SPINAL 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.

Note: Reflexes often have effects in more than one muscle; the muscles may all be at the same joint; sometimes the muscles are at different joints in the same limb or in the opposite limb.

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

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** - 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.

F. Other reflexes are relatively **constant under the same controlled circumstances**; ex. **Monosynaptic stretch reflex (deep tendon reflex)** - can be tested in a variety of skeletal muscles; response is consistent if patient is relaxed. **Reflexes can be modulated by the central nervous system** - reflexes can be changed or blocked in some behaviors.

G. **Functions of many reflexes are complex**. **Reflexes can be incorporated as elements into automatic reactions.** Examples: 1) maintaining balance when standing and walking, 2) regulation of muscle tensions, 3) avoiding painful stimulus (stepping on a nail); **Note: Automatic reactions differ from reflexes in their duration and complexity (ex. many muscles activated); automatic reactions can be influenced by different types of sensory inputs (ex. wearing a backpack changes postural reactions).**

H. **Other 'reflexes' actually represent triggering of more complex behaviors by sensory signals. Some behaviors 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 (ex. walking). 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: Myotatic Reflex, Deep Tendon Reflex)

1. **Stimulus** - fast stretch of muscle; clinically, this is produced by a brief sharp tap to a muscle tendon (this results in sudden small lengthening of muscle, not in stimulation of tendon receptors).

2. **Sense organ excited** - stretch **strongly excites muscle spindle Primary (Group Ia) afferents**; can also produce much weaker discharges of muscle spindle Secondary (Group II) afferents.

3. **Primary response** - **muscle that is stretched contracts rapidly**

a. Synapses - Group Ia muscle spindle sensory neurons make strong monosynaptic excitatory connections with alpha (α) motor neurons of homonymous muscle (same muscle in which spindle is located). Group II muscle spindle sensory neurons have 1) weaker monosynaptic and 2) stronger polysynaptic (through interneurons) excitatory effects on same motor neurons.

Note: Monosynaptic reflex is the fastest reflex known, with a delay of about 1 msec at the synapse.

4. **Other effects**

a. **Excite synergist muscles** - muscle spindle afferents also make excitatory monosynaptic connections with synergist muscles (ex. in arm - biceps spindle sensory neurons excite motor neurons to brachialis muscle).

b. **Inhibit antagonist muscles (RECIPROCAL INHIBITION)** - Spindle sensory neurons also produce inhibition of motor neurons to antagonist muscles (ex. biceps spindle neurons produce inhibition of triceps motor neurons); these connections are polysynaptic. The spindle afferent excites interneurons, which then fire and produce inhibitory synaptic potentials in motor neurons to the antagonist muscle.

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.

6. **Clinical Testing of stretch reflex** - A rapid tap to the tendon produces a very quick, small stretch of the muscle. Most, if not all of the spindles in the muscle, are excited simultaneously, producing a discharge of sensory neurons that **act convergently** upon the motor neurons resulting in a brief and rapid muscle twitch. (Note excellent videos of normal and abnormal reflexes can be found at: **http://library.med.utah.edu/neurologicexam/html/home_exam.html**)

7. **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 must be inhibited in some muscles during voluntary movements

8. **Modification of reflexes** - Even monosynaptic reflexes can be changed. Reflexes can be altered by mechanisms of 1) pre-synaptic inhibition (decrease effectiveness of spindle sensory discharges) and 2) modulation of motor neuron activities (excitability). Some of these changes are produced by activities in neurons of descending motor tracts. Changes in stretch reflexes are also symptomatic: **In general, Decrease stretch reflexes can indicate Lower Motor Neuron Disorders, Increase Stretch reflexes can indicate Upper Motor Neuron Syndromes.**

9. **Renshaw cells** - Alpha motor neurons have recurrent processes (axon collaterals); these branches synapse in the central nervous system; some branches make excitatory synapses upon interneurons (Renshaw cells). Renshaw cells make inhibitory synapses upon the same motor neurons. These circuits can **limit motor neuron firing** and change reflexes. Renshaw cells also receive inputs from descending motor tracts.

9. **Functions of stretch reflex** - **Automatic Reaction: Countering perturbations of balance when standing** (for example: maintaining balance when standing on one foot or when standing on a moving bus). Perturbations (or fatigue) can produce stretch of muscles, generating discharge of muscle spindle afferents. Reflex connections aid in bringing the body back to the original position. These types of circuits are called **Negative feedback systems**: the stimulus causes a response that acts to decrease the stimulus (stretch causes shortening of muscle, which decreases Ia discharge). The same mechanism can work in any motor action if unexpected loads are encountered that produce stretch of muscles. While stretch reflexes contribute to these responses, **Postural reactions** differ from reflexes in that they are 1) longer in duration than stretch reflexes, 2) also involve contractions of muscles not in the

limb (ex. extensor muscles of the back), 3) can be adjusted by other sensory inputs (ex. wearing a back pack).

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 (muscle is strongly contracted)

2. **Sense organ excited** - Golgi tendon organ (Ib afferent)

3. **Primary response** - muscle attached to tendon **relaxes**

a. Synapses - polysynaptic; Ib afferent makes an excitatory synapse upon an interneuron; the interneuron makes an inhibitory synapse upon the motor neuron from the same muscle in which the tendon organ is located.

4. **Other effects**

a. Inhibits synergist muscles - synaptic connections are also polysynaptic; the GTO sensory neuron makes an excitatory synapse upon an interneuron that inhibits motor neurons to the synergist muscles.

b. Excites antagonist muscles - synaptic connections are also polysynaptic; the GTO sensory neuron makes an excitatory synapse upon an interneuron that excites motor neurons to the antagonist muscles.

5. **Function of Autogenic inhibition** - **Automatic Reaction: Regulating muscle tensions** - The force developed by contractions of muscles are automatically controlled so that they do not cause damage to tendons (example: lifting a very heavy object).

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

6. **Clinical significance** - **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.

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** - protective withdrawal of limb (often by exciting flexor muscles)

a. Synapses - polysynaptic; cutaneous afferents make excitatory synapses upon interneurons; the interneurons (one or more in pathway) make excitatory synapses upon motor neurons to flexor muscles.

4. **Other effects**

a. Excite synergist muscles (polysynaptic) - Cutaneous, pain afferents also make excitatory synapses upon interneurons that excite motor neurons to other flexor muscles in the same limb (often at different joints).

b. Inhibit antagonist muscles (polysynaptic) - Cutaneous, pain afferents make excitatory synapses upon interneurons that inhibit motor neurons to extensor muscles in the same limb.

c. **Crossed Extension reflex** - Flexor reflexes can also have effects in the contralateral leg in standing. These effects are opposite those seen in the same leg (called opposite sign of reflex); connections via commissural interneurons **excite extensor motor neurons and inhibit flexor motor neurons of muscles in opposite leg**.

5. **Function of flexor reflexes** - 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 reflex - seen after Upper Motor neuron lesion; normal response - stroking sole of foot normally results in flexion of toes (not strictly a withdrawal reflex); Babinski sign - direction of movement changes from flexing toes, to extending toes.

III. 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. Grovers 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.

TABLE OF COMMON REFLEXES AND SPINAL LEVELS TESTED

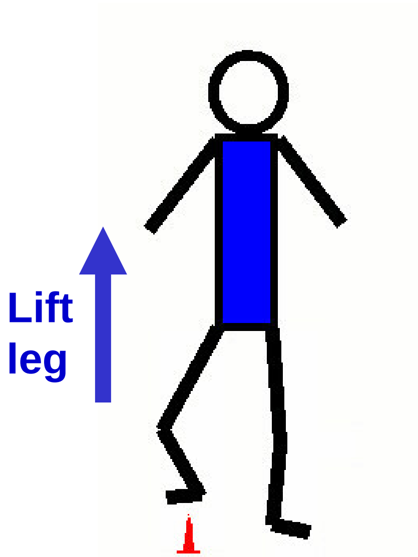
Stretch Reflex Muscles Tested		**Spinal Levels Tested**
Biceps		C5,**6**
Triceps		C6,**7**
Intrinsic hand muscles (ex. interossei)		C7,**8**
Quadriceps (Knee Jerk or Patellar reflex)		L3,**4**
Gastrocnemius, Soleus (Ankle Jerk or Achilles tendon reflex)		S**1**,2
Other Reflexes	**Test**	**Clinical Sign**
Babinski Reflex	Stroke sole of foot	Normal: Flexion (Plantar flexion) of big toe UMN damage: Extension (Dorsiflexion) of big toe
Hoffmann Reflex	Tap distal phalanx of third or fourth finger	UMN damage: Flex fingers
Glabellar Reflex	Tap forehead	Normal: close eyes, extinguishes (stops) with repetition; Abnormal: persists on repetition

SUMMARY OF CHARACTERISTICS OF SPINAL REFLEXES

REFLEX	STIMULUS (CLINICAL TEST)	RESPONSE	SENSORY RECEPTOR	SYNAPSES	EFFECT ON MUSCLE	OTHER EFFECTS	FUNCTION
Stretch (Myotatic) Reflex	**Rapid Stretch of muscle (test: tap on muscle tendon)**	**Stretched muscle contracts rapidly (ex. knee jerk)**	**Muscle Spindle Primary (Ia) and Secondary (II) sensory neurons**	**Ia: Mono-synaptic** **II: Monosynaptic (weak) and Polysynaptic**	**Excite Homon-ymous (same) muscle**	**Also Excite synergist and Inhibit antagonist muscles (Reciprocal Inhibition)**	**Aid in maintaining posture, counter sudden loads**
Autogenic Inhibition (Inverse Myotatic Reflex)	**Large force on tendon (pull on muscle when resisted)**	**Muscle tension decreases (Clasped knife reflex)**	**Golgi Tendon Organ (Ib)**	**Poly-synaptic (via interneuron)**	**Inhibit Homon-ymous (same) muscle**	**Also Inhibit synergist muscles; Excite antagonist muscles**	**Protective, prevent damage to tendon**
Flexor Reflex	**Sharp, painful stimulus (as in stepping on nail)**	**Limb is rapidly withdrawn from stimulus**	**Cutaneous (skin) and pain receptors**	**Poly-synaptic (via interneuron)**	**Excite Flexor muscle**	**Also Inhibit extensors of same limb; Excite extensors and Inhibit flexors of opposite limb (Crossed Extensor Reflex)**	**Protective, withdraw from painful stimulus; Cross extension supports posture when leg is lifted**

SPINAL REFLEXES

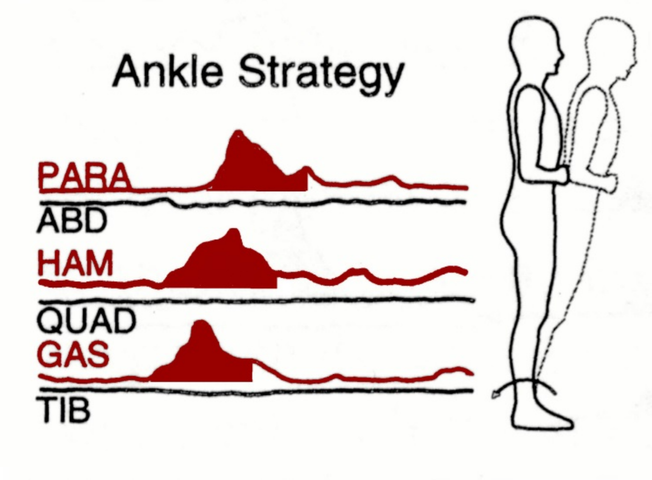
Why is there a nervous system? **The nervous system rapidly generates appropriate reactions to sensory stimuli.**



Step on a nail

RAPID REACTIONS TO STIMULI

POSTURAL SWAY



REFLEXES ARE COMPONENTS OF BEHAVIORS

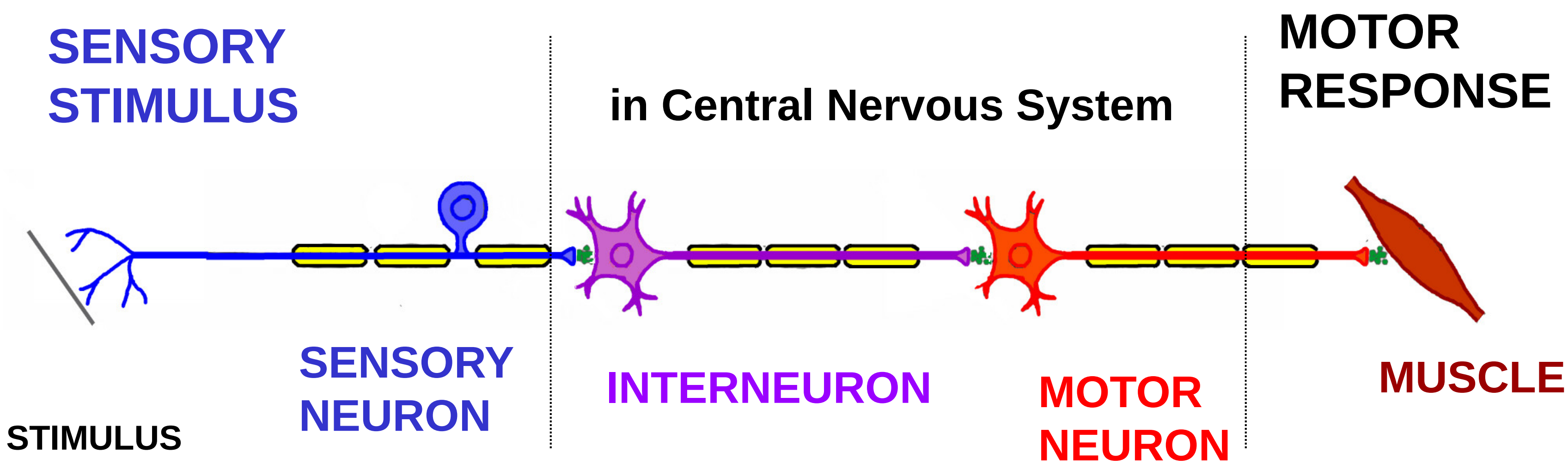
DIAGNOSTIC TESTING OF NERVOUS SYSTEM FUNCTION

REFLEXES CAN FORM PART OF AUTOMATIC REACTIONS AND COMPLEX BEHAVIORS

SENSORY STIMULUS → **MOTOR RESPONSE**

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

TYPICAL REFLEX



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

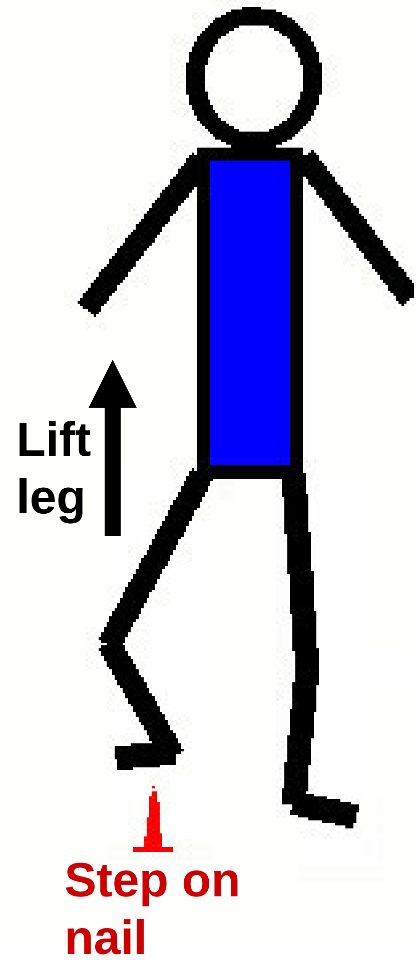
2) interneurons - (most often) effects on motor neuron can be excitatory or inhibitory

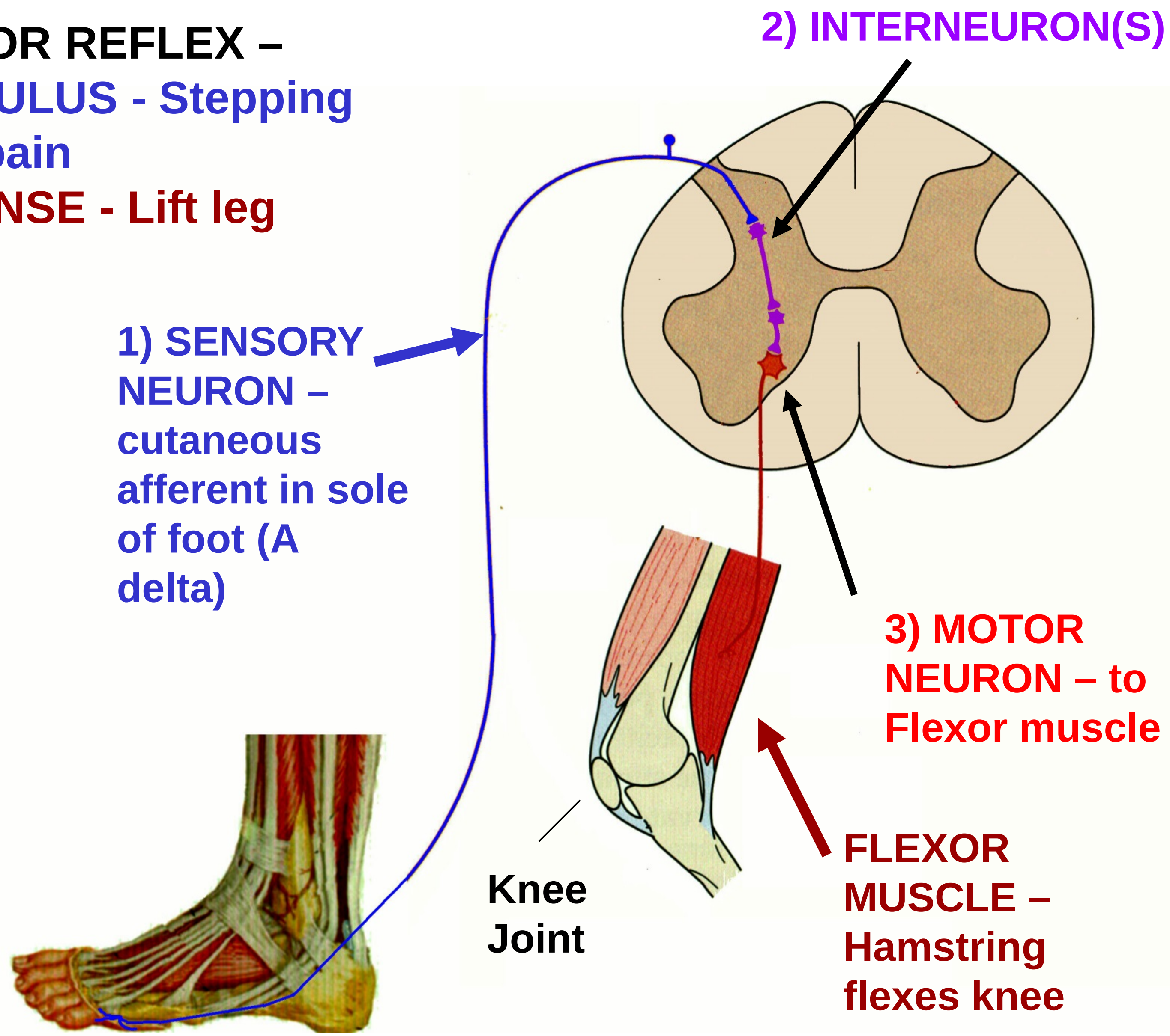
3) motor neurons - produce muscle contraction, motor response (termed efferent arm of reflex arc)

Reflexes often have effects on groups of motor neurons to different muscles, sometimes at different joints or in opposite limb

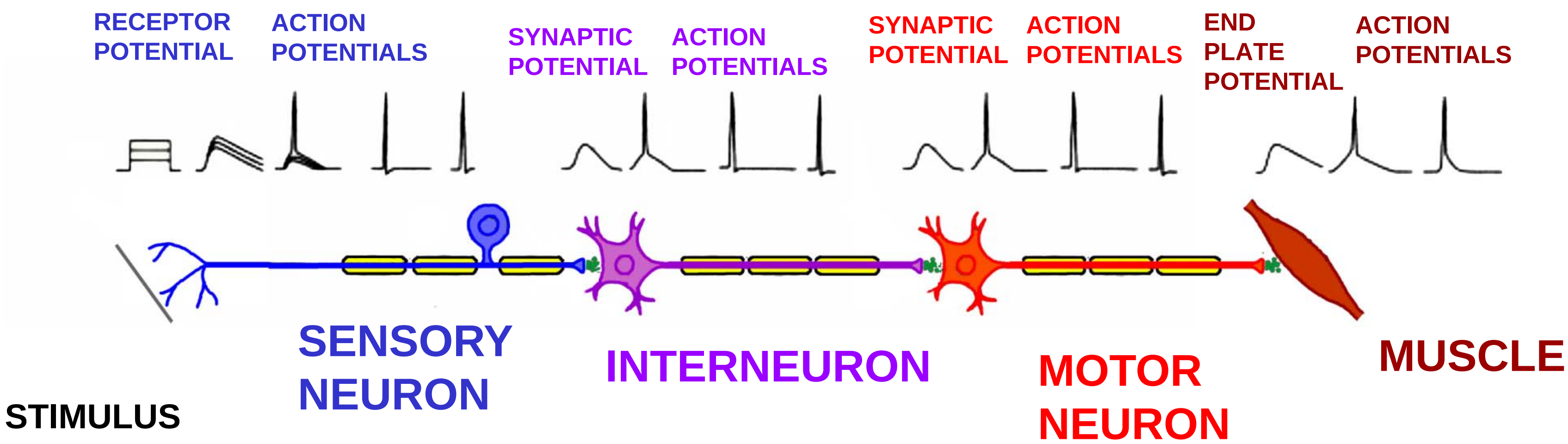
TYPICAL REFLEX

Example: FLEXOR REFLEX –
SENSORY STIMULUS - Stepping on nail causes pain
MOTOR RESPONSE - Lift leg





NEURAL EXCITATION/INHIBITION IS CONDUCTED ALONG REFLEX PATHWAY BY DEFINED CELLULAR MECHANISMS



Typical reflex arc: 1) sensory neuron - detects stimulus

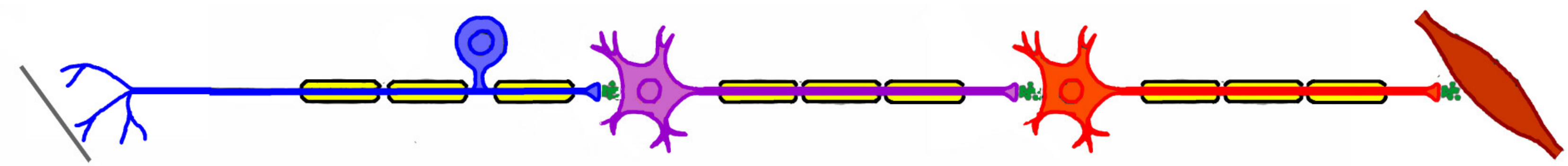
2) interneurons - (most often) can be excitatory or inhibitory

3) motor neurons - produce muscle contraction, motor response

REFLEX TESTING IS A POWERFUL CLINICAL TOOL

1 STIMULUS

RESPONSE **2**



SENSORY NEURON

INTERNEURON

MOTOR NEURON

MUSCLE

AFFERENT ARM OF REFLEX

EFFERENT ARM OF REFLEX

FOR REFLEX TO OCCUR ALL ELEMENTS MUST BE FUNCTIONAL; PATHWAYS MUST BE INTACT

In clinical test apply Stimulus 1 and see if get Response 2
If <u>absent, diagnose where pathway is interrupted</u>.
If <u>abnormal, diagnose where pathway is compromised</u>.

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

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);

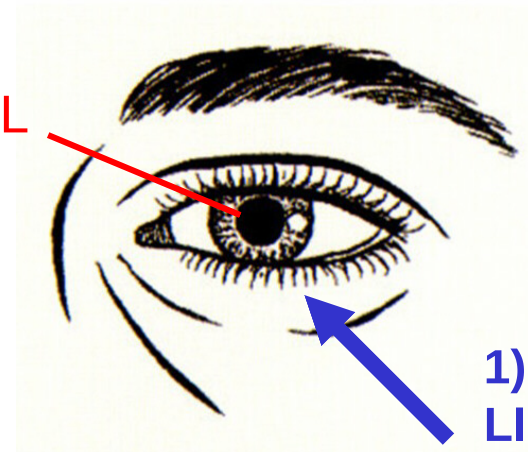
Hyper-reflexia = enhanced reflexes; in some disease processes, damage can enhance reflex responses

Clonus = series of abnormal, rapid alternating contractions and relaxations of muscle produced by single stimulus

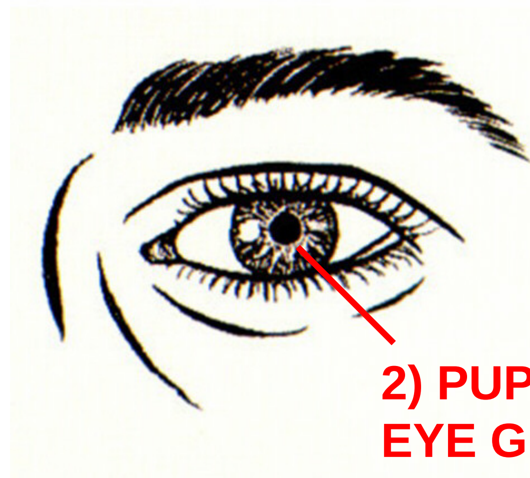
SOME REFLEXES ARE CONSTANT

<u>PUPILLARY LIGHT REFLEX</u> - LIGHT SHONE IN EYE causes PUPILLARY CONSTRICTION; protective reflex that limits light entering eye (protects photoreceptors)

PUPIL



1) SHINE LIGHT IN EYE



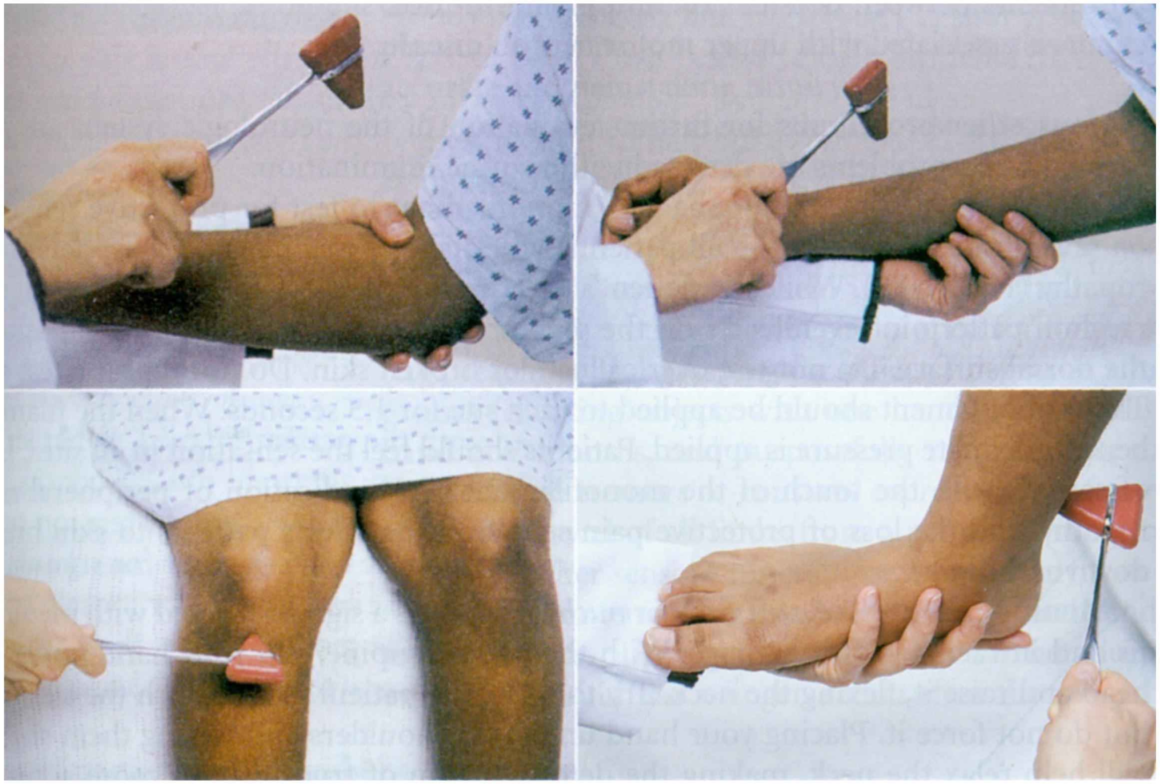
2) PUPIL OF EYE GETS SMALLER (CONSTRICTS)

1) <u>STIMULUS (AFFERENT ARM)</u> - light in eye; sensory neurons (photoreceptors in retina) detect light; sensory signals in <u>OPTIC NERVE (CRANIAL NERVE II, detects light)</u>

2) <u>RESPONSE (EFFERENT ARM) - OCULOMOTOR NERVE</u> (CRANIAL NERVE III, innervates pupillary constrictor muscle)

Note: connection is present at all times.

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.

REFLEXES VS. AUTOMATIC REACTIONS

Reflex - stereotyped motor response to a specific sensory stimulus

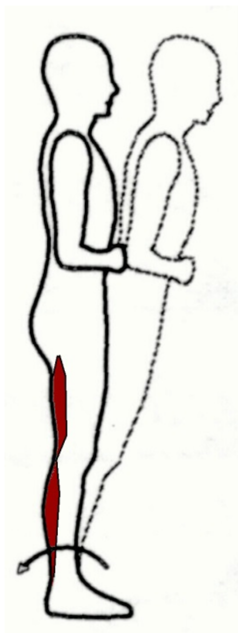
Automatic reactions - more complex responses to sensory stimuli (example: maintaining balance)

Automatic reactions differ from reflexes in

1) **<u>complexity</u> - many muscles activated**
2) **<u>duration</u> - responses last longer**
3) **<u>influenced by different types of sensory inputs</u> (ex. postural responses changed by wearing a backpack)**

SOME REFLEXES FORM PART OF AUTOMATIC REACTIONS

1) **Maintaining balance** when standing and walking

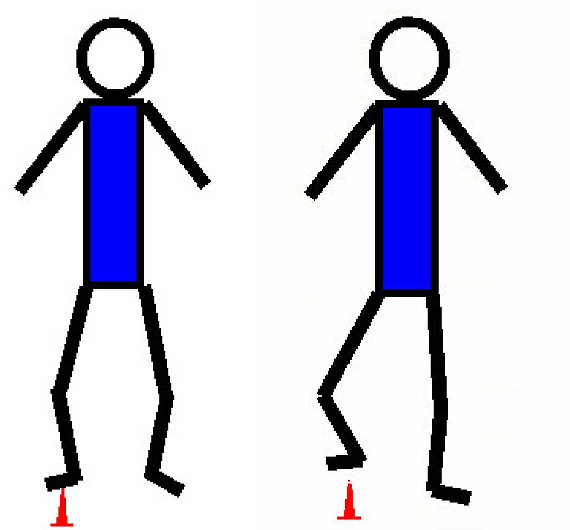


Muscle spindles

2) **Regulating muscle tensions** - not damage muscles or insertions

Golgi tendon organs

3) Stepping on a nail - **avoid painful stimuli**



Cutaneous, nociceptive (pain) receptors

Note: Automatic reactions differ from reflexes in duration and complexity (number of muscles activate); they can also be influenced by different types of sensory inputs (ex. wearing a backpack)

SOME 'REFLEXES' TRIGGER ACTIVITIES PRODUCED BY PATTERN GENERATORS

PALMAR GRASP

PLANTAR GRASP

MORO REFLEX -
arm extend

PLACING REFLEX

STEPPING 'REFLEX' -
actually eliciting a motor pattern

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:

1) <u>Stretch reflex</u> - produced by activating muscle spindles - contributes to maintaining postural stability, countering sudden loads

2) <u>Autogenic inhibition</u> - produced by activating Golgi tendon organs - aids in regulating muscle tension, prevents damage to tendon, bone

3) <u>Flexion reflex</u> - produced by activating cutaneous, pain afferents - avoid obstacle or painful stimulus (stepping on nail)

TERMINOLOGY

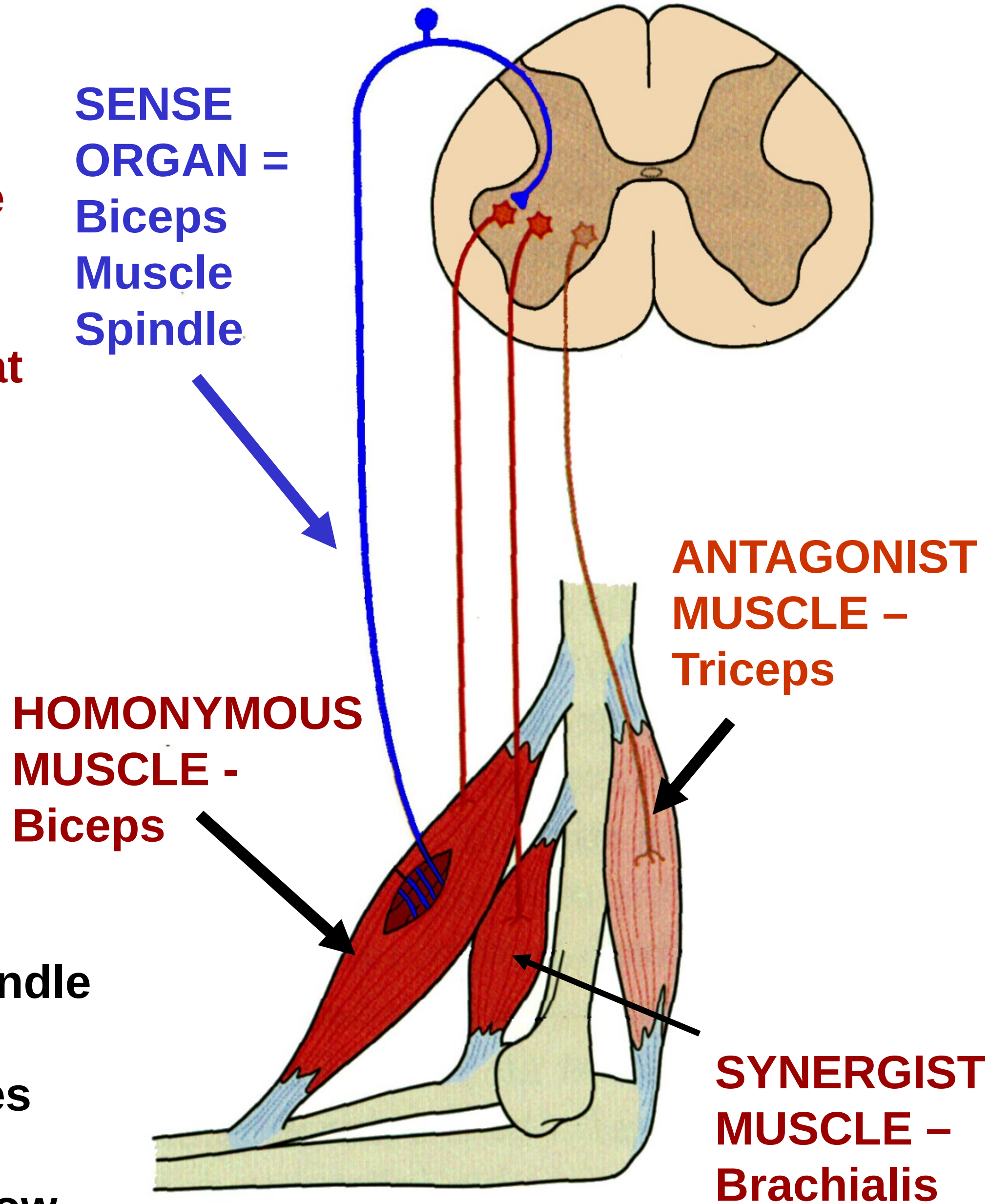
IN DESCRIBING A REFLEX:

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



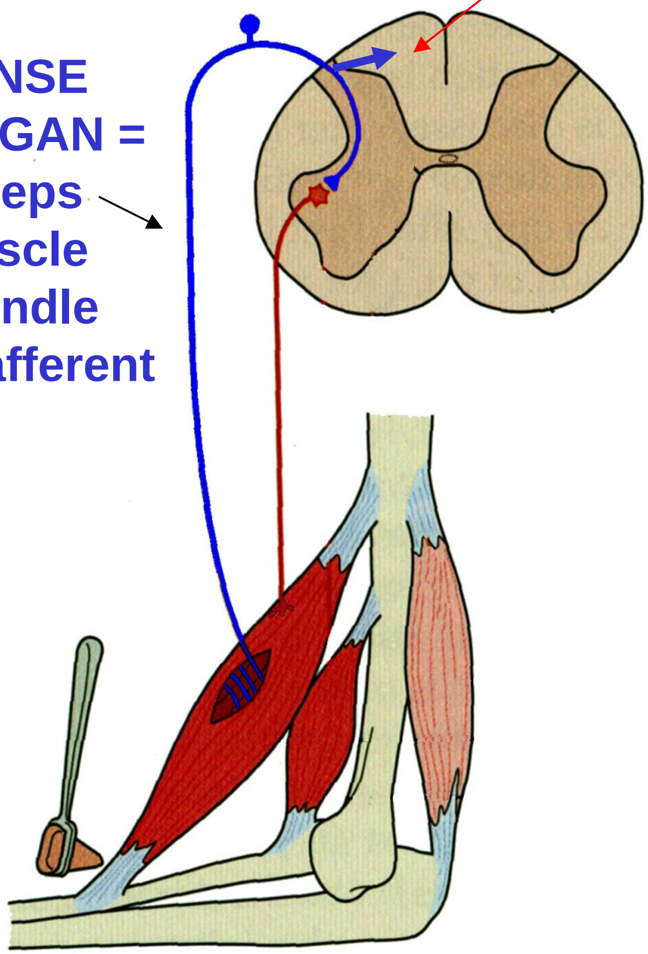
EX. BICEPS TENDON REFLEX in diagram – ELBOW JOINT
BICEPS = homonymous (where spindle is located), flexes elbow
BRACHIALIS = synergist, also flexes elbow
TRICEPS = antagonist, extends elbow

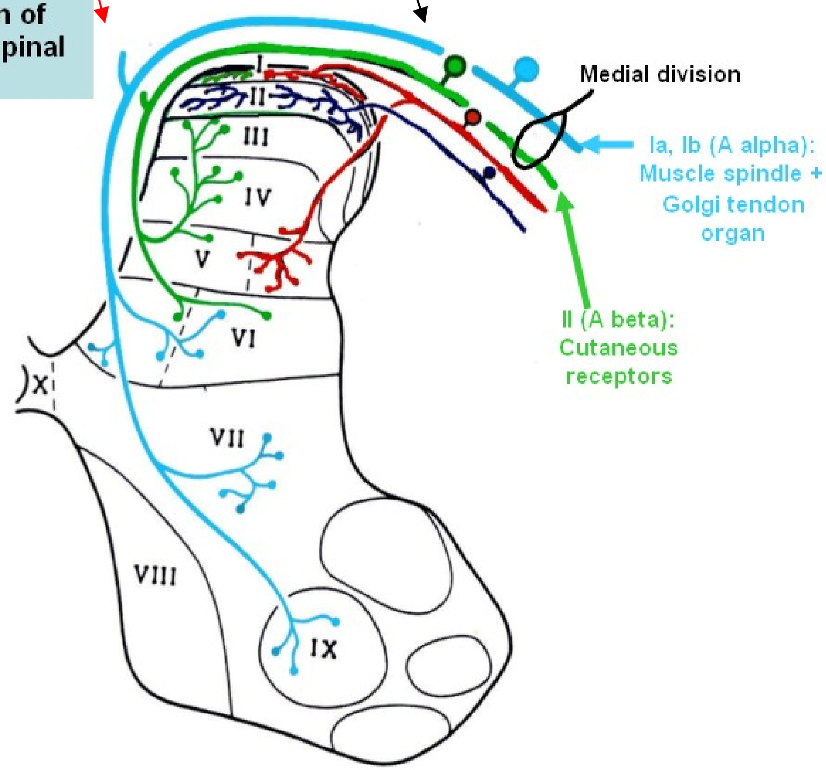
REMEMBER: SENSORY NEURONS BRANCH AND CAN PROJECT TO MANY REGIONS IN CNS

axonal branch

Ia afferent

SENSE
ORGAN =
Biceps
Muscle
Spindle
Ia afferent



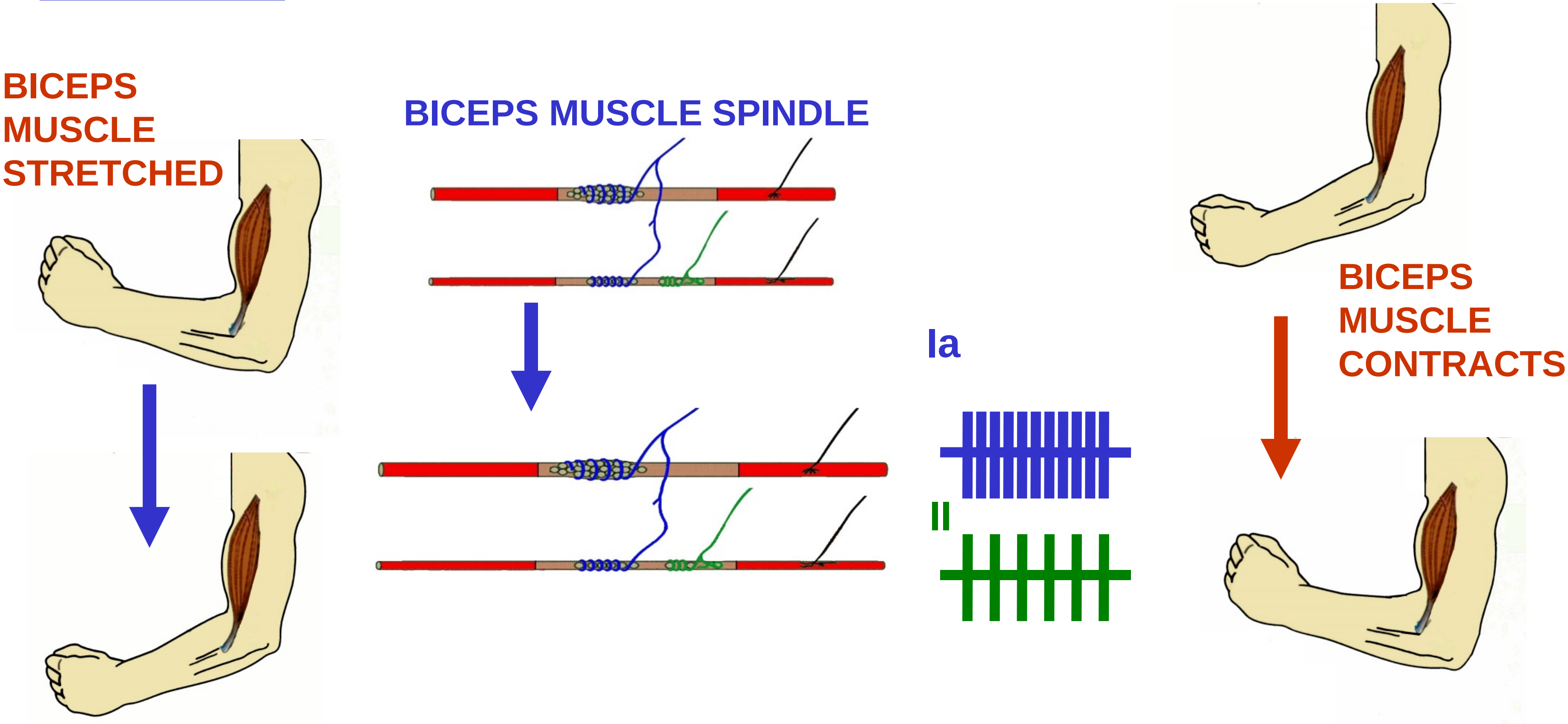


Ia afferents have **a number of axonal branches in CNS**; some branches ascend dorsal columns

STIMULUS

A. STRETCH REFLEX

RESPONSE

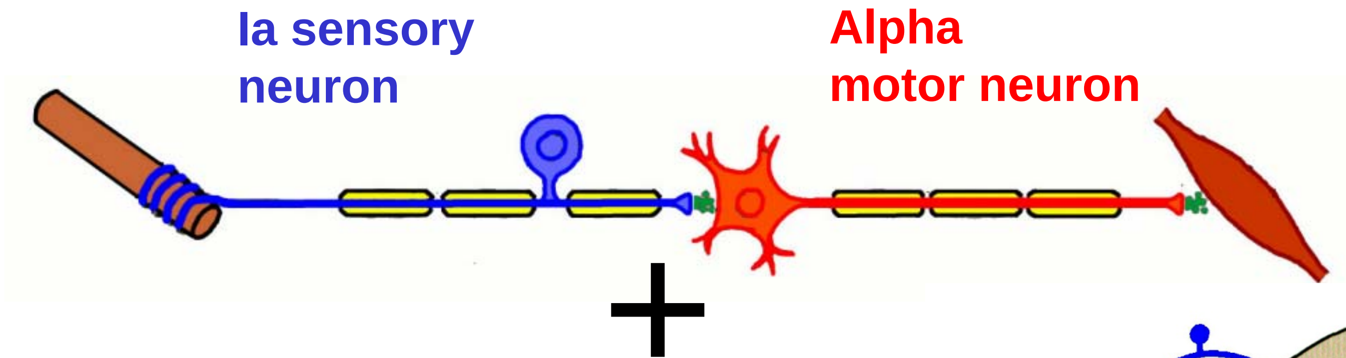


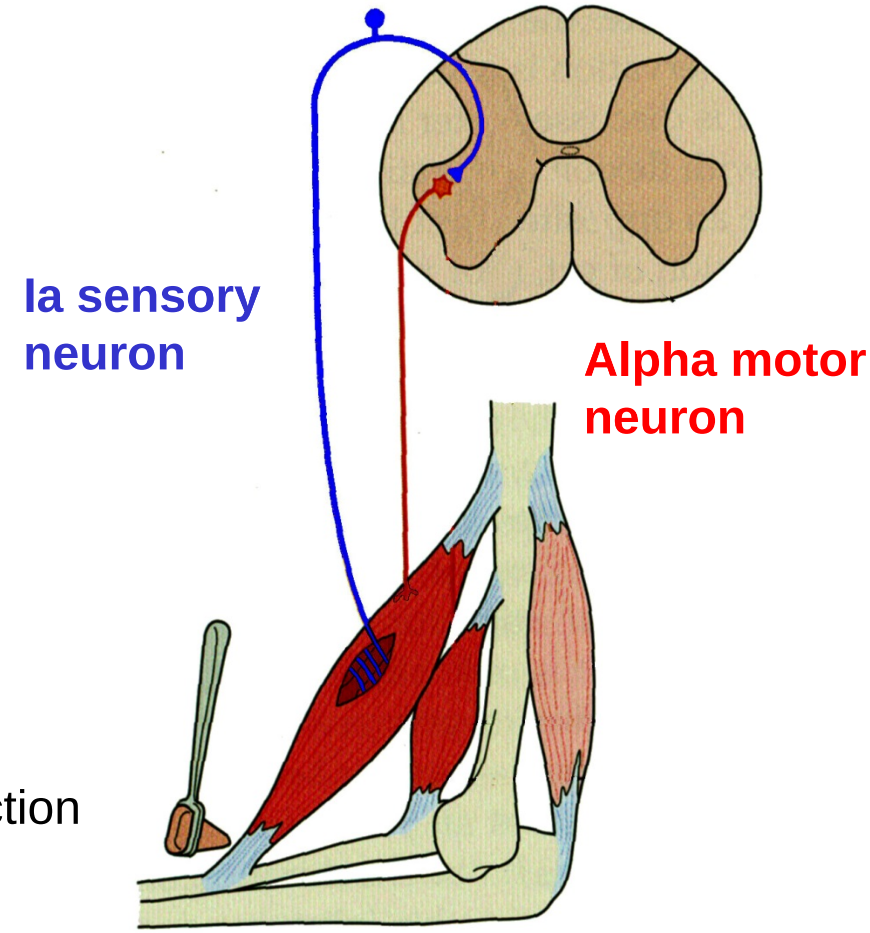
1) Stimulus - <u>fast stretch</u> of muscle

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 - <u>monosynaptic</u> connections with alpha motor neurons (fastest reflex known, delay at synapse about 1 msec)

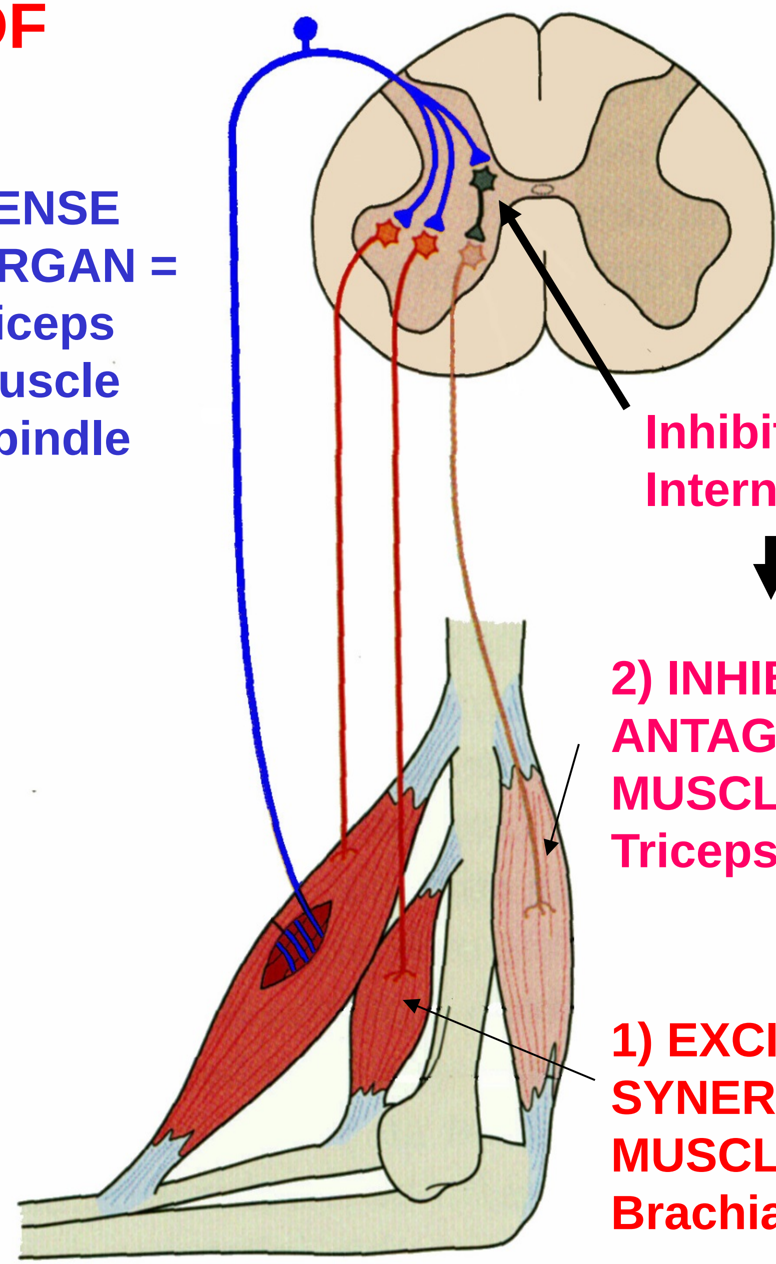
Group II - make 1) monosynaptic connections - direct to motor neuron and 2) polysynaptic connections to motor neurons (through interneuron)

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

OTHER COMPONENTS OF STRETCH REFLEX

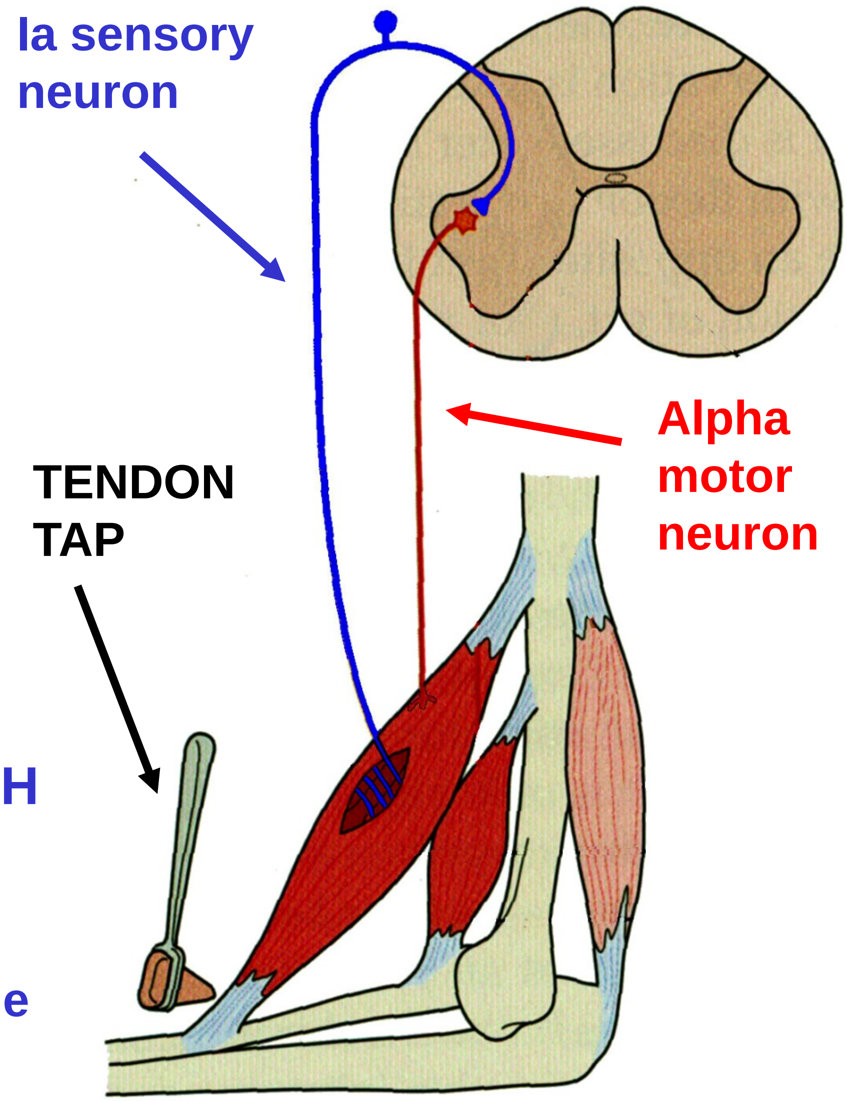
1) Excite synergist muscles - spindle afferents also make excitatory monosynaptic connections with synergist muscles

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, <u>ongoing activity in muscle spindles is important in determining firing of alpha motor neurons at rest</u>.
2- Eliminating activity of spindles can decrease motor neuron firing producing decreased tonus.
3- Increased sensory activity can increase tonus.

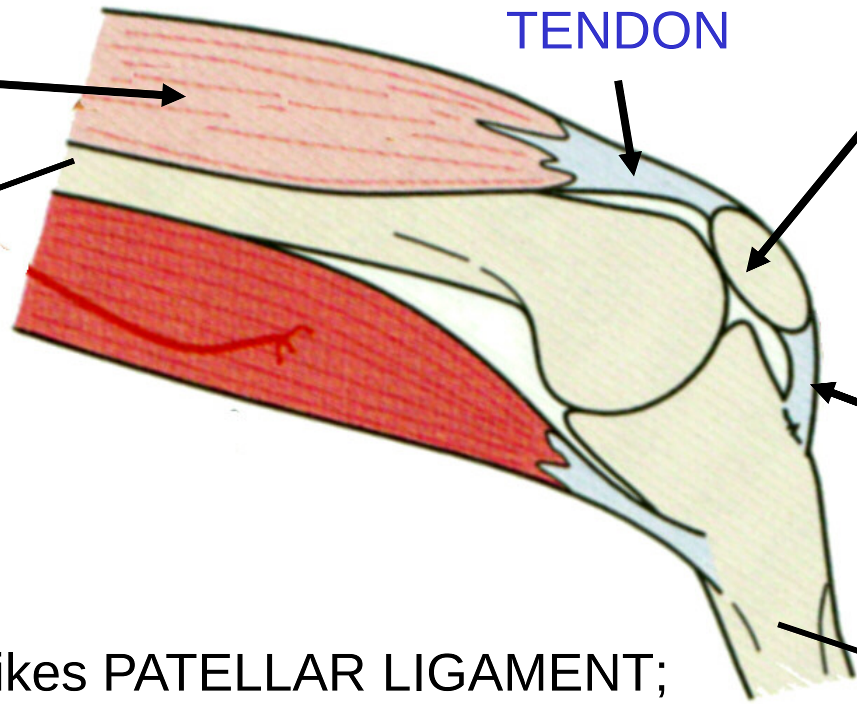


CLINICAL TESTING OF STRETCH REFLEX: TENDON TAP

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

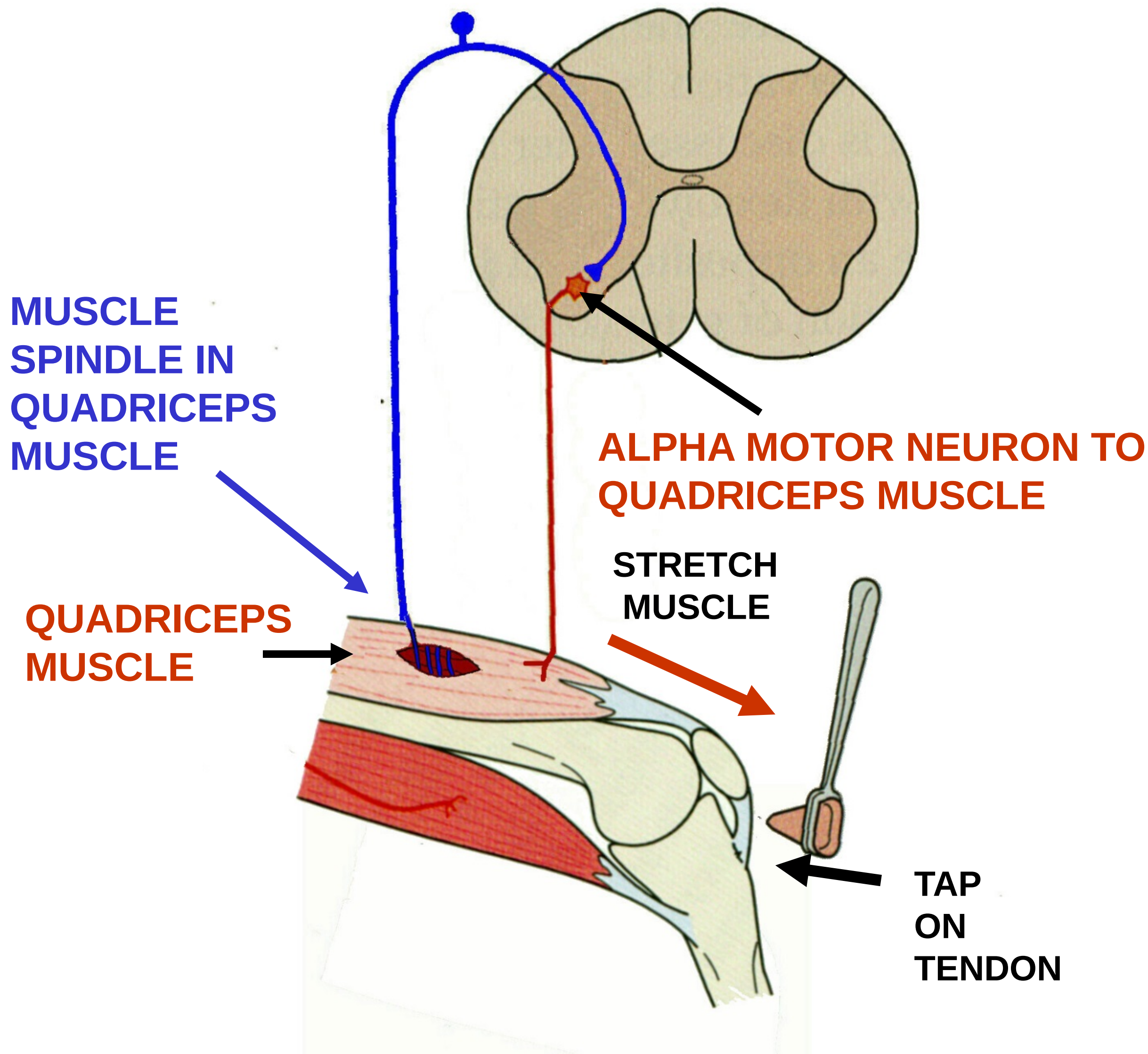
TENDON TAP TO KNEE - TAP ON PATELLAR TENDON (PATELLAR LIGAMENT)

ANATOMY OF KNEE



1) HAMMER strikes PATELLAR LIGAMENT;
2) this pulls on Patella and Quadriceps tendon and produces stretch of Quadriceps Muscle;
3) this excites muscle spindles in quadriceps muscle
4) This elicits a stretch reflex in the Quadriceps muscles which causes the knee to extend.

PATELLAR TENDON (KNEE JERK) REFLEX TESTS FOR SENSORY AND MOTOR FUNCTION OF L2,3,4



1 - QUADRICEPS MUSCLE
IS INNERVATED FROM SPINAL LEVELS LUMBAR 2, 3 AND 4 (L2,3,4 IN FEMORAL NERVE)

2- REFLEX TESTS FOR FUNCTION AT THOSE LEVELS (PREDOMINANTLY L4)

3- GET NO REFLEX IF ALL LEVELS ARE SEVERELY DAMAGED

4- IF ONE LEVEL IS DAMAGED, MAY GET REDUCED REFLEX

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

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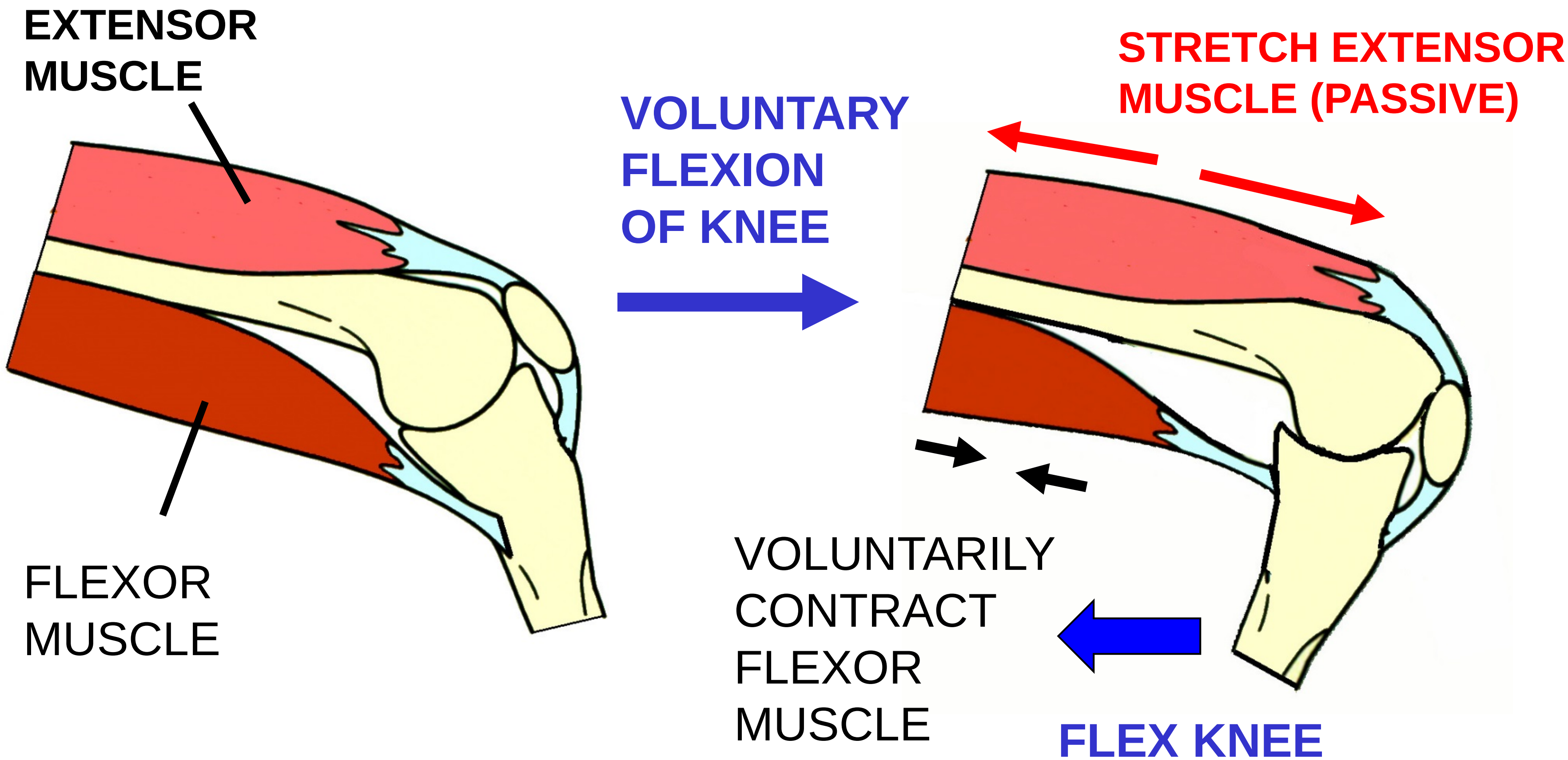
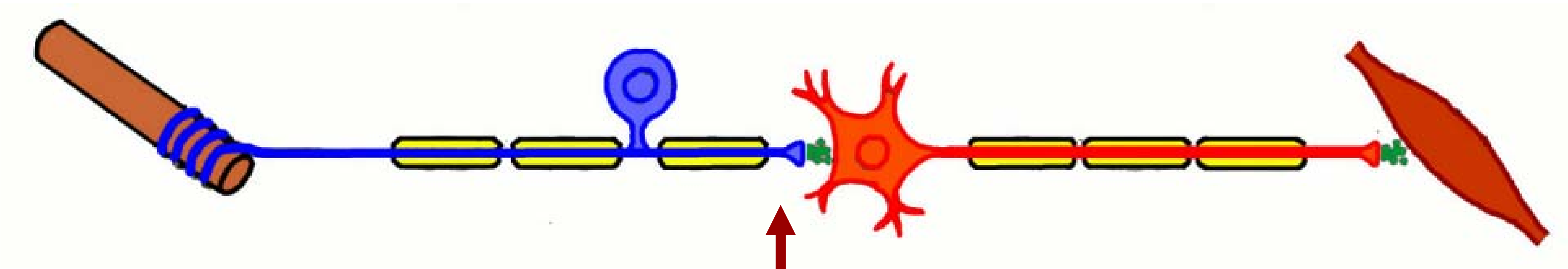
REFLEXES MUST BE MODIFIED DURING VOLUNTARY MOVEMENTS



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 must be inhibited or modified in some muscles during voluntary movements

MODIFICATION OF REFLEXES: MECHANISMS



1- Pre-synaptic inhibition

2- Change excitability of motor neuron by other excitatory or inhibitory inputs

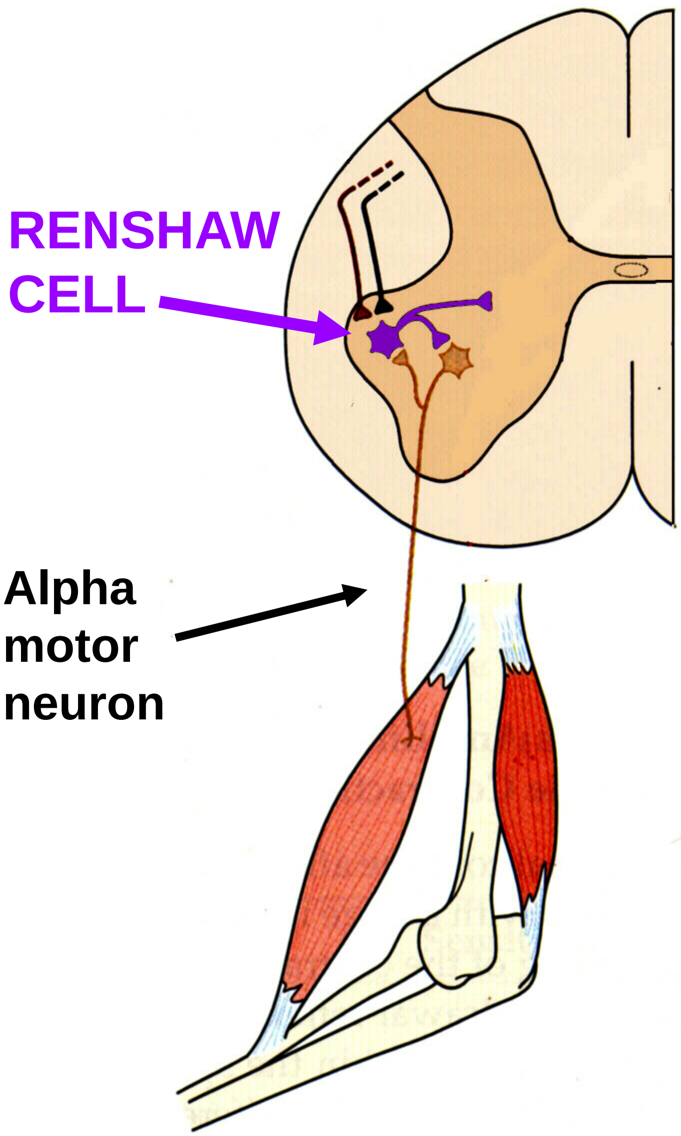
1- Reflexes can be modulated by pre-synaptic inhibition of Ia terminals; this can reduce the amount of transmitter release at the synapse upon motor neuron and dampen monosynaptic reflex

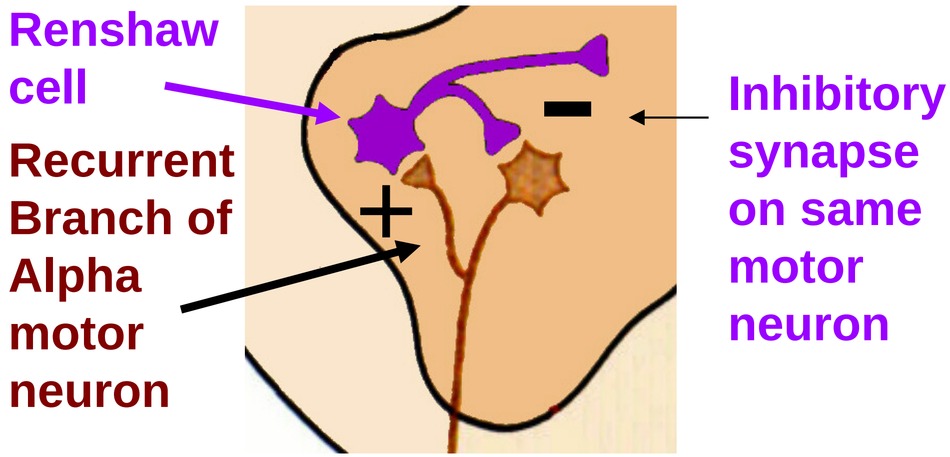
2- Activities of motor neurons can be changed by other excitatory or inhibitory inputs.

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.

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

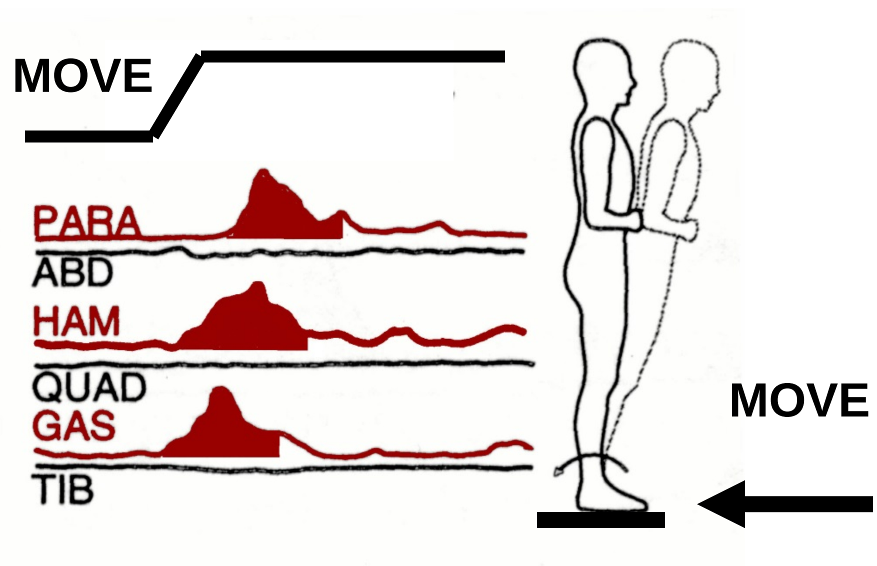
These circuits can limit motor neuron firing; inhibition can dampen or reduce reflexes

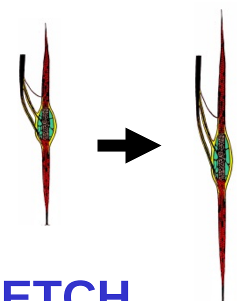
FUNCTION OF STRETCH REFLEX: MAINTAINING BALANCE WHEN STANDING

1) tilting forward stretches muscles on back of leg

2) muscles rapidly contract

TEST: STAND ON MOVING PLATFORM



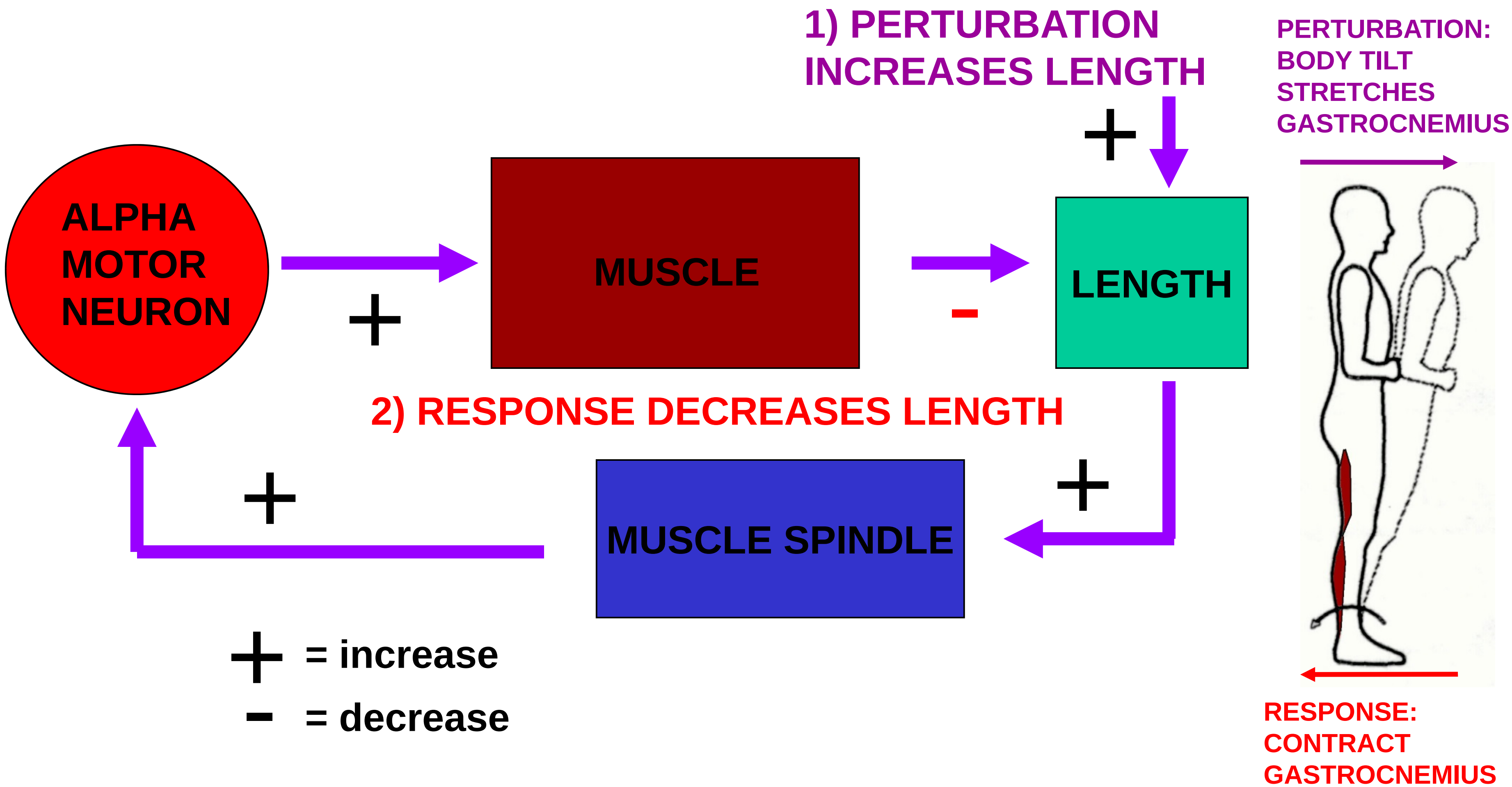


STRETCH MUSCLE SPINDLES

Gastrocnemius excited first (consistent with monosynaptic reflex)

However, responses
1) are longer in duration than stretch reflex
2) activate muscles not just in limbs, ex. extensor muscles of back
3) influenced by other sensory inputs (change when wearing a back pack)

MUSCLE SPINDLE FORMS NEGATIVE FEEDBACK LOOP

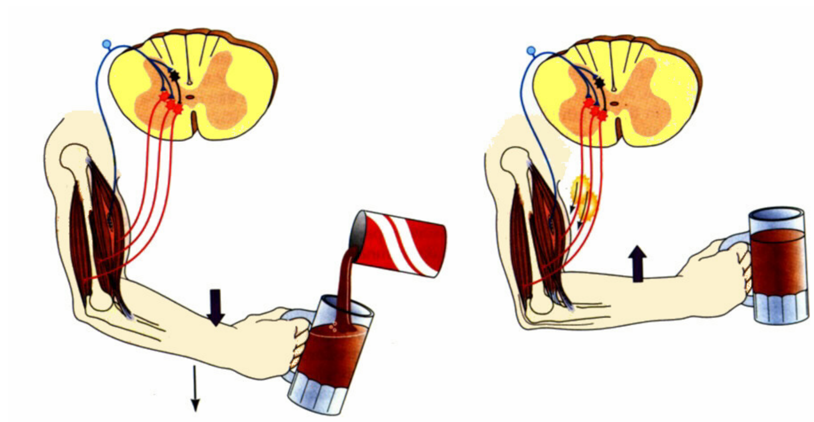


Why called <u>NEGATIVE feedback</u>? 1) Perturbation produces <u>INCREASE in length (stretch)</u> which excites spindle, which 2) excites motor neuron, which <u>excites muscle</u> which <u>DECREASES length</u>.

LOAD COMPENSATION IN OTHER TASKS

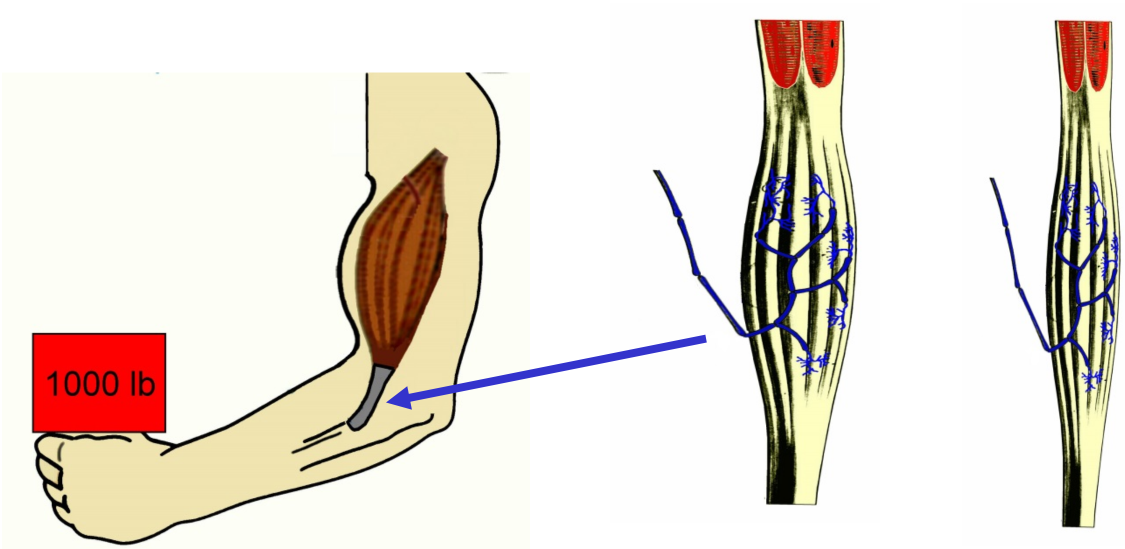
POURING FLUID IN GLASS STRETCHES BICEPS

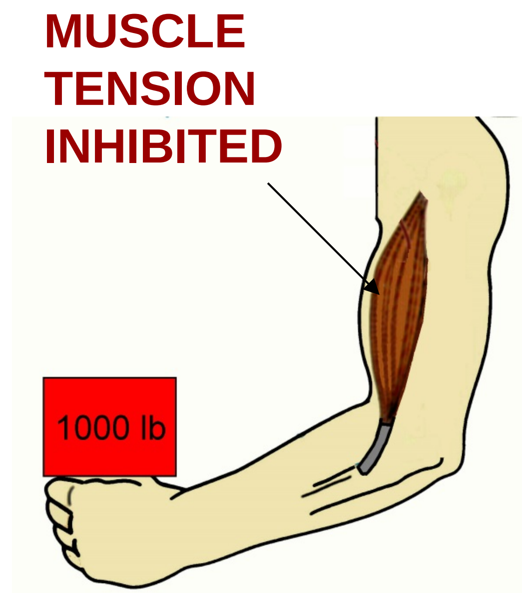
STRETCH REFLEX CAUSES BICEPS CONTRACTION



When stretch reflexes are active, unexpected perturbations that lead to stretch of any skeletal muscle will cause muscle to contract. Example from text: pouring fluid into glass increases weight, stretches biceps muscle.

B. AUTOGENIC INHIBITION



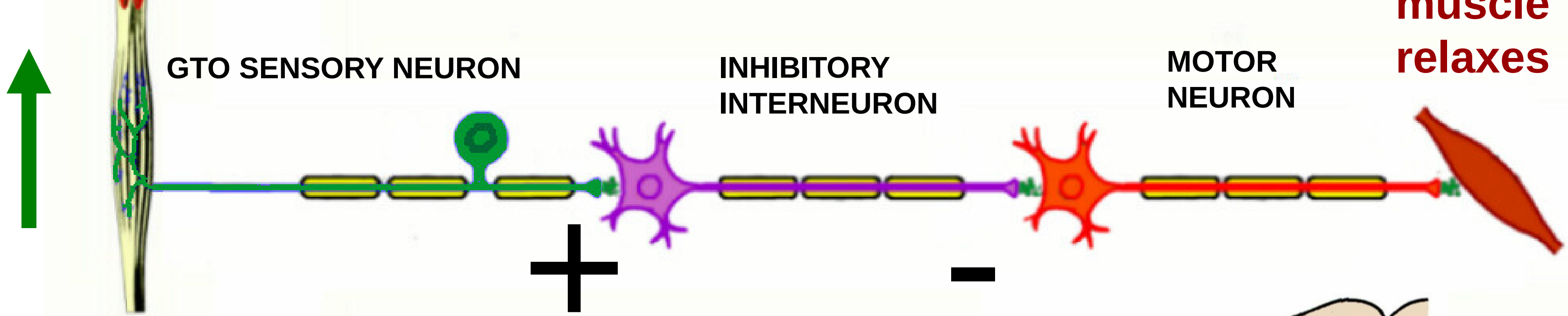


1) Stimulus -
<u>Large force</u>
exerted on
muscle tendon

2) Sense organ
excited -
Golgi tendon
organs

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

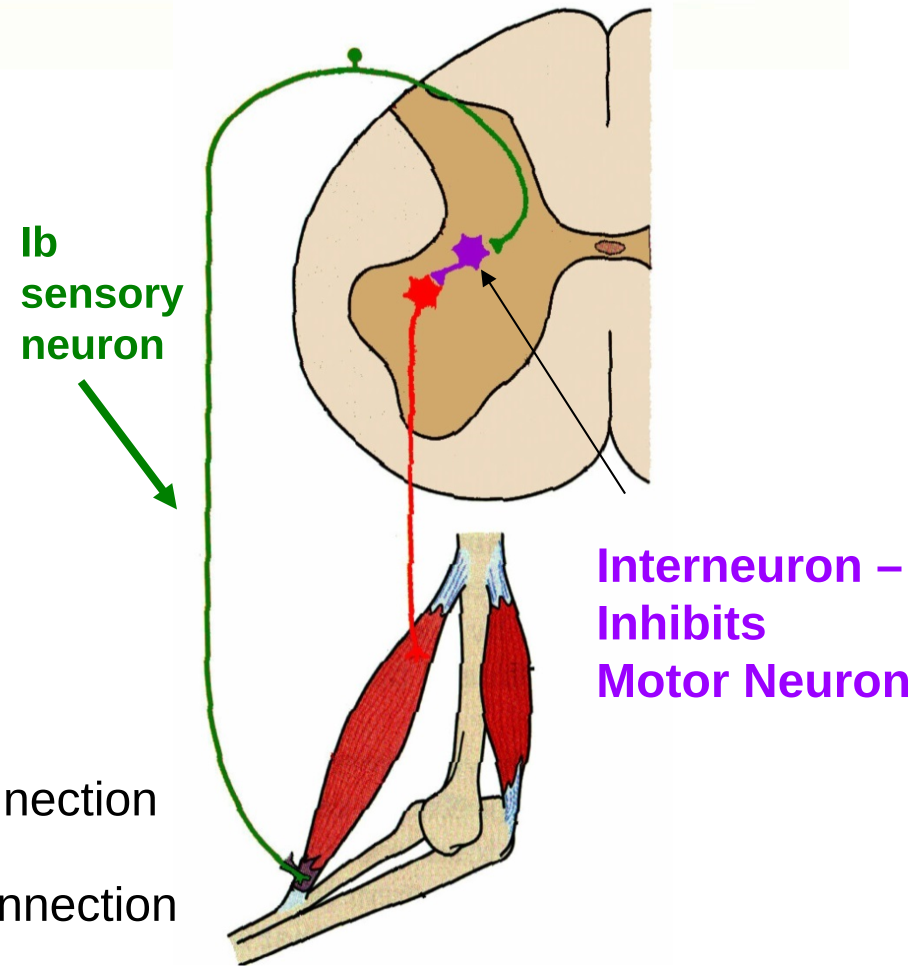
AUTOGENIC INHIBITION



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



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

- note: **minus** indicates **inhibitory** connection

AUTOGENIC INHIBITION

Other effects

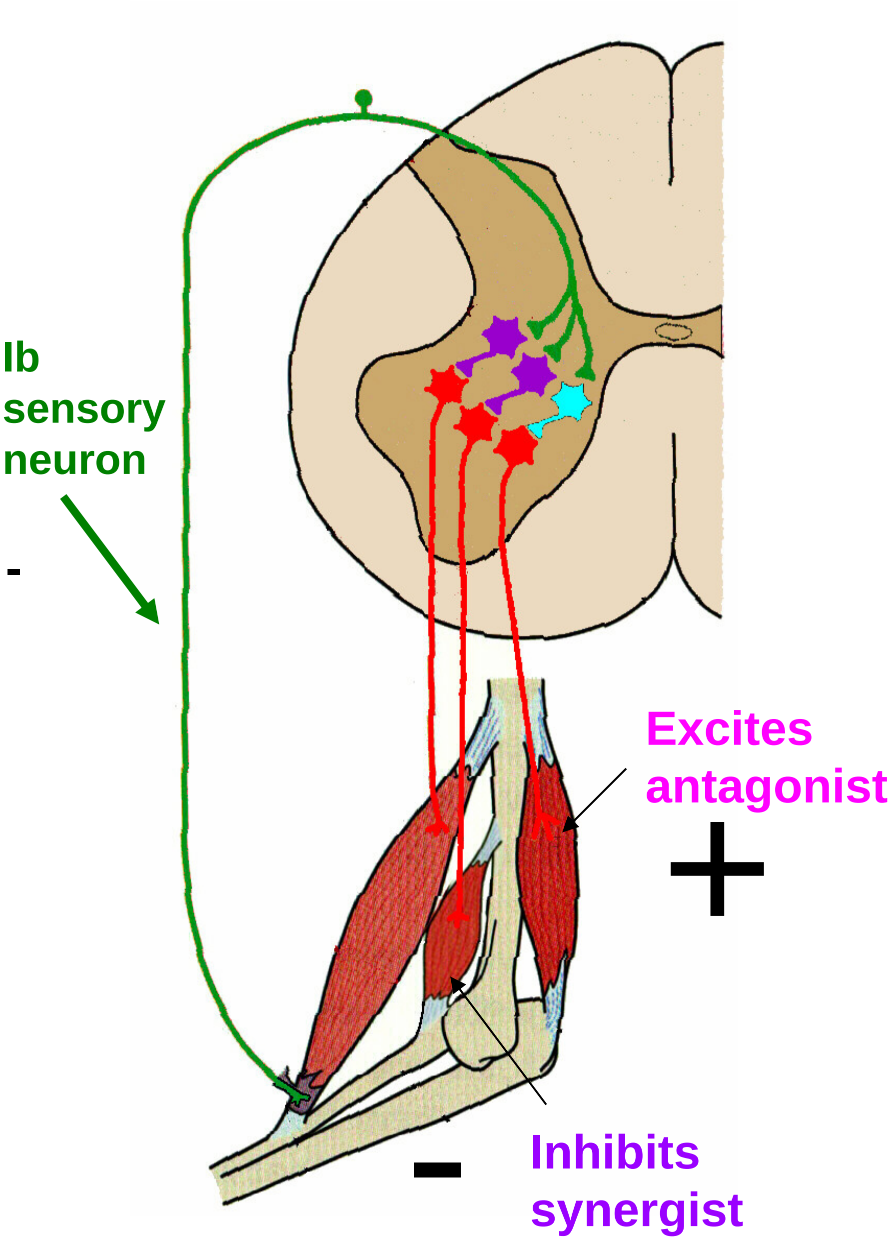
a. Inhibits synergist muscles -

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

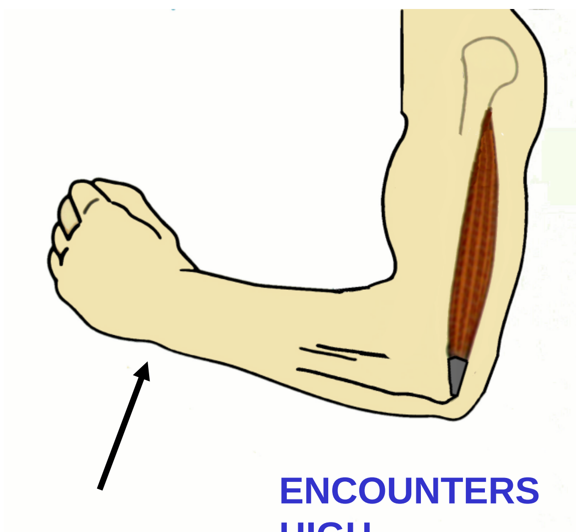
CLASPED KNIFE REFLEX: in Upper motor neuron lesions, tonus increases, resistance to stretch increases; if sufficient force is applied, limb resistance suddenly decreases (like pocket knife snapping shut)



CLASPED KNIFE REFLEX: is an example of Autogenic inhibition.

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

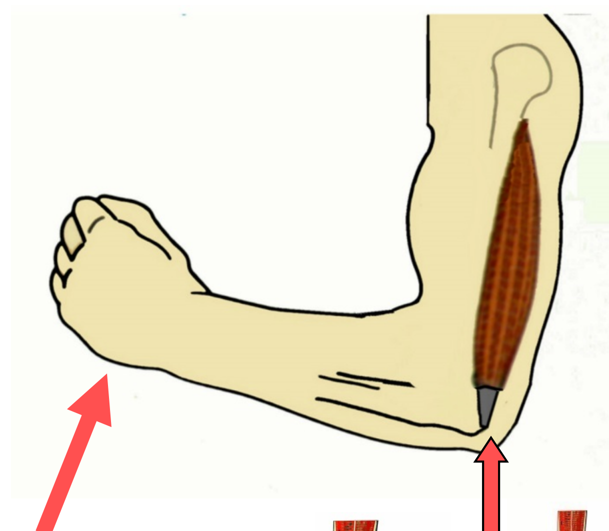
1) PHYSICIAN TRIES TO FLEX ELBOW JOINT OF PATIENT WITH UPPER MOTOR NEURON LESION

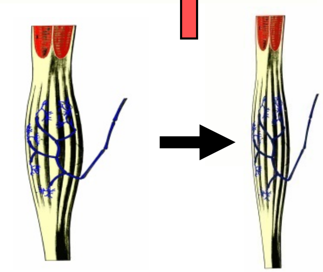


PHYSICIAN HOLDS WRIST AND PUSHES HERE AFTER TELLING PATIENT TO RELAX

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

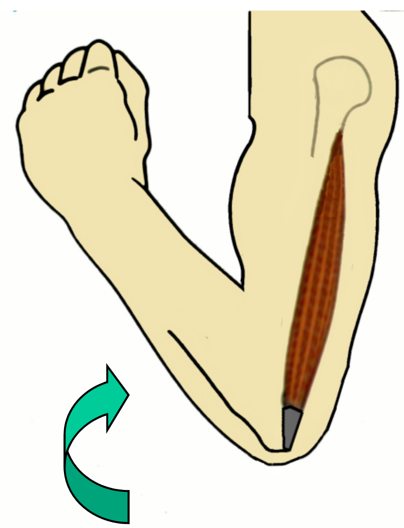
2) KEEP TRYING AND TENSION ON TRICEPS TENDON EXCITES GOLGI TENDON ORGANS





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

AUTOGENIC INHIBITION AND FORCE REGULATION

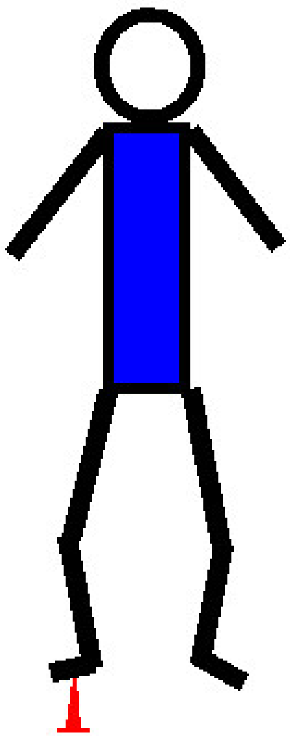
1- Regulating muscle tension - forces developed by contractions of muscles are automatically controlled so that they do not cause damage to tendons (ex. lifting heavy object).

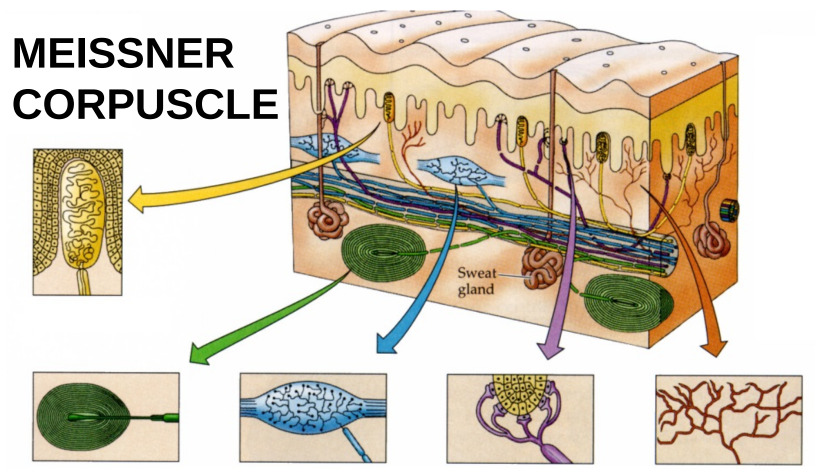
2- Regulation of force during other behavior is more complex (ex. walking) –

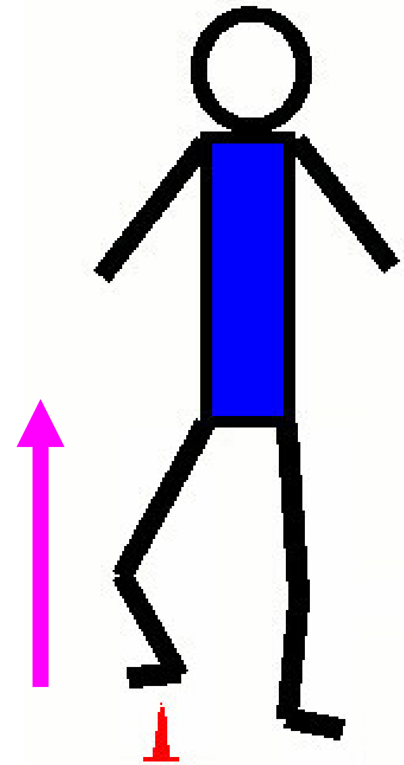
Connections for autogenic inhibition may be inactivated during walking

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

C. FLEXOR REFLEX





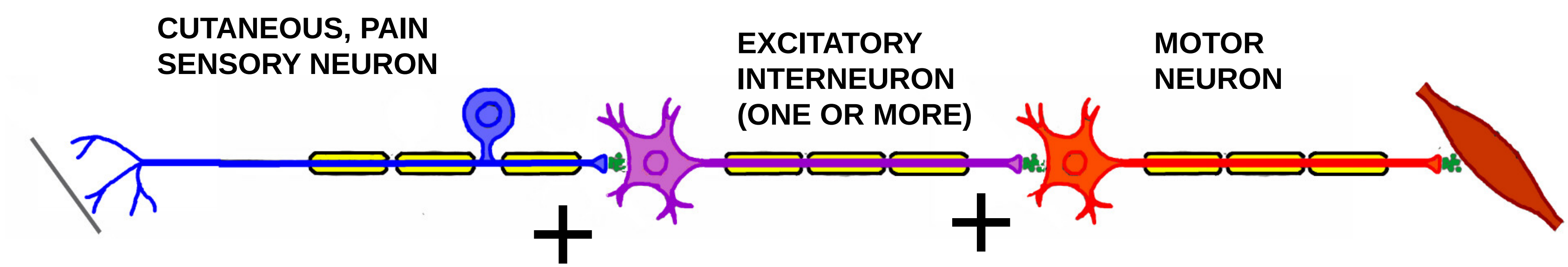


1) Stimulus - painful or noxious stimulus (stepping on nail)

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

3) Primary response - Protective withdrawal of limb

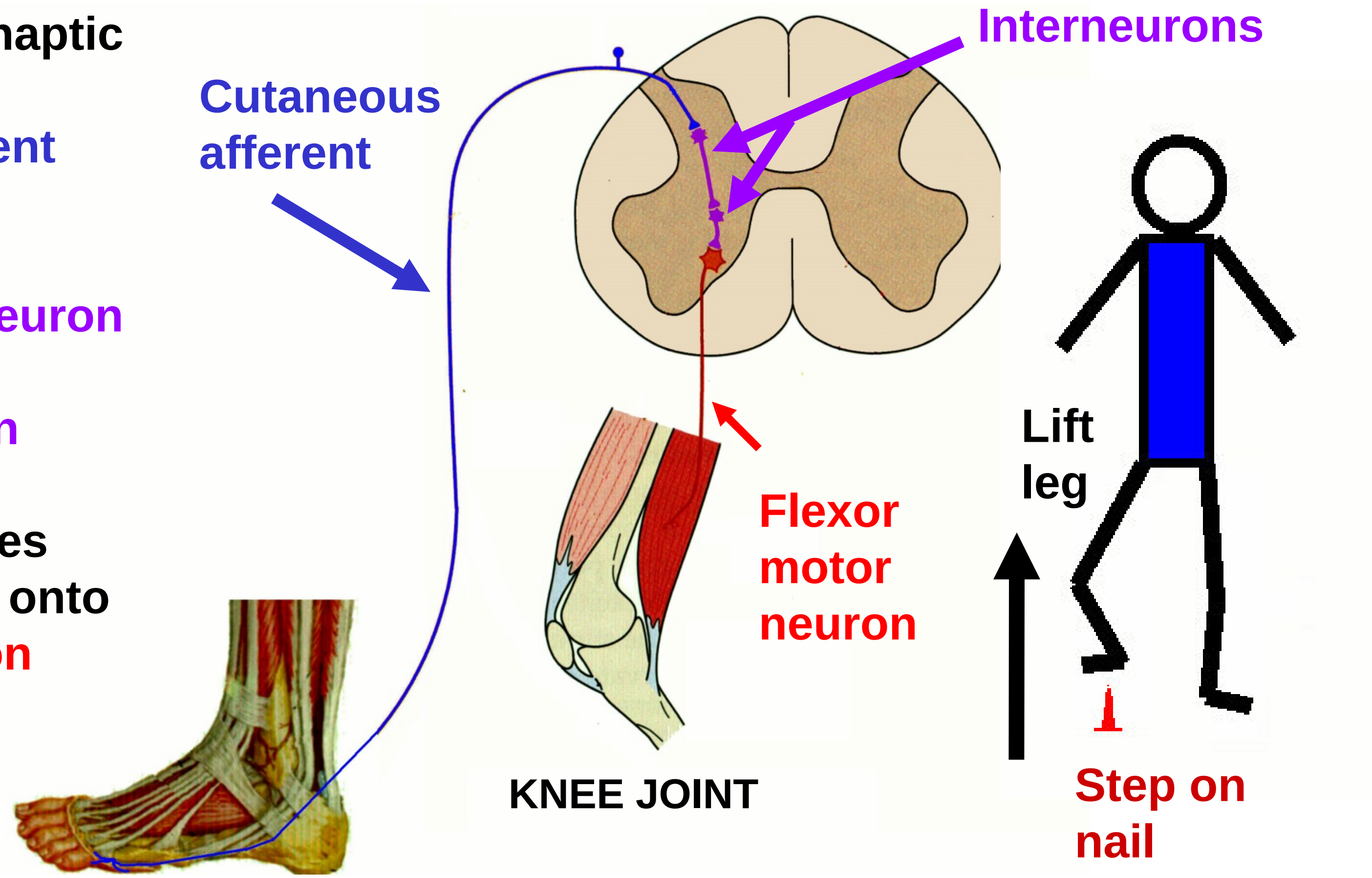
FLEXOR REFLEX: PATHWAYS



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

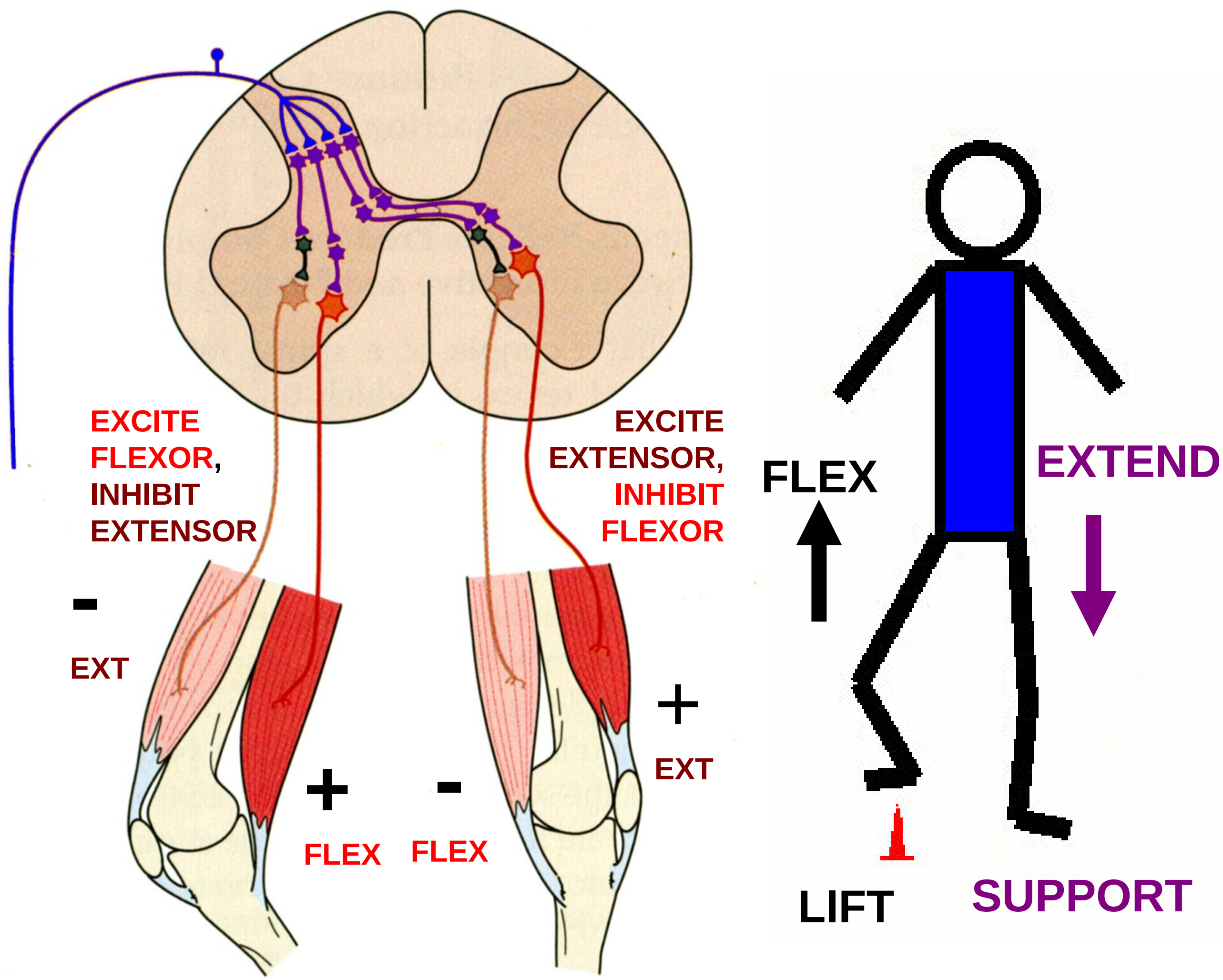


FLEXOR REFLEX: OTHER EFFECTS
ALL ARE POLYSYNAPTIC BY INTERNEURONS

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

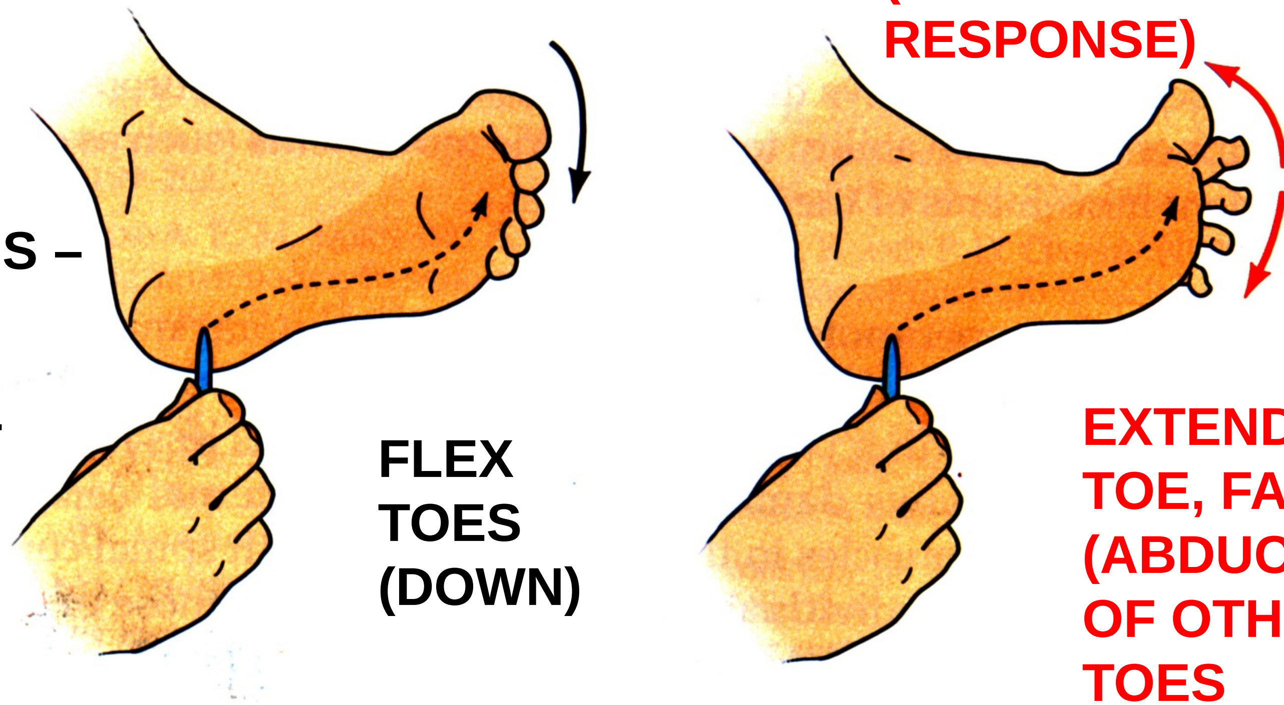
2) Inhibit antagonist muscles - inhibit Extensors in same leg

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



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]**

'FLEXOR' REFLEXES USED FOR CLINICAL TESTS

TABLE OF COMMON REFLEXES AND SPINAL LEVELS TESTED

Stretch Reflex Muscles Tested	Spinal Levels Tested
Biceps	C5,**6**
Triceps	C6,**7**
Intrinsic hand muscles (ex. interossei)	C7,**8**
Quadriceps (Knee Jerk or Patellar reflex)	L3,**4**
Gastrocnemius, Soleus (Ankle Jerk or Achilles tendon reflex)	S**1**,2

Other Reflexes	Test	Clinical Sign
Babinski Reflex	Stroke sole of foot	Normal: Flexion (Plantar flexion) of big toe UMN damage: Extension (Dorsiflexion) of big toe
Hoffmann Reflex	Tap distal phalanx of third or fourth finger	UMN damage: Flex fingers
Glabellar Reflex	Tap forehead	Normal: close eyes, extinguishes (stops) with repetition; Abnormal: persists on repetition

In general: flexor reflex tests use stimulation of cutaneous receptors; changes in reflexes can indicate Upper motor neuron lesions

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

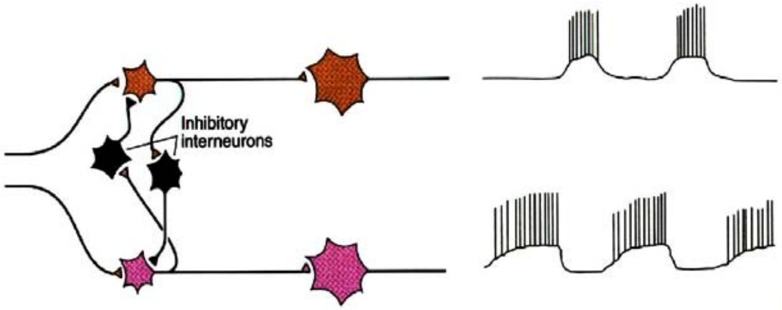
PLACING REFLEX

TONIC NECK REFLEX - extend ipsilateral arm, flex opposite arm

III. 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, next block



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')

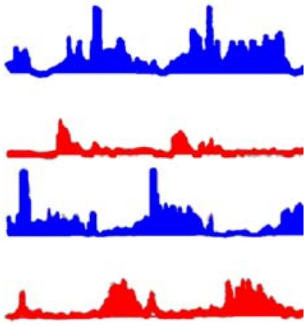
TREADMILL WALKING WITH WEIGHT SUPPORTED

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 REFLEXES

REFLEX	STIMULUS (CLINICAL TEST)	RESPONSE	SENSORY RECEPTOR	SYNAPSES	EFFECT ON MUSCLE	OTHER EFFECTS	FUNCTION
Stretch (Myotatic) Reflex	Rapid Stretch of muscle (test: tap on muscle tendon)	Stretched muscle contracts rapidly (ex. knee jerk)	Muscle Spindle Primary (Ia) and Secondary (II) sensory neurons	Ia: Mono-synaptic II: Monosynaptic (weak) and Polysynaptic	Excite Homon-ymous (same) muscle	Also Excite synergist and Inhibit antagonist muscles (Reciprocal Inhibition)	Aid in maintaining posture, counter sudden loads
Autogenic Inhibition (Inverse Myotatic Reflex)	Large force on tendon (pull on muscle when resisted)	Muscle tension decreases (Clasped knife reflex)	Golgi Tendon Organ (Ib)	Poly-synaptic (via interneuron)	Inhibit Homon-ymous (same) muscle	Also Inhibit synergist muscles; Excite antagonist muscles	Protective, prevent damage to tendon
Flexor Reflex	Sharp, painful stimulus (as in stepping on nail)	Limb is rapidly withdrawn from stimulus	Cutaneous (skin) and pain receptors	Poly-synaptic (via interneuron)	Excite Flexor muscle	Also Inhibit extensors of same limb; Excite extensors and Inhibit flexors of opposite limb (Crossed Extensor Reflex)	Protective, withdraw from painful stimulus; Cross extension supports posture when leg is lifted

Spinal reflexes are important tools; behaviors are more complex and can incorporate, change and adapt reflex connections

SUMMARY OF CLINICAL REFLEXES

TABLE OF COMMON REFLEXES AND SPINAL LEVELS TESTED

Stretch Reflex Muscles Tested	Spinal Levels Tested
Biceps	C5,**6**
Triceps	C6,**7**
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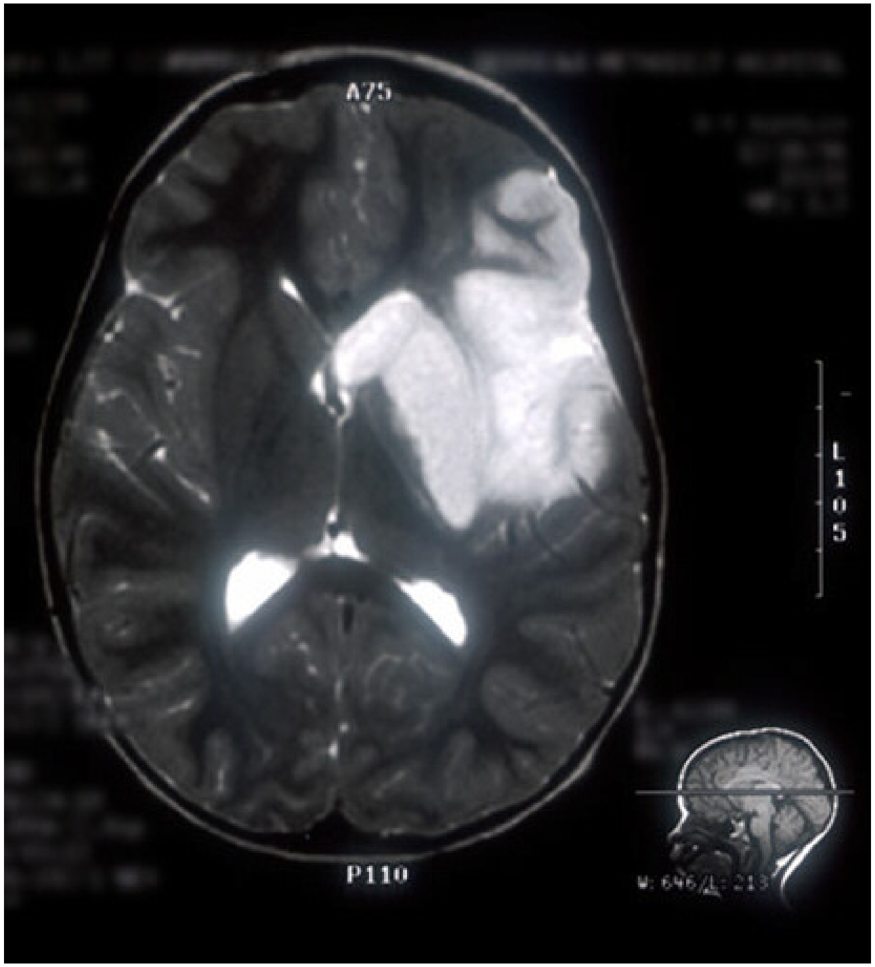
Hoffmann Reflex	Tap distal phalanx of third or fourth finger	UMN damage: Flex fingers
Glabellar Reflex	Tap forehead	Normal: close eyes, extinguishes (stops) with repetition; Abnormal: persists on repetition

PATIENT WITH HYPER-REFLEXIA AND (POSITIVE) BABINSKI

Case No. 02 Girl with Sudden Weakness

http://library.med.utah.edu/neurologicexam/cases/html_case02/case02_history.html



MRI - vascular lesion affects front cortex and internal capsule

Patient had the acute onset of right sided weakness and inability to speak most consistent with a vascular event or a stroke.

Symptoms -

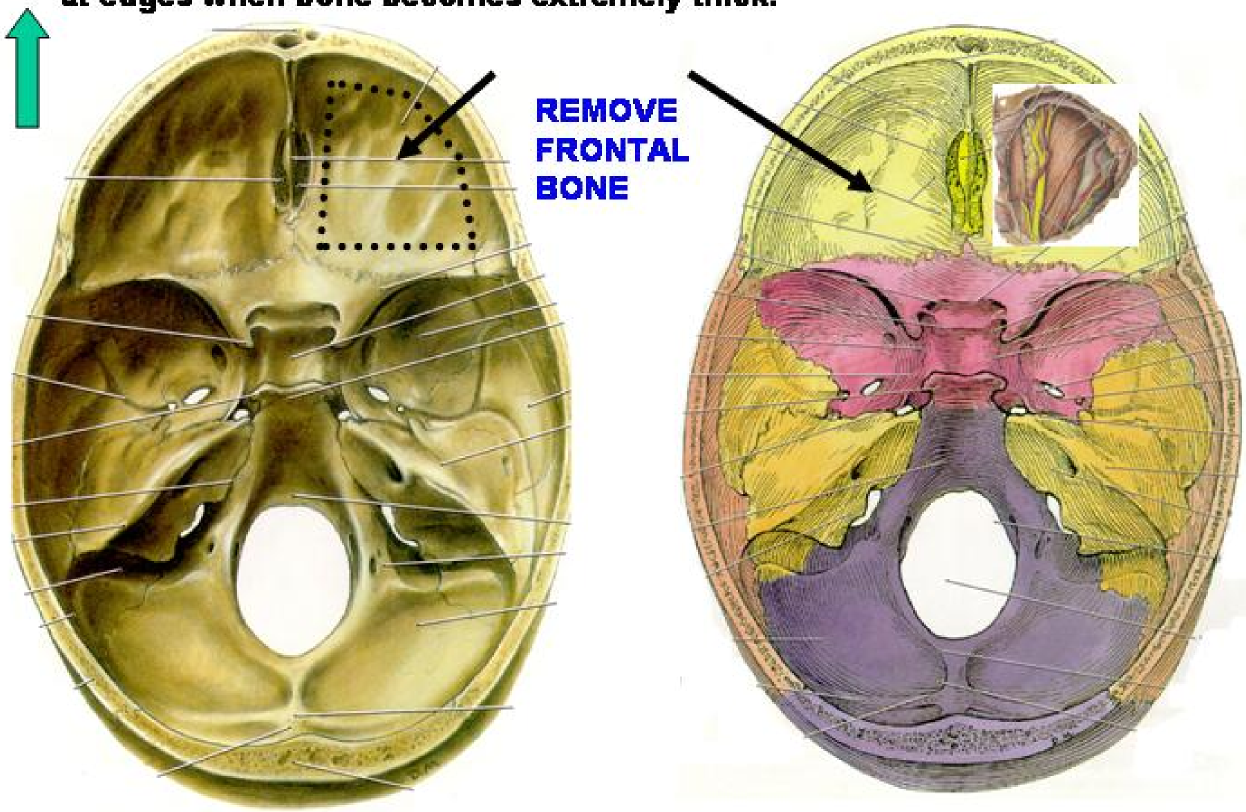
1) Hyper-reflexia upper and lower extremities
2) Expressive aphasia - problems with expressive language. She could understand what was said to her but she couldn't say anything, Frontal cortex Broca's are
3) (Positive) Babinski sign

DIAGNOSIS - Right hemiparesis caused by an upper motor lesion

ORBIT DISSECTION INSTRUCTIONS 2016

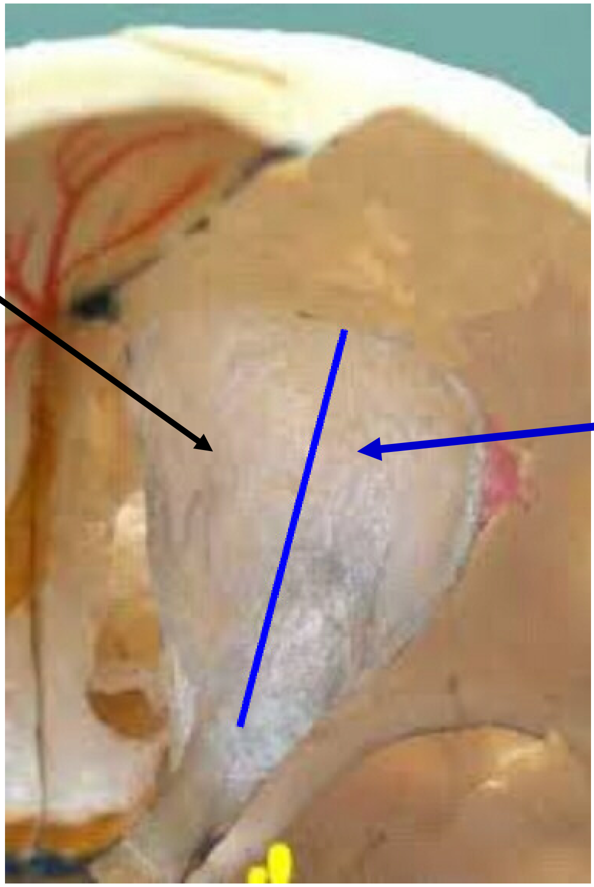
1- <u>REMOVE BONE OF ROOF OF ORBIT</u> - Gently hit bone of orbit with chisel (propelled by hammer) until it cracks. Then use cutters (wire cutters) to piece out frontal bone. Stop at edges when bone becomes extremely thick.

1. <u>REMOVE BONE OF ROOF ORBIT</u> - Gently hit bone of orbit until it cracks. Then use cutters (wire cutters) to piece out frontal bone. Stop at edges when bone becomes extremely thick.



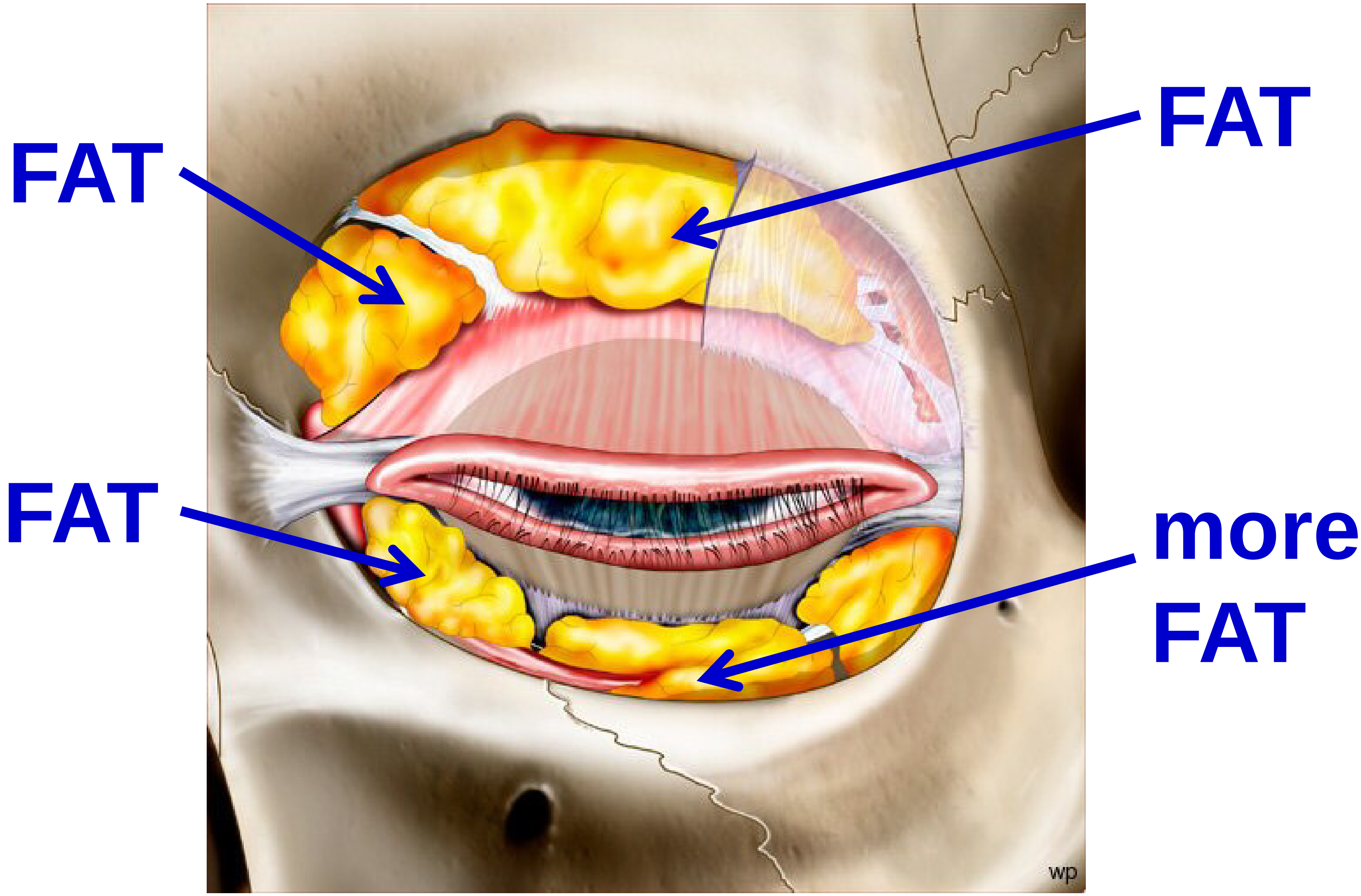
2- <u>REMOVE PERIOSTEUM LINING ORBIT (PERIORBITA)</u> – Incise white connective tissue layer in midline and cut away from underlying structures. Should now see muscles and nerves surrounded by fat.

PERIORBITA



Carefully cut through CT layer with scalpel

ORBIT IS FULL OF FAT



3- SUPERFICIAL DISSECTION: REMOVE FAT WITH FORCEPS - Gently pull on globules of fat and remove them from surrounding tissues. This requires patience to preserve small nerves and arteries that course in the fat. When fat is removed, use scissors technique to separate nerves and arteries. Remove arteries and veins. Identify structures in Superficial Orbit.

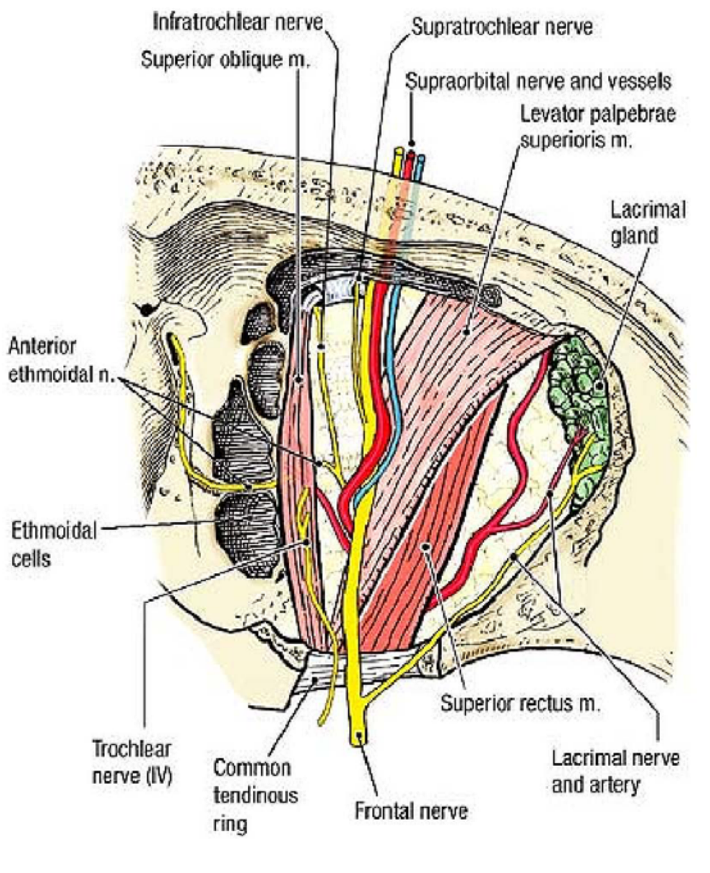


Figure 7.57. Right orbit in superior view.

Superficial Dissection

Levator Palpebrae Superioris muscle
Frontal nerve (V1) dividing to Supraorbital and Supratrochlear nerves
Superior oblique muscle
Trochlear nerve – enters proximal end of Superior Oblique
Lacrimal gland
Lacrimal nerve (V1)
Anterior Ethmoidal nerve (courses under Superior Oblique)

D- DEEP DISSECTION CUT AND REFLECT LEVATOR PALPEBRAE SUPERIOR AND SUPERIOR RECTUS MUSCLES - Cut across both muscles and reflect them anteriorly (not posteriorly as in illustration). Then very carefully remove underlying fat to expose structures of Deep Orbit. Look for Long and Short Ciliary nerves piercing sclera on posterior eye (medial to Optic Nerve). It will now be useful to remove Lesser Wing of Sphenoid bone (overlying structures entering Superior Orbital Fissure).

Optic Nerve
Nasociliary nerve (giving off Anterior and Posterior Ethmoidal nerves)
(Long Ciliary nerves – with luck)
Short Ciliary nerves – immediately dorsal and lateral to Optic nerve
Ciliary ganglion – swelling on Short Ciliary nerves
Trochlea (pulley) of Superior Oblique muscle
Medial Rectus Muscle
Lateral Rectus Muscle
(Abducens nerve – medial to Lateral Rectus

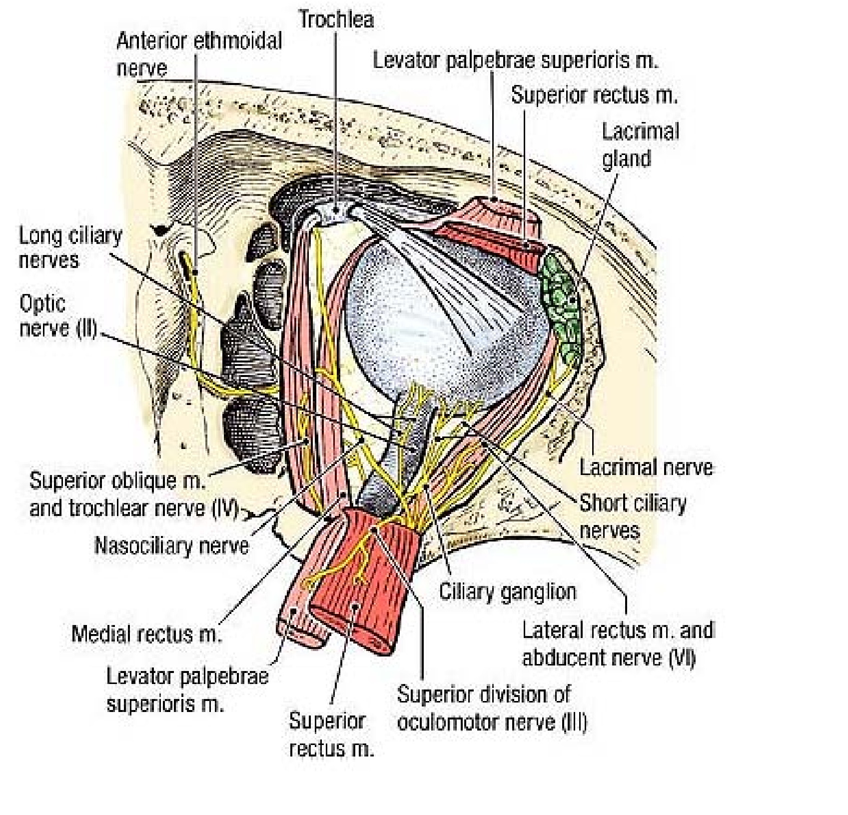


Figure 7.58. Deeper dissection of right orbit in superior view.

STRUCTURES TO IDENTIFY IN ORBIT

Superficial Dissection

Levator Palpebrae Superioris muscle
Frontal nerve (V1) dividing to Supraorbital and Supratrochlear nerves
Superior oblique muscle
Trochlear nerve – enters proximal end of Superior Oblique
Lacrimal gland
Lacrimal nerve (V1)
Anterior Ethmoidal nerve (courses under Superior Oblique)

Deep Dissection

Optic Nerve
Nasociliary nerve (giving off Anterior and Posterior Ethmoidal nerves)
(Long Ciliary nerves – with luck)
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Ciliary ganglion – swelling on Short Ciliary nerves
Trochlea (pulley) of Superior Oblique muscle
Medial Rectus Muscle
Lateral Rectus Muscle
(Abducens nerve – medial to Lateral Rectus

ORBIT DISSECTION CHECKLIST 2016

Superficial Dissection

___ Levator Palpebrae Superioris muscle
___ Frontal nerve (V1) dividing to Supraorbital and Supratrochlear nerves
___ Superior oblique muscle
___ Trochlear nerve – enters proximal end of Superior Oblique
___ Lacrimal gland
___ Lacrimal nerve (V1)
___ Anterior Ethmoidal nerve (courses under Superior Oblique)

Deep Dissection

___ Optic Nerve
___ Nasociliary nerve (giving off Anterior and Posterior Ethmoidal nerves)
___ (Long Ciliary nerves – with luck)
___ Short Ciliary nerves – immediately dorsal and lateral to Optic nerve
___ Ciliary ganglion – swelling on Short Ciliary nerves
___ Trochlea (pulley) of Superior Oblique muscle
___ Medial Rectus Muscle
___ Lateral Rectus Muscle
___ (Abducens nerve – medial to Lateral Rectus)

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.

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.

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; 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.

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

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

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

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

C. Muscles

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

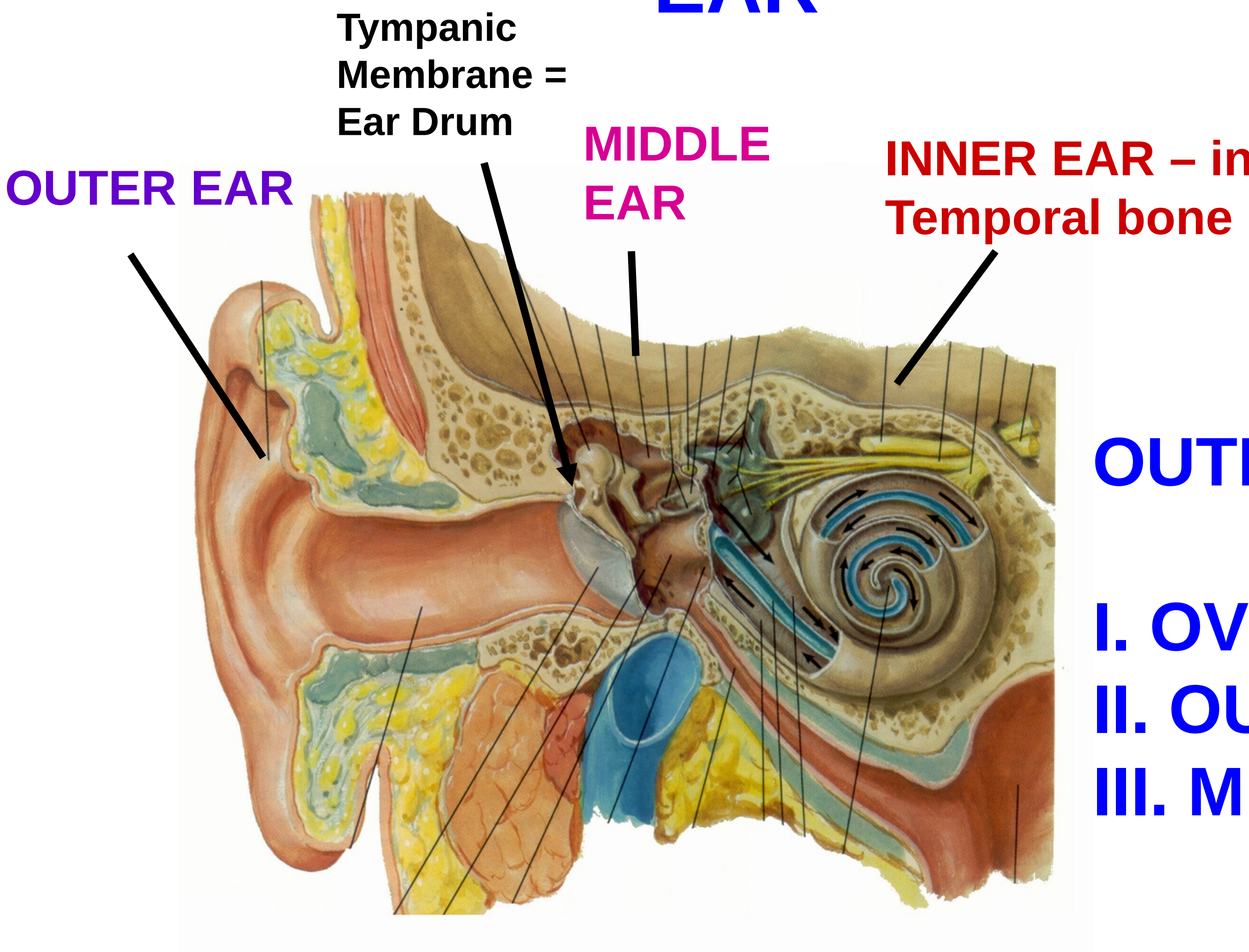
2. **Stapedius muscle** - origin - posterior wall (landmark is pyramid); insertion - neck of stapes; innervation - VII

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

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

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

EAR



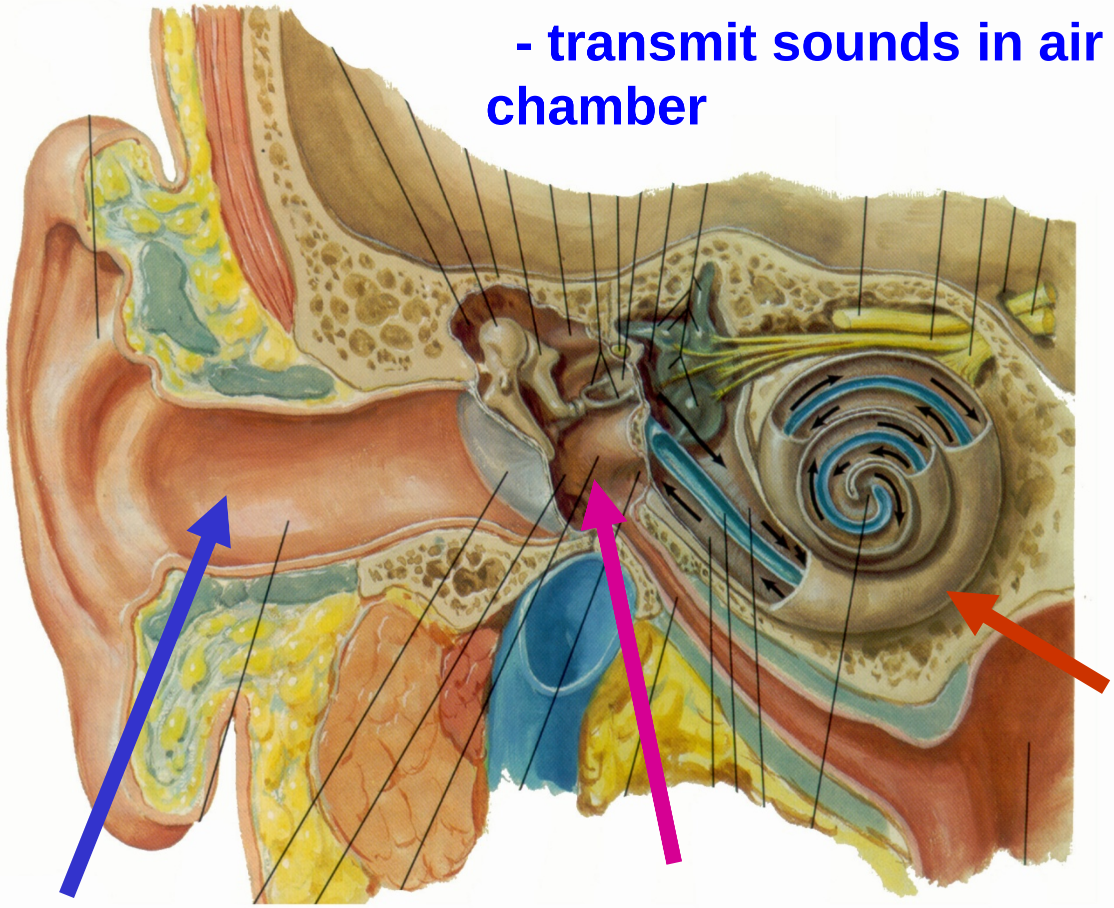
OUTLINE

I. OVERVIEW
II. OUTER EAR
III. MIDDLE EAR

Outer and middle ear transmit sound to inner ear.
Middle ear is dead end space filled with air and connected to nasopharynx; Middle ear infections common (otitis media)

I. EAR - overview

- 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

INNER EAR DETECTS TRANSMITTED VIBRATIONS

Weber test – tuning fork on calvarium causes bone to vibrate; conducted to directly 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)

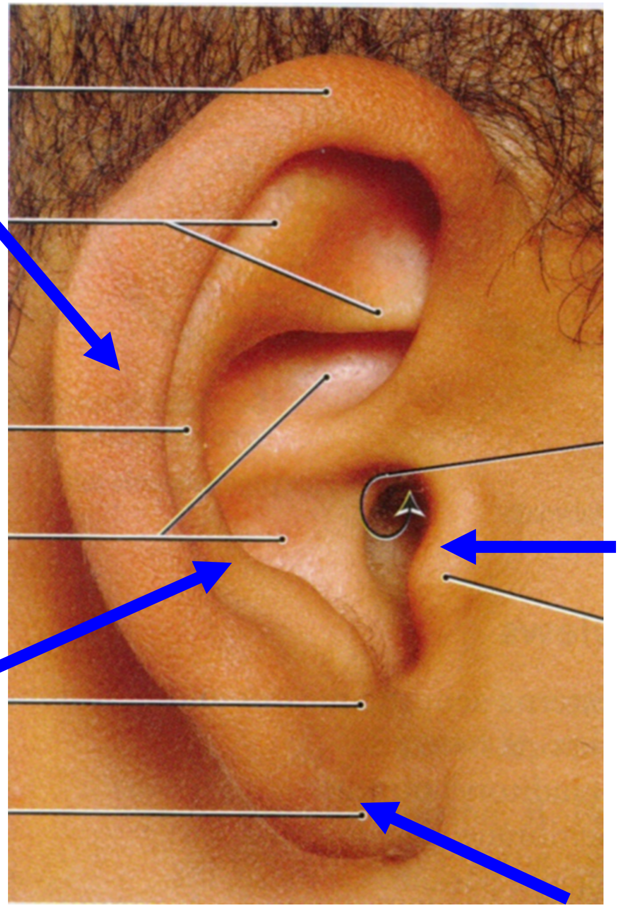
CONDUCTIVE HEARING LOSS - damage to middle ear (tympanic membrane, auditory ossicles (bones)

SENSORINEURAL HEARING LOSS - damage to inner ear.

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

Helix

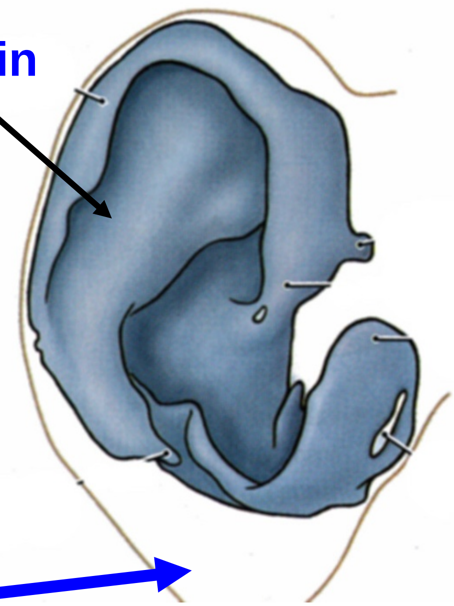


Antihelix

Tragus

A. <u>AURICLE</u> (pinna) - elastic cartilage and skin - Reflects sound waves

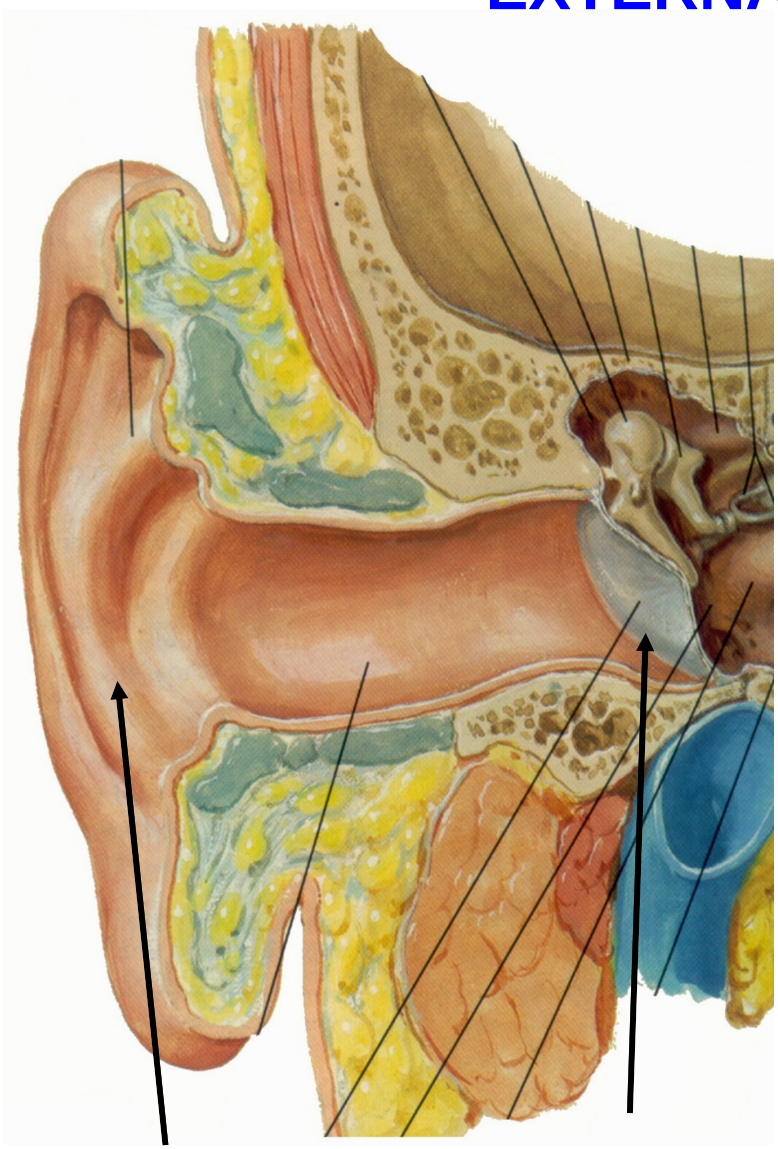
cartilage under skin



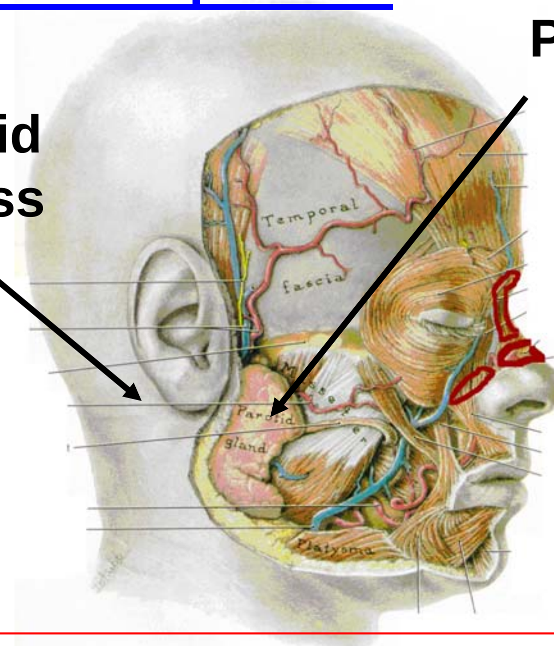
Lobule

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

EXTERNAL AUDITORY MEATUS - location

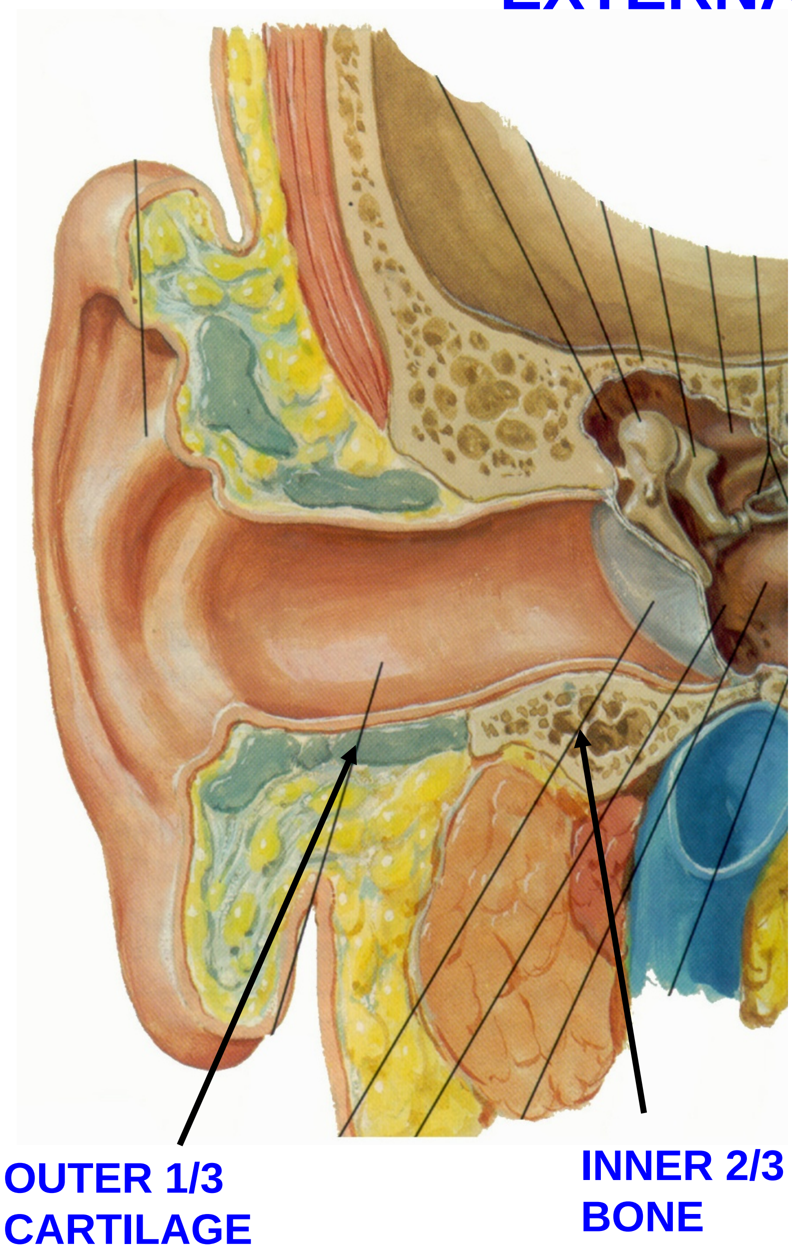


- Tube from auricle to the tympanic membrane; <u>posterior to Parotid gland and TMJ; anterior to mastoid process</u>



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

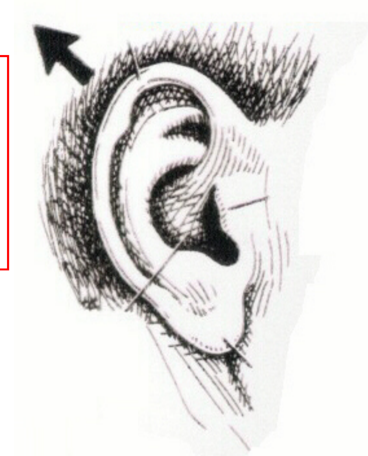


<u>Outer 1/3</u> - <u>Cartilage</u> - contains hair, sebaceous and ceruminous glands (ear wax [insect repellent]); protects tymp. membrane,

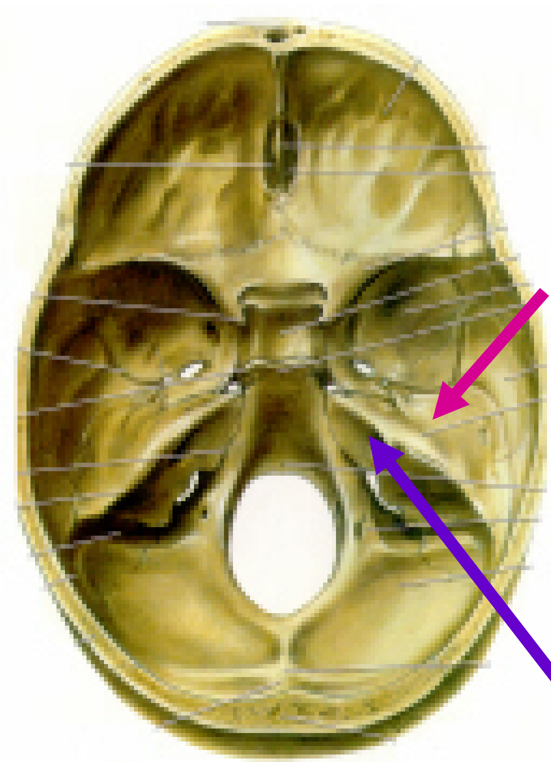
<u>Inner 2/3</u> - <u>Bone</u> covered by skin

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

In Adult - pull up and back to insert otoscope

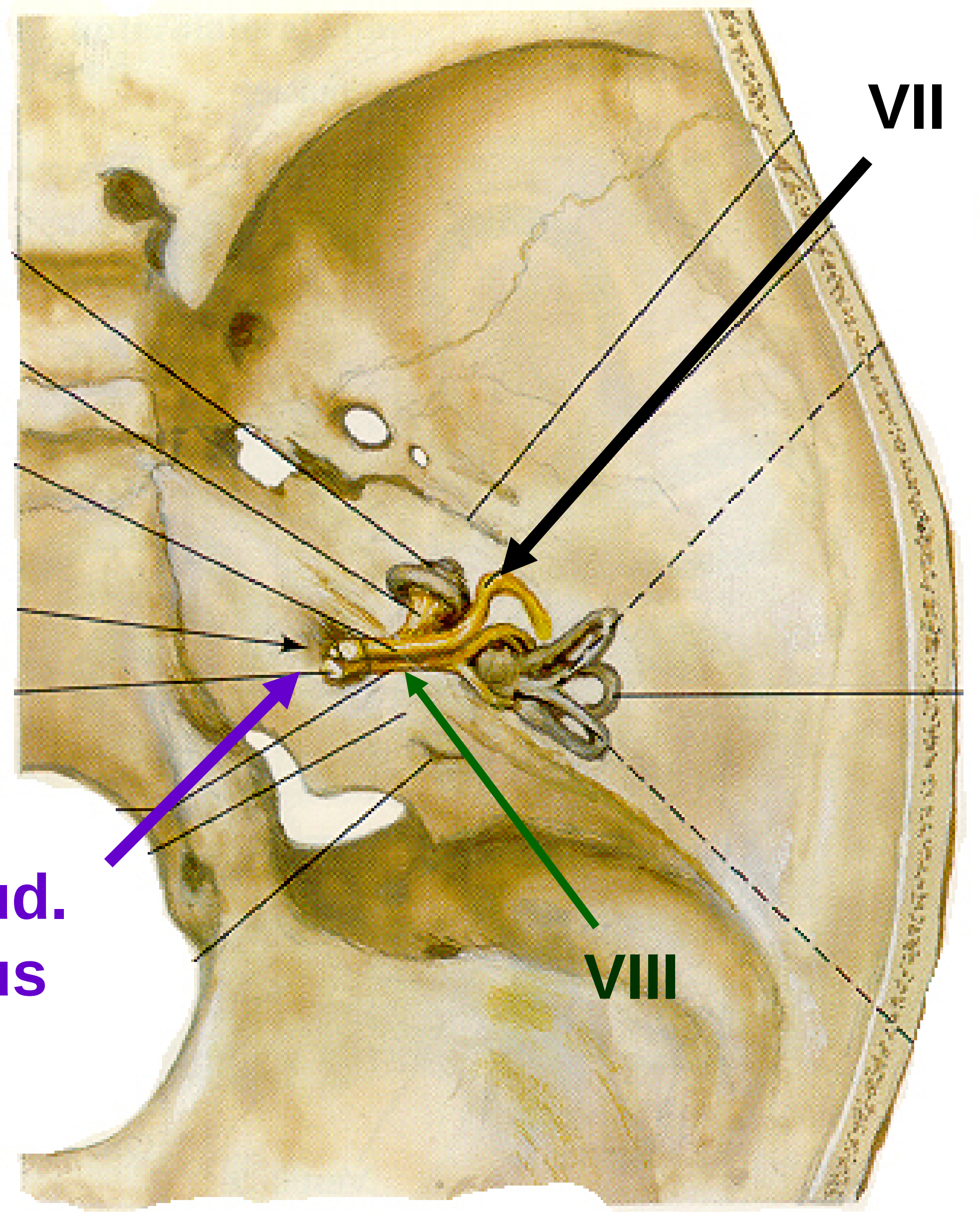


III. MIDDLE EAR - hard to visualize

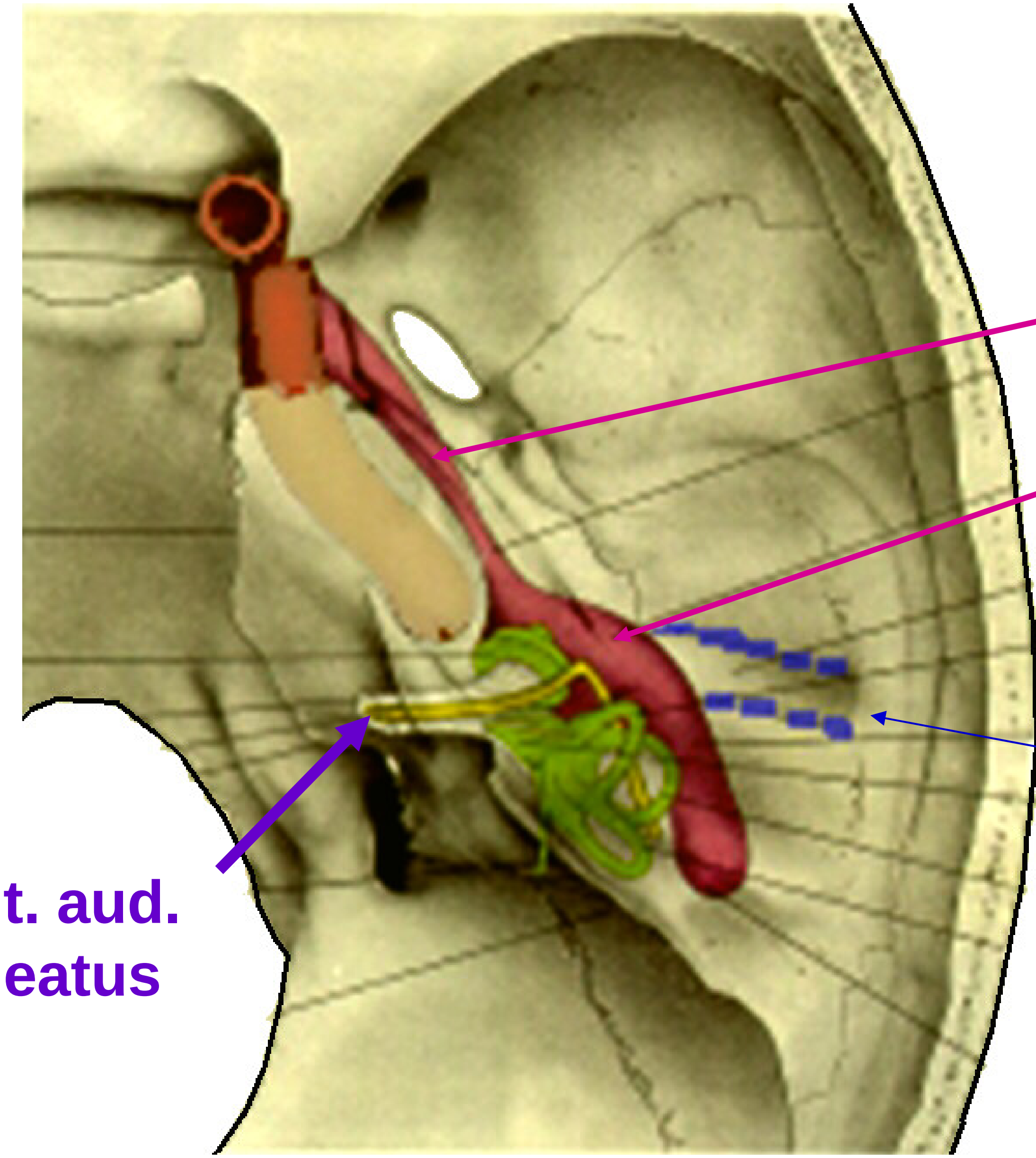


LOCATION OF MIDDLE EAR AND INNER EAR DIFFICULT TO DEMONSTRATE

ORIENT: LOCATION OF INNER EAR

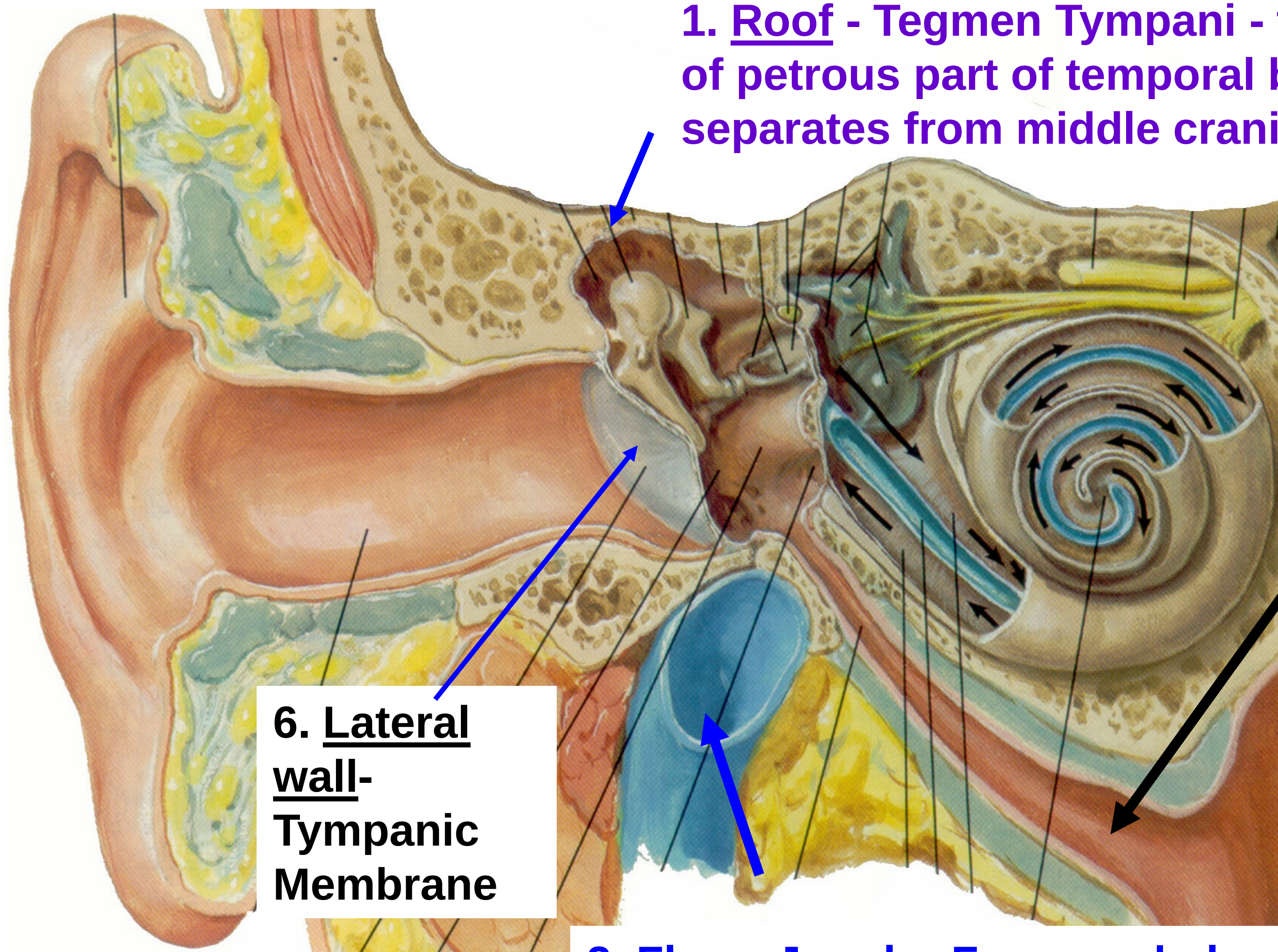


ORIENT: LOCATION OF MIDDLE EAR



Meatus = passage, L.

III. MIDDLE EAR - BOUNDARIES



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

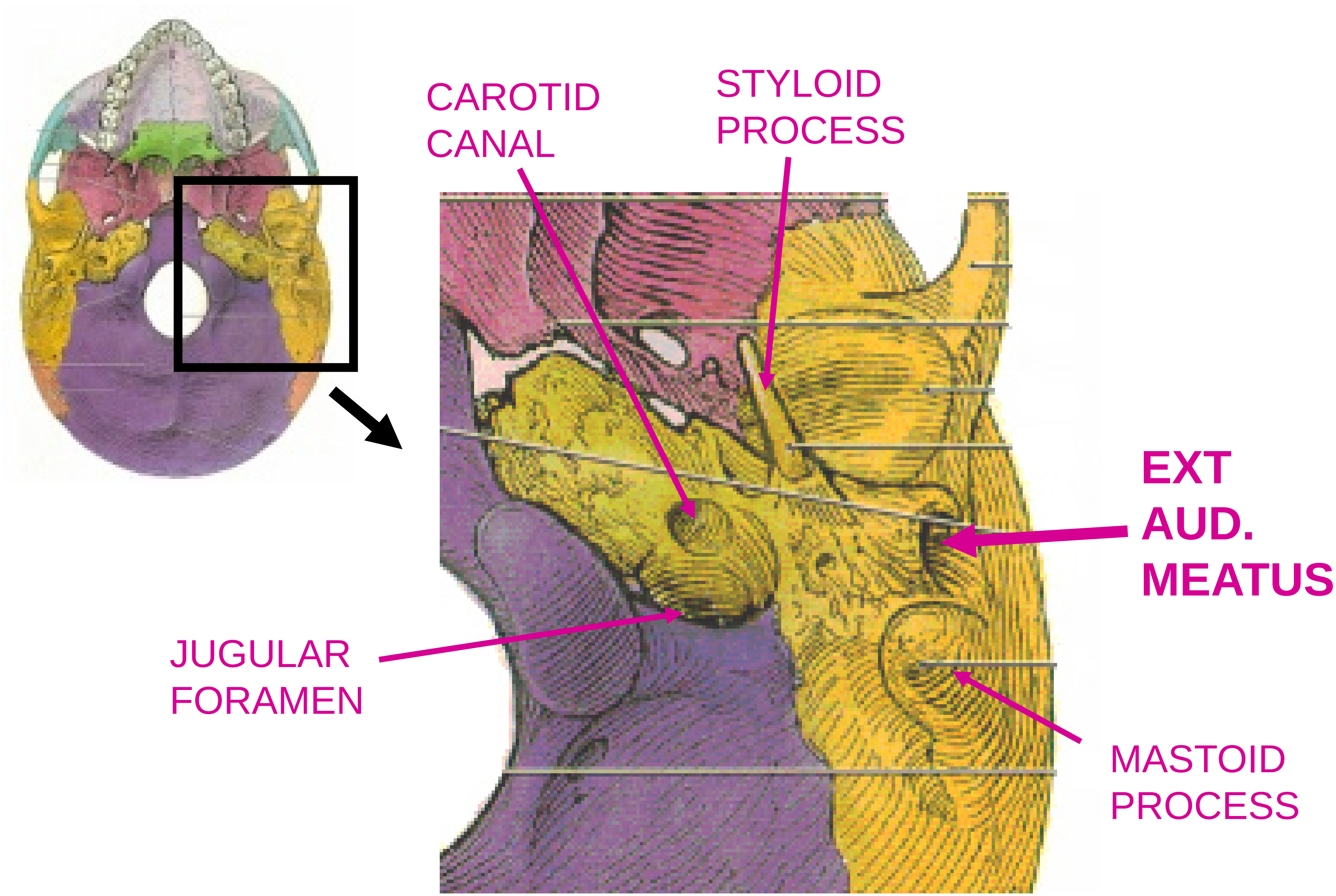
3. **Ant. wall** -

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

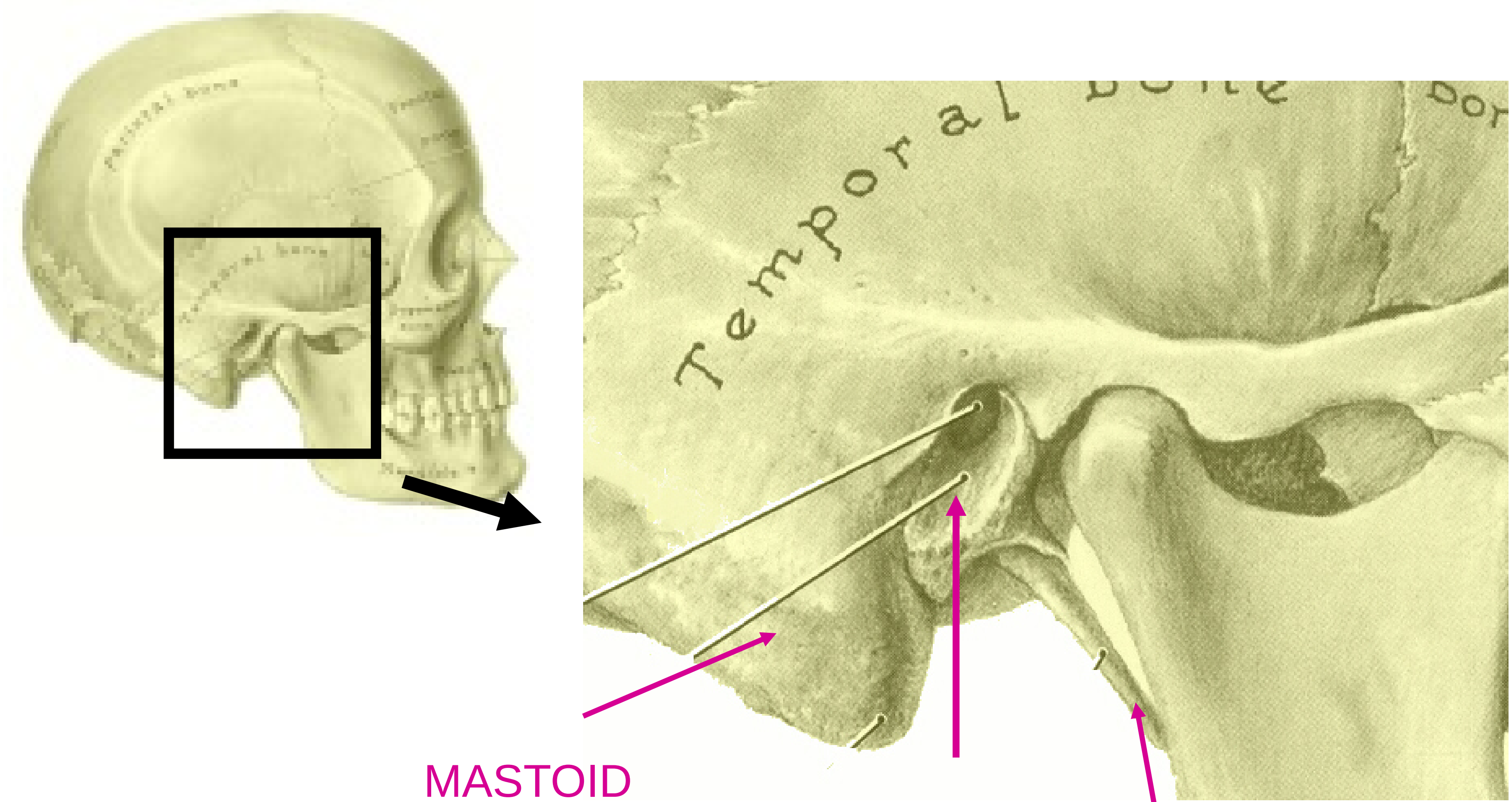
6. **Lateral wall**- Tympanic Membrane

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

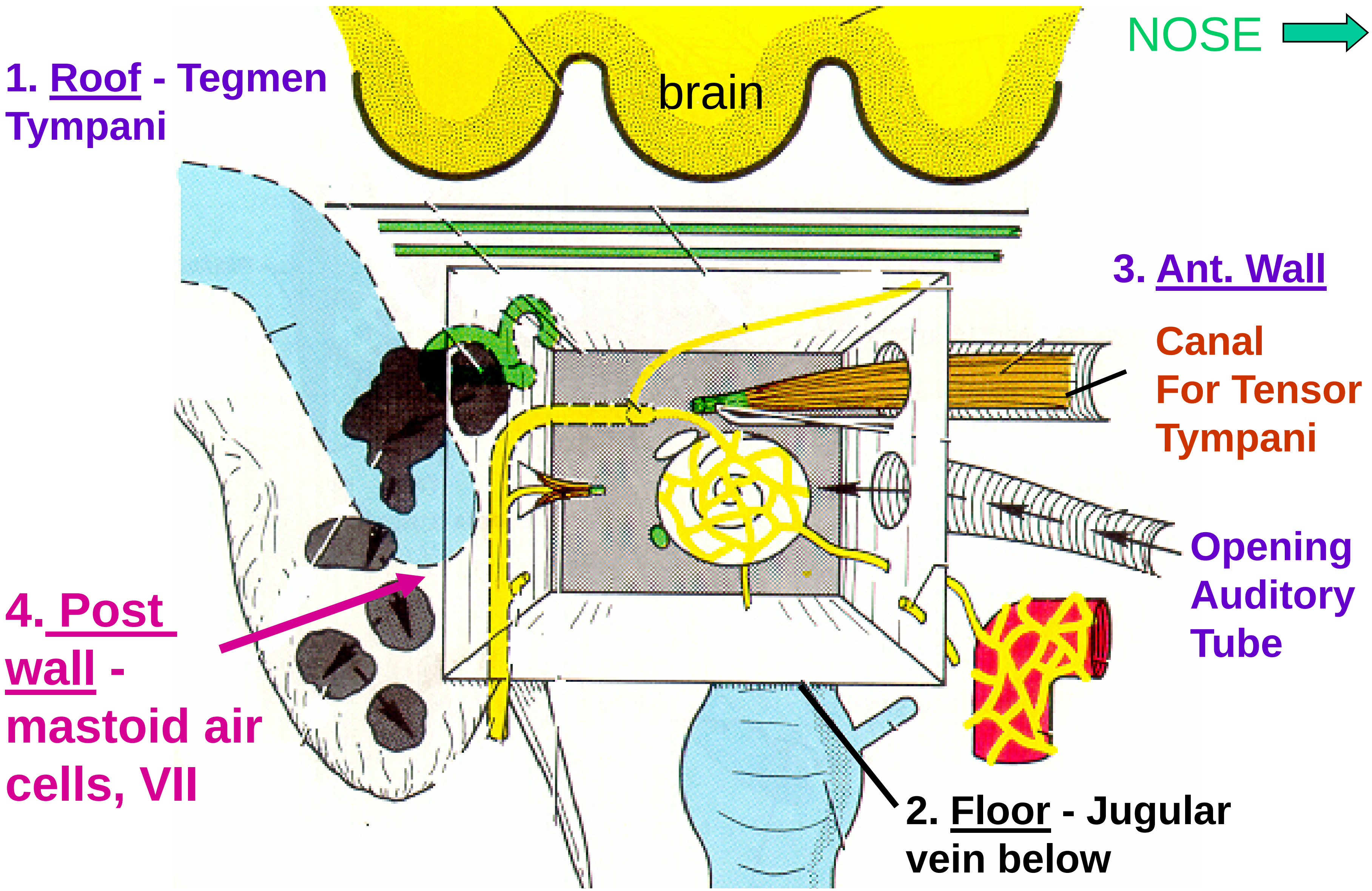
ORIENT: LOCATION OF MIDDLE EAR ON SKULL



ORIENT: LOCATION OF MIDDLE EAR ON SKULL

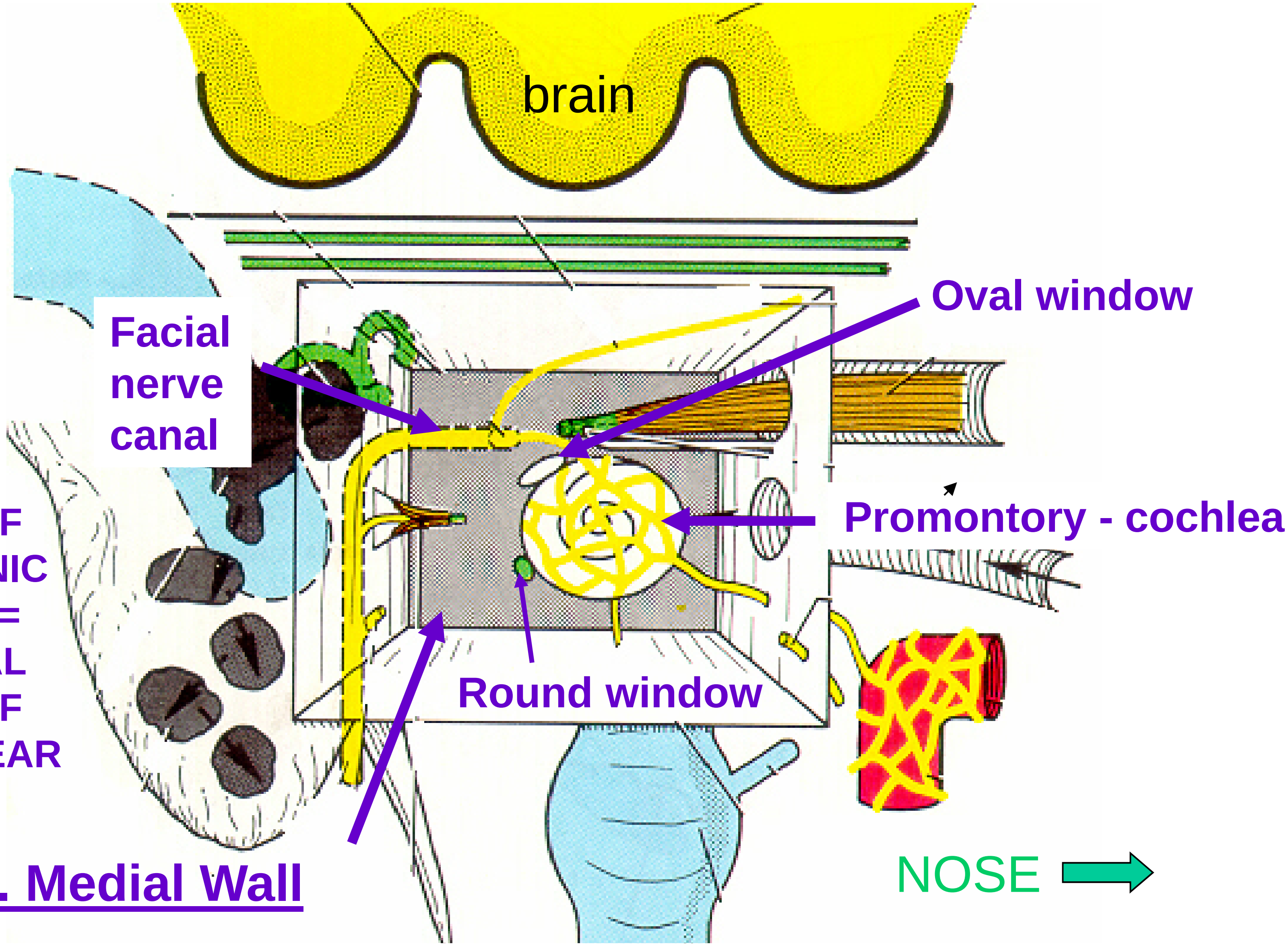


MIDDLE EAR: BOUNDARIES



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

MIDDLE EAR: BOUNDARIES



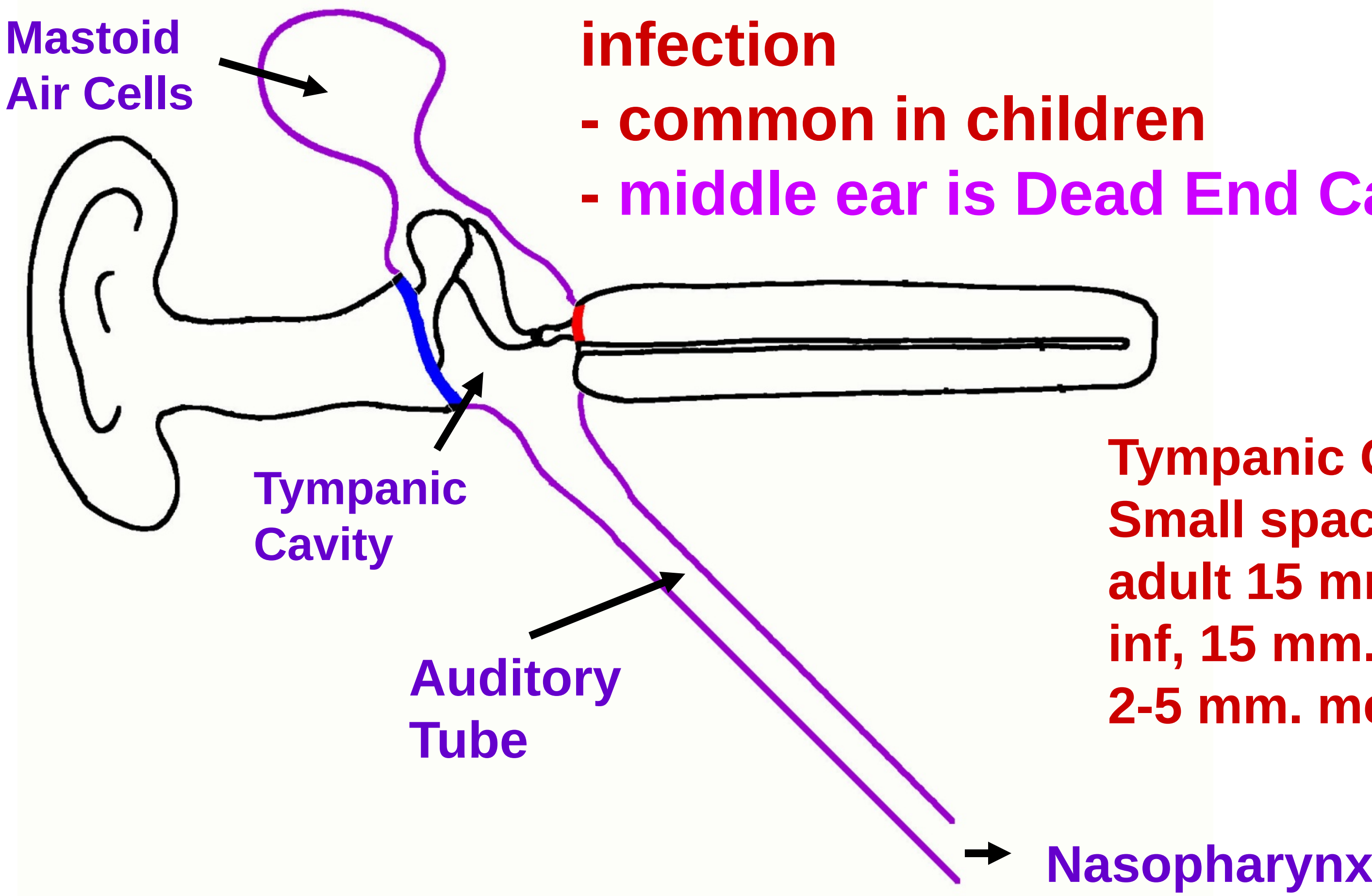
MEDIAL WALL OF TYMPANIC CAVITY = LATERAL WALL OF INNER EAR

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

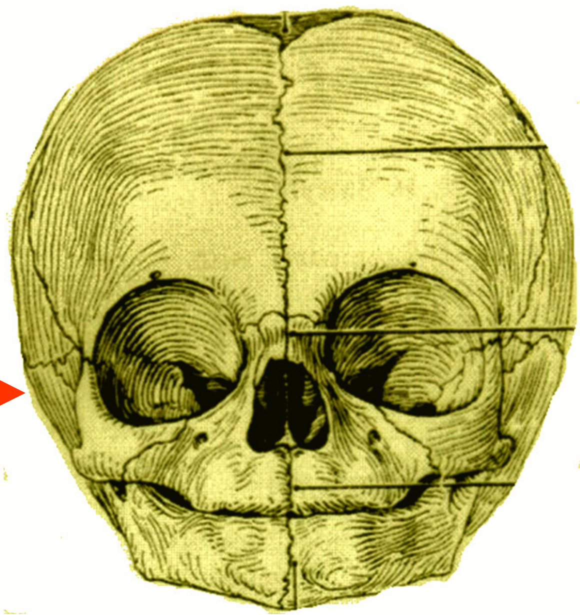


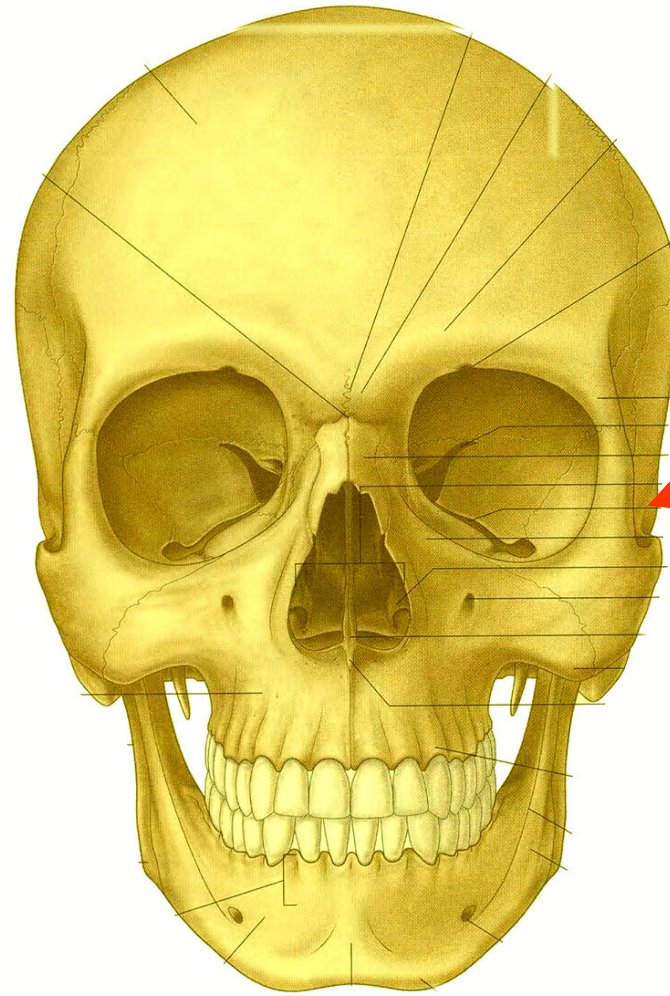
Tympanic Cavity Small space - In adult 15 mm. sup-inf, 15 mm. ant-post, 2-5 mm. med-lat

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



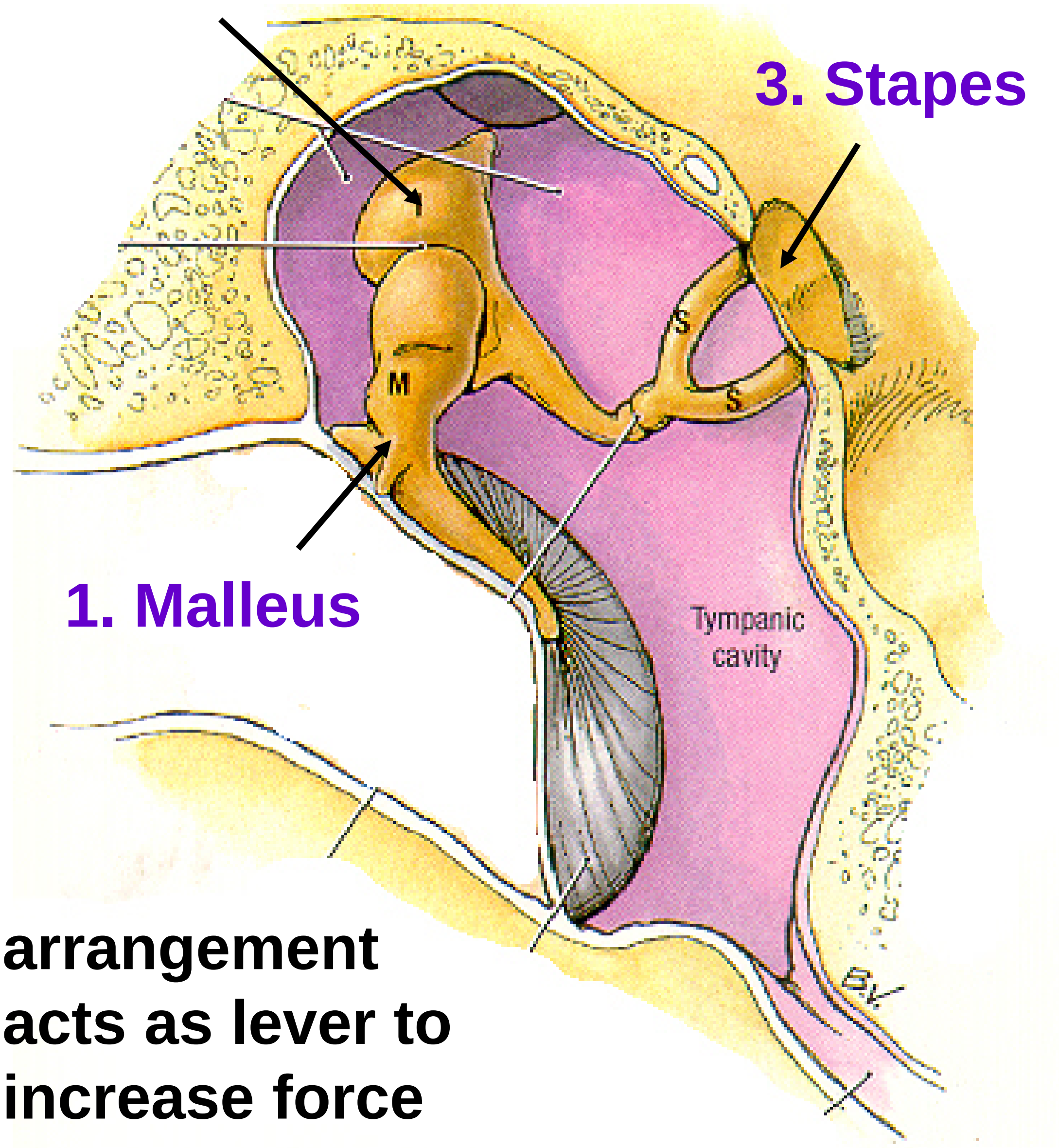


orient
of
aud.
tube

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

B. AUDITORY OSSICLES



2. Incus

3. Stapes

1. Malleus

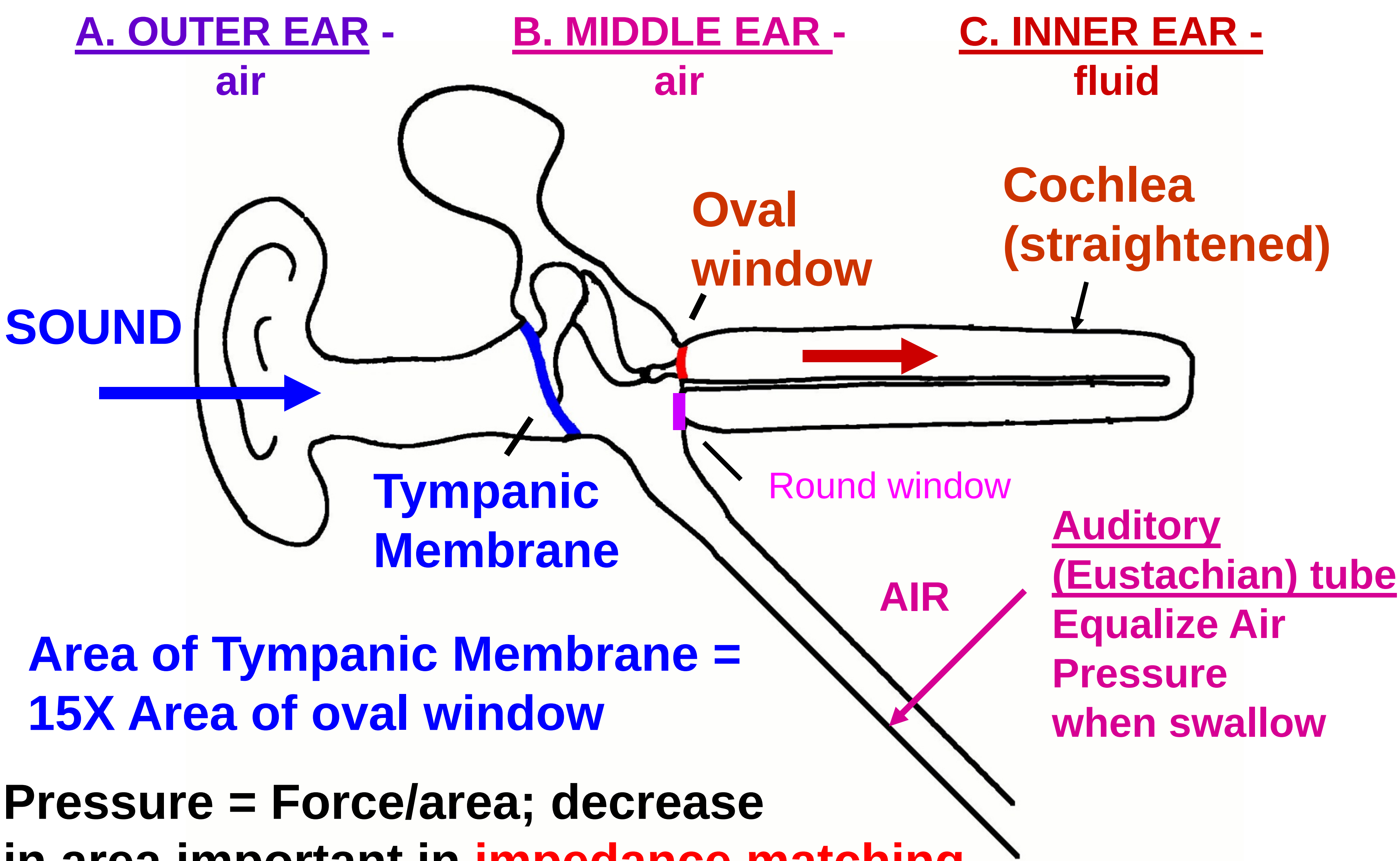
arrangement acts as lever to increase force

- link tympanic membrane to oval window and cochlea –
- anchored by ligaments

Malleus = hammer
Incus = anvil
Stapes = stirrup

- Broad attachment of <u>Malleus</u> to tympanic membrane

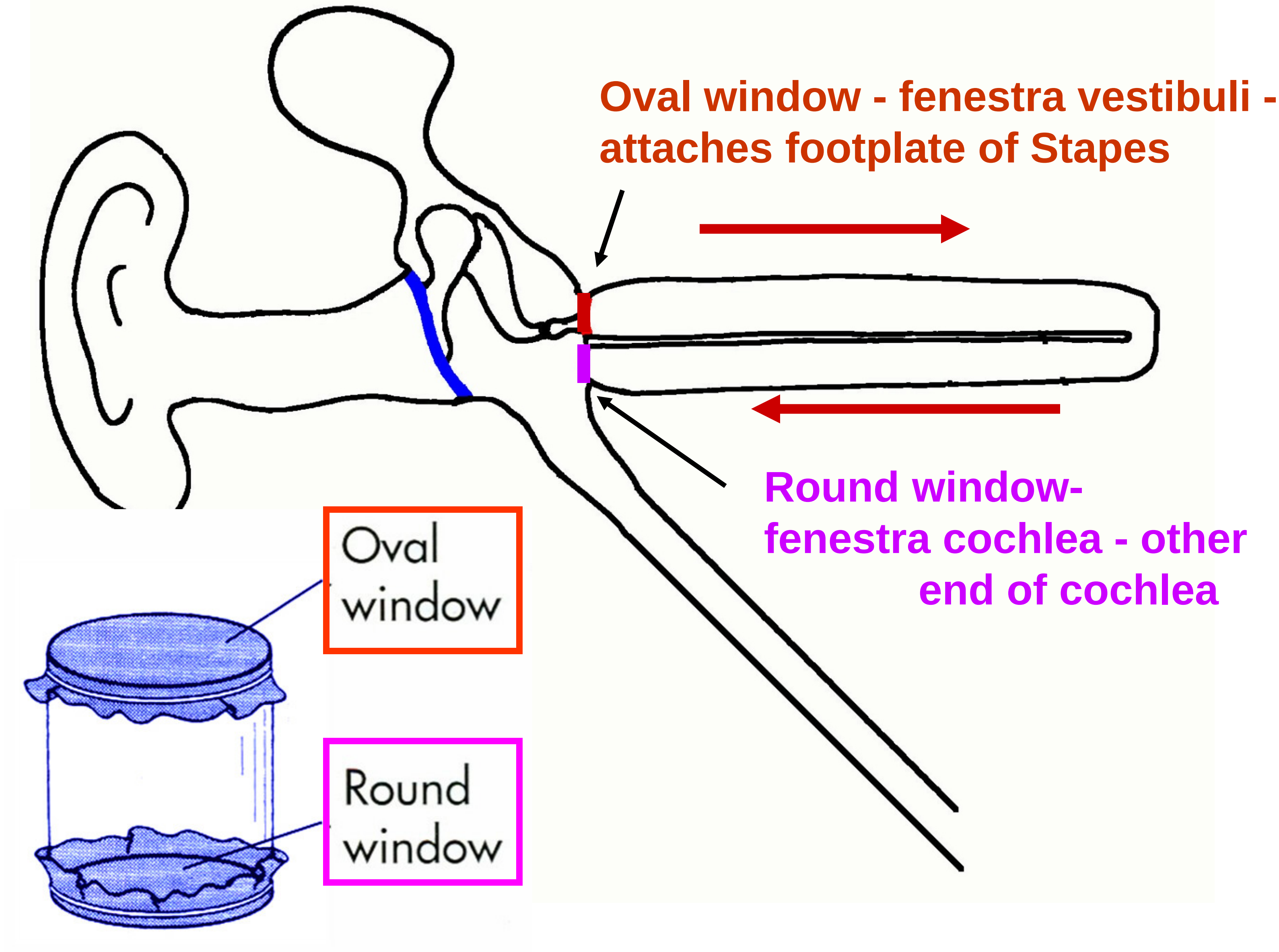
EAR: DIAGRAMMATICALLY - transmission of sound (Cochlea straightened)



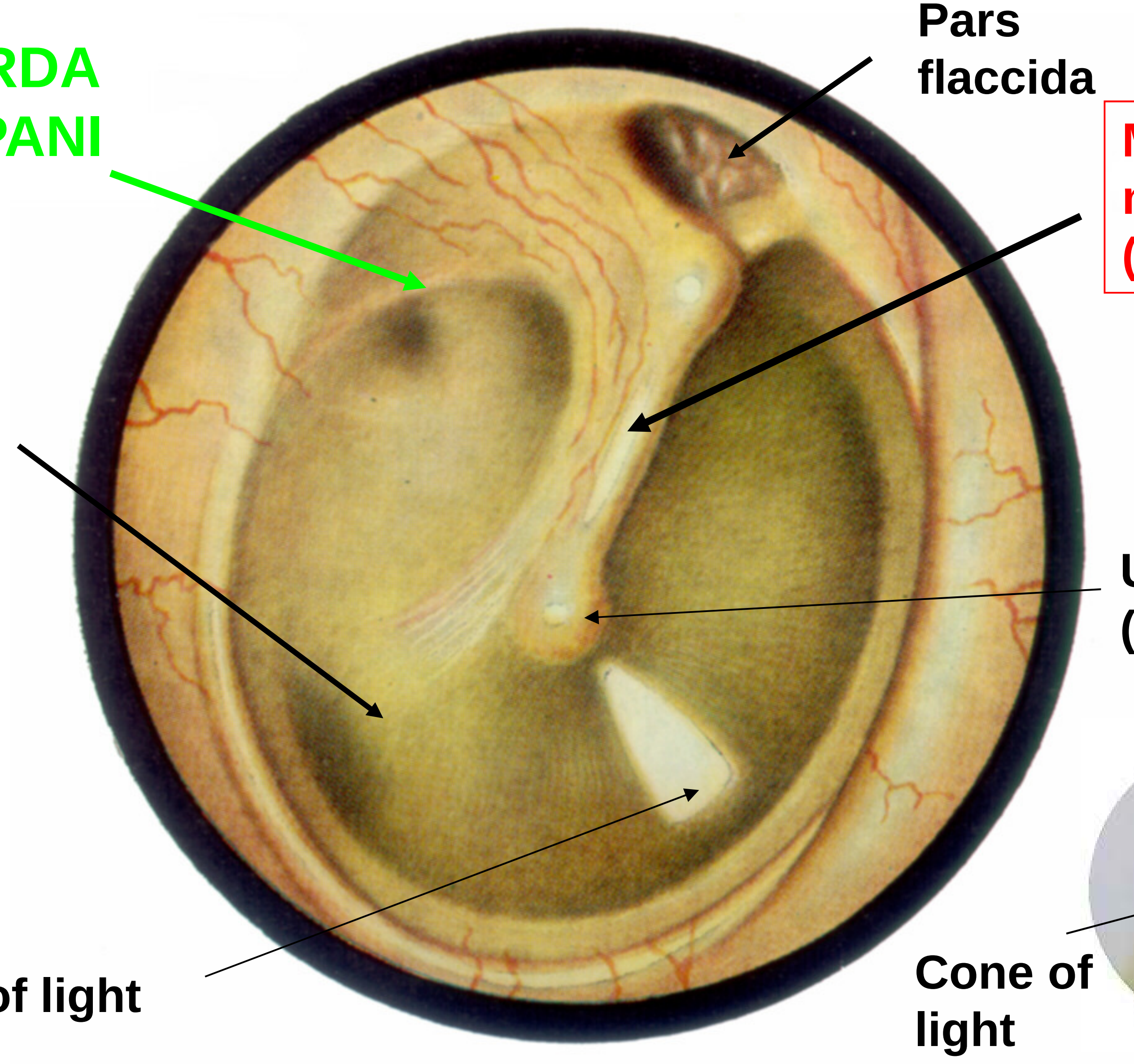
Area of Tympanic Membrane = 15X Area of oval window

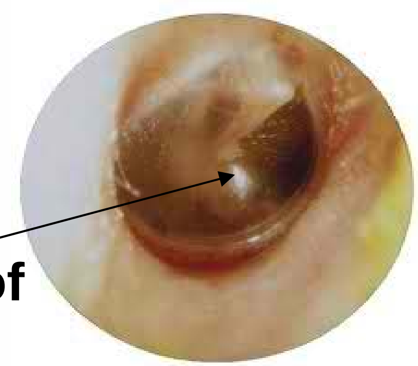
Pressure = Force/area; decrease in area important in impedance matching

PRESSURE IN COCHLEA

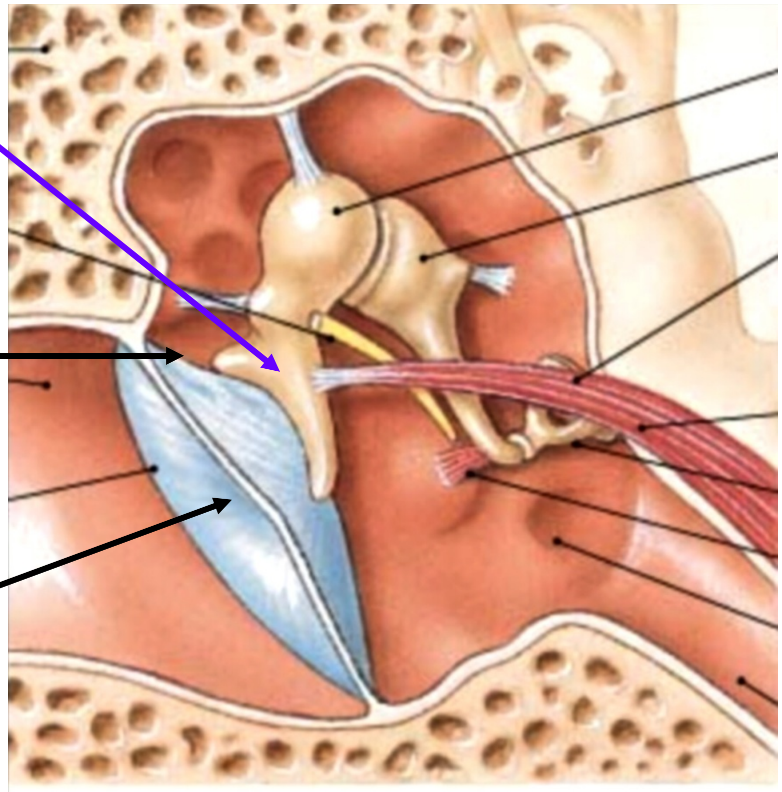


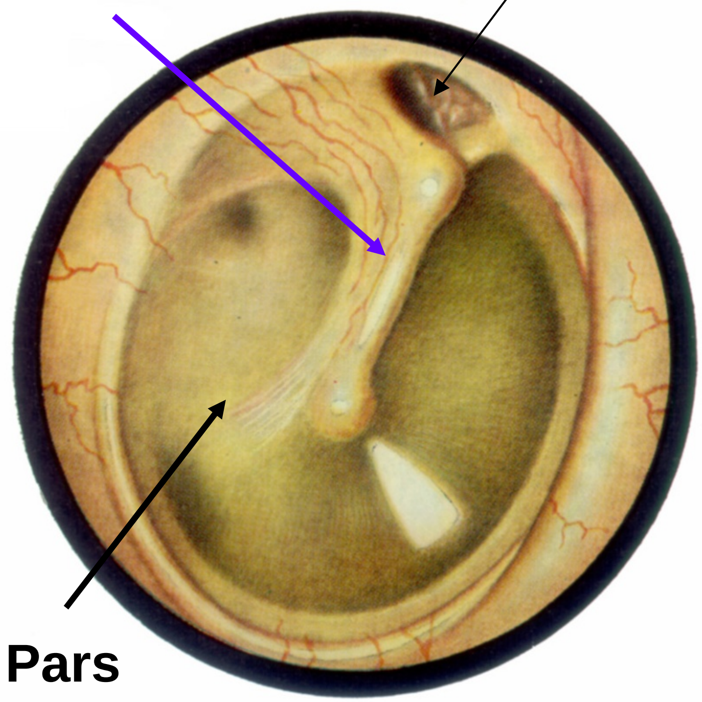
OTOSCOPE VIEW OF TYMPANIC MEMBRANE





OTOSCOPE VIEW OF TYMPANIC MEMBRANE

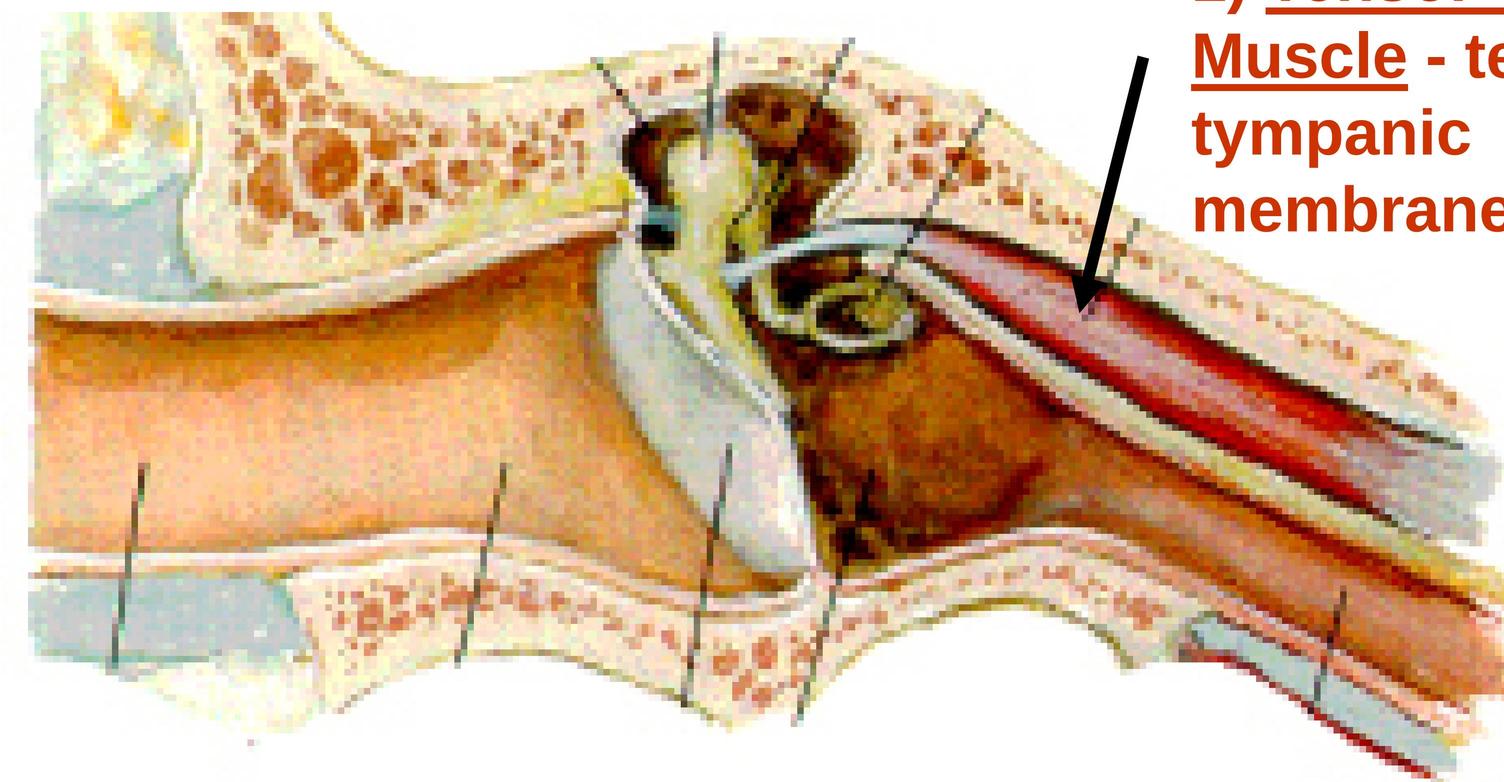




Handle malleus is attached to upper half of Tympanic membrane; malleus is supported by ligaments linking it to wall of Tympanic cavity; part of Tympanic membrane surrounding handle is tense (pars tensa); upper end is less tense (pars flaccida)

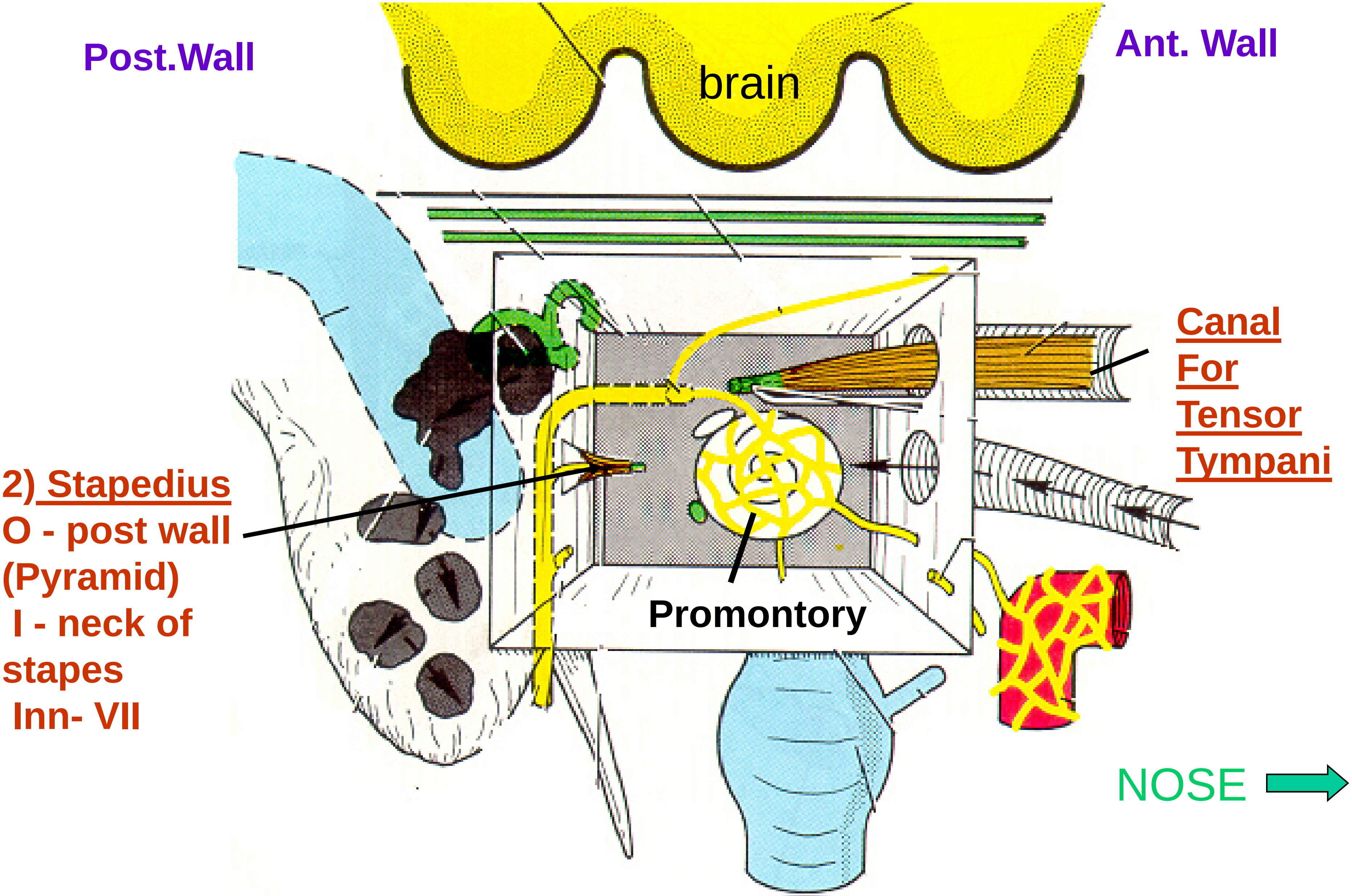
MUSCLES OF MIDDLE EAR - dampen sound

1) <u>Tensor Tympani Muscle</u> - tenses tympanic membrane



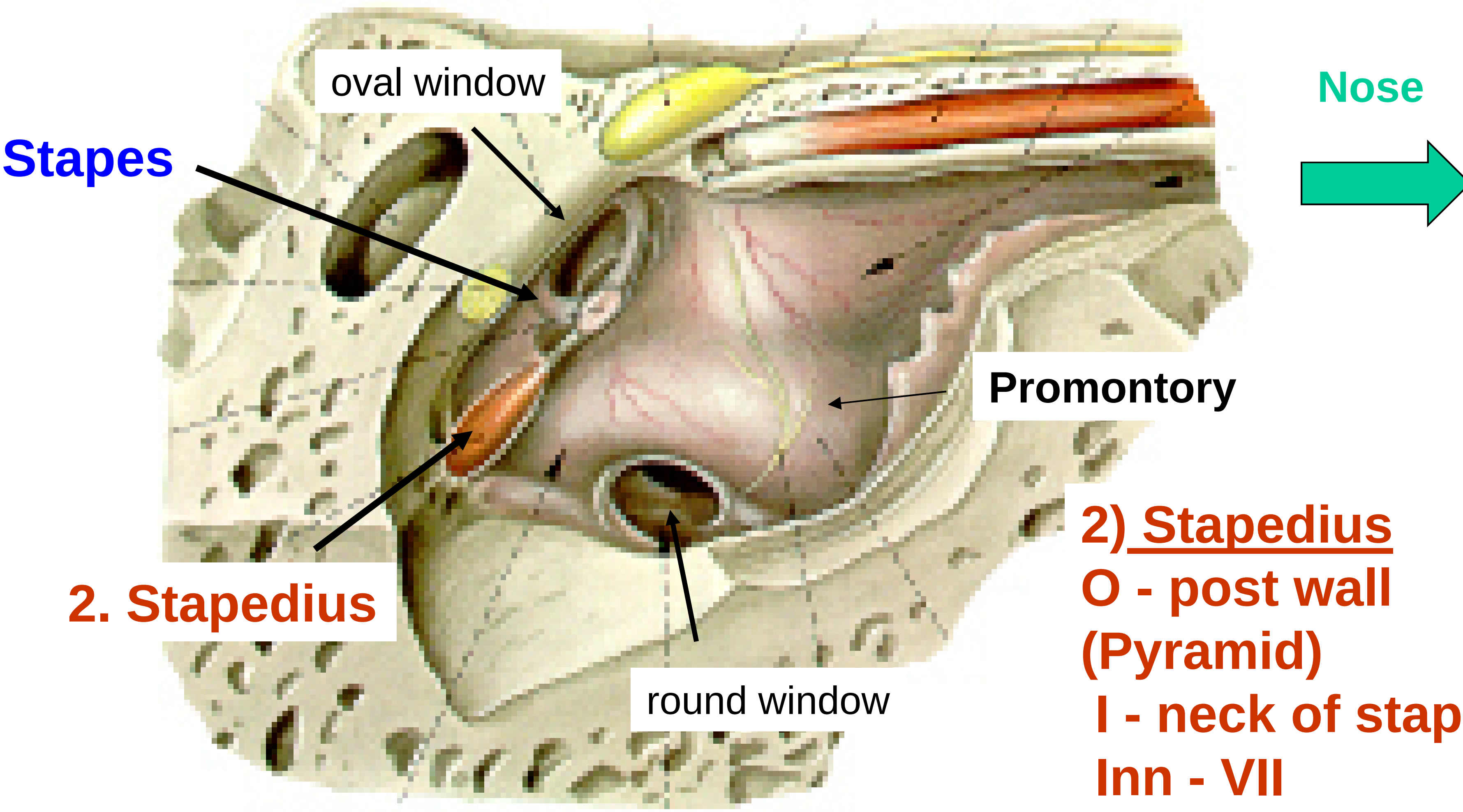
O - canal in ant. wall
I - handle of malleus
Inn - V3

MUSCLES OF MIDDLE EAR



C. MUSCLES OF MIDDLE EAR - dampen sound

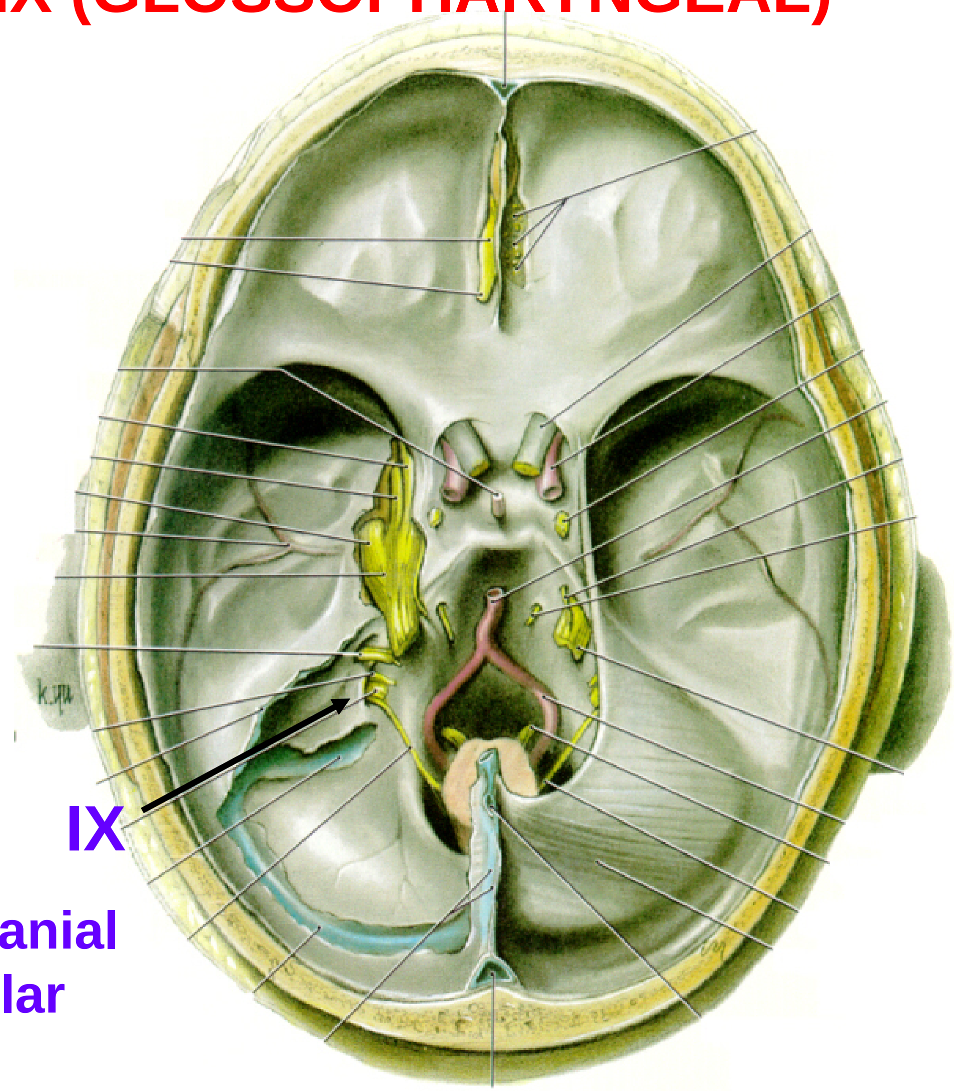
View of Medial Wall of tympanic cavity



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

Damage to VII - Hyperacousia - sounds seem too loud

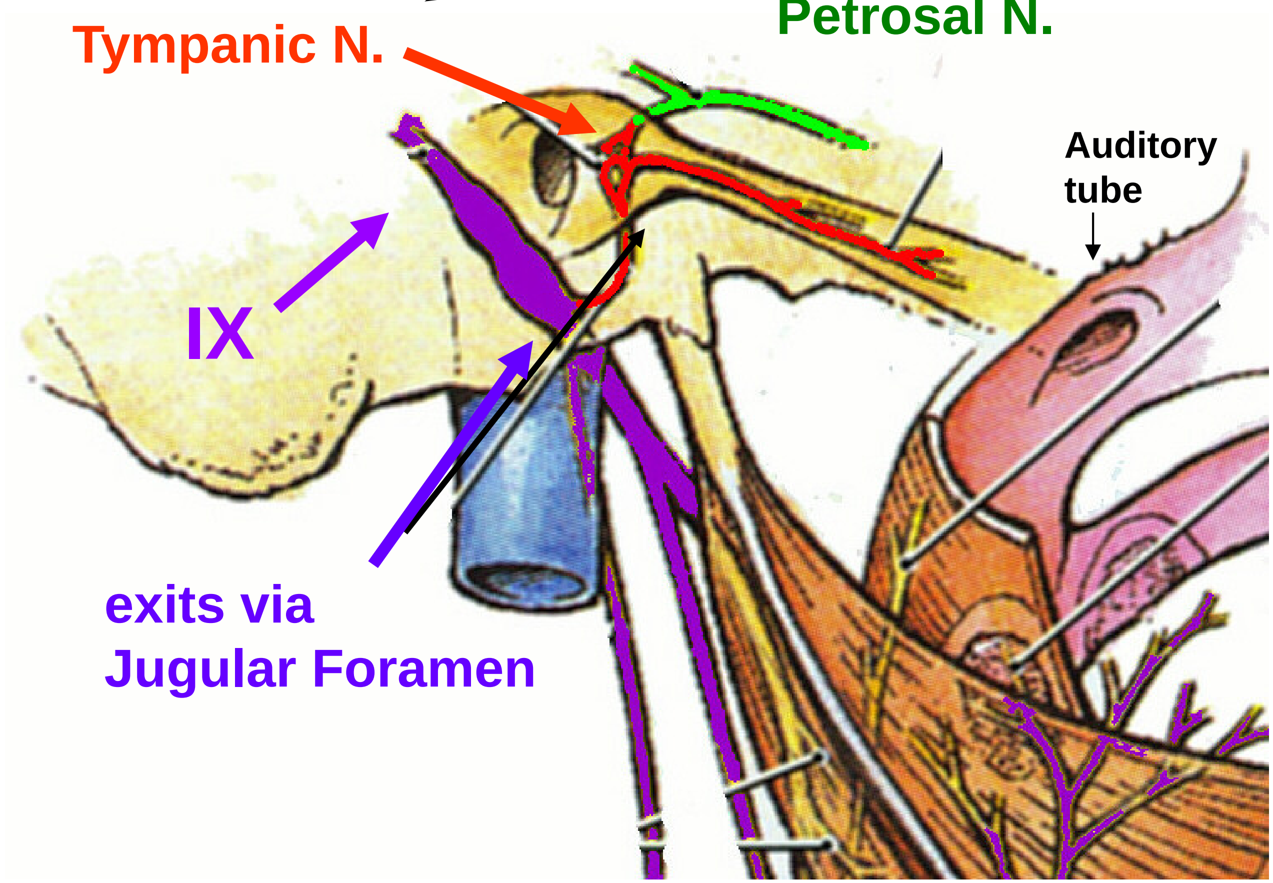
D. SENSORY INNERVATION - VISCERAL SENSORY (GVA) FROM TYMPANIC PLEXUS OF CN IX (GLOSSOPHARYNGEAL)



leaves Post. Cranial Fossa via Jugular Foramen

IX - GLOSSOPHARYNGEAL

exits via
Jugular Foramen

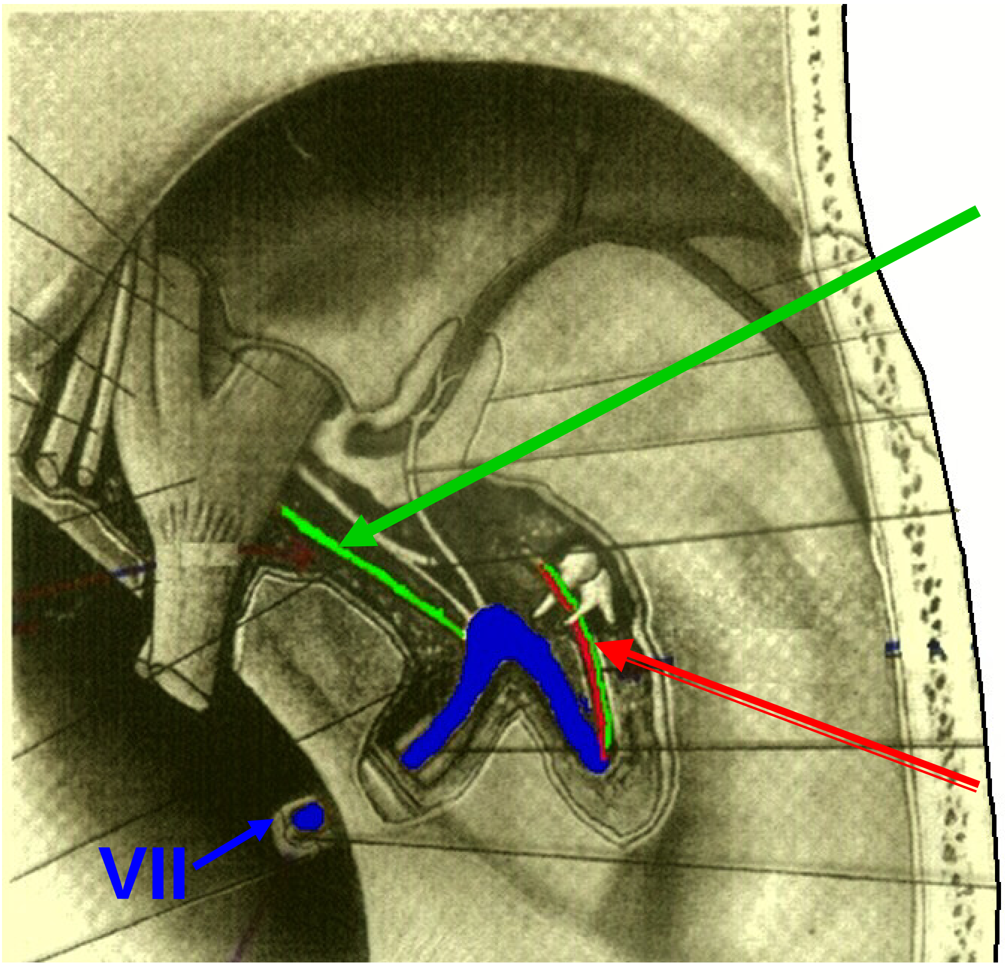


1. Tympanic Nerve
Forms tympanic plexus; VISCERAL SENSORY to middle ear
Mastoid sinus
auditory tube

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

VII - FACIAL

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

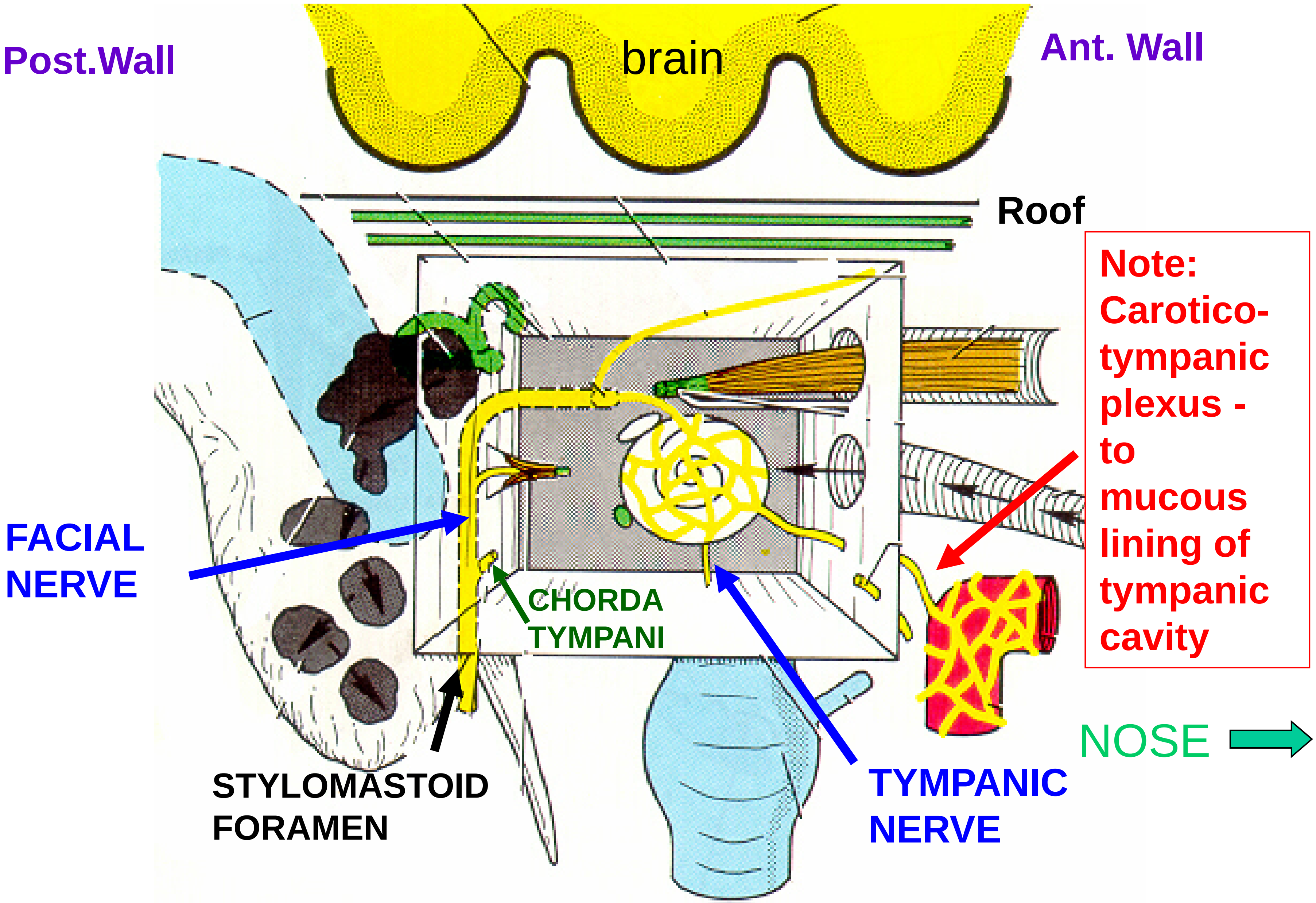


1. Greater Petrosal N.
VISCERAL MOTOR
Parasympathetics to Lacrimal gland, mucous glands of nose and palate, [Visceral sensory to Nasopharynx]

2. Stapedial N. -
Branchiomotor to Stapedius

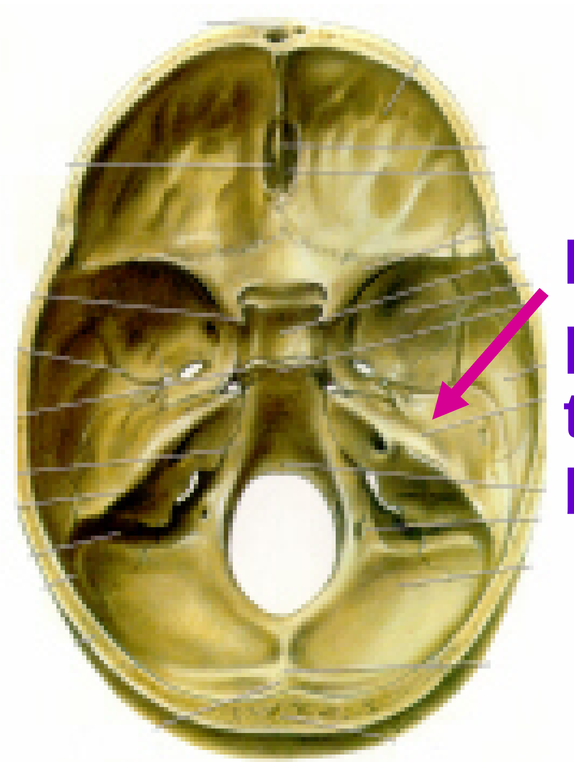
3. Chorda Tympani - has
A) Taste to ant 2/3 tongue
B) Parasympathetics to Submandibular, Sublingual salivary glands

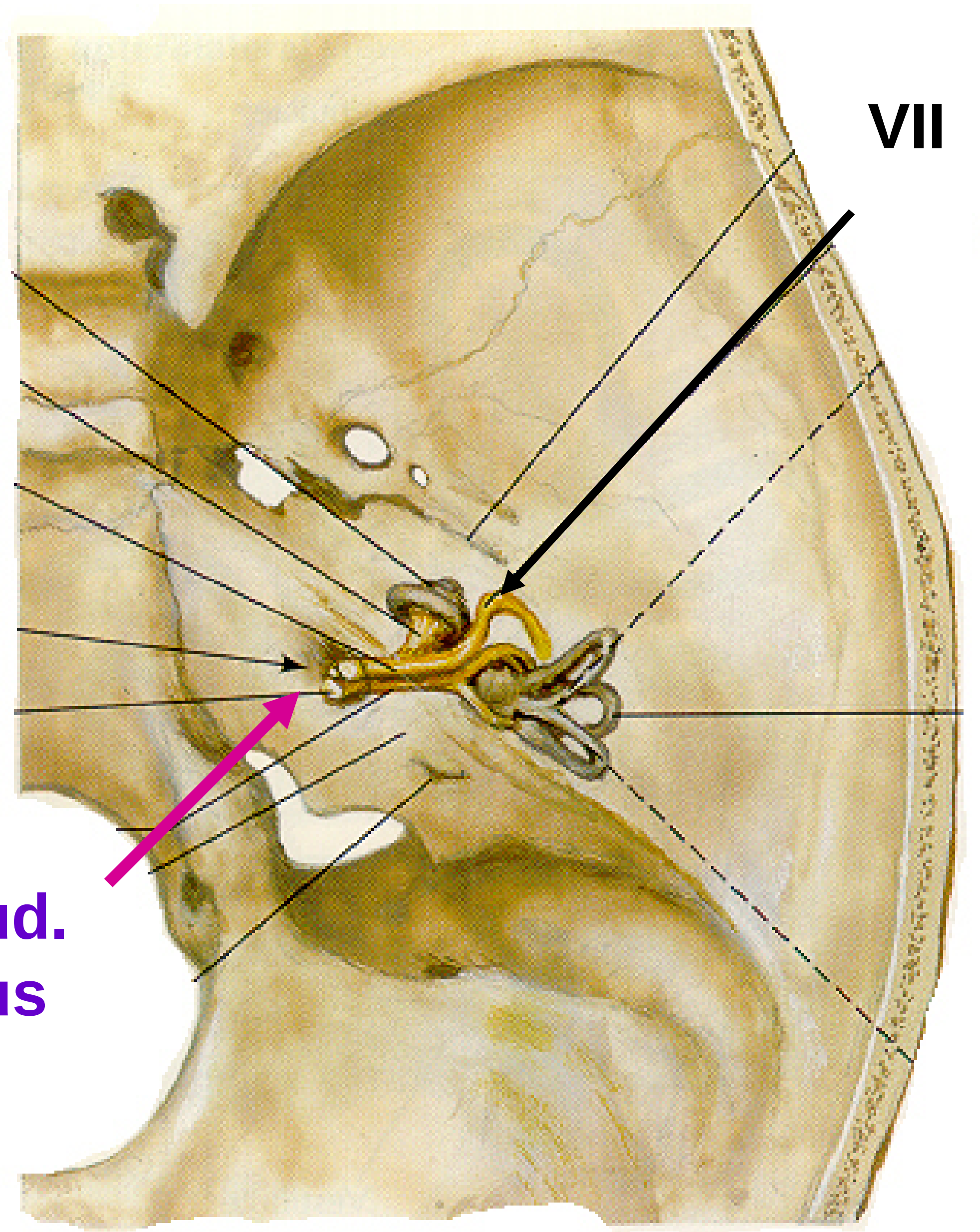
LOCATION OF NERVES IN MIDDLE EAR



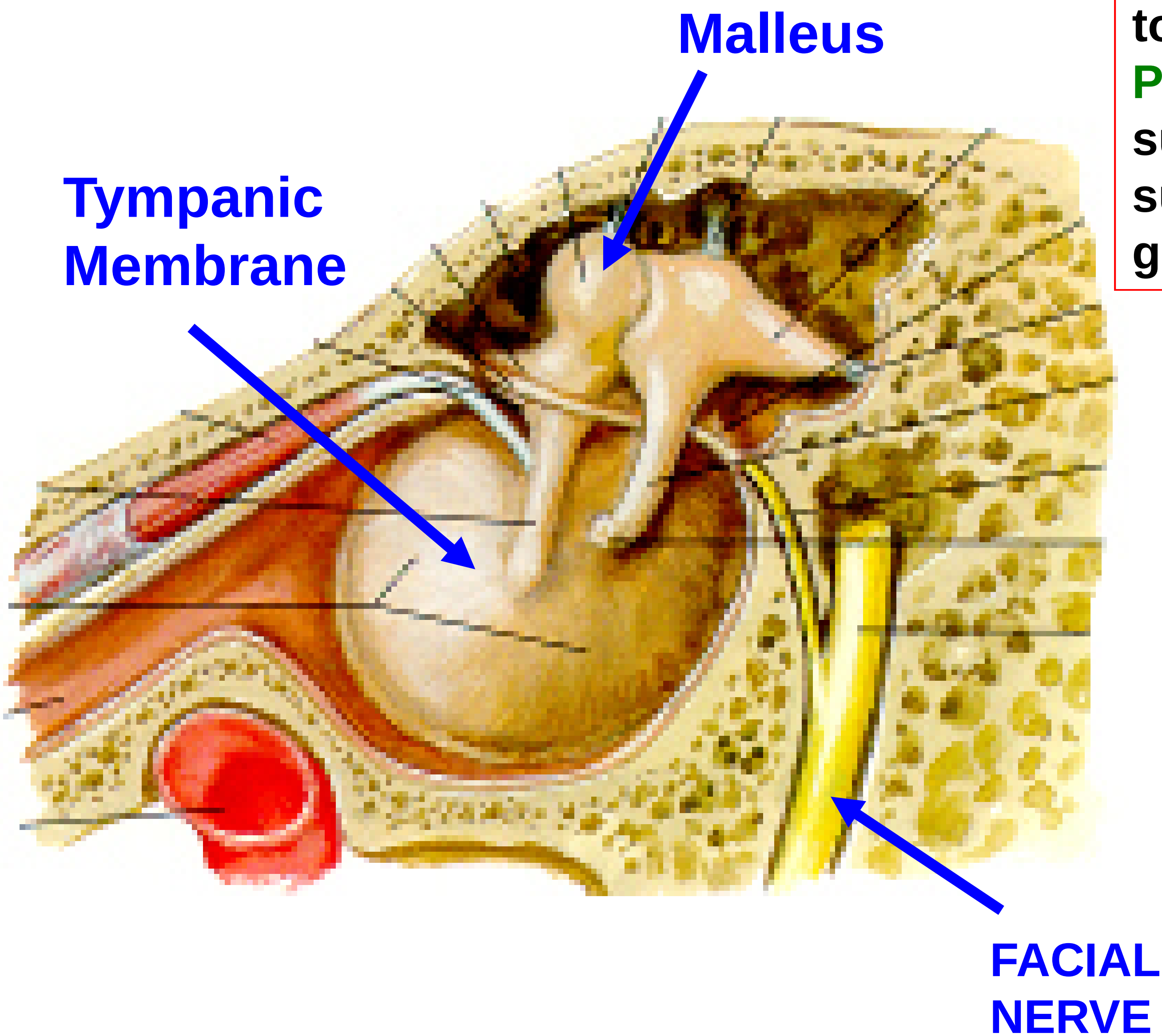
Looking at Medial Wall of Right Middle Ear with Ossicles Removed

COURSE OF FACIAL NERVE (VII)





CHORDA TYMPANI



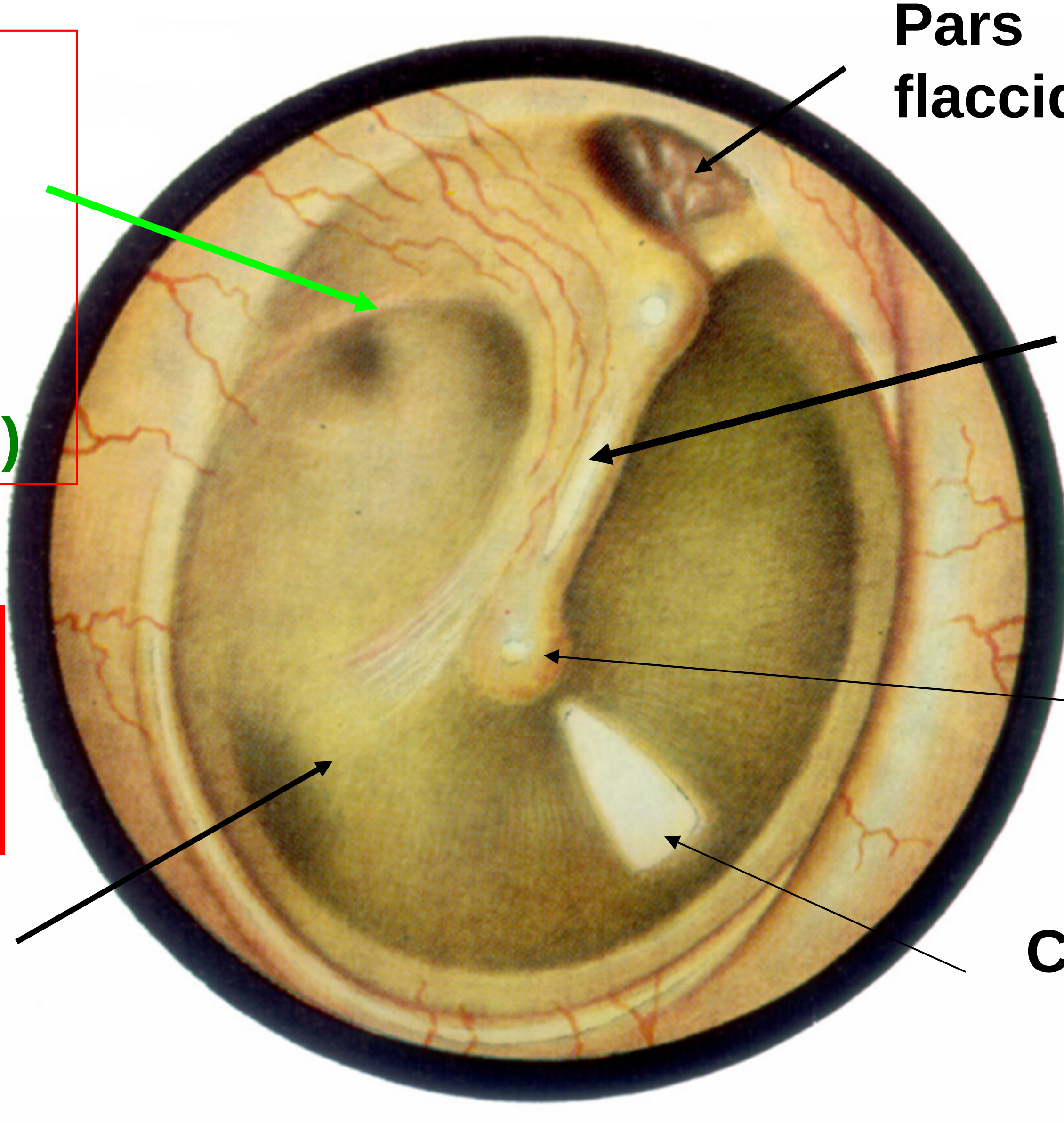
Taste to ant. 2/3 of tongue
Parasympathetic to submandibular, sublingual salivary glands

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

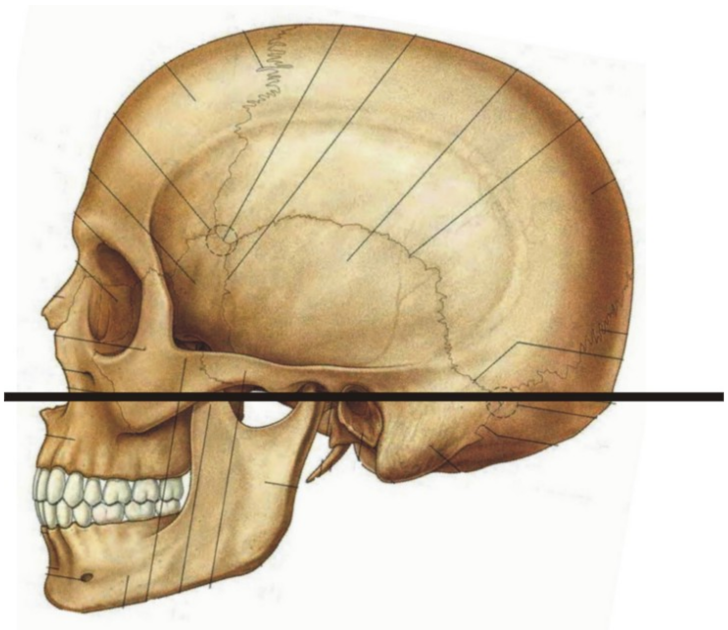
OTOSCOPE VIEW OF TYMPANIC MEMBRANE

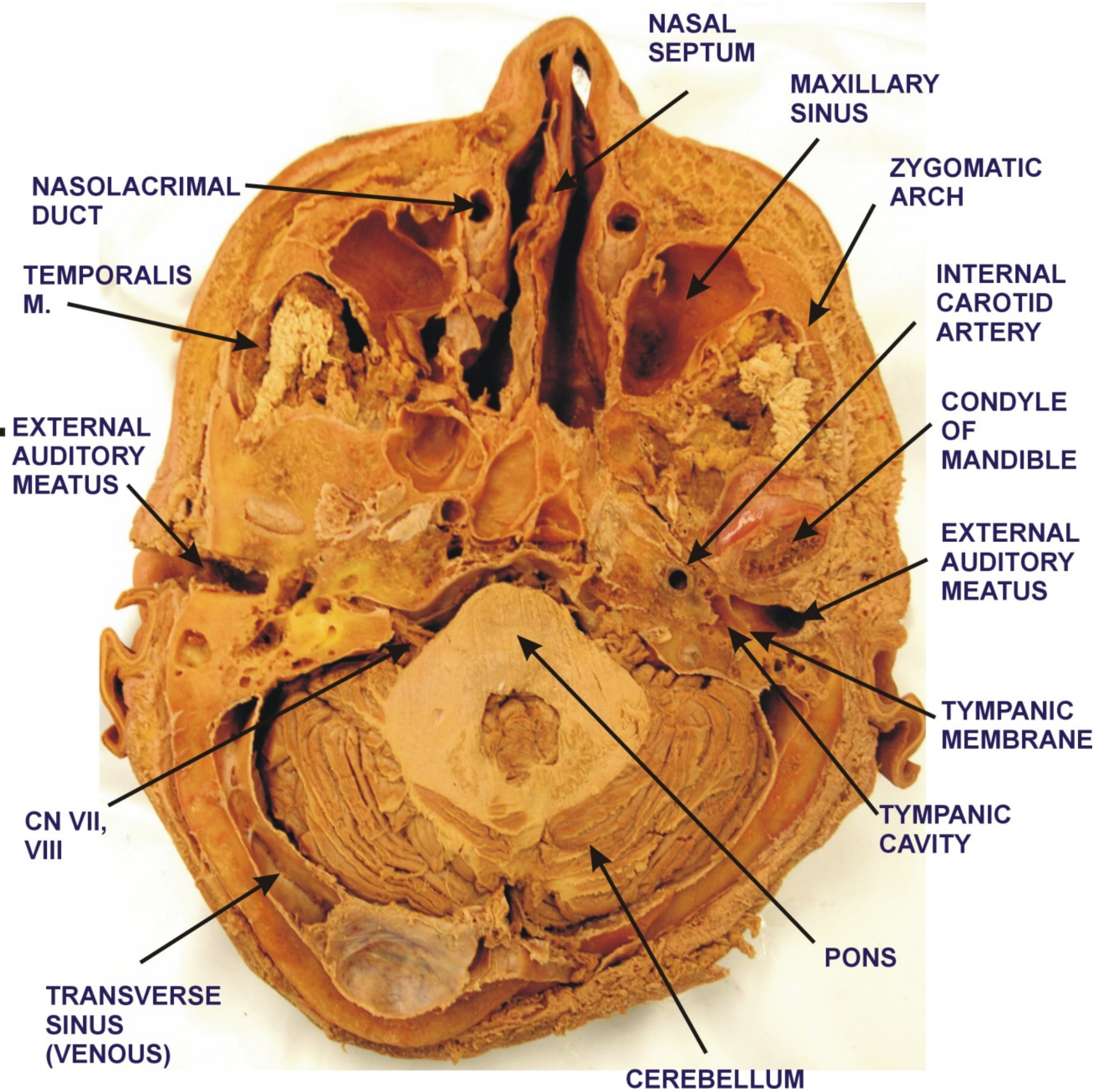
CHORDA TYMPANI: TASTE, VISCERAL MOTOR (parasymp)

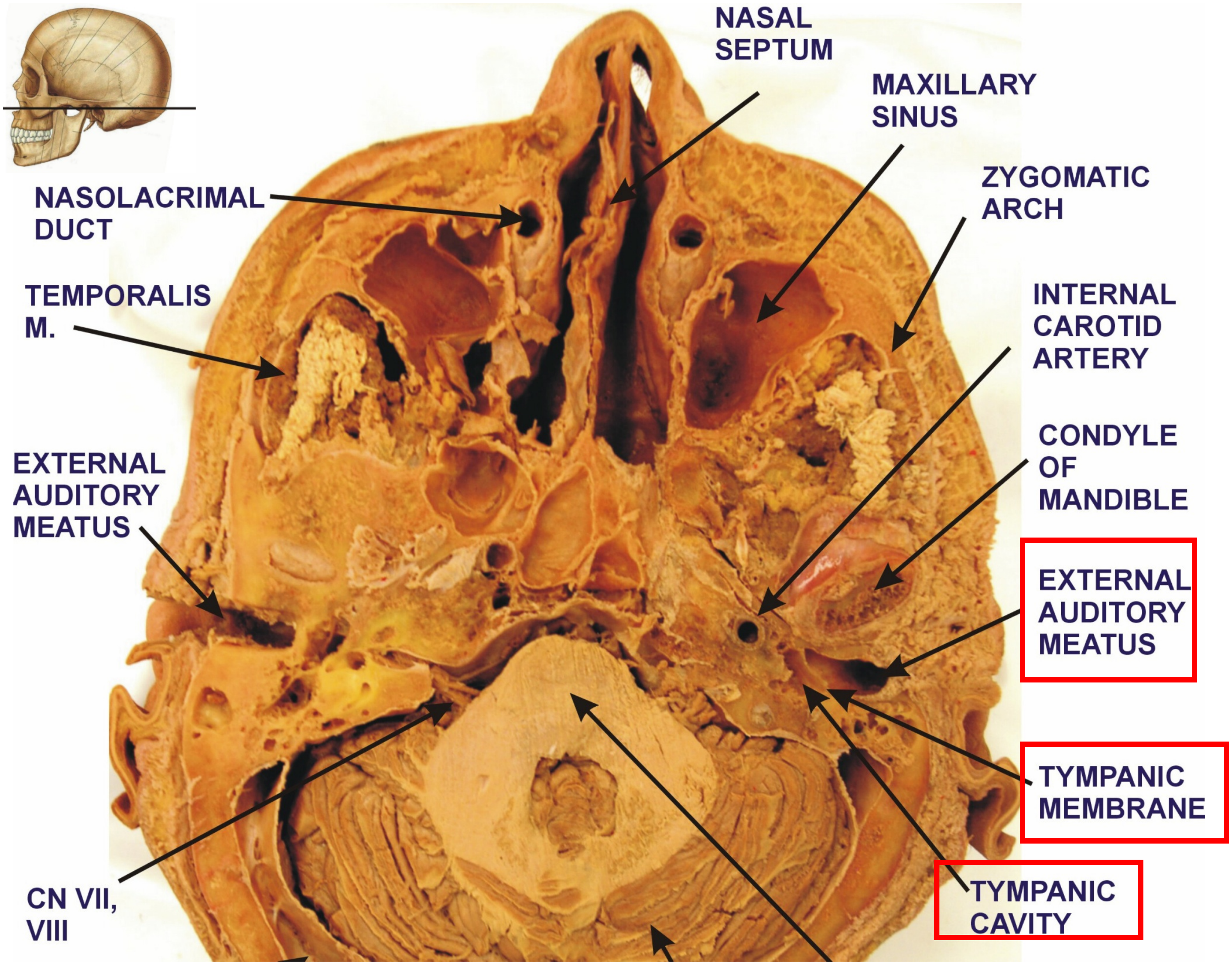
Lose taste if pierce tympanic membrane



PROSECTION 1067: EAR: HEAD CUT IN PLANE OF CT






NASAL
SEPTUM
MAXILLARY
SINUS
ZYGOMATIC
ARCH
NASOLACRIMAL
DUCT
TEMPORALIS
M.
INTERNAL
CAROTID
ARTERY
CONDYLE
OF
MANDIBLE
EXTERNAL
AUDITORY
MEATUS
EXTERNAL
AUDITORY
MEATUS
TYMPANIC
MEMBRANE
TYMPANIC
CAVITY
CN VII,
VIII