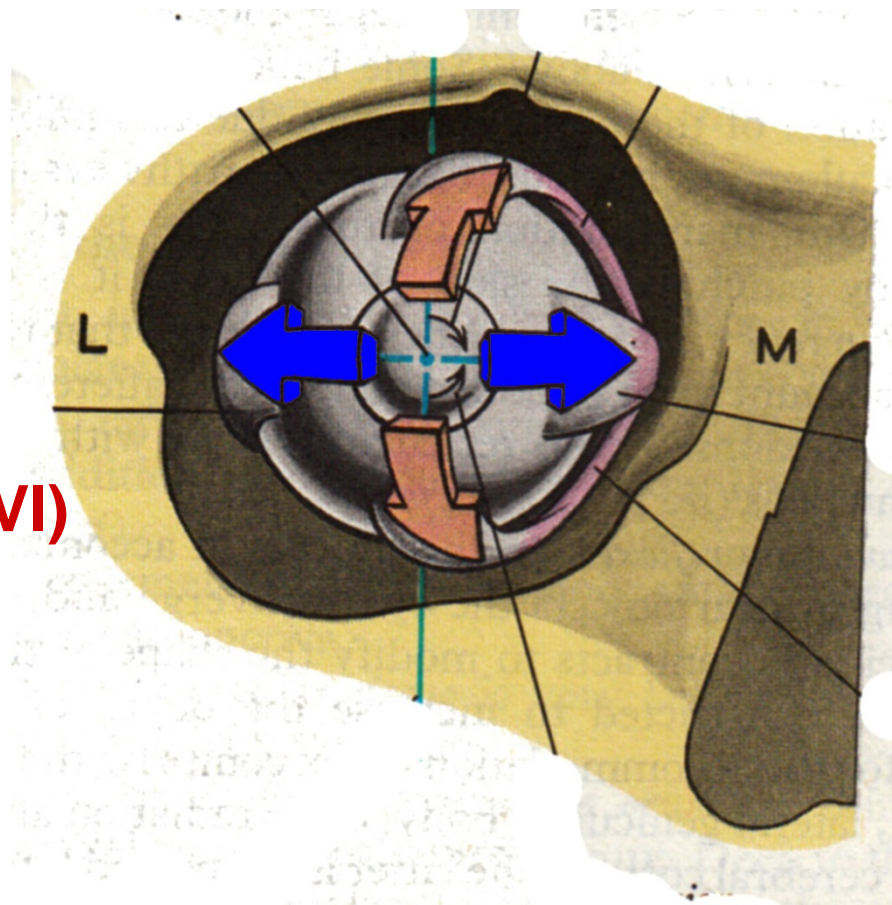
TENDINOUS RING- RING  
OF CT SURROUNDING  
OPTIC CANAL AND  
SUPERIOR ORBITAL  
FISSURE

NOTE: NOT INFERIOR  
OBLIQUE - FROM FLOOR  
OF ORBIT

## B. ACTIONS - EYE MOVEMENTS

### ACTIONS - MEDIAL RECTUS AND LATERAL RECTUS STRAIGHTFORWARD

LATERAL  
RECTUS  
ABDUCT (VI)



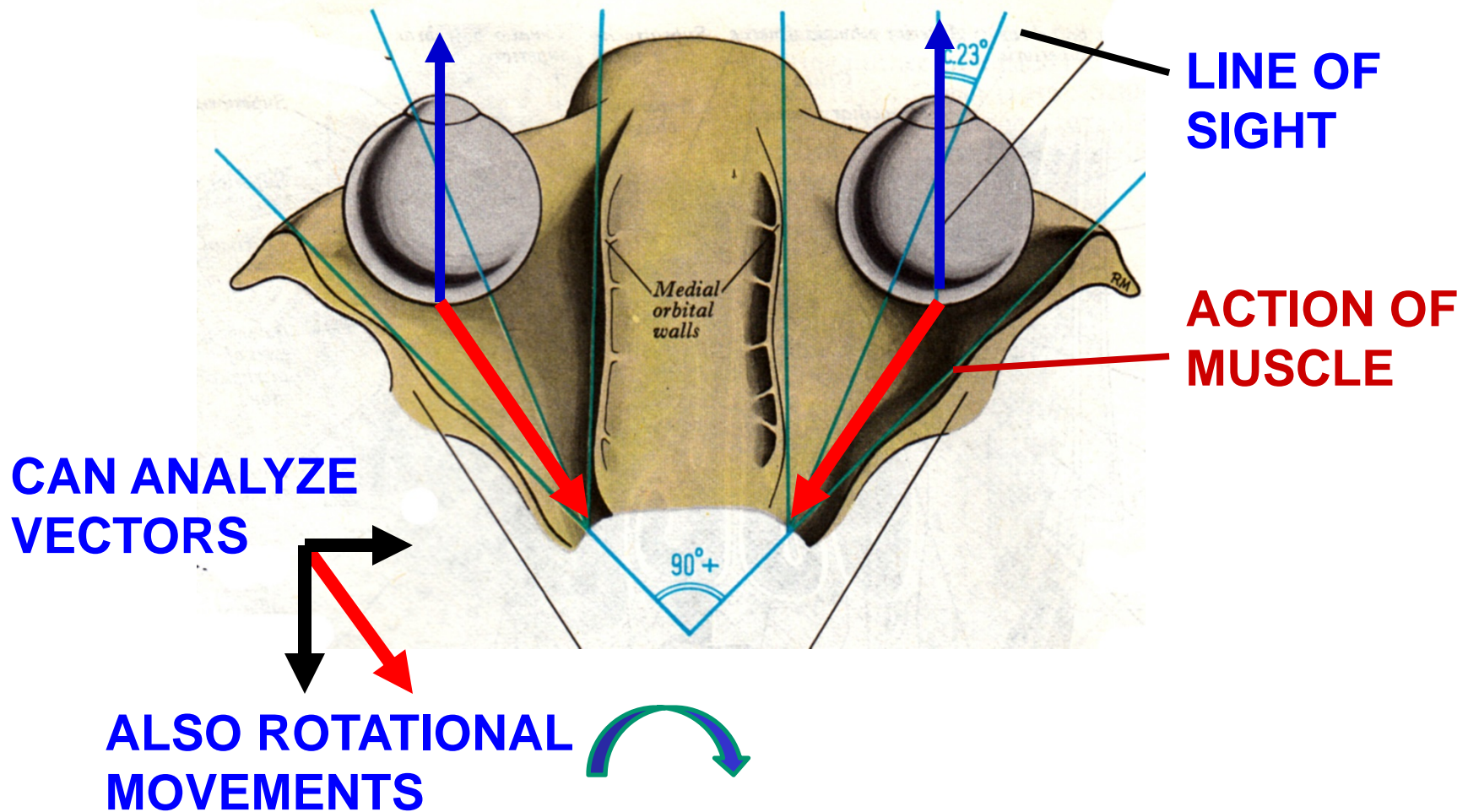
MEDIAL  
RECTUS-  
ADDUCT  
EYE (III)



# EYE MOVEMENTS

- ACTIONS OF OTHER MUSCLES COMPLEX

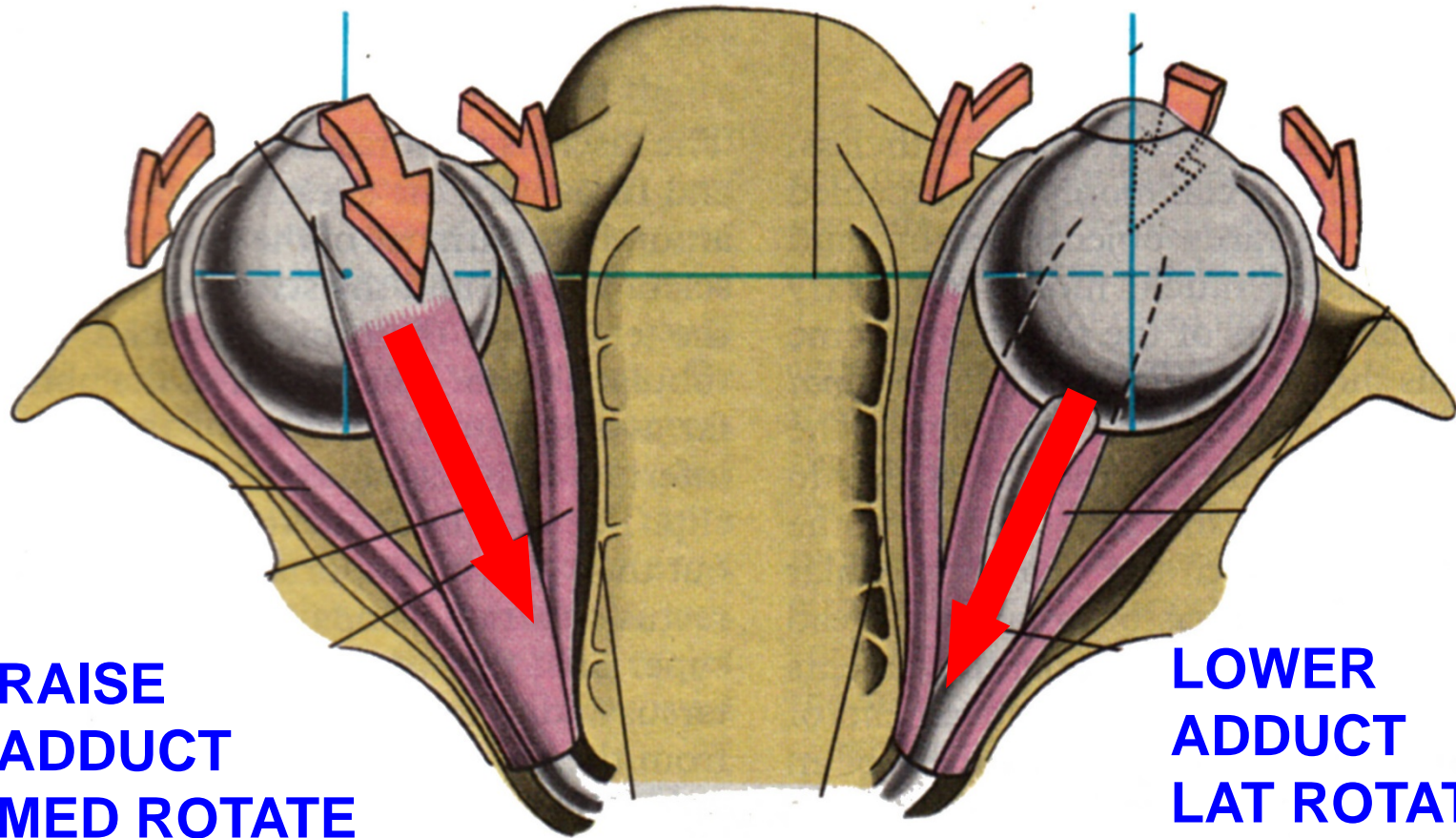
- PULL OF **SUP. AND INF. RECTUS** AT ANGLE WITH LINE OF SIGHT



# EYE MOVEMENTS

**SUP RECTUS (III)**

**INF RECTUS (III)**



**RAISE  
ADDUCT  
MED ROTATE**

**LOWER  
ADDUCT  
LAT ROTATE**

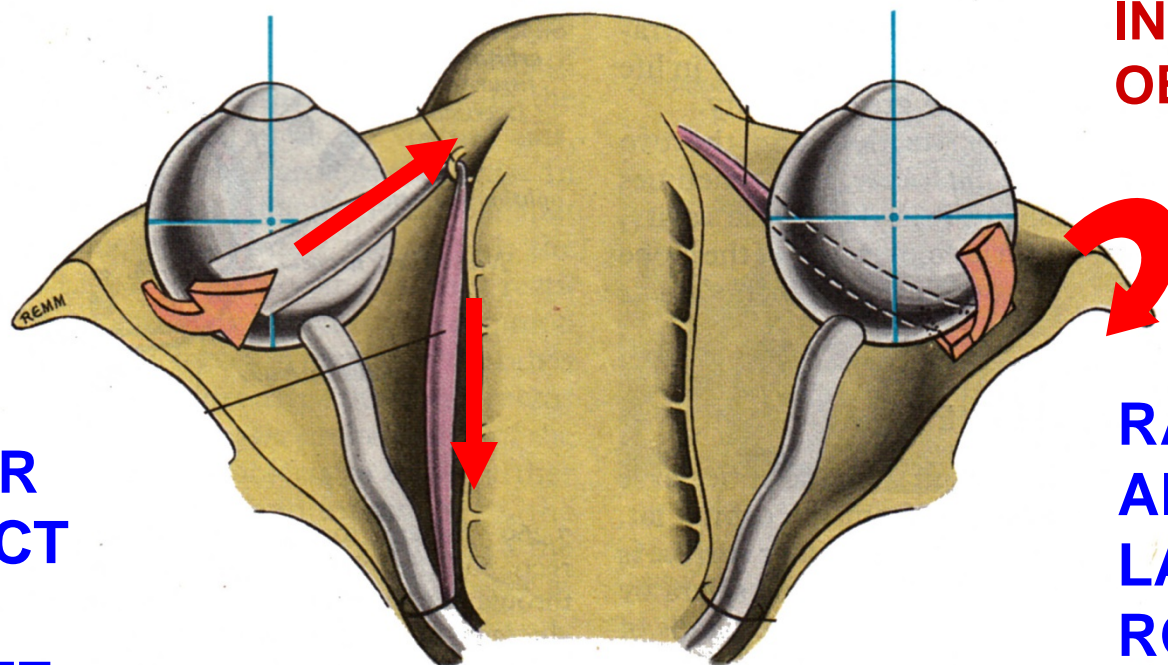
# EYE MOVEMENTS

**ACTION OF OBLIQUE MUSCLES COMPLEX (COUNTERINTUITIVE)**

**SUP OBLIQUE (IV) - ACTS THROUGH PULLEY (TROCHLEA) LIKE MUSCLE ON NOSE**

**INF OBLIQUE (III) - ORIGIN FROM FLOOR OF ORBIT- LIKE MUSCLE ON EAR**

**SUP  
OBLIQUE**



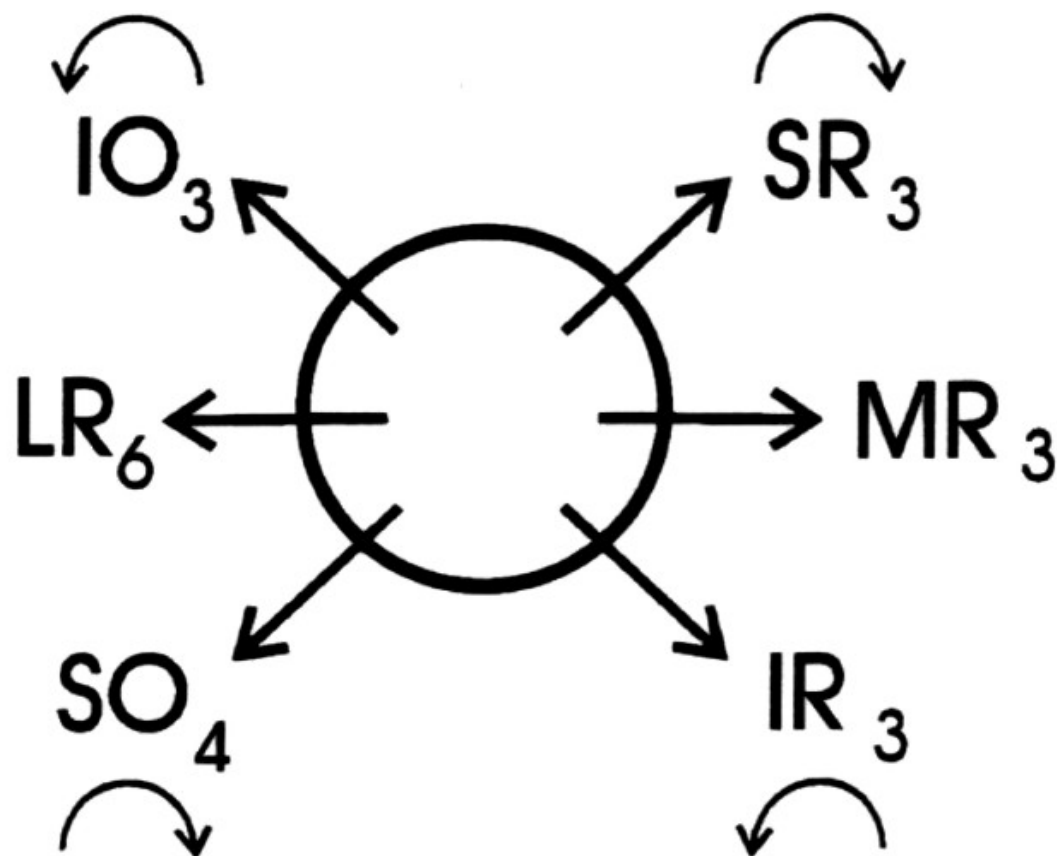
**INF  
OBLIQUE**

**LOWER  
ABDUCT  
MED  
ROTATE**

**RAISE  
ABDUCT  
LAT  
ROTATE**



## EYE MOVEMENTS DIAGRAM

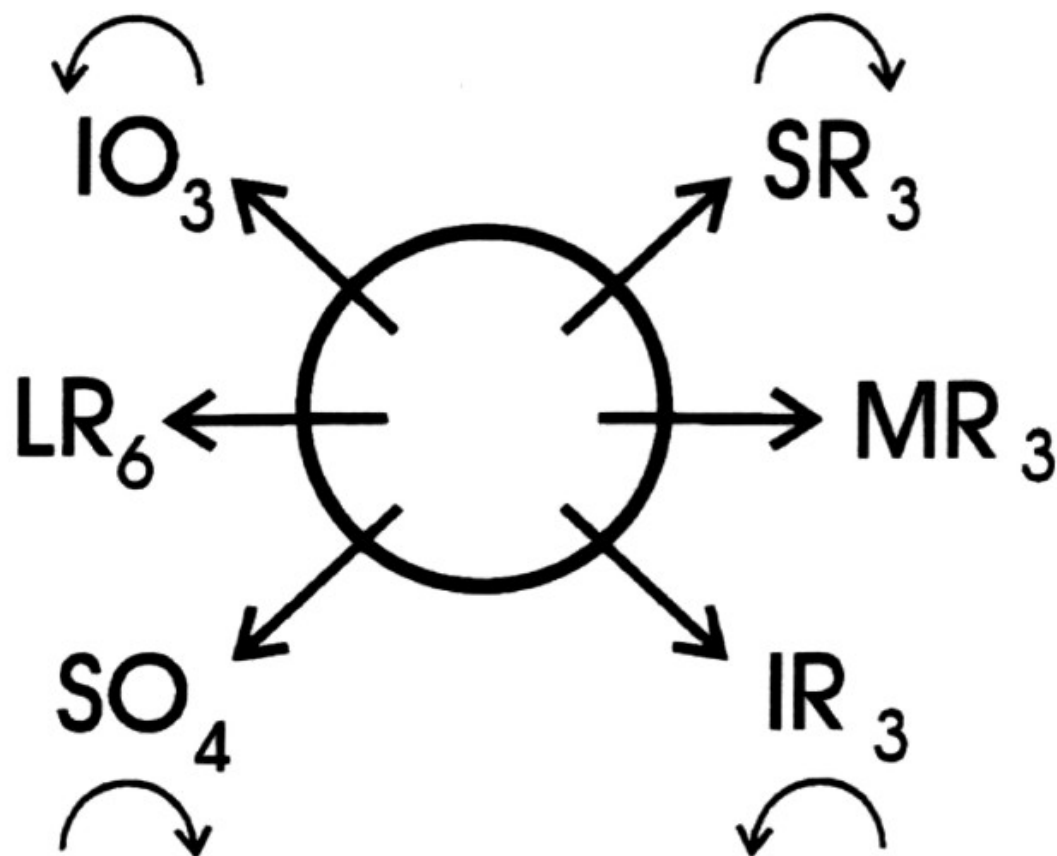


NOSE



- 1- Resting position of eye depends upon tonic activities in muscles.
- 2- Damage to any one muscle does not entirely eliminate abduction, adduction, elevation or depression; only get weakness.

## EYE MOVEMENTS DIAGRAM

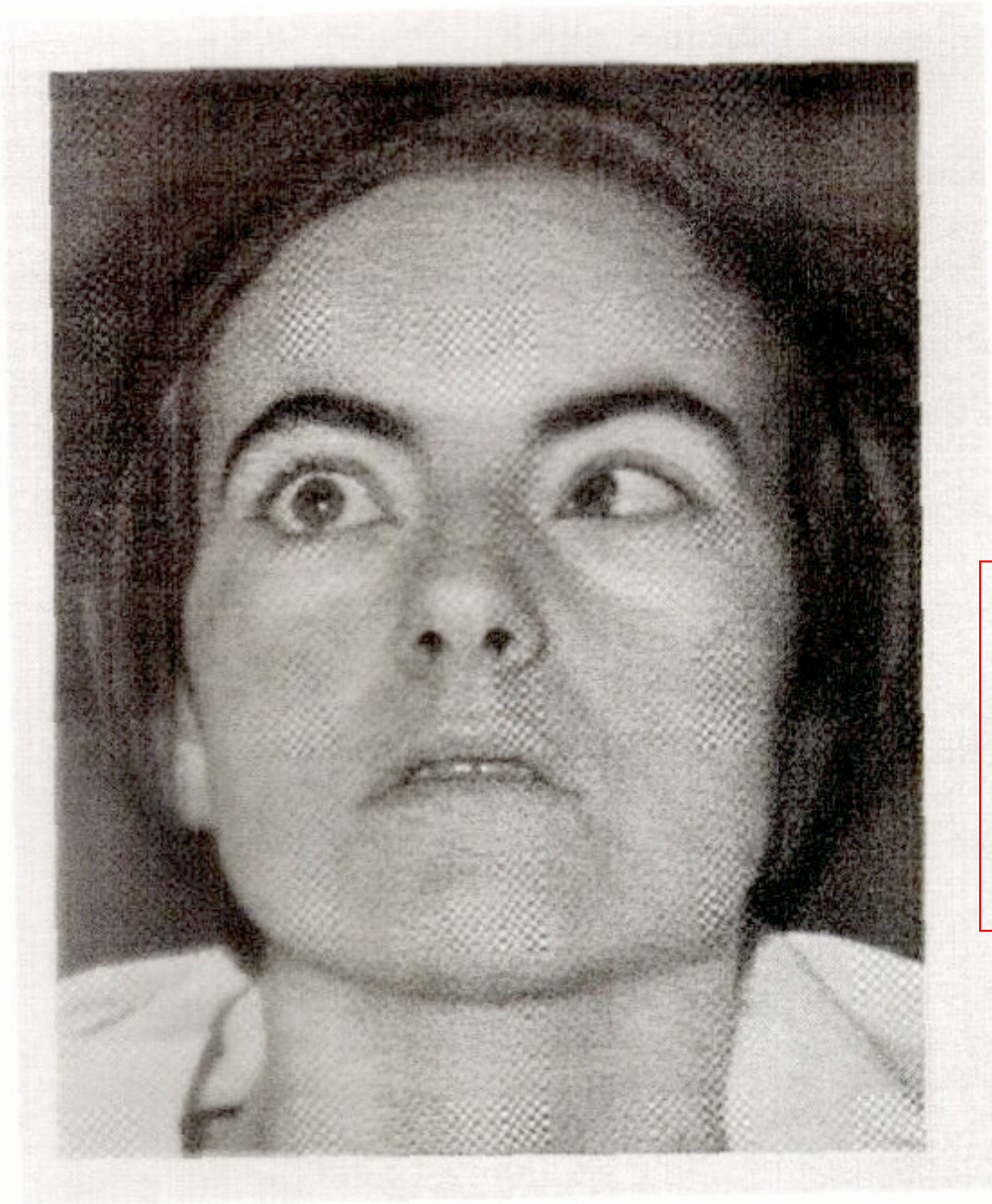


NOSE



**SAMPLE QUESTIONS: 1- WHAT ARE ACTIONS OF INFERIOR OBLIQUE?  
2- WHAT ARE ACTIONS OF SUPERIOR OBLIQUE?  
2- WHAT IS SYMPTOM OF DAMAGE TO ABDUCENS NERVE?**

## VIII. NERVE DAMAGE - all clinically important

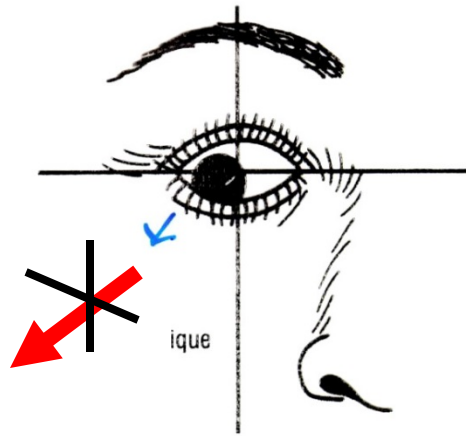


### A. ABDUCENS (VI) NERVE DAMAGE

**ABDUCENS (VI): AT REST 1)  
MEDIAL STRABISMUS  
(CROSS-EYED) DUE TO  
DAMAGE/PARALYZE  
LATERAL RECTUS**



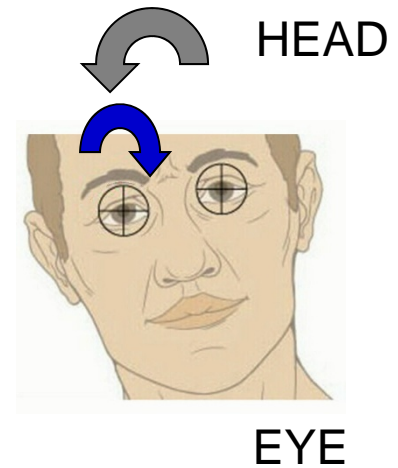
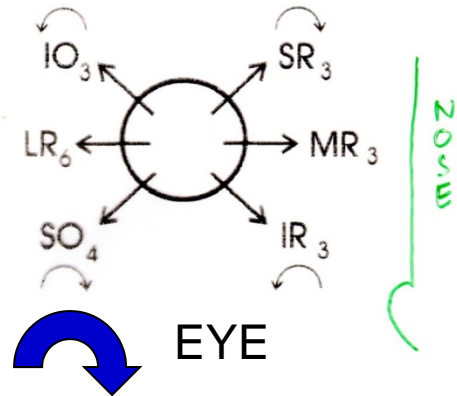
# B. TROCHLEAR (IV) NERVE DAMAGE: INABILITY TO TURN EYE DOWN AND OUT; ALSO HEAD TILT



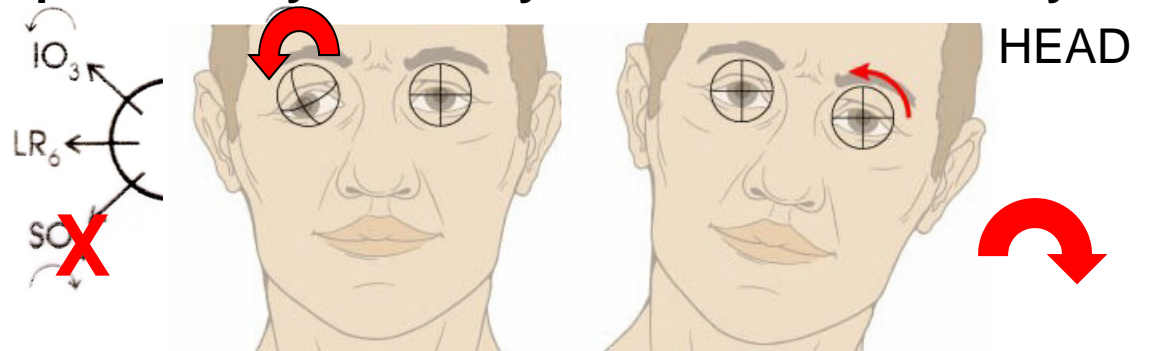
**PATIENT CANNOT LOOK DOWN AND OUT**

**Symptoms - Difficulty walking down stairs; HEAD TILTED**

NORMAL



**NORMAL Rotation** - occurs when tilt head; rotate ipsilateral eye medially when tilt head laterally



**AFTER IV DAMAGE - eye rotated laterally; PATIENT TILTS HEAD TO OPPOSITE SIDE so both eyes rotated**

## C. OCULOMOTOR (III) NERVE DAMAGE



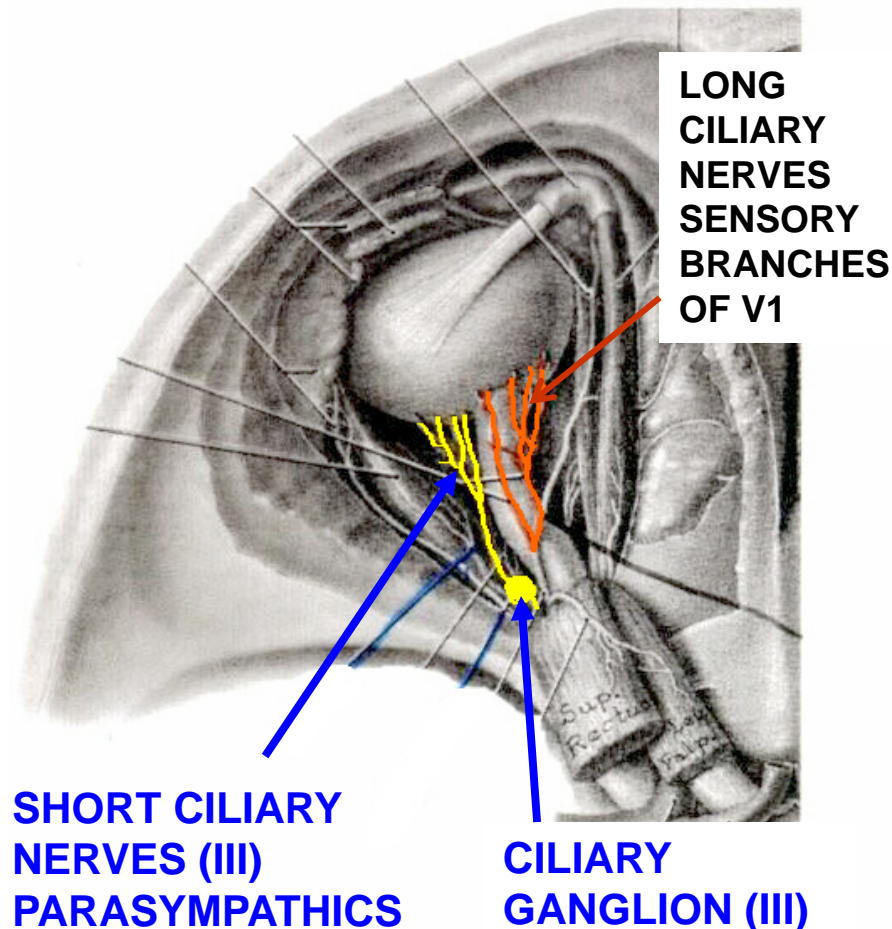
### AT REST

1) LATERAL STRABISMUS (WALL-EYED) DUE TO PARALYZE MEDIAL RECTUS

2) PTOSIS - DROOPING EYELID PARALYZE LEV. PALPEBRAE SUPERIORIS

3) DILATED PUPIL - (MYDRIASIS) PARALYZE PUPILLARY CONSTRICTOR

## VII. CILIARY GANGLION - PARASYMPATHETIC



CILIARY GANGLION-  
PARASYMPATHETICS OF  
OCULOMOTOR N (III); TRAVEL IN  
SHORT CILIARY NERVES - (FOUND  
LATERAL AND DORSAL TO OPTIC  
NERVE)

**INNERVATE:** 1) CILIARY MUSCLES  
2) SPHINCTER (CONTRACTOR)  
PUPILLAE

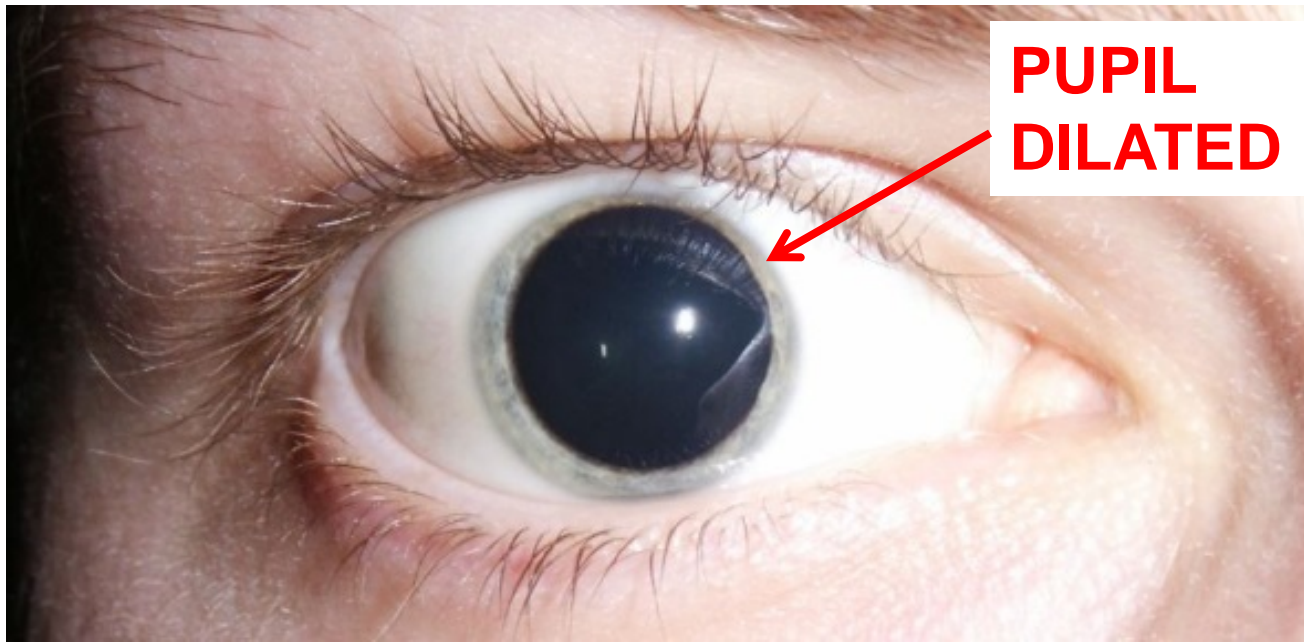
**NOTE:** LONG CILIARY NERVES  
BRANCHES OF V1 (OPHTHALMIC) -  
SENSORY TO CORNEA - (FOUND  
MEDIAL AND DORSAL TO OPTIC  
NERVE)

## CLINICAL

**DAMAGE SHORT CILIARY NERVES (ONLY) - MAIN  
SYMPTOM: PUPIL IS DILATED = MYDRIASIS**



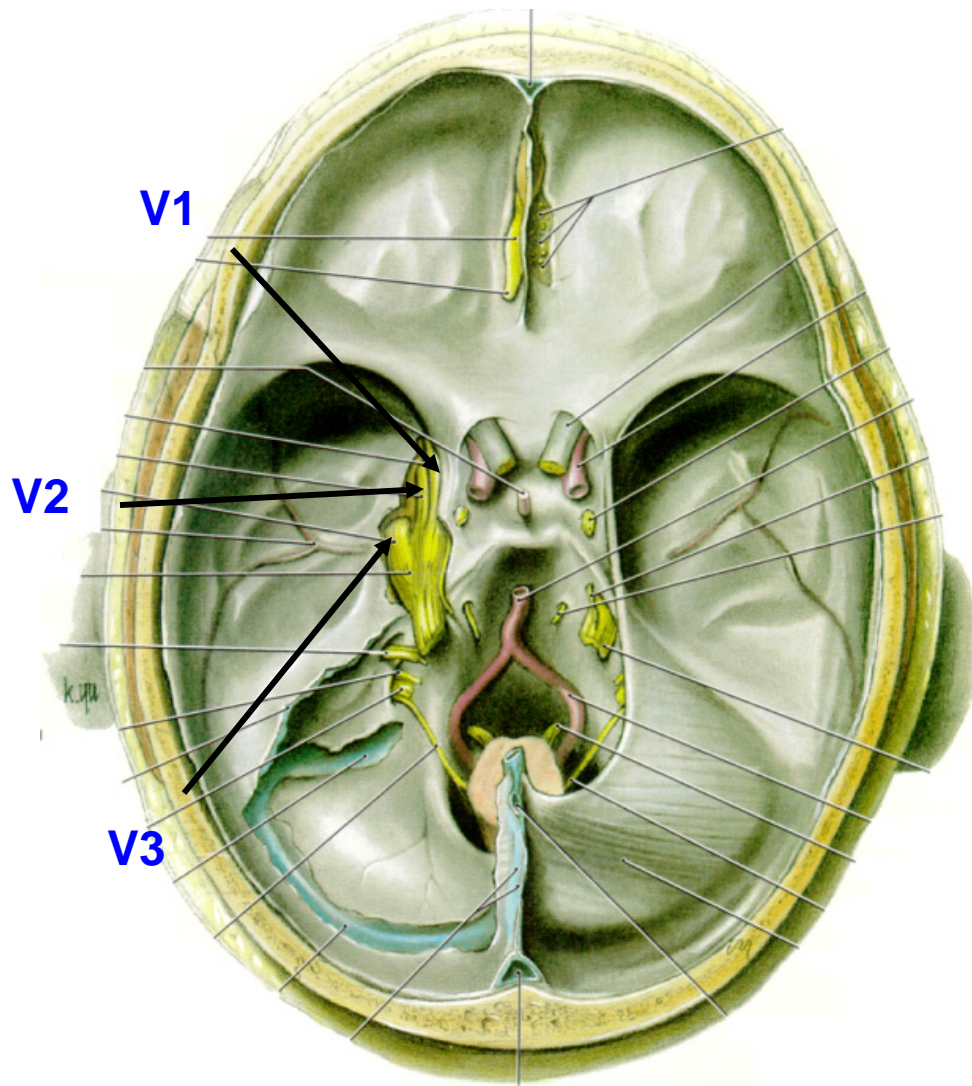
# 'BLOWN PUPIL' = MYDRIASIS (muh-dry'-a-sis)



**'BLOWN PUPIL' = MYDRIASIS - PUPIL DILATED, UNABLE TO CONSTRICT IN RESPONSE TO LIGHT - INDICATES CATASTROPHE - STROKE, HERNIATION, ETC.**

**Note; Anisocoria – pupils of unequal size (normal or abnormal)**

# TRIGEMINAL NERVE - V

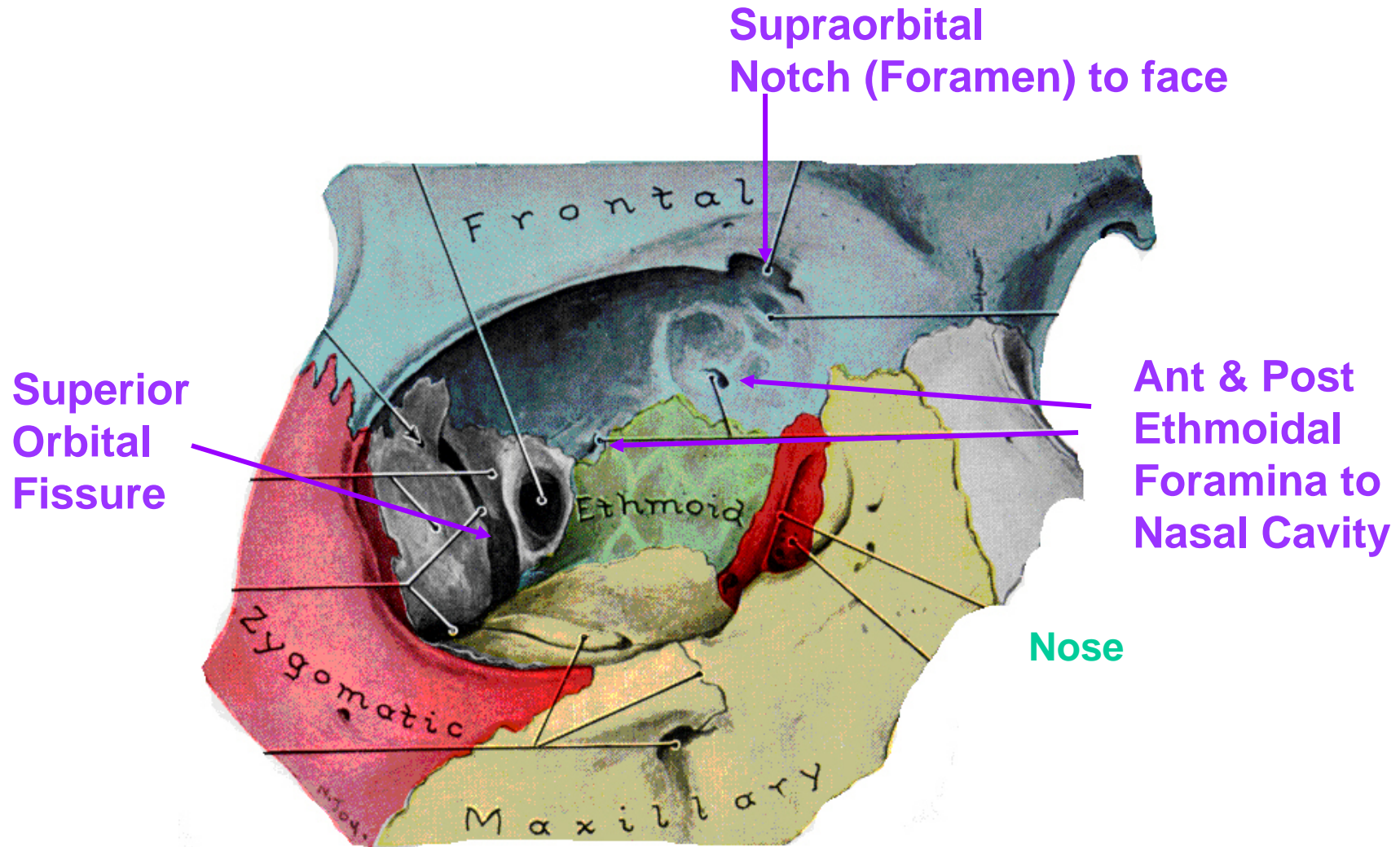


**V1 – OPHTHALMIC -Sup.**  
**Orbital fissure – SOMATIC**  
**SENSORY**

**V2 - MAXILLARY - Foramen**  
**rotundum – SOMATIC**  
**SENSORY**

**V3 – MANDIBULAR - -**  
**Foramen ovale – SOMATIC**  
**SENSOR AND**  
**BRANCHIOMOTOR**

# V1 - OPHTHALMIC - SOMATIC SENSORY



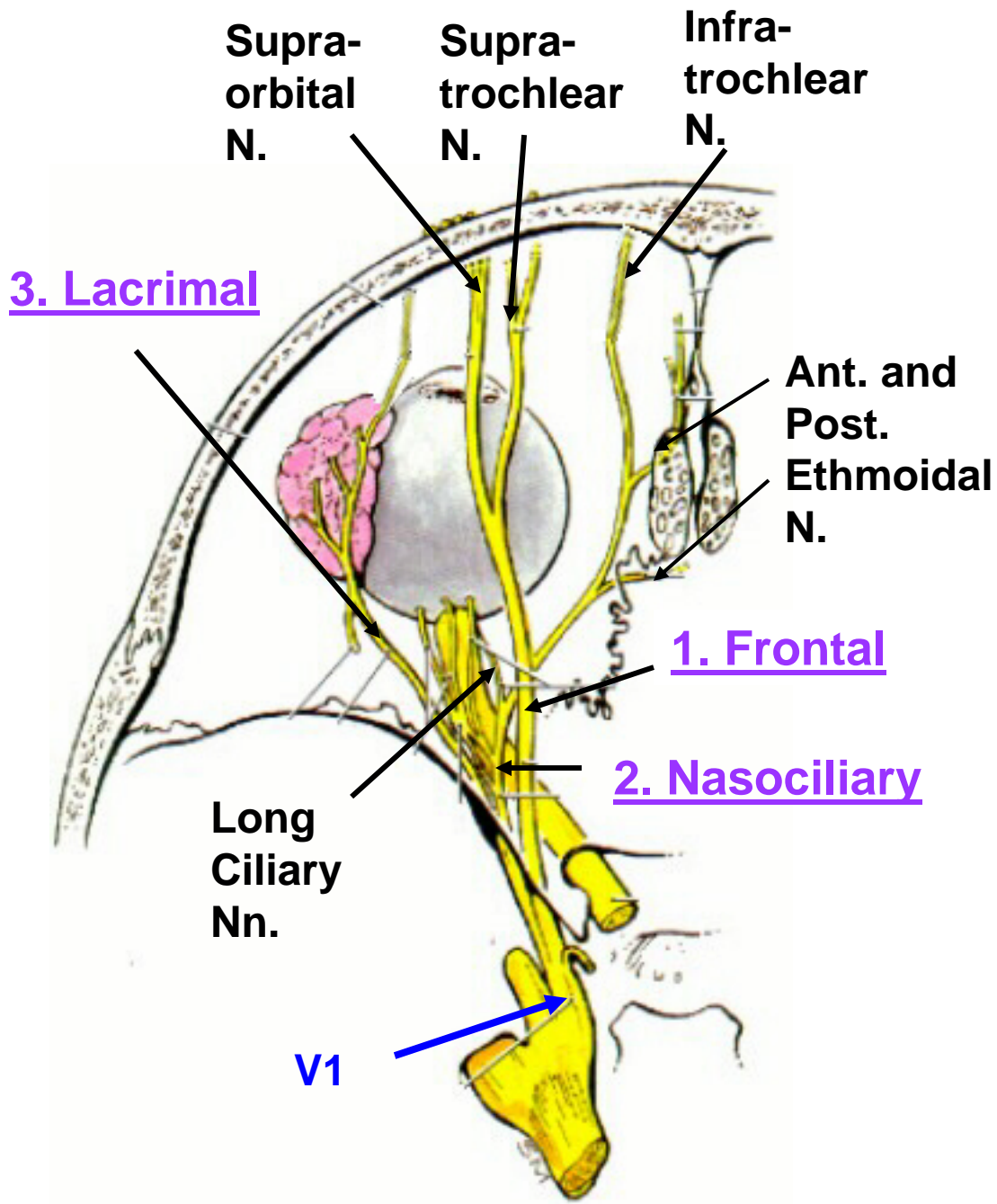
**Recall : Orbit is used as way to reach face, nasal cavity**



### V1 Ophthalmic - GSA (Sensory) only - through Superior Orbital Fissure to Orbit

<b>Nerve</b>	<b>Branches</b>	<b>Innervates</b>
1. Frontal Nerve	a. Supraorbital Nerve	Scalp forehead, upper eyelid
	b. Supratrochlear Nerve	Scalp forehead, upper eyelid
2. Lacrimal Nerve		Upper eyelid
3. Nasociliary Nerve	a. Long Ciliary Nerve	Cornea of eye
	b. Ant. and Post. Ethmoidal Nerves	Nasal cavity, ethmoid sinus, tip of nose
	c. Infratrochlear Nerve	Upper eyelid, nose

# V1 - OPHTHALMIC - ALL SOMATIC SENSORY



- 1. Frontal N.
  - a) Supraorbital N.
  - b) Supratrochlear N.

**Forehead, Upper Eyelid**
  
- 2. Lacrimal N.

**Upper eyelid**
  
- 3. Nasociliary N.
  - a) Ant. and Post. Ethmoidal N.

**Nasal Cavity**  
**Ethmoid Sinus , Tip of Nose**

  - b) Long Ciliary N.

**Sensory to Cornea**

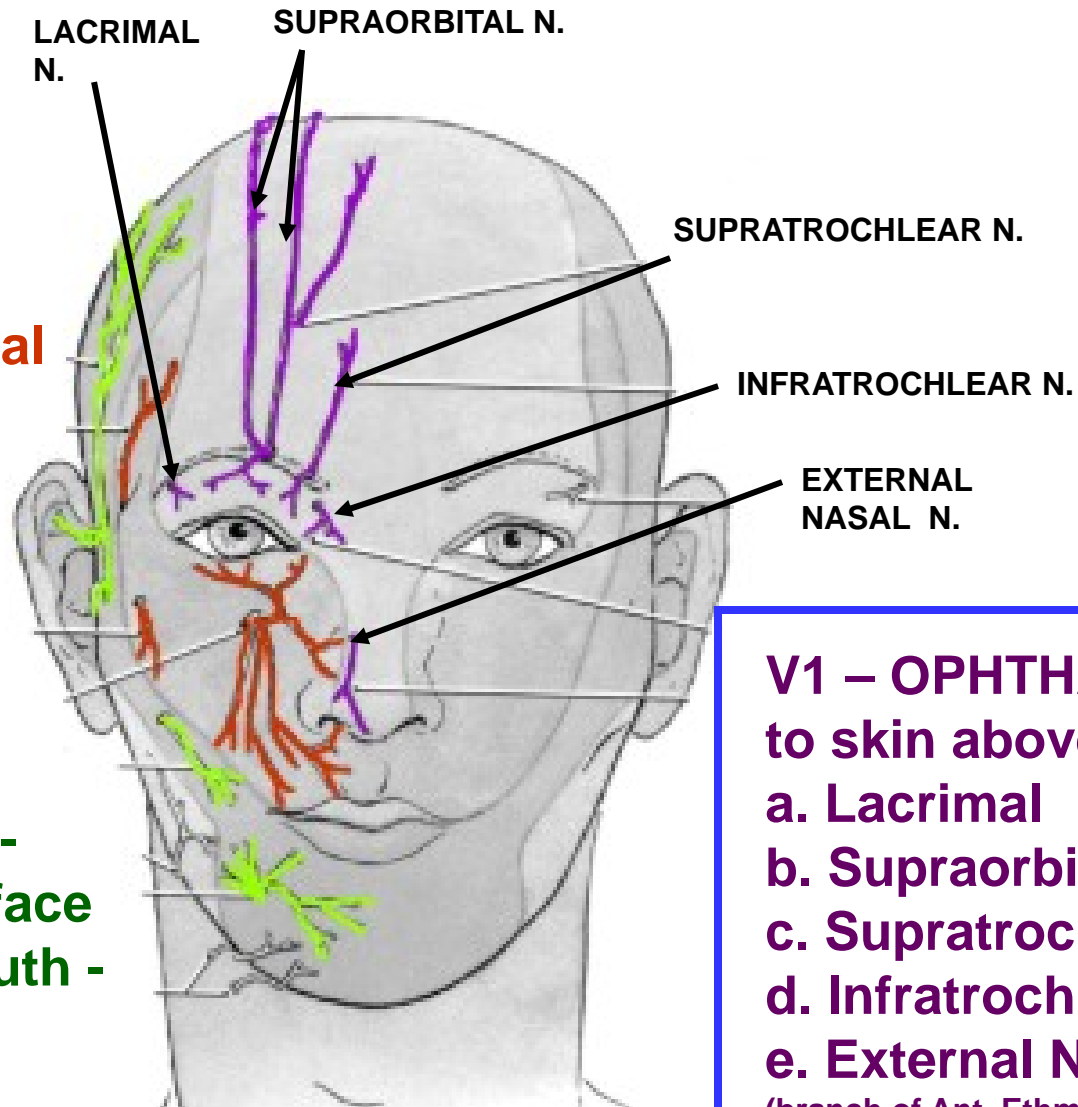
  - c) Infratrochlear N.

**Upper eyelid, Nose**

## TRIGEMINAL – SENSORY BRANCHES TO FACE

**V2 – MAXILLARY -**  
to skin of cheek  
below orbit -  
Zygomaticotemporal  
Zygomaticofacial  
Infraorbital

**V3- MANDIBULAR -**  
to skin of jaw and face  
below angle of mouth -  
Auriculotemporal  
Buccal  
Mental



**V1 – OPHTHALMIC -**  
to skin above orbit -  
a. Lacrimal  
b. Supraorbital  
c. Supratrochlear  
d. Infratrochlear  
e. External Nasal Nerve  
(branch of Ant. Ethmoidal N.)



## FORAMINA OF SKULL: PART ONE

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The skull is rigidly structured to protect the brain but has many foramina (openings) for passage of nerves (nn.), arteries (aa.) and veins (vv.); knowledge of the foramina of the skull is ESSENTIAL to understanding head and neck anatomy. The foramina are listed below according to how one can view them on a skull. Each entry indicates the bone the foramen is in, the areas it connects and structures that pass through it; many foramina are doubly listed as they can be seen from the inside or outside of the skull.

### I. FACE

1. Supraorbital notch or foramen - in frontal bone; connects orbit and forehead; contains Supraorbital n., a. and v.
2. Infraorbital foramen - in maxillary bone; connects orbit and face; contains Infraorbital n., a. and v.
3. Mental foramen - in mandible; connects mandibular canal to face; contains Mental n., a. and v.

### II. CALVARIUM AND CRANIAL VAULT

1. Parietal foramen - in parietal bone on either side of sagittal suture; connects; diploe in bone to scalp; contains Emissary veins.

### III. INTERIOR OF SKULL

1. Olfactory foramen - located in cribriform plate of ethmoid bone in anterior cranial fossa; connects anterior cranial fossa and nasal cavity; contains branches of Olfactory nerve (fila olfactoria) (I).
2. Optic foramen and canal - located at base of Lesser wing of sphenoid bone in middle cranial fossa; connects middle cranial fossa to orbit; contains Optic nerve (II) and Ophthalmic artery.
3. Superior Orbital fissure - located between Greater and Lesser wings of Sphenoid bone in Middle Cranial fossa; connects middle cranial fossa and orbit; contains Oculomotor (III), Trochlear (IV), Abducens (VI) nerves and Ophthalmic division of Trigeminal nerve (V1) and Ophthalmic veins.
4. Carotid canal - located in temporal bone; connects base of skull to middle cranial fossa (opening of Carotid canal in middle cranial fossa called Foramen Lacerum); contains Internal carotid artery and Sympathetic Plexus surrounding artery.

5. Foramen rotundum - located in Greater wing of Sphenoid bone; connects middle cranial fossa and Pterygopalatine fossa; contains Maxillary division of Trigeminal nerve (V2).
6. Foramen ovale - located in sphenoid bone; connects middle cranial fossa and infratemporal fossa; contains Mandibular division of V (V3) and Accessory Meningeal artery (when present).
7. Foramen spinosum - located in sphenoid bone; connects middle cranial fossa and infratemporal fossa; contains Middle meningeal artery and Nervus spinosus (from V3).
8. Internal auditory meatus - located in temporal bone; connects posterior cranial fossa to Inner ear and (via facial canal) Stylomastoid foramen; contains Facial (VII) and Vestibulocochlear (VIII) nerves.
9. Jugular foramen - located in temporal and occipital bones; connects posterior cranial fossa and base of skull; contains Internal Jugular vein, Glossopharyngeal (IX), Vagus (X) and Accessory (XI) nerves.
10. Hypoglossal canal - located in occipital bone; connects posterior cranial fossa and base of skull; contains Hypoglossal nerve (XII).
11. Foramen magnum - located in occipital bone; connects posterior cranial fossa and vertebral canal; contains Spinal Cord (with meninges) and Vertebral arteries and veins.

#### IV. ORBIT

1. Optic foramen and canal - located at base of Lesser wing of sphenoid bone in middle cranial fossa; connects middle cranial fossa to orbit; contains Optic nerve (II) and Ophthalmic artery.
2. Superior Orbital fissure - located between Greater and Lesser wings of Sphenoid bone in Middle Cranial fossa; connects middle cranial fossa and orbit; contains Oculomotor (III), Trochlear (IV), Abducens (VI) nerves and Ophthalmic division of Trigeminal nerve (V1) and Ophthalmic veins.
3. Inferior Orbital fissure - located between sphenoid and maxillary bones; connects pterygopalatine fossa and infratemporal fossa to orbit; contains Infraorbital and Zygomatic nn., aa. and vv. (nerves are branches of V2).
4. Anterior and Posterior Ethmoidal Foramina - located between ethmoid and frontal bones; connect orbit and nasal cavity; contain (respectively) Anterior and Posterior Ethmoidal nerves (branches of V1), arteries (branches of Ophthalmic artery), and veins.

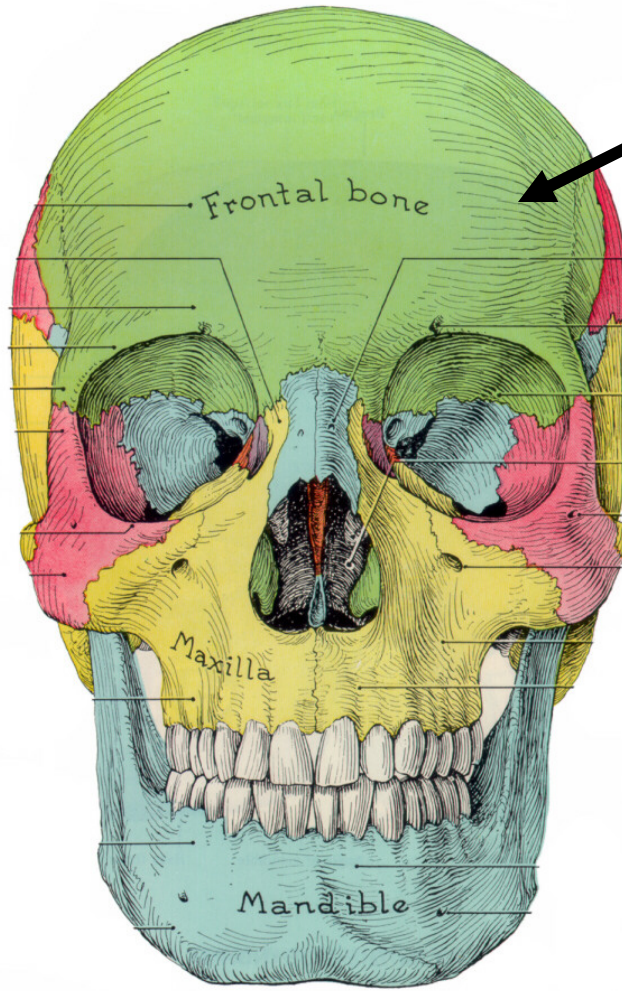
5. Supraorbital notch or foramen - located in frontal bone; connect orbit and forehead; contain Supraorbital n., a. and v.
6. Infraorbital foramen - in maxillary bone; connects orbit and face; contains Infraorbital n., a. and v.
7. Nasolacrimal duct - located in maxillary, lacrimal bones and Inferior nasal concha; connects orbit and nasal cavity; contains Membranous Nasolacrimal duct and tears.



# SKULL SESSION- bones rigidly connected by sutures to protect brain; attach, move eyes

## I. CALVARIUM = SKULL CAP-

Consists of  
bones linked  
by sutures →



**FRONTAL (1)**

# BONES OF CALVARIUM

PARIETAL (2)

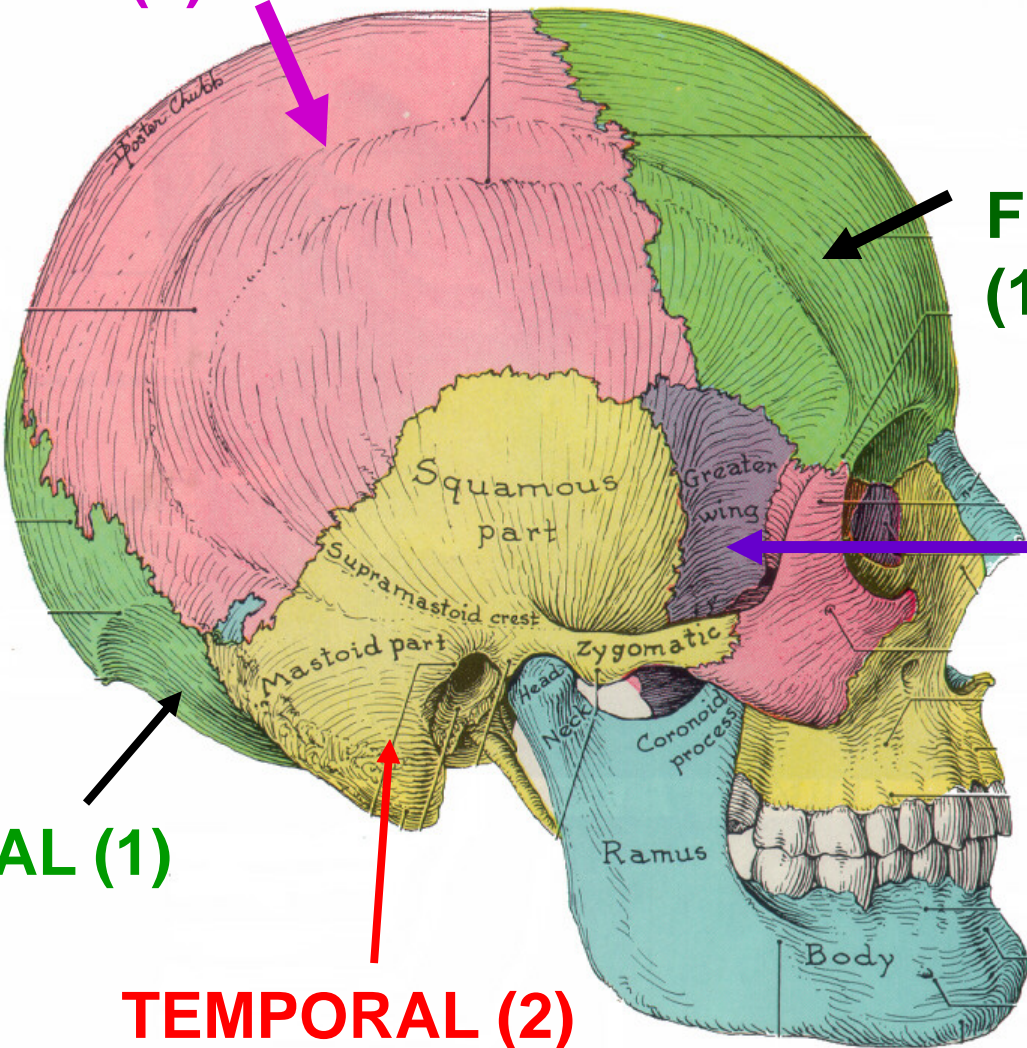
FRONTAL (1)

SPHENOID (1)

OCCIPITAL (1)

TEMPORAL (2)

NOSE

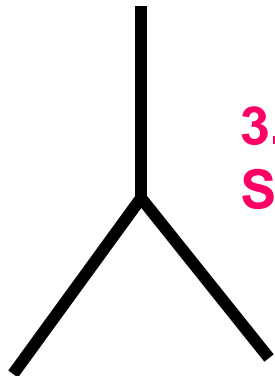


## B. SUTURES

1. CORONAL SUTURE

2. SAGITTAL SUTURE

3. LAMBDOIDAL SUTURE



LAMBDA -  
Greek letter



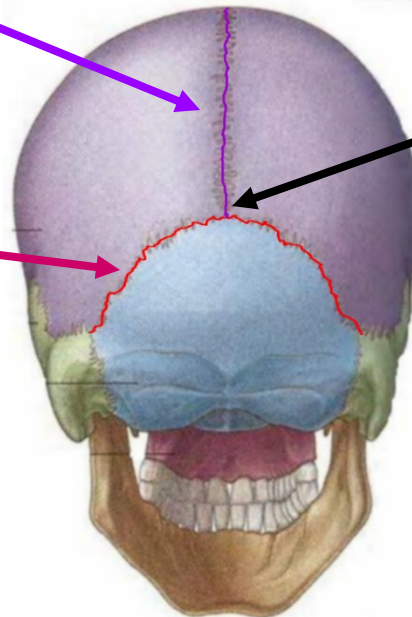
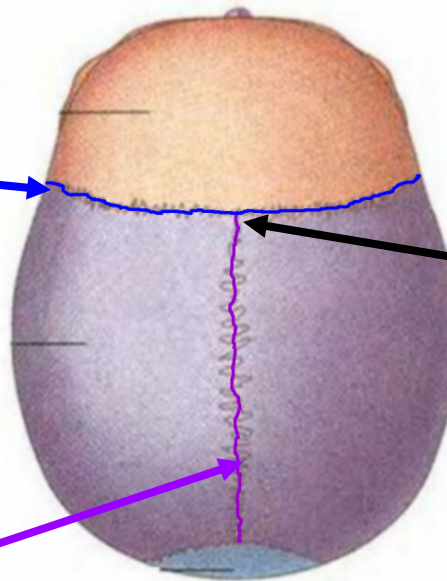
## C. LANDMARKS

1. BREGMA – MID-POINT OF CORONAL SUTURE

2. LAMBDA – MID-POINT OF LAMBDOIDAL SUTURE

superior (top) view

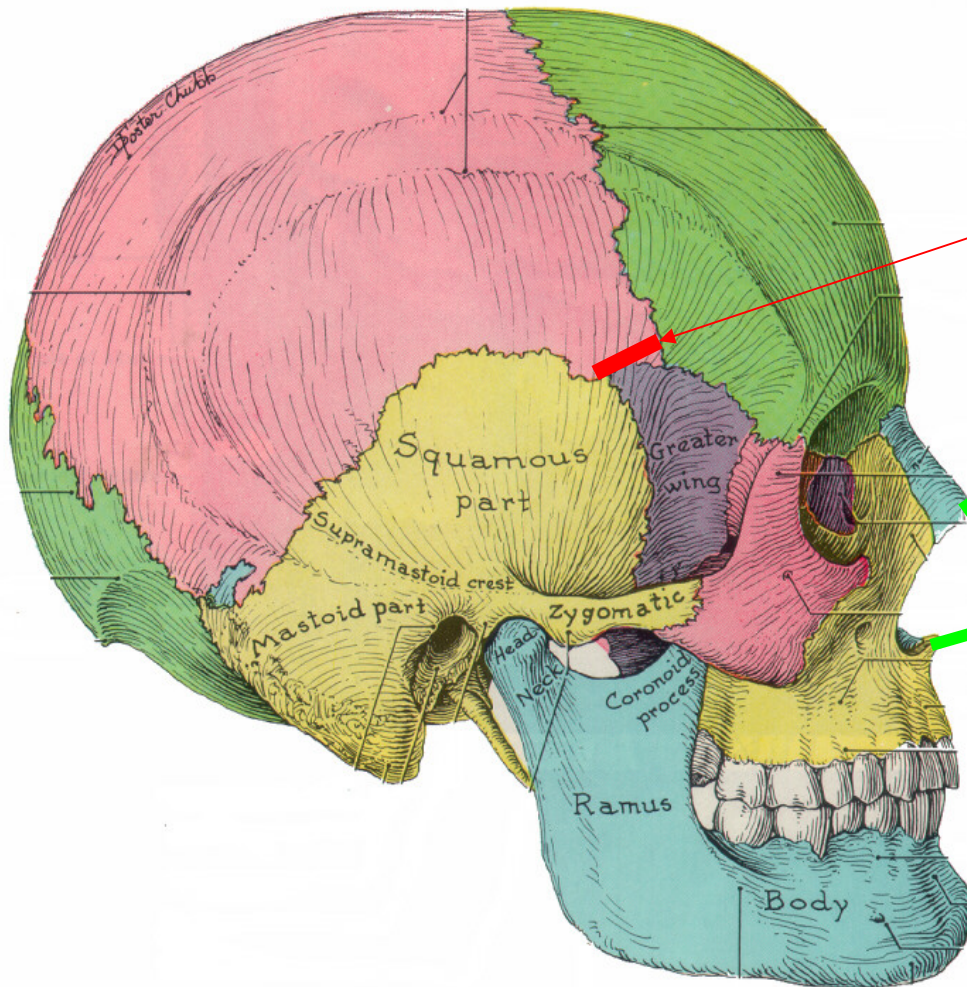
posterior (back) view





**CORONAL SUTURE**

# LANDMARKS



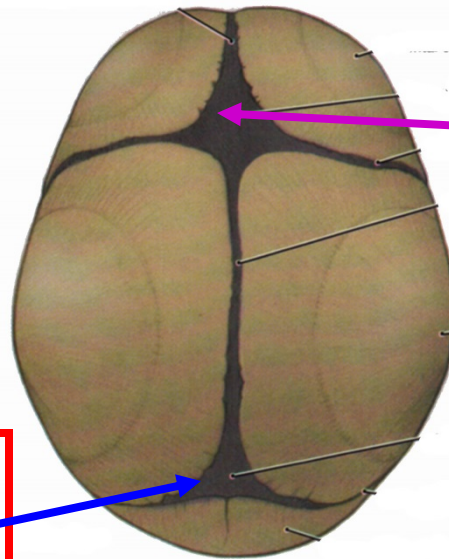
**3. PTERION**

**- JUNCTION OF  
TEMPORAL  
SPHENOID PARIETAL  
AND FRONTAL  
BONES**

**NOSE**

# D. FONTANELLES – Membranes that link bones at birth

- FONTANELLES ('soft spots') PERMIT CRANIAL COMPRESSION AT BIRTH - CRANIAL GROWTH

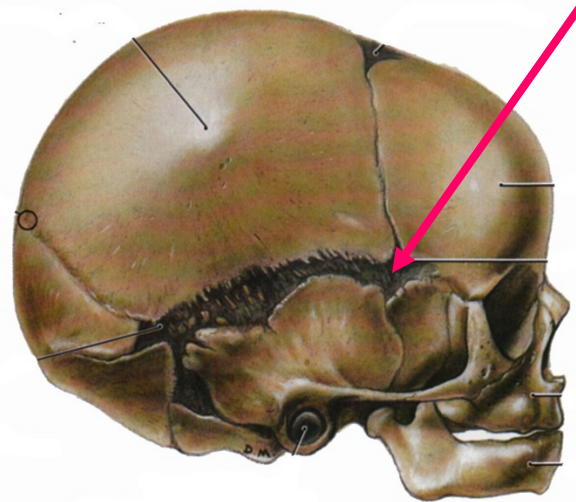


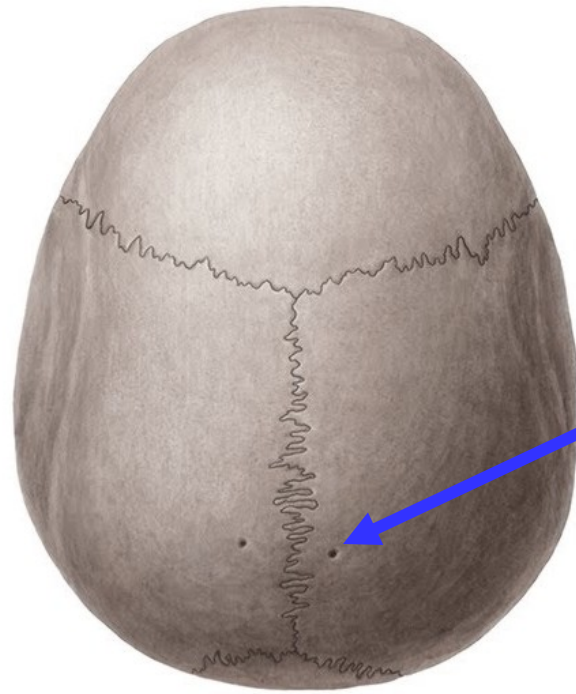
1. ANTERIOR FONTANELLE AT BREGMA \*

\* 2. POSTERIOR FONTANELLE - AT LAMBDA

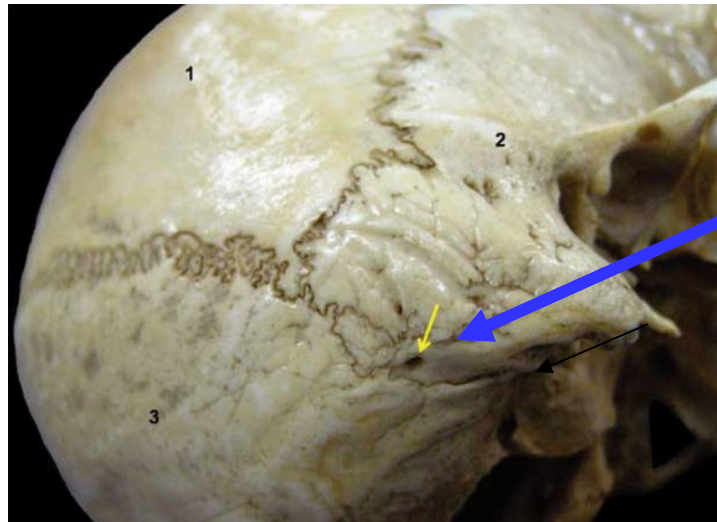
3. LATERAL FONTANELLE AT PTERION \*

Note: Anterior fontanelle can be used to access Superior Sagittal venous sinus in neonates





**PARIETAL  
EMISSARY  
FORAMINA**

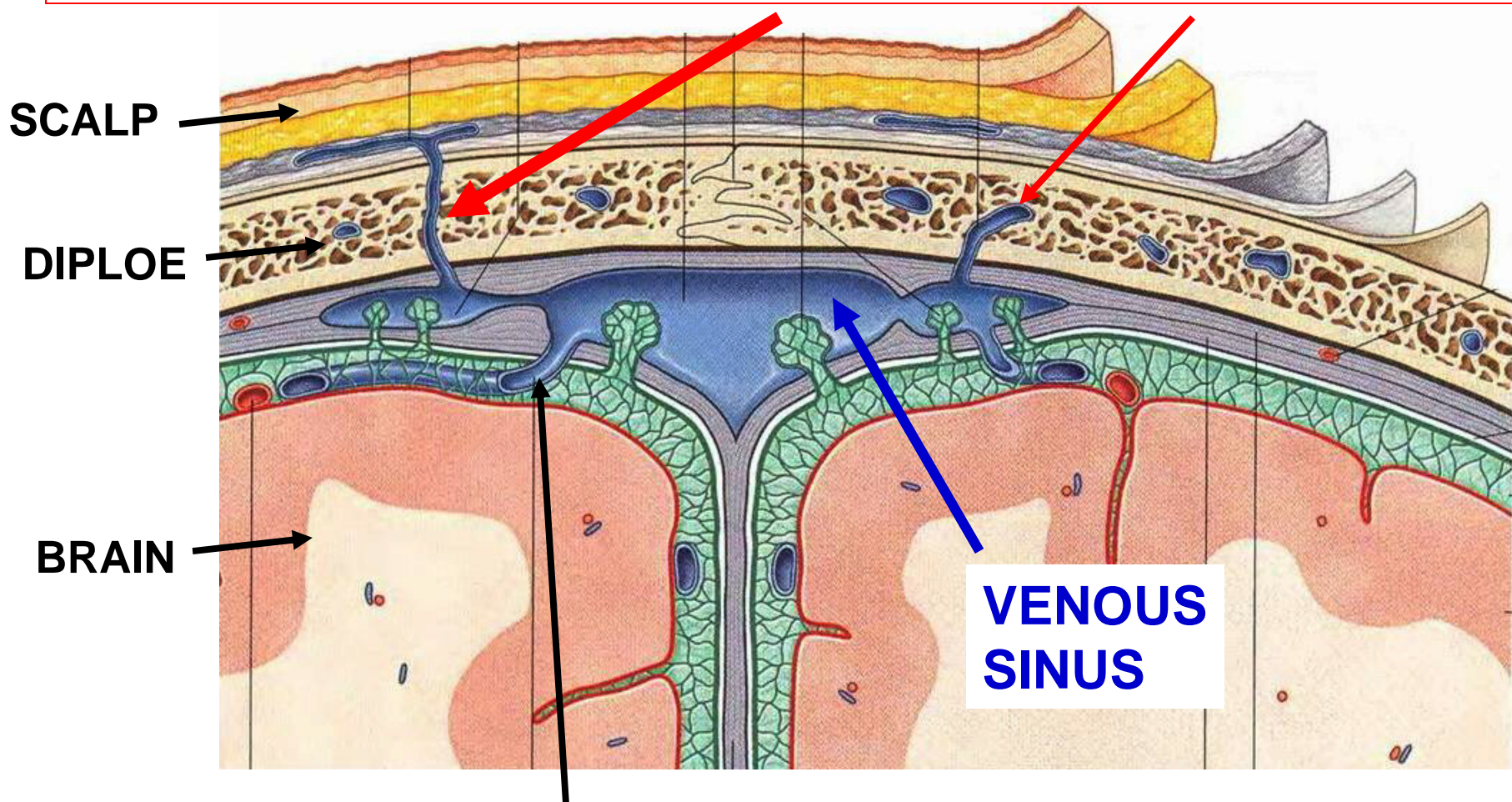


**MASTOID  
EMISSARY  
FORAMEN**



## EMISSARY VEINS VS BRIDGING VEINS

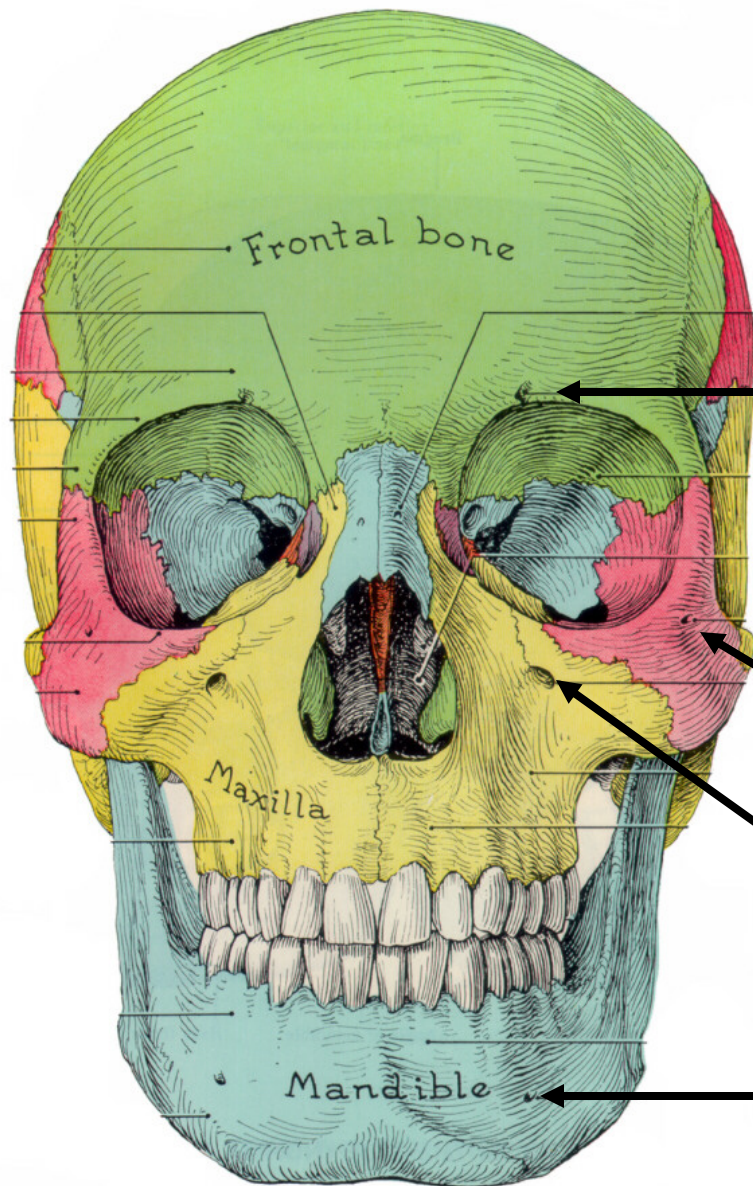
**EMISSARY VEIN - SCALP TO DIPLOE, SCALP TO SINUS, DIPLOE TO SINUS**



**BRIDGING VEIN - SURFACE OF BRAIN (CEREBRAL VEIN) TO VENOUS SINUS**

**note: Emissary vein - 'outside' to sinus; Bridging vein - brain (inside) to sinus**

# FACE - FRONT OF SKULL



**SUPRAORBITAL FORAMEN – IN  
MAXILLARY BONE**

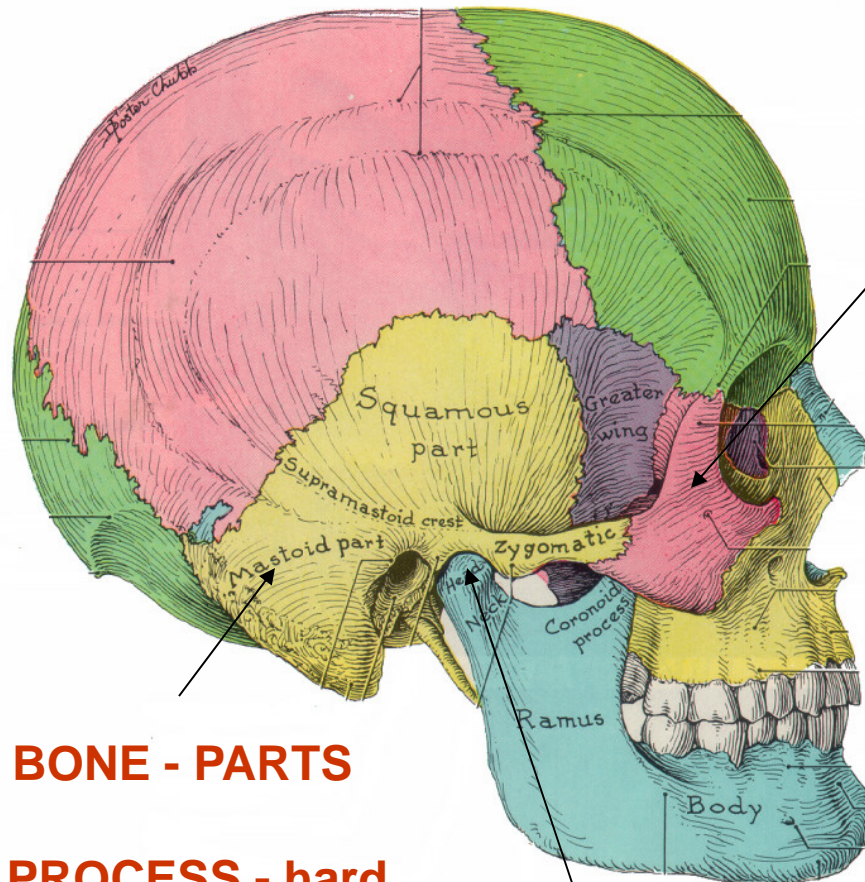
**ZYGOMATICO-FACIAL FORAMEN  
– IN ZYGOMATIC BONE**

**INFRAORBITAL FORAMEN - IN  
MAXILLARY BONE**

**MENTAL FORAMEN- IN MANDIBLE  
BELOW SECOND PREMOLAR  
TOOTH**



## 2. LATERAL VIEW OF SKULL



### ZYGOMATIC ARCH-

1) ZYGOMATIC BONE

2) MAXILLARY BONE-  
ZYGOMATIC PROCESS

3) TEMPORAL BONE-  
ZYGOMATIC PROCESS

**KNOW FOR FACIAL  
FRACTURES**

### TEMPORAL BONE - PARTS

1) MASTOID PROCESS - hard

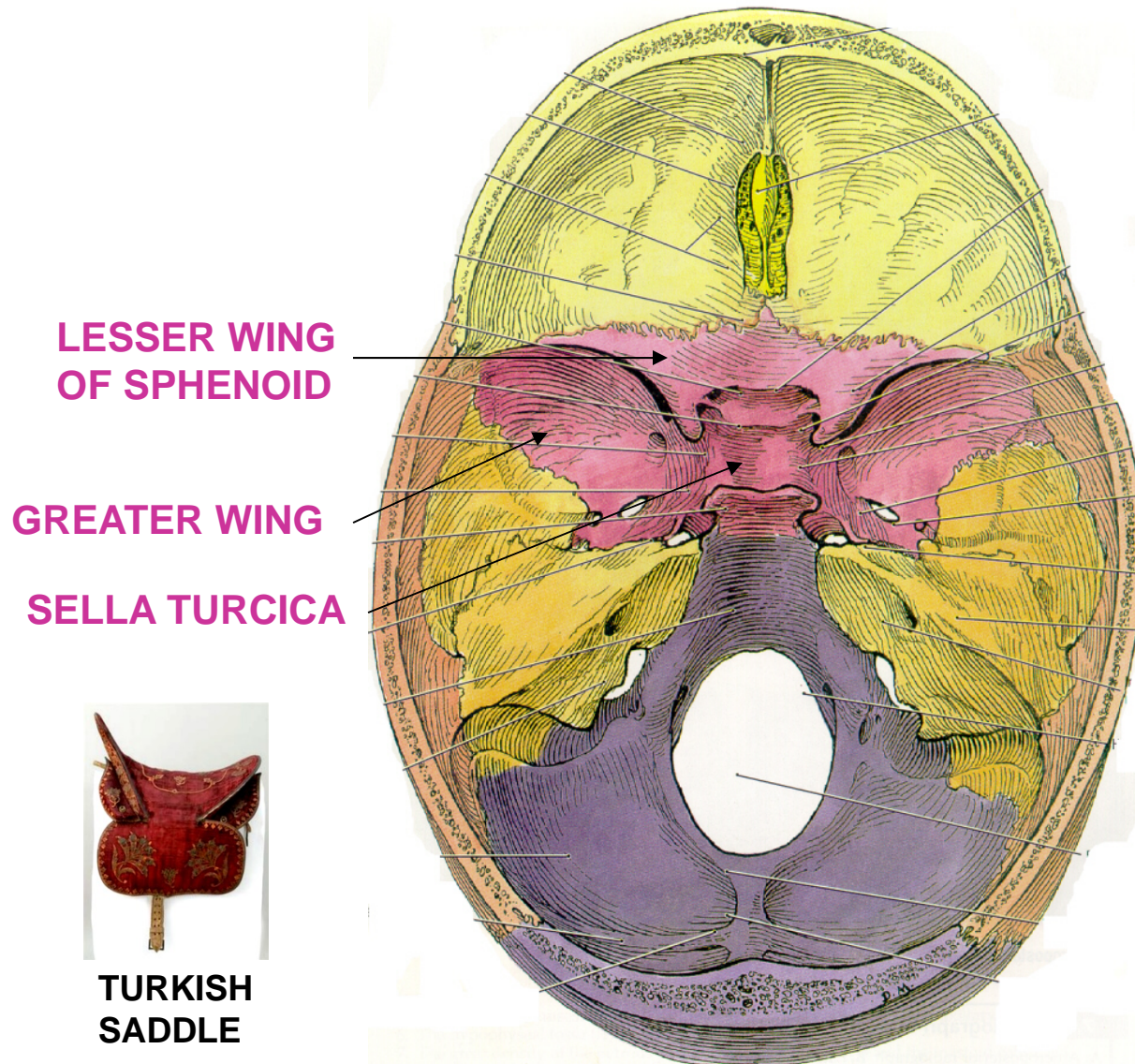
2) SQUAMOUS PART - flat

3) TYMPANIC PART - ANT. TO  
EXTERNAL AUDITORY  
MEATUS

4) PETROUS PART – inside skull

TEMPORO-MANDIBULAR JOINT-  
FROM RAMUS OF MANDIBLE

# SPHENOID BONE - INSIDE SKULL



- Sphenoid bone forms parts of all cranial fossae; has:

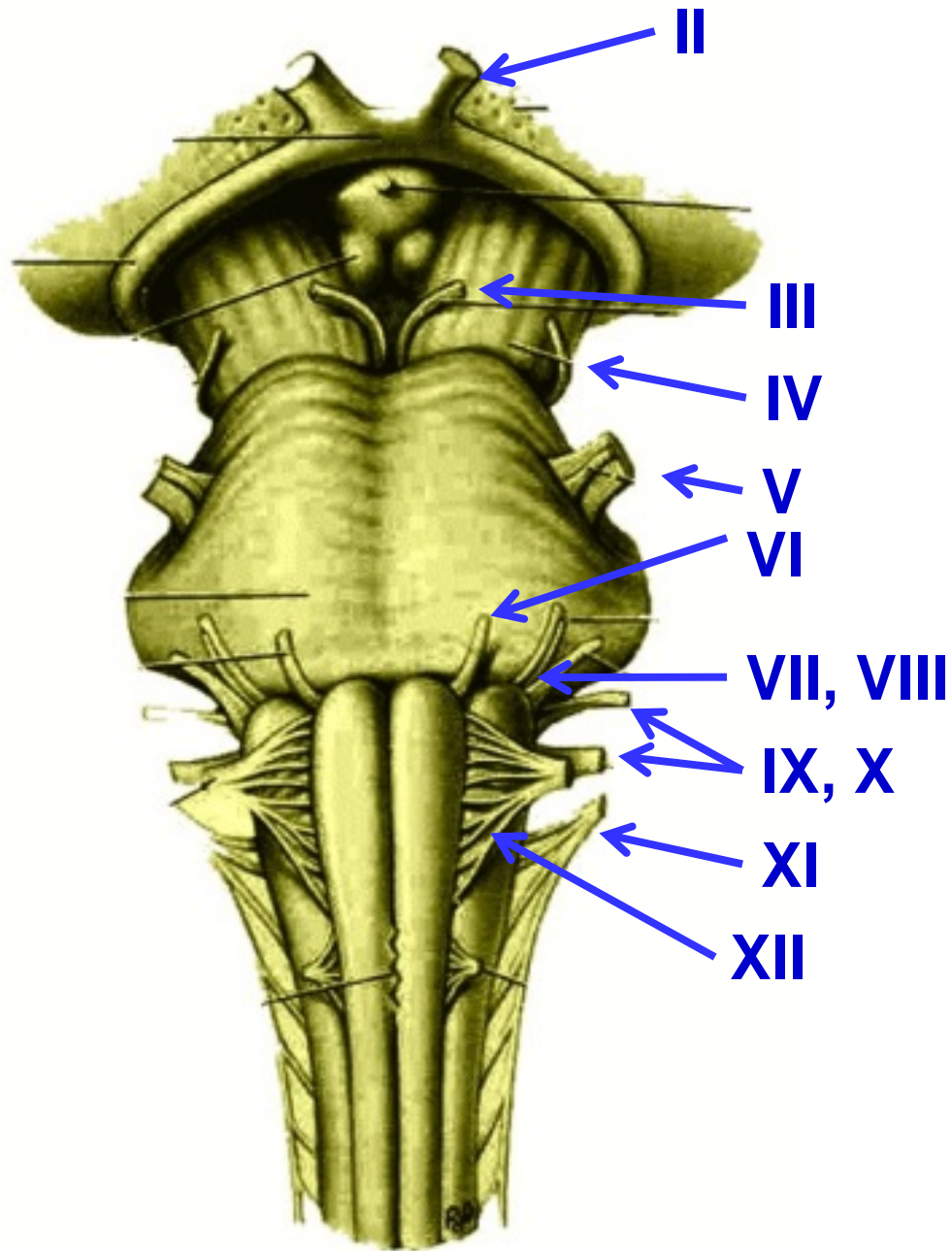
i) Lesser Wing above Superior Orbital Fissure;

ii) Greater Wing- Below Superior Orbital Fissure extends laterally;

iii) Sella Turcica- (turkish saddle) depression above main part (body)

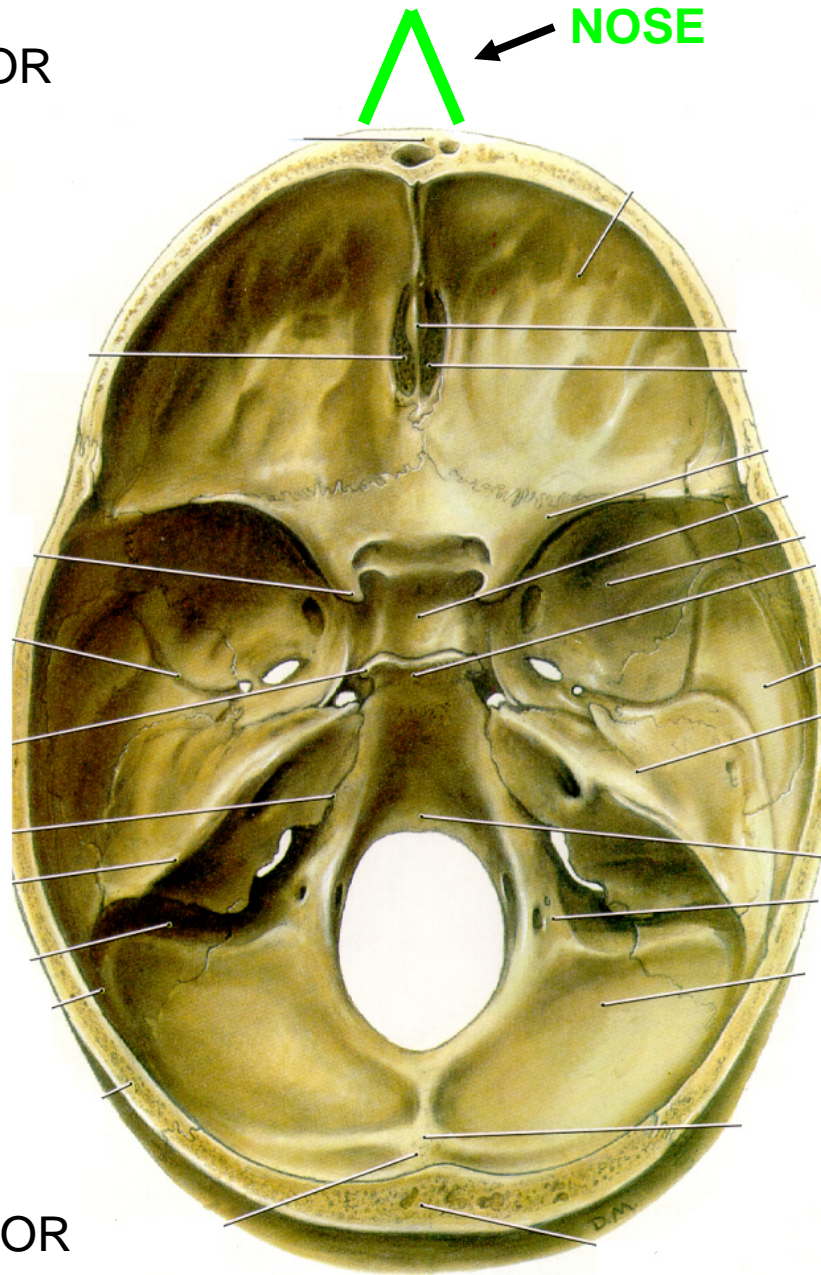


**CRANIAL  
NERVES  
ARE  
NUMBERED  
ACCORDING  
TO THEIR  
POSITION  
ON THE  
BRAINSTEM**



ANTERIOR

NOSE



POSTERIOR

## CRANIAL NERVES

I

II

III, IV, V1, VI

V2

V3

**Middle Meningeal A.**

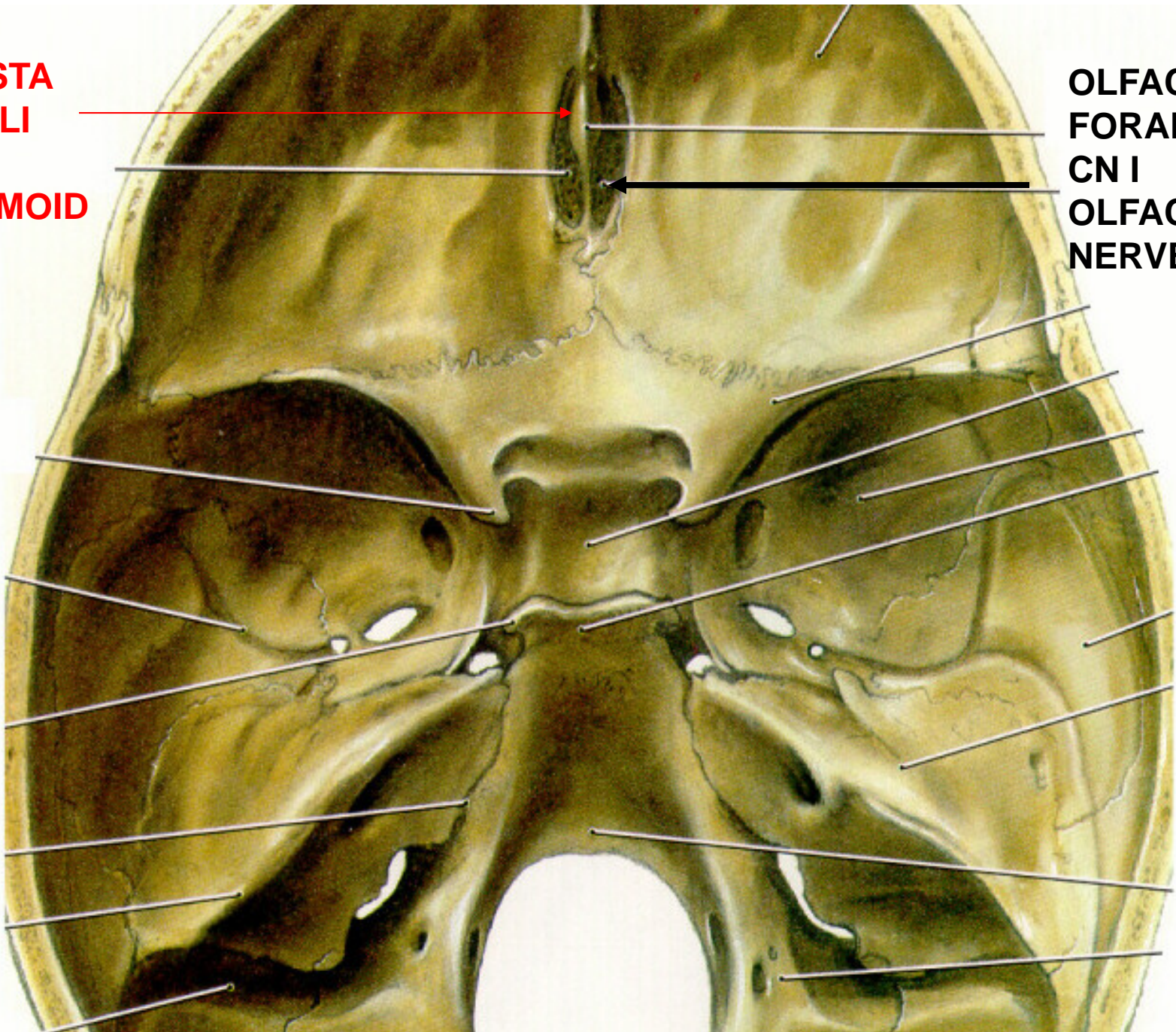
VII, VIII

IX, X, XI

XII

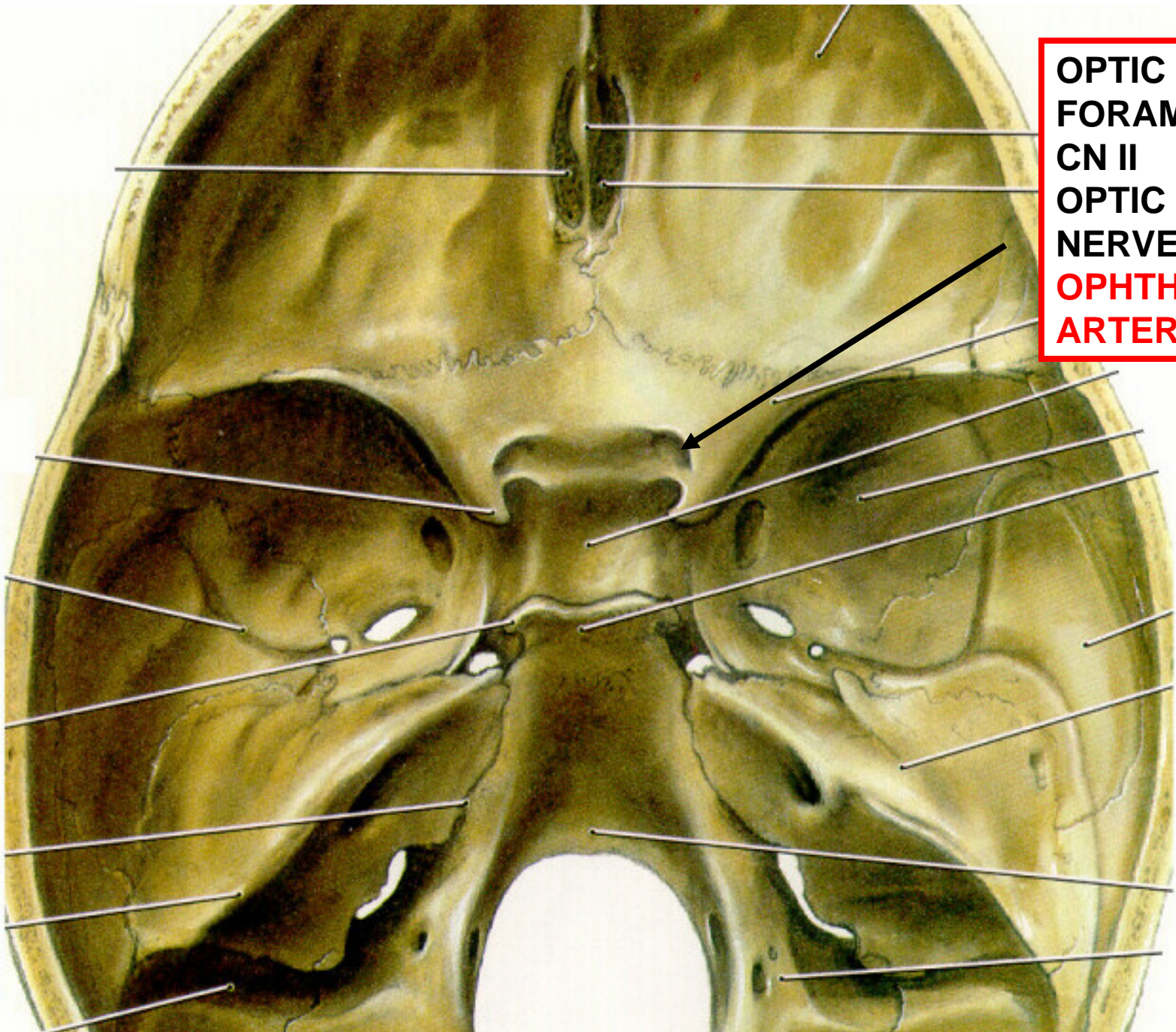


**CRISTA  
GALLI  
OF  
ETHMOID**

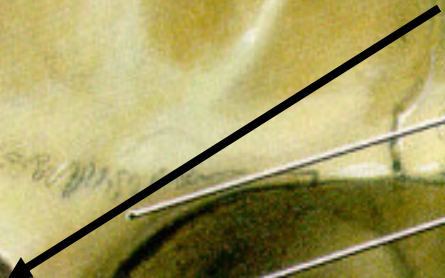


**OLFACTORY  
FORAMEN –  
CN I  
OLFACTORY  
NERVE**

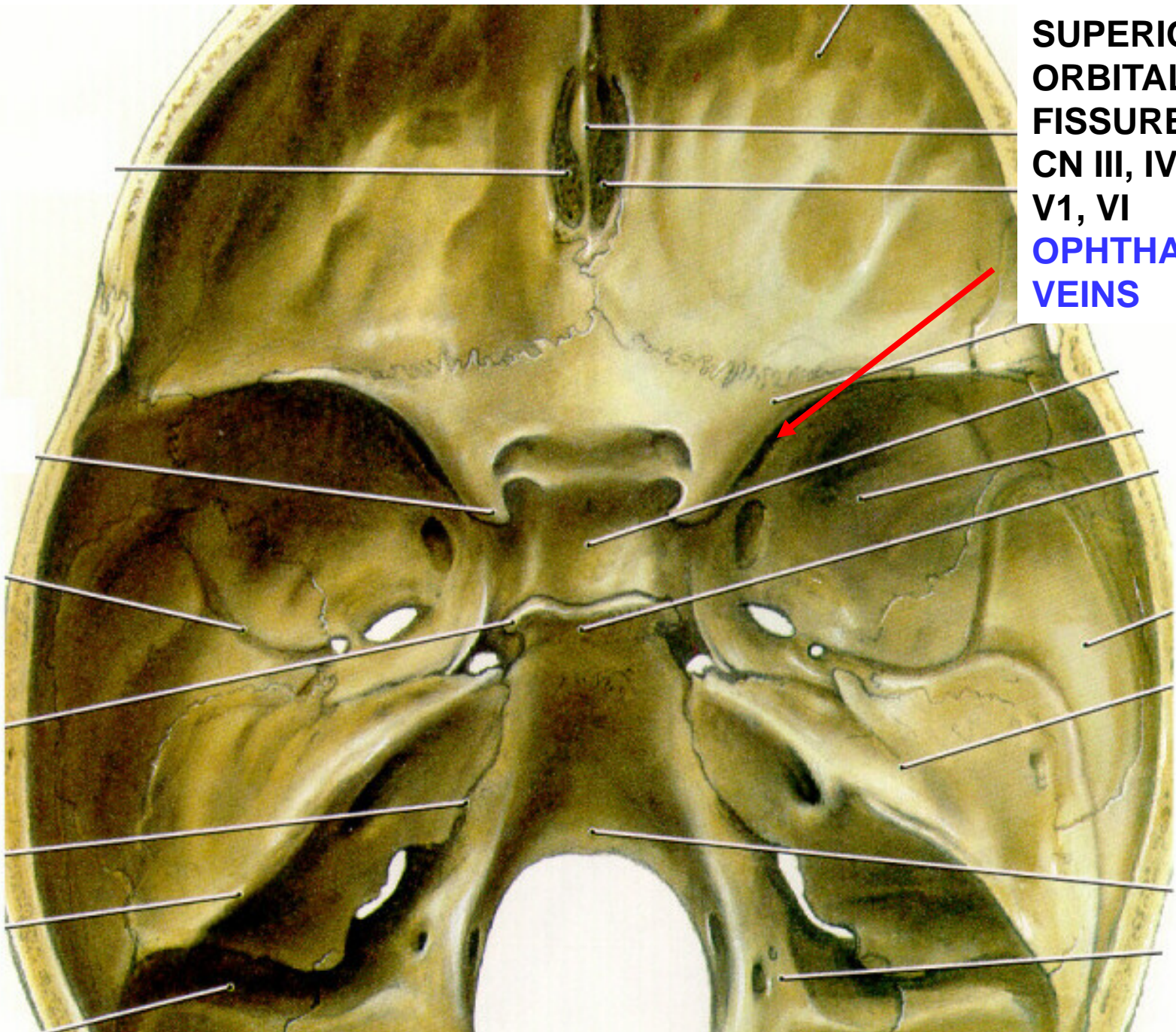




**OPTIC  
FORAMEN  
CN II  
OPTIC  
NERVE,  
OPHTHALMIC  
ARTERY**





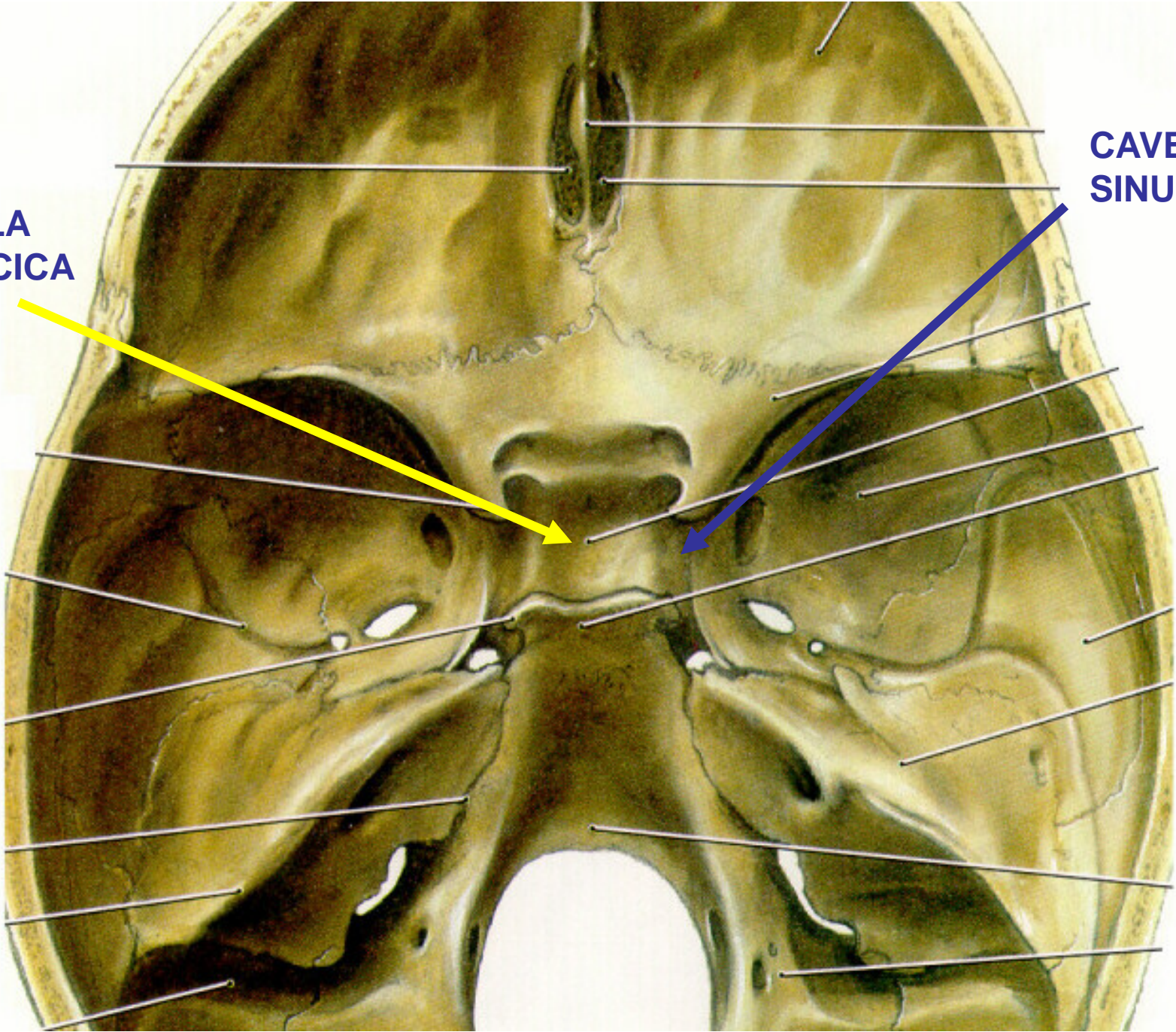


**SUPERIOR  
ORBITAL  
FISSURE –  
CN III, IV  
V1, VI  
OPHTHALMIC  
VEINS**

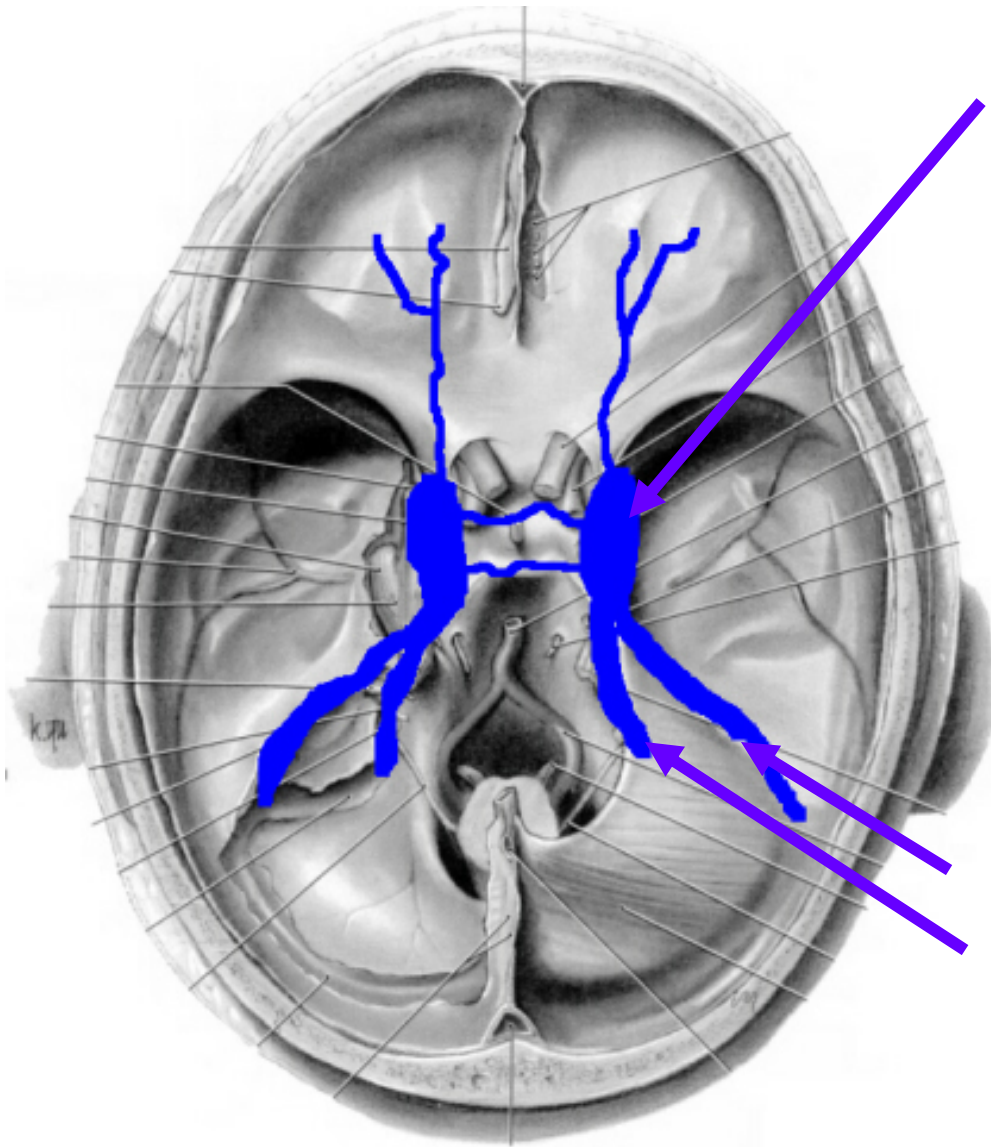


**SELLA  
TURCICA**

**CAVERNOUS  
SINUS**



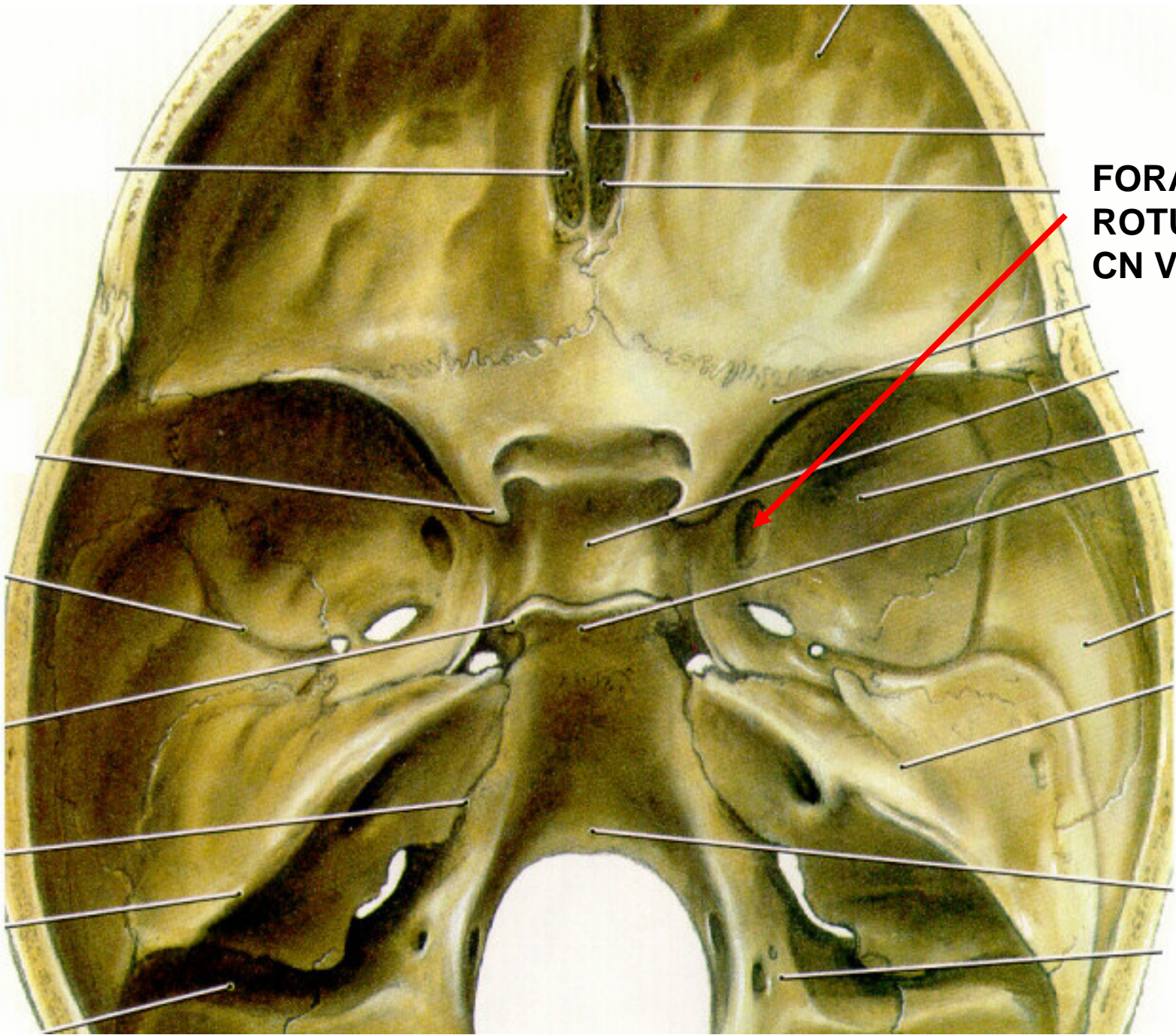
# VENOUS SINUSES



7. Cavernous sinuses - in middle cranial fossa; on side of the body of the sphenoid bone; connected by Intercavernous sinus; receive blood from Sup. and Inf. Ophthalmic veins, Cerebral veins; drain to Sup. and Inf. Petrosal sinuses

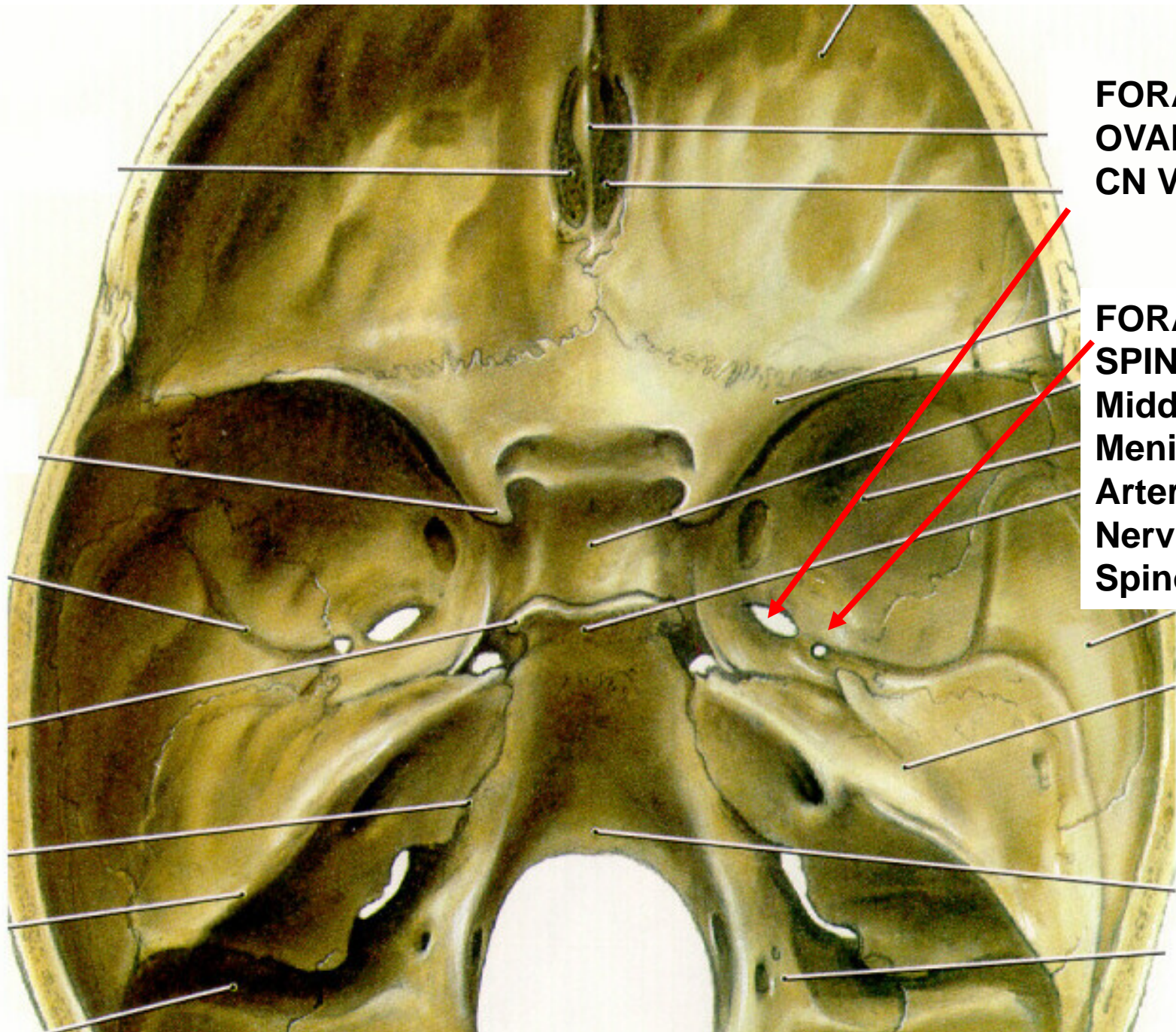
8. Sup. and Inf. Petrosal sinuses - on petrous part of temporal bone  
Sup. drains to Transverse  
Inf. Drains to Internal Jugular





**FORAMEN  
ROTUNDUM -  
CN V2**

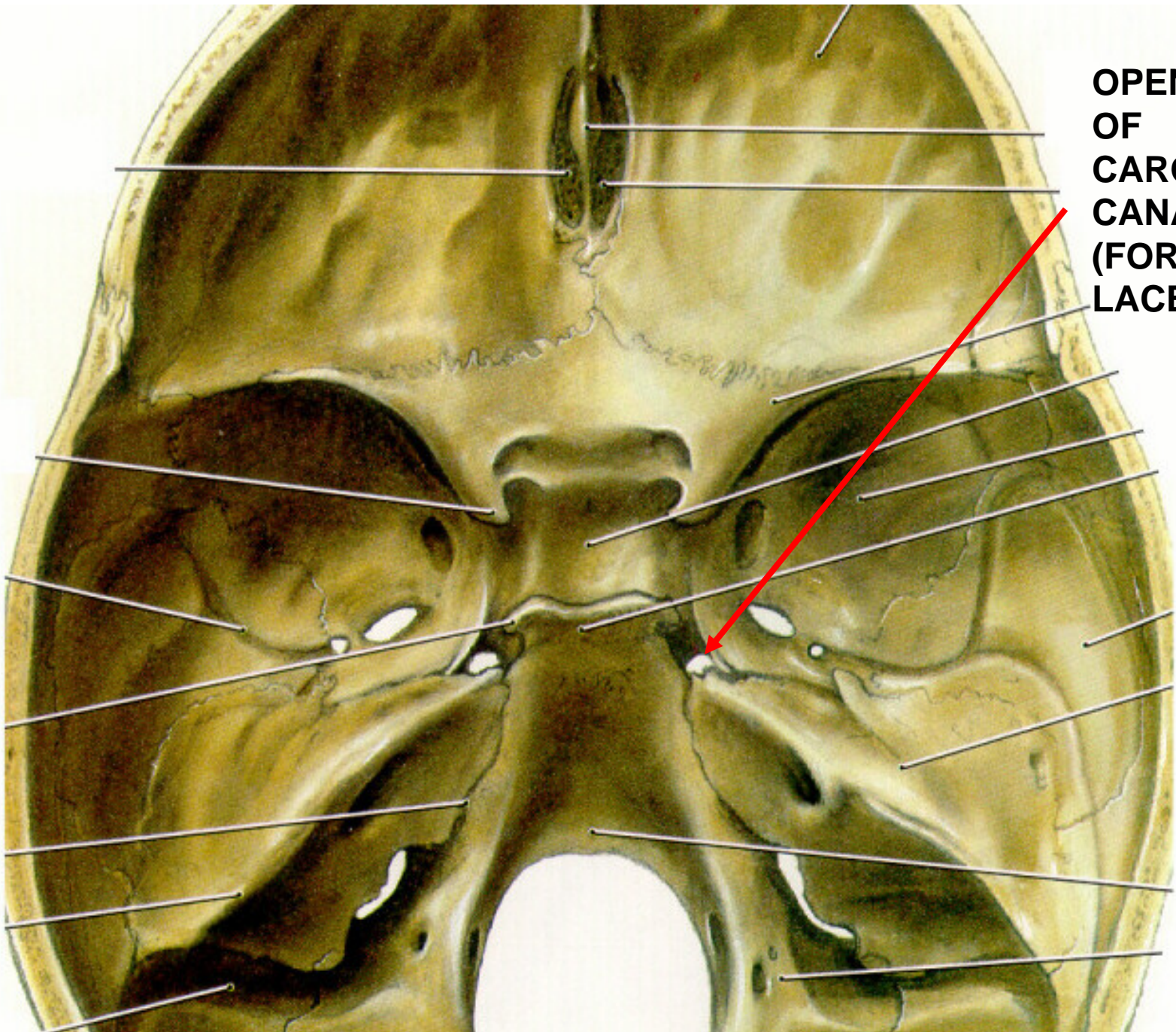




**FORAMEN  
OVALE –  
CN V3**

**FORAMEN  
SPINOSUM -  
Middle  
Meningeal  
Artery,  
Nervus  
Spinosus**



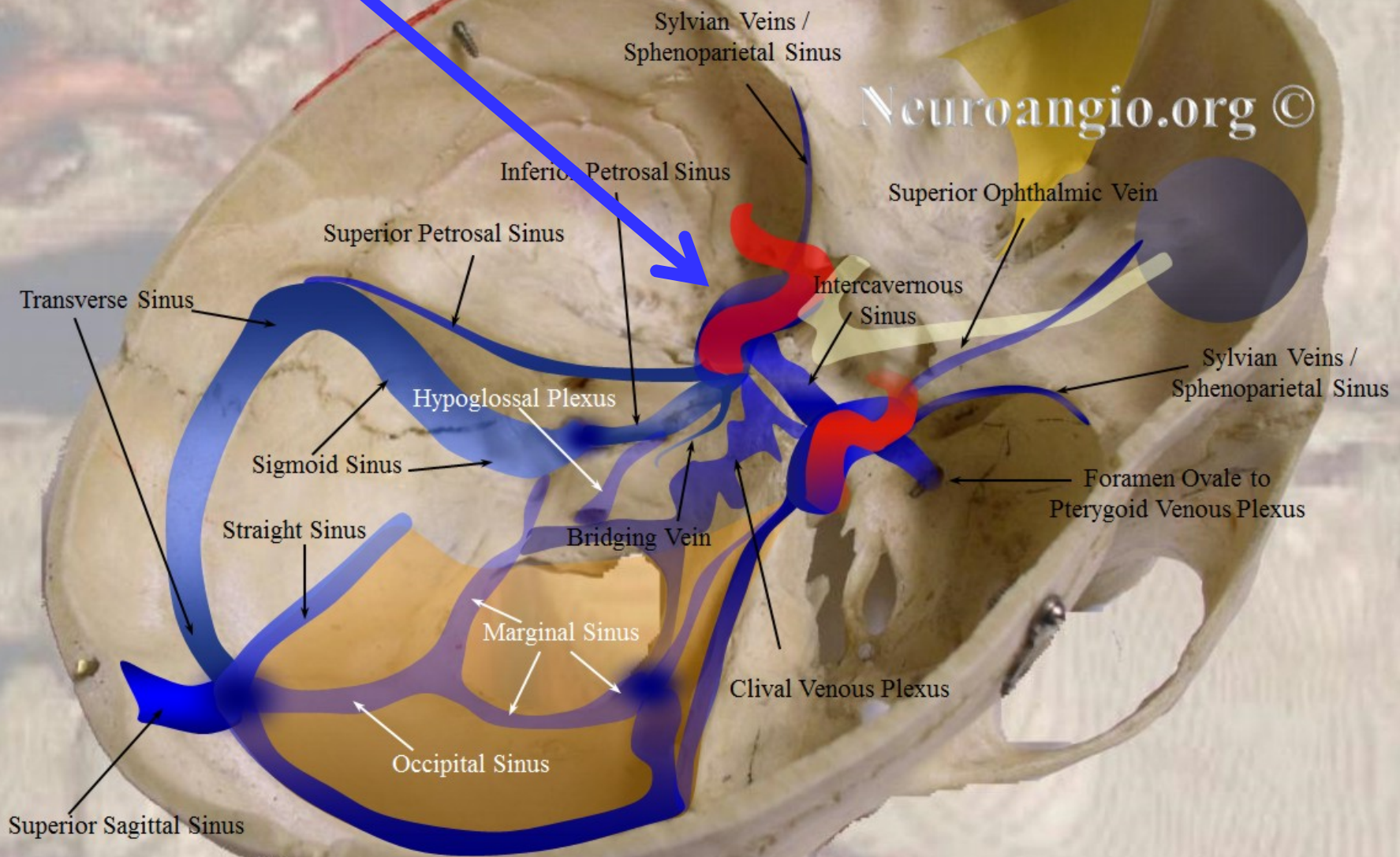


**OPENING  
OF  
CAROTID  
CANAL  
(FORAMEN  
LACERUM)**

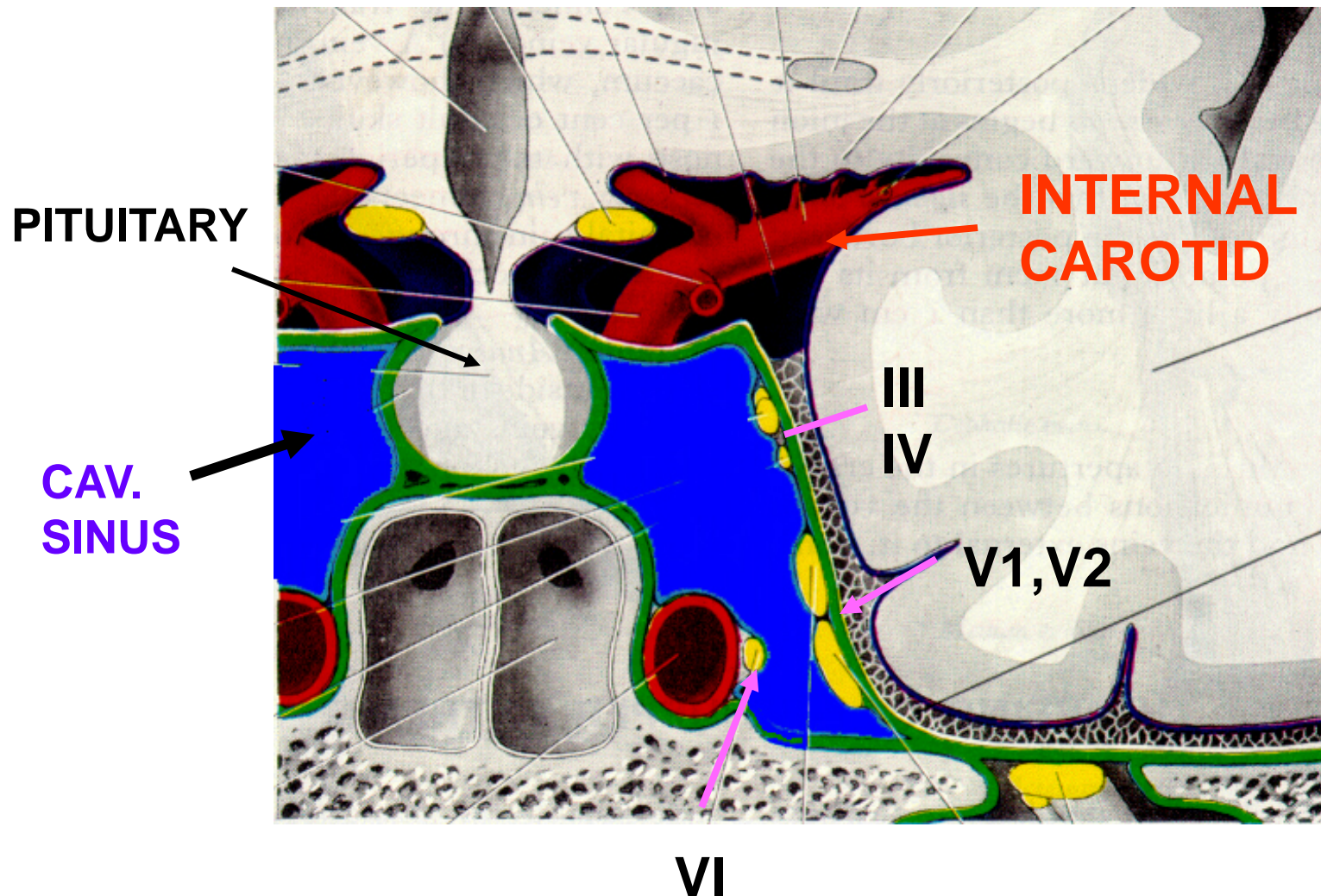


# CAVERNOUS SINUS

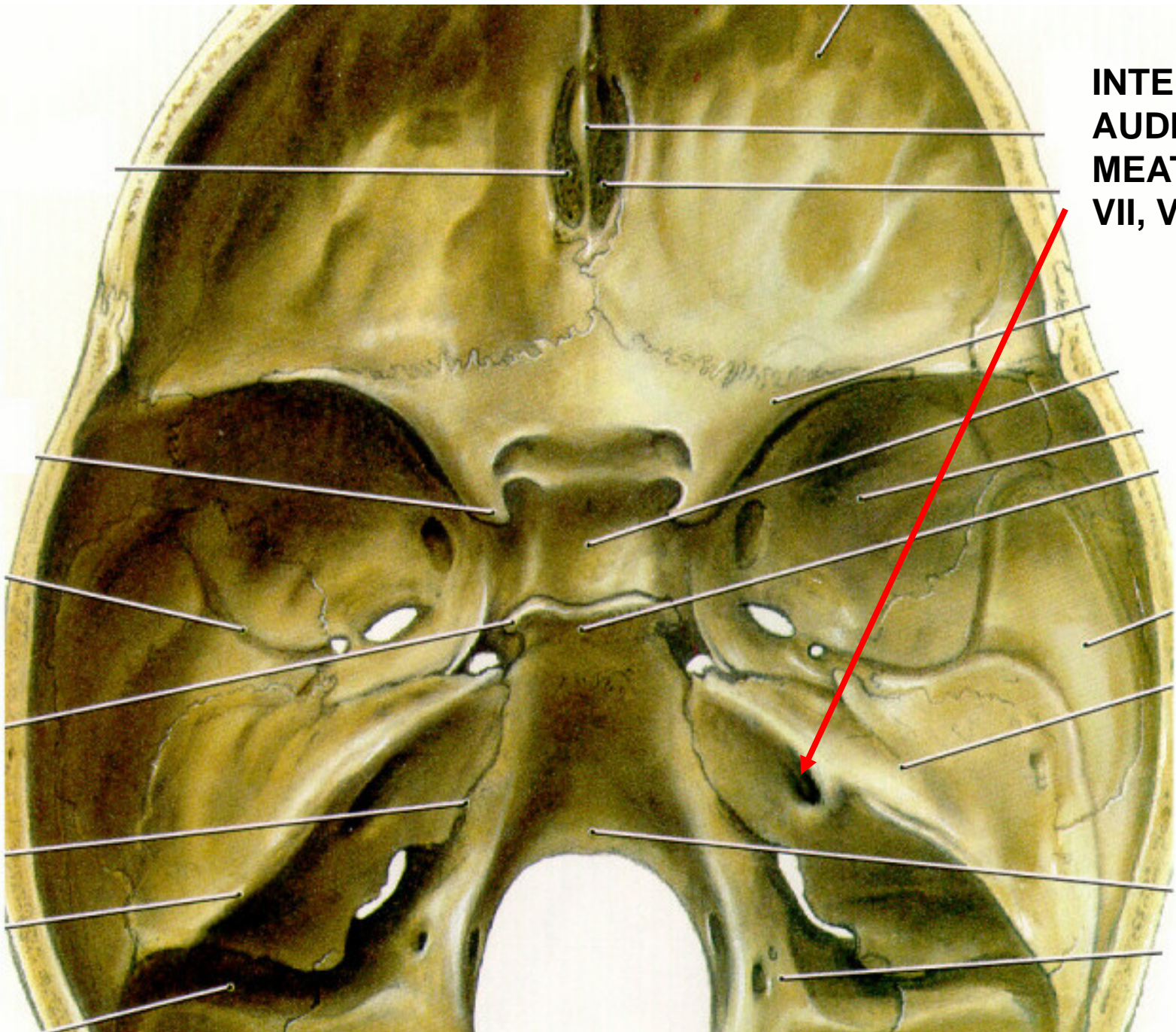
Neuroangio.org ©



**STRUCTURES PASSING THROUGH WALL OF CAVERNOUS SINUS - Int. Carotid A., Cranial N.'s III, IV, V1, V2, VI;**  
**Clinical sign of Infection in Sinus – ‘BLURRED’ VISION (Diplopia)**

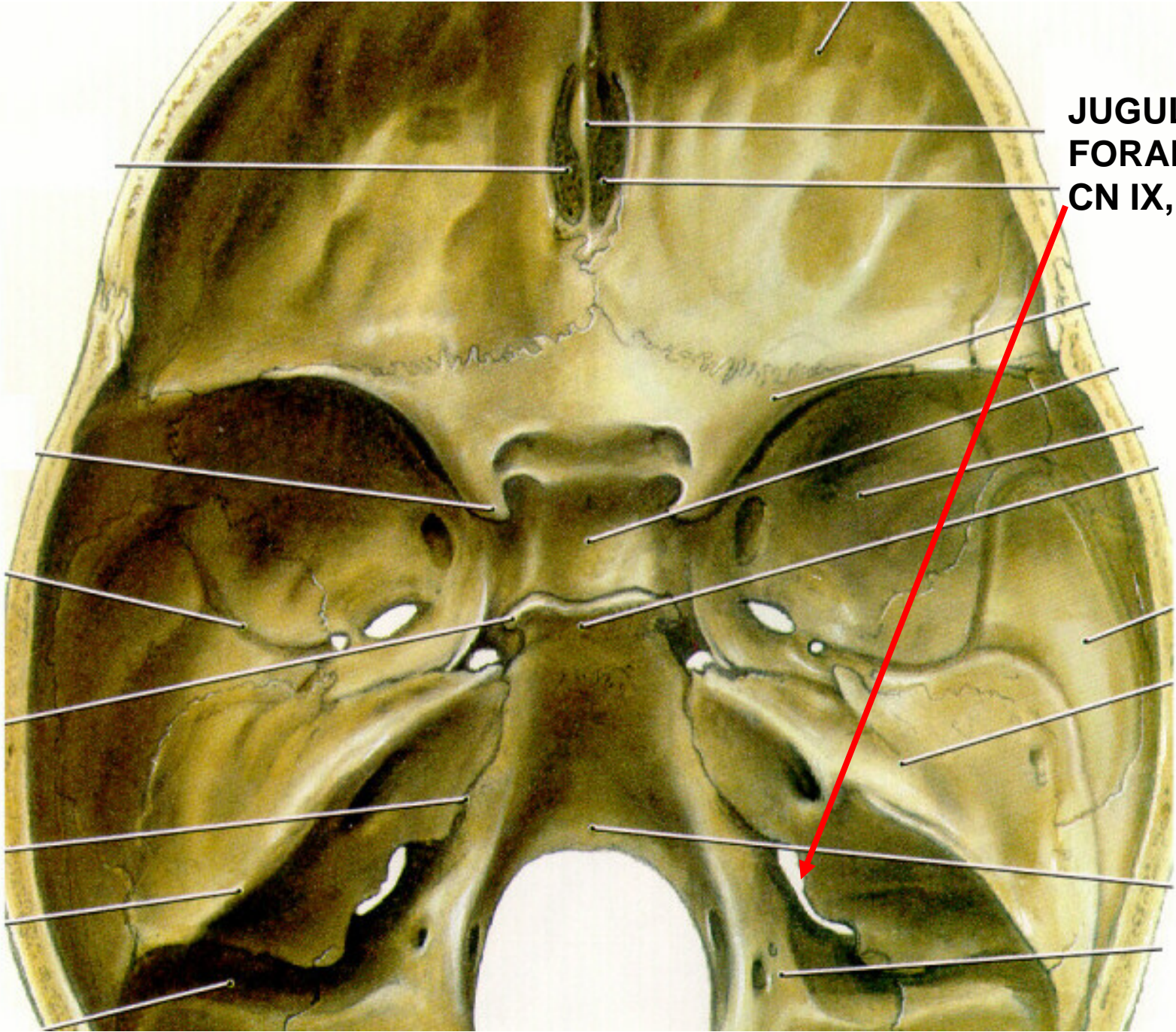






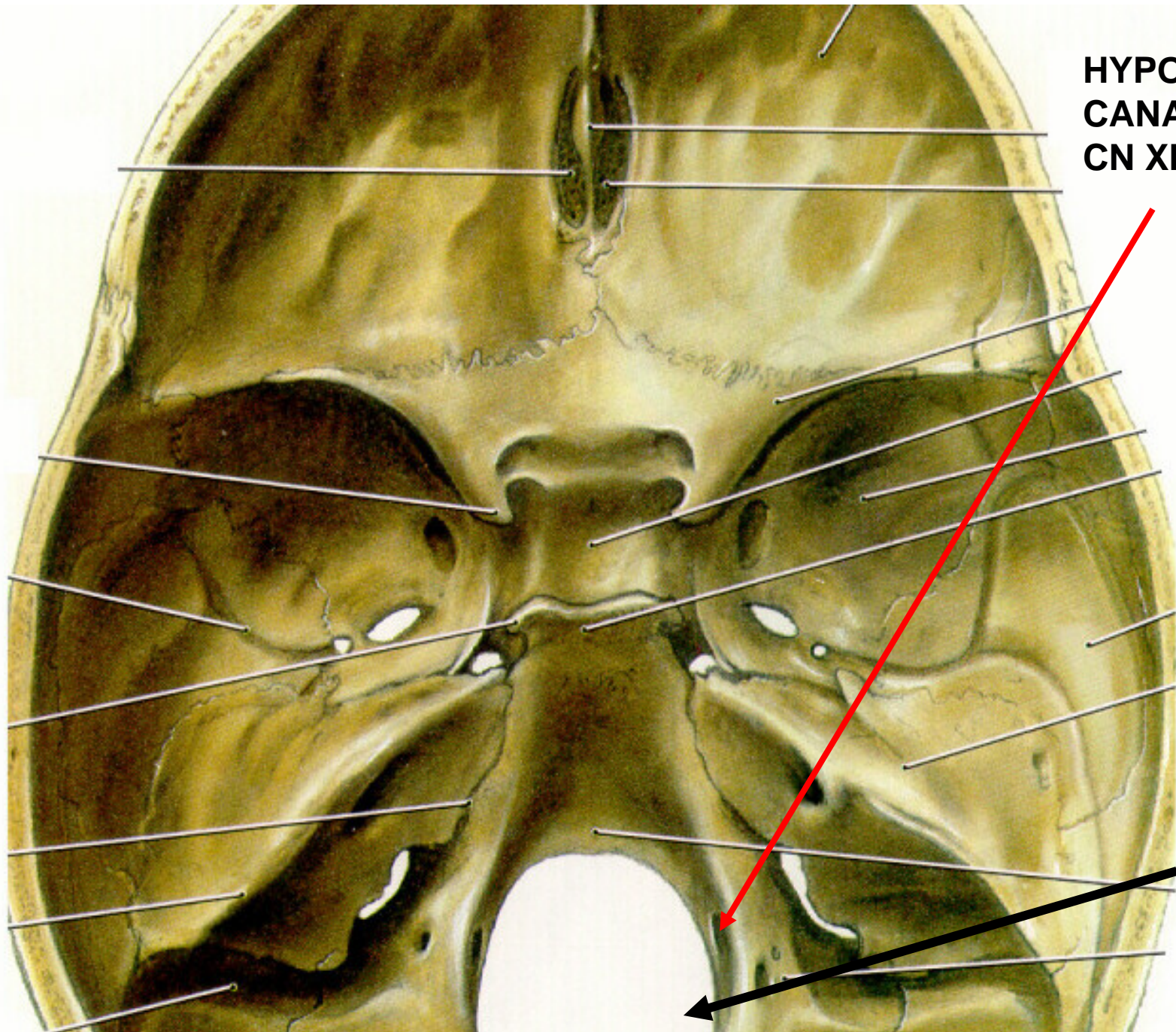
**INTERNAL  
AUDITORY  
MEATUS –  
VII, VIII**





**JUGULAR  
FORAMEN -  
CN IX, X, XI**



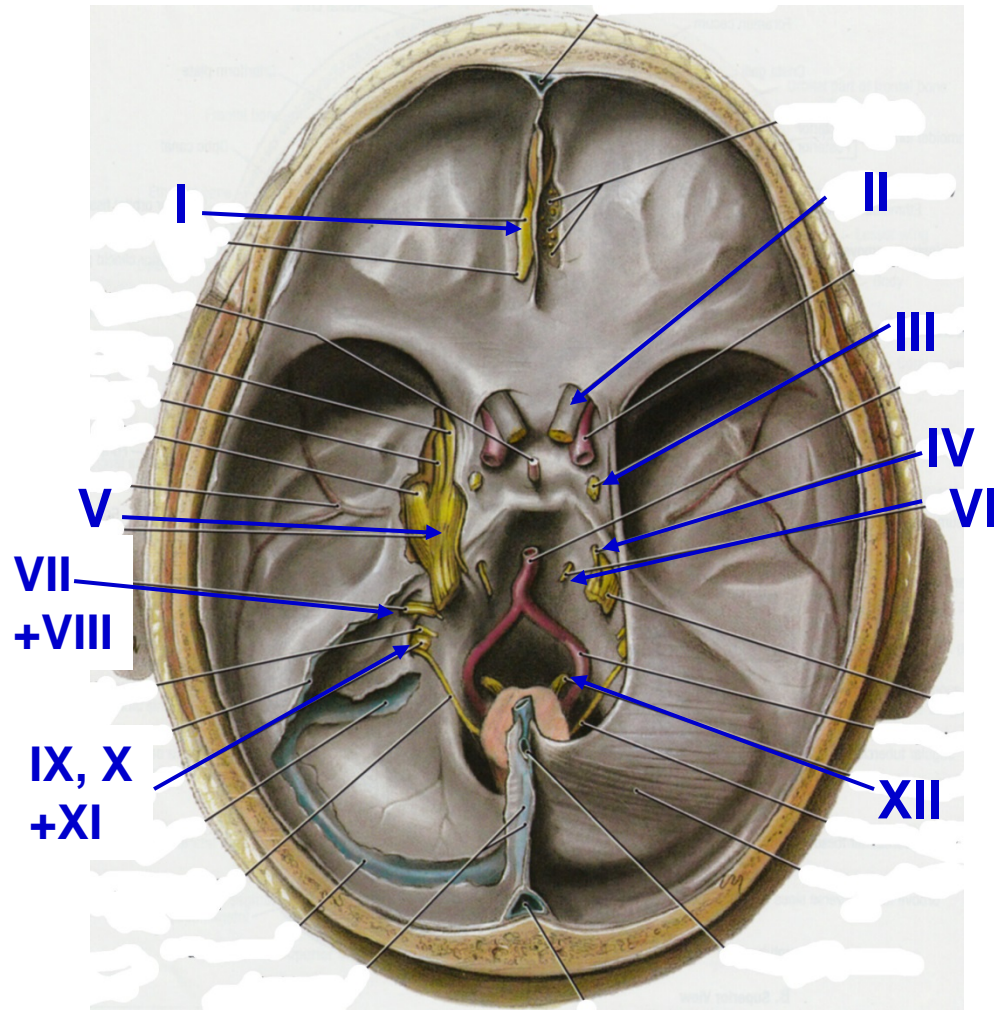


**HYPOGLOSSAL  
CANAL –  
CN XII**

**FORAMEN  
MAGNUM**



# CRANIAL NERVES



- I. OLFACTORY - sense of smell
- II. OPTIC - vision
- III. OCULOMOTOR - eye movement
- IV. TROCHLEAR - eye movement
- V. TRIGEMINAL - touch, general sensation to skin, oral cavity, nasal cavity + more
- VI. ABDUCENS - eye movement
- VII. FACIAL - muscles of facial expression + lots more
- VIII. VESTIBULO-COCHLEAR - hearing and balance
- IX. GLOSSOPHARYNGEAL - sensory to pharynx + more
- X. VAGUS - larynx, pharynx + rest of body
- XI. ACCESSORY - sternocleidomastoid, trapezius
- XII. HYPOGLOSSAL - muscles of tongue



# VENOUS SINUSES OF BRAIN

SUPERIOR SAGITTAL SINUS

falx cerebri

STRAIGHT SINUS

INFERIOR SAGITTAL SINUS

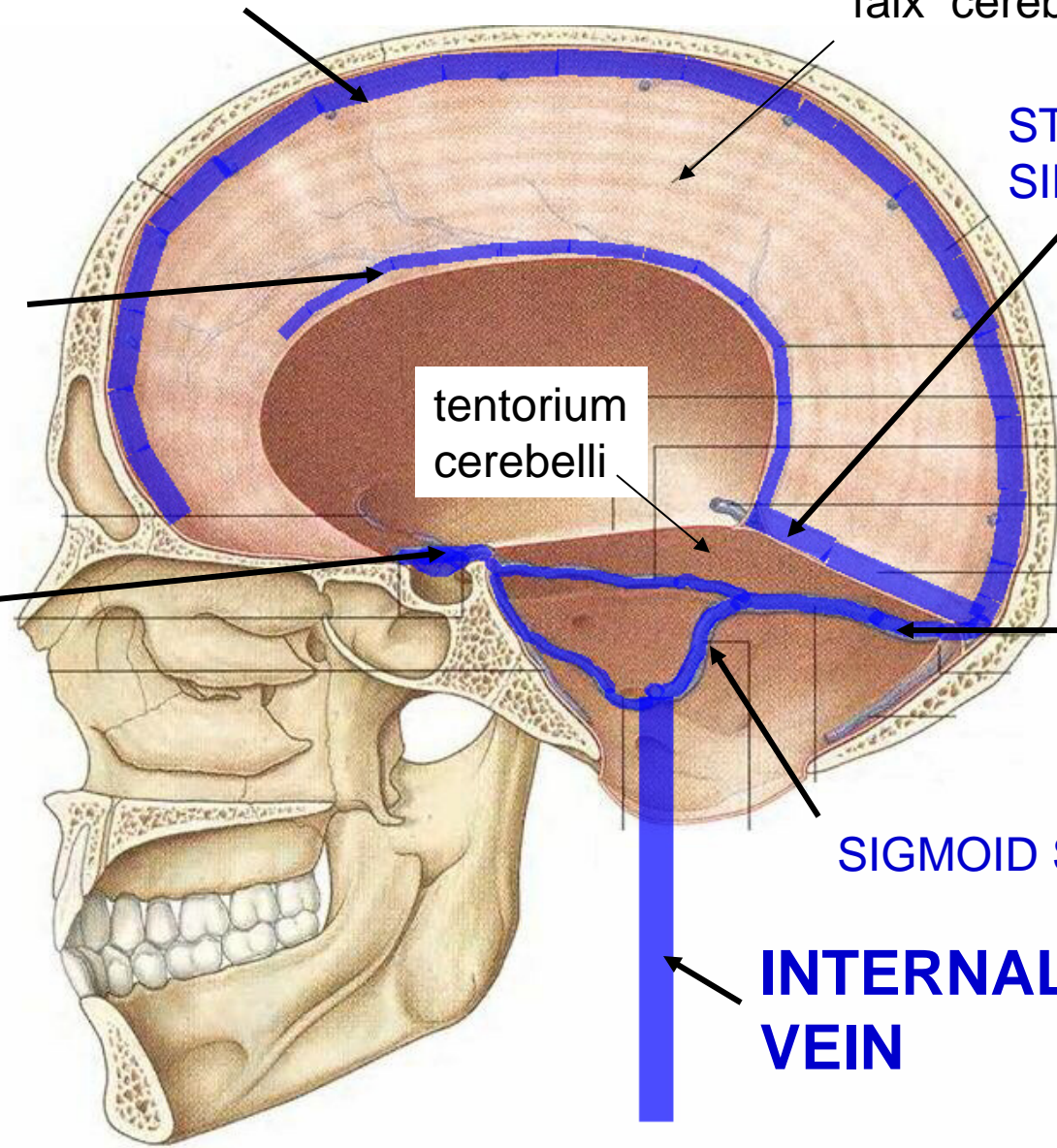
tentorium cerebelli

CAVERNOUS SINUS

TRANSVERSE SINUS

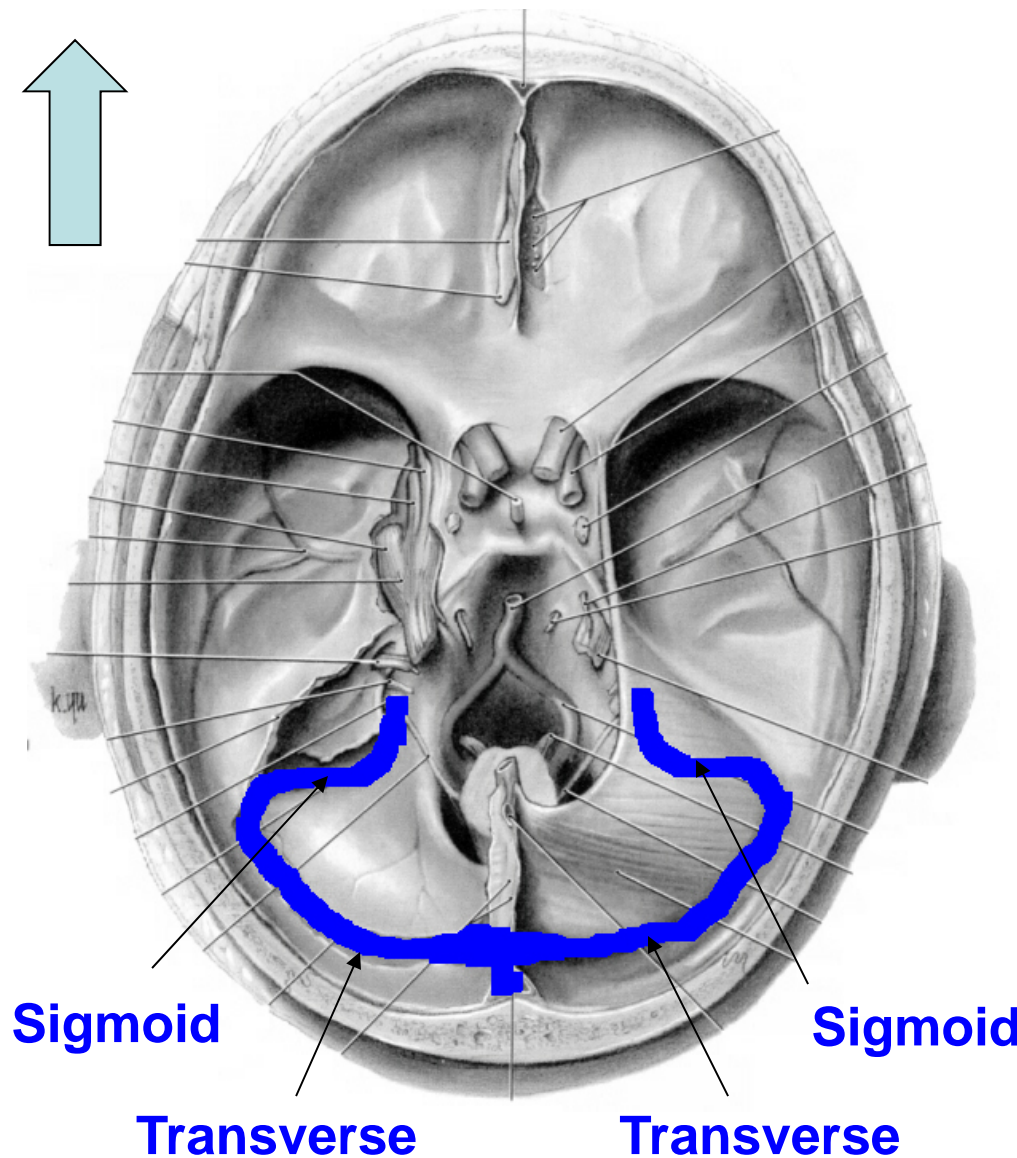
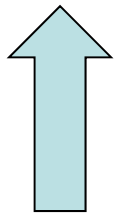
SIGMOID SINUS

INTERNAL JUGULAR VEIN



# VENOUS SINUSES

NOSE



4. Transverse sinuses - in lateral fixed part of tentorium; receive blood from Sup. Sagittal or Confluens

5. Sigmoid sinuses - S-shaped continuation of Transverse; end in Jugular Foramen; form Internal Jugular Vein

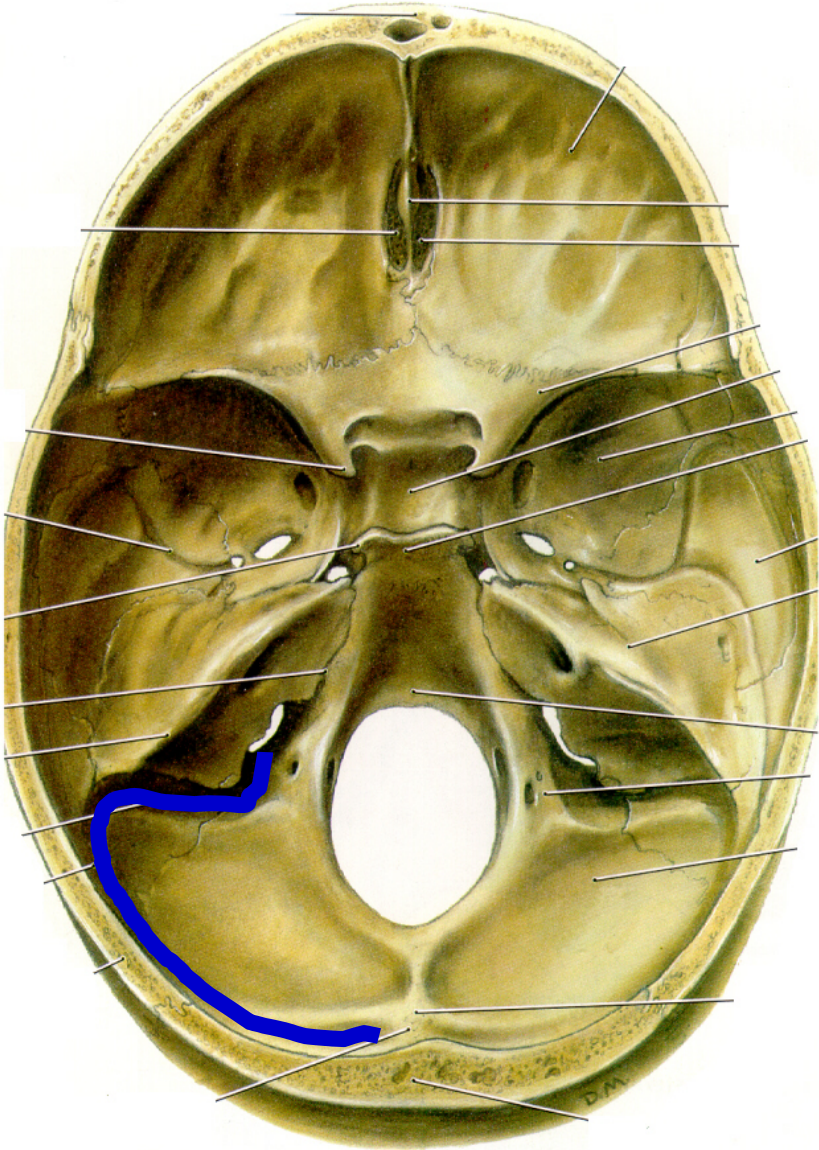
6. Occipital Sinuses - in falx cerebelli; drain to Confluens



# VENOUS SINUSES MAKE GROOVES IN CRANIAL CAVITY

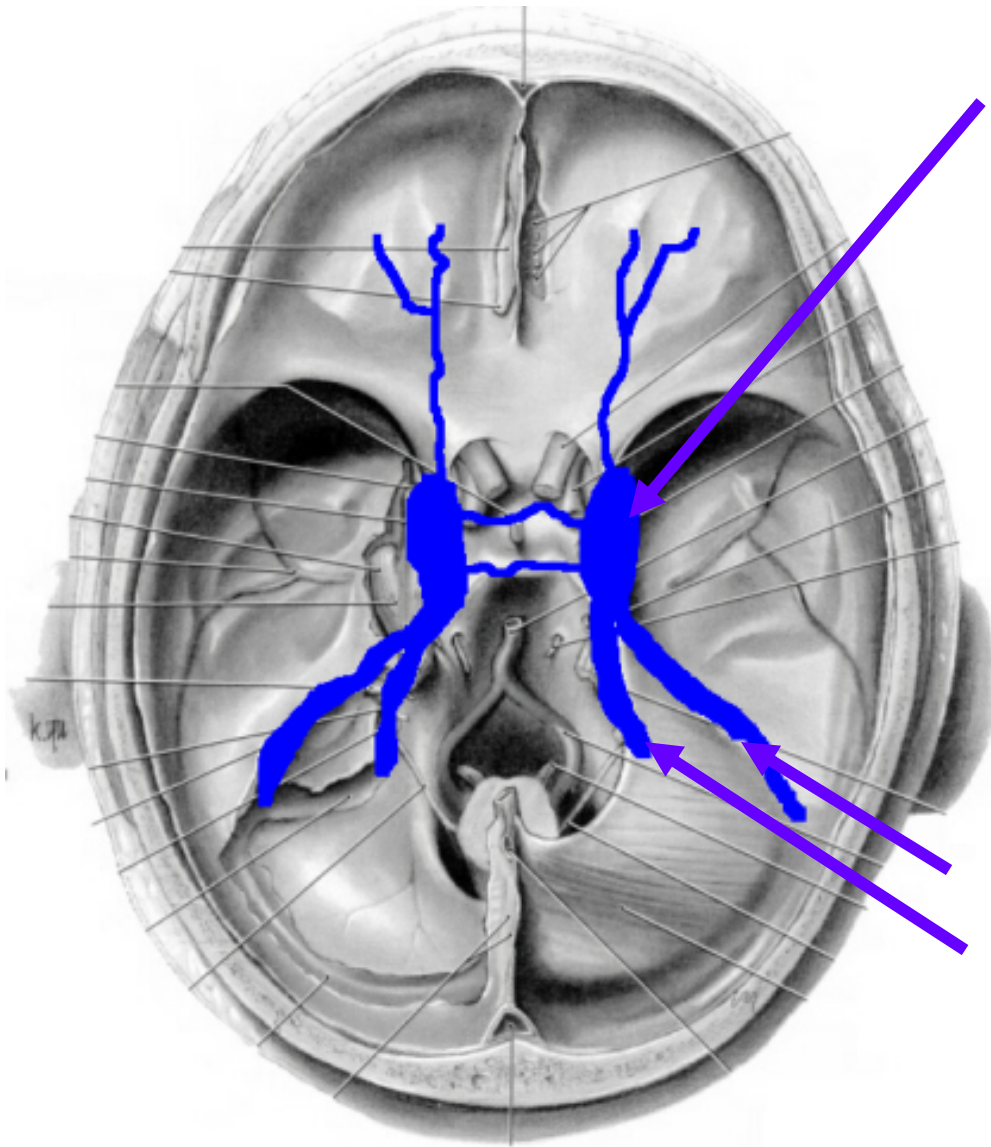
**SIGMOID  
SINUS**

**TRANSVERSE  
SINUS**





# VENOUS SINUSES



7. Cavernous sinuses - in middle cranial fossa; on side of the body of the sphenoid bone; connected by Intercavernous sinus; receive blood from Sup. and Inf. Ophthalmic veins, Cerebral veins; drain to Sup. and Inf. Petrosal sinuses

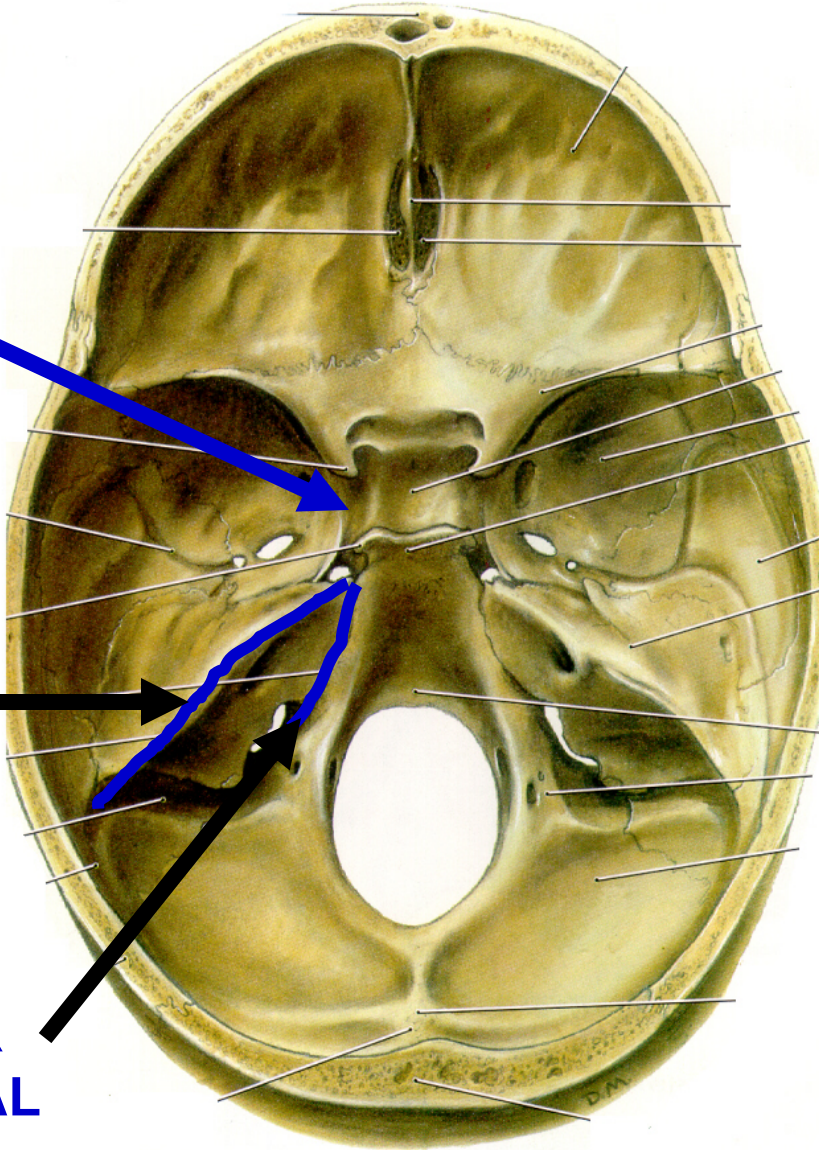
8. Sup. and Inf. Petrosal sinuses - on petrous part of temporal bone  
Sup. drains to Transverse  
Inf. Drains to Internal Jugular

# VENOUS SINUSES MAKE GROOVES IN CRANIAL CAVITY

**CAVERNOUS  
SINUS**

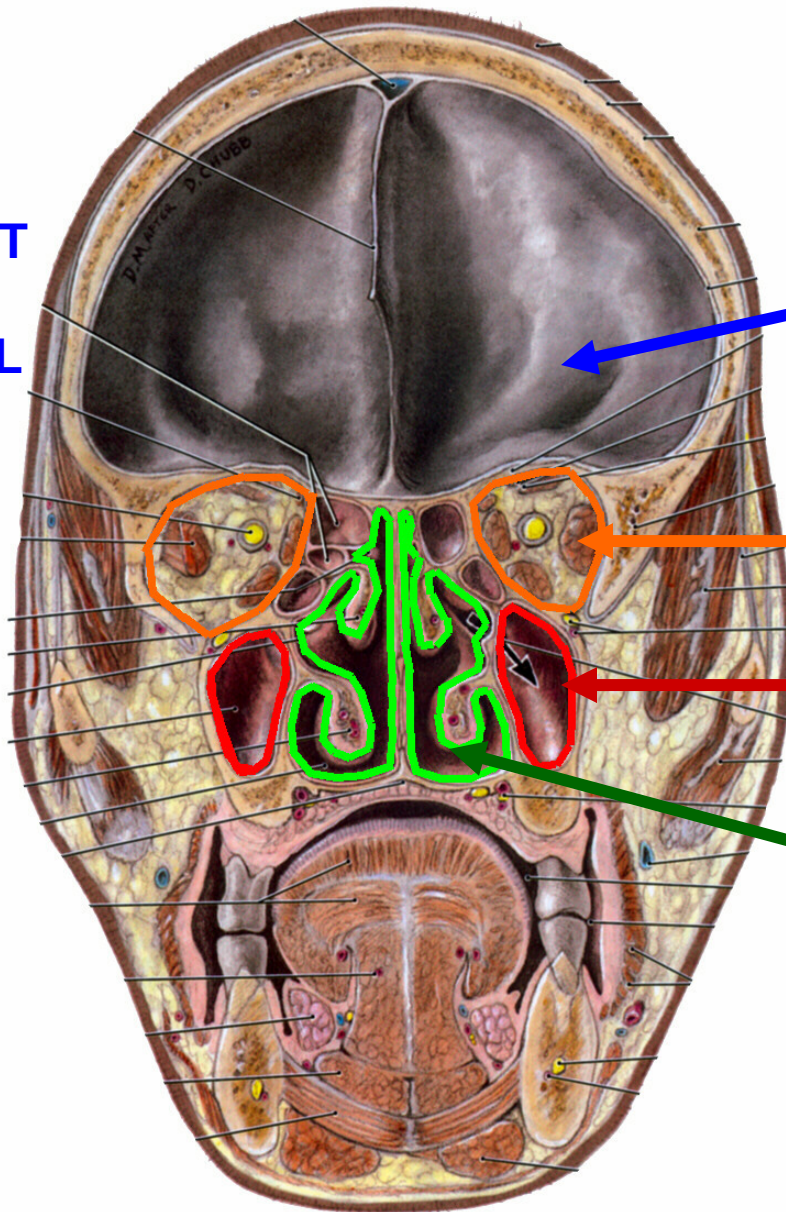
**SUPERIOR  
PETROSAL  
SINUS**

**INFERIOR  
PETROSAL  
SINUS**



# BONES OF ORBIT

HEAD CUT  
IN  
CORONAL  
PLANE



## RELATIONS OF ORBIT

1) ANTERIOR CRANIAL FOSSA - SUPERIOR TO ROOF

ORBIT

2) MAXILLARY SINUS - INFERIOR TO FLOOR

3) NASAL CAVITY - MEDIAL TO MEDIAL WALL OF ORBIT

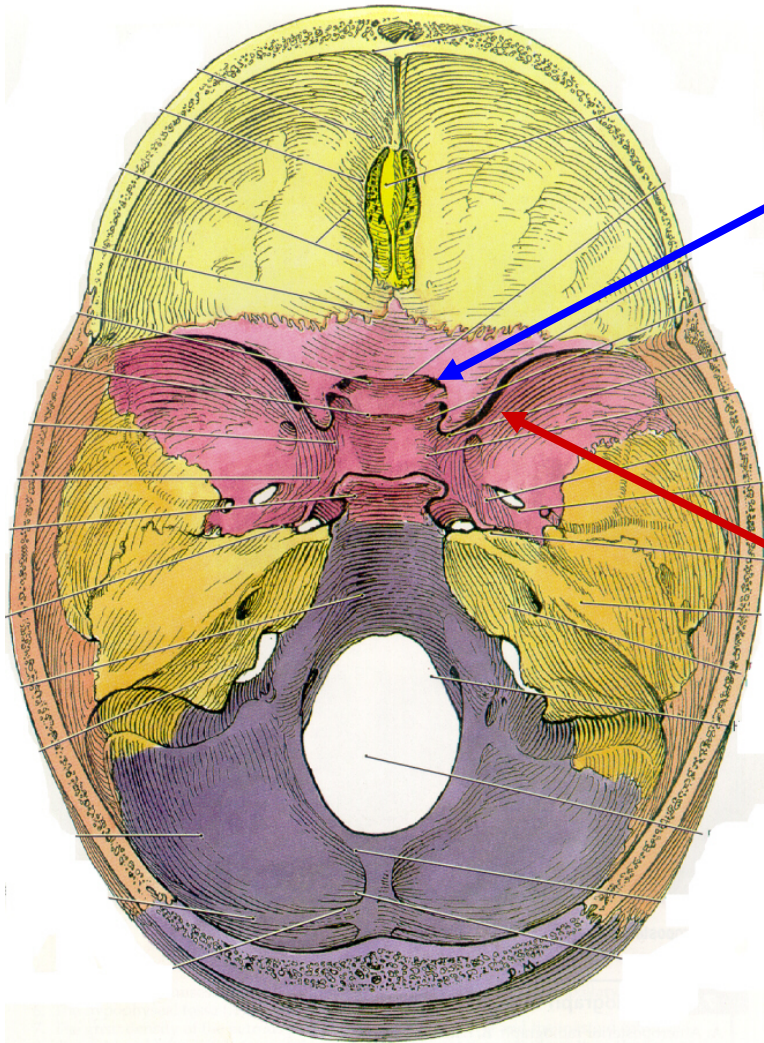


## B. FORAMINA OF ORBIT

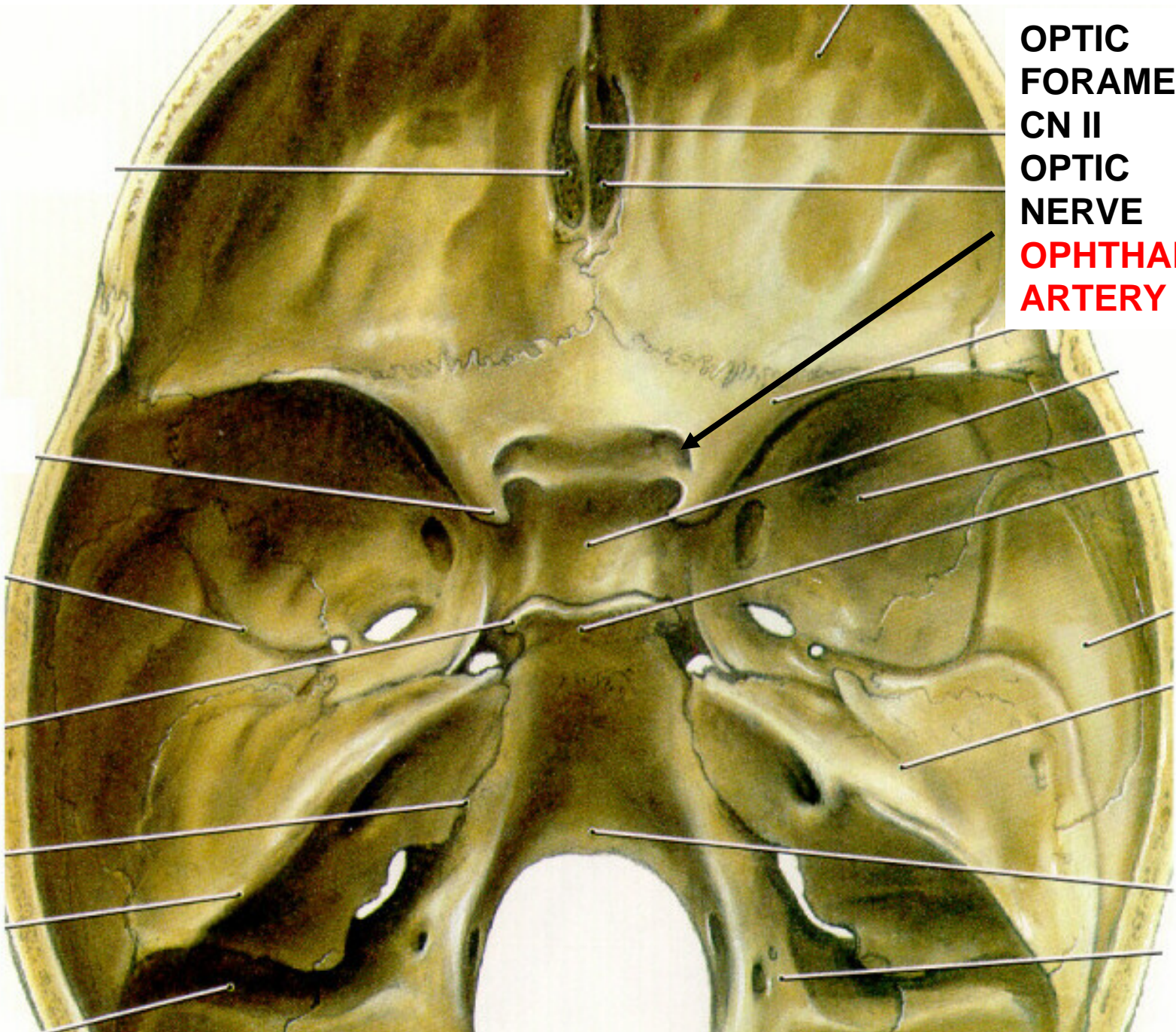
FORAMINA- MOST THINGS ENTER ORBIT FROM MIDDLE CRANIAL FOSSA

1) **OPTIC CANAL**- IN BASE OF LESSER WING OF SPHENOID BONE, CONTAINS **OPTIC NERVE (II)** and **OPHTHALMIC ARTERY**

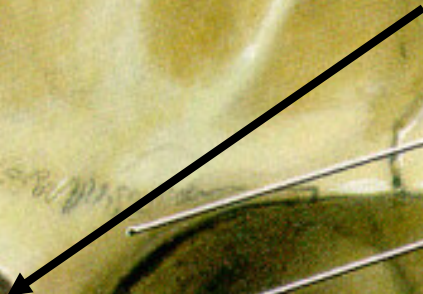
2) **SUPERIOR ORBITAL FISSURE** - BETWEEN GREATER AND LESSER WINGS OF SPHENOID, CONTAINS **III, IV, V1, VI, OPTHALMIC VEINS**



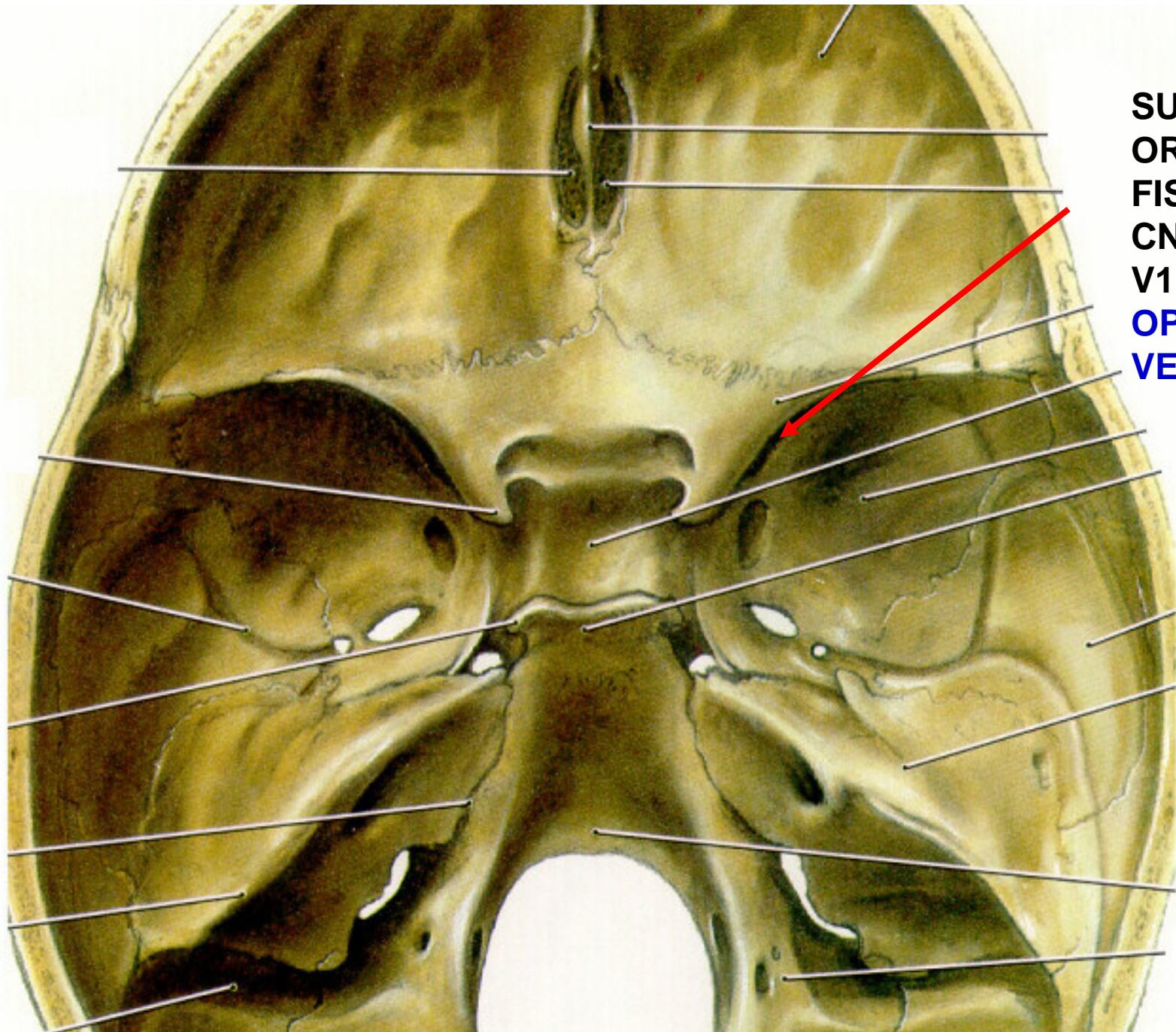




**OPTIC FORAMEN**  
**CN II**  
**OPTIC NERVE**  
**OPHTHALMIC ARTERY**



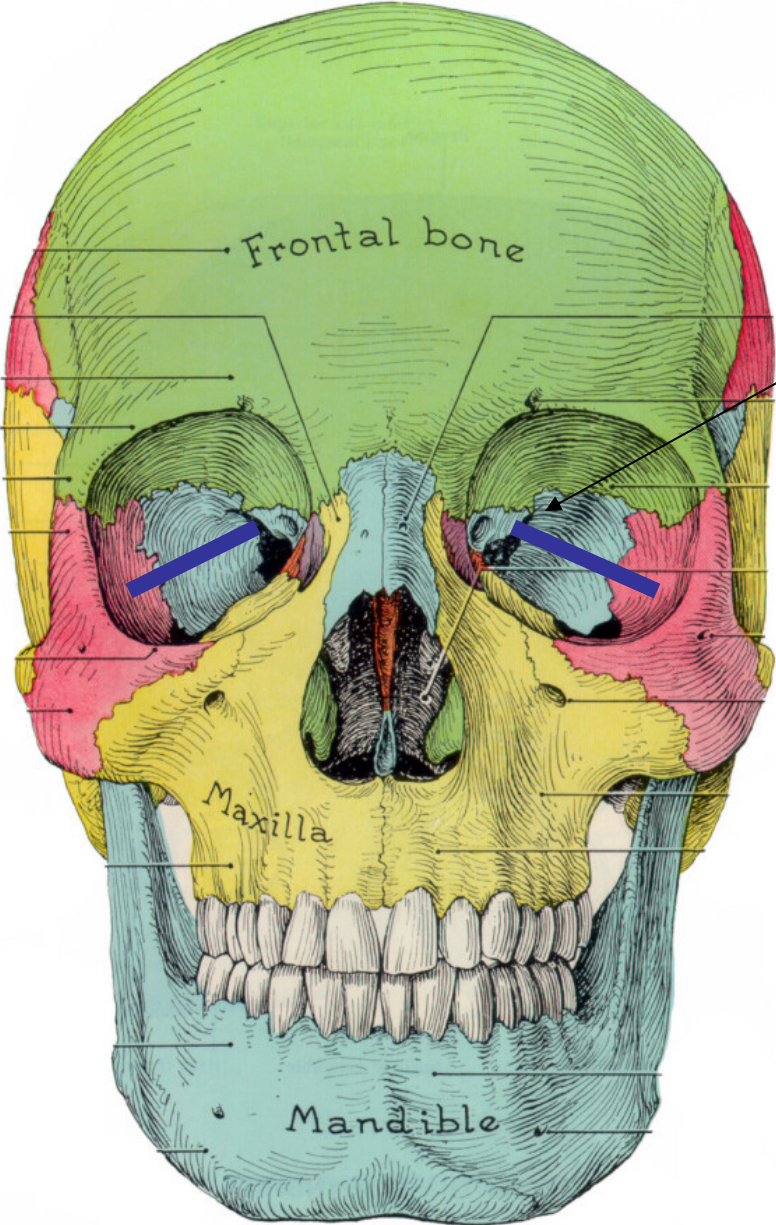




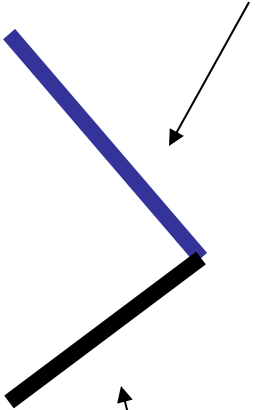
**SUPERIOR  
ORBITAL  
FISSURE –  
CN III, IV  
V1, VI,  
OPHTHALMIC  
VEINS**



# SUPERIOR ORBITAL FISSURE

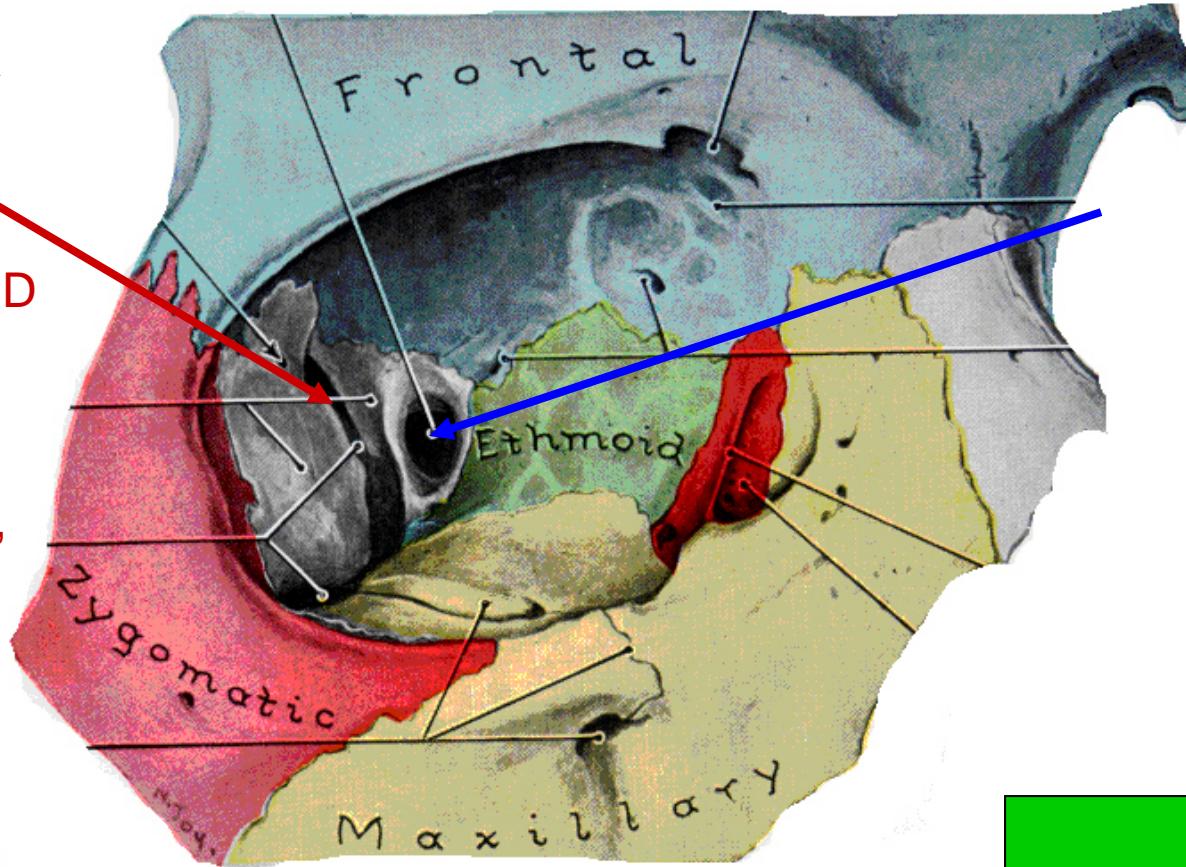


**SUPERIOR  
ORBITAL  
FISSURE**



**INFERIOR  
ORBITAL  
FISSURE**

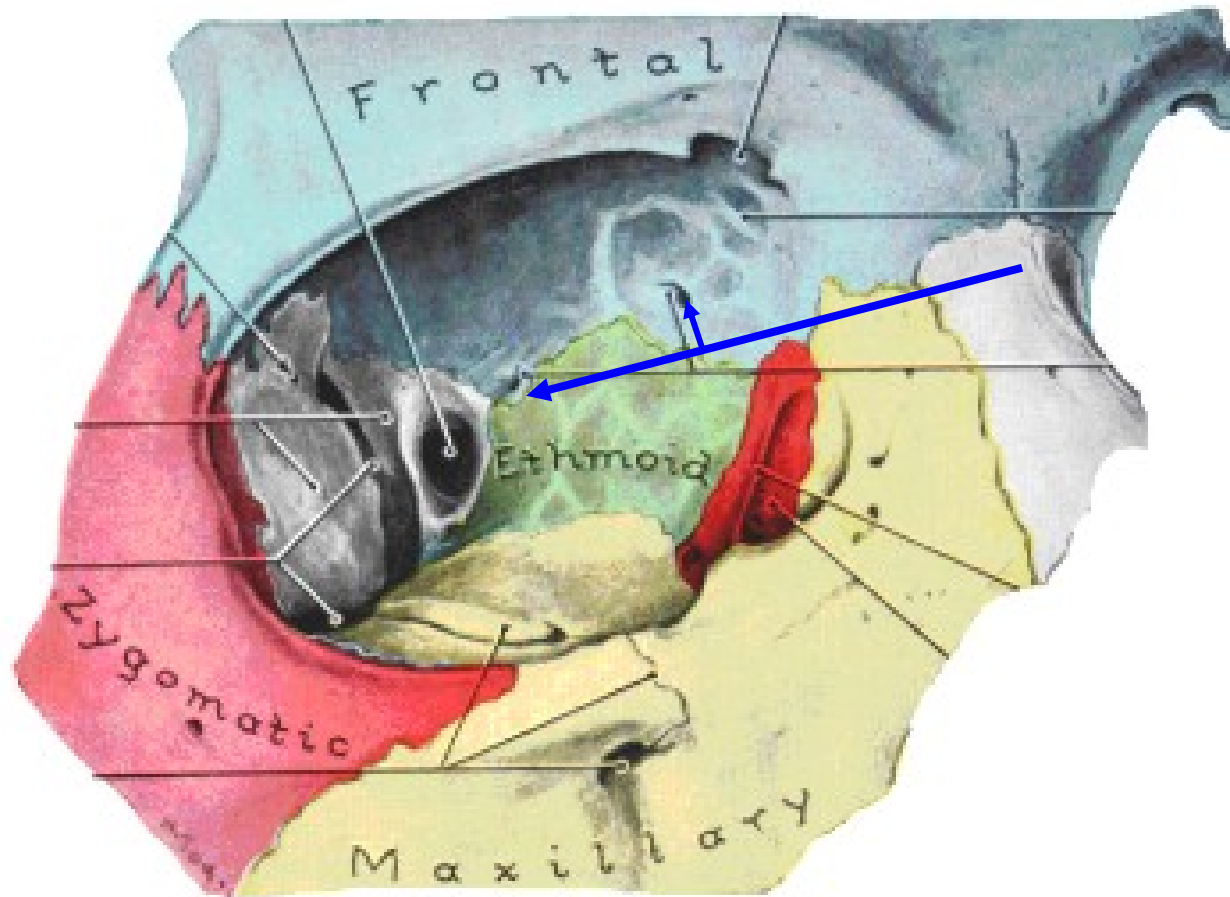
2) **SUPERIOR ORBITAL FISSURE**  
BETWEEN  
GREATER AND  
LESSER  
WINGS OF  
SPHENOID,  
CONTAINS III,  
IV, V1, VI,  
OPHTHALMIC  
VEINS



1) **OPTIC CANAL- IN**  
BASE OF  
LESSER  
WING OF  
SPHENOID  
BONE,  
CONTAINS  
OPTIC NERVE  
AND  
OPHTHALMIC  
ARTERY



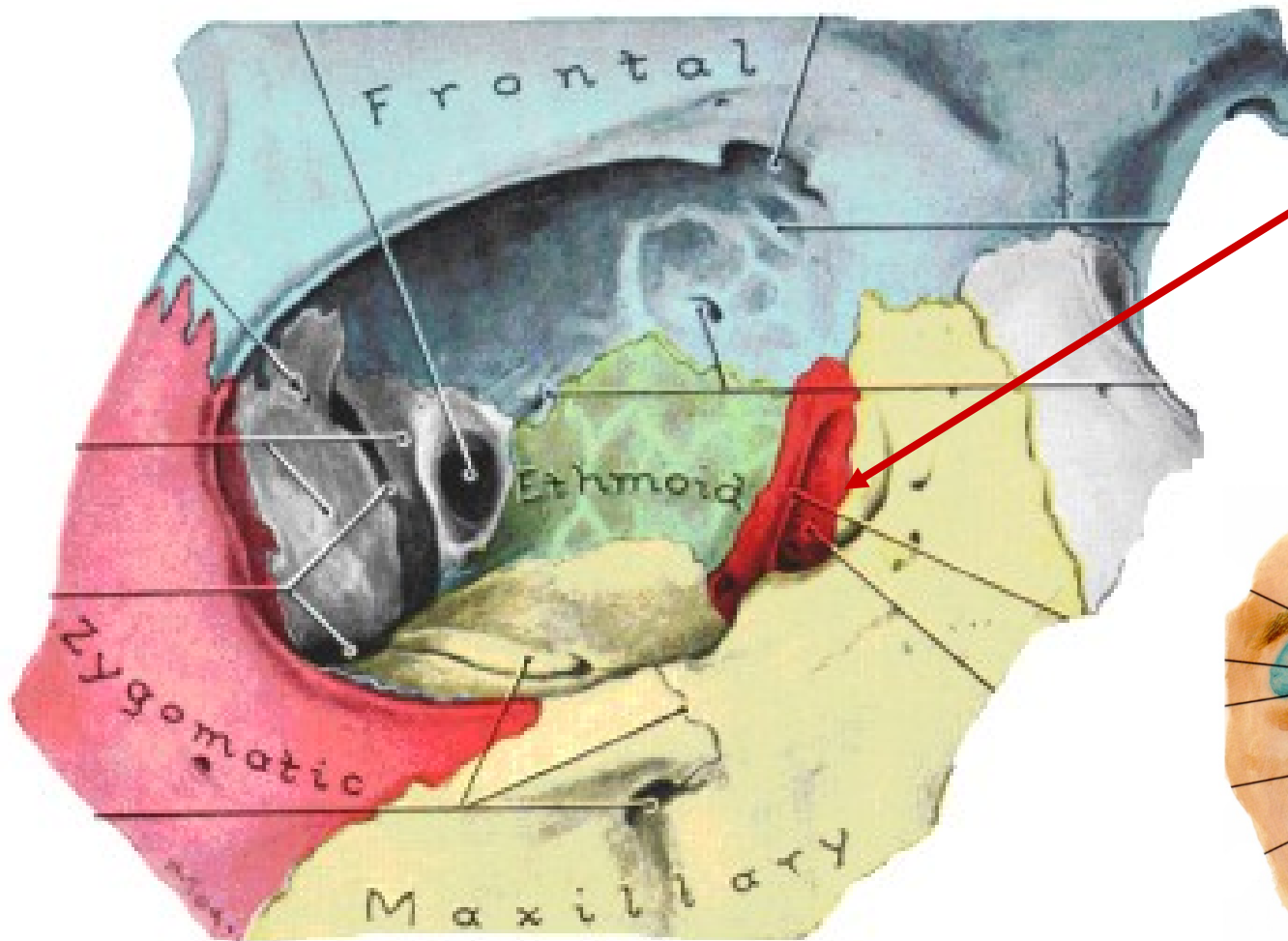
# ANTERIOR AND POSTERIOR ETHMOIDAL FORAMINA



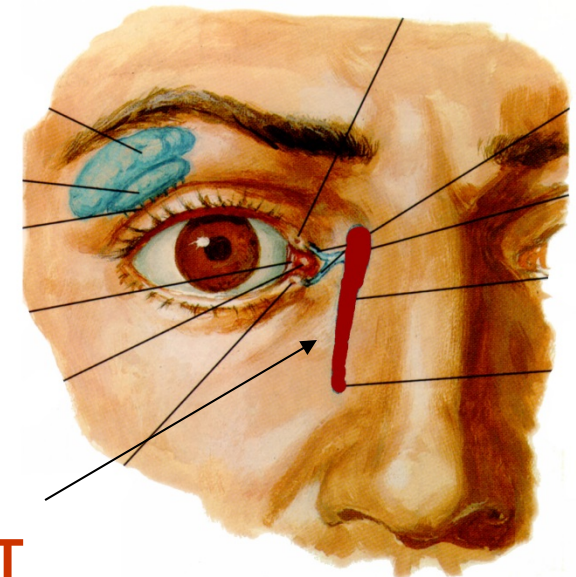
2) ANT. AND POST. ETHMOIDAL FORAMINA-  
BETWEEN ETHMOID AND FRONTAL BONES -CONNECT ORBIT AND NASAL CAVITIES -CONTAIN ANT AND POST ETHMOIDAL N., A. AND V. (V1 AND OPHTHALMIC A.)



# NASOLACRIMAL DUCT



**OPENING OF 3)  
NASOLACRIMAL  
DUCT- IN  
MAXILLARY,  
LACRIMAL BONES  
AND INF. NASAL  
CONCHA -  
CONTAINS  
MEMBRANEOUS  
NASOLACRIMAL  
DUCT AND TEARS**



**NASOLACRIMAL DUCT**

## CIRCLE OF WILLIS

© 2018zillmusom

**DEFINE ANEURYSM:** an excessive localized enlargement of an artery caused by a weakening of the arterial wall.

**DEFINE EMBOLISM:** obstruction in a blood vessel due to a blood clot or other matter that traveled through the bloodstream.

**I. BLOOD SUPPLY TO BRAIN** – Brain has high metabolic activity (15% of cardiac output). Damage rapid: 10 seconds lose consciousness, 5 minutes irreversible damage. Brain receives arterial supply from two major sources:

1. **Internal Carotid Artery** – arise (both sides) from **Common Carotid arteries** at bifurcation in neck (upper border of thyroid cartilage, site of **Pulse of Common Carotid artery**); ascends in neck to base of skull and enters **Carotid Canal**; courses anteriorly and opens internally via **Foramen Lacerum**; Internal Carotid artery then courses anteriorly **in wall of Cavernous Sinus** then turns posteriorly at **Carotid Siphon**; terminates by bifurcating into Anterior and Middle Cerebral arteries

2. **Vertebral Arteries** - arises from Subclavian artery (first branch); then courses through Foramina Transversaria of cervical vertebra (C1-C6); enters skull via **Foramen Magnum**; courses on ventral surface of medulla and joins Vertebral artery of opposite side to form single **Basilar artery**; Basilar artery courses on brainstem; terminates by giving rise to Posterior Cerebral arteries (bilateral).

**III. Branches of Internal Carotid Artery** - Major branches - more discussed in Neuroanatomy:

1. **Ophthalmic artery** - supplies orbit and eye, face, scalp; enters Orbit by Optical Canal (with Optic Nerve); Occlusion of Ophthalmic artery or Central Artery of Retina produces sudden blindness in one eye (total except in case of sparing by Cilioretinal arteries).

2. Middle Cerebral artery - **not part of Circle of Willis** - supplies deep structures and much of Cerebral Hemispheres

3. Anterior Cerebral artery - supplies Anterior Frontal Lobe, medial aspect Cerebral hemisphere

**IV. Major Branches of Vertebral artery**

A. Branches to Spinal Cord and Brain Stem – covered in Neuroanatomy

B. Posterior Cerebral artery - Branch to Brain Stem and Posterior Cortex (arises immediately below Tentorium cerebelli).

**V. Circle of Willis** - anastomosis at base of brain; links circulation provided by Internal Carotid and Vertebral arteries; formed on each side by:

1. **Posterior Cerebral Artery** - from Vertebral Artery

2. **Posterior Communicating artery** - connects Post. Cerebral to Int. Carotid

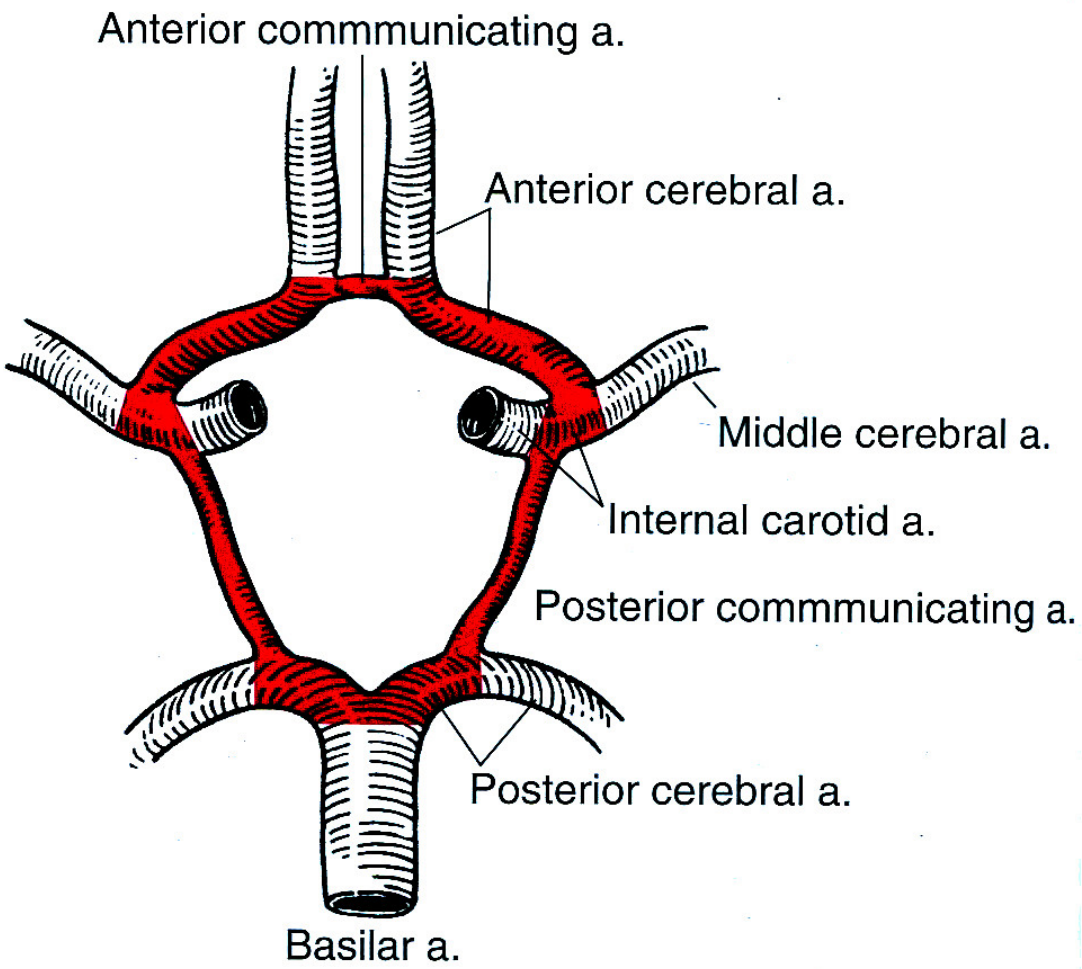
3. **Internal Carotid Artery**

4. **Anterior Cerebral Artery** - from Internal Carotid

5. **Anterior Communicating Artery** - connects Ant. Cerebral Arts. of two sides

Note: **Adequacy of Collateral Circulation** - in most cases of **rapid occlusion, anastomosis is most often inadequate**; can dilate if occlusion is slow; also **Variations are common** - in 20% of individuals, Posterior Cerebral is predominantly supplied by Internal Carotid.

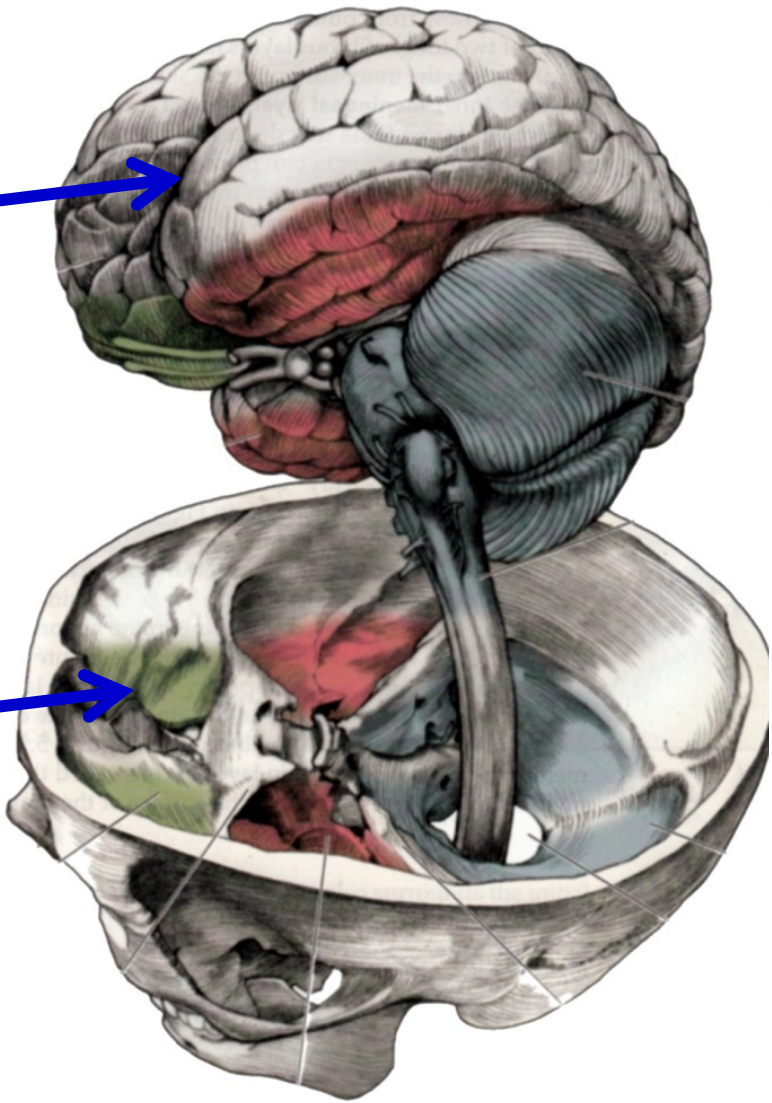
Note: **Aneurysms** - swellings in wall of arteries; in cerebral circulation, often found in Circle of Willis ('**Berry**' aneurysms); rupture of Berry aneurysms is often fatal; can be treated by Endovascular techniques (ex. coiling) through catheterization.





# GROSS BRAINSTEM DISSECTION: HOW THE BRAIN FITS IN THE BODY

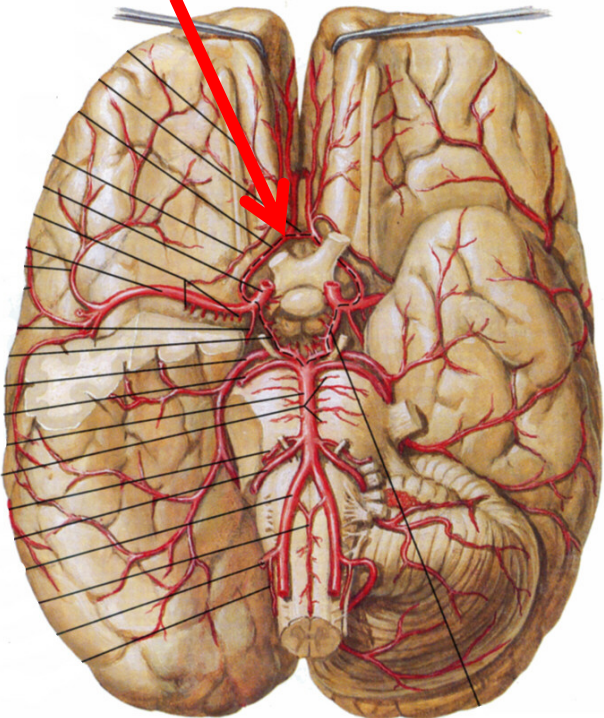
**BRAIN**



**BODY**



**ARTERIES TO BRAIN – ANASTOMOSIS: CIRCLE OF WILLIS**



# OVERVIEW OF BRAIN

LOBES OF  
CEREBRAL  
CORTEX –  
NAMED FOR  
BONES

PARIETAL  
LOBE

TEMPORAL  
LOBE

OCCIPITAL  
LOBE

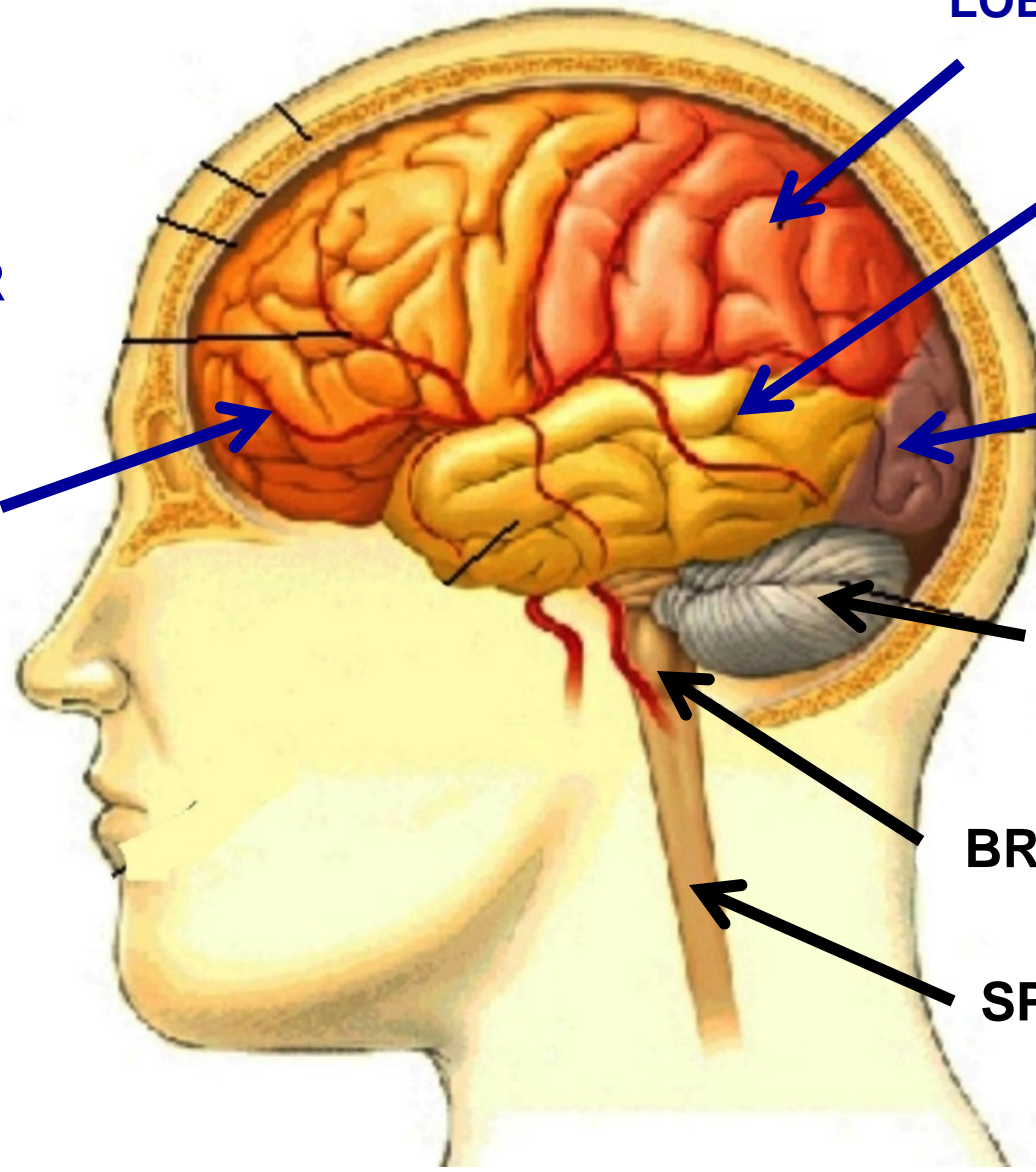
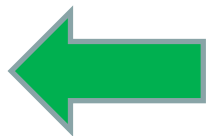
FRONTAL  
LOBE

CEREBELLUM

BRAIN STEM

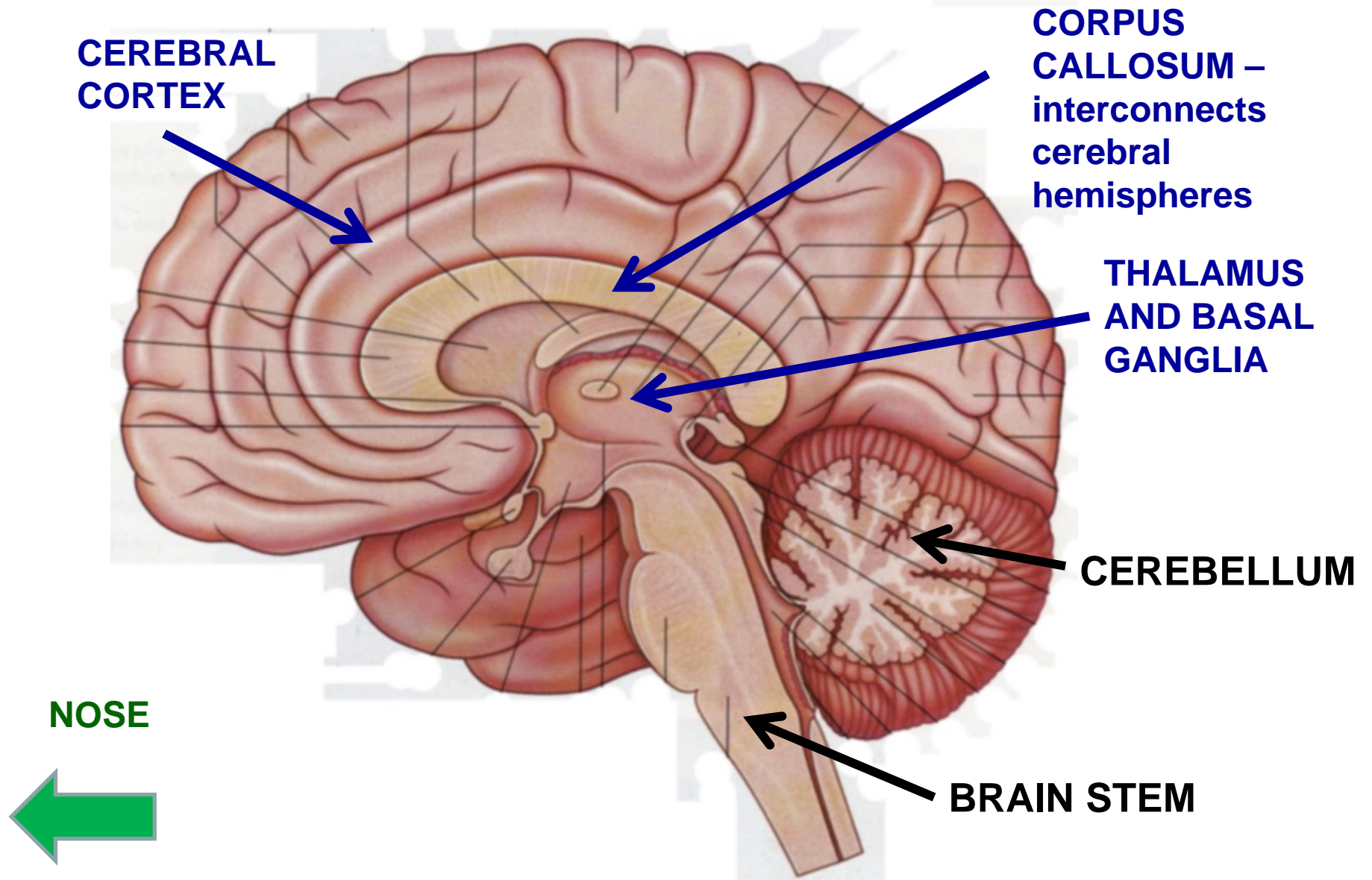
SPINAL CORD

NOSE



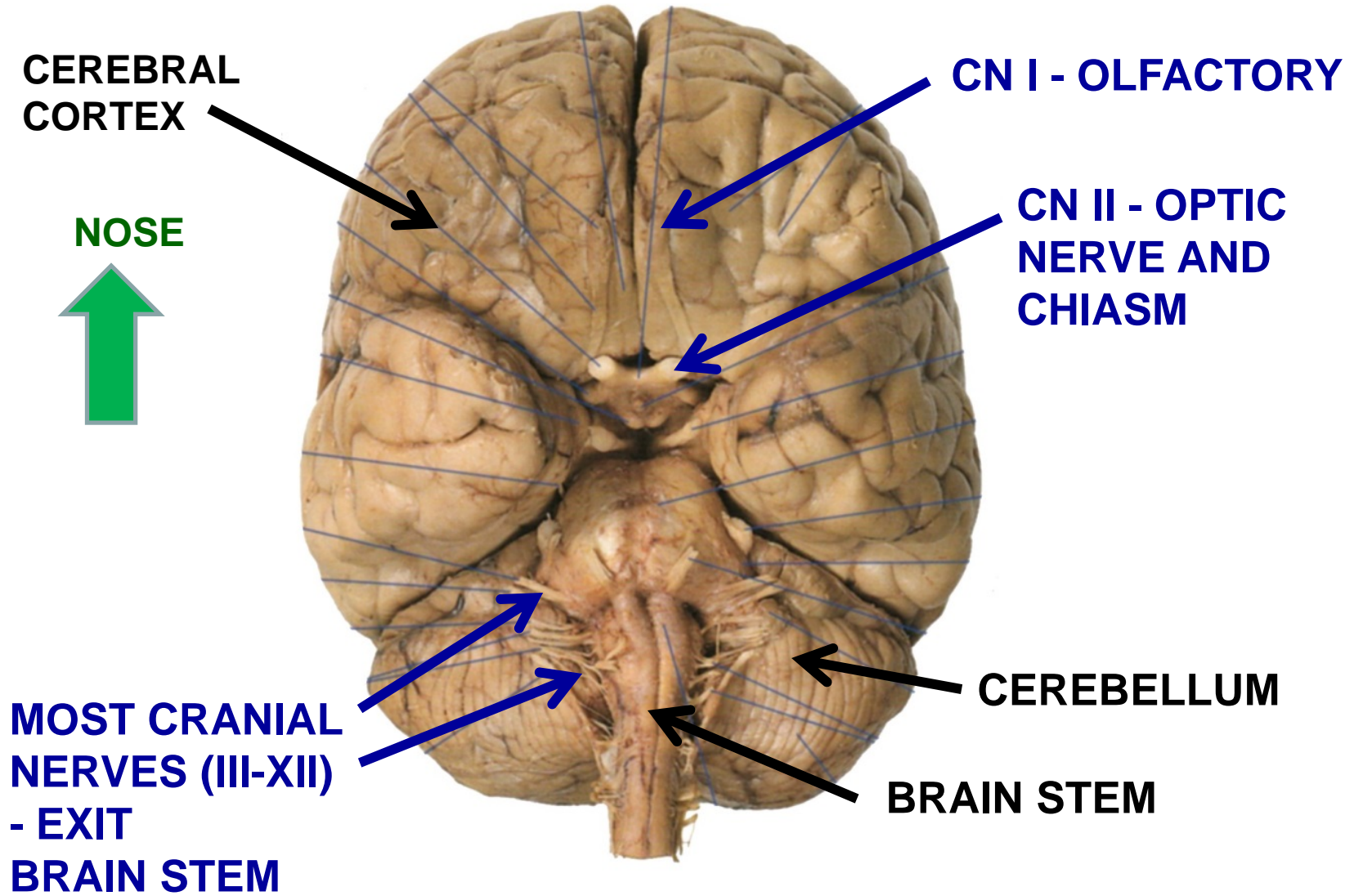


# OVERVIEW OF BRAIN – MID-SAGGITAL VIEW



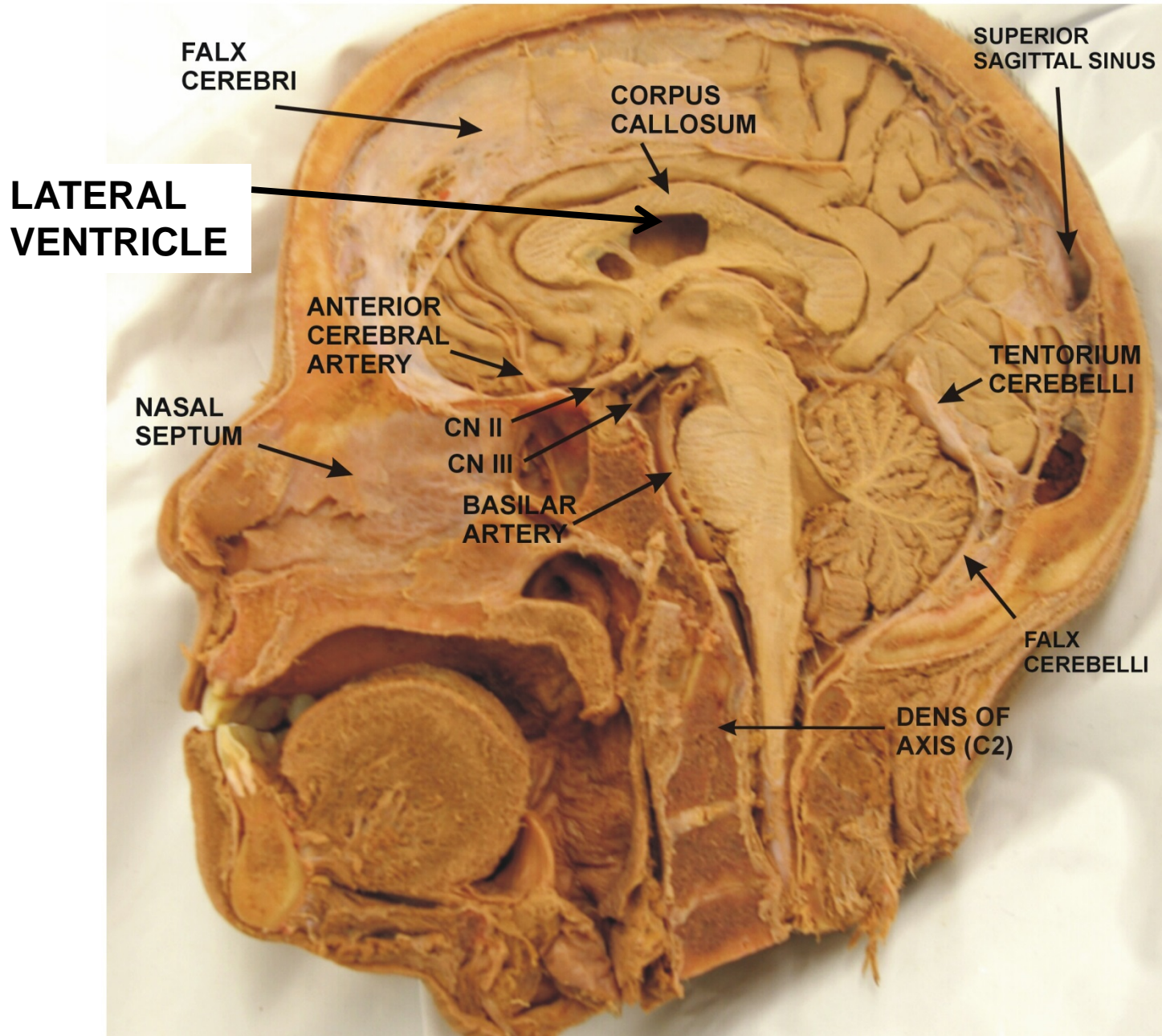


# CRANIAL NERVES



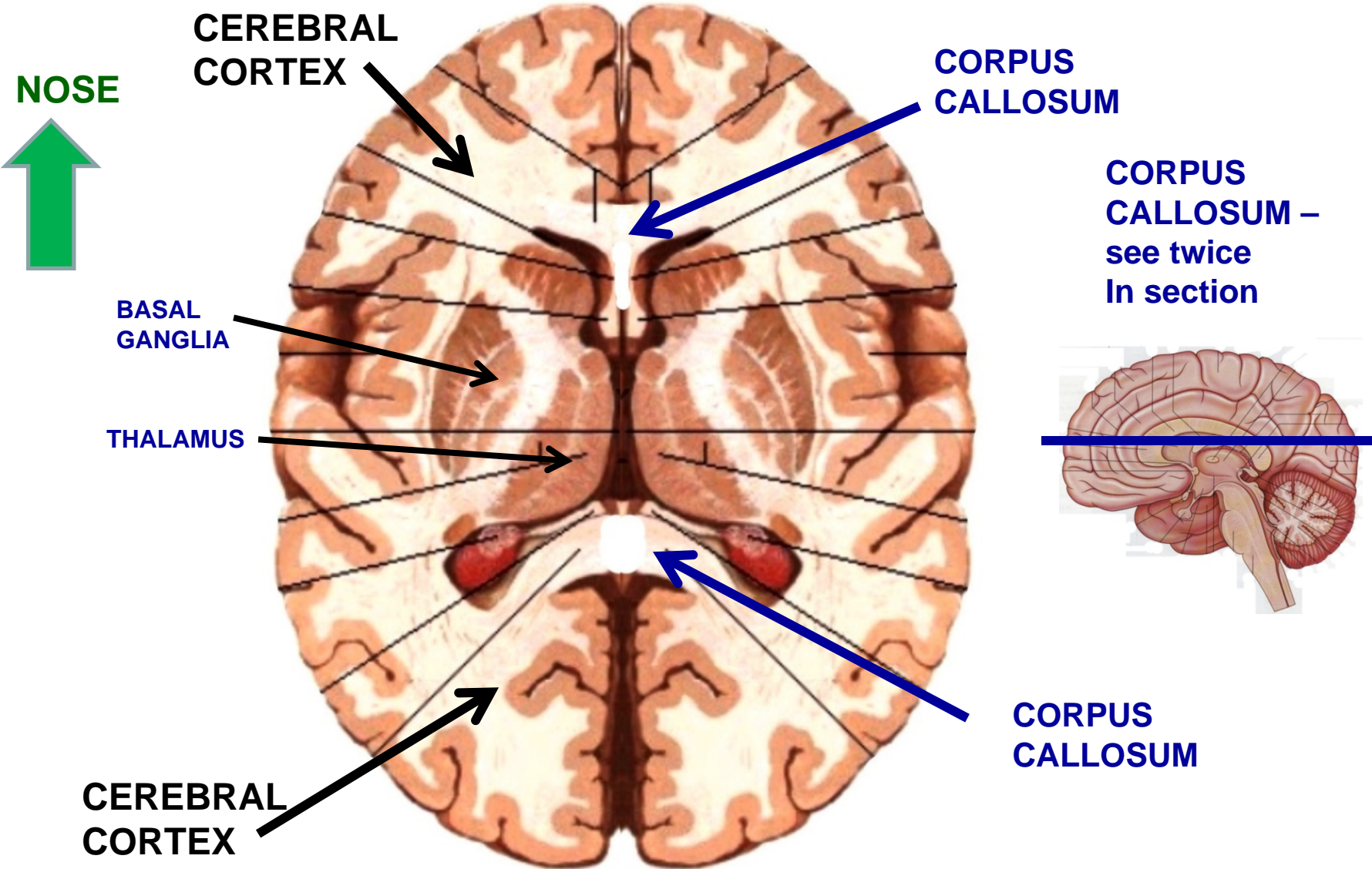
# MEDIAL VIEW OF BISECTED HEAD

1069



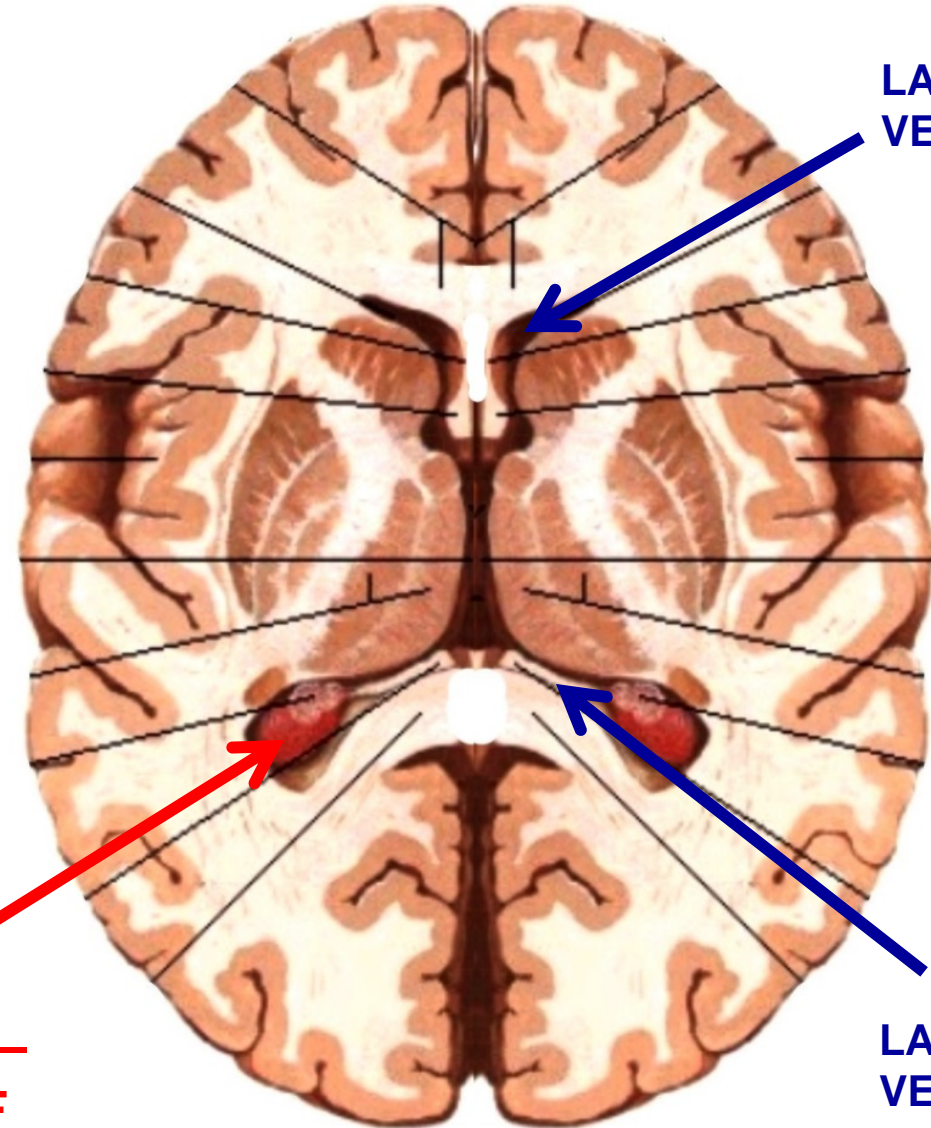


# ORIENT TO BRAIN SECTION: CORPUS CALLOSUM





# ORIENT TO BRAIN SECTION: LATERAL VENTRICLES AND CHOROID PLEXUS

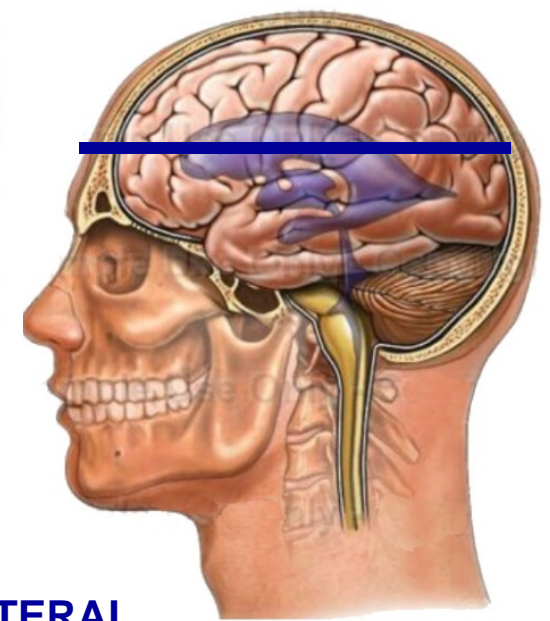


LATERAL VENTRICLE

LATERAL VENTRICLE – see twice In section

CHOROID PLEXUS IN LATERAL VENTRICLE – SITE OF CSF PRODUCTION

LATERAL VENTRICLE



**TABLE 4 - LOWER**



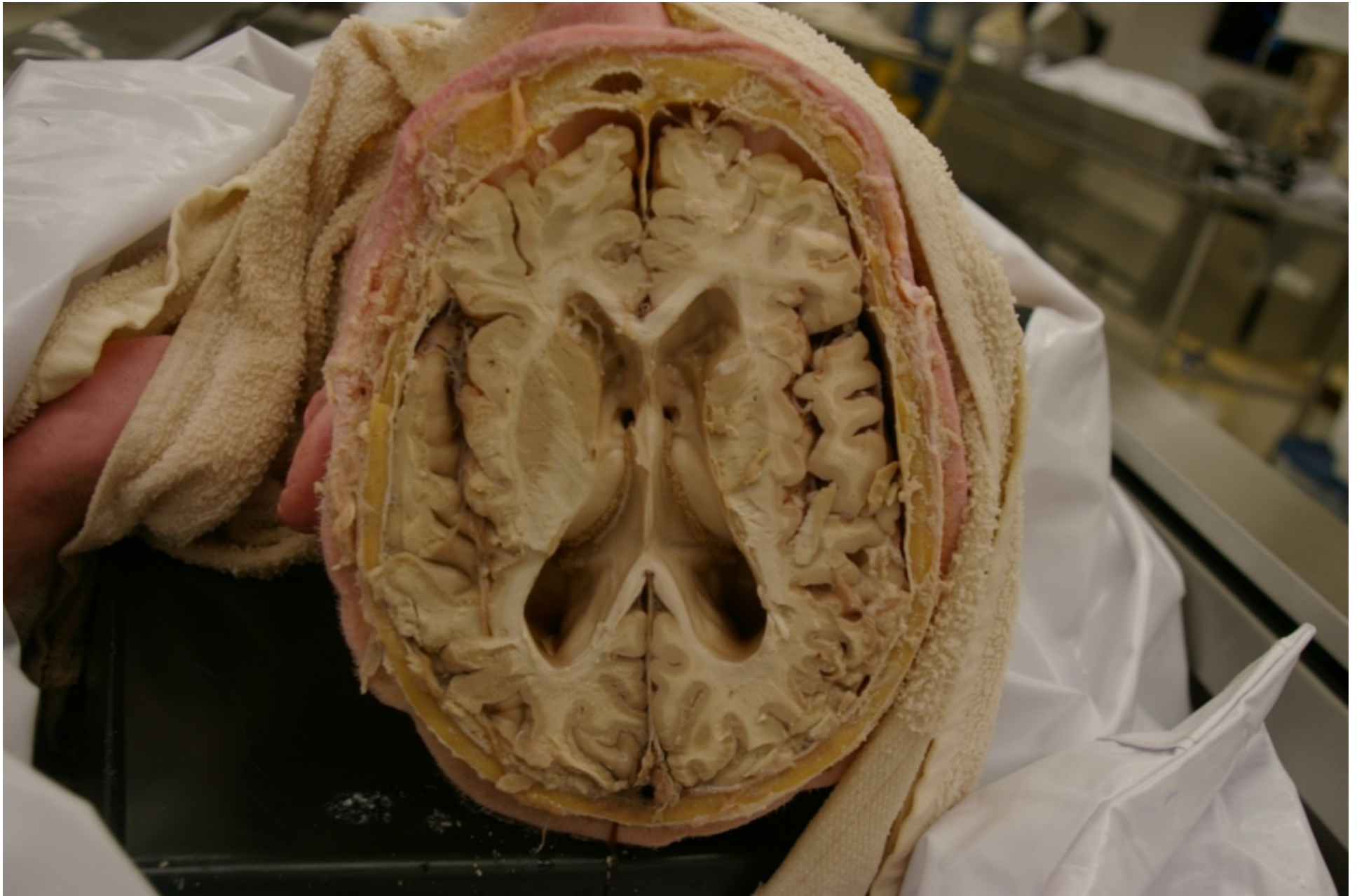


**TABLE 8 - LOWER**

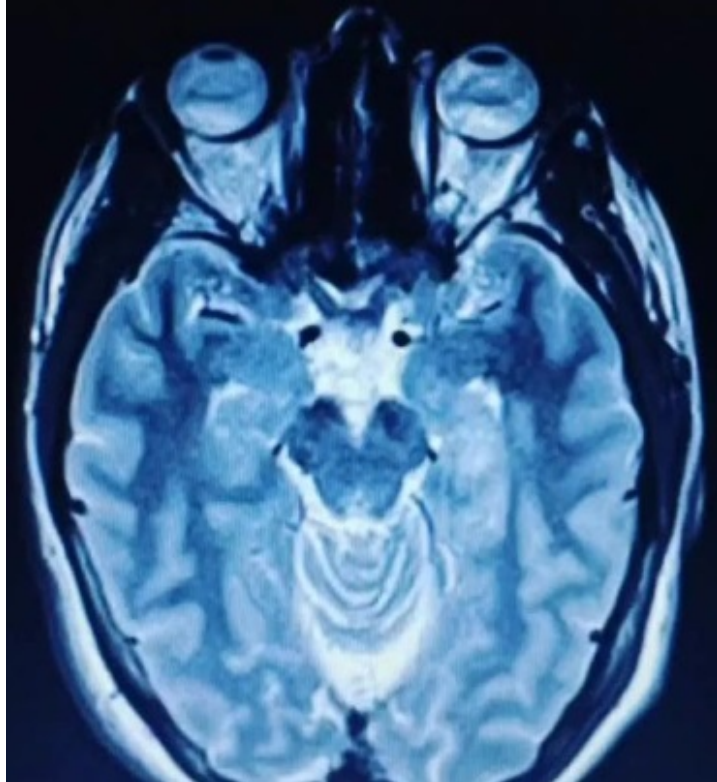




**TABLE 7 - LOWER**



## LECTURE: CIRCLE OF WILLIS SEE HANDOUT



MRI of brain of Jasmyn Atalla, MSIII

**PROBLEM:** Brain requires a continuous supply of oxygenated blood:

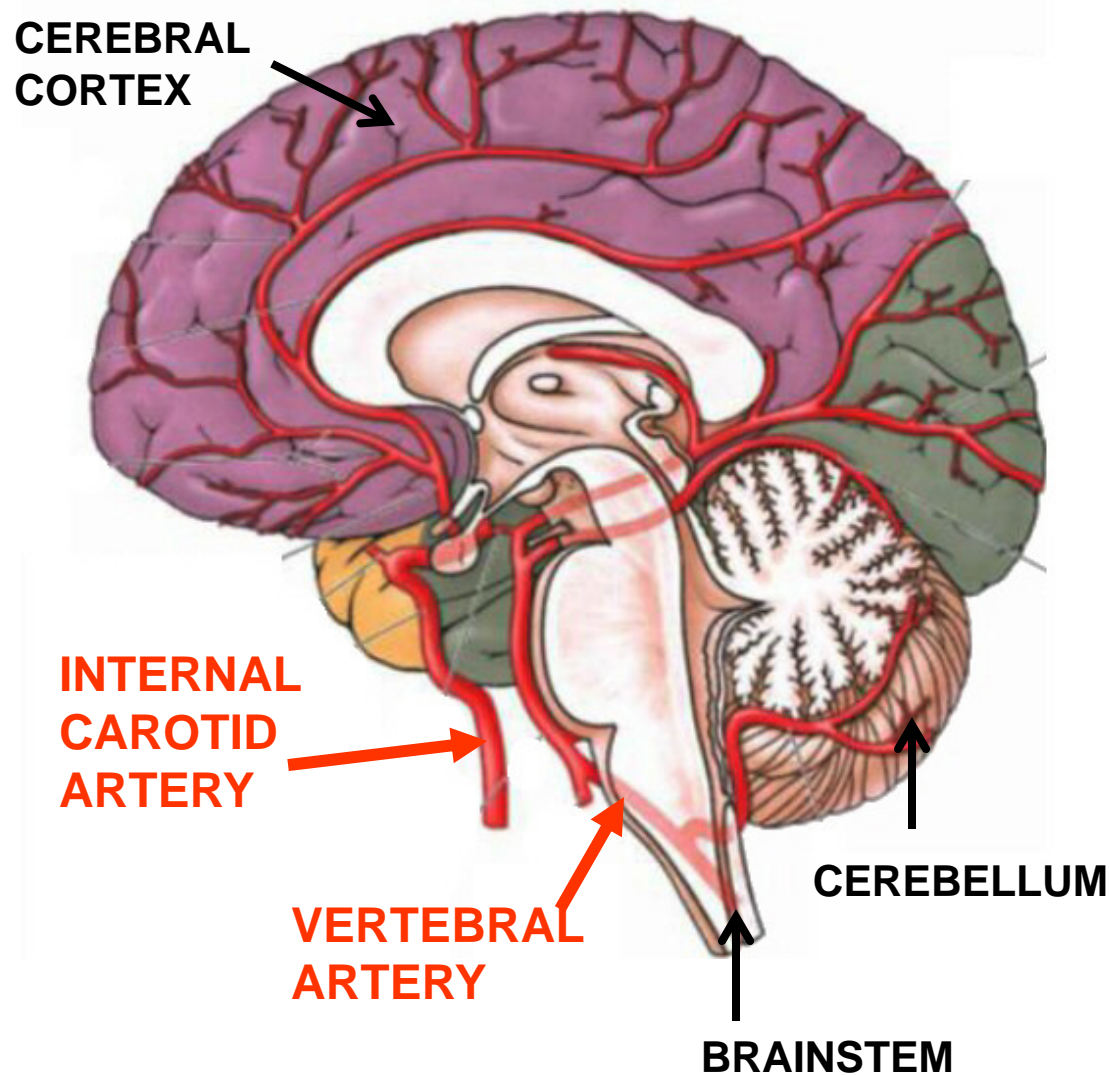
1. **High metabolic activity** - Brain uses about 15% of total cardiac output
2. **Damage from interruption of supply** - After about 10 seconds lose consciousness, after about 5 minutes get irreversible damage.

**Solution: two sources of blood**

**WORDS OF DAY: ANEURYSM:** an excessive **localized enlargement** of an artery caused by a weakening of the arterial wall.

**EMBOLISM:** **obstruction** in a blood vessel due to a blood clot or other matter (ex. plaque) that **traveled through the bloodstream**

## SOLUTION: TWO MAJOR ARTERIES SUPPLY BRAIN



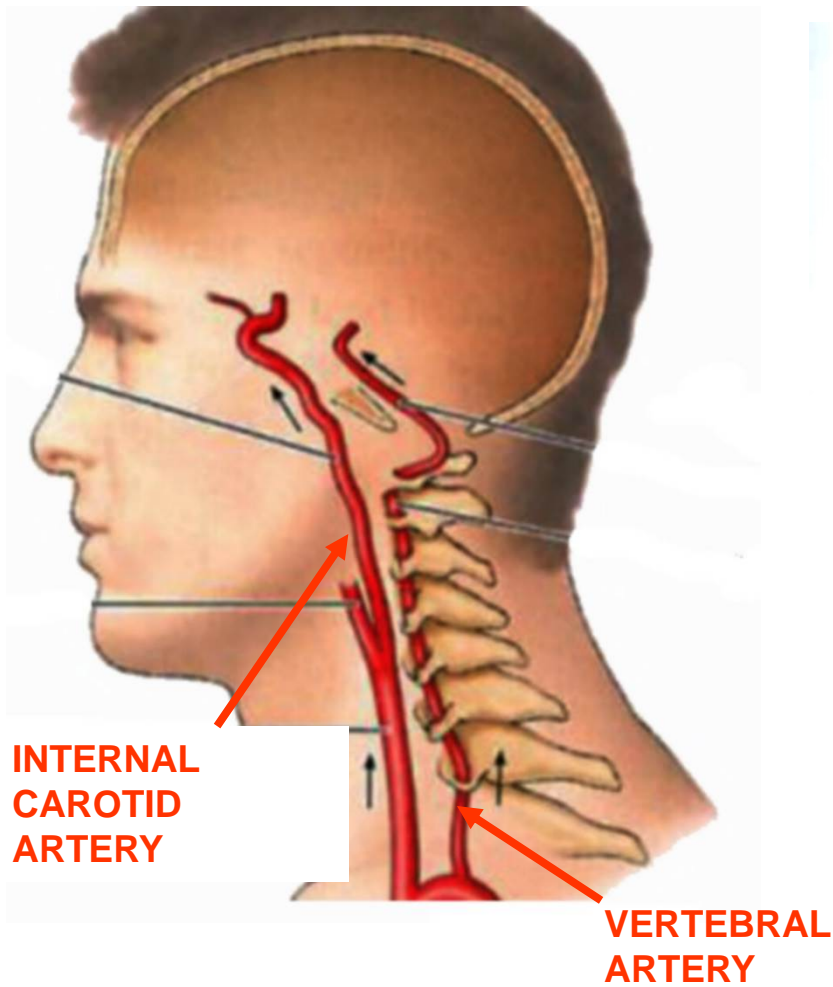
**Solution - Rich blood supply supplied at high pressure from two sources**

- Internal Carotid arteries supply 80% of brain
- Vertebral arteries supplies remaining 20%.
- However, Vertebral arteries are major supply to brainstem (essential for life)

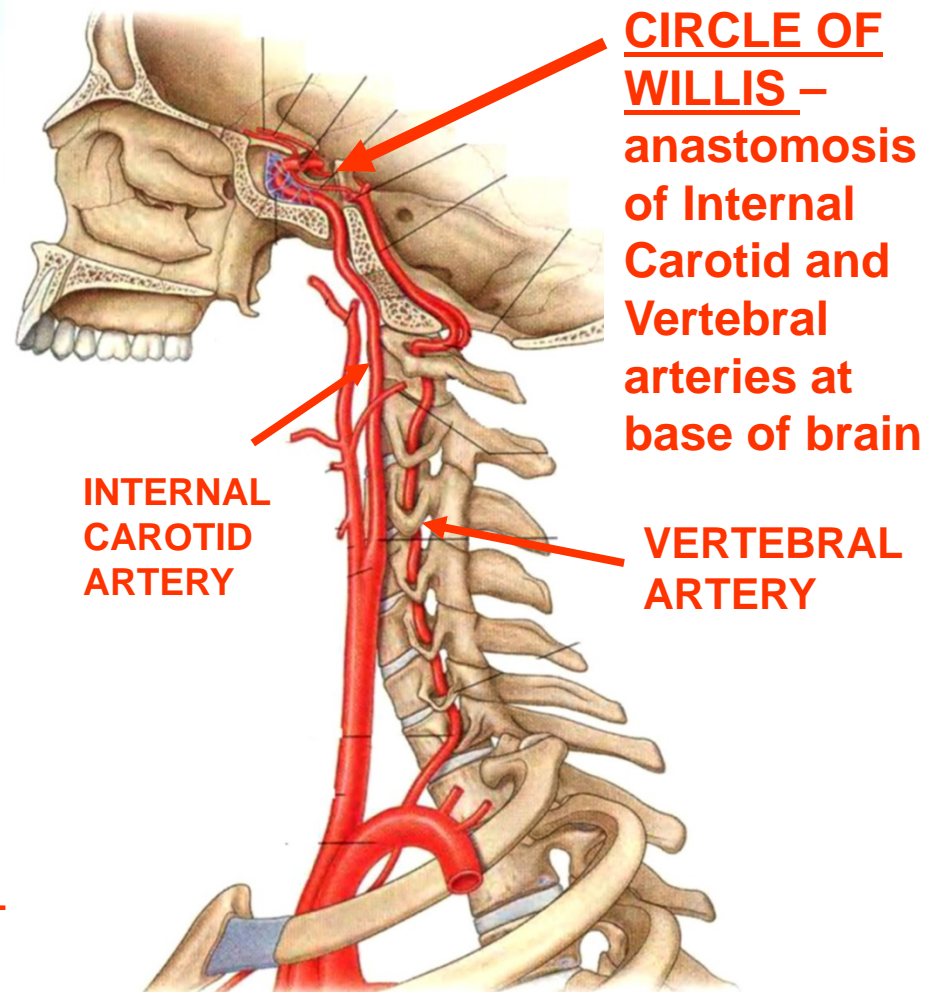


# ARTERIES ANASTOMOSE AT CIRCLE OF WILLIS

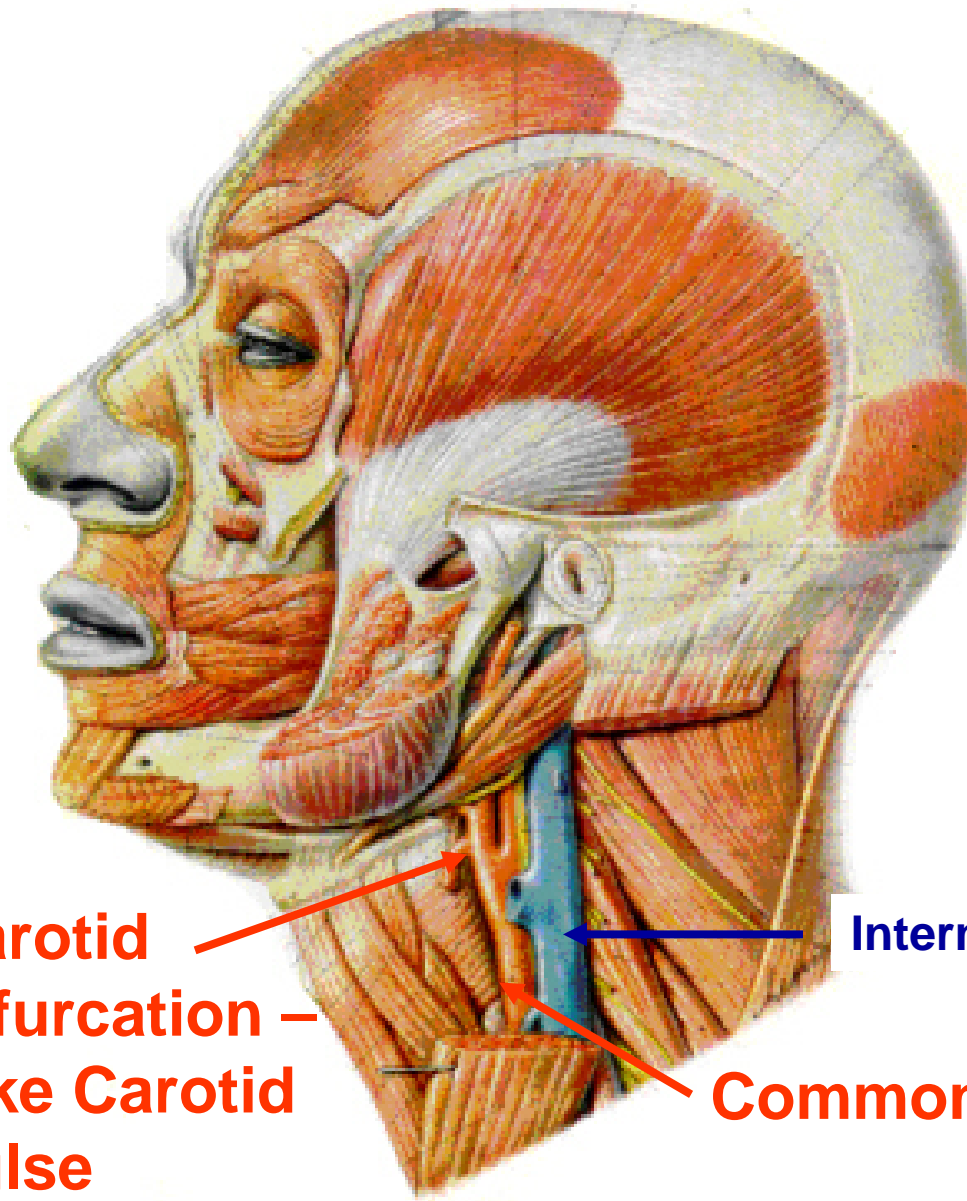
TWO MAJOR ARTERIES ENTER CRANIAL CAVITY



ARTERIES ARE LINKED (ANASTOMOSE) AT CIRCLE OF WILLIS



# COMMON CAROTID ARTERY



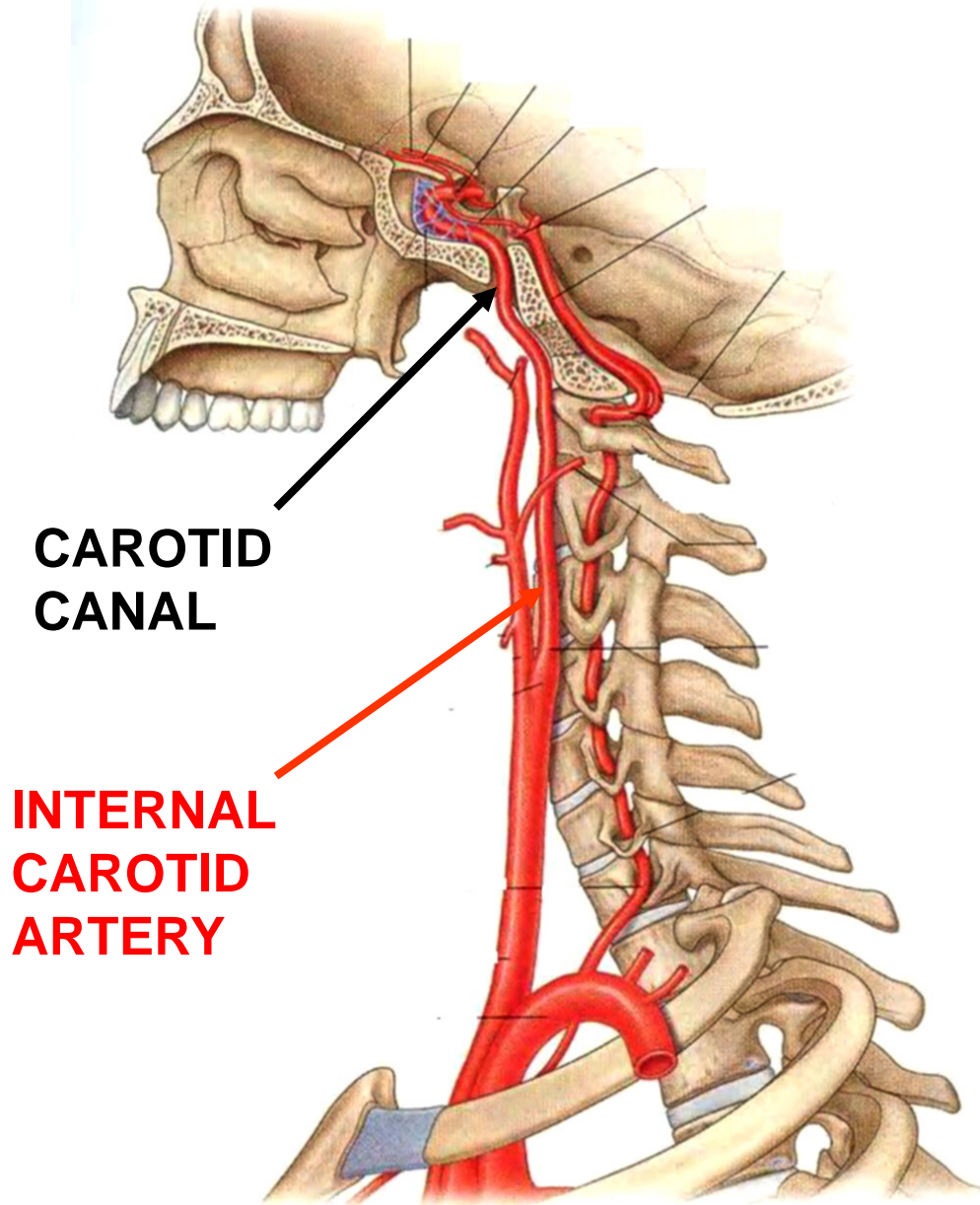
Common Carotid Artery ascends in neck and bifurcates at upper border of Thyroid cartilage to External and Internal Carotid arteries (site of Carotid Pulse)

Carotid Bifurcation – take Carotid pulse

Internal Jugular Vein

Common Carotid

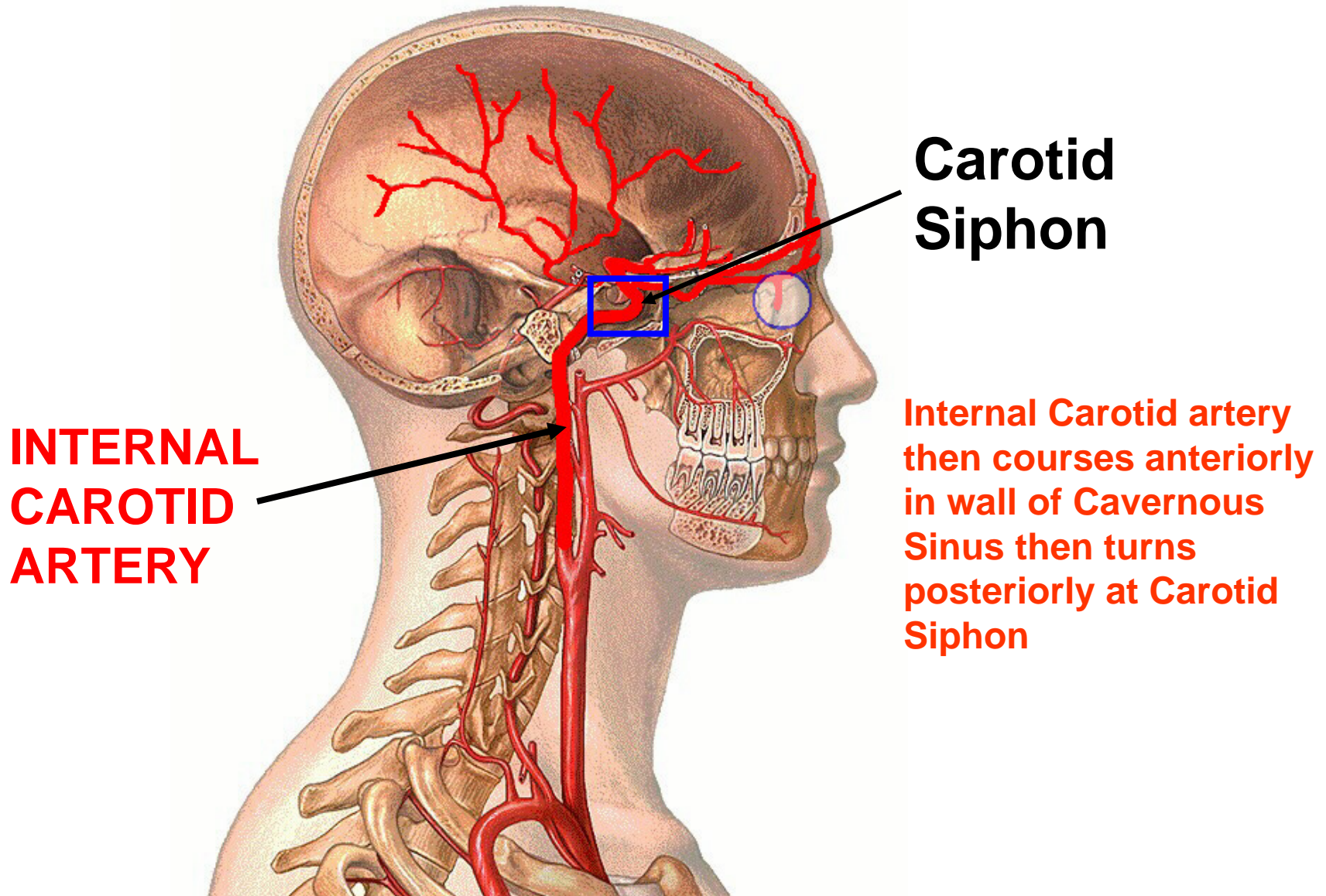
# INTERNAL CAROTID ARTERY



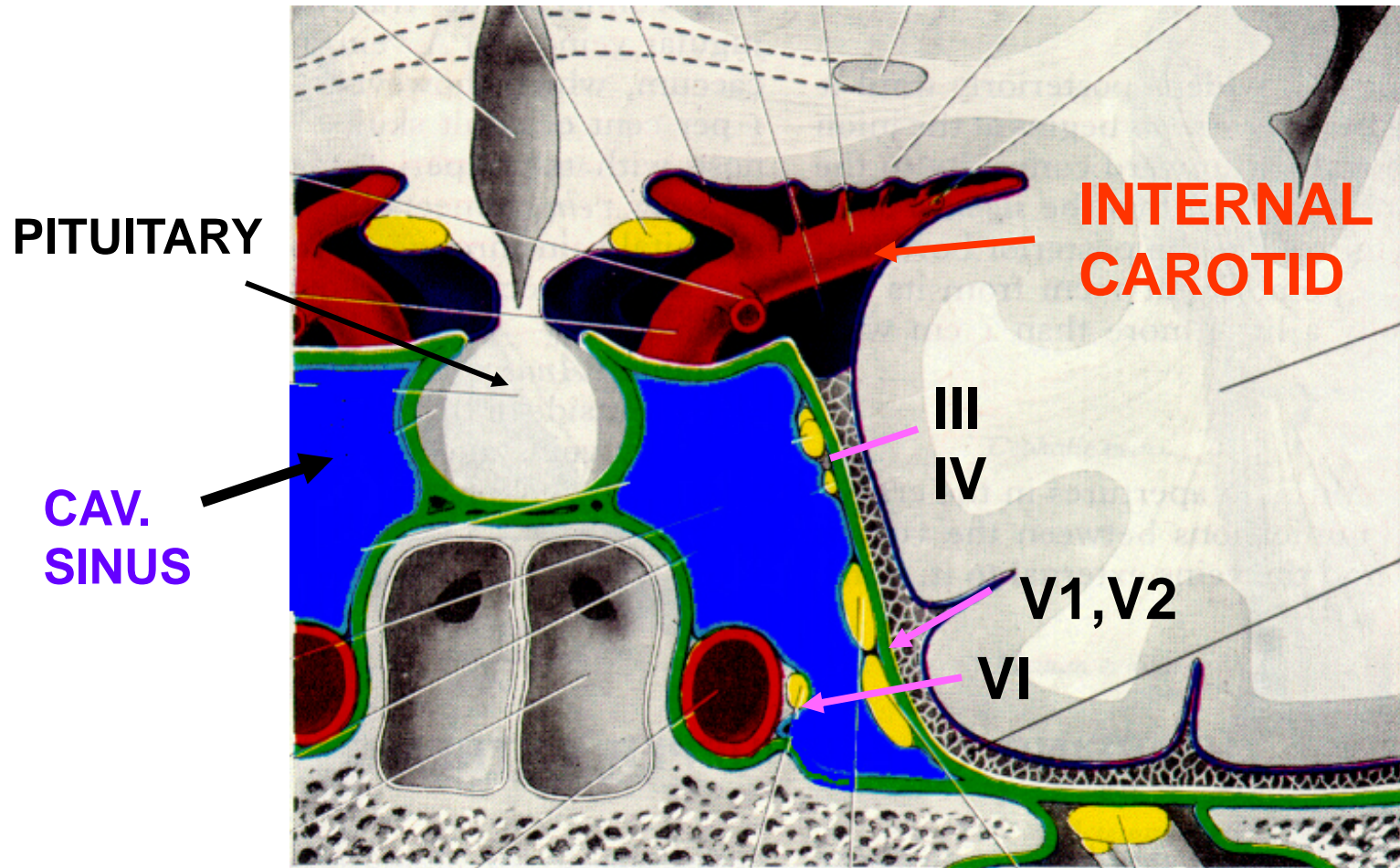
- arises from bifurcation of Common Carotid artery, ascends in neck to base of skull and enters Carotid Canal; courses anteriorly and opens internally via Foramen Lacerum



**INTERNAL CAROTID ARTERY PASSES THROUGH CAVERNOUS SINUS**



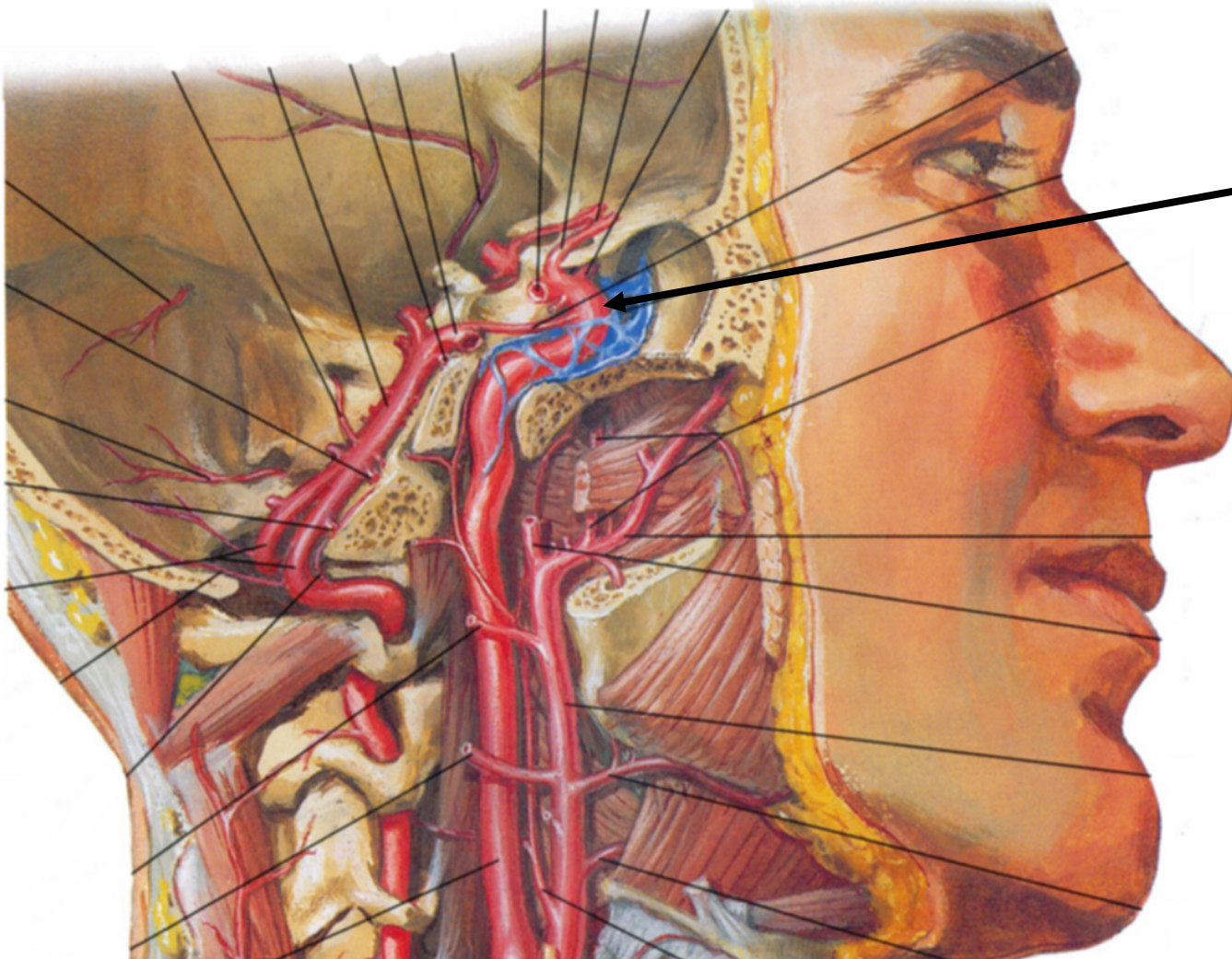
**INTERNAL CAROTID ARTERY: PASSES IN WALL OF CAVERNOUS SINUS**



**STRUCTURES PASSING THROUGH WALL OF CAVERNOUS SINUS - Int. Carotid A., Cranial N.'s III, IV, V1, V2, VI; sign of Infection 'BLURRED' VISION = DIPLOPIA**



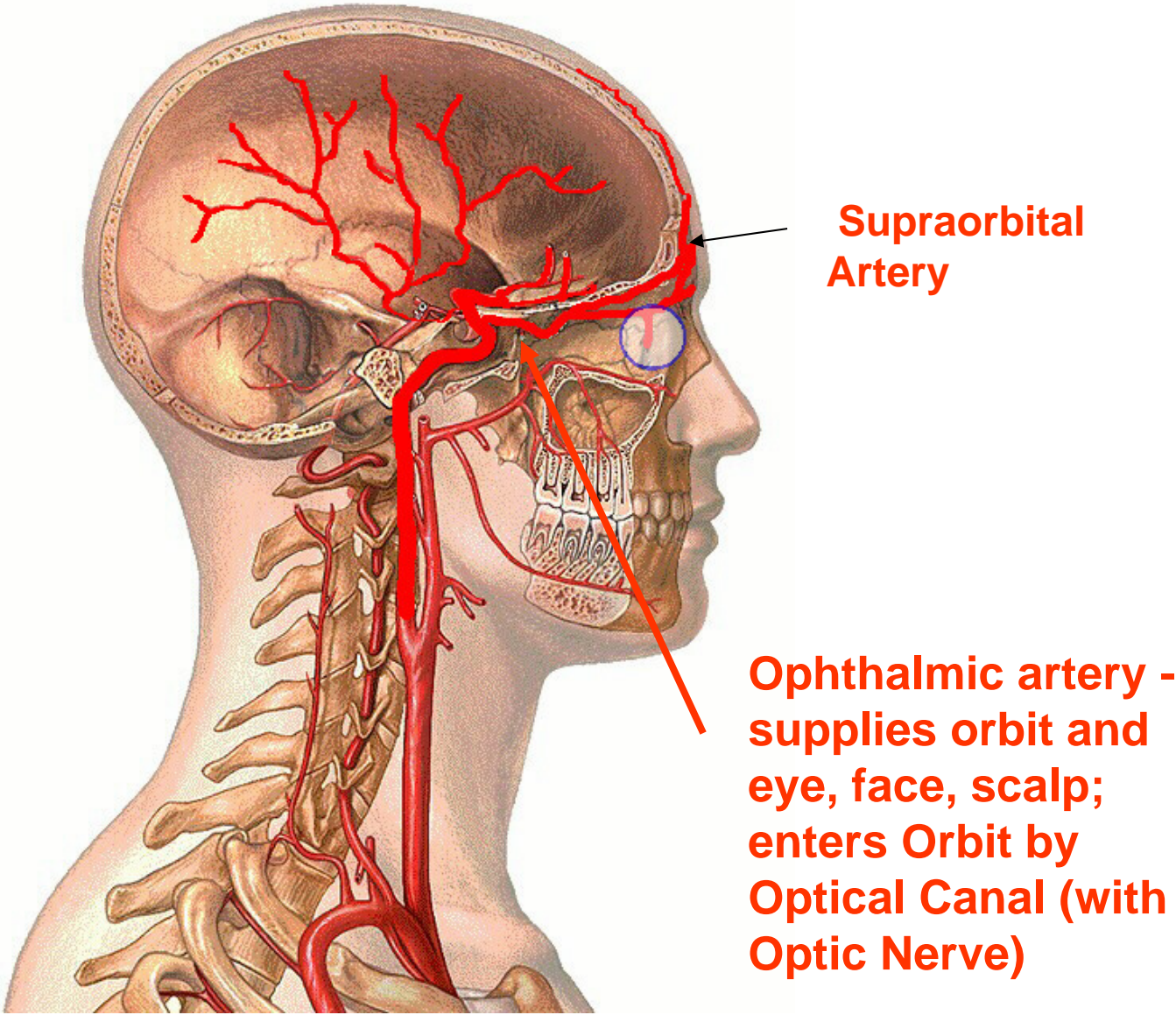
# CAROTID FISTULA

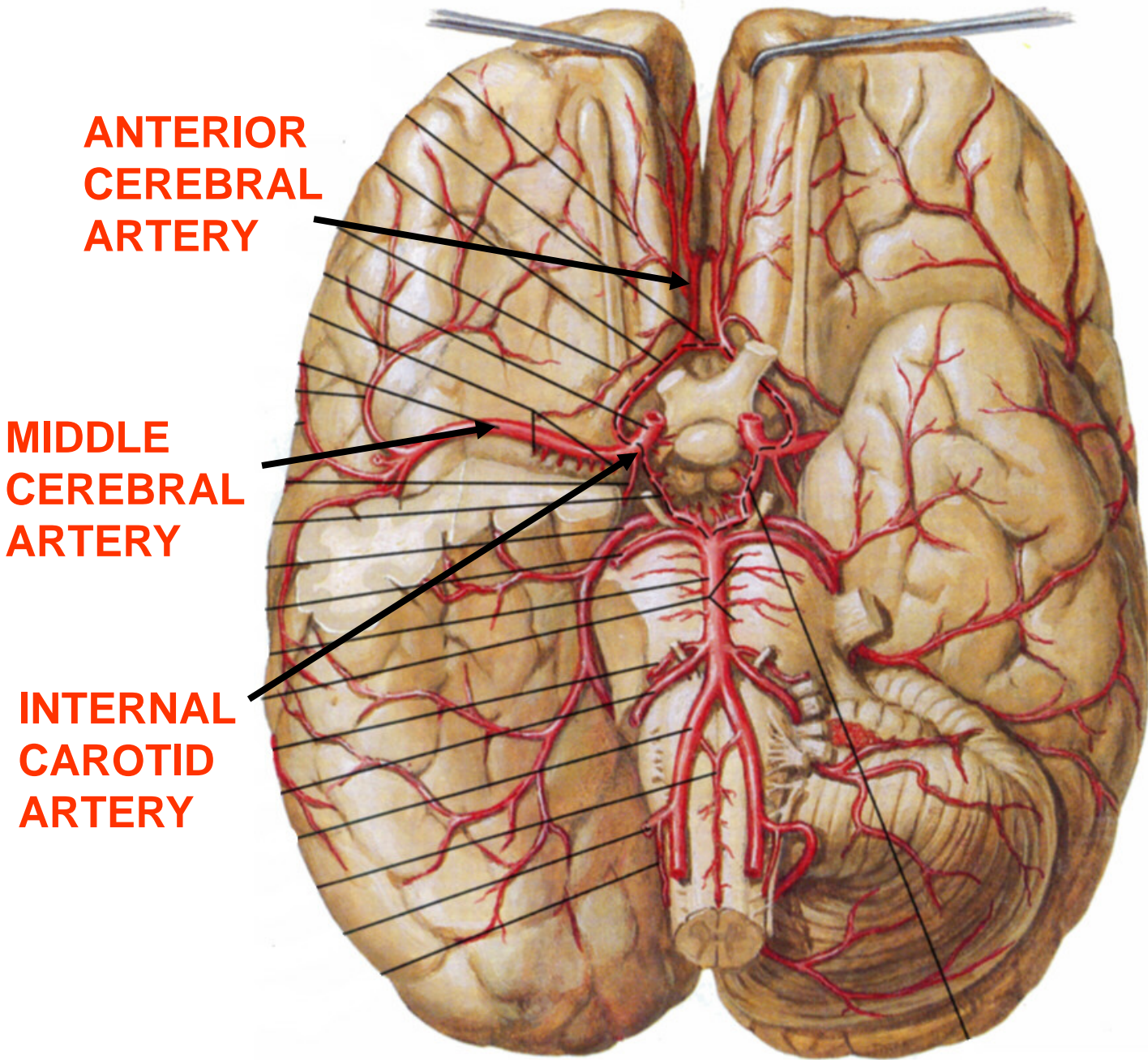


**Internal Carotid artery can rupture and bleed into Cavernous sinus (Carotid Fistula).**



# OPHTHALMIC ARTERY





**ANTERIOR  
CEREBRAL  
ARTERY**

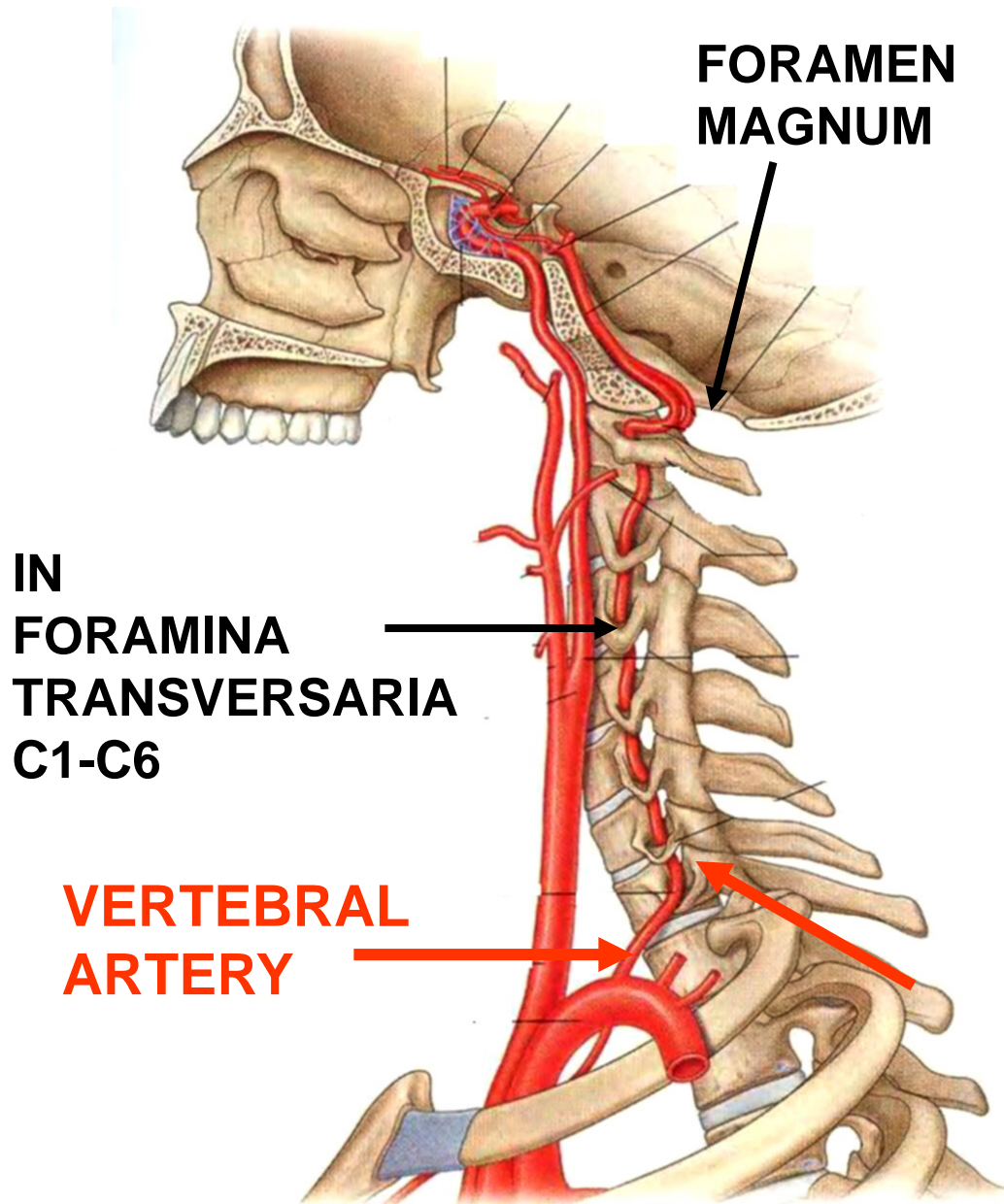
**MIDDLE  
CEREBRAL  
ARTERY**

**INTERNAL  
CAROTID  
ARTERY**

**Internal  
Carotid  
terminates  
by  
bifurcating  
into  
Anterior  
and  
Middle  
Cerebral  
arteries on  
each  
side**

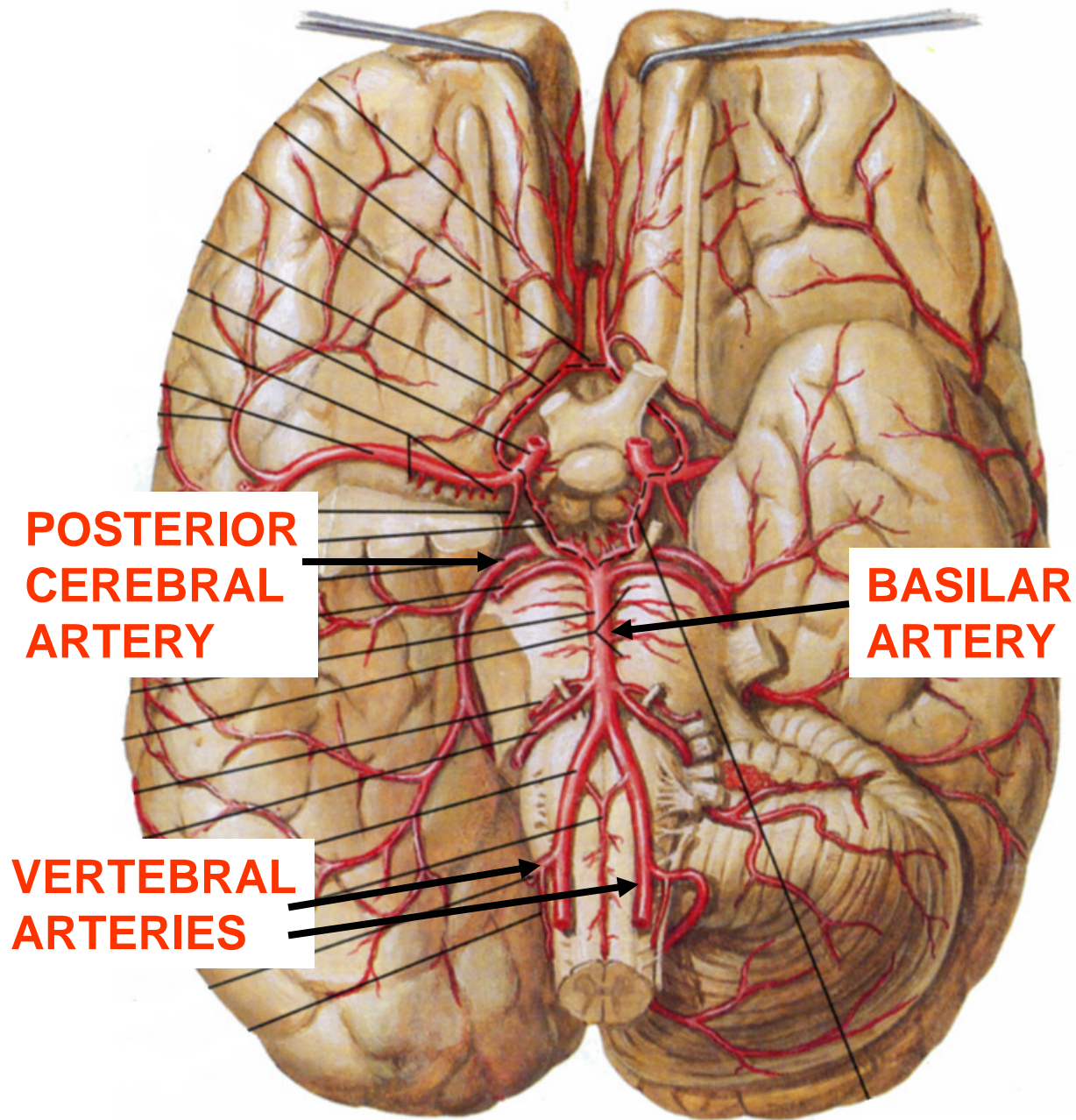


# VERTEBRAL ARTERY



Arises from  
Subclavian artery  
(first branch)  
- then courses  
through  
Foramina  
Transversaria of  
cervical vertebra  
(C1-C6)  
- enters skull via  
Foramen  
Magnum



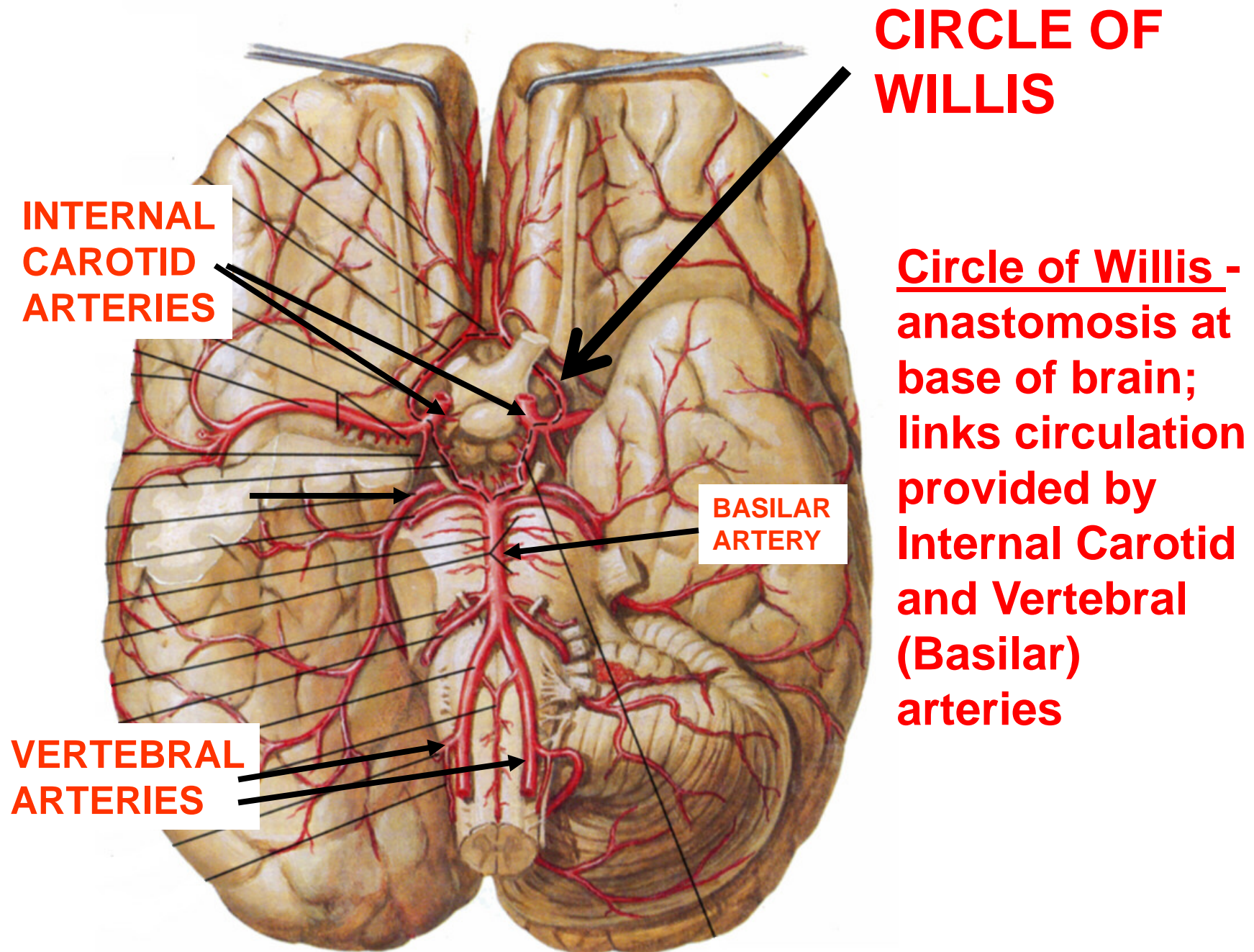


## VERTEBRAL ARTERY

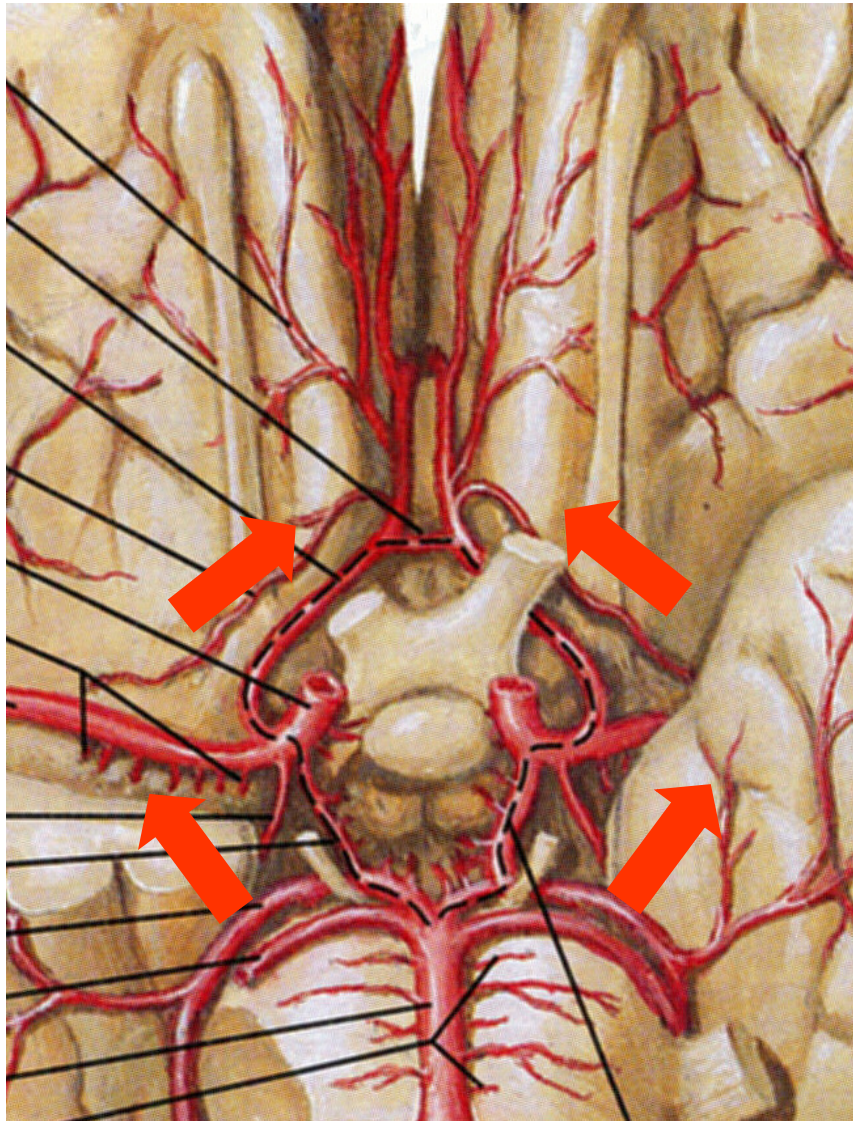
Vertebral artery courses on ventral surface of medulla -

- joins Vertebral artery of opposite side to form single **Basilar artery** (link of two sides assures adequate blood supply)

- Basilar artery terminates by giving rise to **Posterior Cerebral arteries** (one to a side).



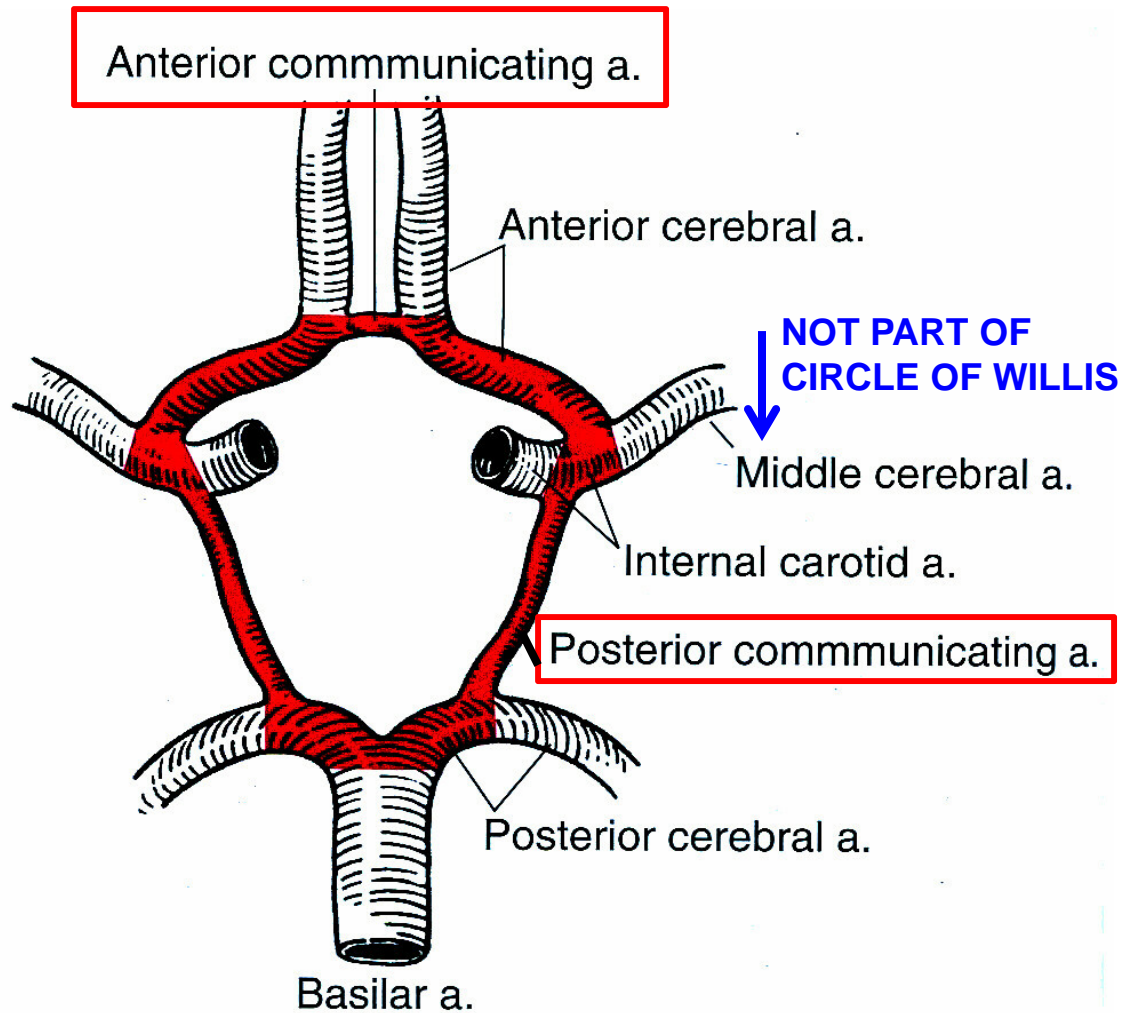




**CIRCLE OF WILLIS**  
- anastomosis at  
base of brain  
- links circulation  
provided by Internal  
Carotid and  
Vertebral arteries



# CIRCLE OF WILLIS

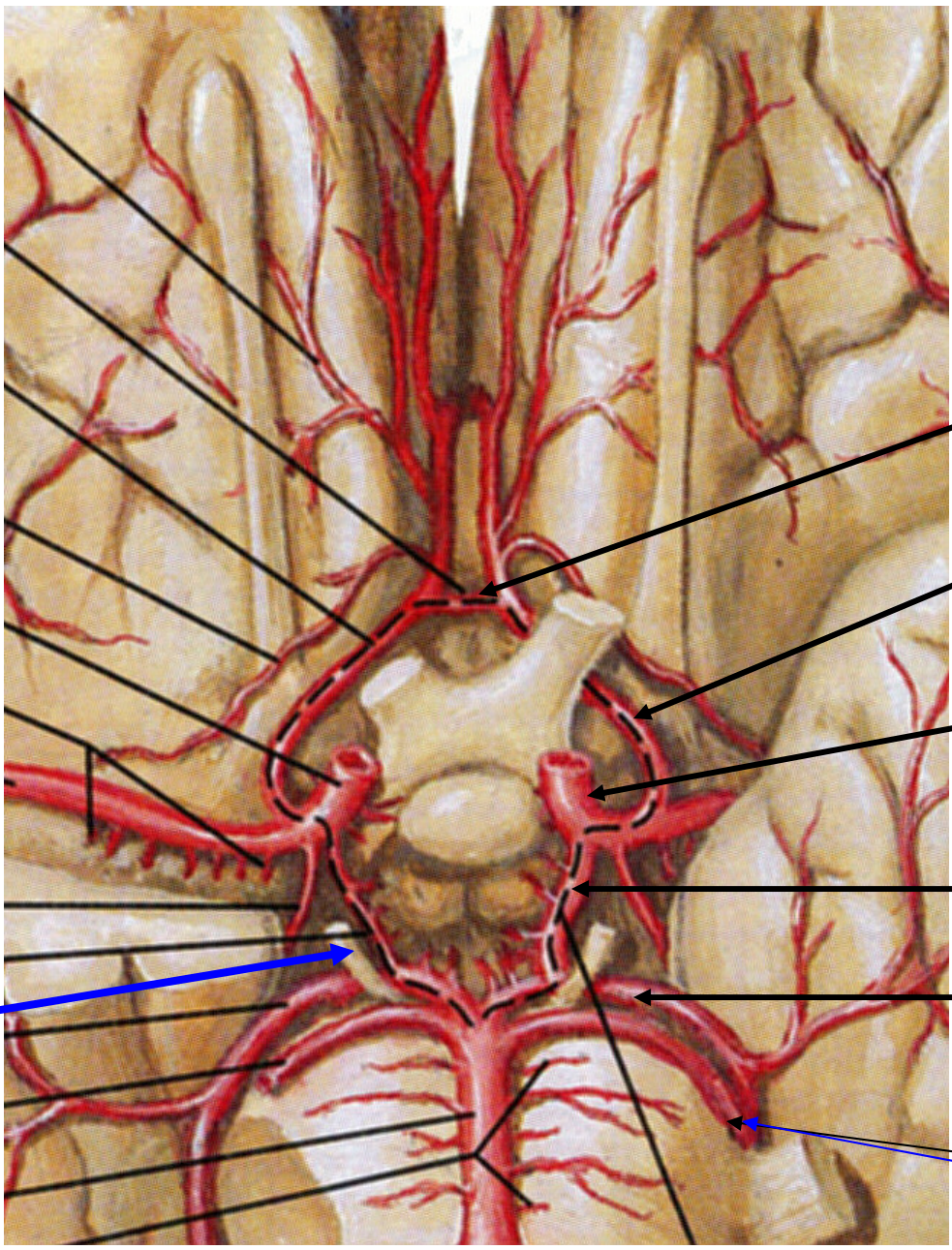


**note: All arteries in Circle are branches of Internal Carotid except Posterior Cerebral Artery**

formed on each side by

1. Posterior Cerebral Artery - from **Vertebral Artery**
2. Posterior Communicating artery - connects **Post. Cerebral to Int. Carotid**
3. Internal Carotid Artery
4. Anterior Cerebral Artery - from **Internal Carotid**
5. Anterior Communicating Artery - connects **Ant. Cerebral Arts. of two sides**

# CIRCLE OF WILLIS



ANTERIOR COMMUNICATING A.

ANTERIOR CEREBRAL A.

INTERNAL CAROTID A.

POST. COMMUNICATING A.

POST. CEREBRAL A.

(Superior Cerebellar artery)



**THOMAS WILLIS  
(1621-1675)**

**English physician  
and Neuroanatomist**

- **Arterial circle**
- **Neuroanatomy of  
cranial nerves**

**mustache**

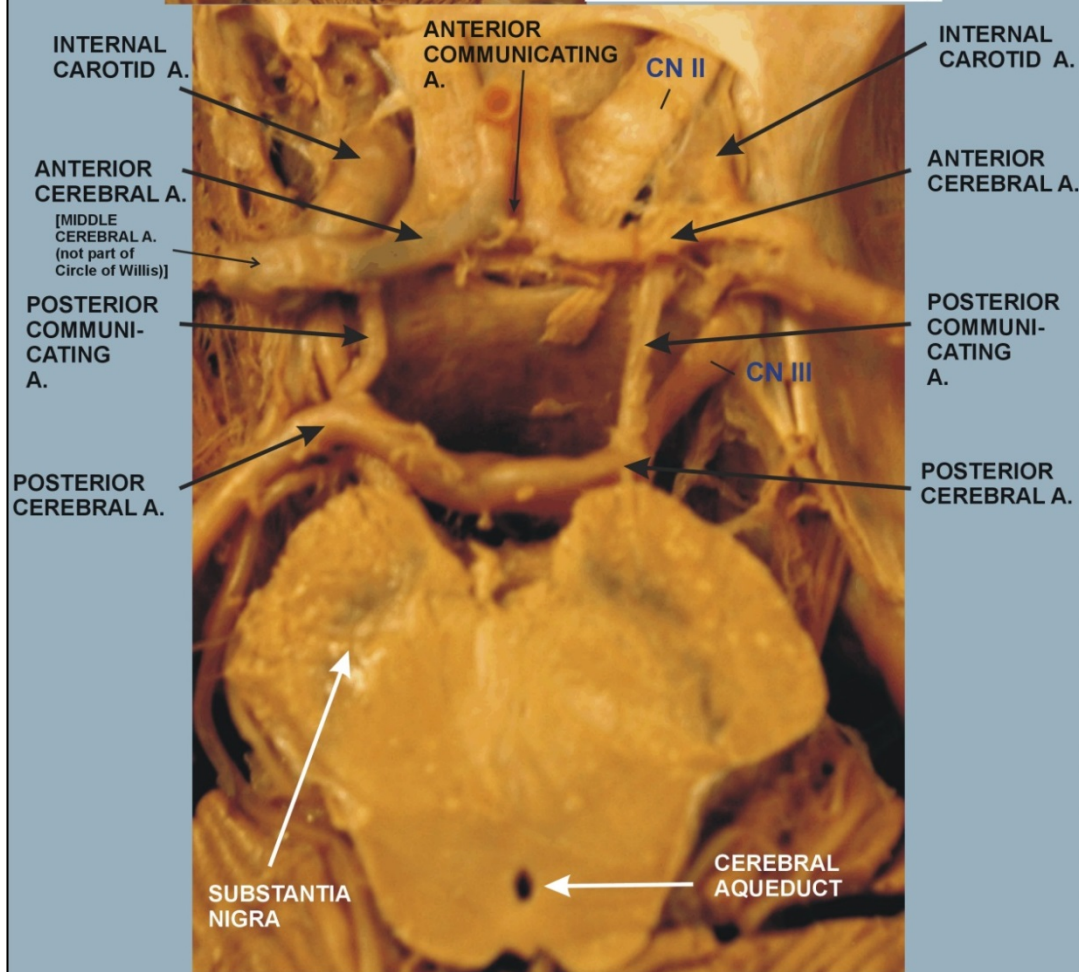
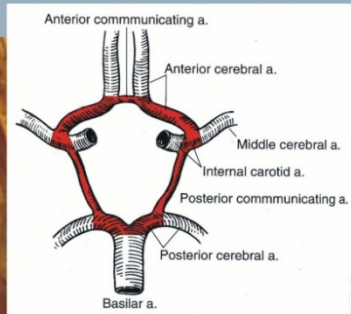




# CIRCLE OF WILLIS

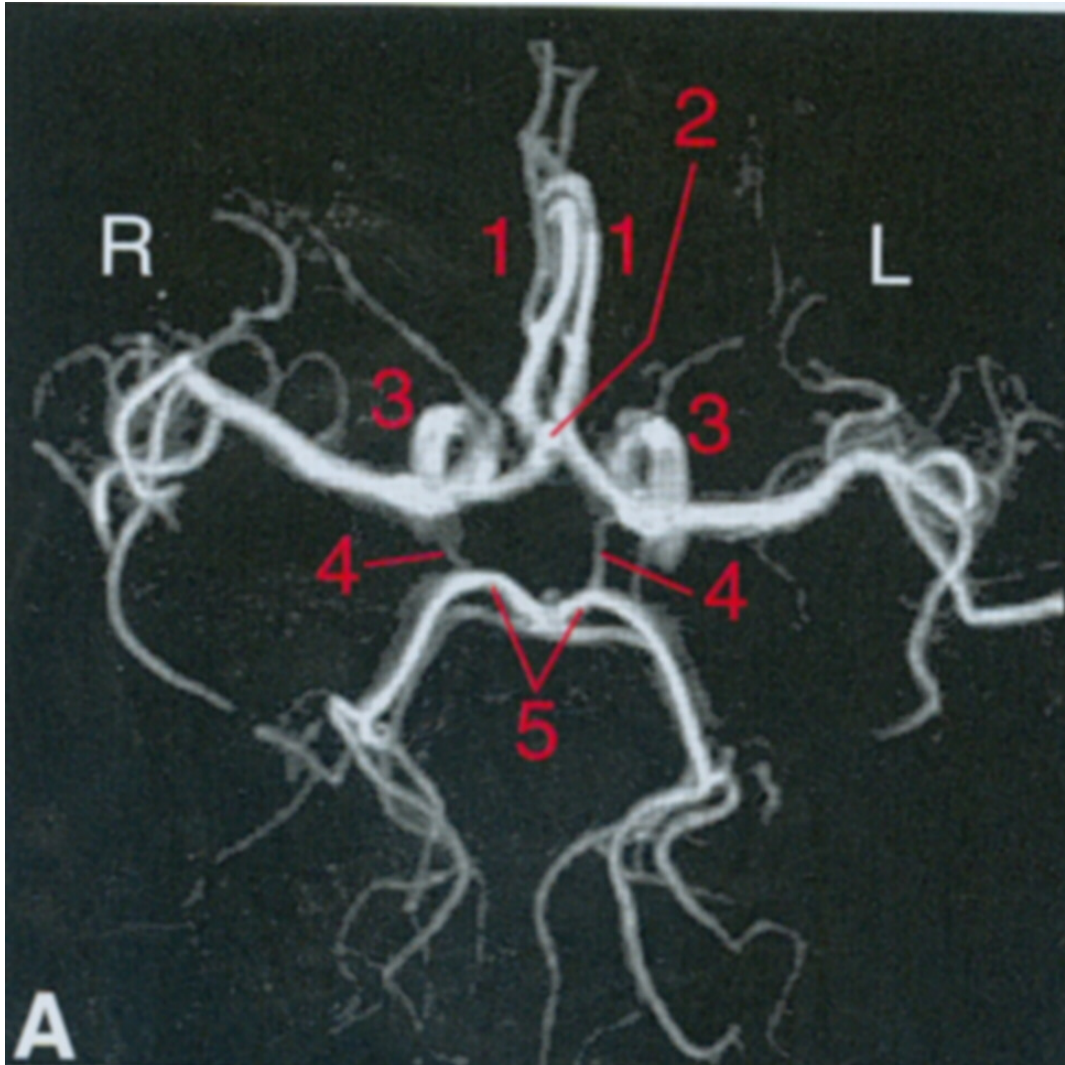
278

## ORIENT



# Adequacy of Collateral Circulation

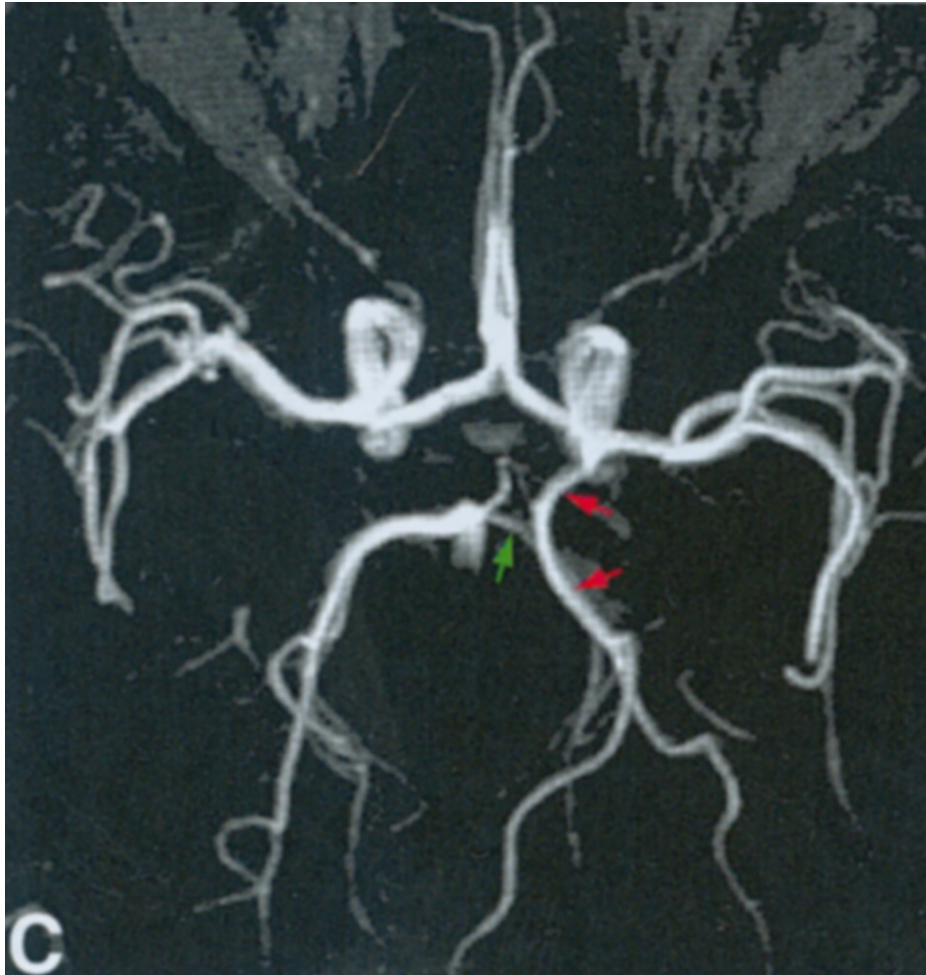
## MRA OF CIRCLE OF WILLIS



- in most cases of rapid occlusion, anastomosis is inadequate. Can dilate if occlusion is slow.

- 1- Ant. Cerebral
- 2- Ant. Communicating
- 3- Internal Carotid
- 4- Post. Communicating
- 5- Post. Cerebral

**Many Anatomical Variants** - 'Normal' less than 50%



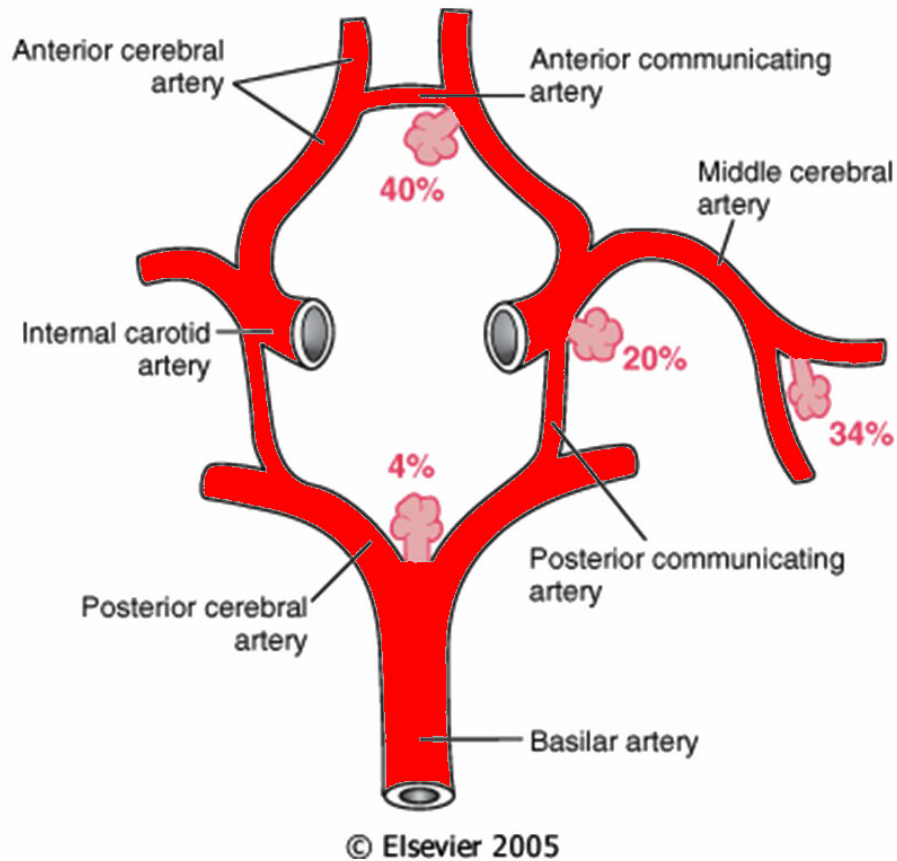
Post. Cerebral  
Origin from Internal  
Carotid - 20%

- Post. Cerebral  
arises from Int.  
Carotid. (red arrows)

- Post  
Communicating  
connects to Post.  
Cerebral from  
Basilar (green  
arrow)



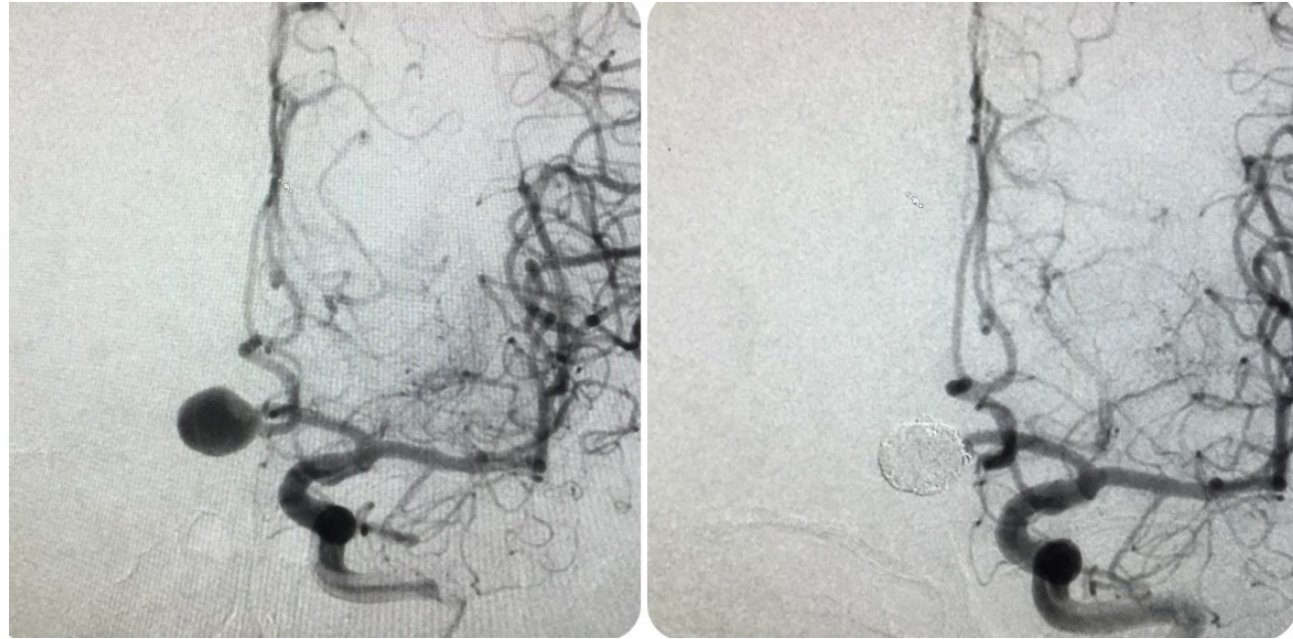
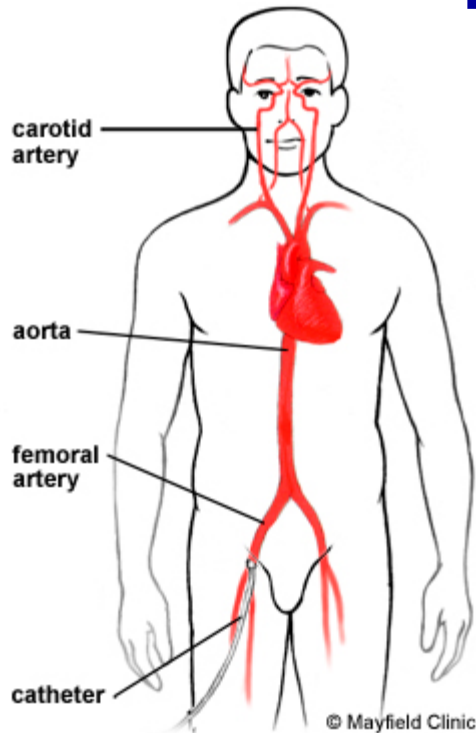
# BERRY ANEURYSMS = thin-walled outpouching of arteries



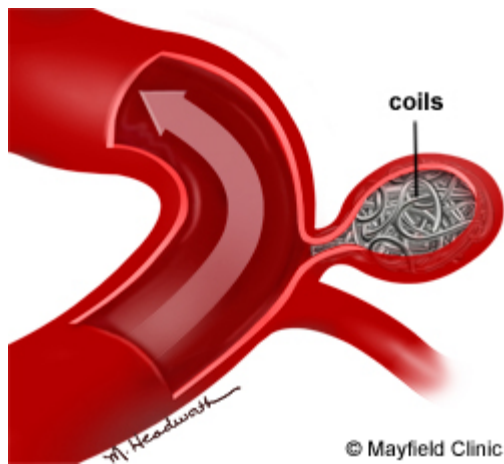
Many berry aneurysms are found in arteries of Circle of Willis



# TREATMENT: ENDOVASCULAR COILING



Images: thanks to Dalton Borders, MSI



A catheter is passed through the Femoral Artery up to the artery containing the aneurysm. Platinum or titanium coils are then released into the aneurysm. The coils induce clotting (embolization) and block blood flow to the aneurysm.

See Dr. Nancy Norton MSII Lecture: CNS Trauma, Vascular

## BERRY ANEURYSMS

1. **Etiology** (definition: cause or set of causes)  
- **Unknown, Most Sporadic**
2. Predisposing factors: **SMOKING, HYPERTENSION**
3. **NOT IDENTIFIABLE AT BIRTH**
4. Usually rupture at Apex
5. **First Rupture: 25-50% die**
6. Signs: Sudden excruciating headache, rapid loss of consciousness



# ANATOMY AND DIAGNOSTIC USE OF AUTONOMIC NERVOUS SYSTEM PATHWAYS

© 2018zillmusom

**I. GENERAL REVIEW OF AUTONOMIC NERVOUS SYSTEM** - Autonomic nervous system (= Visceral nervous system) is considered part of peripheral nervous that is not under voluntary control (Autonomic means automatic or self-regulating)

## A. OVERVIEW -

1. Autonomic nervous system innervates visceral structures: smooth and cardiac muscles, blood vessels, glands (sweat glands, salivary glands, etc) and internal organs (ex. GI tract, heart, etc.).

2. The autonomic nervous system is **often thought of as reactive** to stimuli (ex. fight or flight). However, many autonomics provide pathways for the CNS to **continuously regulate and control body functions**:

examples 1) Thermoregulation - regulate body temperature; 2) Cardiovascular function in heart and blood vessels - monitor and regulate heart rate, blood pressure, etc.;3) GI function - secretion, motility.

**B. Basic pathway - 2 neuron arc; pre-ganglionic neuron is in CNS;** axon leaves CNS; synapses in autonomic ganglion - post-ganglionic cell in autonomic ganglion innervates smooth muscle, glands, etc.

**C. Divergence** - Why have a two neuron arc? Autonomics can activate many targets at the same time. A single pre-ganglionic neuron synapses on many post-ganglionic neurons (ratio 1 pre/15 post up to 1 pre/200 post). This divergence can allow for widespread effects (ex. in thermoregulation, many sweat glands are activated simultaneously).

## D. Parts Autonomic Nervous System - Sympathetic and Parasympathetic: Review:

1. **Sympathetics: 'FIGHT OR FLIGHT'** - Out CNS at **Thoraco-Lumbar levels; ganglia close to CNS** (paravertebral); pre-ganglionics short, post-ganglionics long; Actions - ex. Increase heart rate, decrease gastric movements and secretions, decrease secretion of salivary glands.

2. **Parasympathetics: 'REST AND DIGEST'** - Out CNS at **Cranio-Sacral levels** (Cranial nerves and Sacral Spinal nerves); **ganglia close to target**; pre-ganglionics long, post-ganglionics short; Actions - ex. decrease heart rate, increase gastric movements and secretions; increase secretion of salivary glands.

**E. Asymmetry - Some body structures receive only Sympathetics NOT Parasympathetics - Classic description: 'Parasympathetics do not go to body wall'; examples:**

**1. Skin - sweat glands and arrector pilae muscles are only innervate by Sympathetics not Parasympathetics.**

**2. Peripheral blood vessels - Blood vessels are innervated by Sympathetics not parasympathetics.**

Consequence of Asymmetry: **Sympathetics are much more widely distributed than Parasympathetics** - pathways are more complex.

**F. Thermoregulation by sweating** - sweating decreases body temperature by evaporation; mediated by Sympathetics to skin.

**G. CNS Regulation** - Centers in the CNS regulate autonomic function (ex. brainstem reticular formation). The **Hypothalamus** (part of CNS) is a major center for regulation of autonomic function.

## **II. ANATOMICAL ORGANIZATION OF SYMPATHETIC PATHWAYS**

**A. Pathways** - Sympathetics (pre-ganglionic neurons) come out Spinal cord (at Thoracic and Upper Lumbar Levels); can do three things.

**1. Synapse in ganglion at level of outflow** - Pre-ganglionics course in Communicating rami (connect to Sympathetic ganglion); Post-ganglionics join spinal nerve of that segment. (ex. Skin of thorax - innervated by Intercostal nerves).

**2. Ascend or descending chain and synapse in other ganglia of chain;** Post-ganglionics then course in Communicating rami to join spinal nerves at those segments (ex. cervical spinal nerves of Brachial plexus).

**3. Not synapse in chain; pre-ganglionics continue to ganglia nearer to target organ;** ex. Splanchnic nerves to gut (covered in Spring semester)

## **III. SYMPATHETICS TO HEAD AND HORNER'S SYNDROME**

**A. Sympathetic pathway** - Sympathetics to head come **out T1 and T2; ascend sympathetic chain; Synapse in Superior Cervical Ganglion;** Post-ganglionics **distributed with plexus on Carotid arteries.**

**B. Horner's Syndrome - interruption/damage to Sympathetic pathway**

<u>Symptom</u>	<u>Structure innervated</u>	<u>Damage</u>
Anhydrosis (lack of sweating)	Sweat glands in skin	lack of sweating in skin (ex. forehead)
Ptosis (eyelid droop)	Levator Palpebrae Superioris - sympathetics to Smooth muscle part	Levator lifts upper eyelid; damage produces eyelid droop
Miosis (constricted pupil)	Pupillary Dilator muscle	Damage paralyzes Dilator muscle; pupil is constricted (Constrictor Pupillae muscle is intact - innervation CN III)

**3. Differential Diagnosis of Ptosis = EYELID DROOP; cause - damage to innervation of Levator Palpebrae Superioris - Levator Palpebrae Superioris is innervated by both Sympathetics and Somatic Motor Neurons (CN III, Oculomotor); however, differential effects on Pupil of Eye, Sweat glands.**

<u>Structure</u>	<u>Horner's Syndrome</u>	<u>Oculomotor Palsy (nerve damage)</u>
Upper eyelid	Ptosis (eyelid droop) - paralyze Smooth muscle part of Levator Palpebrae Superioris	Ptosis (eyelid droop) - paralyze Skeletal muscle part of Levator Palpebrae Superioris
Pupil of eye	Pupil constricted (Miosis) - Pupillary Dilator muscle paralyzied; Pupillary constrictor muscle intact	Pupil dilated (Mydriasis) - Pupillary constrictor muscle paralyzied; Dilator muscle is intact
Sweat glands in skin	Anhydrosis - lack of sweating in skin (ex. forehead)	No effect (parasympathetics do not innervate skin)

**Also: Eye Movements - Oculomotor nerve innervates Extraocular muscles; damage effects eye movements; no deficit in eye movements in Horner's syndrome.**

**Note: Others causes of Ptosis - Myasthenia Gravis; Aponeurotic ptosis (levator palpebrae loses insertion to tarsal plate); Orbital Fracture; etc.**



# ANATOMY AND DIAGNOSTIC USE OF AUTONOMIC NERVOUS SYSTEM PATHWAYS

## GOALS:

1) UNDERSTAND STRUCTURES AND PATHWAYS SEEN IN GROSS ANATOMY PROSECTIONS OF AUTONOMICS - **SEE IN JANUARY**

2) REVIEW AUTONOMICS TO EYE FOCUS: **HORNER'S SYNDROME** - damage to Sympathetic pathways:

## SYMPTOMS -

**MIOSIS** - pupillary constriction

**PTOSIS** - drooping eyelid

**ANHYDROSIS** - lack of sweating

**CLINICALLY IMPORTANT**

## HORNER'S SYNDROME



# OUTLINE

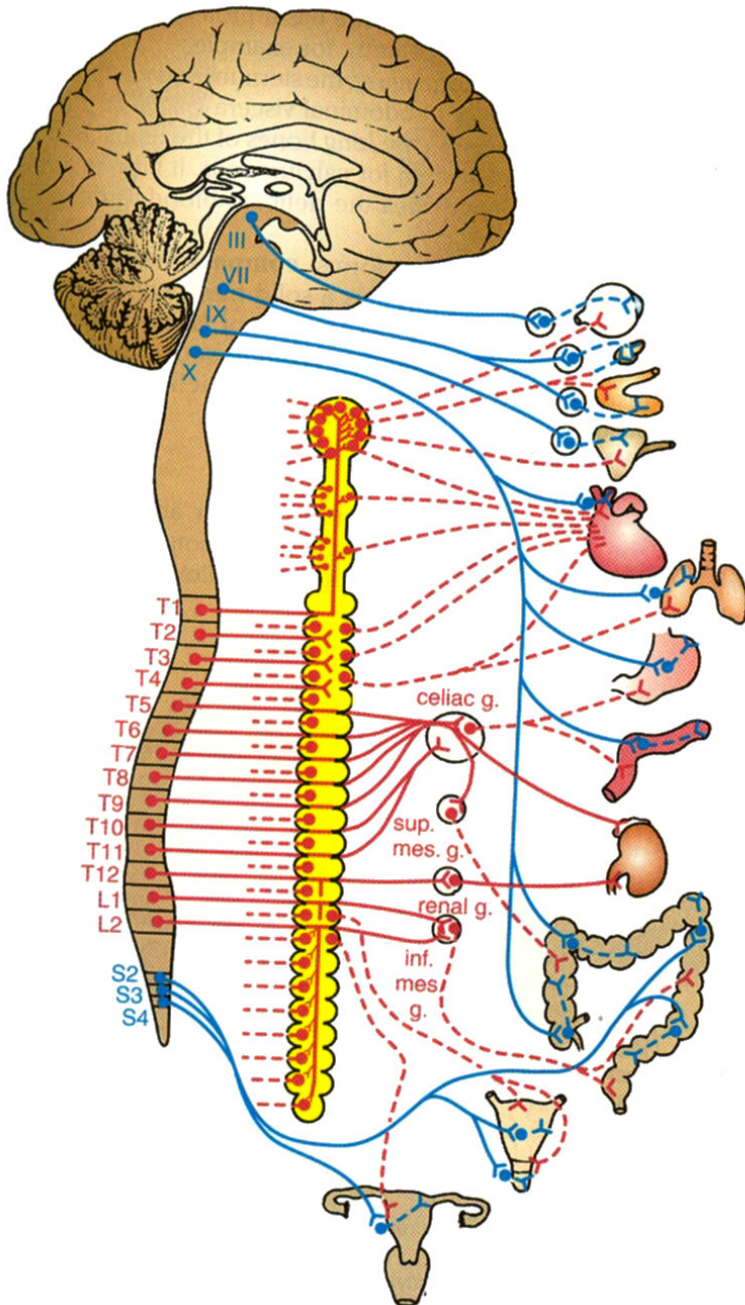
**1. GENERAL REVIEW OF AUTONOMIC NERVOUS SYSTEM -**  
**Sympathetics and Parasympathetics - Asymmetry:**  
**Sympathetics are widespread; Parasympathetics are much more localized (except Vagus nerve)**

**Why? Sympathetics go to Skin, not Parasympathetics; ex. control of sweating**

**2. ANATOMY OF SYMPATHETIC PATHWAYS** - structures can be seen in prosections **NEXT JANUARY.**

**3. SYMPATHETICS TO HEAD AND HORNER'S SYNDROME (= damage to Sympathetics)** - **CLINICAL FOCUS:** Autonomic pathways to **EYE** (and head) are **used diagnostically**

## GENERAL REVIEW AUTONOMIC = VISCERAL NERVOUS SYSTEM



Autonomic Nervous system = Visceral nervous system -part of peripheral nervous system; **involuntary, unconscious part of nervous system**; (autonomic means self-regulating or automatic)

a. Visceral Motor (parasympathetic and sympathetic efferents) -

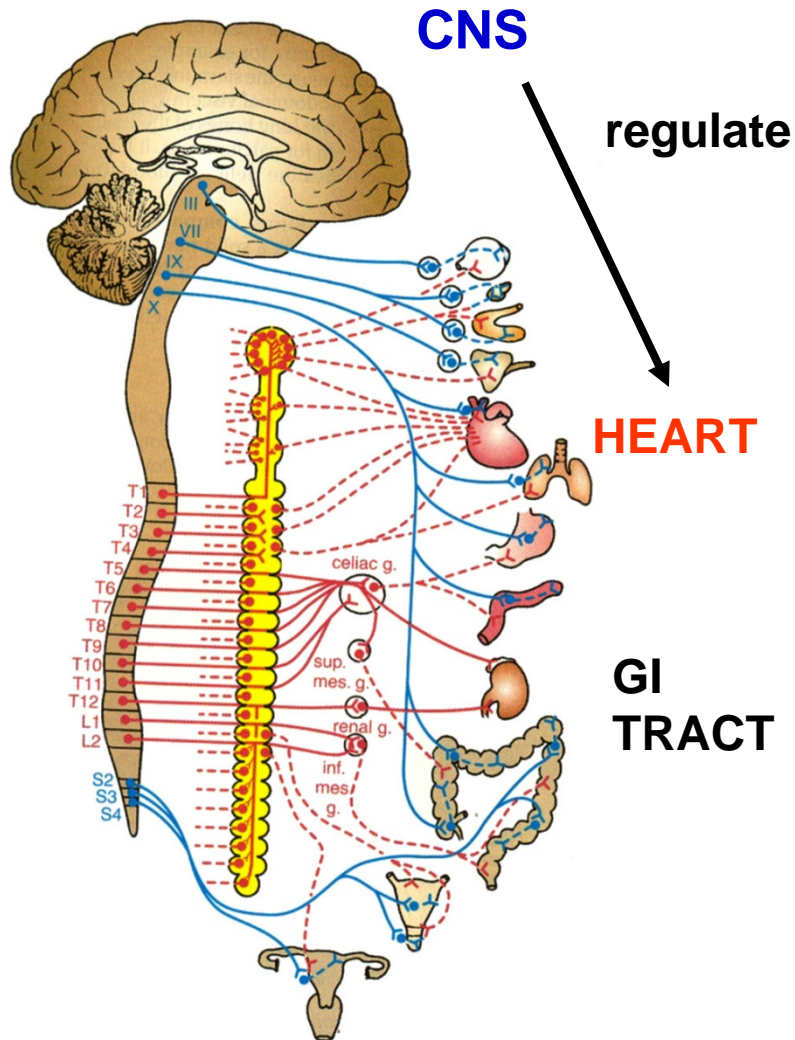
innervate **smooth and cardiac muscle, blood vessels glands (ex. sweat glands) and internal organs**; largely unconscious actions.

b. Visceral Sensory (afferents) -

sensory neurons that innervate internal organs, blood vessels; only provide **imprecise localization of sensation** and dull sense of pressure, pain, etc.



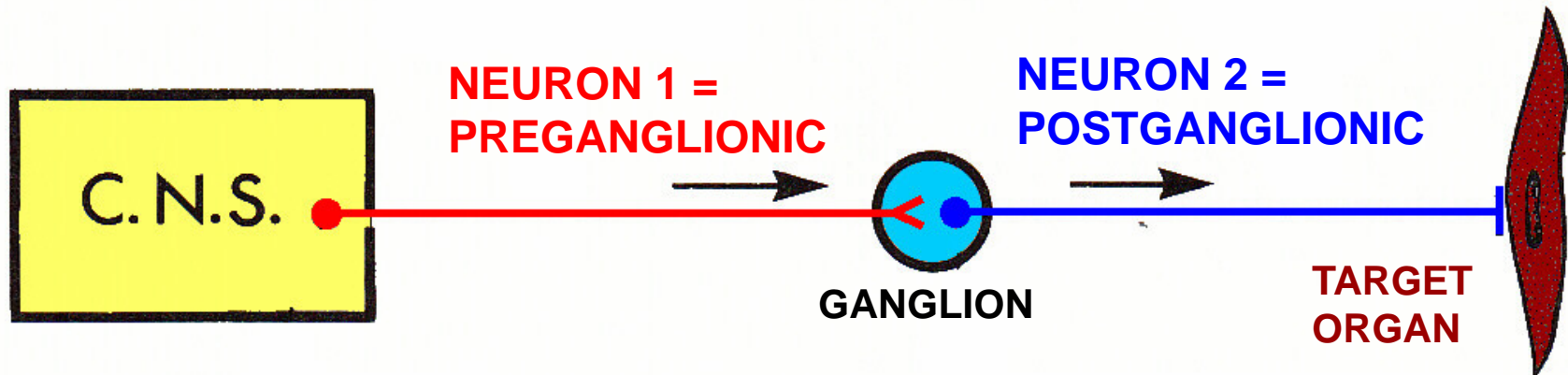
# AUTONOMICS ARE NOT JUST REACTIVE BUT CONTINUOUSLY REGULATES AND CONTROLS BODY FUNCTIONS (HOMEOSTASIS)



The autonomic nervous system is often **thought of as reactive to stimuli (ex. fight or flight)**. However, many autonomies provide pathways for the CNS to **continuously regulate and control body functions:**  
ex

- 1) Thermoregulation - regulate body temperature
- 2) Cardiovascular function in heart and blood vessels - monitor and regulate heart rate, blood pressure, etc.
- 3) GI function - secretion, motility

# VISCERAL MOTOR = AUTONOMIC NERVOUS SYSTEM



All two neuron pathways:

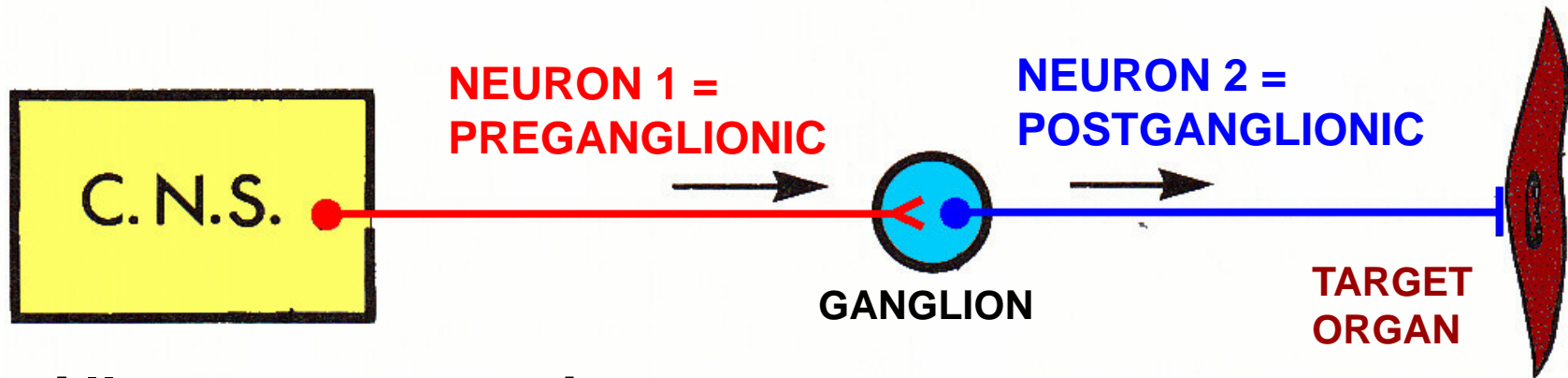
- 1) **Neuron 1 = Preganglionic neuron** - cell body in CNS; axon leaves CNS and synapses in autonomic ganglion
- 2) **Neuron 2 = Post ganglionic neuron** - cell body in autonomic ganglion; axon goes to target organ

note: **Sympathetic - ganglia close to vertebrae**  
**Parasympathetic - ganglia close to target organ**

**Sympathetic - preganglionic short; postganglionic long**

**Parasympathetic - preganglionic long; postganglionic short**

## BASIC PATHWAY: 2 NEURON ARC



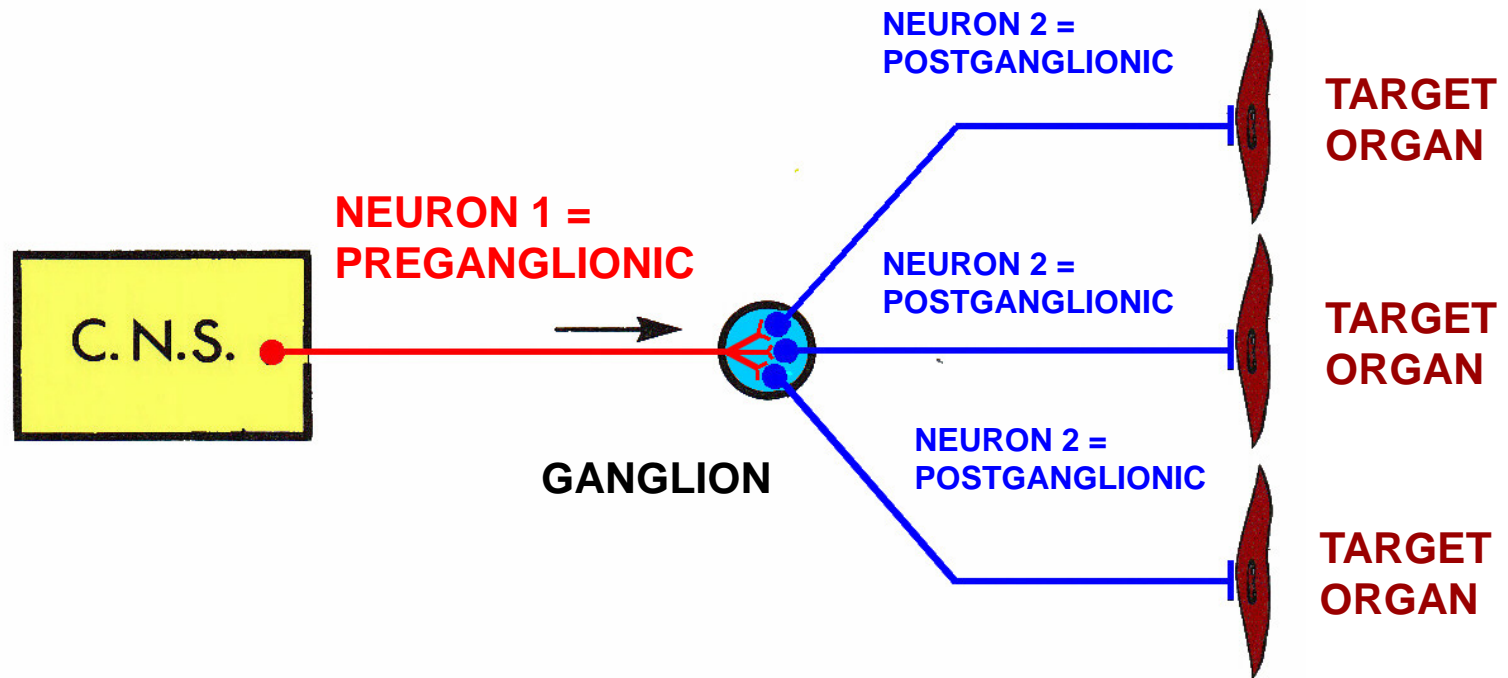
All two neuron pathways:

- 1) **Neuron 1 = Pre-ganglionic neuron** - cell body in CNS; axon leaves CNS and synapses in autonomic ganglion
- 2) **Neuron 2 = Post-ganglionic neuron** - cell body in autonomic ganglion; axon goes to target organ

# WHY?



## DIVERGENCE : AUTONOMICS CAN ACTIVATE MANY TARGETS SIMULTANEOUSLY



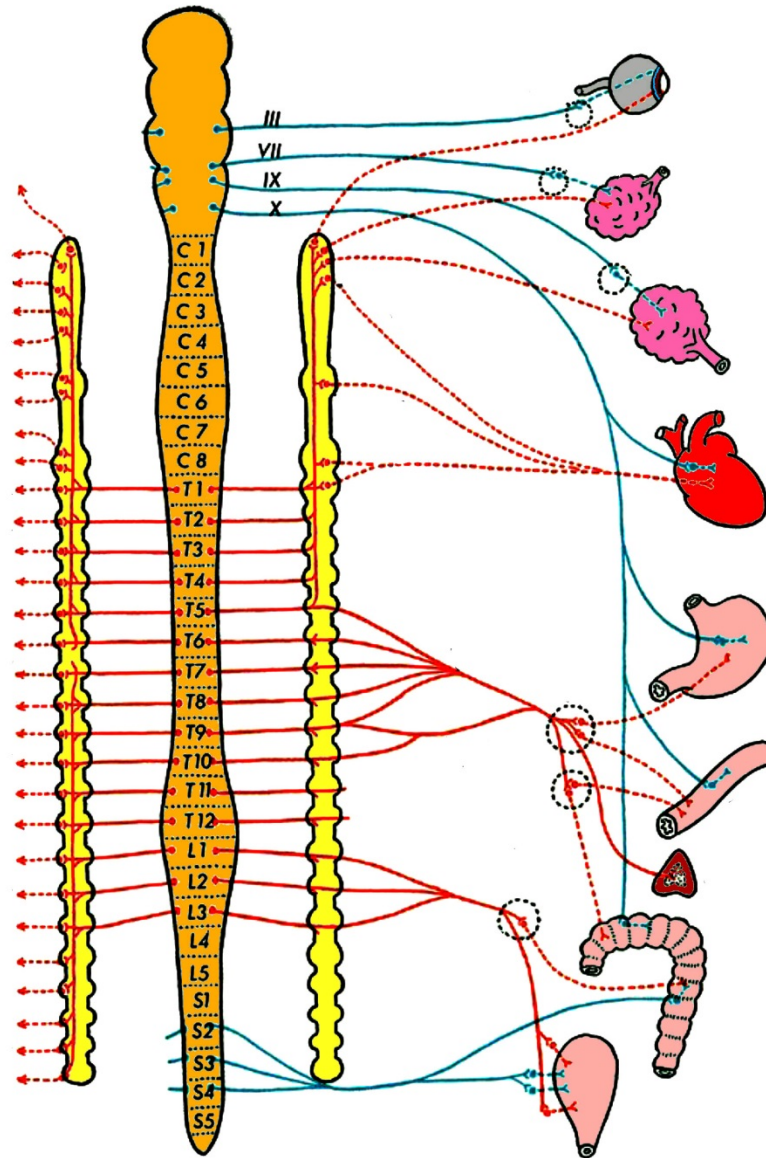
Considerable divergence of signal - One Pre-ganglionic neuron usually activates many (15 - 200) Post-ganglionic neurons; Autonomics can activate many targets simultaneously (ex. Thermoregulation - many sweat glands secrete at the same time)

# PARTS OF AUTONOMIC NERVOUS SYSTEM: SYMPATHETICS AND PARASYMPATHETICS

SYMPATHETICS  
– ‘FIGHT OR FLIGHT’

OUT: Thoraco-lumbar levels

GANGLIA: Near CNS (most)



PARA-SYMPATHETICS  
– ‘REST AND DIGEST’

OUT: Cranio-sacral levels

GANGLIA: Near TARGET (all)

**TWO DIVISIONS - PARASYMPATHETIC AND SYMPATHETIC** - in some systems have opposite effects  
examples:

<b>SYSTEM</b>	<b><u>SYMPATHETIC - 'FIGHT OR FLIGHT'</u></b>	<b><u>PARASYMPATHETIC - REST AND DIGEST</u></b>
<b>HEART</b>	<b>INCREASE RATE, CONTRACTION</b>	<b>DECREASE RATE</b>
<b>GI SYSTEM</b>	<b>DECREASE STOMACH MOVEMENTS, DECREASE SECRETIONS</b>	<b>INCREASE STOMACH MOVEMENTS, INCREASE SECRETIONS</b>
<b>SALIVARY GLANDS</b>	<b>DECREASE SECRETION</b>	<b>INCREASE SECRETION</b>



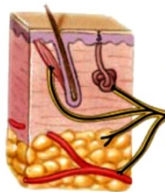
# ASYMMETRY: SOME BODY STRUCTURES RECEIVE ONLY SYMPATHETICS NOT PARASYMPATHETICS

## SYMPATHETICS

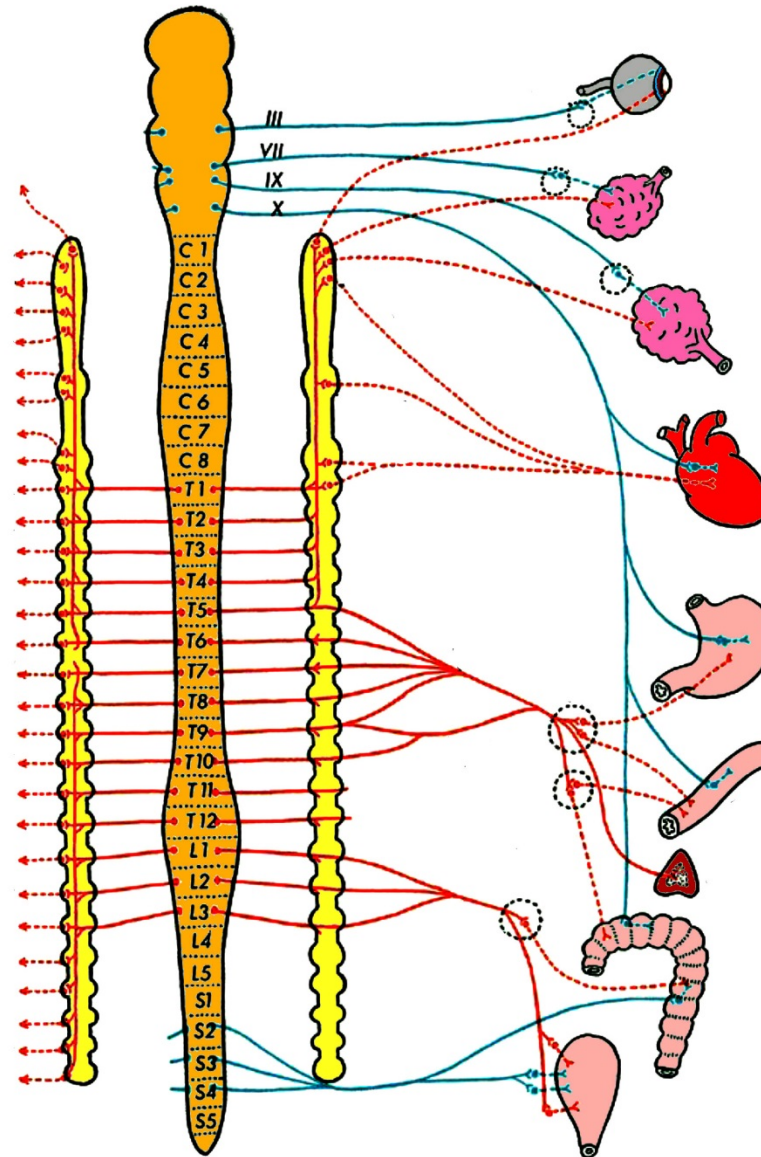
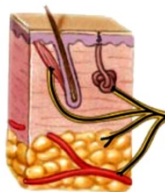
INNERVATE:

- 1) Skin
- 2) Peripheral blood vessels

SKIN



SKIN



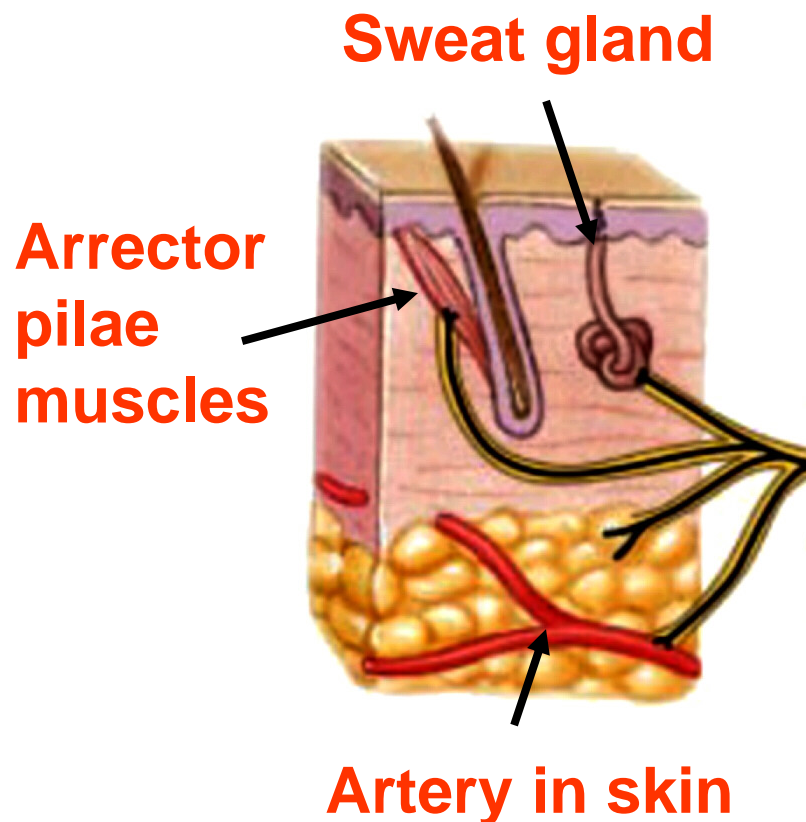
## PARA-SYMPATHETICS

INNERVATE:

Do NOT innervate skin and peripheral blood vessels

Classic description:  
Para-sympathetics do not go to the body wall

# STRUCTURES OF SKIN ARE INNERVATED ONLY BY SYMPATHETICS (NOT PARASYMPATHETICS)



**ONLY RECEIVE SYMPATHETICS,  
NOT PARASYMPATHETICS  
(examples)**

**1) SKIN - sweat glands, arrector  
pilae muscles**

**2) PERIPHERAL BLOOD VESSELS**

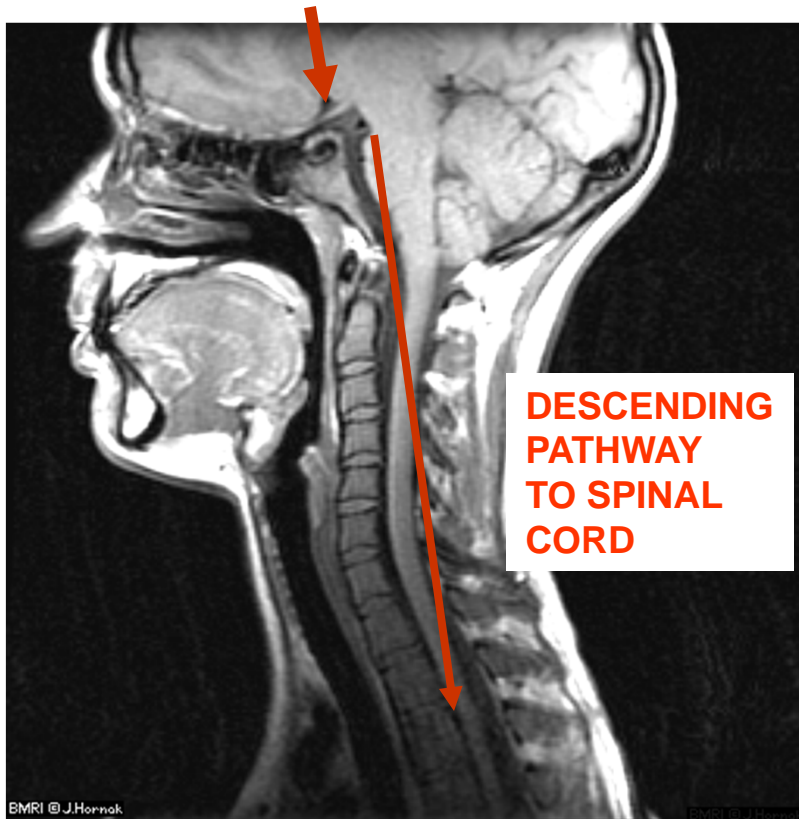
**Consequence; SYMPATHETICS  
ARE ANATOMICALLY MUCH  
MORE WIDESPREAD THAN PARA-  
SYMPATHETICS; PATHWAYS  
MORE COMPLEX**

**CLINICAL**

**SWEAT GLANDS ARE ONLY INNERVATED BY SYMPATHETICS**

# THERMOREGULATION - controlled in HYPOTHALAMUS

## HYPOTHALAMUS



SIGNALS FROM HYPOTHALAMUS PROJECT VIA HYPOTHALMOSPINAL TRACT (+brainstem) TO AUTONOMIC NUCLEI IN SPINAL CORD (LATERAL HORN)

## RESPONSES TO INCREASED TEMPERATURE (Anterior Hypothalamus/Preoptic area)

(Anterior Hypothalamus/Preoptic area)

- Peripheral Vasodilation
- Increased Sweating
- Water and Electrolyte retention

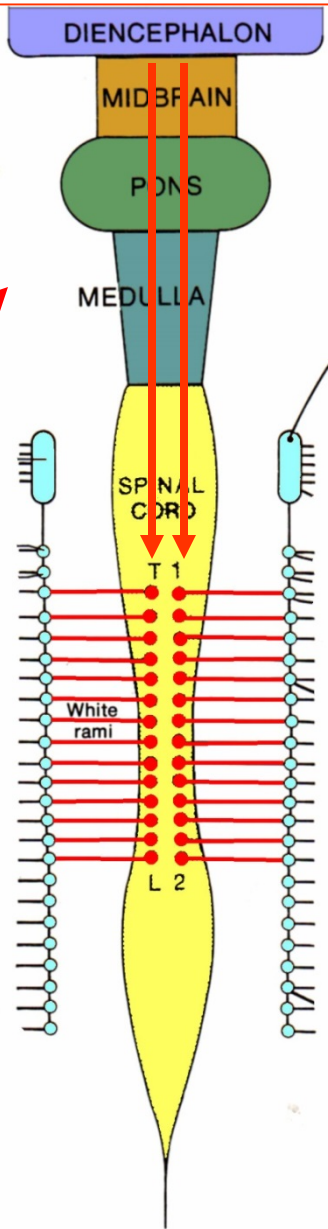
## RESPONSES TO DECREASED TEMPERATURE (Caudal hypothalamus)

- Peripheral vasoconstriction
- Decreased sweating
- Contract arrector pilae muscles
- Shivering



**BRAIN -  
parts of  
brainstem**

**HYPOTHALAMUS**



**HYPOTHALMUS:  
CONTROL OF  
SYMPATHETIC  
FUNCTION**

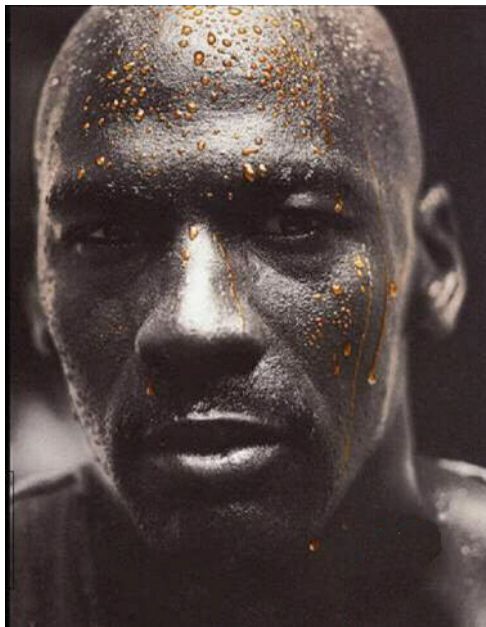
**Hypothalamo-  
spinal tract -  
signals to  
Pre-ganglionic  
neurons in  
Spinal Cord**

**Sympathetic  
outflow at  
Thoracic and  
Lumbar  
levels**

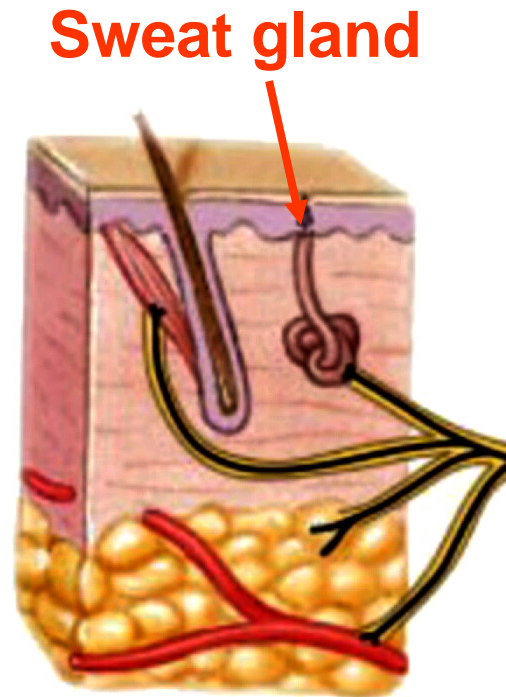
**MEDIATED BY  
SYMPATHETICS**

# SOME REGULATORY PROCESS REQUIRE WIDESPREAD ACTIVATION OF TARGET ORGANS

## EXAMPLE: THERMOREGULATION



Michael Jordan sweating  
Gatorade (\$)



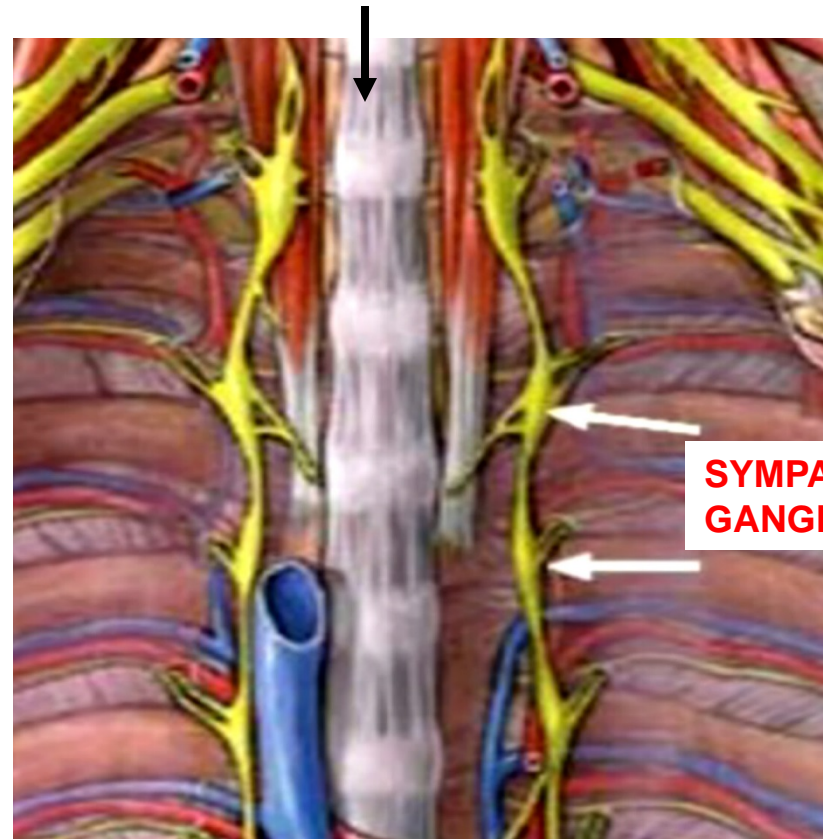
RESPONSE TO  
CHANGES IN BODY  
TEMPERATURE  
MEDIATED BY  
SYMPATHETICS (NOT  
PARASYMPATHETICS)

INCREASED  
TEMPERATURE  
- increased secretion  
of sweat glands

There are over 2 million sweat glands in the human body; how does the Nervous system activate them simultaneously?

**SYMPATHETICS HAVE WIDESPREAD EFFECTS BY SYMPATHETIC CHAIN - called Paravertebral Ganglia**

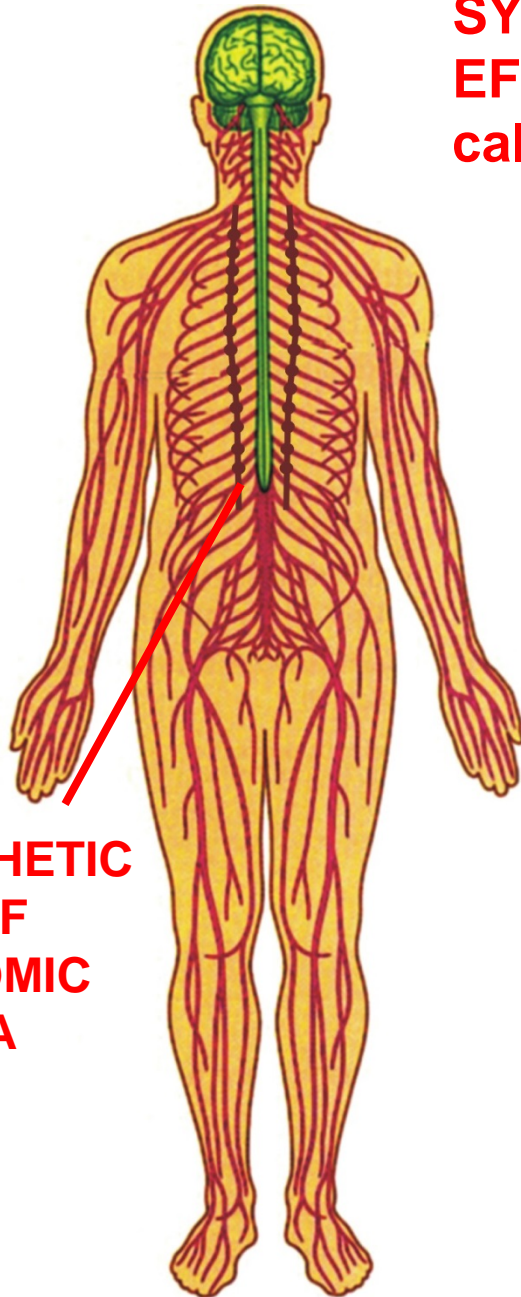
**Bodies of Thoracic Vertebrae (anterior side)**



**SYMPATHETIC GANGLIA**

**View of the anterior side (front) of vertebrae inside the thorax (chest cavity); chain of ganglia are on sides of vertebrae (paravertebral)**

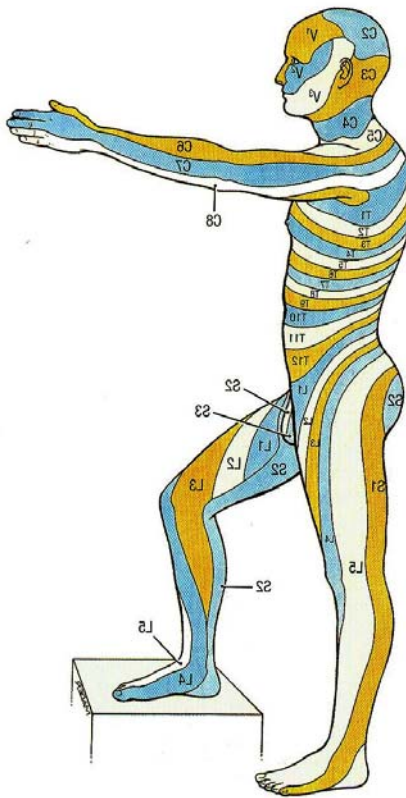
**SYMPATHETIC CHAIN OF AUTONOMIC GANGLIA**



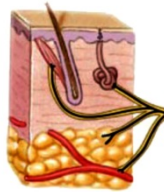


# SYMPATHETICS ARE DISTRIBUTED WITH PERIPHERAL NERVES

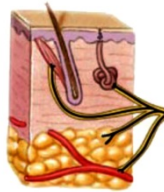
## PATHWAYS TO SKIN



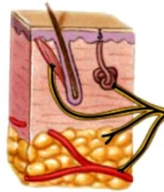
SKIN



SKIN



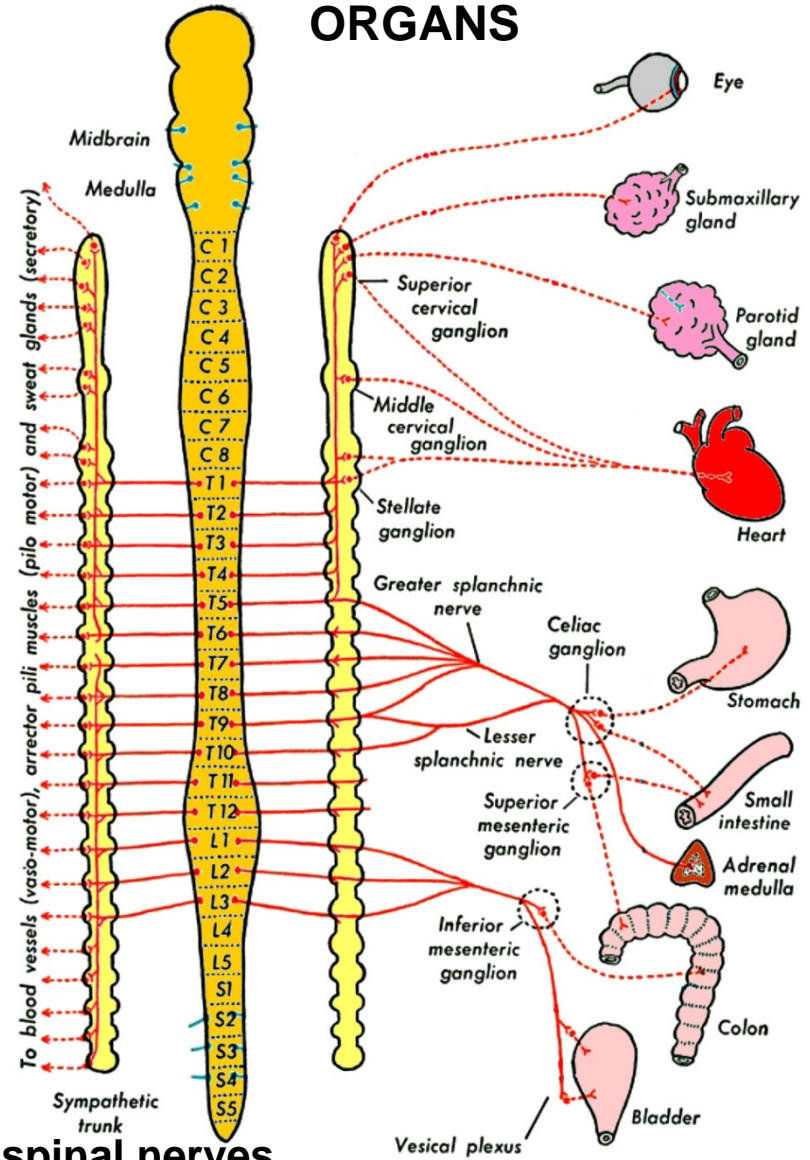
SKIN



## PATHWAYS TO SKIN

- sympathetics make up ~8% of axons in spinal nerves

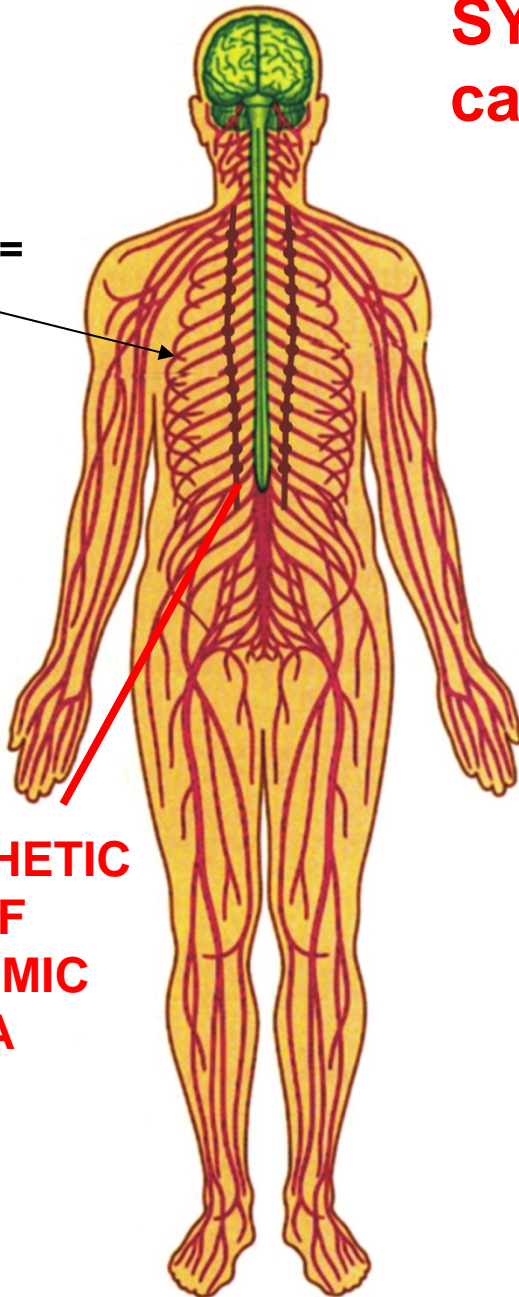
## PATHWAYS TO INTERNAL ORGANS



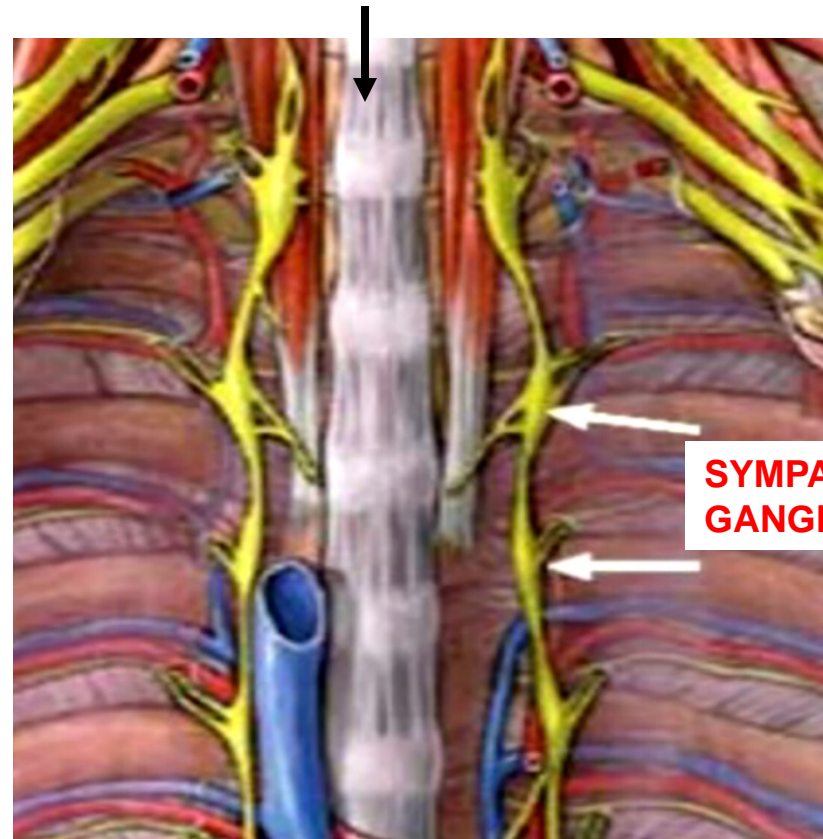
# SYMPATHETIC CHAIN OF GANGLIA - called Paravertebral Ganglia

THORAX =  
CHEST

SYMPATHETIC  
CHAIN OF  
AUTONOMIC  
GANGLIA



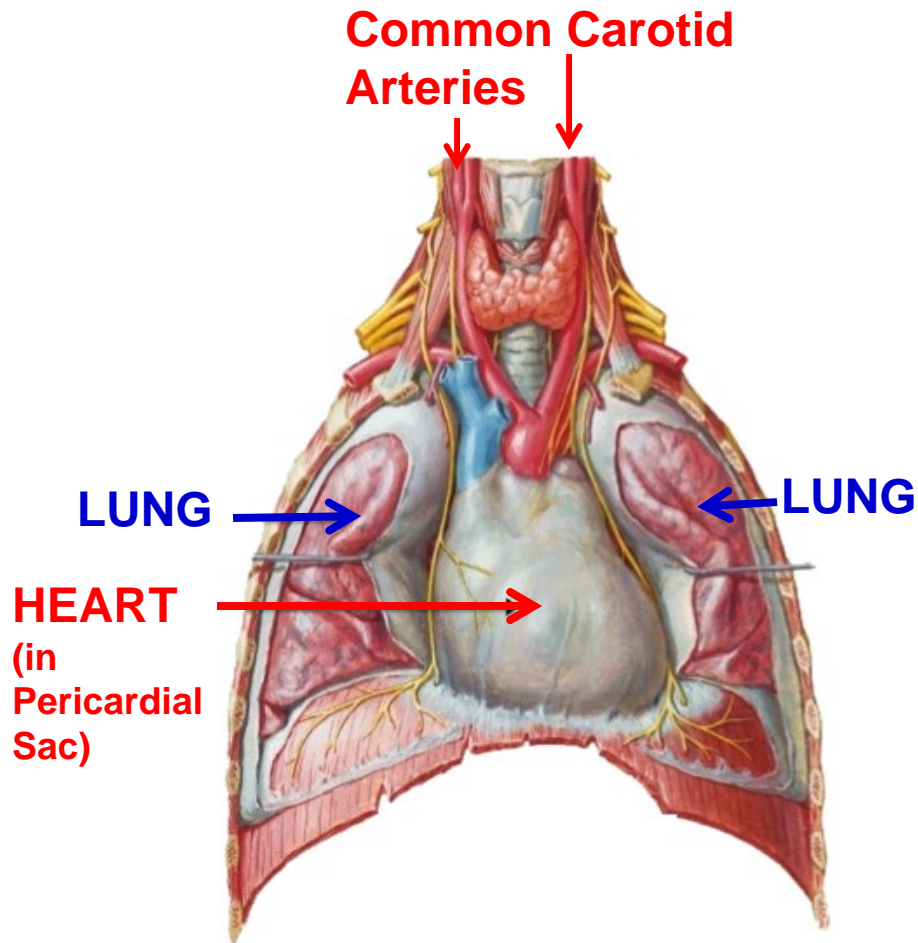
Bodies of Thoracic Vertebrae (anterior side)



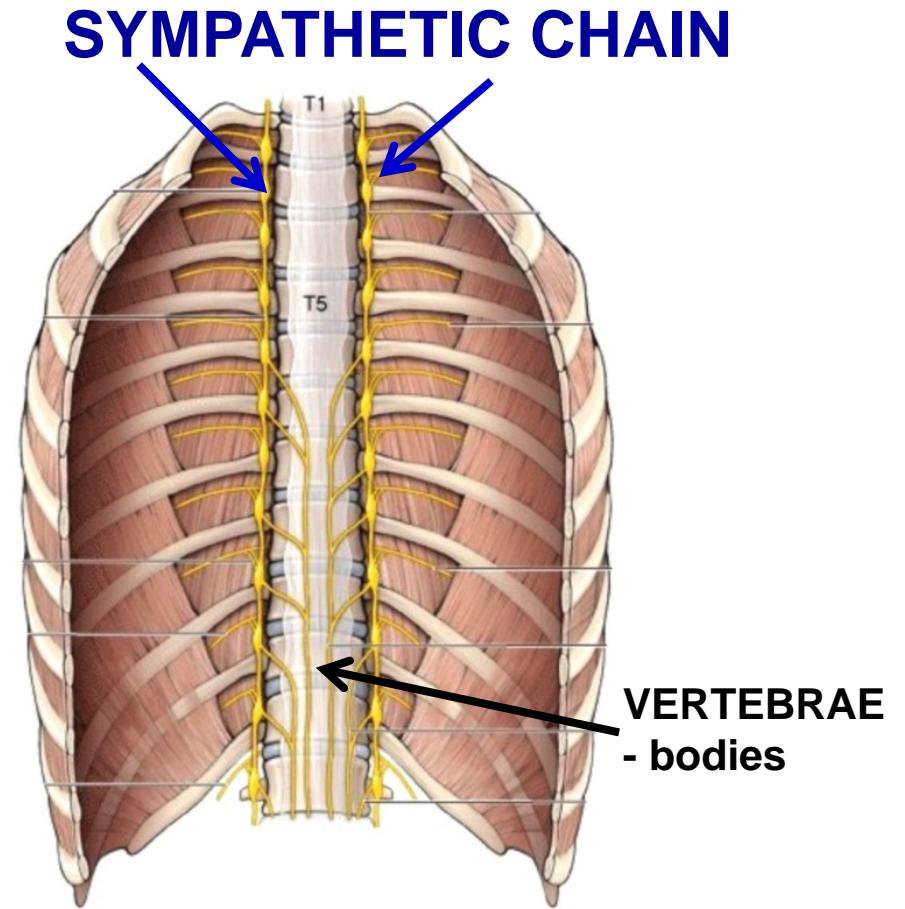
View of the anterior side (front) of vertebrae  
inside the thorax (chest cavity); chain of  
ganglia are on sides of vertebrae (paravertebral)



# LOCATION OF SYMPATHETIC CHAIN



**THORAX DISSECTION - remove ribs from anterior wall; see Heart and Lungs**

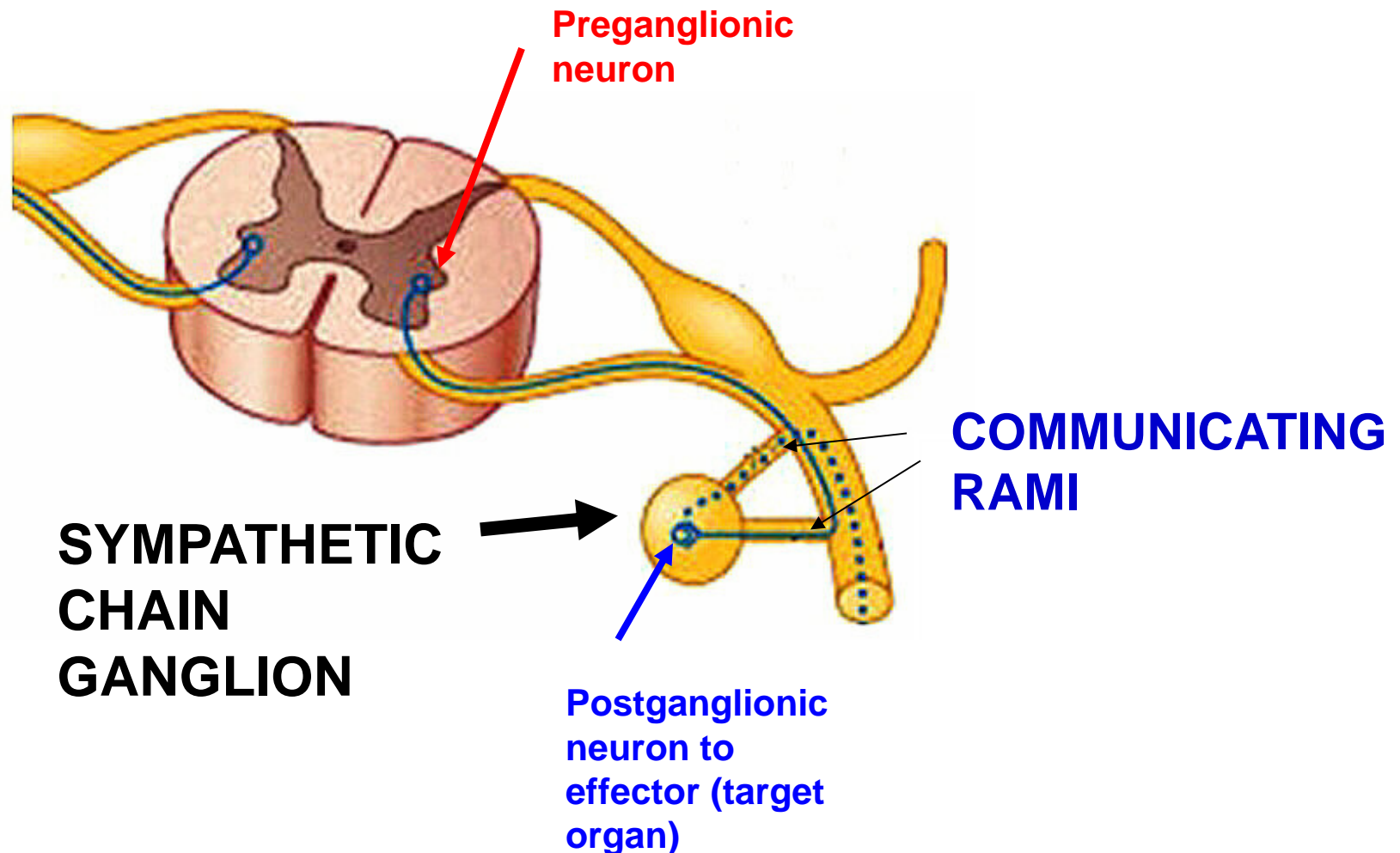


**REMOVE HEART AND LUNGS - Thorax is hollow; Vertebral bodies on posterior wall; Sympathic chain on sides of vertebral bodies**

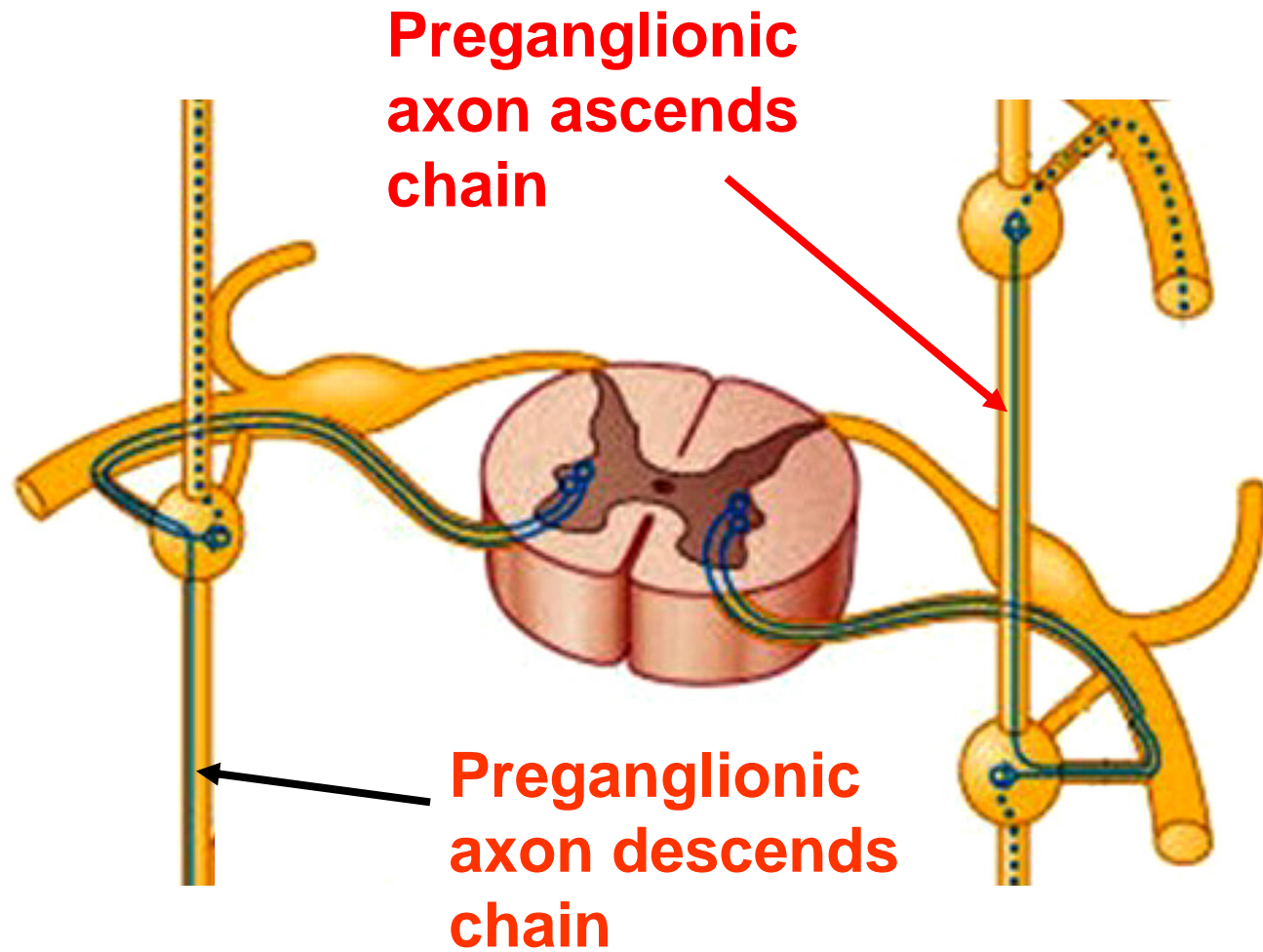


## II. ANATOMICAL ORGANIZATION SYMPATHETIC OUTFLOW OCCURS BY THREE PATHWAYS

1) COME OUT THORACIC AND LUMBAR VENTRAL ROOTS AND SYNAPSE IN GANGLION AT THAT LEVEL

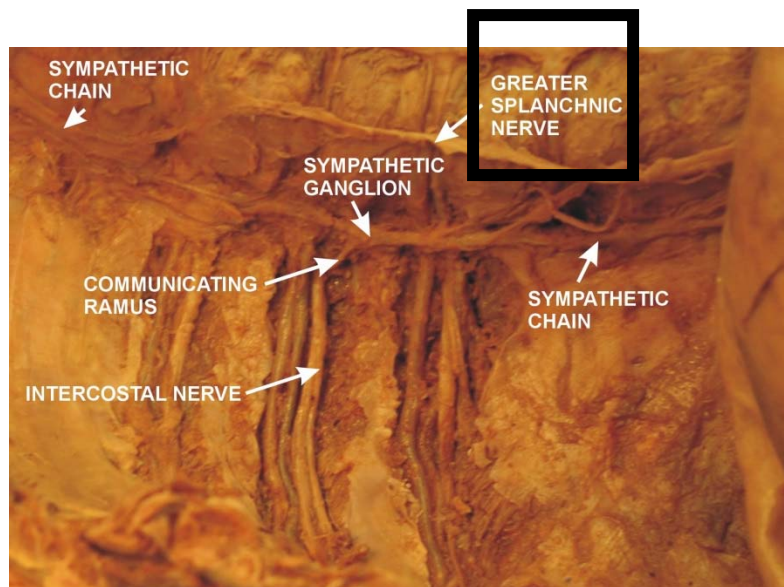


**2) SYMPATHETICS ASCEND OR DESCEND SYMPATHETIC CHAIN TO TERMINATE IN OTHER GANGLIA**

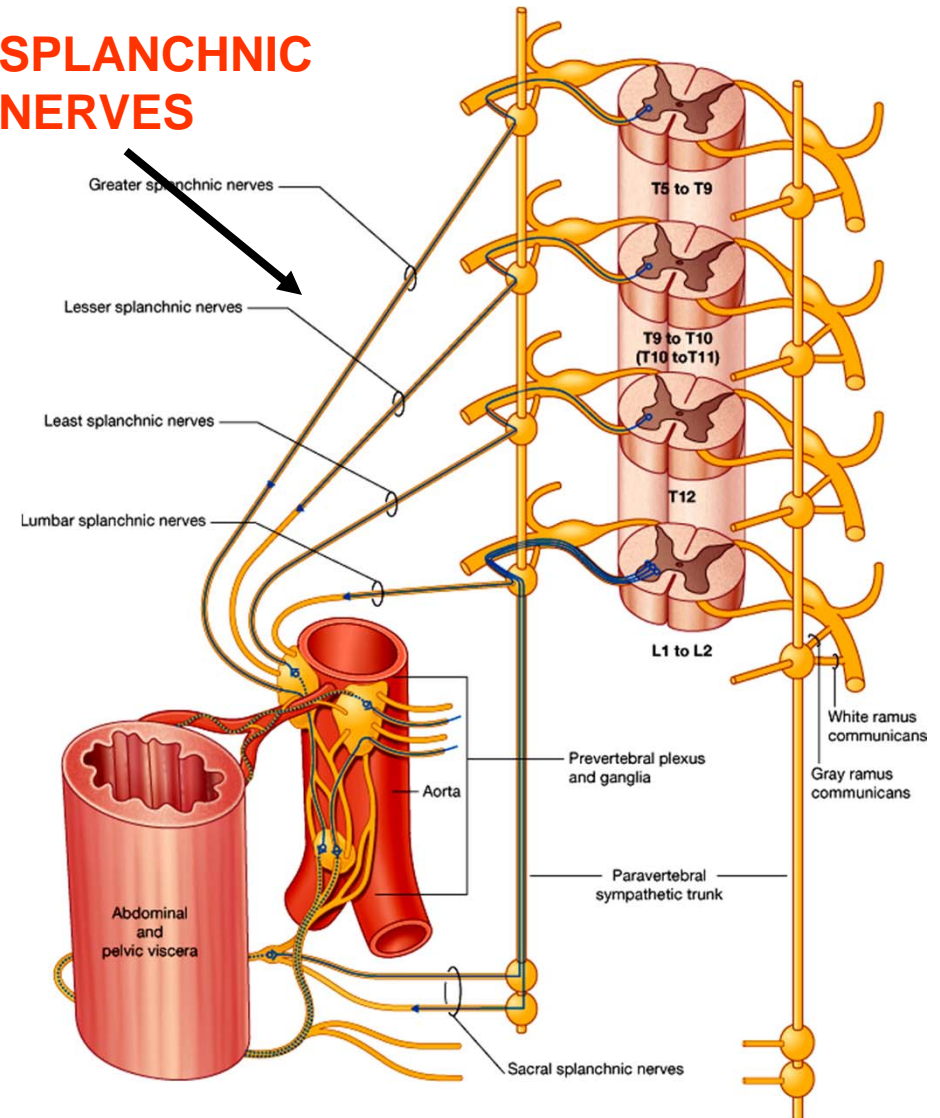


### 3) SYMPATHETICS LEAVE CHAIN WITHOUT SYNAPSING; FORM NERVES CALLED SPLANCHNIC NERVES - SYNAPSE IN PRE-AORTIC GANGLIA

Preganglionic axon leaves chain in Splanchnic nerve; nerves descending to abdomen; synapse on Pre-aortic ganglia



### SPLANCHNIC NERVES

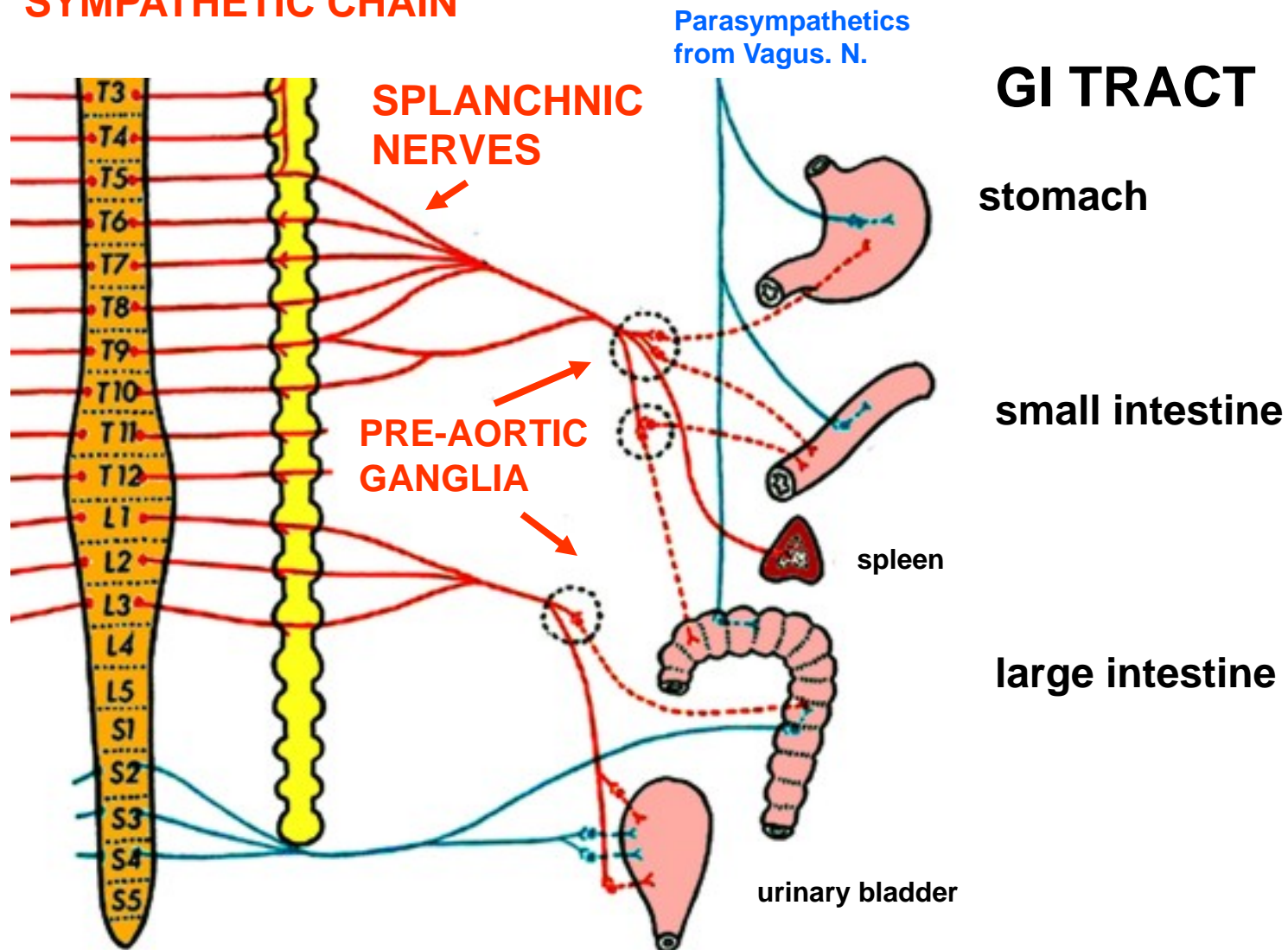


SEE IN JANUARY



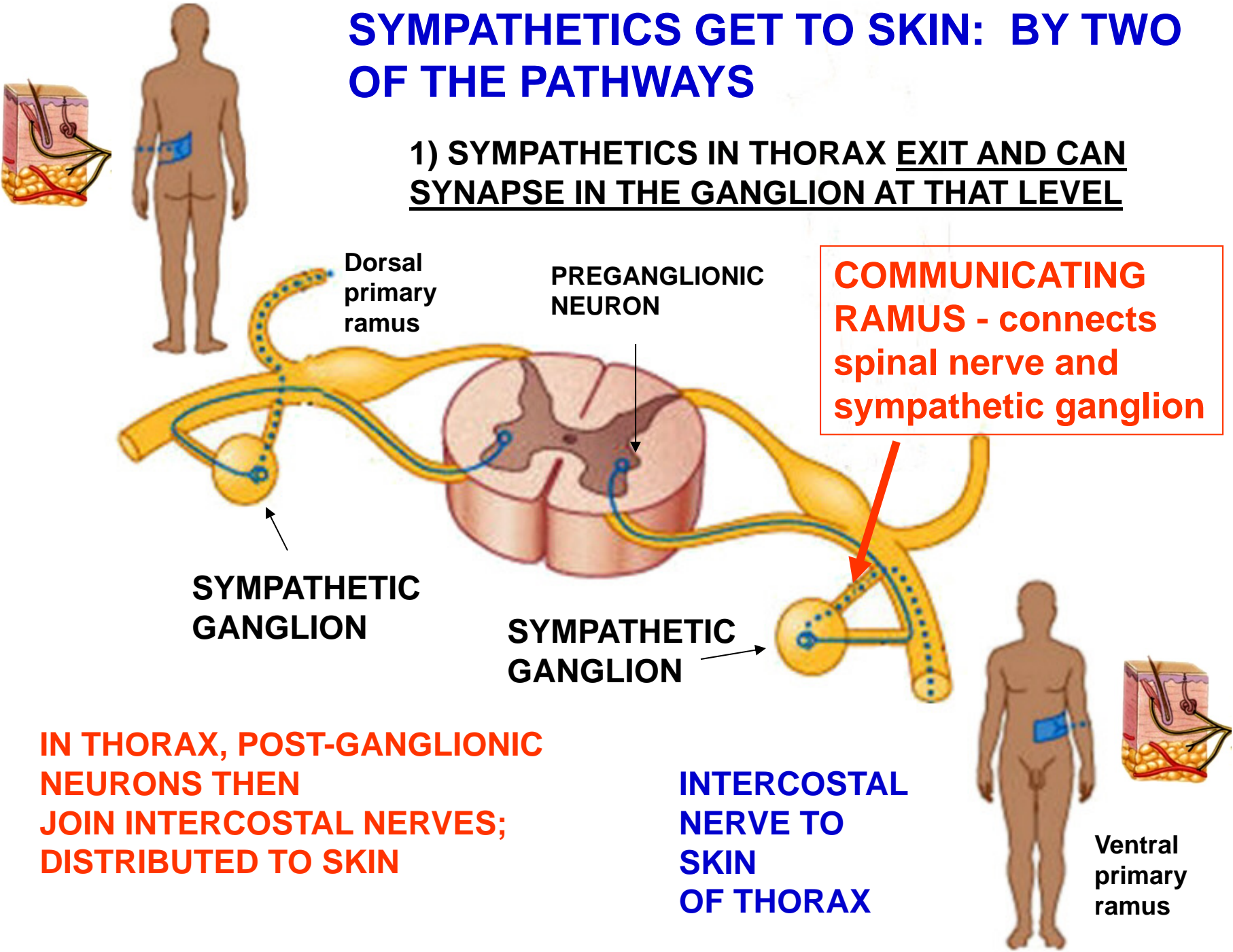
# SPLANCHNIC NERVES: SYMPATHETICS TO INTERNAL ORGANS IN ABDOMEN, PELVIS - COVERED IN SPRING

## SYMPATHETIC CHAIN



# SYMPATHETICS GET TO SKIN: BY TWO OF THE PATHWAYS

1) SYMPATHETICS IN THORAX EXIT AND CAN SYNAPSE IN THE GANGLION AT THAT LEVEL

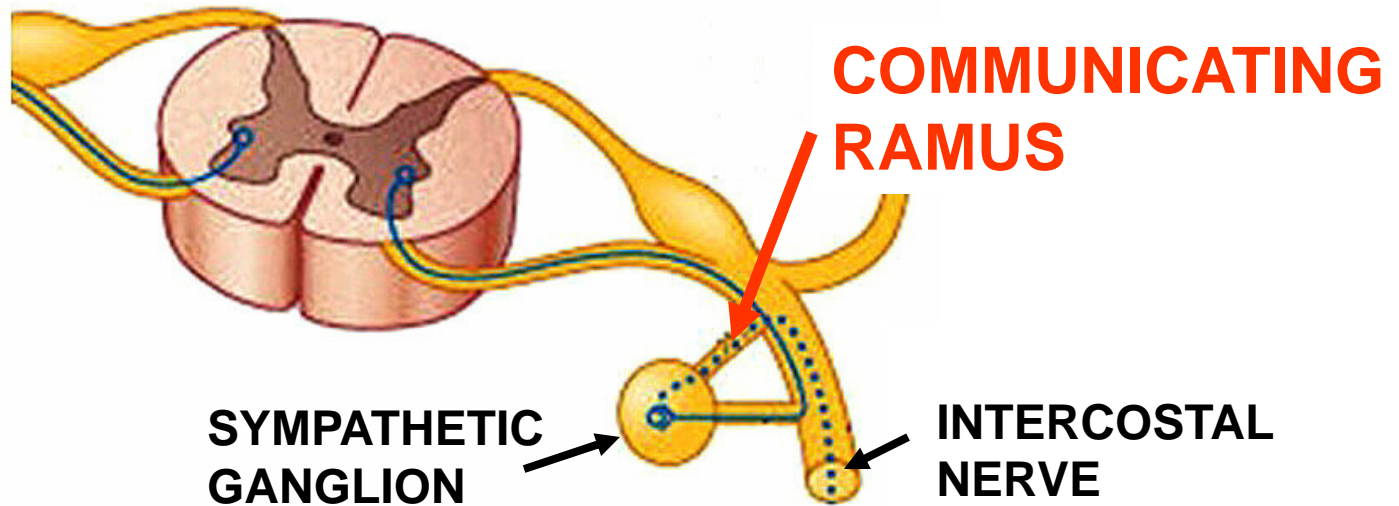
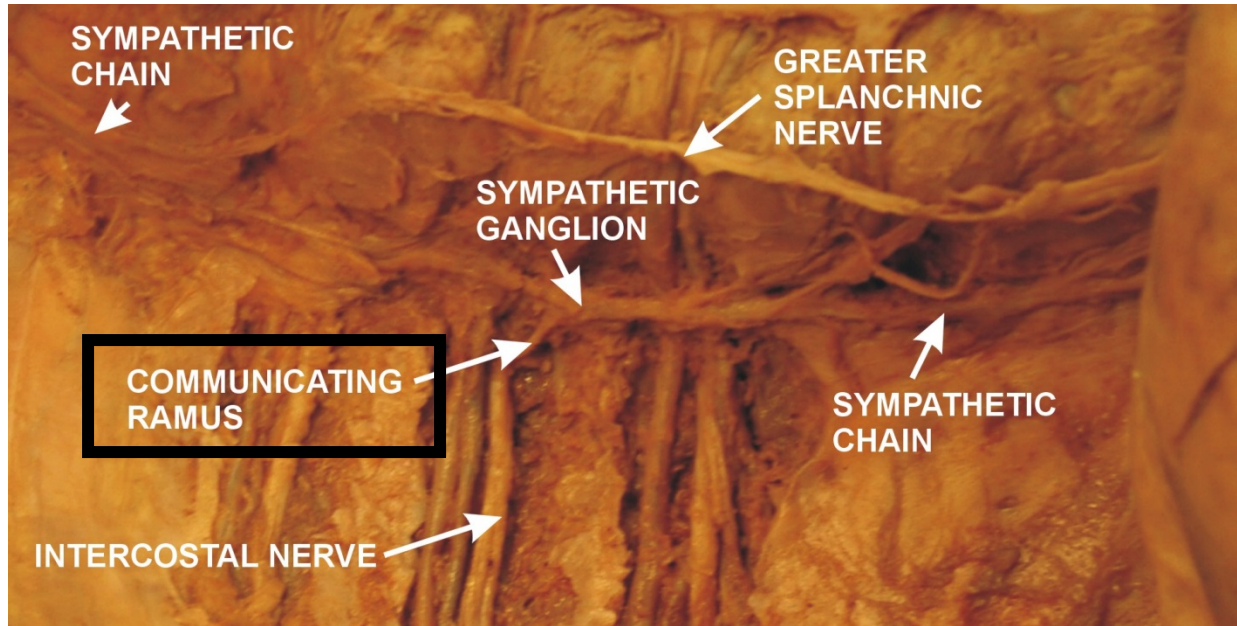


**COMMUNICATING RAMUS - connects spinal nerve and sympathetic ganglion**

**IN THORAX, POST-GANGLIONIC NEURONS THEN JOIN INTERCOSTAL NERVES; DISTRIBUTED TO SKIN**

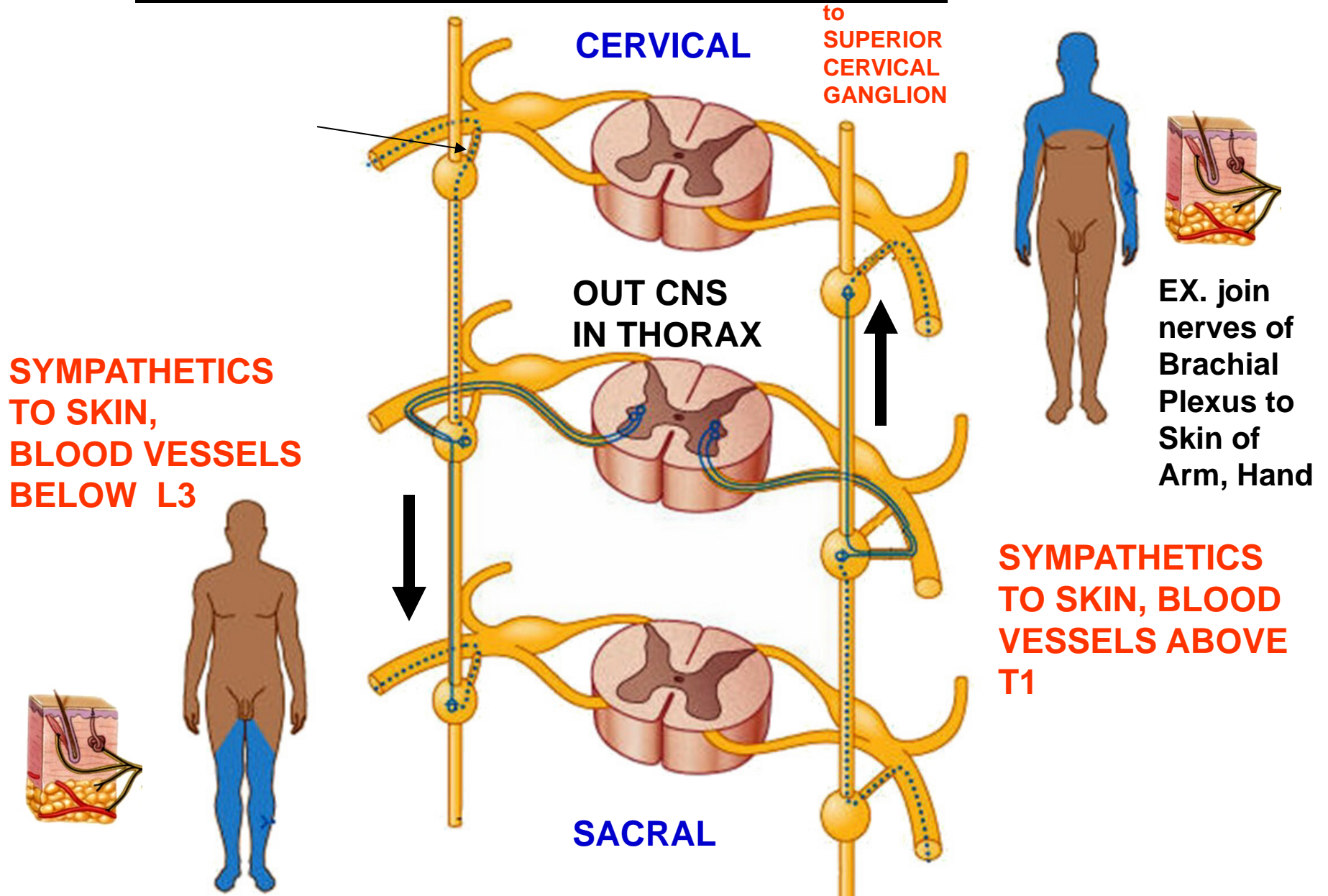
**INTERCOSTAL NERVE TO SKIN OF THORAX**

**Ventral primary ramus**





## 2) SYMPATHETICS TO SKIN - IN THORAX CAN COME OUT AND ASCEND OR DESCEND CHAIN OF GANGLIA

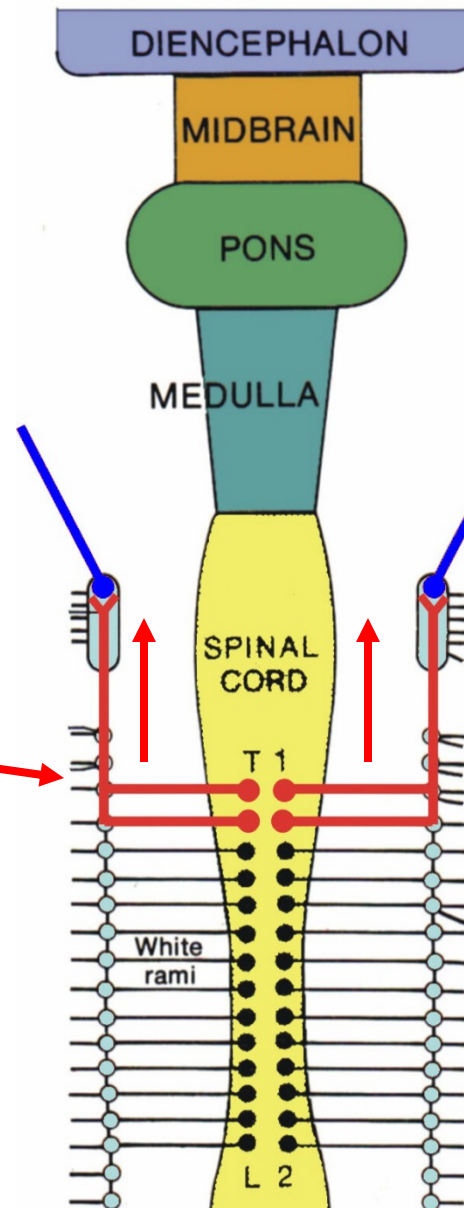


# SYMPATHETICS TO HEAD

## PATHWAY TO HEAD -

1) Neuron 1 (Preganglionic neuron) in spinal cord at T1, T2

- leaves and ascends sympathetic chain

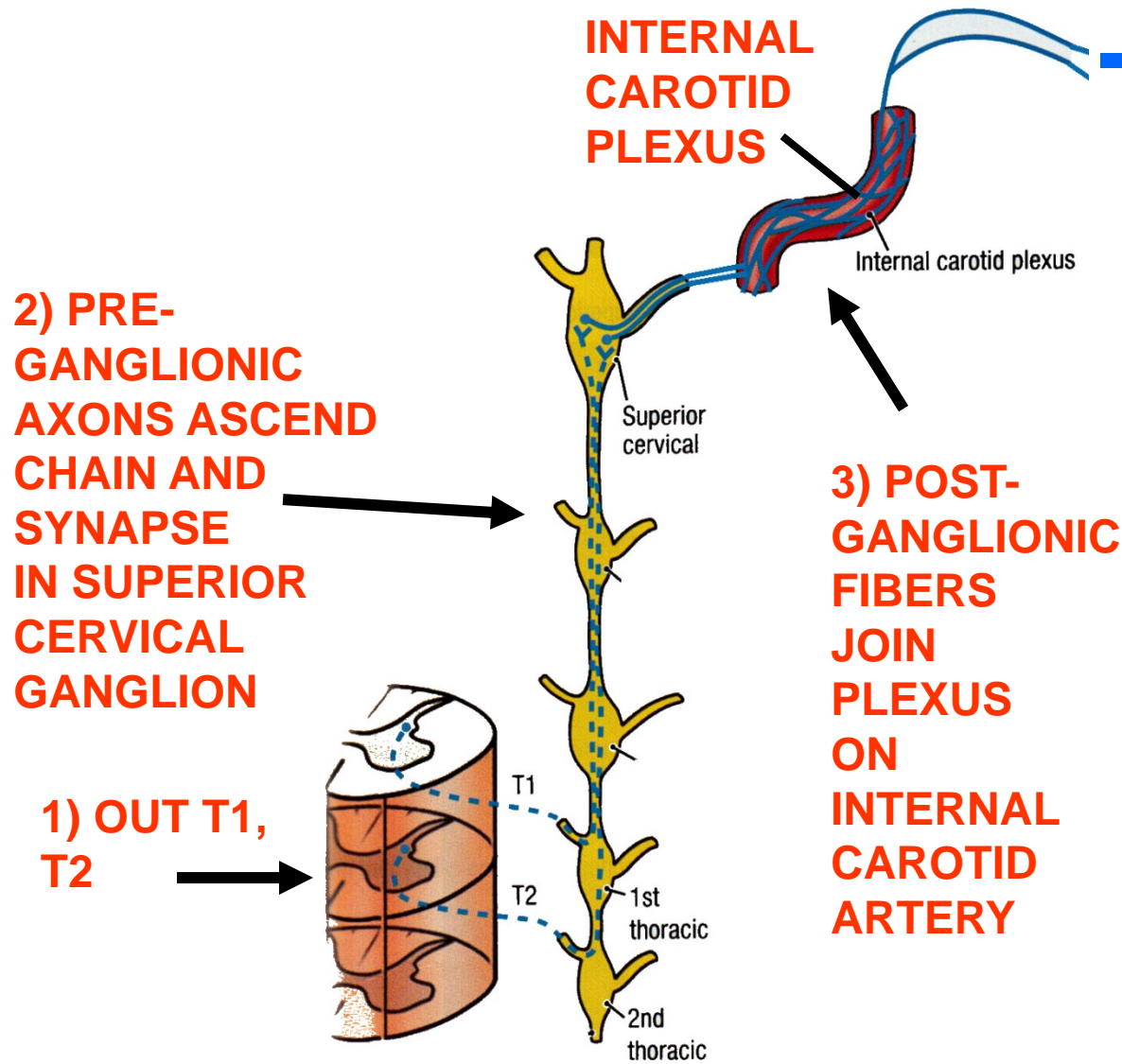


to Target Organ

Joins Plexus on Internal and External Carotid Arteries in mostly Unnamed branches

2) Neuron 2 (Postganglionic neuron) In Superior Cervical Ganglia

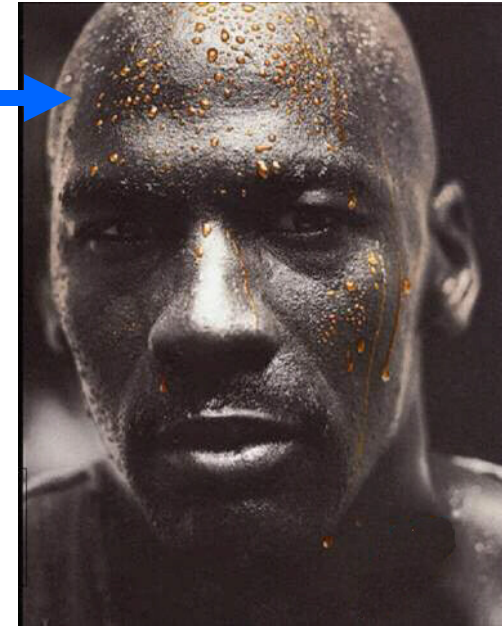
# SYMPATHETICS TO SKIN OF HEAD



**2) PRE-GANGLIONIC AXONS ASCEND CHAIN AND SYNAPSE IN SUPERIOR CERVICAL GANGLION**

**1) OUT T1, T2**

**3) POST-GANGLIONIC FIBERS JOIN PLEXUS ON INTERNAL CAROTID ARTERY**



**4) POST-GANGLIONIC FIBERS END IN SKIN OF FACE; MICHAEL JORDAN SWEATS**



# LESIONS OF SYMPATHETICS PRODUCE SYMPTOMS IN EYE: HORNER'S SYNDROME

## HORNER'S SYNDROME



**HORNER'S SYNDROME** - damage to Sympathetic pathways:  
symptoms involve structures of eye and head -

## SYMPTOMS -

**MIOSIS** - pupillary constriction

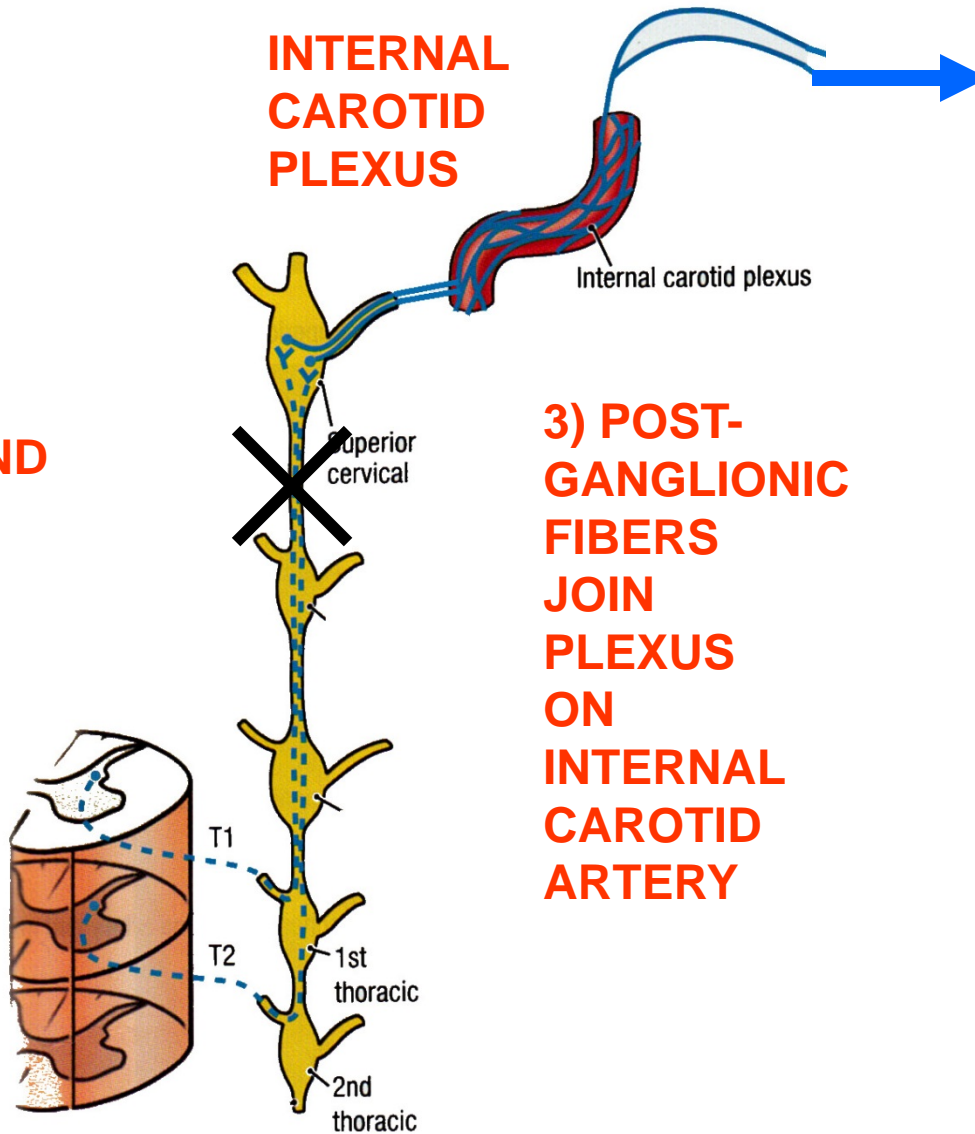
**PTOSIS** - drooping eyelid

**ANHYDROSIS** - lack of sweating

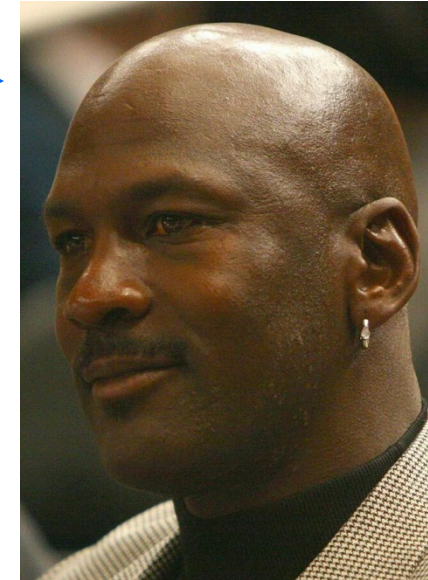
# 1) ANHYDROSIS - LESION TO SYMPATHETICS BLOCKS SWEATING

2) PRE-GANGLIONIC AXONS ASCEND CHAIN AND SYNAPSE IN SUPERIOR CERVICAL GANGLION

1) OUT T1, T2



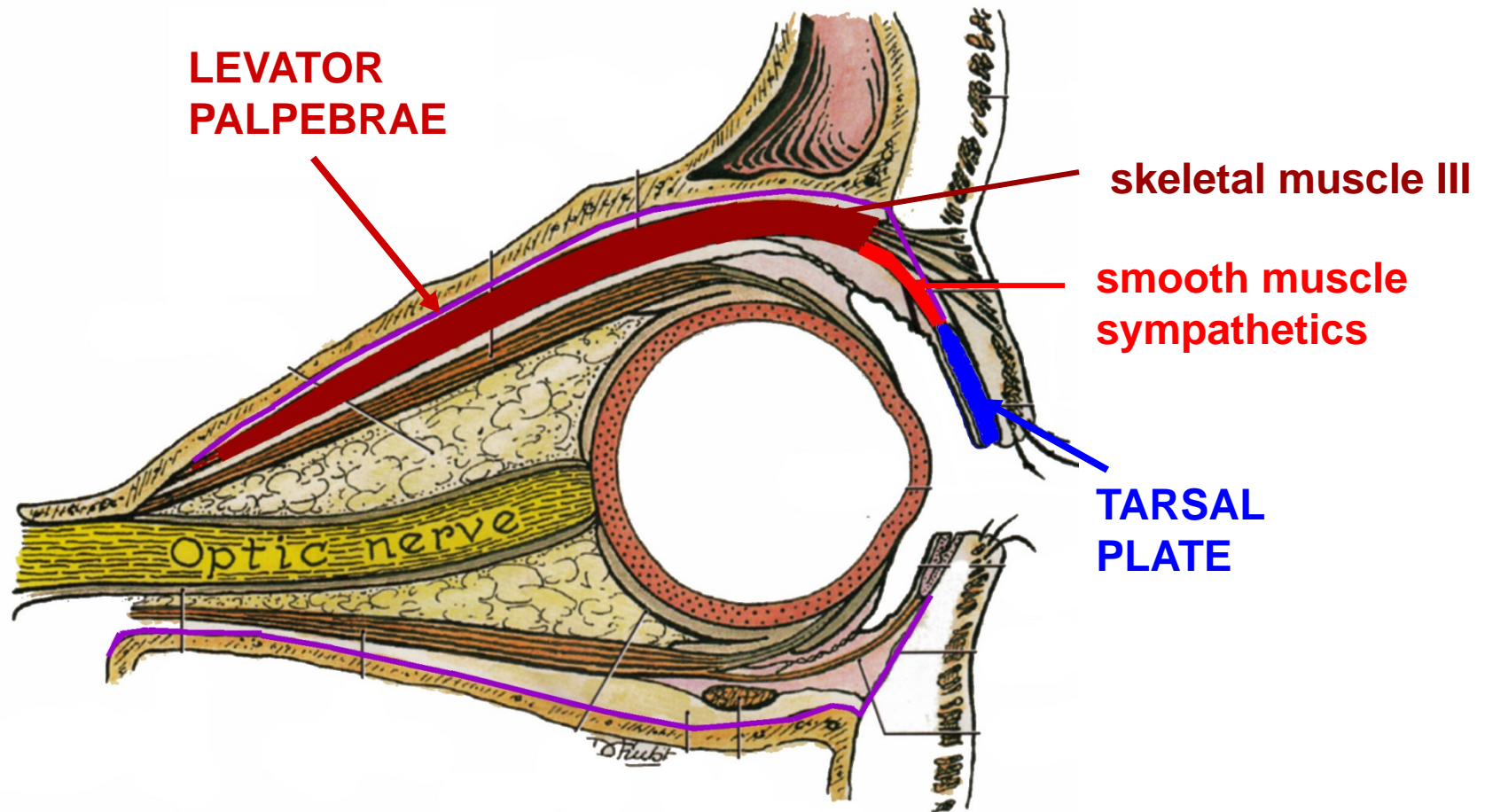
3) POST-GANGLIONIC FIBERS JOIN PLEXUS ON INTERNAL CAROTID ARTERY



LACK OF SWEATING = ANHYDROSIS

CAN LESION SYMPATHETIC CHAIN (EX. PANCOST TUMOR OF LUNG)

## 2) PTOSIS: MUSCLE OF EYELID: LEVATOR PALPEBRAE SUPERIORIS



**LEVATOR PALPEBRAE SUPERIORIS MUSCLE - ORIGIN FROM TENDINOUS RING - COMPOSED OF SKELETAL (CN III) & SMOOTH (SYMPATHETICS) MUSCLE PARTS**

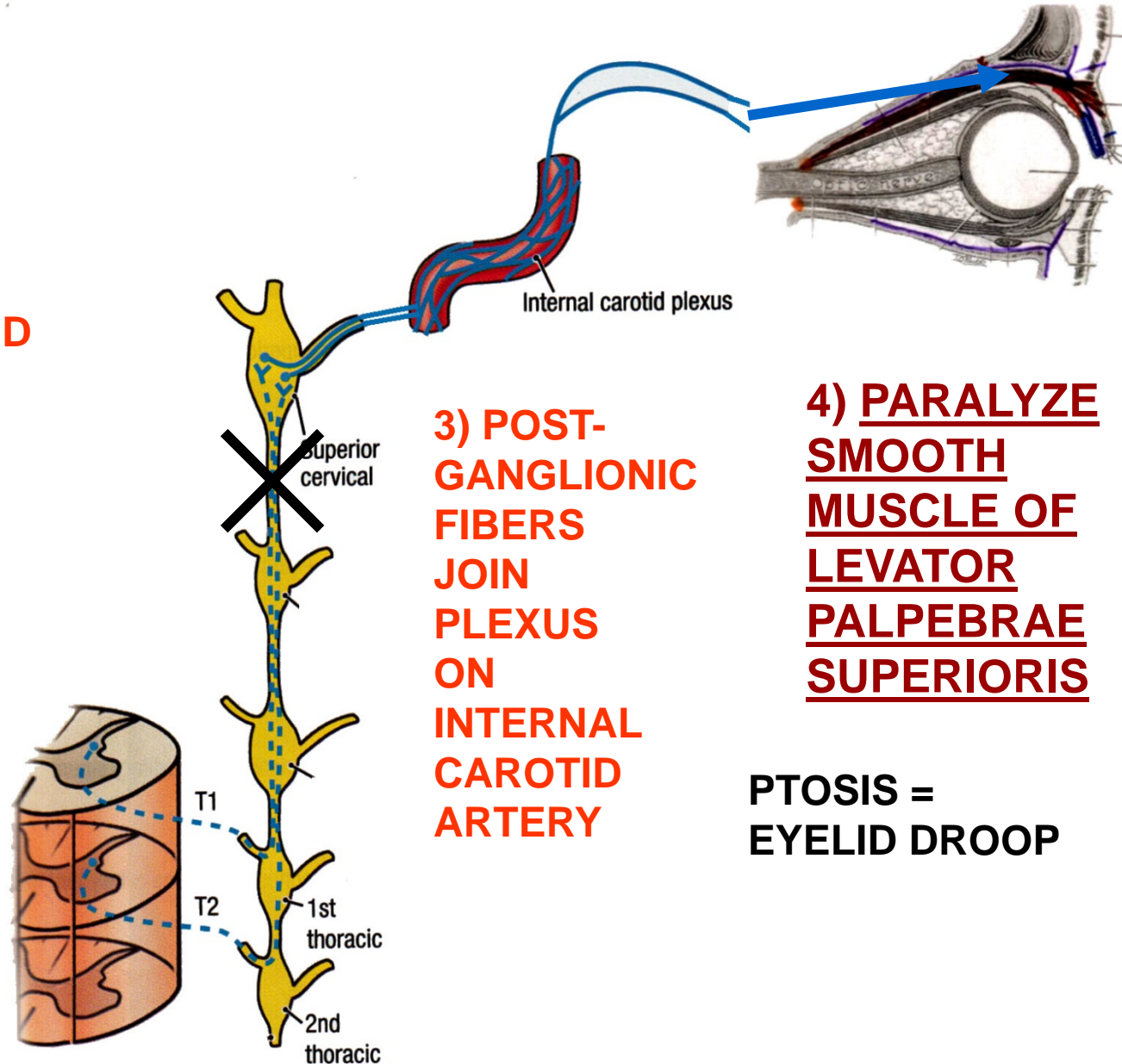
**DAMAGE INNERVATION PTOSIS = DROOPING EYELID**



## 2) PTOSIS - DAMAGE PATHWAY OF SYMPATHETICS TO EYE

2) **PRE-GANGLIONIC AXONS ASCEND CHAIN AND SYNAPSE IN SUPERIOR CERVICAL GANGLION**

1) **OUT T1, T2**



3) **POST-GANGLIONIC FIBERS JOIN PLEXUS ON INTERNAL CAROTID ARTERY**

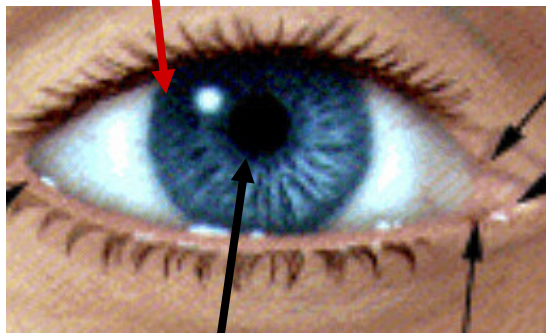
4) **PARALYZE SMOOTH MUSCLE OF LEVATOR PALPEBRAE SUPERIORIS**

**PTOSIS = EYELID DROOP**

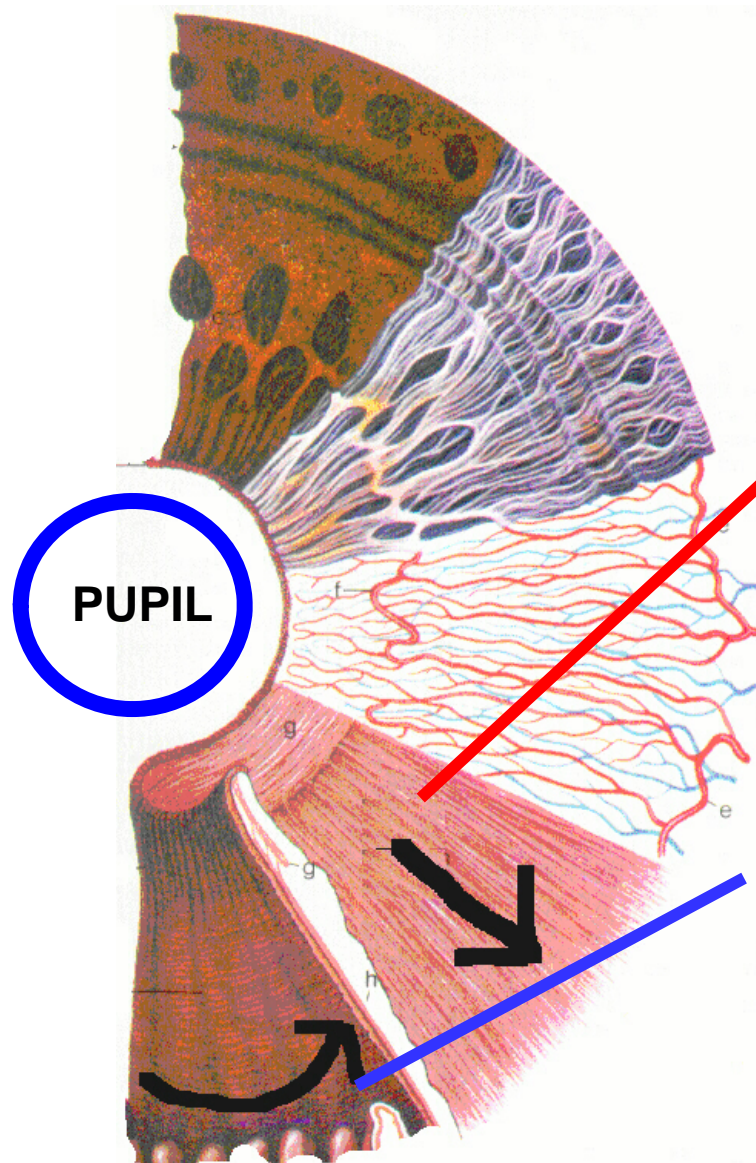
### 3) MIOSIS - CONSTRICTED PUPIL

IRIS - PIGMENTED,  
CONTRACTILE LAYER  
SURROUNDING PUPIL

IRIS - PIGMENTED



PUPIL



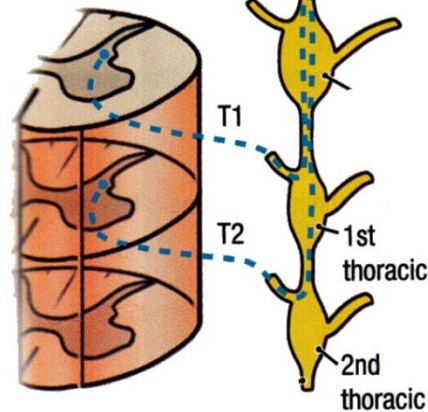
DILATOR  
PUPIL M.-  
RADIAL  
SMOOTH  
MUSCLE;  
SYMPA-  
THETICS

CONSTRUCTOR  
PUPIL M. -  
CIRCULAR  
SMOOTH  
MUSCLE;  
PARA-  
SYMPATHETICS  
III

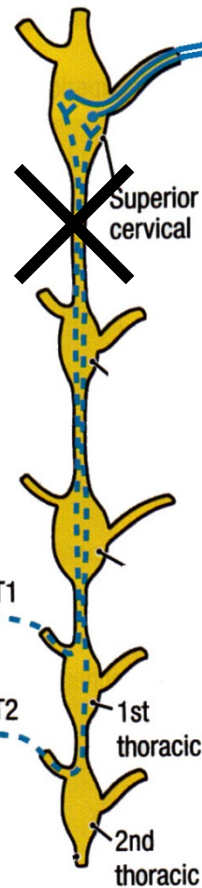
**3) MIOSIS -  
DAMAGE  
PATHWAY OF  
SYMPATHETICS  
TO EYE**

**2) PRE-  
GANGLIONIC  
AXONS ASCEND  
CHAIN AND  
SYNAPSE  
IN SUPERIOR  
CERVICAL  
GANGLION**

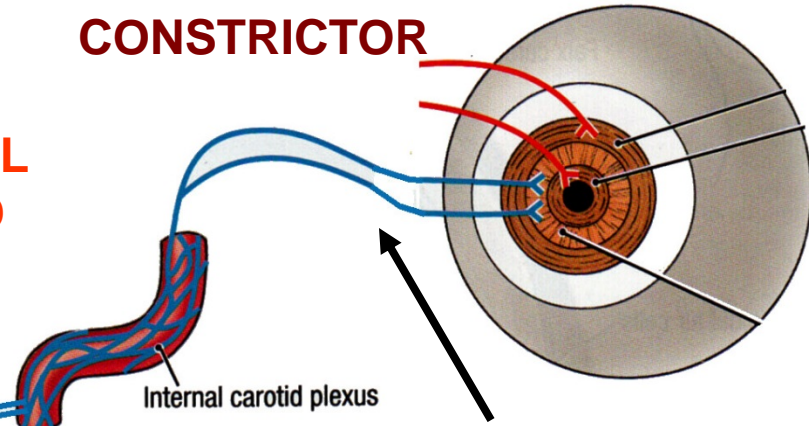
**1) OUT T1,  
T2**



**INTERNAL  
CAROTID  
PLEXUS**



**CN III - OCULOMOTOR  
CONSTRUCTOR**



**3) POST-  
GANGLIONIC  
FIBERS  
JOIN  
PLEXUS  
ON  
INTERNAL  
CAROTID  
ARTERY**

**4) PARALYZE  
DILATOR  
PUPILLAE  
(RADIAL  
SMOOTH  
MUSCLE)**

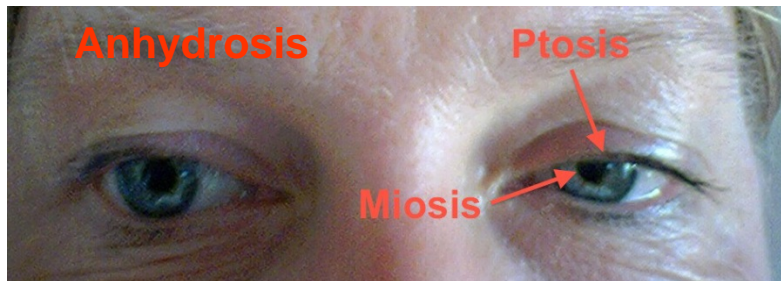
**PUPIL IS  
CONSTRICTED -  
SKELETAL PART  
INNERVATED BY  
OCULOMOTOR NERVE  
(III)**



# LESIONS OF SYMPATHETICS PRODUCE SYMPTOMS IN EYE: HORNER'S SYNDROME

HORNER'S SYNDROME - damage to Sympathetic pathways: symptoms involve structures of eye and head -

## HORNER'S SYNDROME



## CLINICAL

CAN DAMAGE SYMPATHETIC  
CHAIN IN NECK; SHOW  
SYMPTOMS IN EYE AND FACE

## SYMPTOMS -

- 1) MIOSIS - pupillary constriction;  
PARALYSIS OF PUPILLARY  
DILATOR MUSCLE
- 2) PTOSIS - drooping eyelid;  
PARALYSIS OF SMOOTH MUSCLE  
PART OF LEVATOR PALPEBRAE  
SUPERIORIS
- 3) ANHYDROSIS - lack of sweating;  
LOSS OF INNERVATION OF SWEAT  
GLANDS

## SUMMARY CHART: HORNER'S SYNDROME

Symptom	Structure innervated	Damage
<u>Anhydrosis</u> (lack of sweating)	Sweat glands in skin	lack of sweating in skin (ex. forehead)
<u>Ptosis</u> (eyelid droop)	<u>Levator Palpebrae Superioris</u> - <u>sympathetics</u> to Smooth muscle part	<u>Levator</u> lifts upper eyelid; damage produce eyelid droop
<u>Miosis</u> (constricted pupil)	<u>Pupillary dilator</u> muscle	Damage paralyzes Dilator muscle; pupil is constricted (Constrictor <u>pupillae</u> muscle is intact)

**HYPOTHALAMUS**

**DIENCEPHALON**

**MIDBRAIN**

**POIS**

**MEDULLA**

**SPINAL CORD**

**T 1**

**L 2**

**White rami**

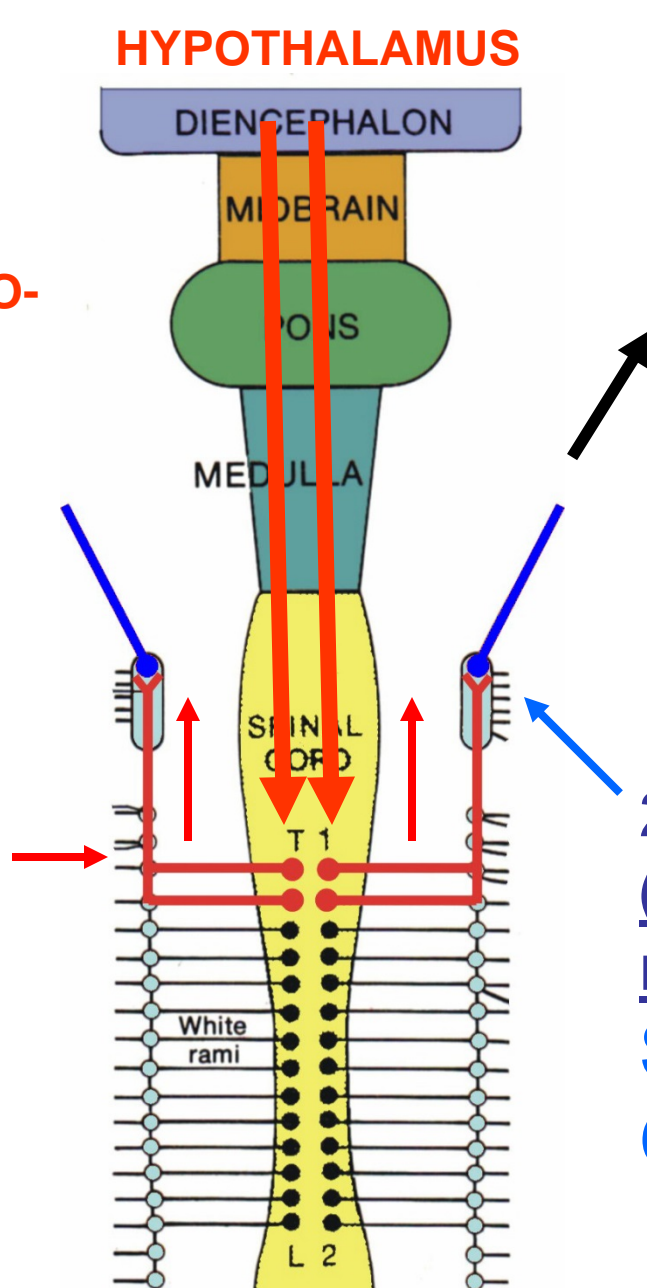
**HYPOTHALAMO-  
SPINAL  
TRACT**

**PATHWAY TO  
HEAD -  
1) Neuron 1  
(Preganglionic  
neuron) in  
spinal cord at  
T1, T2**

**LESIONS CAN  
OCCUR IN MANY  
PLACES IN  
PATHWAY**

**to Target Organ**

**2) Neuron 2  
(Postganglionic  
neuron) In  
**Superior  
Cervical Ganglia****





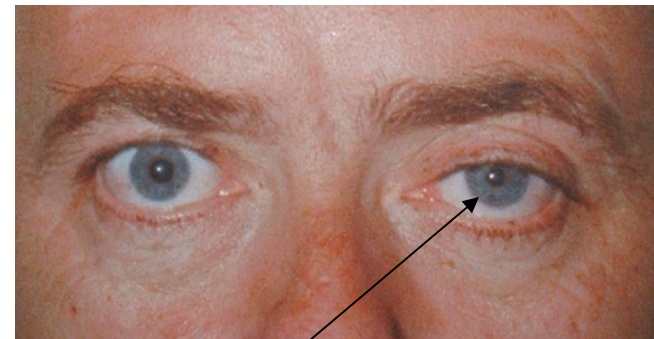
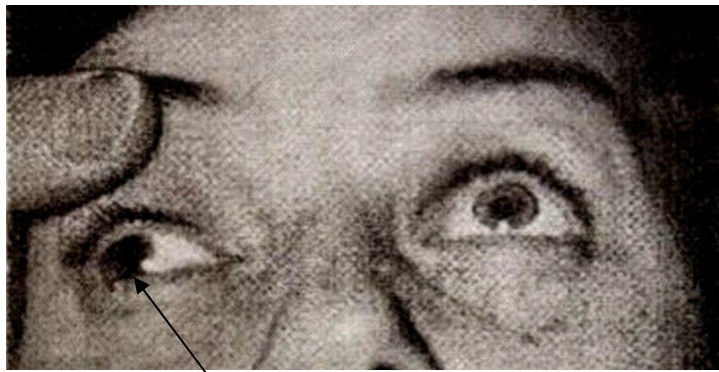
Ptosis (drooping of the eyelid)

**PTOSIS = DROOPING EYELID; CAN BE SIGN OF DAMAGE TO OCULOMOTOR NERVE (III) OR SYMPATHETICS**



**SKELETAL MUSCLE PART**

**SMOOTH MUSCLE PART**



**OCULOMOTOR NERVE PALSY**

other symptoms:

- Pupil is dilated - denervate Pupillary constrictor (Mydriasis)
- Also affect **Eye movements**
- Accommodation

**SYMPATHETICS - HORNER'S SYNDROME -**

- Miosis - denervate Pupillary dilator; constricted pupil
- Anhidrosis - lack of sweating

## SUMMARY CHART: HORNER'S SYNDROME VS OCULOMOTOR PALSY

Structure	Horner's Syndrome	Oculomotor Palsy (nerve damage)
Upper eyelid	<u>Ptosis (eyelid droop)</u> - paralyze Smooth muscle part of <u>Levator Palpebrae Superioris</u>	<u>Ptosis (eyelid droop)</u> - paralyze Skeletal muscle part of <u>Levator Palpebrae Superioris</u>
Pupil of eye	Pupil constricted ( <u>Miosis</u> ) - <u>Pupillary Dilator muscle</u> paralyzed; <u>Pupillary constrictor muscle</u> intact	Pupil dilated ( <u>Mydriasis</u> ) - <u>pupillary constrictor muscle</u> paralyzed; Dilator muscle is intact
Sweat glands in skin	<u>Anhydrosis</u> - lack of sweating in skin (ex. forehead)	No effect ( <u>parasympathetics</u> do not innervate skin)

**also: Eye movements - affect by Oculomotor Palsy; no effect if damage Sympathetics.**

## DEVELOPMENT OF BRANCHIAL ARCHES

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I. **DEVELOPMENT OF BRANCHIAL ARCHES** - structures which develop in an embryo that are comparable to gills of fish; reflect fact that ontogeny (development of individual) resembles phylogeny (evolution of species); are important in understanding the final structure and innervation of head and neck.

A. Week 4 - Neural crest cells invade future head and neck region of embryo; cells form ridges on side of head and neck located lateral to rostral part of the foregut; will form branchial arch components. Terminology is confusing. (Note: Branchial Arch = Pharyngeal Arch, Branchial Arch Artery = Aortic Arch, Cleft = Groove)

B. Branchial apparatus - Composed of 4 elements (including branchial arches):

1. **Branchial arch** - components - arches are covered by ectoderm externally; lined internally by endoderm; core of arch formed by mesenchyme; mesenchyme will form muscles, arteries, connective tissue, cartilage and parts of skeleton; each arch has a specific nerve that innervates the muscles that develop from that arch; some arteries will form adult vessels (considered as Aortic Arches).

2. **Branchial groove** (Pharyngeal cleft) - ectodermal (external) cleft between adjacent arches

3. **Branchial pouch** - endodermal outpocketing of rostral part of foregut; pouches are located between adjacent branchial arches.

4. **Branchial membrane** - site of contact of ectoderm of branchial groove with endoderm of pharyngeal pouch.

D. Branchial apparatus of embryo is reshaped into new structures; structures can disappear or form vestigial remnants by the end of the embryonic period.

II. **FATE OF BRANCHIAL ARCHES** - contribute to formation of face, neck, mouth, larynx, and pharynx – see chart

A. Branchial Arch Cartilages – form skeletal elements (bones, cartilages and ligaments)

B. Branchial Arch Nerves are cranial nerves (**Branchiomotor, SVE component**) - **First** arch = **Trigeminal** (V), **Second** arch = **Facial N.** (VII); **Third** arch = **Glossopharyngeal N.** (IX); **Fourth** arch = **Vagus** (X); **Sixth** arch (caudal) = **Accessory N.** (XI)

Note: Fifth arch forms no adult structures in humans; Sixth arch is small; descriptions of Fourth and Sixth Arches vary among authors.

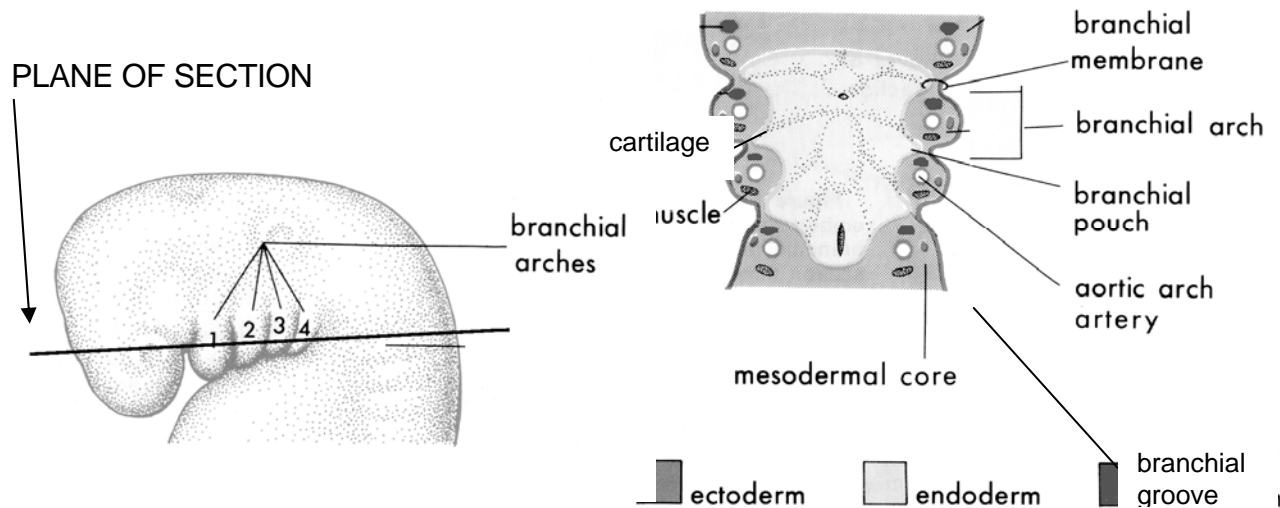


C. Branchial arch muscles – many (see chart); each muscle migrates but continues to be innervated by the cranial nerve to the arch from which the muscle is derived.

**STRUCTURES DERIVED FROM BRANCHIAL ARCHES**

ARCH/NERVE	SKELETAL	LIGAMENTS	MUSCLES
First (V)	1) Malleus 2) Incus	1) Ant. ligament of malleus 2) Sphenomandibular ligament	1) Muscles of Mastication 2) Tensor tympani 3) Tensor palati 4) Mylohyoid 5) Ant. belly of Digastric
Second (VII)	1) Stapes 2) Styloid process 3) Hyoid bone - lesser horn, upper half of body	Stylohyoid ligament	1) Muscles of Facial Expression 2) Stapedius 3) Stylohyoid 4) Post. belly of Digastric
Third (IX)	Hyoid bone - greater horn, lower half of body	-----	Stylopharyngeus
Fourth (X)	Cartilages of Larynx	-----	1) All muscles of Larynx 2) All muscles of Pharynx (except Stylopharyngeus) 3) All muscles of Soft Palate (except Tensor palati)
Sixth (XI)	-----	-----	1) Sternocleidomastoid 2) Trapezius

Note: First Branchial Groove (Cleft) becomes External Auditory Meatus  
First Branchial Membrane becomes Tympanic Membrane



### III. FATE OF BRANCHIAL POUCHES

A. **Pouch 1** - elongates into tubotympanic recess; forms **Auditory tube** and **Tympanic cavity (middle ear cavity)**.

B. **Pouch 2** - forms epithelial lining of **Crypts** (spaces) **of the Palatine tonsils**.

C. **Pouch 3** - Upper part forms **Inferior Parathyroid gland**; lower part forms **Thymus gland**

D. **Pouch 4** - forms **Superior Parathyroid gland** and **C cells of Thyroid gland** (produce hormone calcitonin).

NOTE: Superior parathyroid gland develops from Pouch 4 and Inferior parathyroid gland from Pouch 3; final position occurs because **elements from Pouch 3 migrate caudal to Pouch 4**.

### IV. FATE OF BRANCHIAL GROOVES AND MEMBRANES, ANOMALIES

A. Four branchial grooves separate the branchial arches externally on each side; only one pair of branchial grooves forms a structure in the adult; the **First Branchial Groove** forms the **External Auditory meatus** (outer ear canal), the **First Branchial Membrane** forms the **Tympanic Membrane**.

B. The other **branchial grooves** develop to lie in a larger depression called the **Cervical Sinus**; this sinus is **normally obliterated** during development

Note: **Cervical sinus can persist as a Branchial sinus** (blind pouch off pharynx) or a **Branchial Cyst Fistula** (channel connecting pharynx to skin); when present are found **anterior to Sternocleidomastoid**.

Note: **Branchial fistula (channel)** - when present often extends from 2nd pharyngeal pouch and passes between Internal and External Carotid arteries and exits to skin Anterior to the sternocleidomastoid muscle; can become infected.

## STRUCTURES DERIVED FROM BRANCHIAL POUCHES, CLEFT AND MEMBRANES

POUCH	FORMS	CLINICAL
First	1) Auditory tube 2) Tympanic cavity	First Branchial 'Cleft' cyst - tract linked to external auditory meatus
Second	Lining (crypts) of palatine tonsils	Second Branchial 'Cleft' cyst - tract linked to tonsillar fossa (palatine tonsils)
Third	1) Inferior parathyroid gland 2) Thymus	Third Branchial 'Cleft' cyst - tract at thyrohyoid membrane or piriform recess
Fourth	1) Superior parathyroid gland 2) C-cells of Thyroid	does not form
Sixth (XI)	-----	-----

Note: Cysts and fistuli - in lateral neck are **anterior to Sternocleidomastoid muscle**

Note: **Branchial Pouch structures are NOT innervated by the same nerves as the Branchial arches** (see lectures on Pharynx).

CLEFT	FORMS
First	External Auditory Meatus

MEMBRANE	FORMS
First	Tympanic membrane

## V. DEVELOPMENT OF THYROID GLAND

A. Initial stage - a median endodermal thickening forms in floor of primitive pharynx at site of **junction of future anterior 2/3's and posterior 1/3 of tongue**.

B. Later - thickening elongates into floor of pharynx as the **Thyroid diverticulum**; opening of diverticulum on surface of developing tongue called the Foramen Cecum.

C. Developing Thyroid diverticulum descends in the neck anterior to the hyoid bone and larynx; as diverticulum (developing gland) elongates into neck, a Thyroglossal duct connects diverticulum with foramen cecum.

D. Developing thyroid gland reaches final site in neck (anterior to upper rings of trachea); thyroglossal duct disintegrates; foramen cecum remains as a vestigial pit on the



tongue.

#### E. Congenital malformations

1. **Persistent thyroglossal duct remnants** - part of duct can remain and form thyroglossal cysts anywhere from foramen cecum of tongue to thyroid gland in neck; cysts found in midline of neck and can be located anterior to hyoid bone or larynx.

Clinical note: **Lingual Thyroid** – Developing Thyroid Gland can fail to migrate and remain in tongue as Lingual Thyroid; can produce difficulty in swallowing (but should not be inadvertently removed).

2. **Pyramidal lobe** - present in 50 percent of people; represents persistent part of thyroglossal duct, which can contain some thyroid tissue; lobe can be attached to hyoid bone by fibrous strand; usually no associated clinical problems.

# DEVELOPMENT OF BRANCHIAL ARCHES



**~4 weeks**



**~11 weeks**



## OUTLINE

I. EARLY DEVELOPMENT/  
TERMINOLOGY

II. FATE OF ARCHES  
(CHART) - CARTILAGES,  
LIGAMENTS, NERVES,  
MUSCLES

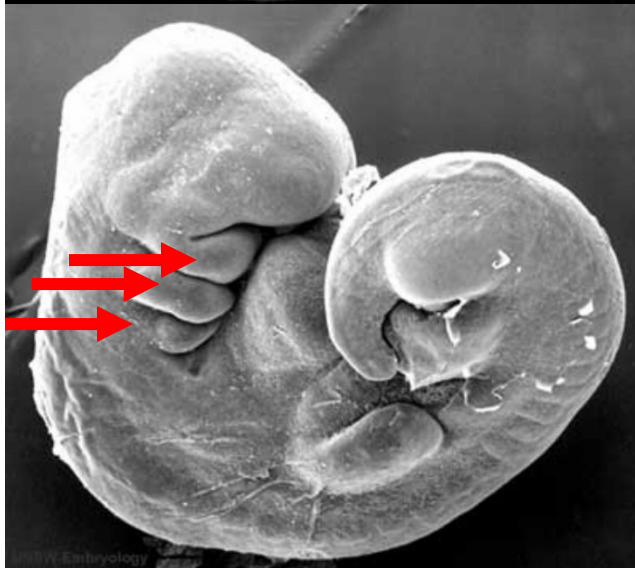
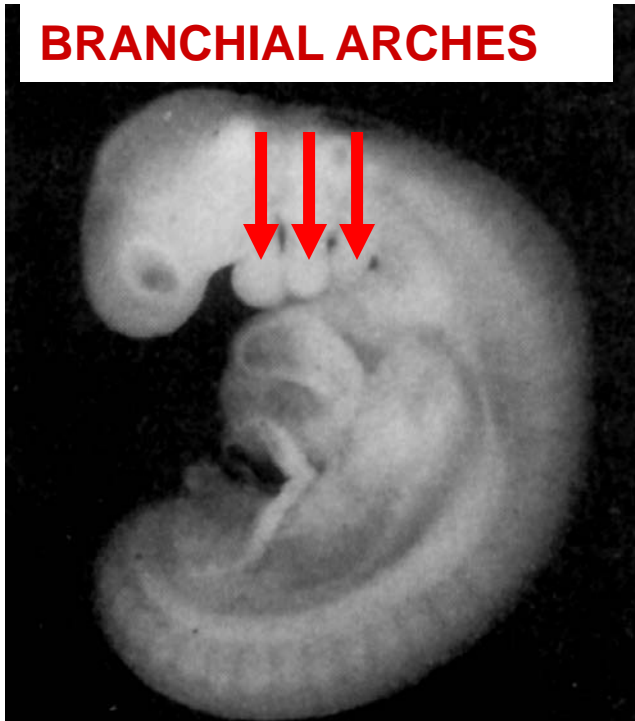
III. BRANCHIAL POUCHES,  
GROOVES, MEMBRANES

IV. DEVELOPMENT OF  
THYROID

- ADULT STRUCTURE IS RESULT OF TRANSFORMATION;
- SPECIFIC SYNDROMES OCCUR IF DEVELOPMENT IS ABNORMAL

## Photo of 4 Week Embryo

### BRANCHIAL ARCHES



## I. BRANCHIAL ARCHES

- Structures which develop that are similar in origin and structure to gills of fish

- **Gill = Branchial**

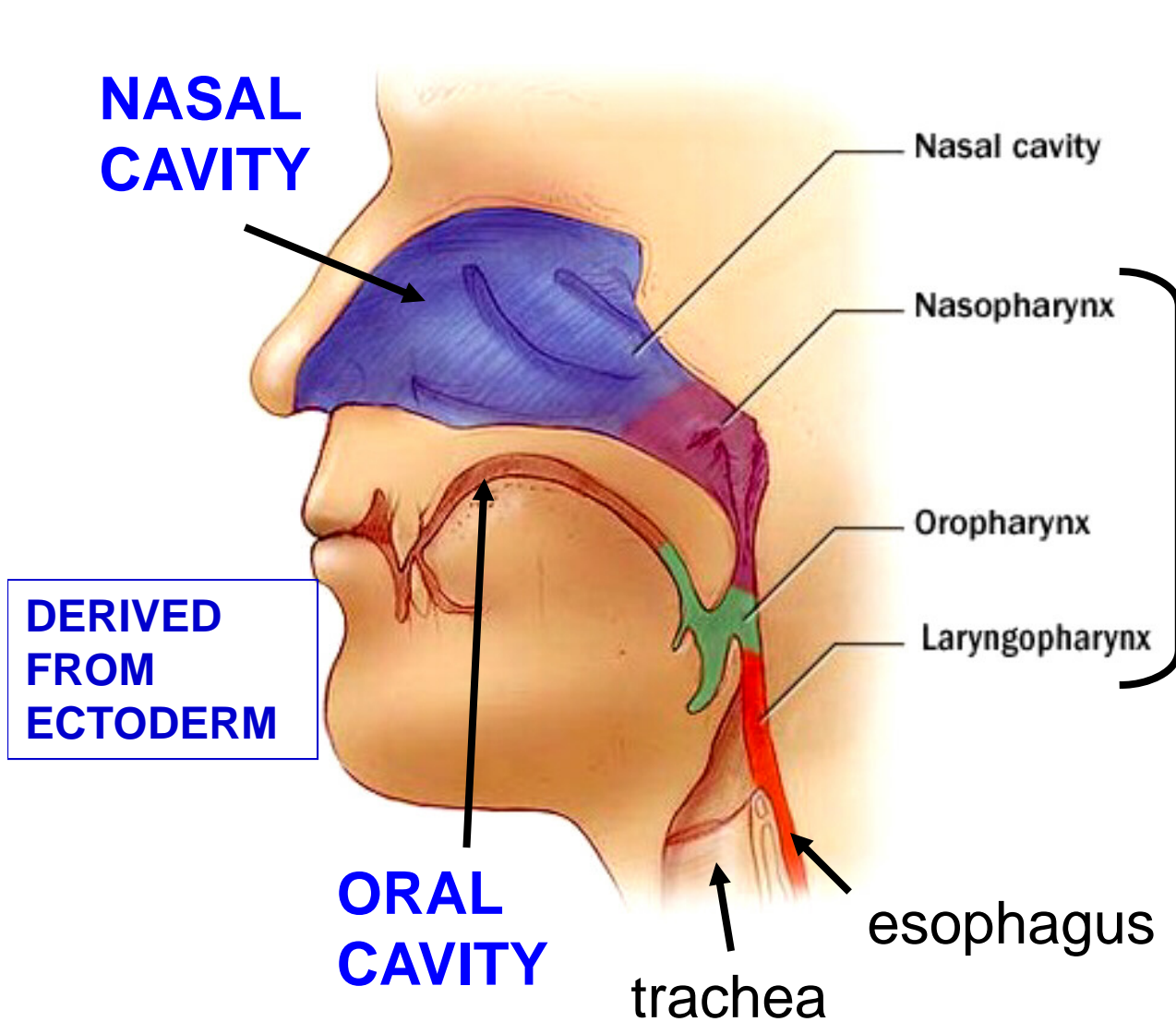
- Ontogeny resembles Phylogeny

- Reorganize to produce Adult structures

Note Terminology :  
Branchial Arch =  
Pharyngeal Arch



# WHERE/WHAT IS THE PHARYNX?

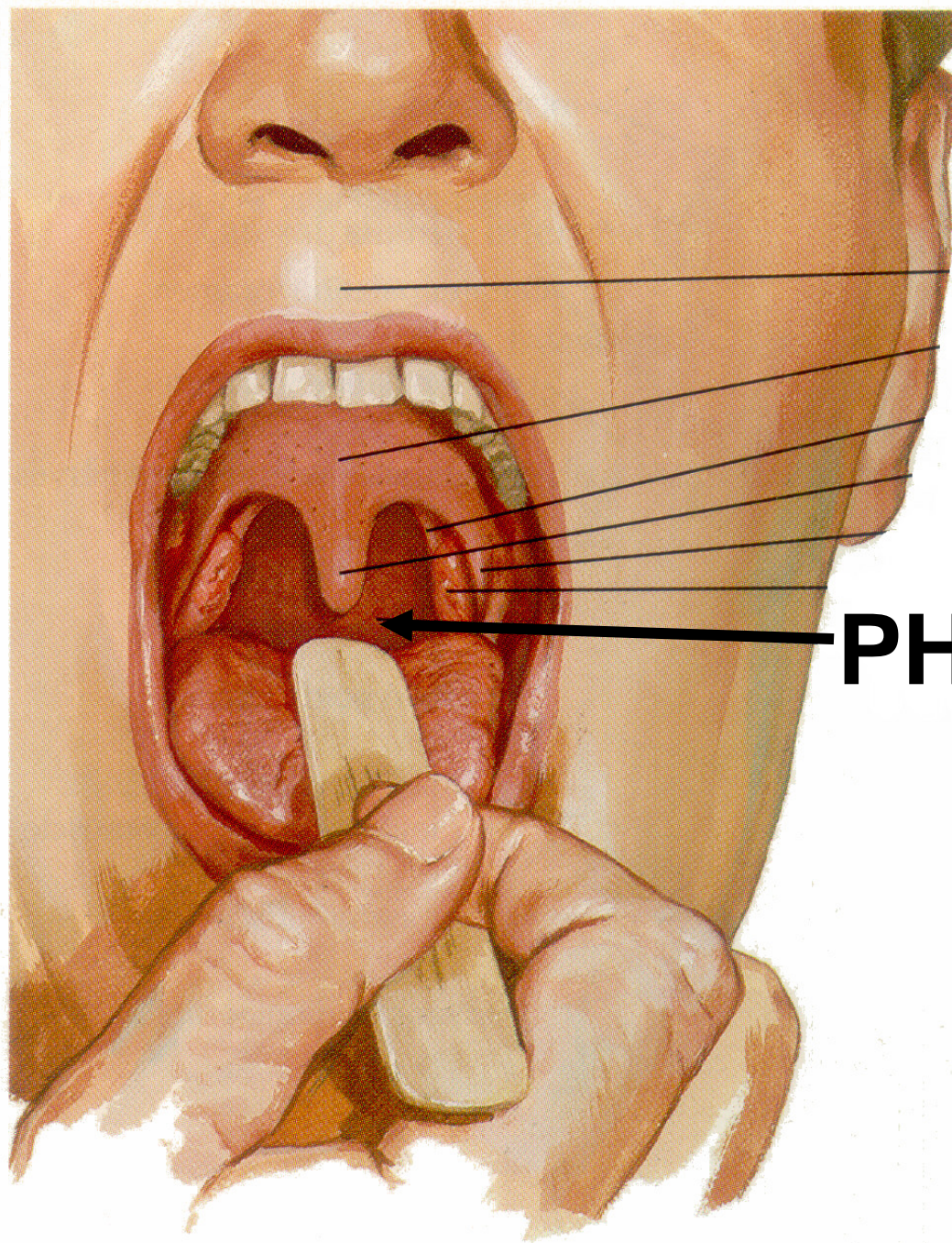


**DERIVED  
FROM  
ENDODERM**

**PHARYNX -**  
region behind  
Oral and Nasal  
Cavities

**PHARYNX IS  
CONNECTED TO  
TRACHEA  
(RESPIRATORY  
SYSTEM) AND  
ESOPHAGUS  
(GI) SYSTEM**

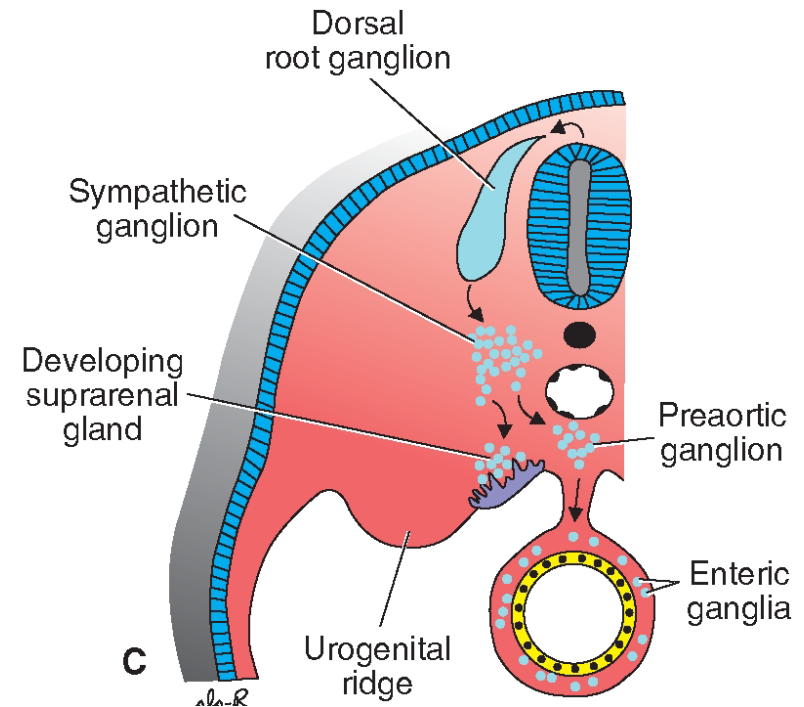
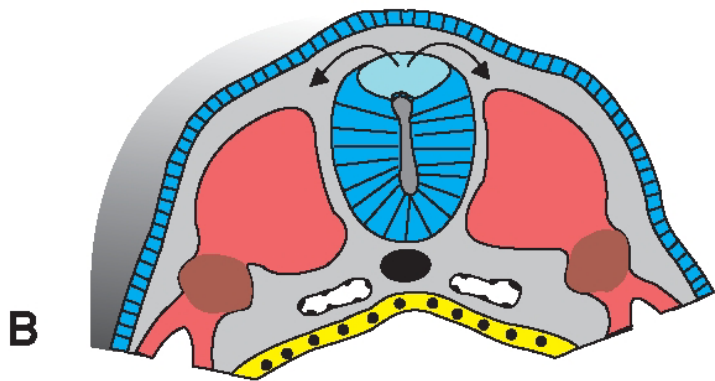
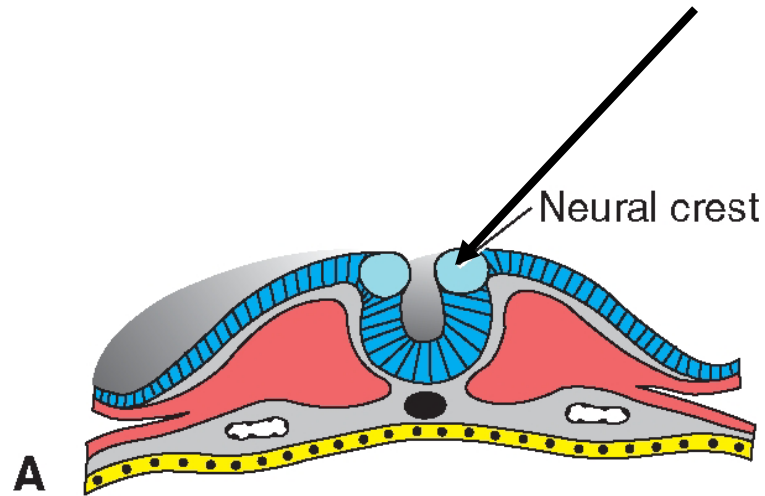
**SAY  
AAHH!**



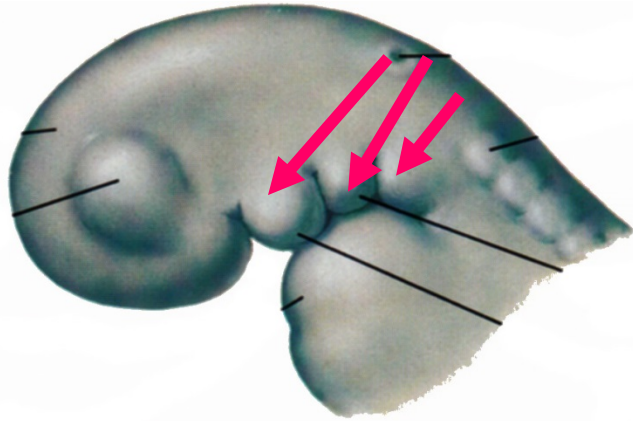
**PHARYNX**



## A. Week 4 - Neural Crest Cells Migrate

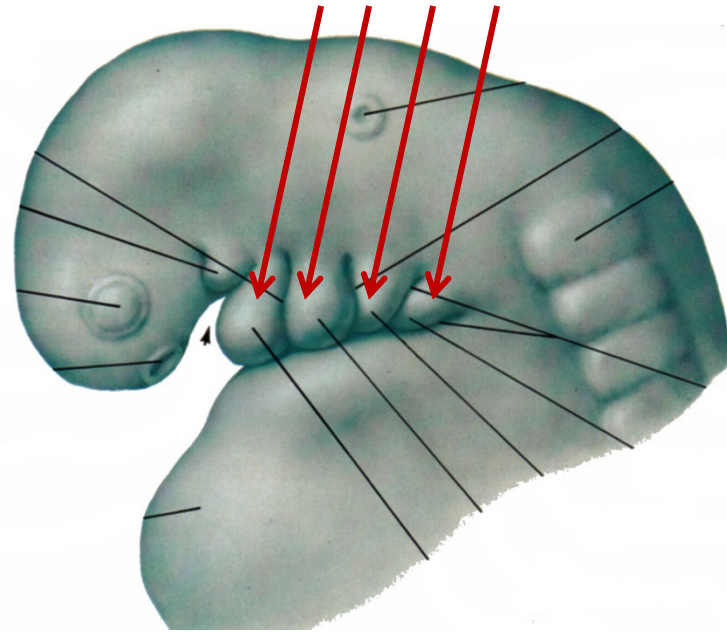






**Neural Crest  
Cells  
Invade Head  
and Neck  
Lateral  
To Rostral Part  
of Foregut  
= PHARYNX**

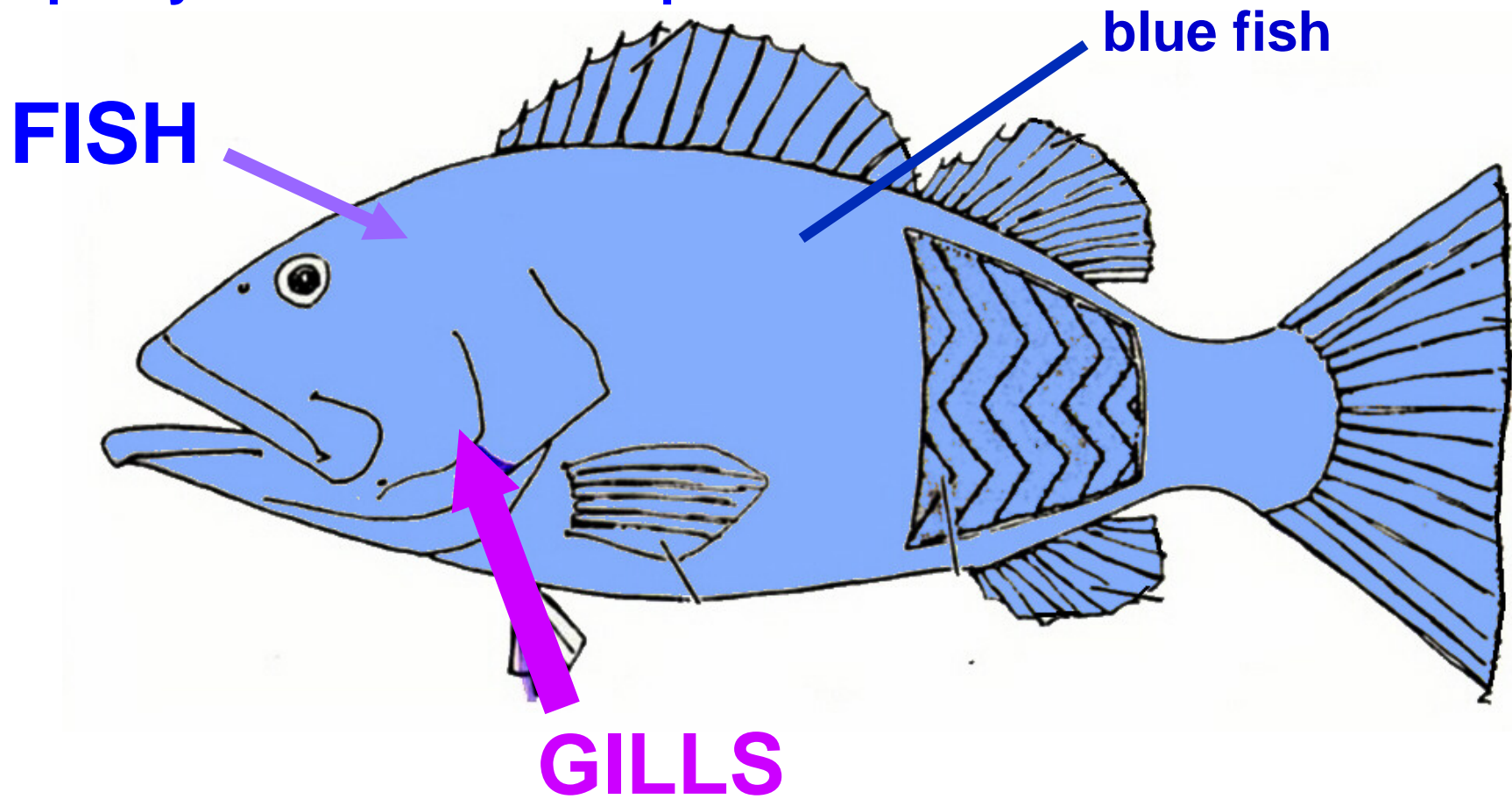
**Form Ridges = Branchial Arches**



**Branchia  
Means Gill  
In Greek;  
In fish, similar  
structures  
form Gills**

# GILLS OF FISH

Gills - located lateral to Rostral (proximal) end of pharynx - covered and protected



# GILLS HAVE ARTERIES, MUSCLES AND NERVES

Gills have filaments attached to cartilages

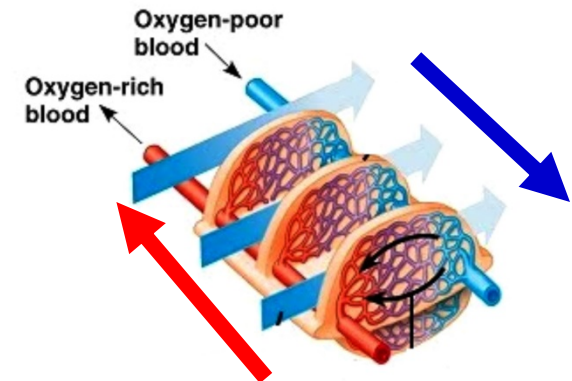
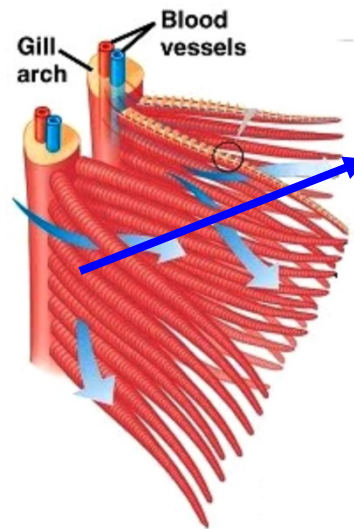
- arteries pass through filaments for gas exchange

- Gills moveable (filter feeding) - each has skeletal muscle and nerve  
(CRANIAL NERVE)



**water flow**

**blood flow**



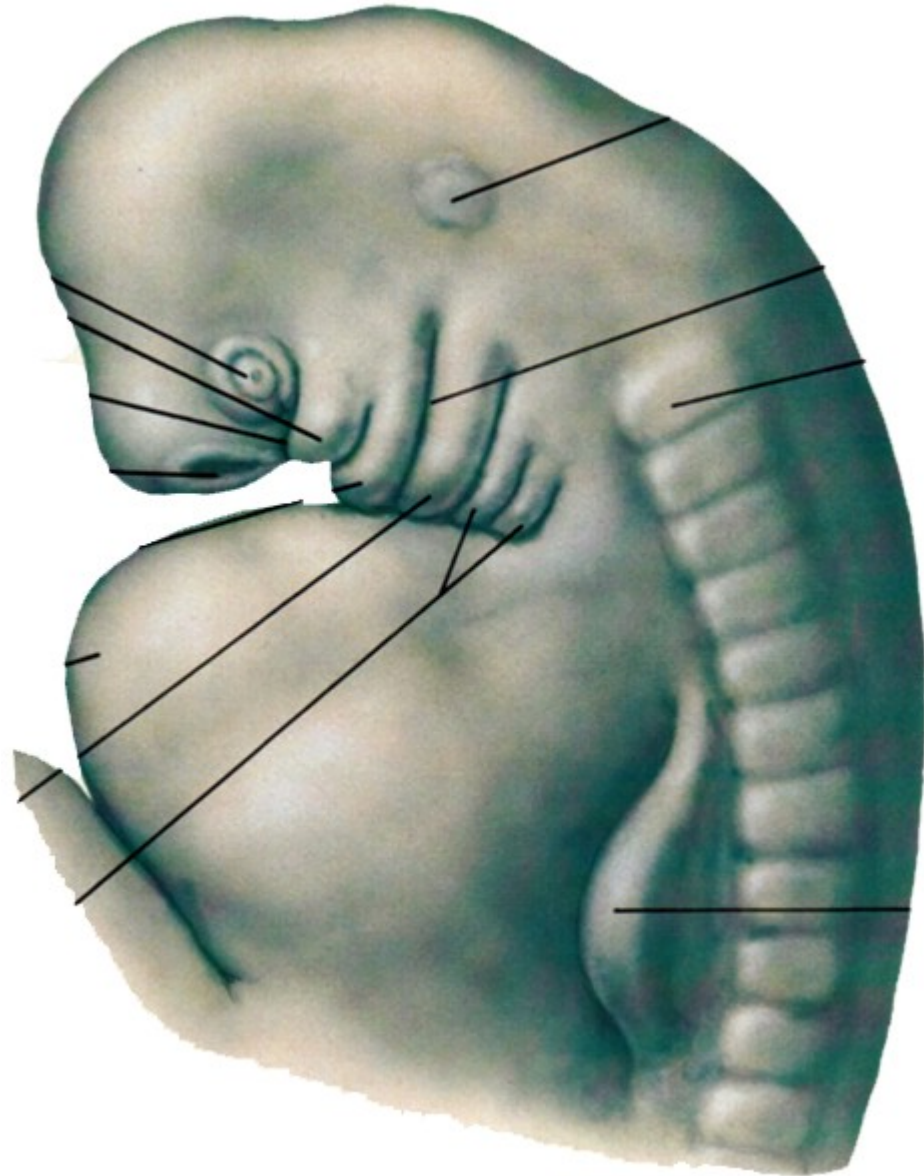
**Large surface area - Mackerel (swim a lot) - surface of gills 10 times surface area of body**



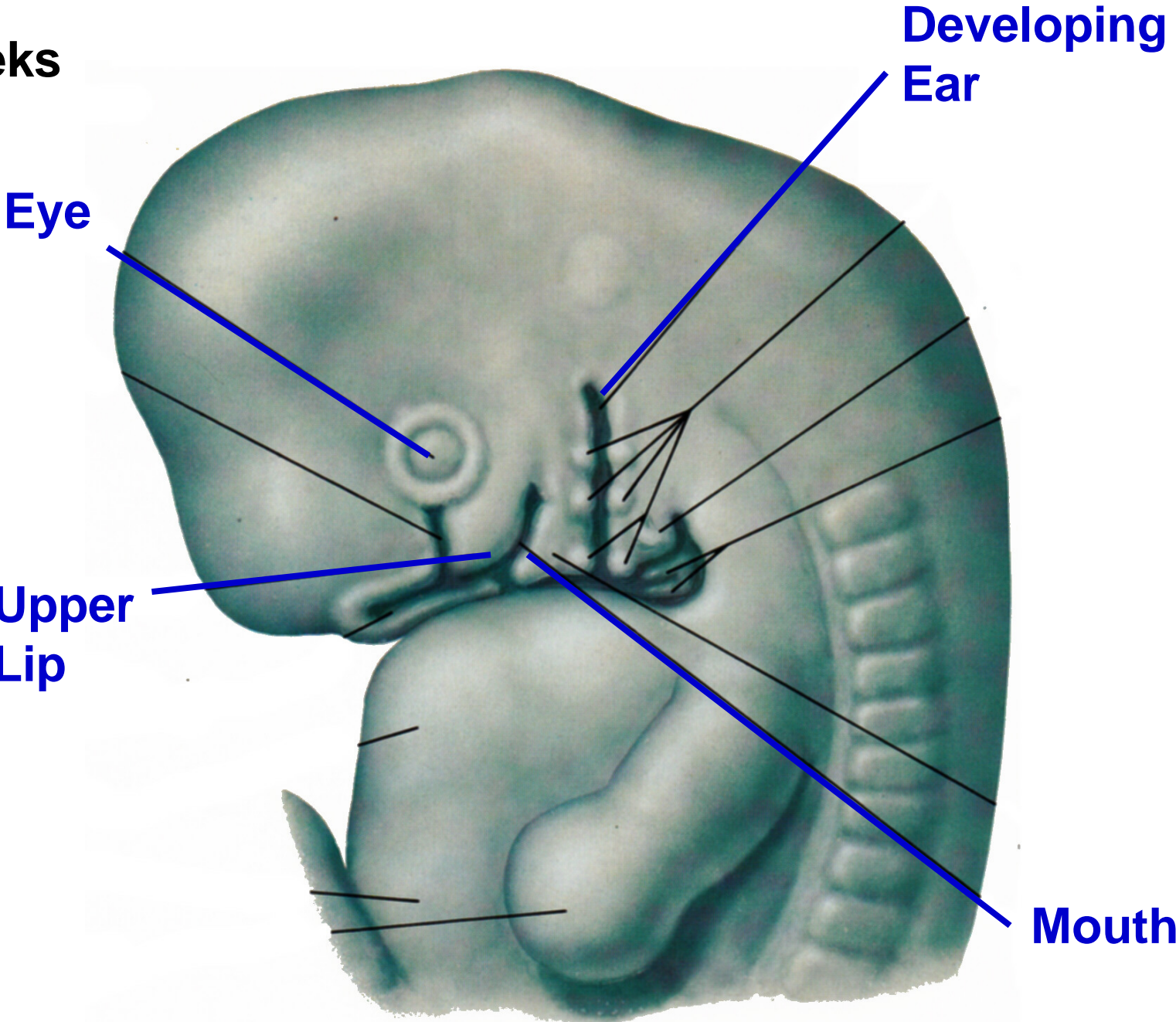
**Structures in Embryonic Branchial Arches Reorganize to form cartilages, nerve, muscles & arteries in fetus.**

**5- 6 weeks**

**Forms much of musculature of head some of neck**



**6-7 weeks**



**Eye**

**Developing Ear**

**Upper Lip**

**Mouth**

**8-10 weeks**



**Congenital Malformations of Head & Neck Result from incorrect Transformation of Branchial Apparatus to Adult Structures**

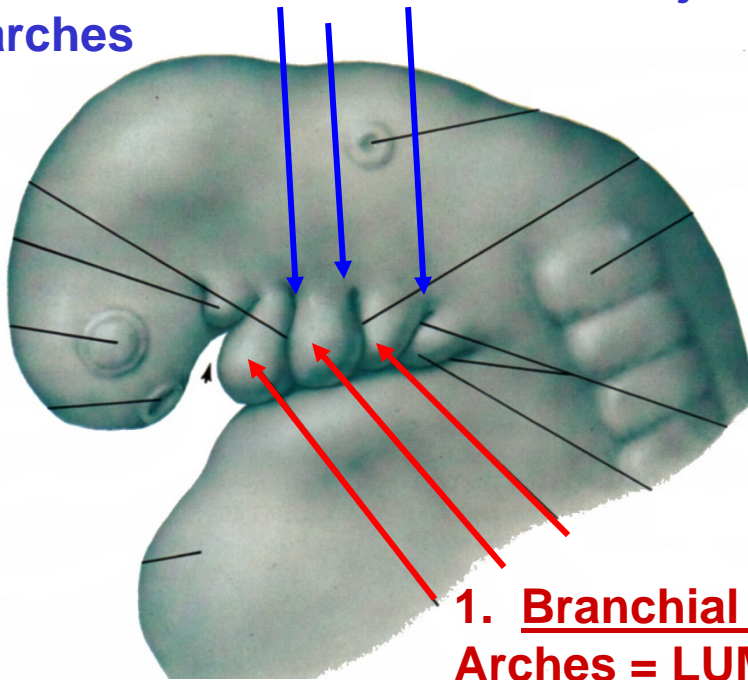


# TERMINOLOGY: ARCHES, GROOVES, POUCHES, MEMBRANES

## VIEW OF EXTERIOR OF EMBRYO

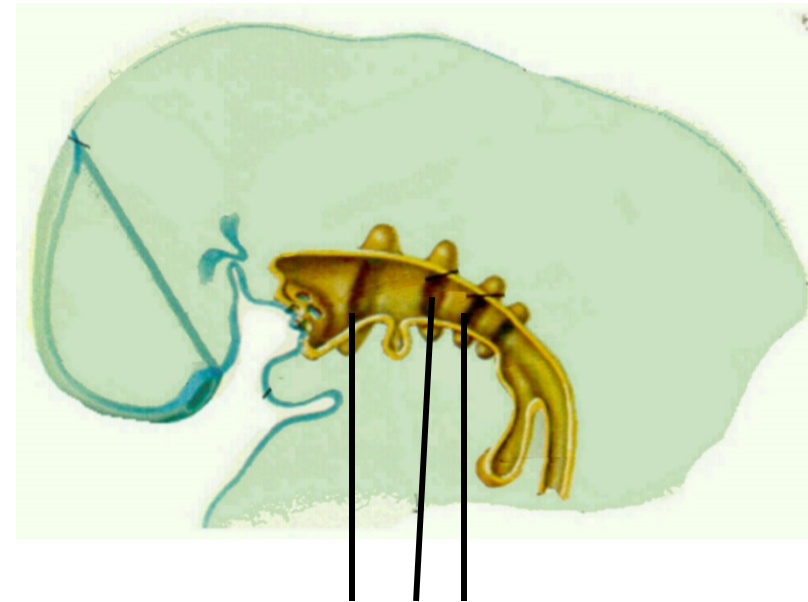
### 2. Branchial Grooves (Clefts)

- ectodermal clefts between adjacent arches



1. Branchial Arches = LUMPS

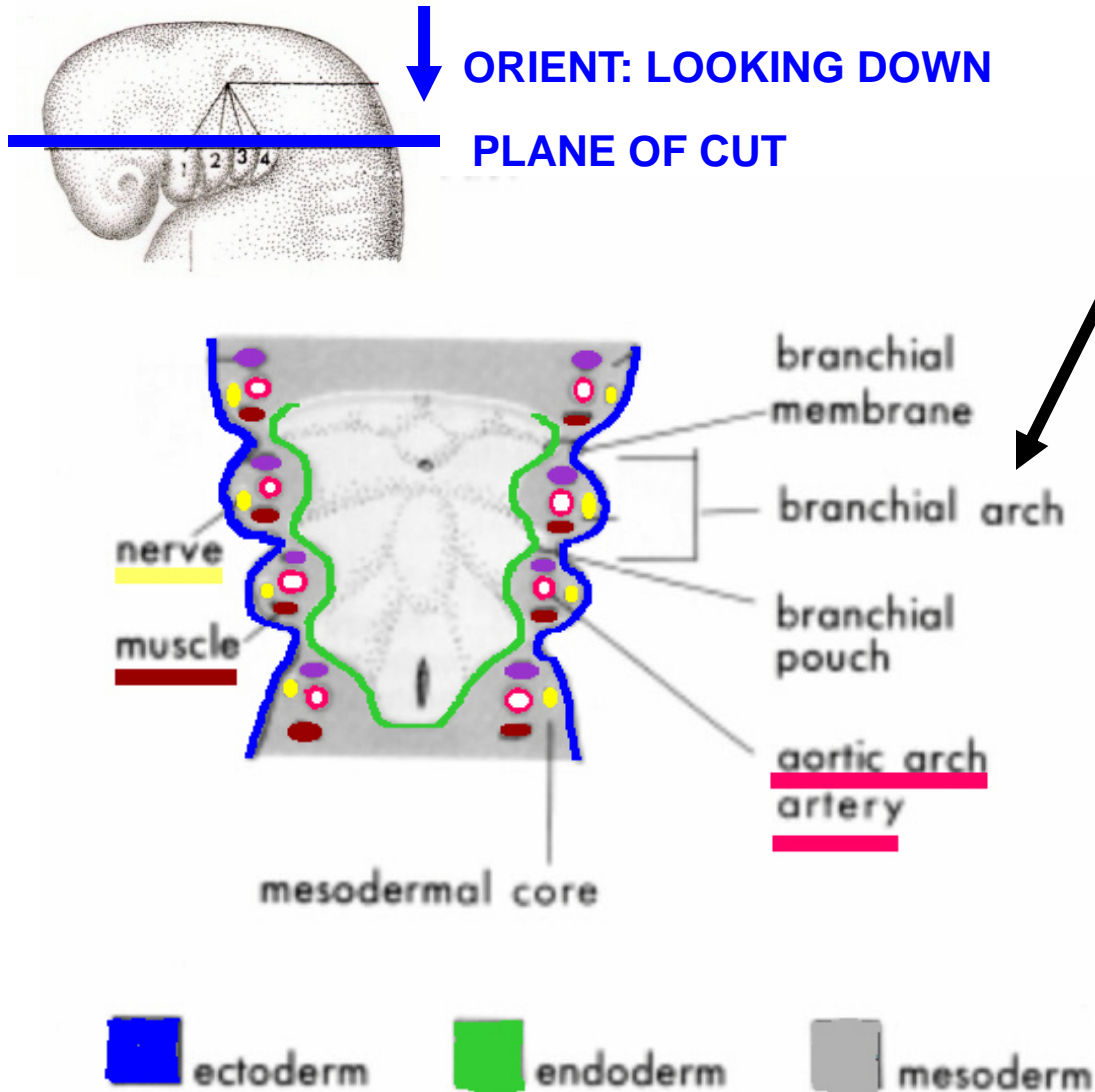
## VIEW OF EMBRYO BISECTED IN SAGITTAL PLANE



### 3. Branchial Pouch

- endodermal out pocketing from rostral foregut  
- between adjacent arches

## B. BRANCHIAL APPARATUS - 4 elements

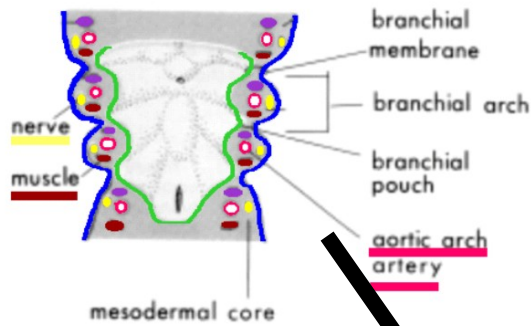


1. Branchial Arch  
covered by:  
Ectoderm - externally  
Endoderm - lined internally  
(Mesenchyme - core)

Each arch has own  
cartilage, nerve, muscle  
and artery (= aortic arch  
artery)

Each nerve innervates  
structures derived from  
its associated arch

# BRANCHIAL APPARATUS - 4 elements



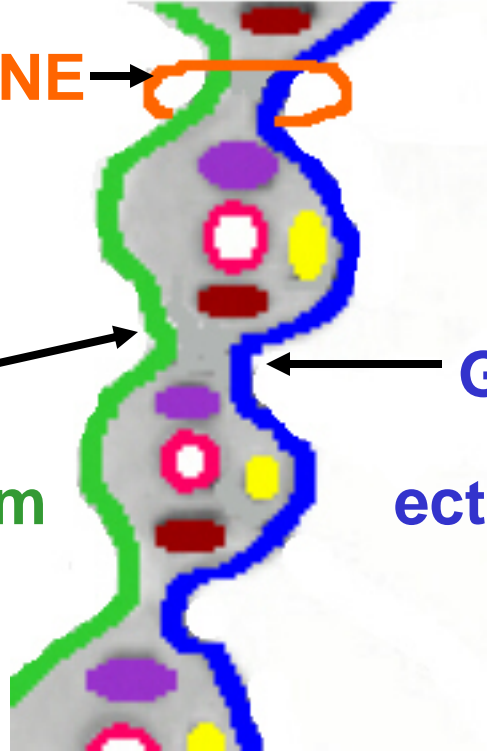
**MEMBRANE**

**POUCH**

**endoderm**

**GROOVE**

**ectoderm**



2. Branchial Groove  
(Pharyngeal Cleft)

- ectodermal cleft  
between adjacent  
arches

3. Branchial Pouch -

endodermal  
outpocketing from  
rostral foregut  
-between adjacent  
arches

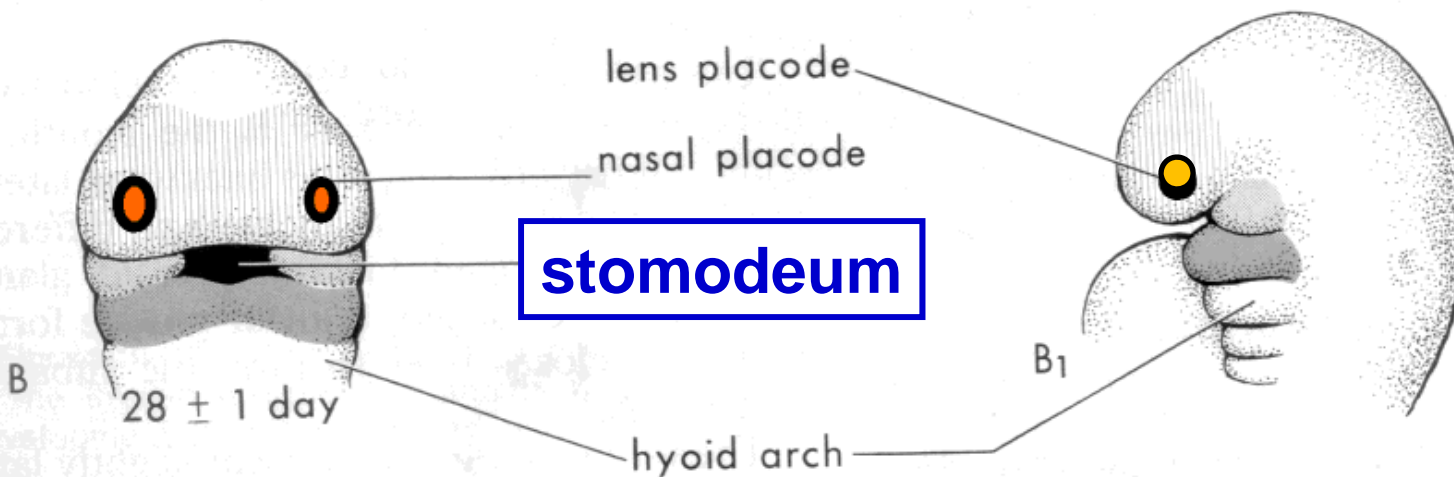
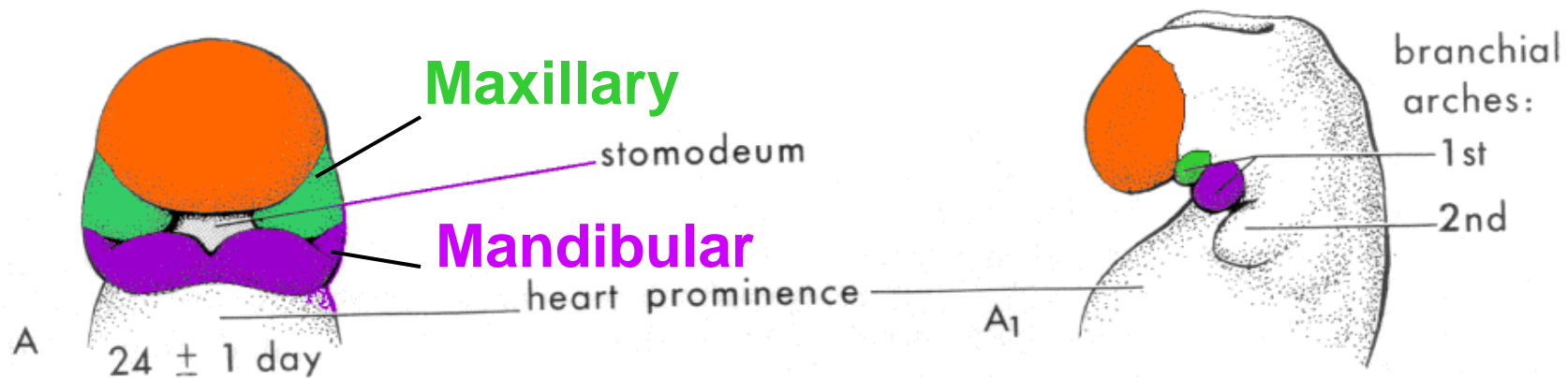
4. Branchial Membrane

- site of contact of  
Groove (ectoderm)  
Pouch (endoderm)



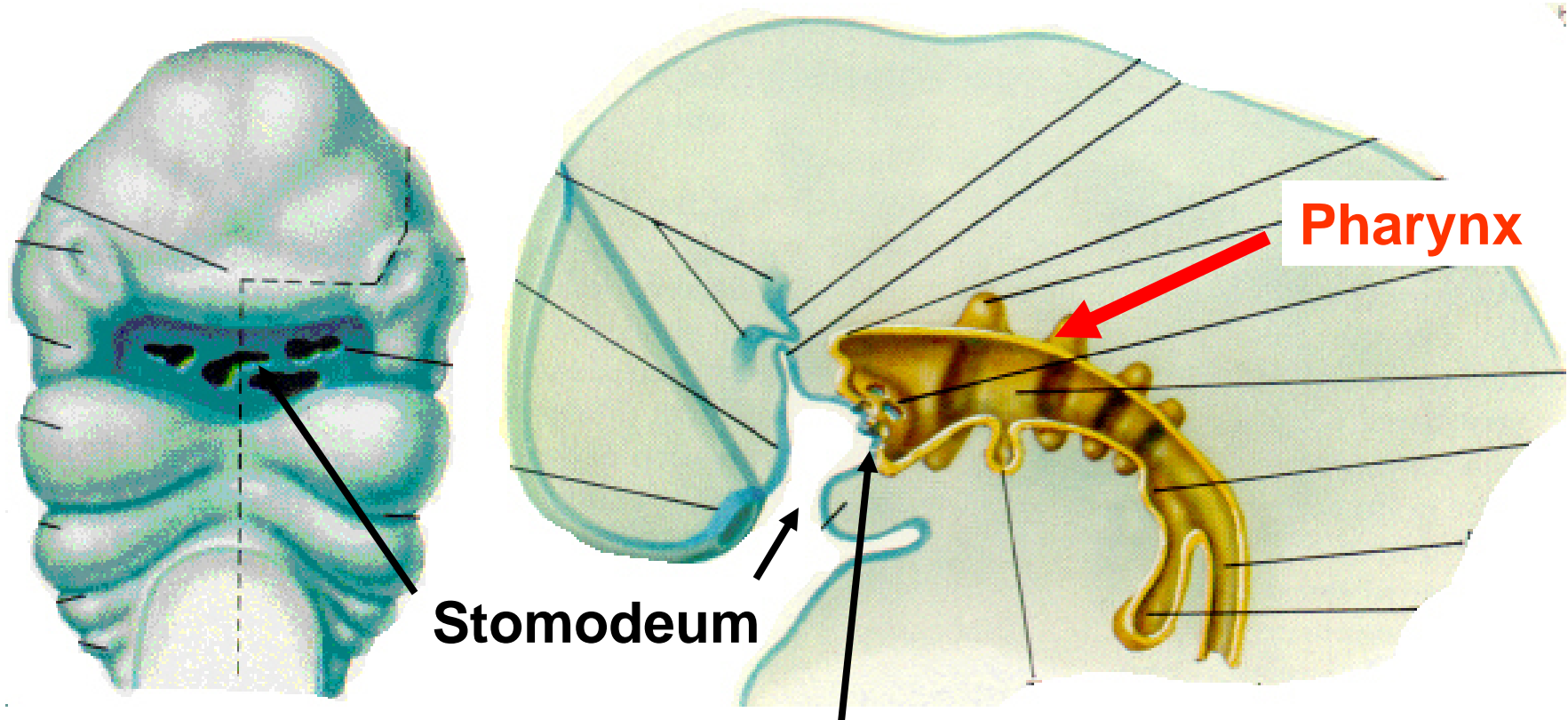
# First Arch - forms face, has maxillary and mandibular processes

- surrounds stomodeum (primitive mouth)

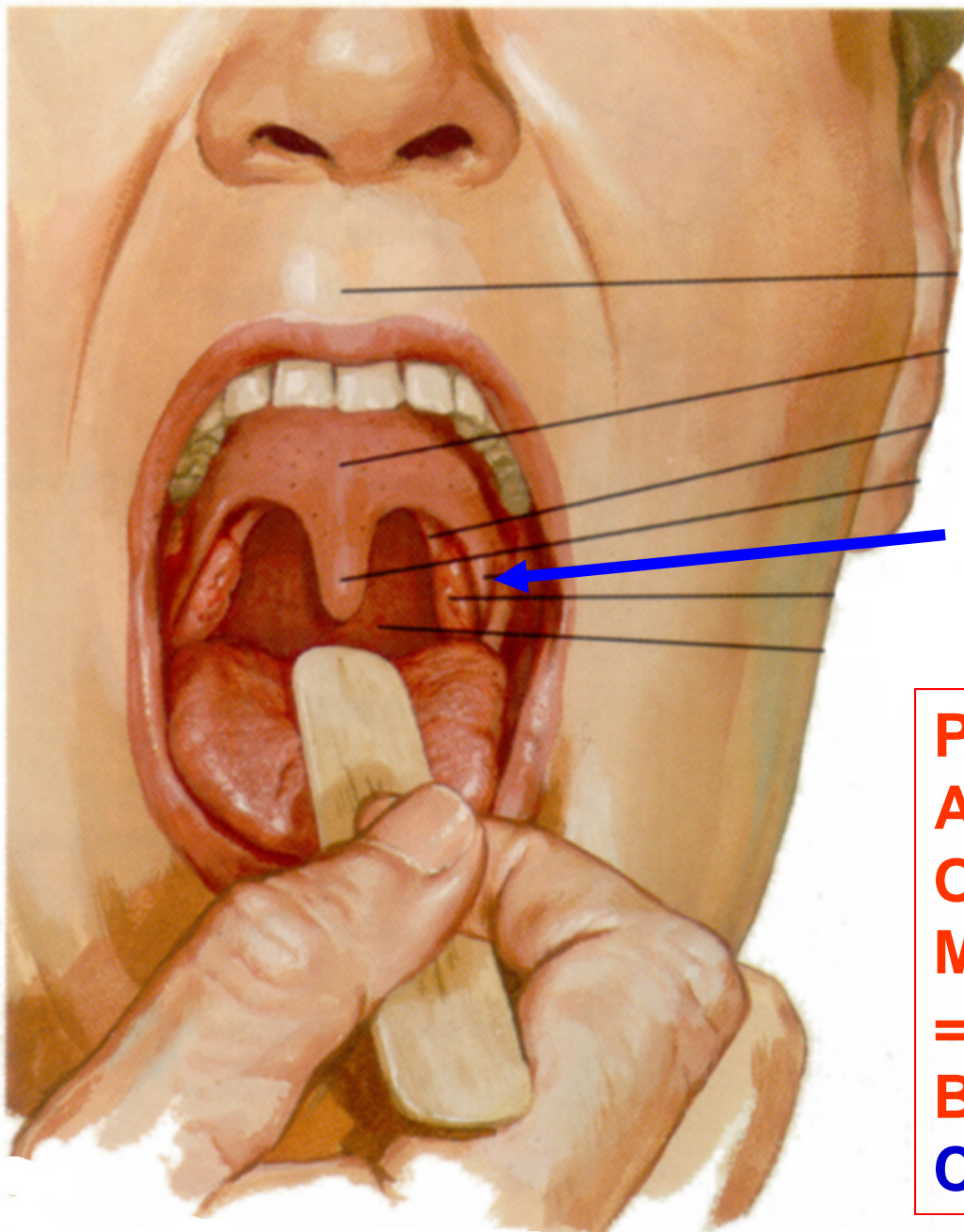


**NOTE: LENS PLACODE IS CORRECT**

- Stomodeum formed by Ectoderm; forms Oral Cavity and Nasal Cavity
- Contacts Endoderm at Oropharyngeal Membrane
- Pharynx – rostral foregut - formed by Endoderm



**Oropharyngeal Membrane = BOUNDARY**



**SAY  
AAHH!**

**PALATOGLOSSAL  
ARCH\*\***

**PALATOGLOSSAL  
ARCH = SITE OF  
OROPHARYNGEAL  
MEMBRANE  
= BOUNDARY,  
BETWEEN ORAL  
CAVITY AND PHARYNX**





<b>ARCH/NERVE</b>	<b>SKELETAL</b>	<b>LIGAMENTS</b>	<b>MUSCLES</b>
First (V)	1) Malleus 2) Incus	1) Ant. ligament of malleus 2) Sphenomandibular ligament	1) Muscles of Mastication 2) Tensor tympani 3) Tensor palati 4) Mylohyoid 5) Ant. belly of Digastric
Second (VI)	1) Stapes 2) Styloid process 3) Hyoid bone - lesser horn, upper half of body	Stylohyoid ligament	1) Muscles of Facial Expression 2) Stapedius 3) Stylohyoid 4) Post. belly of Digastric
Third (IX)	Hyoid bone - greater horn, lower half of body	-----	Stylopharyngeus
Fourth (X)	Cartilages of Larynx	-----	1) All muscles of Larynx 2) All muscles of Pharynx (except Stylopharyngeus) 3) All muscles of Soft Palate (except Tensor palati)
Sixth (XI)	-----	-----	1) Sternocleidomastoid 2) Trapezius

Note: First Branchial Groove (Cleft) becomes External Auditory Meatus  
First Branchial Membrane becomes Tympanic Membrane

**Note:**

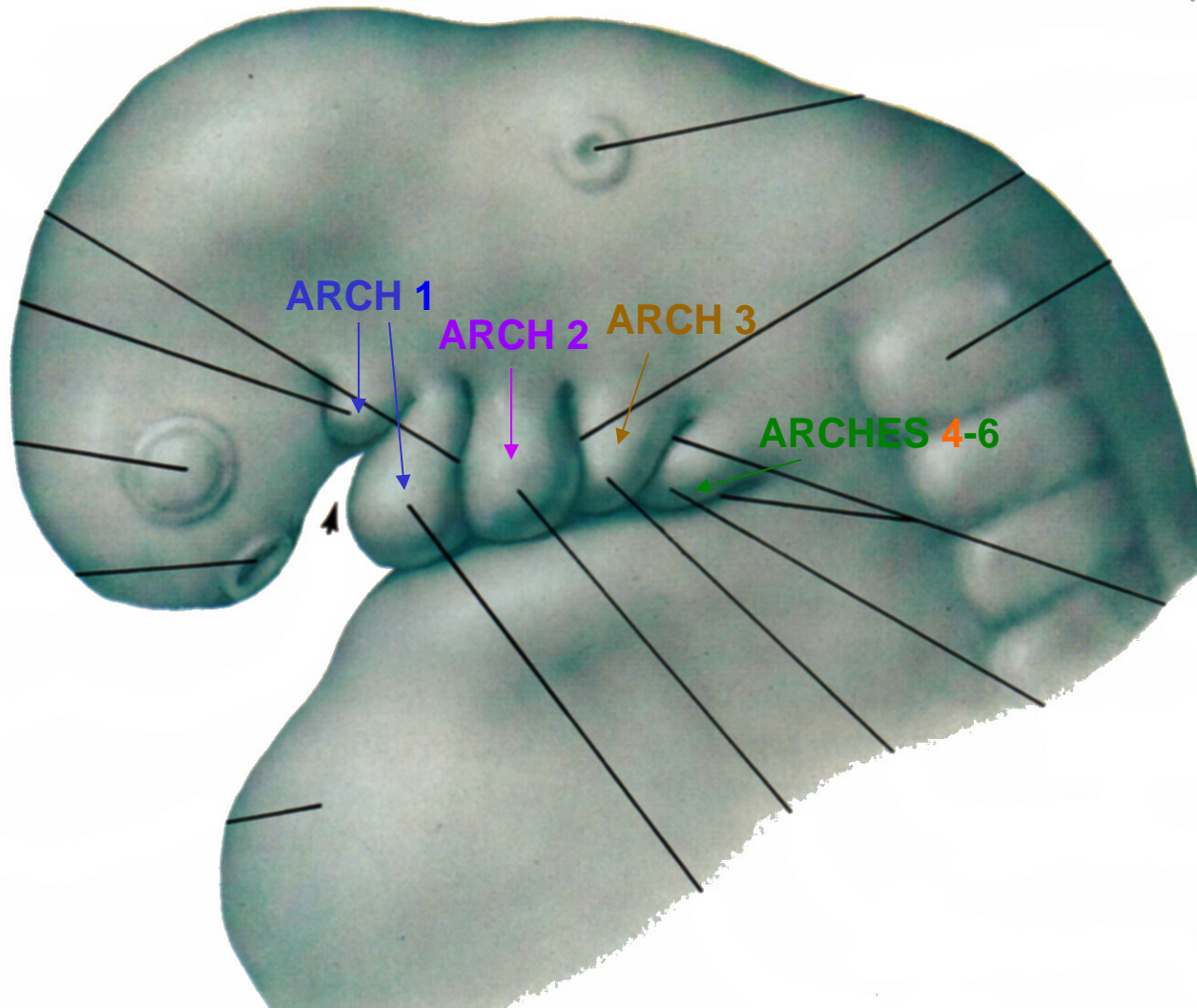
**All authors agree on:**

**1) Fate of Arches**

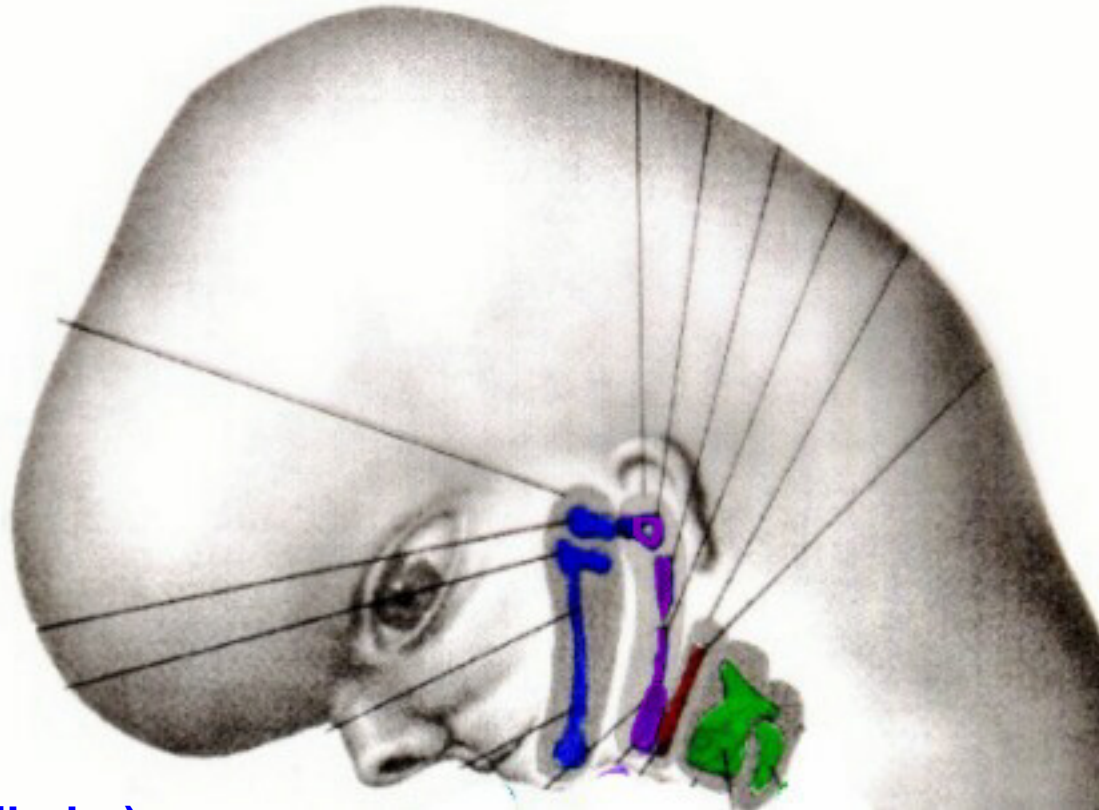
**1- 3;**

**2) Arch 5 does not form structures in humans**

**Accounts vary on Arches 4 and 6 (6 is small)**



# BRANCHIAL ARCH CARTILAGES



## I First (Mandibular)

### Arch -

1. Malleus
2. Incus
3. Ant. Ligament  
Of malleus
4. Sphenomandibular  
ligament

## II Second (Hyoid) Arch

1. Stapes
2. Styloid Process
3. Stylohyoid Ligament
4. Lesser horn, Upper  
 $\frac{1}{2}$  body Hyoid

## III Third Arch -

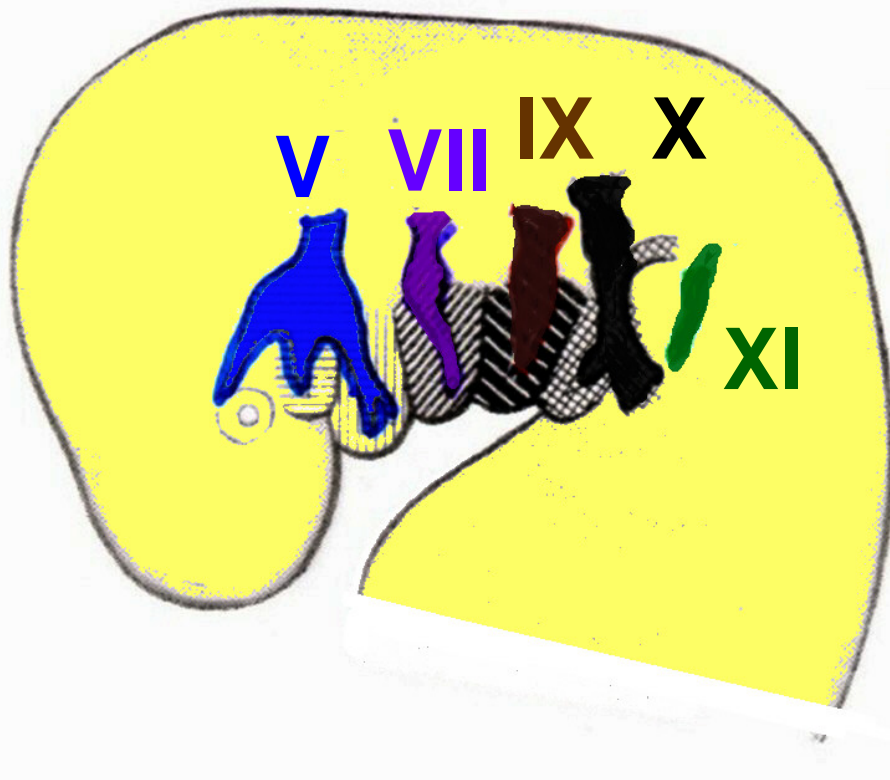
- Lower  $\frac{1}{2}$   
Body, Greater  
Horn Of hyoid

## IV Fourth (Sixth) Arch - Cartilages Of larynx



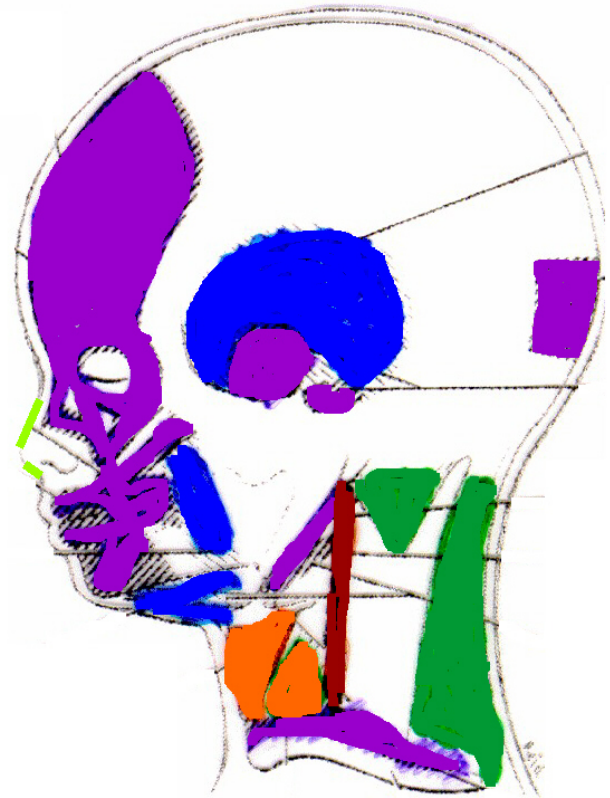
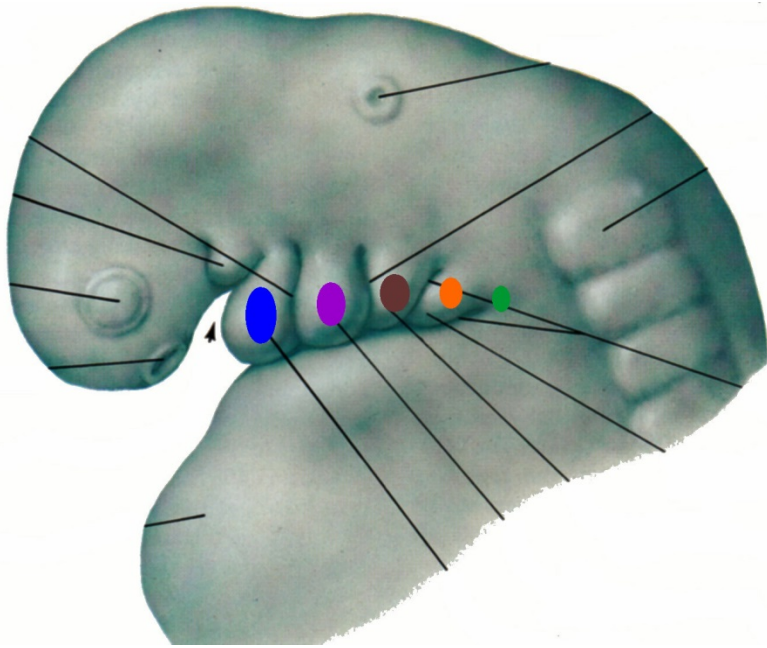
# BRANCHIAL ARCH NERVES

Muscles of Arches are innervated by Cranial Nerves



- 1) First Arch – Trigeminal (V)
- 2) Second Arch – Facial (VII)
- 3) Third Arch – Glossopharyngeal (IX)
- 4) Fourth Arch – Vagus (X)
- 5) Caudal Sixth – Accessory (XI)

# MUSCLES OF BRANCHIAL ARCHES



Innervated by

**First -  
Trigeminal  
V**

**Second -  
Facial  
VII**

**Third  
Glosso-  
pharyngeal  
IX**

**Fourth  
Vagus  
X**

**Sixth  
Accessory  
XI**

**10) BRANCHIOMOTOR** - voluntary motor to skeletal muscles of face, ear, pharynx and neck that are derived from branchial arches.

	<u>Nerve</u>	<u>Innervates</u>
<b>FIRST ARCH</b>	V (Trigeminal) (all in V3)	muscles of mastication mylohyoid tensor tympani tensor palati anterior belly of digastric
<b>SECOND ARCH</b>	VII (Facial)	muscles of facial expression stylohyoid posterior belly of digastric stapedius
<b>THIRD ARCH</b>	IX (Glossopharyngeal)	stylopharyngeus
<b>FOURTH ARCH</b>	X (Vagus)	all muscles of pharynx (except stylopharyngeus) muscles of larynx all muscles of palate (except tensor palati)
<b>CAUDAL SIXTH ARCH</b>	XI (Accessory)	sternocleidomastoid trapezius

**KNOW THIS:  
QUESTIONS  
ON EXAM,  
BOARDS**

**note: Innervation pattern of Cranial Nerves applies to muscles of BRANCHIAL ARCHES: DOES NOT APPLY TO POUCHES OR CLEFTS**

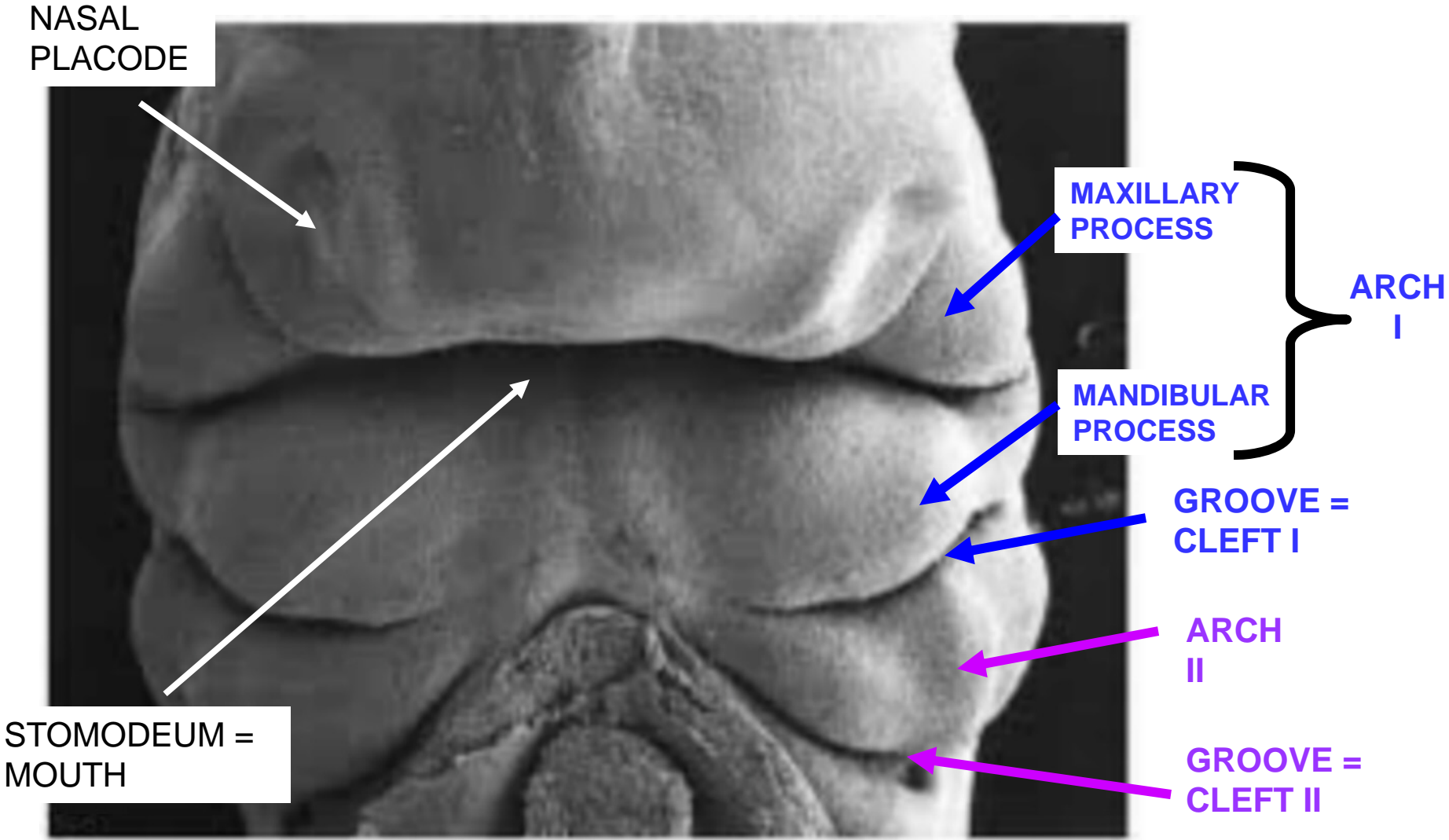


# BRANCHIOMOTOR (SVE) = SKELETAL MUSCLES DERIVED FROM BRANCHIAL ARCHES

ARCH/NERVE	SKELETAL	LIGAMENTS	MUSCLES
First (V)	1) Malleus 2) Incus	1) Ant. ligament of malleus 2) Sphenomandibular ligament	1) Muscles of Mastication 2) Tensor tympani 3) Tensor palati 4) Mylohyoid 5) Ant. belly of Digastric
Second (VI)	1) Stapes 2) Styloid process 3) Hyoid bone - lesser horn, upper half of body	Stylohyoid ligament	1) Muscles of Facial Expression 2) Stapedius 3) Stylohyoid 4) Post. belly of Digastric
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Sixth (XI)	-----	-----	1) Sternocleidomastoid 2) Trapezius

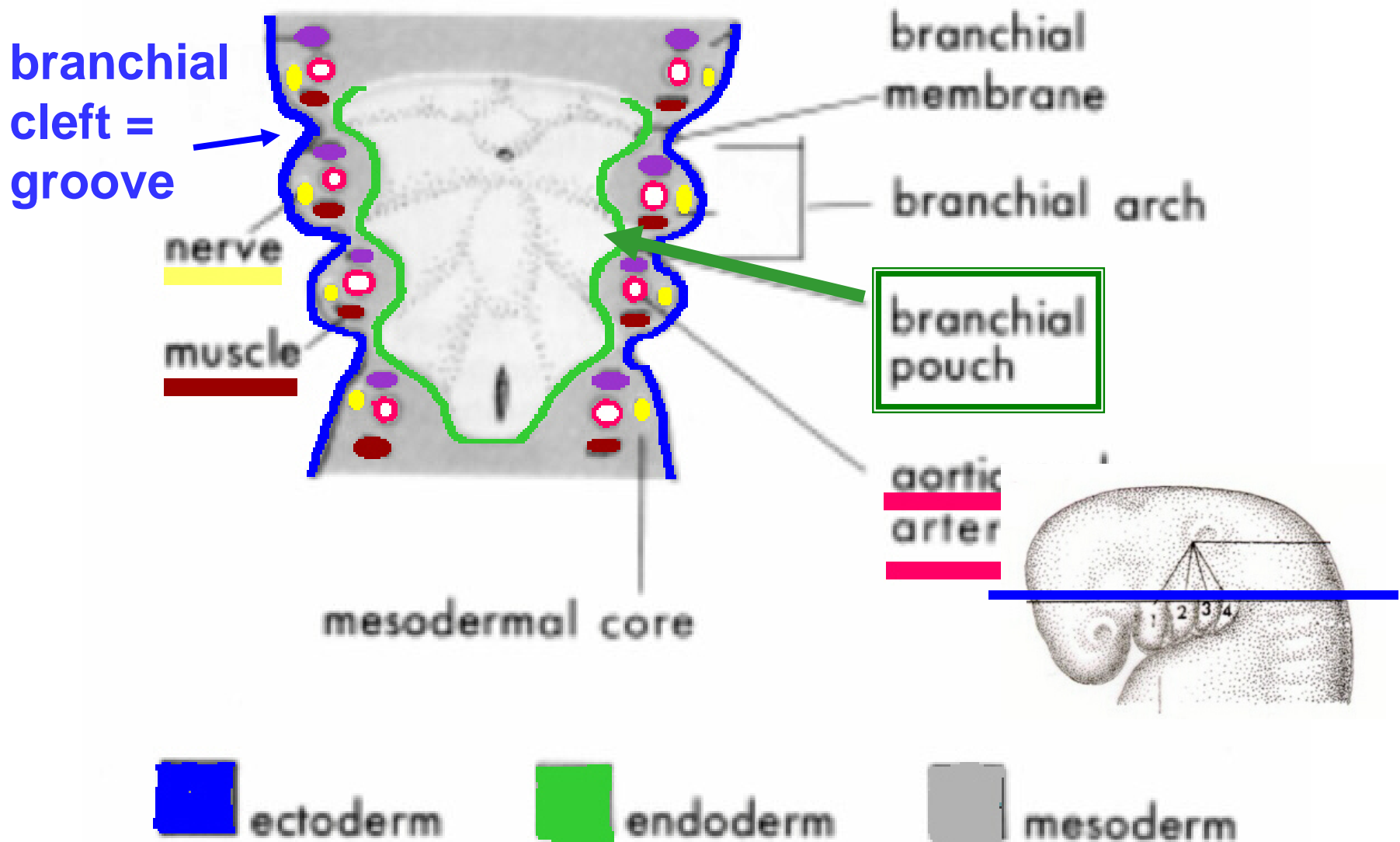
Note: First Branchial Groove (Cleft) becomes External Auditory Meatus  
First Branchial Membrane becomes Tympanic Membrane

# BRANCHIAL ARCHES AND CLEFTS



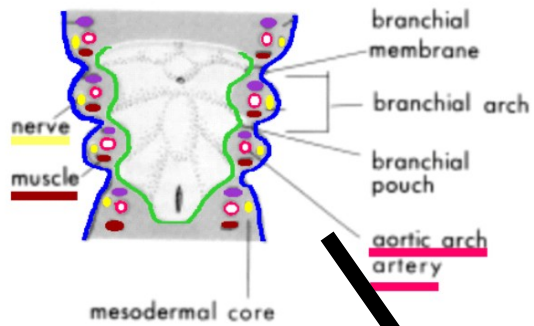
24 DAY HUMAN EMBRYO

# BRANCHIAL POUCHES, GROOVES, MEMBRANES





# BRANCHIAL APPARATUS - 4 elements



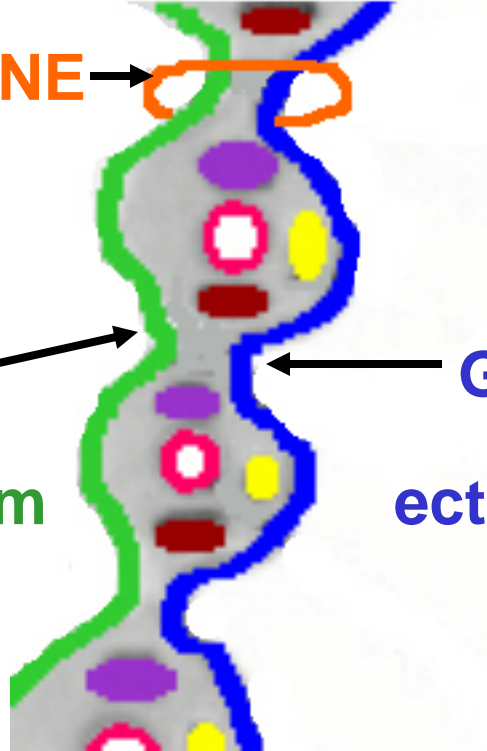
**MEMBRANE**

**POUCH**

**endoderm**

**GROOVE**

**ectoderm**



2. Branchial Groove  
(Pharyngeal Cleft)

- ectodermal cleft  
between adjacent  
arches

3. Branchial Pouch -

endodermal  
outpocketing from  
rostral foregut  
-between adjacent  
arches

4. Branchial Membrane

- site of contact of  
Groove (ectoderm)  
Pouch (endoderm)

# BRANCHIAL POUCHES, GROOVES, MEMBRANES

POUCH	FORMS	CLINICAL
First	1) Auditory tube 2) Tympanic cavity	First Branchial 'Cleft' cyst - tract linked to external auditory meatus
Second	Lining (crypts) of palatine tonsils	Second Branchial 'Cleft' cyst - tract linked to tonsillar fossa (palatine tonsils)
Third	1) Inferior parathyroid gland 2) Thymus	Third Branchial 'Cleft' cyst - tract at thyrohyoid membrane or piriform recess
Fourth	1) Superior parathyroid gland 2) C-cells of Thyroid	does not form
Sixth (XI)	-----	-----

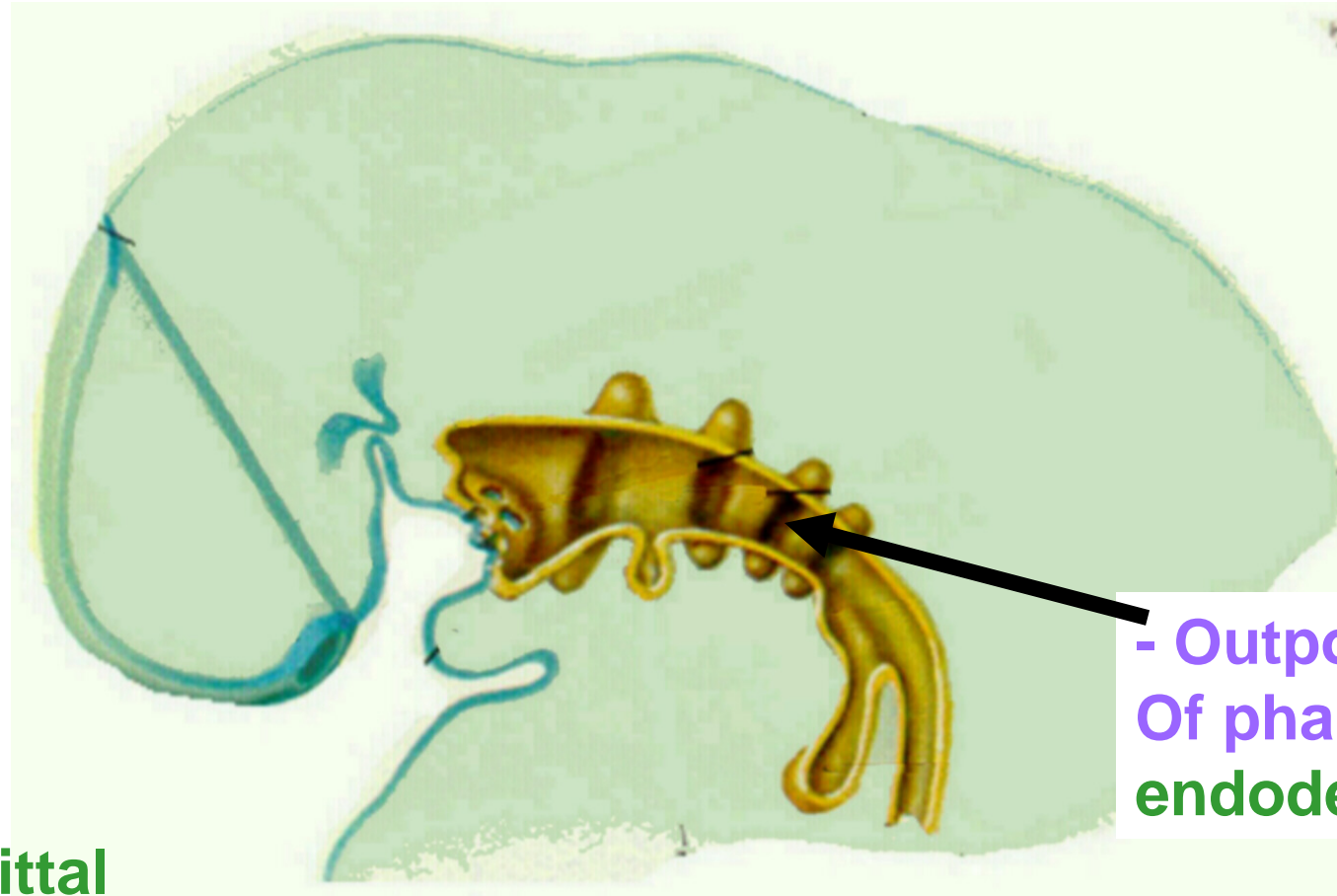
Note: Cysts and fistuli - in lateral neck are **anterior to Sternocleidomastoid muscle**

CLEFT	FORMS
First	External Auditory Meatus

MEMBRANE	FORMS
First	Tympanic membrane

**NOTE: CLEFT = GROOVE**

## IV. BRANCHIAL POUCHES



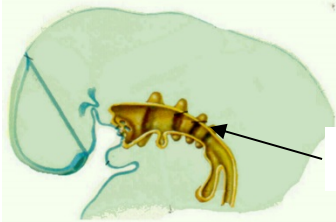
- Outpocketings  
Of pharynx  
endoderm

Sagittal  
View – embryo  
6-7 weeks

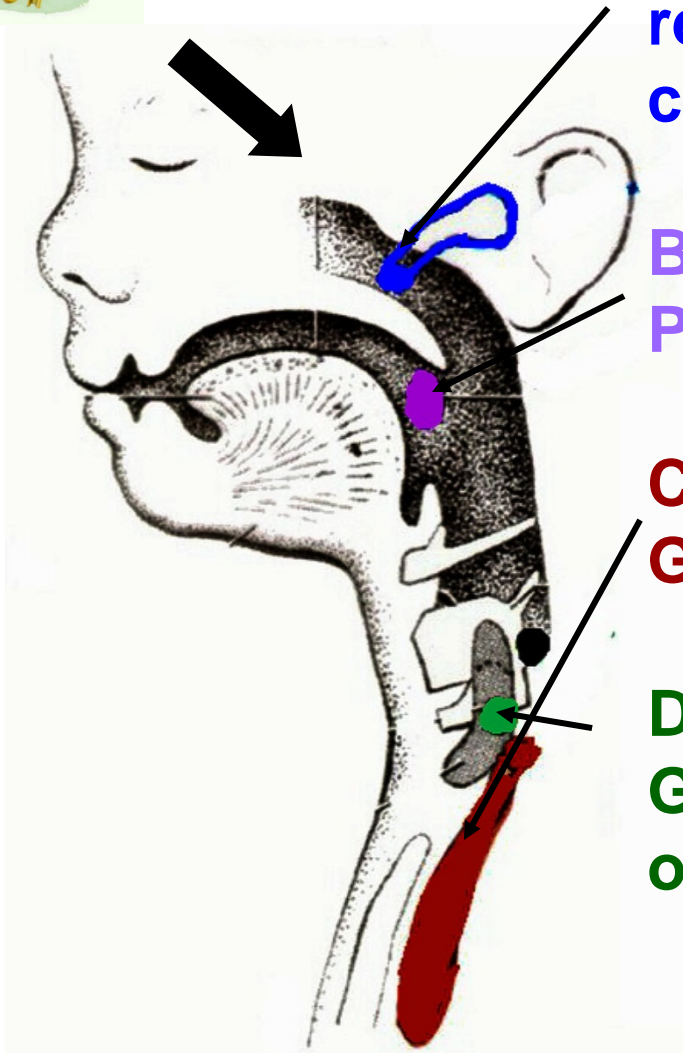
View  
Inside Pharynx  
Endoderm



# BRANCHIAL POUCH DERIVATIVES



Branchial Pouch



**A. Pouch 1 - forms Tubotympanic recess - Auditory Tube, Tympanic cavity**

**B. Pouch 2 - lining (crypts) of Palatine Tonsils**

**C. Pouch 3- Inferior Parathyroid Glands and Thymus Gland**

**D. Pouch 4 - Superior Parathyroid Glands and C-Cells (Calcitonin) of Thyroid**

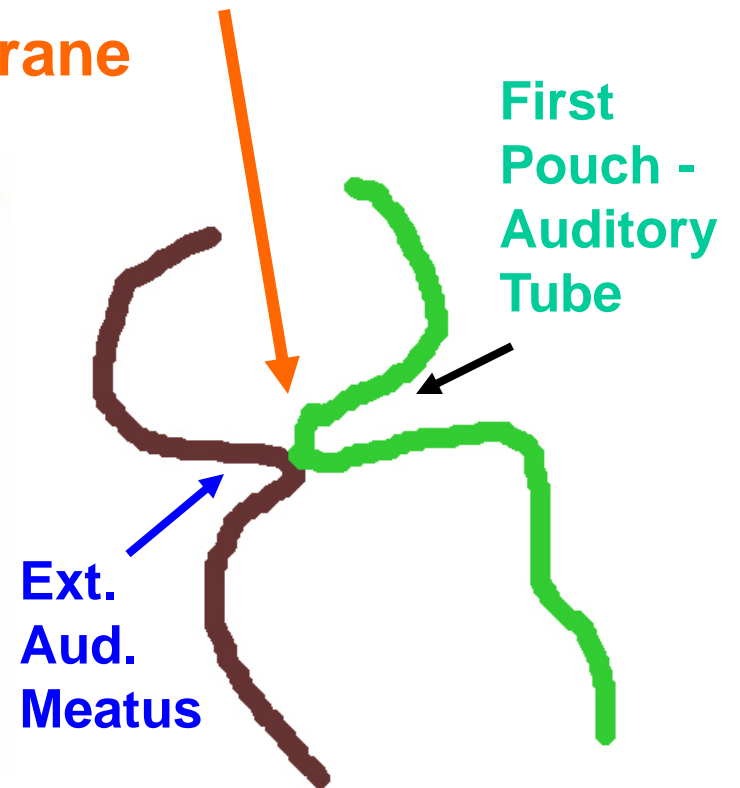
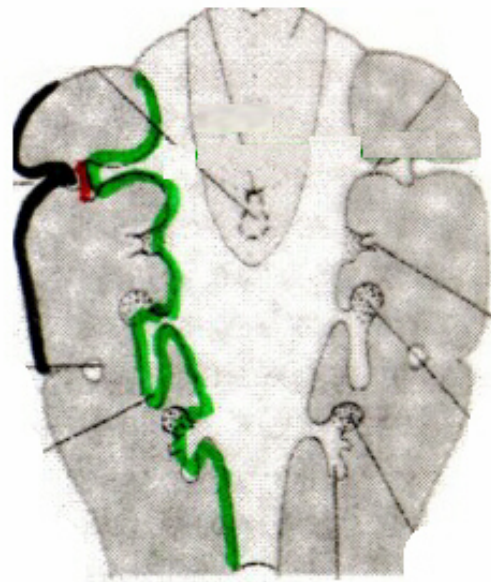
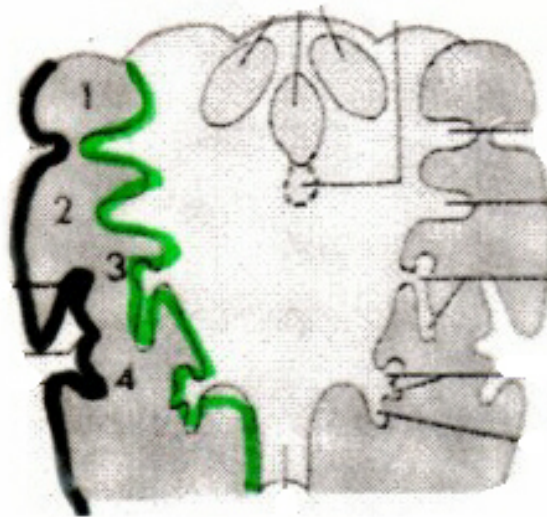
**Note: Pouch 3 derivatives migrate caudal to pouch 4**

### III. BRANCHIAL GROOVES AND MEMBRANES

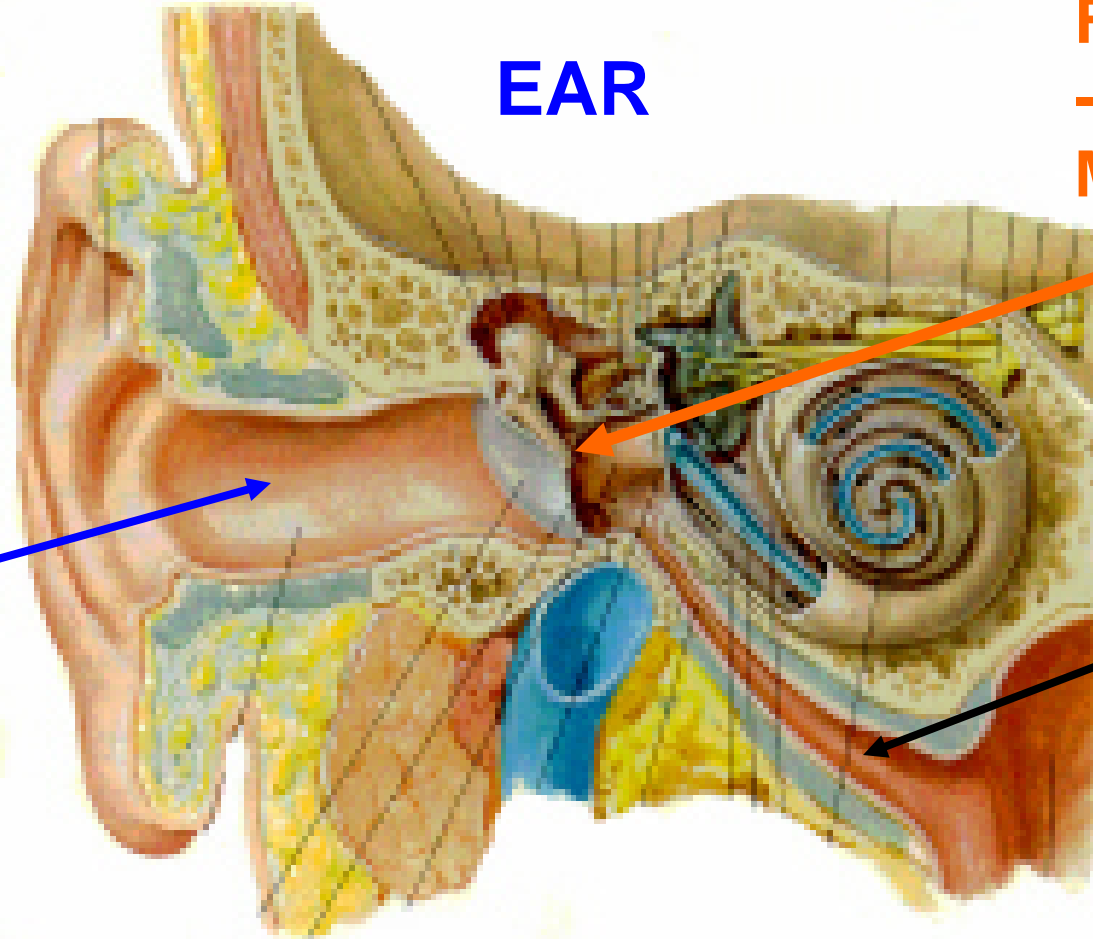
Only First Branchial Groove & Membrane Normally form Structures in Adult

First Groove - External Auditory Meatus

First Membrane - Tympanic Membrane



# EAR



**FIRST GROOVE -**  
Ext. Aud.  
Meatus

**First Membrane**  
- Tympanic  
Membrane

**FIRST POUCH -**  
Auditory  
Tube,  
Tympanic  
Cavity

## Outer Ear

- 1) funnel shaped
- 2) directs sounds to tympanic membrane
- 3) binaural hearing

## Middle Ear

- 1) bones link tympanic membrane to cochlea  
amplify pressure
- 2) muscles can dampen loud sounds

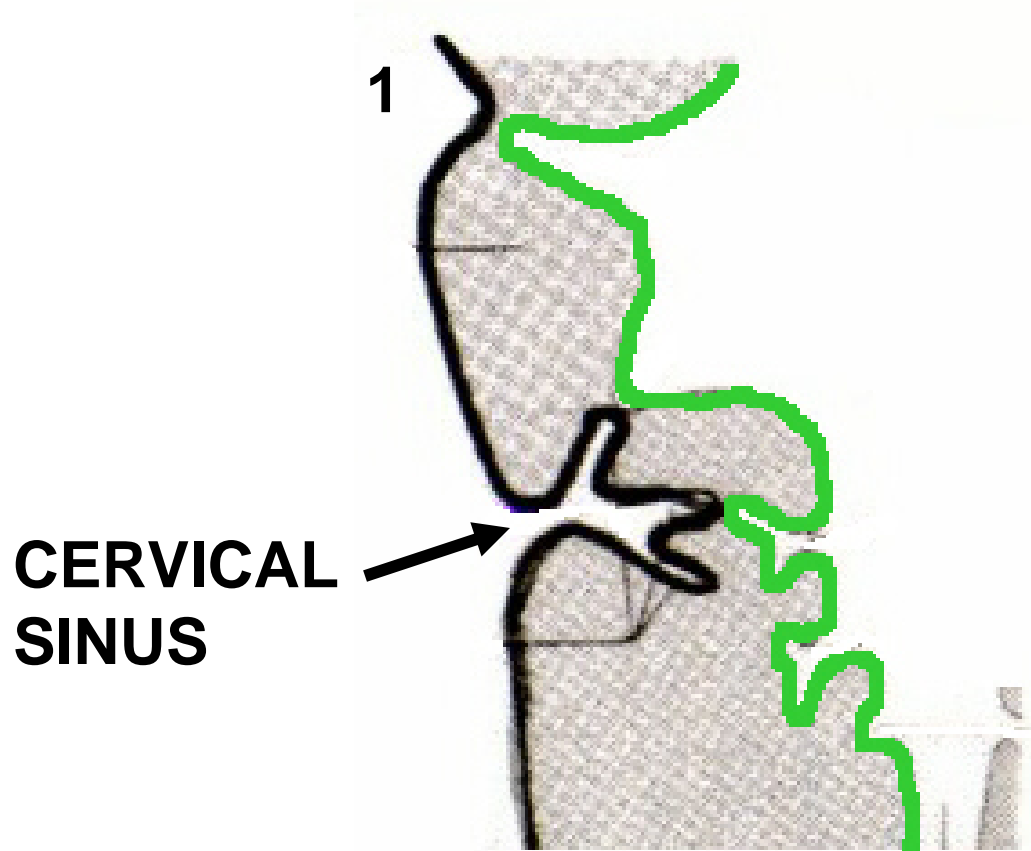
## Inner Ear

- 1) cochlea-  
hearing  
vestibular  
apparatus-  
gravity



# BRANCHIAL GROOVES

Other Grooves develop in longer depression  
Cervical Sinus

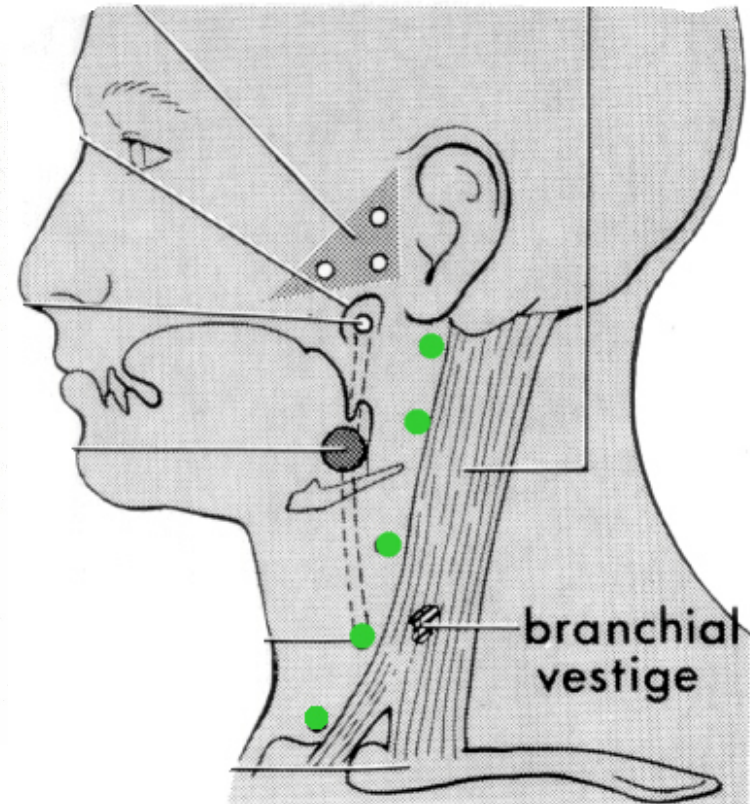
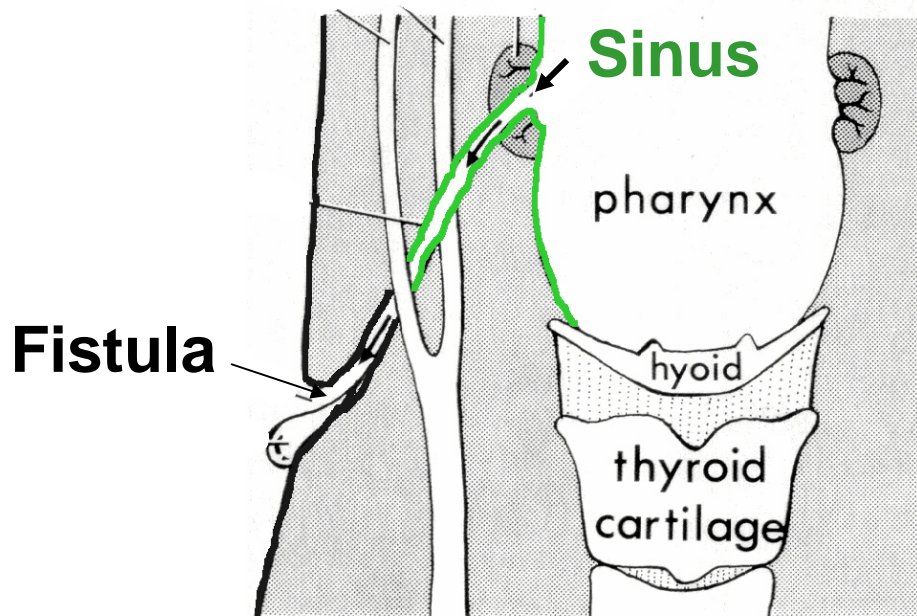


**Note:**  
Cervical  
sinus  
normally  
obliterated  
but  
can persist

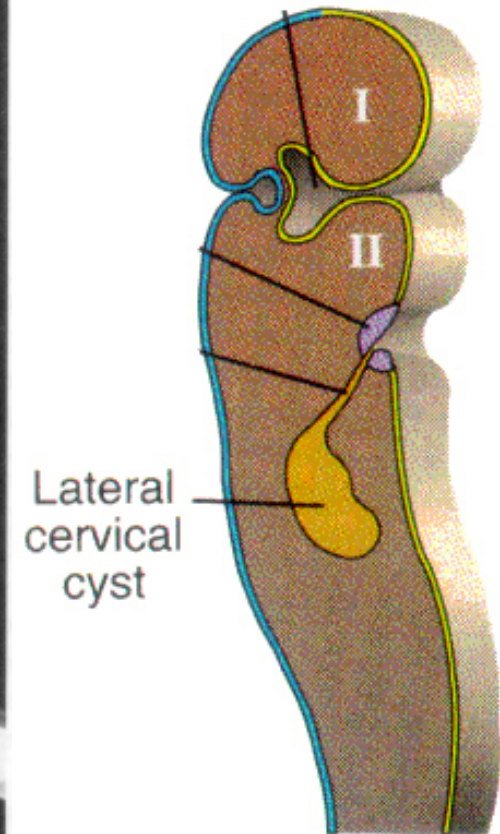
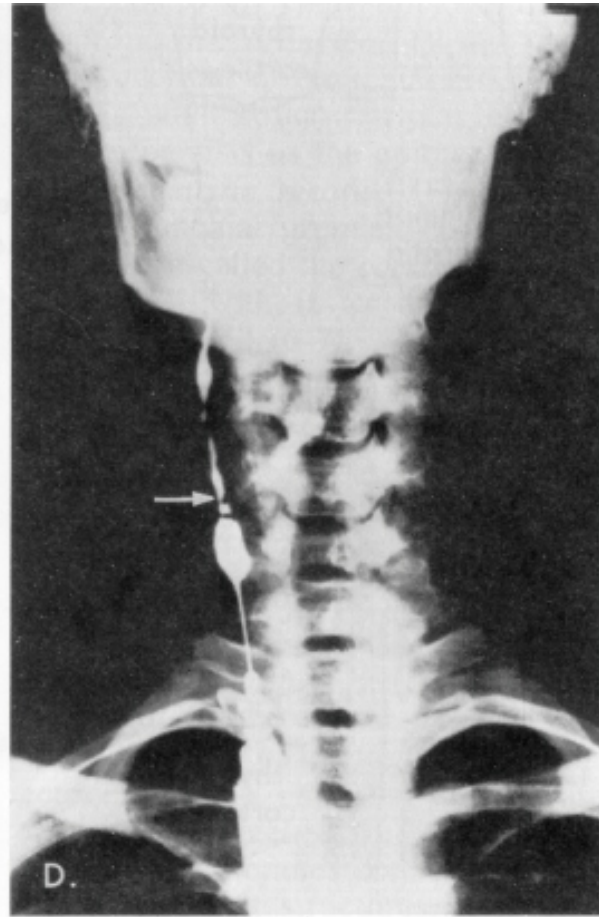
## BRANCHIAL ANOMALIES

Branchial Sinus = Blind pouch from Pharynx

Branchial Fistula = Channel, often connecting Pharynx to skin of neck; usually passes Anterior to Sternocleidomastoid, between Int. and Ext. Carotid A.



## BRANCHIAL ANOMALIES



**Branchial Fistula - drains to neck**

**Branchial Cyst  
often remnant  
of Cervical Sinus**



# BRANCHIAL POUCHES, GROOVES, MEMBRANES

POUCH	FORMS	CLINICAL
First	1) Auditory tube 2) Tympanic cavity	First Branchial 'Cleft' cyst - tract linked to external auditory meatus
Second	Lining (crypts) of palatine tonsils	Second Branchial 'Cleft' cyst - tract linked to tonsillar fossa (palatine tonsils)
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Fourth	1) Superior parathyroid gland 2) C-cells of Thyroid	does not form
Sixth (XI)	-----	-----

Note: Cysts and fistuli - in lateral neck are **anterior to Sternocleidomastoid muscle**

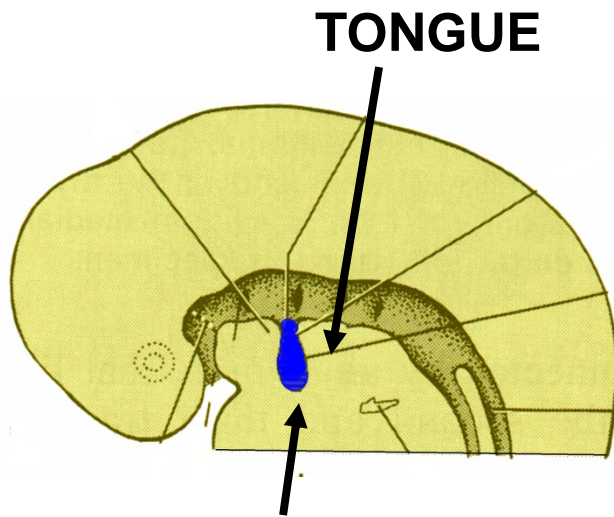
CLEFT	FORMS
First	External Auditory Meatus

MEMBRANE	FORMS
First	Tympanic membrane

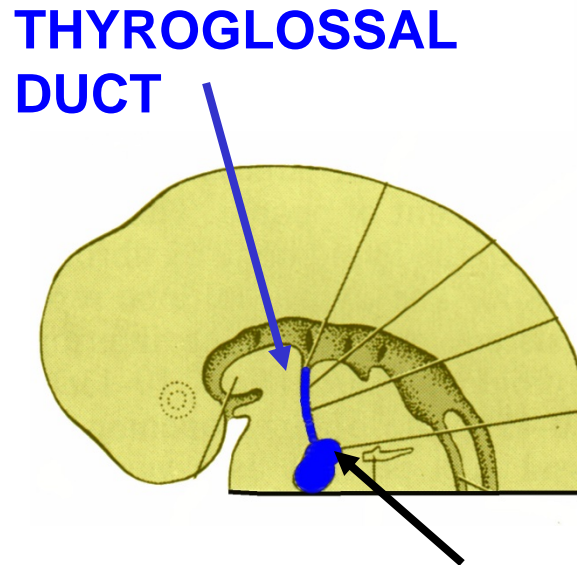
**KNOW THESE CHARTS QUESTIONS ON EXAM, BOARDS**

**NOTE: CLEFT = GROOVE**

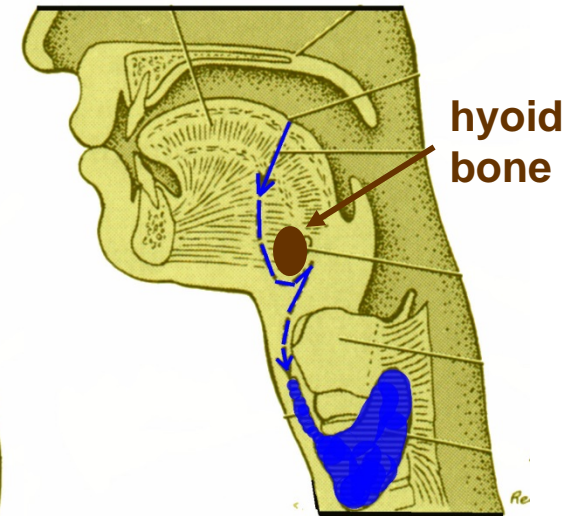
## V. DEVELOPMENT OF THYROID



1) Thyroid start as Median endodermal Thickening on floor of pharynx at future junction of ant 2/3 & post 1/3 of tongue (marked by Foramen Cecum)

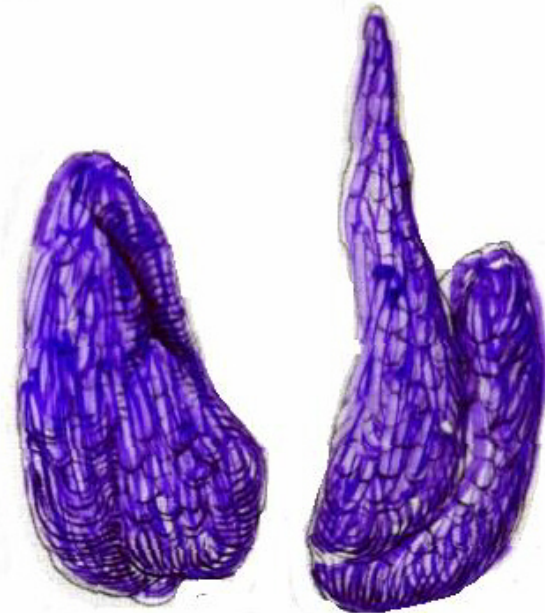
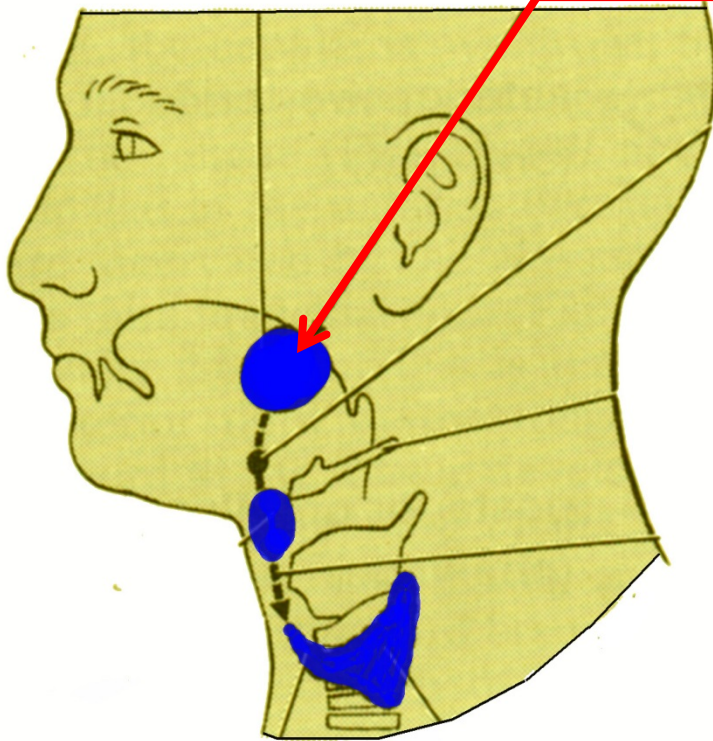


2) Elongates to form Thyroid Diverticulum; descends ant. to hyoid bone and larynx  
3) Thyroglossal duct connects Diverticulum to Foramen cecum



# CONGENITAL MALFORMATIONS

**LINGUAL THYROID\* - gland in tongue**



C. PYRAMIDAL LOBE. ABSENCE OF ISTHMUS

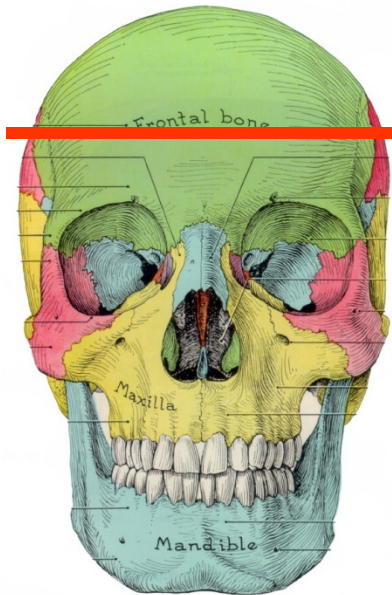
**Thyroglossal Duct Remnants - can form thyroid tissue (cysts) along path (midline, ant. to hyoid, larynx)**

**Pyramidal Lobe - 50% of people; attached to hyoid by fibrous strand; no clinical problems**

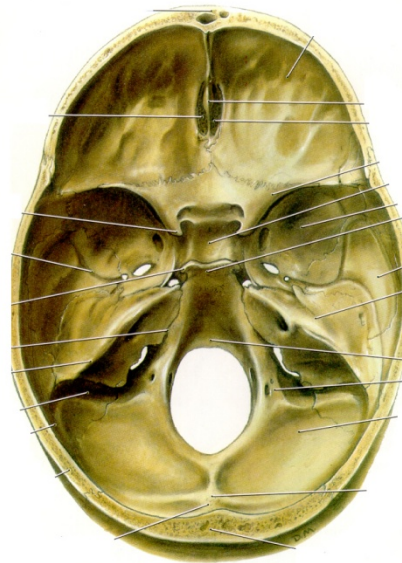


# DISSECTION: EXPOSE BRAINSTEM IN CRANIAL CAVITY

STRUCTURE OF CRANIAL CAVITY – saw cut to remove calvarium

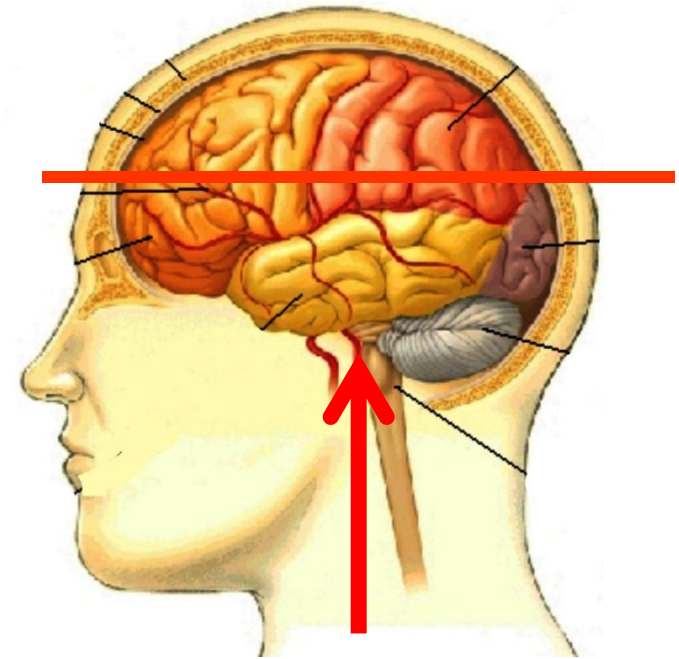


SKULL



INTERIOR OF SKULL -  
LEARN OPENINGS FORAMINA

ALSO CUT THROUGH BRAIN – DISSECT LOWER HALF TO EXPOSE BRAIN STEM

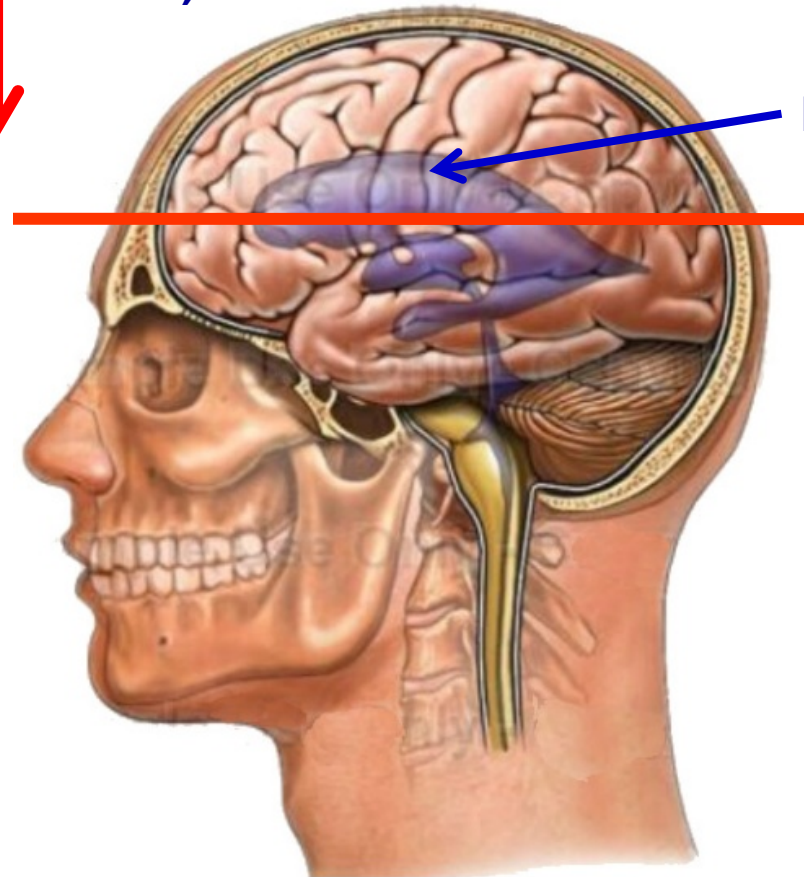


BRAIN STEM –  
SEE CRANIAL NERVES,  
ARTERIAL CIRCLE OF WILLIS

**VIEW FROM ABOVE AFTER  
REMOVE CALVARIUM (SKULL  
CAP)**

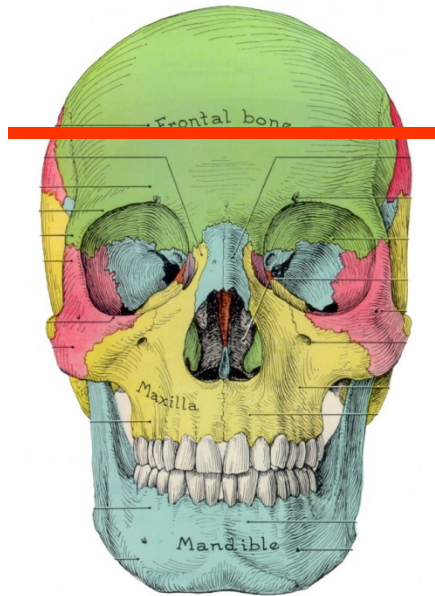


**LATERAL VENTRICLE**

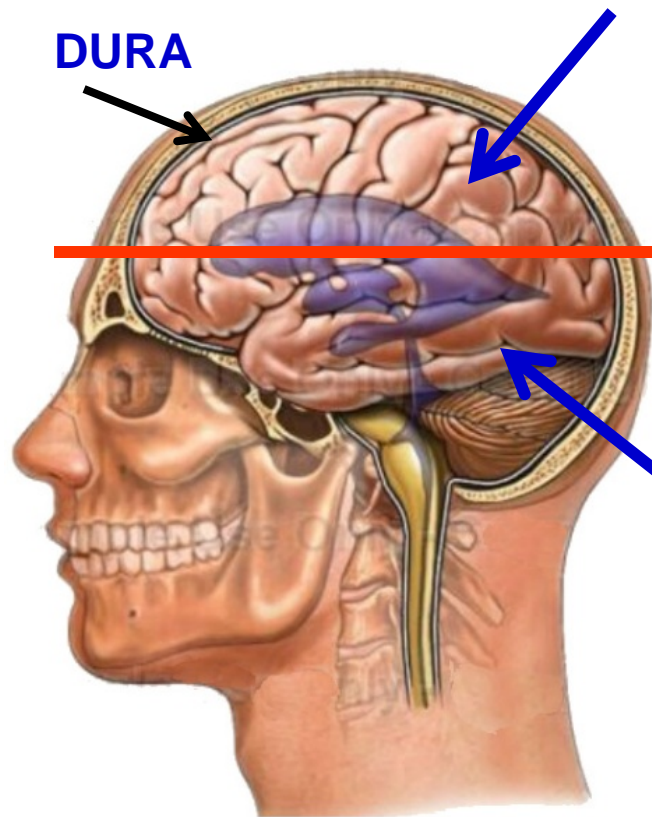


**CUT  
THROUGH  
BRAIN – VIEW  
VENTRICLES  
OF BRAIN,  
CHOROID  
PLEXUS**

# SEPARATE DURA AND BRAIN FROM CALVARIUM: LIFT DURA TO SEE 'BRIDGING' VEINS



REMOVE CALVARIUM  
(SAW CUTS ALREADY MADE)



DURA

UPPER HALF HAS  
CALVARIUM (WITH  
DURA) AND UPPER  
HALF OF BRAIN

LOWER HALF  
HAS REMAINDER  
OF BRAIN,  
BRAINSTEM,  
CRANIAL  
NERVES,  
ARTERIES

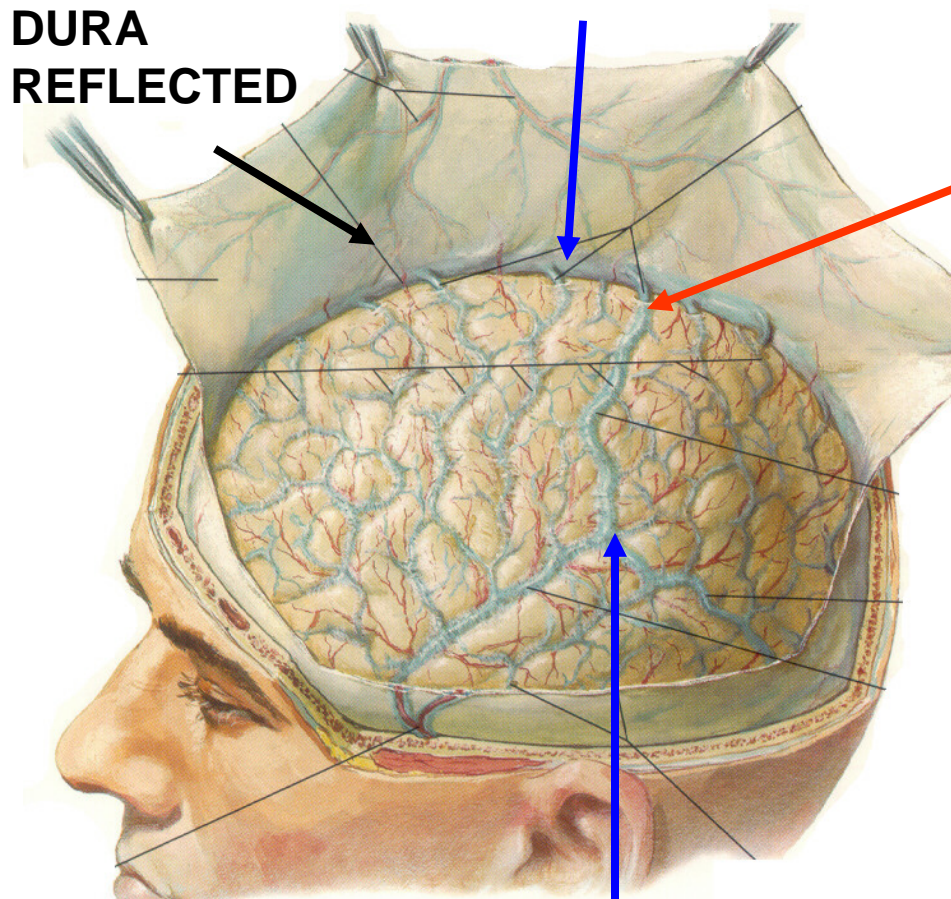
CALVARIUM ALREADY REMOVED  
WITH UPPER HALF OF BRAIN;  
DURA CUT BUT STILL TIGHTLY  
ATTACHED TO CALVARIUM



# SEPARATE DURA AND BRAIN FROM CALVARIUM: LIFT DURA TO SEE 'BRIDGING' VEINS

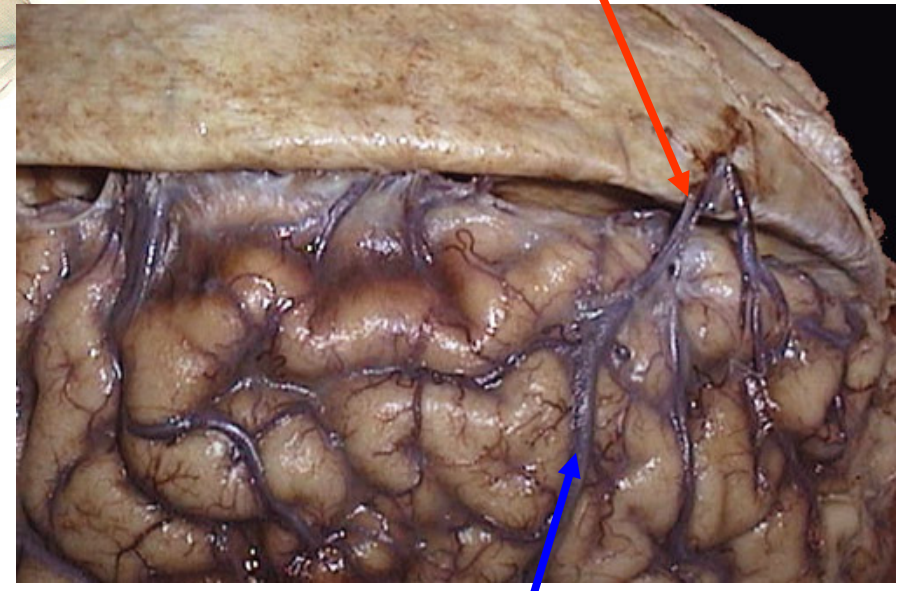
## Superior Sagittal Sinus

DURA REFLECTED



Superior Cerebral veins

## 'BRIDGING' VEINS

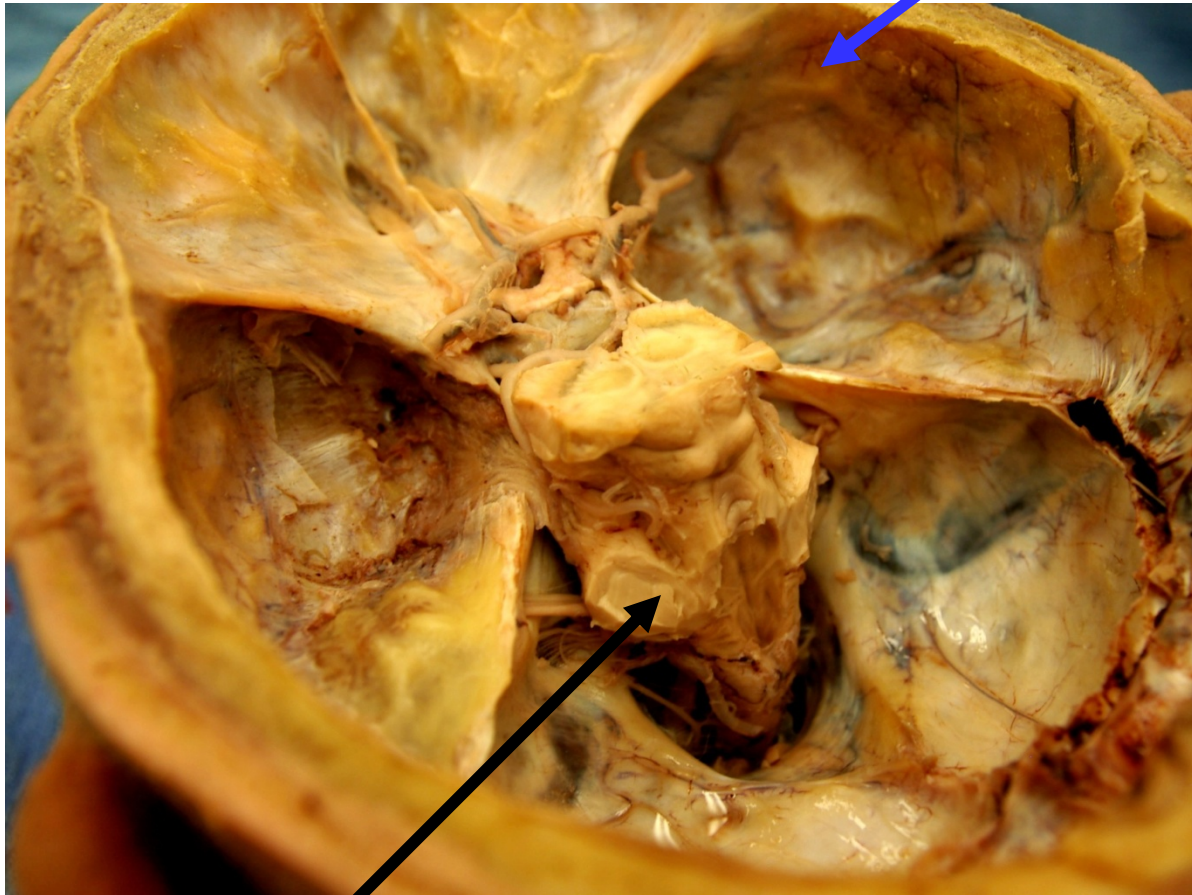


Superior Cerebral veins

Photo from lecture of Dr. Nancy Norton

**END OF DISSECTION SHOULD LOOK LIKE THIS**

**CRANIAL CAVITY**



**REMOVE BRAIN AND  
LEAVE BRAIN STEM  
AND CRANIAL NERVES**

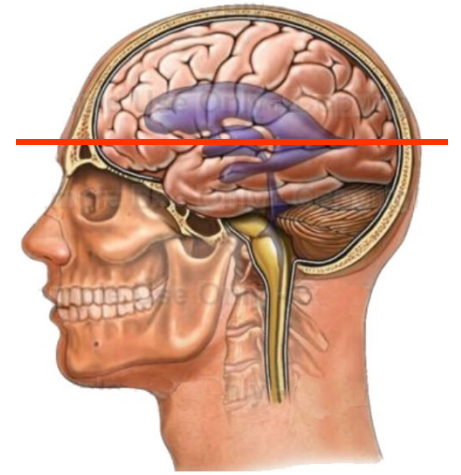
**OVERALL: HOW BRAIN  
FITS INTO CRANIAL  
CAVITY**

**DONE ON BODIES ON  
WHICH YOU HAVE  
ALREADY WORKED**

**BRAINSTEM**



# DISSECTION IN ONE LAB



**TABLE 3**



**TABLE 7**

**ALREADY DONE: SAW CUTS TO REMOVE CALVARIUM AND TOP OF SKULL**

**CUT MADE THROUGH ENTIRE BRAIN**

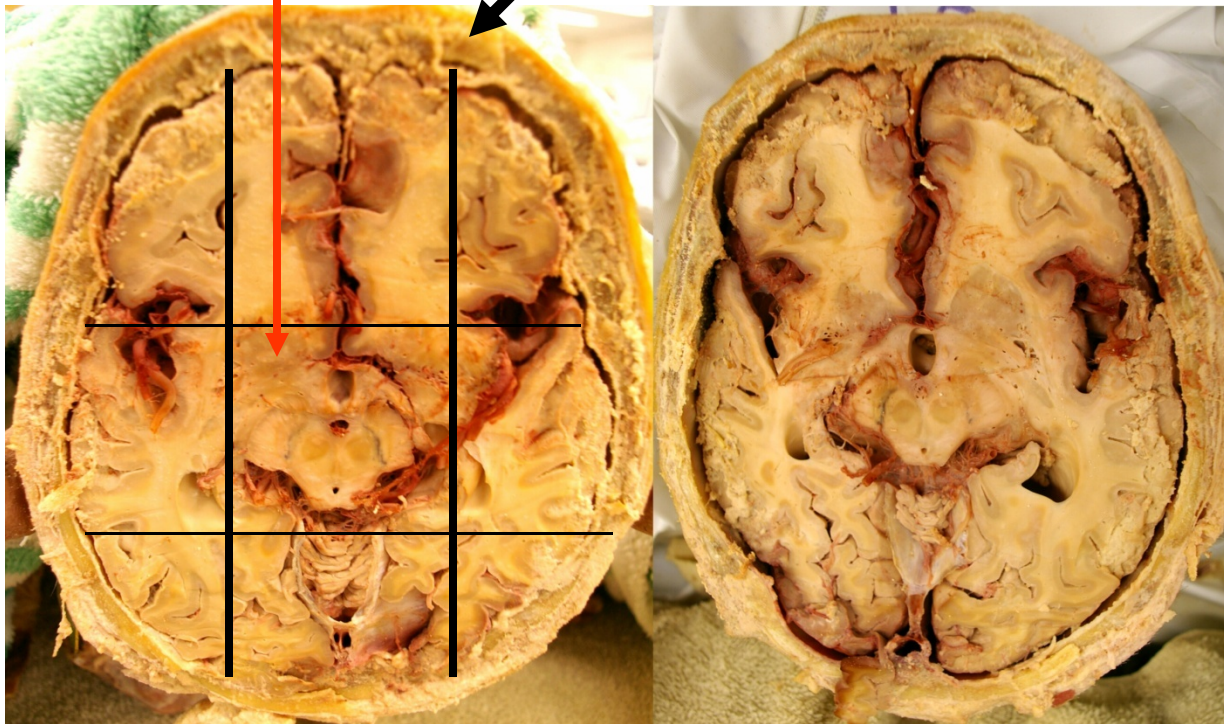
**DISSECT PART STILL IN BODY**

**PART OF BRAIN IN CALVARIUM WILL STILL BE INTACT**



**BRAINSTEM**

**CUTS TO REMOVE CORTEX**

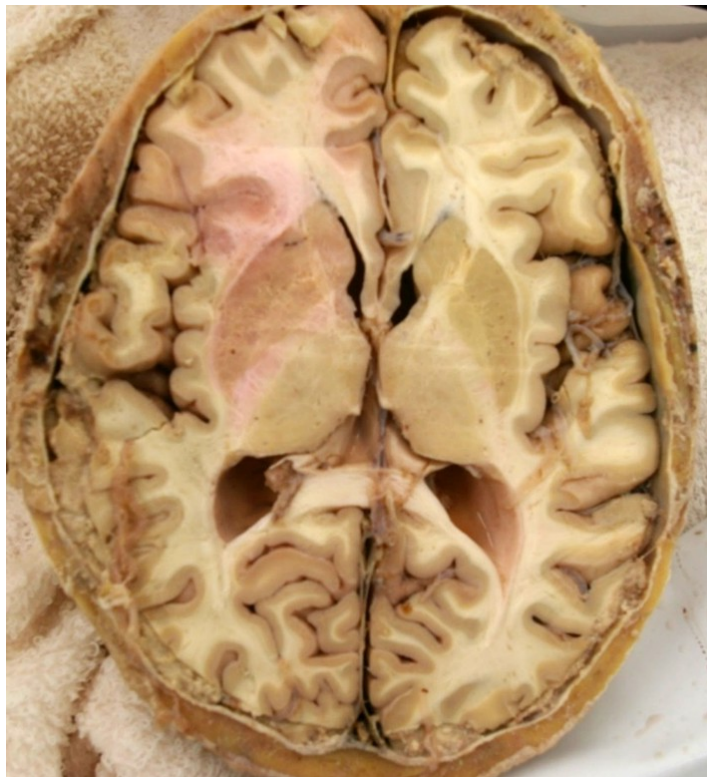


**CUTS WILL BE  
MADE TO REMOVE  
CORTEX AND  
OTHER BRAIN  
STRUCTURES  
SURROUNDING  
BRAIN STEM**

**SURROUNDING  
TISSUE IS  
REMOVED BY  
HAND**

**NOTE: PART OF  
BRAIN IN  
CALVARIUM WILL  
BE LEFT INTACT**

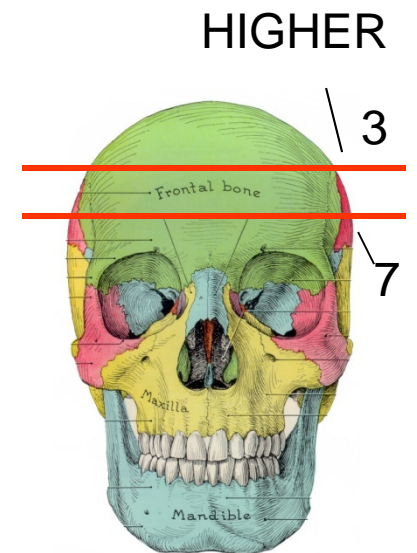
**NOTE: SPECIMENS HAVE BEEN CUT AT DIFFERENT LEVELS  
SOME DISSECTIONS WILL BE REQUIRE REMOVAL OF LESS TISSUE  
TO REACH MID BRAIN**



**TABLE 3**



**TABLE 7**





## DISSECTION SEQUENCE: EXPOSE BRAINSTEM IN CRANIAL CAVITY



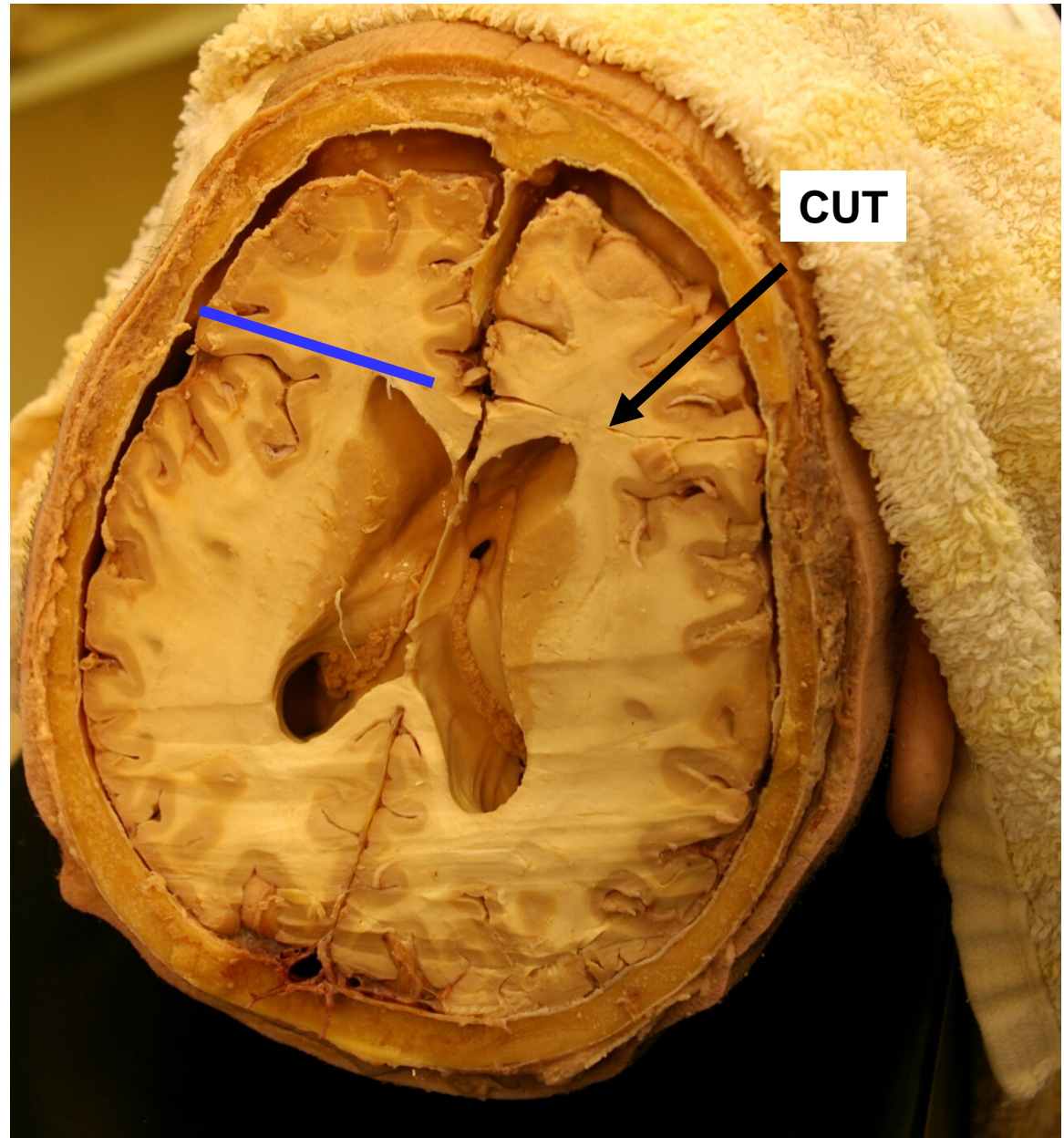
- SUPPORT HEAD WITH PLASTIC BLOCKS (IN CENTER ISLAND)
- ELEVATE SO YOU CAN EASILY LOOK IN CRANIAL CAVITY



## DISSECTION: EXPOSE BRAINSTEM IN CRANIAL CAVITY

### FIRST CUT:

- 1) LIFT UP FRONTAL LOBE GENTLY (FRONTAL POLE) AND SEE OLFACTORY BULB BELOW
- 2) TRY TO PUSH DOWN AND RETAIN BULB IN CRANIAL CAVITY
- 3) THEN CUT ACROSS FRONTAL POLE ANTERIOR TO GENU OF CORPUS CALLOSUM (ALL THE WAY THROUGH)



## DISSECTION: EXPOSE BRAINSTEM IN CRANIAL CAVITY

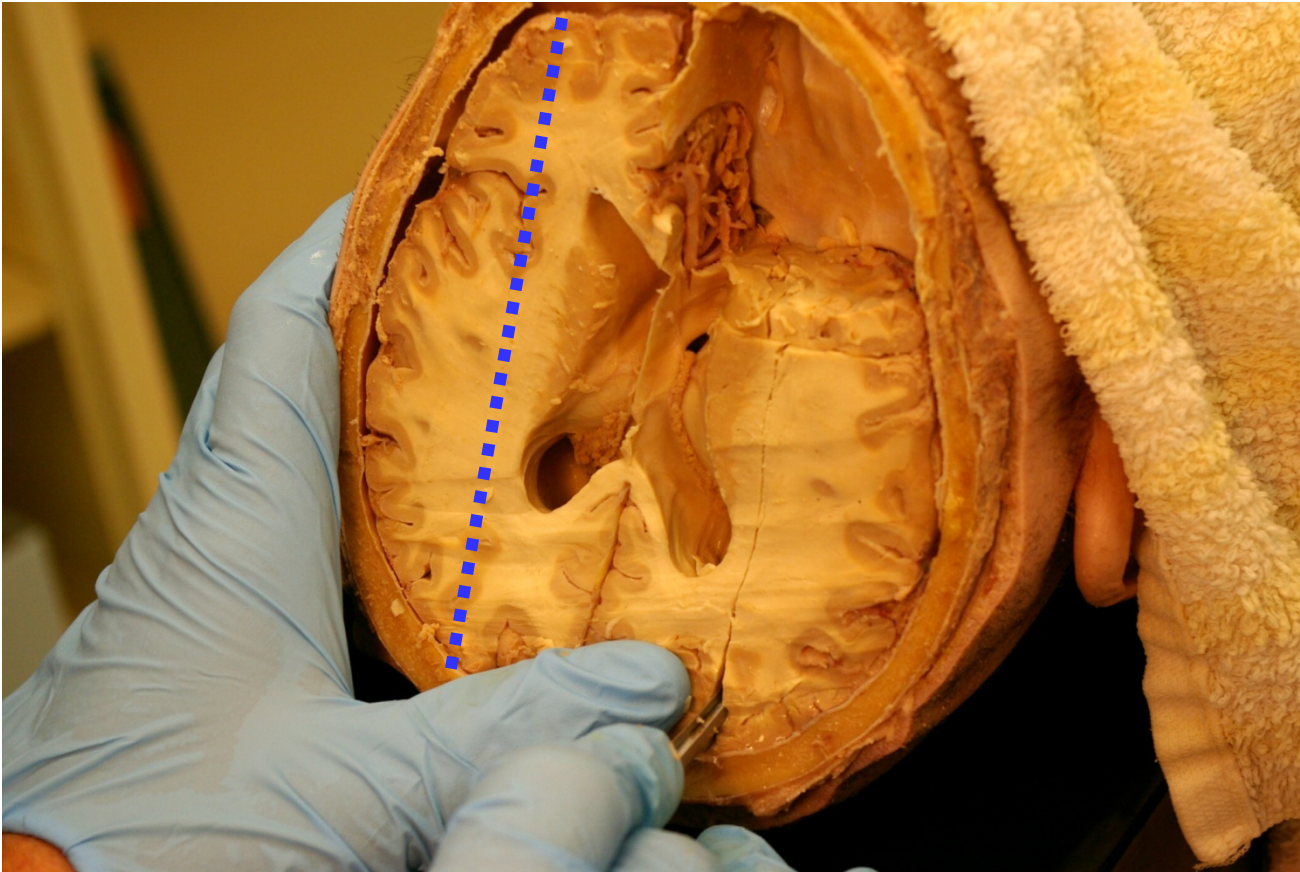


FRONTAL  
CORTEX IS  
THEN GENTLY  
REMOVED  
BY HAND



## DISSECTION: EXPOSE BRAINSTEM IN CRANIAL CAVITY

PLANE OF CUT 2



**SECOND CUT:**

- 1) CUT THROUGH TEMPORAL AND OCCIPITAL LOBES IN PARASAGITTAL PLANE
- 2) PUSH DOWN SCALPEL UNTIL MEET RESISTANCE OF BONE OR TENTORIUM CEREBELLI



**DISSECTION: EXPOSE BRAINSTEM IN CRANIAL CAVITY**



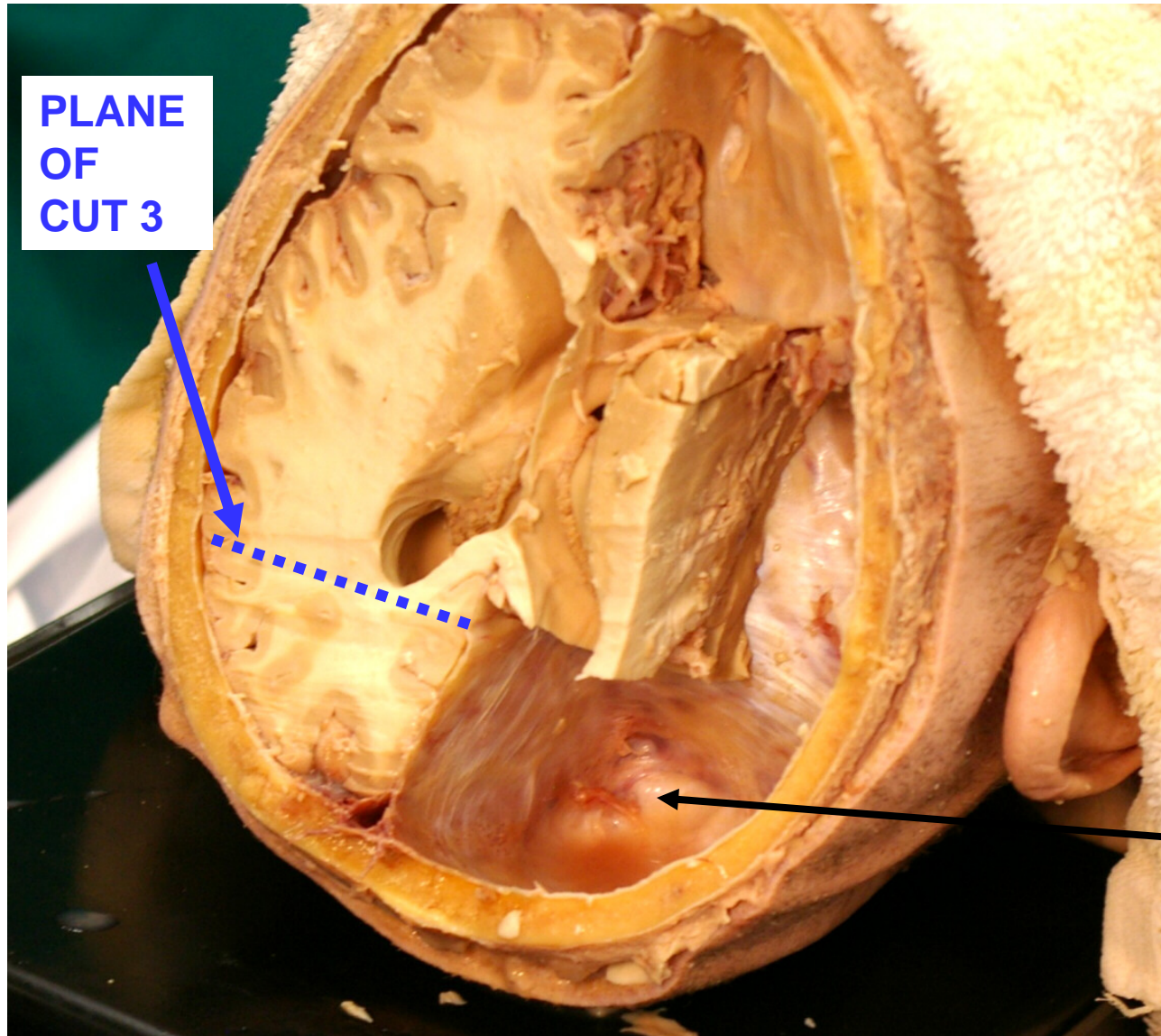
## DISSECTION: EXPOSE BRAINSTEM IN CRANIAL CAVITY



CUT SECTION  
OF TEMPORAL  
AND OCCIPITAL  
LOBES  
THEN  
REMOVED BY  
HAND



## DISSECTION: EXPOSE BRAINSTEM IN CRANIAL CAVITY



PLANE  
OF  
CUT 3

THIRD CUT:

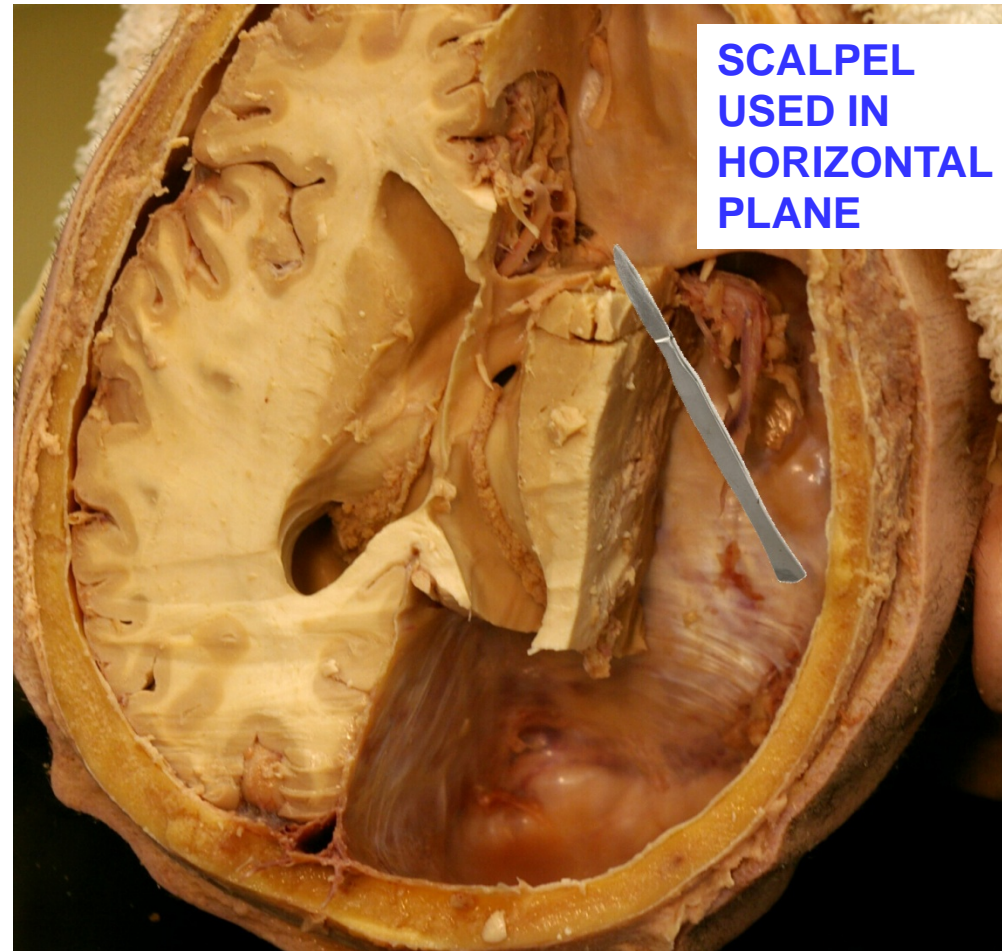
- 1) CUT THROUGH OCCIPITAL LOBE IN CORONAL PLANE
- 2) CAREFULLY REMOVED REMAINING PART OF OCCIPITAL LOBE BY HAND

see Tentorium cerebelli overlying cerebellum



## DISSECTION: EXPOSE BRAINSTEM IN CRANIAL CAVITY

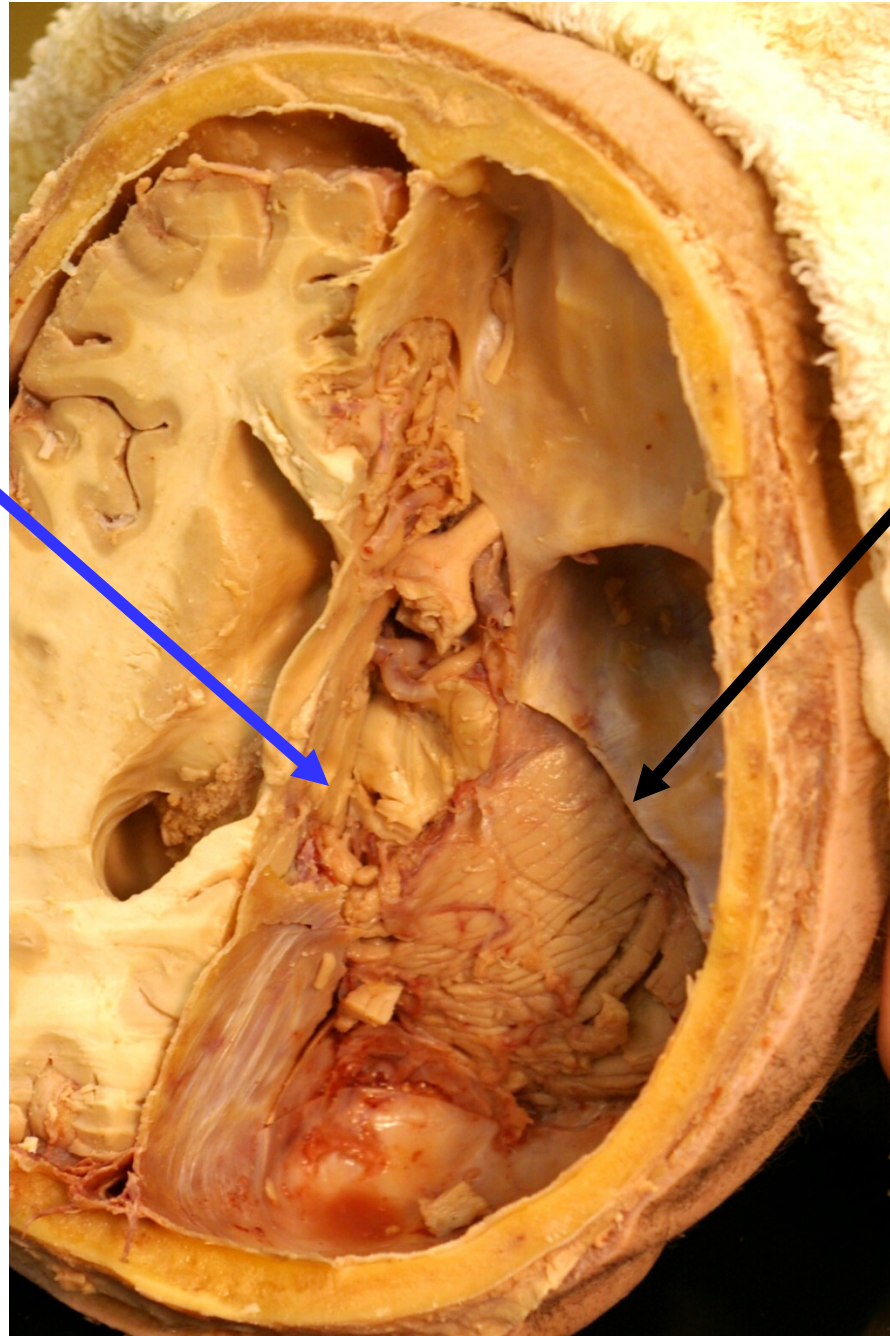
**NEXT CUTS:** Use scalpel to cut thalamus and basal ganglia in horizontal plane; remove progressively as sections (carefully cut down to level of optic nerve, int. carotid a.)



**KNIFE CUTTING SECTIONS IN HORIZONTAL PLANE**

**BRAINSTEM  
CUT TO  
MIDBRAIN,  
OPTIC CHIASM;**

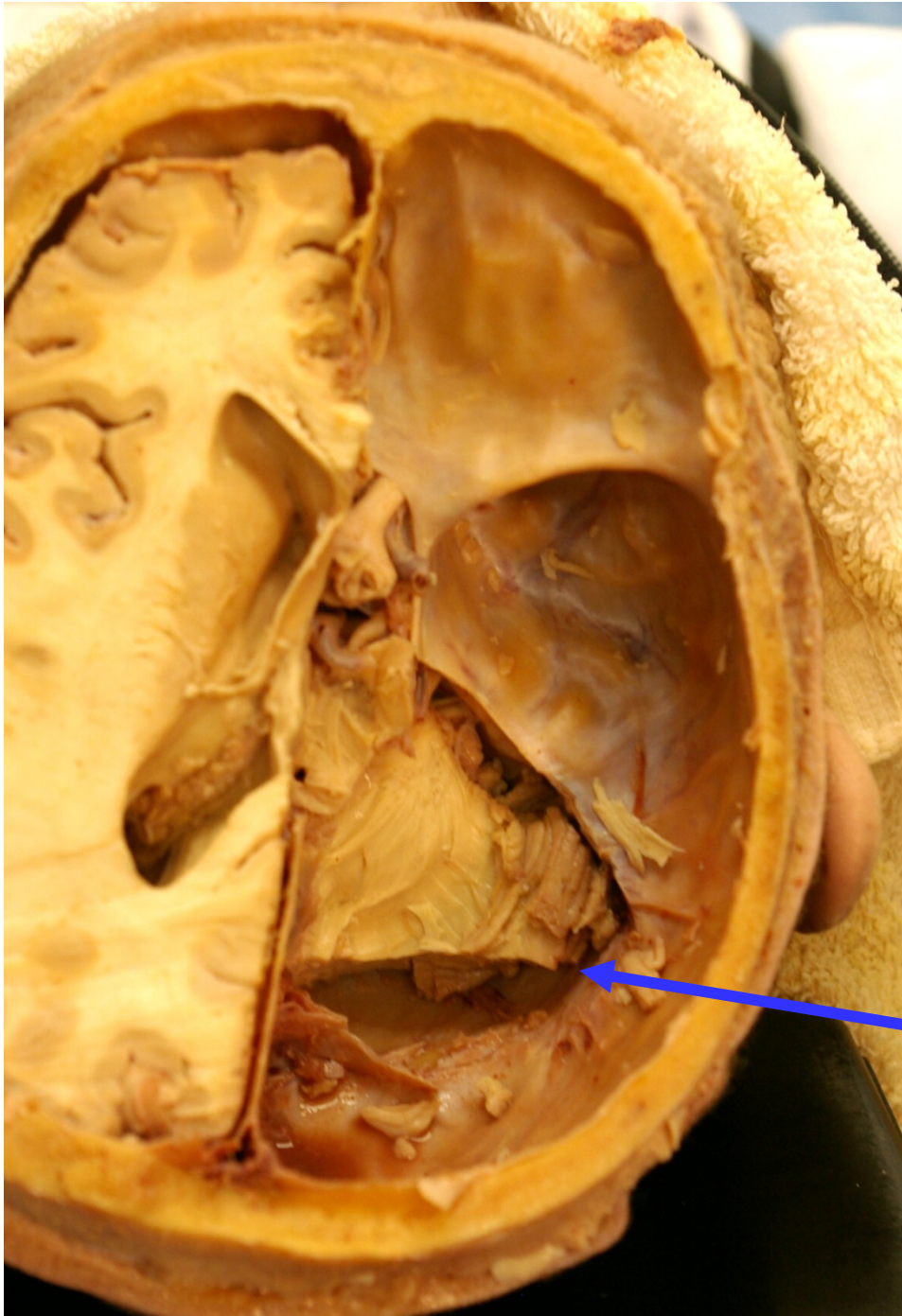
**RETAIN  
INTERNAL  
CAROTID  
ARTERY AND  
CUT  
BRANCHES**



**NEXT CUT:  
INCISE MARGING  
OF TENTORIUM  
CEREBELLI AT  
TEMPORAL BONE  
AND EXTEND  
POSTERIORLY  
THROUGH  
TRANSVERSE  
SINUS**

**REMOVE  
TENTORIUM AND  
EXPOSE  
CEREBELLUM**





**NEXT CUT:  
POSTERIOR PART  
OF CEREBELLUM  
IS CUT IN A  
CORONAL PLANE  
AND REMOVED**

**REMAINING PART  
OF CEREBELLUM  
IS CAREFULLY  
REMOVED AND  
CUT AT  
PEDUNCLES**

**CUT**

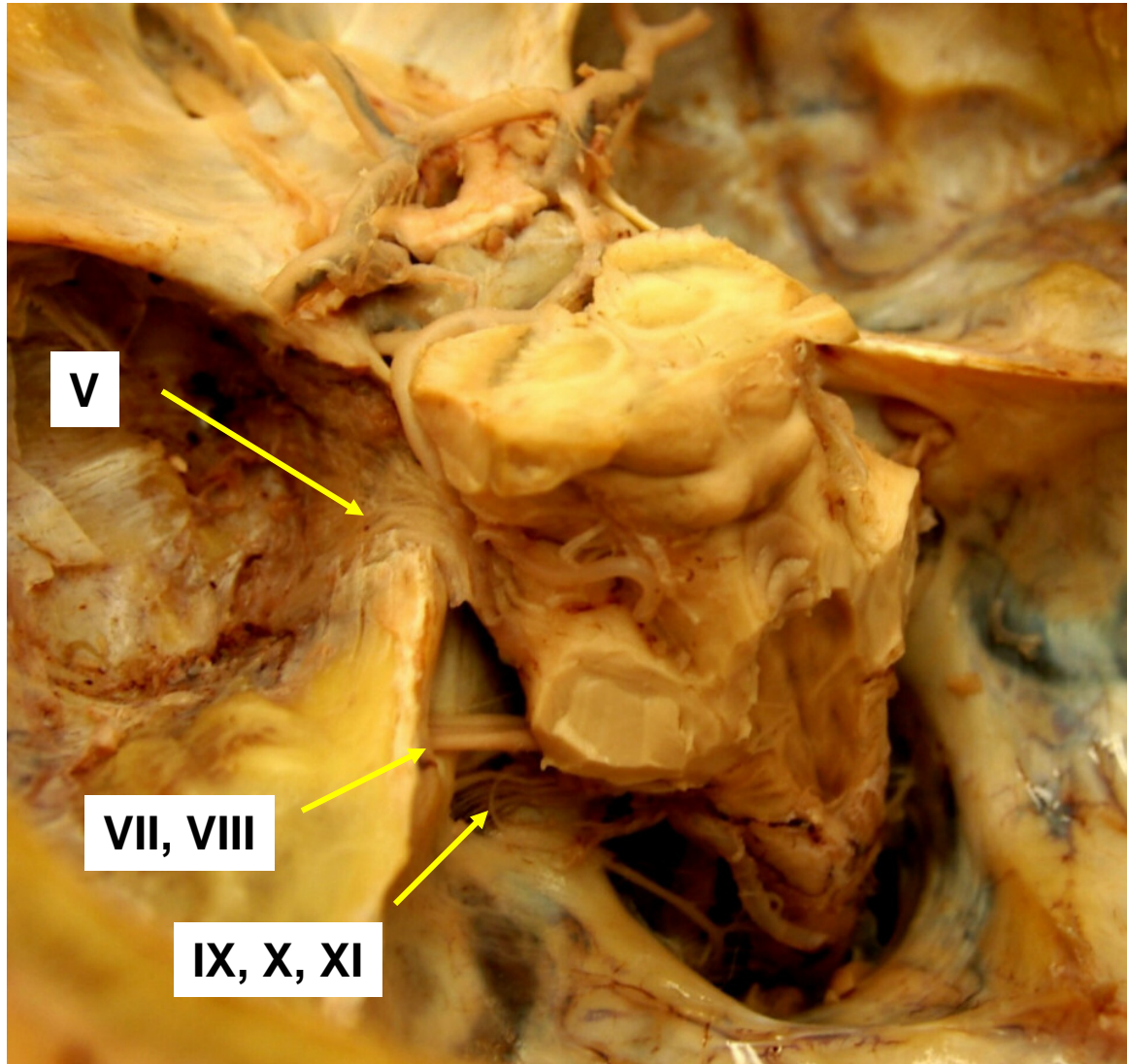




**CAREFULLY  
EXPOSE CRANIAL  
NERVES FROM  
SURROUNDING PIA  
MATER**

**TRIM REMAINING  
TENTORIUM IF  
NECESSARY**

## FINAL RESULT: BRAINSTEM IN SITU IN CRANIAL CAVITY



DO DISSECTION ON BOTH SIDES

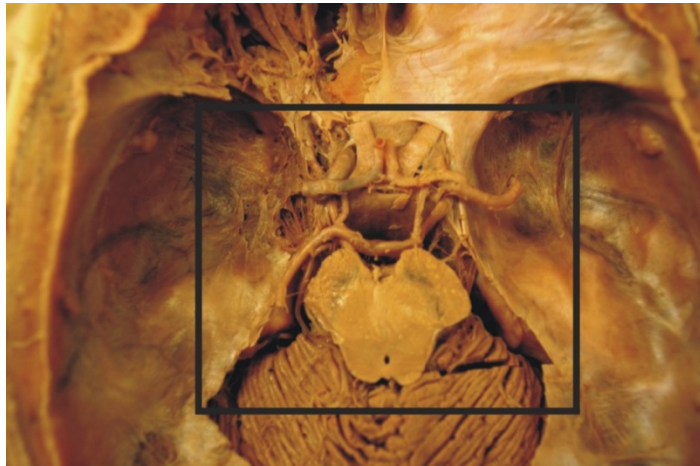
WHEN COMPLETE CAN SEE CN I-XII, BRANCHES OF INTERNAL CAROTID AND BASILAR ARTERIES

CAN CAREFULLY REMOVE DURA MATER FROM MIDDLE CRANIAL FOSSA TO EXPOSE V1, V2, V3 AND TRIGEMINAL GANGLION

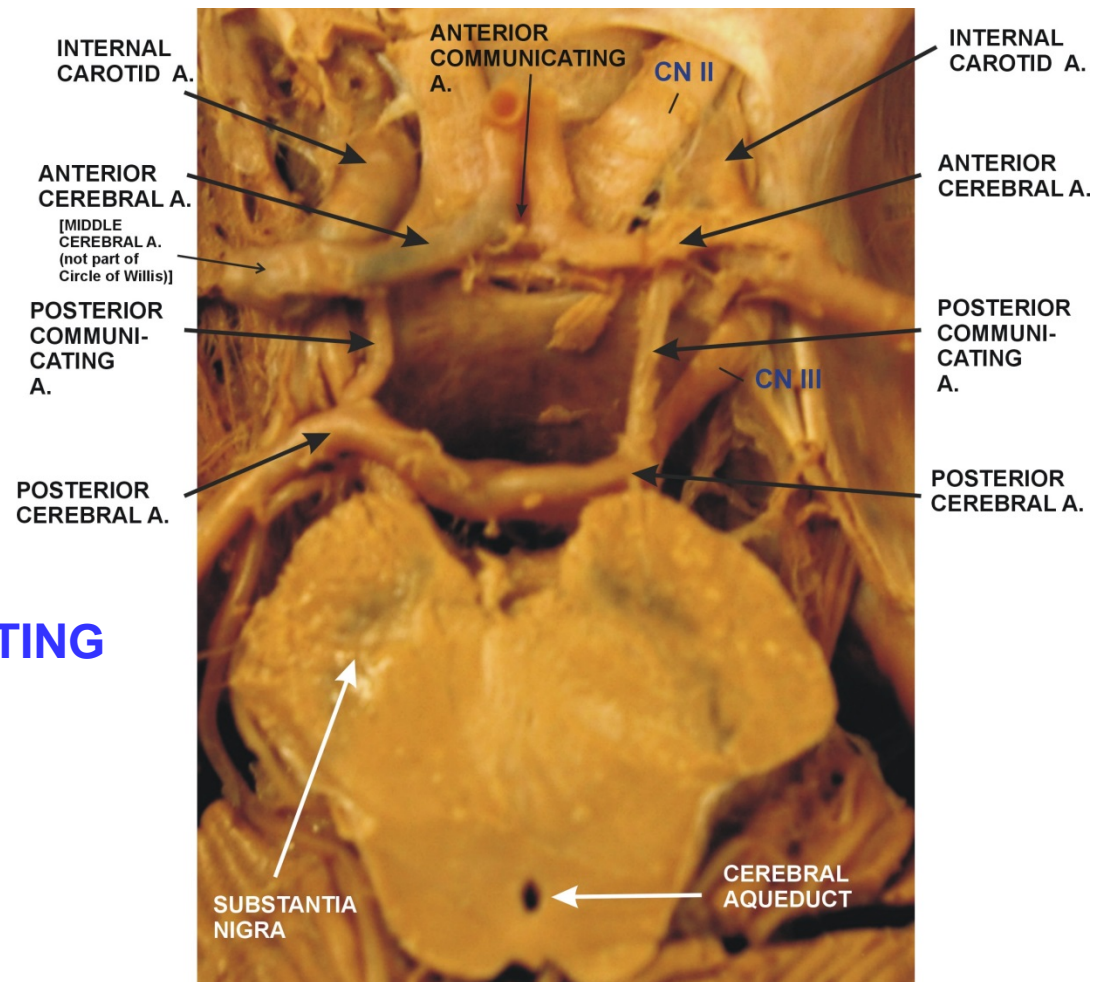


## FINAL RESULT: SEE CIRCLE OF WILLIS

### VIEW INSIDE CRANIAL CAVITY



### RING OF ARTERIES CONNECTING INTERNAL CAROTID AND VERTEBRAL (BASILAR) ARTERIES





## **DISSECTION CHECKLIST BRAIN DISSECTION - 2018**

### **ORIENT BEFORE DISSECTION: SEE**

- \_\_\_\_\_ LATERAL VENTRICLE
- \_\_\_\_\_ CHOROID PLEXUS

### **MENINGES**

- \_\_\_\_\_ ARACHNOID GRANULATIONS
- \_\_\_\_\_ SUPERIOR SAGITTAL SINUS
- \_\_\_\_\_ FALX CEREBRI

### **VEINS**

- \_\_\_\_\_ BRIDGING VEINS

### **NERVES -**

- \_\_\_\_\_ OLFACTORY BULB CN I
- \_\_\_\_\_ OPTIC NERVE AND OPTIC CHIASM CN II
- \_\_\_\_\_ OCULOMOTOR NERVE CN III
- \_\_\_\_\_ TROCHLEAR NERVE CN IV
- \_\_\_\_\_ TRIGEMINAL NERVE CN V
- \_\_\_\_\_ ABDUCENS NERVE CN VI
- \_\_\_\_\_ FACIAL AND VESTIBULOCOCHLEAR NERVES  
CN VII AND VIII
- \_\_\_\_\_ GLOSSOPHARYNGEAL, VAGUS AND  
ACCESSORY NERVES CN IX, X, XI
- \_\_\_\_\_ HYPOGLOSSAL NERVE CN XII

### **ARTERIES -**

- \_\_\_\_\_ INTERNAL CAROTID ARTERY
- \_\_\_\_\_ BASILAR ARTERY

### **CIRCLE OF WILLIS**

- \_\_\_\_\_ ANTERIOR CEREBRAL ARTERY
- \_\_\_\_\_ ANTERIOR COMMUNICATING ARTERY
- \_\_\_\_\_ MIDDLE CEREBRAL ARTERY
- \_\_\_\_\_ POSTERIOR CEREBRAL ARTERY
- \_\_\_\_\_ POSTERIOR COMMUNICATING ARTERY

### **VENOUS SINUSES -**

- \_\_\_\_\_ SUPERIOR SAGITTAL SINUS
- \_\_\_\_\_ TRANSVERSE SINUS

# EAR

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## I. Overview - specialized for sound detection

A. Outer ear - funnel shaped structure of cartilage and skin that leads to Tympanic membrane; directs sound toward Tympanic membrane; helps detect source of sound.

B. Middle ear - air filled chamber that contains bones (ossicles) that link Tympanic membrane to cochlea; also contains muscles that dampen sounds; middle ear is linked to Nasopharynx by auditory tube which allows for equilibration of air pressure on inner side of Tympanic membrane.

C. Inner ear - fluid filled chamber in petrous part of temporal bone; inner ear contains Cochlea (hearing) and Vestibular apparatus for gravity detection (both innervated by CN VIII).

**Clinical Note: Functioning of inner ear can be tested independently by vibrations transmitted directly through bone** (Weber test: tuning fork on calvarium is perceived as sound); **CONDUCTIVE HEARING LOSS** - damage to middle ear (tympanic membrane, auditory ossicles); **SENSORINEURAL HEARING LOSS** - damage to inner ear (cochlea, CN VIII).

## II. Outer Ear - composed of two parts:

A. Auricle (pinna) - elastic cartilage covered with skin; functions to reflect sound waves. Parts: helix, antihelix, tragus and lobule.

Decorative Note: Cartilage does not extend into Lobule; Lobule can be readily pierced to provide support for decorative metal objects.

B. **External auditory meatus** - tube from auricle to the Tympanic membrane; posterior to Parotid gland and TMJ (Temporomandibular joint); located anterior to mastoid process. Outer third consists of elastic cartilage; contains hairs, sebaceous glands and ceruminous glands (produce cerumen = ear wax); serves to protect Tympanic membrane; Inner two thirds is composed of bone lined with skin.

Clinical note: **External auditory meatus** is curved **anteriorly in adults**, is **straight in children**; in **adults, auricle is pulled up and back to insert otoscope**.

Clinical note - **sensory innervation of Outer Ear is complex and derived from CN V, VII, IX and X; patient's with Bell's palsy can have sensation of ear ache**.

**III. Middle Ear (Tympanic cavity)** - cavity in the petrous portion of the temporal bone that is hard to visualize; lies below middle cranial fossa

## A. Boundaries

1. Roof - tegmen tympani (thin plate of petrous part of temporal bone) separates Tympanic cavity from middle cranial fossa.
2. Floor - Jugular foramen lies below cavity; rupture of the internal jugular vein can result in hemorrhaging into the Tympanic cavity.
3. Anterior wall - has opening of Auditory tube (posterior 1/3 of tube is in bony canal, anterior 2/3 is cartilage); Auditory tube links middle ear with nasopharynx for equilibration of pressure; anterior wall also has bony canal containing tensor tympani muscle.
4. Posterior wall - leads to mastoid air cells in mastoid process (opening is called aditus); canal for Facial nerve (CN VII) courses in posterior wall (after passing from medial wall).
5. Medial wall - is lateral wall of inner ear; landmarks - **Oval window** (fenestra vestibuli) is **attachment for stapes**; Round window (fenestra cochlea) is other end of coiled cochlea; landmarks - promontory is bulge in wall from first turn of cochlea; prominence of facial nerve canal - horizontal ridge from underlying facial nerve.
6. Lateral wall - Tympanic membrane.

Note: **Otitis media** (middle ear infection) is common in children. Middle ear is functionally a dead end cavity that opens to nasopharynx. Infection can spread from upper respiratory system. Damage to auditory ossicles can cause hearing loss. Prolonged infection in Tympanic cavity can spread through tegmen tympani to brain.

Note: **Incidence of Otitis media declines rapidly after age of 5**; growth is associated with a change in orientation of the auditory tube (from horizontal to angled inferiorly) and an increase in the size of its lumen; both factors may contribute to decreased incidence of Otitis media.

**B. Auditory ossicles** - from lateral to medial: **malleus** (hammer), **incus** (anvil) and **stapes** (stirrup); ossicles amplify effect of vibration; in addition, Tympanic membrane has 15-20 times greater area than footplate of stapes; this increases force per unit area and helps transmit sound vibrations from air to fluid in inner ear (impedance matching).

**Otoscope view:** Handle malleus is attached to upper half of Tympanic membrane; malleus is supported by ligaments linking it to wall of Tympanic cavity; part of Tympanic membrane surrounding handle is tense (pars tensa); upper end is less tense (pars flaccida)

## C. Muscles



1. **Tensor tympani muscle** - origin - canal in anterior wall; insertion - handle of malleus; innervation - V3

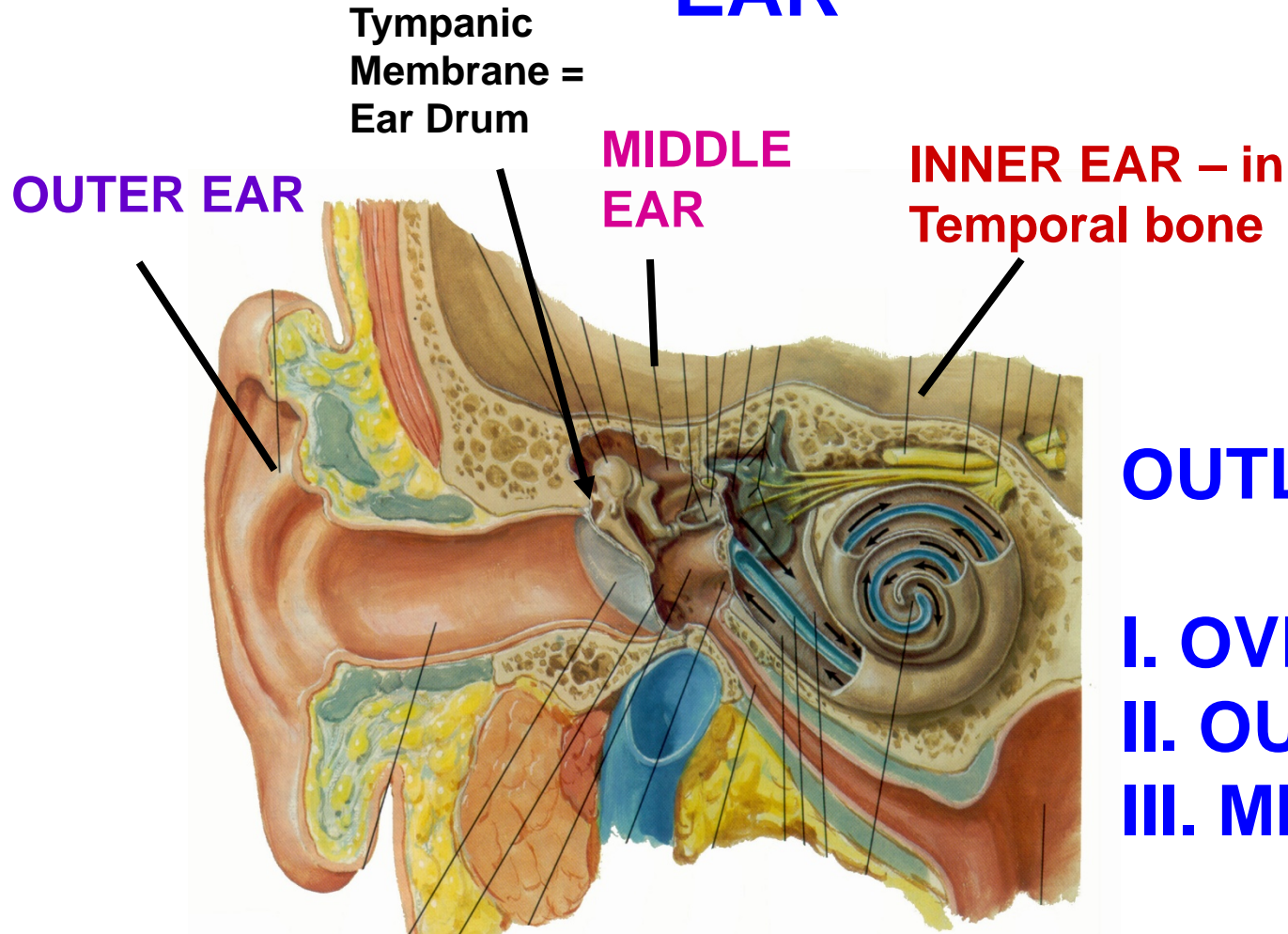
2. **Stapedius muscle** - origin - posterior wall (landmark is pyramid); insertion - neck of stapes; innervation - VII

Actions - Both muscles act to dampen movements of ossicles (decrease intensity of sound); tensor also makes Tympanic membrane tighter; prevents damage to inner ear; **paralysis of muscles produces hyperacusia (sounds seem too loud, Bell's palsy).**

D. Innervation - **Tympanic nerve - Visceral Sensory** (GVA, imprecise sensation) branch of **IX** that enters Tympanic cavity). Nerve forms Tympanic plexus that also innervates mastoid air sinus and auditory tube; can give rise to Lesser Petrosal nerve (to Parotid Gland).

Note: **Chorda tympani** (branch of VII) - Chorda tympani has no function in middle ear; it provides taste to anterior 2/3 of tongue, Parasympathetics to Submandibular ganglion; however, it leaves facial canal and passes through Tympanic cavity and crosses over upper end of handle of malleus before exiting via petrotympanic fissure; if Tympanic membrane is pierced, can damage Chorda tympani and lose taste to anterior tongue on that side; this fact may have baffled early physicians and patients.

# EAR



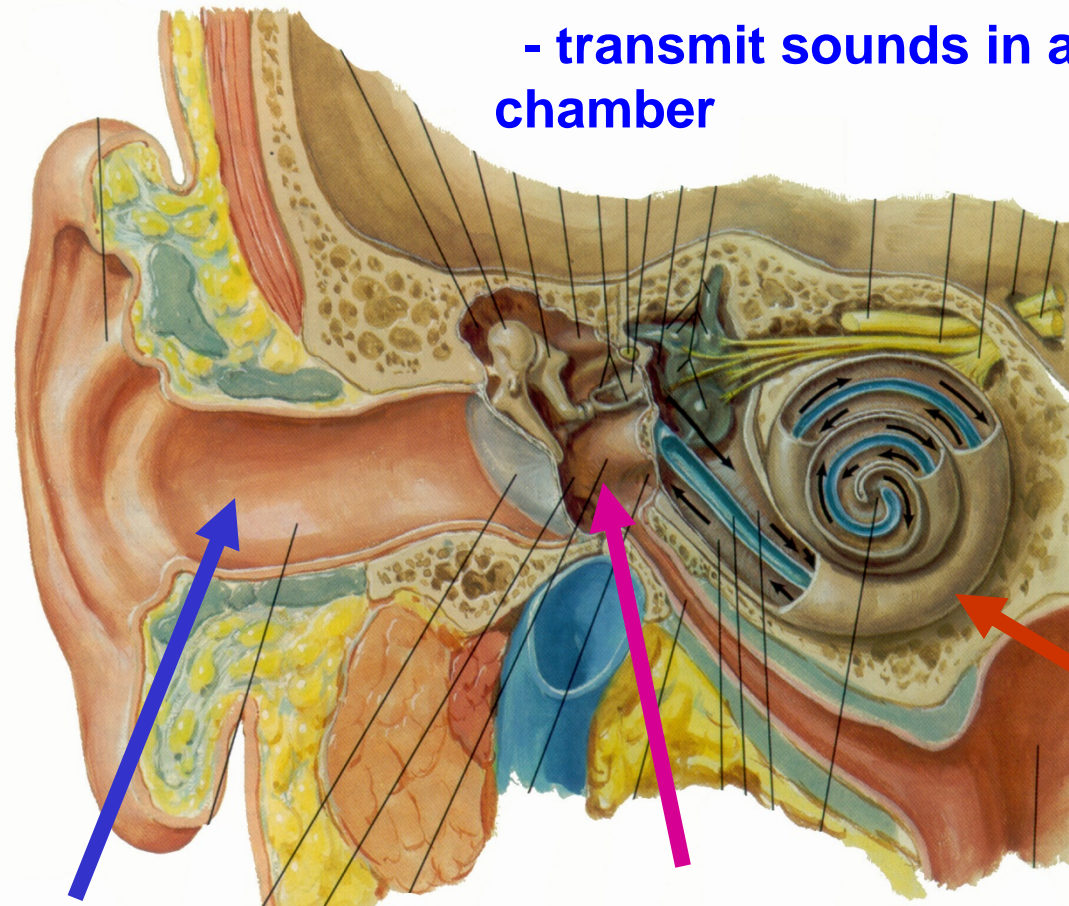
## OUTLINE

- I. OVERVIEW
- II. OUTER EAR
- III. MIDDLE EAR

Outer and middle ear transmit sound to inner ear.

Middle ear is dead end space filled with air and connected to nasopharynx; Middle ear infections common (otitis media)

# I. EAR - overview



## REGIONS

**A. Outer Ear**  
1) funnel shaped cartilage and skin  
2) directs sound (pressure waves in air) to tympanic membrane

**B. Middle Ear - air-filled chamber**  
1) bones link tympanic membrane to cochlea; amplify force/area  
2) muscles can dampen loud sounds

**C. Inner Ear- fluid-filled chamber inside BONE**  
1) cochlea- hearing;  
2) vestibular apparatus- gravity



**CONDUCT SOUND**

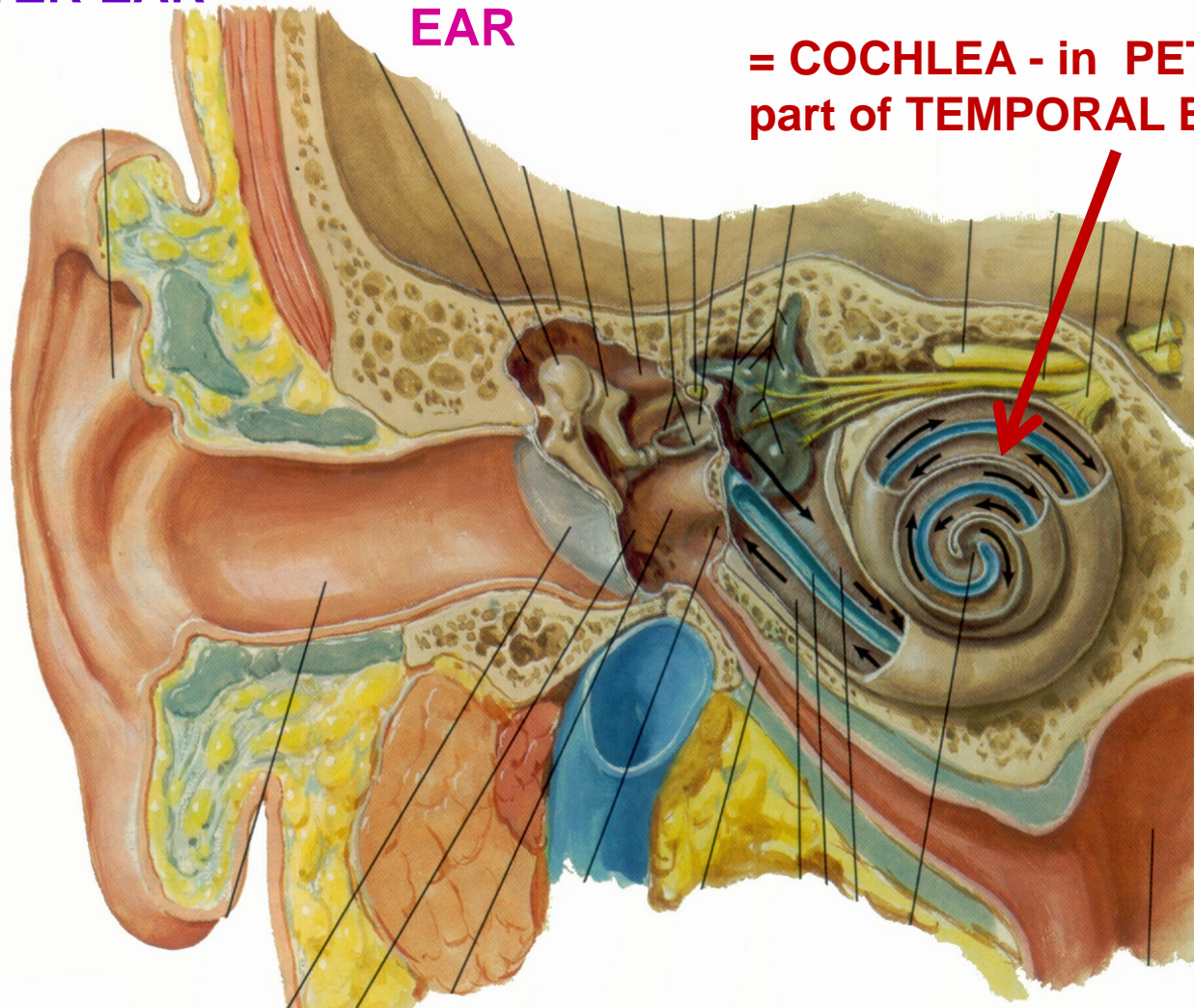
**DETECT SOUND  
(= SENSORINEURAL PART)**

**OUTER EAR**

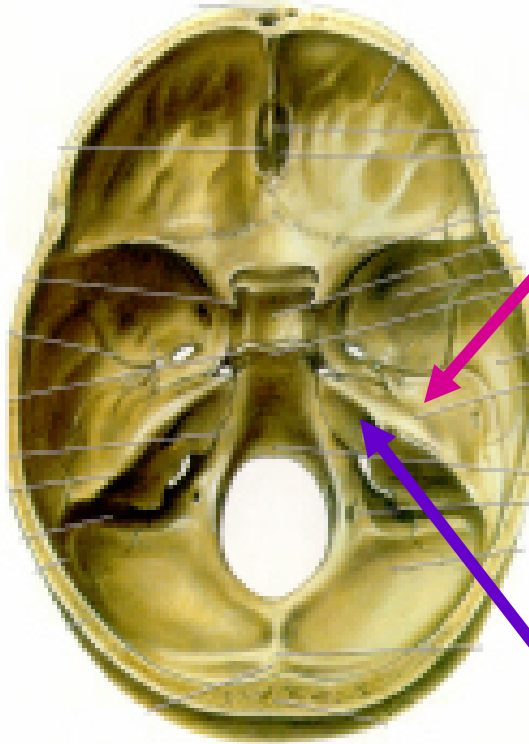
**MIDDLE  
EAR**

**INNER EAR**

**= COCHLEA - in PETROUS  
part of TEMPORAL BONE**

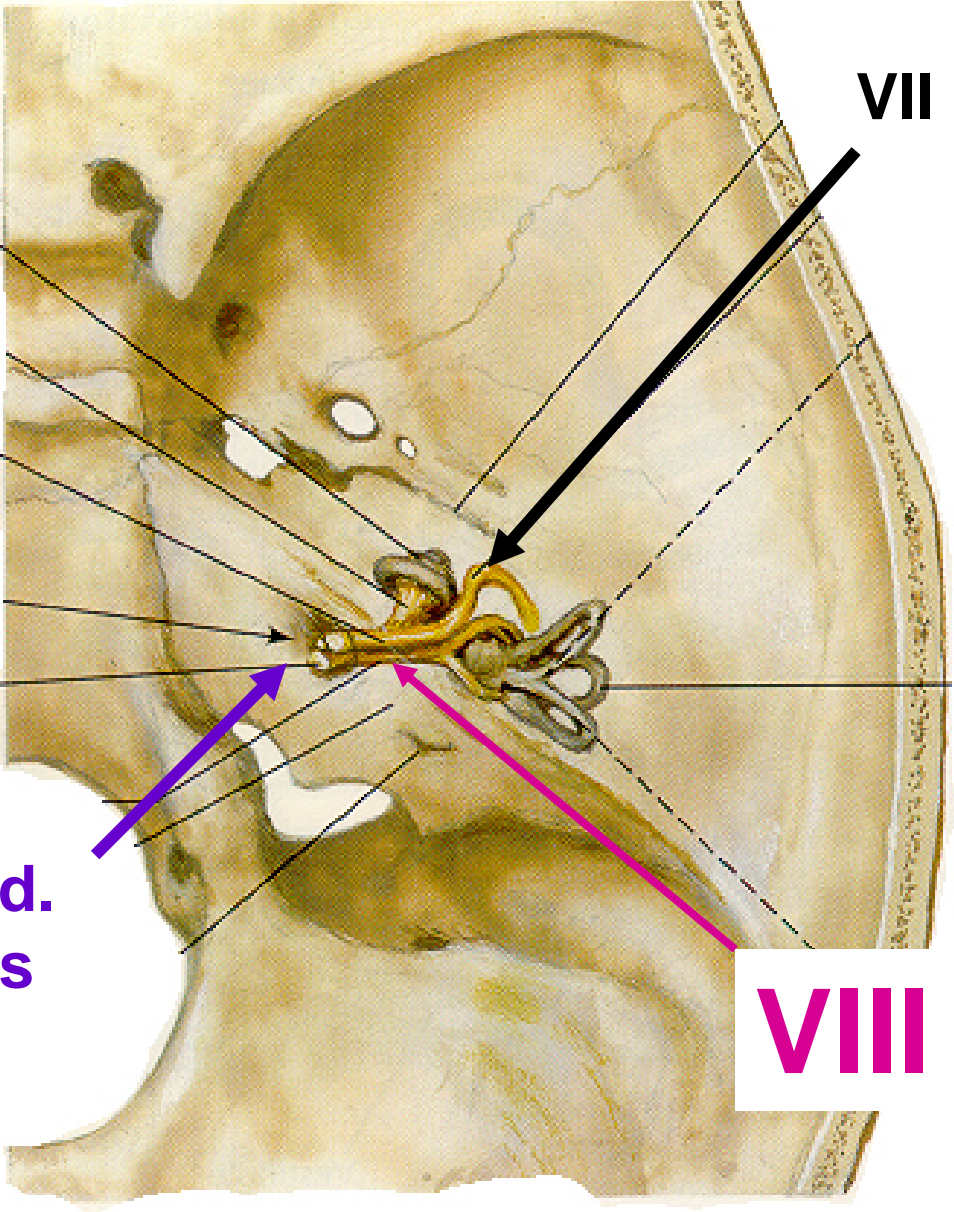


**ORIENT: LOCATION OF INNER EAR**



**Petrous part of temporal bone**

**Int. aud. meatus**



**VII**

**VIII**

## CLINICAL TEST: INNER EAR DETECTS TRANSMITTED VIBRATIONS

Weber test – tuning fork on calvarium directly causes bone to vibrate; conducted to cochlea by bone; perceived as sound by patient

Can use to test functioning of inner ear (Sensorineural hearing loss) independent of outer, middle ear (Conductive hearing loss)

CONDUCTIVE HEARING LOSS - damage to middle ear (tympanic membrane, auditory ossicles (bones)

SENSORINEURAL HEARING LOSS - damage to inner ear (cochlea).



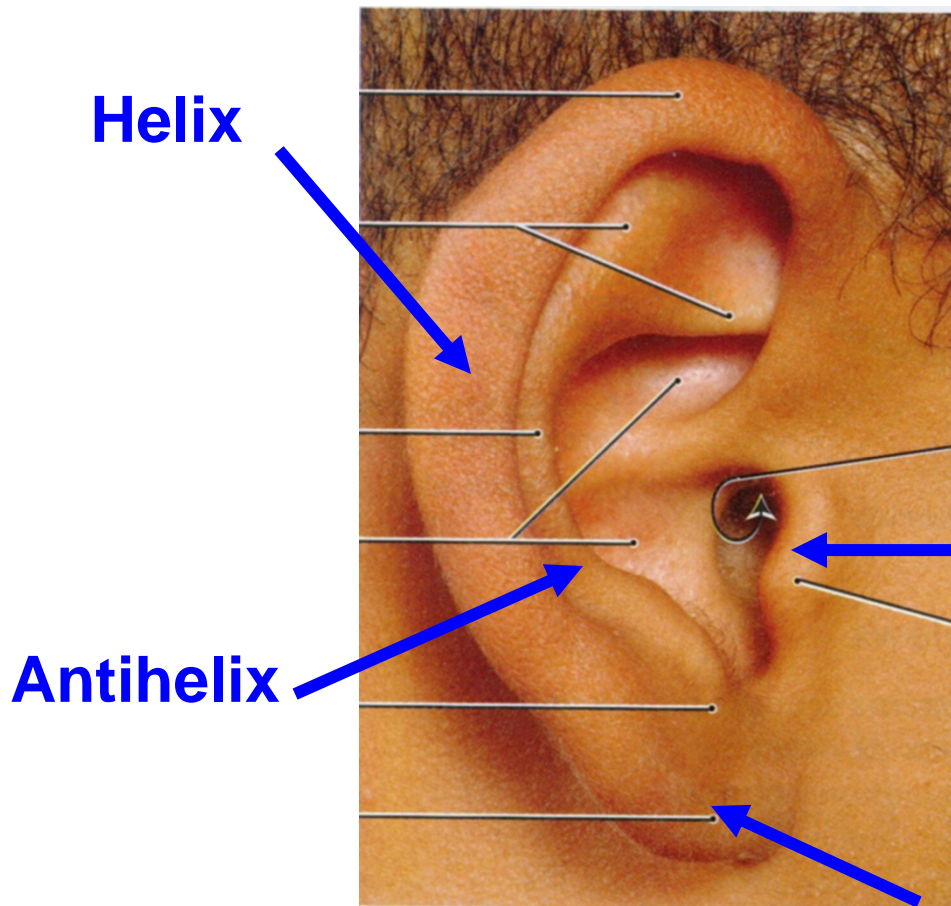
**FIGURE 11-18**

Weber test. Place the base of the tuning fork on the midline of the skull.



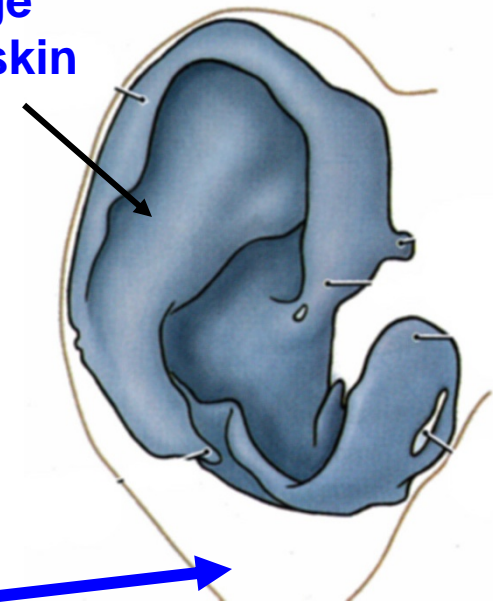
## II. OUTER EAR - composed of two parts

A. AURICLE (pinna) -  
elastic cartilage and skin -  
Reflects sound waves



Tragus

cartilage  
under skin

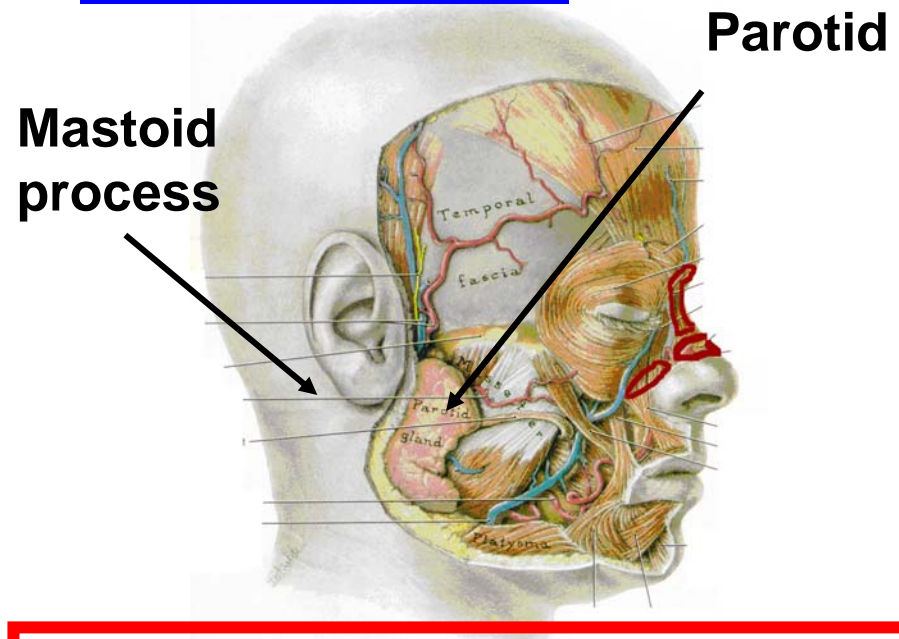
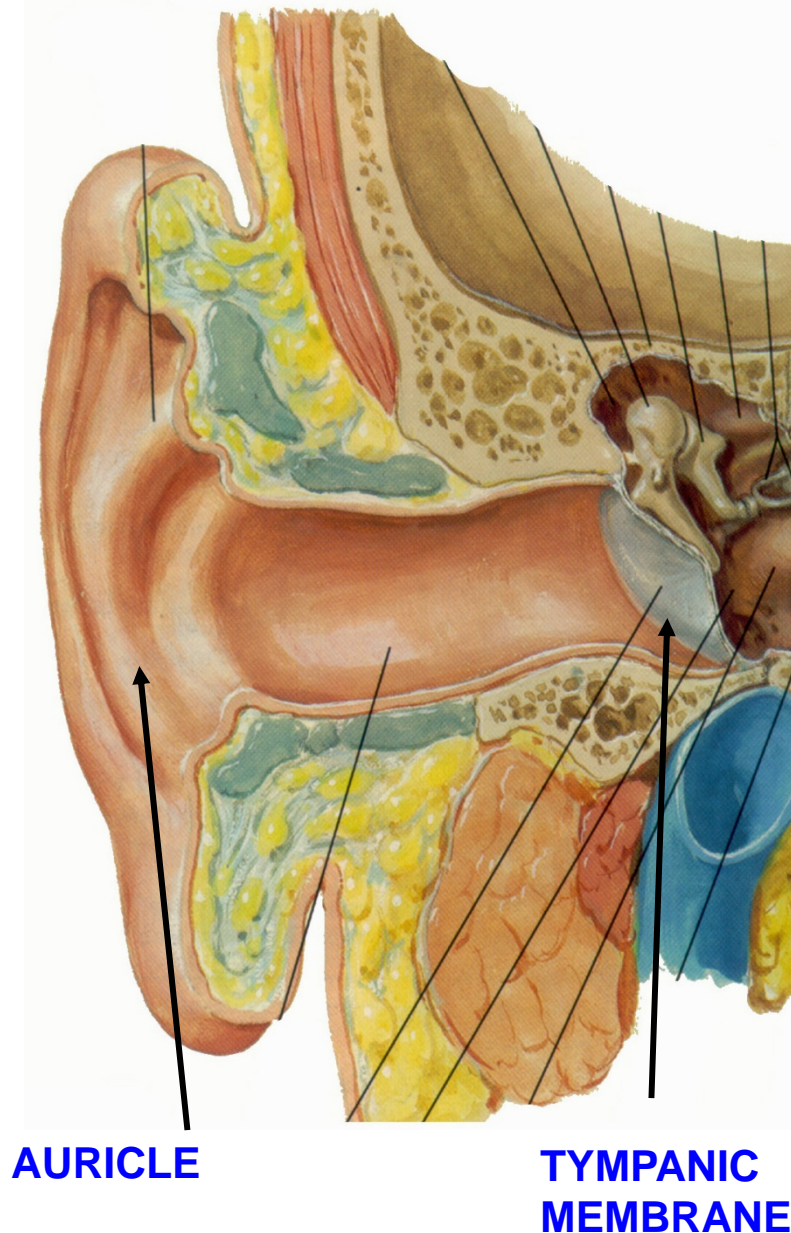


Lobule

Cartilage does not extend into lobule - Can safely pierce and suspend  
**decorative metal objects from lobule**

## EXTERNAL AUDITORY MEATUS - location

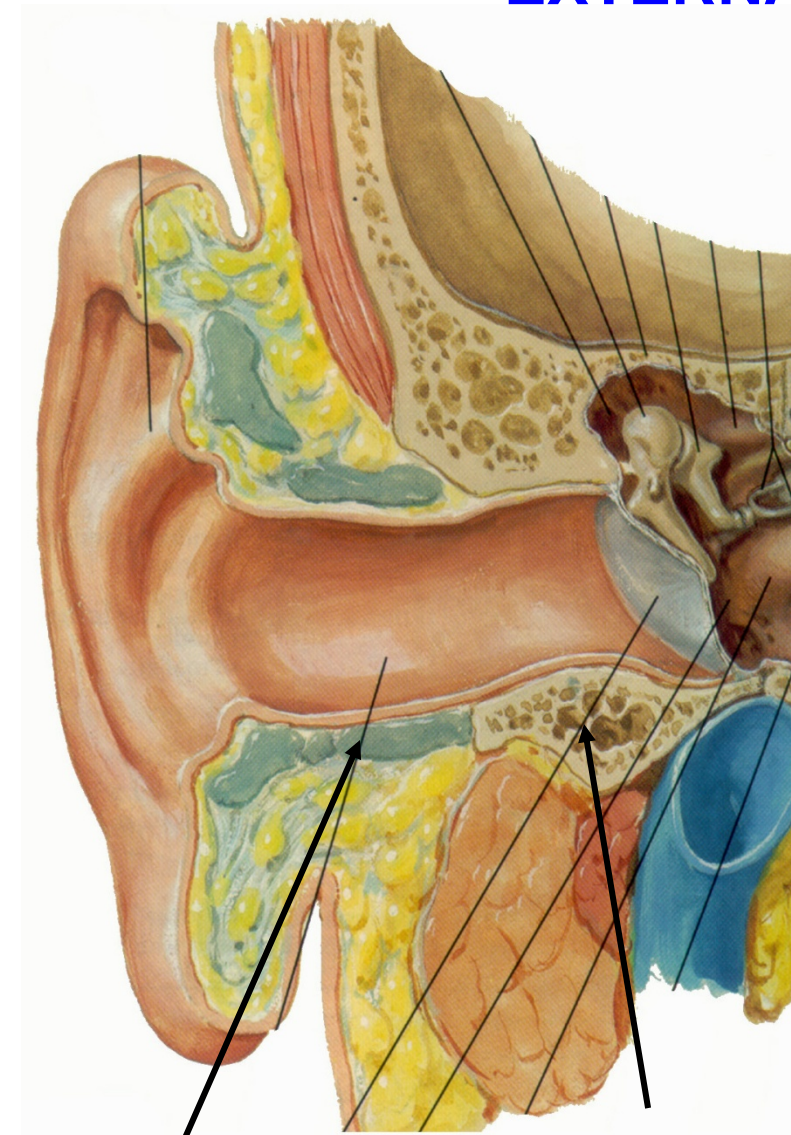
- Tube from auricle to the tympanic membrane; posterior to Parotid gland and TMJ; anterior to mastoid process



**Clinical** note - sensory innervation of Outer Ear from CN V, VII, IX and X; **patient's with Bell's palsy can have sensation of ear ache.**



# EXTERNAL AUDITORY MEATUS



OUTER 1/3  
CARTILAGE

INNER 2/3  
BONE

Outer 1/3 - Cartilage - contains hair, sebaceous and ceruminous glands (ear wax [insect repellent]); protects tympanic membrane,

Inner 2/3 - Bone covered by skin

**Clinical note: ext. auditory meatus is straight in children, curved anteriorly in adults**

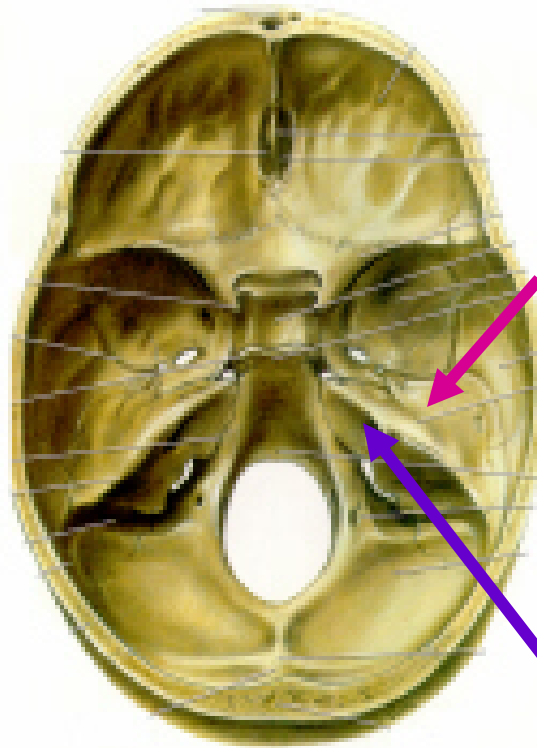
**In Adult - pull up and back to insert otoscope**





### III. MIDDLE EAR - hard to visualize

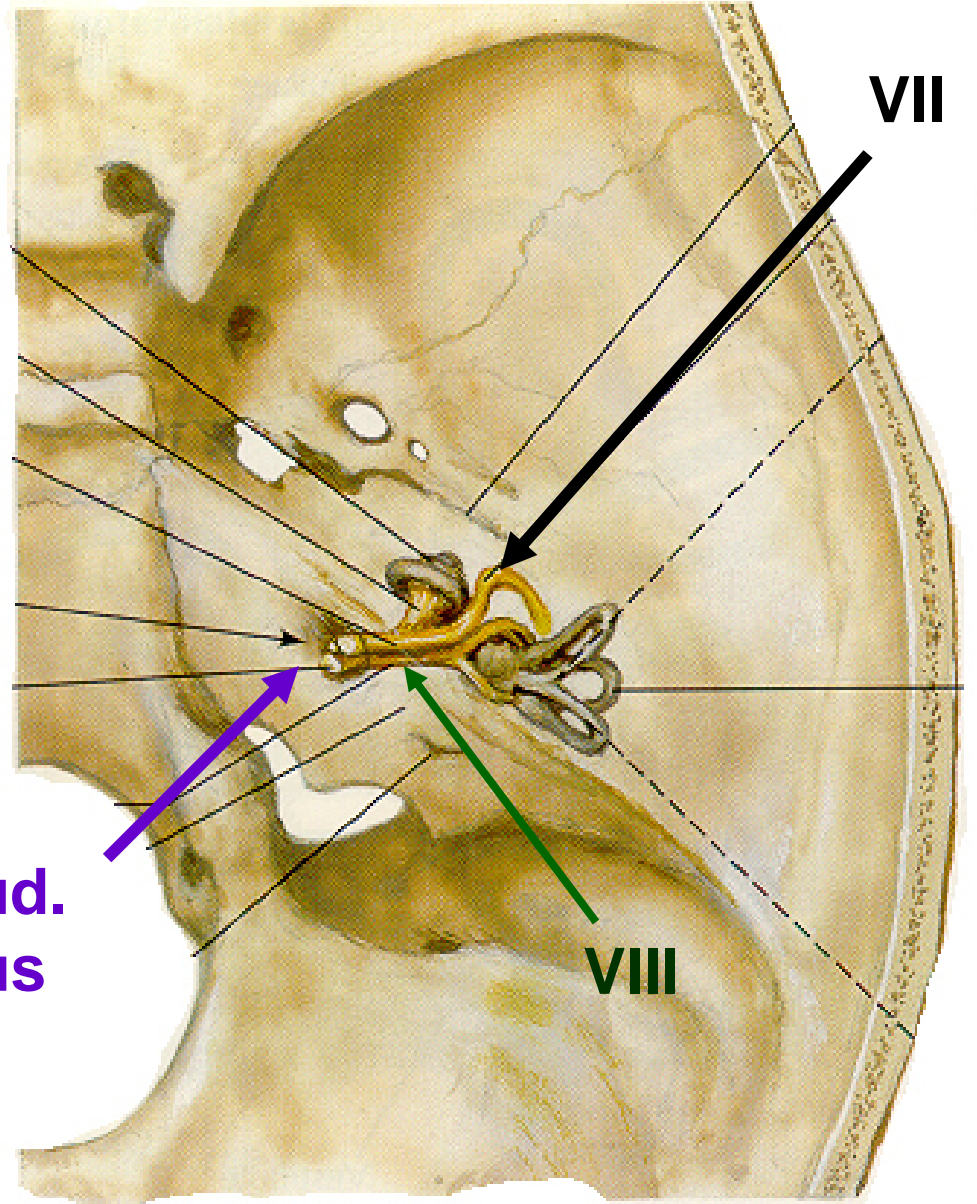
ORIENT: LOCATION OF INNER EAR



Petrous part of temporal bone

LOCATION OF MIDDLE EAR AND INNER EAR DIFFICULT TO DEMONSTRATE

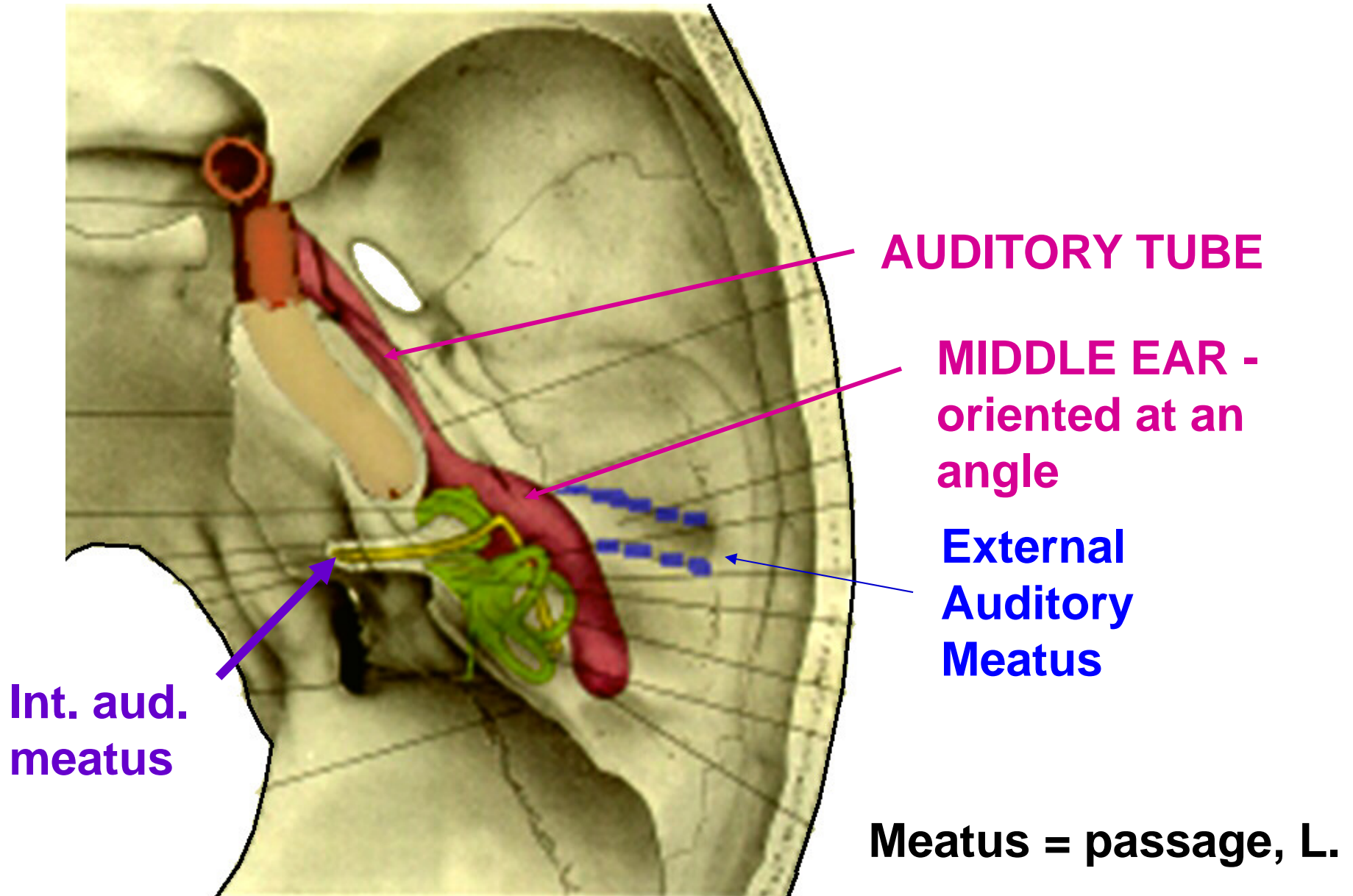
Int. aud. meatus



VII

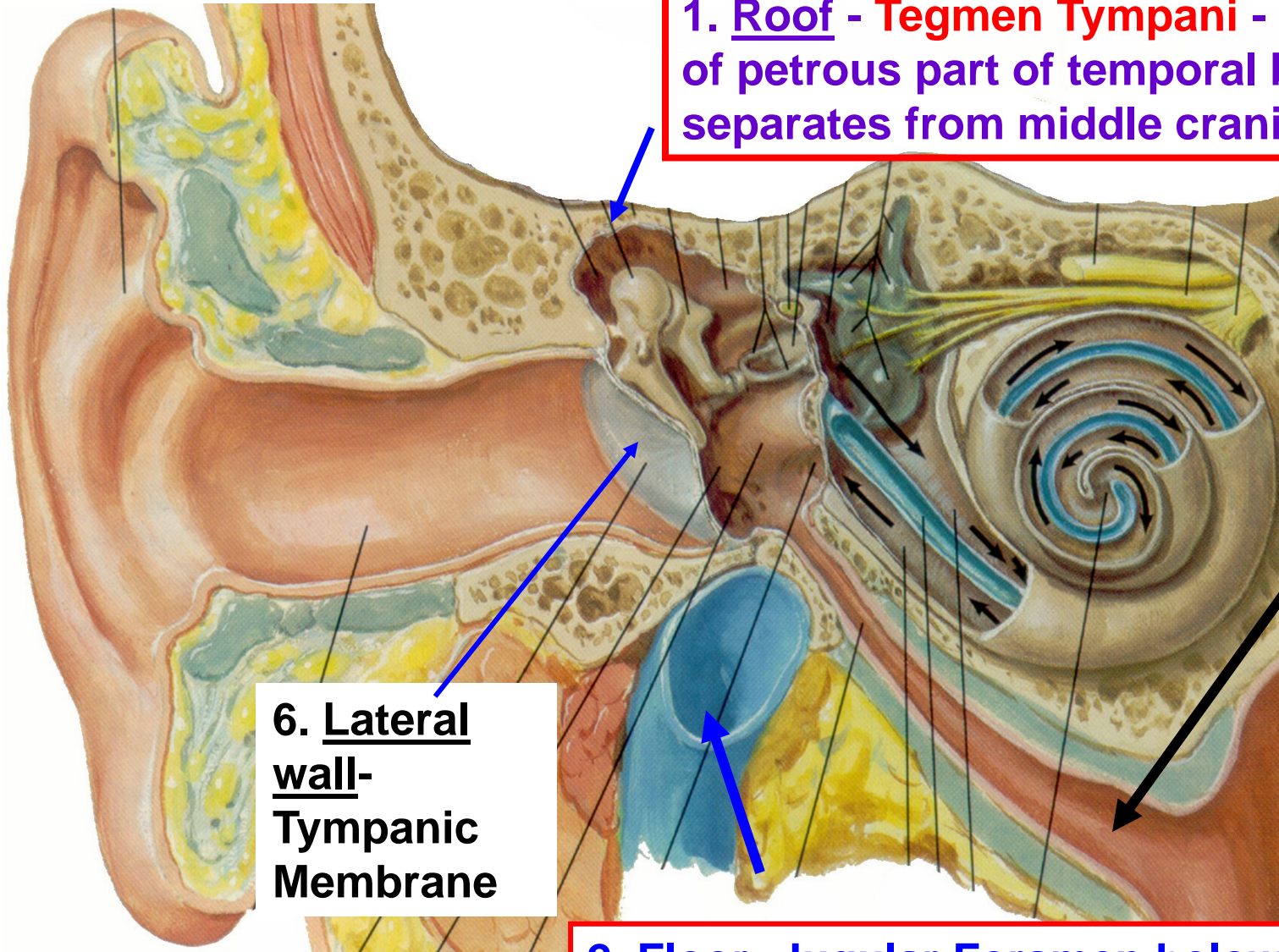
VIII

## ORIENT: LOCATION OF MIDDLE EAR



### III. MIDDLE EAR - BOUNDARIES

1. Roof - **Tegmen Tympani** - thin plate of petrous part of temporal bone; separates from middle cranial fossa



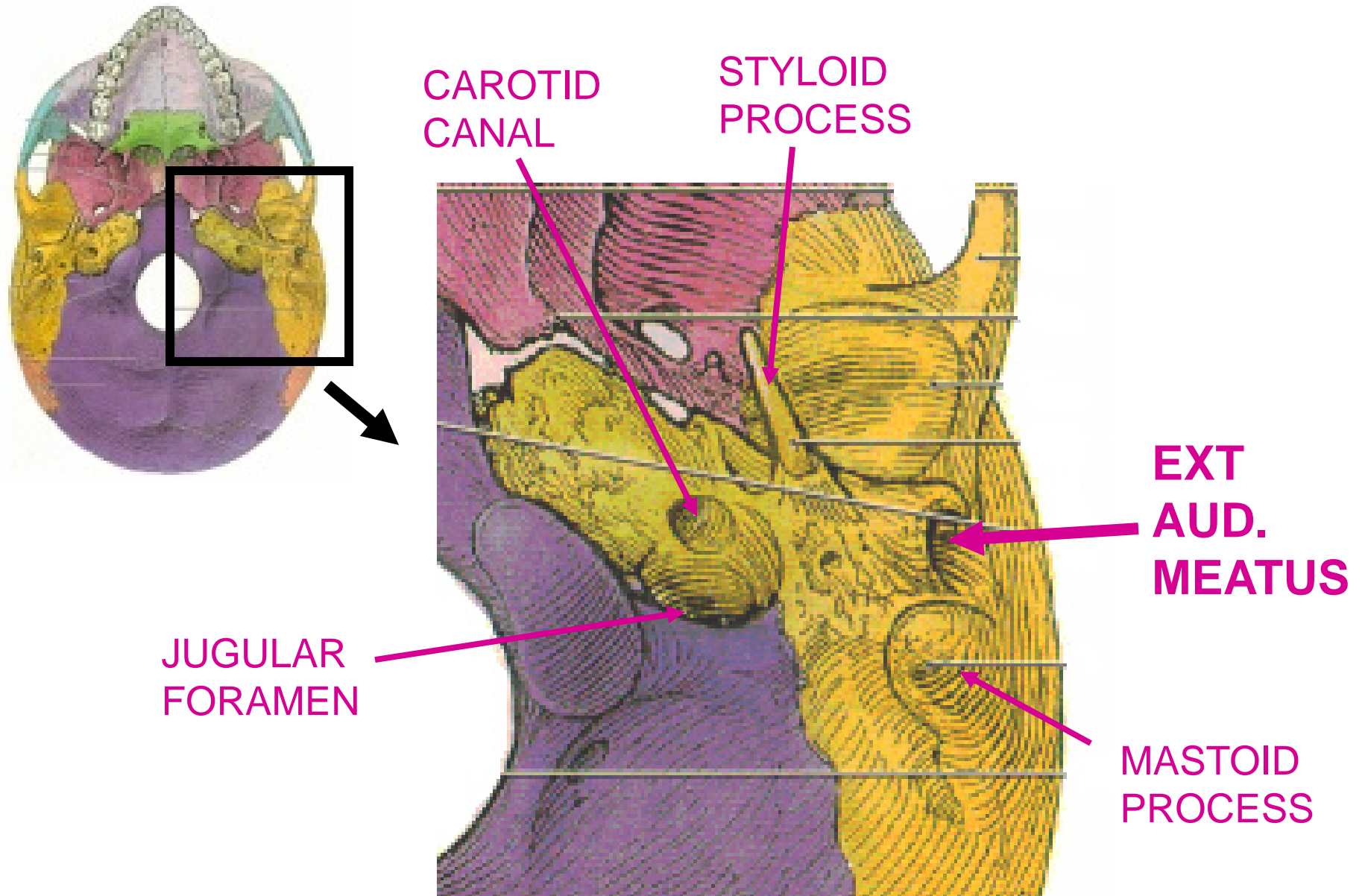
3. Ant. wall -  
Opening of **Auditory Tube** (ant. 2/3 cartilage; post. 1/3 bone)

6. Lateral wall -  
Tympanic Membrane

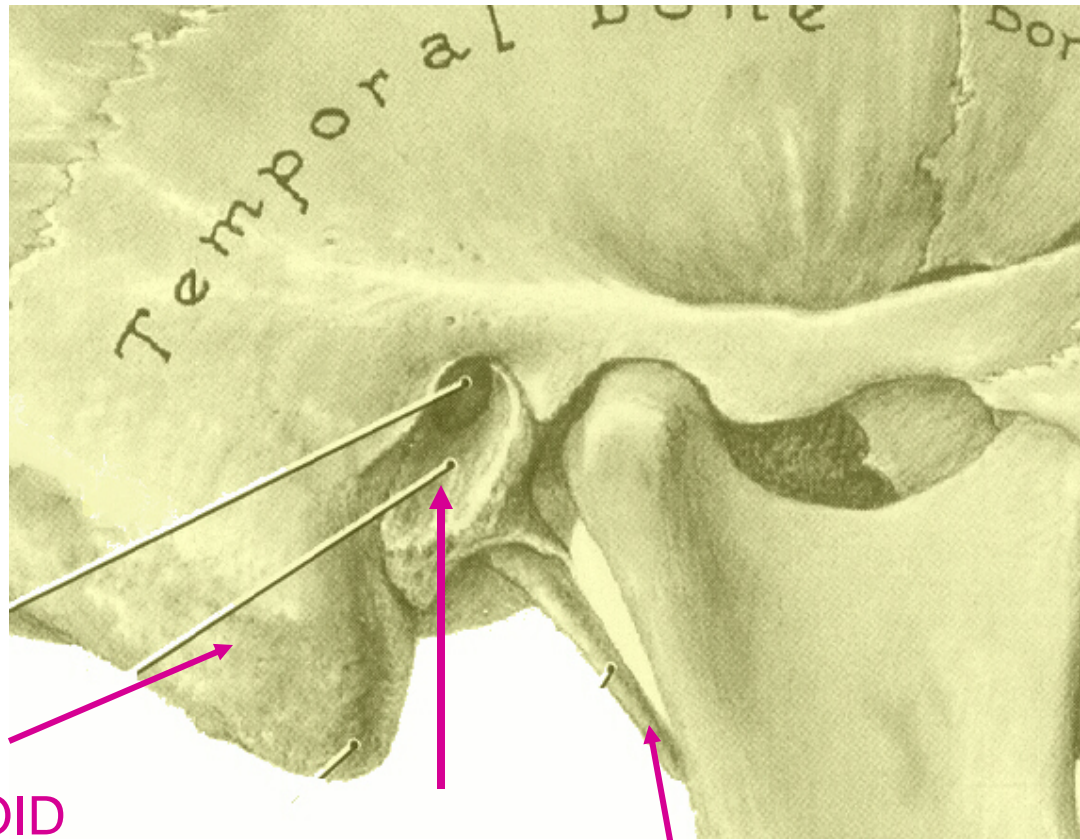
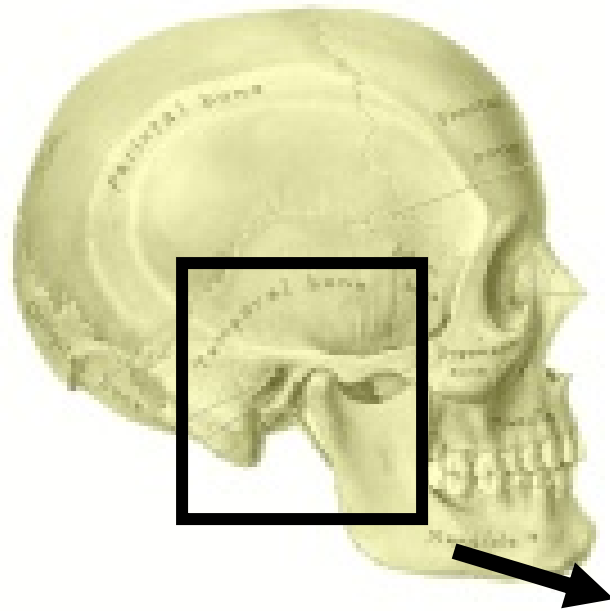
2. Floor - Jugular Foramen below - Internal Jugular vein can rupture to middle ear



# ORIENT: LOCATION OF MIDDLE EAR ON SKULL



## ORIENT: LOCATION OF MIDDLE EAR ON SKULL

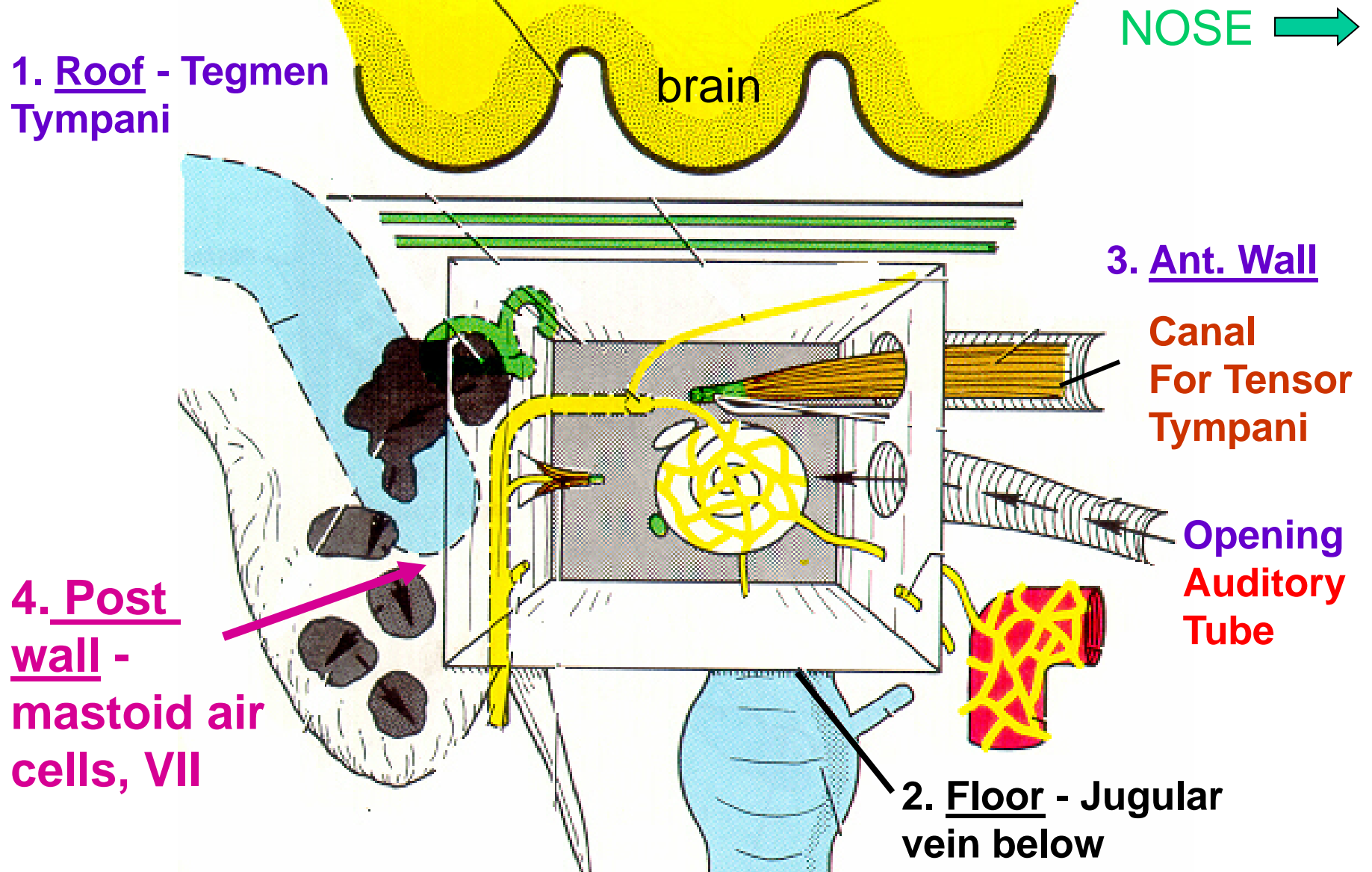


MASTOID  
PROCESS

EXT. AUD.  
MEATUS

STYLOID  
PROCESS

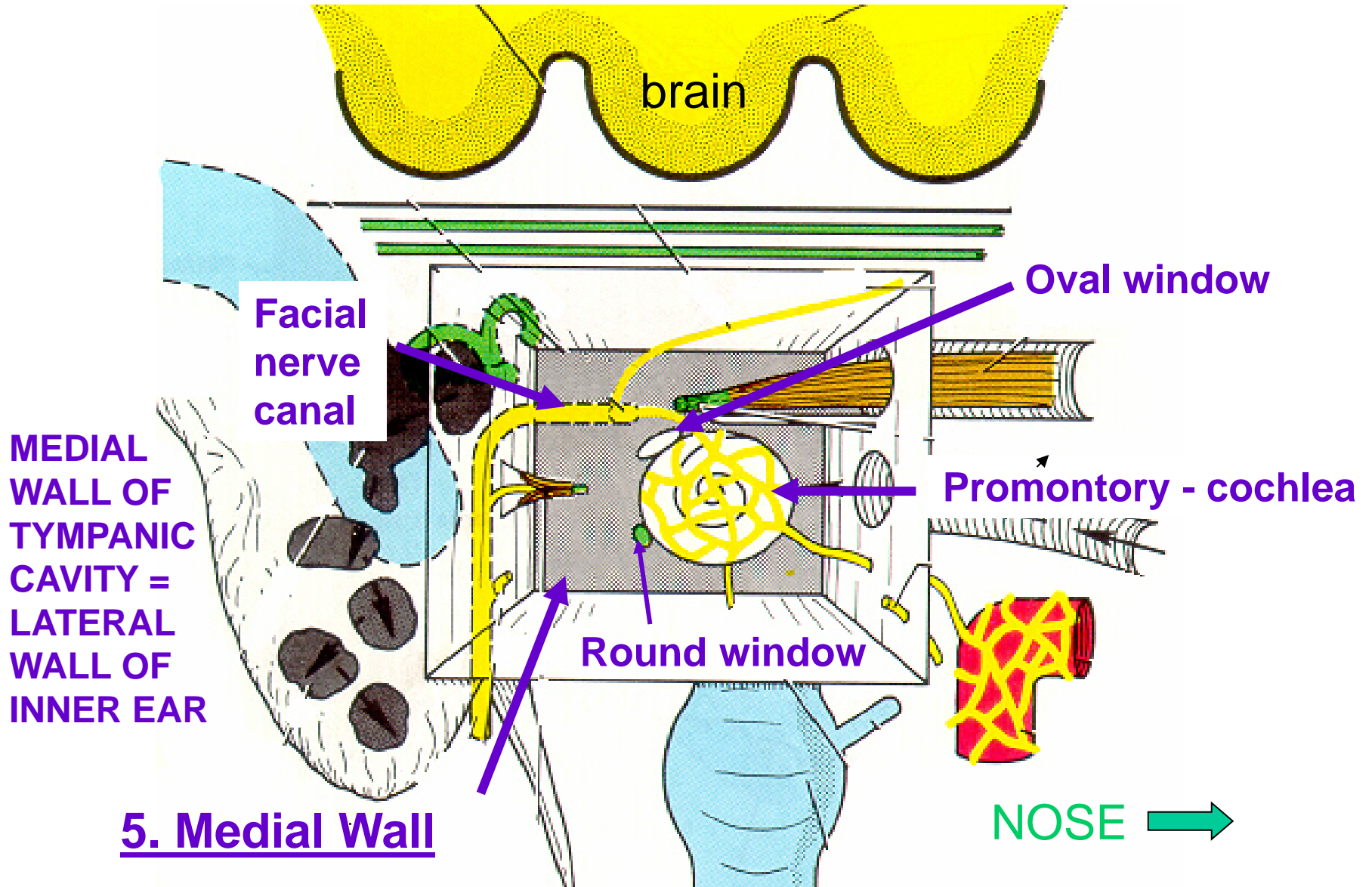
# MIDDLE EAR: BOUNDARIES



View of Medial Wall of Right Middle Ear with Tympanic membrane and Ossicles Removed (note: Promontory = bulge in wall from Cochlea)

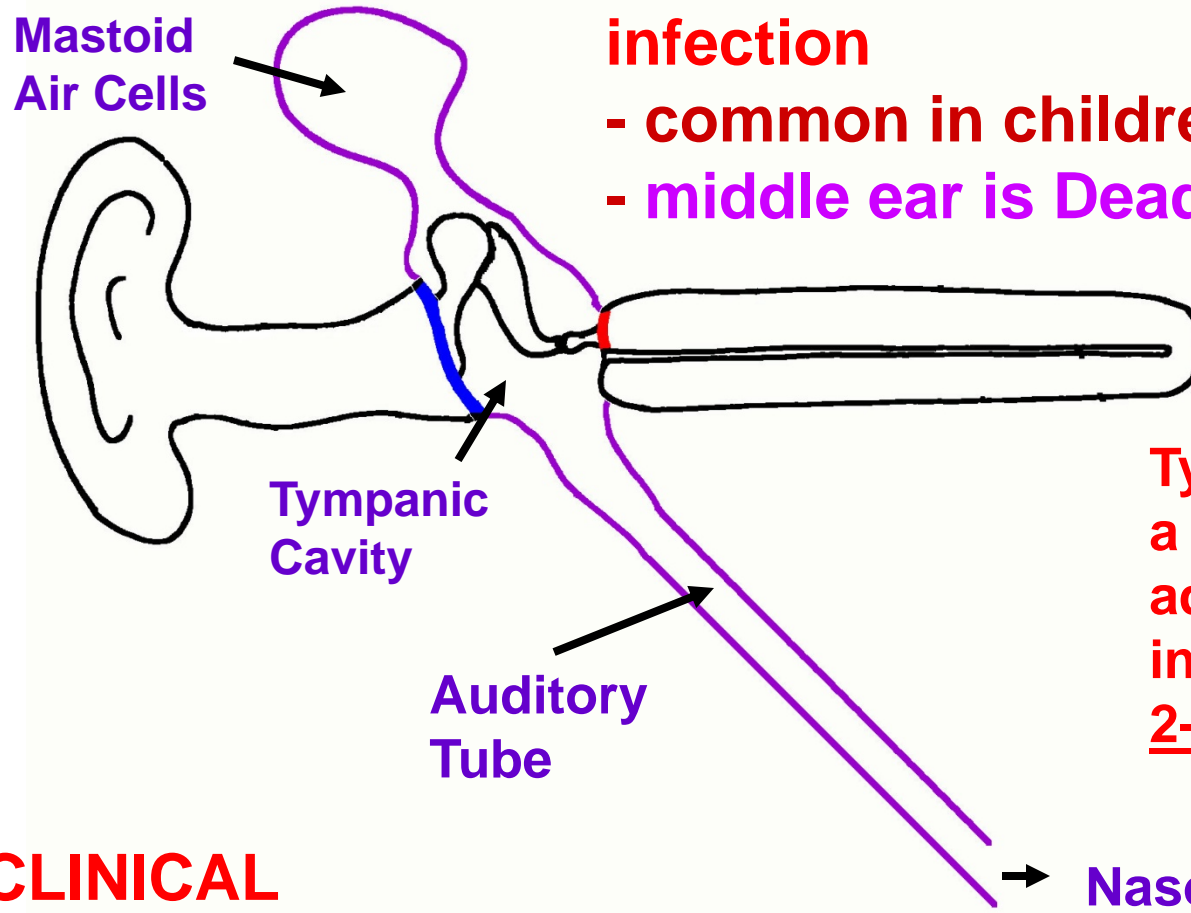


# MIDDLE EAR: BOUNDARIES



Oval window (fenestra vestibuli) = attach stapes; Round window (fenestra cochlea) other end of cochlea

# OTITIS MEDIA



## 1. Otitis Media – middle ear infection

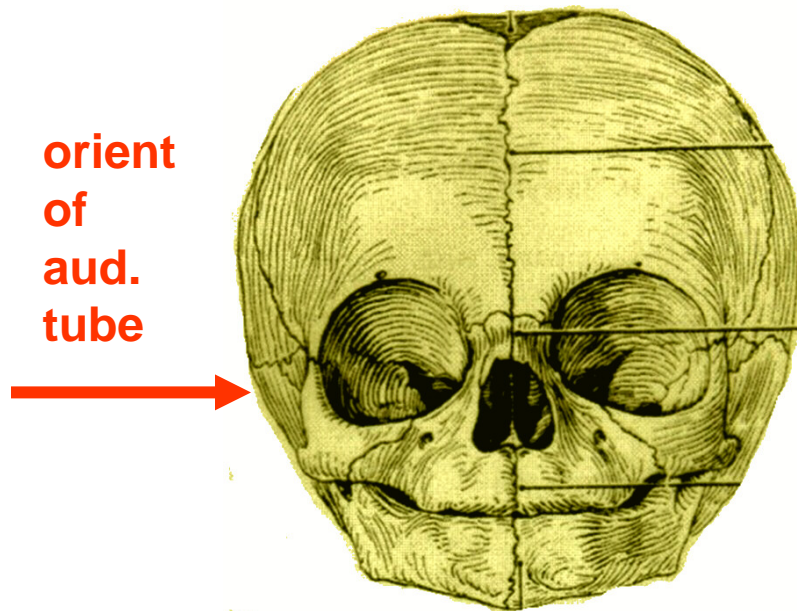
- common in children
- middle ear is Dead End Cavity

**Tympanic Cavity is a Small space - In adult 15 mm. sup-inf, 15 mm. ant-post, 2-5 mm. med-lat**

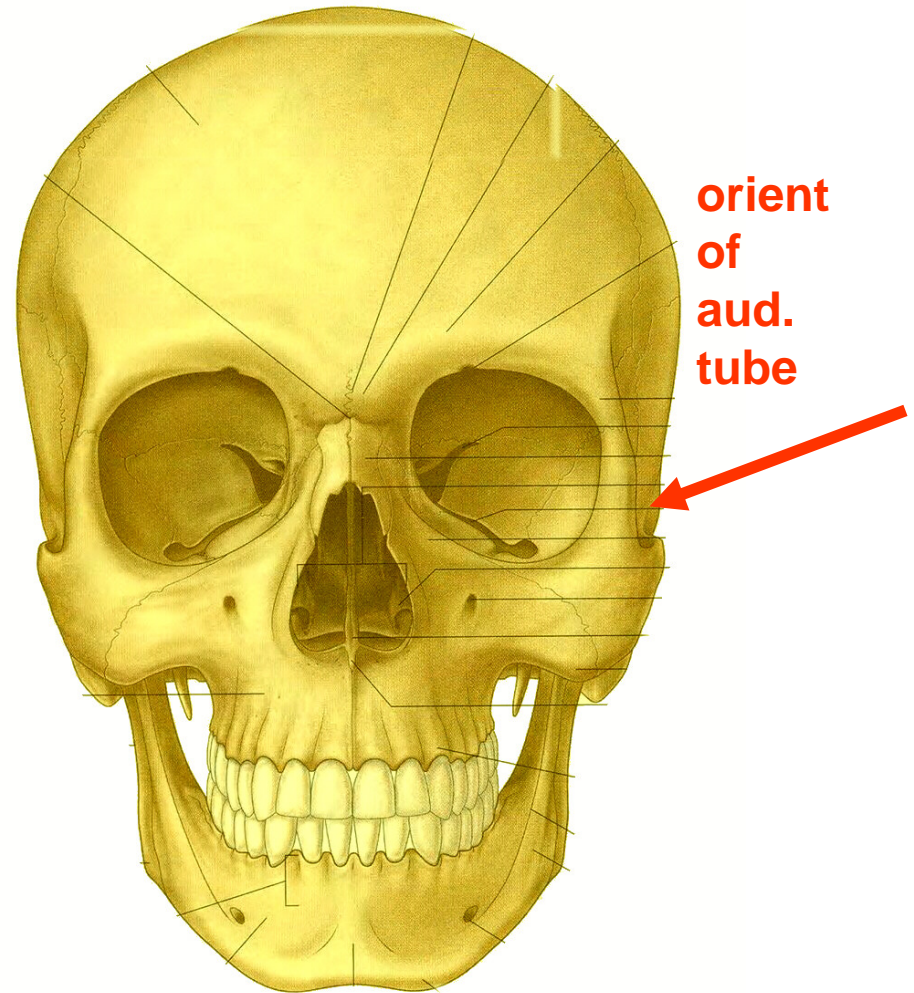
## CLINICAL

**Spread of infection from Respiratory System can damage Auditory Ossicles - Hearing Loss; Prolonged infection - Tegmen Tympani to Brain; treatment tympanostomy - tube through tympanic membrane**

# OCCURRENCE OF OTITIS MEDIA DECLINES WITH AGE OF CHILD



**ORIENTATION OF AUDITORY TUBE CHANGES FROM HORIZONTAL TO ANGLED WITH CRANIAL GROWTH (but contribution debated); diameter of lumen of auditory tube also increases**

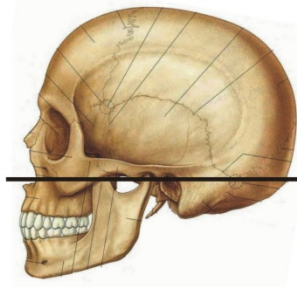


**Last peak incidence of Otitis media at about 5 years of age**



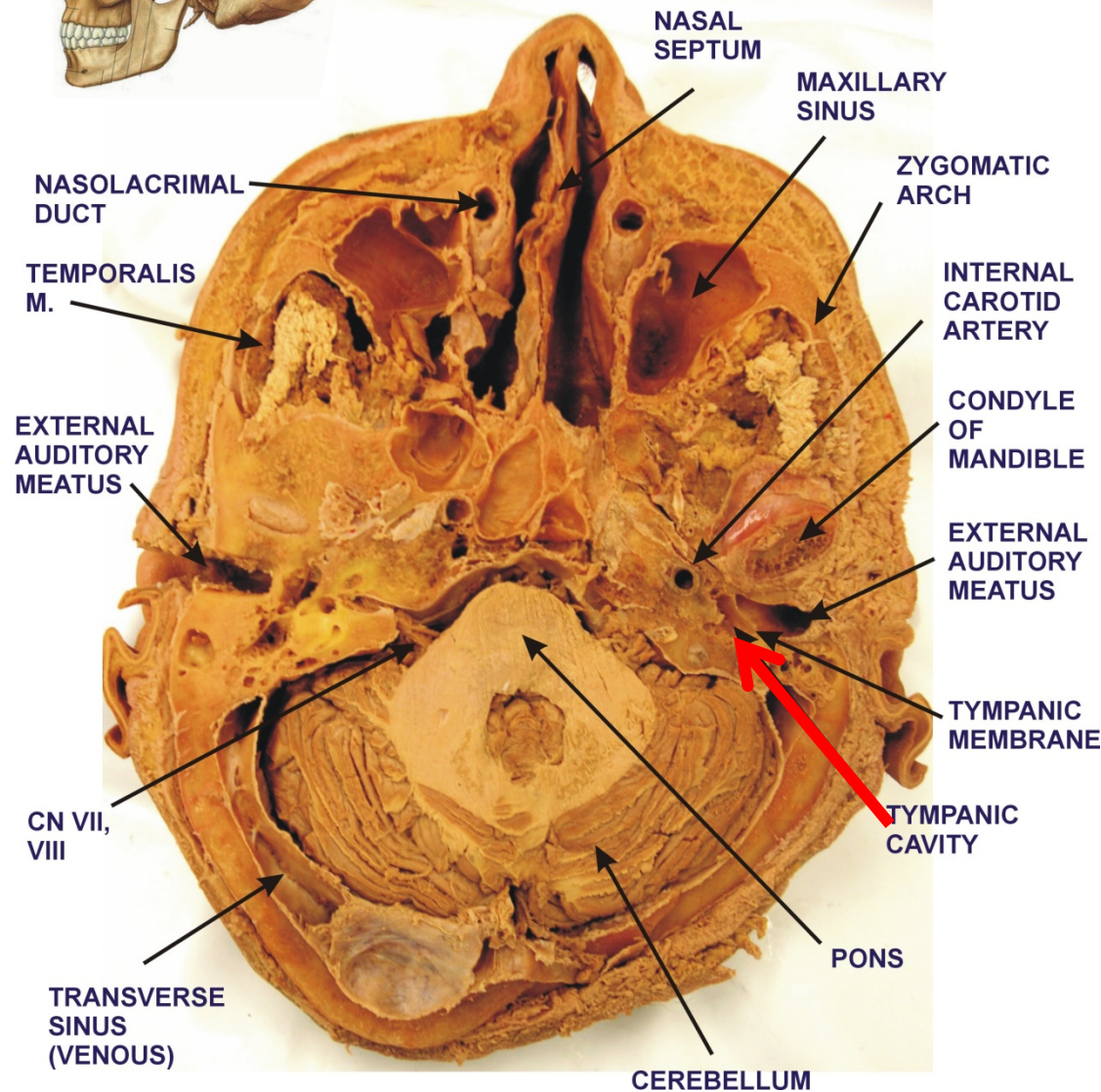
# MIDDLE EAR: HEAD IN PLANE OF CT

1067



ORIENT TO PLANE OF SECTION:  
Inferior to orbit, through external  
auditory meatus

PROSECTIONS BY ELIZABETH DUKE  
JCESOM CLASS OF 2010

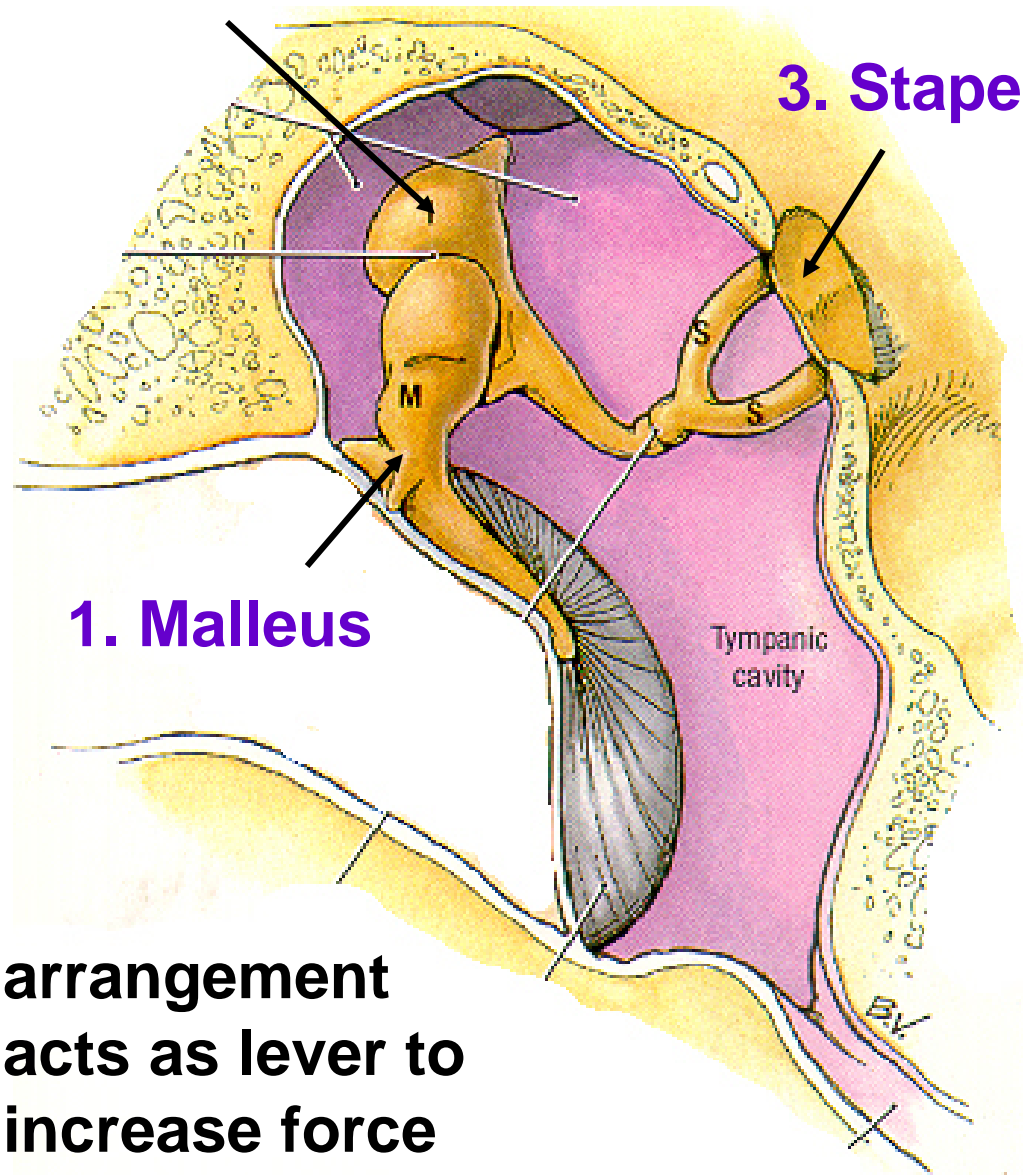


**PROSECTIONS  
IN LAB:  
NOT  
REQUIRED  
BUT  
INTERESTING  
SEE  
DIAMETER OF  
TYMPANIC  
CAVITY**

## B. AUDITORY OSSICLES

2. Incus

3. Stapes



1. Malleus

Tympanic cavity

arrangement  
acts as lever to  
increase force

- link tympanic membrane to oval window and cochlea –

- anchored by ligaments

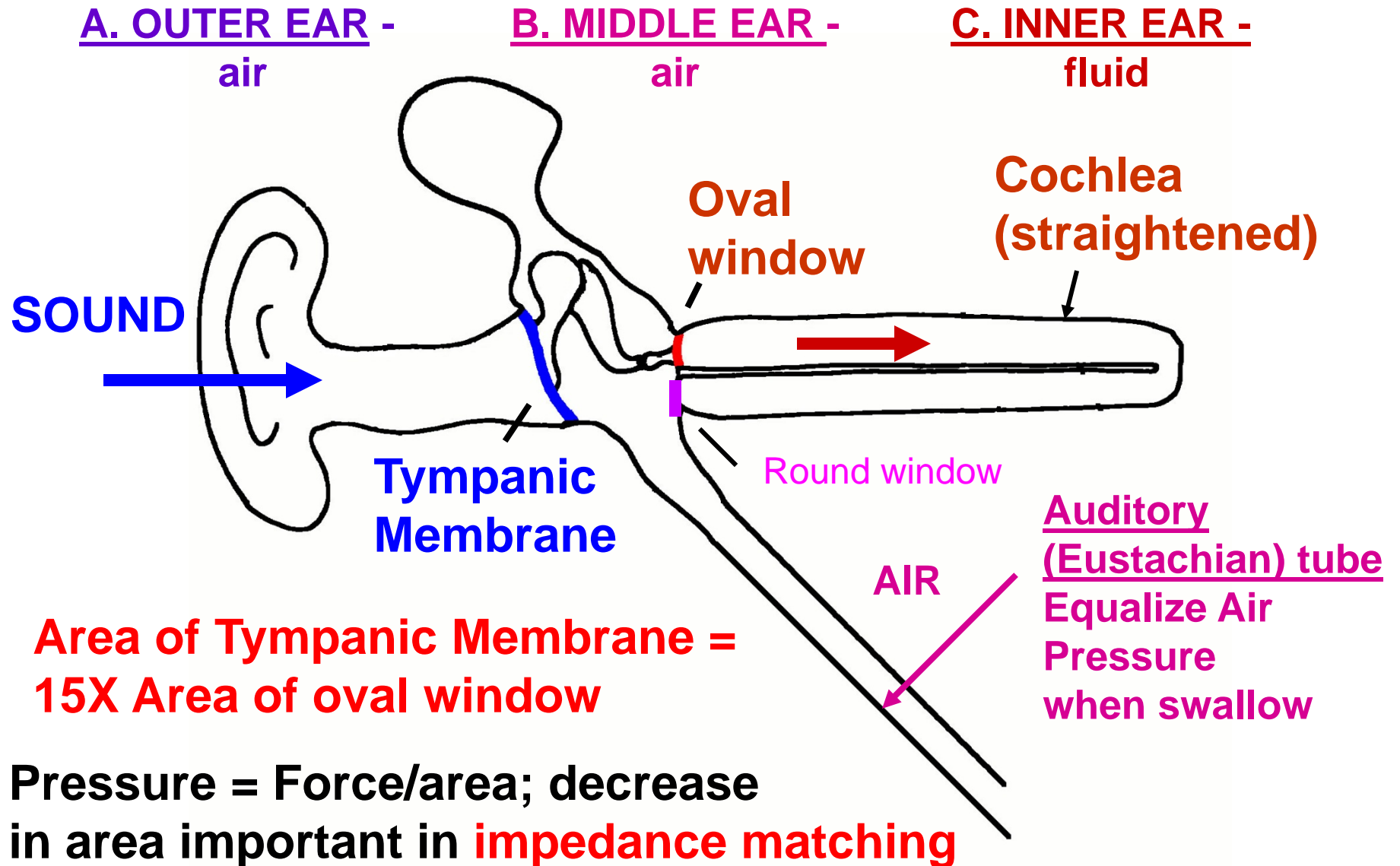
Malleus = hammer

Incus = anvil

Stapes = stirrup

- Broad attachment of Malleus to tympanic membrane

# EAR: DIAGRAMMATICALLY - transmission of sound (Cochlea straightened)





# OTOSCOPE VIEW OF TYMPANIC MEMBRANE

**CHORDA  
TYMPANI**  
(branch  
of VII)

Pars  
flaccida

**MALLEUS –  
manubrium  
(handle)**

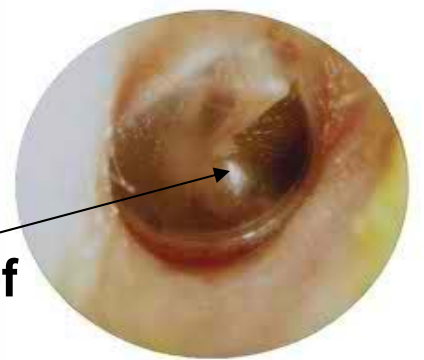
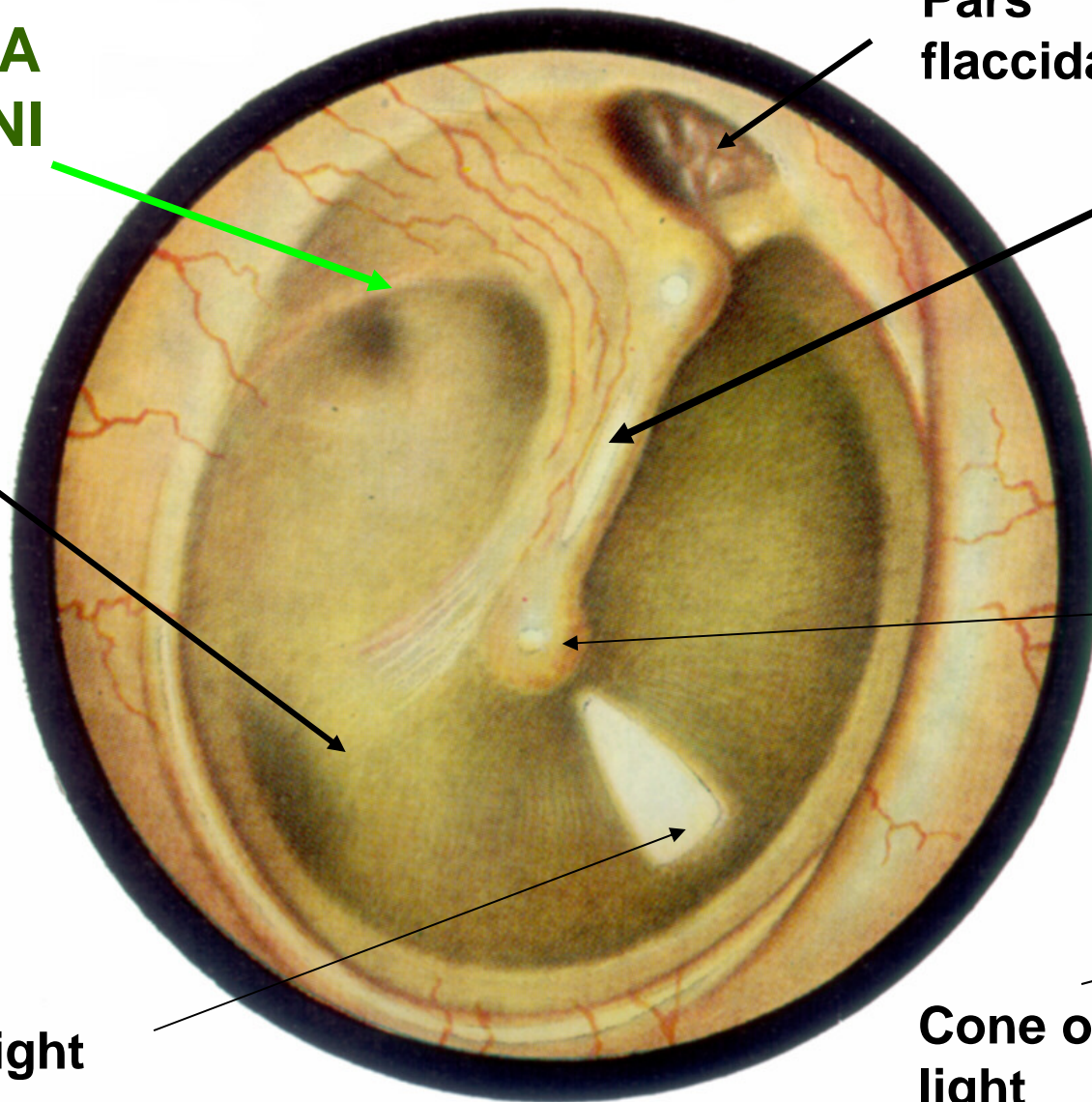
Pars  
tensa

Umbo  
(protuberance)

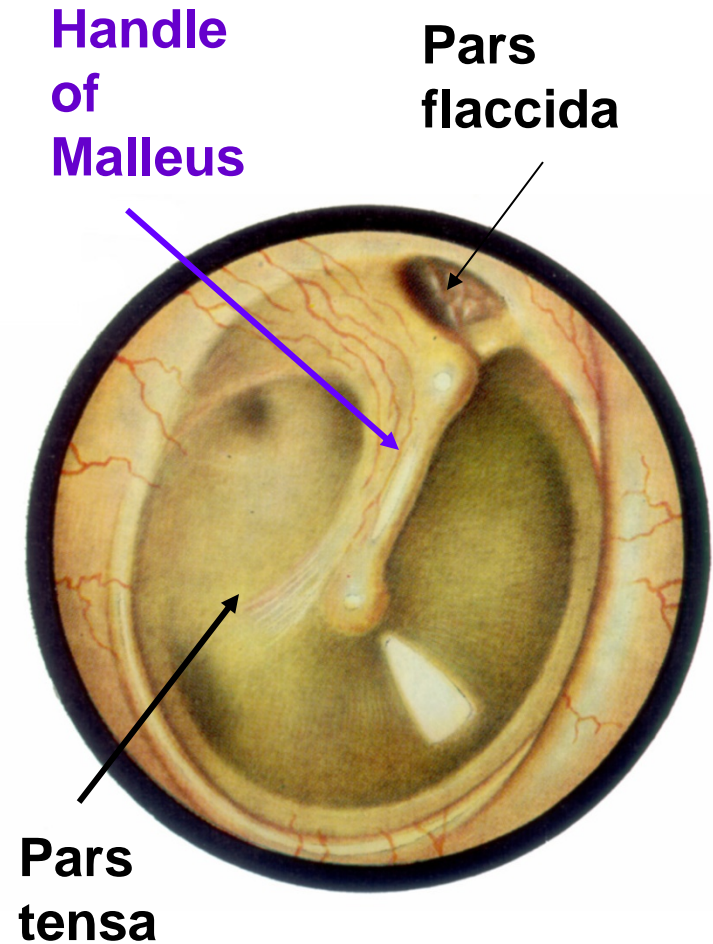
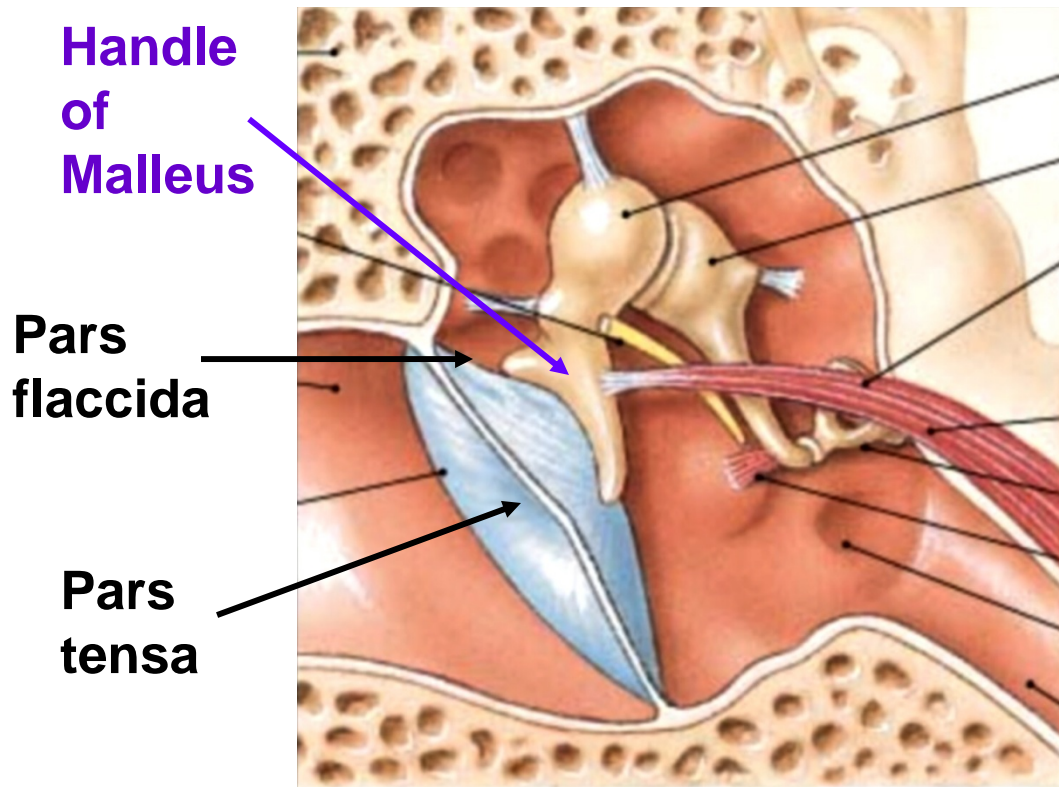
**RIGHT  
EAR**

Cone of light

Cone of  
light

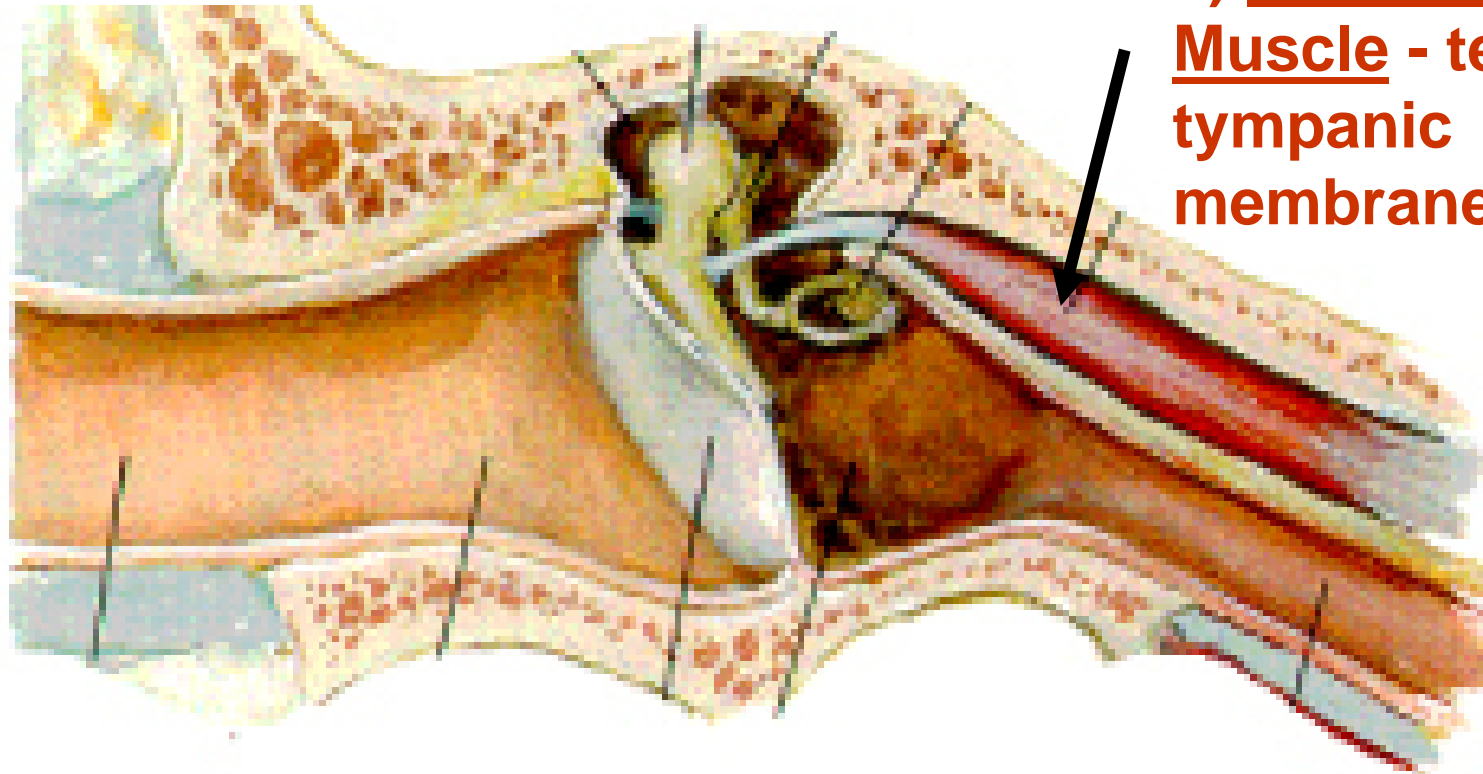


# OTOSCOPE VIEW OF TYMPANIC MEMBRANE



Handle malleus is attached to upper half of Tympanic membrane; malleus is supported by ligaments linking it to wall of Tympanic cavity; part of Tympanic membrane surrounding handle is tense (pars tensa); upper end is less tense (pars flaccida)

# MUSCLES OF MIDDLE EAR - dampen sound

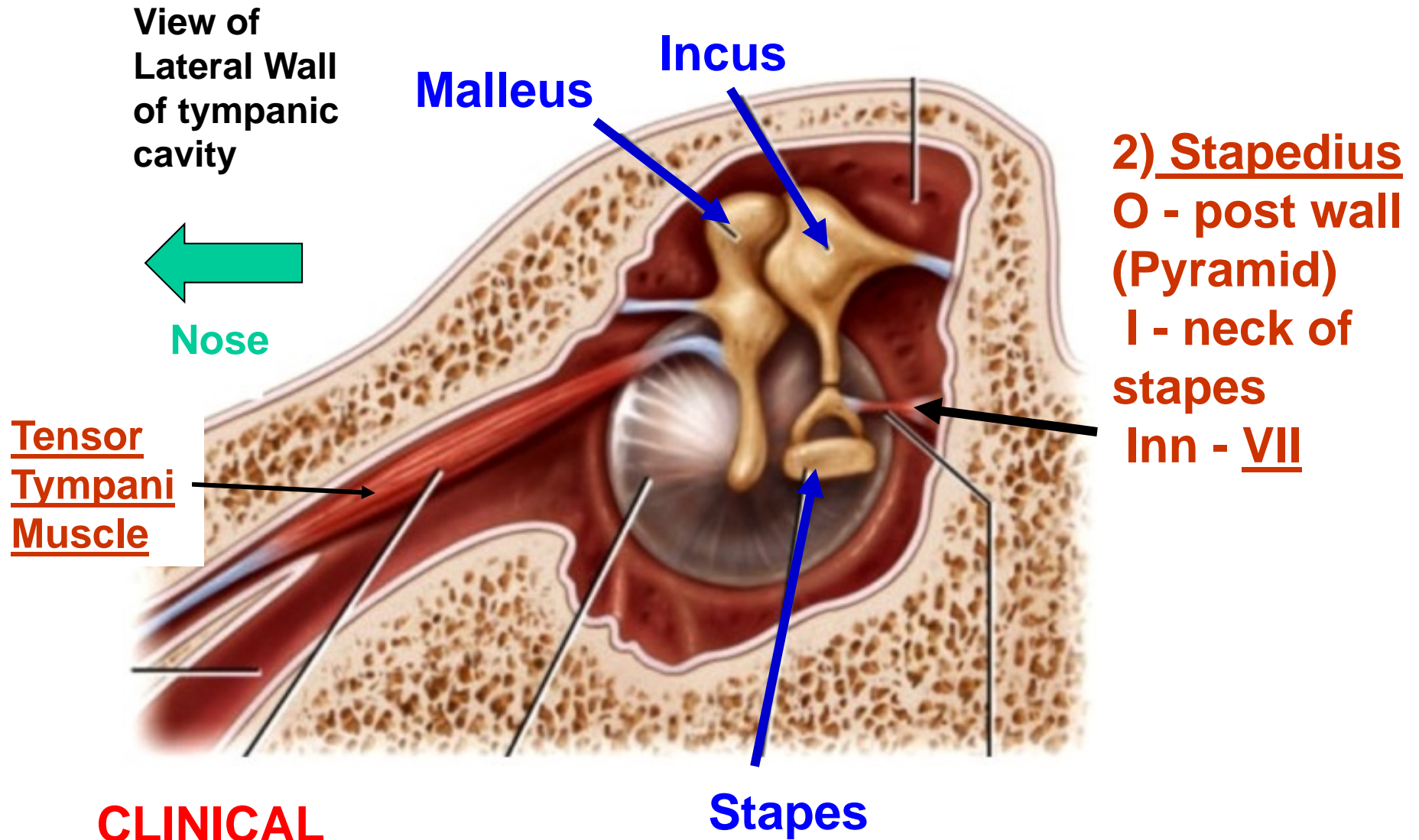


1) Tensor Tympani Muscle - tenses tympanic membrane

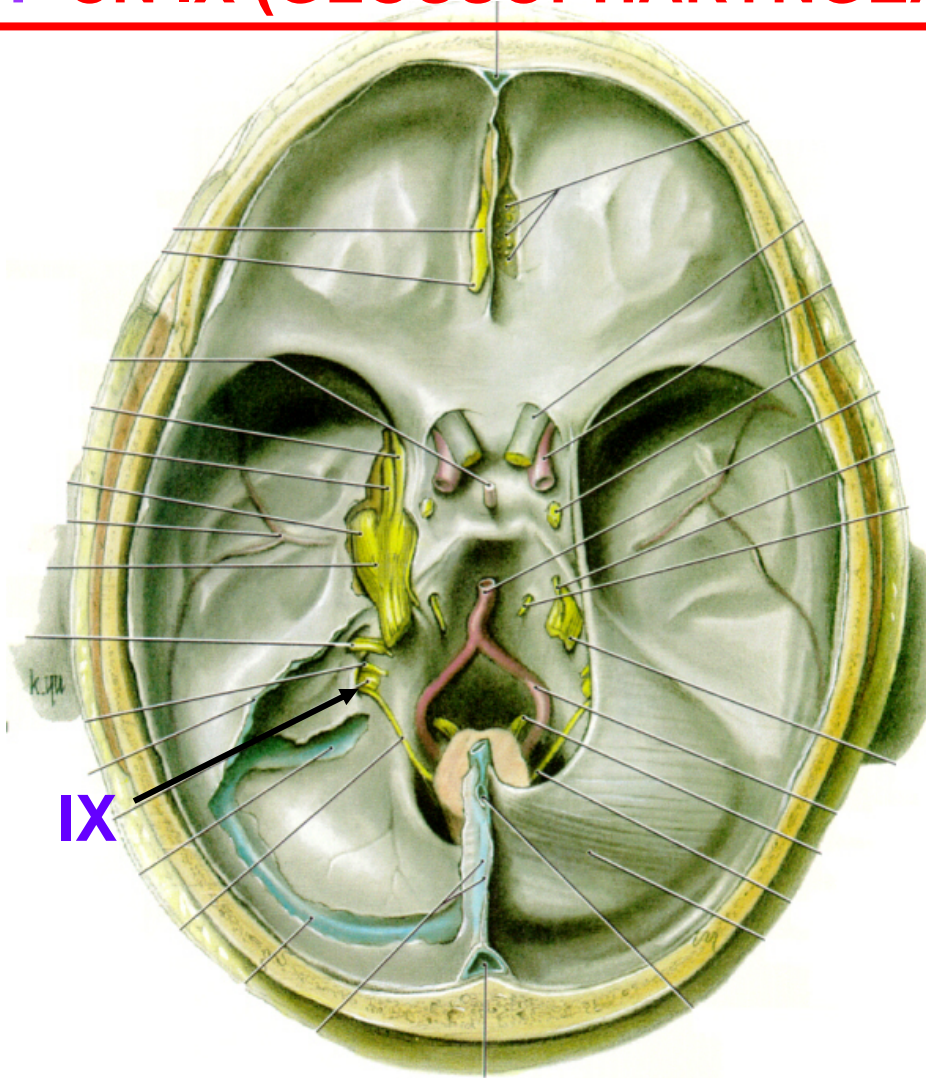
O - canal in ant. wall  
I - handle of malleus  
Inn - V3



# C. MUSCLES OF MIDDLE EAR - dampen sound



**D. SENSORY INNERVATION - VISCERAL  
SENSORY (GVA) FROM TYMPANIC PLEXUS  
OF CN IX (GLOSSOPHARYNGEAL)**



**CLINICAL \*\*\***  
- Innervation of middle ear is visceral sensory from CN IX (Glossopharyngeal)  
- Children with Middle Ear infections cannot localize pain - 'my head hurts'

**BOARD QUESTION**



# IX - GLOSSOPHARYNGEAL

NOSE



Lesser  
Petrosal N.

exits via  
Jugular Foramen

Tympanic N.

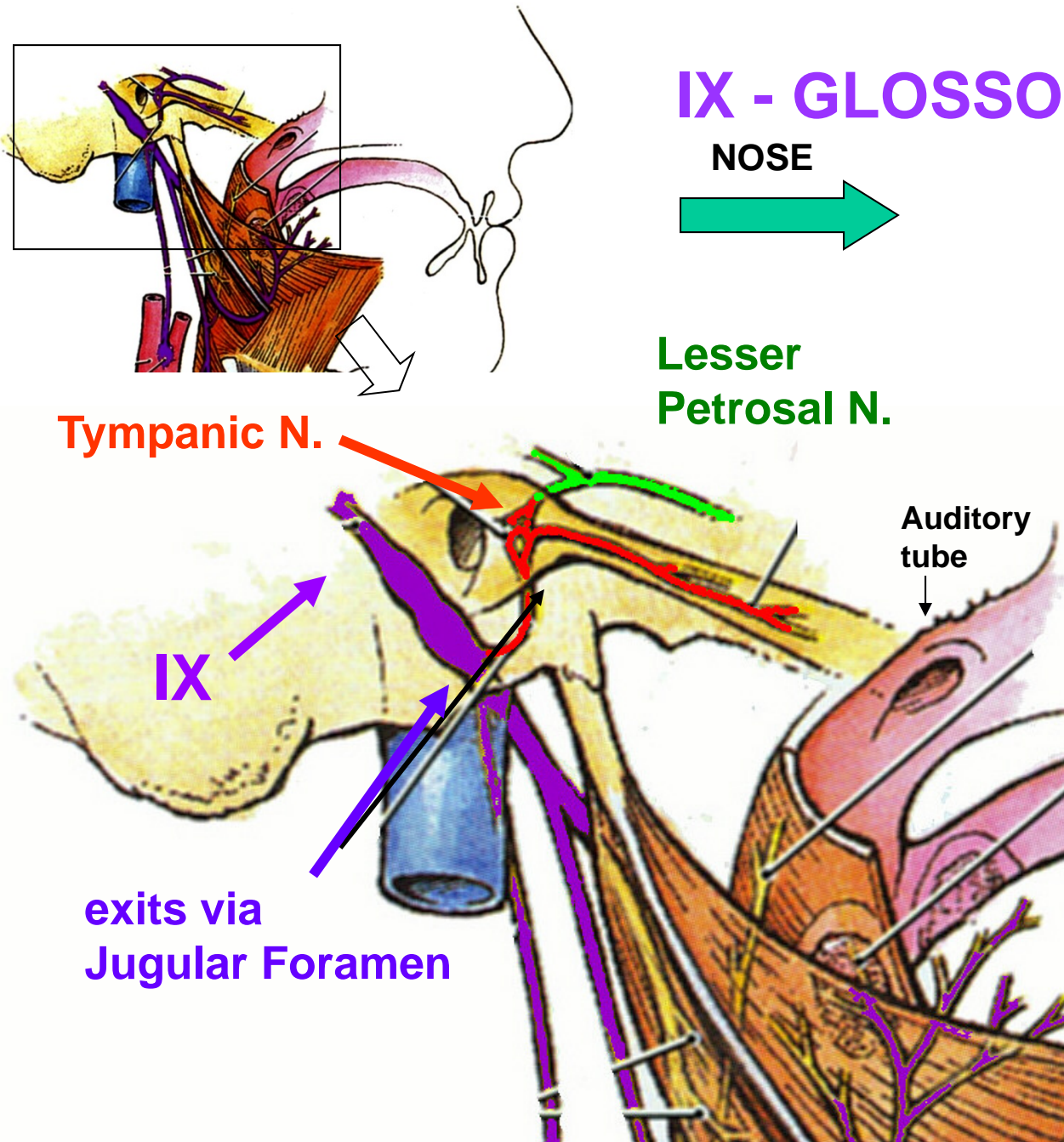
IX

exits via  
Jugular Foramen

Auditory  
tube

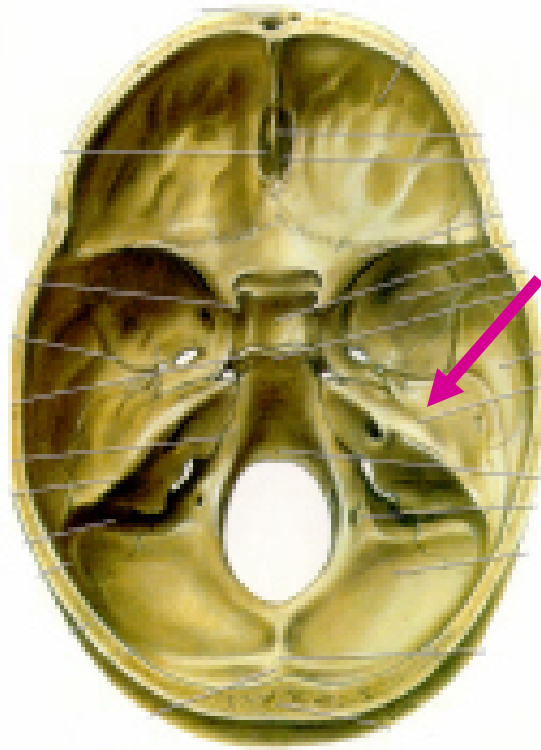
**1. Tympanic Nerve**  
Forms tympanic  
plexus; **VISCERAL  
SENSORY** to  
middle ear  
Mastoid sinus  
auditory tube

**2. Lesser Petrosal**  
**VISCERAL MOTOR**  
(parasymp)  
To Parotid Gland

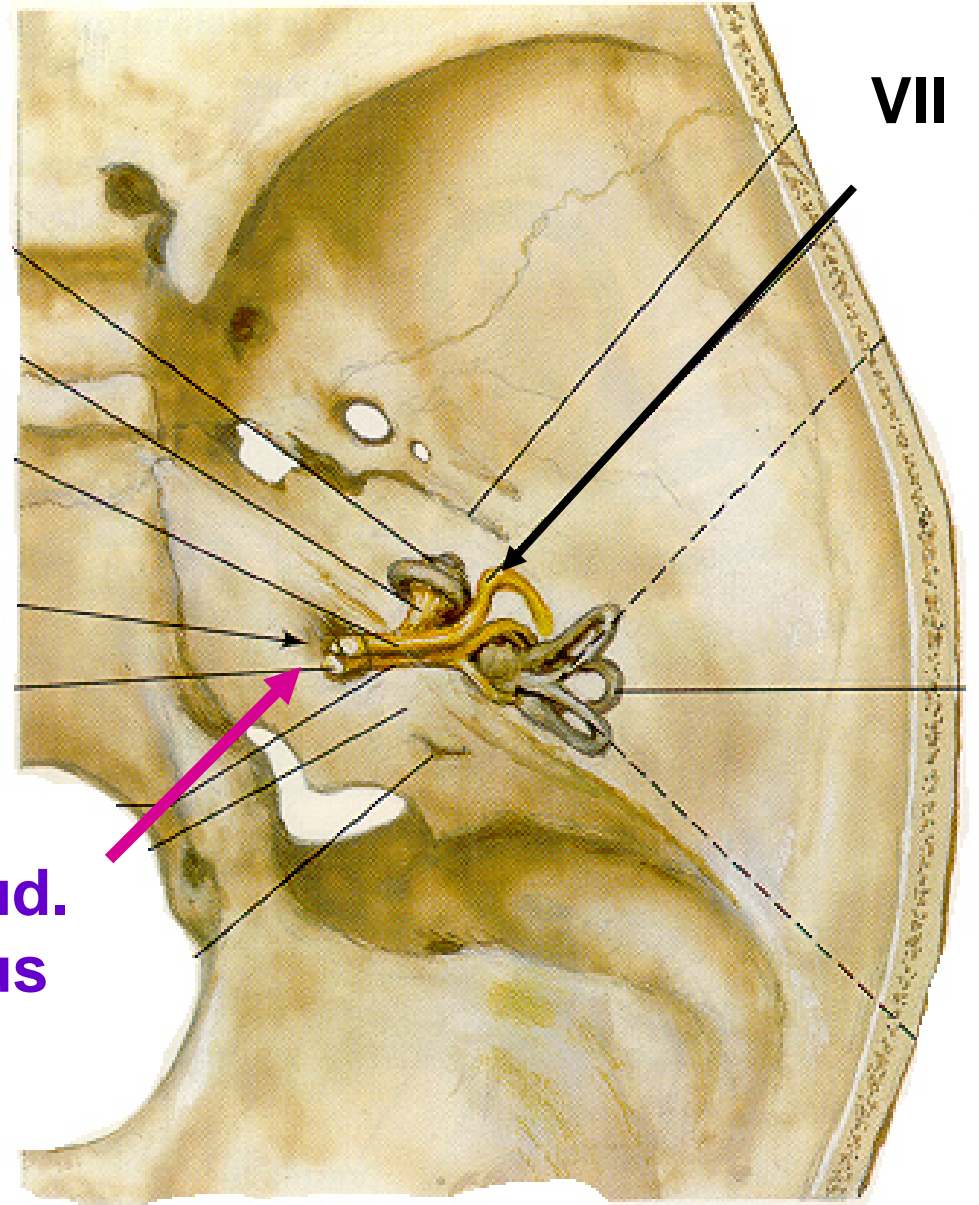




# COURSE OF FACIAL NERVE (VII)



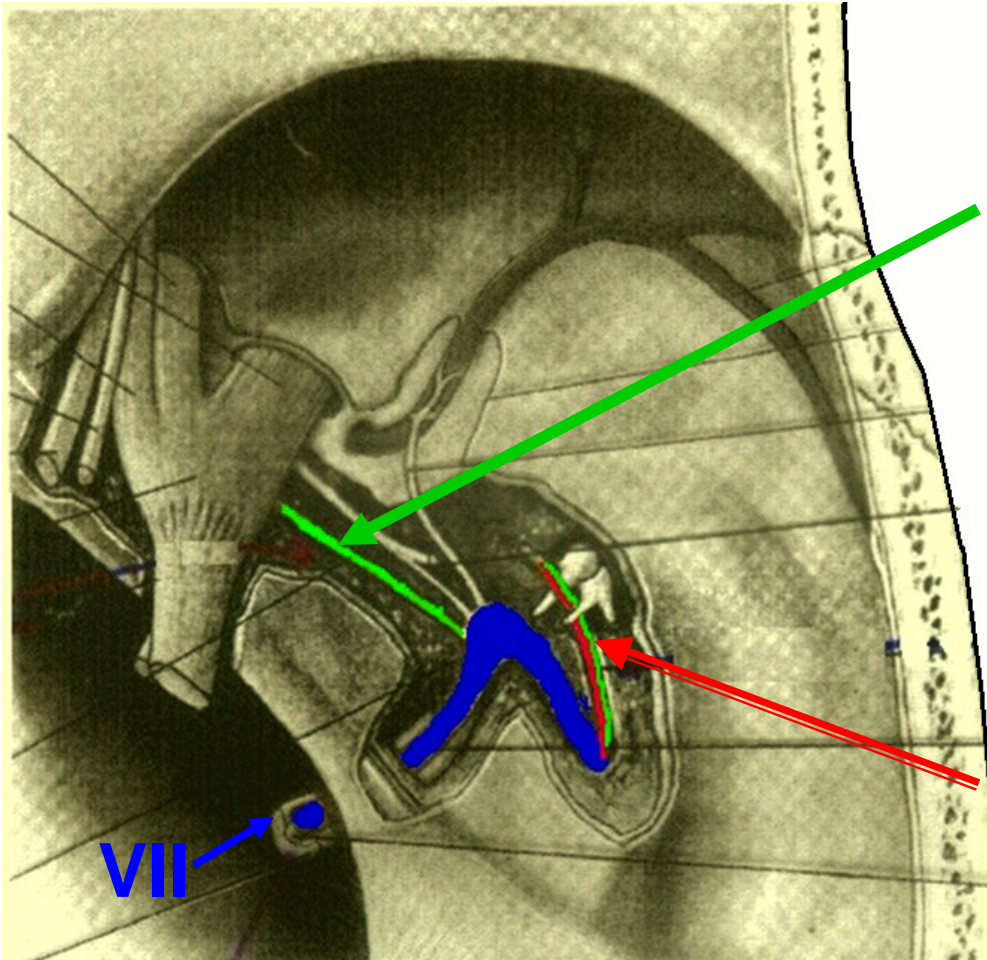
Petrous part of temporal bone



Int. aud. meatus

# VII - FACIAL

leaves Posterior Cranial fossa via Internal Auditory Meatus - enters facial canal

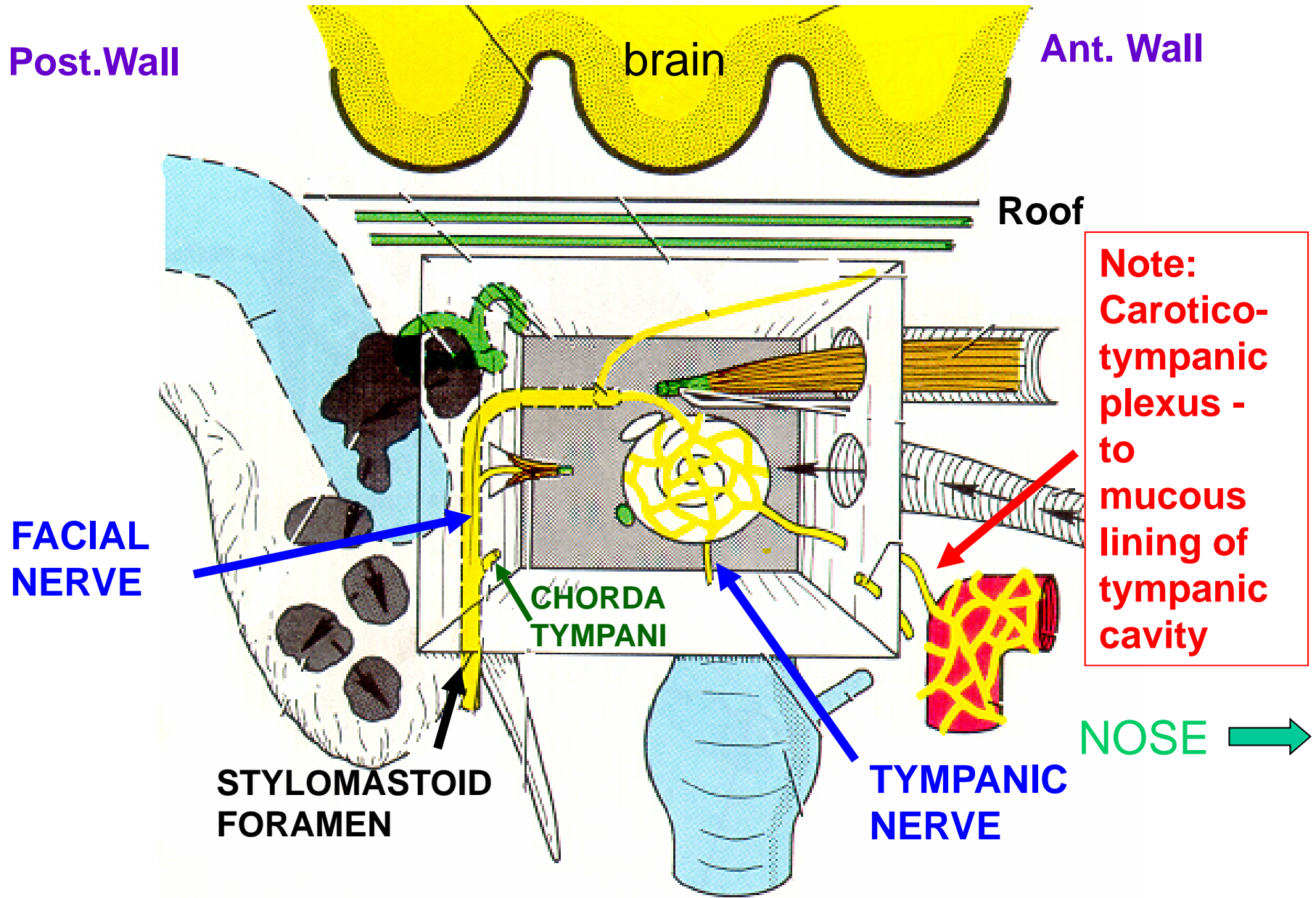


1. Greater Petrosal N.  
**VISCERAL MOTOR**  
Parasympathetics to  
Lacrimal gland, mucous  
glands of nose and palate,  
[Visceral sensory to  
Nasopharynx]

2. Stapedial N. -  
Branchiomotor to  
Stapedius

3. Chorda Tympani - has  
A) Taste to ant 2/3 tongue  
B) Parasympathetics to  
Submandibular, Sublingual  
salivary glands

# LOCATION OF NERVES IN MIDDLE EAR



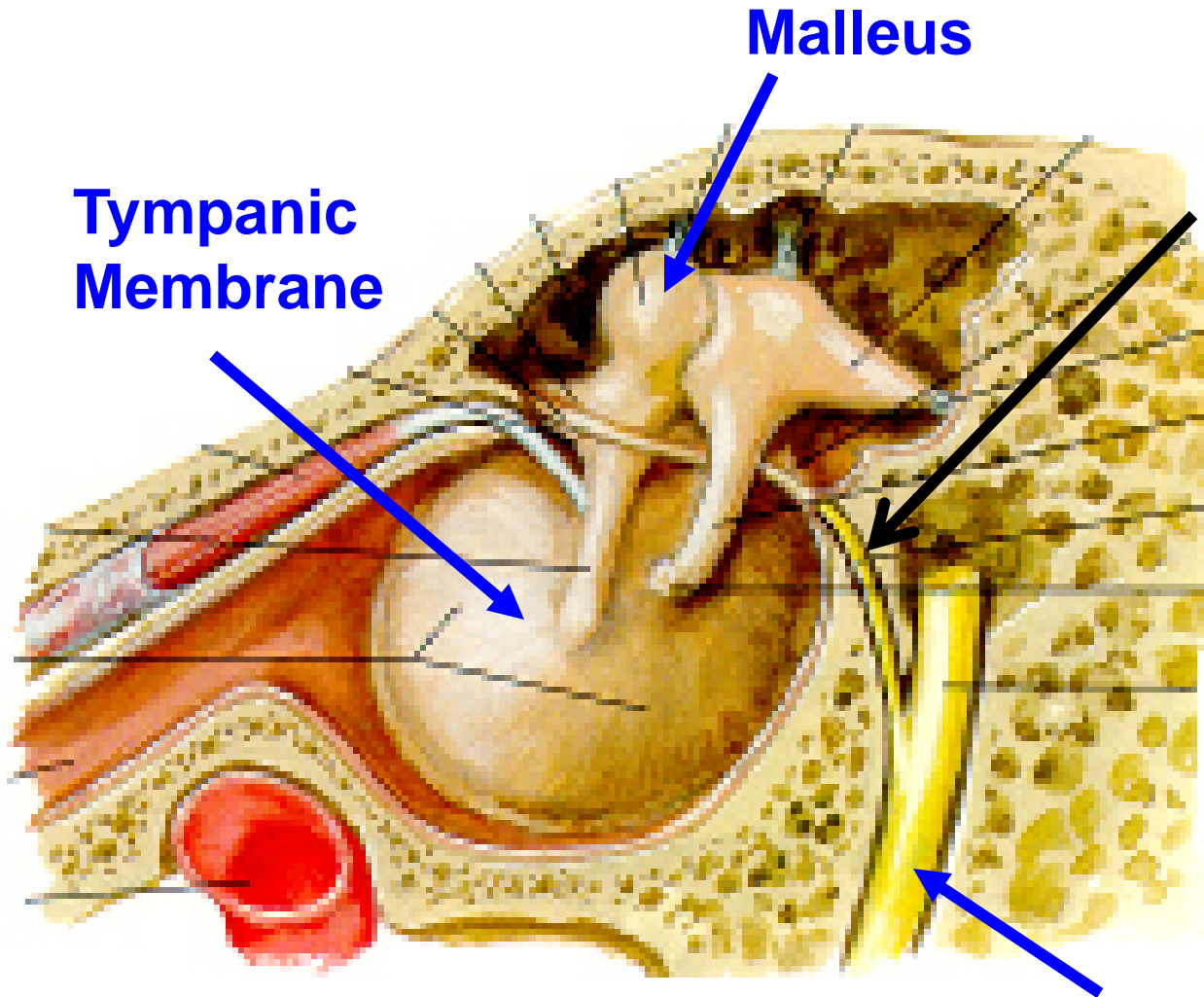
Looking at Medial Wall of Right Middle Ear with Ossicles Removed



# CHORDA TYMPANI

## CLINICAL

**Taste** to ant. 2/3 of tongue  
**Parasympathetic** to Submandibular, Sublingual Salivary glands



- Chorda Tympani has no function in middle ear
- Crosses through tympanic cavity
- Over handle of malleus

FACIAL NERVE

# OTOSCOPE VIEW OF TYMPANIC MEMBRANE

Pars  
flaccida

**CHORDA  
TYMPANI:**  
TASTE,  
VISCERAL  
MOTOR  
(parasymp)

**MALLEUS –  
manubrium  
(handle)**

**CLINICAL\***

**Lose  
taste if  
pierce  
tympanic  
membrane**

**Umbo**

**Cone of light**

