SPINAL AND CRANIAL NERVE REFLEXES

I. DEFINITION AND OVERVIEW OF REFLEXES

A. **Definition of a reflex** = **stereotyped motor response to a specific sensory stimulus.**

B. **A reflex usually consists of sensory receptors, interneurons and motor neurons:**

1. **sensory receptor** - detects stimulus (termed: **afferent arm** of reflex arc)
2. **interneurons** - receive inputs from sensory receptors and synapse on motor neurons; effects on motor neurons can be excitatory or inhibitory; not present in monosynaptic reflexes.
3. **motor neurons** - (termed **efferent arm** of reflex arc) produce muscle contraction, motor response.

C. Reflexes are **valuable tools for clinical evaluation of nervous system function**. For reflex to occur, all elements must be functional and pathways must be intact. If reflexes are absent, a physician can diagnose where the pathway is interrupted; if reflexes are abnormal, can diagnose where function is compromised.

D. **Reflexes are evaluated according to**
1) **amount (size, magnitude) of motor response**
2) **latency (time to elicit motor response)**

Note: Changes in reflexes are clinical signs - In some disease processes, damage can enhance motor responses (hyper-reflexia = abnormally large reflex responses); responses can also occur with abnormal muscle contractions (ex. Clonus - rapid alternating contraction and relaxation following a single stimulus)

RATING STRETCH (DEEP TENDON) REFLEXES – Decreased = 0,1, Normal = 2, Increased = 3,4

Rating	Characteristics
0	Absent
1	Diminished
2	Normal
3	Brisk, Hyper-reflexic
4	Hyper-reflexic, Pathologic

E. **Some reflexes are protective and relatively constant**; ex. **Pupillary light reflex**

F. **Other reflexes are constant under the same controlled circumstances**; ex. **Stretch reflex (deep tendon reflex)** - **Reflexes can be modulated by the central nervous system**: GET PATIENT TO RELAX.

G. **Other 'reflexes' actually represent triggering of more complex behaviors by sensory signals (ex. 'stepping reflexes' in neonates, infants). Some behaviors (ex. walking) are produced by pattern generators (see below).** Pattern generators are groups of interneurons in the CNS that produce activities in motor neurons and generate rhythmic behaviors. Stepping 'reflexes' in infants may represent triggering of activity in the walking pattern generator.

II. THREE CLASSIC SPINAL REFLEXES - Each reflex has a specific sensory stimulus and motor response

Note: **Terminology** - In describing a reflex:

Homonymous muscle - the muscle that contains or is associated directly with the sense organ producing the reflex
Synergist muscle - muscle that produces a similar motor action (movement)
Antagonist muscle - muscle that produces the opposite motor action (movement)
Contralateral muscle - muscle of opposite limb (leg or arm).

A. **Stretch reflex** (also termed: Monosynaptic Stretch Reflex, Myotatic Reflex, Deep Tendon Reflex)

1. **Stimulus** - fast stretch of muscle; clinically, produced by a brief sharp tap to a muscle tendon. This produces a sudden small lengthening of muscle (not stimulation of tendon receptors).
2. **Sense organ excited** - **Muscle spindle Primary (Group Ia) afferents**; can also produce much weaker discharges of muscle spindle Secondary (Group II) afferents.
3. **Primary response** - **MONOSYNAPTIC** and polysynaptic activation of alpha motor neurons in **muscle that is stretched contracts rapidly**. Monosynaptic reflex is the fastest reflex known, with a central delay of about 1 msec at the synapse.
4. **Effects on synergist and antagonist muscles -** a. **Excite synergist muscles** - Activate muscles with similar action (ex. in arm - biceps spindle sensory neurons excite motor neurons to brachialis muscle). b. **Inhibit antagonist muscles (RECIPROCAL INHIBITION)** - Decrease activity in muscles with opposing action (ex. biceps spindle neurons produce inhibition of triceps motor neurons); these connections are polysynaptic.
5. **Muscle Tonus** - Because the reflex connection is monosynaptic, the ongoing activity in muscle spindles is important determining the level of activity of motor neurons to muscles at rest. Decreases in sensory activity can cause a decrease in muscle tonus (measured by resistance to slow stretch of the muscle). Increased sensory activity can increase muscle tonus.

Note: **Spasticity/Rigidity** – **Increased tonus** (rigidity) occurs after **Upper Motor Neuron lesions** (ex. cortical strokes) due, in part, to **loss of modulation of stretch reflexes** (see below).

6. **Reflexes must be modified during voluntary movements**. Reflexes can be altered by mechanisms of 1) **gamma motor neurons** (reset muscle spindles) 2) **descending inputs from brain** - pre-synaptic inhibition (decrease effectiveness of spindle sensory discharges) and 3) **modulation of motor neuron activities (excitability)**. Some of these changes are produced by activities in neurons of descending motor tracts. 4) **Renshaw cells** - Alpha motor neurons have recurrent processes (axon collaterals); some of these branches make excitatory synapses upon interneurons (Renshaw cells). Renshaw cells can **limit motor neuron firing** and change reflexes (see Dr. Grover's lecture in January).

Note: Changes in stretch reflexes are also symptomatic: **In general, <u>Decrease stretch reflexes can indicate Lower Motor Neuron Disorders</u>, <u>Increase Stretch reflexes can indicate Upper Motor Neuron Syndromes.</u>**

B. **Autogenic Inhibition** (also termed: Inverse Myotatic Reflex, Tendon Organ Reflex or Clasped-

Knife Reflex)

1. **Stimulus** - large force exerted by pulling on muscle tendon (ex. isometric contraction)
2. **Sense organ excited** - Golgi tendon organ (Ib afferent)
3. **Primary response** – motor neurons to muscle are inhibited (hyperpolarized) and muscle attached to tendon **relaxes; effect is polysynaptic.**
4. **Effect on synergist (similar action) and antagonist (opposing action) muscles – all effects polysynaptic -** a. Inhibit synergist muscles - b. Excites antagonist muscles
5. **Function of Autogenic inhibition** - **Regulating muscle tensions.**

Note: **Clasped knife reflex**: In Upper Motor neuron lesions, tonus may increase and resistance of muscle to stretch increases; if sufficient force is applied, **limb resistance suddenly decreases** (like a pocket knife snapping shut); this is thought to be mediated by reflexes of Golgi tendon organs.

Note: The connections for autogenic inhibition are inactivated during walking; Effects of Golgi tendon organs then become excitatory (through other interneurons).

C. **Flexor reflex** - reflex withdrawal from a painful or noxious stimulus; can produce excitation of flexor motor neurons; can also take other forms (exciting muscles with other actions, ex. abductor muscles that pull limb away from midline)

1. **Stimulus** - noxious or painful stimulus to skin
2. **Sense organs excited** - Cutaneous touch receptors, pain (nociceptors)
3. **Primary response** - polysynaptic excitation of motor neurons to flexor muscles.
4. **Other effects - a. Same side – excite flexors, inhibit extensors. b. Opposite side – excite extensors, inhibit flexors.**
5. **Function of Flexor Reflex** - Protective (example: stepping on a nail). The net effect of these connections is that very rapid adjustments are made so that one leg is lifted rapidly and the other supports the weight of the body.
6. **Clinical Changes in Flexor Reflexes** - Flexor Reflexes can change after lesions, disease processes;

ex. **Babinski Sign** - seen after **Upper Motor neuron lesion**; normal response - stroking sole of foot **normally** results in **flexion (plantar flexion) of toes** (not strictly a withdrawal reflex); Babinski sign - direction of movement **changes to extending (dorsiflexing) toes**.

III. REFLEXES OF CRANIAL NERVES

A. Pupillary light reflex (Optic Nerve CNII in; Oculomotor CN III out) - Light shone in the eye causes the pupil to constrict; Stimulus - light; detected by sensory neurons (photoreceptors) in retina; sensory signals in Optic Nerve (Cranial Nerve II); Response - motor signals in Oculomotor Nerve (Cranial Nerve III, innervates pupillary constrictor muscle); Function - limit amount of light; protects photoreceptors in retina; connection present at all times.

B. Corneal reflex (Trigeminal nerve CNV in; Facial nerve CN VII out) - Touching corning of eye causes closing of eyelids. Stimulus - touch detected by sensory neurons (Somatic Sensory) in Trigeminal nerve V (Long Ciliary Nerves V1); Response – Motor signals in Facial Nerve (CN VII) innervate Orbicularis Oculi muscle (muscle of Facial Expression) which closes eyes; Function –

protective of Cornea.

C. Gag Reflex (Glossopharyngeal nerve CNIX in; Vagus nerve CNX out) - Touching pharynx induces gagging. Stimulus - Touch detected by Visceral Sensory neurons in Oropharynx innervated by Glossopharyngeal nerve CNIX; Response - motor signals in Vagus nerve (CNX) cause contraction of pharyngeal constrictor muscles.

D. Jaw Jerk Reflex (Stretch Reflex of Muscles of Mastication (ex. Masseter) (Trigeminal nerve V in; Trigeminal nerve V out) - Tap down on mandible induces contraction of muscles that elevate mandible (close mouth). Stimulus – detected by Muscle spindles in muscles of mastication (ex. jaw closer, Masseter) contained in Trigeminal nerve (CNV); Response - motor neurons also contained in Trigeminal nerve cause. contraction of jaw closer muscle

IV. PATTERN GENERATORS IN SPINAL CORD AND BRAINSTEM

A. Spinal cord contains networks of interneurons that generate patterned motor activities (networks are called Pattern Generators; see Dr. Grover's lecture, Neuronal Integration, next block).

B. ex. Walking - Walking is thought to be produced by pattern generators. In addition, after spinal cord lesion, rear limbs of animals and legs of humans can walk on treadmills (if body weight is supported). This has led to new therapies for patients with spinal cord injuries (ex. Christopher Reeve, actor who played 'Superman')

Note: Stepping reflexes in infants probably represent activation of the pattern generator for walking. Infants don't learn to walk; they learn to maintain balance while walking.

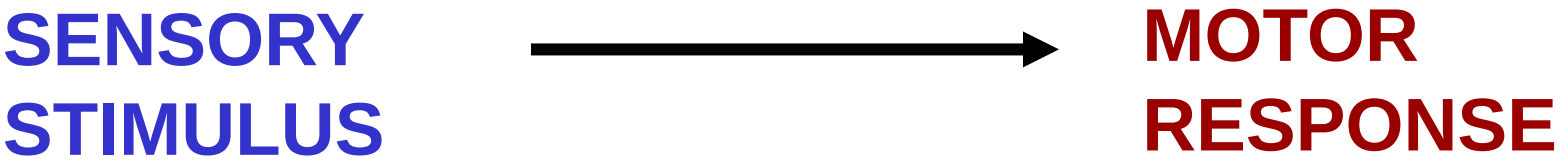
SPINAL REFLEXES AND DISORDERS

REFLEX	STIMULUS/SENSE ORGAN(S) EXCITED	NORMAL RESPONSE	UPPER MOTOR NEURON DISORDERS
Stretch (Myotatic, Deep Tendon) Reflex – Compensatory maintain position (ex. riding on moving bus)	Rapid Stretch of muscle (test: tap on muscle tendon) Excites Muscle Spindle Primary (Ia) and Secondary (II) sensory neurons (NOT Golgi Tendon Organ)	Stretched muscle contracts rapidly (monosynaptic connection); also Excite synergist and Inhibit antagonist Note: Gamma motor neurons can enhance stretch reflexes, tell patient to relax before test	Hyperreflexia - (increase) - characteristic of Upper Motor Neuron lesions (ex. spinal cord injury, damage Corticospinal tract); note: Clonus = hyperreflexia with repetitive or sustained contractions to single stimulus
Autogenic Inhibition - Limits Muscle Tension	Large force on tendon excites Golgi Tendon Organ Ib (test: pull on muscle when resisted)	Muscle tension decreases; Also inhibit synergist muscles; excite antagonist muscles	Clasped Knife Reflex - occurs in Upper Motor Neuron lesions - forceful stretch of muscle is first resisted then collapses
Flexor Reflex - Protective avoidance reflex	Sharp, painful stimulus, as in stepping on nail; Excites - Cutaneous and pain receptors (test: stroke foot with pointed object)	Limb is rapidly withdrawn from stimulus; protective reflex; also inhibit extensors of same limb and excite extensors of opposite limb (Crossed Extensor Reflex)	Babinski sign- toes extend (dorsiflex) to cutaneous stimulus of sole of foot (normally plantar flex); characteristic of Upper Motor Neuron lesion

REFLEXES OF CRANIAL NERVES

REFLEX	STIMULUS	SENSORY	RESPONSE	CLINICAL
Pupillary Light Reflex (II to III)	Test: Shine light in eye	Light detected by Optic Nerve	Excite Constrictor of pupil of eye (III Short Ciliary nerves (Ciliary Ganglion, parasympathetic)	Extensively used to check CN II; Absence of Pupillary Light Reflex can indicate catastrophe (brain herniation)
Corneal Reflex (V to VII)	Touch cornea of eye with cotton	Touch detected by Long Ciliary nerves (V1), Somatic sensory	Close eye (VII to Orbicularis Oculi muscle) Branchiomotor	Absence of Corneal Reflex; Test for damage to V1 sensory, VII motor
Gag Reflex (IX to X)	Test: Touch posterior tongue, oropharynx;	Excites Visceral Sensory endings in Glossopharyngeal N. (IX)	Excite muscles of pharynx, palate; Vagus N. (X), Branchiomotor	Other symptoms of Vagus damage (X); Patient Say's Ahh: soft palate not elevated on ipsilateral side (paralyze Levator Palati); uvula deviated away from side of lesion
Jaw Jerk Reflex Stretch (Deep Tendon) Reflex (V to V)	Test: tap down on mandible; Stretch muscles of mastication (ex. Masseter)	Excites Muscle Spindle sensory neurons in Trigeminal nerve (V)	Contract muscles that elevate mandible Motor - V3	Hyporeflexia - indicates Trigeminal nerve damage

SPINAL REFLEXES



Definition of a Reflex - stereotyped motor response to a specific sensory stimulus

TYPICAL REFLEX

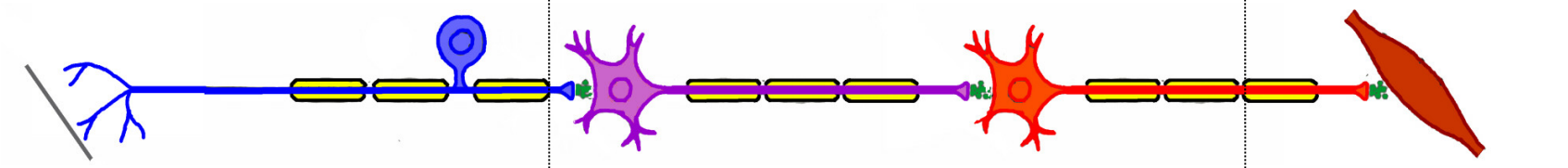
AFFERENT ARM OF REFLEX

SENSORY STIMULUS

in Central Nervous System

EFFERENT ARM OF REFLEX

MOTOR RESPONSE



STIMULUS

SENSORY NEURON

INTERNEURON

MOTOR NEURON

MUSCLE

Typical reflex arc: 1) sensory neuron - detects stimulus (termed afferent arm of reflex arc)

2) interneurons - (most often) effects on motor neuron can be excitatory or inhibitory

3) motor neurons - produce muscle contraction, motor response (termed efferent arm of reflex arc)

For reflex to occur, all elements must be functional:

If absent, diagnose where pathway is interrupted.

If abnormal, diagnose where pathway is compromised.

REFLEXES CAN BE USED TO TEST NERVOUS SYSTEM FUNCTION, LOCATE SITE OF LESION

D. EVALUATING REFLEXES

TABLE 21-8 Scoring Deep Tendon Reflexes

Grade	Deep Tendon Reflex Response
0	No response
1+	Sluggish or diminished
2+	Active or expected response
3+	More brisk than expected, slightly hyperactive
4+	Brisk, hyperactive, with intermittent or transient clonus

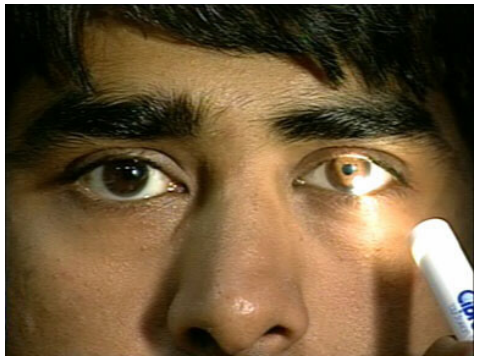
NOTE: DEEP TENDON REFLEX = STRETCH REFLEX

Reflex is evaluated according to:

1) amount (size, magnitude) of motor response,
2) latency (time to elicit motor response);

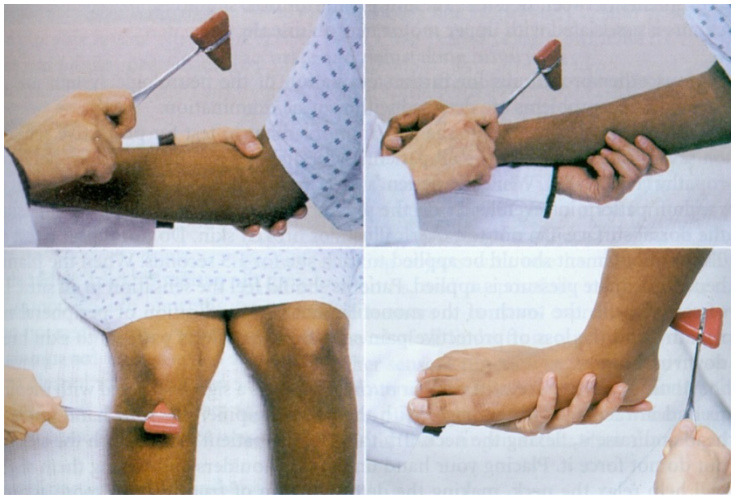
Hyper-reflexia = enhanced reflexes; in some disease processes, damage can enhance reflex responses
Clonus = series of abnormal, rapid alternating contractions and relaxations of muscle produced by single stimulus

E. SOME REFLEXES ARE PROTECTIVE AND CONSTANT



Ex. Pupillary light reflex – shine light in eye, pupil constricts

F. SOME REFLEXES ARE CONSTANT UNDER SAME CIRCUMSTANCES



STRETCH (DEEP TENDON) REFLEXES - can be tested in a number of muscles; activate muscle spindles

Patient positioned correctly, told to relax; focus patient's attention elsewhere (ex. tell patient to clench hands and try pulling apart);
COMPARE REFLEXES ON RIGHT AND LEFT SIDES;
Reason: reflexes can be modulated (changed or blocked) by activities in CNS.

G. SOME 'REFLEXES' TRIGGER ACTIVITIES PRODUCED BY PATTERN GENERATORS

PALMAR GRASP

MORO REFLEX - arm extend

STEPPING 'REFLEX' - actually eliciting a motor pattern

PLANTAR GRASP

PLACING REFLEX

TONIC NECK REFLEX - extend ipsilateral arm flex opposite arm

PATTERN GENERATOR - group of interneurons that are interconnected. Pattern generators produce activities in motor neurons and can generate rhythmic behaviors.

II. CLASSIC SPINAL REFLEXES

Three basic reflexes:

A) Stretch reflex - produced by activating muscle spindles - contributes to maintaining postural stability, countering sudden loads

B) Autogenic inhibition - produced by activating Golgi tendon organs - aids in regulating muscle tension, prevents damage to tendon, bone

C) Flexion reflex - produced by activating cutaneous, pain afferents - avoid obstacle or painful stimulus (stepping on nail)

TERMINOLOGY

IN DESCRIBING A REFLEX:

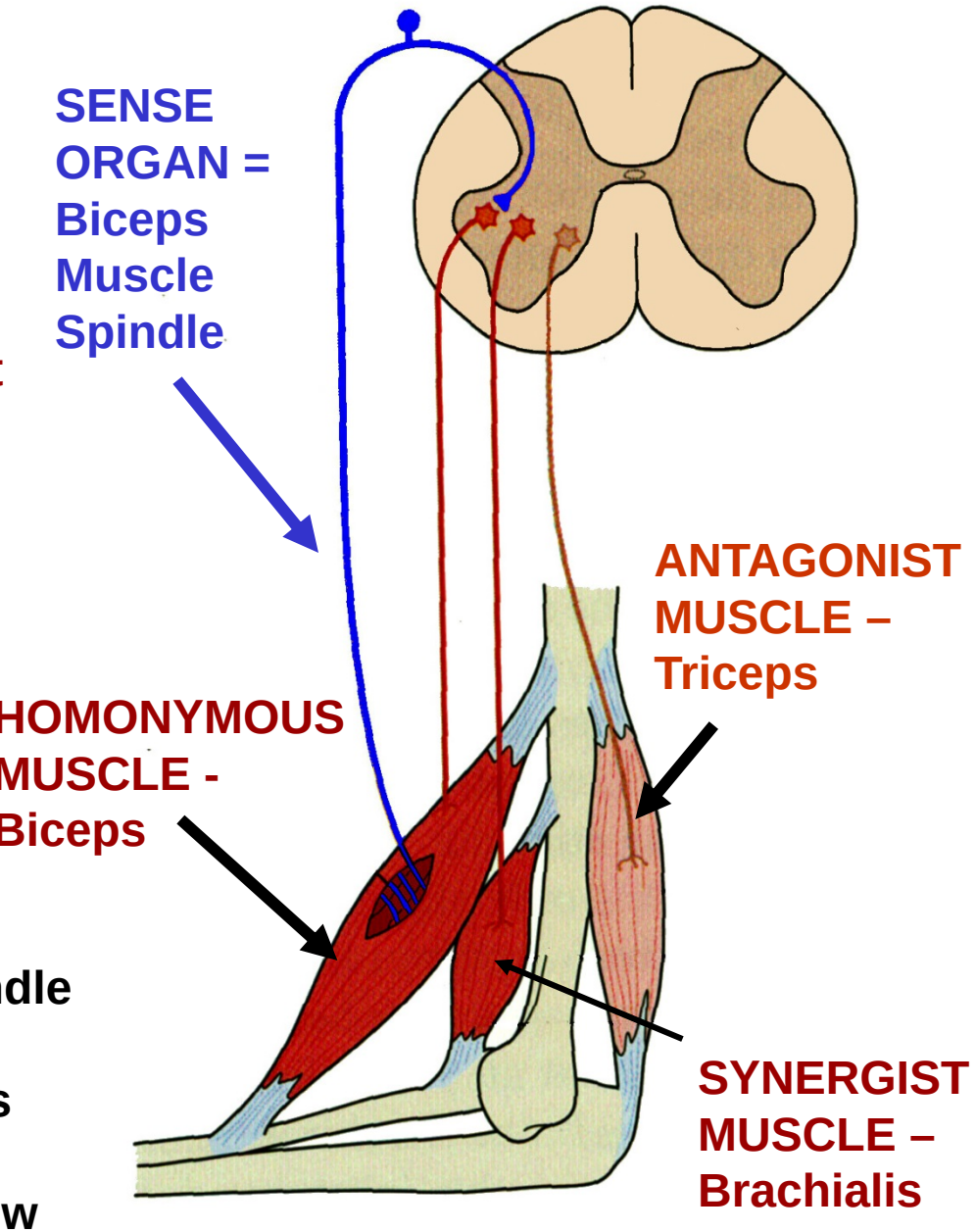
HOMONYMOUS MUSCLE = muscle that contains sense organ

SYNERGIST MUSCLE = muscle that produces similar action

ANTAGONIST MUSCLE = muscle that produces opposite action

CONTRALATERAL MUSCLE = muscle of opposite arm or leg

EX. BICEPS TENDON REFLEX in diagram – ELBOW JOINT
BICEPS = homonymous (where spindle is located), flexes elbow
BRACHIALIS = synergist, also flexes elbow
TRICEPS = antagonist, extends elbow

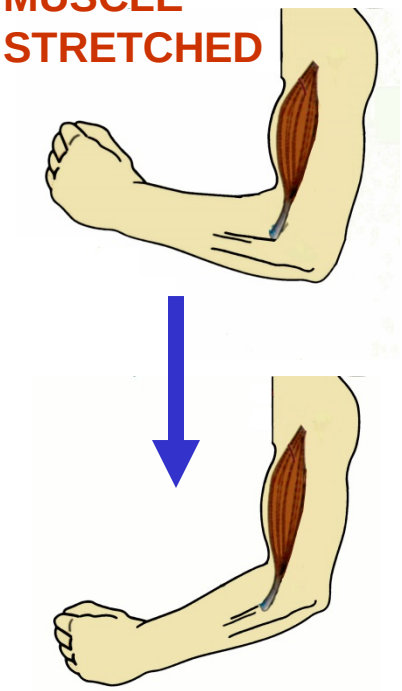


A. STRETCH REFLEX

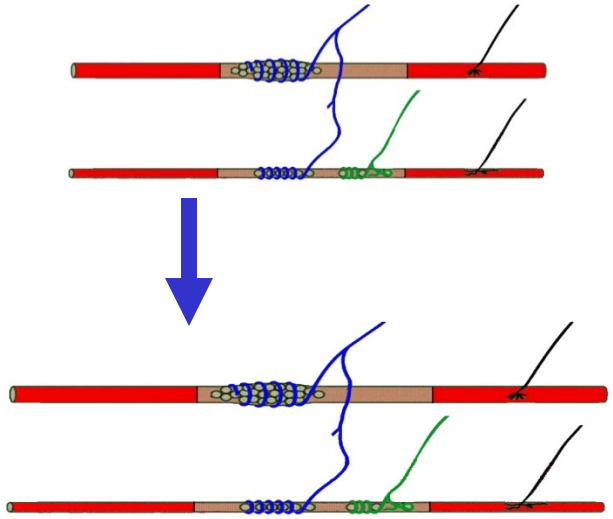
STIMULUS

RESPONSE

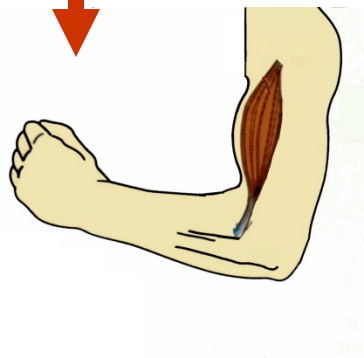
BICEPS MUSCLE STRETCHED



BICEPS MUSCLE SPINDLE



BICEPS MUSCLE CONTRACTS

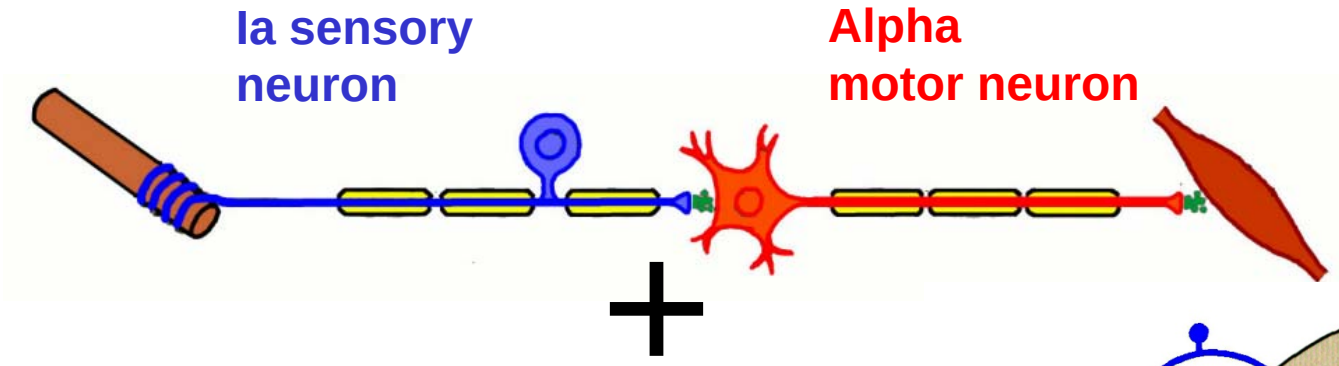


1) Stimulus - <u>fast stretch</u> of muscle

2) Sense organ excited - Muscle spindle Ia and II sensory neurons

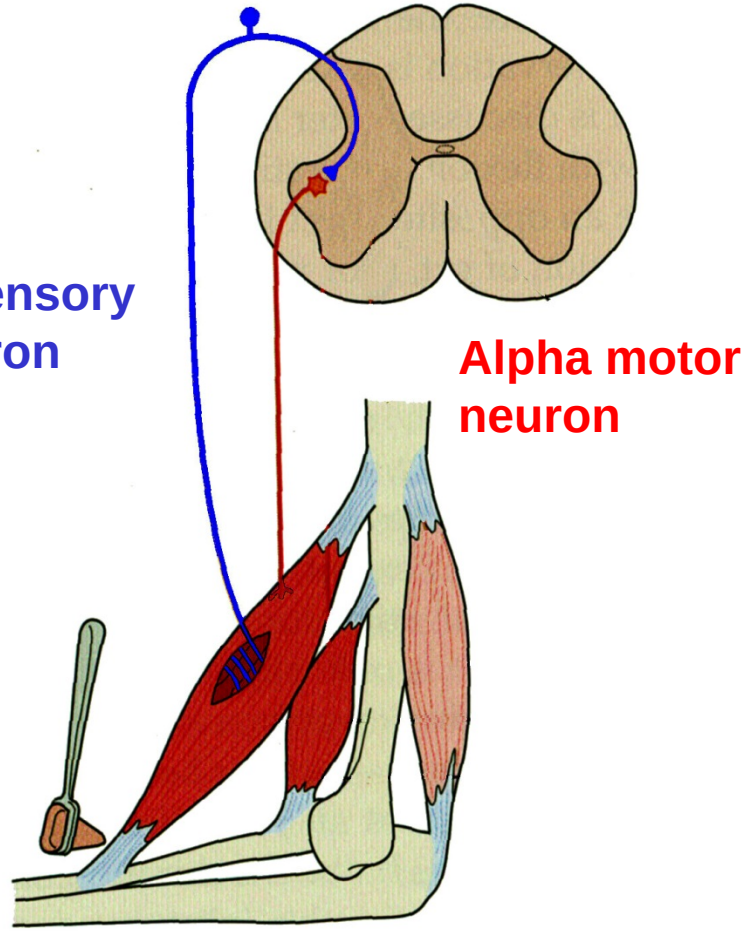
3) Primary response - muscle that is stretched <u>contracts rapidly</u>

SYNAPSES: MONOSYNAPTIC CONNECTION



Group Ia - monosynaptic connections with alpha motor neurons (fastest reflex known, delay at synapse about 1 msec)

Group II – response weaker make 1) monosynaptic and 2) polysynaptic (through interneuron)



+ note: **plus** indicates **excitatory** connection

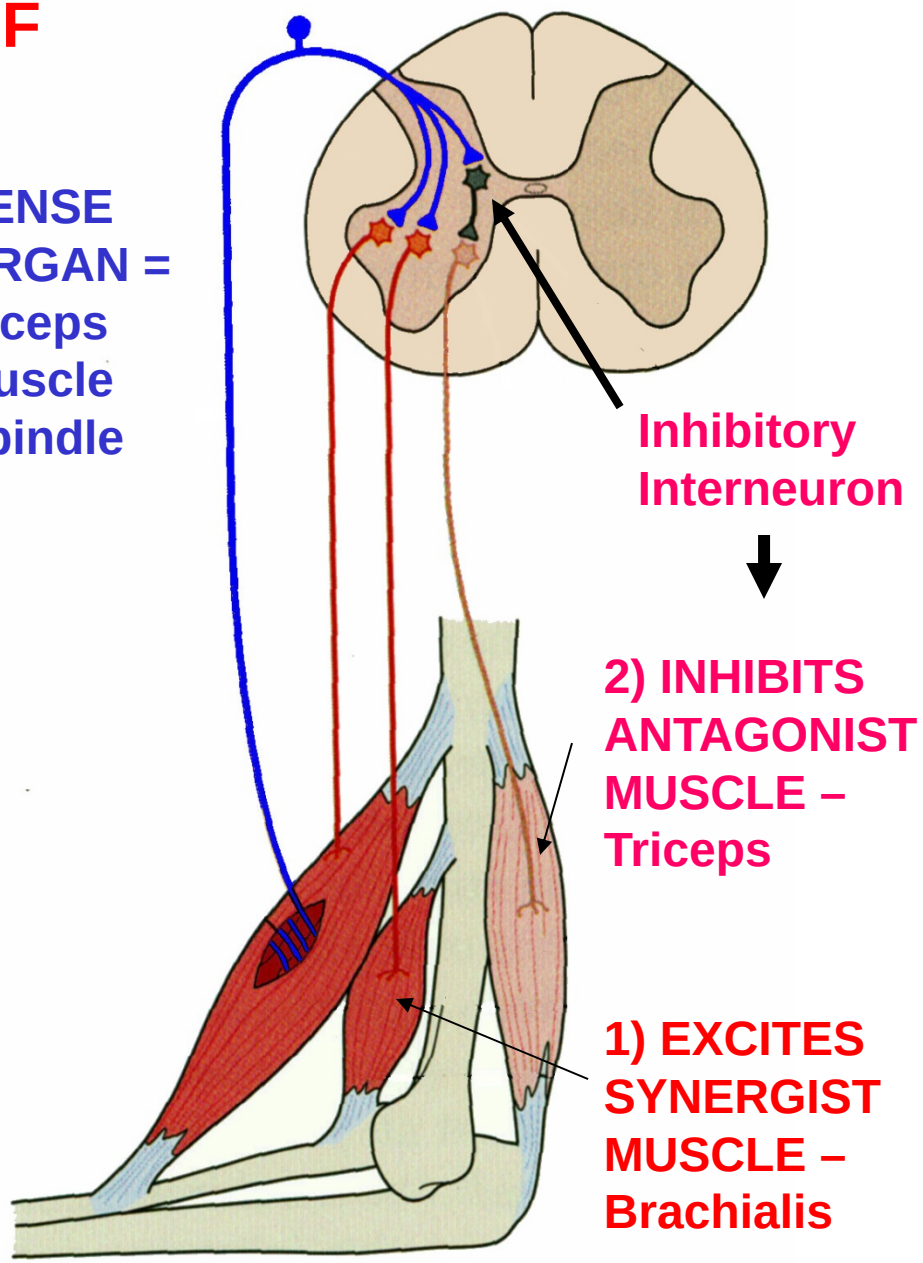
OTHER COMPONENTS OF STRETCH REFLEX

**

1) Excite synergist muscles - spindle afferents also make excitatory monosynaptic connections with synergist muscles

**

2) Inhibit antagonist muscles - RECIPROCAL INHIBITION - Spindle activity also excites interneurons that make inhibitory synapses on motor neurons to antagonist muscles (polysynaptic)

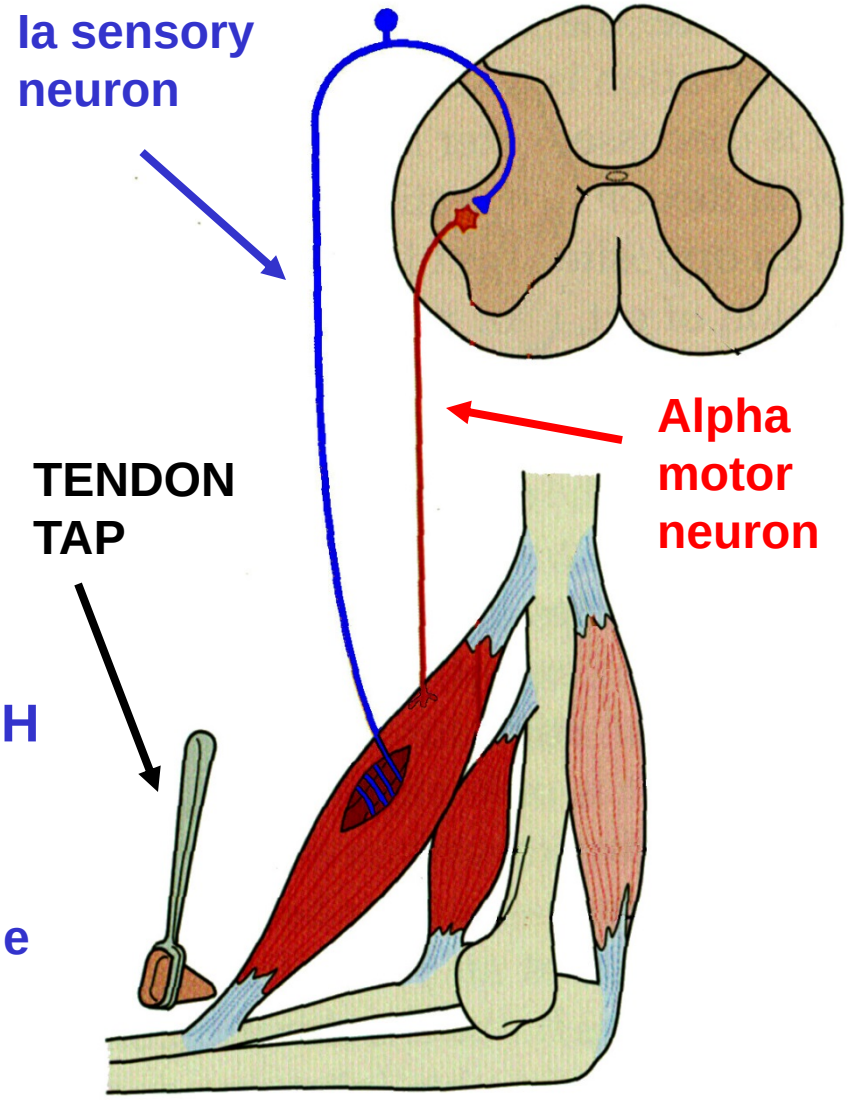


MUSCLE TONUS

1- Because connection is monosynaptic, ongoing activity in muscle spindles is important in determining firing of alpha motor neurons at rest.
2- Eliminating activity of spindles can decrease motor neuron firing producing decreased tonus.
3- Increased sensory activity can increase tonus.

CLINICAL TESTING OF STRETCH REFLEX: TENDON TAP

1- Tendon tap elicits twitch because it excites almost all muscle spindles simultaneously
2- Excitation converges upon motor neuron



Spasticity/Rigity – Increased tonus occurs after Upper Motor Neuron Lesion (ex. stroke); due to loss of modulation of reflex

CLINICAL TESTING OF STRETCH REFLEX: TENDON TAP
NOTE: COMPARE REFLEXES ON RIGHT AND LEFT SIDES

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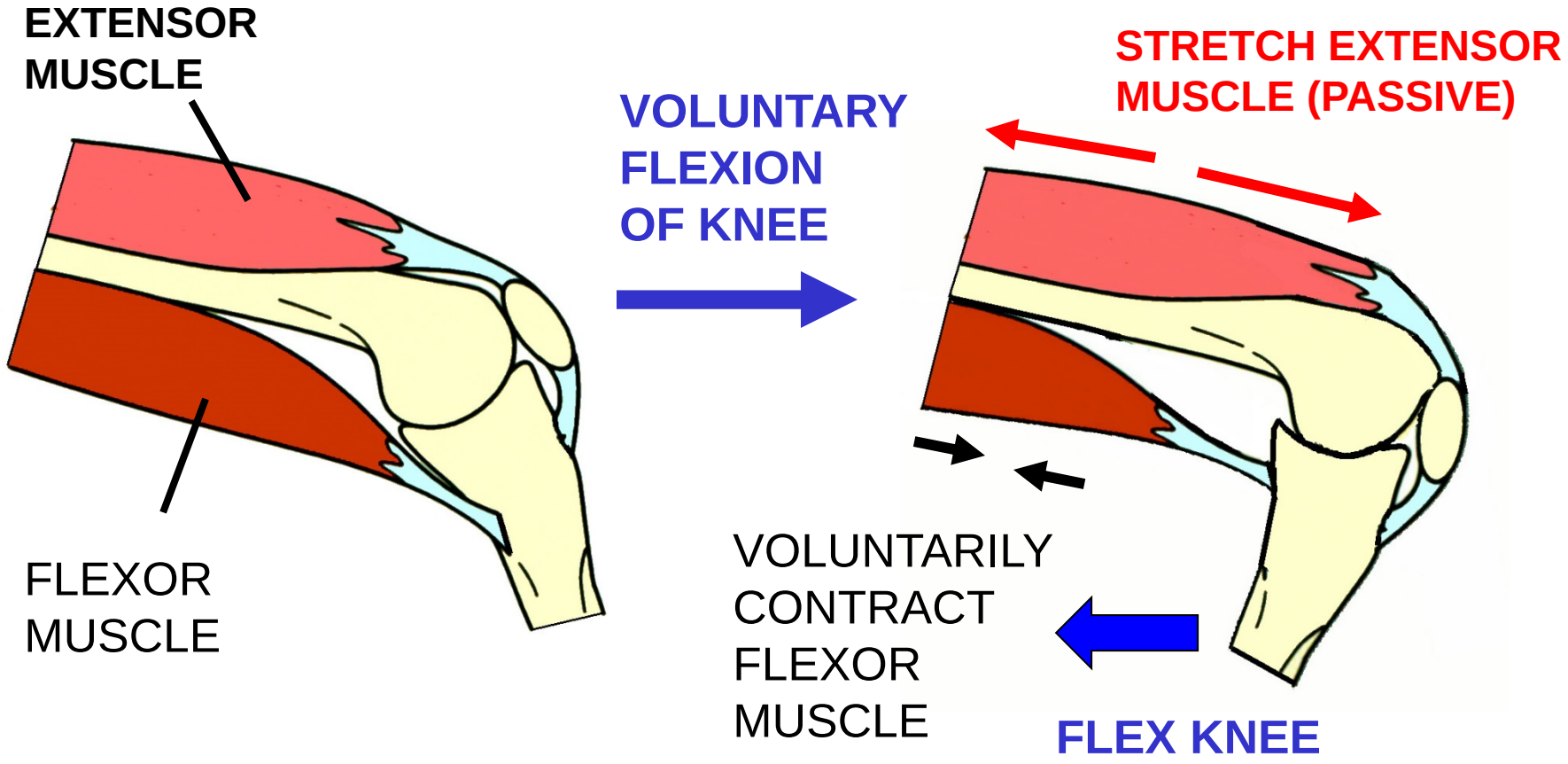
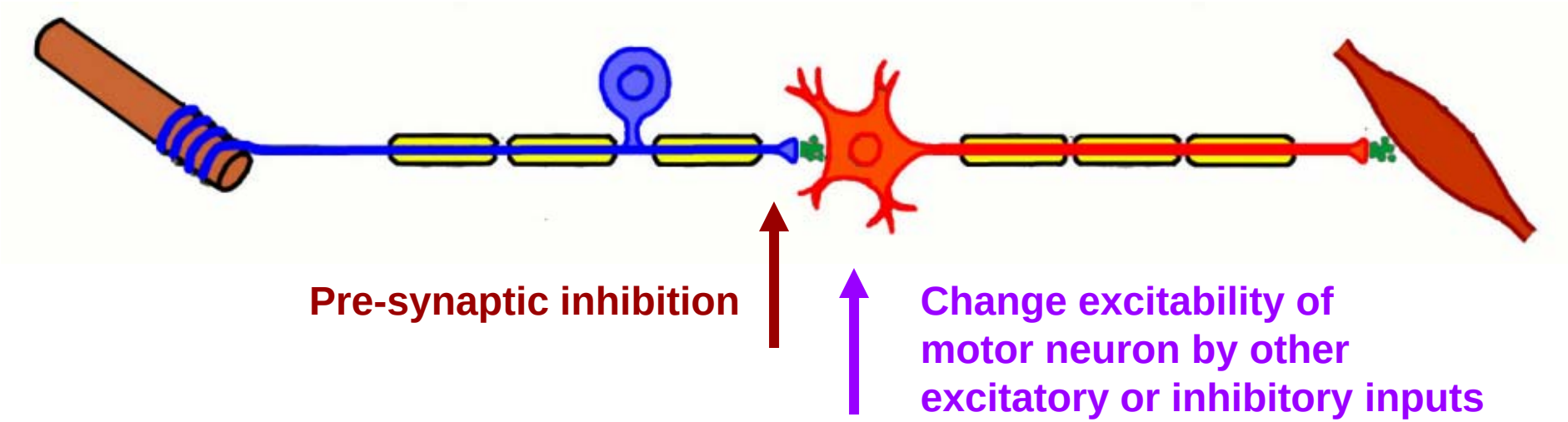
REFLEXES MUST BE MODIFIED DURING VOLUNTARY MOVEMENTS



Voluntary contraction of one muscle often produces stretch of the antagonist muscle. If stretch reflexes were always active, voluntary contraction of one muscle would produce reflex contraction in the antagonist.

- Therefore, stretch reflexes can be modified in some muscles during voluntary movements

MODIFICATION OF REFLEXES: MECHANISMS



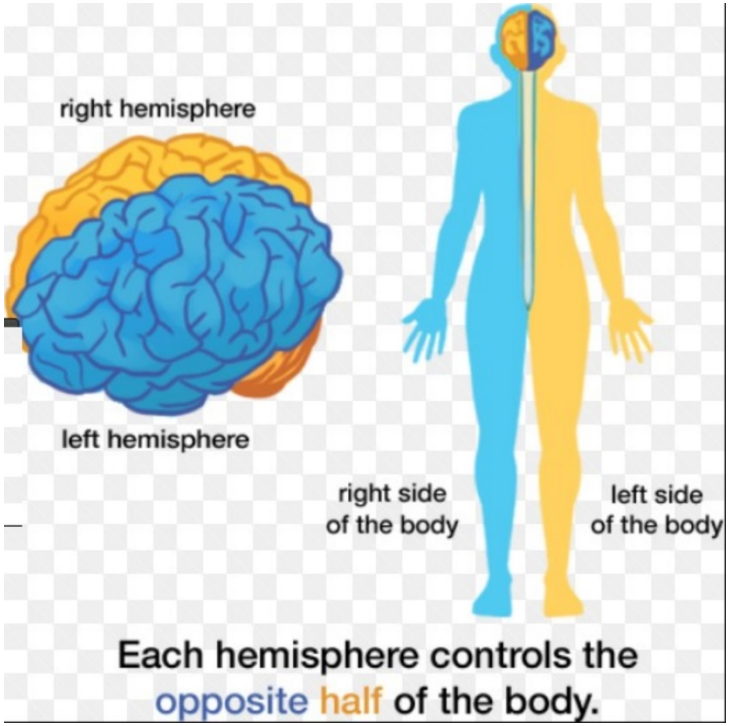
1- Reflexes can be modulated by

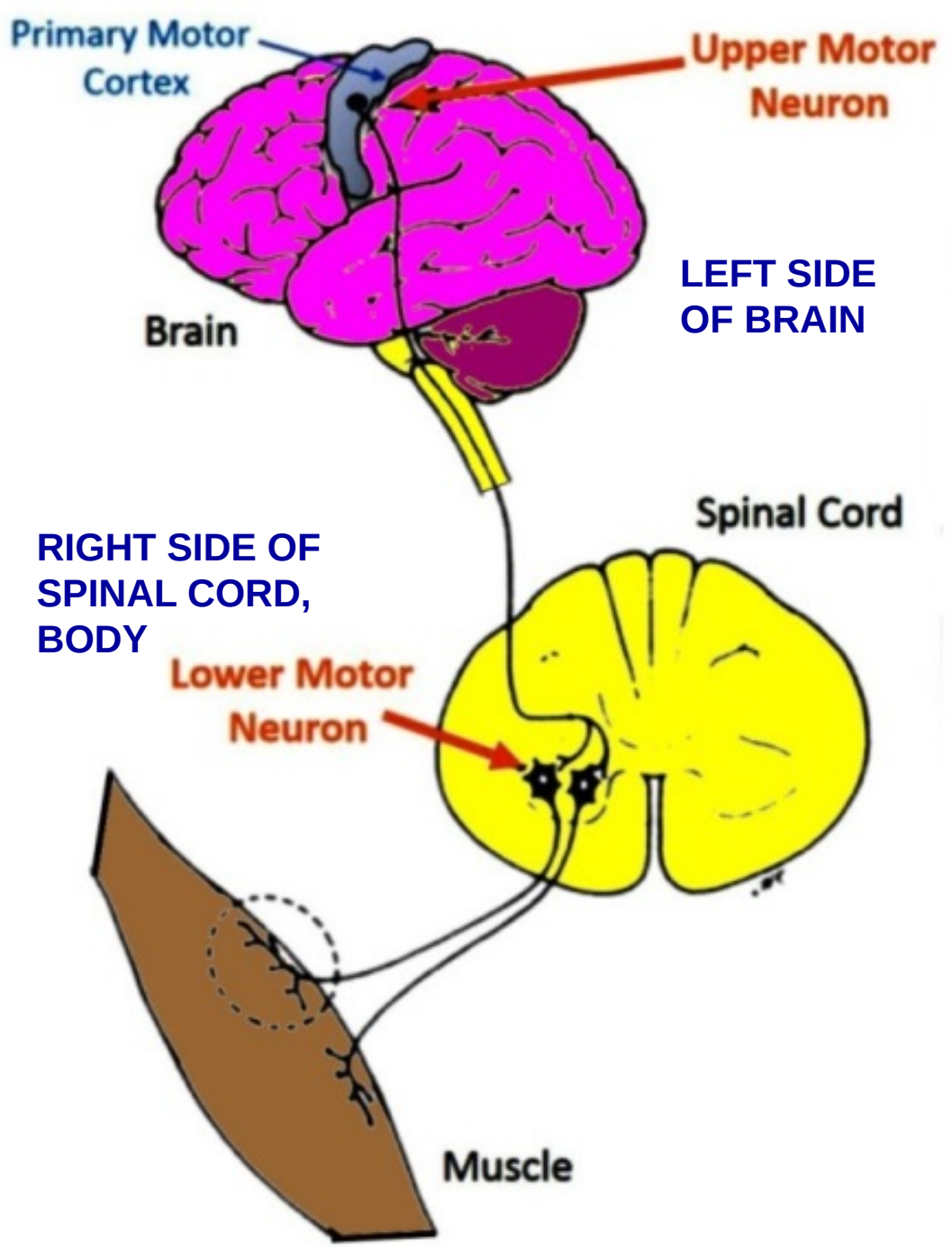
1) Gamma motor neurons – change muscle spindle sensitivity

2) Descending inputs from brain – some produce pre-synaptic inhibition of Ia terminals; some change excitability of motor neurons..

Changes in reflexes are symptomatic: In general, Decreased Stretch reflexes can indicate Lower Motor Neuron Disorders, Increased Stretch reflexes can indicate Upper Motor Neuron Syndromes.

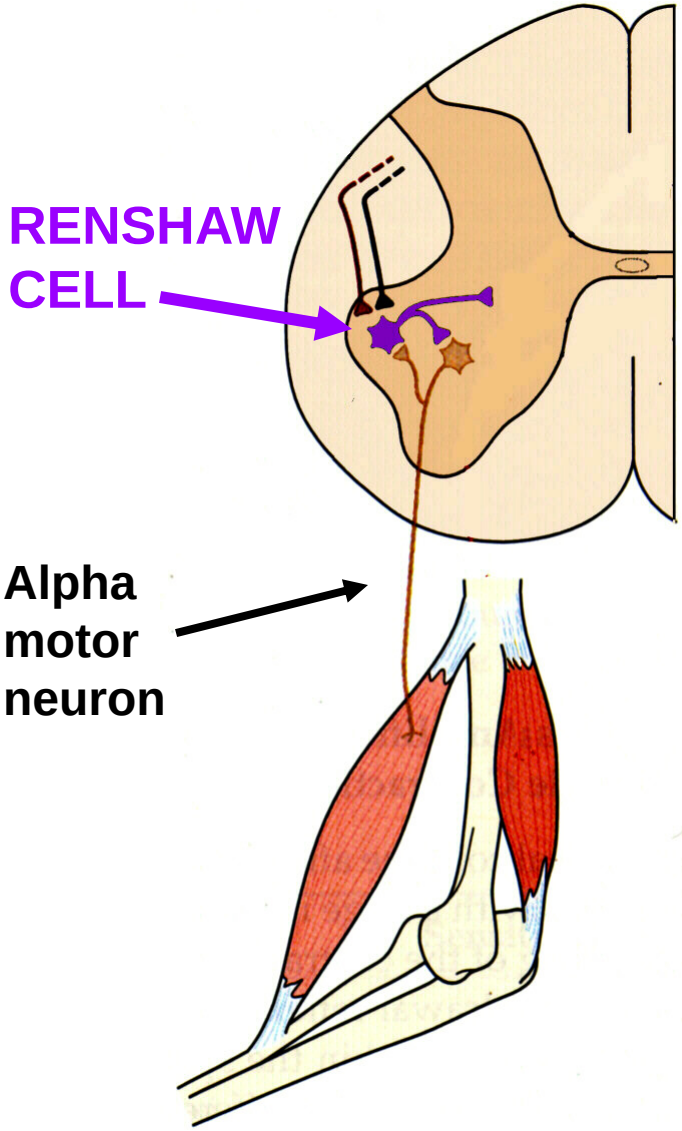
UPPER VS LOWER MOTOR NEURON

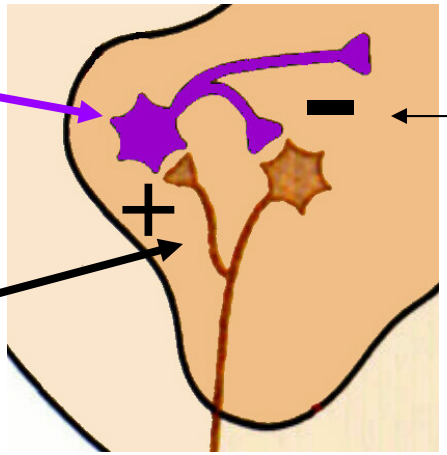




HYPERREFLEXIA: INCREASED STRETCH REFLEX ON ONE SIDE [**used by permission of Paul D. Larsen, M.D., University of Nebraska Medical Center; http://library.med.utah.edu/neurologicexam]**

ACTIVITIES OF MOTOR NEURONS CAN BE MODULATED BY RENSHAW CELLS



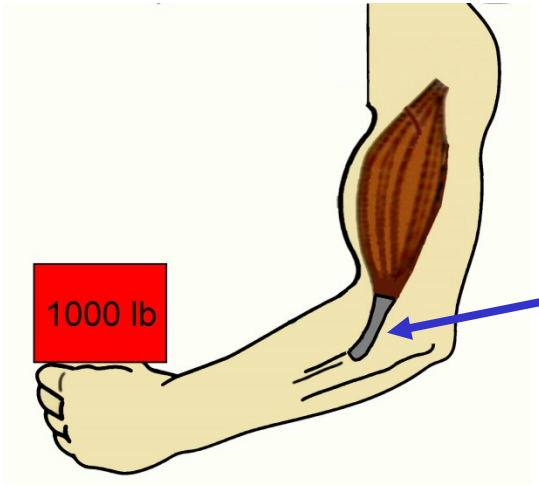


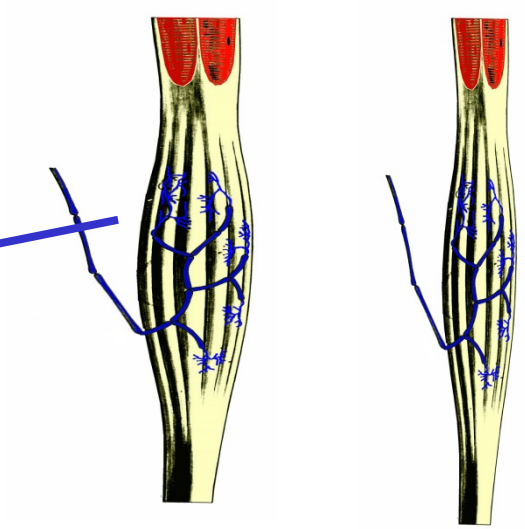
Axons of Alpha motor neurons have branches that synapse in central nervous system; these branches are called Recurrent Branches.

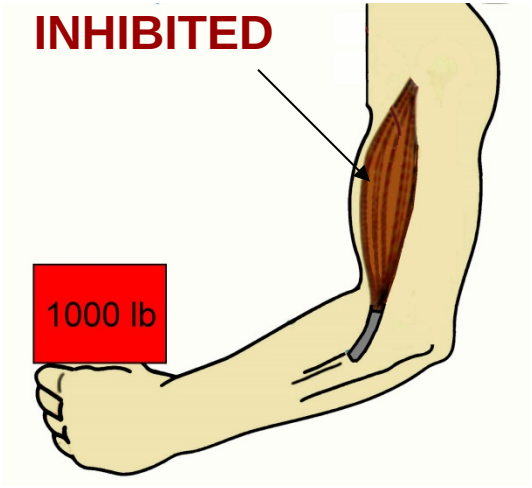
Renshaw cells are interneurons that receive excitatory inputs from Recurrent branches of motor neurons and make inhibitory synapses upon the same motor neurons
These circuits can limit motor neuron firing; inhibition can dampen or reduce reflexes

Camillo Golgi (1843-1926)

B. AUTOGENIC INHIBITION





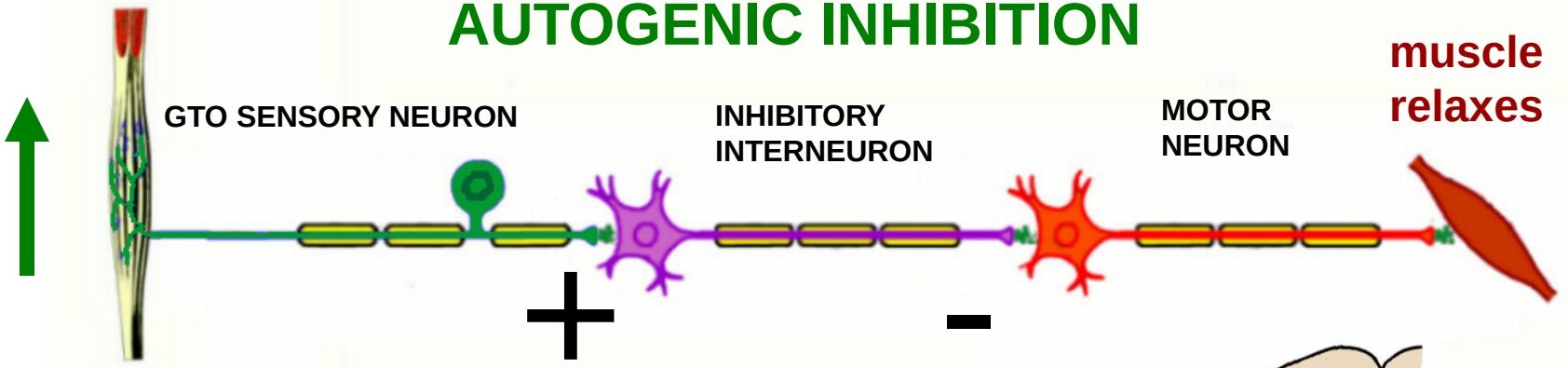


1) Stimulus - <u>Large force</u> exerted on muscle tendon

2) Sense organ excited - <u>Golgi tendon organs</u>

3) Primary response - <u>muscle</u> attached to tendon <u>relaxes</u>

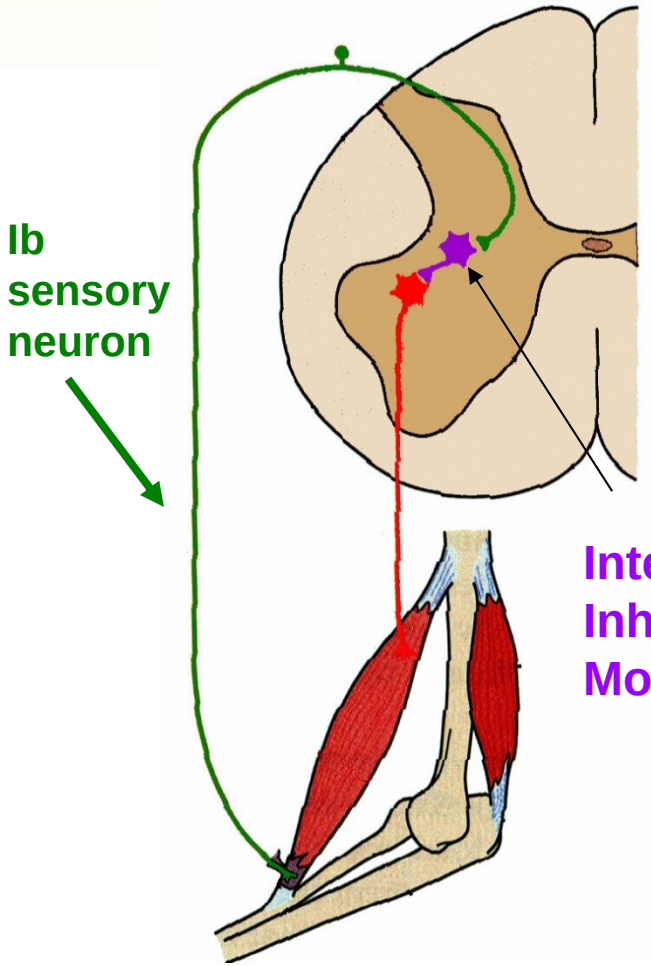
AUTOGENIC INHIBITION



PRIMARY RESPONSE
Synapses - polysynaptic

1) Ib sensory neuron (GTO) makes excitatory synapse onto interneuron
2) Interneuron makes inhibitory synapse onto motor neuron;
Motor neuron decreases firing

Function of Autogenic inhibition - Regulating muscle tensions (protective, prevent damage to tendon)



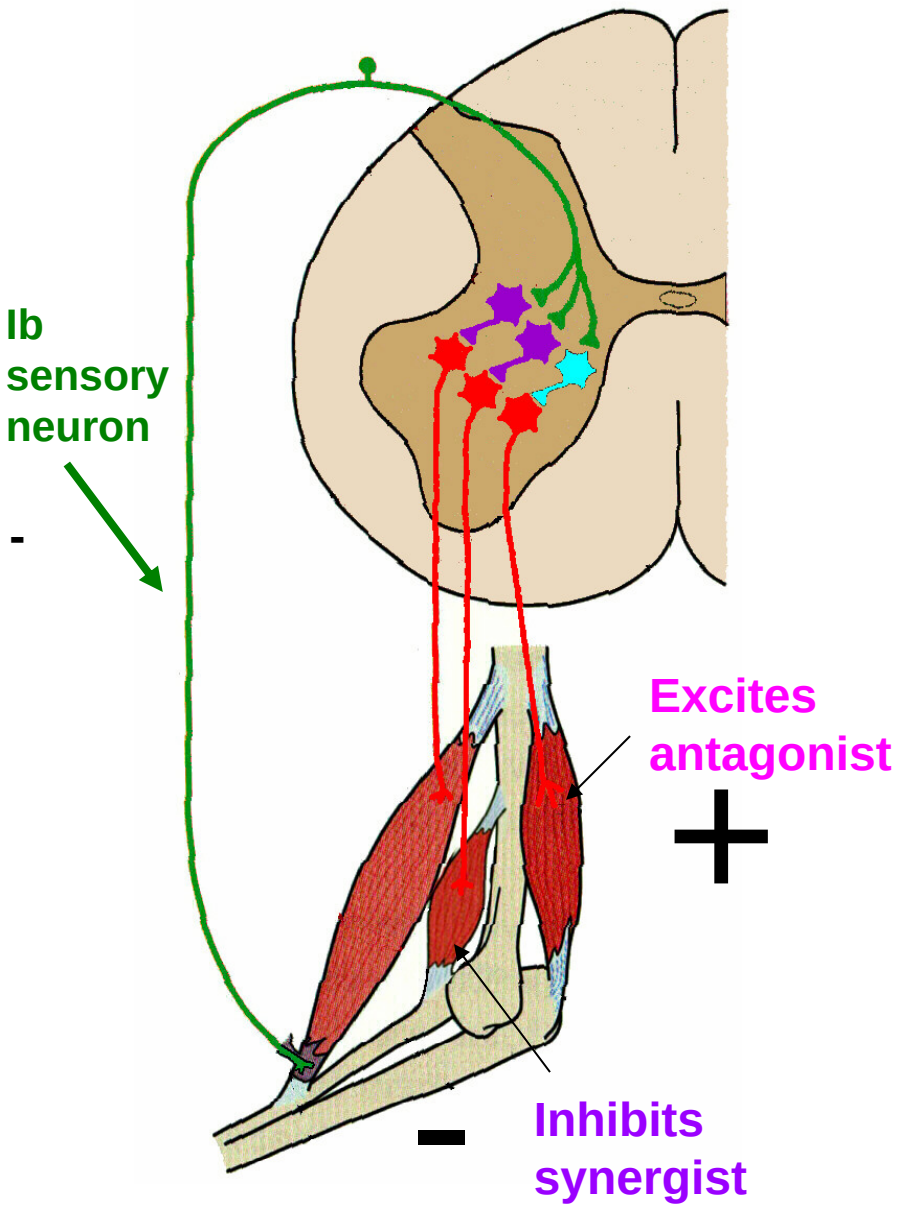
AUTOGENIC INHIBITION

Other effects

a. Inhibits synergist muscles -
GTO makes excitatory synapse on interneuron; interneuron makes inhibitory synapse on motor neurons to synergist muscle

b. Excites antagonist muscles -
GTO makes excitatory synapse on interneuron; interneuron makes excitatory synapse on motor neurons to antagonist muscles

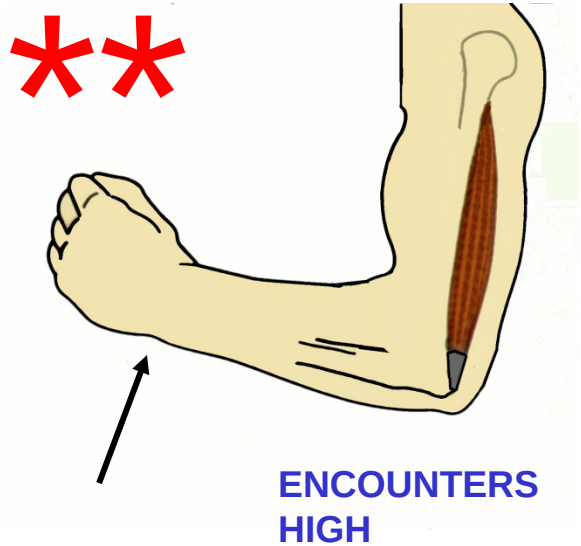
CLASPED KNIFE REFLEX: in Upper motor neuron lesions, tonus increases, resistance to stretch increases; if sufficient force is applied, limb resistance suddenly decreases (like pocket knife snapping shut)



CLASPED KNIFE REFLEX: is an example of Autogenic inhibition.

It is elicited in patients with UMN lesions due to high tonus in muscle.

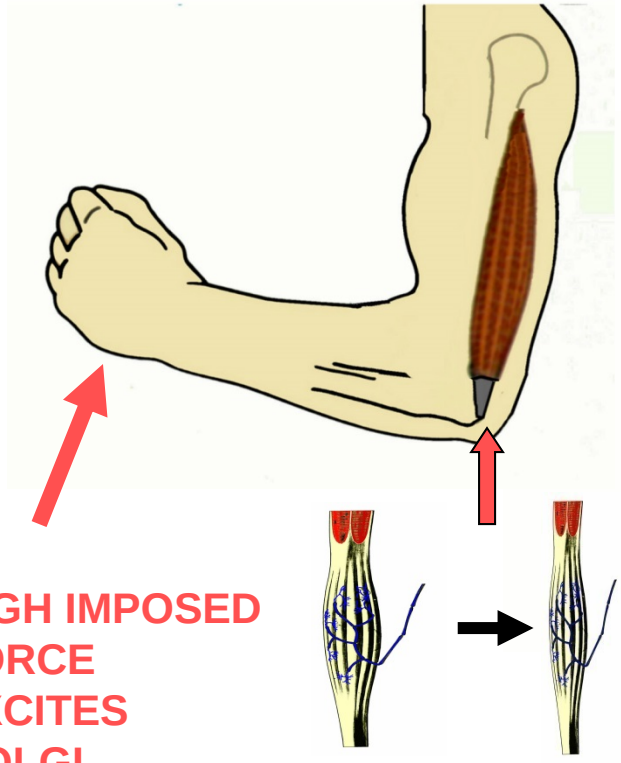
1) PHYSICIAN TRIES TO FLEX ELBOW JOINT OF PATIENT WITH UPPER MOTOR NEURON LESION



PHYSICIAN HOLDS WRIST AND PUSHES HERE AFTER TELLING PATIENT TO RELAX

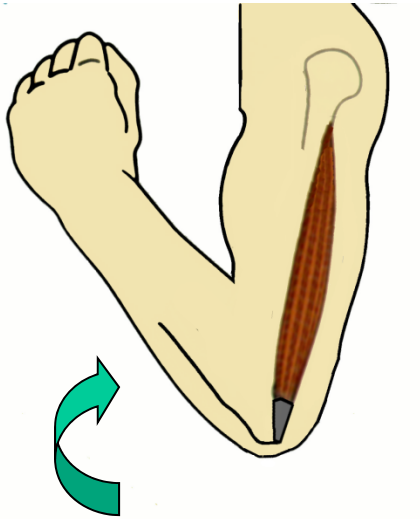
ENCOUNTERS HIGH RESISTANCE DUE TO HIGH TONUS IN TRICEPS AND HIGH STRETCH REFLEXES

2) KEEP TRYING AND TENSION ON TRICEPS TENDON EXCITES GOLGI TENDON ORGANS



HIGH IMPOSED FORCE EXCITES GOLGI TENDON ORGANS IN TRICEPS TENDON WHICH INHIBITS MOTOR NEURONS TO TRICEPS MUSCLE

3) TRICEPS RELAXES AND RESISTANCE SUDDENLY DECREASES: ELBOW JOINT FLEXES



ELBOW JOINT SNAPS SHUT LIKE A POCKET KNIFE = CLASPED KNIFE REFLEX

CLASPED KNIFE REFLEX

AUTOGENIC INHIBITION AND FORCE REGULATION

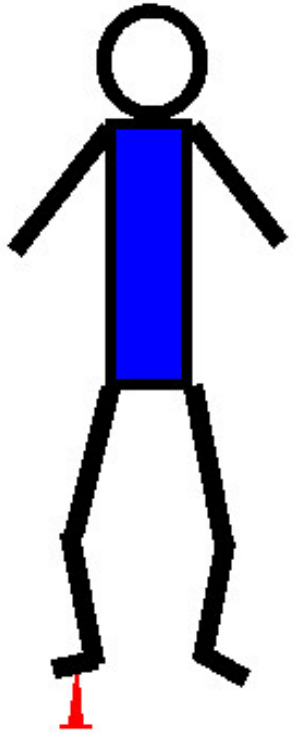
1- Regulating muscle tension - forces developed by contractions of muscles are automatically controlled so that they do not cause damage to tendons (ex. lifting heavy object).

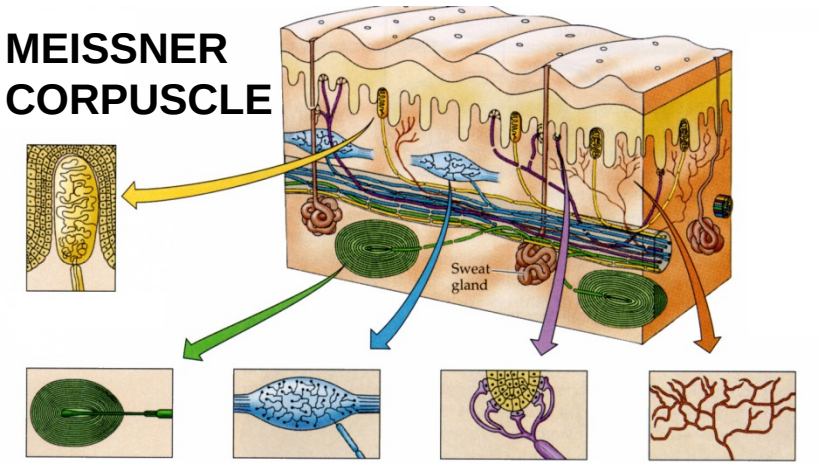
2- Regulation of force during other behavior is more complex (ex. walking) –

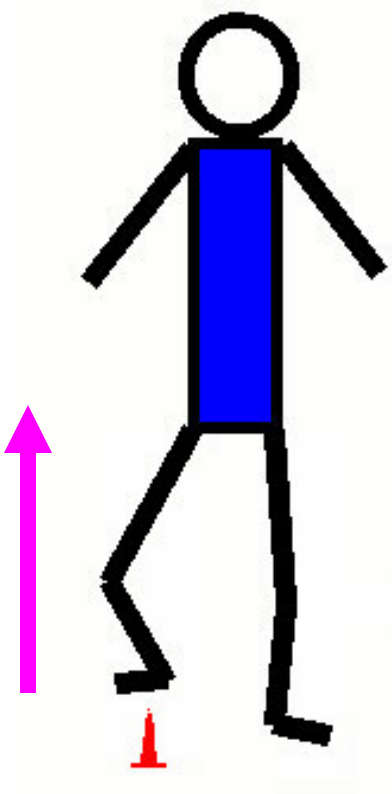
Connections for autogenic inhibition may be inactivated during walking

Effects of Golgi tendon organs can then become excitatory via other interneurons

C. FLEXOR REFLEX





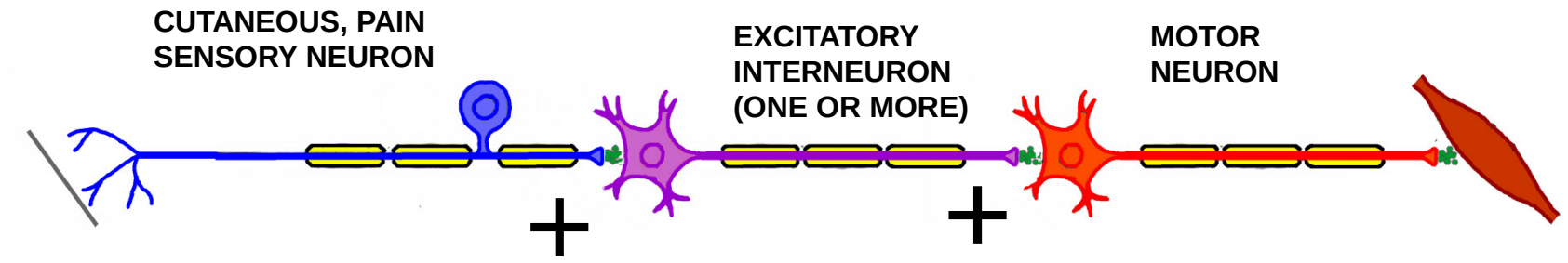


1) Stimulus - painful or noxious stimulus (stepping on nail)

2) Sense organ excited - Cutaneous receptors, Pain receptors (nociceptors)

3) Primary response - Protective withdrawal of limb

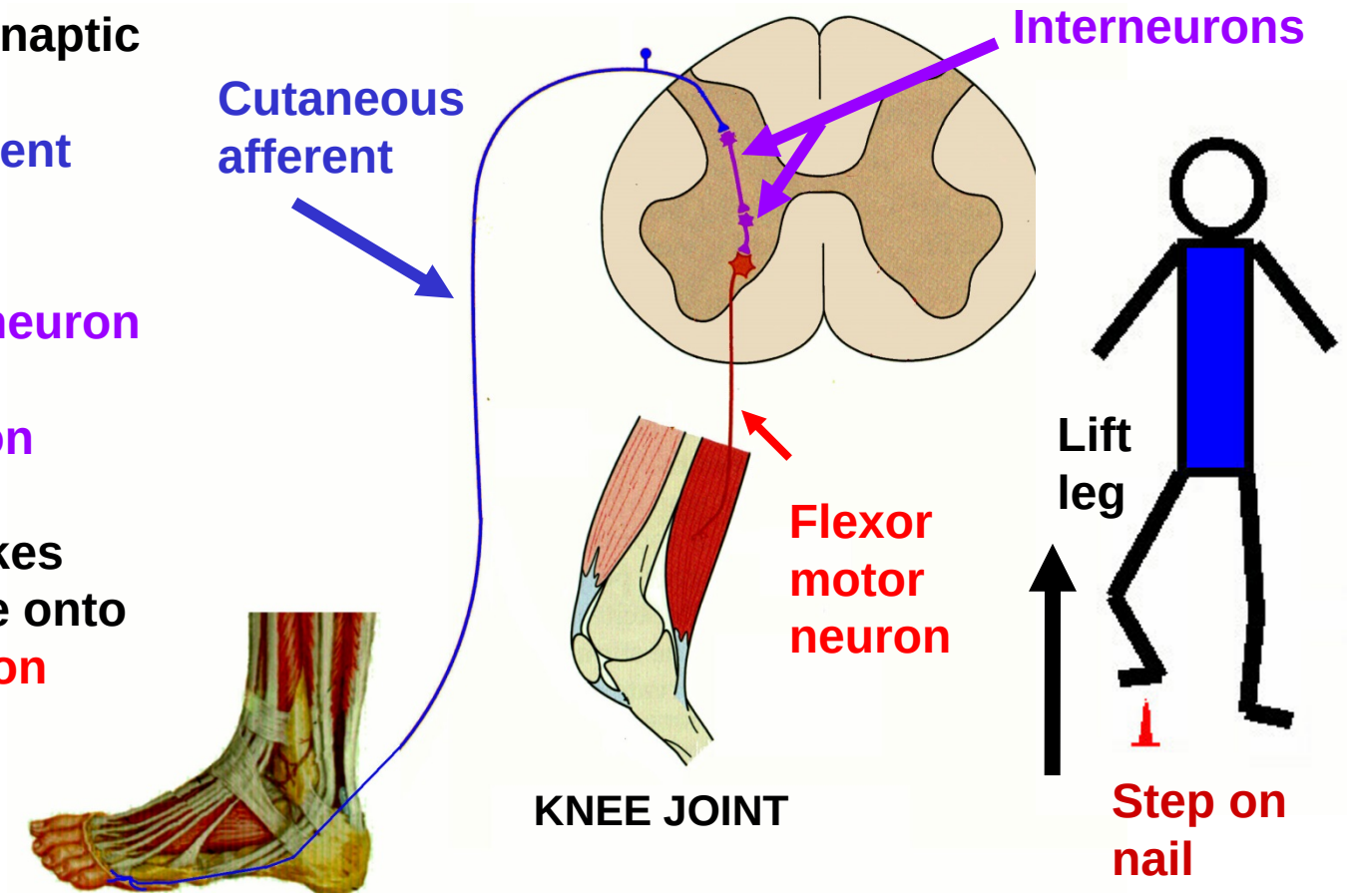
FLEXOR REFLEX: PATHWAYS



Synapses - Polysynaptic

1) Cutaneous afferent makes excitatory synapse onto Interneuron; Interneuron can synapse upon another interneuron

2) Interneuron makes excitatory synapse onto Flexor motor neuron



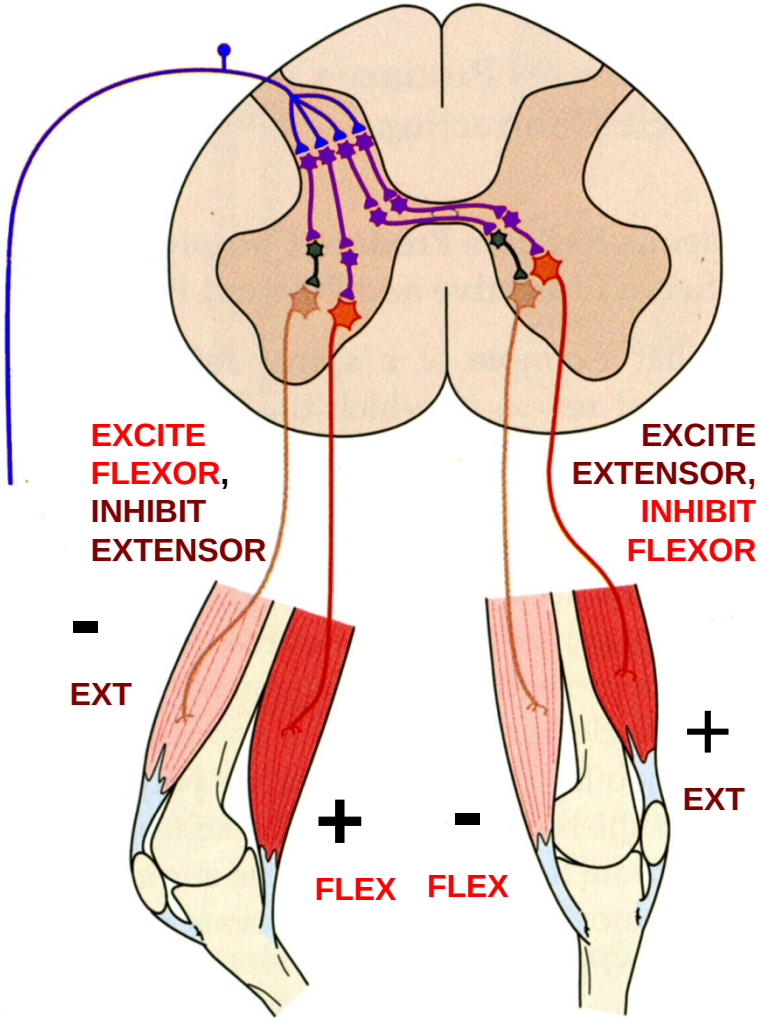
FLEXOR REFLEX: OTHER EFFECTS
ALL ARE POLYSYNAPTIC BY INTERNEURONS

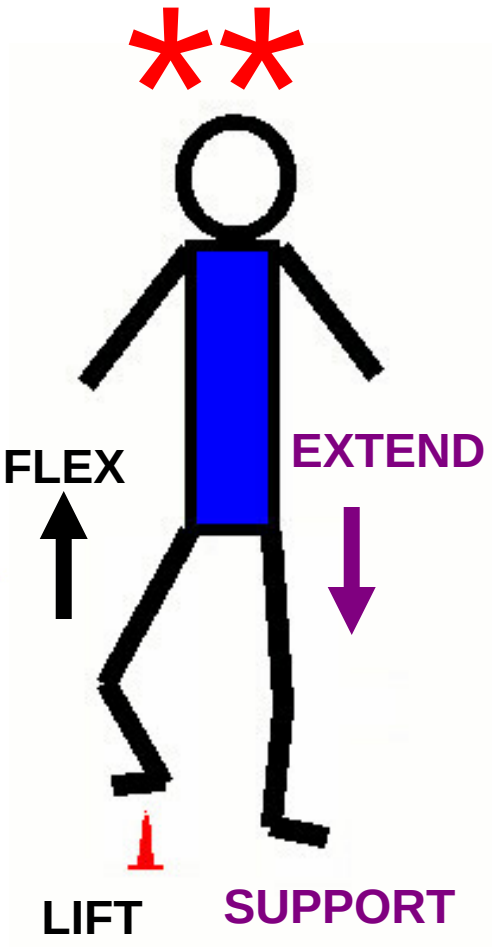
1) Excite synergist muscles - excite other flexors in same leg (other joints)

2) Inhibit antagonist muscles - inhibit Extensors in same leg

3) CROSSED EXTENSION REFLEX - EXCITE EXTENSORS AND INHIBIT FLEXORS IN OPPOSITE LEG

**





FUNCTION: OTHER LEG PROVIDES SUPPORT WHEN FIRST LEG IS LIFTED

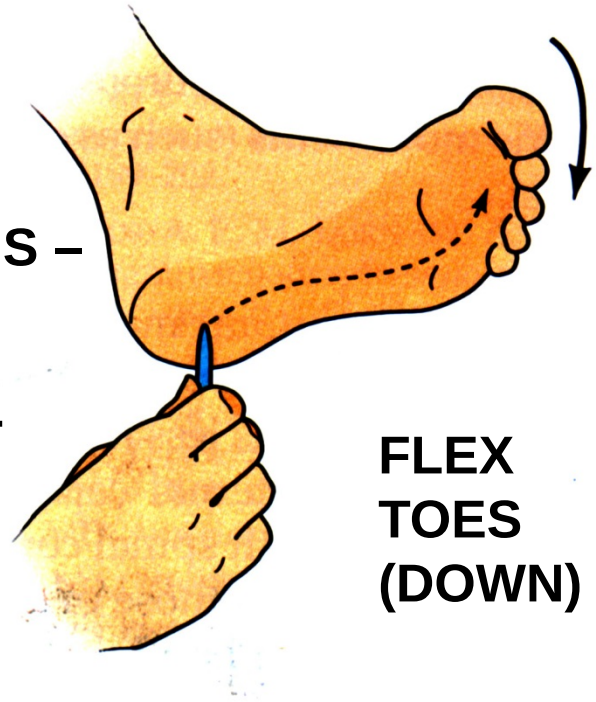
REFLEXES ARE MODULATED: SOME FLEXOR REFLEXES CAN CHANGE AFTER LESIONS, DISEASE PROCESSES

**

NORMAL RESPONSE

**

BABINSKI SIGN – (EXTENSOR PLANTAR RESPONSE)



STIMULUS – TO SKIN OF SOLE OF FOOT

FLEX TOES (DOWN)

EXTEND BIG TOE, FANNING (ABDUCTION) OF OTHER TOES

Babinski sign - seen after **Upper Motor neuron lesion**
-direction of movement **changes from flexing toes to extending and fanning (abducting) toes**

PLANTAR REFLEX: ‘FLEXOR’ REFLEX (PLANTAR FLEXION) IN FOOT: NORMAL [**used by permission of Paul D. Larsen, M.D., University of Nebraska Medical Center; http://library.med.utah.edu/neurologicexam]**

PLANTAR REFLEX: ABNORMAL, (POSITIVE) BABINSKI SIGN ON ONE SIDE [**used by permission of Paul D. Larsen, M.D., University of Nebraska Medical Center; http://library.med.utah.edu/neurologicexam]**

** 1. PUPILLARY LIGHT REFLEX - II TO III

AFFERENT ARM OF REFLEX

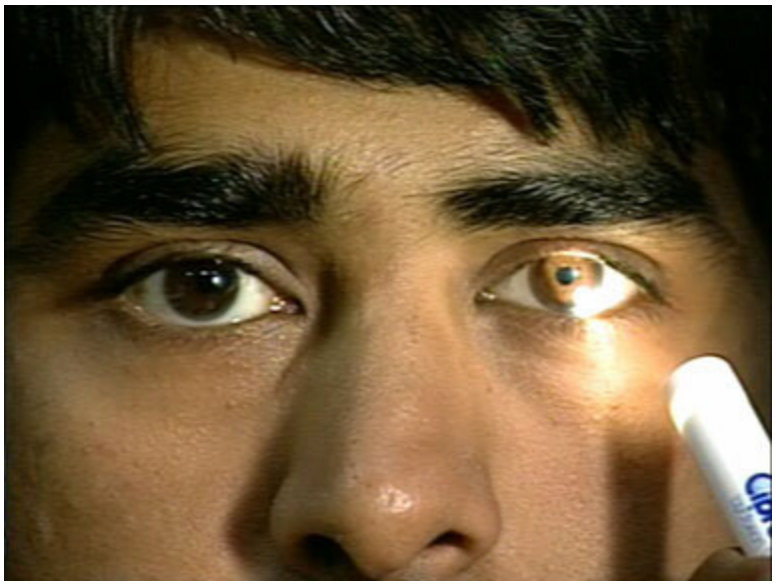
SENSORY STIMULUS

LIGHT IN EYE

EFFERENT ARM OF REFLEX

MOTOR RESPONSE

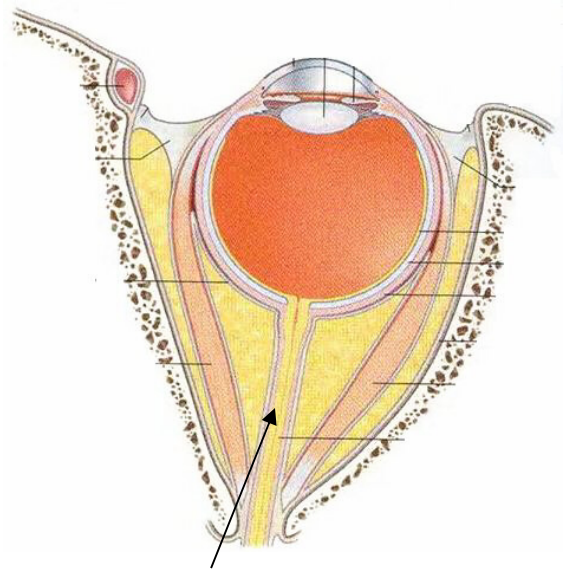
CONSTRICT PUPIL



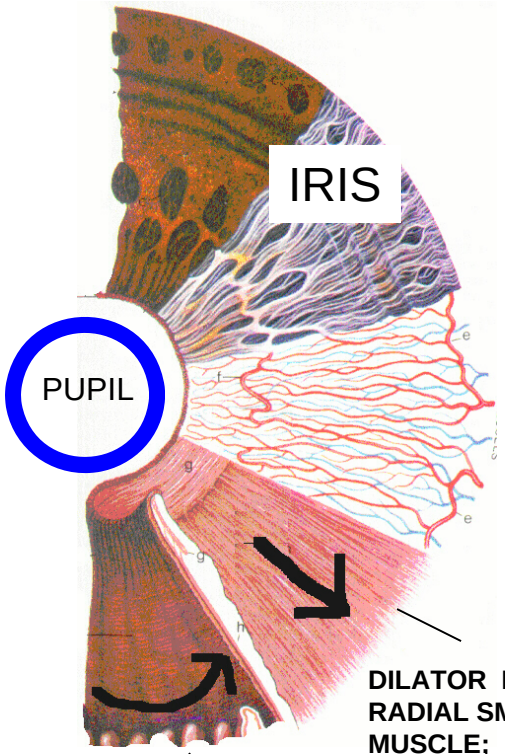
PUPILLARY LIGHT REFLEX

CN II - OPTIC NERVE - DETECTS LIGHT

CN III - OCULOMOTOR - parasympathetics from Ciliary Ganglion in Short Ciliary nerves

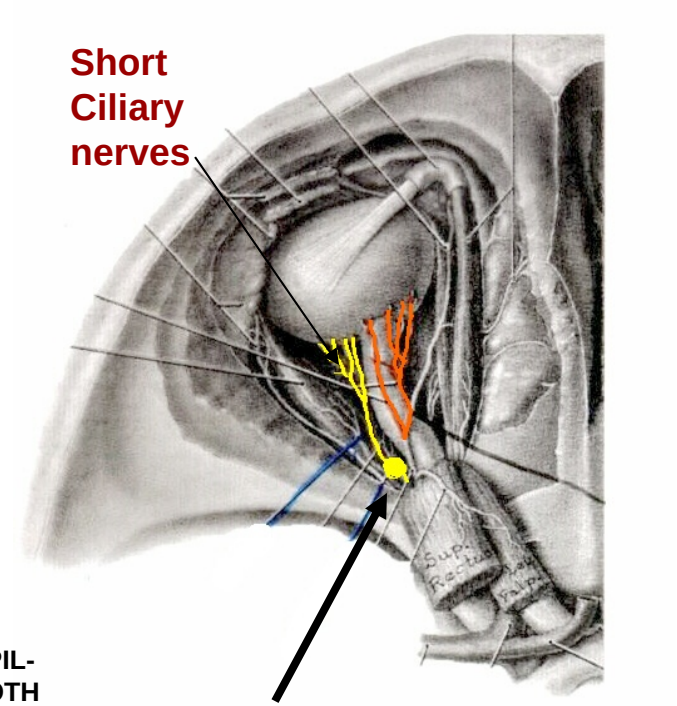


OPTIC NERVE - CN II VISION



DILATOR PUPIL- RADIAL SMOOTH MUSCLE; SYMPATHETICS

CONSTRICTOR PUPIL- CIRCULAR SMOOTH MUSCLE; PARASYMPATHETICS - CN III



Ciliary Ganglion of CN III

PUPILLARY LIGHT REFLEX

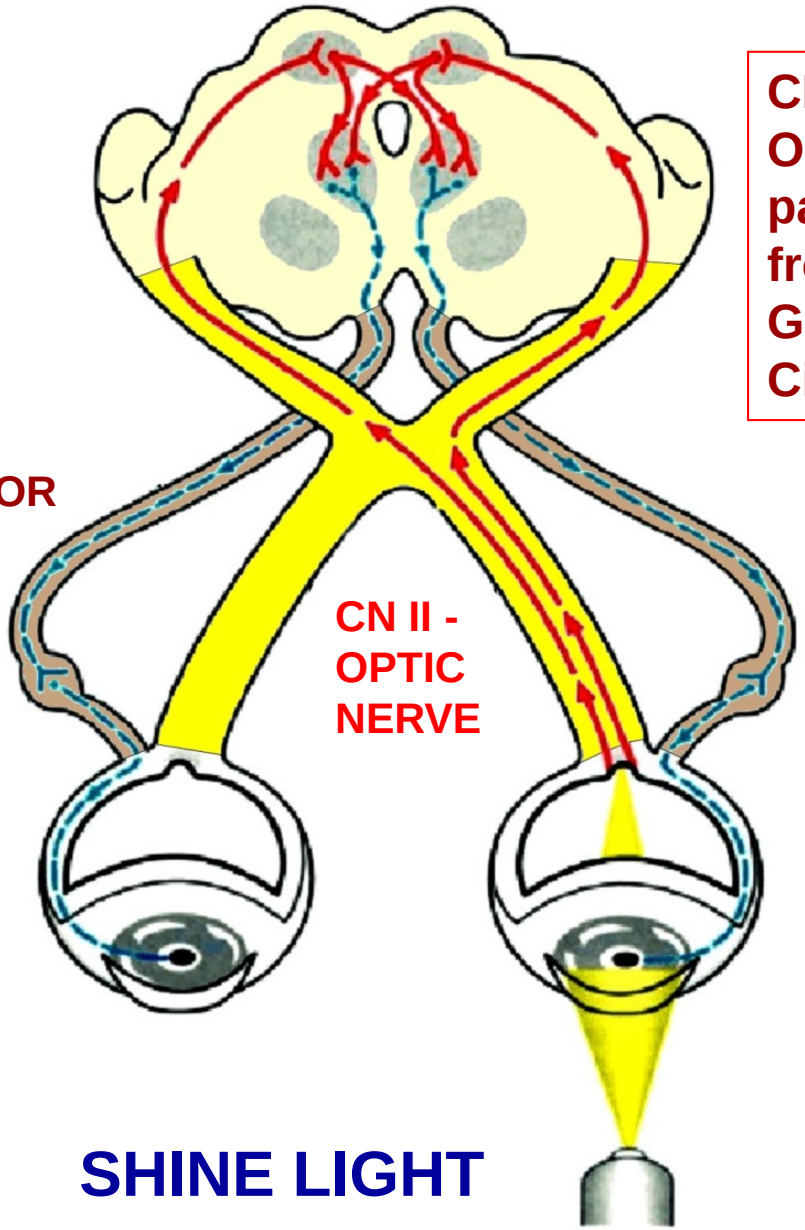
CN II - OPTIC NERVE - DETECTS LIGHT

CN III - OCULOMOTOR - parasympathetics from Ciliary Ganglion in Short Ciliary nerves

CN III - OCULOMOTOR

CN III - OCULOMOTOR

CN II - OPTIC NERVE



CONSENSUAL REFLEX – PUPIL CONSTRICTS IN OPPOSITE EYE

DIRECT REFLEX – PUPIL CONSTRICTS IN SAME EYE

SHINE LIGHT

2. CORNEAL REFLEX - V TO VII

AFFERENT ARM OF REFLEX

SENSORY STIMULUS

TOUCH CORNEA

TRIGEMINAL - V1 - LONG CILIARY NERVES TO CORNEA

EFFERENT ARM OF REFLEX

MOTOR RESPONSE

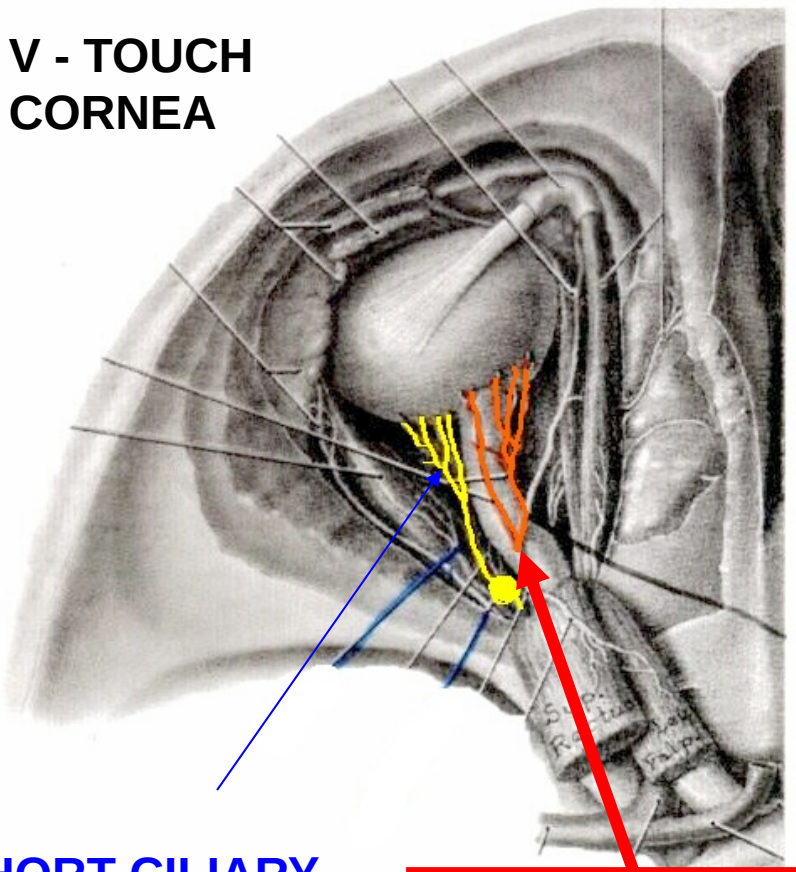
CLOSE EYELID

FACIAL - VII - MOTOR TO ORBICULARIS OCULI (SVE)

CORNEAL REFLEX - V to VII

**

V - TOUCH CORNEA



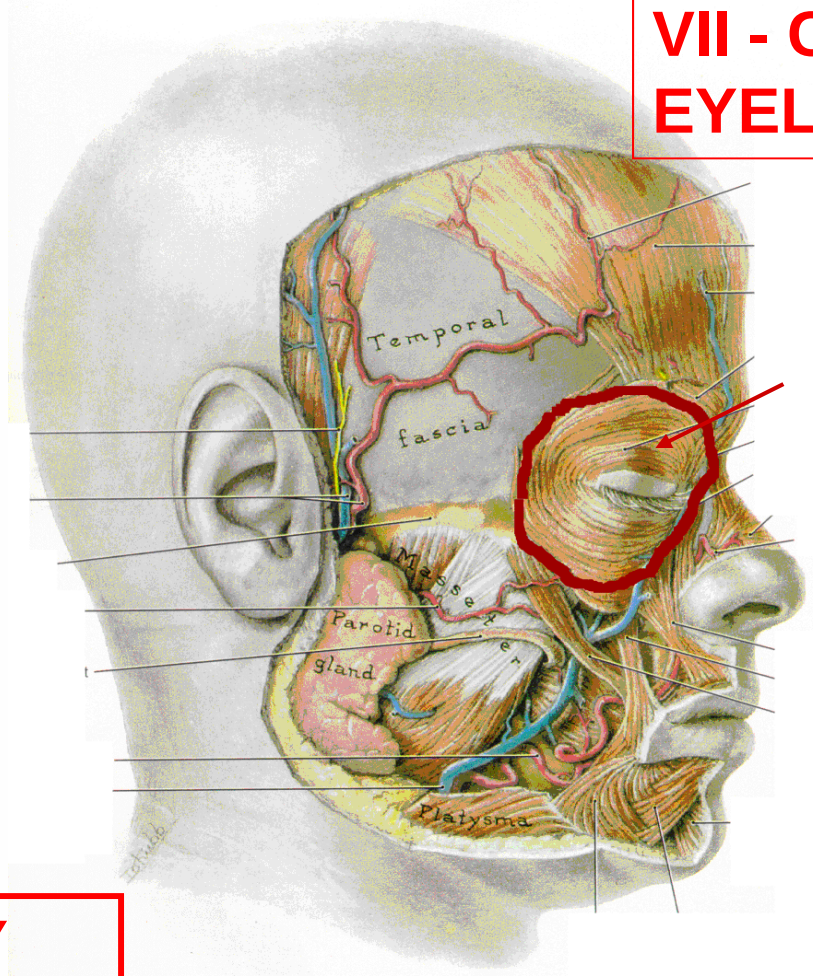
SHORT CILIARY NERVES (III),

CILIARY GANGLION

PARASYMPATHETIC

LONG CILIARY NERVES (V1) - SOMATIC SENSORY TO CORNEA

VII - CLOSE EYELID



ORBICU-LARIS OCULI M.

- Palpebral part - Close eyelids
- Orbital part - Buries eyelids, Ex. sandstorm
BRANCHIOMOTOR - VII

3. GAG REFLEX - IX to X **

AFFERENT ARM OF REFLEX

SENSORY STIMULUS

TOUCH ORO-PHARYNX

EFFERENT ARM OF REFLEX

MOTOR RESPONSE

PATIENT GAGS - CONTRACT PHARYNGEAL MUSCLES

GAG REFLEX

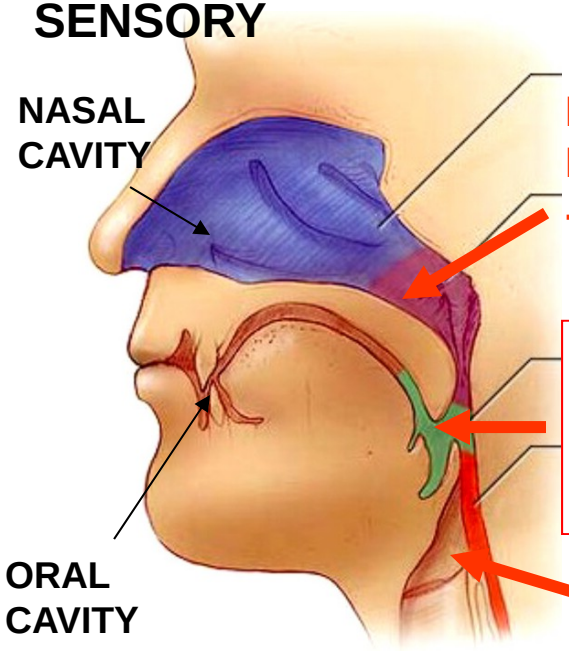
CRANIAL NERVES LECTURE

IX - SENSORY INNERVATION TO OROPHARYNX

All Pharynx is Visceral Sensory In 3 Cranial Nerves

SOMATIC SENSORY

VISCERAL SENSORY

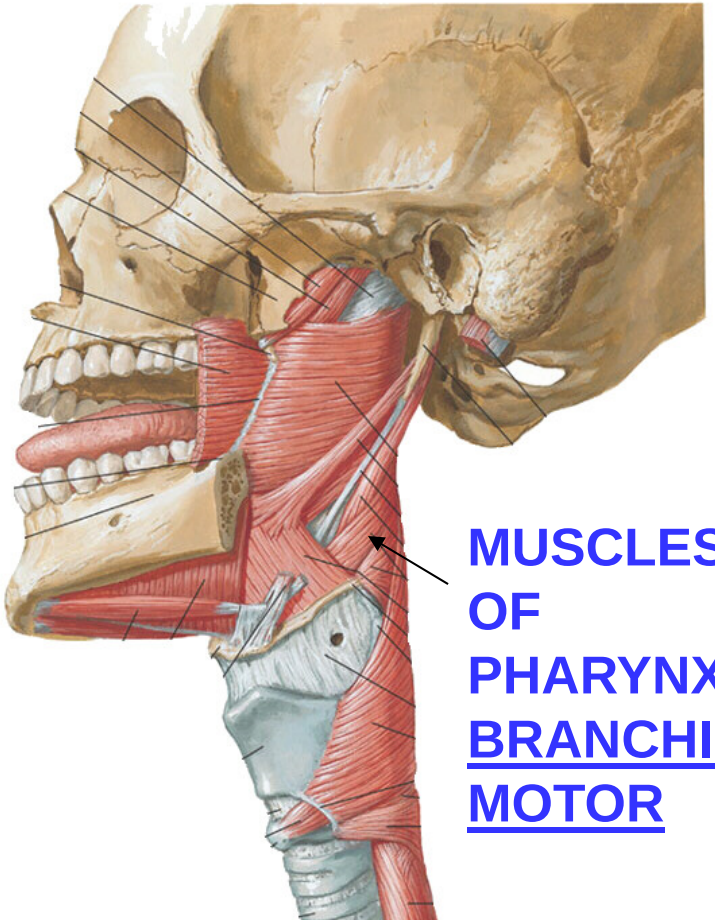


NASO-PHARYNX - VII

ORO-PHARYNX - IX

LARYNGO-PHARYNX - X

X - INNERVATES ALL MUSCLES OF PHARYNX (except Stylopharyngeus)



MUSCLES OF PHARYNX - BRANCHIO-MOTOR

**

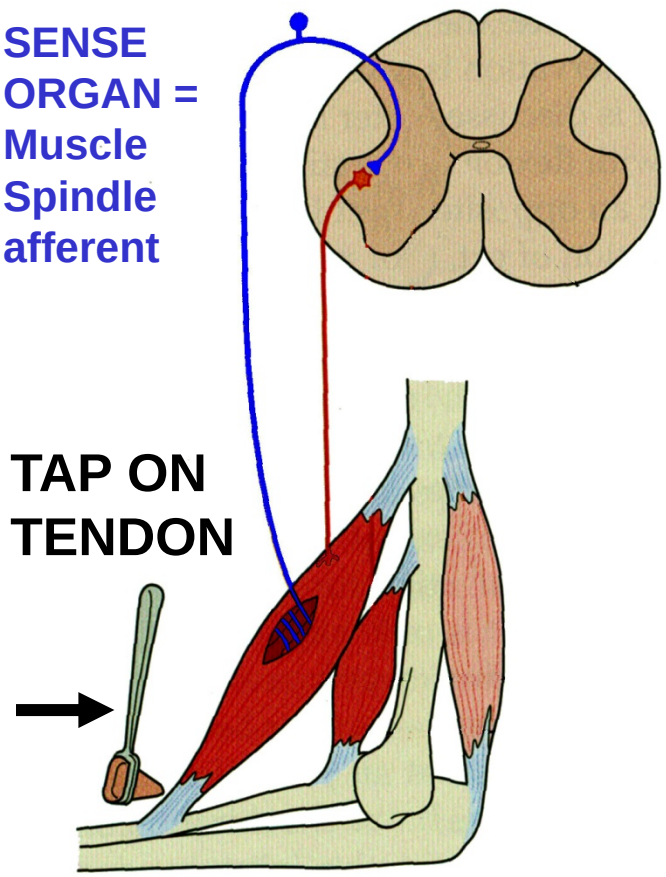
IX AND X - LEAVE MEDULLA, EXIT BY JUGULAR FORAMEN - CAN DIAGNOSE DAMAGE IN BRAINSTEM BY TESTING REFLEXES

4. STRETCH REFLEX OF MUSCLES OF MASTICATION
- JAW JERK REFLEX - sensory and motor in Trigeminal V3

STRETCH REFLEX

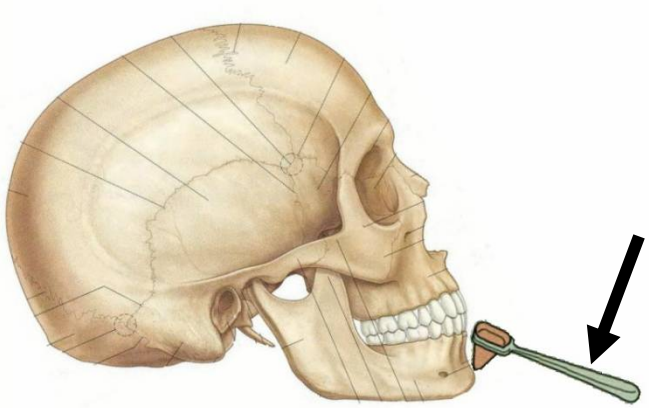
SENSE ORGAN = Muscle Spindle afferent

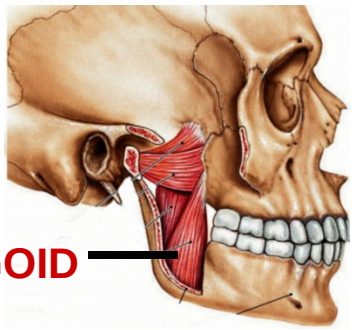
TAP ON TENDON



STRETCH REFLEX IN MUSCLES OF MASTICATION

TAP DOWN ON CHIN

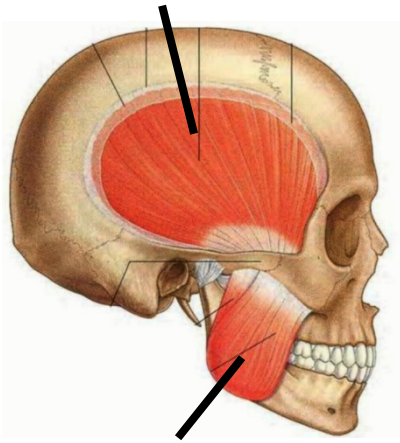




MEDIAL PTERYGOID

STRETCH MUSCLES THAT CLOSE MOUTH (ELEVATE MANDIBLE)

TEMPORALIS



MASSETER

TEST FUNCTION OF TRIGEMINAL NERVE (V3)

SOME 'REFLEXES' ARE ACTUALLY INHERENT MOTOR PATTERNS THAT ARE ELICITED BY SENSORY STIMULI - MUCH MORE COMPLEX

PALMAR GRASP

MORO REFLEX - arm extend

STEPPING 'REFLEX' - actually eliciting motor pattern

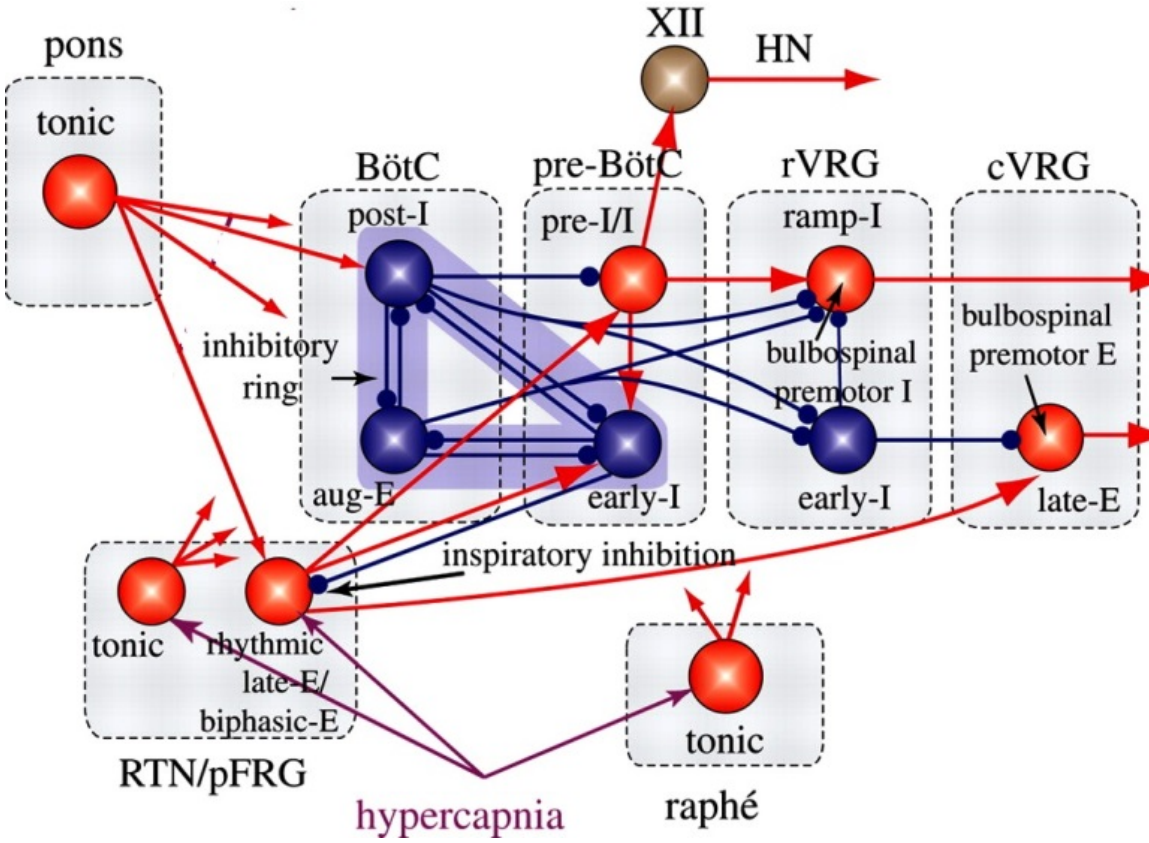
PLANTAR GRASP

PLACING REFLEX

TONIC NECK REFLEX - extend ipsilateral arm, flex opposite arm

IV. COMPLEX BEHAVIORS ARE PRODUCED BY PATTERN GENERATORS - CIRCUITS OF INTERCONNECTED NEURONS: ex. NEURONAL CIRCUIT PRODUCING RESPIRATION

Neurons in Brainstem (Pons and Medulla) that generate Respiration



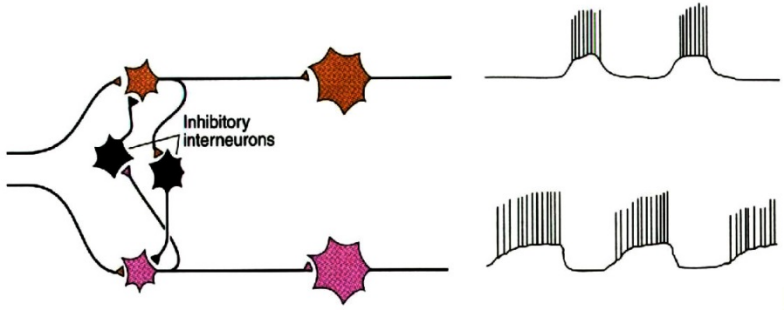
PN - Phrenic nerve inspiration

AbN - nerves to Abdominal muscles expiration

IV. PATTERN GENERATORS - SPINAL CORD CONTAINS NETWORKS OF INTERNEURONS THAT GENERATE MOTOR ACTIVITIES (EX. WALKING)

PATTERN GENERATORS are networks of interneurons that are synaptically connected and than can produce patterns of repetitive movements (ex. walking)

PATTERN GENERATOR - see Dr. Grover's lecture



REHABILITATION AFTER SPINAL CORD INJURY - Walking is thought to be produced by pattern generators within spinal cord (and brain stem). Patients can walk on treadmills (if body weight is supported) (ex. Christopher Reeve, actor who played 'Superman')

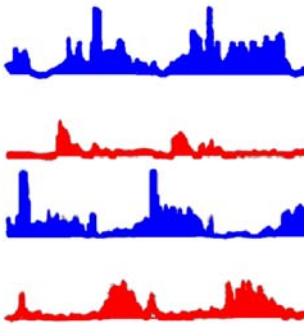
TREADMILL WALKING WITH WEIGHT SUPPORTED

Christopher Reeve

PATTERN GENERATORS IN HUMANS: BABY HELD WITH WEIGHT SUPPORTED ABOVE TREADMILL

Note: Goo-Goo Person

MUSCLE ACTIVITIES IN WALKING ARE SIMILAR TO ADULT



BABY HELD WITH WEIGHT SUPPORTED ABOVE TREADMILL: Changes in direction similar to adult

Stepping 'reflex' probably represents activation of pattern generating neurons

Infants don't learn to walk; they learn to maintain balance while walking.

SUMMARY OF SPINAL, CRANIAL NERVE REFLEXES

SPINAL REFLEXES AND DISORDERS

REFLEX	STIMULUS/SENSE ORGAN(S) EXCITED	NORMAL RESPONSE	UPPER MOTOR NEURON DISORDERS
Stretch (Myotatic, Deep Tendon) Reflex – Compensatory maintain position (ex. riding on moving bus)	Rapid Stretch of muscle (test: tap on muscle tendon) Excites Muscle Spindle Primary (Ia) and Secondary (II) sensory neurons (NOT Golgi Tendon Organ)	Stretched muscle contracts rapidly (monosynaptic connection); also Excite synergist and Inhibit antagonist Note: Gamma motor neurons can enhance stretch reflexes, tell patient to relax before test	Hyperreflexia - (increase) - characteristic of Upper Motor Neuron lesions (ex. spinal cord injury, damage Corticospinal tract); note: Clonus = hyperreflexia with repetitive or sustained contractions to single stimulus
Autogenic Inhibition - Limits Muscle Tension	Large force on tendon excites Golgi Tendon Organ Ib (test: pull on muscle when resisted)	Muscle tension decreases; Also inhibit synergist muscles; excite antagonist muscles	Clasped Knife Reflex - occurs in Upper Motor Neuron lesions - forceful stretch of muscle is first resisted then collapses
Flexor Reflex - Protective avoidance reflex	Sharp, painful stimulus, as in stepping on nail; Excites - Cutaneous and pain receptors (test: stroke foot with pointed object)	Limb is rapidly withdrawn from stimulus; protective reflex; also inhibit extensors of same limb and excite extensors of opposite limb (Crossed Extensor Reflex)	Babinski sign- toes extend (dorsiflex) to cutaneous stimulus of sole of foot (normally plantar flex); characteristic of Upper Motor Neuron lesion

REFLEXES OF CRANIAL NERVES

REFLEX	STIMULUS	SENSORY	RESPONSE	CLINICAL
Pupillary Light Reflex (II to III)	Test: Shine light in eye	Light detected by Optic Nerve	Excite Constrictor of pupil of eye (III Short Ciliary nerves (Ciliary Ganglion, parasympathetic)	Extensively used to check CN II; Absence of Pupillary Light Reflex can indicate catastrophe (brain herniation)
Corneal Reflex (V to VII)	Touch cornea of eye with cotton	Touch detected by Long Ciliary nerves (V1), Somatic sensory	Close eye (VII to Orbicularis Oculi muscle) Branchiomotor	Absence of Corneal Reflex; Test for damage to V1 sensory, VII motor
Gag Reflex (IX to X)	Test: Touch posterior tongue, oropharynx;	Excites Visceral Sensory endings in Glossopharyngeal N. (IX)	Excite muscles of pharynx, palate; Vagus N. (X), Branchiomotor	Other symptoms of Vagus damage (X); Patient Say's Ahh: soft palate not elevated on ipsilateral side (paralyze Levator Palati); uvula deviated away from side of lesion
Jaw Jerk Reflex Stretch (Deep Tendon) Reflex (V to V)	Test: tap down on mandible; Stretch muscles of mastication (ex. Masseter)	Excites Muscle Spindle sensory neurons in Trigeminal nerve (V)	Contract muscles that elevate mandible Motor - V3	Hyporeflexia - indicates Trigeminal nerve damage

ANATOMY AND DIAGNOSTIC USE OF AUTONOMIC NERVOUS SYSTEM PATHWAYS

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-gangliionic 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**

Symptom	**Structure innervated**	**Damage**
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.**

Structure	**Horner's Syndrome**	**Oculomotor Palsy (nerve damage)**
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 paralyzed;** Pupillary constrictor muscle intact	**Pupil dilated (Mydriasis) - Pupillary constrictor muscle paralyzed;** Dilator muscle is intact
Sweat glands in skin	**Anhydrosis - lack of sweating in skin** (ex. forehead)	**No effect (**parasympathetics do not innervate skin)

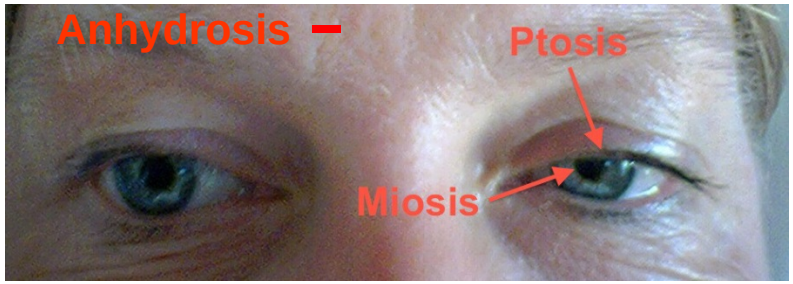
Also: Eye Movements - Oculomotor nerve innervates Extraocular muscles; damage effects eye movements; no deficit in eye movements in Horner's syndrome.

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

CLINICALLY IMPORTANT

HORNER'S SYNDROME



GOALS:

1) UNDERSTAND STRUCTURES AND PATHWAYS SEEN IN GROSS ANATOMY PROSECTIONS OF AUTONOMICS (NEXT BLOCK)

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

SYMPTOMS -
MIOSIS - pupillary constriction
PTOSIS - drooping eyelid
ANHYDROSIS - lack of sweating

OUTLINE

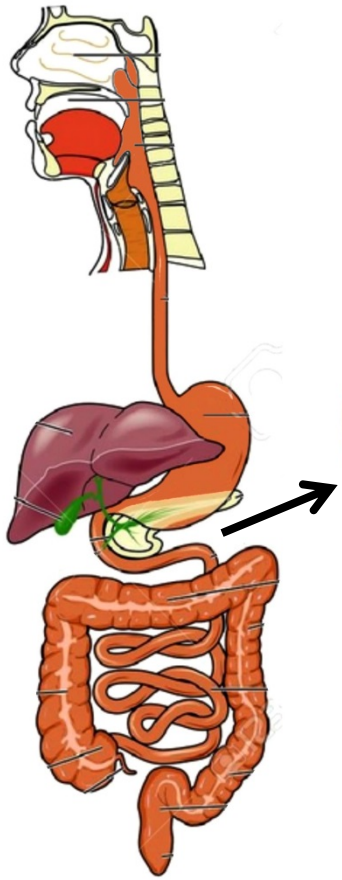
1. GENERAL REVIEW OF AUTONOMIC NERVOUS SYSTEM - Sympathetics and Parasympathetics - Asymmetry: Sympathetics are widespread; Parasympathetics are much more localized (except Vagus nerve)

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

2. ANATOMY OF SYMPATHETIC PATHWAYS - structures can be seen in prosections in thorax.

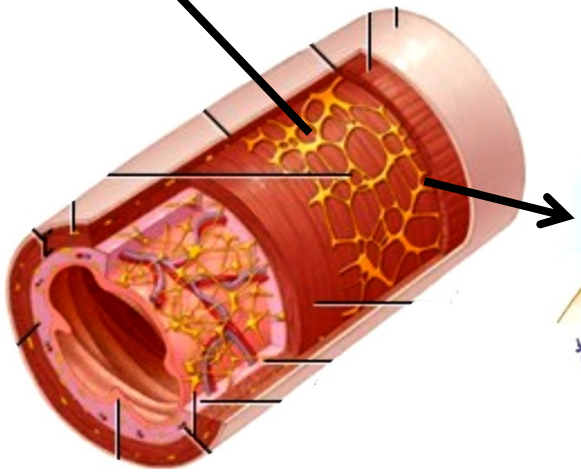
3. SYMPATHETICS TO HEAD AND HORNER'S SYNDROME (= damage to Sympathetics) - CLINICAL FOCUS: Autonomic pathways to EYE (and head) are used diagnostically

WHY IS THE AUTONOMIC NERVOUS SYSTEM A MESS? EVOLUTION OF NERVOUS SYSTEM - starts as primitive nerve net (meshwork of neurons) - organization preserved in human GUT (GI tract) = ENTERIC NERVOUS SYSTEM

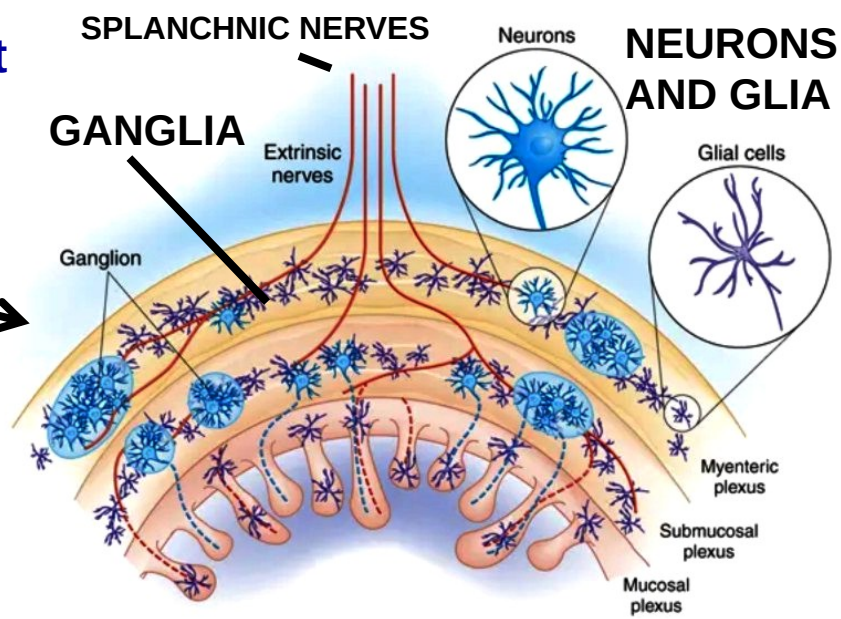


GUT (GI tract)

ENTERIC NERVOUS SYSTEM - in wall of gut



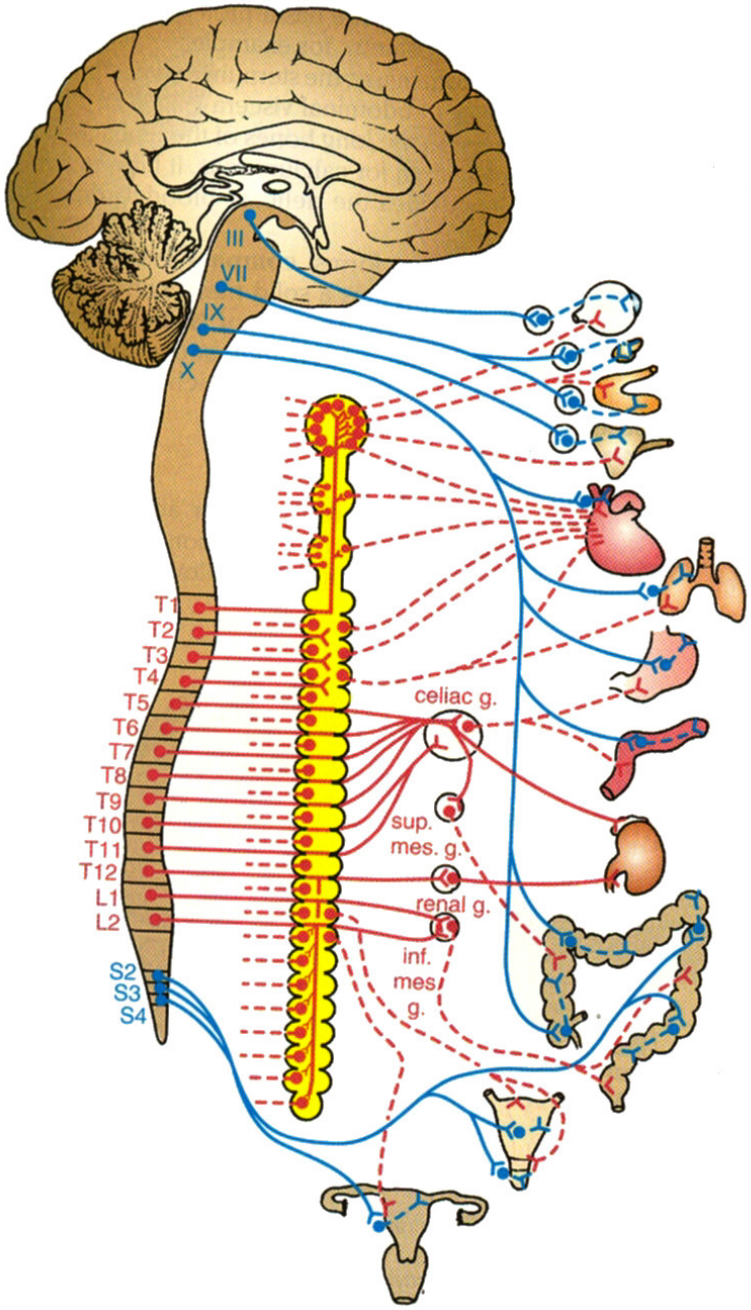
SECTION THROUGH WALL OF INTESTINE



COVERED IN GI SYSTEM: SPRING 2020

ENTERIC NERVOUS SYSTEM

- ganglia (neurons, glia) in wall of gut produces contractions (peristalsis) in gut muscle cells
- can operate independent of autonomic nervous system but modulated by it (Splanchnic nerves)
- recent research: immune system acts on Enteric nervous system



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.

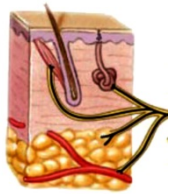
b. **Visceral Sensory (afferents)** - sensory neurons that innervate internal organs, blood vessels; only provide **imprecise localization of sensation** and dull sense of pressure, pain, etc.

ASYMMETRY: SOME BODY STRUCTURES RECEIVE ONLY SYMPATHETICS NOT PARASYMPATHETICS

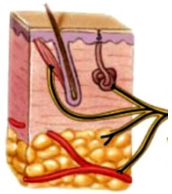
SYMPATHETICS

INNERVATE:
1) Skin
2) Peripheral blood vessels

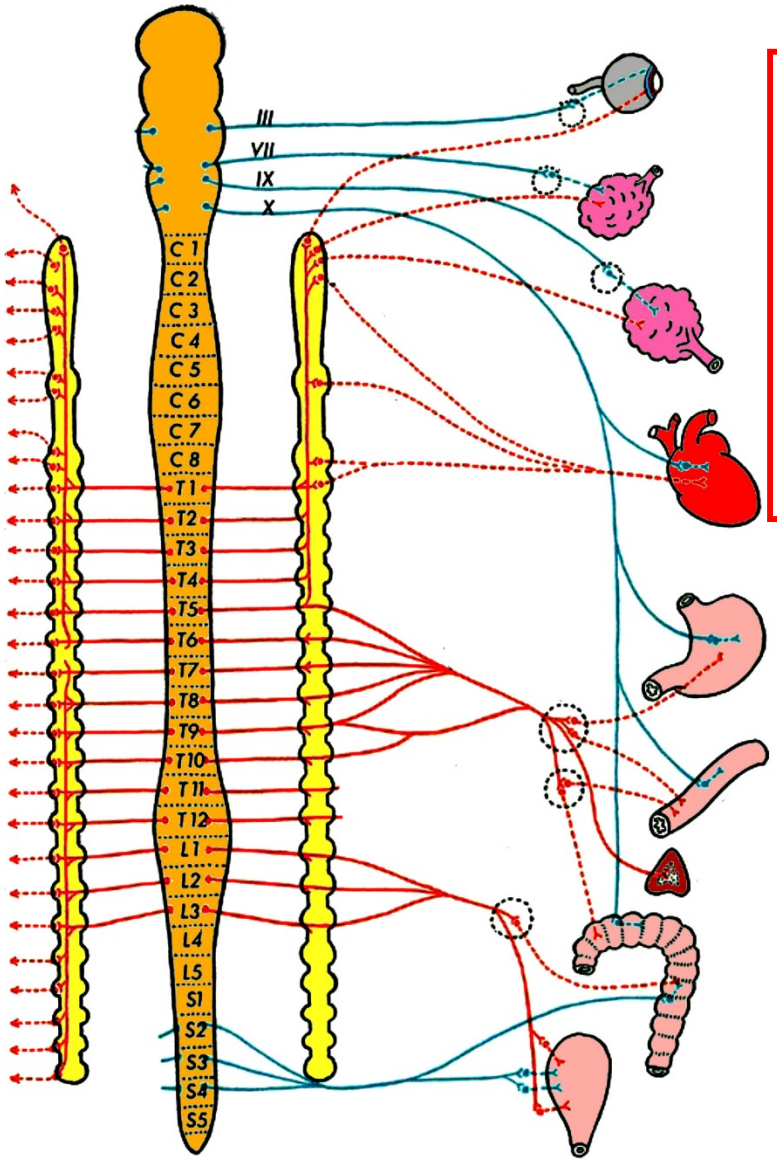
SKIN



SKIN



Sympa-thetics go to the body wall, i.e. Skin

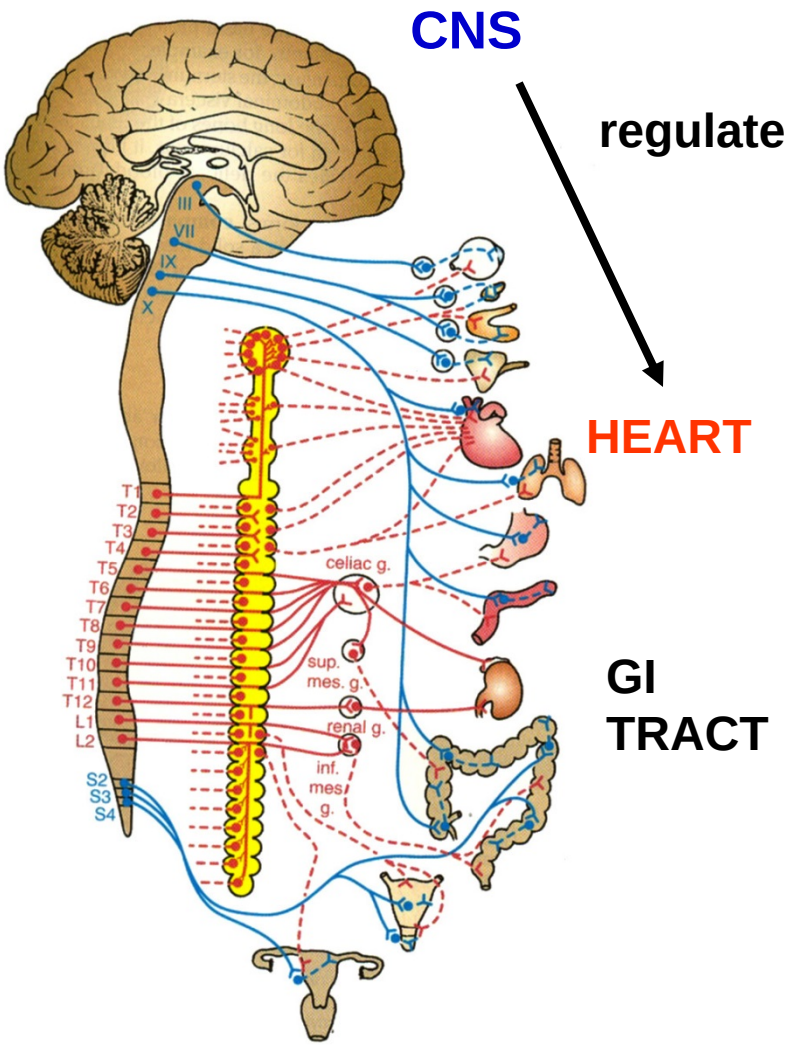


PARA-SYMPATHETICS

INNERVATE:
Do NOT innervate skin and peripheral blood vessels

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

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 autonomics provide pathways for the CNS to continuously regulate and control body functions:

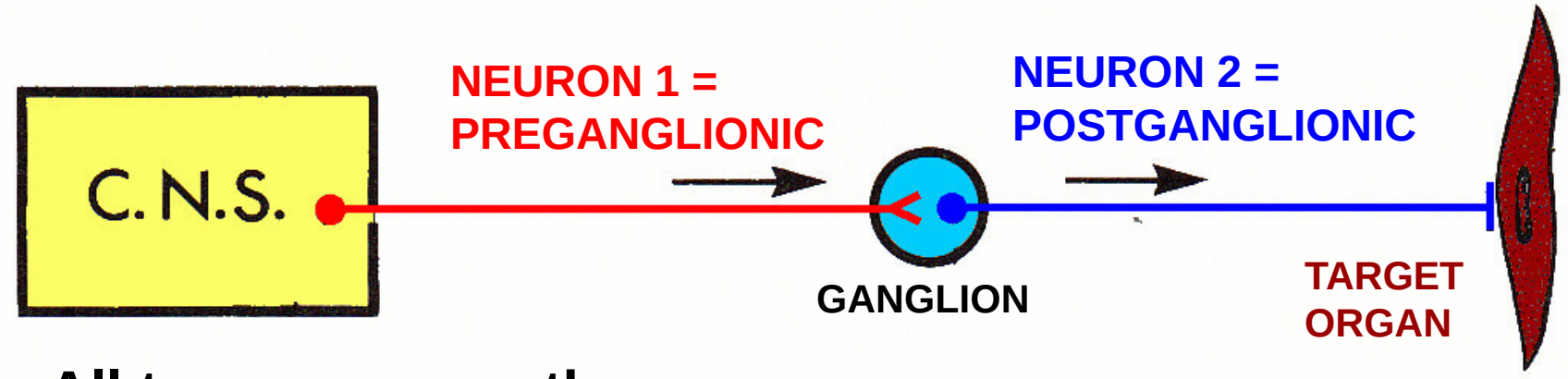
ex

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

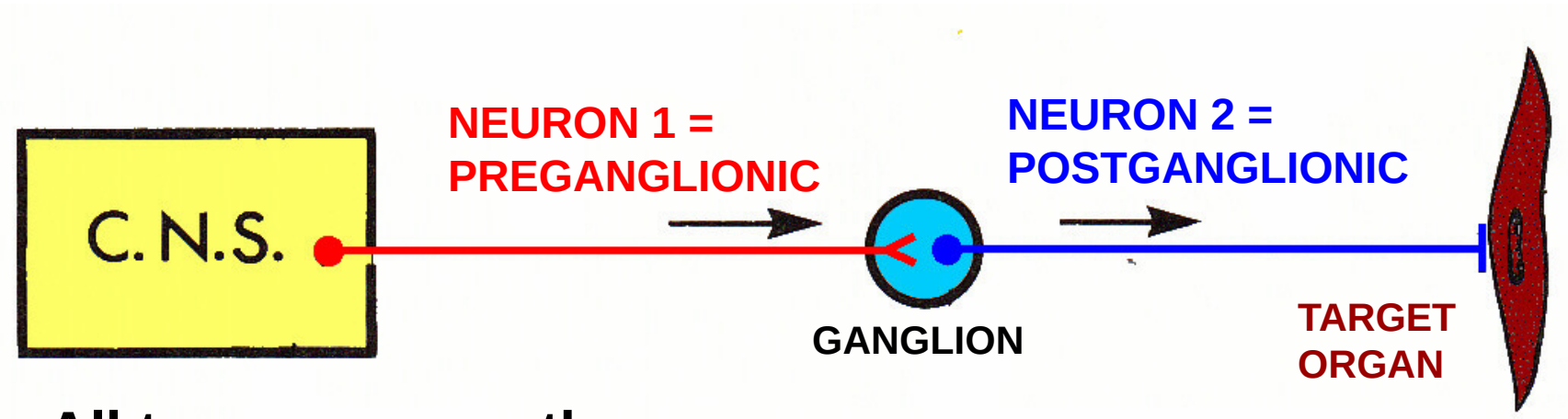
2) Neuron 2 = Post ganglionic neuron - cell body in autonomic ganglion; axon goes to target organ

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



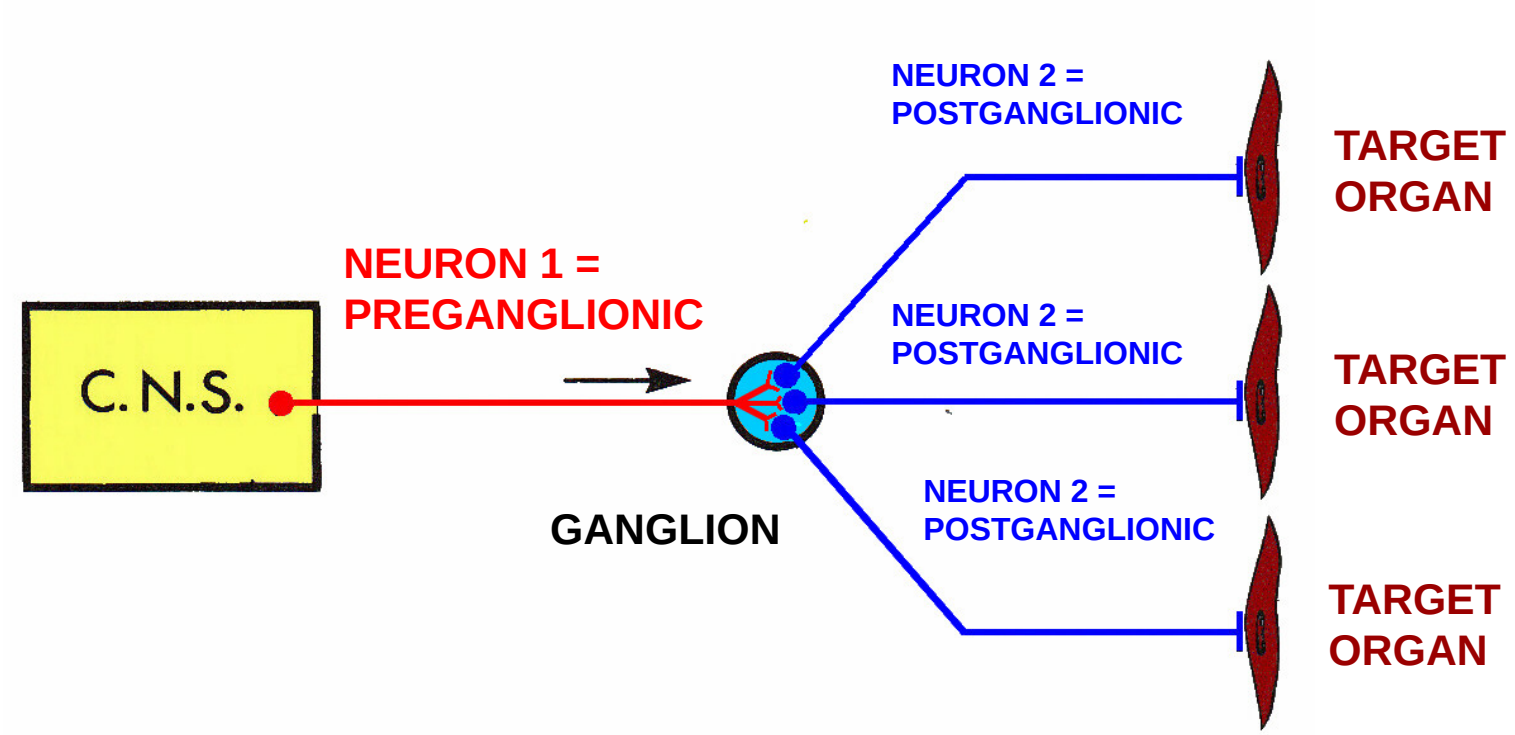
All two neuron pathways:

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



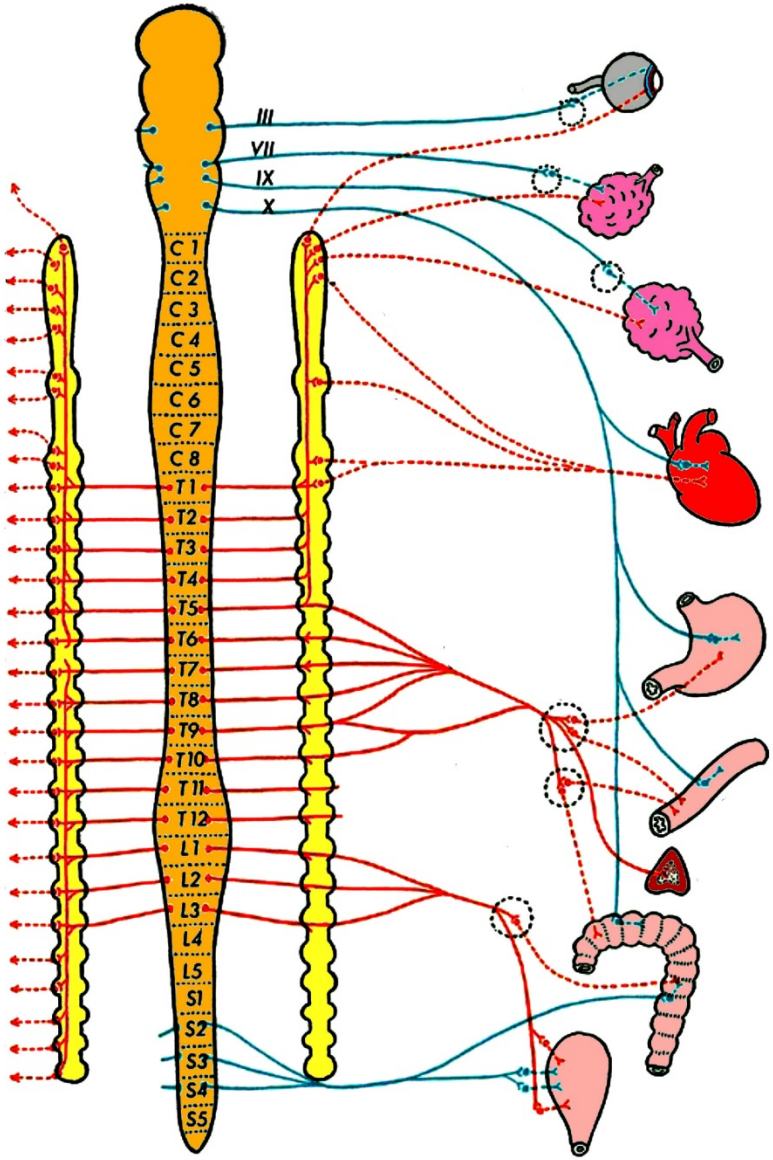
Considerable divergence of signal - One Pre-ganglionic neuron usually activates many (15 - 200) Post-ganglionic neurons; Autonomics can activate many targets simultaneously (ex. Thermoregulation - many sweat glands secrete at the same time)

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:

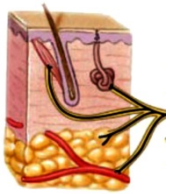
SYSTEM	SYMPATHETIC - 'FIGHT OR FLIGHT'	PARASYMPATHETIC - REST AND DIGEST
HEART	INCREASE RATE, CONTRACTION	DECREASE RATE
GI SYSTEM	DECREASE STOMACH MOVEMENTS, DECREASE SECRETIONS	INCREASE STOMACH MOVEMENTS, INCREASE SECRETIONS
SALIVARY GLANDS	DECREASE SECRETION	INCREASE SECRETION

ASYMMETRY: SOME BODY STRUCTURES RECEIVE ONLY SYMPATHETICS NOT PARASYMPATHETICS

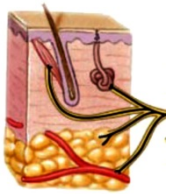
SYMPATHETICS

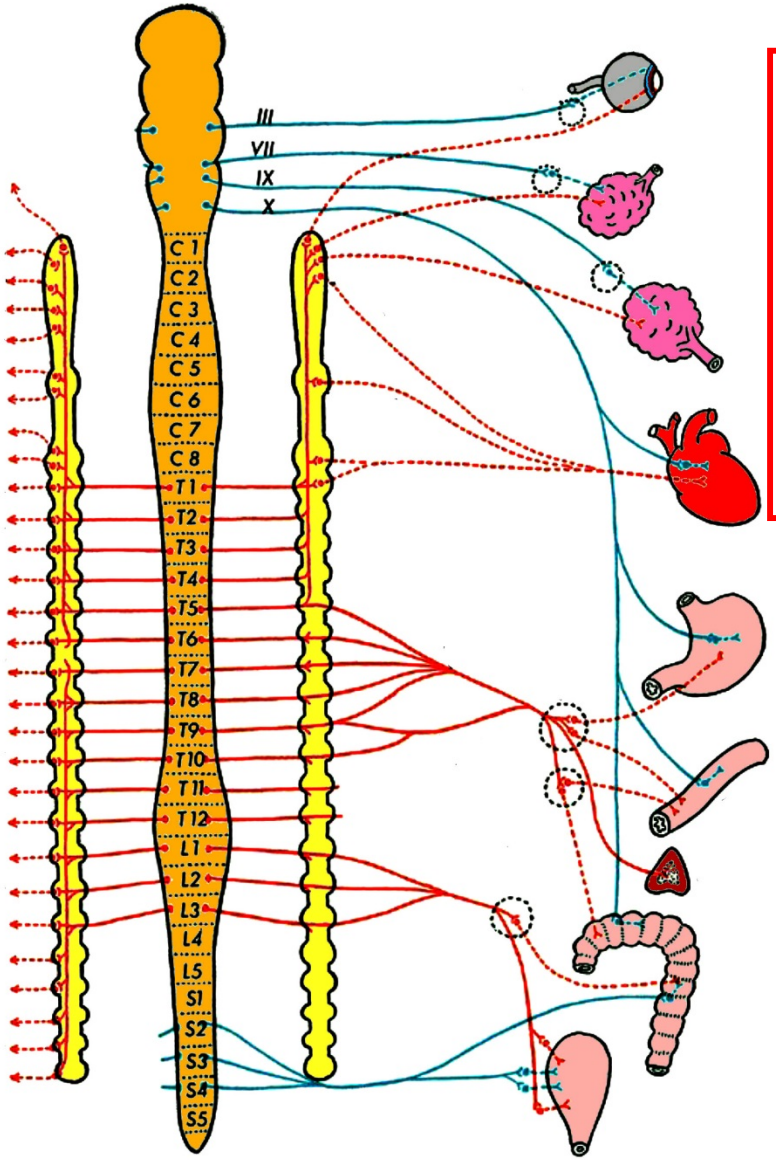
INNERVATE:
1) Skin
2) Peripheral blood vessels

SKIN



SKIN

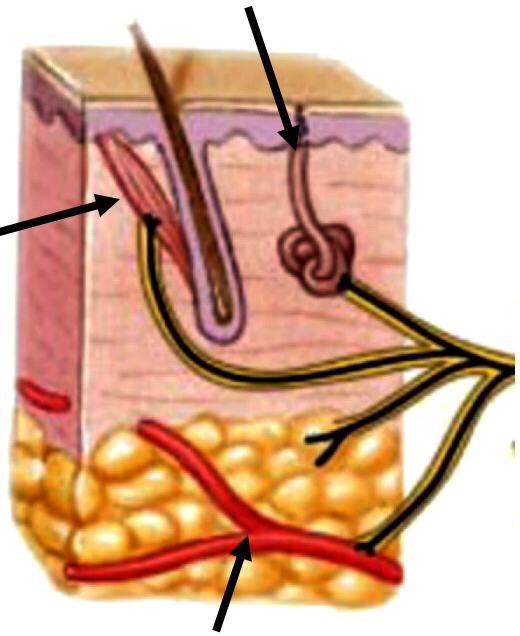




PARA-SYMPATHETICS

INNERVATE:
Do NOT innervate skin and peripheral blood vessels

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

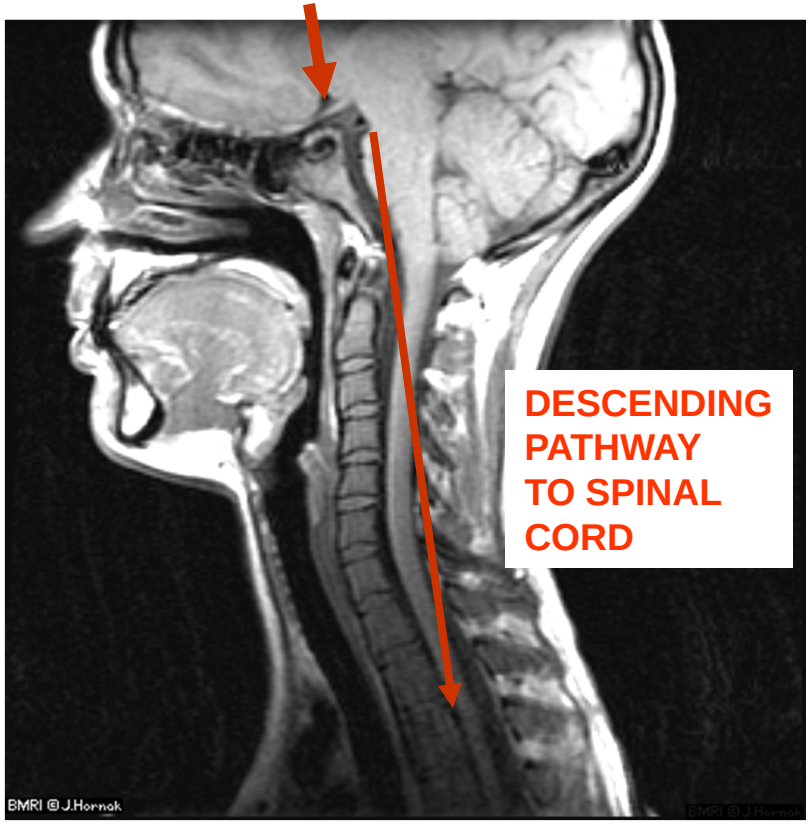
Consequence; SYMPATHETICS ARE ANATOMICALLY MUCH MORE WIDESPREAD THAN PARA-SYMPATHETICS; PATHWAYS MORE COMPLEX

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)

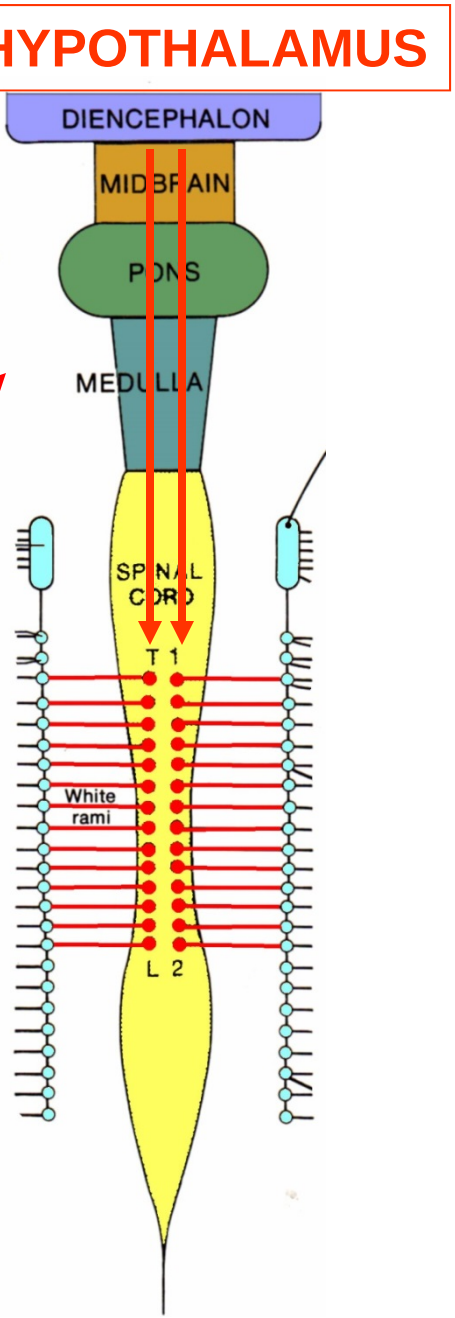
RESPONSES TO INCREASED TEMPERATURE (Anterior Hypothalamus/Preoptic area)

- 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



HYPOTHALMUS: CONTROL OF SYMPATHETIC FUNCTION

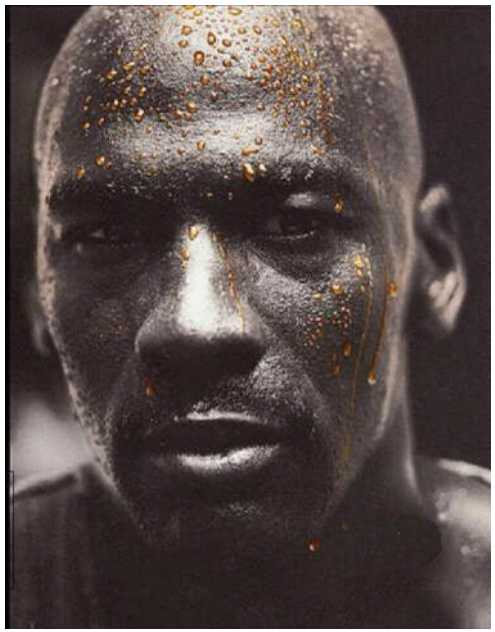
Hypothalamo-spinal tract - descending signals to Pre-ganglionic neurons in Spinal Cord

Sympathetic outflow at Thoracic and Lumbar levels

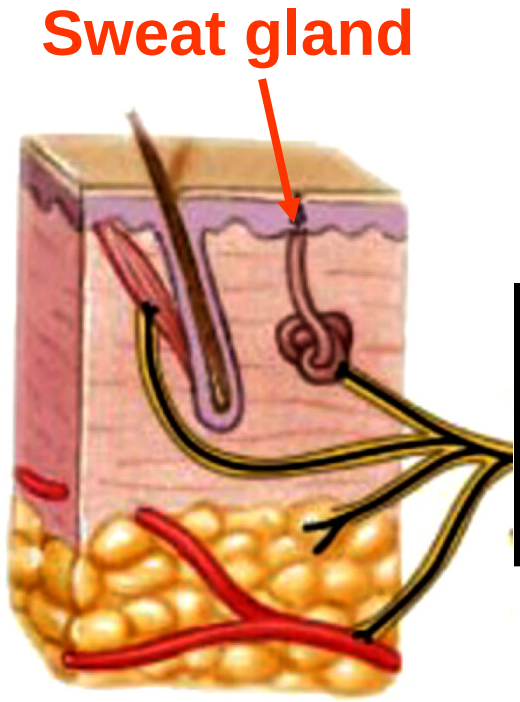
MEDIATED BY SYMPATHETICS

SOME REGULATORY PROCESS REQUIRE WIDESPREAD ACTIVATION OF TARGET ORGANS

EXAMPLE: THERMOREGULATION



Michael Jordan sweating Gatorade ($)

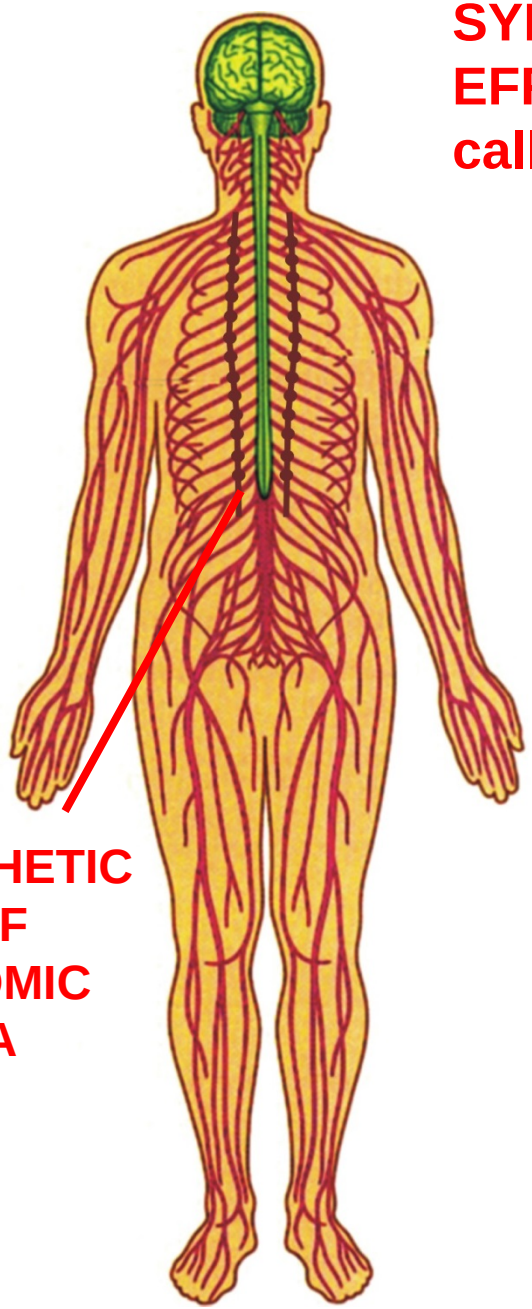


RESPONSE TO CHANGES IN BODY TEMPERATURE MEDIATED BY SYMPATHETICS (NOT PARASYMPATHETICS)

INCREASED TEMPERATURE
- increased secretion of sweat glands

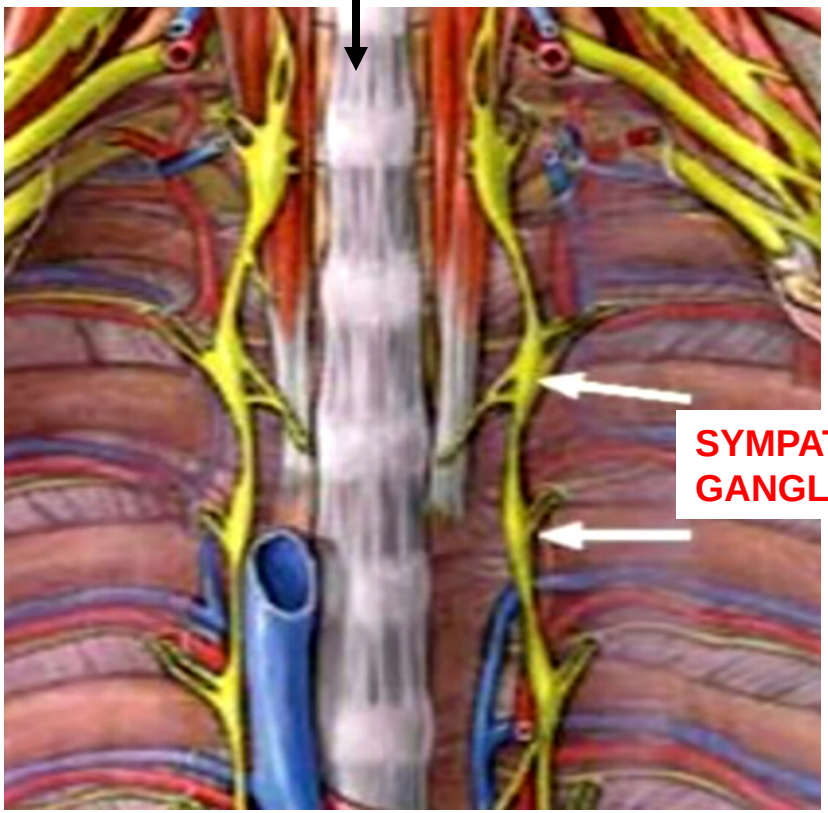
There are over 2 million sweat glands in the human body; how does the Nervous system activate them simultaneously?

SYMPATHETICS HAVE WIDESPREAD EFFECTS BY SYMPATHETIC CHAIN - called Paravertebral Ganglia



SYMPATHETIC CHAIN OF AUTONOMIC GANGLIA

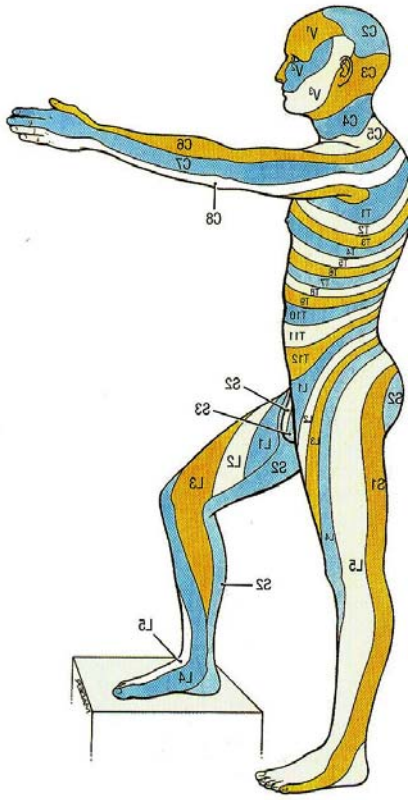
Bodies of Thoracic Vertebrae (anterior side)



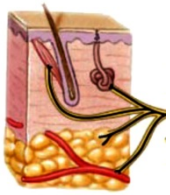
View of the anterior side (front) of vertebrae inside the thorax (chest cavity); chain of ganglia are on sides of vertebrae (paravertebral)

SYMPATHETICS ARE DISTRIBUTED WITH PERIPHERAL NERVES

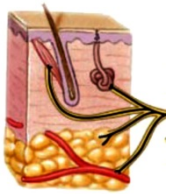
PATHWAYS TO SKIN



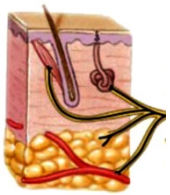
SKIN



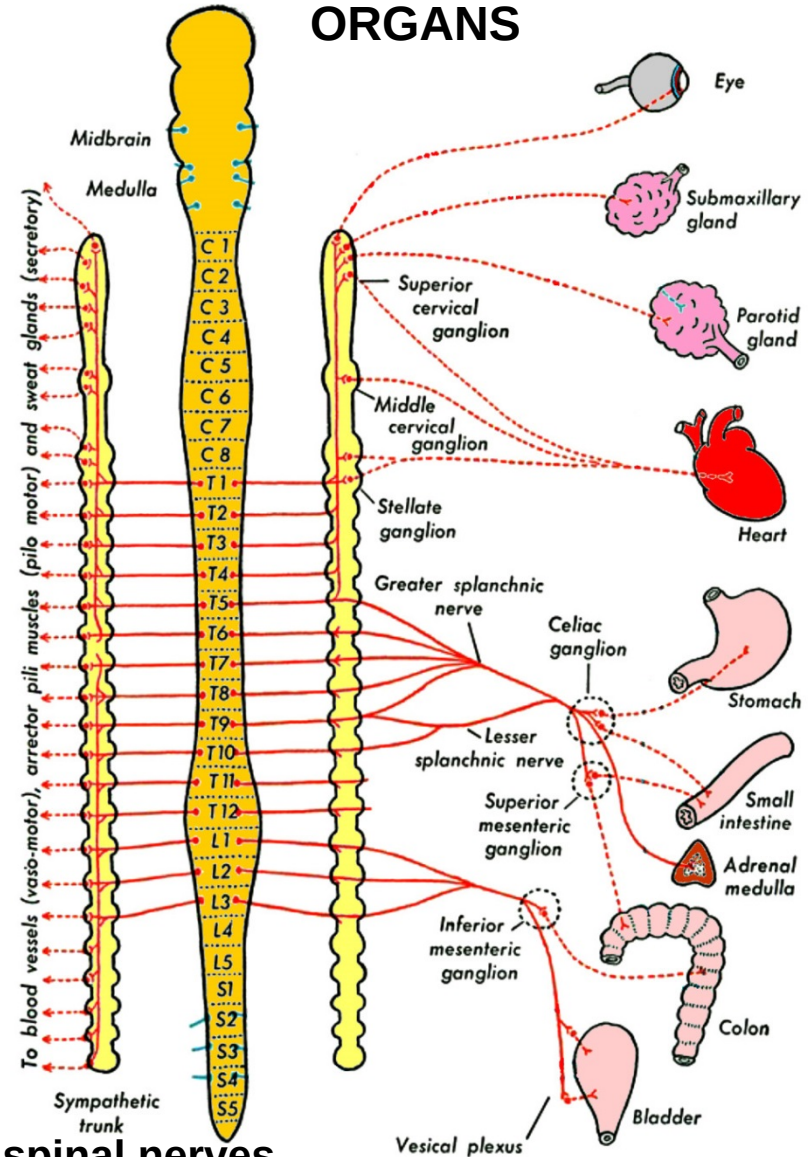
SKIN



SKIN



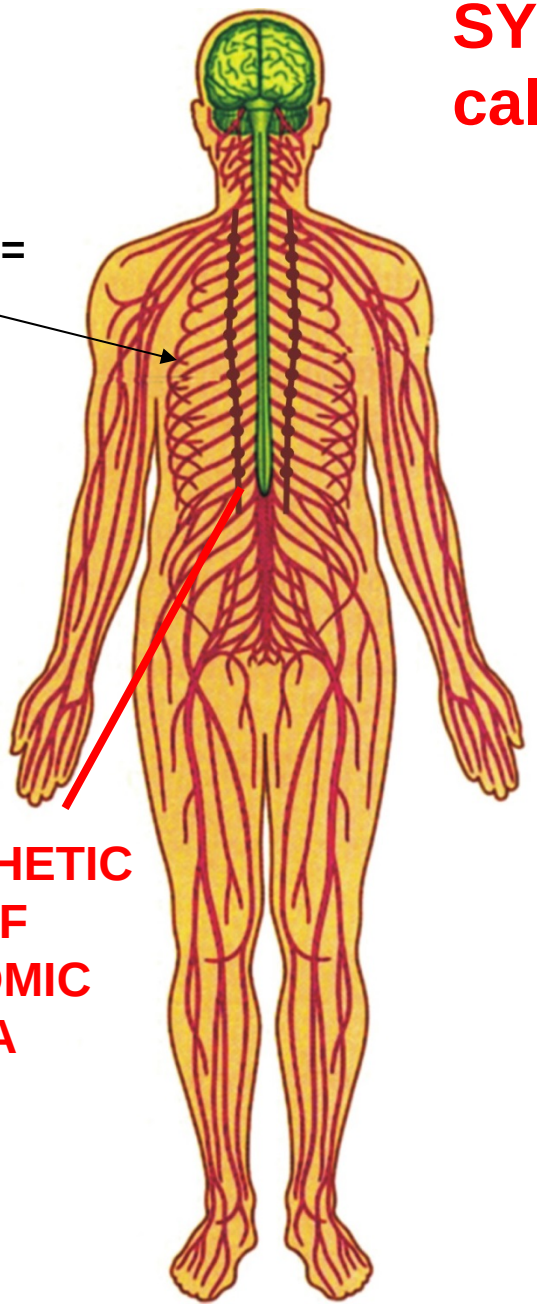
PATHWAYS TO INTERNAL ORGANS



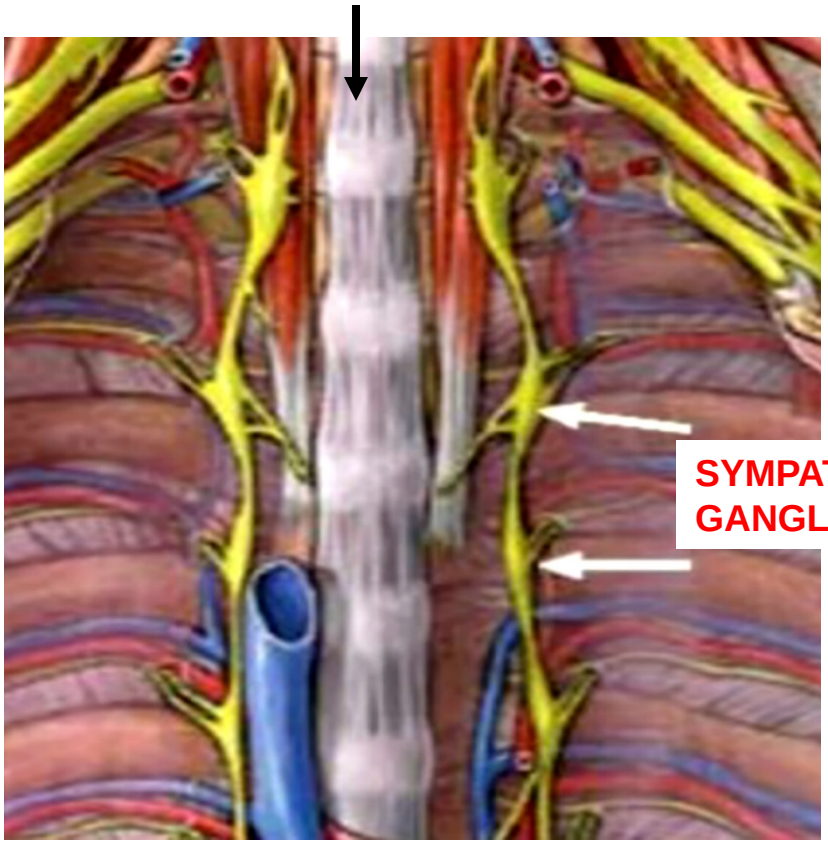
PATHWAYS TO SKIN

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

SYMPATHETIC CHAIN OF GANGLIA - called Paravertebral Ganglia

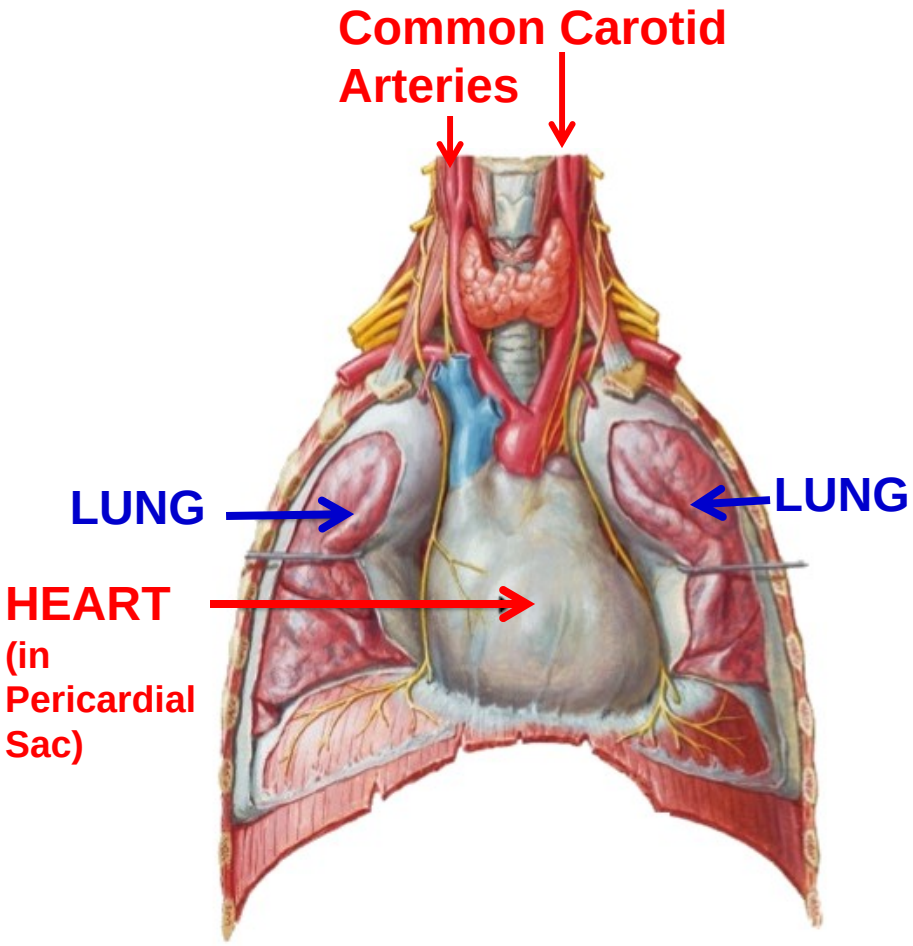


Bodies of Thoracic Vertebrae (anterior side)

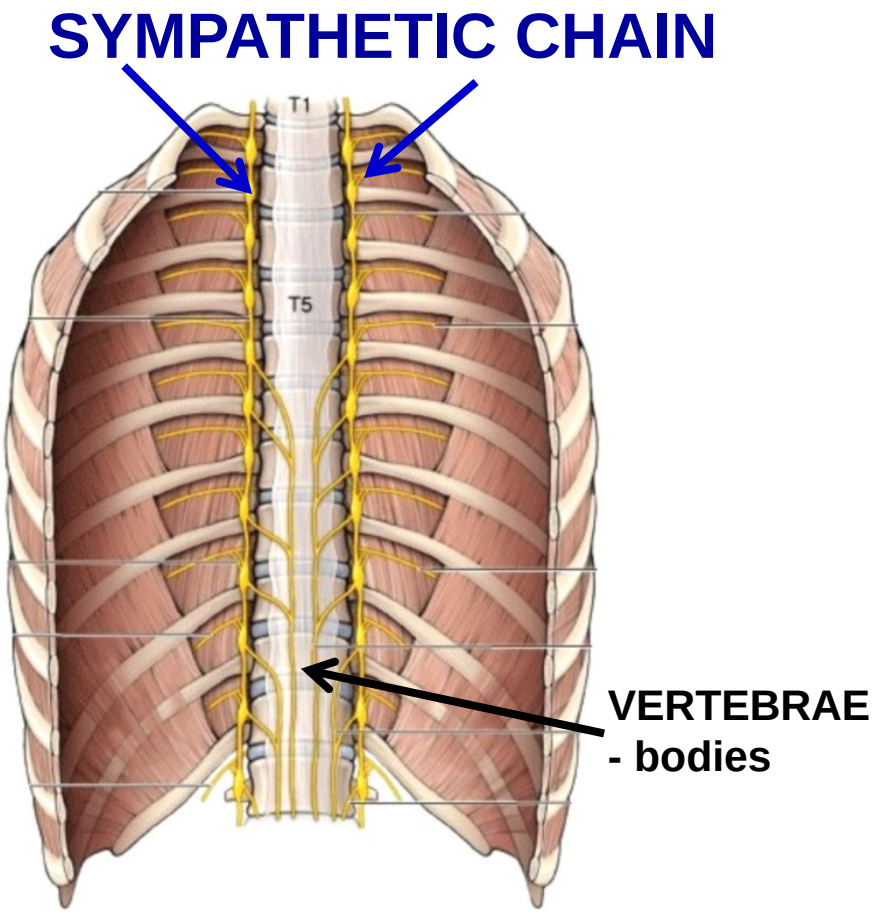


View of the anterior side (front) of vertebrae inside the thorax (chest cavity); chain of ganglia are on sides of vertebrae (paravertebral)

LOCATION OF SYMPATHETIC CHAIN



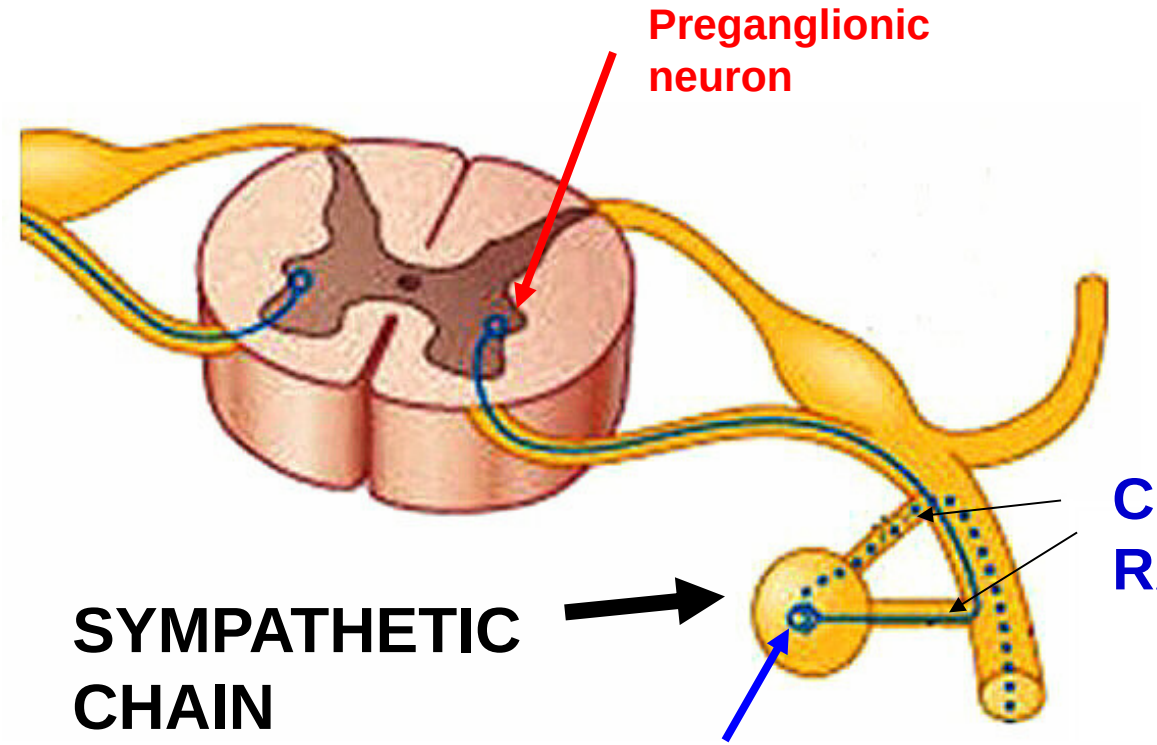
THORAX DISSECTION - remove ribs from anterior wall; see Heart and Lungs



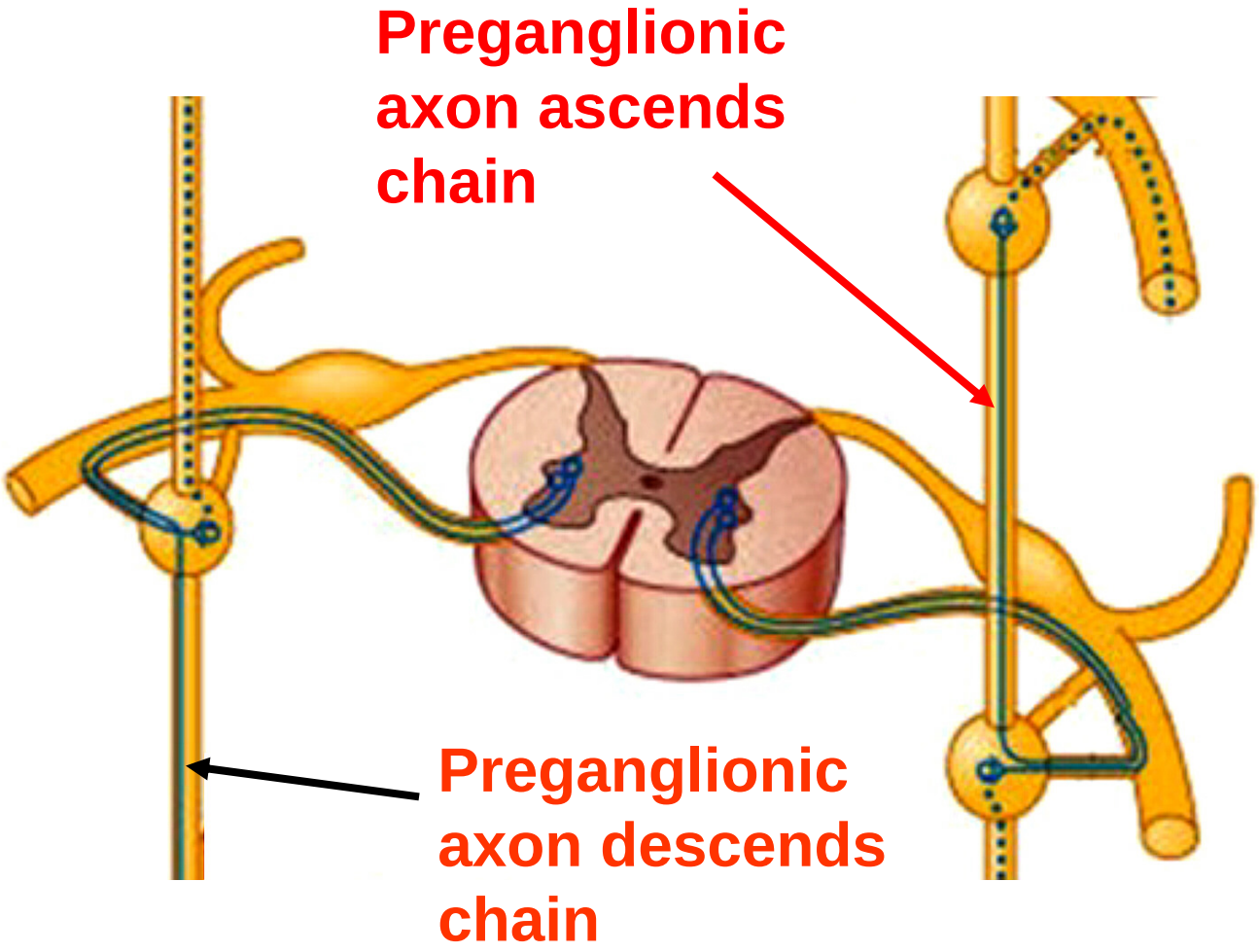
REMOVE HEART AND LUNGS - Thorax is hollow; Vertebral bodies on posterior wall; Sympathic chain on sides of vertebral bodies

II. ANATOMICAL ORGANIZATION SYMPATHETIC OUTFLOW OCCURS BY THREE PATHWAYS

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

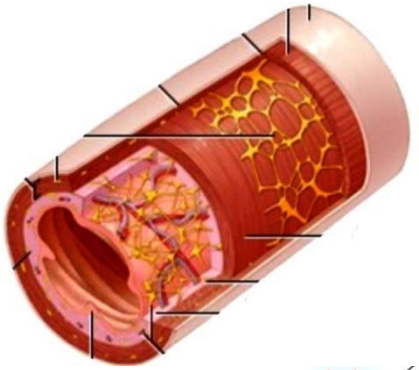


2) SYMPATHETICS ASCEND OR DESCEND SYMPATHETIC CHAIN TO TERMINATE IN OTHER GANGLIA

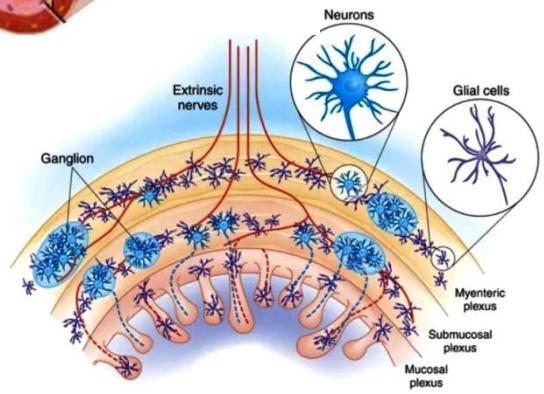


3) SYMPATHETICS LEAVE CHAIN WITHOUT SYNAPSING; FORM NERVES CALLED SPLANCHNIC NERVES - SYNAPSE IN PRE-AORTIC GANGLIA

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

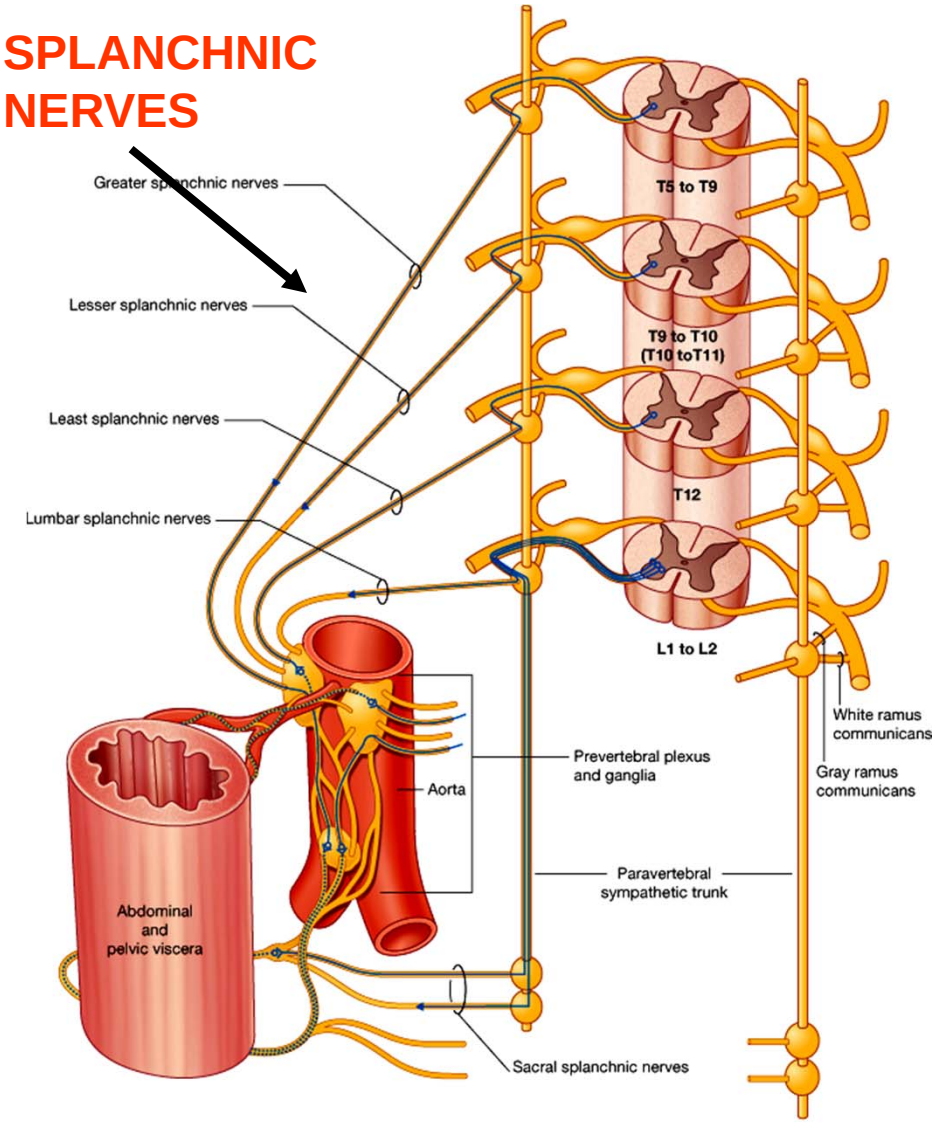


GUT - ENTERIC NERVOUS SYSTEM

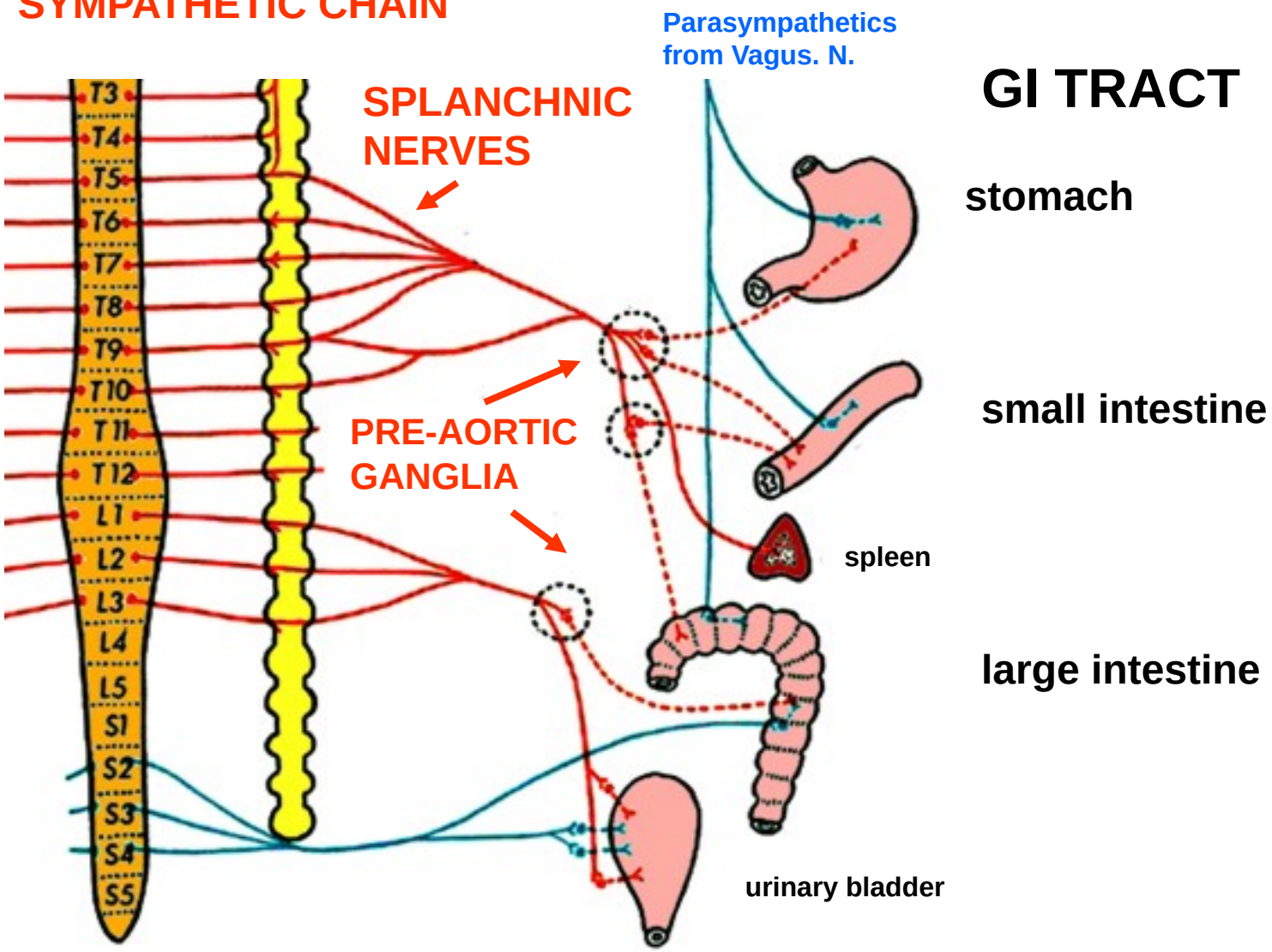


RECENT RESEARCH - INTERACTION BETWEEN IMMUNE SYSTEM AND NERVOUS SYSTEM: Rescigno, Nature 2008

SPLANCHNIC NERVES

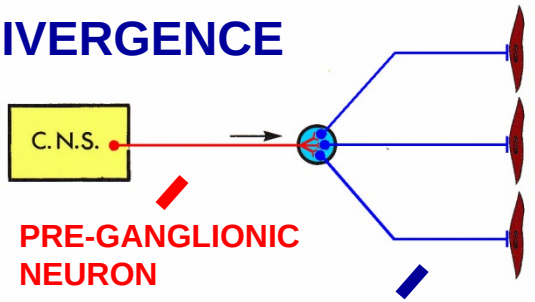


SPLANCHIC NERVES: SYMPATHETICS TO INTERNAL ORGANS IN ABDOMEN, PELVIS - COVERED IN SPRING



FUNCTION OF COMPLEXITY, 2 NEURON ARC: DIVERGENCE

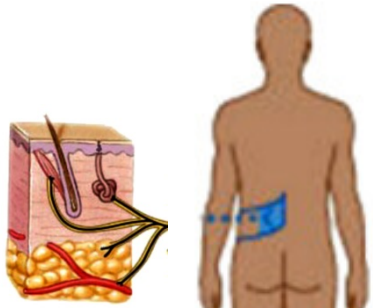
ONE PRE-GANGLIONIC NEURON ACTIVATES MANY POST-GANGLIONIC NEURONS

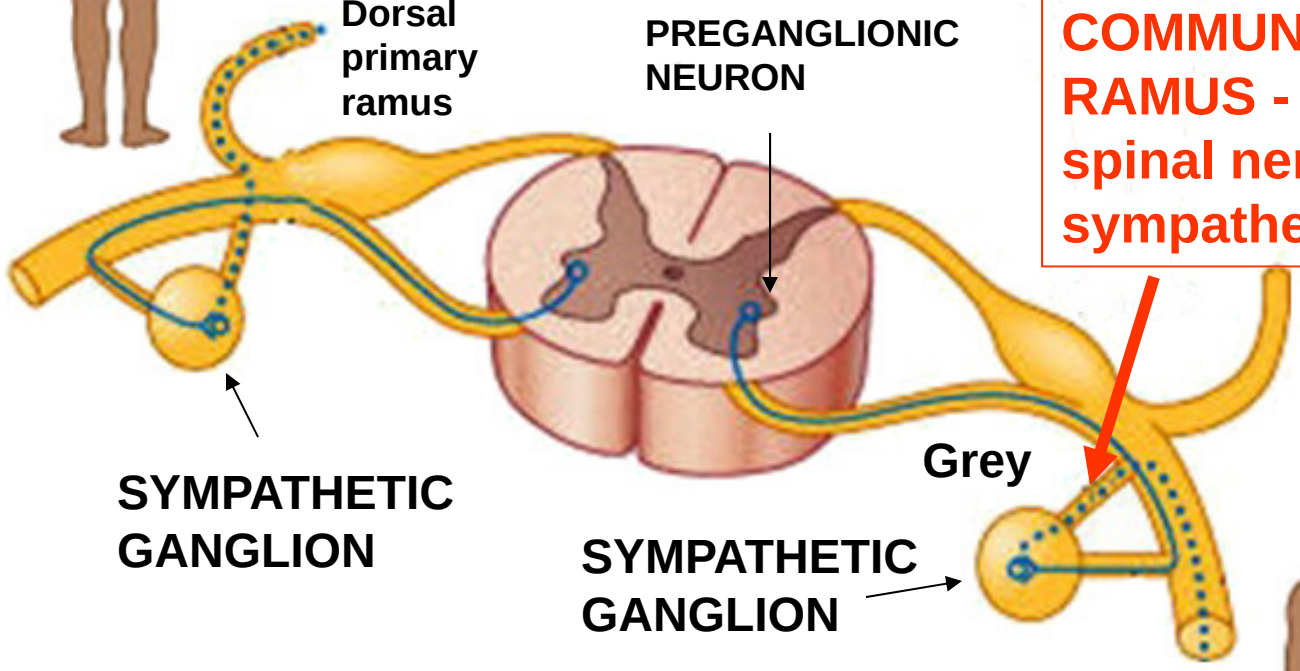


MIDNIGHT RIDE OF PAUL REVERE - 'British are coming, British are coming....'

SYMPATHETICS GET TO SKIN: BY TWO OF THE PATHWAYS

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

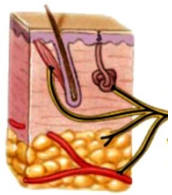




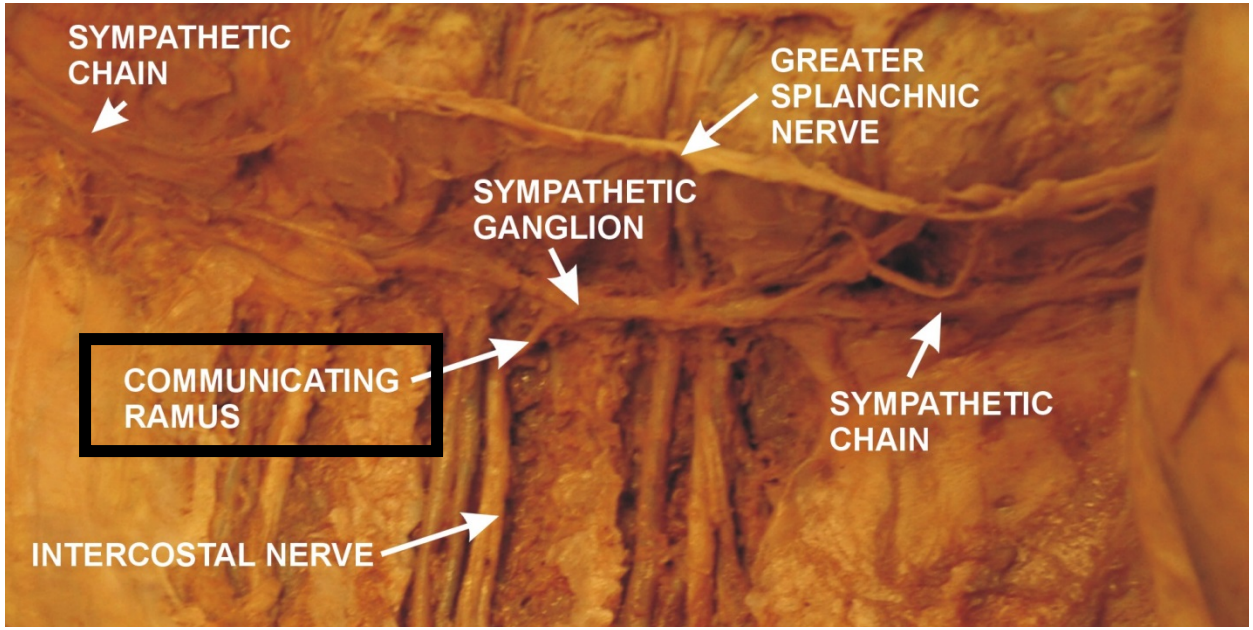
COMMUNICATING RAMUS - connects spinal nerve and sympathetic ganglion

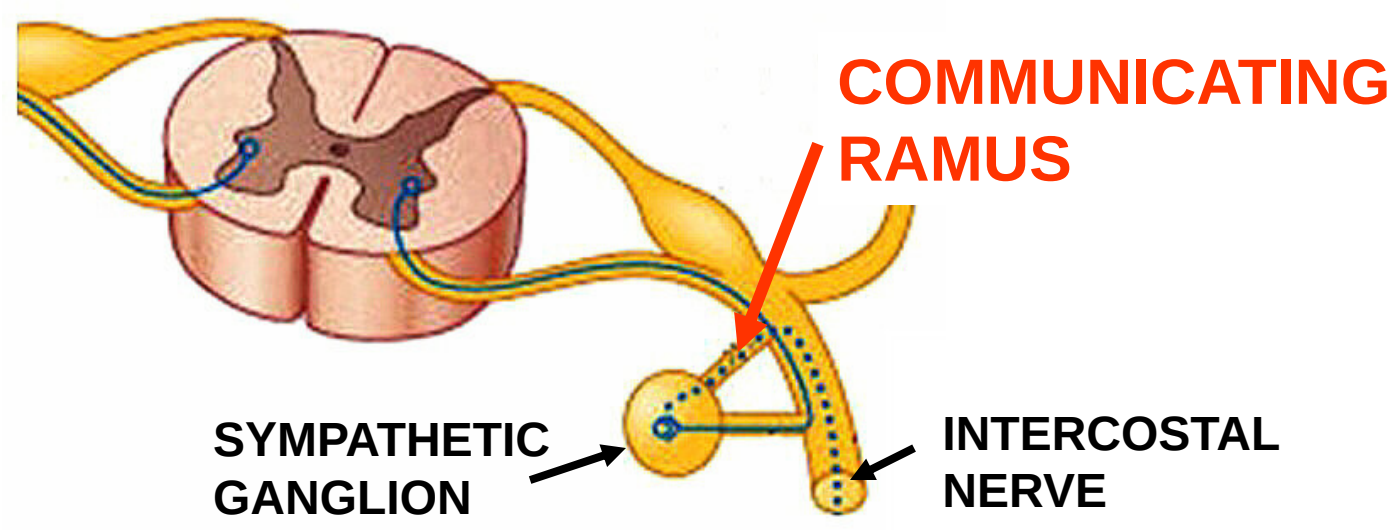
IN THORAX, POST-GANGLIONIC NEURONS THEN JOIN INTERCOSTAL NERVES; DISTRIBUTED TO SKIN

INTERCOSTAL NERVE TO SKIN OF THORAX

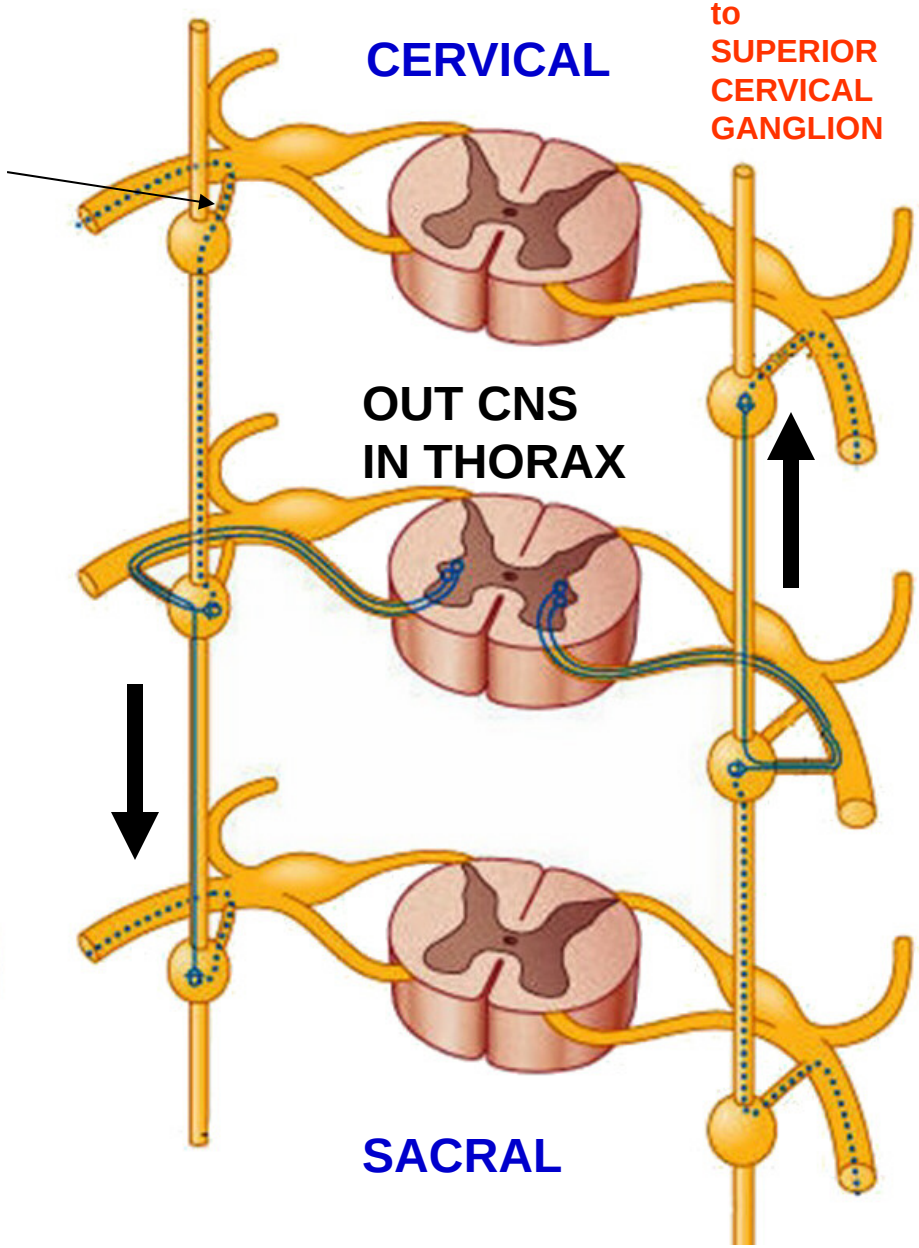


Ventral primary ramus

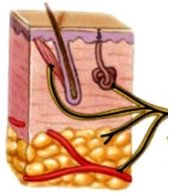

SYMPATHETIC CHAIN
GREATER SPLANCHNIC NERVE
SYMPATHETIC GANGLION
COMMUNICATING RAMUS
SYMPATHETIC CHAIN
INTERCOSTAL NERVE

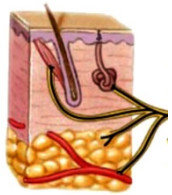

COMMUNICATING RAMUS
SYMPATHETIC GANGLION
INTERCOSTAL NERVE

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



SYMPATHETICS TO SKIN, BLOOD VESSELS BELOW L3





EX. join nerves of Brachial Plexus to Skin of Arm, Hand

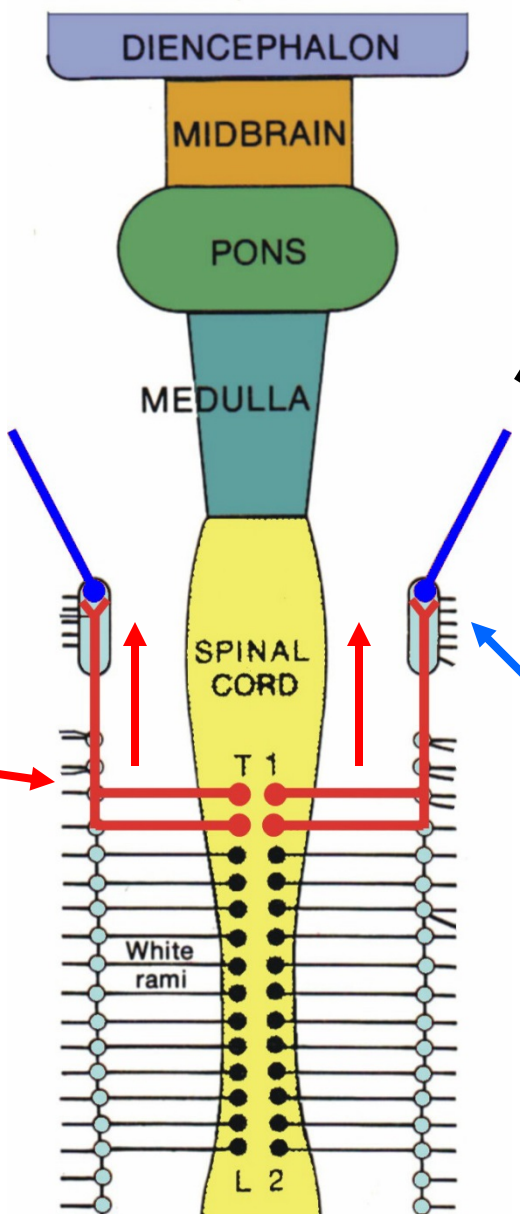
SYMPATHETICS TO SKIN, BLOOD VESSELS ABOVE T1

SYMPATHETICS TO HEAD

PATHWAY TO HEAD -

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

- leaves and ascends sympathetic chain



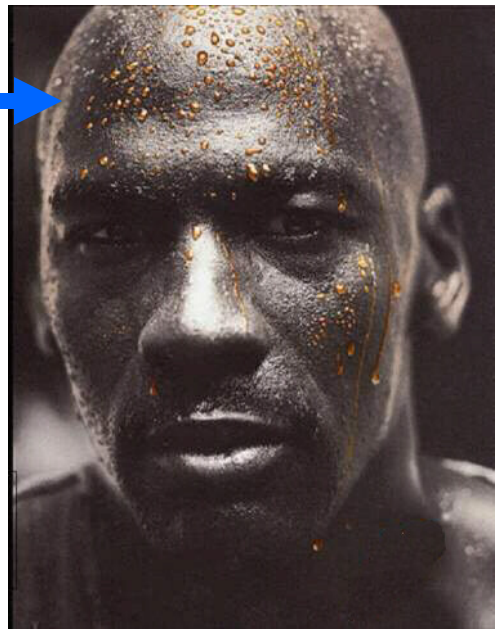
to Target Organ

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

INTERNAL CAROTID PLEXUS



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

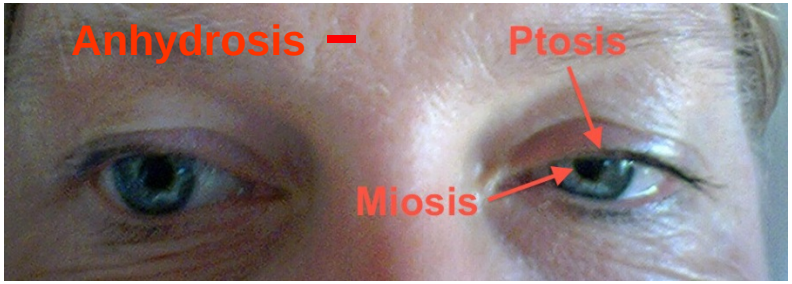
1) OUT T1, T2

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

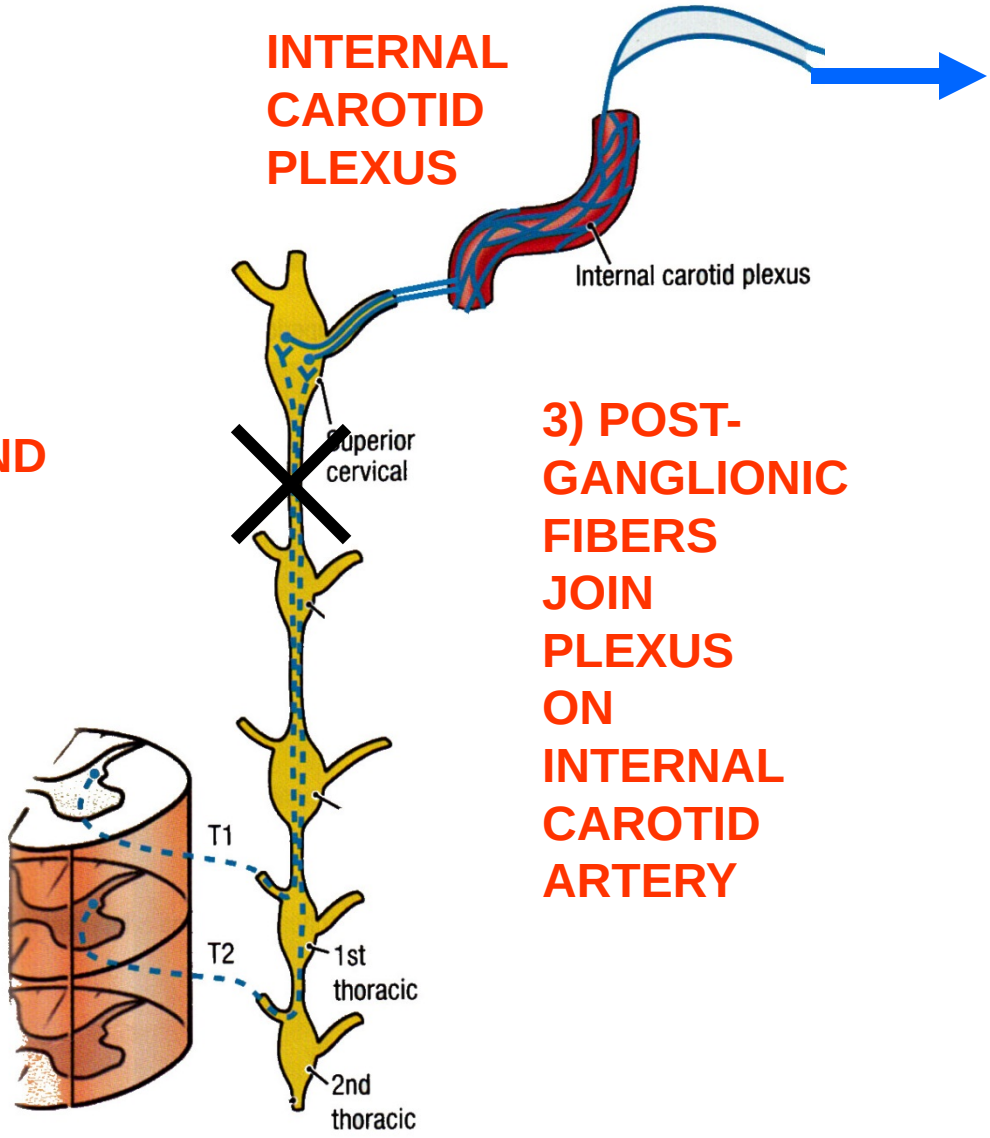


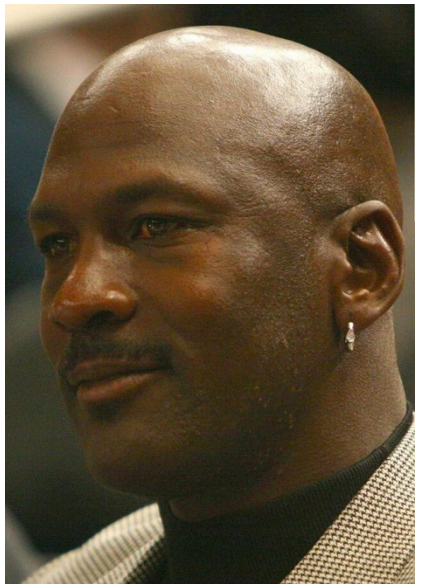
HORNER'S SYNDROME - damage to Sympathetic pathways: symptoms involve structures of eye and head -

SYMPTOMS -
MIOSIS - pupillary constriction
PTOSIS - drooping eyelid
ANHYDROSIS - lack of sweating

1) ANHYDROSIS - LESION TO SYMPATHETICS BLOCKS SWEATING

INTERNAL CAROTID PLEXUS





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

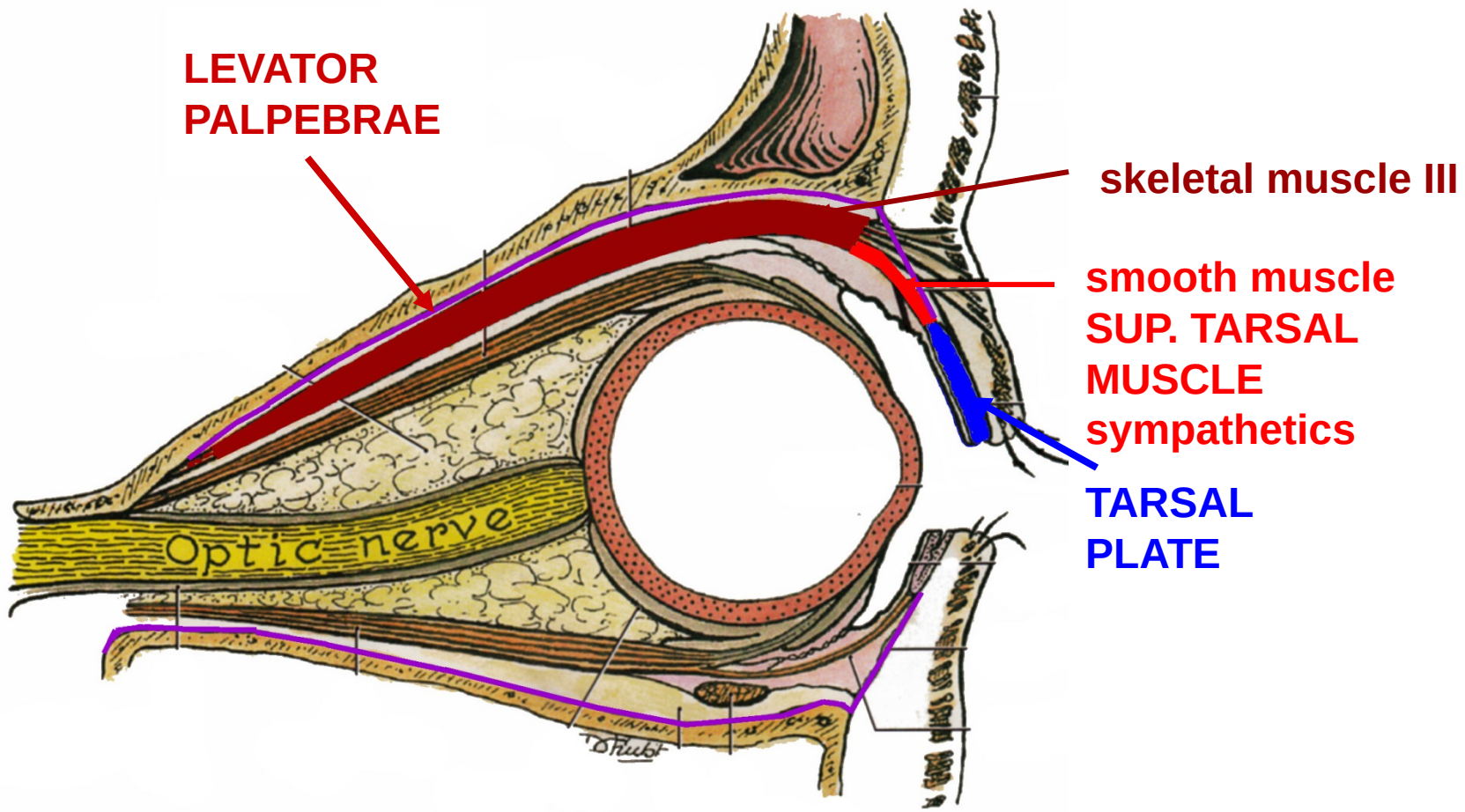
3) POST-GANGLIONIC FIBERS JOIN PLEXUS ON INTERNAL CAROTID ARTERY

LACK OF SWEATING = ANHYDROSIS

1) OUT T1, T2

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

2) PTOSIS: MUSCLE OF EYELID: LEVATOR PALPEBRAE SUPERIORIS

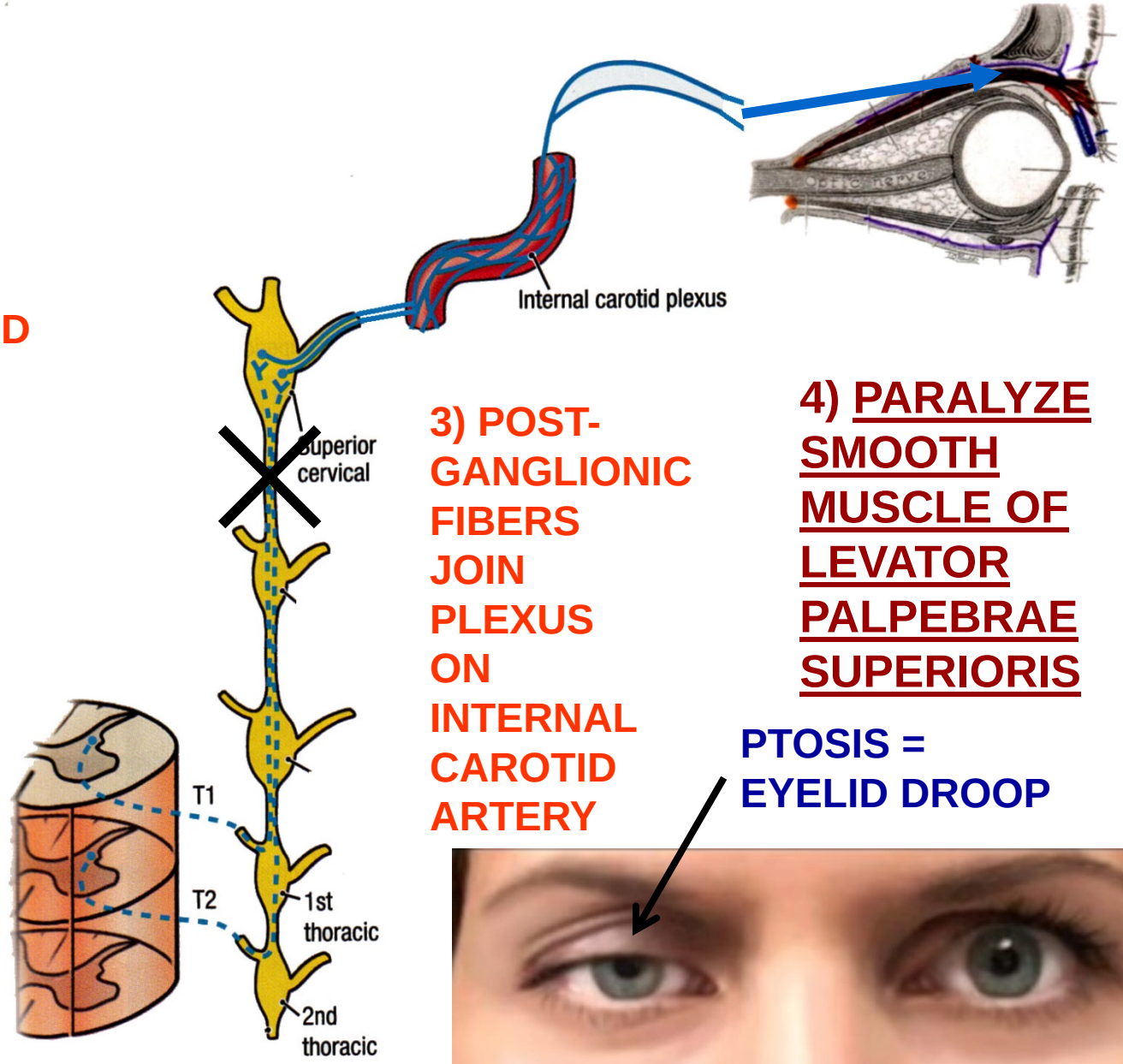


LEVATOR PALPEBRAE SUPERIORIS MUSCLE - ORIGIN FROM TENDINOUS RING - COMPOSED OF SKELETAL (CN III) & SMOOTH (SYMPATHETICS) MUSCLE PARTS

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

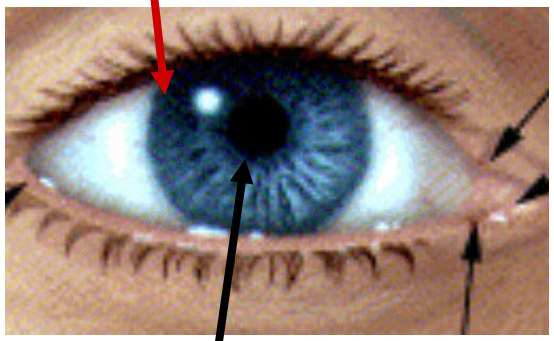
4) PARALYZE SMOOTH MUSCLE OF LEVATOR PALPEBRAE SUPERIORIS

PTOSIS = EYELID DROOP

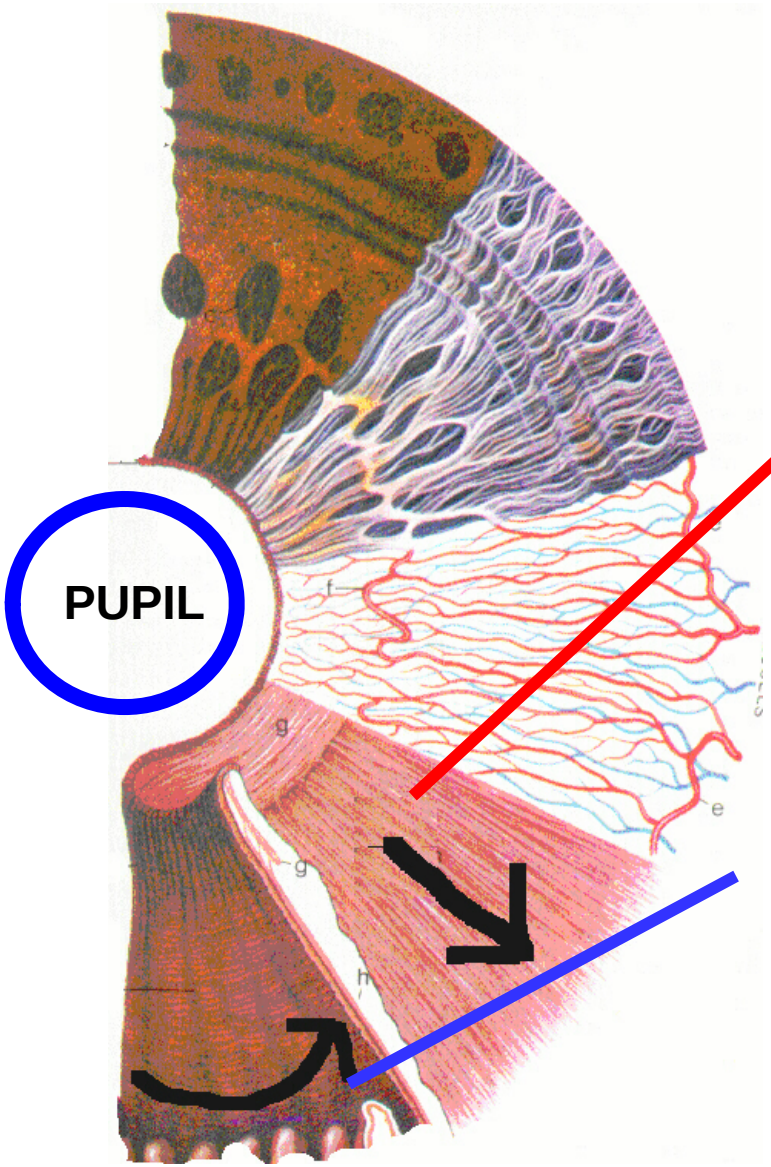
3) MIOSIS - CONSTRICTED PUPIL

IRIS - PIGMENTED, CONTRACTILE LAYER SURROUNDING PUPIL

IRIS - PIGMENTED



PUPIL



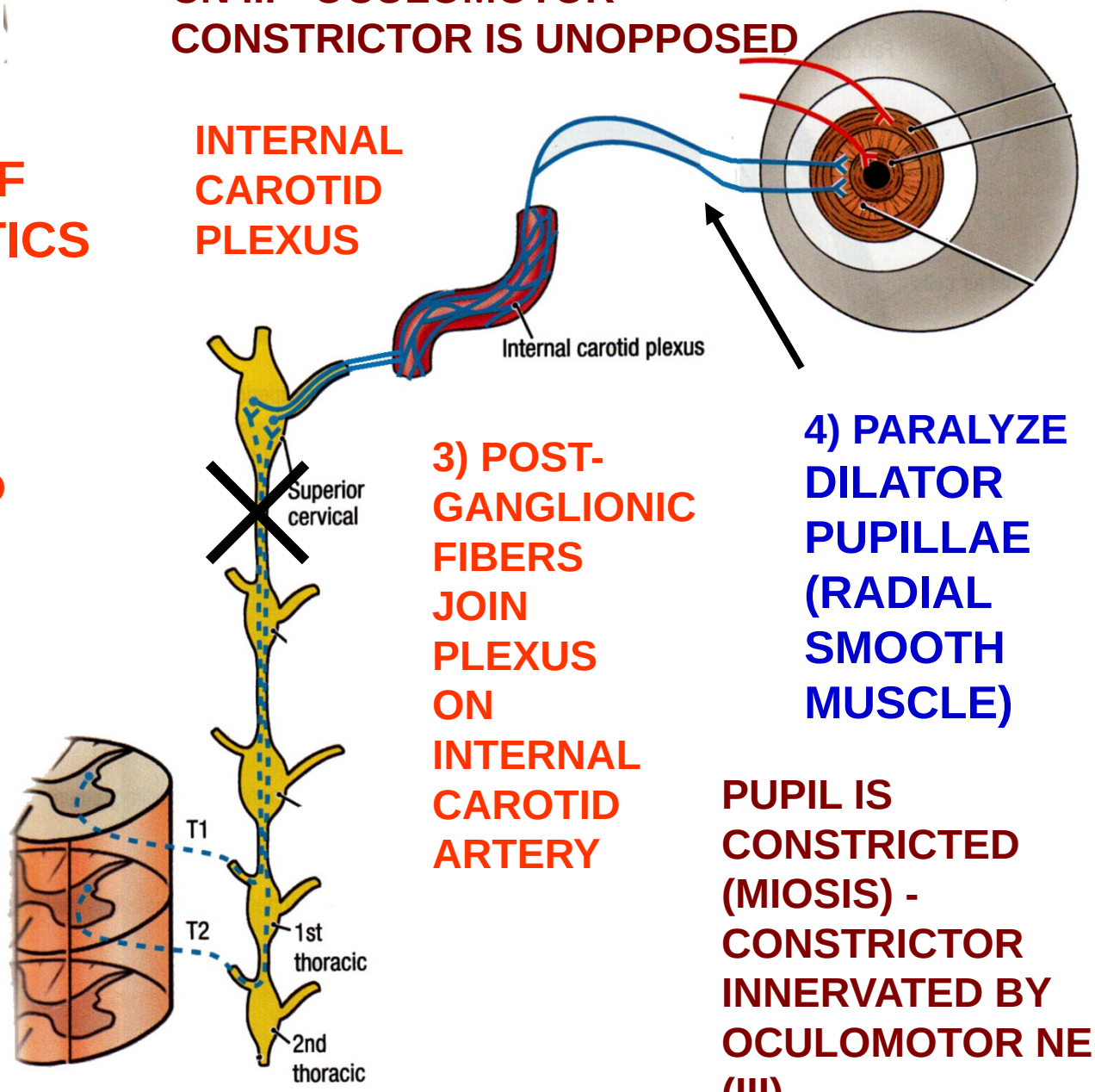
DILATOR PUPIL M.- RADIAL SMOOTH MUSCLE; SYMPA-THETICS

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

CN III - OCULOMOTOR CONSTRICTOR IS UNOPPOSED

3) MIOSIS - DAMAGE PATHWAY OF SYMPATHETICS TO EYE

INTERNAL CAROTID PLEXUS



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

1) OUT T1, T2

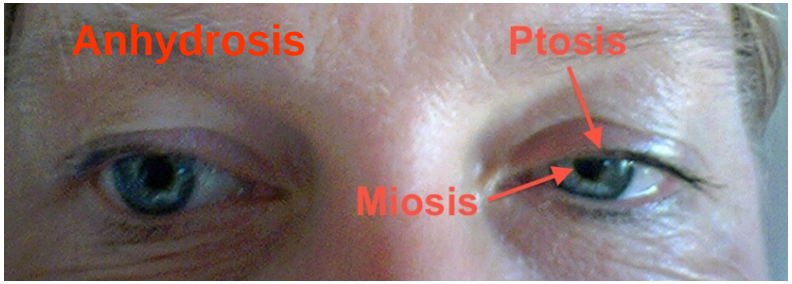
3) POST-GANGLIONIC FIBERS JOIN PLEXUS ON INTERNAL CAROTID ARTERY

4) PARALYZE DILATOR PUPILLAE (RADIAL SMOOTH MUSCLE)

PUPIL IS CONSTRICTED (MIOSIS) - CONSTRICTOR INNERVATED BY OCULOMOTOR NERVE (III)

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

HORNER'S SYNDROME



CLINICAL

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

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

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

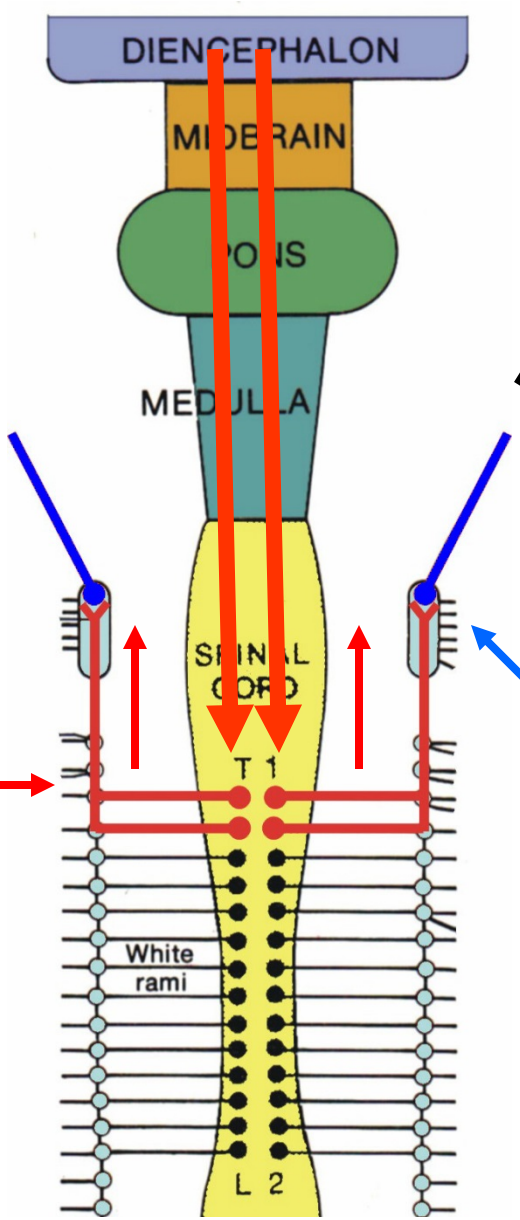
SUMMARY CHART: HORNER'S SYNDROME

Symptom	Structure innervated	Damage
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 produce eyelid droop
Miosis (constricted pupil)	Pupillary dilator muscle	Damage paralyzes Dilator muscle; pupil is constricted (Constrictor pupillae muscle is intact)

HYPOTHALAMUS

LESIONS CAN OCCUR IN MANY PLACES IN PATHWAY

HYPOTHALAMO-SPINAL TRACT



to Target Organ

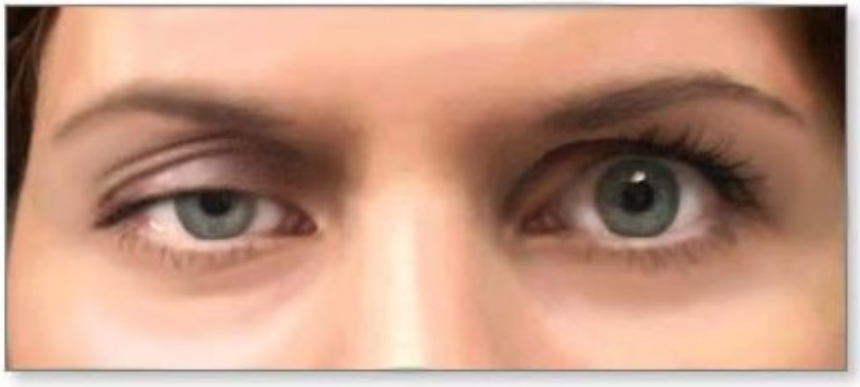
PATHWAY TO HEAD -

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

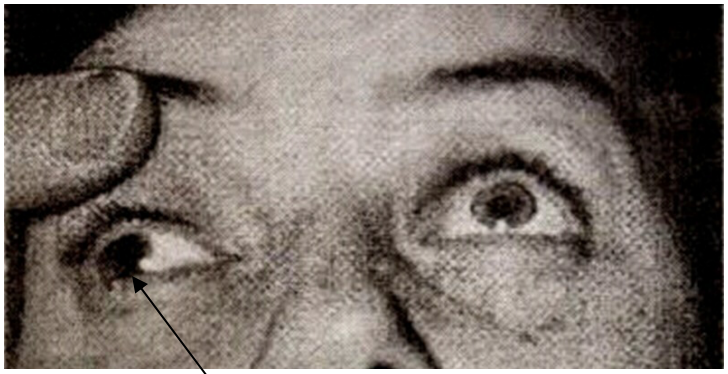
2) Neuron 2 (Postganglionic neuron) In Superior Cervical Ganglia

PTOSIS = DROOPING EYELID; CAN BE SIGN OF DAMAGE TO <u>OCULOMOTOR NERVE (III) OR</u> SYMPATHETICS

Ptosis (drooping of the eyelid)

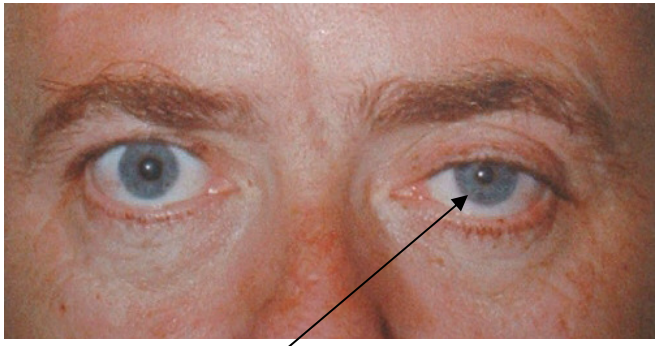


SKELETAL MUSCLE PART



OCULOMOTOR NERVE PALSY
other symptoms:
- <u>Pupil is dilated - denervate Pupillary constrictor (Mydriasis)</u>
- Also affect Eye movements
- Accommodation

SMOOTH MUSCLE PART



SYMPATHETICS - HORNER'S SYNDROME -
- <u>Miosis - denervate Pupillary dilator; constricted pupil</u>
- Anhydrosis - lack of sweating

**

SYMPTOM – EYELID DROOP + CONSTRICTED PUPIL

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

Structure	Horner's Syndrome	Oculomotor Palsy (nerve damage)
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 paralyzed; Pupillary constrictor muscle intact	Pupil dilated (Mydriasis) - pupilllary constrictor muscle paralyzed; 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 - affect by Oculomotor Palsy; no effect if damage Sympathetics.

NASAL CAVITY

I. **NASAL CAVITY** - openings - anteriorly opens to Anterior Nares, posteriorly at Choanae (Posterior Nares); cavity lined by mucoperiosteum.

A. Nasal Cartilages - Septal Cartilage with fused Lateral Nasal Cartilages; Alar Cartilages - surround medial side of nostrils; function - direct inhalation toward mouth (smell what you eat).

B. Nasal Cavity Boundaries; Floor = palate - Maxillary bone (palatine process) and Palatine (horizontal plate) bones; Roof - Nasal, Frontal, Ethmoid and Sphenoid bones; Medial wall = nasal septum: Septal cartilage, Ethmoid bone and Vomer; Lateral Wall - Nasal, Maxillary, Ethmoid, Palatine and Sphenoid bones and Inferior Nasal Concha.

Clinical Note: **Fractures of nose are common**; **fractures of cribriform plate** of Ethmoid (which forms roof of nasal cavity and floor of anterior cranial fossa) can lead to meningitis or **cerebrospinal fluid leakage** into nasal cavity if the dura is torn.

C. Nasal Conchae (L. shell) - also called Turbinates - projections from lateral wall increase surface area of mucosa to warm, humidify, and clean air; Superior and Middle conchae are part of Ethmoid bone; Inferior concha is a separate bone.

Note: Opening of auditory tube is in nasopharynx, posterior to inferior concha.

1. Four Spaces of Nasal Cavity associated with conchae, each space (Meatus, L. passage) has its own openings for nerves, air sinuses or nasolacrimal duct.

Space	**Location**	**Openings/Sinuses**
Sphenoethmoidal Recess	**Above Superior Concha**	1) Olfactory foramina of cribriform plate and 2) Sphenoidal air sinus (opening)
Superior Meatus	**Below Superior Concha**	1) Posterior Ethmoidal Air sinus (opening)
Middle Meatus	**Below Middle Concha - parts** **Ethmoidal Bulla -** rounded elevation in wall **Hiatus Semilunaris -** slit below Ethmoid Bulla **Infundibulum -** anterior part of Hiatus	1) Middle Ethmoidal sinuses open onto Ethmoidal bulla 2) Anterior Ethmoidal sinus - open to Hiatus 3) Maxillary sinus opens to Hiatus Semilunaris; 4) Frontal sinus drains to Infundibulum
Inferior Meatus	**Below Inferior Concha**	1) Nasolacrimal duct (opening)

Clinical Note: **Opening of Maxillary sinus is high up (superior)** on wall of sinus, can lead to **poor drainage** of sinus when infected.

C. Divisions - Respiratory area - lower part of mucosa, lined with respiratory epithelium; Olfactory area - upper part of mucosa, lined with olfactory epithelium

D. Nerves

1. **Olfactory** area - Olfactory nerve (CN I, sense of smell)
2. **General sensation** (touch, temperature, etc.) **Somatic Sensory branches from V1 and V2** - Anterior Ethmoidal nerve (from V1) and Nasopalatine nerve and Nasal branches (from V2)
3. **Parasympathetic Innervation to nasal mucous glands** - **Facial nerve (CN VII)** - Visceral Motor (Parasympathetic) from Pterygopalatine ganglion; branches of Facial nerve (VII) travel with Trigeminal nerve (V)

E. Blood supply

1. Arteries - Mostly from Sphenopalatine artery (branch of Maxillary artery); also from Anterior and Posterior Ethmoidal arteries (branches of Ophthalmic artery) and branches of Facial artery (anteriorly).

2. Veins - Ethmoidal veins drain to Ophthalmic vein; other branches to Pterygoid venous plexus and Facial vein.

Clinical Note: **Epistaxis (Nosebleed)** - Rich anastomoses in nose results in epistaxis (nosebleed) often due to tearing of veins; spurting of blood occurs from tears of arteries.

F. Lymphatics - drain to Retropharyngeal nodes.

II. **PARANASAL AIR SINUSES** - air filled extensions of nasal cavities; all are paired; develop after birth; lined by mucous membrane; serve to lighten growing bones; possibly a mistake of evolution as could have filled growing bones with spongy (cancellous) bone and would not get infected.

A. Frontal sinus - two sinuses separated by a median septum; variable in size.
B. Sphenoid sinus - paired sinuses located in body of sphenoid bone
C. Ethmoidal sinus (also call air cells) - Anterior, Middle, and Posterior groups
D. Maxillary sinus - largest, occupies entire body of maxilla; Roof - floor of orbit; Medial wall - related to lower part nasal cavity.

Clinical Note: **Blocked Ethmoidal sinuses** may cause **infection** to pass laterally through thin medial wall of **Orbit** to infect eye.

Clinical Note: **Tooth Extraction Fractures Maxillary Bone** - Roots of teeth closely related to floor of sinus; Extraction of molar teeth can result in fracture of floor of sinus.

Clinical Note: **Maxillary Sinus Infections are sensed as Toothache** - Anterior and Posterior Superior alveolar branches of CN V2 supplies mucous membrane of maxillary sinus and teeth; infected sinus can result in sensation of **tooth ache**.

III. **PALATE DEVELOPMENT**

A. Development - occurs during 5-12th week

1. Two parts form palate: primary and secondary palates.

a. Primary palate (Median palatine process) - formed by union of Medial Nasal Processes, become part of palate anterior to incisive foramen, bearing incisor teeth

b. Secondary palate (posterior to incisive foramen) - formed of Maxillary processes of Arch I; Maxillary processes fuse with the Median Palatine processes anteriorly; posteriorly, Maxillary processes fuse with each other at midline; fusion proceeds anteriorly to posteriorly.

2. Malformations

a. **Anterior Cleft palate** - improper fusion of primary and secondary palates (**Medial Nasal processes and Maxillary processes fail to fuse**); cleft is anterior to incisive foramen; 1:1000 births

b. **Posterior Cleft palate** - improper fusion of parts of secondary palate (**Maxillary processes from each side fail to fuse with each other**); cleft is posterior to incisive foramen; 1:2500 births

IV. **PALATINE TONSILS** - located between palatoglossal and palatopharyngeal folds on lateral side of oropharynx; tonsils are a collection of lymphoid tissue covered by mucous membrane; lateral to tonsil is the tonsillar bed (lateral wall of pharynx)

A. Arteries - mainly from Tonsillar branch of Facial artery.

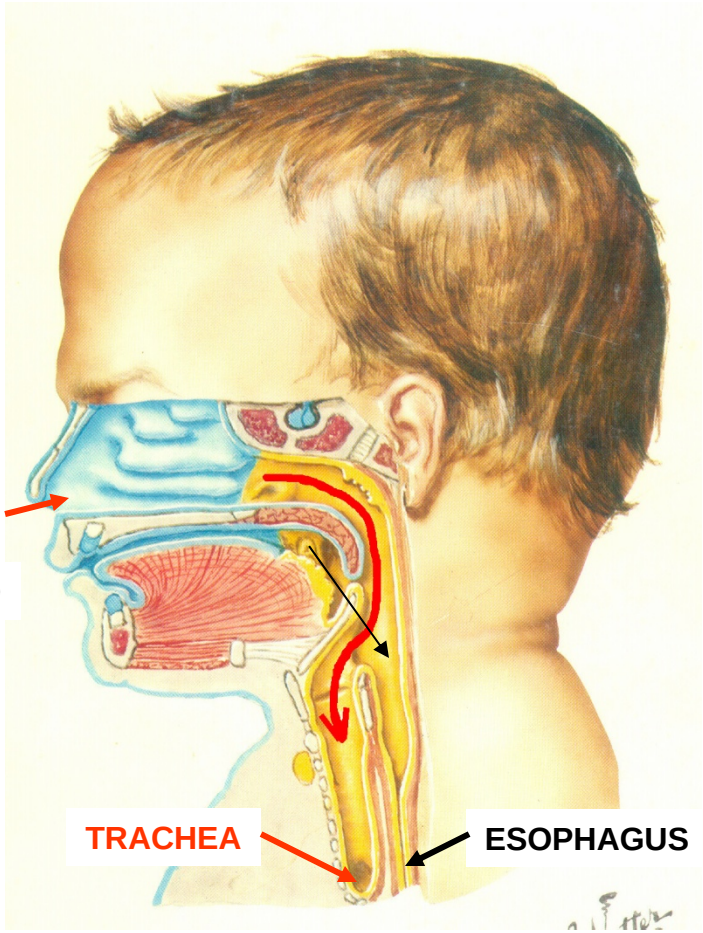
B. Veins - join pharyngeal plexus of veins which drain to Facial, Lingual or Internal Jugular veins.

Clinical Note: Bleeding after tonsillectomy - Tonsillar branch of Facial artery can bleed extensively after tonsillectomy.

Clinical Note: Damage Glossopharyngeal nerve in tonsillectomy - Glossopharyngeal n. - passes forward with Tonsillar artery in lateral wall of pharynx; only mucosa and fascia cover nerve; can be damaged in removal of tonsil.

C. Lymphatics - Drain to Jugulodigastric node (one of the Deep Cervical nodes, becomes enlarged during tonsillitis); located near angle of mandible and inferior to posterior belly of Digastric muscle.

NASAL CAVITY



OUTLINE:

I. NASAL CAVITY
II. PARANASAL AIR SINUSES
III. PALATE
IV. PALATINE TONSILS

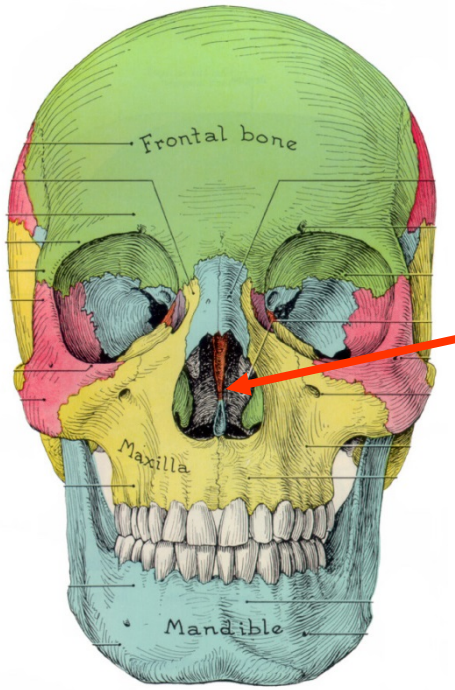
Problem: Nasal Cavity and Oral Cavity open to Pharynx; Path of air crosses path of food intake; Permits breathing when chewing
Solution: Soft Palate functions as flap valve
Clinical: Burrito story; Other - sinus infections, tonsillitis

NASAL CAVITY

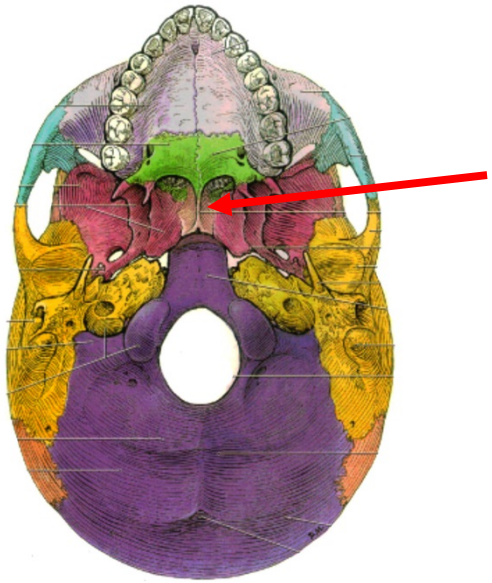
Upper most part of respiratory system

Functions:

1) Modifies air – warms, humidifies and filters
2) Sense smell – hunt animals, enjoy flowers, avoid noxious odors, allure of perfume

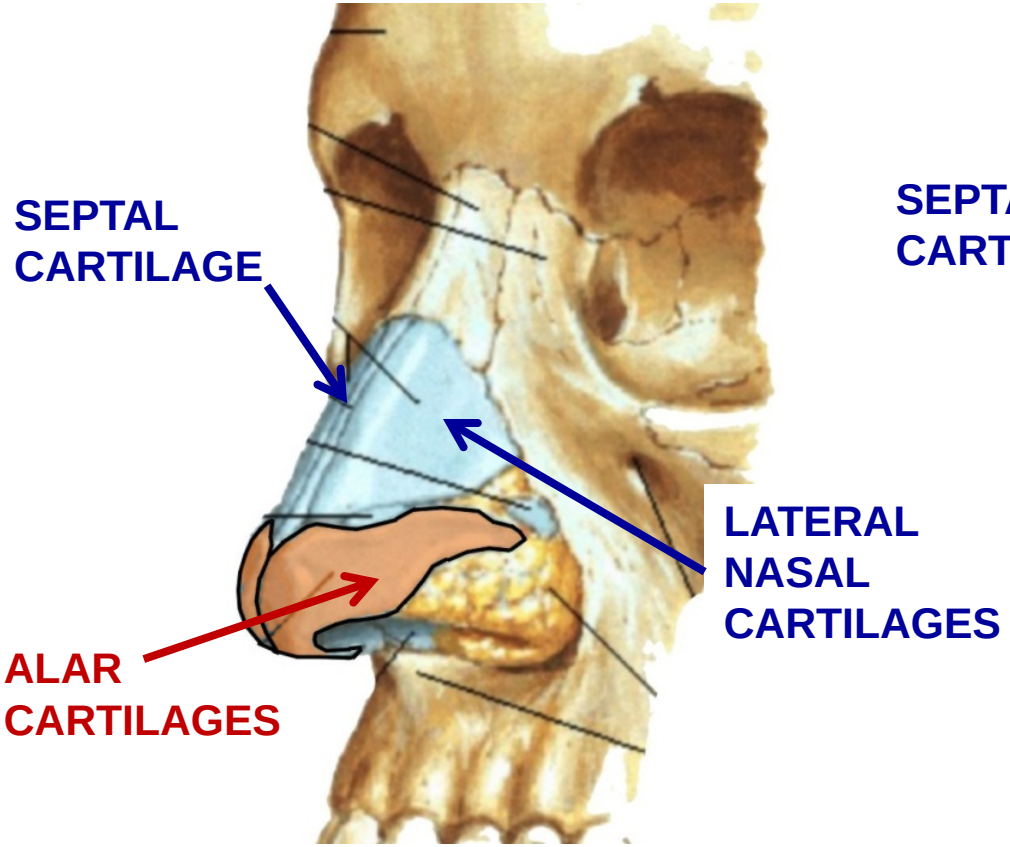


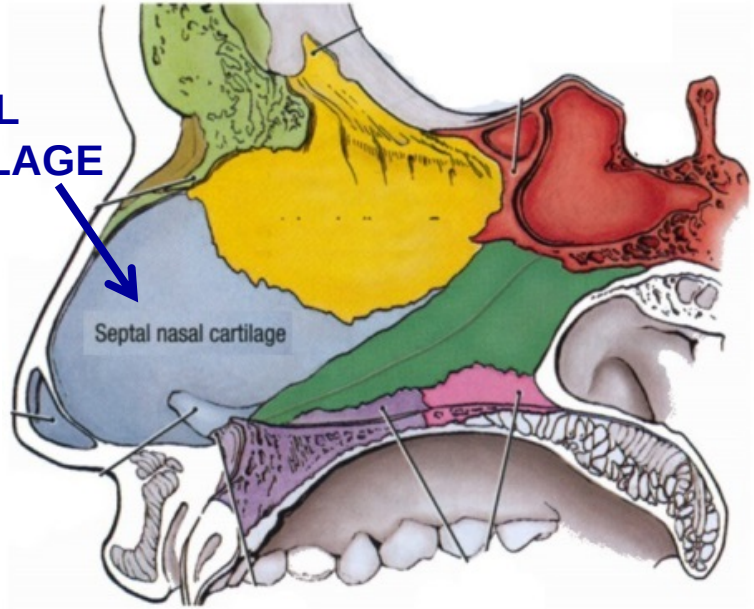
Ant. Opening = Anterior Nares



Post opening = Posterior Nares = Choanae (ko'-an-ay) (greek for funnels)

A. NASAL CARTILAGES





MIDLINE = VIEW OF NASAL SEPTUM

Nasal Cartilages -

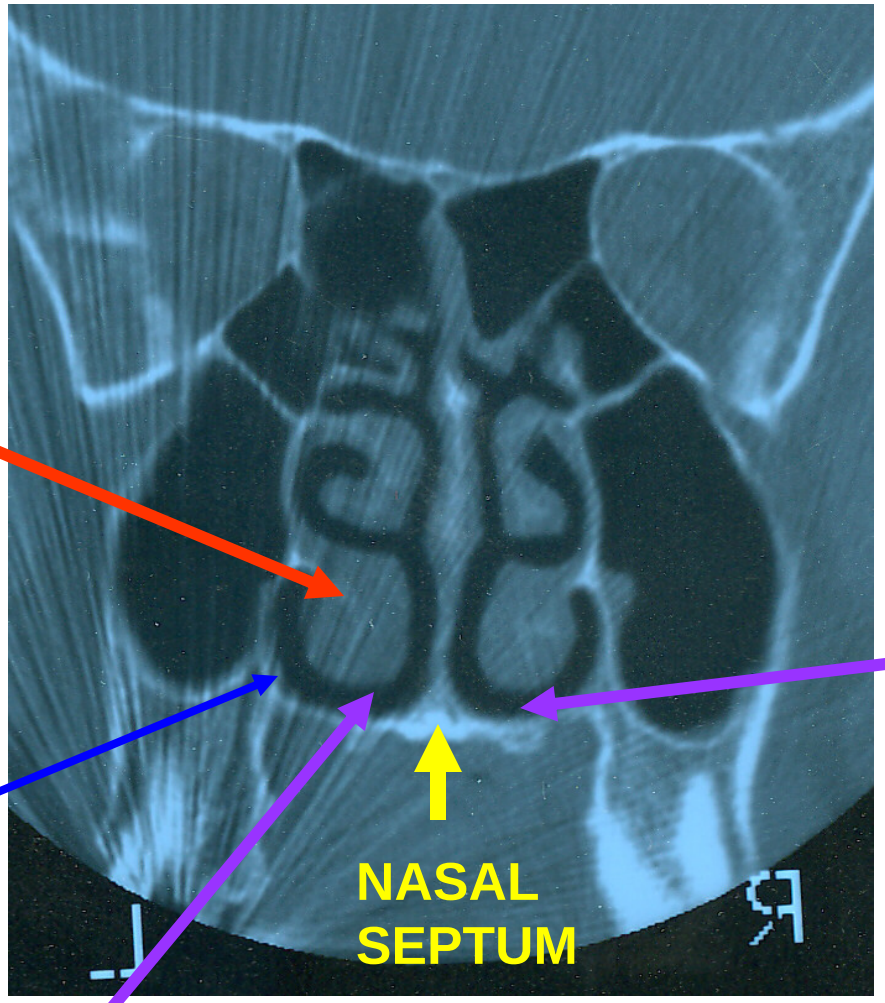
1) Septal cartilage with fused Lateral Nasal Cartilages

2) Alar cartilages - surround medial side of nostrils

Function of Cartilages - flexible, opening inferiorly directs inhalation toward mouth (smell what you eat)

CORONAL CT of INTERIOR OF NASAL CAVITY

Projections that <u>increase surface area</u> called Nasal Conchae (con'-key)= Turbinates



AIR

<u>Cavity is lined with mucoperiosteum</u>

SPACE BELOW CONCHA IS CALLED MEATUS (L. passage)

B. BOUNDARIES OF NASAL CAVITY

Boundaries

Floor = Palate

1) Maxillary Bone (Palatine Process)

2) Palatine Bone (Horizontal Plate)

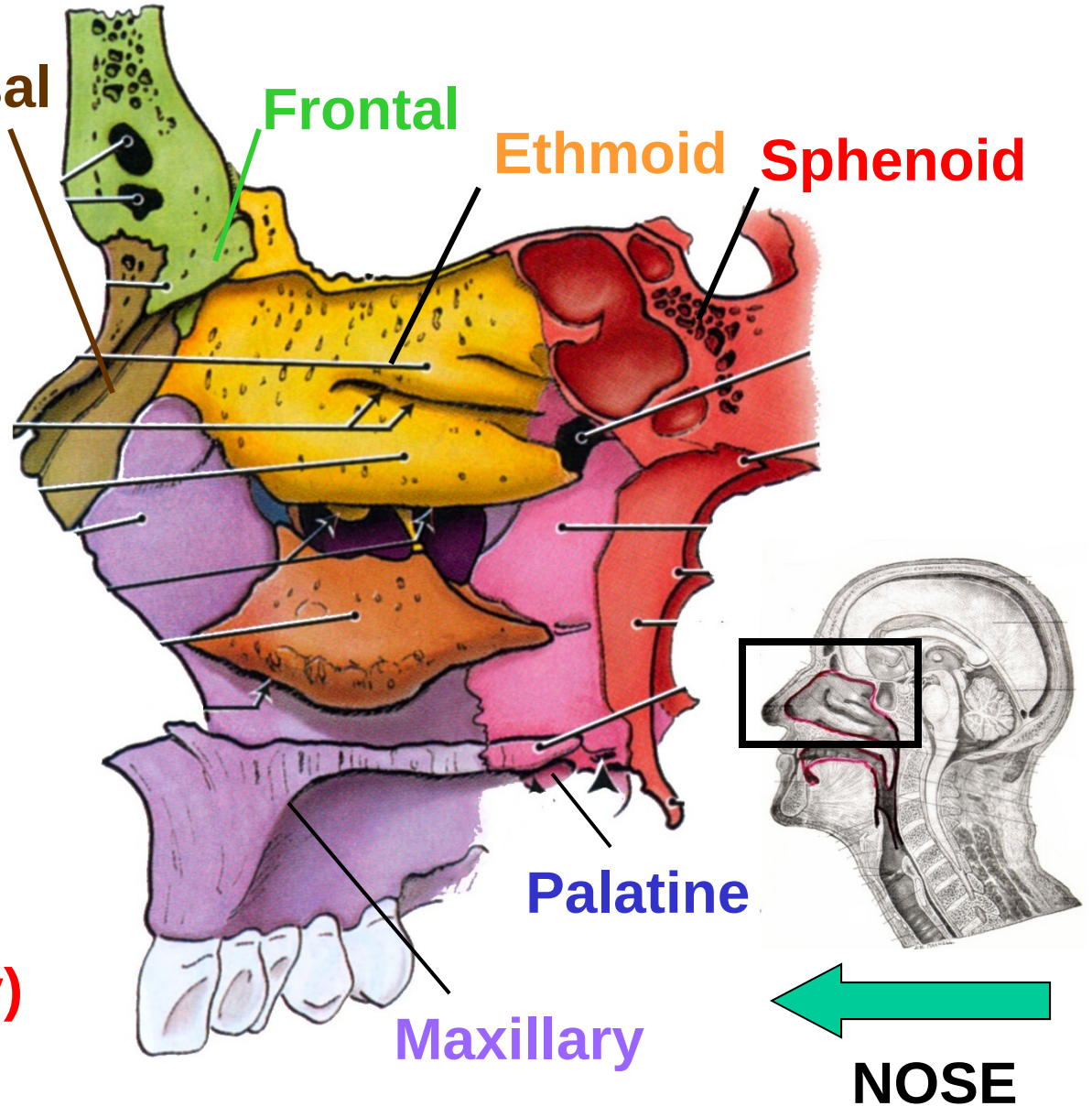
Roof

1) Nasal Bone

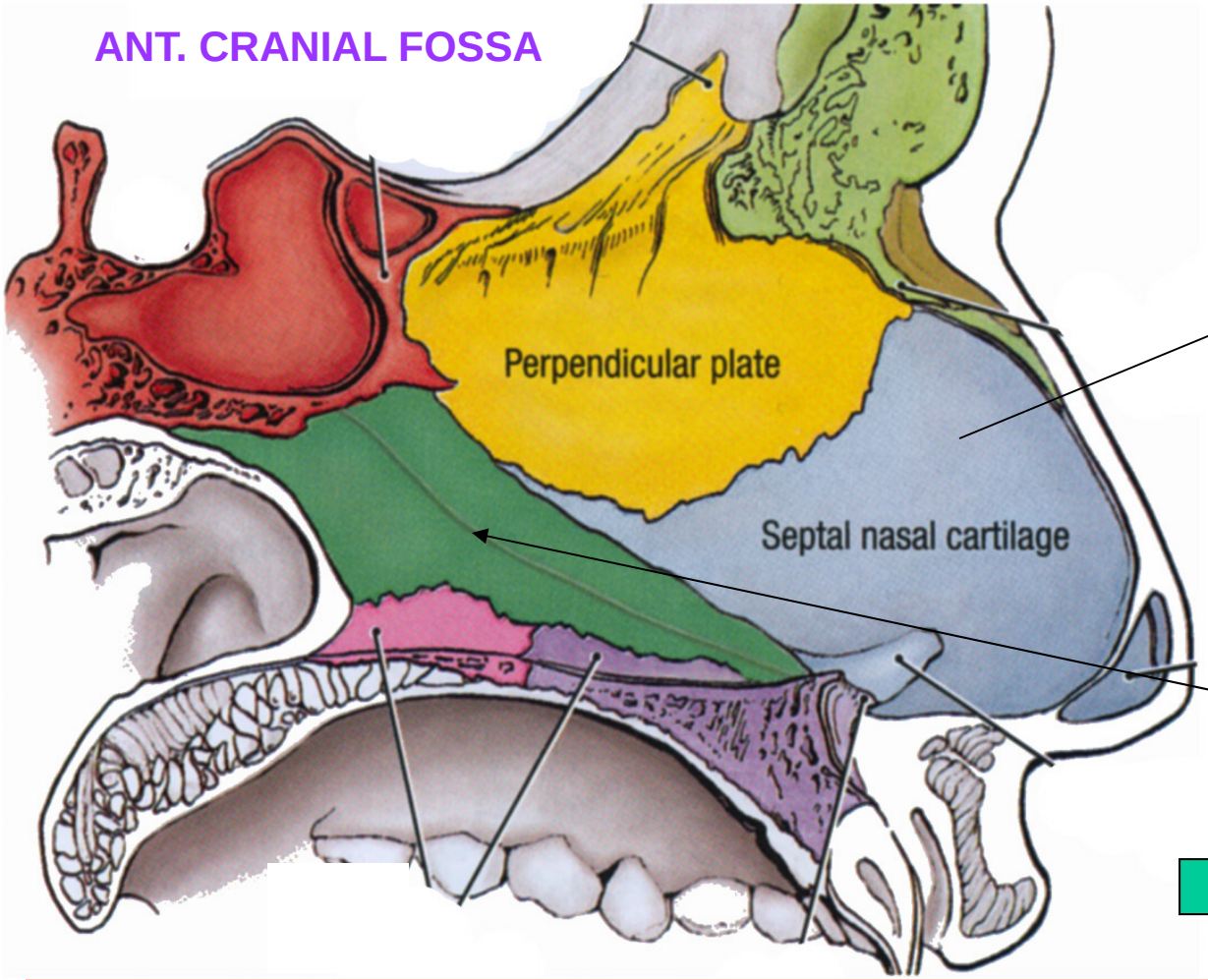
2) Frontal Bone

3) Ethmoid (Cribriform Plate)

4) Sphenoid (Body)



B. BOUNDARIES OF NASAL CAVITY



Medial = Nasal Septum

1) Septal Cartilage

2) Ethmoid (Perpendicular Plate)

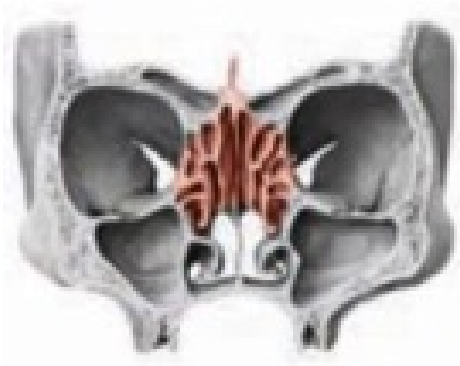
3) Vomer

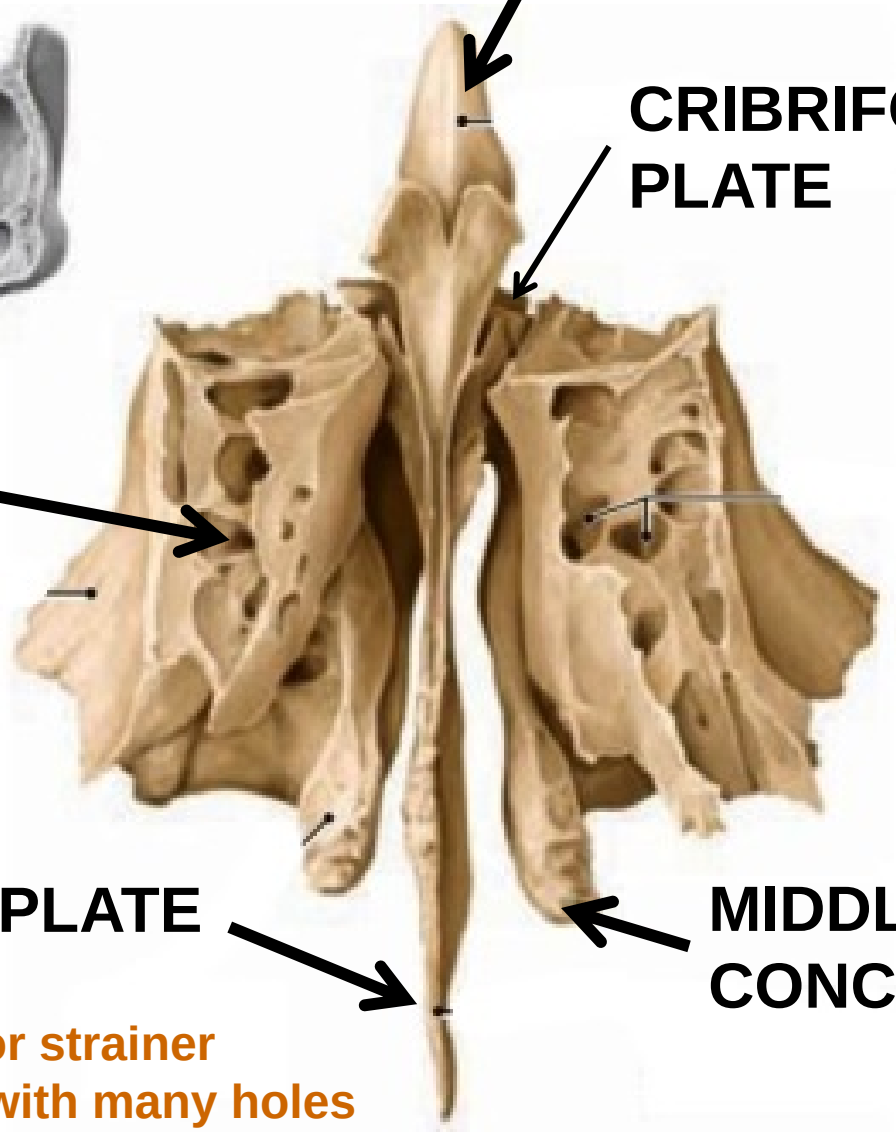
NOSE

**

CLINICAL – Fracture of nose can break Cribriform plate, floor of Ant. Cranial fossa - leak CSF from nose; can result in Meningitis

ETHMOID BONE (anterior view)





CRISTA GALLI

CRIBRIFORM PLATE

ETHMOID AIR CELLS (SINUS)

PERPENDICULAR PLATE

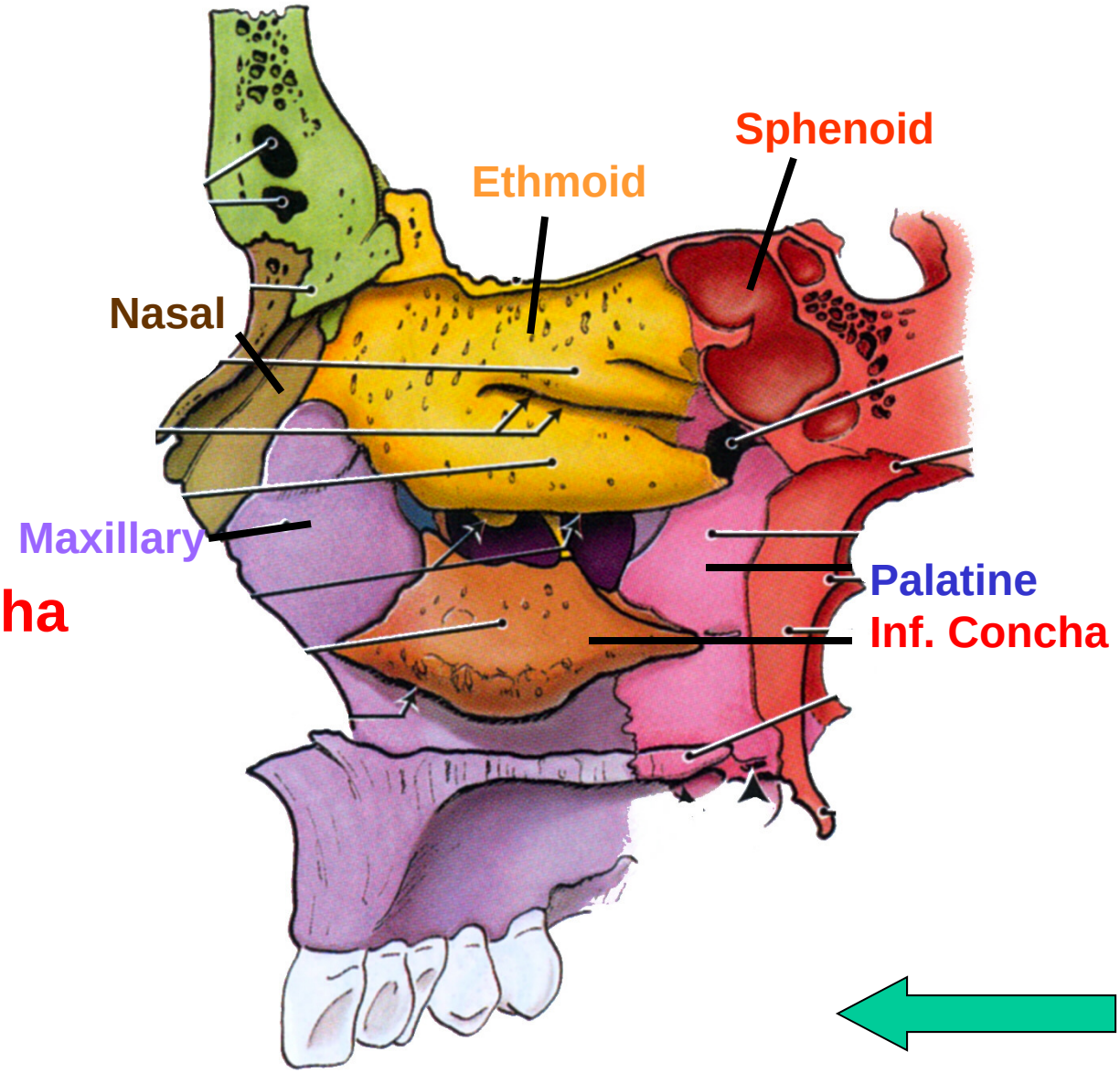
MIDDLE CONCHA

ETHMOID - Gk. for sieve or strainer
CRIBRIFORM - structure with many holes

C. LATERAL WALL OF NASAL CAVITY

Lateral Wall

1) Nasal Bone
2) Maxillary
3) Inferior Concha
4) Palatine
5) Ethmoid
6) Sphenoid



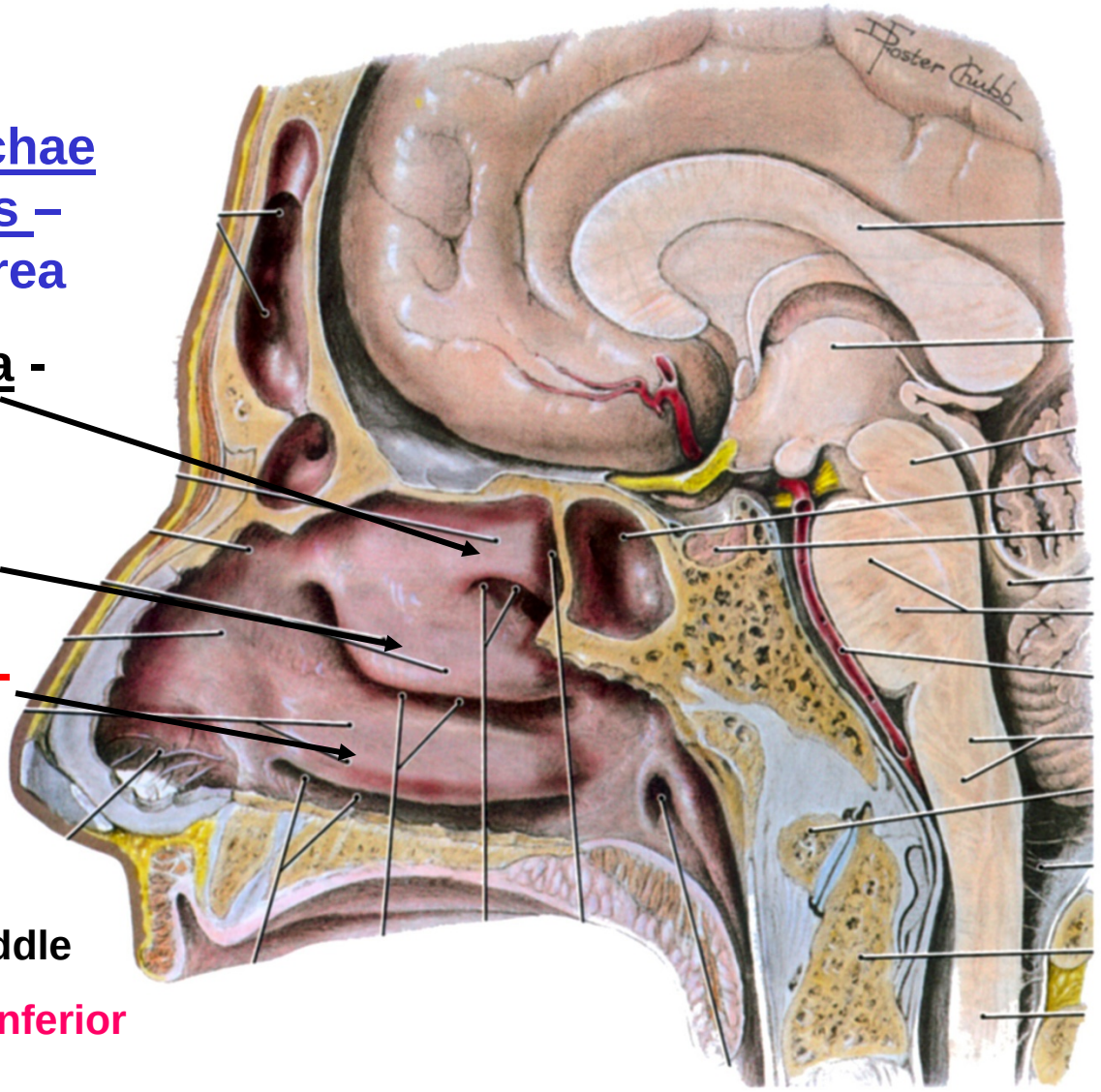
C. LATERAL WALL OF NASAL CAVITY

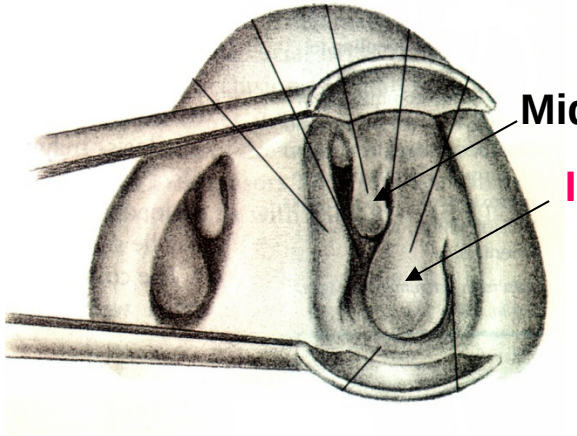
Projections = Conchae (shell) or turbinates – increase surface area

1) Superior Concha - Ethmoid

2) Middle Concha - Ethmoid

3) Inferior Concha - separate bone

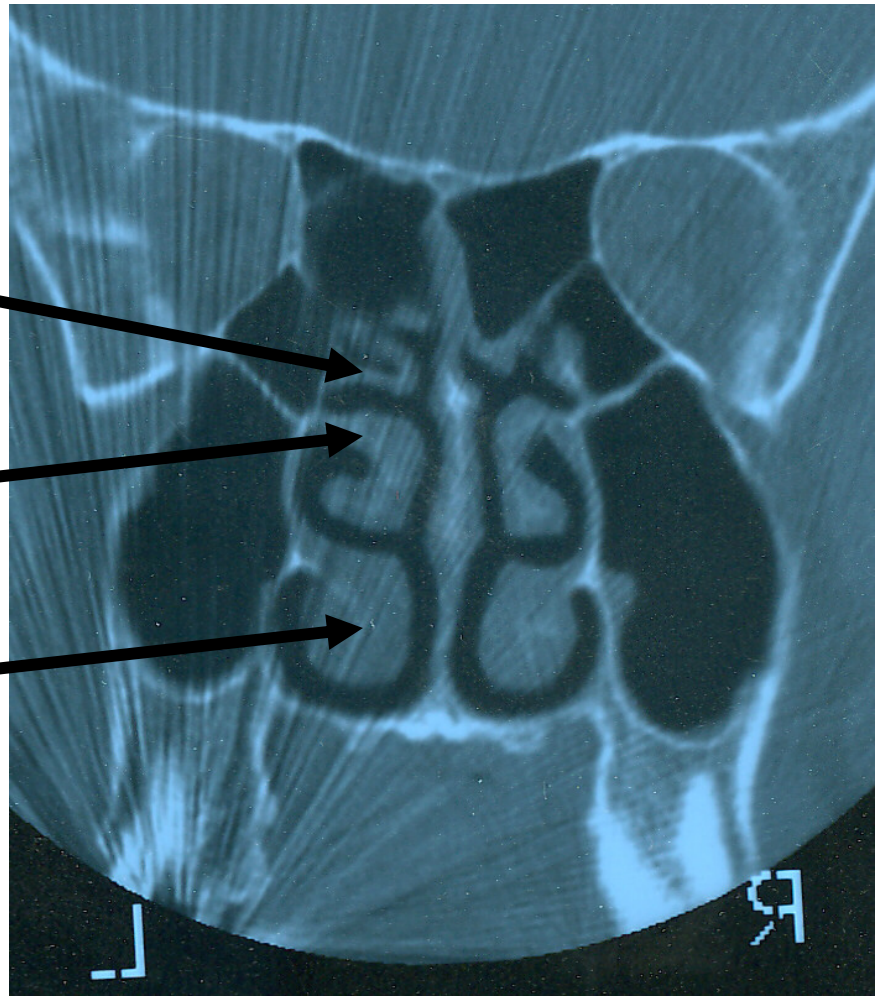




In nasal speculum view,
See only Middle and Inferior Conchae (Turbinates)

CORONAL CT of NASAL CAVITY

1) Superior Concha - Ethmoid
2) Middle Concha - Ethmoid
3) Inferior Concha - separate bone



NASAL CAVITY: SPACES

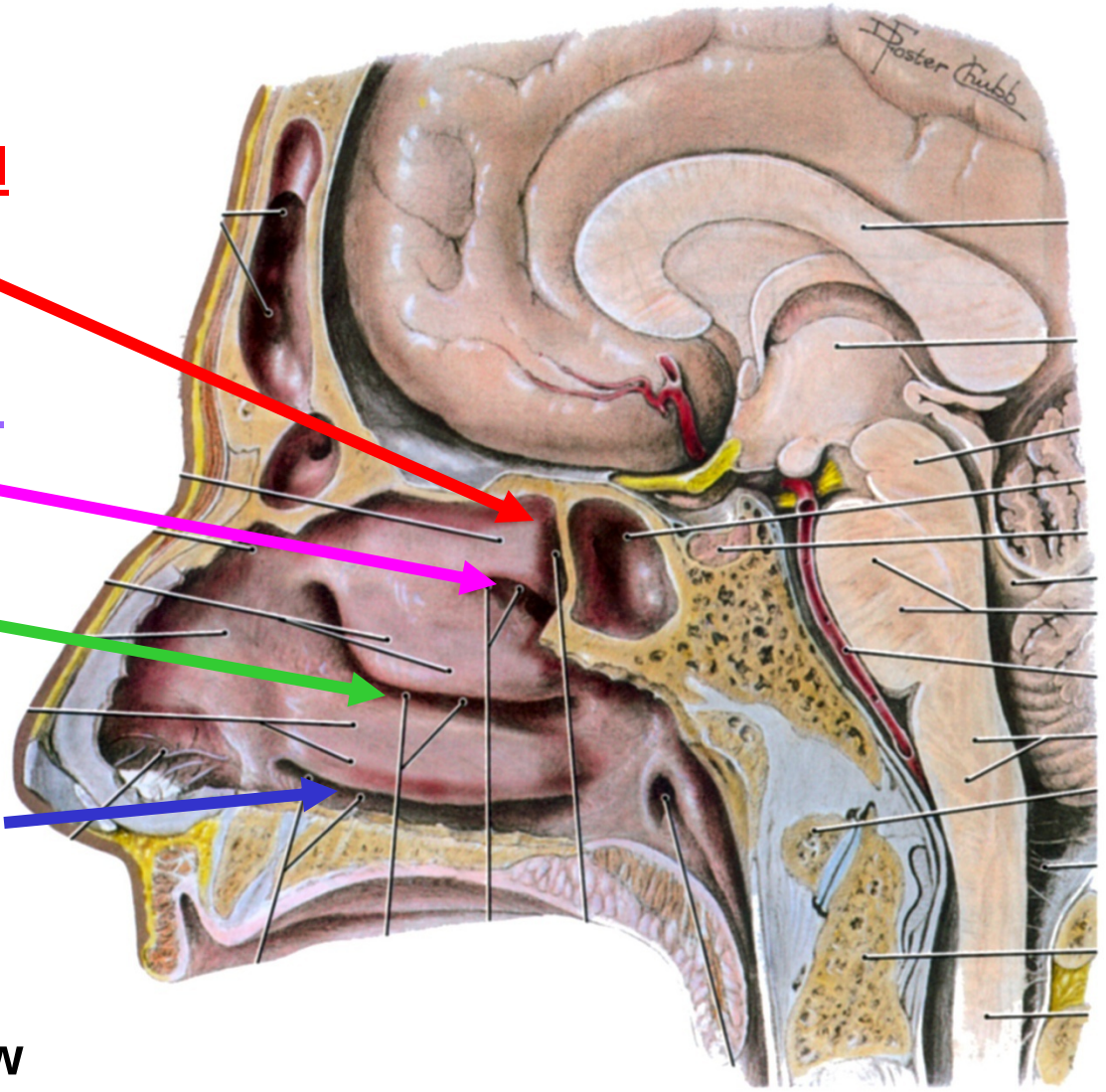
a. Spheno-Ethmoidal Recess - above Sup. Concha

b. Superior Meatus - Below Sup. Concha

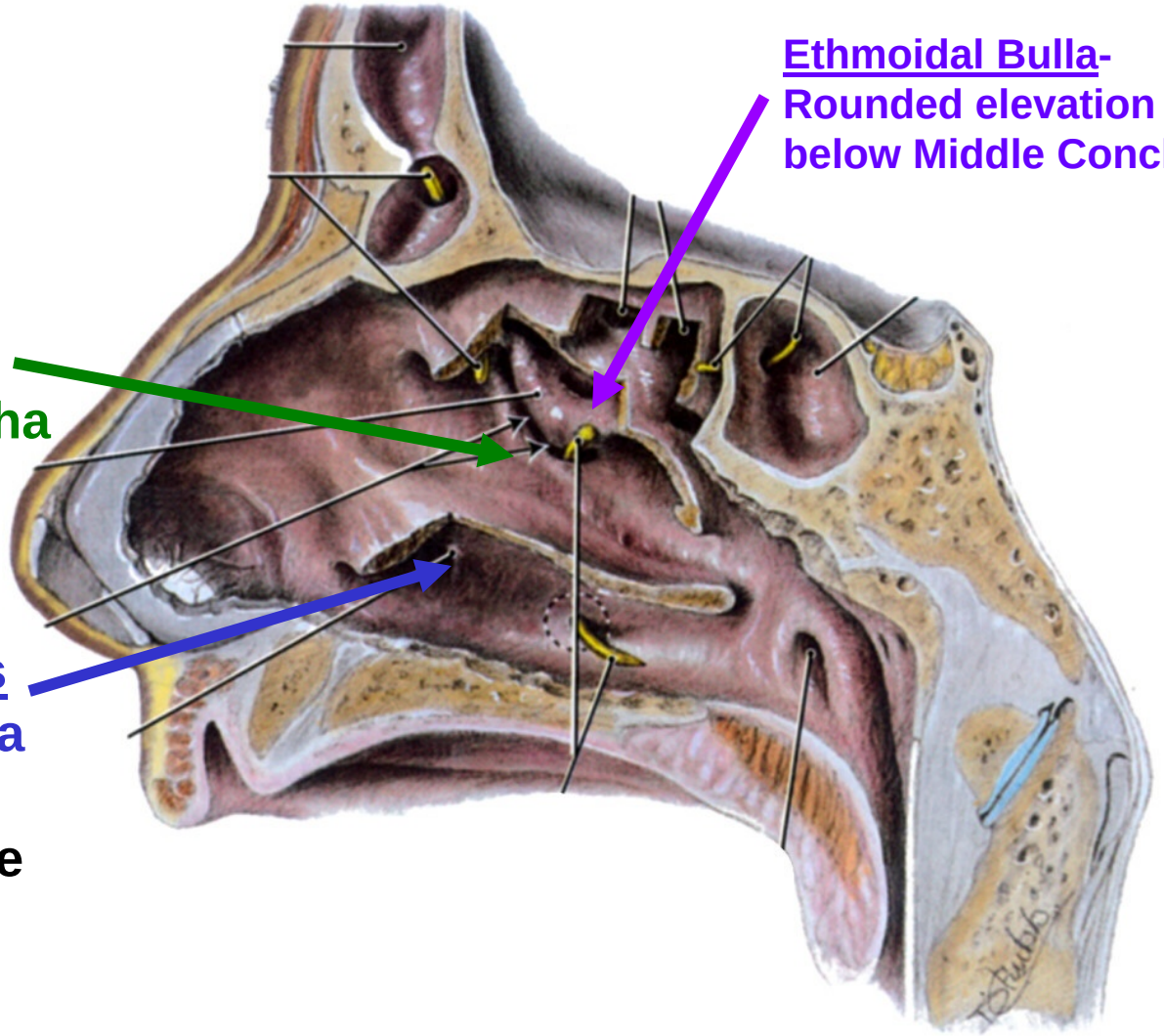
c. Middle Meatus - Below Mid. Concha

d. Inferior Meatus - Below Inf. Concha

Meatus = Passage (Latin), located below concha



NASAL CAVITY: REMOVE (REFLECT) CONCHAE IN DISSECTION



Ethmoidal Bulla-
Rounded elevation below Middle Concha

3) Middle Meatus
Below Mid. Concha

4) Inferior Meatus
Below Inf. Concha

Meatus = Passage (Lat.)

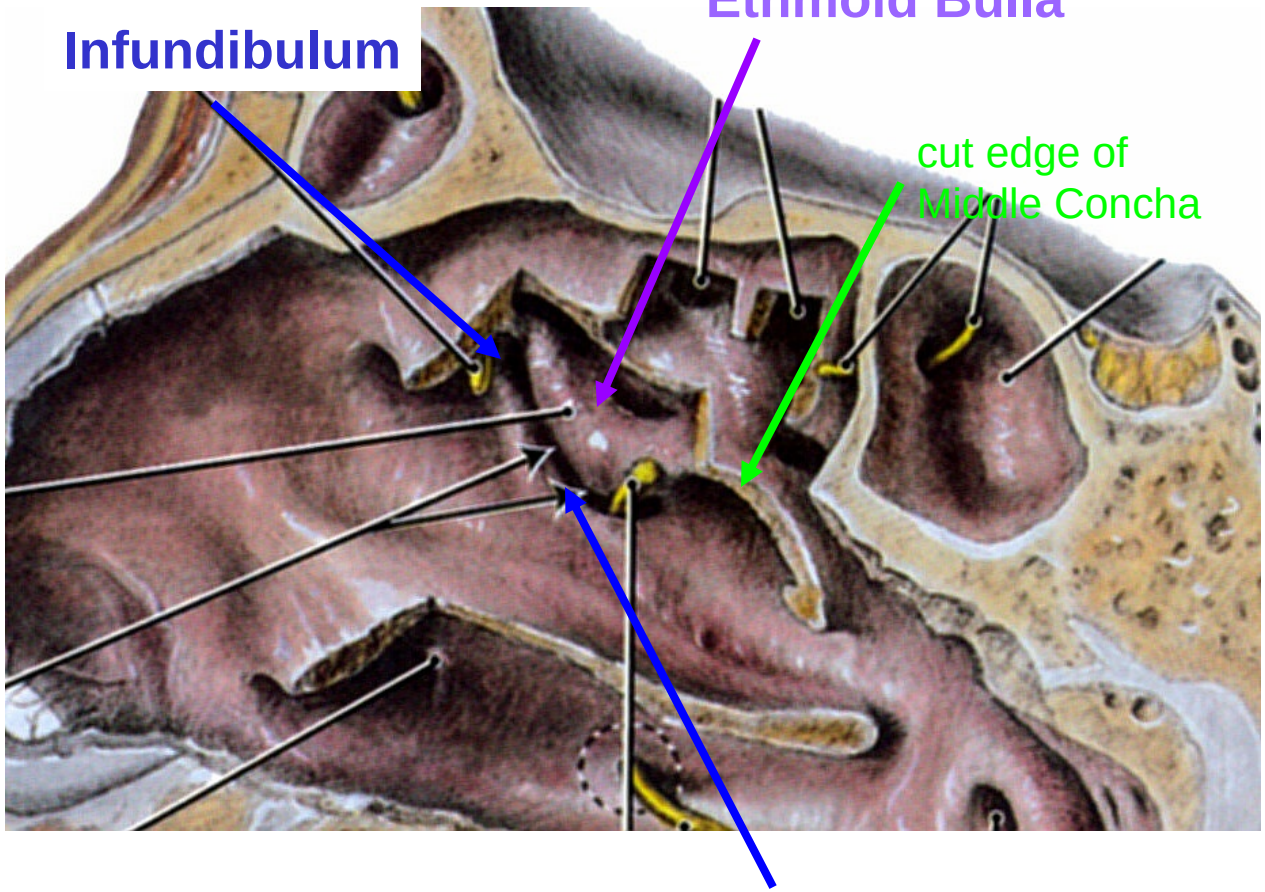
ORIENT/TERMINOLOGY: STRUCTURES IN MIDDLE MEATUS

Terms

1) Ethmoidal Bulla- Rounded elevation below Middle Concha - Formed by projection of Middle Ethmoidal air cells

2) Hiatus Semilunaris = C-shaped slit below Bulla

- Infundibulum is anterior part of Hiatus



Bulla = L. rounded prominence, blister

NASAL CAVITY: OPENINGS

a. Sphenoethmoidal Recess
- 1) Olfactory Foramina
- 2) Sphenoid air sinus

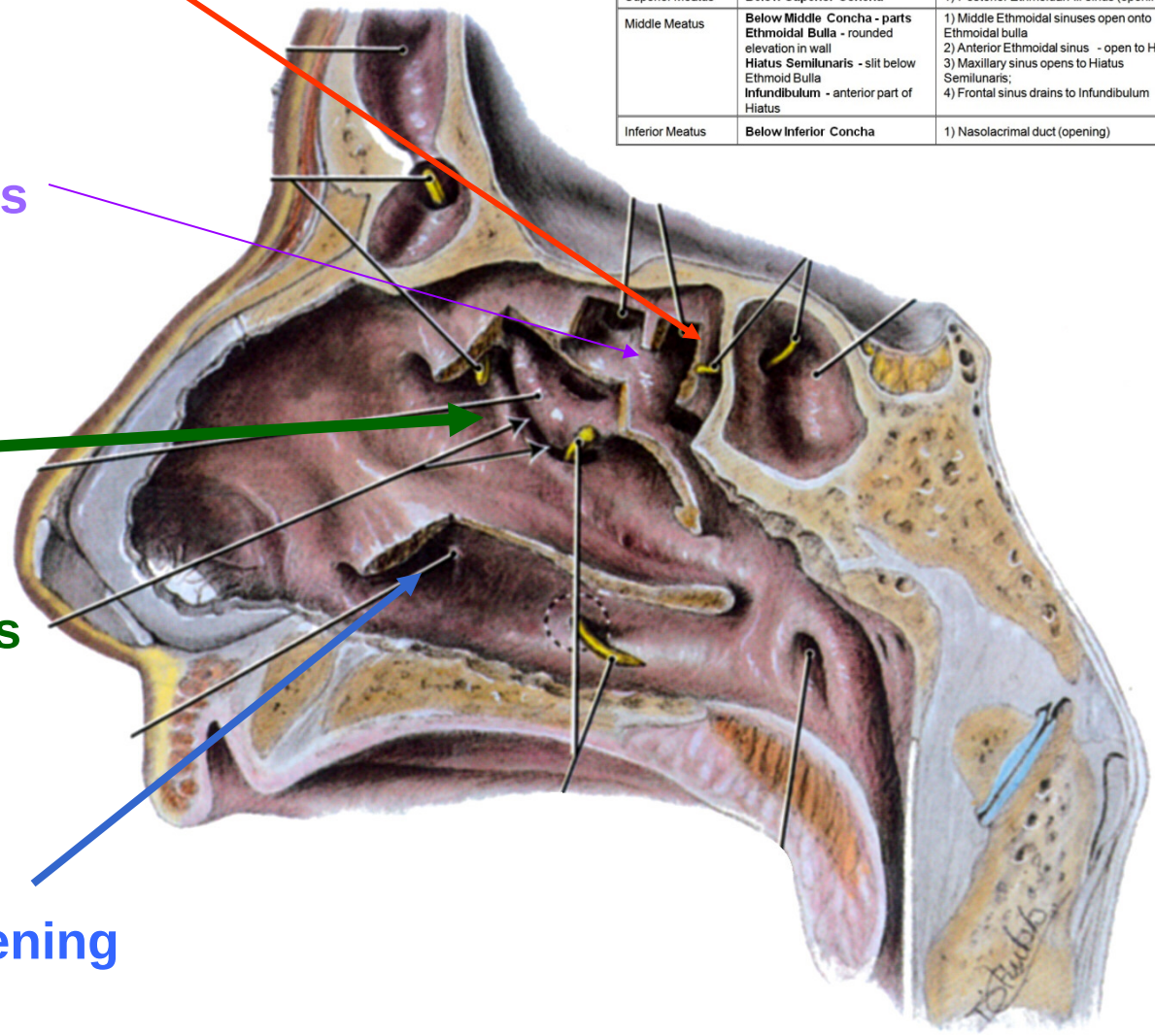
b. Superior Meatus – Post. Ethmoidal air cells

c. Middle Meatus
- 1) Middle ethmoidal air cells - Bulla
- 2) Ant. Ethmoidal air cells - Hiatus Sem.
- 3) Max. Sinus - Hiatus Semilunaris
- 4) Frontal Sinus - Infundibulum.

d. Inferior Meatus – opening of Nasolacrimal duct

SUMMARY CHART IN HANDOUT

Space	Location	Openings/Sinuses
Sphenoethmoidal Recess	**Above Superior Concha**	1) Olfactory foramina of cribriform plate and 2) Sphenoidal air sinus (opening)
Superior Meatus	**Below Superior Concha**	1) Posterior Ethmoidal Air sinus (opening)
Middle Meatus	**Below Middle Concha - parts** **Ethmoidal Bulla** - rounded elevation in wall **Hiatus Semilunaris** - slit below Ethmoid Bulla **Infundibulum** - anterior part of Hiatus	1) Middle Ethmoidal sinuses open onto Ethmoidal bulla 2) Anterior Ethmoidal sinus - open to Hiatus 3) Maxillary sinus opens to Hiatus Semilunaris; 4) Frontal sinus drains to Infundibulum
Inferior Meatus	**Below Inferior Concha**	1) Nasolacrimal duct (opening)



C. AND D. NERVES of NASAL CAVITY

Nerves

1.Olfactory N. - SMELL Olfactory Area

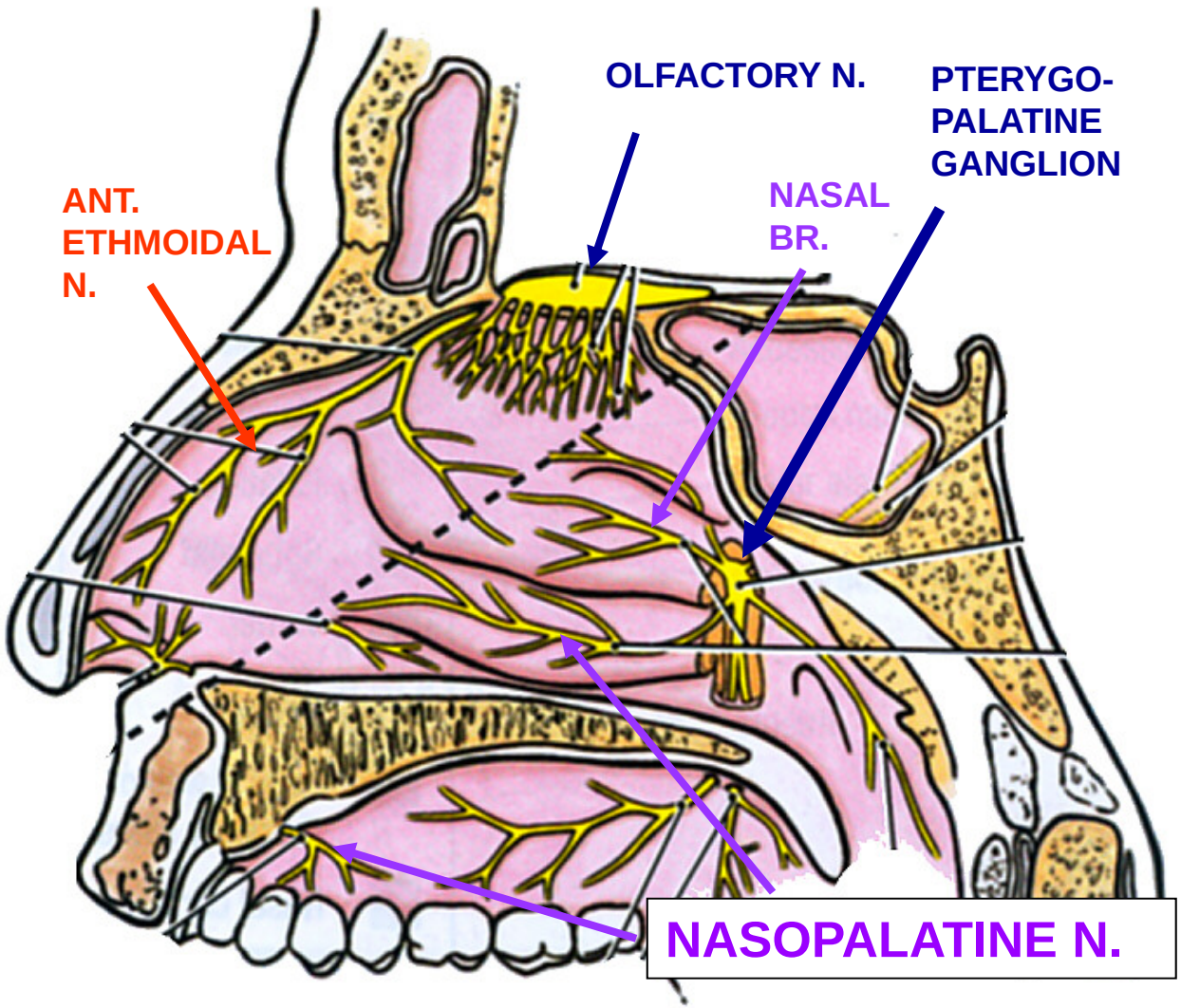
2.General Sensation -

ALL SOMATIC SENSORY touch, pain, etc.

V1 + V2 *

- V1 Anterior Ethmoidal N.
- V2 Nasal Branches
- V2 Nasopalatine N.

3. Mucous Glands of nose - VISCERAL MOTOR PARASYMP. - VII - Facial N. by Pterygopalatine Ganglion *

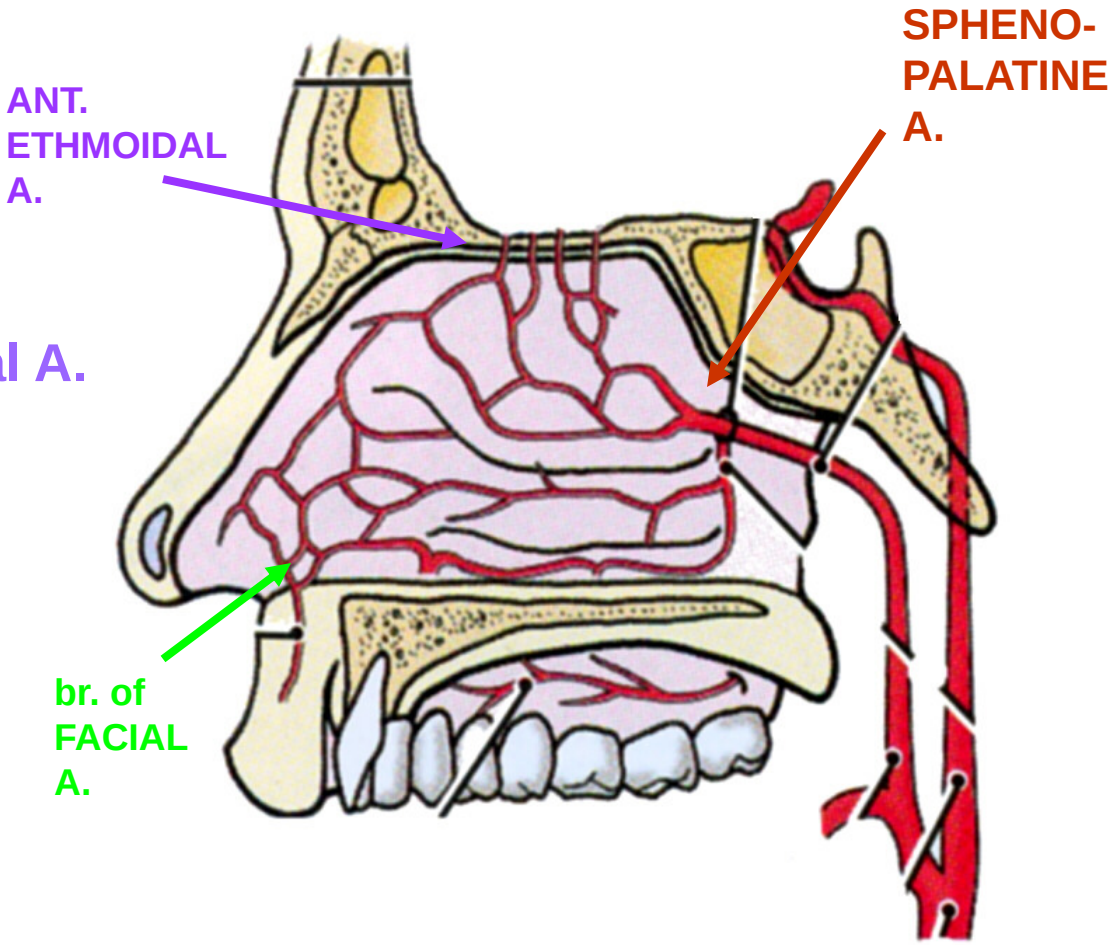


OLFACTORY AREA = area of Olfactory nerve endings
RESPIRATORY AREA = rest of nasal cavity

E. and F. ARTERIES/VEINS, LYMPHATICS

1. Arteries
a. Sphenopalatine Artery
- from Maxillary A.
b. Ant. and Post Ethmoidal A.
- from Ophthalmic A.
c. Branches of Facial A.

2. Veins
a. Ethmoidal vein
drain to Ophthalmic v.
b. Other branches to
Pterygoid Venous Plexus
c. Facial Vein

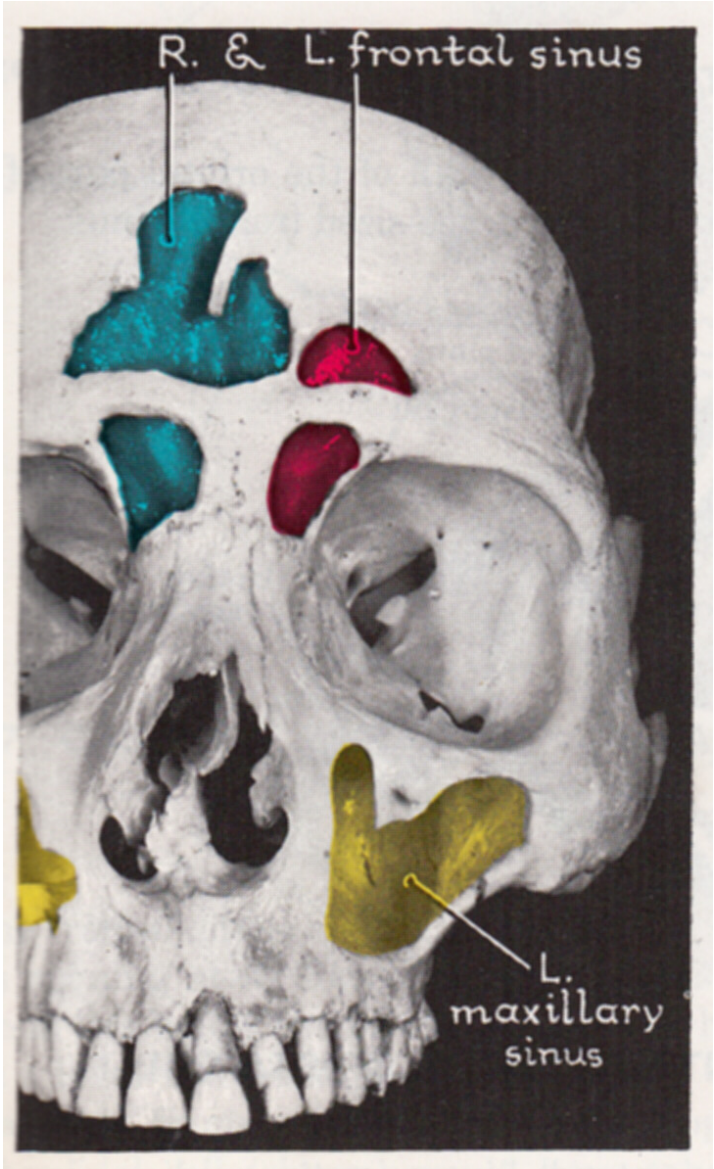


F. Lymphatics-
Retro-
pharyngeal
Nodes

**

Note: Epistaxis (nosebleed) can be extensive due to Anastomoses – Spurting if arterial

II. PARANASAL AIR SINUSES



1) Air filled extensions of Nasal Cavity

2) All Paired

- Develop and enlarge after birth

- Lined by mucous membrane

- Serve to lighten bones

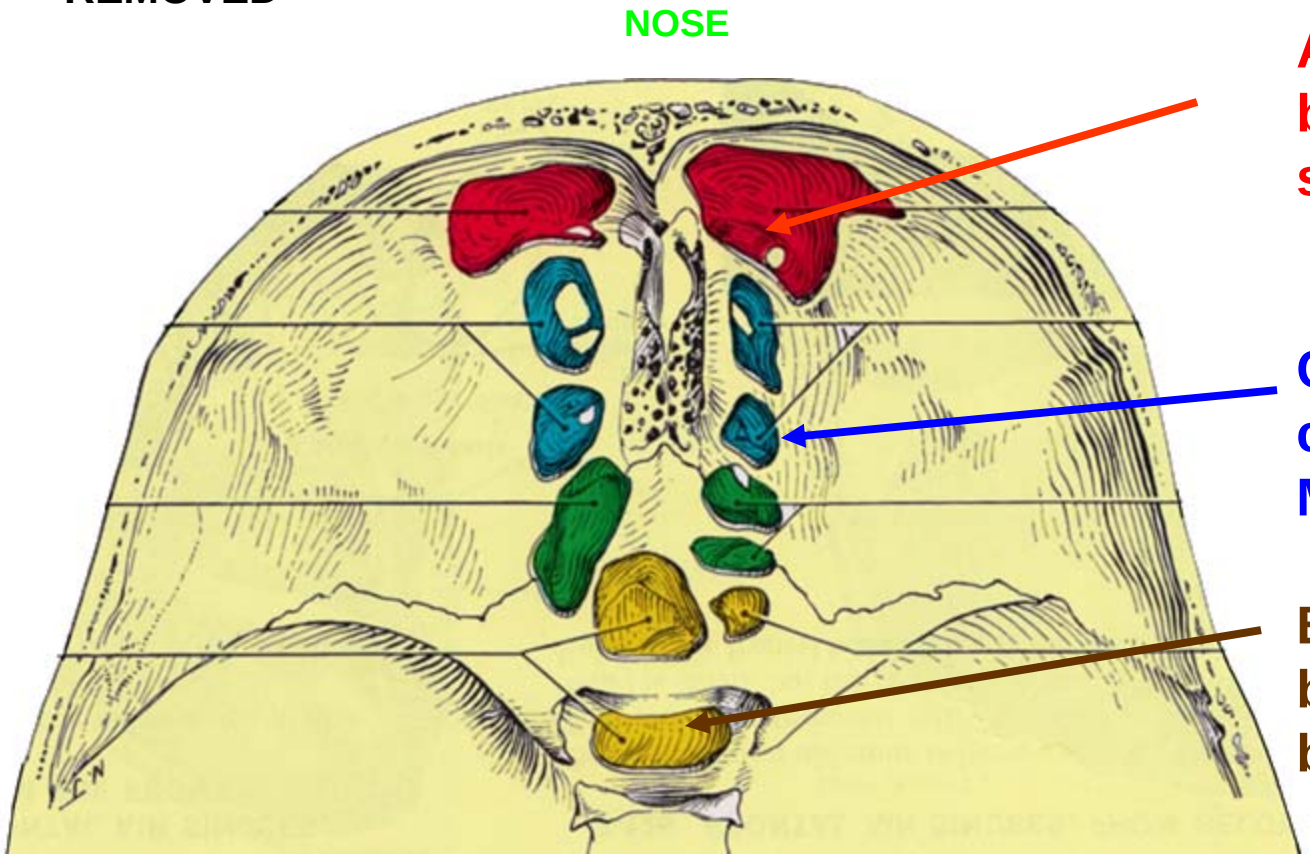
3) A mistake of evolution?

- If filled bones with spongy (cancellous) bone, would not get infected

PARANASAL AIR SINUSES

VIEW: FLOOR OF ANT. CRAN. FOSSA WITH BONE REMOVED

All usually paired



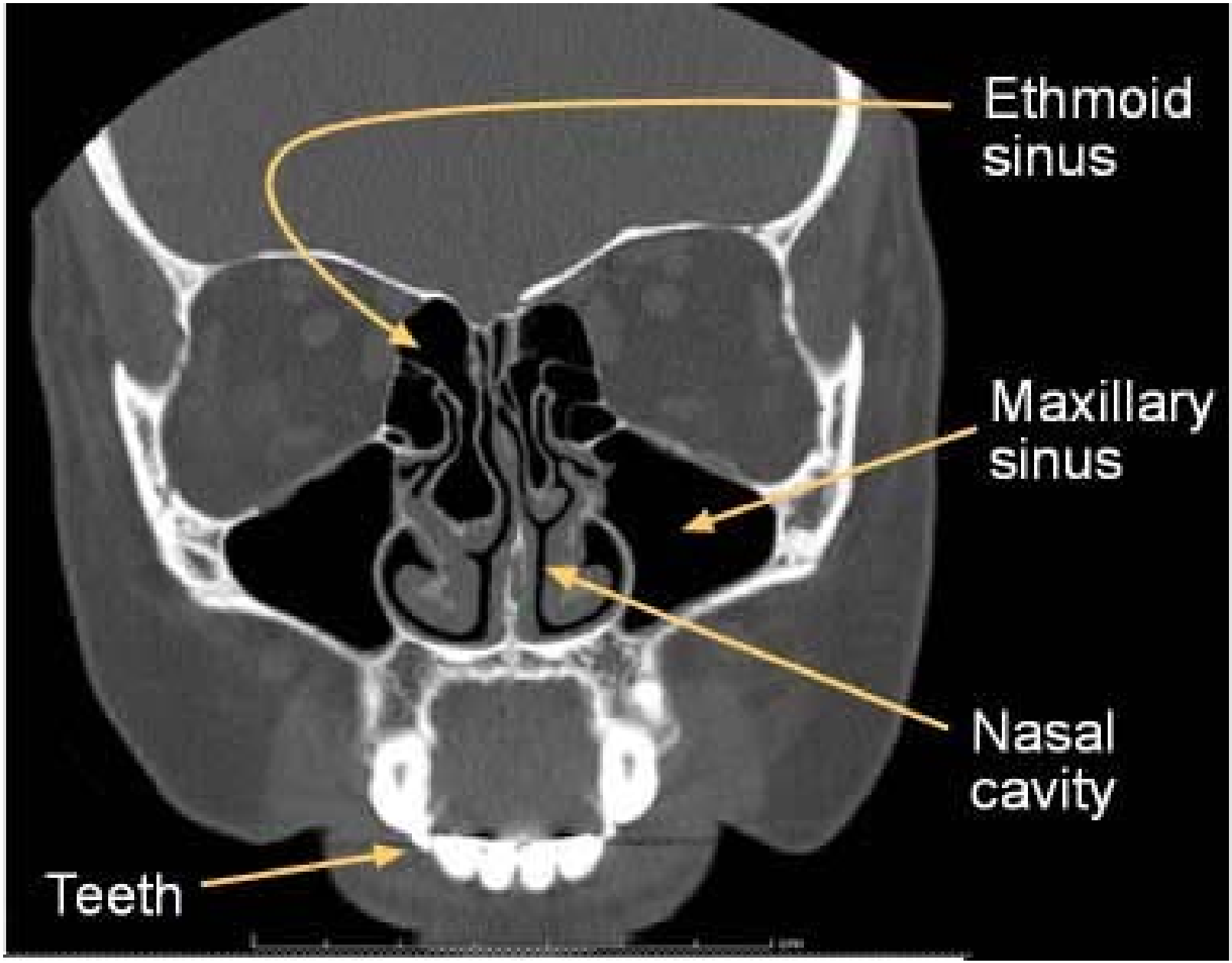
A. Frontal - separate by septum, variable size

C. Ethmoid- also called air cells (Ant., Mid., Post.)

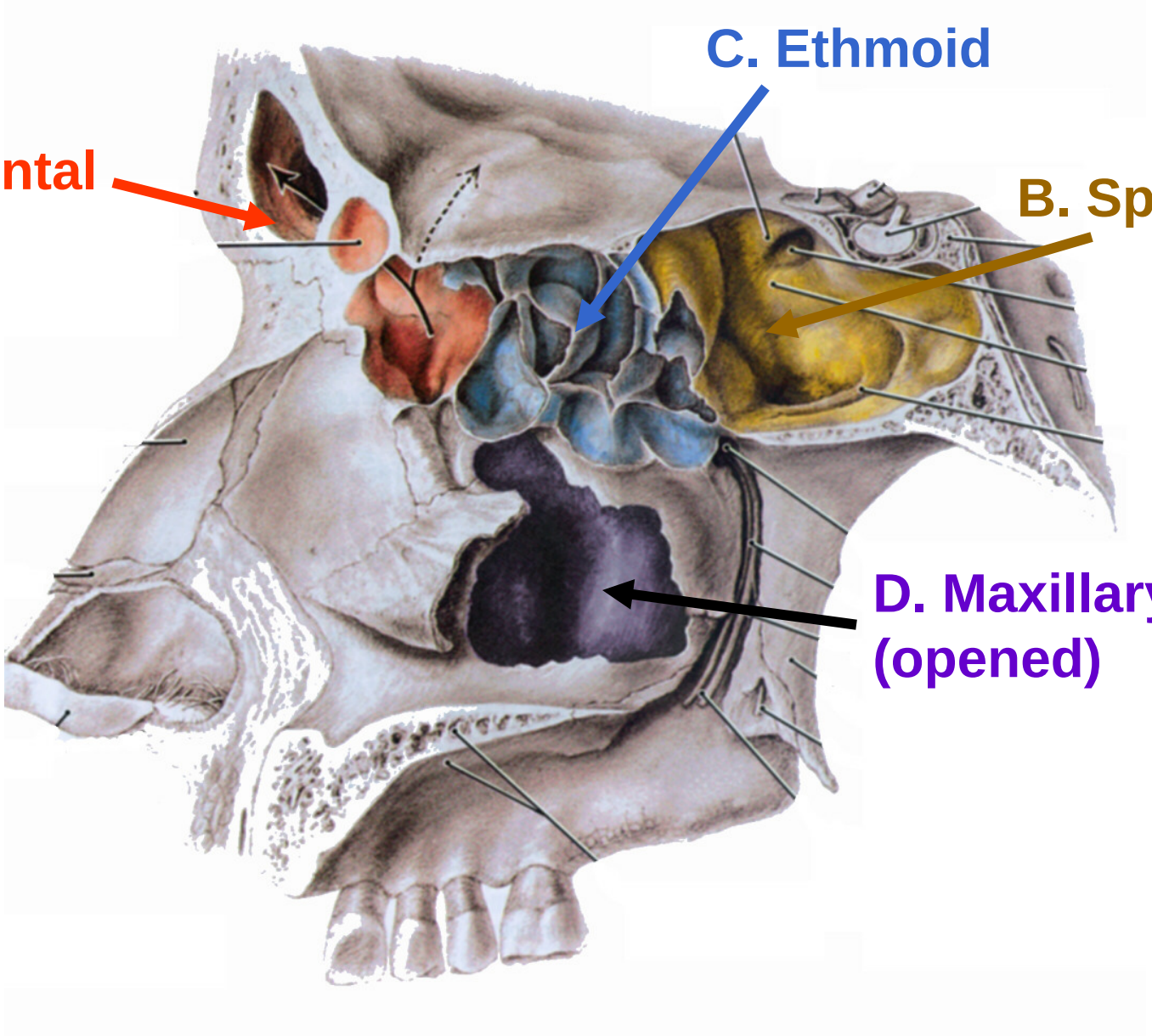
B. Sphenoid - in body of Sphenoid bone

*

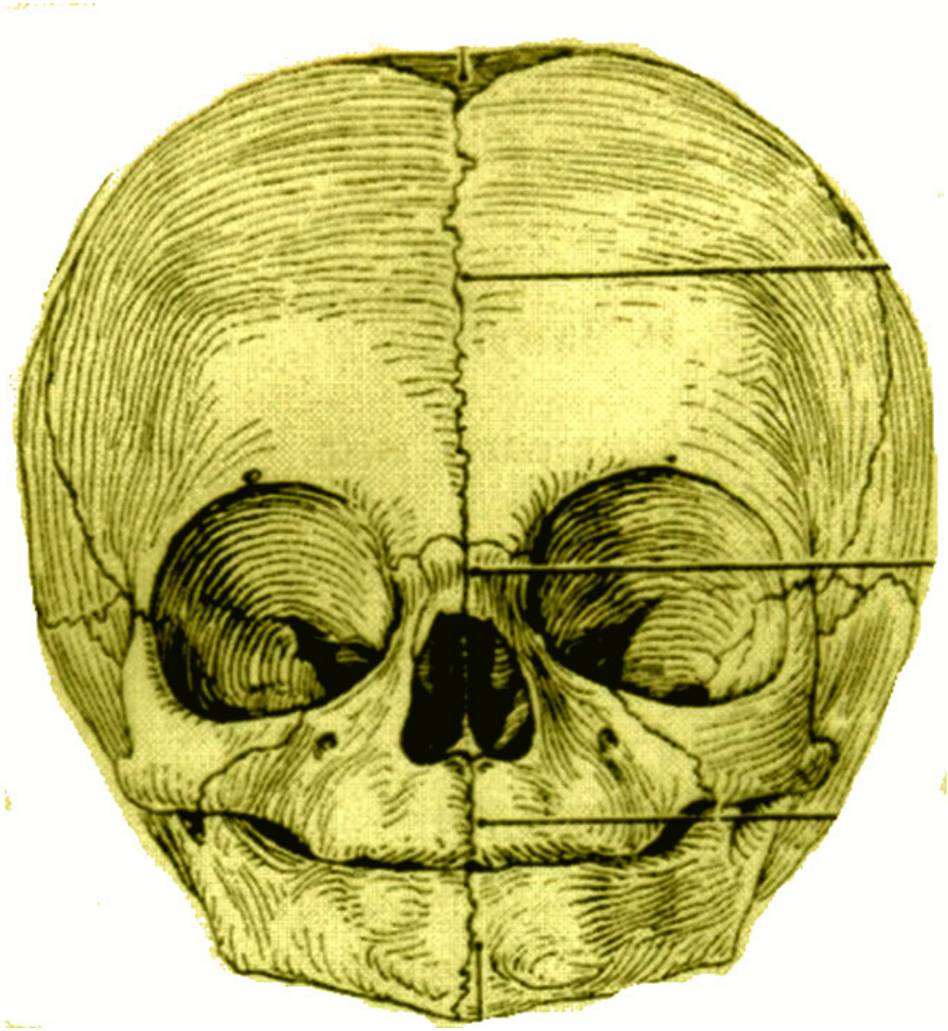
Ethmoid - Blocked Sinus Infection Can Spread to Orbit


Ethmoid sinus
Maxillary sinus
Nasal cavity
Teeth

PARANASAL AIR SINUSES



PARANASAL AIR SINUSES



No (or small) Sinuses at birth = Baby Face

Maxilla – Small
- No Maxillary Air Sinus
- No Teeth
Mouth is under eyes

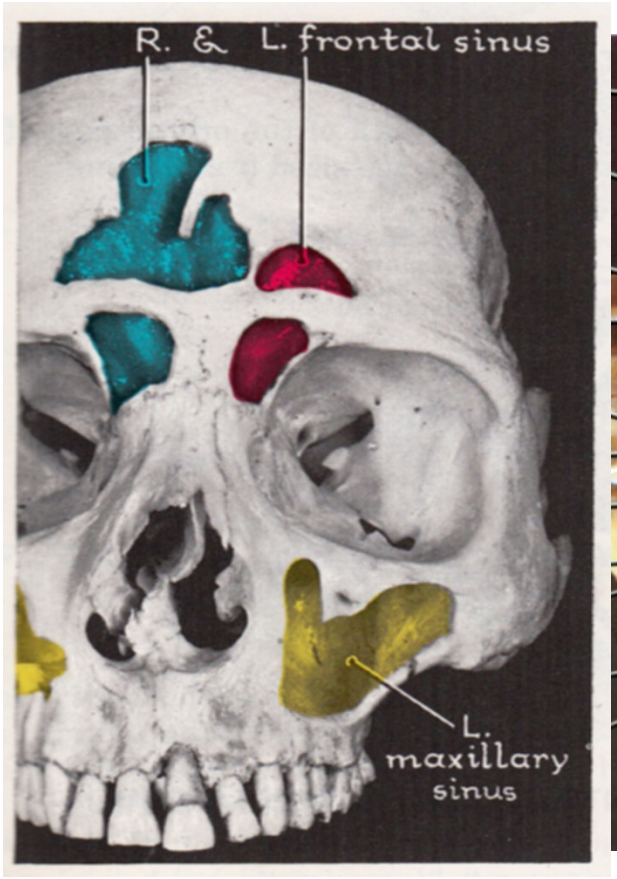
Google search - cute baby
1.5 billion results

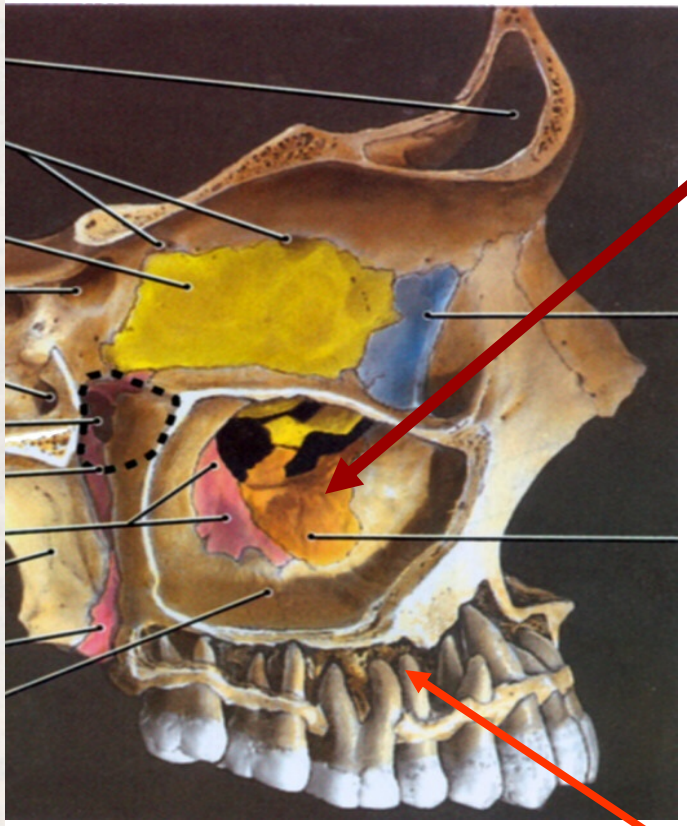
CUTE BABY

3 YEAR OLD BOY

Cute - correlated with undeveloped maxillary sinus (also teeth not erupted)?

PARANASAL AIR SINUSES





D. <u>Maxillary Sinus</u>

- Largest

- Occupies entire Body of Maxilla

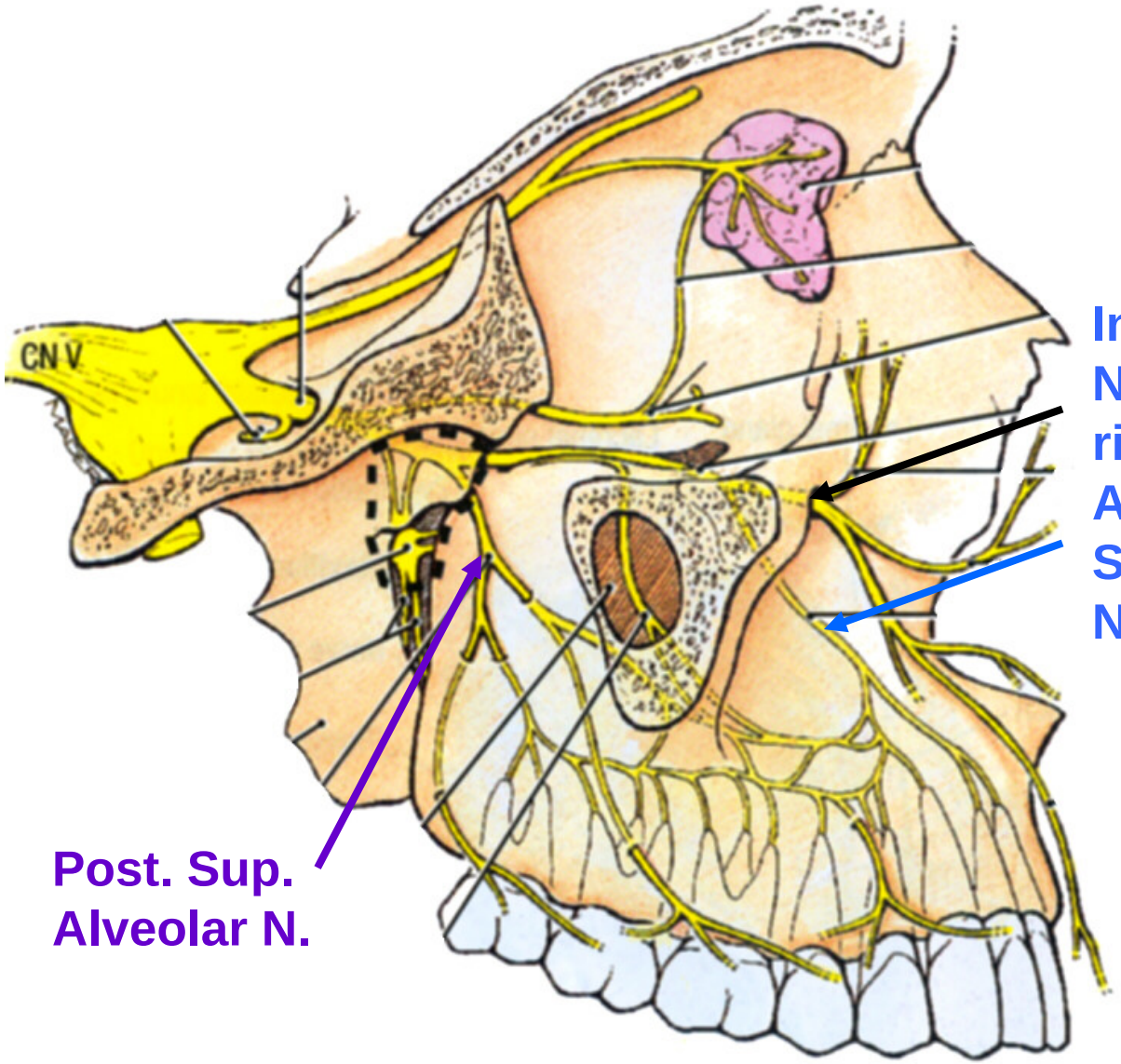
- Roof = Floor of Orbit

- Nasal Cavity is medial to sinus

*

CLINICAL - Roots of Maxillary Teeth are in Floor of Sinus - can damage by tooth extraction

PARANASAL AIR SINUSES: NERVES



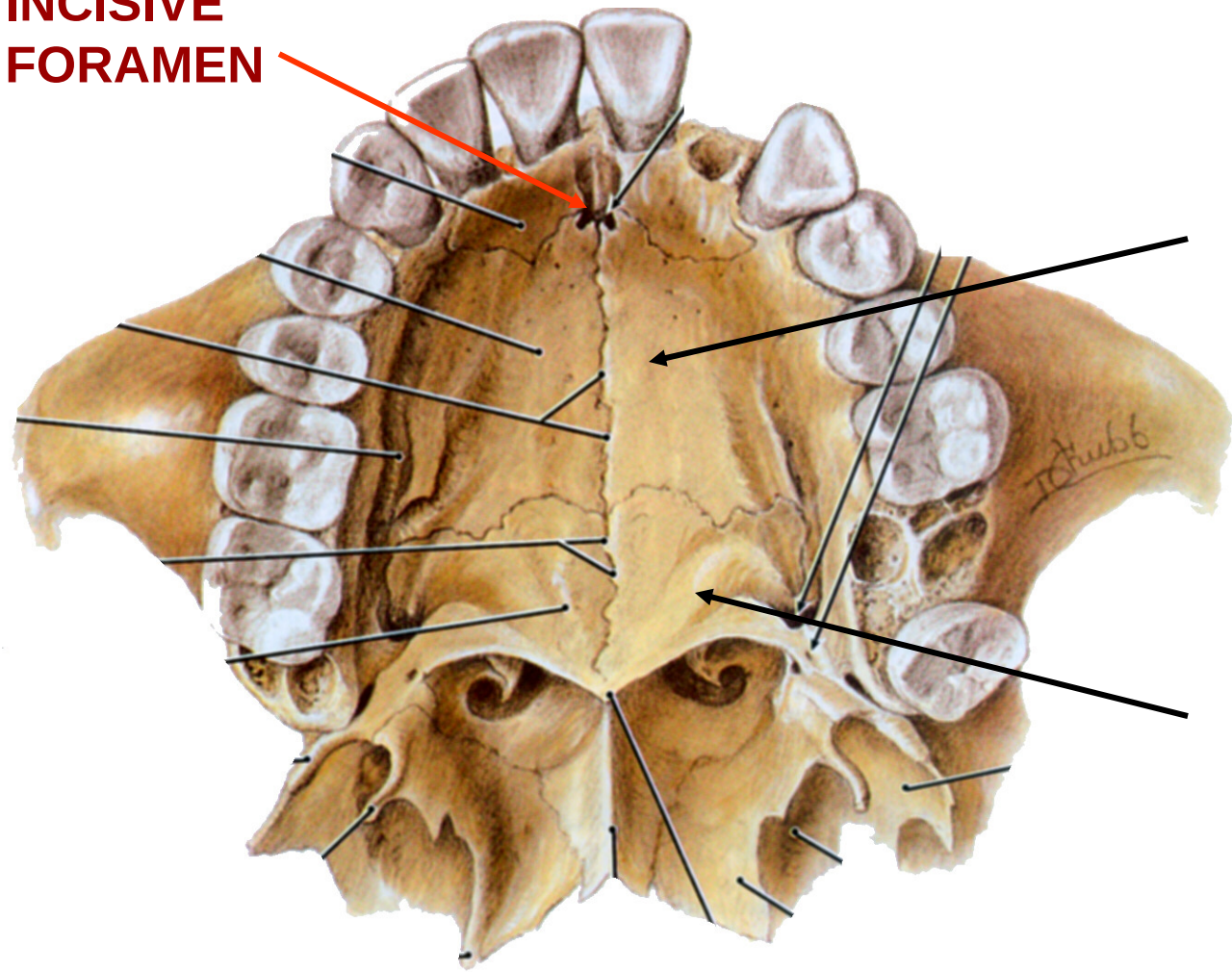
Infraorbital N. - gives rise to Ant. Sup Alveolar N.

Post. Sup. Alveolar N.

* *

V2 - Ant. & **Post.** Sup. Alveolar N. supply Max Sinus & Teeth;
(Infected sinus can feel like a tooth ache)

III. PALATE DEVELOPMENT



B. Anatomy

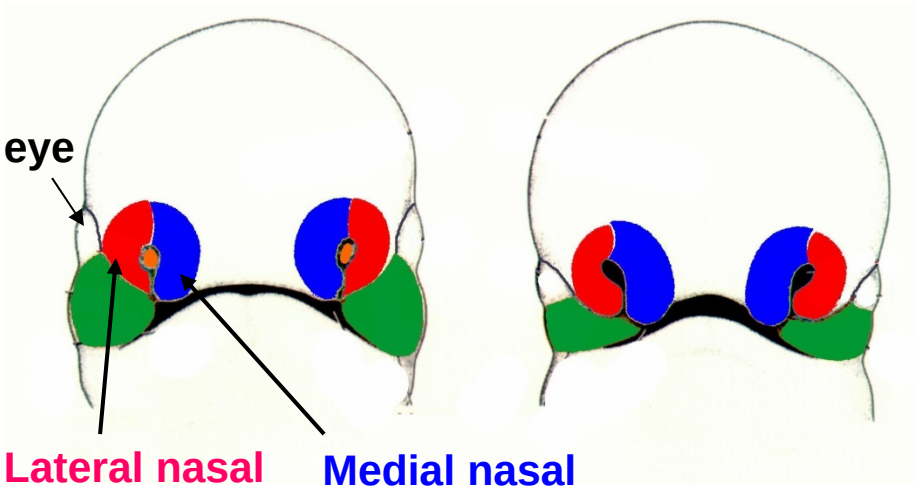
1. Hard Palate

a. Maxillary Bones (palatine process)

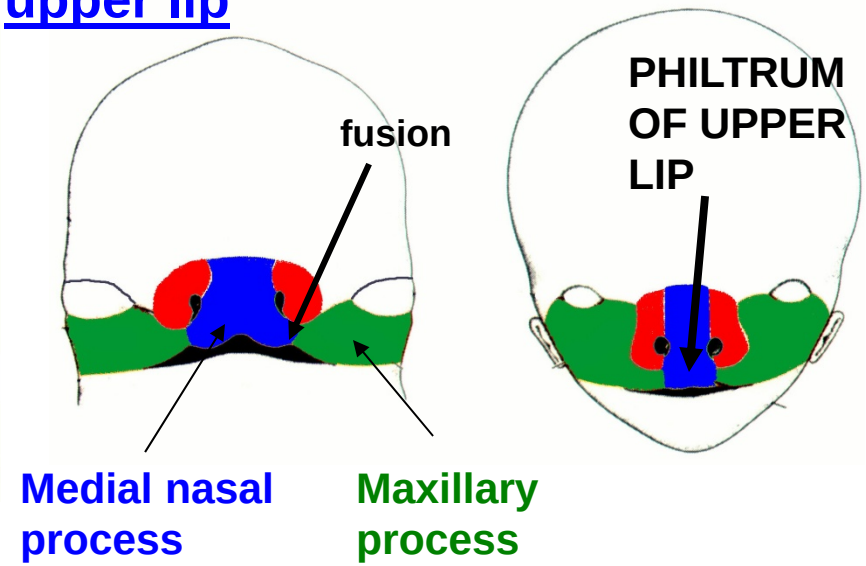
b. Palatine bones (horizontal plate)

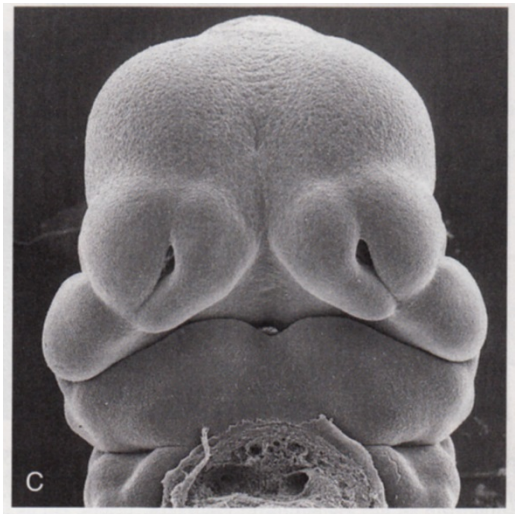
DEVELOPMENT OF FACE

2. Medial and Lateral Nasal Processes – form at margins of nasal placodes



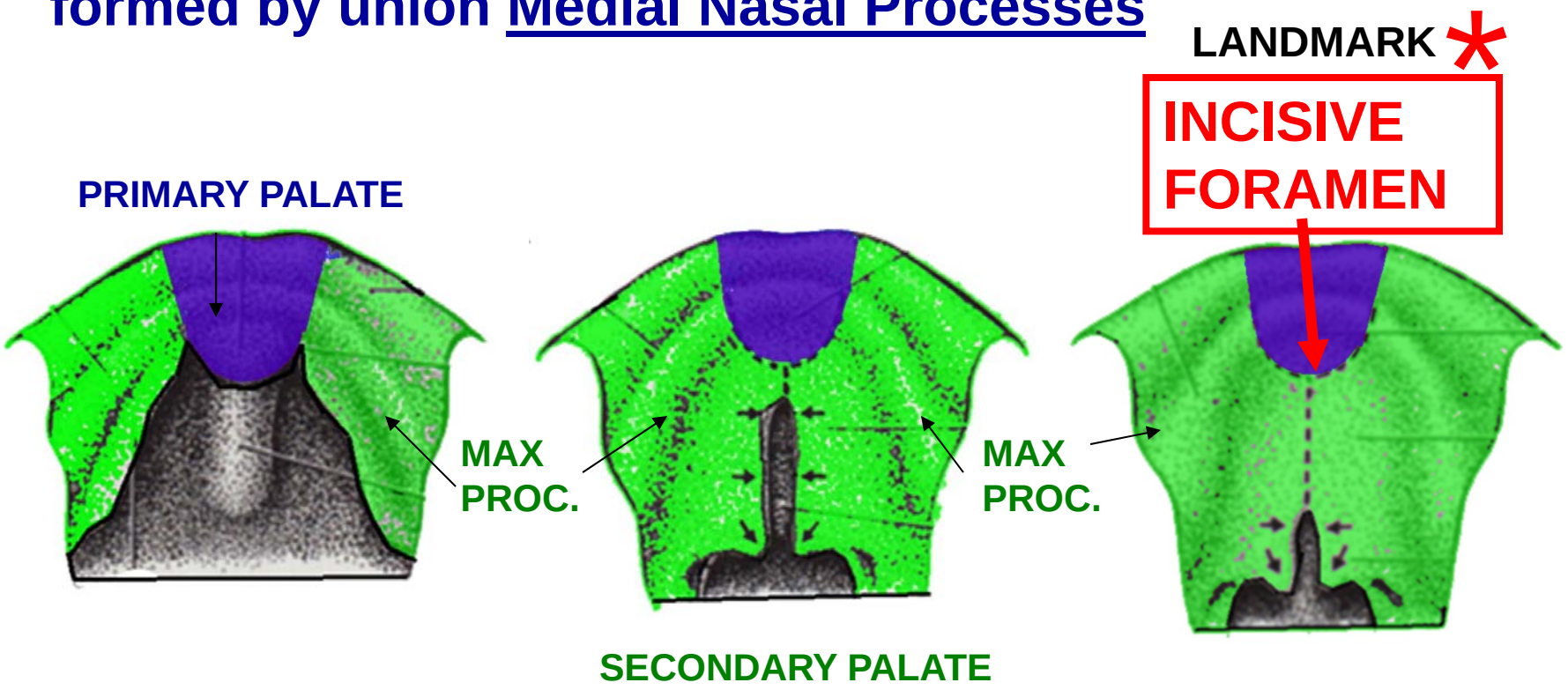
3. Medial nasal process and Maxillary Process – fuse to form upper lip





A. PALATE DEVELOPMENT

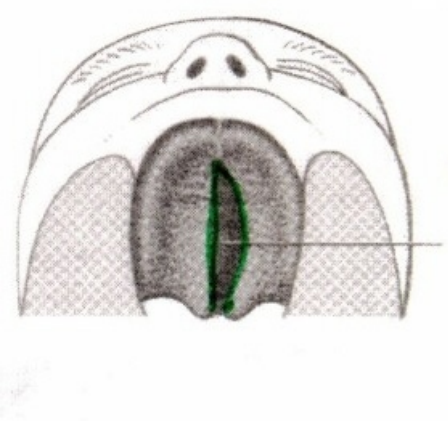
a. Primary Palate – Anterior to Incisive Foramen formed by union Medial Nasal Processes



b. Secondary Palate – Posterior to Incisive Foramen- formed by fusion of Maxillary processes

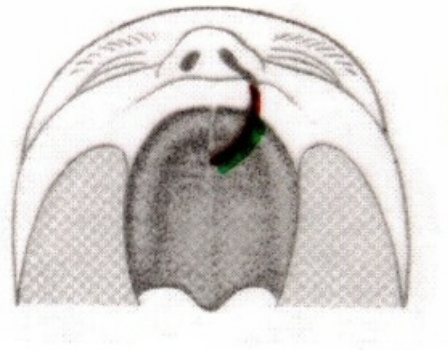
MALFORMATIONS: CLEFT PALATE

2) Posterior Cleft Palate - Not fuse Secondary palate (not fuse Maxillary Processes each side) *



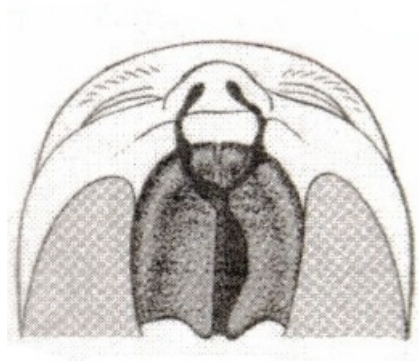
1:2500 births

1) Anterior Cleft Palate - Not fuse Medial Nasal Process and Maxillary Process *

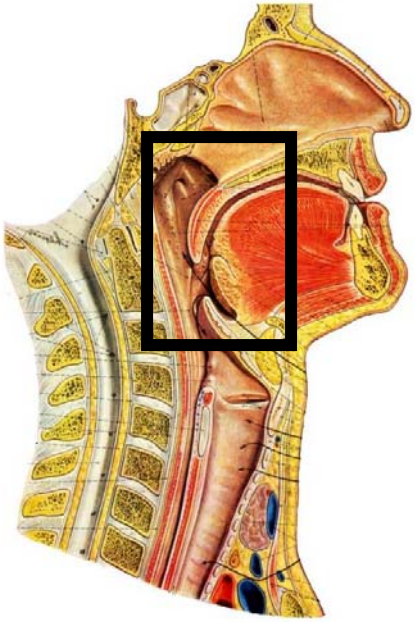


1:1000 Births

Can be unilateral or bilateral



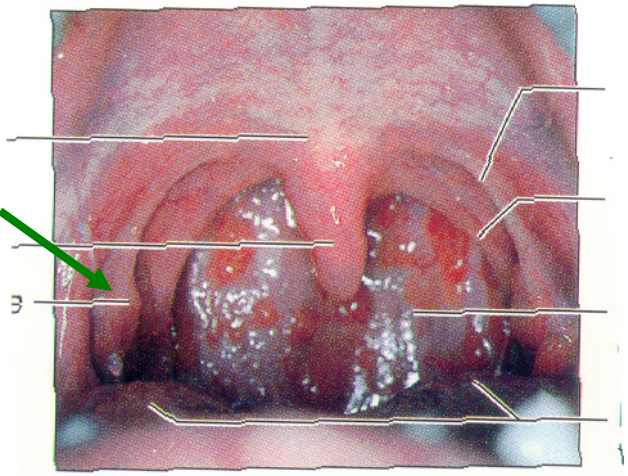
Note: Ant. Cleft Palate is same as Cleft Lip

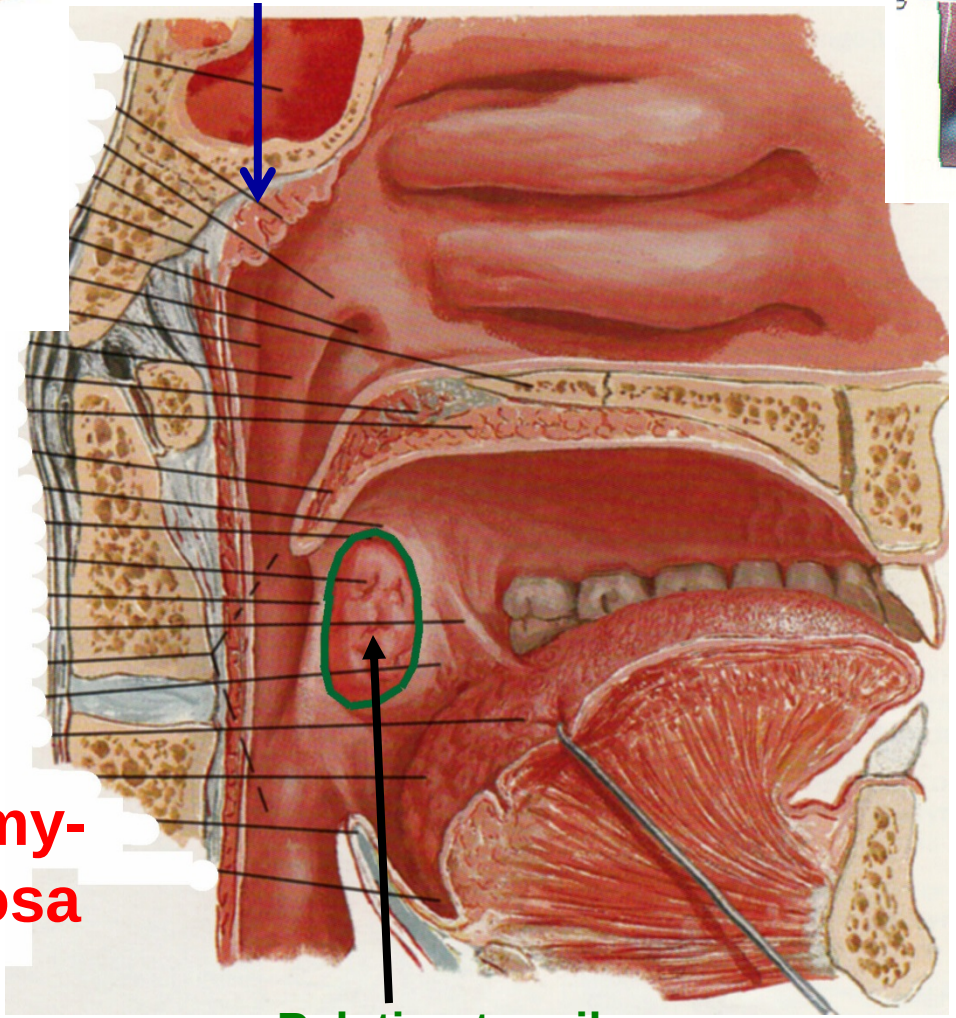


VI. PALATINE TONSILS

PHARYNGEAL TONSIL = ADENOIDS

Palatine Tonsil





Palatine tonsil

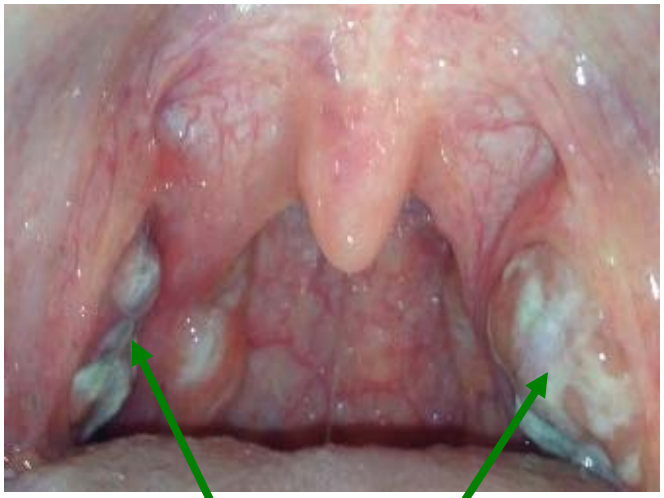
Palatine Tonsil - lymphoid tissue In oropharynx between Palatoglossal and Palatopharyngeal Arches

Tonsillectomy- incise mucosa to remove Palatine tonsil

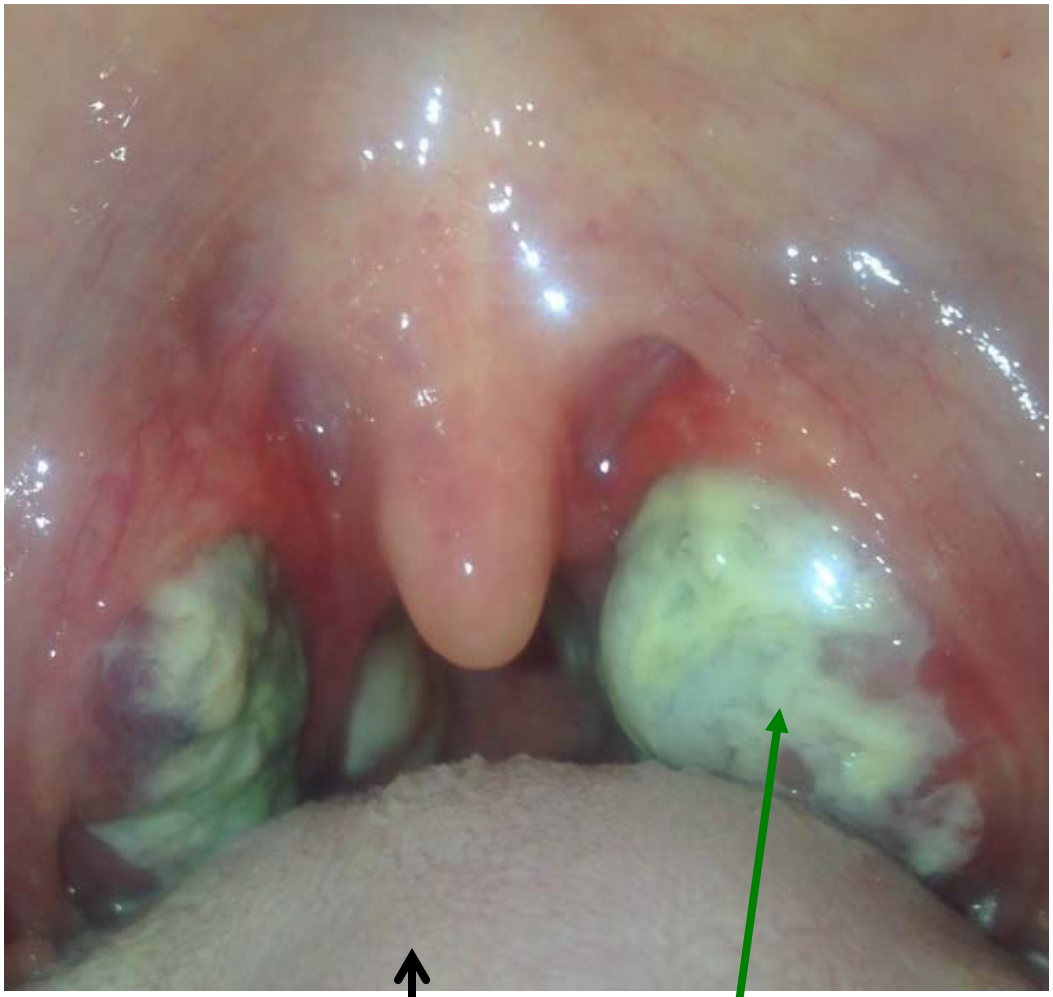
TONSILLITIS = inflammation of (Palatine) tonsils

Cause - bacterial (Streptococcus) or viral infection

UVULA



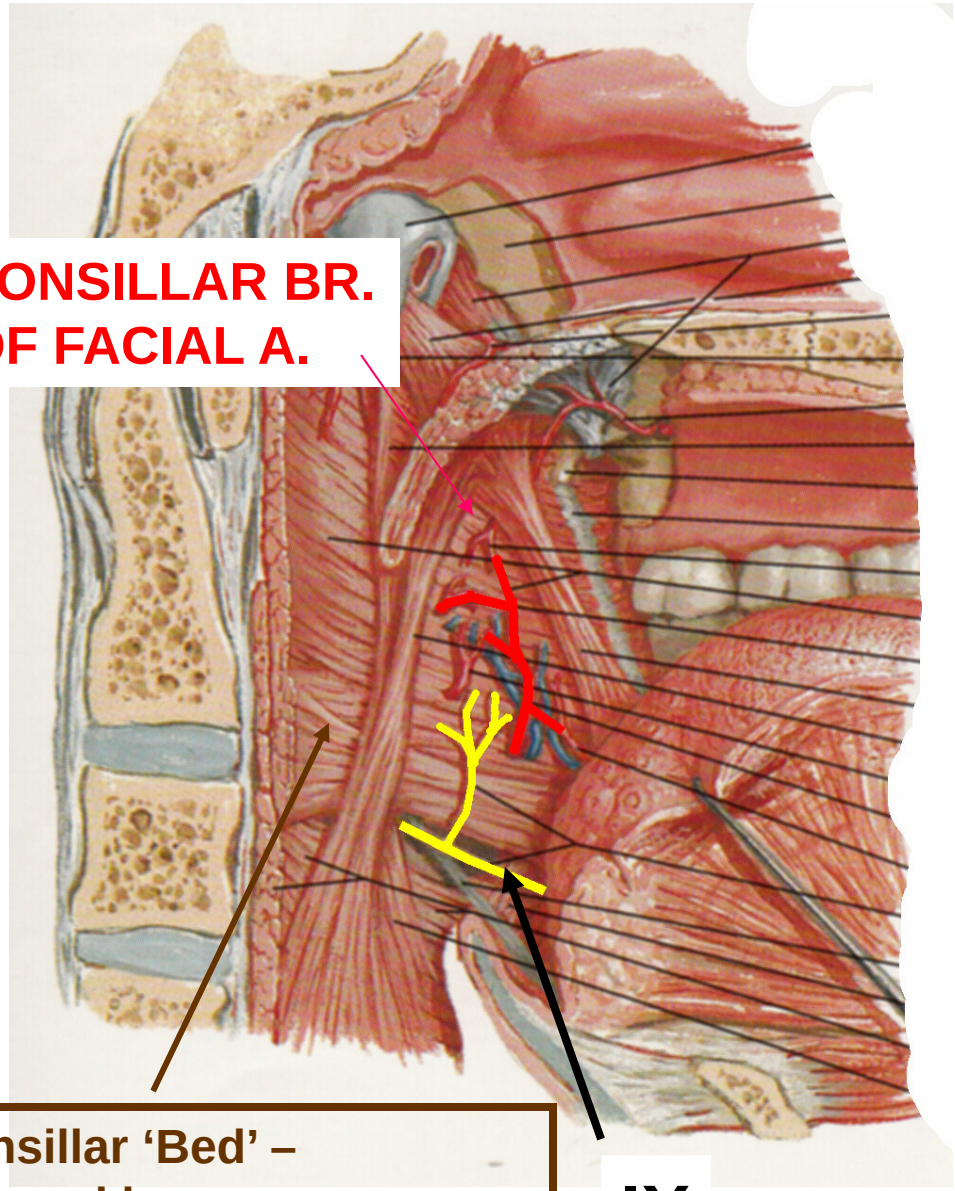
Palatine Tonsils



hi mag image:
tilt head

Palatine Tonsil

PALATINE TONSILS



A. Arteries-
From Tonsillar branch of Facial Artery - can be large

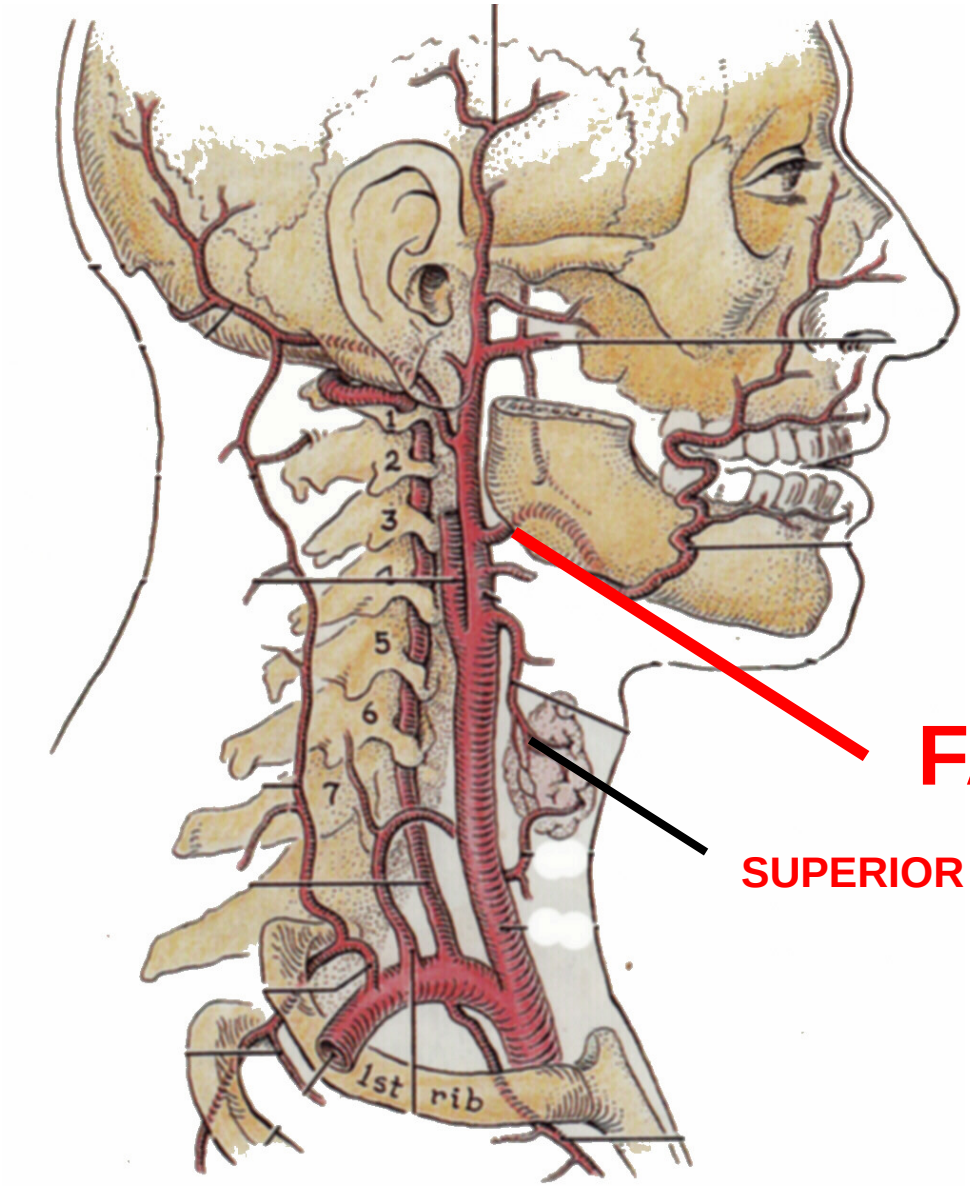
B. Veins – join Pharyngeal Plexus of Veins – Drain to Facial lingual or Inf. Jugular

C. Lymphatics –Deep cervical nodes
***Jugulo-Digastric- Enlarged**

Tonsillar 'Bed' –
Formed by
1) Superior Constrictor of Pharynx
2) Styloglossus

Note:
1) Glossopharyngeal Nerve only covered by Pharyngo-Basilar Fascia can be damaged ***
2) Extensive bleeding after tonsillectomy - tonsillar branch of Facial Artery

FACIAL ARTERY



NOSE

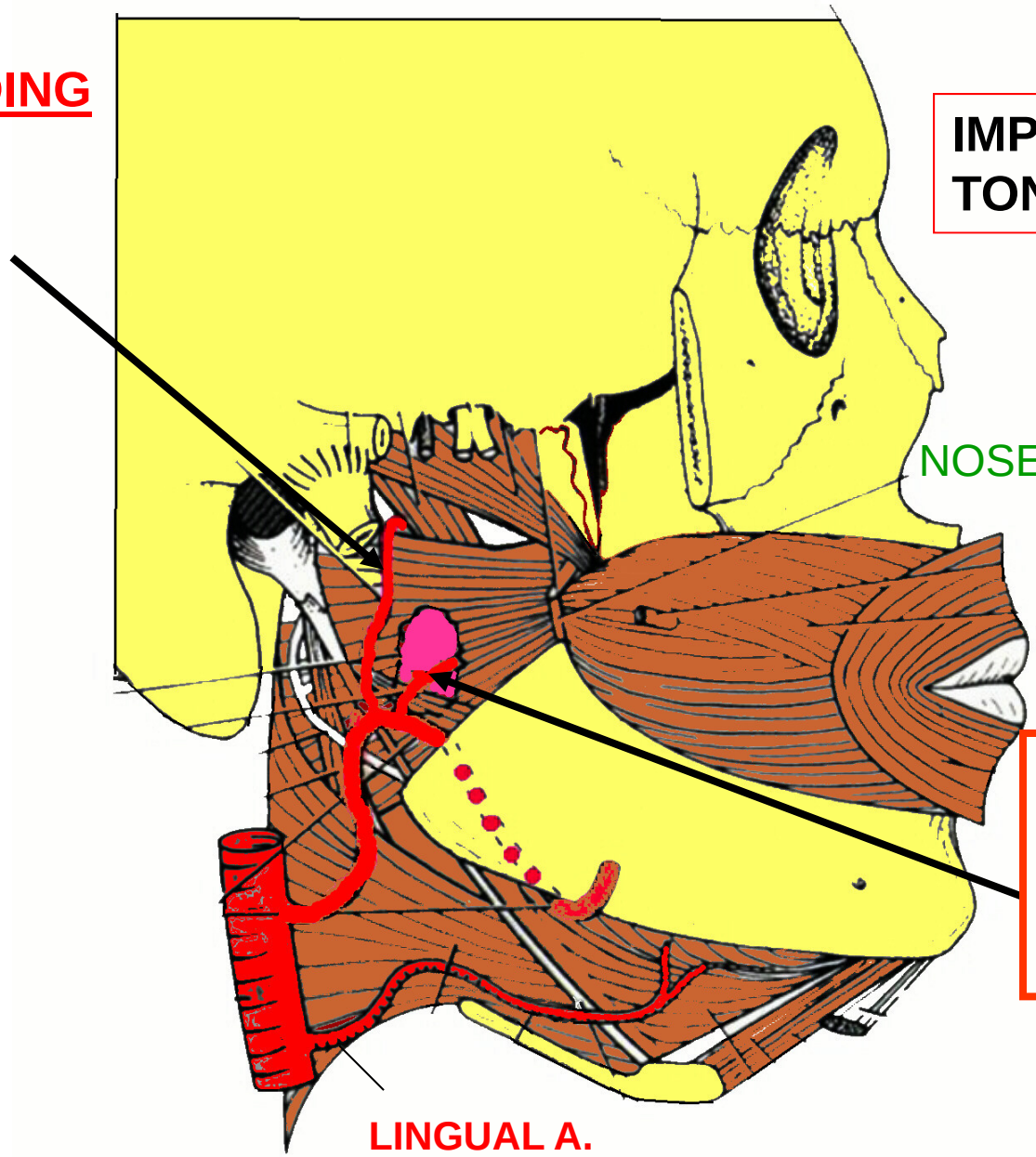
FACIAL A.

COURSE =
'WIGGLE' X 3

SUPERIOR THYROID A.

FACIAL ARTERY- BRANCHES MEDIAL TO MANDIBLE

a) ASCENDING PALATINE ARTERY - PALATE

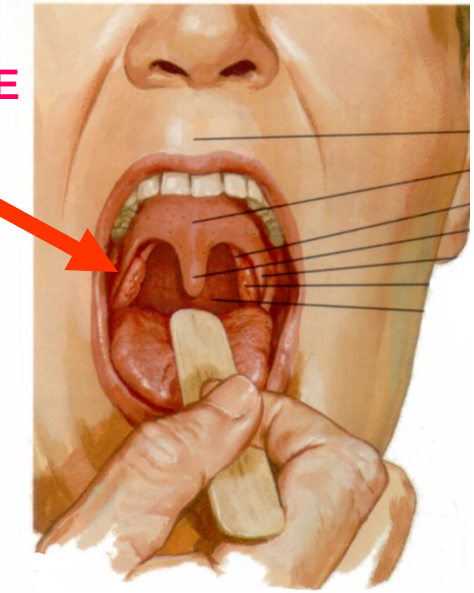


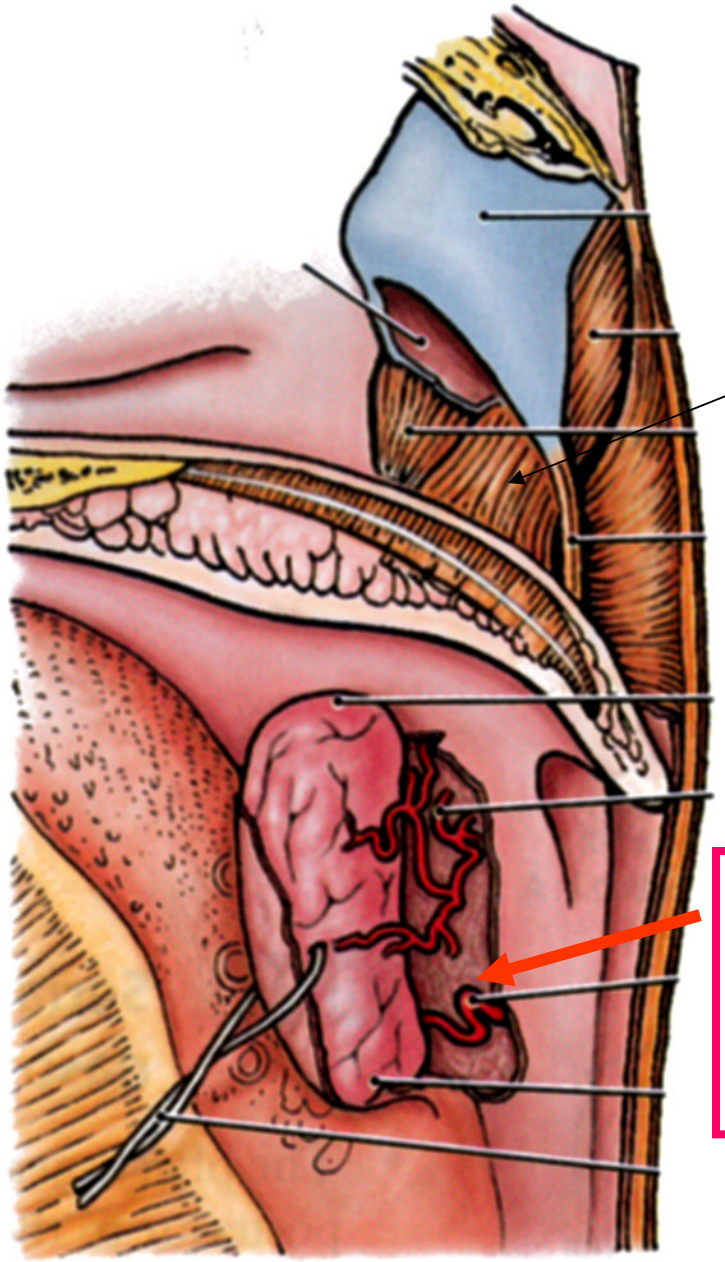
IMPORTANT IN TONSILLECTOMY

b) TONSILLAR BRANCH - PALATINE TONSIL

FACIAL ARTERY- BRANCHES MEDIAL TO MANDIBLE

PALATINE TONSIL





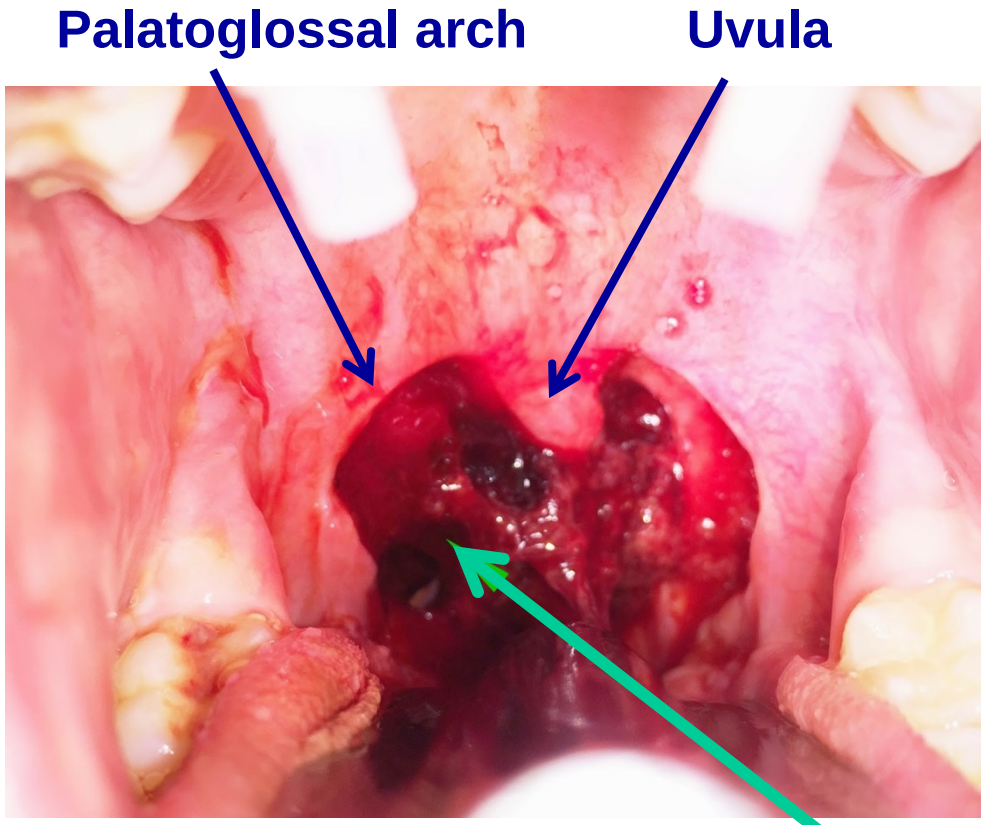
what muscle?

NOTE: TONSILLECTOMY - Post-operative bleeding of Tonsillar branch of Facial artery is complication of removal of palatine tonsils; also damage IX **

b) **TONSILLAR BRANCH** - PALATINE TONSIL

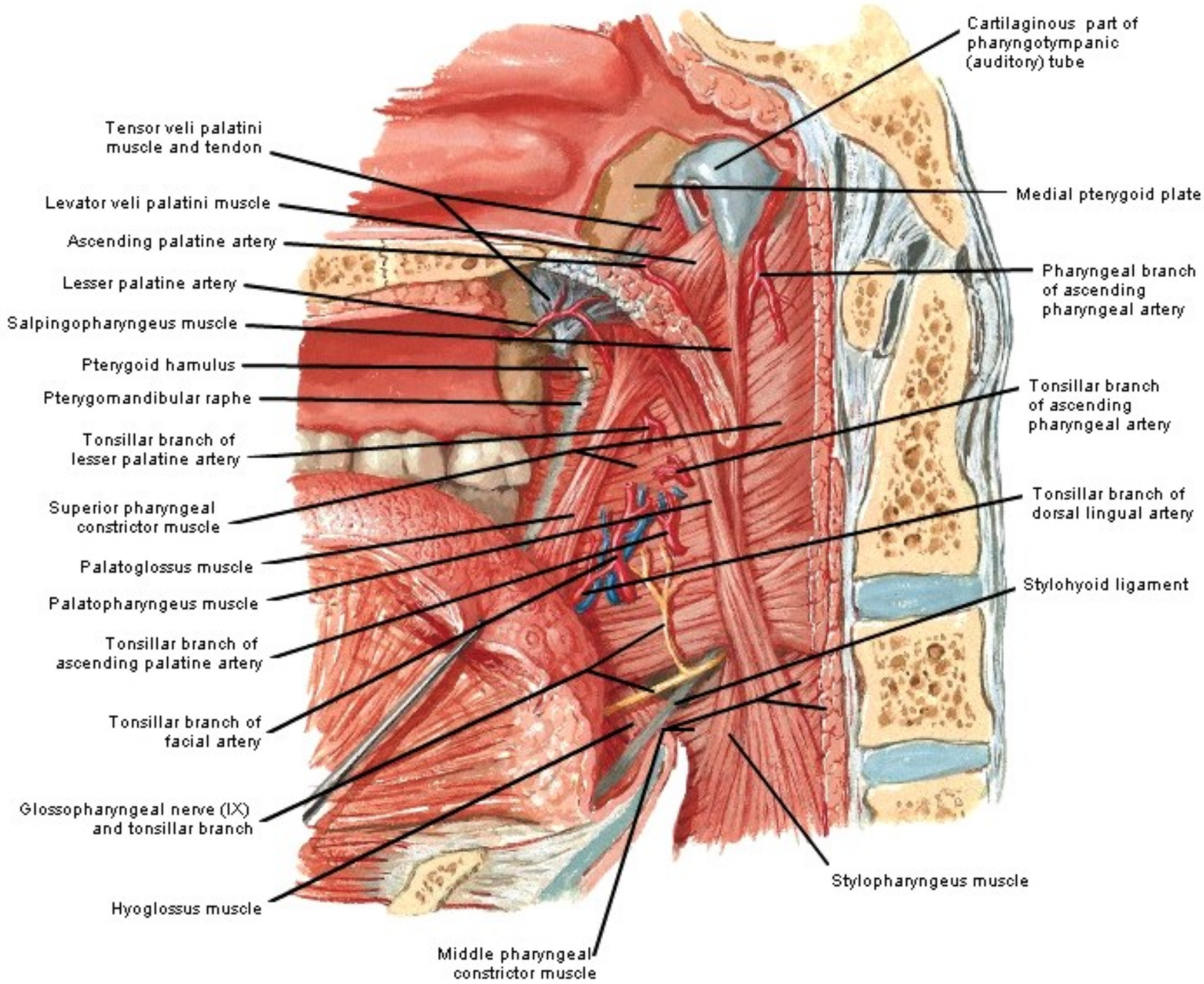
note: Board question

POSTOPERATIVE BLEEDING FOLLOWING TONSILLECTOMY



Palliative Technique: Eat ice cream without spoon

Note: define Palliative - relieving pain without dealing with the cause of the condition.


Cartilaginous part of pharyngotympanic (auditory) tube
Tensor veli palatini muscle and tendon
Medial pterygoid plate
Levator veli palatini muscle
Ascending palatine artery
Pharyngeal branch of ascending pharyngeal artery
Lesser palatine artery
Salpingopharyngeus muscle
Pterygoid hamulus
Tonsillar branch of ascending pharyngeal artery
Pterygomandibular raphe
Tonsillar branch of lesser palatine artery
Tonsillar branch of dorsal lingual artery
Superior pharyngeal constrictor muscle
Palatoglossus muscle
Stylohyoid ligament
Palatopharyngeus muscle
Tonsillar branch of ascending palatine artery
Tonsillar branch of facial artery
Glossopharyngeal nerve (IX) and tonsillar branch
Stylopharyngeus muscle
Hyoglossus muscle
Middle pharyngeal constrictor muscle

LARYNX

I. **CARTILAGES** - larynx consists of cartilages which are connected by membranes and ligaments and moved by muscles; larynx sits above trachea; produces sound, prevents objects from entering respiratory system.

A. Thyroid cartilage - shield shaped cartilage; has horns (cornua) projecting from upper and lower edges; have synovial hinge joints with cricoid cartilage.

B. Cricoid cartilage - complete ring of cartilage resting on first tracheal cartilage; has narrow arch (anterior part) and broad lamina (posterior part).

C. Arytenoid cartilages- two pyramidal shaped cartilages that rest above lamina of cricoid; have synovial joints with cricoid cartilage that allow for swivel and sliding movements.

D. Corniculate cartilages - two small nodule shaped cartilages that articulate with apices of the arytenoid cartilages, give attachment to aryepiglottic folds (see below).

E. Cuneiform cartilages - two small rod shaped cartilages in aryepiglottic folds.

F. Epiglottic cartilage - leaf-shaped cartilage posterior to root of tongue; connected to body of hyoid bone and back of thyroid cartilage.

II. **LIGAMENTS OF LARYNX**

A. Structural ligaments - hold larynx, hyoid and trachea together

1. Thyrohyoid membrane - links thyroid cartilage to hyoid bone; thickened medial part called median thyrohyoid ligament.

2. Cricothyroid membrane - links cricoid to thyroid cartilage; thickened medial and anterior part called Median cricothyroid ligament.

3. Cricotracheal ligament - links cricoid to first tracheal cartilage.

4. Quadrangular membrane - links arytenoid to epiglottis; lower free edge is called vestibular ligament.

5. Thyroepiglottic ligament - links epiglottis to thyroid cartilage.

B. Functional Ligaments

1. Conus elasticus - elastic membrane forming vibrating lips; arises from entire upper edge of arch of cricoid; attaches anteriorly to thyroid cartilage, posteriorly to vocal processes of arytenoid cartilages; upper free edges are thickened to form vocal ligaments; opening between vocal ligaments is called rima glottidis.

C. Functions of conus elasticus

1. Sound production - When the vocal ligaments are brought close together, air forced through rima glottidis causes ligaments to vibrate producing sound.

2. Closing rima glottidis - When vocal ligaments are pressed tightly together the rima glottidis is closed; this prevents upward movement of the diaphragm when the abdominal muscles contract; contraction of the abdominal muscles therefore increases pressure in the abdomino-pelvic cavity; this is useful in childbirth, micturition, defecation, etc.

III. **MUSCLES OF THE LARYNX**

A. Extrinsic muscles of larynx - move entire larynx, active during swallowing; suprahyoid muscles elevate larynx, infrahyoid muscles depress larynx.

B. Intrinsic muscles of larynx - mostly well named for their origins and insertions.

MUSCLE	**ACTION**	**NERVE**
Cricothyroid	Tenses vocal fold, raises pitch of sound	External Laryngeal n. (X)
Thyroarytenoid	Relaxes vocal fold, decreases pitch of sound	Recurrent Laryngeal n. (X)
Posterior cricoarytenoid	Abducts vocal folds, opens rima glottidis	Recurrent Laryngeal n. (X)
Lateral cricoarytenoid	Adducts vocal folds, closes rima glottidis	Recurrent Laryngeal n. (X)
Arytenoid (Transverse arytenoid)	Adducts vocal folds, closes rima glottidis	Recurrent Laryngeal n. (X)
Aryepiglottic muscle	Pulls down epiglottis during swallowing	Recurrent Laryngeal n. (X)

Note: the branch of the Recurrent Laryngeal n. (X) innervating the laryngeal muscles is specifically called the Inferior Laryngeal n. (this was a picky question on the board exams)

IV. **TERMS ASSOCIATED WITH LARYNX**

A. Folds

1. Vocal (True Vocal) folds - overlie vocal ligaments.
2. Vestibular (False Vocal) folds - overlie vestibular ligaments.
3. Aryepiglottic folds - overlie upper edge of quadrangular membrane.

B. Areas

1. Vestibule - inlet above false vocal folds.
2. Ventricle - between false and true vocal folds; laryngeal sinus is lateral extension of ventricle.

V. **INNERVATION** - from Vagus

A. Superior Laryngeal nerve

1. Internal Laryngeal nerve - Visceral sensory to larynx above vocal folds.

2. External Laryngeal nerve - Branchiomotor to cricothyroid muscle.

B. Recurrent Laryngeal nerve - Visceral sensory to larynx below vocal folds; Branchiomotor to all other muscles of larynx.

VI. **BLOOD SUPPLY** - Superior Laryngeal Artery - from Superior Thyroid a.; Inferior Laryngeal Artery - from Inferior Thyroid a.

VII. **LYMPHATICS** - Superior deep cervical nodes - drain larynx above vocal folds; Inferior deep cervical nodes - drain larynx below vocal folds.

Clinical Note: **Anaphylactic Shock** - Mucosa is tightly attached to vocal folds; in Anaphylactic Shock (acute allergic reaction) swelling of Vestibular folds can constrict airway and lead to asphyxiation)

VIII. **OBSTRUCTION OF LARYNX** - asphyxiation may also result if food or foreign object becomes lodged in larynx; in emergency a cut may be made through the cricothyroid membrane to open air passage (**Cricothyrotomy)**; this is preferable to cutting into the trachea (Tracheotomy) because the Thyroid veins overlie the trachea.

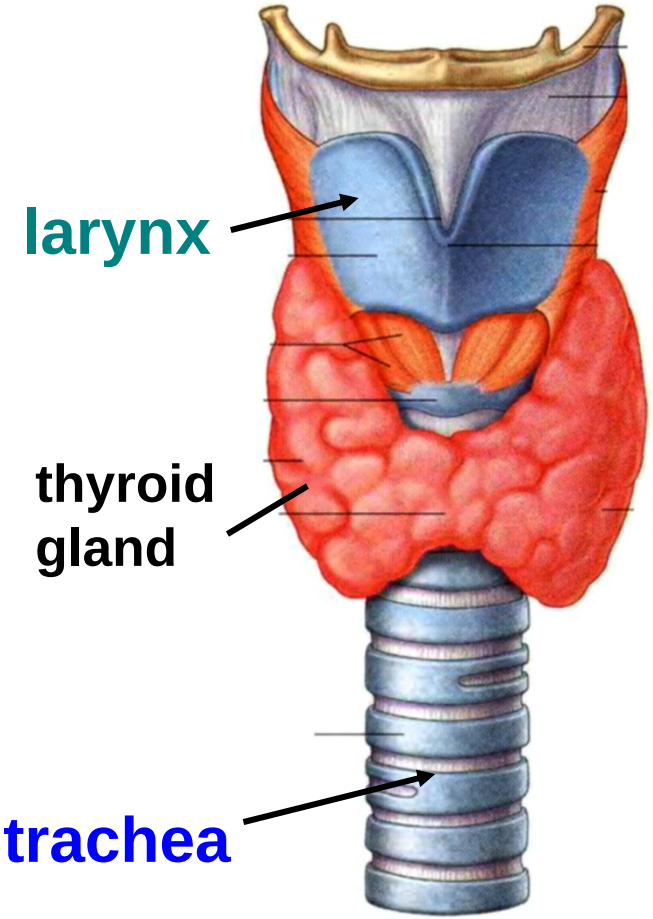
LARYNX

OUTLINE

I. CARTILAGES
II. LIGAMENTS
III. MUSCLES
IV. TERMS/AREAS
V. INNERVATION
VI. BLOOD SUPPLY
VII. LYMPHATICS
VIII. OBSTRUCTION OF LARYNX

LARYNX IS SOUND GENERATOR; HOWEVER, SOUNDS ARE EXTENSIVELY MODIFIED IN SPEECH AND SINGING BY RESONANCE OF PHARYNX, NASAL CAVITY, ORAL CAVITY

LARYNX

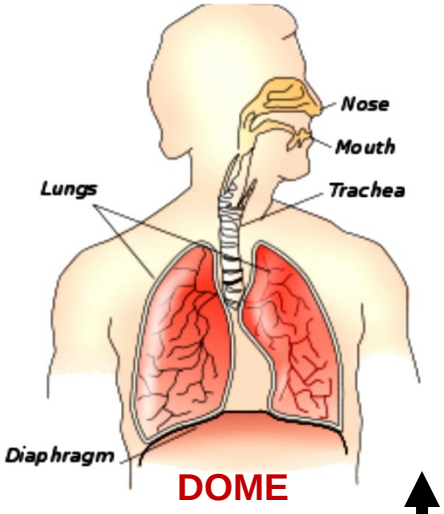


Cartilages connected by membranes and ligaments, moved by muscles

2 Functions: 1) Sound production

2) Closes of Respiratory System - allows increase in Abdominal Pressure

Note: In Respiration - Inspire - Diaphragm; Expire - Some muscles but largely passive; Forced Expire - Abdominal Muscles



DOME

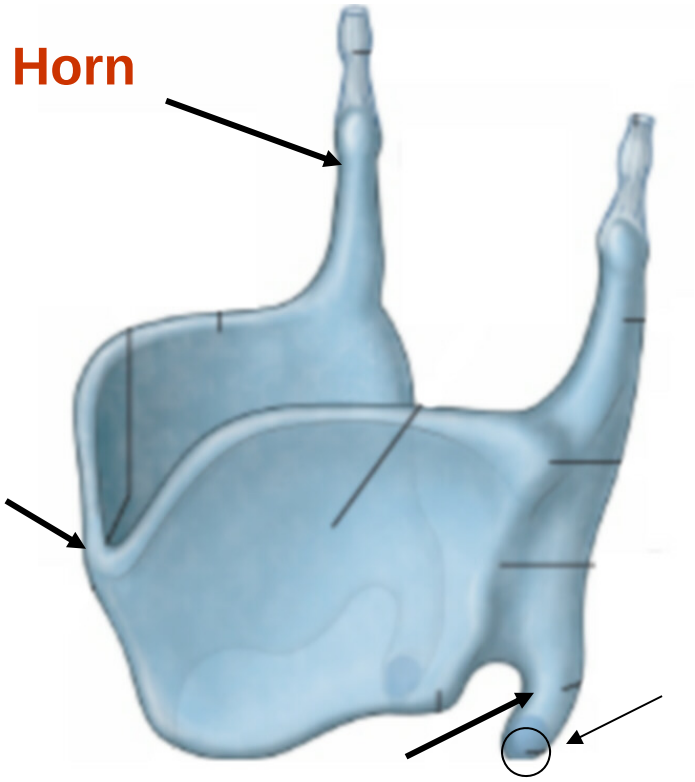
INSPIRE - diaphragm

EXPIRE - abdominal muscles

When larynx closes off trachea, forced expiration produces increased abdominal pressure: push- childbirth; defecation etc.

I. LARYNX: CARTILAGES

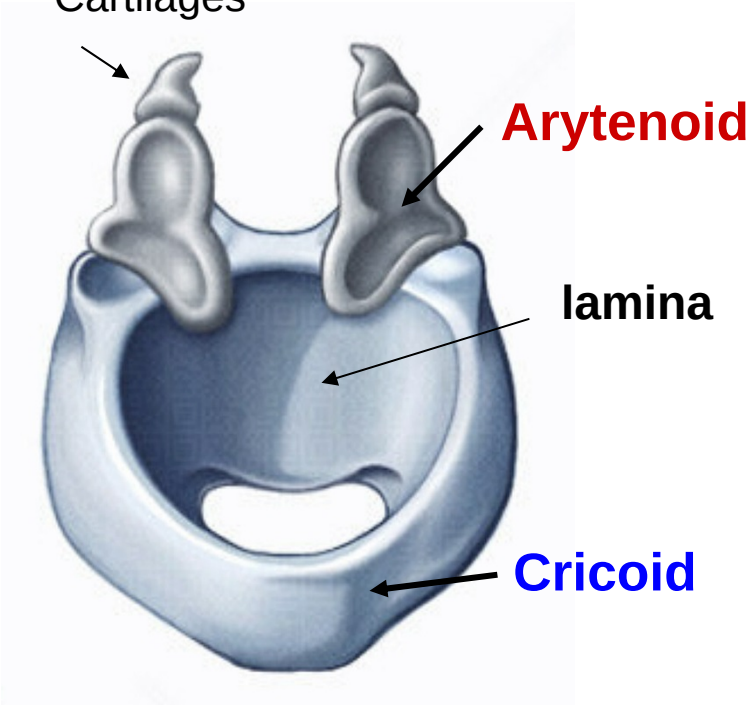
A. <u>THYROID CARTILAGE</u> – Shield shaped
- has Sup. and Inf. Horns from upper and lower edges



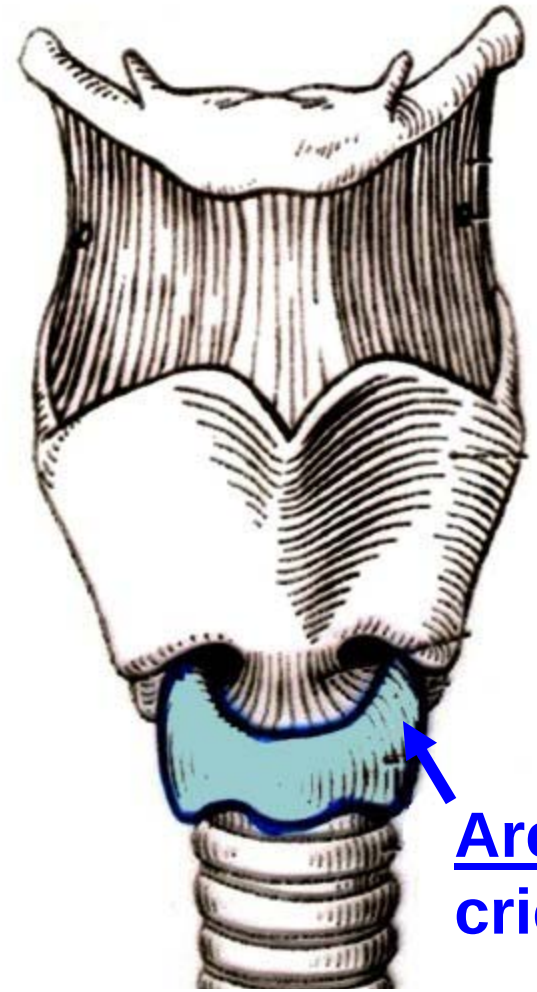
- <u>Inferior horns</u> make synovial hinge joints with Cricoid Cartilage; - <u>Laryngeal Prominence = Adam's Apple</u>, more prominent in males

LARYNX: CARTILAGES

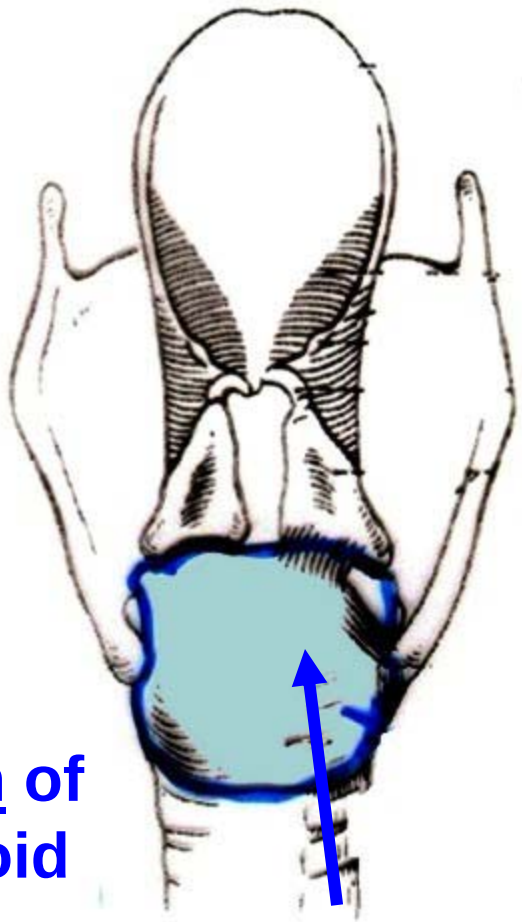
B. CRICOID- complete ring of cartilage has narrow Arch ant., broad Lamina post.



ANT VIEW



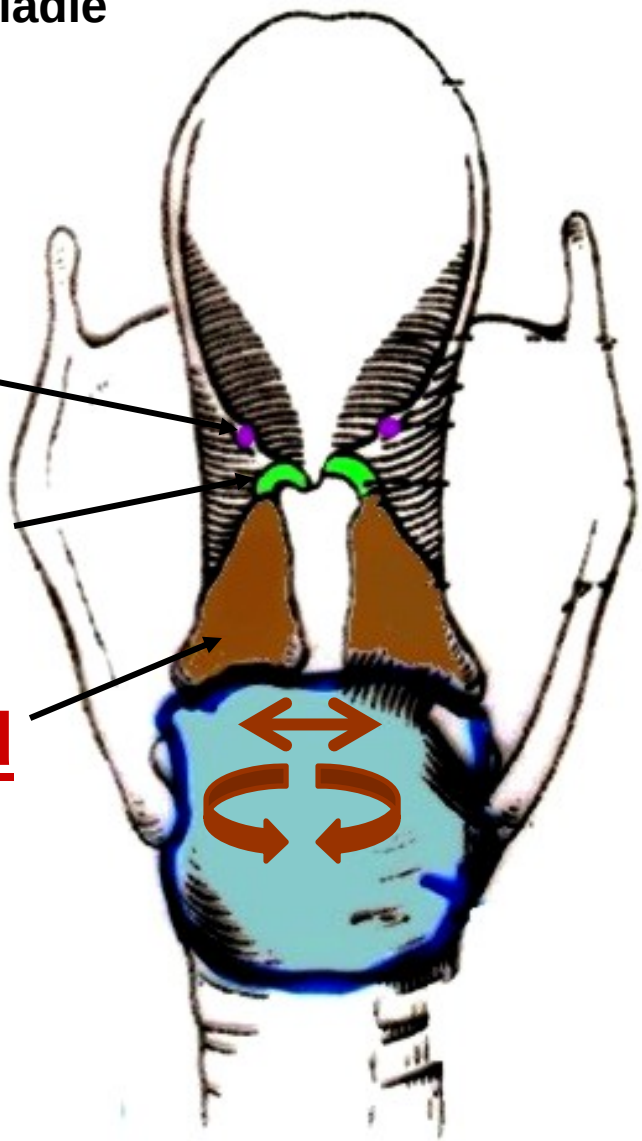
POST VIEW



Cricoid means Signet Ring

LARYNX: CARTILAGES

arytenoid - Gk. ladle
cornu - L. horn



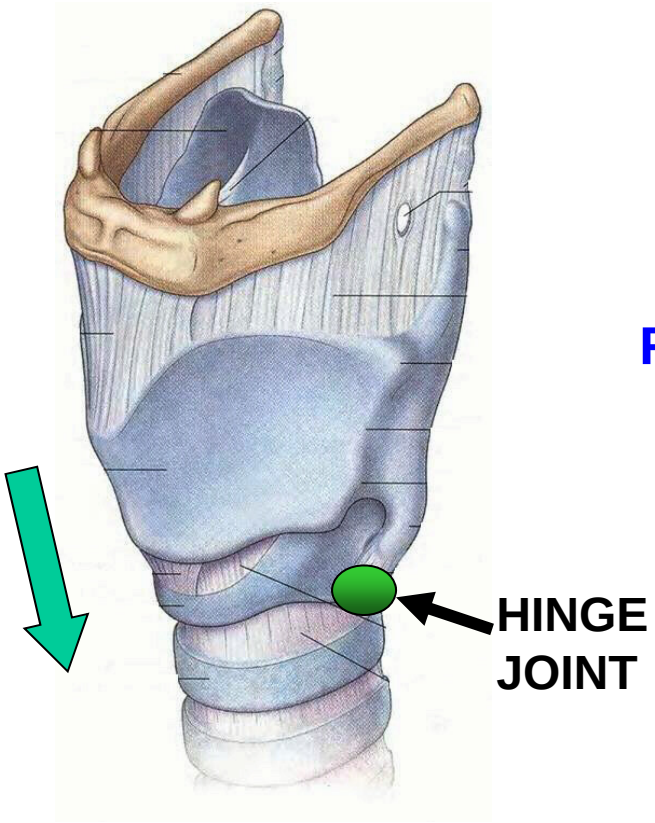
C. Arytenoid - 2 pyramidal shaped cartilages above lamina – have synovial joints with Cricoid permit
Swivel = Rotate
Sliding = Ab/Adduct

D. Corniculate - nodules above arytenoids in aryepiglottic folds

E. Cuneiform - rod shaped, above corniculate cartilages

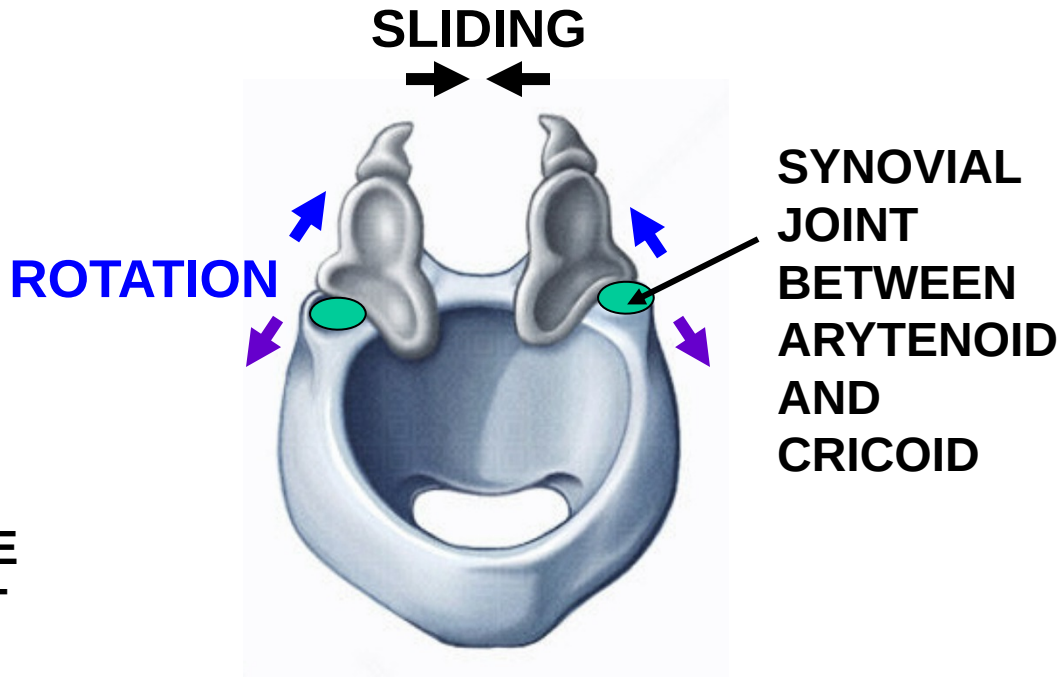
LARYNX: SYNOVIAL JOINTS

THYROID and CRICOID



JOINTS PERMIT TILTING OF THYROID-CRICOID:
- CHANGE PITCH OF SOUND (TENSE OR RELAX VOCAL LIGAMENTS)

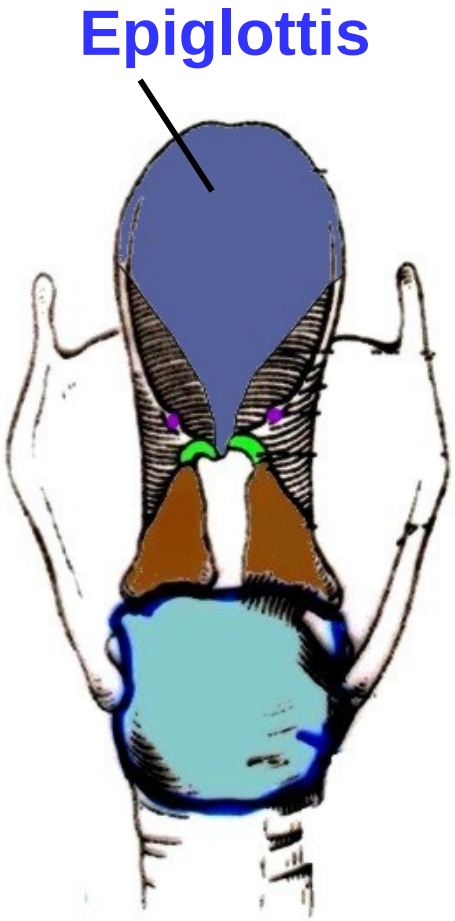
ARYTENOID and CRICOID

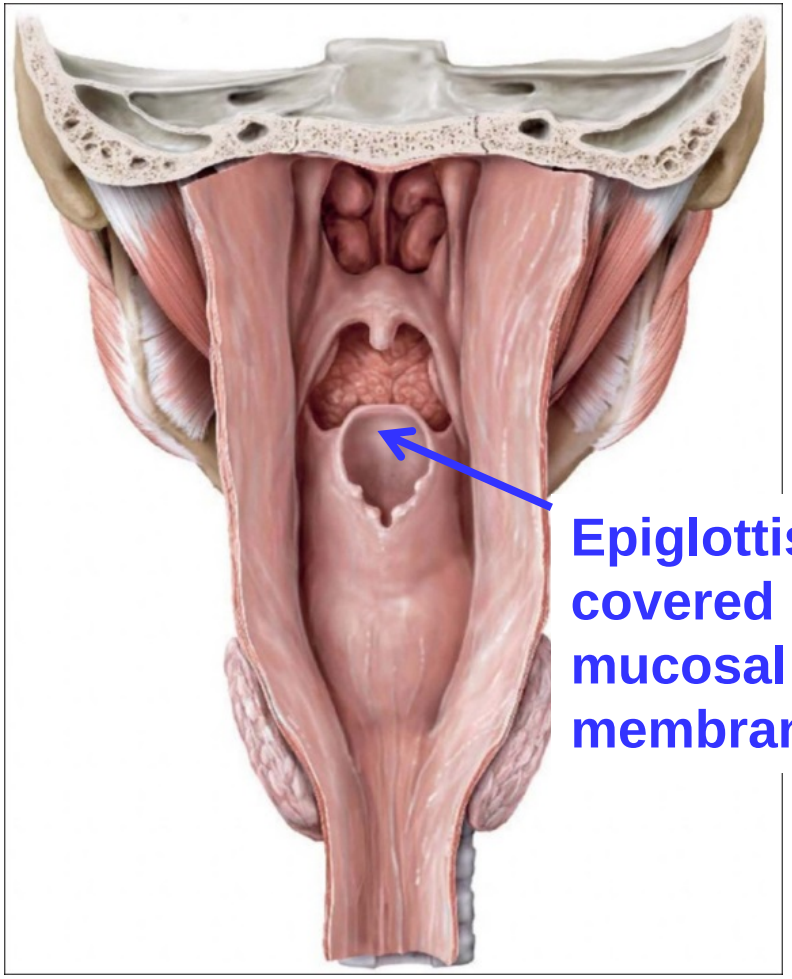


JOINTS PERMIT ROTATION AND SLIDING:
- OPEN OR CLOSE LARYNX (ABDUCT OR ADDUCT VOCAL LIGAMENTS)

LARYNX CARTILAGES: EPIGLOTTIS

POST. VIEW

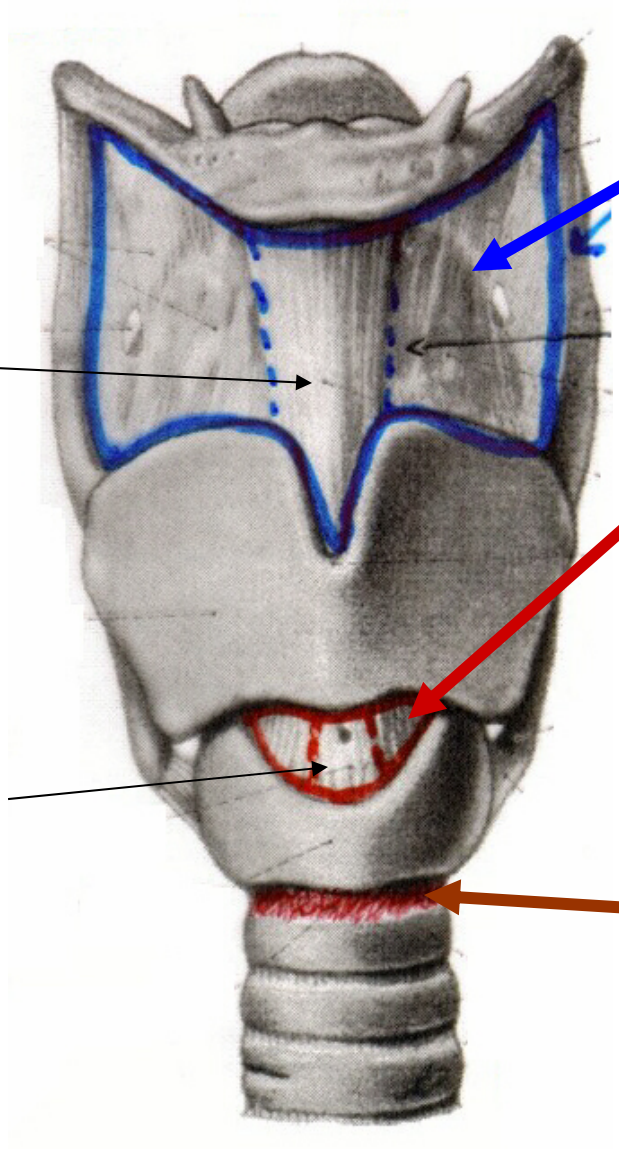




F. <u>EPIGLOTTIS</u> - <u>leaf shaped</u> cartilage posterior to root of tongue; connected to body of hyoid and post side of thyroid cartilage

II. LIGAMENTS OF LARYNX

A. Structural ligaments - hold larynx, hyoid, trachea together

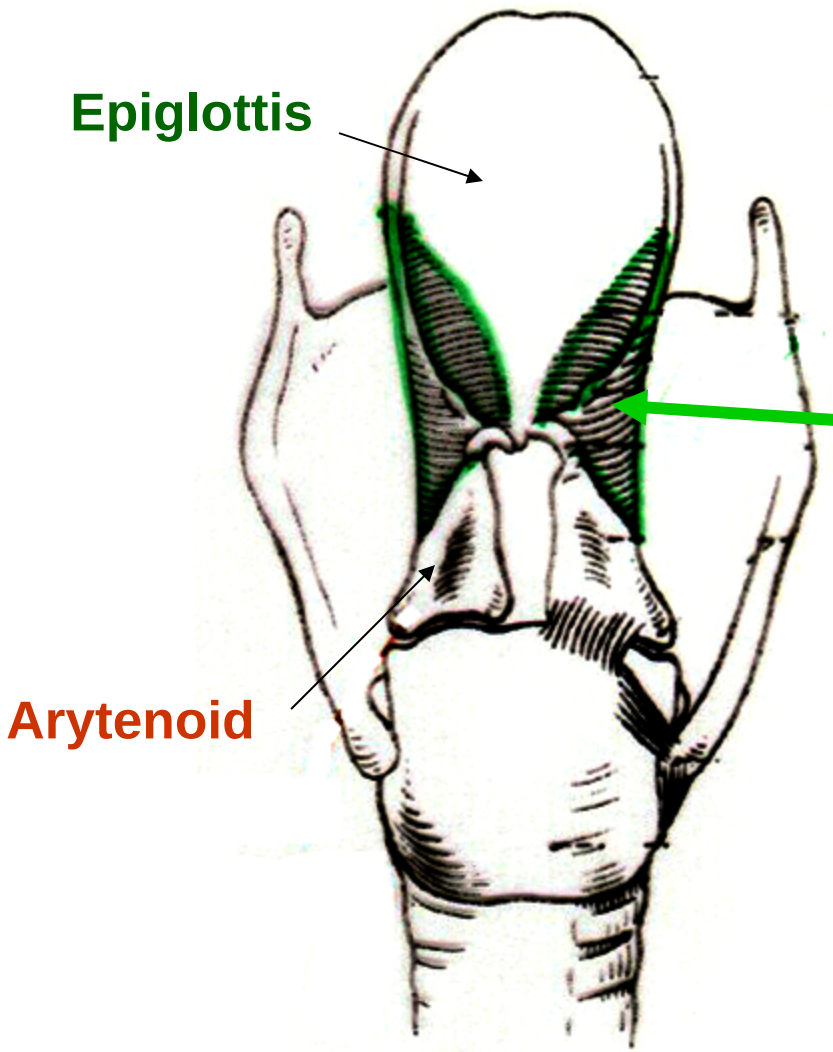


1. Thyrohyoid Membrane links larynx to hyoid; Median Thyrohyoid Ligament - thickened midline part

2. Cricothyroid Membrane links thyroid to cricoid; Median Cricothyroid Ligament - thickened midline part

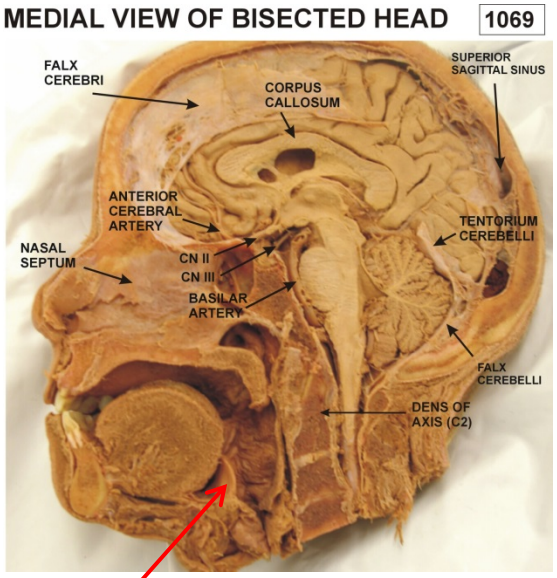
3. Cricotracheal ligament links Cricoid to first tracheal cartilage

STRUCTURAL LIGAMENTS

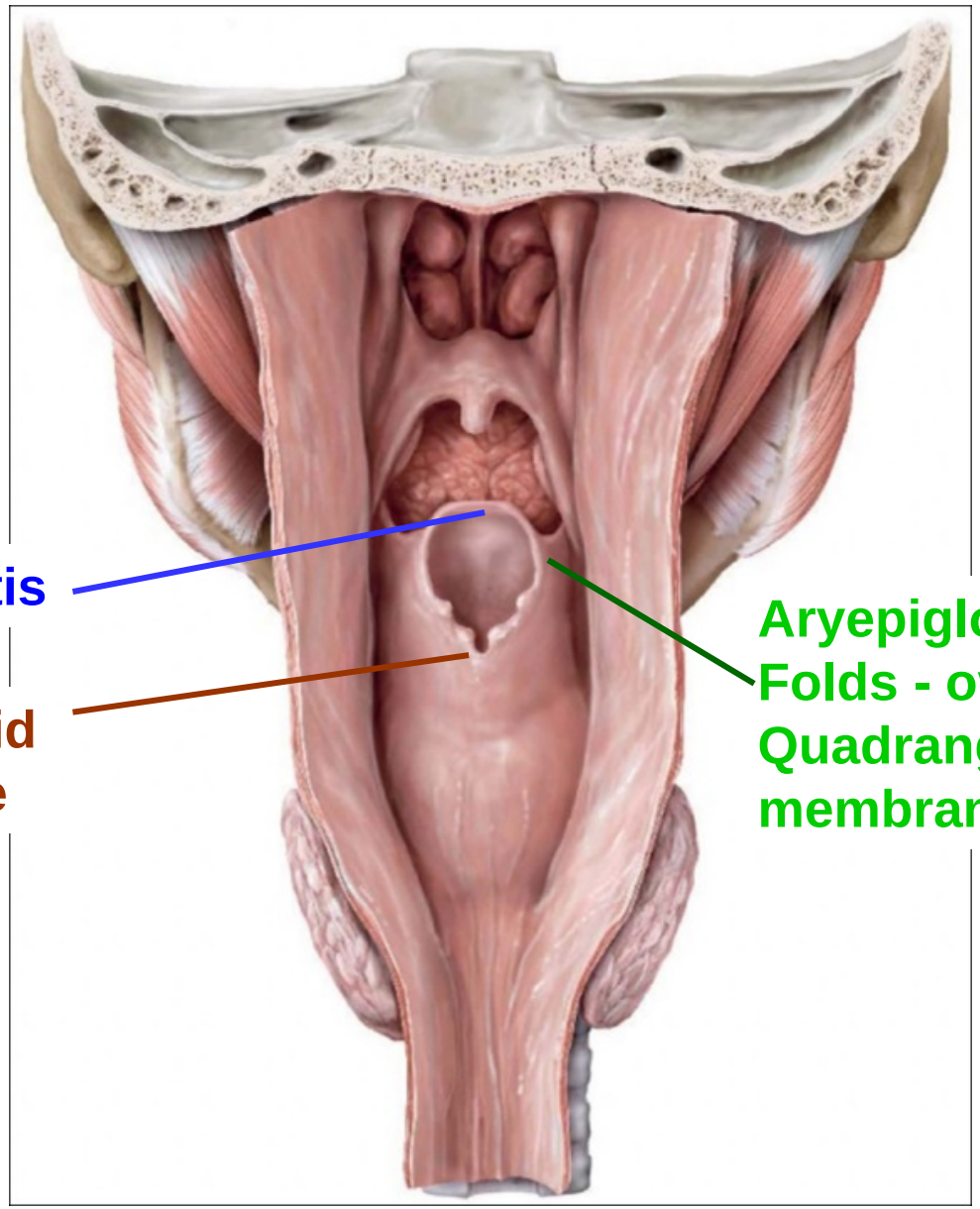


4. <u>Quadrangular Membrane</u> links
Arytenoid
To epiglottis

STRUCTURAL LIGAMENTS



EPIGLOTTIS



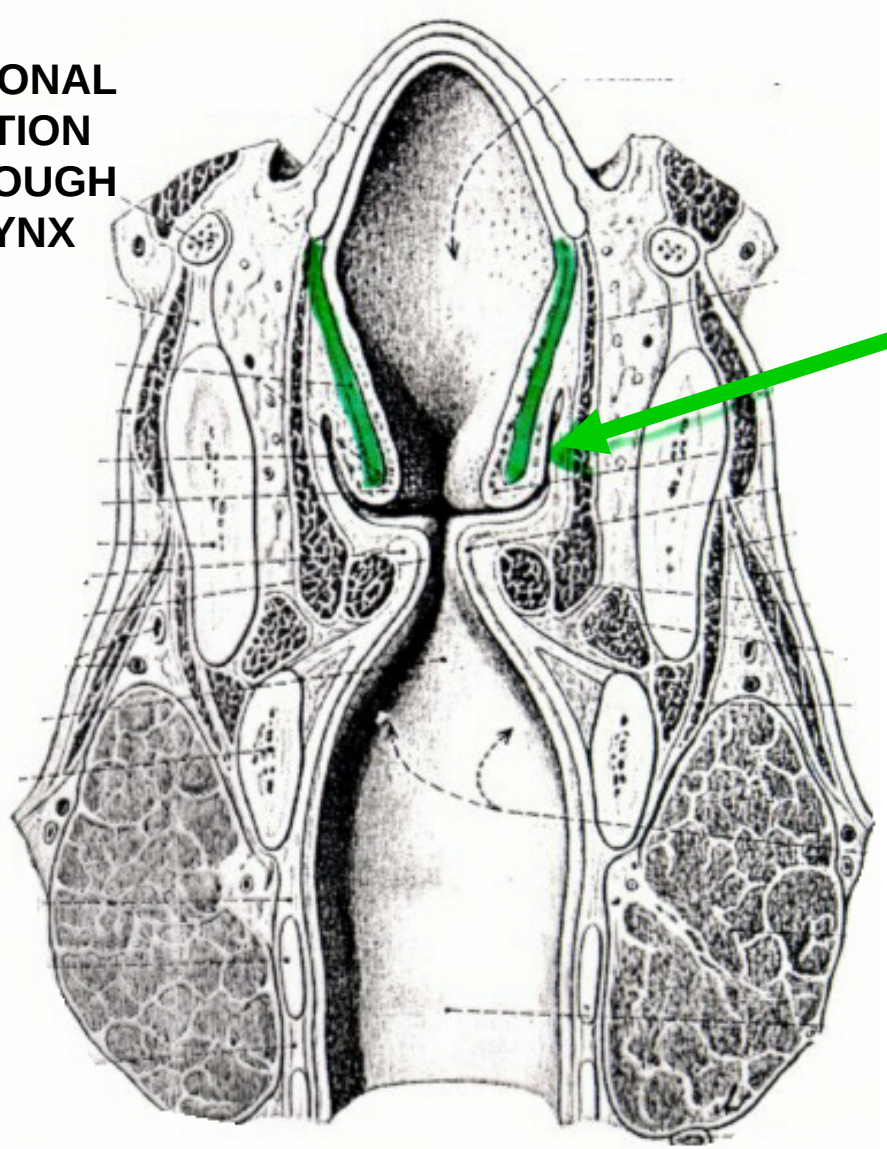
Epiglottis

Arytenoid cartilage

Aryepiglottic Folds - overlie Quadrangular membrane

STRUCTURAL LIGAMENTS

CORONAL SECTION THROUGH LARYNX



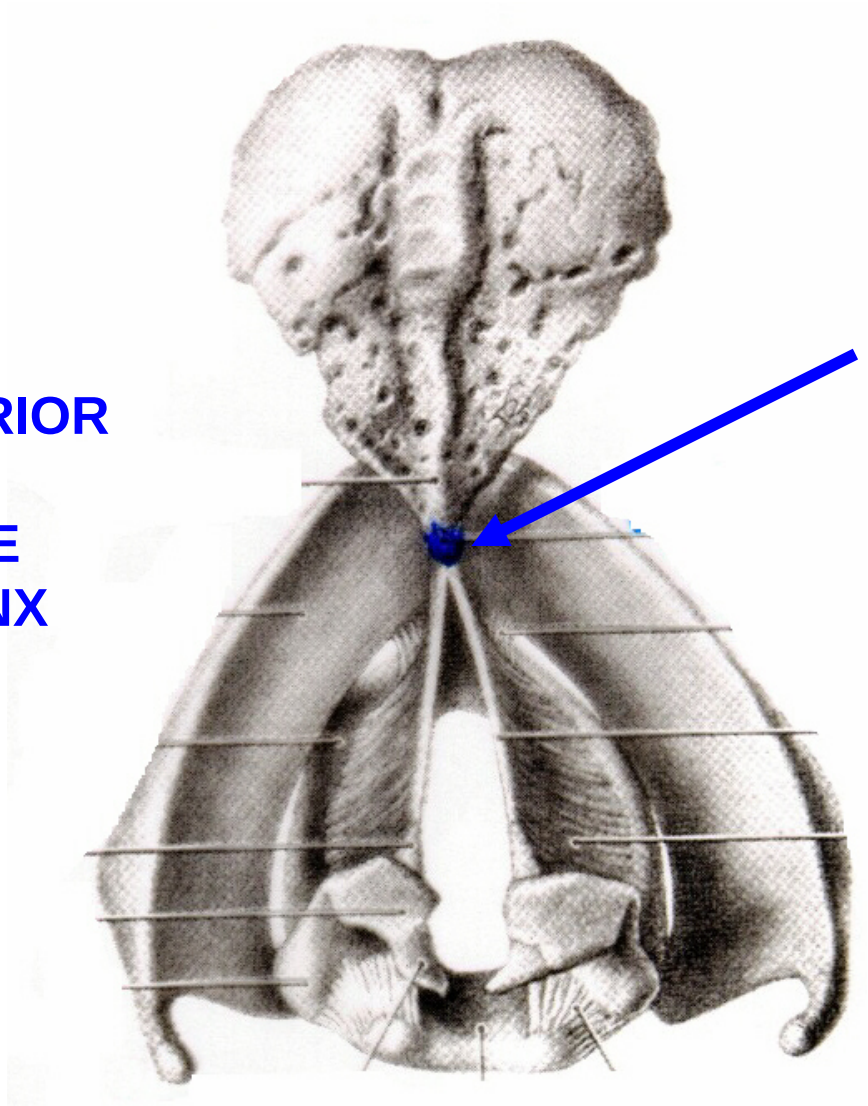
trachea

Lower free edge of Quadrangular membrane is Called <u>Vestibular Ligament</u>; deep to Vestibular (False Vocal) Folds

STRUCTURAL LIGAMENTS

NOSE

SUPERIOR VIEW ABOVE LARYNX



5. <u>Thyroepiglottic Ligament</u>
links epiglottis to thyroid cartilage

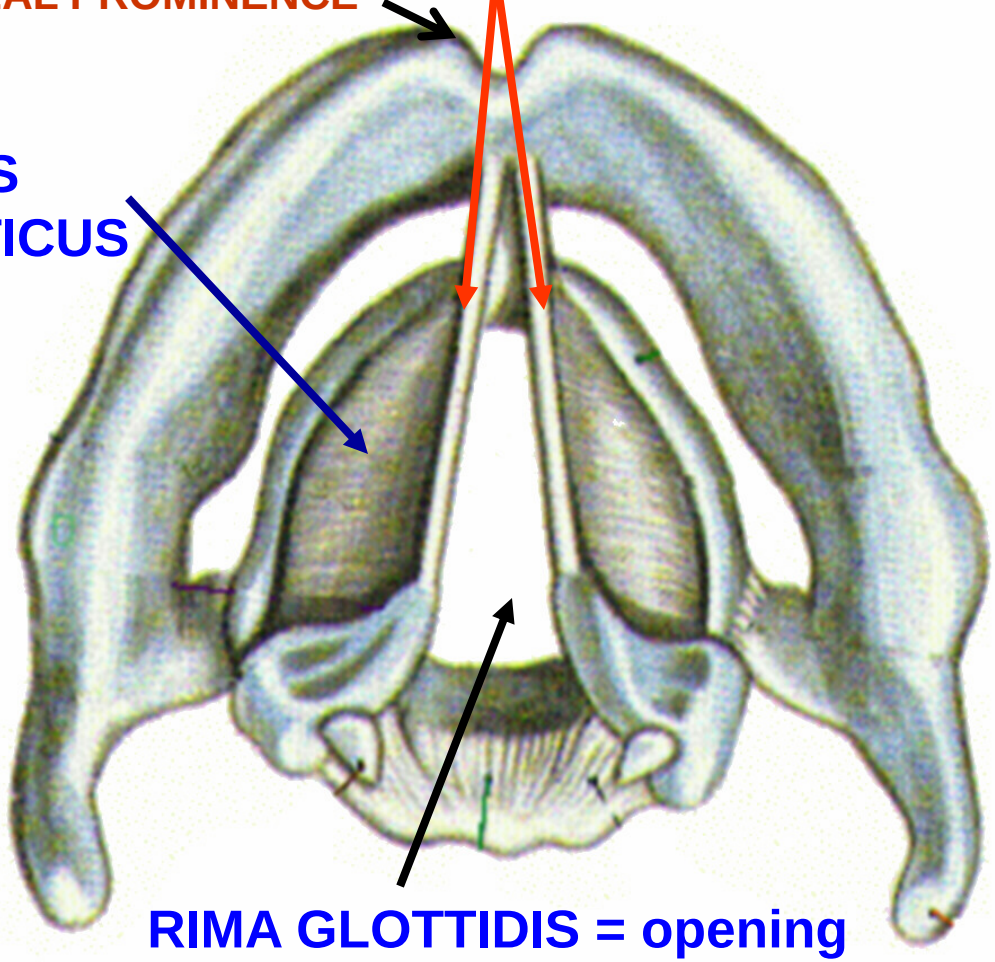
B. FUNCTIONAL LIGAMENTS

NOSE
top view

VOCAL LIGAMENTS = UPPER FREE EDGE OF CONUS

LARYNGEAL PROMINENCE

CONUS ELASTICUS



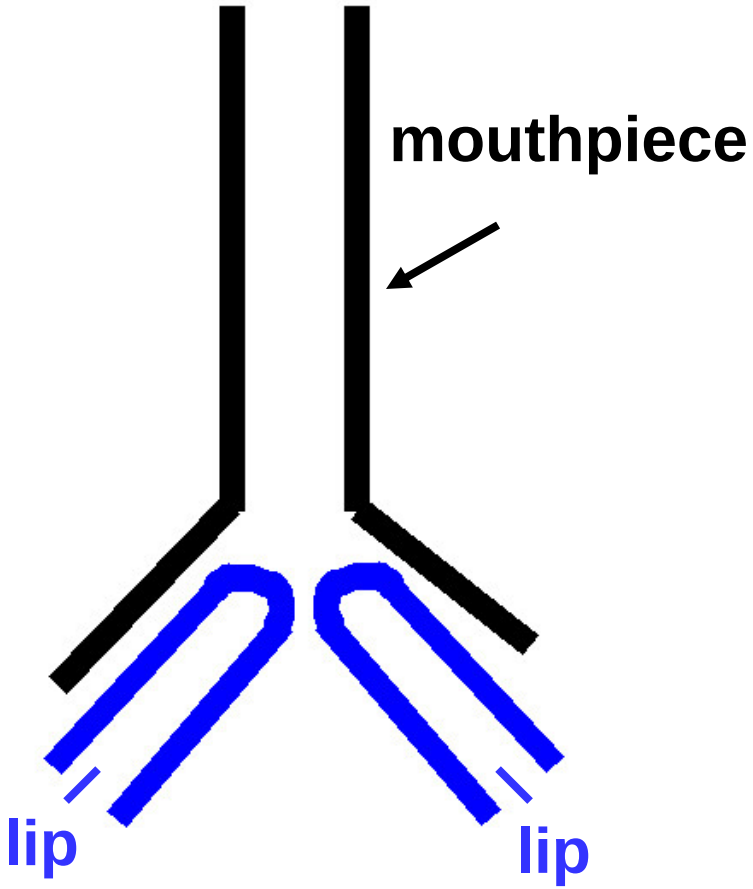
RIMA GLOTTIDIS = opening between Vocal ligaments

Functional ligaments: Conus Elasticus -
Vibrating lips that arise from entire upper edge of arch of cricoid
Attach: ant. to Thyroid, post. to Arytenoid

VOCAL LIGAMENTS - longer in males than females
- Laryngeal Prominence is Adam's apple not Eve's apple

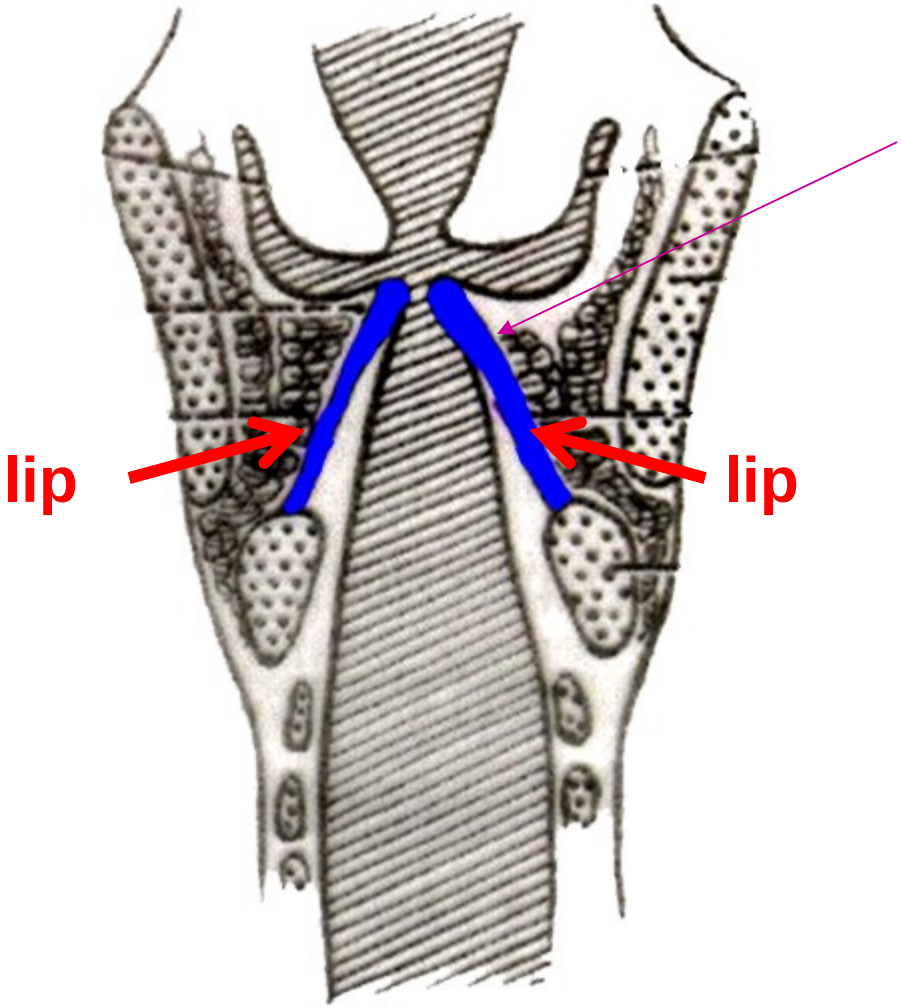
LARYNX PRODUCES SOUND LIKE LIPS OF TRUMPET PLAYER

Trumpet player –
Clifford Brown



Tense lips - raise pitch
Relax lips - lower pitch

FUNCTIONAL LIGAMENTS

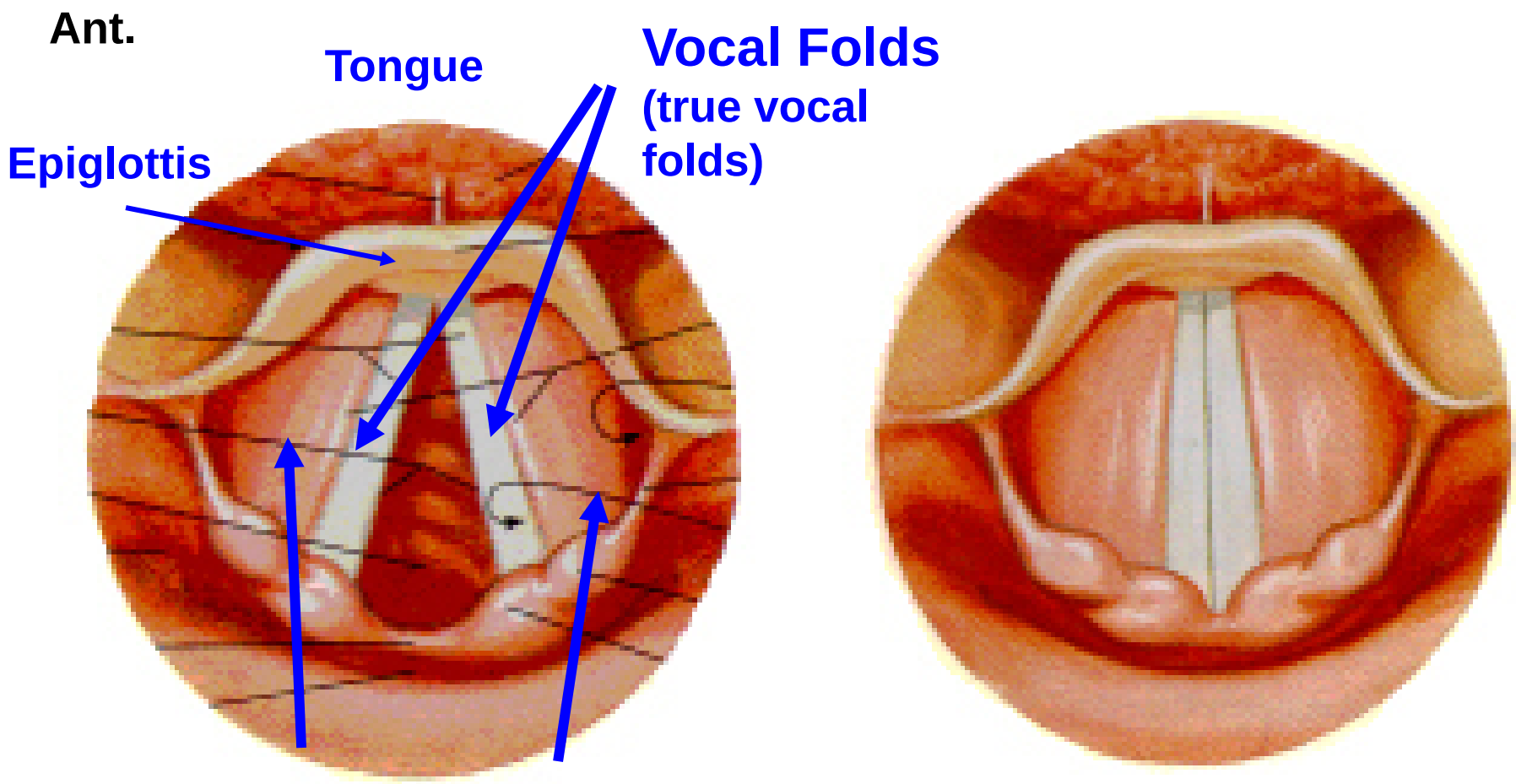


(In Coronal Section)

Conus Elasticus Functions

1) Sound Production – Vibrate like lips of trumpet player;
2) Close Rima Glottidis stops outflow air, upward movement of diaphragm - when contract abdominal muscle pressure increases in abdominal cavity; occurs in childbirth, defecation

LARYNGOSCOPE VIEW OF LARYNX

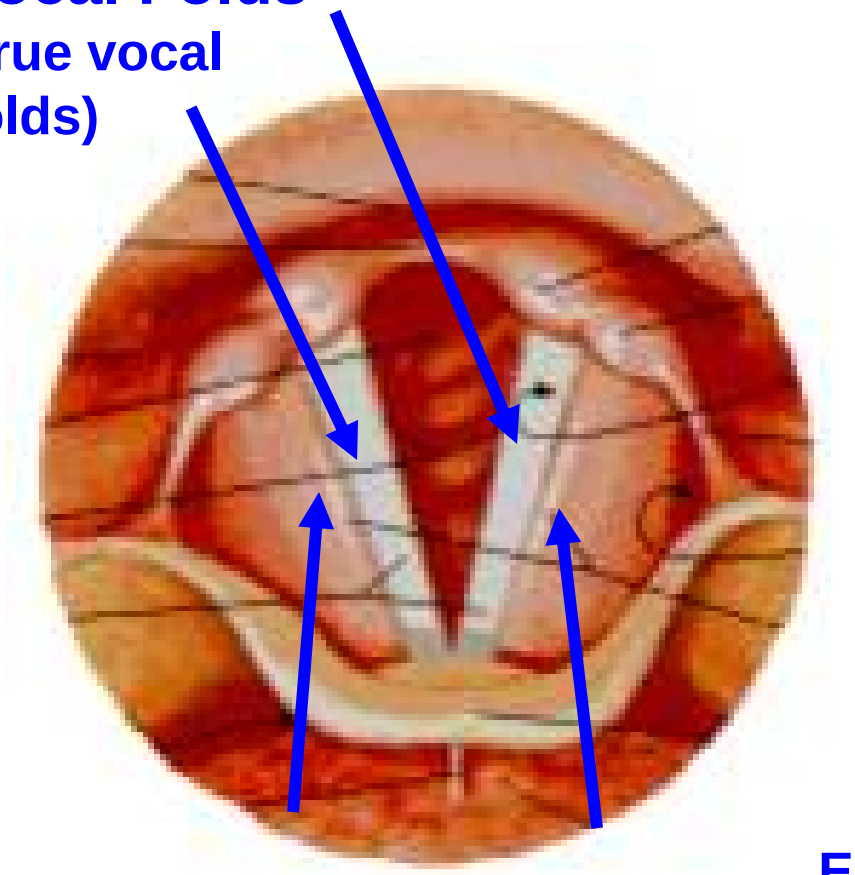


vocal folds adducted when talking or singing

LARYNGOSCOPE VIEW OF LARYNX

Post.

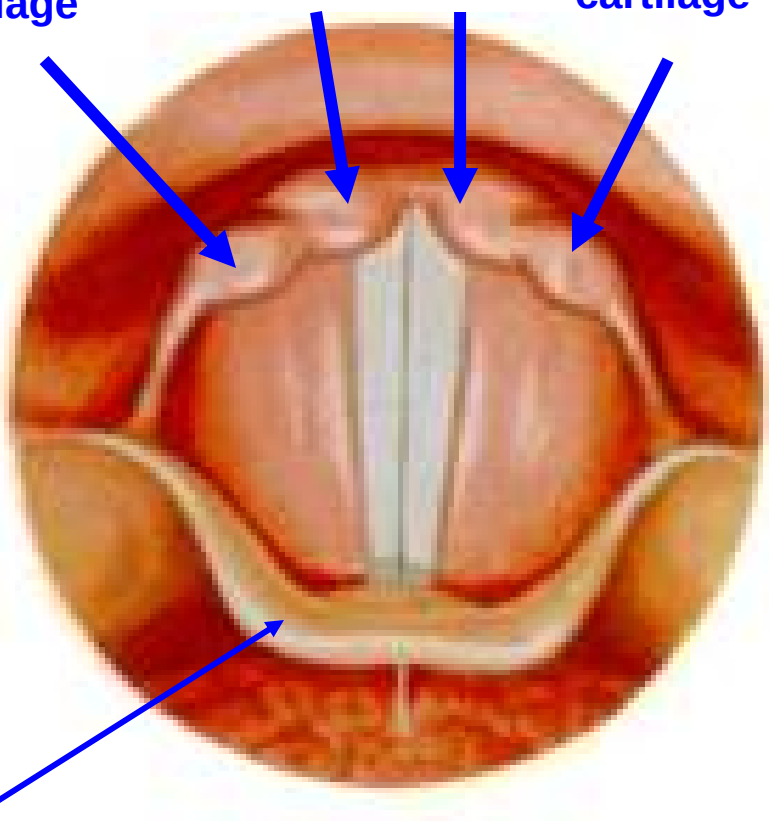
Vocal Folds
(true vocal folds)



Cuneiform cartilage

Corniculate cartilages

Cuneiform cartilage



Epiglottis

Vestibular Folds
(false vocal folds)

Ant.

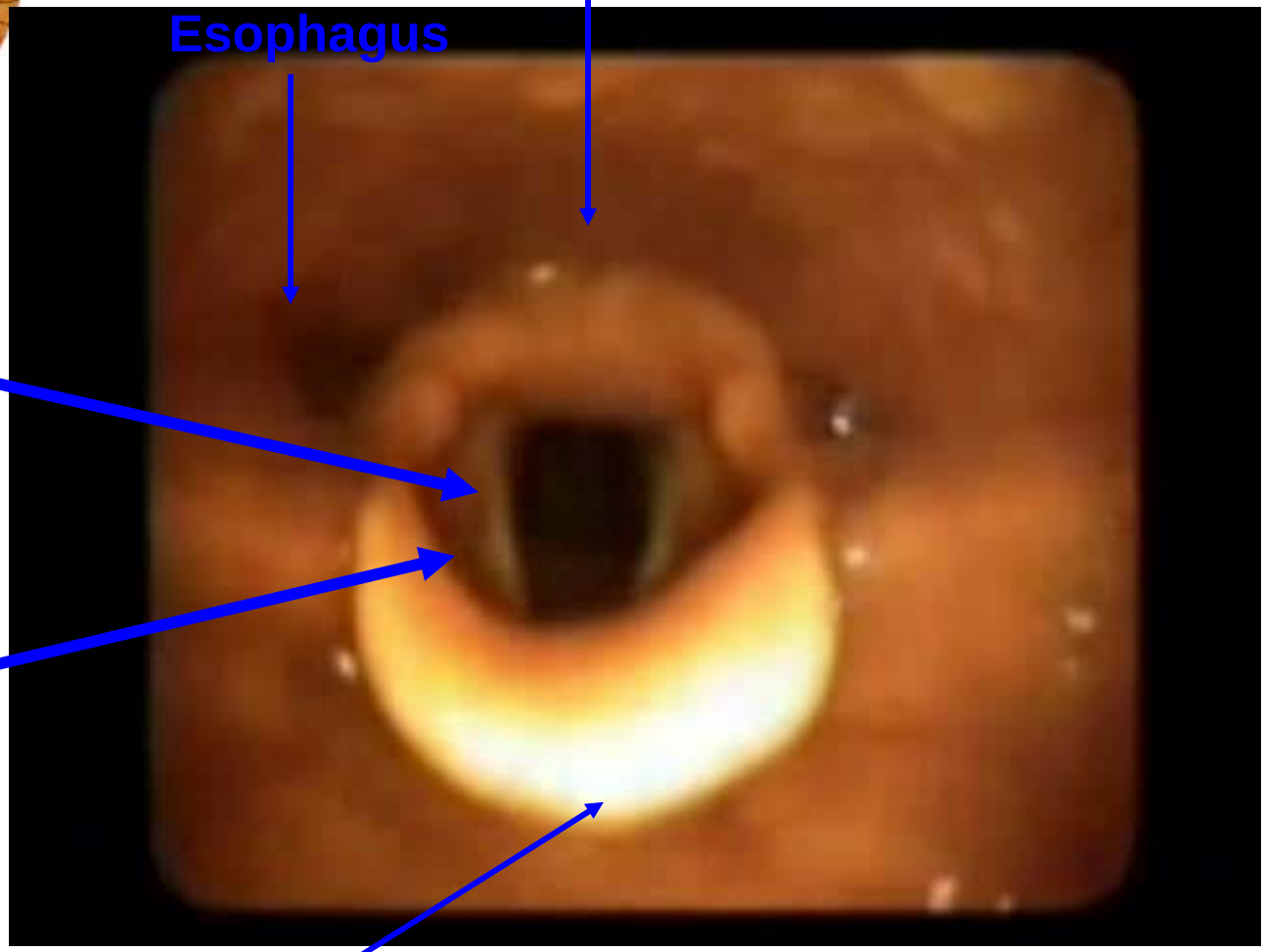
Tongue

vocal folds adducted when talking or singing

BREATHING (INHALATION)

Leads to Esophagus

Leads to Esophagus

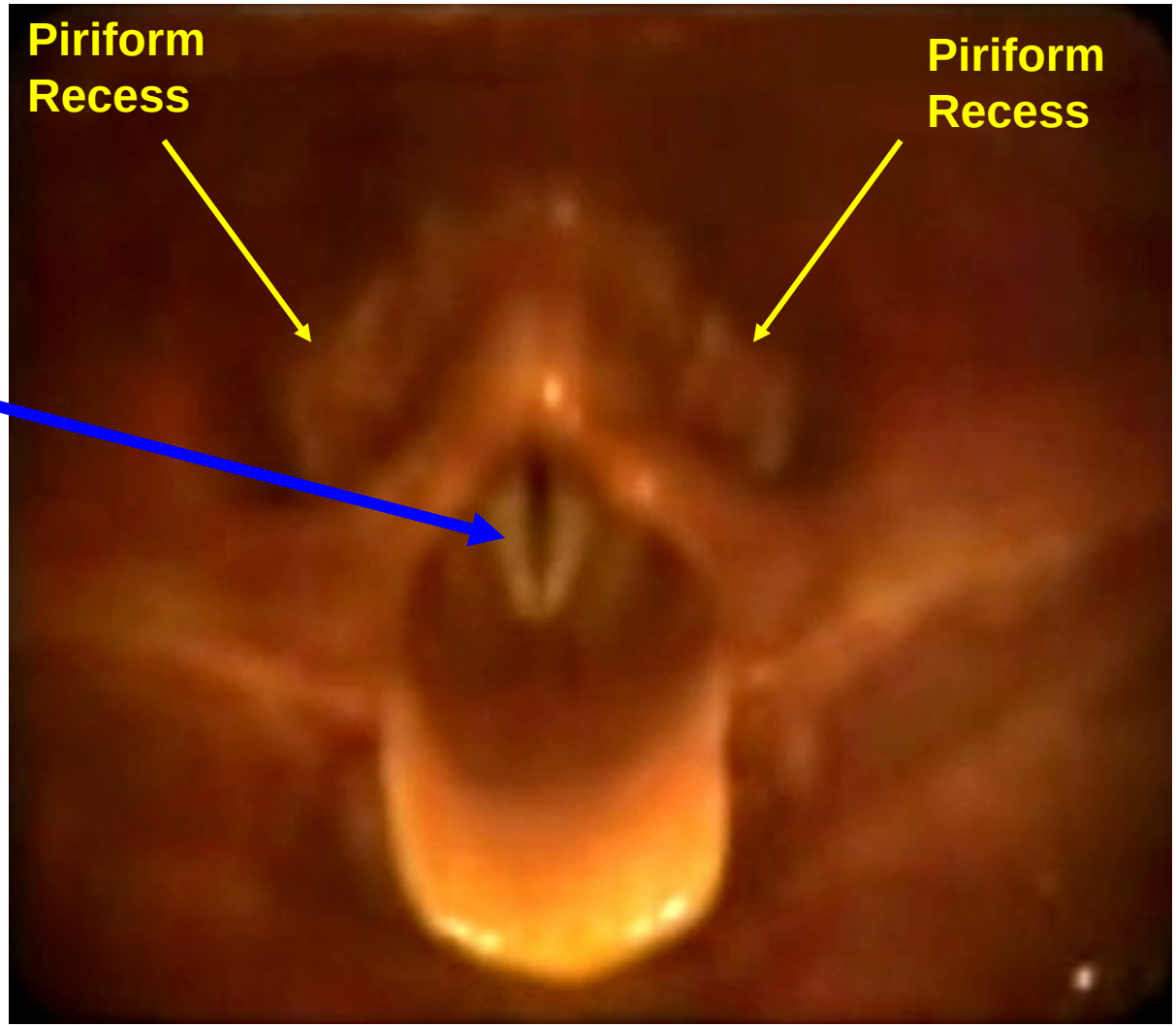


Vocal Folds (True, white)

Vestib-ular Folds (False, Reddish)

Epiglottis

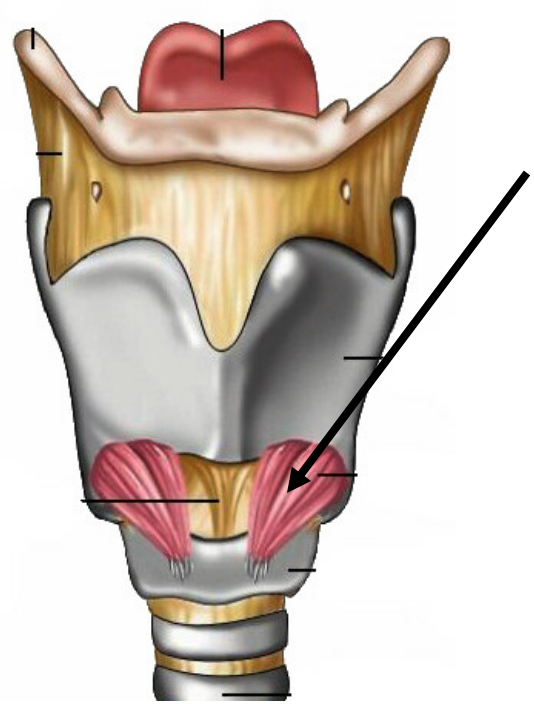
LARYNX PRODUCING SOUND



III. MUSCLES OF LARYNX - well named

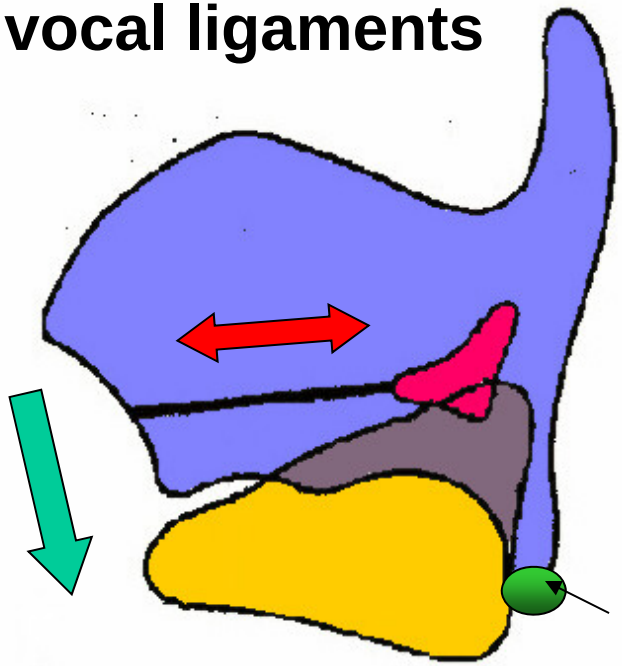
A. Extrinsic muscles (ex. hyoid muscles) - Move whole larynx as in swallowing

B. Intrinsic Muscles 1) change pitch by changing tension in vocal lig; increase tension raises pitch, decreased tension lowers pitch; 2) open and close Rima Glottidis



1) CRICOTHYROID- Tenses Vocal Ligament Increasing Pitch

Tilting - STRETCHES vocal ligaments



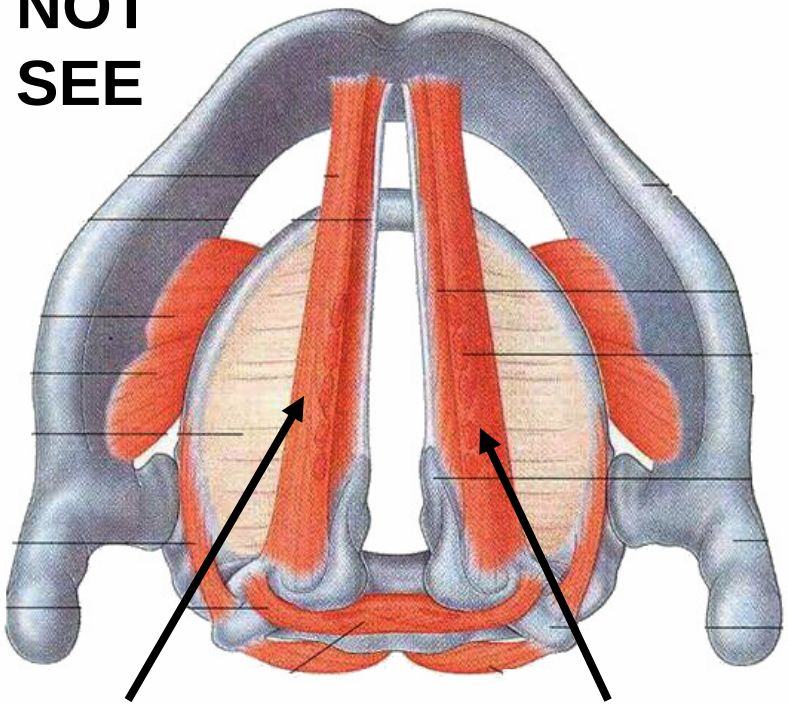
HINGE JOINT

STRETCH vocal ligament

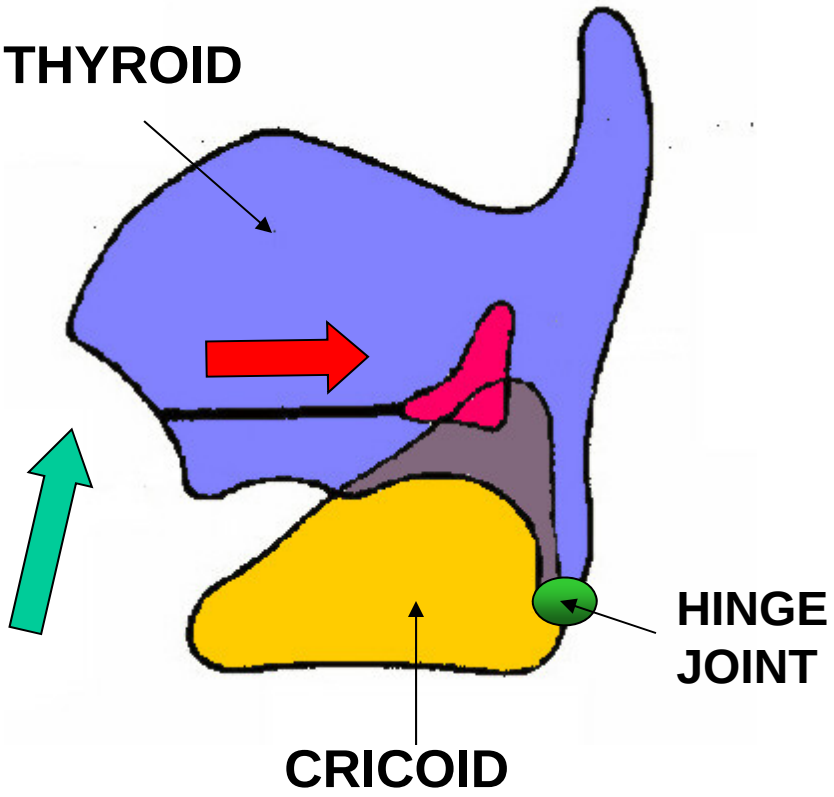
INCREASE PITCH - CRICOTHYROID

MUSCLES OF LARYNX

NOT SEE



THYROARYTENOID MUSCLES - adjacent to vocal ligament - Relaxes Vocal Ligaments Decreases pitch

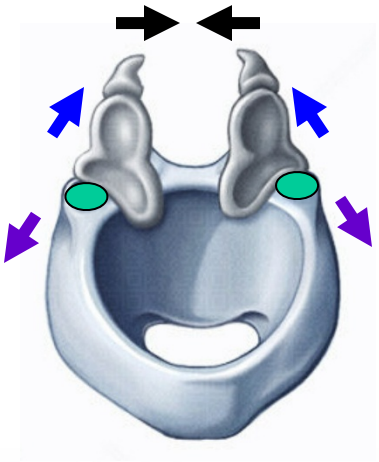


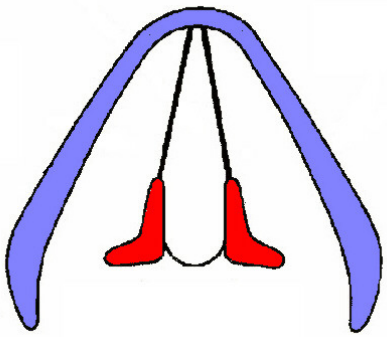
RELAX vocal ligament
DECREASE PITCH - THYROARYTENOID

OPEN AND CLOSE RIMA GLOTTIDIS BY ROTATING/SLIDING ARYTENOIDS -

Rotate laterally opens; Rotate medially or slide closes

more close than open

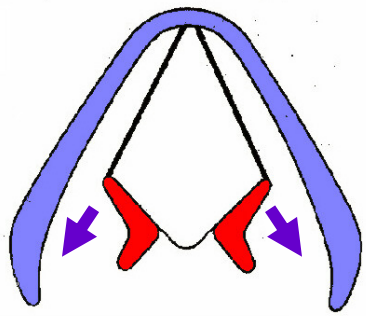




REST POSITION

OPEN

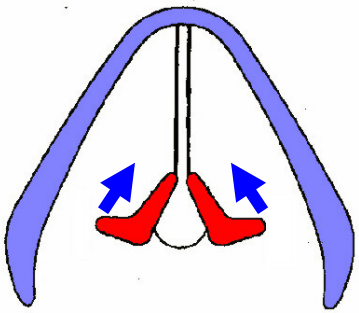
ROTATE LATERALLY



POSTERIOR CRICO-ARYTENOID

CLOSE

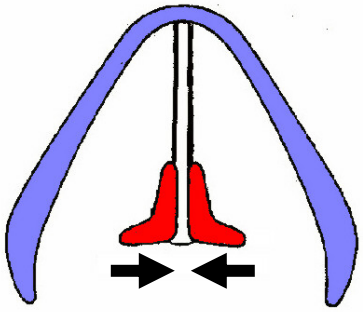
ROTATE MEDIALLY



LATERAL CRICO-ARYTENOID

CLOSE

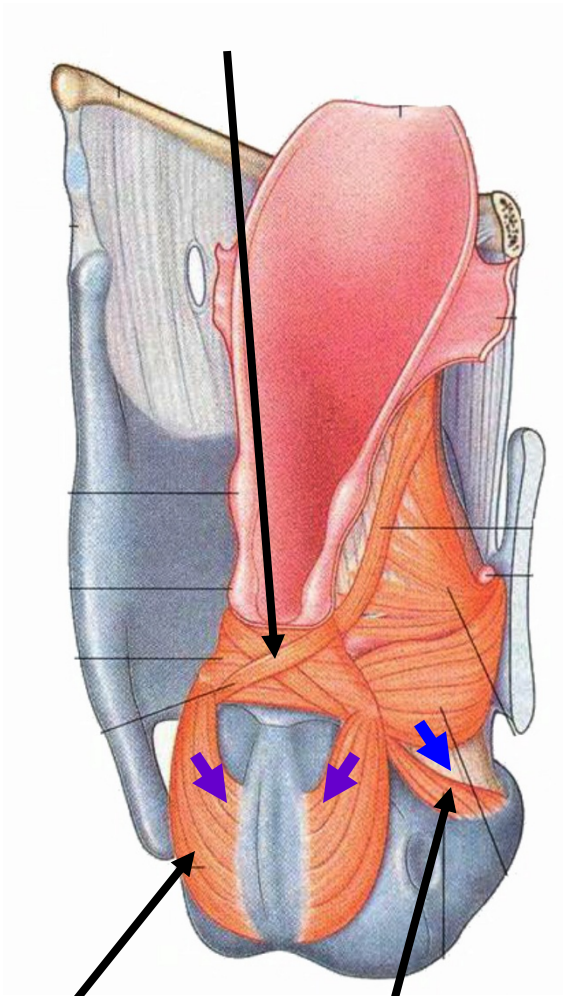
SLIDE



ARYTENOIDEUS

Larynx open for deep breathing; close for speech; completely close to raise abdominal pressure (Valsalva maneuver)

MUSCLES OF LARYNX



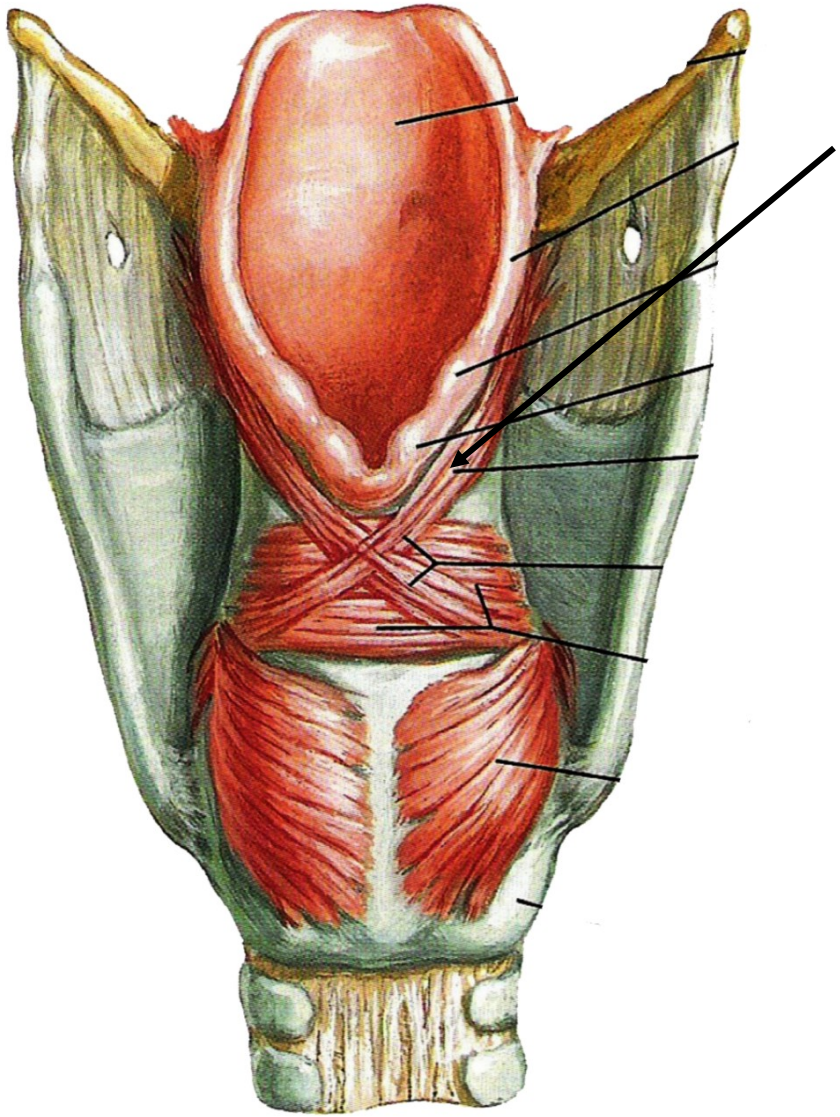
5) ARYTENOID (Transverse and oblique arytenoid) - Adduct vocal folds

4) LATERAL CRICO-ARYTENOID - Adduct vocal folds

3) POSTERIOR CRICO-ARYTENOID – Abducts vocal fold

Adduct closes rima glottidis
Abduct opens rima glottidis

MUSCLES OF LARYNX



5) ARYEPIGLOTTIC MUSCLE

Pulls epiglottis down during swallowing

- Covers inlet to larynx

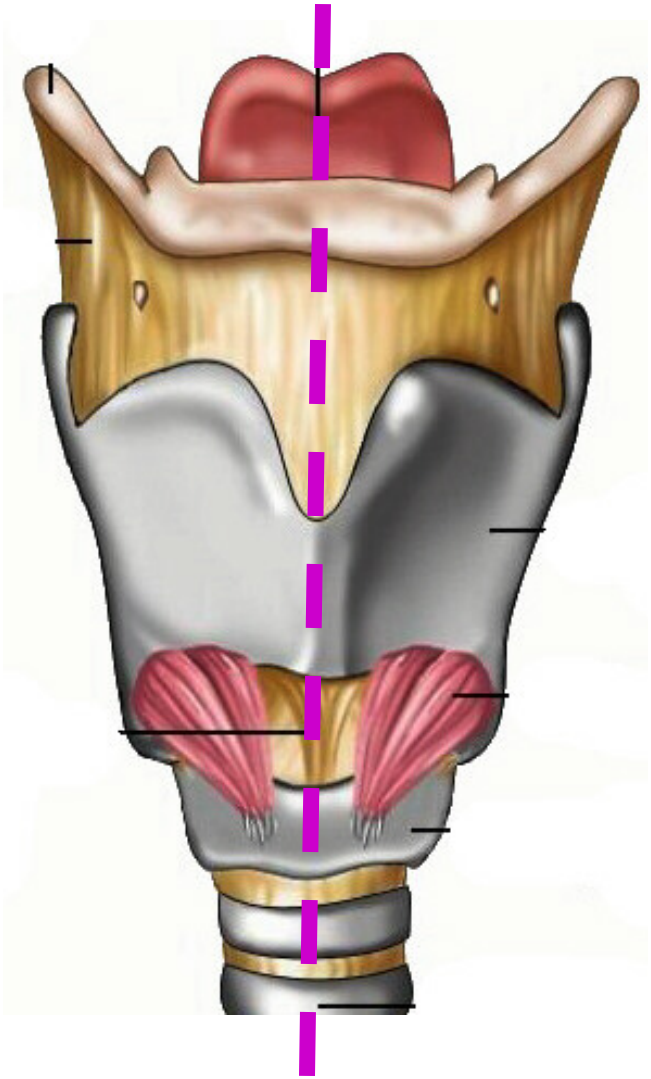
- Not necessary in adult humans

LARYNX MUSCLES - KNOW MUSCLE, ACTION, INNERVATION

***

MUSCLE	ACTION	NERVE
Cricothyroid	Tenses vocal fold, raises pitch of sound	External Laryngeal n. (X)
Thyroarytenoid	Relaxes vocal fold, decreases pitch of sound	Recurrent Laryngeal n. (X)
Posterior cricoarytenoid	Abducts vocal folds, opens rima glottidis	Recurrent Laryngeal n. (X)
Lateral cricoarytenoid	Adducts vocal folds, closes rima glottidis	Recurrent Laryngeal n. (X)
Arytenoid (Transverse arytenoid)	Adducts vocal folds, closes rima glottidis	Recurrent Laryngeal n. (X)
Aryepiglottic muscle	Pulls down epiglottis during swallowing	Recurrent Laryngeal n. (X)

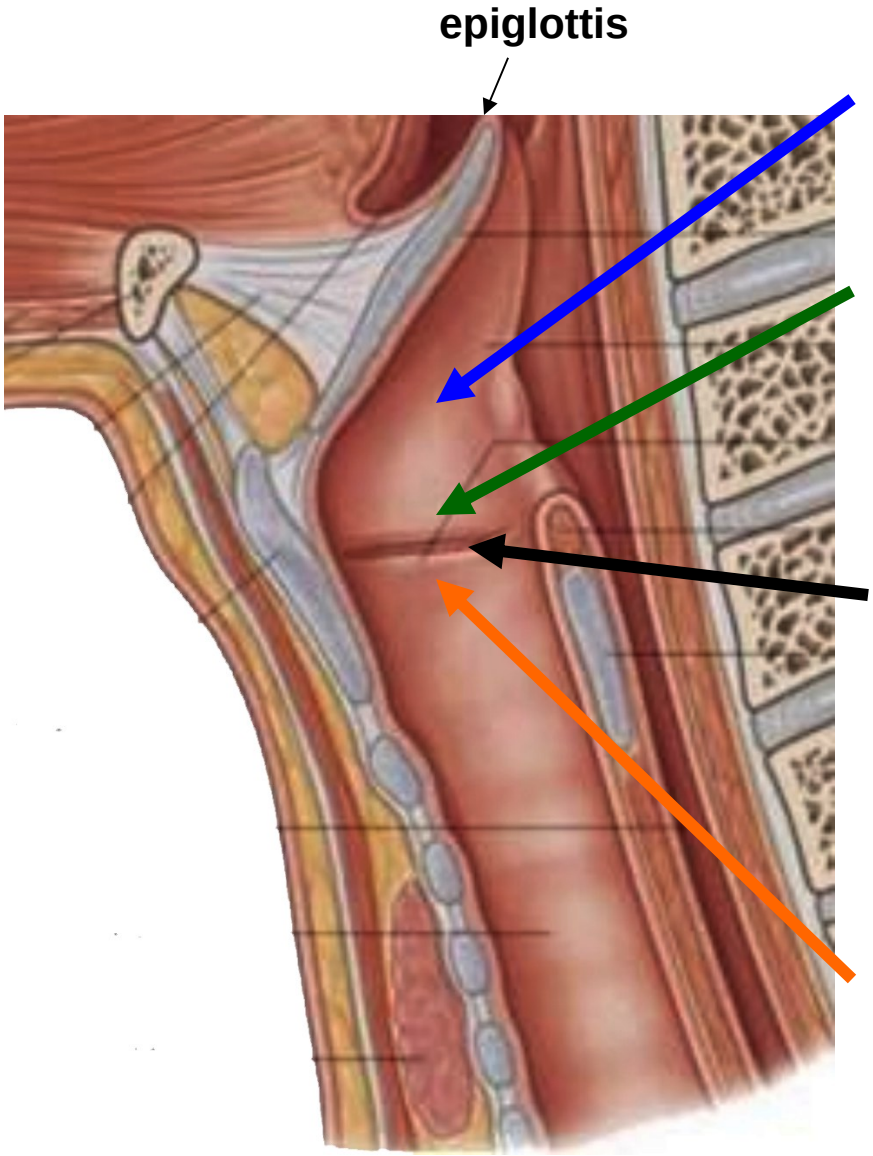
IV. TERMS ASSOCIATED WITH LARYNX



Bisect Larynx to see interior structures

TERMS ASSOCIATED WITH LARYNX

NOSE



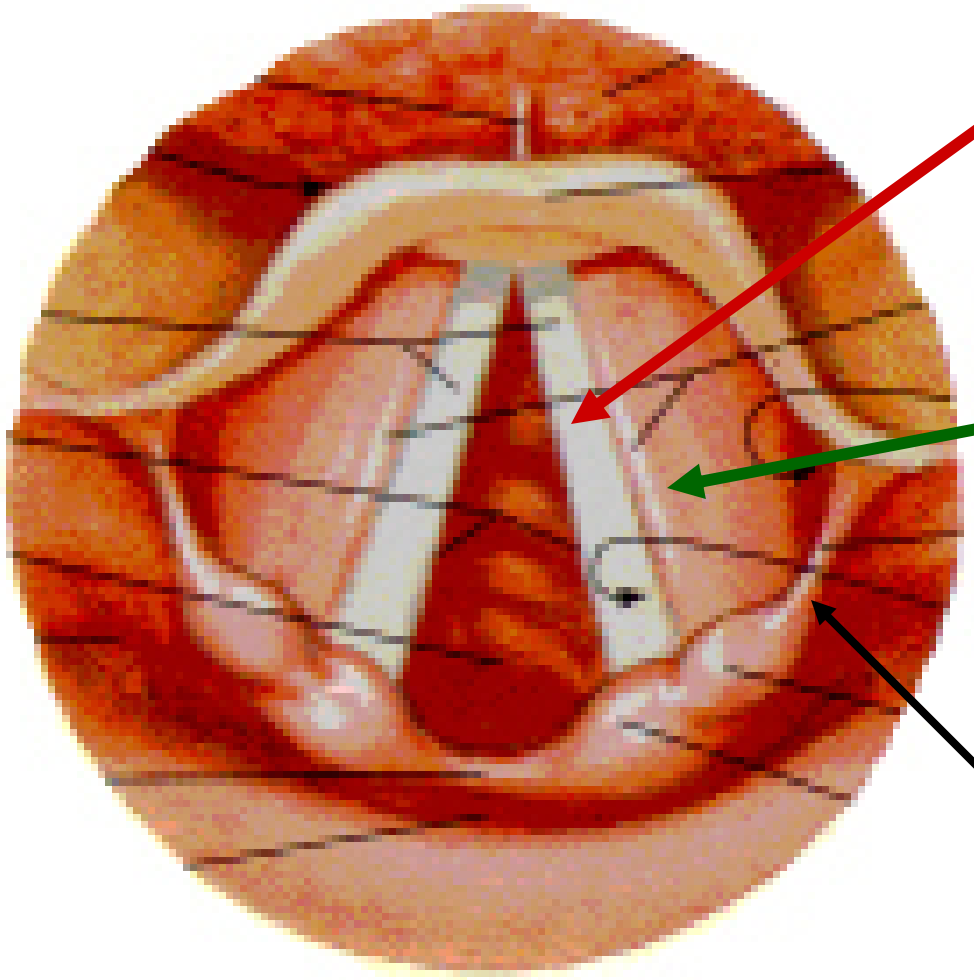
VESTIBULE - inlet above false vocal folds

VESTIBULAR (FALSE VOCAL) FOLDS - overlie vestibular ligaments

VENTRICLE - area between true and false vocal folds; lateral extension is Laryngeal Sinus

VOCAL (TRUE VOCAL) FOLDS - overlie vocal ligaments

LARYNGOSCOPE VIEW OF LARYNX



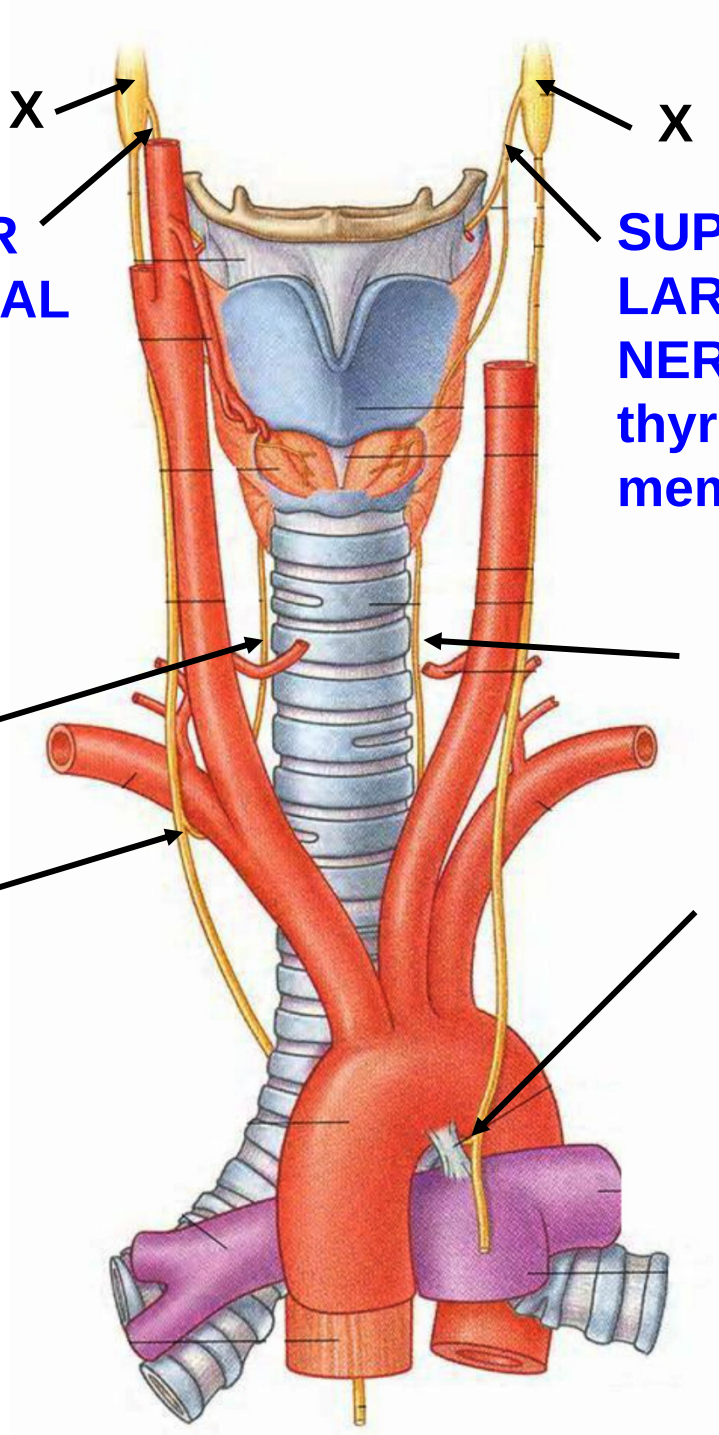
TRUE VOCAL FOLDS -overlie vocal ligaments

FALSE VOCAL FOLDS - overlie vestibular ligaments

ARYEPIGLOTTIC FOLD - overlie Quadrangular membrane

NERVES OF LARYNX –

All are Branches of Vagus CN X



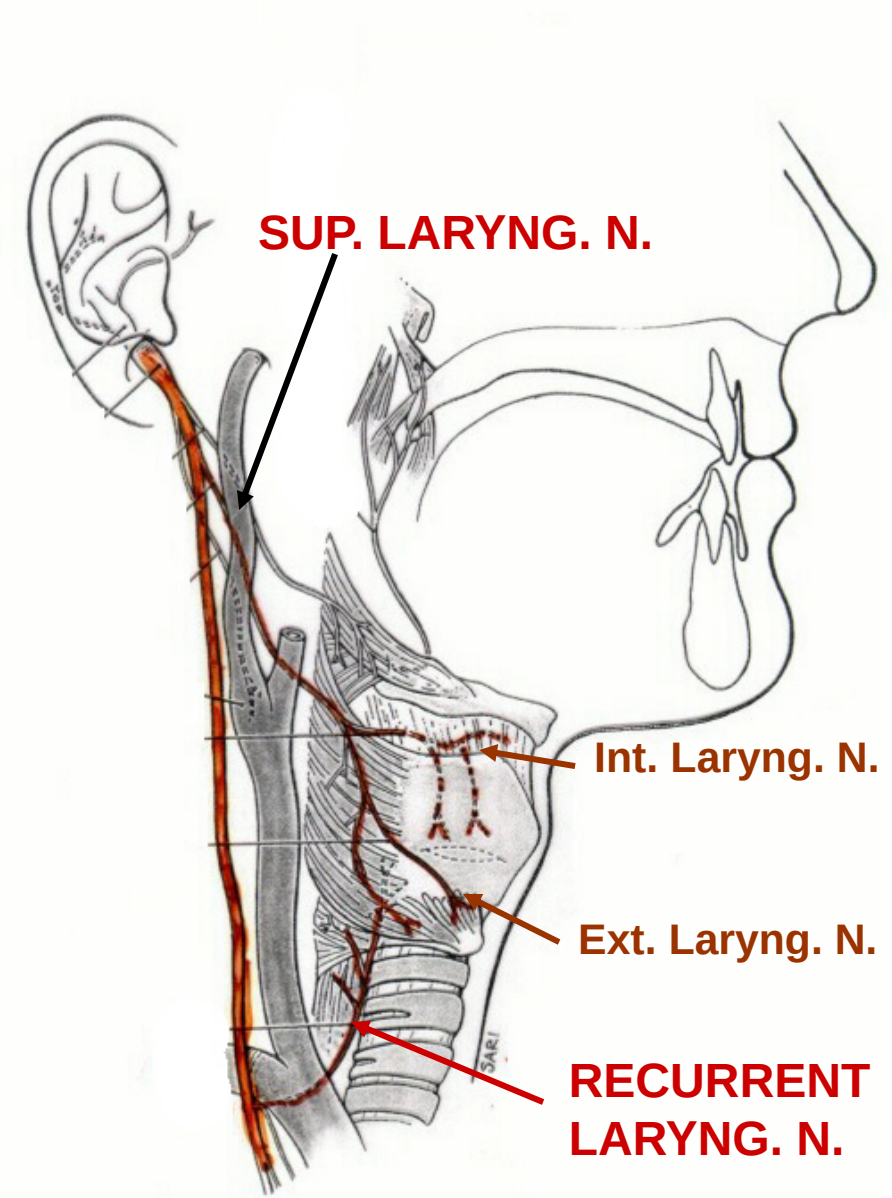
SUPERIOR LARYNGEAL NERVE

SUPERIOR LARYNGEAL NERVE - pierces thyrohyoid membrane

RIGHT RECURRENT LARYNGEAL NERVE - passes under Subclavian Artery

LEFT RECURRENT LARYNGEAL NERVE - passes under Arch of Aorta

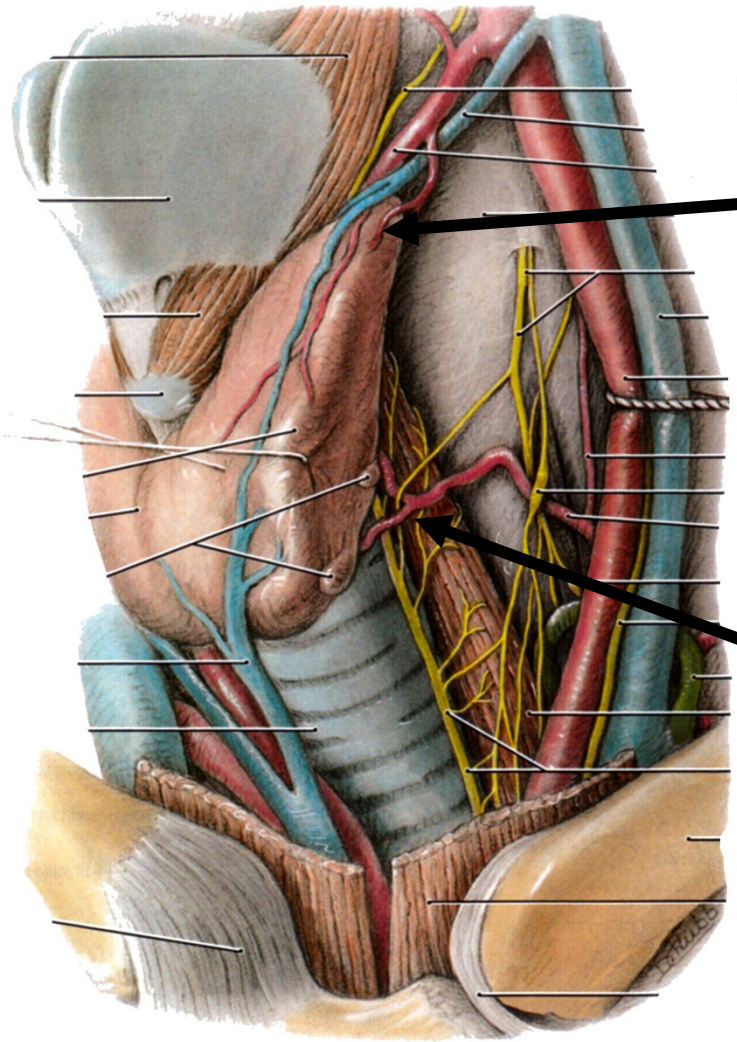
V. NERVES OF LARYNX – Branches of Vagus



A. <u>Superior Laryngeal N.</u>
divides to -
1. Internal Laryngeal N.
Visceral Sensory to Larynx
<u>Above</u> True Vocal Folds
2. External Laryngeal N.
Branchiomotor to Cricothyroid

B. <u>Recurrent Laryngeal N.</u>
- Visceral Sensory to Larynx
<u>Below</u> True Vocal Folds
- Branchiomotor to all other Muscles of Larynx

VI. LARYNX - ARTERIAL SUPPLY



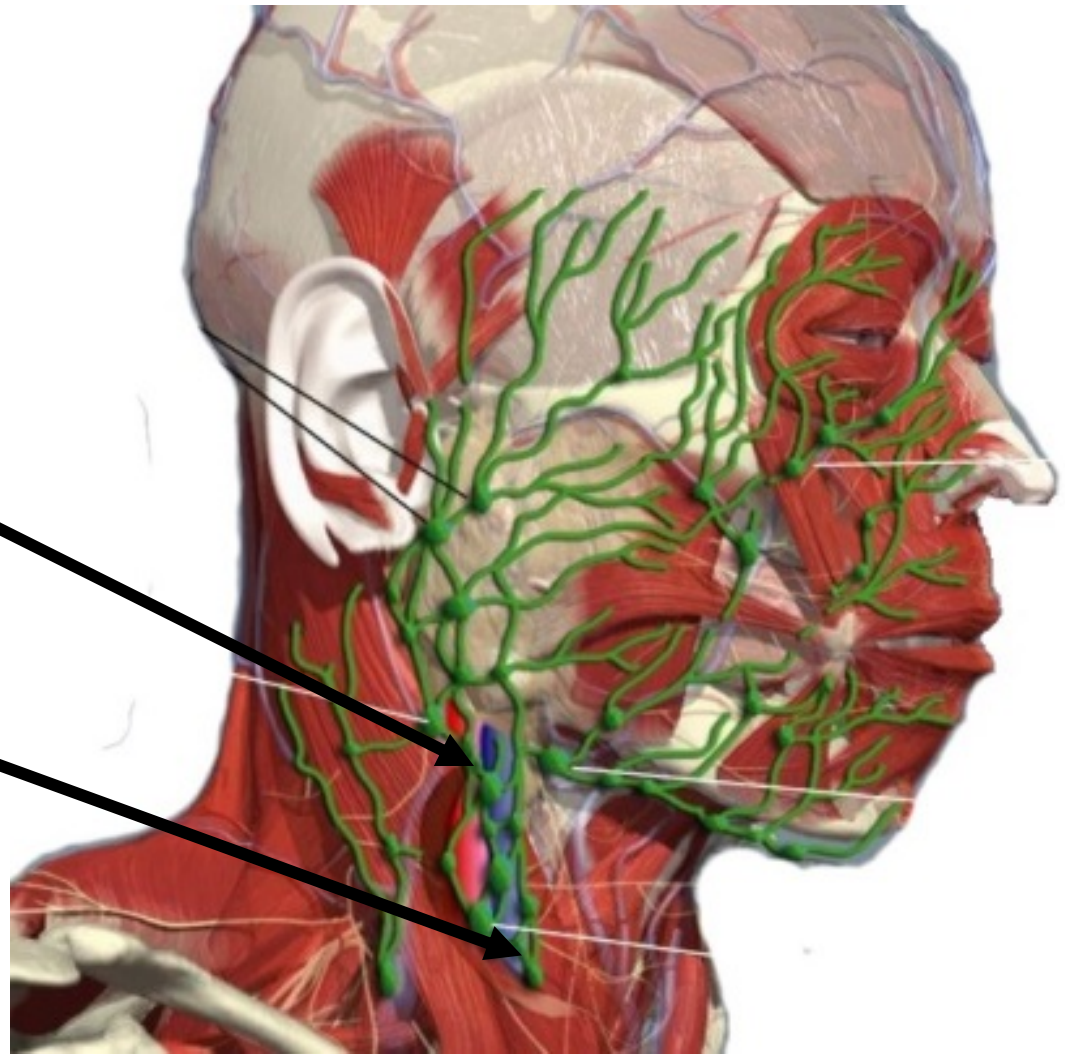
Superior Laryngeal Artery from Superior Thyroid artery

Inferior Laryngeal Artery from Inferior Thyroid artery

VII. LARYNX - LYMPHATICS

Superior Deep Cervical Nodes - drain Larynx above true vocal folds

Inferior Deep Cervical Nodes - drain Larynx below true vocal folds



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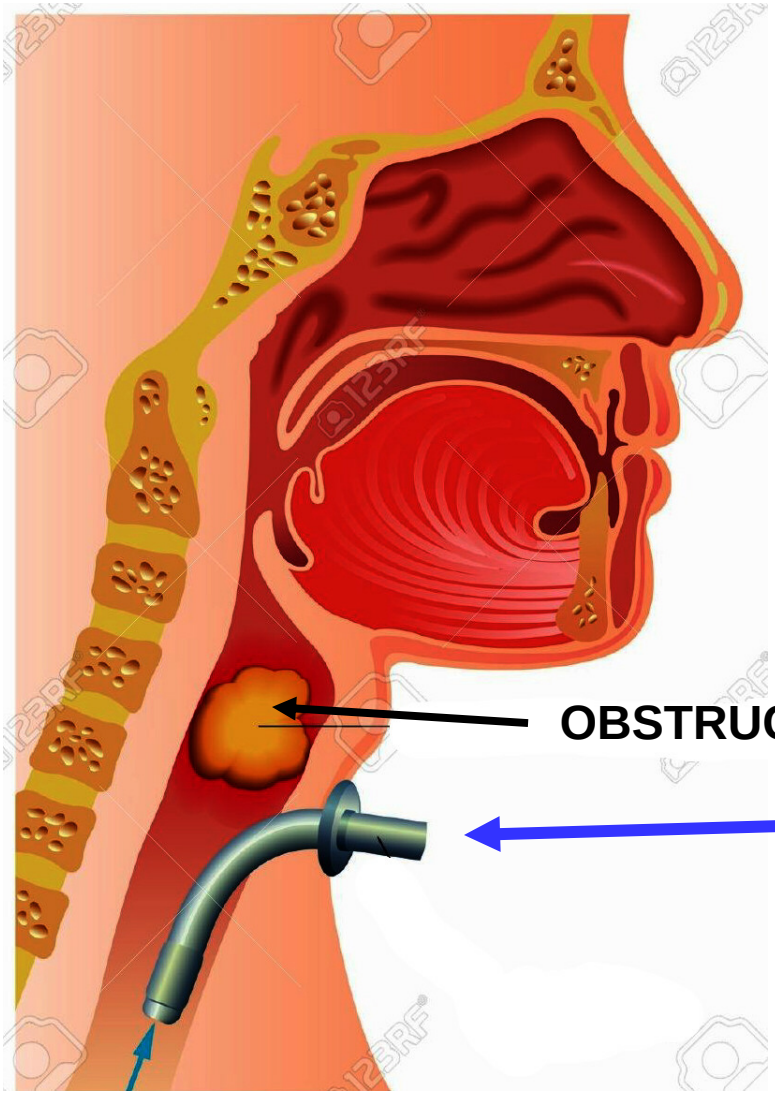
CLINICAL Note: Mucosa is tightly attached to vocal folds; in Anaphylactic Shock (acute allergic reaction) swelling of Vestibular folds can constrict airway and lead to Suffocation)

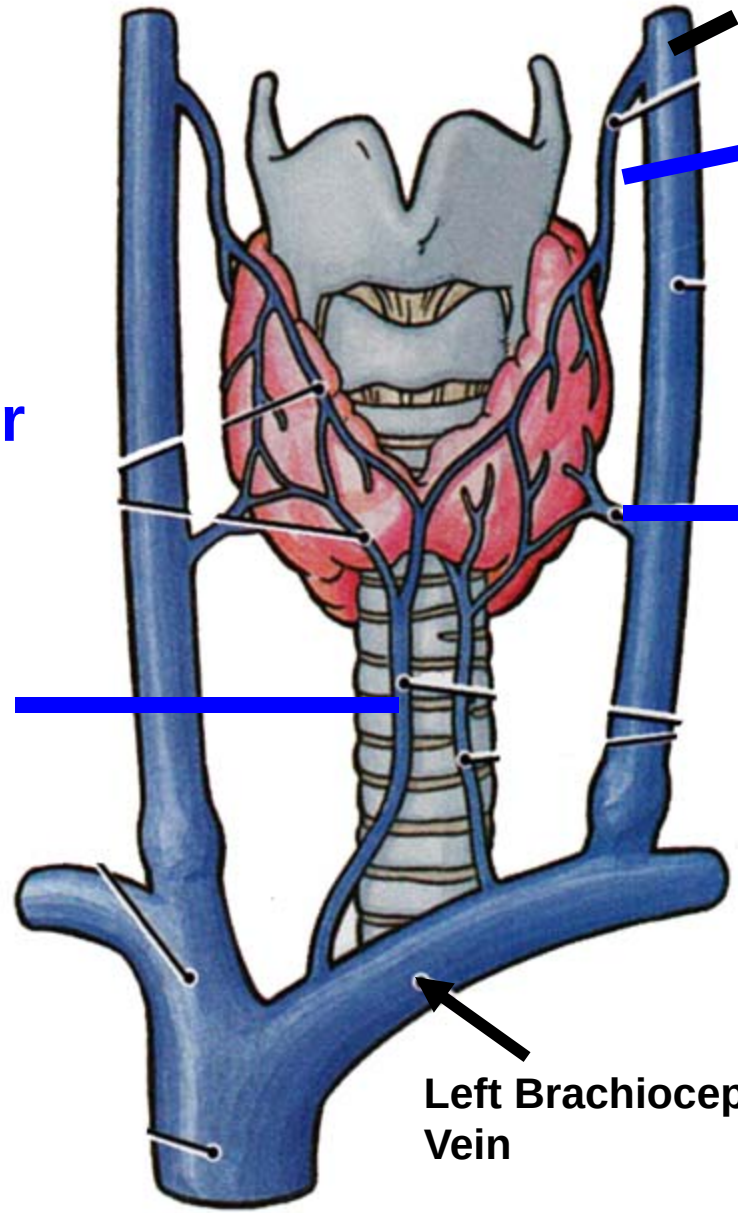
VIII. OBSTRUCTION OF LARYNX: TRACHEOTOMY



open airway to lungs below obstructed larynx

Tracheotomy
- cut between 1st and 2nd or 2nd and 3rd Tracheal cartilages

THYROID GLAND - LOTS OF VEINS



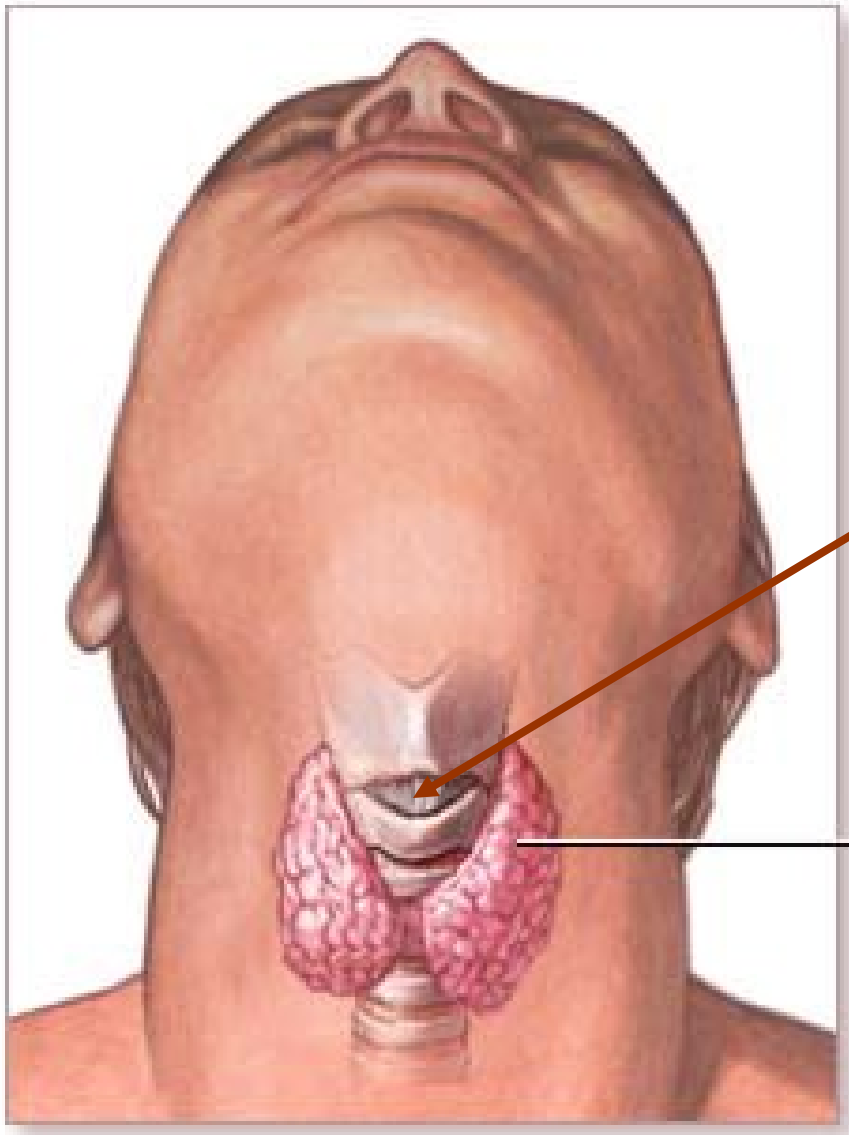
1) Superior Thyroid vein follows SuperiorThyroid artery

2) Middle Thyroid vein - to Internal Jugular

3) Inferior Thyroid vein(s) - drain to Left Brachio-cephalic Vein

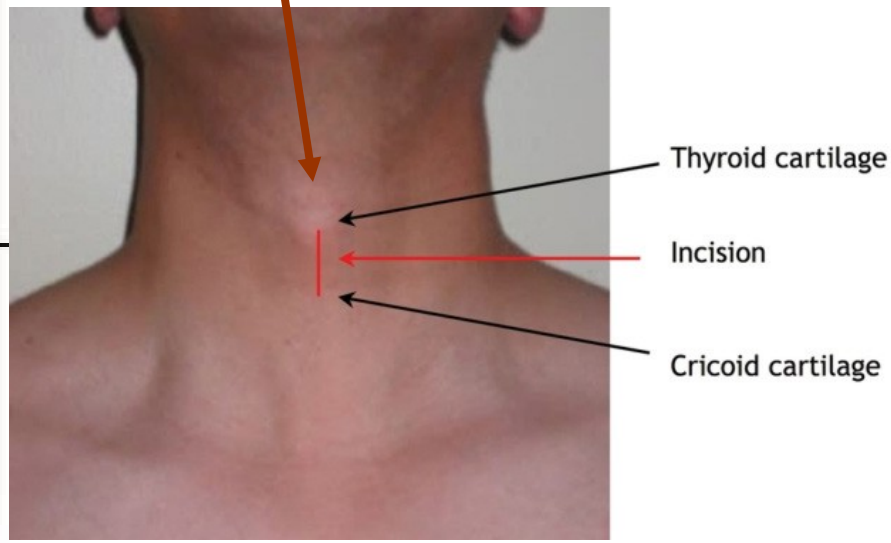
CLINICAL NOTE: THERE CAN BE A LARGE VEIN IN FRONT OF (ANTERIOR TO) THE TRACHEA - IMPORTANT IN TRACHEOTOMY; BLEEDING AVOIDED BY CRICOTHYROTOMY

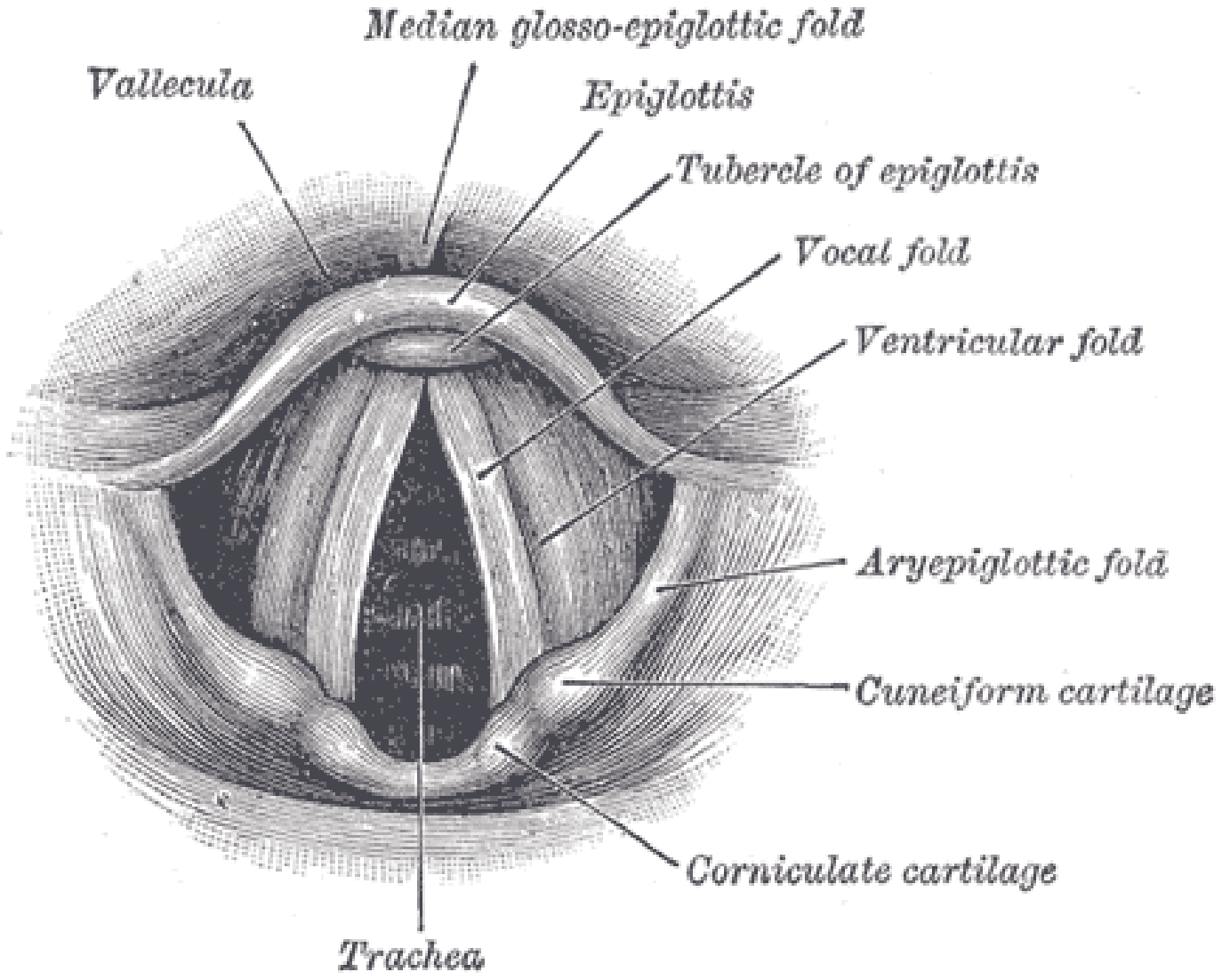
OBSTRUCTION OF LARYNX: CRICOTHYROTOMY

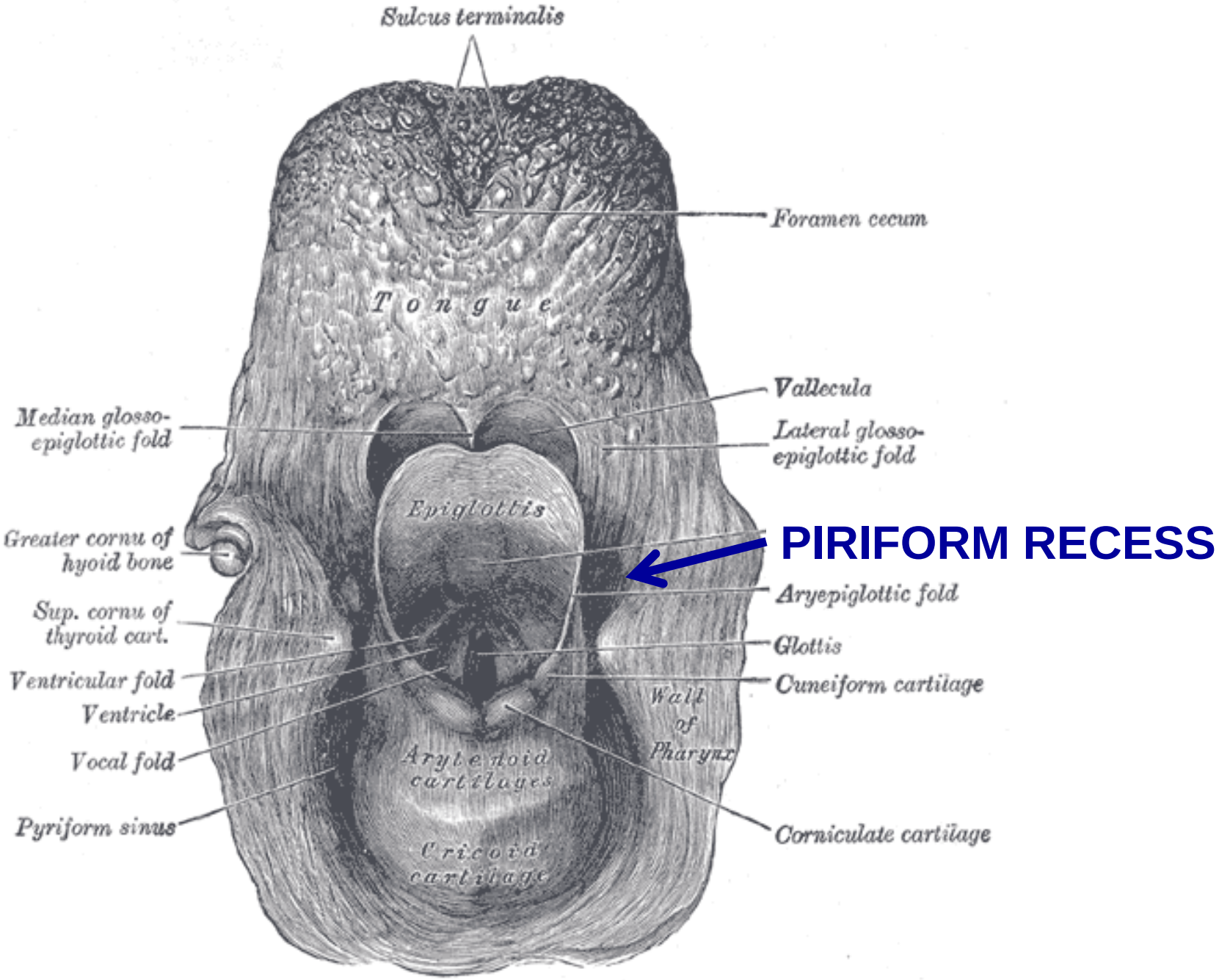


CLINICALLY IMPORTANT:
IN ANAPHYLACTIC SHOCK, INSERT TUBE TO CRICOTHYROID MEMBRANE (LESS BLEEDING)

Cricothyroid Membrane




Median glosso-epiglottic fold
Vallecula
Epiglottis
Tubercle of epiglottis
Vocal fold
Ventricular fold
Aryepiglottic fold
Cuneiform cartilage
Corniculate cartilage
Trachea


Sulcus terminalis
Foramen cecum
Tongue
Vallecula
Median glosso-epiglottic fold
Lateral glosso-epiglottic fold
Epiglottis
Greater cornu of hyoid bone
PIRIFORM RECESS
Aryepiglottic fold
Sup. cornu of thyroid cart.
Glottis
Ventricular fold
Cuneiform cartilage
Ventricle
Wall of Pharynx
Vocal fold
Arytenoid cartilages
Pyriform sinus
Corniculate cartilage
Cricoid cartilage

EAR

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 call 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.

Clinical 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**.

Clinical 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

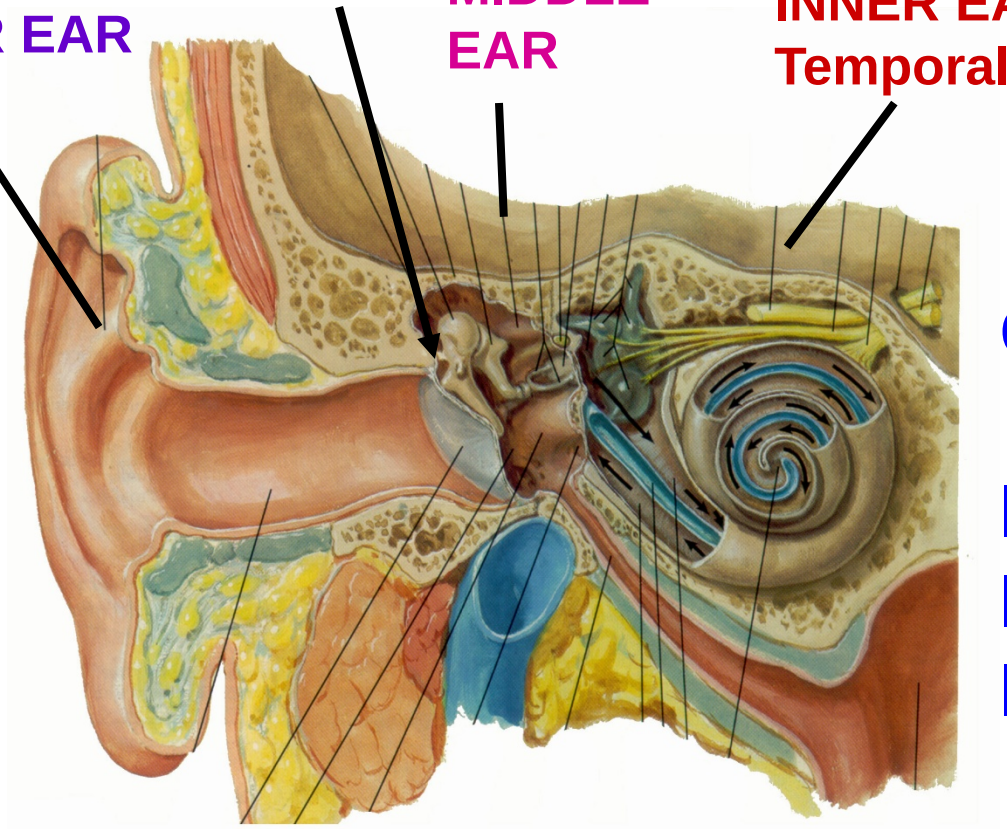
2. **Stapedius muscle** - origin - posterior wall (landmark is pyramid); insertion - neck of stapes; innervation - VII

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 hyperacousia (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).

Clinical Note: Damage 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; <u>if Tympanic membrane is pierced, can damage Chorda tympani and lose taste to anterior tongue</u> on that side; this fact may have baffled early physicians and patients.

EAR



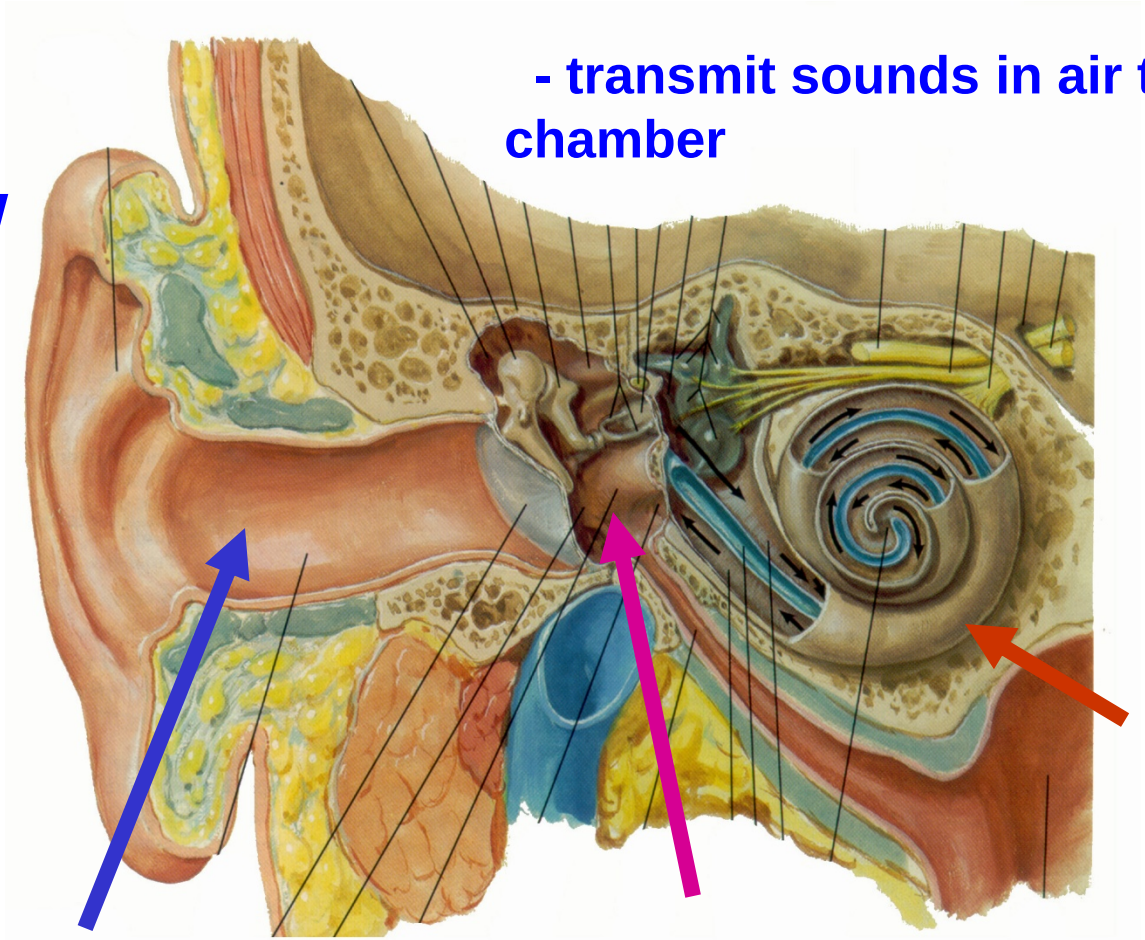
OUTLINE

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

- transmit sounds in air to fluid filled chamber



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

(CONDUCTIVE HEARING LOSS)

DETECT SOUND

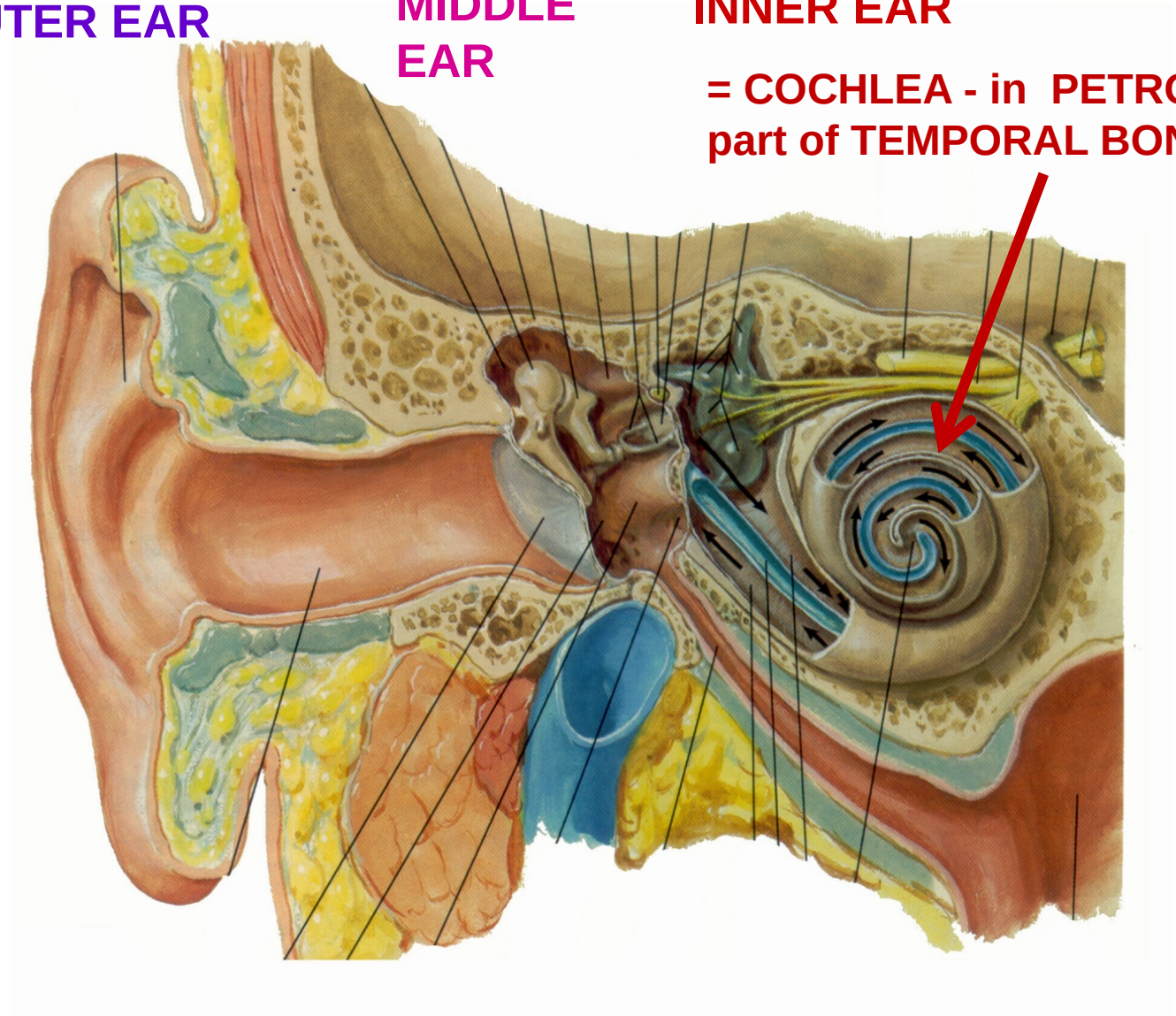
(= SENSORINEURAL PART)

OUTER EAR

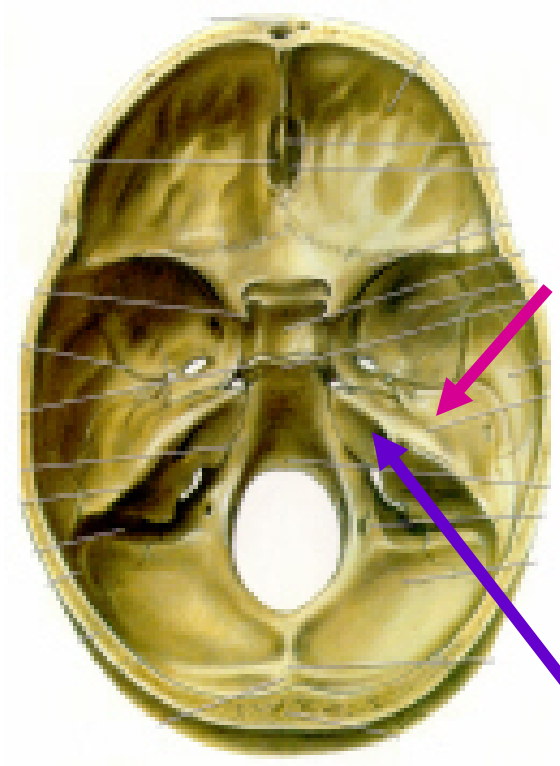
MIDDLE EAR

INNER EAR

= COCHLEA - in PETROUS part of TEMPORAL BONE

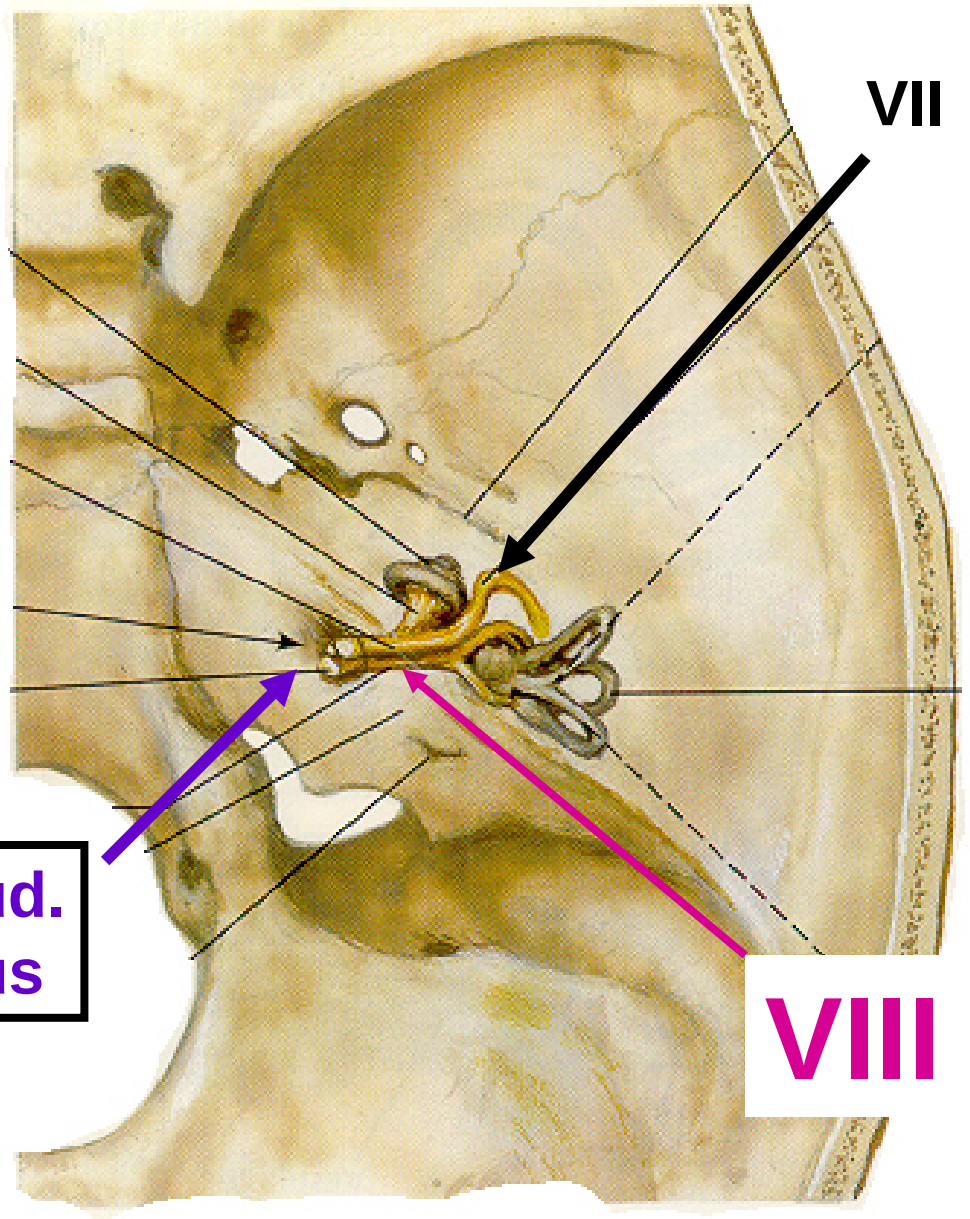


ORIENT: LOCATION OF INNER EAR



Petrous part of temporal bone

Int. aud. meatus



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

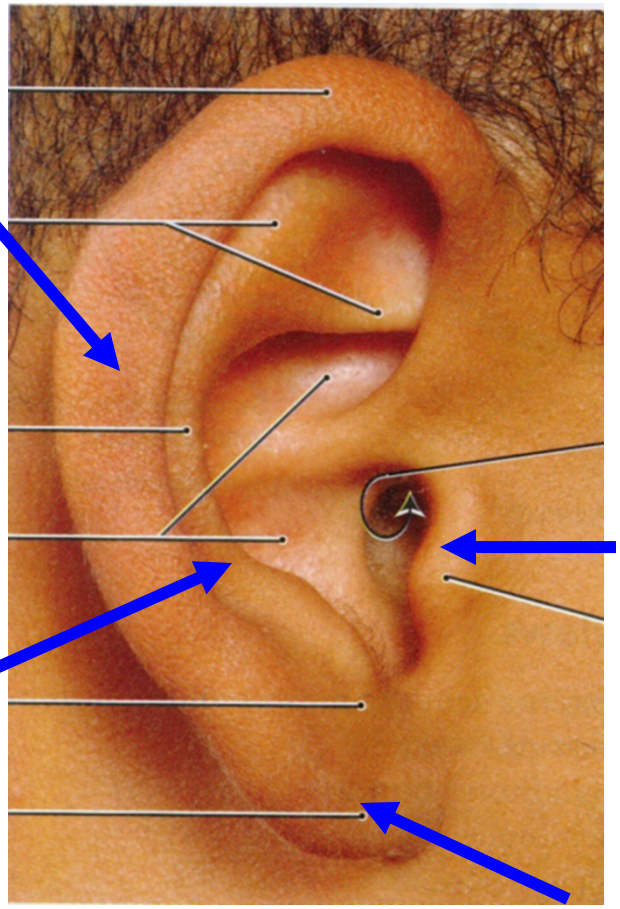
Can use to test functioning of inner ear (Sensorineural hearing loss) independent of outer, middle ear (Conductive hearing loss)

**

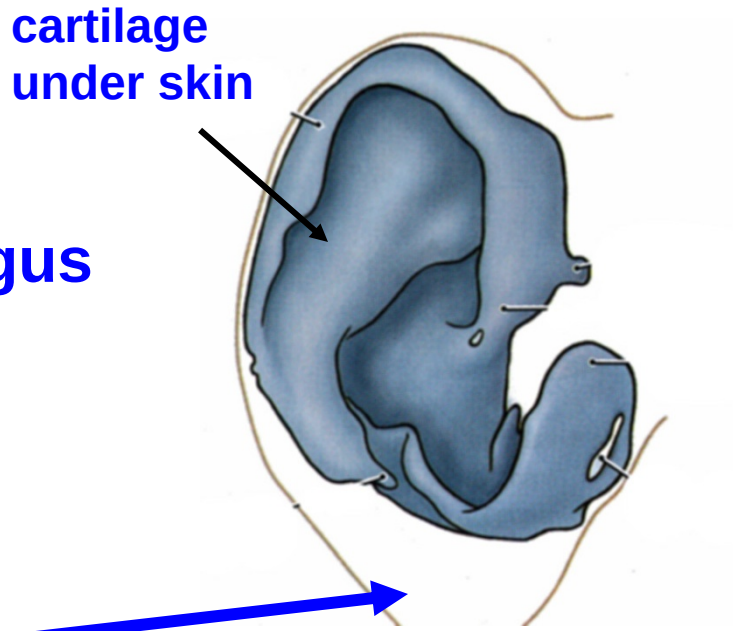
CONDUCTIVE HEARING LOSS - damage to middle ear (tympanic membrane, auditory ossicles (bones)
SENSORINEURAL HEARING LOSS - damage to inner ear (cochlea).

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

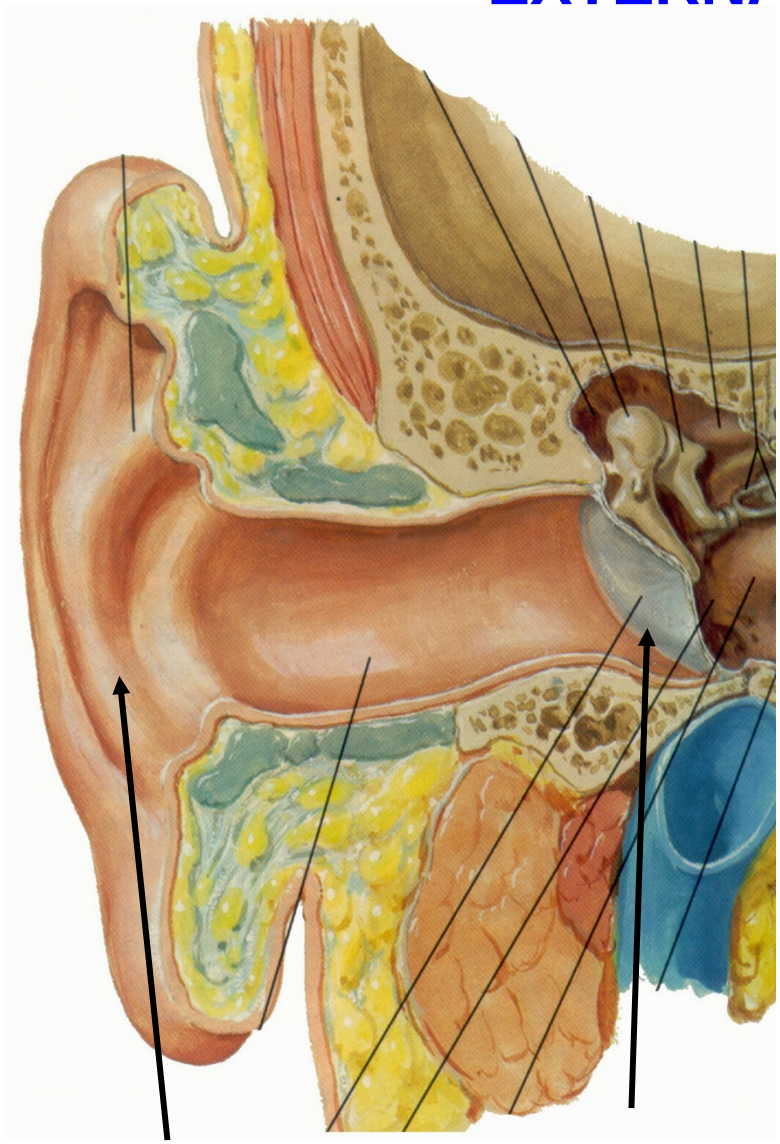


A. AURICLE (pinna) - elastic cartilage and skin - Reflects sound waves



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

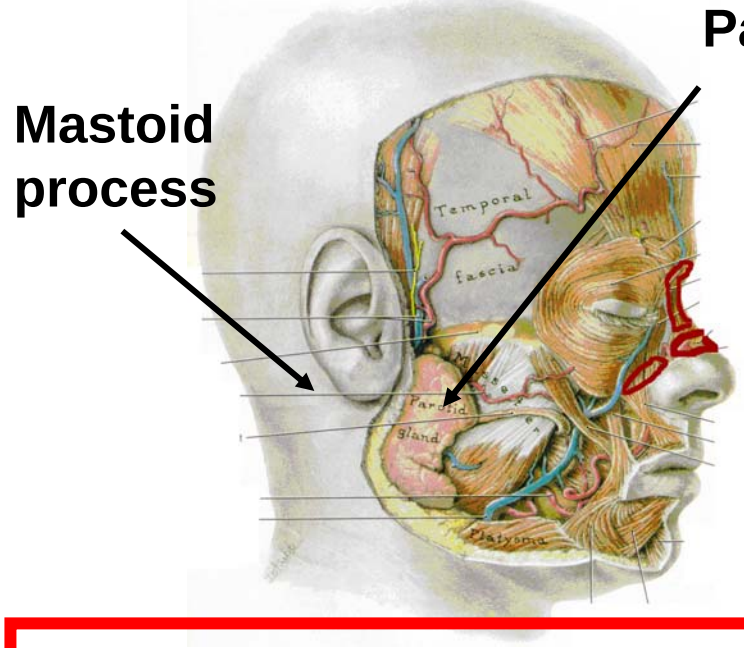
EXTERNAL AUDITORY MEATUS - location



AURICLE

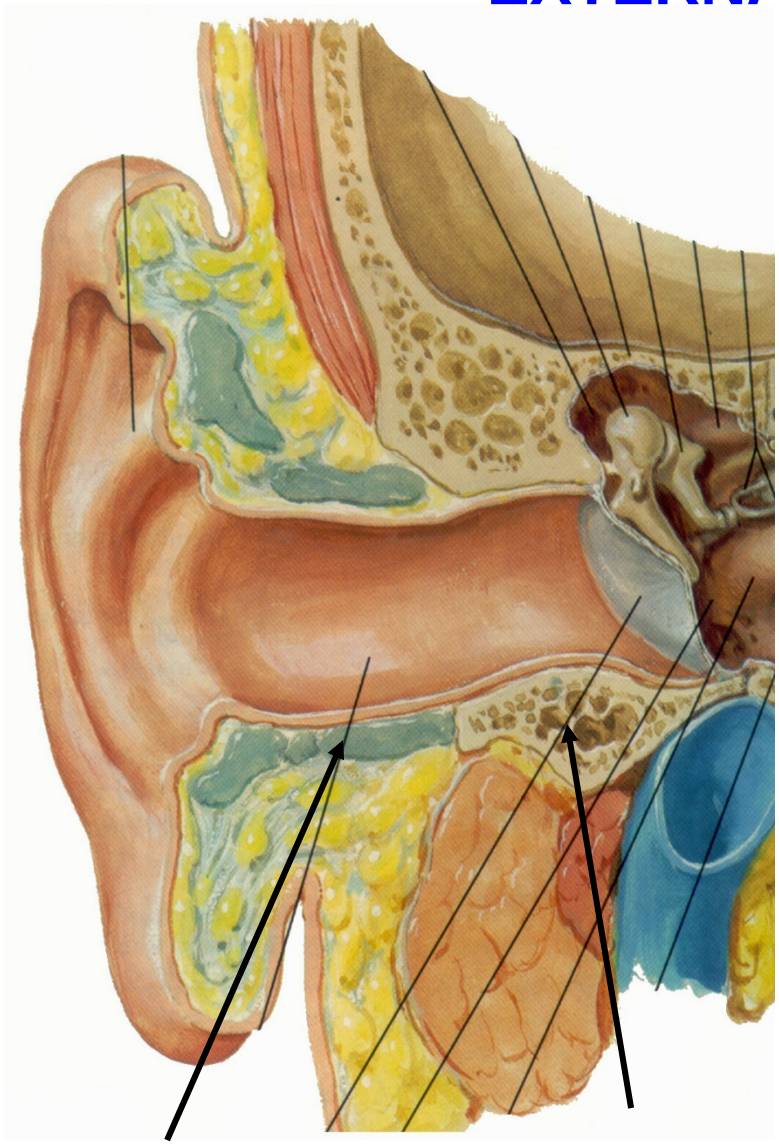
TYMPANIC MEMBRANE

- 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

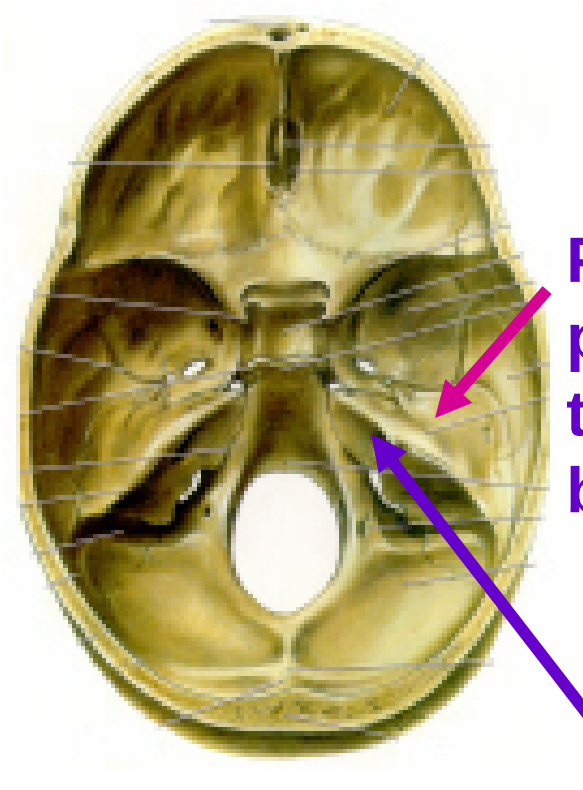
Outer 1/3 - Cartilage - contains hair, sebaceous and ceruminous glands (ear wax [insect repellent]); protects tymp. membrane,

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

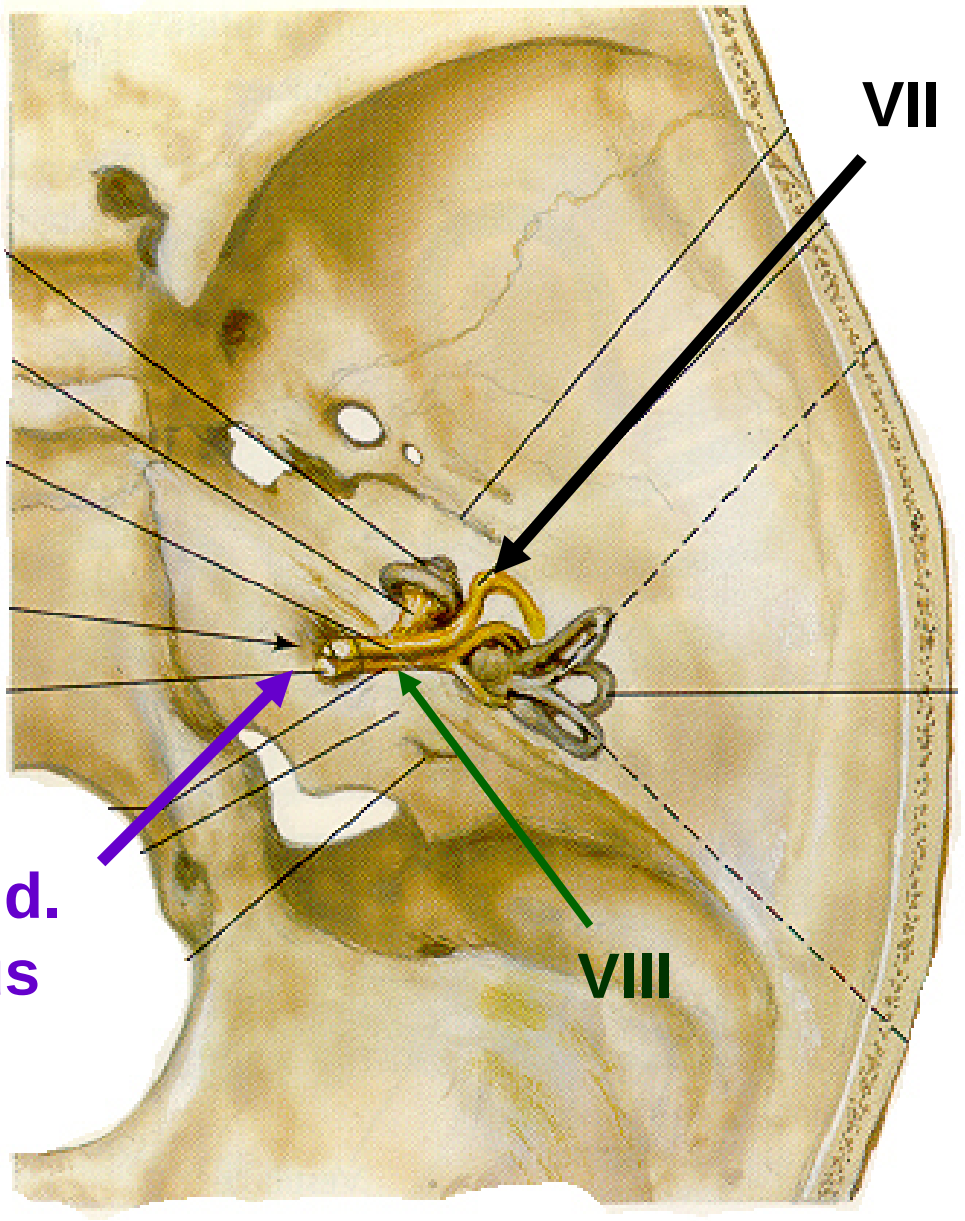


Petrous part of temporal bone

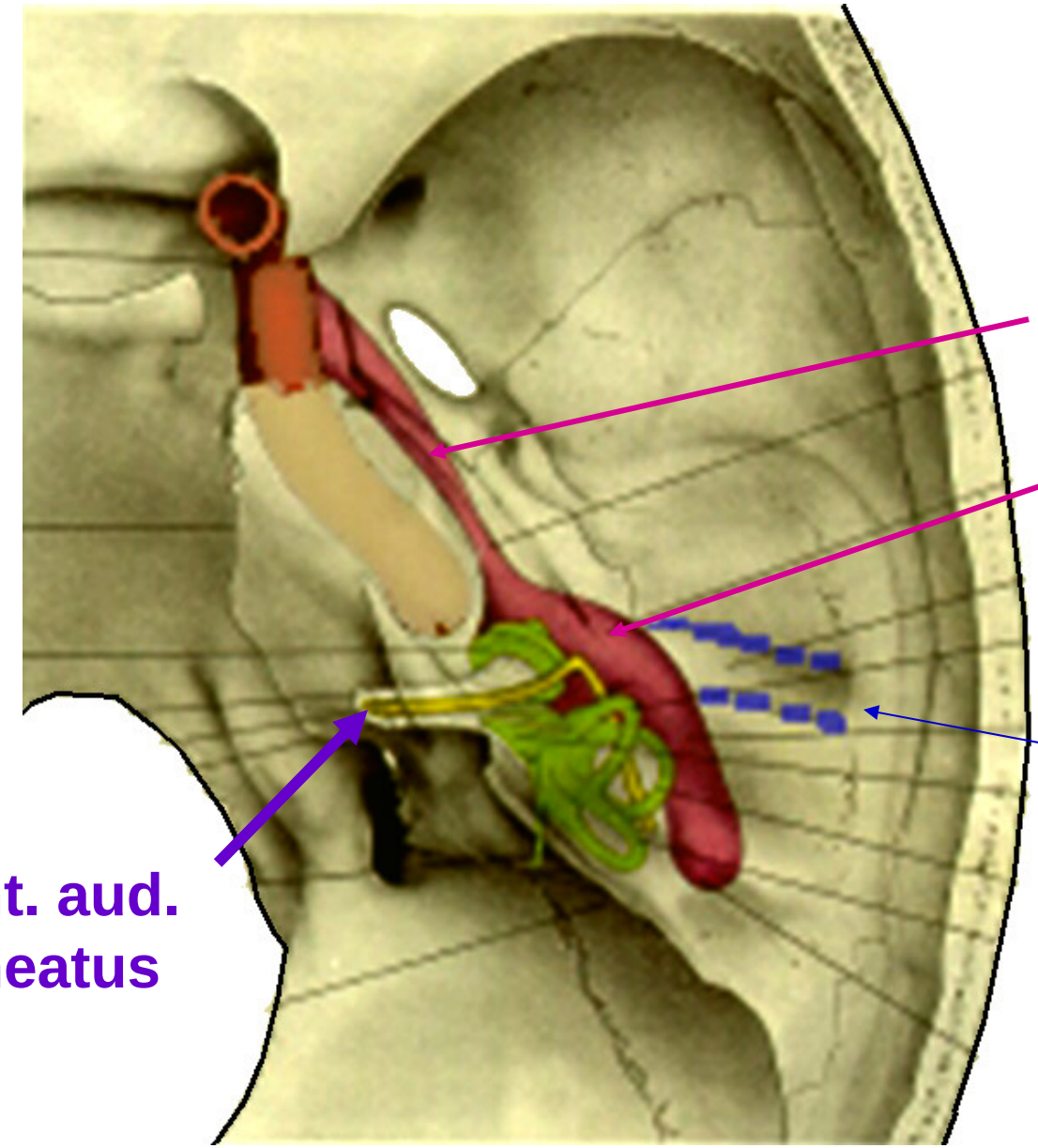
Int. aud. meatus

LOCATION OF MIDDLE EAR AND INNER EAR DIFFICULT TO DEMONSTRATE

ORIENT: LOCATION OF INNER EAR



ORIENT: LOCATION OF MIDDLE EAR



AUDITORY TUBE

MIDDLE EAR - oriented at an angle

External Auditory Meatus

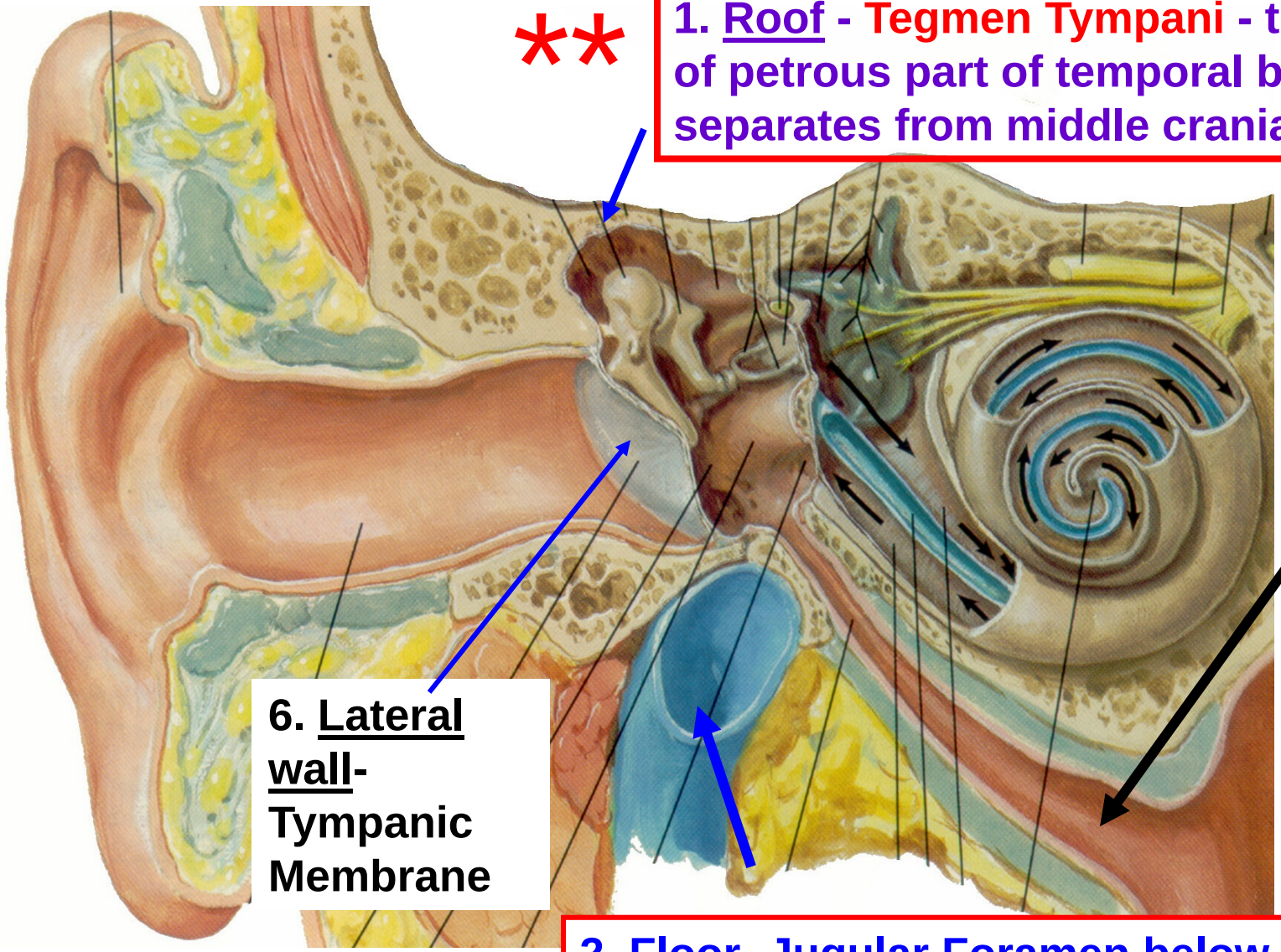
Int. aud. meatus

Meatus = passage, L.

III. MIDDLE EAR - BOUNDARIES

**

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



3. Ant. wall -

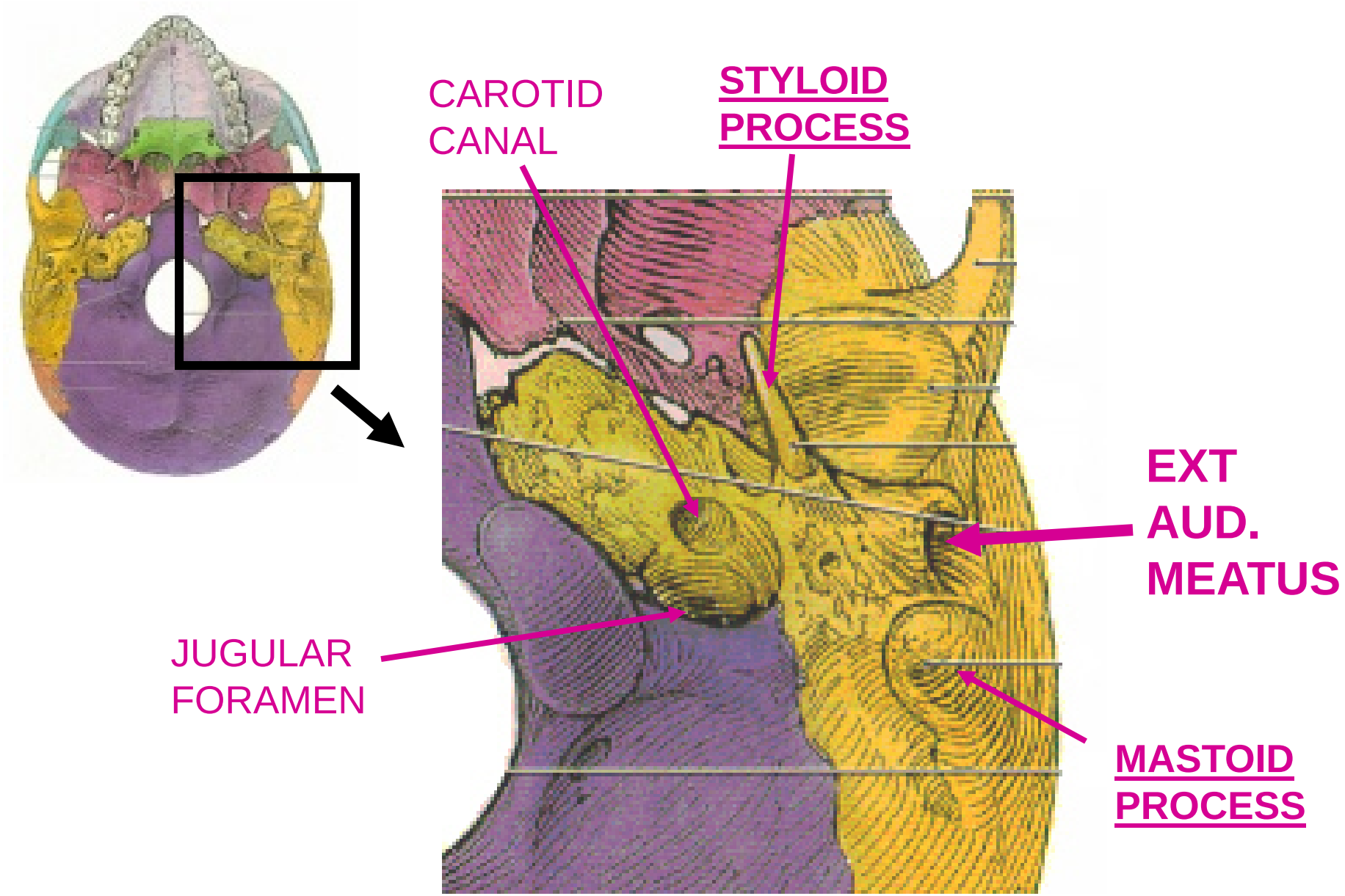
Opening of Auditory Tube (ant. 2/3 cartilage; post. 1/3 bone

6. Lateral wall- Tympanic Membrane

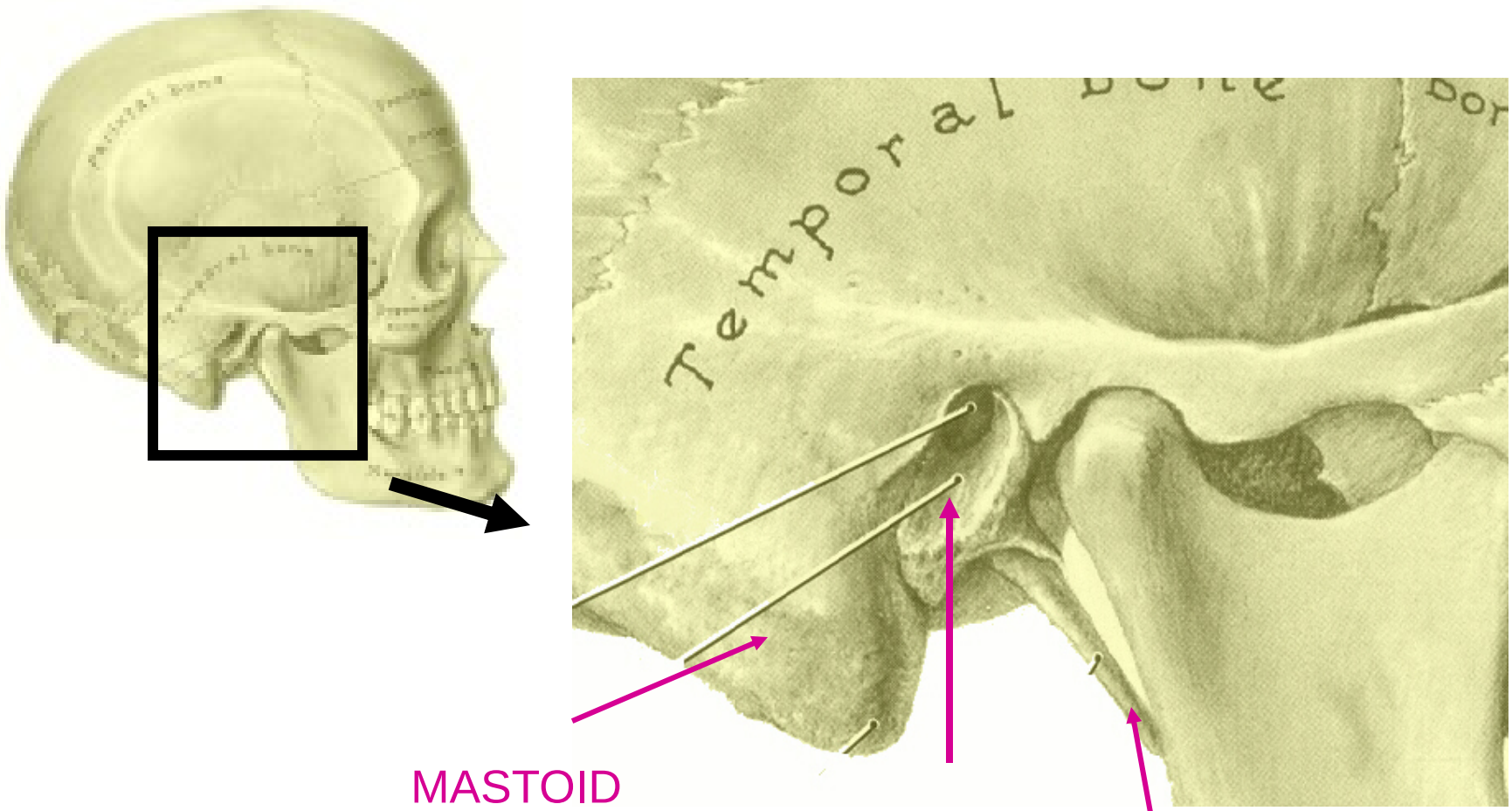
2. Floor- Jugular Foramen below- Internal Jugular vein can rupture to middle ear

Tegmen = L. roof

ORIENT: LOCATION OF MIDDLE EAR ON SKULL



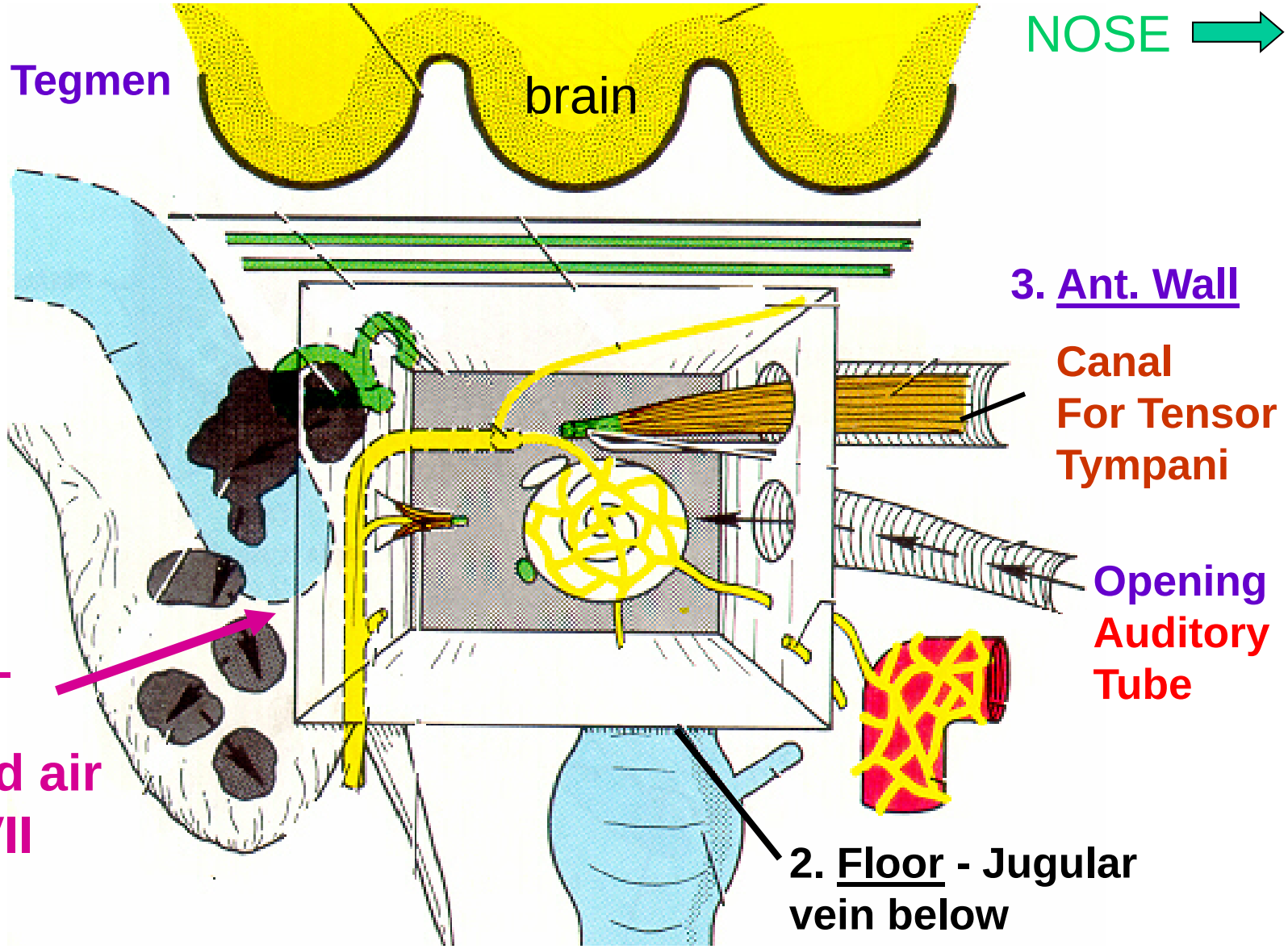
ORIENT: LOCATION OF MIDDLE EAR ON SKULL



MIDDLE EAR: BOUNDARIES

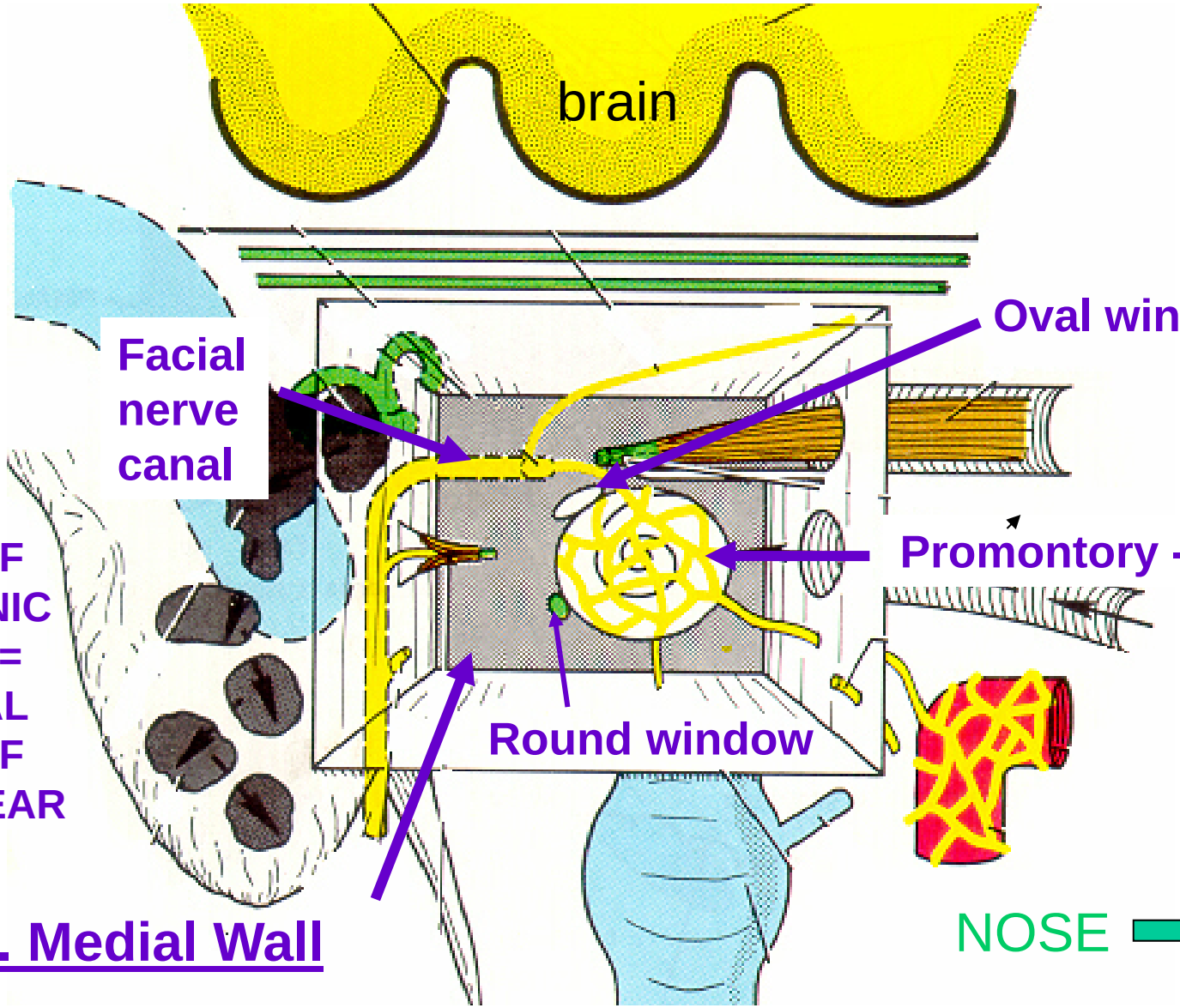
**

1. Roof - Tegmen Tympani



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

MIDDLE EAR: BOUNDARIES



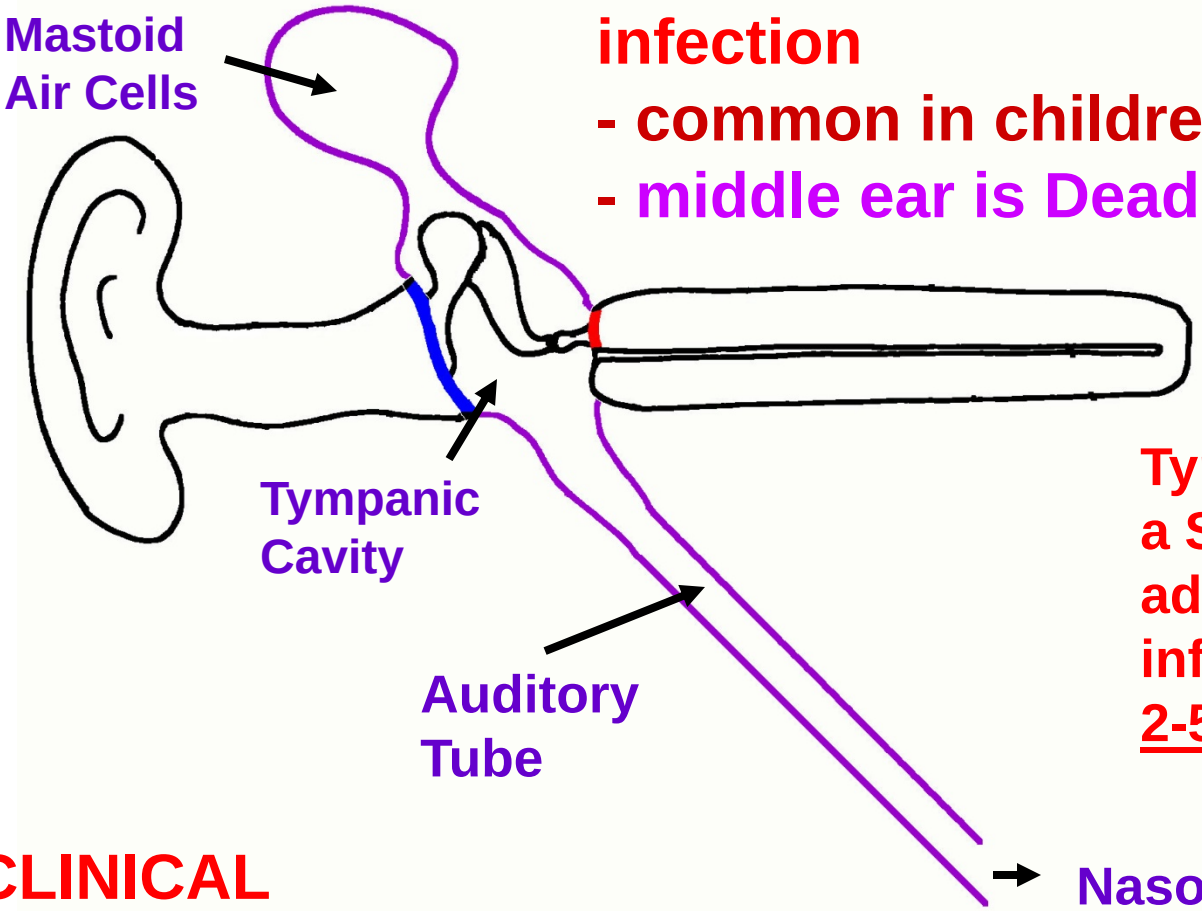
MEDIAL WALL OF TYMPANIC CAVITY = LATERAL WALL OF INNER EAR

5. Medial Wall

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



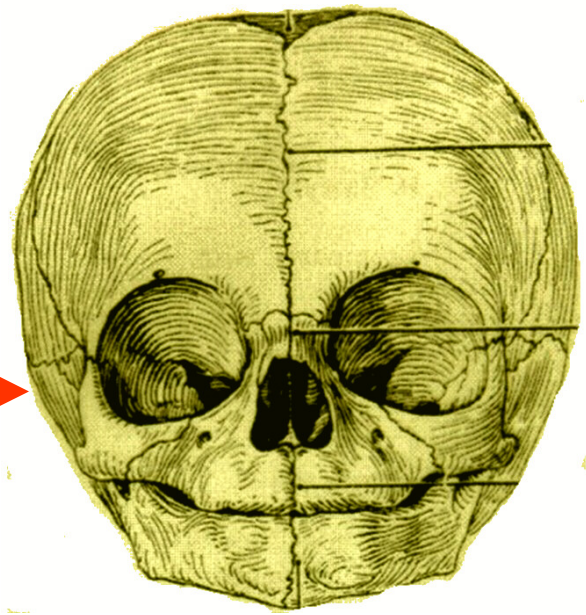
Tympanic Cavity is a Small space - In adult 15 mm. sup-inf, 15 mm. ant-post, 2-5 mm. med-lat

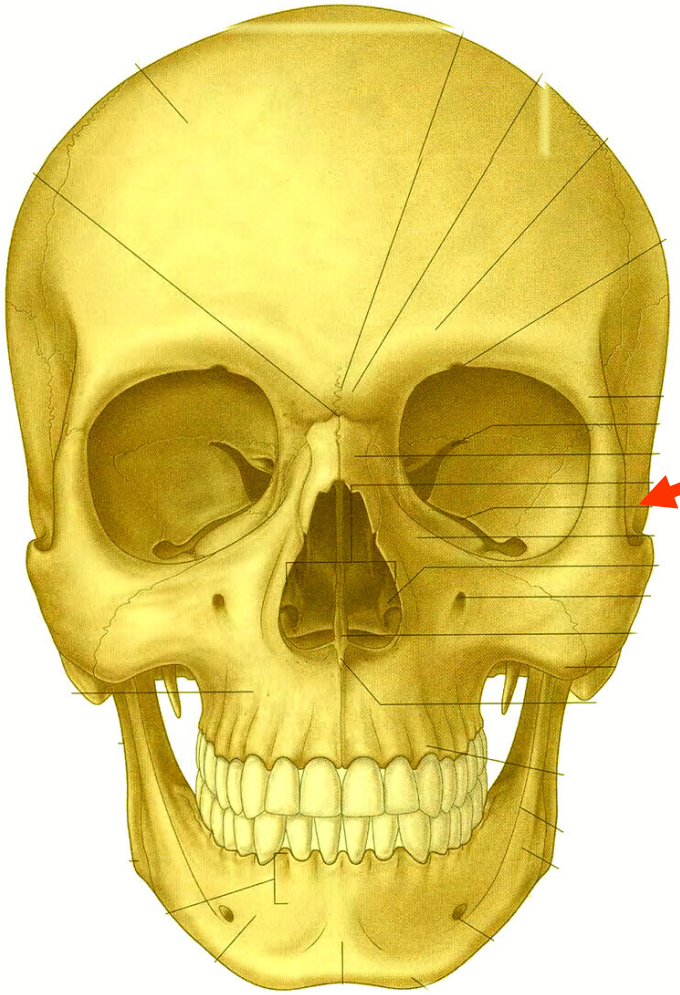
CLINICAL **

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

orient of aud. tube





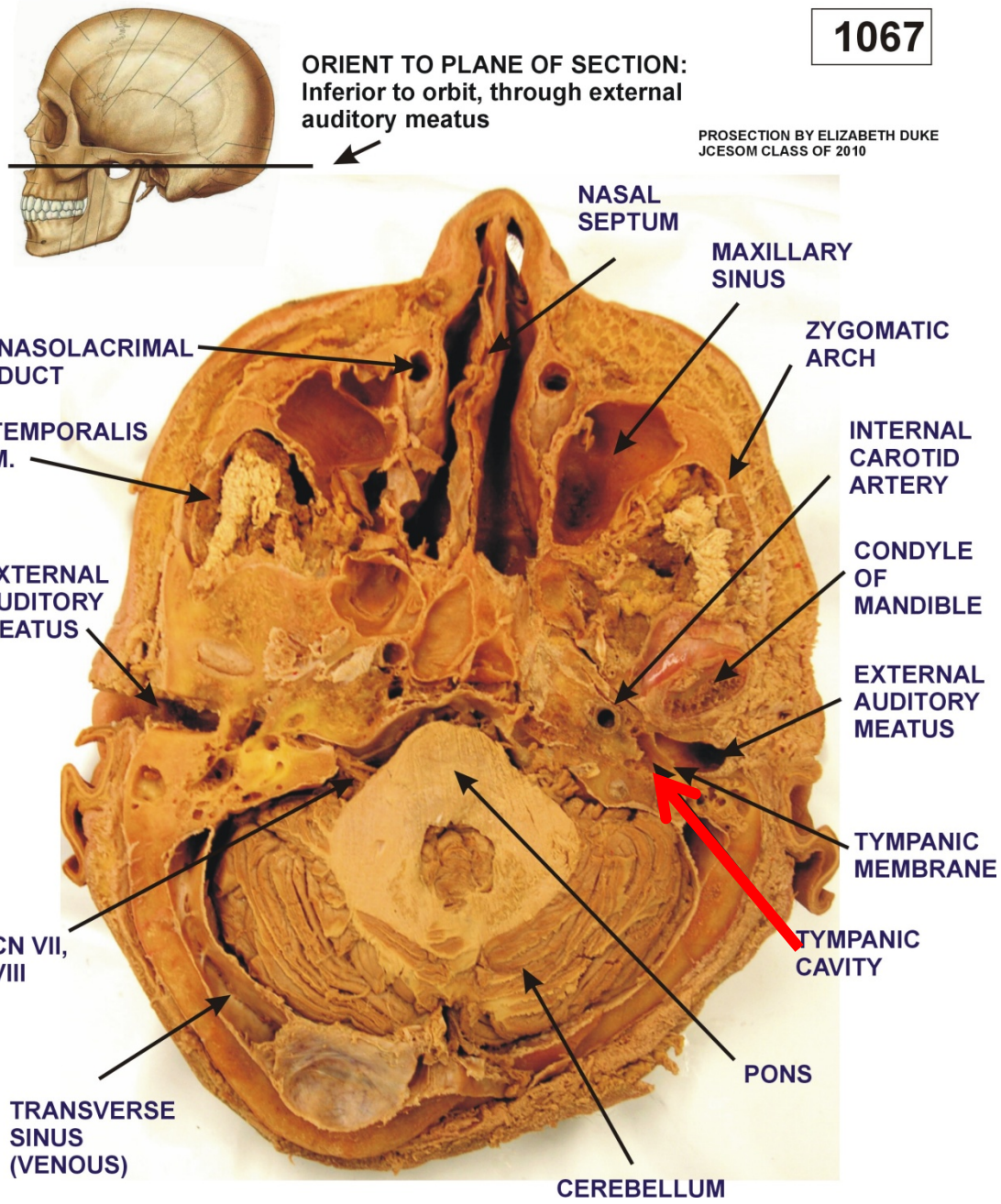
orient of aud. tube

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

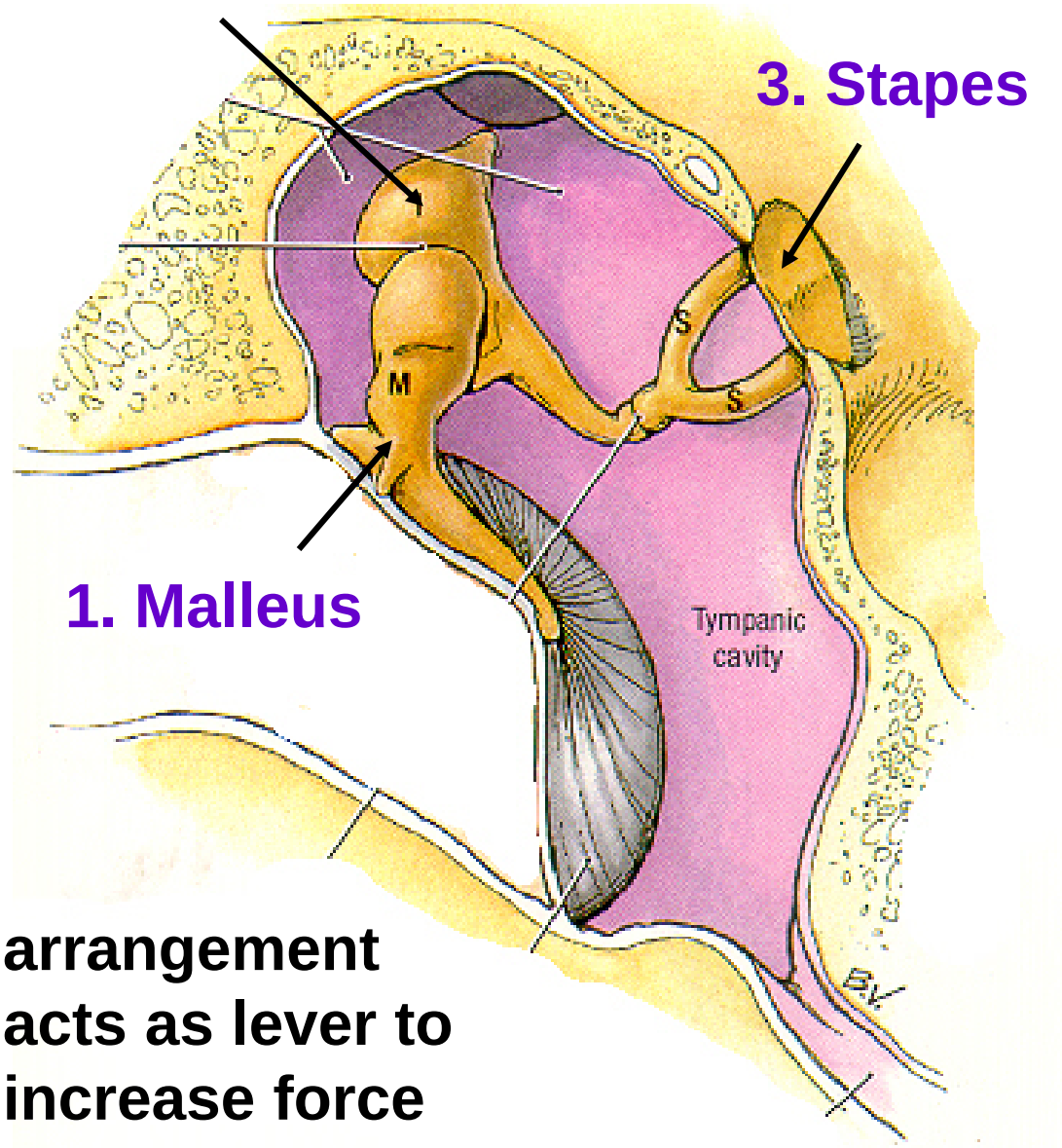
1067



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

B. AUDITORY OSSICLES

2. Incus



arrangement acts as lever to increase force

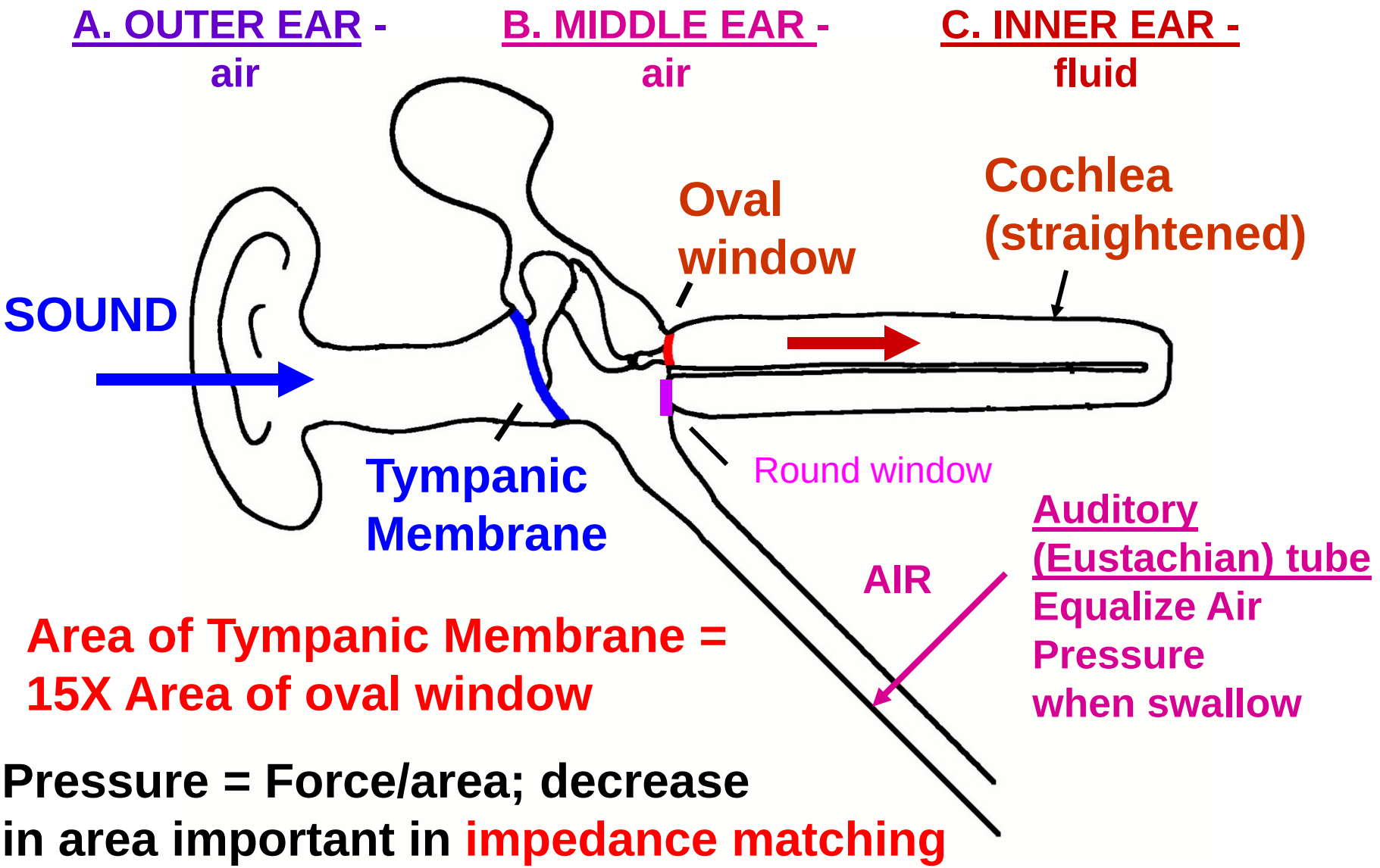
- link tympanic membrane to oval window and cochlea –

- anchored by ligaments

Malleus = hammer
Incus = anvil
Stapes = stirrup

- Broad attachment of Malleus to tympanic membrane

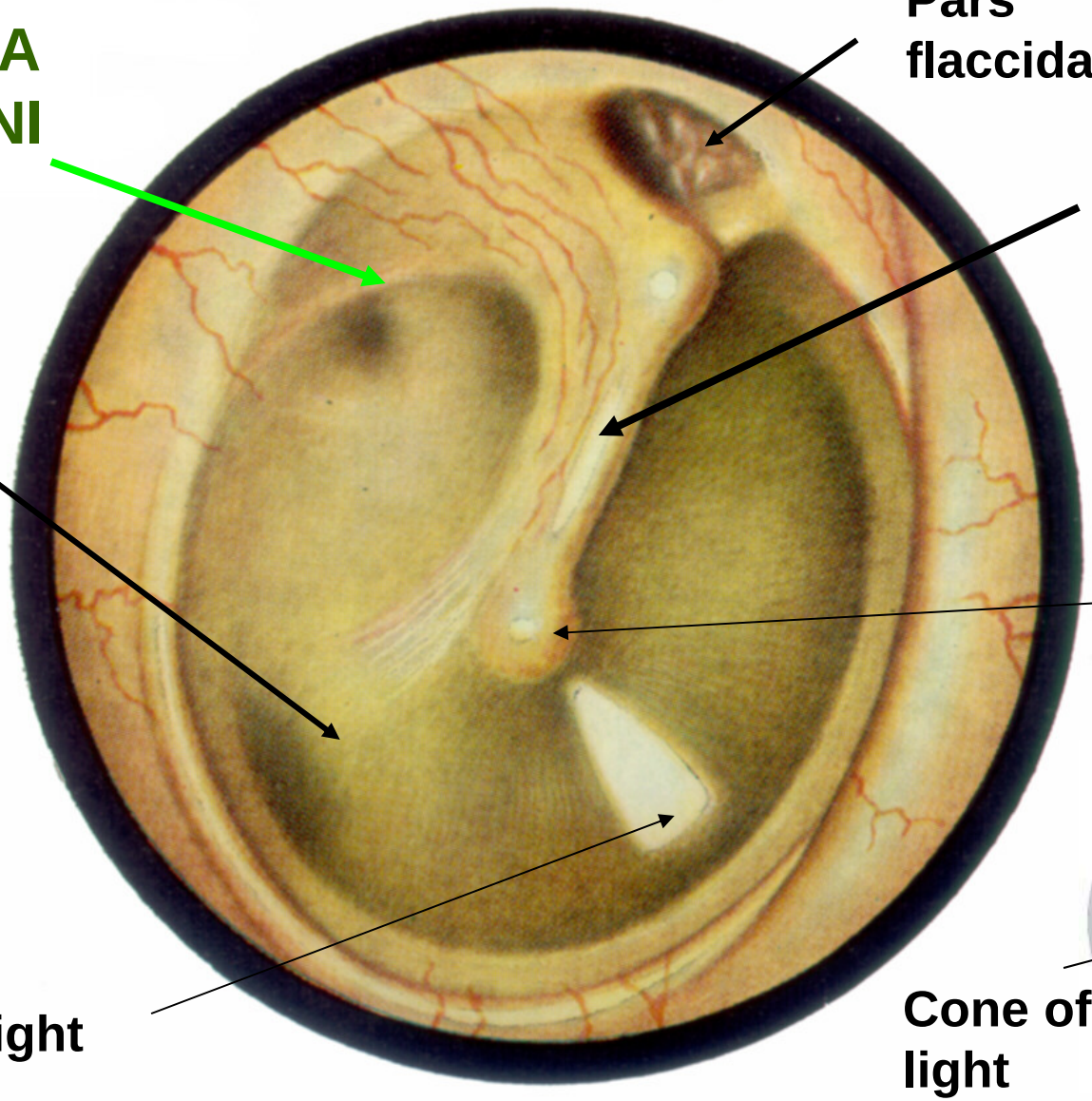
EAR: DIAGRAMMATICALLY - transmission of sound (Cochlea straightened)



Area of Tympanic Membrane = 15X Area of oval window

Pressure = Force/area; decrease in area important in impedance matching

OTOSCOPE VIEW OF TYMPANIC MEMBRANE



CHORDA TYMPANI (branch of VII)

Pars flaccida

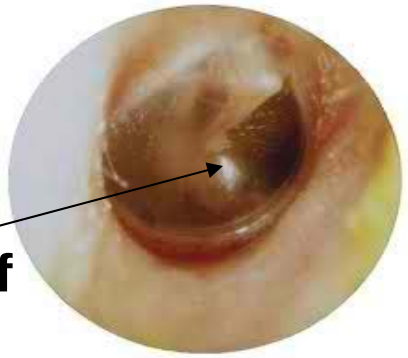
MALLEUS – manubrium (handle)

Pars tensa

Umbo (protuberance)

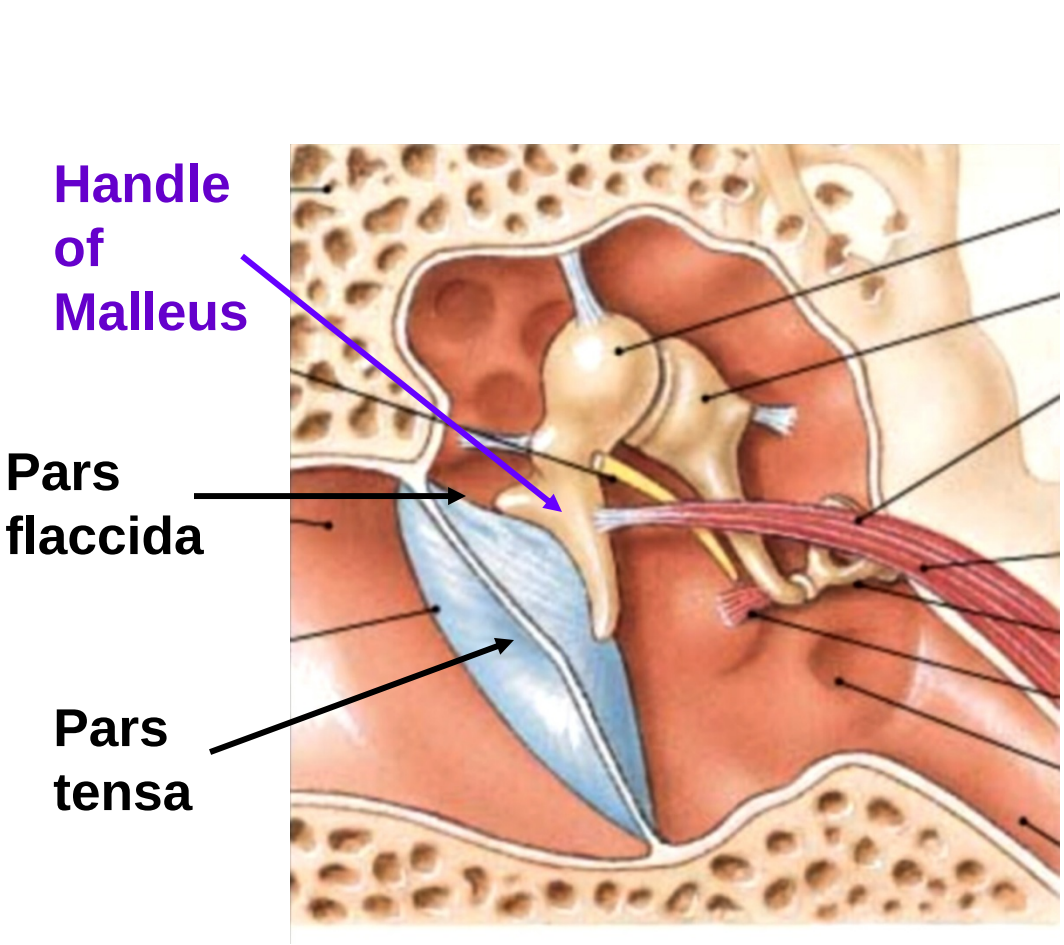
RIGHT EAR

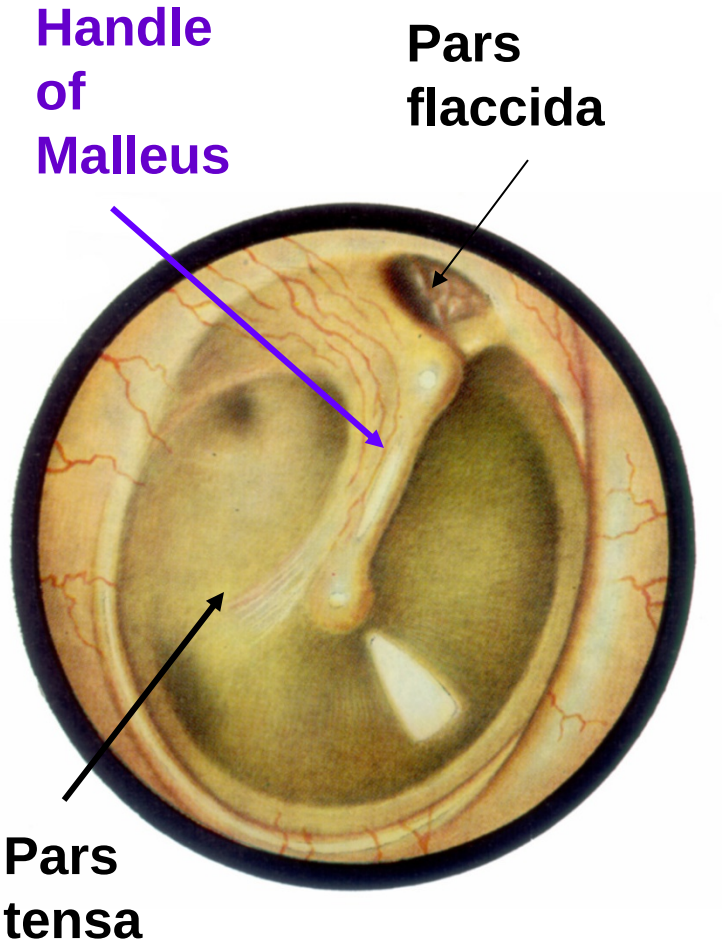
Cone of light



Cone of light

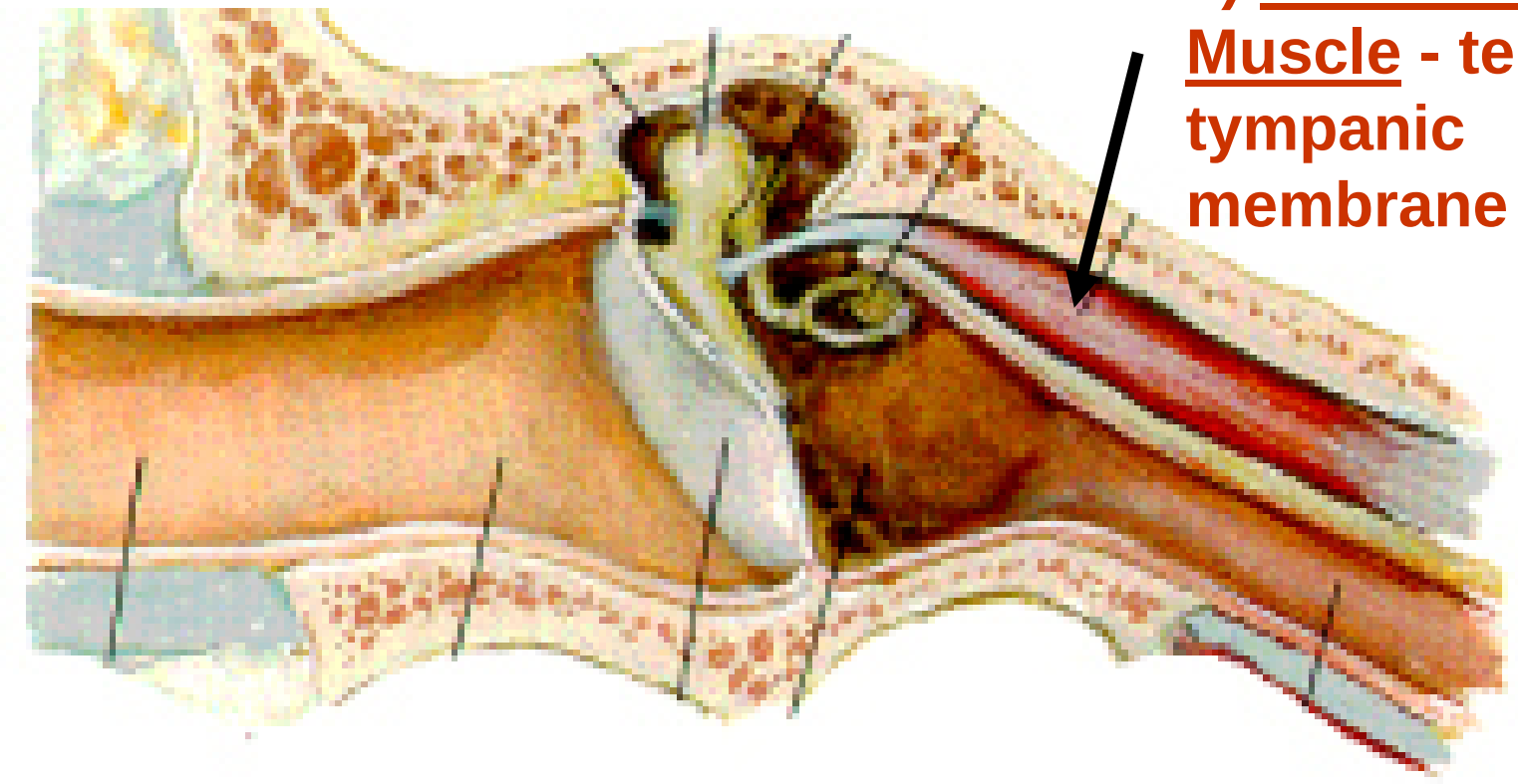
OTOSCOPE VIEW OF TYMPANIC MEMBRANE





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

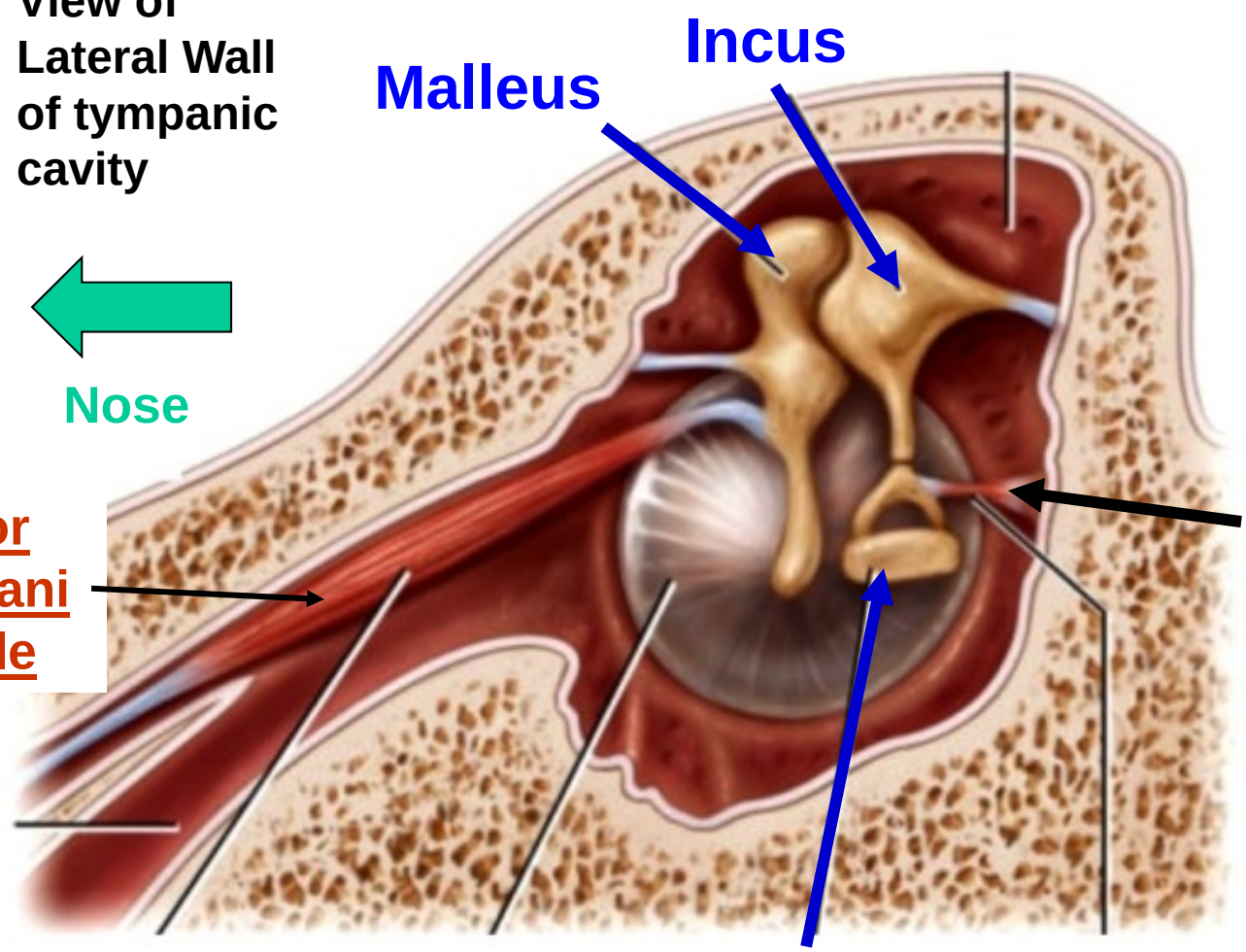


1) Tensor Tympani Muscle - tenses tympanic membrane

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

C. MUSCLES OF MIDDLE EAR - dampen sound

View of Lateral Wall of tympanic cavity

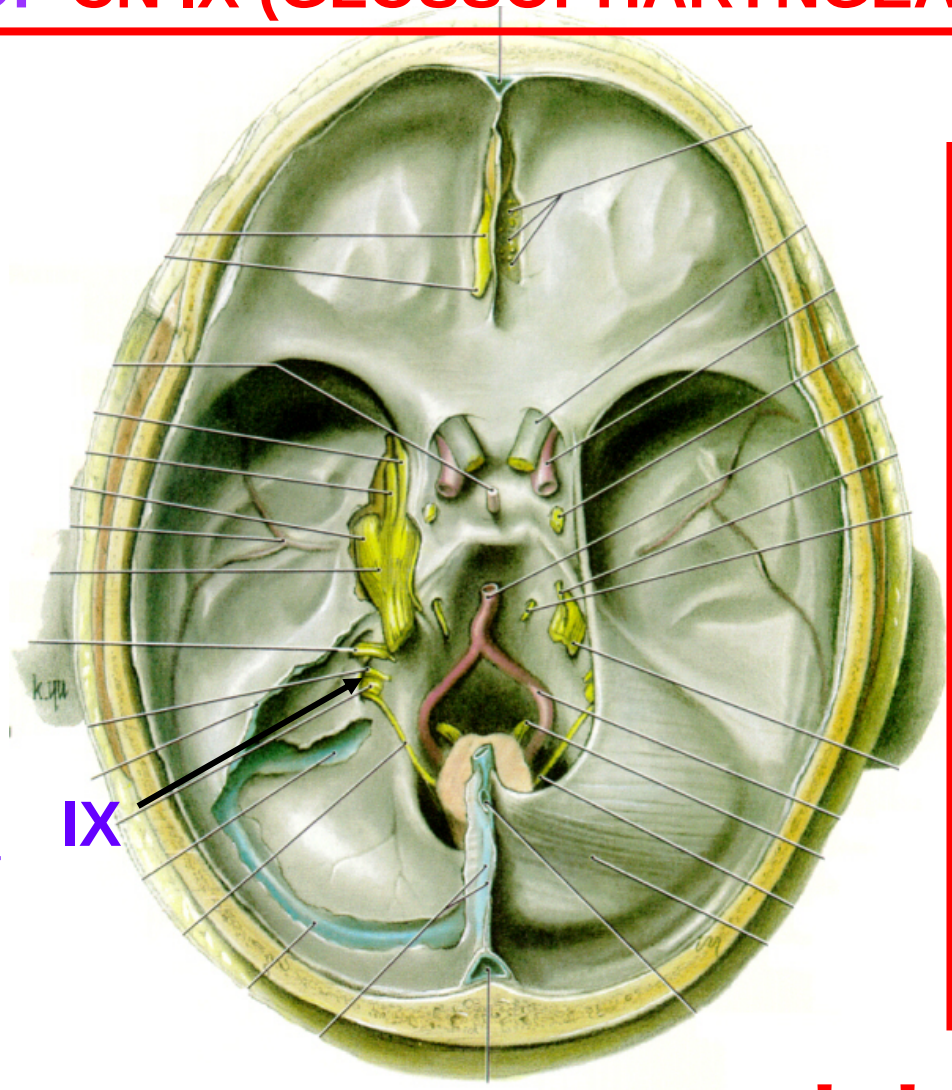


2) Stapedius
O - post wall (Pyramid)
I - neck of stapes
Inn - VII

CLINICAL **

Damage to VII - Hyperacousia - sounds seem too loud

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



leaves Posterlor Cranial Fossa via Jugular Foramen

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

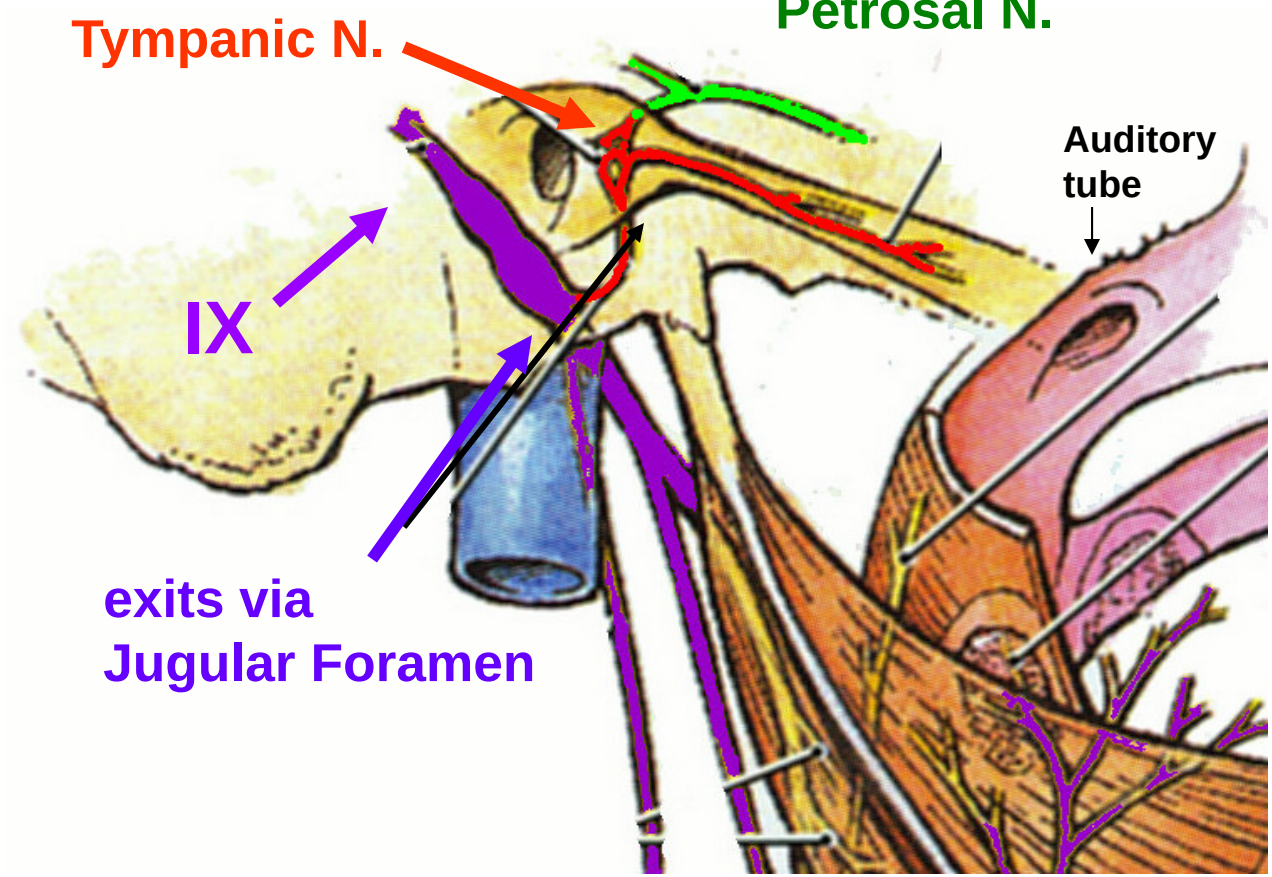
IX - GLOSSOPHARYNGEAL

NOSE

exits via
Jugular Foramen

Lesser
Petrosal N.

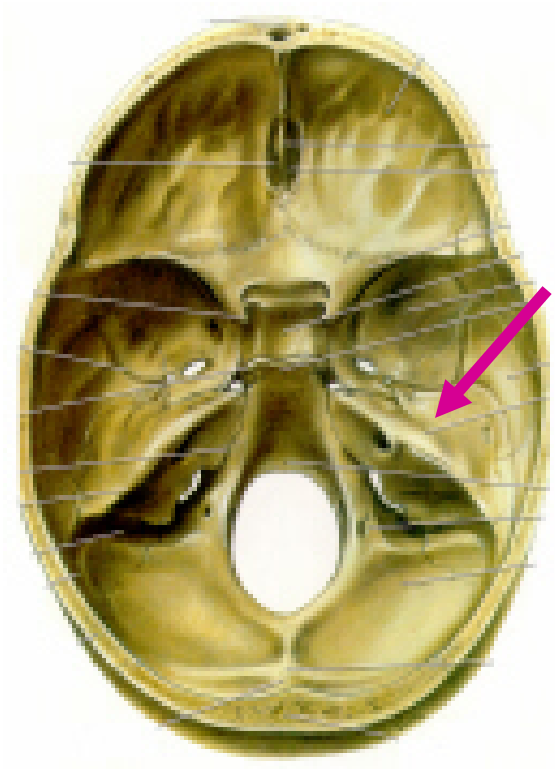
Tympanic N.



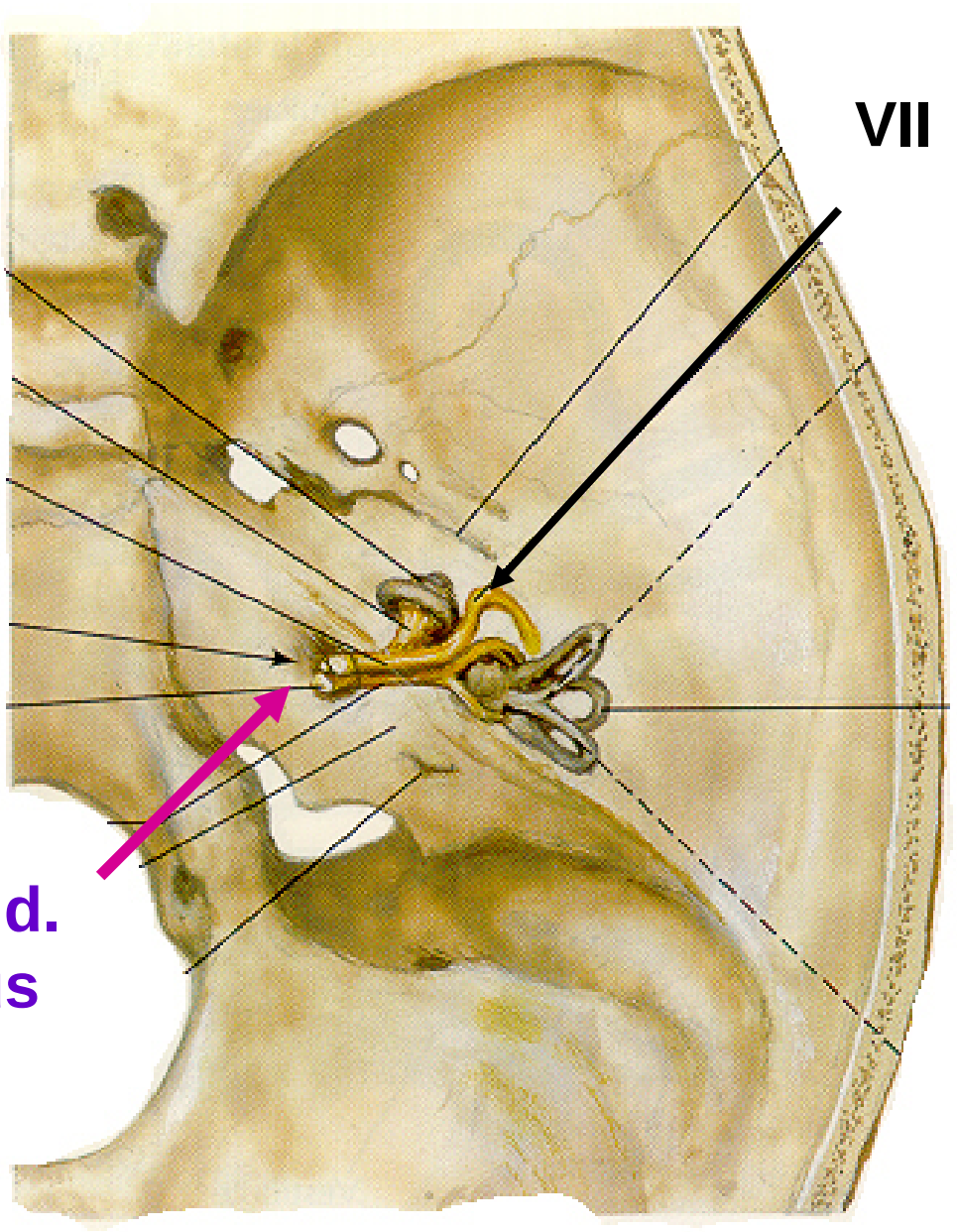
1. Tympanic Nerve
Forms tympanic plexus; VISCERAL SENSORY to middle ear
Mastoid sinus
auditory tube

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

COURSE OF FACIAL NERVE (VII)



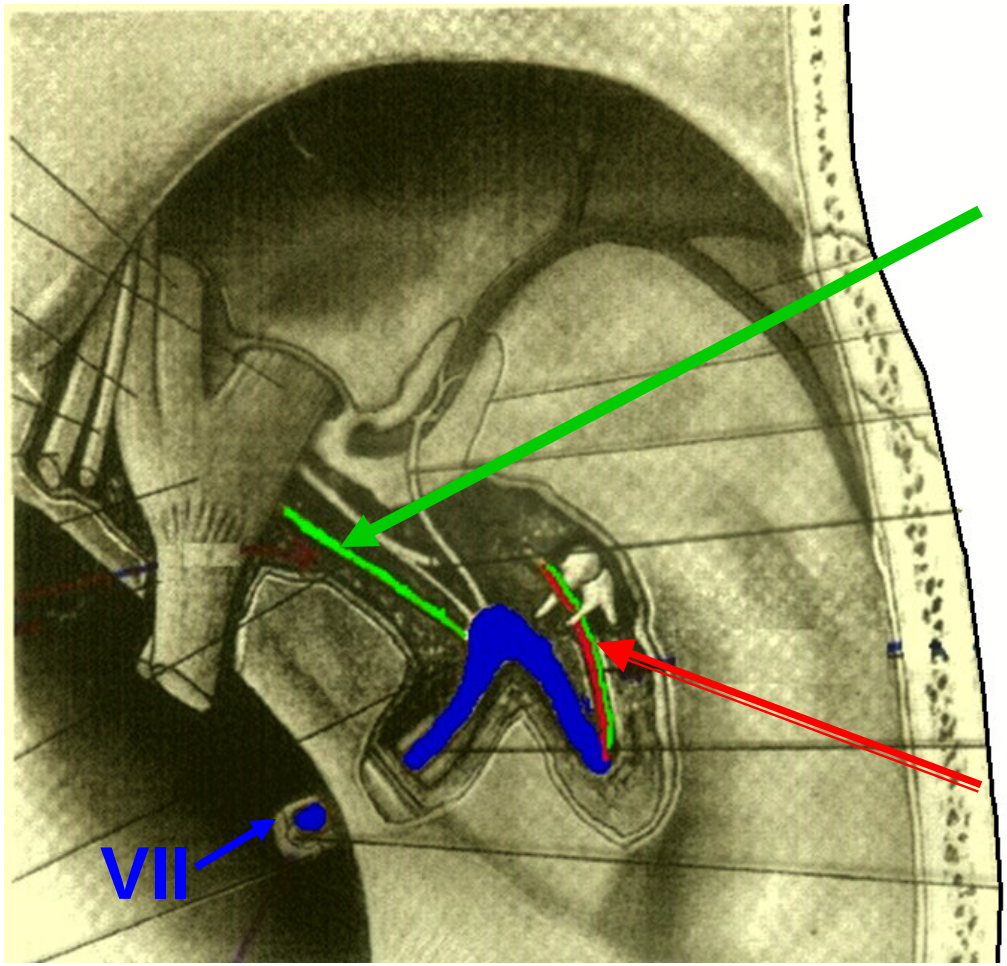
Petrous part of temporal bone



Int. aud. meatus

VII - FACIAL

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

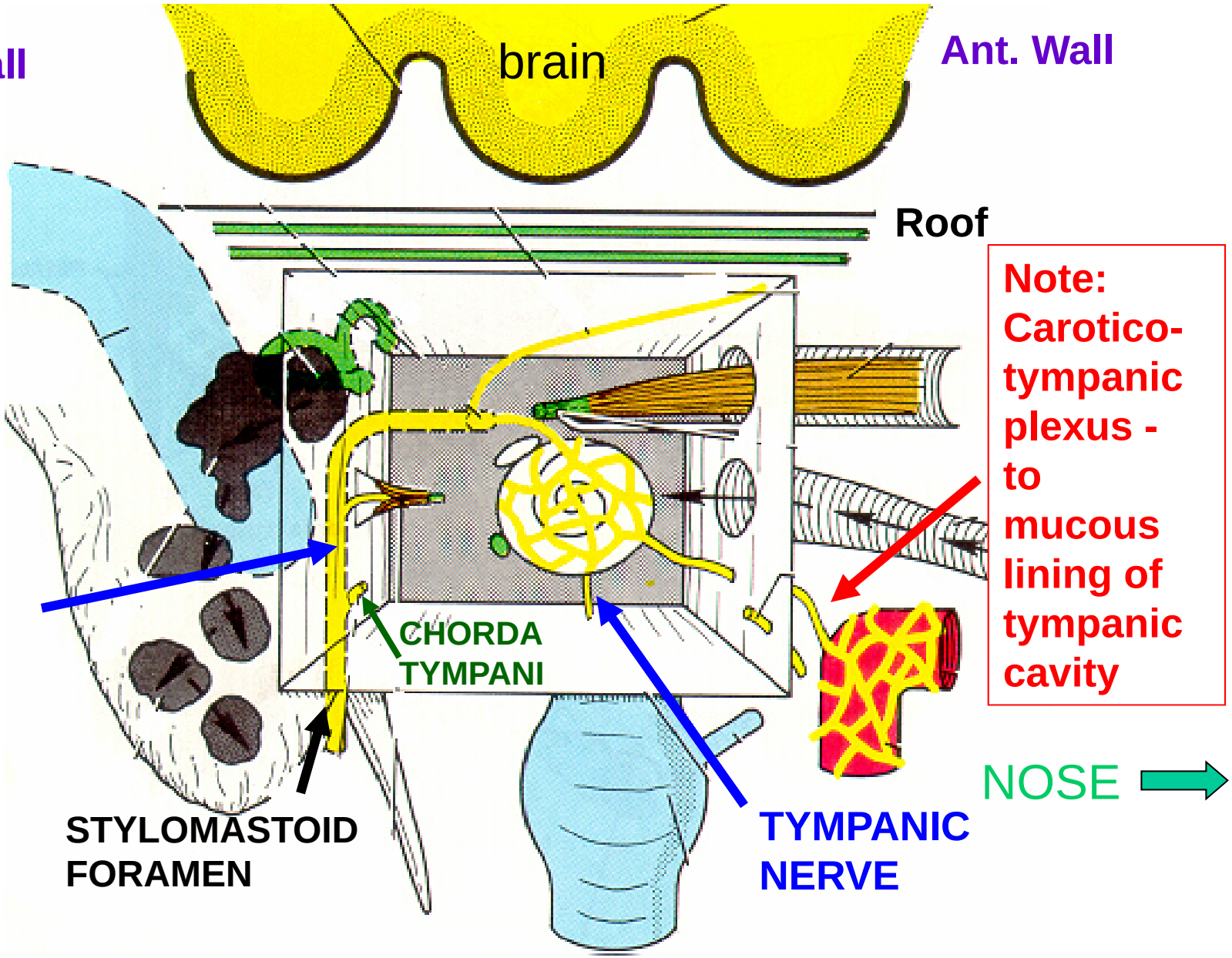


1. Greater Petrosal N.
VISCERAL MOTOR
Parasympathetics to Lacrimal gland, mucous glands of nose and palate, [Visceral sensory to Nasopharynx]

2. Stapedial N. - Branchiomotor to Stapedius

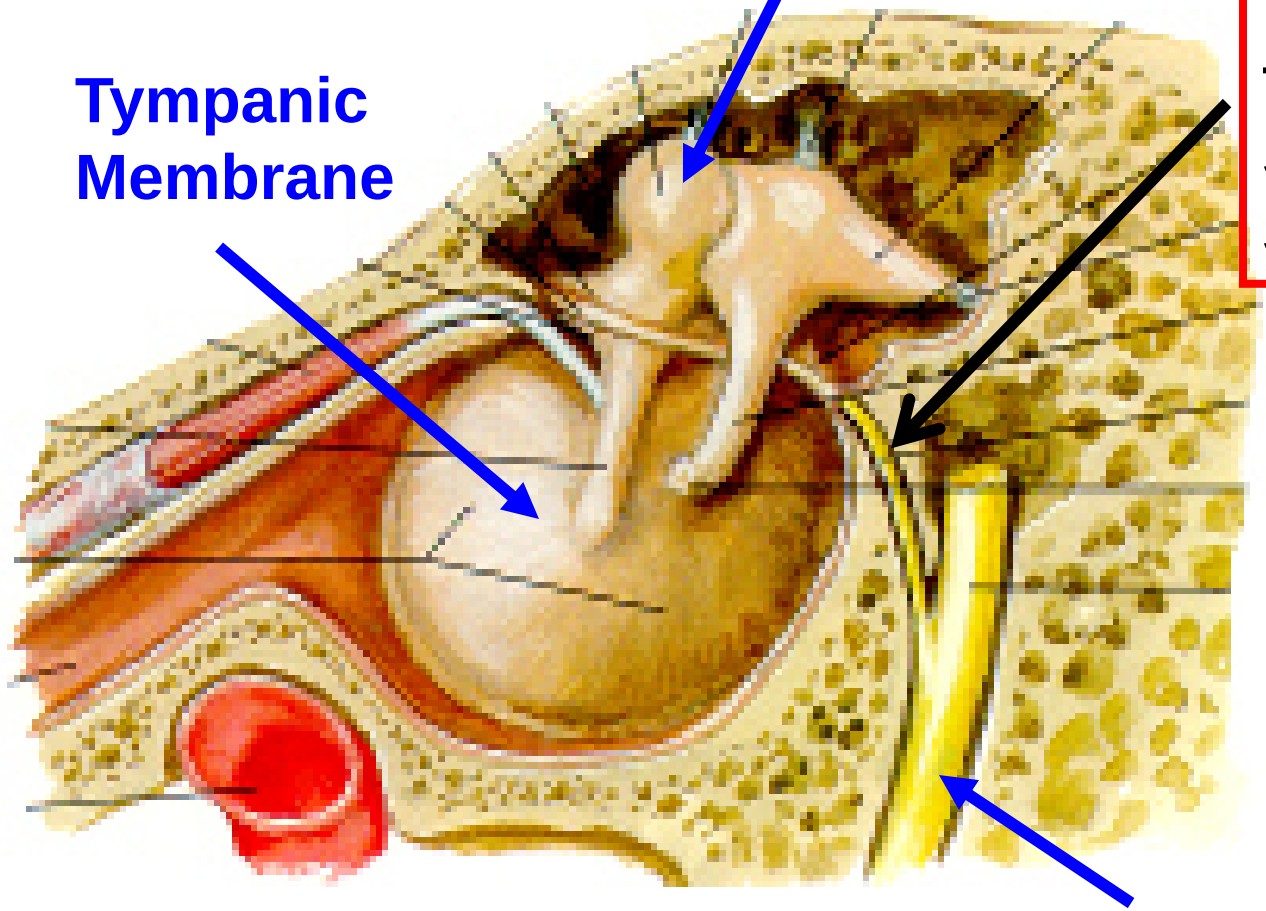
3. Chorda Tympani - has
A) Taste to ant 2/3 tongue
B) Parasympathetics to Submandibular, Sublingual salivary glands

LOCATION OF NERVES IN MIDDLE EAR



Looking at Medial Wall of Right Middle Ear with Ossicles Removed

CHORDA TYMPANI

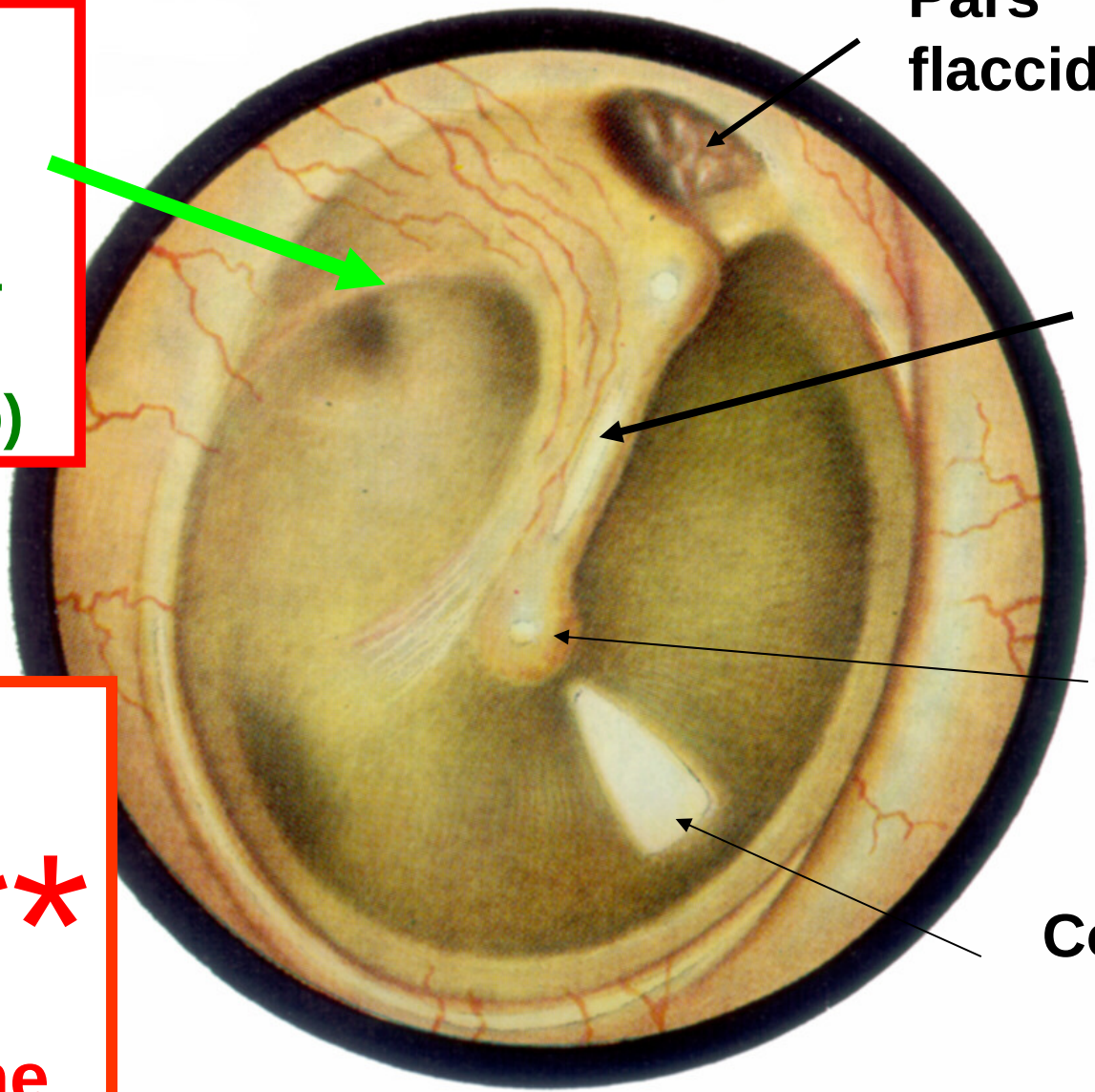


CLINICAL

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

OTOSCOPE VIEW OF TYMPANIC MEMBRANE



CHORDA TYMPANI: TASTE, VISCERAL MOTOR (parasymp)

Pars flaccida

MALLEUS – manubrium (handle)

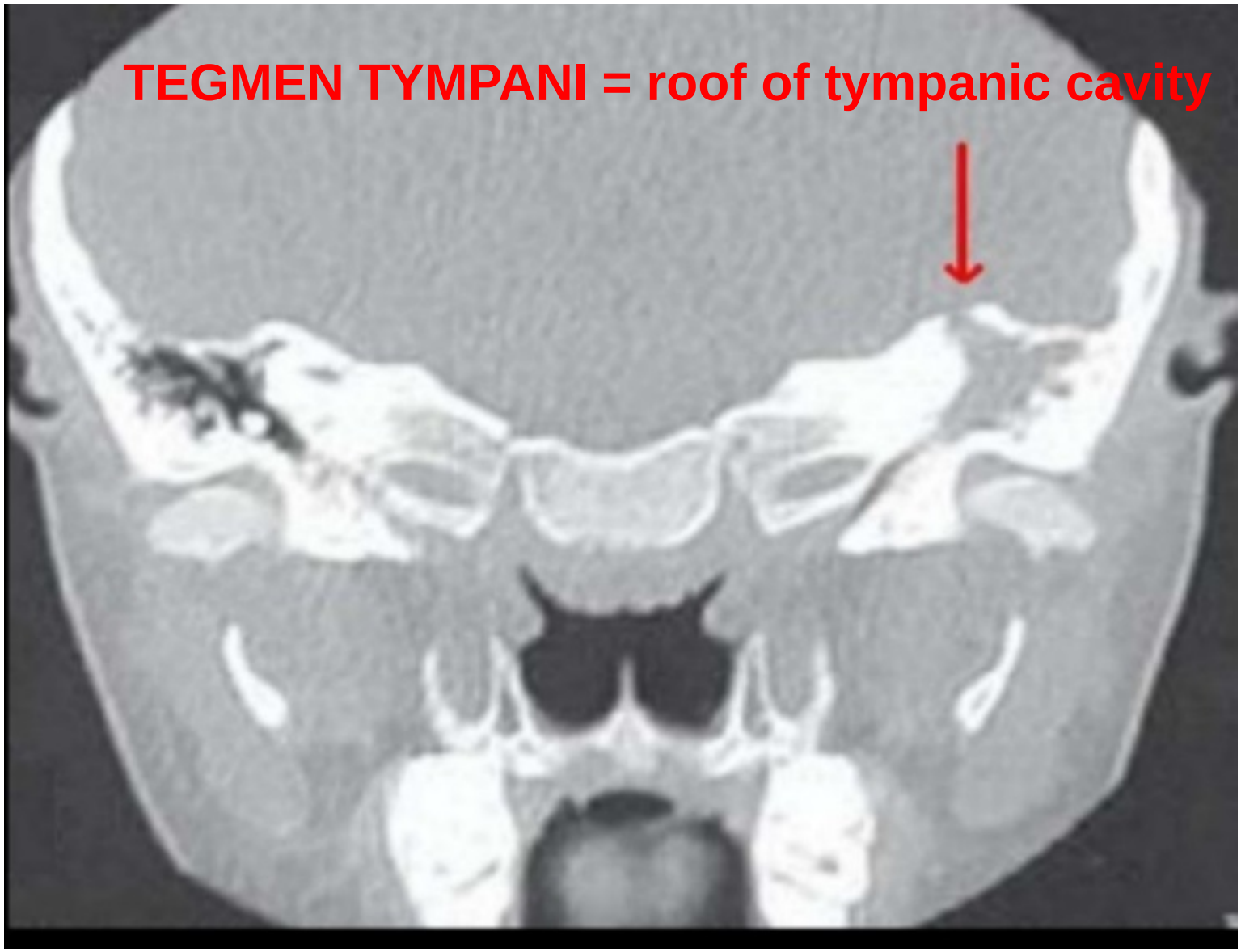
Umbo

Cone of light

CLINICAL*

Lose taste if pierce ** tympanic membrane

EROSION OF TEGMEN TYMPANI IN OTITIS MEDIA



tegman L. = covering