REFLEXES OF SPINAL AND CRANIAL NERVES

SENSORY STIMULUS → **MOTOR RESPONSE**

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

TYPICAL REFLEX

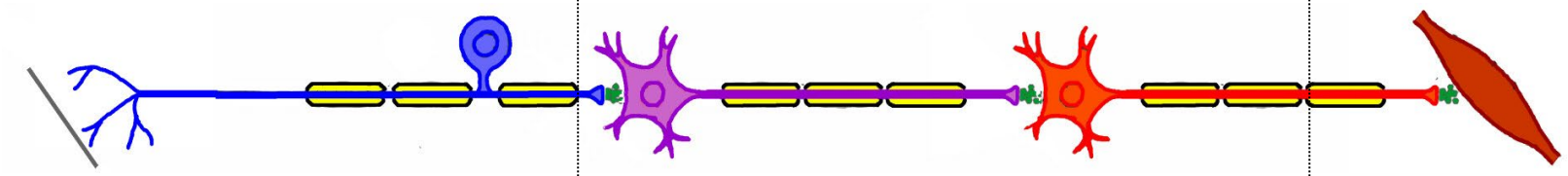
AFFERENT ARM OF REFLEX

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

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

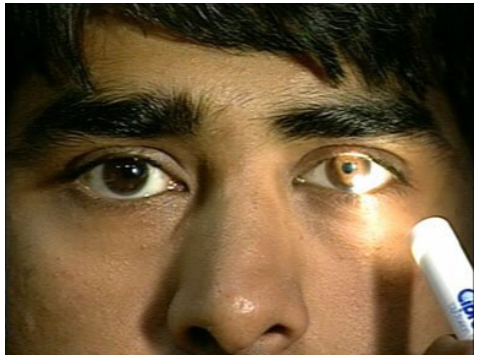
NOTE: DEEP TENDON REFLEX = STRETCH REFLEX

Reflex is evaluated according to:

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

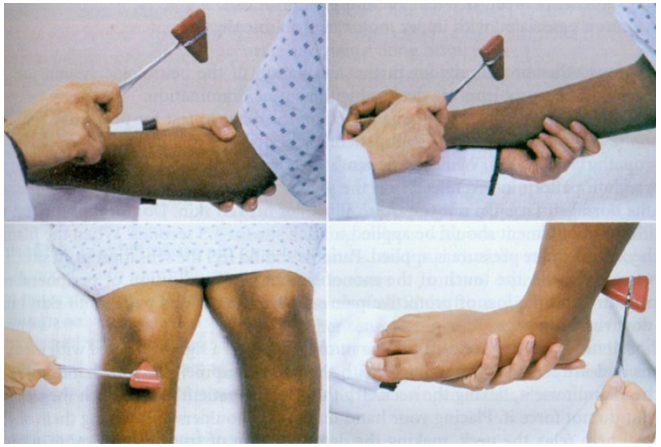
Hyper-reflexia = enhanced reflexes; in some disease processes, damage can enhance reflex responses
Clonus = series of abnormal, rapid alternating contractions and relaxations of muscle produced by single stimulus

SOME REFLEXES ARE PROTECTIVE AND CONSTANT



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

SOME REFLEXES ARE CONSTANT UNDER SAME CIRCUMSTANCES



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

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

II. SPINAL REFLEXES

Three basic reflexes:

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

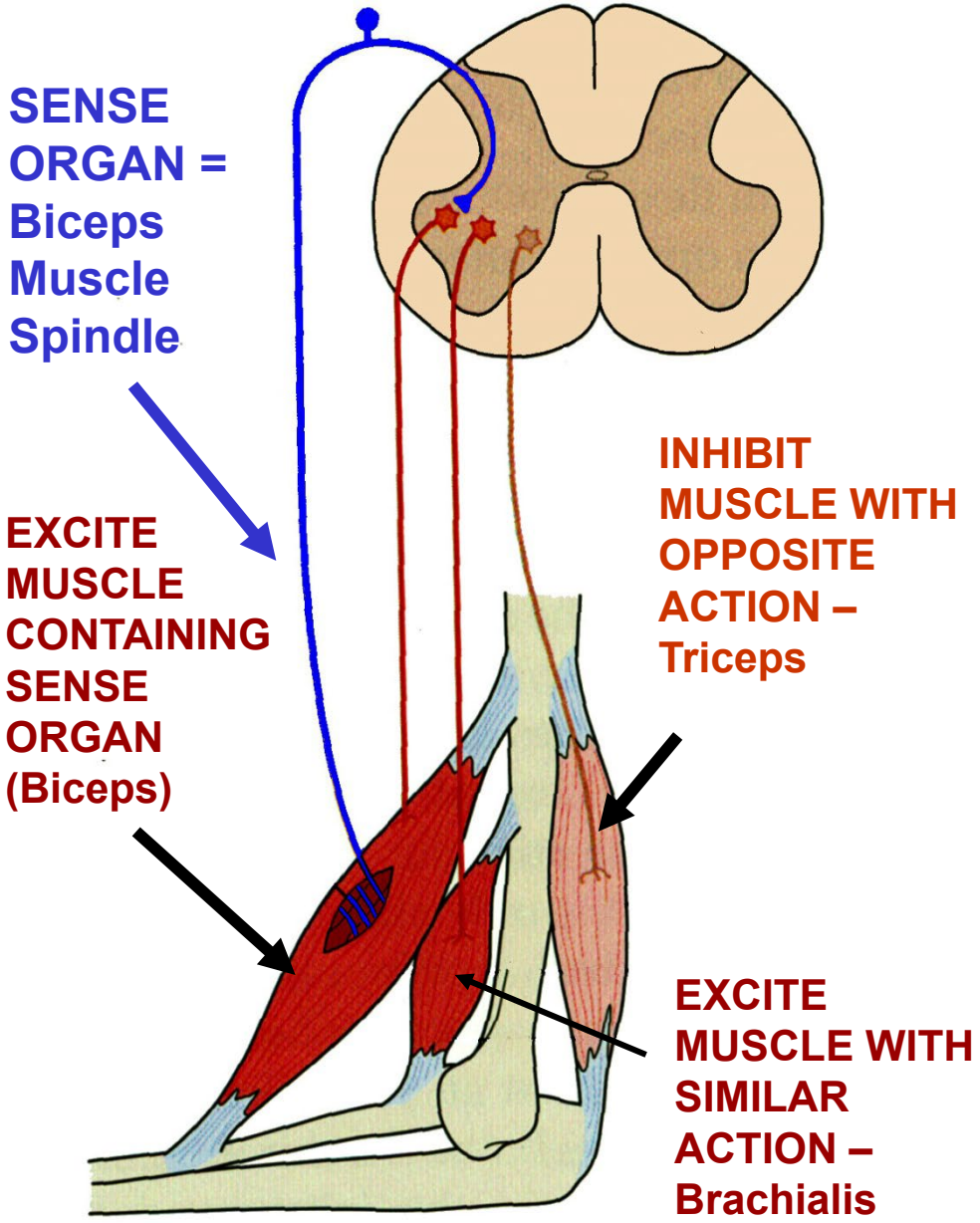
B) Autogenic inhibition - produced by activating Golgi tendon organs - aids in regulating muscle tension, prevents damage to tendon, bone

C) Flexion reflex - produced by activating Cutaneous, Pain receptors - avoid obstacle or painful stimulus (stepping on nail)

REFLEXES CAN HAVE WIDESPREAD EFFECTS

EFFECTS:

1. Excite muscle containing the sense organ;
2. Excite muscles with same action (termed Synergist muscles)
3. Inhibit muscles with opposite action (termed Antagonist 4. Some reflexes have effects in opposite limb (termed Contralateral muscles; ex. in flexor reflex, reflex causes lifting of one leg and extension in opposite leg to prevent falling.

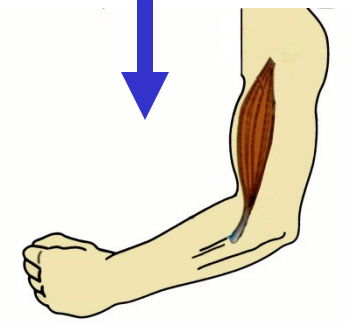


A. STRETCH REFLEX

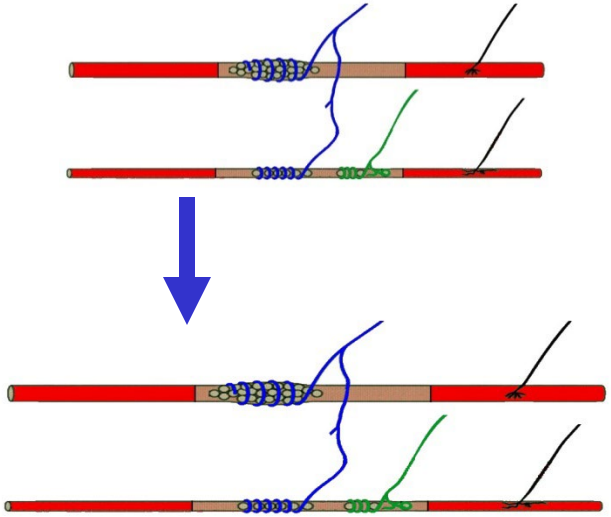
STIMULUS

RESPONSE

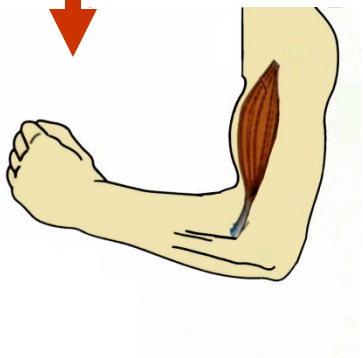
BICEPS MUSCLE STRETCHED



BICEPS MUSCLE SPINDLE



BICEPS MUSCLE CONTRACTS

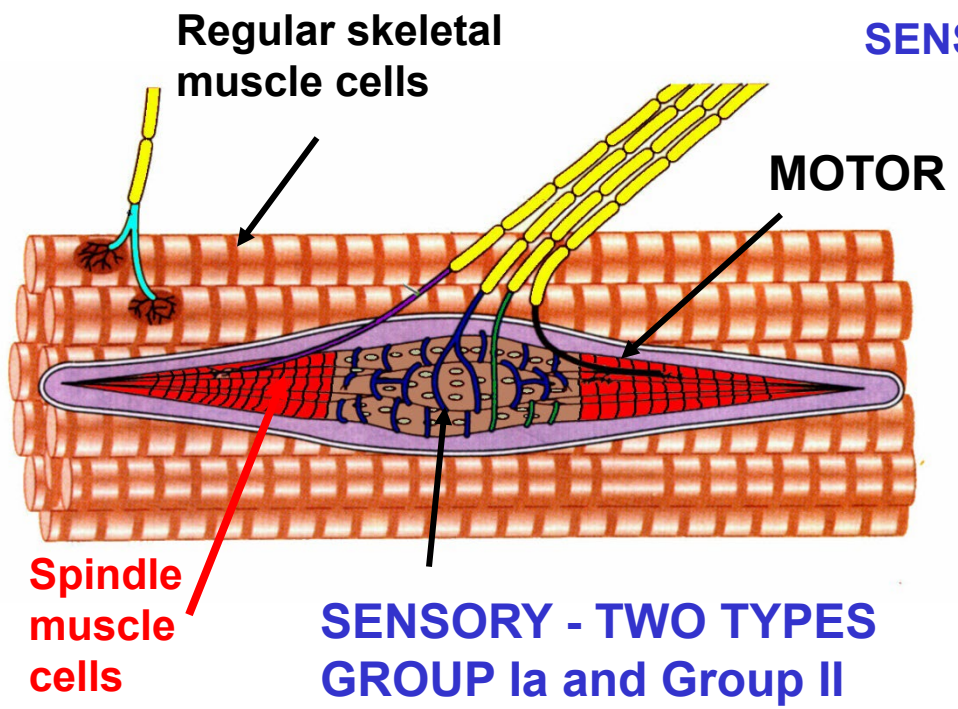


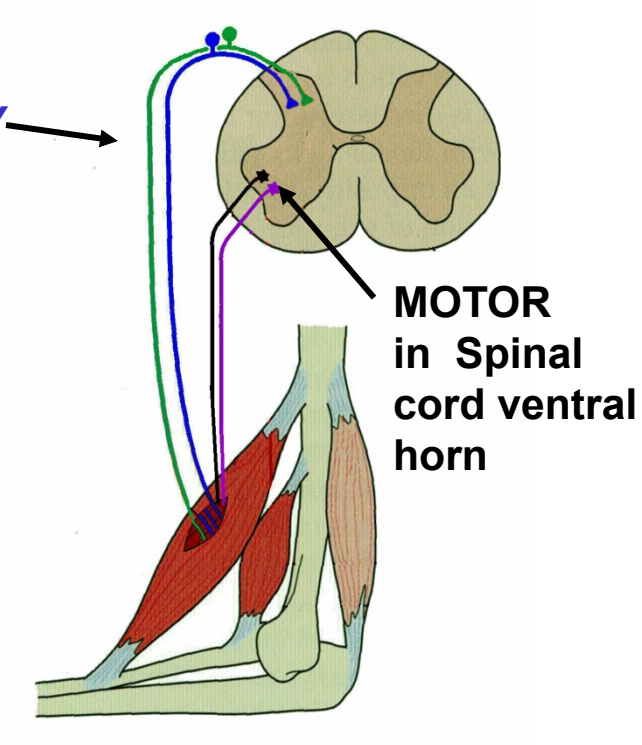
1) Stimulus - <u>fast stretch</u> of muscle

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

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

SENSORY EXCITED - MUSCLE SPINDLES - SPINDLES HAVE SENSORY AND MOTOR (GAMMA) NEURONS

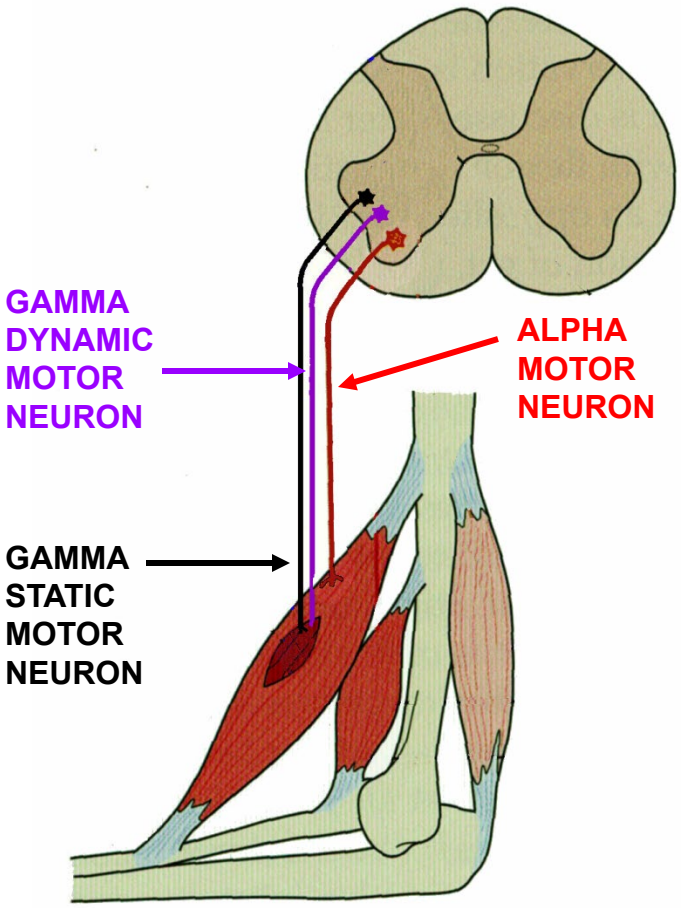


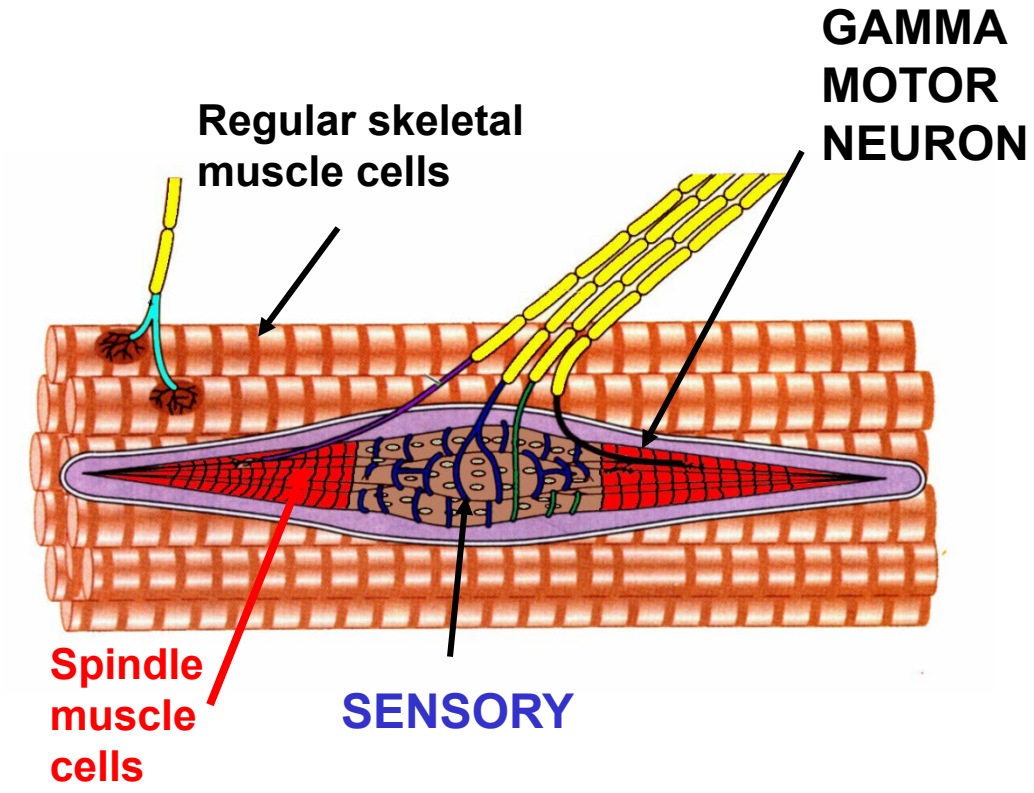


Spindle muscle cells are specialized skeletal muscle cells innervated both by Sensory neurons (cell bodies in dorsal root ganglia) and Motor neurons (cell bodies in ventral horn)

MUSCLE SPINDLES ARE STRETCHED AND SENSORY NEURONS DISCHARGE WHEN A MUSCLE IS STRETCHED

MUSCLE SPINDLES HAVE BOTH SENSORY AND MOTOR INNERVATION (GAMMA MOTOR NEURONS);





Gamma motor neurons innervate only muscle cells in muscle spindles, not regular skeletal muscle cells (alpha motor neurons);
Gamma motor neurons can adjust sensitivity of muscle spindles to stretch (nervous patient shows exaggerated stretch reflexes).

GAMMA DYNAMIC MOTOR NEURONS CAN ENHANCE SENSITIVITIES OF SPINDLE SENSORY NEURONS

Gamma motor neuron activity is increased in anticipation of perturbations (ex. walking on a thin rope)

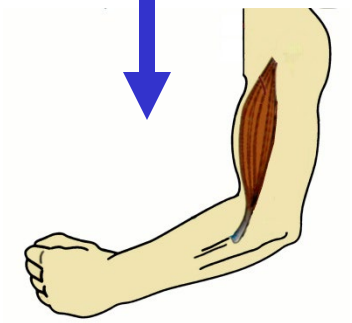
Gamma motor neuron activity is increased (probably) in patients who are nervous.

STIMULUS

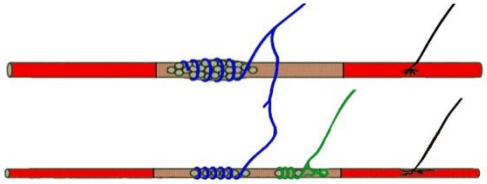
A. STRETCH REFLEX

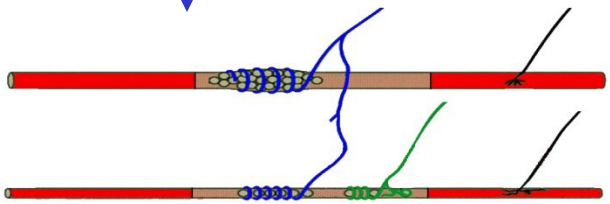
RESPONSE

BICEPS MUSCLE STRETCHED



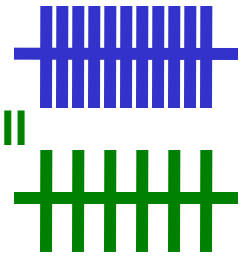
BICEPS MUSCLE SPINDLE



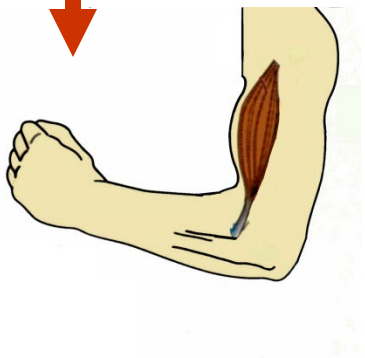


Ia

II



BICEPS MUSCLE CONTRACTS

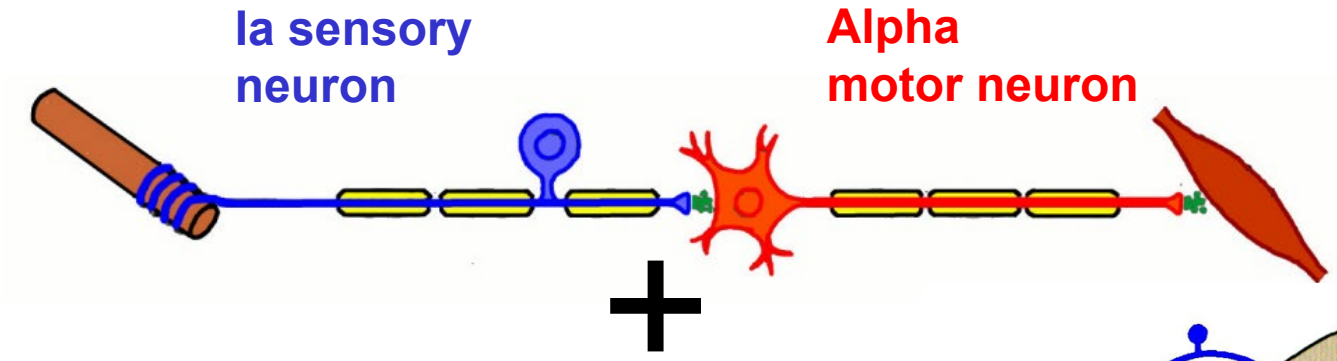


1) Stimulus - <u>fast stretch</u> of muscle

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

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

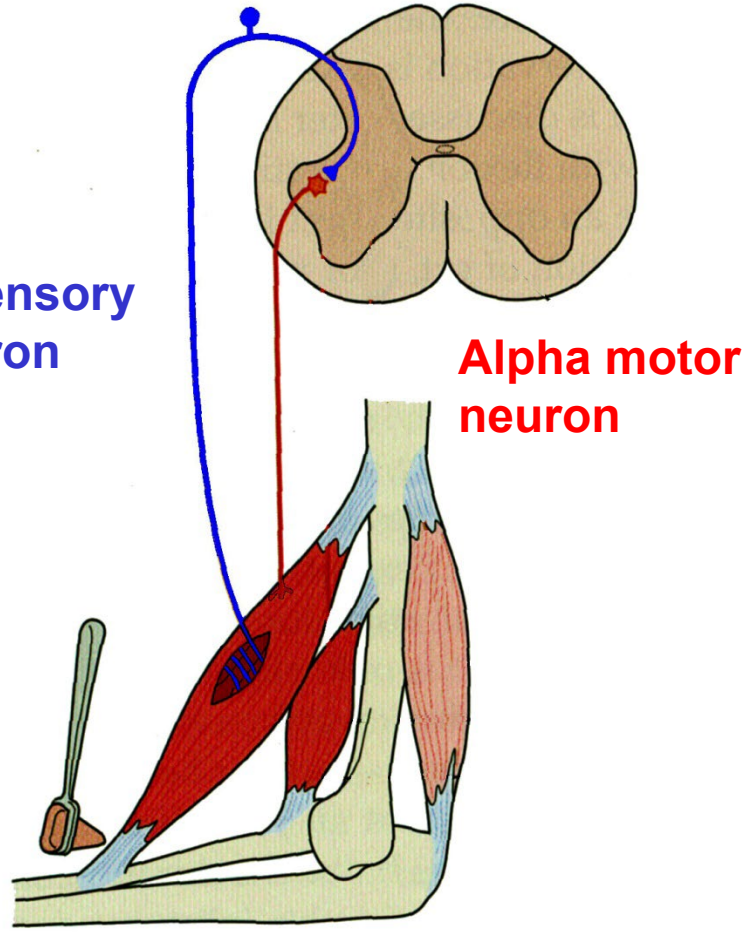
EFFECT ON MUSCLE: MONOSYNAPTIC CONNECTION



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

Group II – signal positioin (amount of stretch) response weaker make 1) monosynaptic and 2) polysynaptic (through interneuron)

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



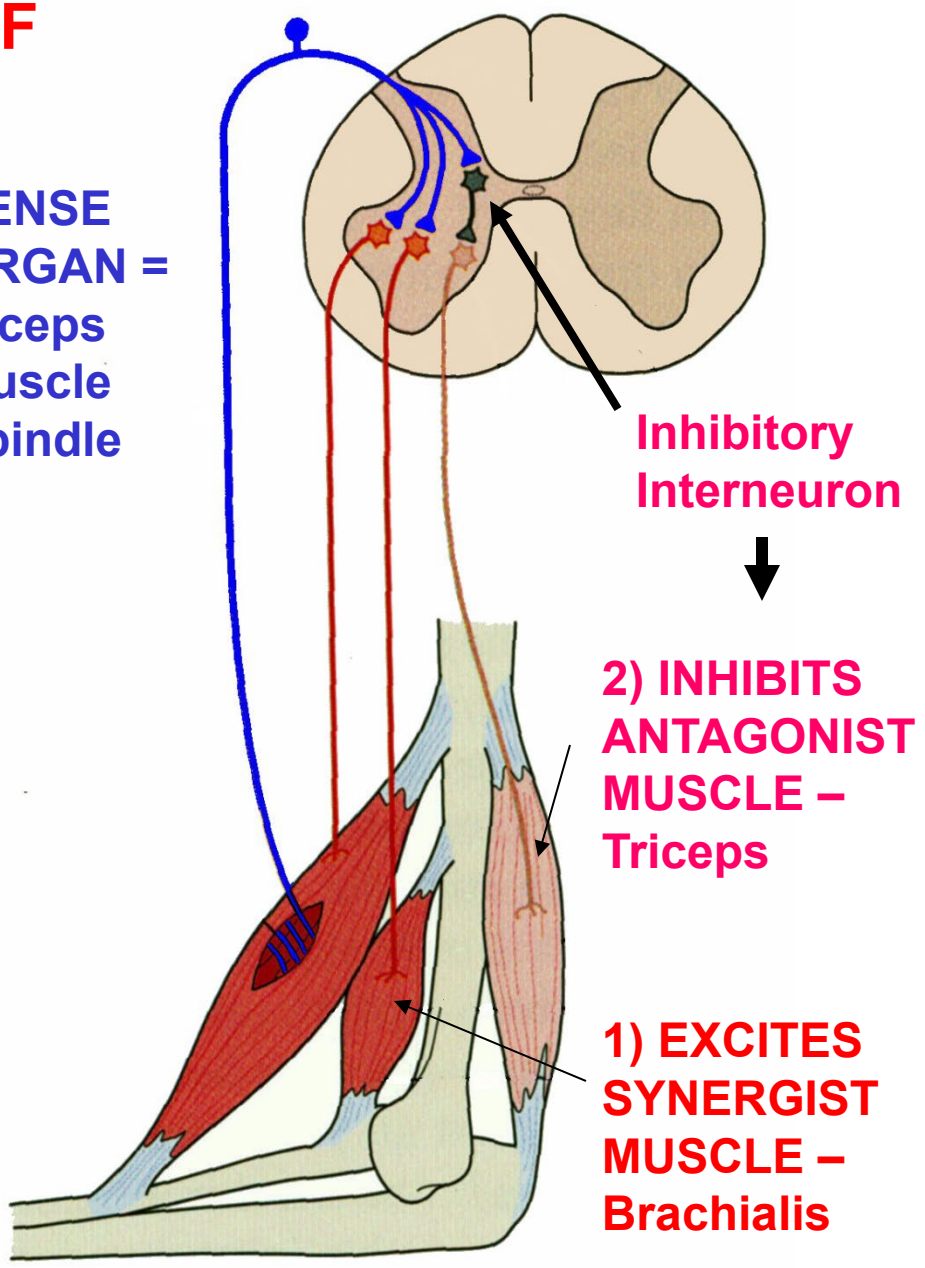
OTHER COMPONENTS OF STRETCH REFLEX

**

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.

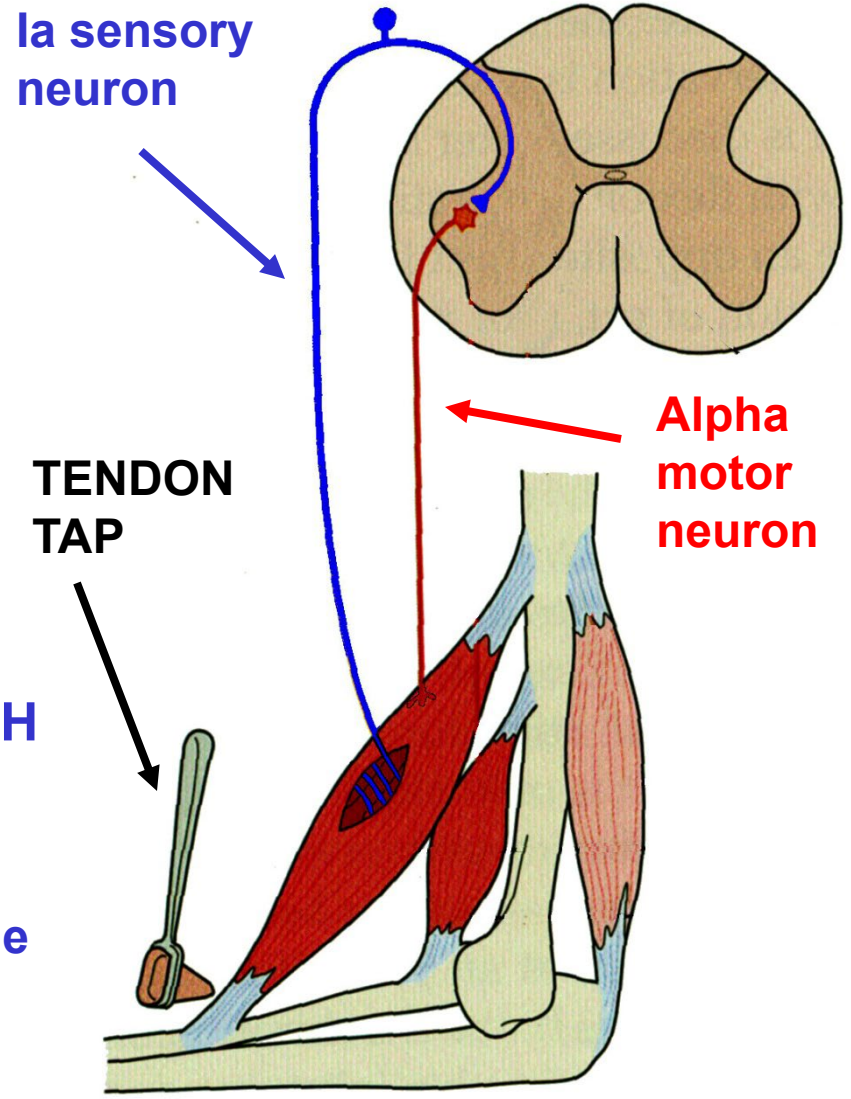
2- Eliminating activity of spindles can decrease motor neuron firing producing decreased tonus.

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



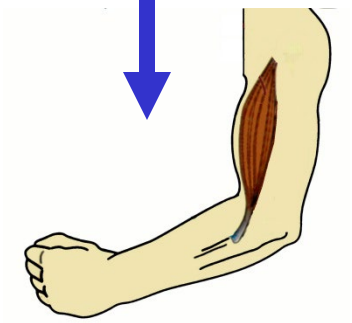
Spasticity/Rigity – Increased tonus occurs after Upper Motor Neuron Lesion (ex. stroke); due to loss of modulation of reflex

STIMULUS

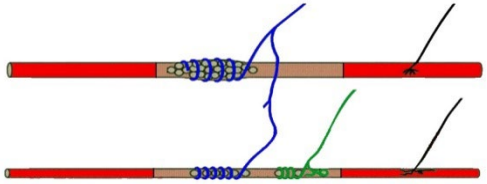
A. STRETCH REFLEX

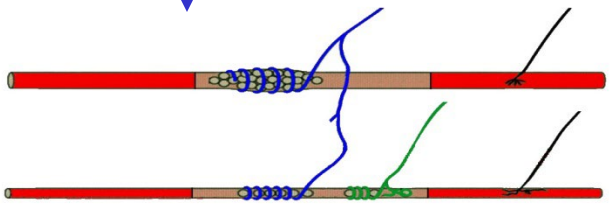
RESPONSE

BICEPS MUSCLE STRETCHED



BICEPS MUSCLE SPINDLE





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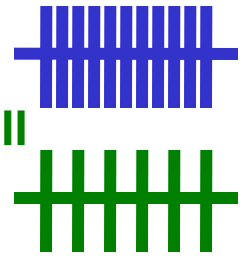
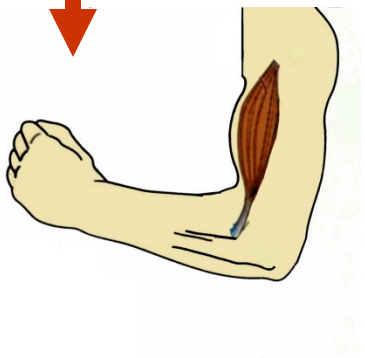


BICEPS MUSCLE CONTRACTS



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

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

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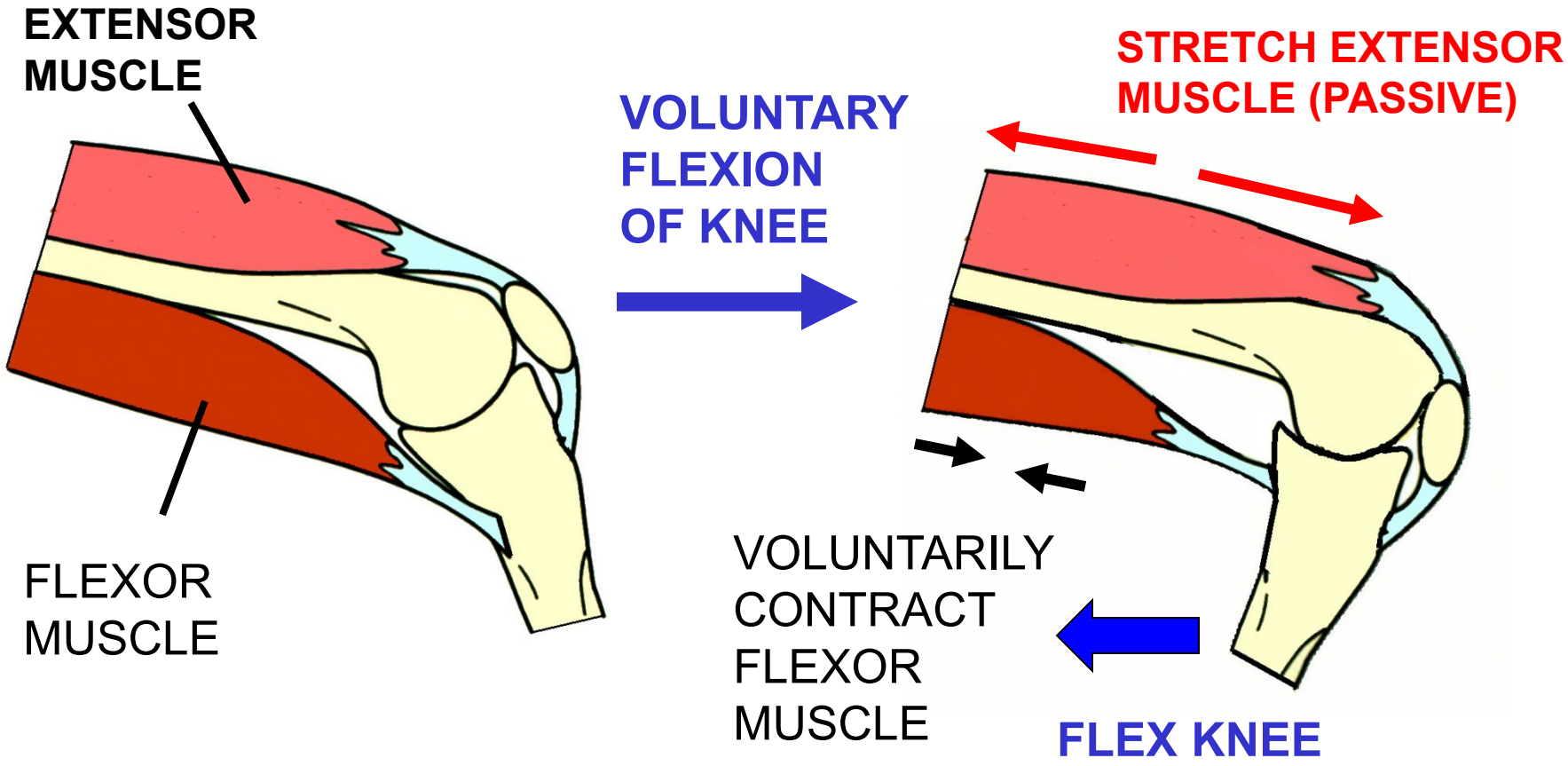
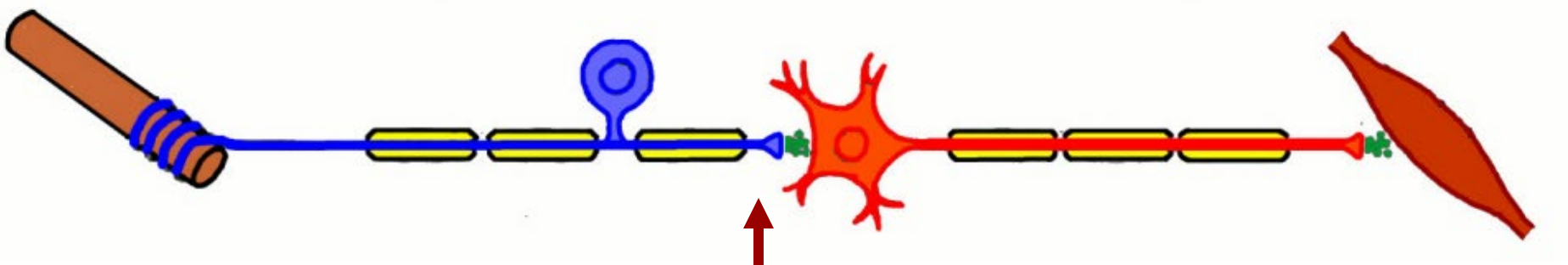
REFLEXES MUST BE MODIFIED DURING VOLUNTARY MOVEMENTS



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

- Therefore, <u>stretch reflexes can be modified</u> in some muscles during voluntary movements

MODIFICATION OF REFLEXES: MECHANISMS



Pre-synaptic inhibition

Change excitability of motor neuron by other excitatory or inhibitory inputs

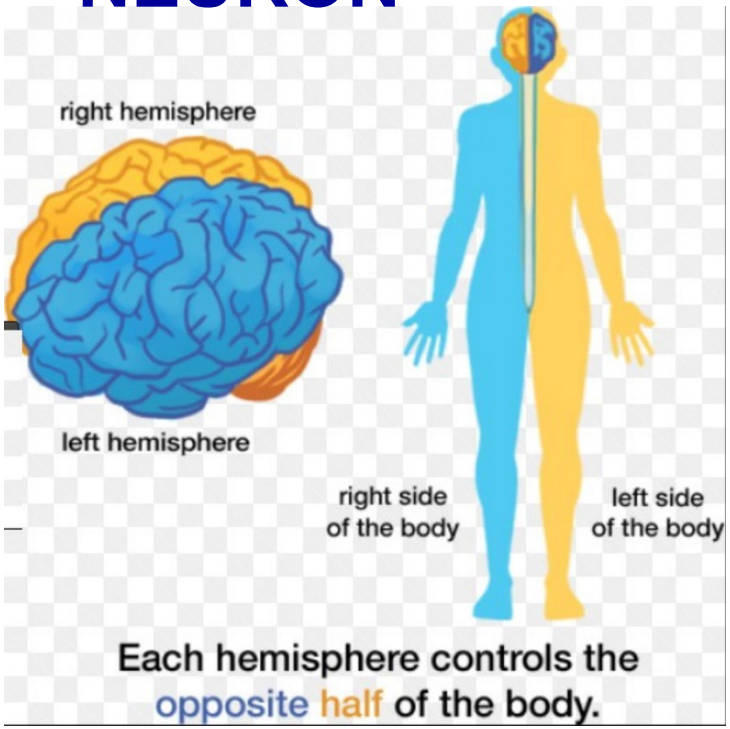
1- Reflexes can be modulated by

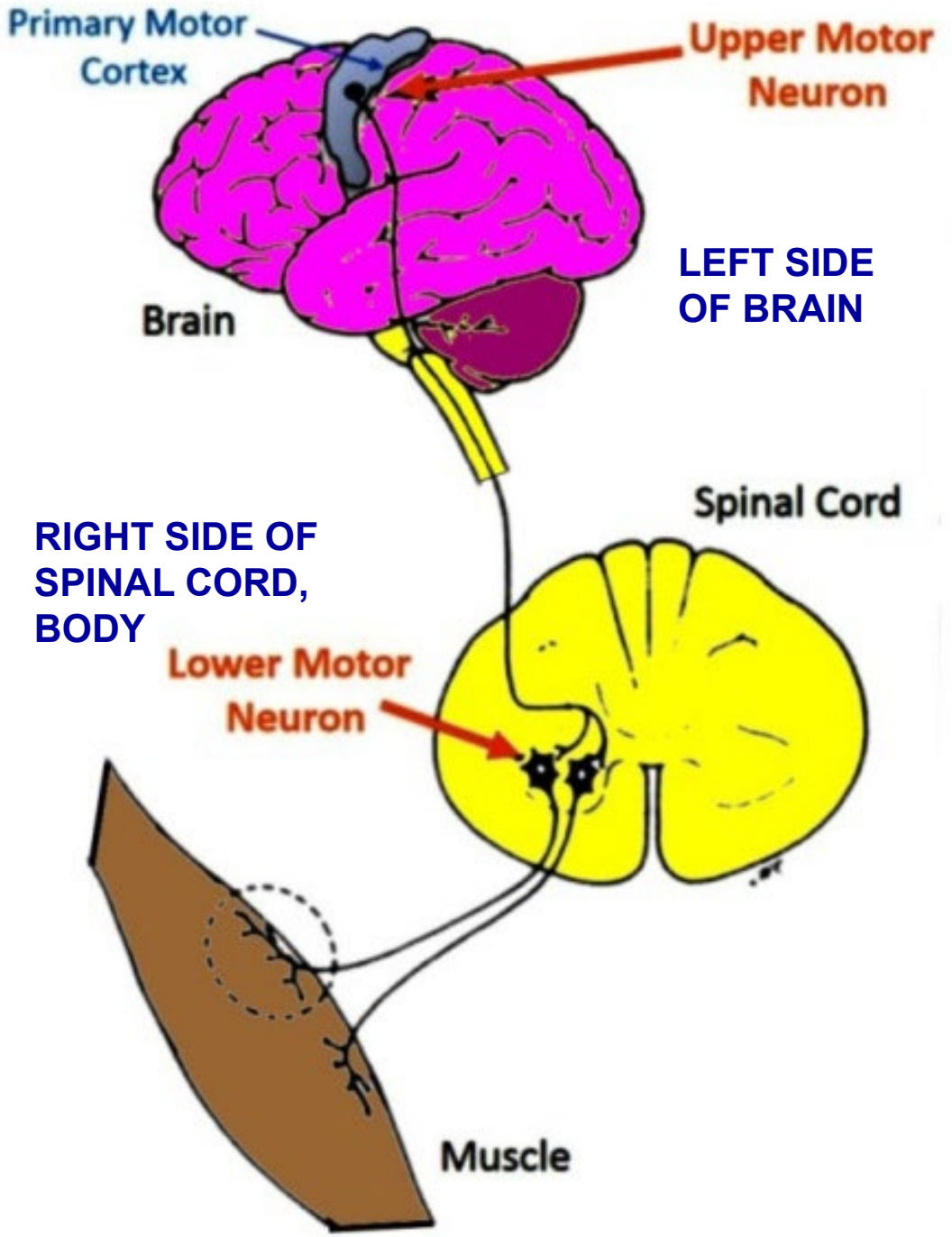
1) Gamma motor neurons – change muscle spindle sensitivity

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.

REMINDER: UPPER VS LOWER MOTOR NEURON



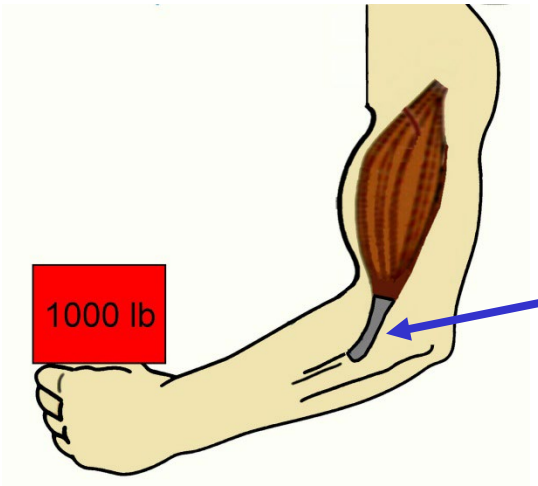


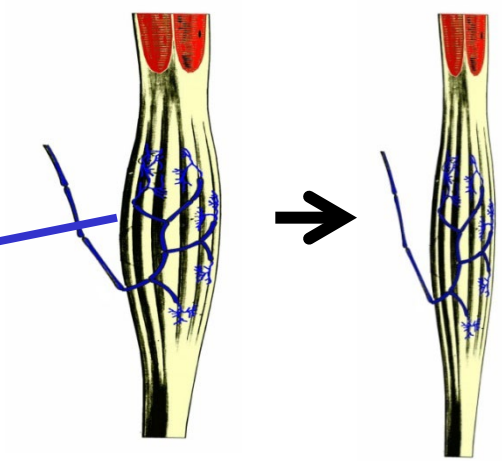
HYPERREFLEXIA: INCREASED STRETCH REFLEX ON ONE SIDE [used by permission of Paul D. Larsen, M.D., University of Nebraska Medical Center; http://library.med.utah.edu/neurologicexam]

Camillo Golgi (1843-1926)

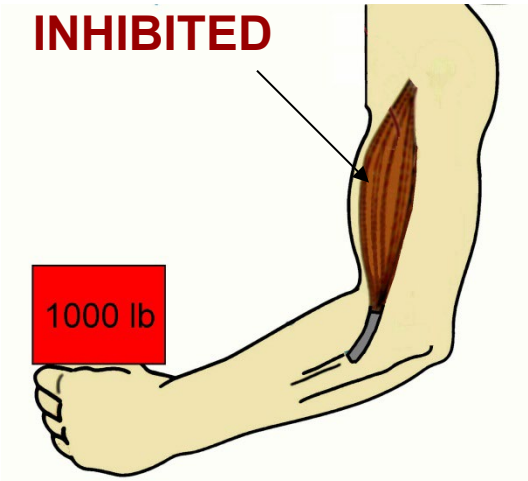
excellent mustache

B. AUTOGENIC INHIBITION





MUSCLE TENSION INHIBITED

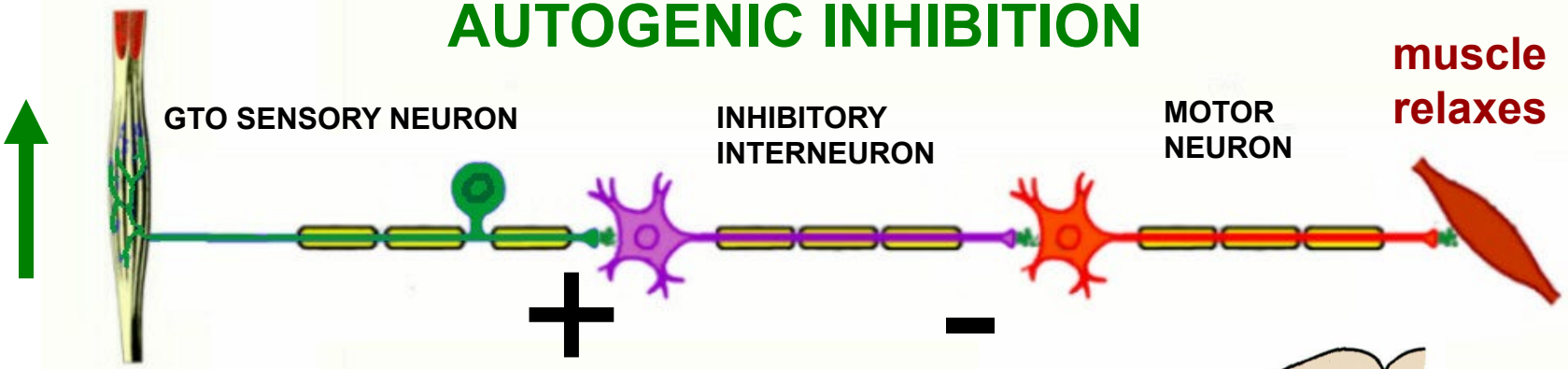


1) Stimulus - Large force exerted on muscle tendon

2) Sense organ excited - Golgi tendon organs - located in muscle tendon, signal FORCE

3) Primary response - muscle attached to tendon relaxes

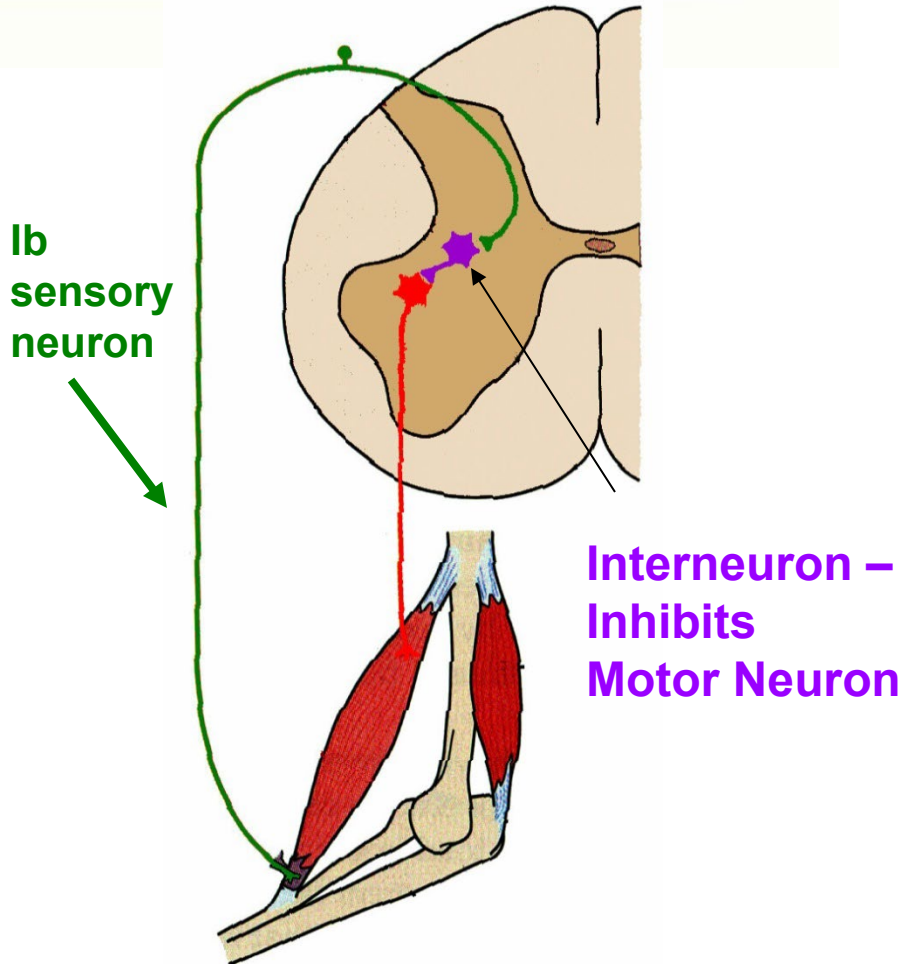
AUTOGENIC INHIBITION



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 -

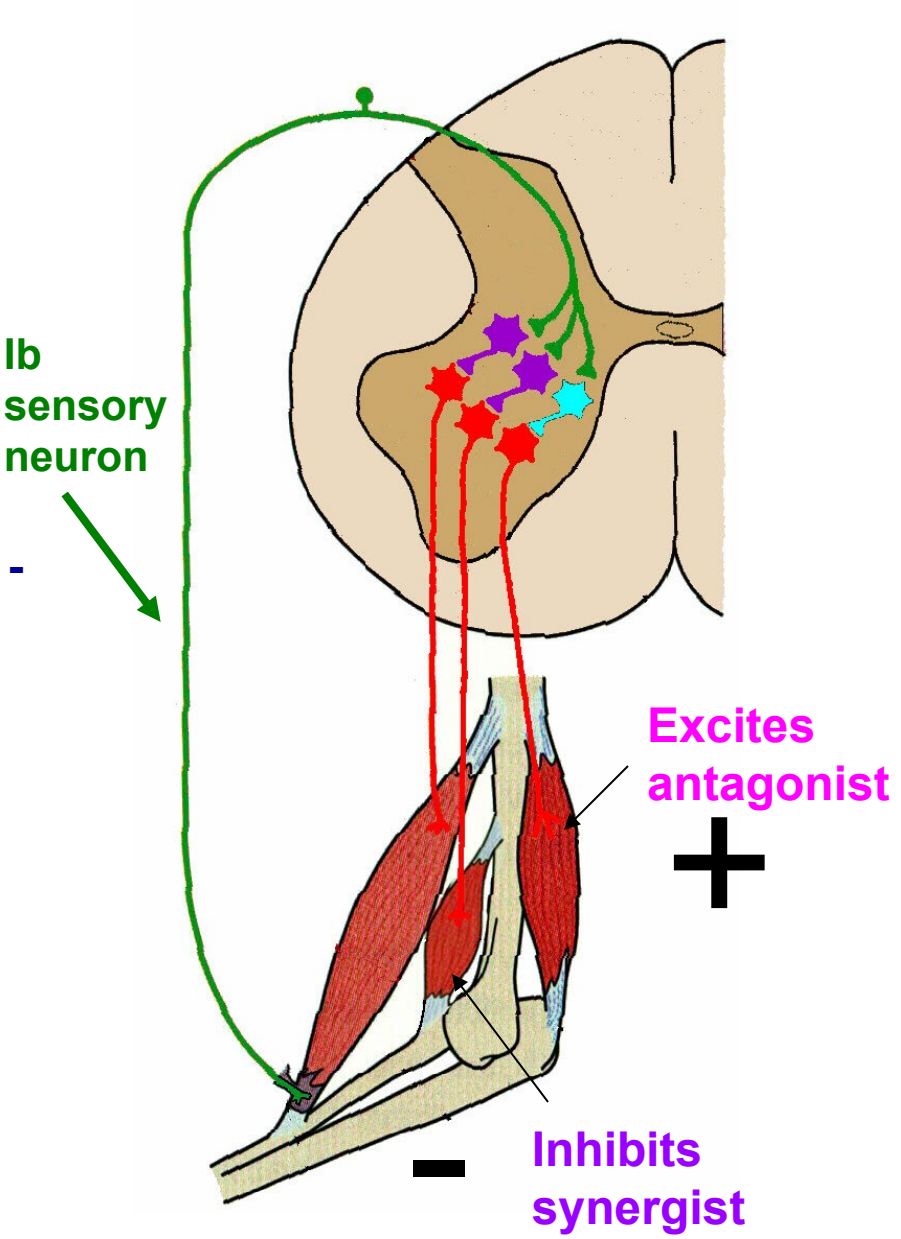
GTO makes excitatory synapse on interneuron; interneuron makes inhibitory synapse on motor neurons to synergist muscle

b. Excites antagonist muscles -

GTO makes excitatory synapse on interneuron; interneuron makes excitatory synapse on motor neurons to antagonist muscles

CLASPED KNIFE REFLEX: in

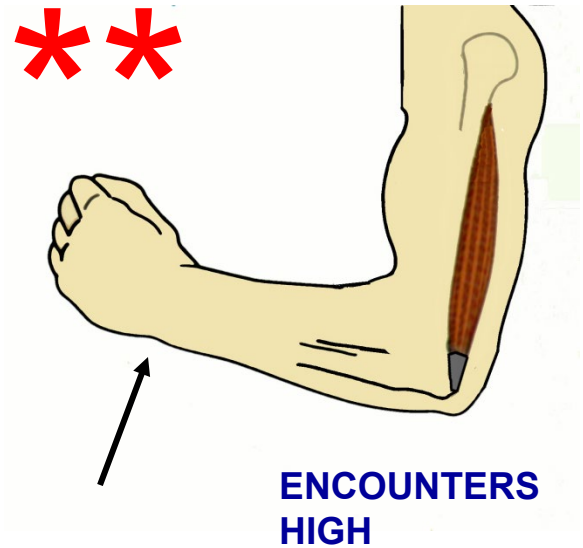
Upper motor neuron lesions, tonus increases, resistance to stretch increases; if sufficient force is applied, limb resistance suddenly decreases (like pocket knife snapping shut)



CLASPED KNIFE REFLEX: is an example of Autogenic inhibition.

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

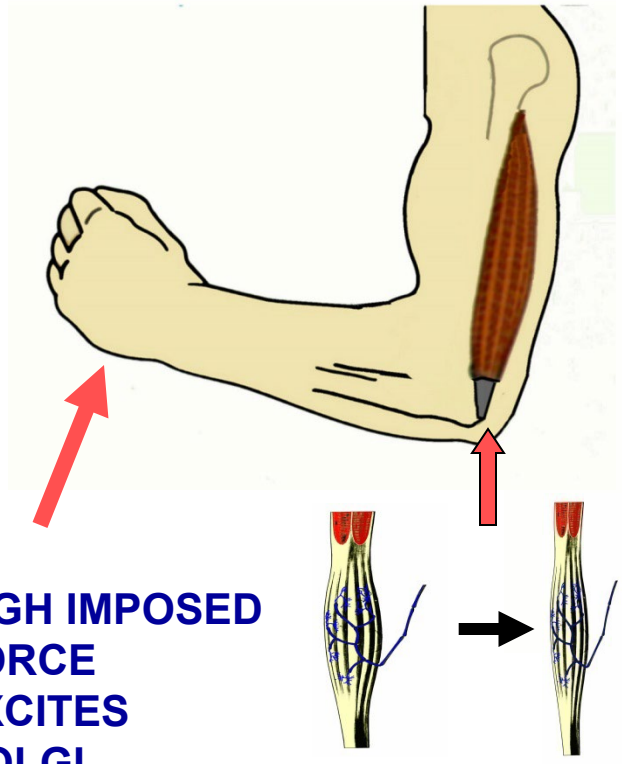
1) PHYSICIAN TRIES TO FLEX ELBOW JOINT OF PATIENT WITH UPPER MOTOR NEURON LESION



PHYSICIAN HOLDS WRIST AND PUSHES HERE AFTER TELLING PATIENT TO RELAX

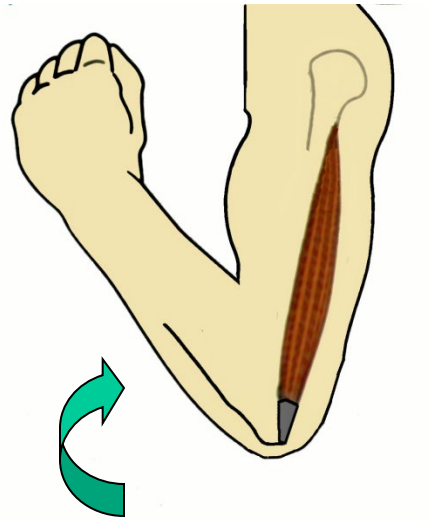
ENCOUNTERS HIGH RESISTANCE DUE TO HIGH TONUS IN TRICEPS AND HIGH STRETCH REFLEXES

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

AUTOGENIC INHIBITION AND FORCE REGULATION

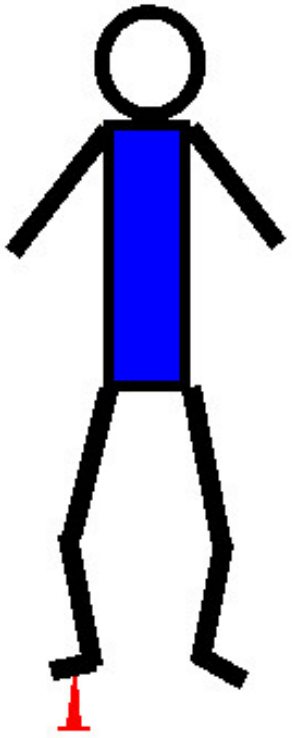
1- Regulating muscle tension - forces developed by contractions of muscles are automatically controlled so that they do not cause damage to tendons (ex. lifting heavy object).

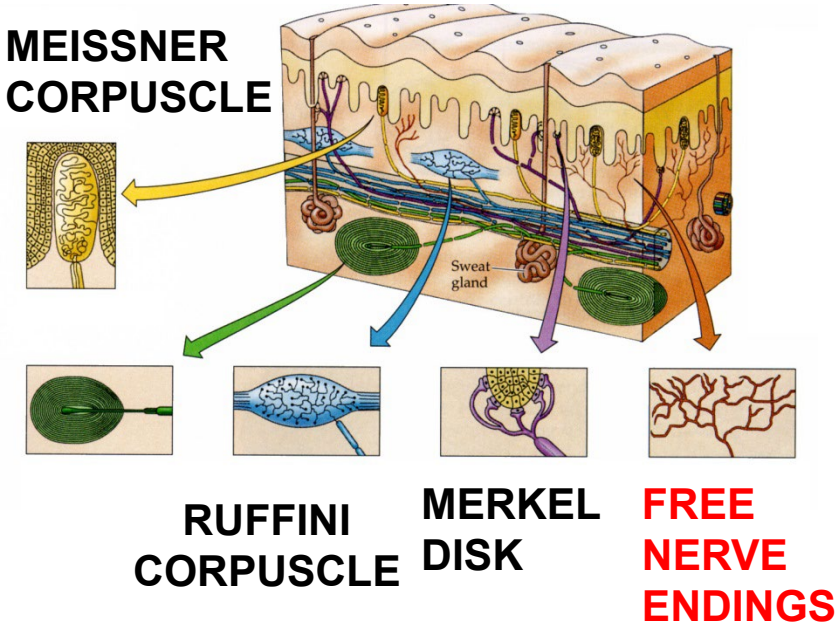
2- Regulation of force during other behavior is more complex (ex. walking) –

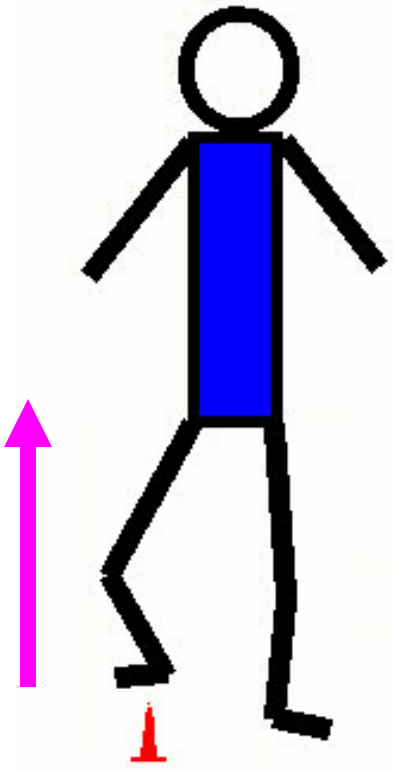
Connections for autogenic inhibition may be inactivated during walking

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

C. FLEXOR REFLEX





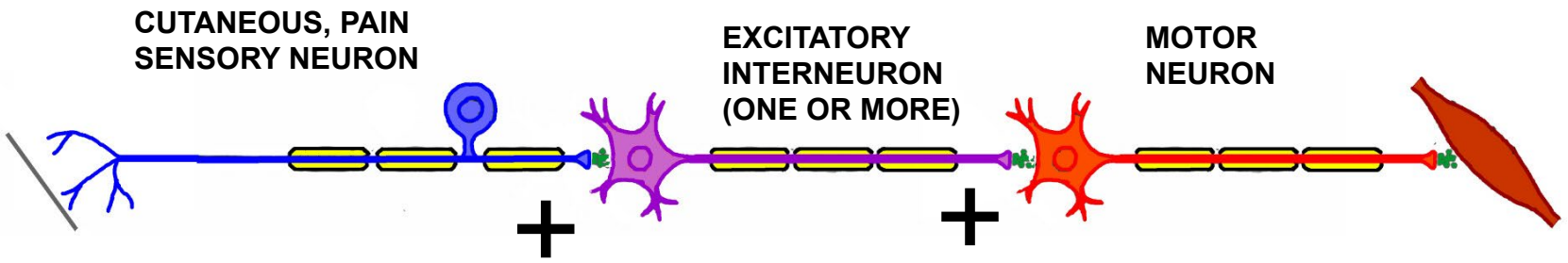


1) Stimulus - painful or noxious stimulus (stepping on nail)

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

3) Primary response - Protective withdrawal of limb

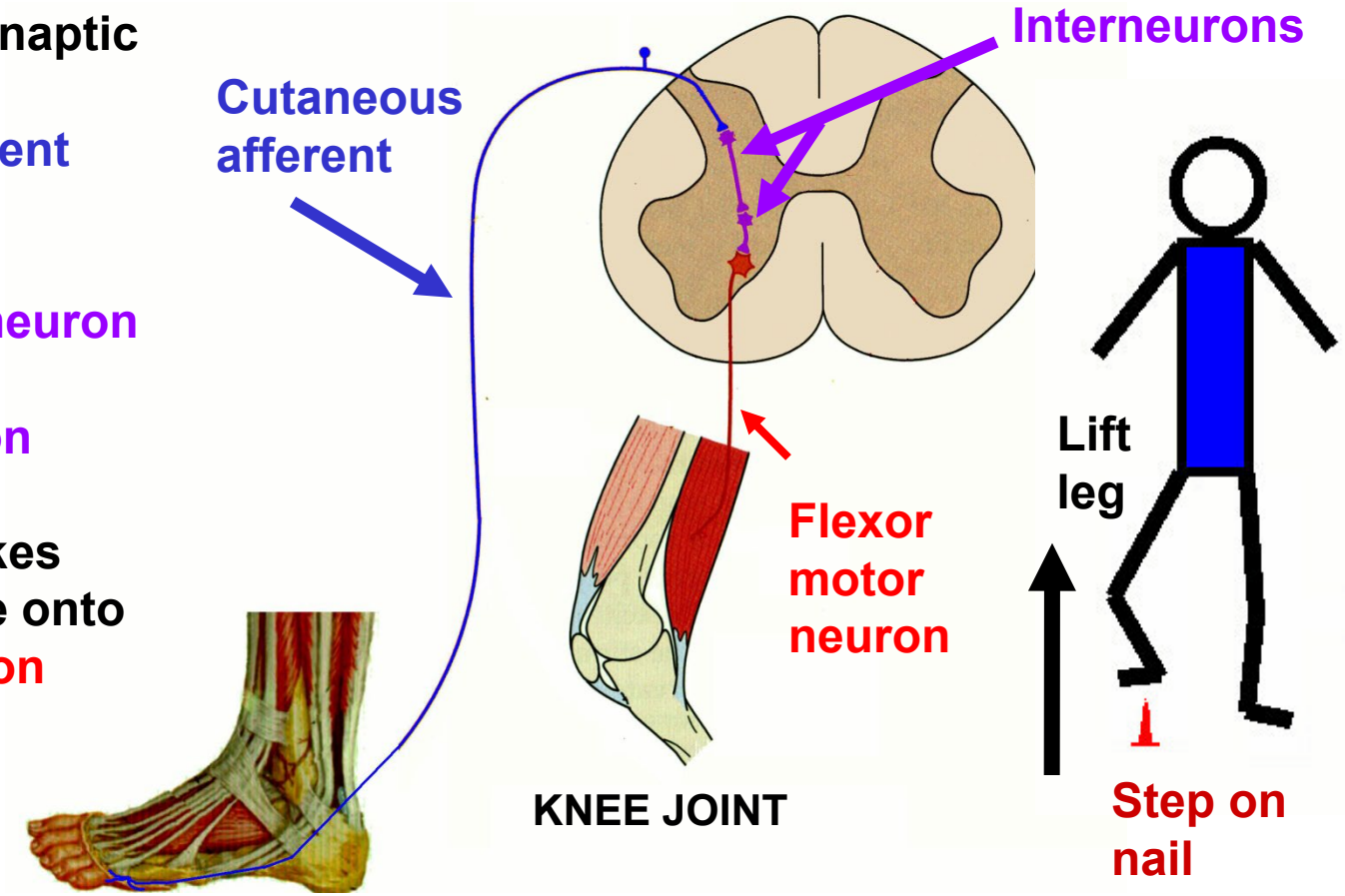
FLEXOR REFLEX: PATHWAYS



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



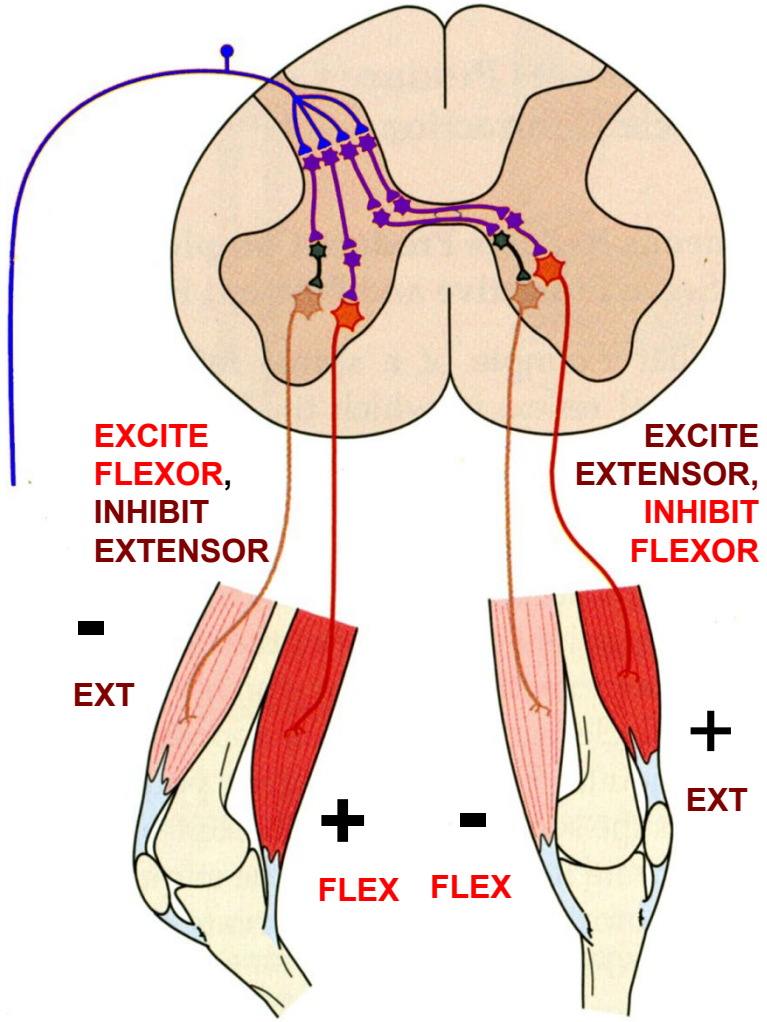
FLEXOR REFLEX: OTHER EFFECTS
ALL ARE POLYSYNAPTIC BY INTERNEURONS

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

**



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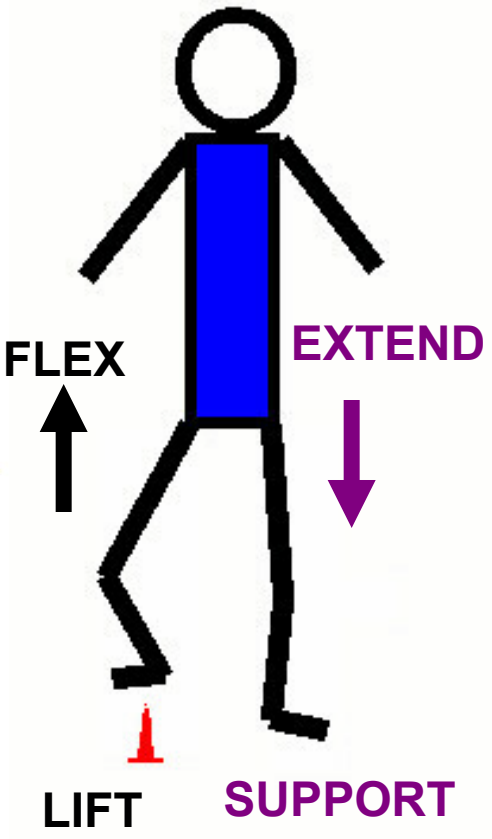


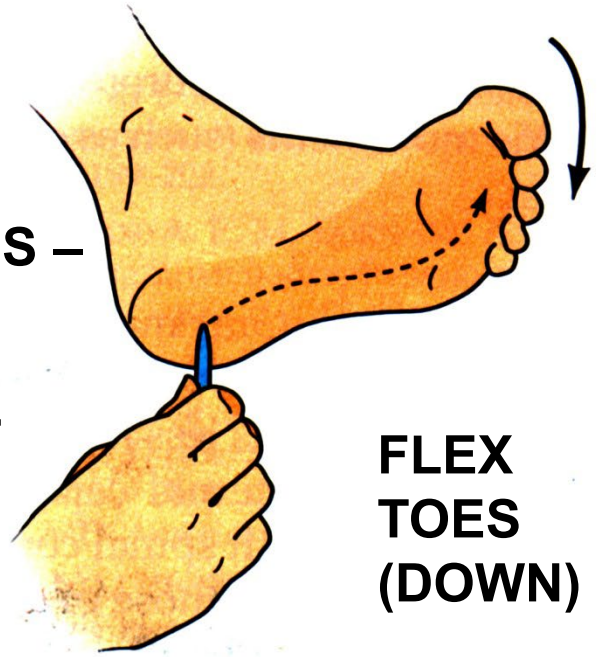
FUNCTION: OTHER LEG PROVIDES SUPPORT WHEN FIRST LEG IS LIFTED

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

**

NORMAL RESPONSE

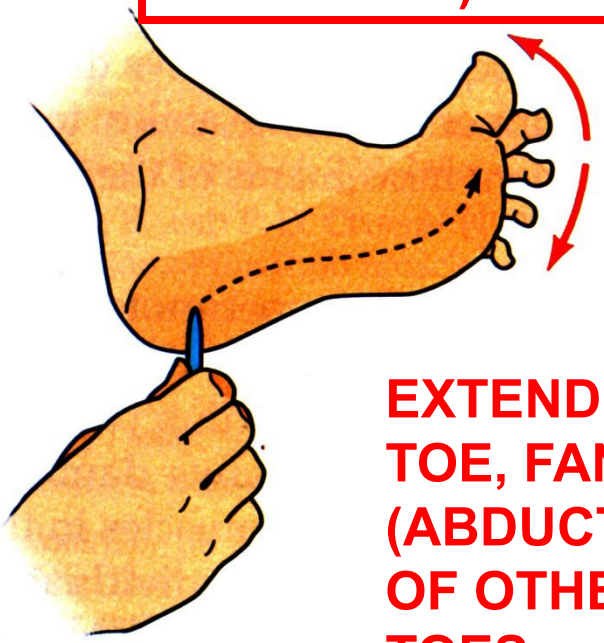
STIMULUS – TO SKIN OF SOLE OF FOOT



FLEX TOES (DOWN)

**

BABINSKI SIGN – (EXTENSOR PLANTAR RESPONSE)



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

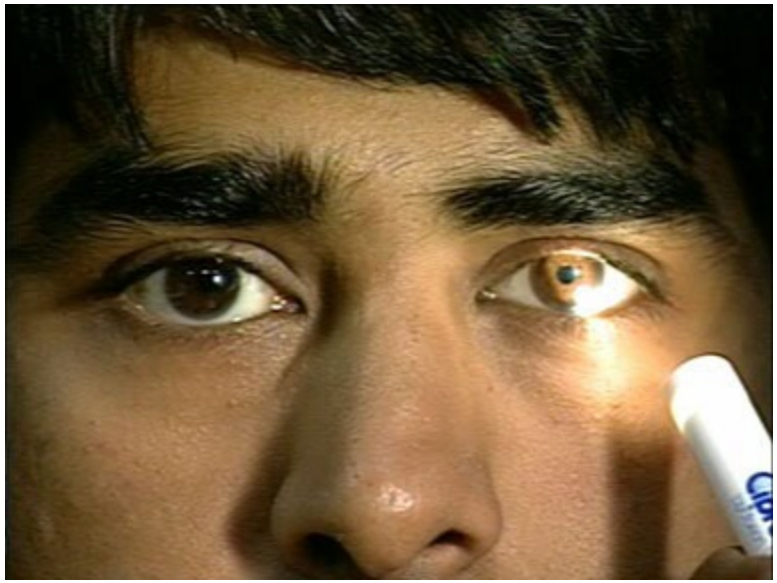
SENSORY STIMULUS

LIGHT IN EYE

EFFERENT ARM OF REFLEX

MOTOR RESPONSE

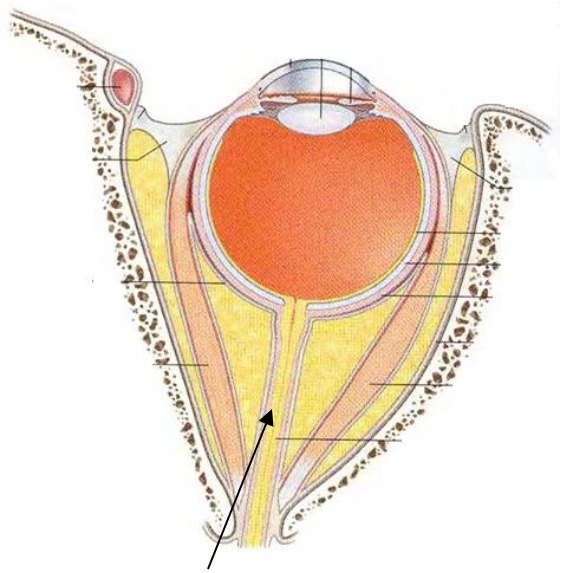
CONSTRICT PUPIL



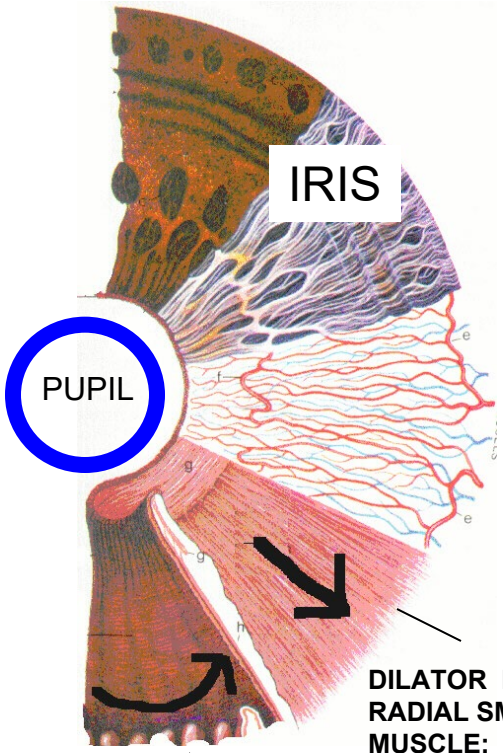
PUPILLARY LIGHT REFLEX

CN II - OPTIC NERVE - DETECTS LIGHT

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

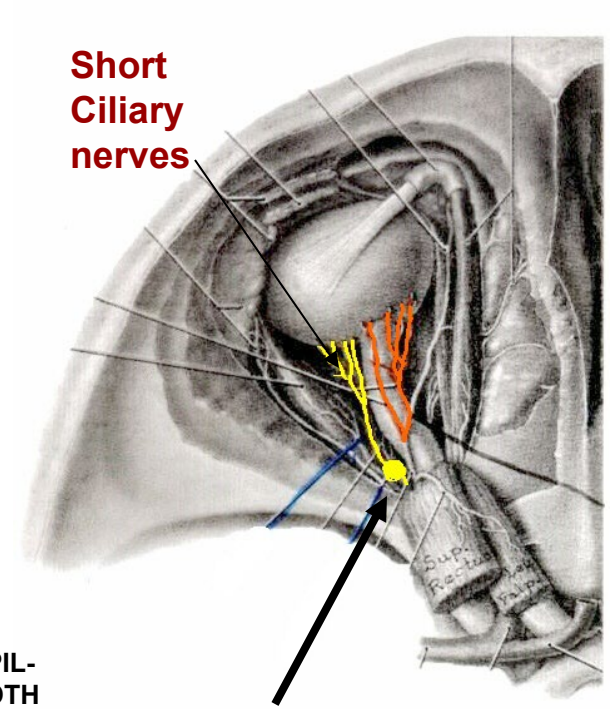


OPTIC NERVE - CN II VISION



DILATOR PUPIL- RADIAL SMOOTH MUSCLE; SYMPATHETICS

CONSTRICTOR PUPIL- CIRCULAR SMOOTH MUSCLE; PARASYMPATHETICS - CN III



Ciliary Ganglion of CN III

PUPILLARY LIGHT REFLEX

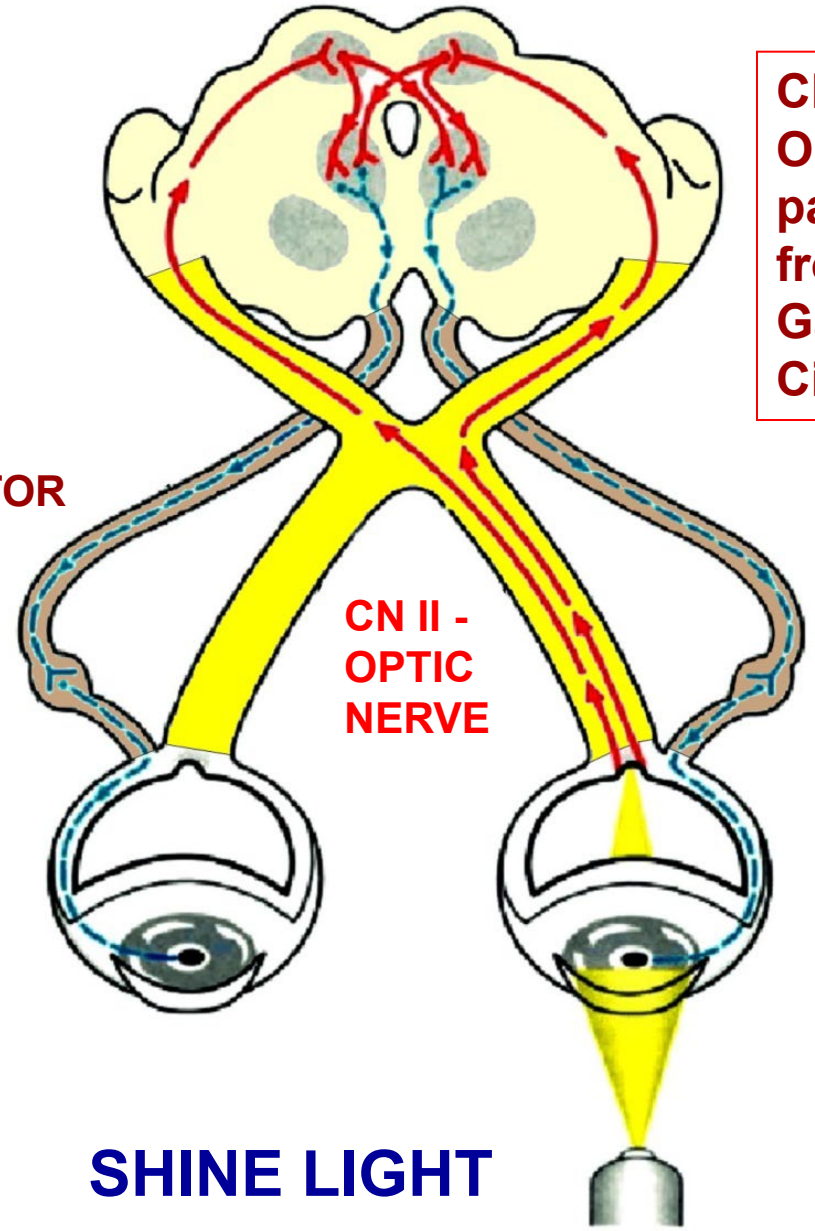
CN II - OPTIC NERVE - DETECTS LIGHT

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

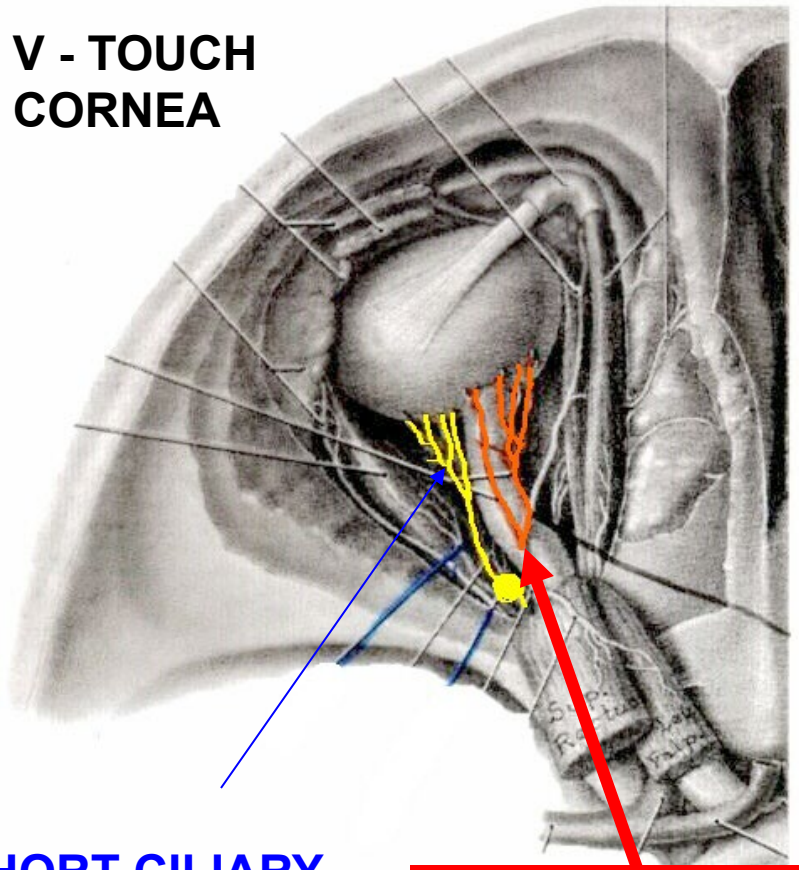
CLOSE EYELID

FACIAL - VII - MOTOR TO ORBICULARIS OCULI (SVE)

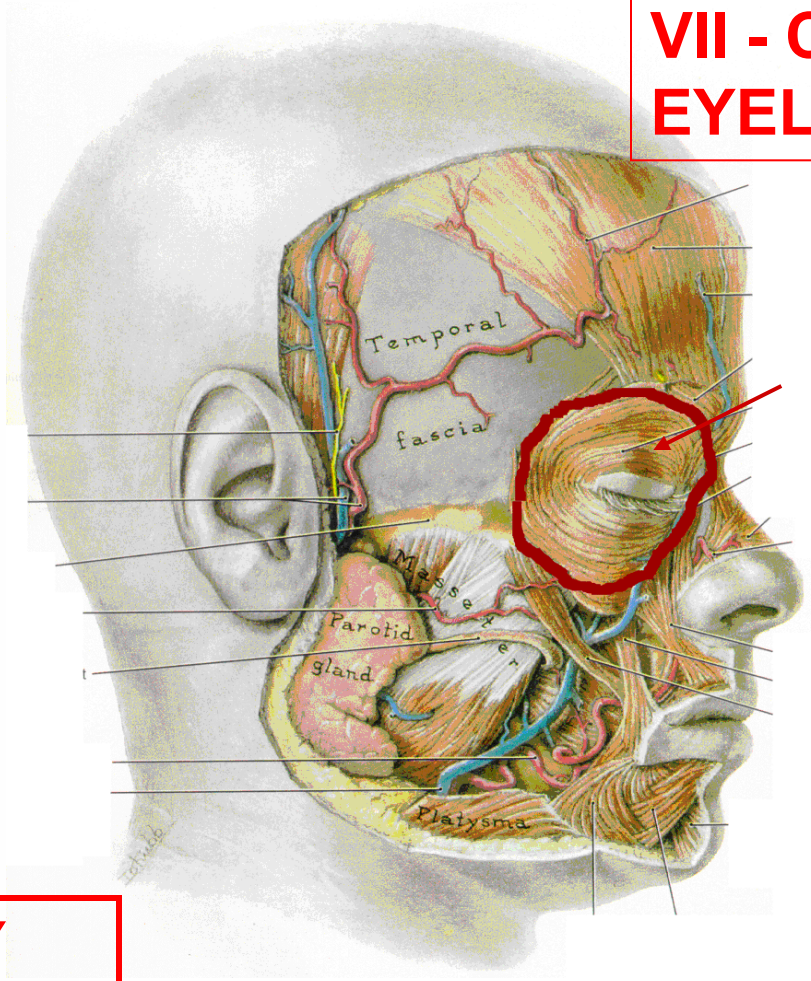
CORNEAL REFLEX - V to VII

**

V - TOUCH CORNEA



VII - CLOSE EYELID



ORBICU-LARIS OCULI M.

SHORT CILIARY NERVES (III),

CILIARY GANGLION

PARASYMPATHETIC

LONG CILIARY NERVES (V1) - SOMATIC SENSORY TO CORNEA

- 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

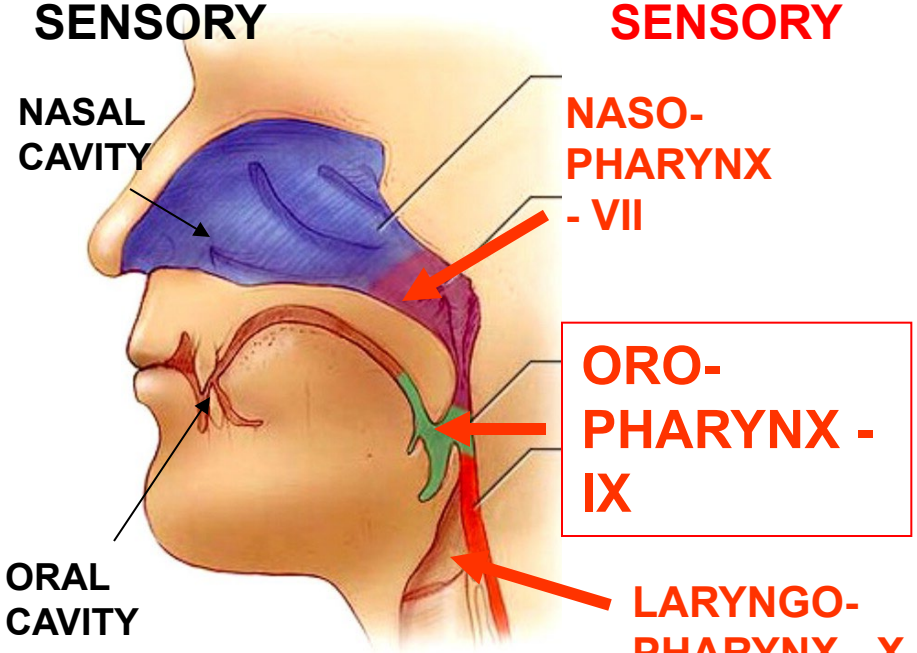
CRANIAL NERVES LECTURE

IX - SENSORY INNERVATION TO OROPHARYNX

All Pharynx is Visceral Sensory In 3 Cranial Nerves

SOMATIC SENSORY

VISCERAL SENSORY



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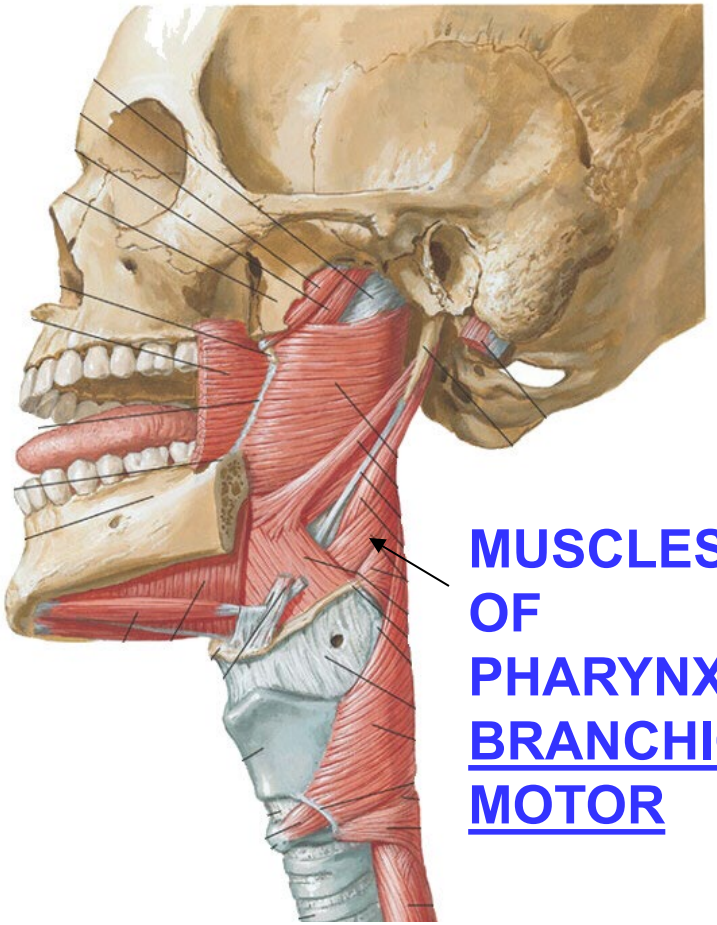
X - INNERVATES ALL MUSCLES OF PHARYNX (except Stylopharyngeus)

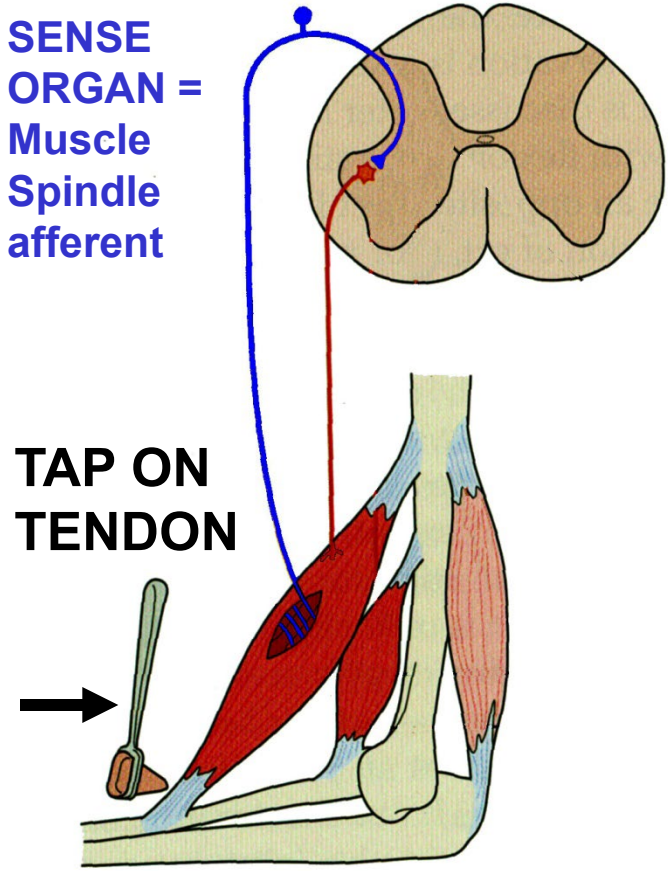


MUSCLES OF PHARYNX - BRANCHIO-MOTOR

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

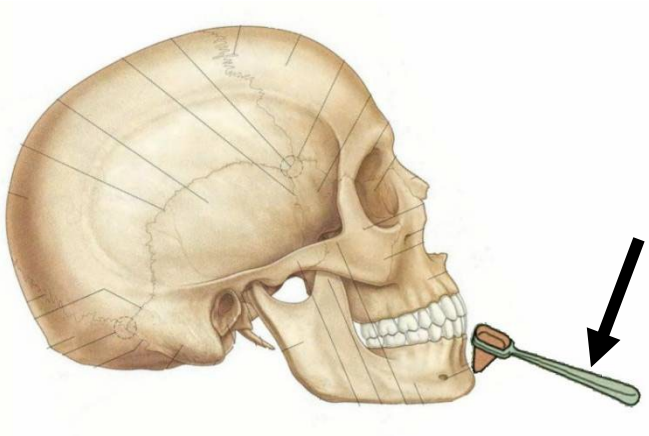
4. STRETCH REFLEX OF MUSCLES OF MASTICATION
- JAW JERK REFLEX - sensory and motor in Trigeminal V3

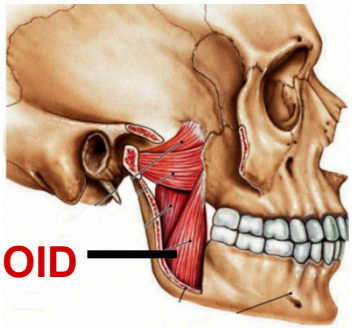
STRETCH REFLEX



STRETCH REFLEX IN MUSCLES OF MASTICATION

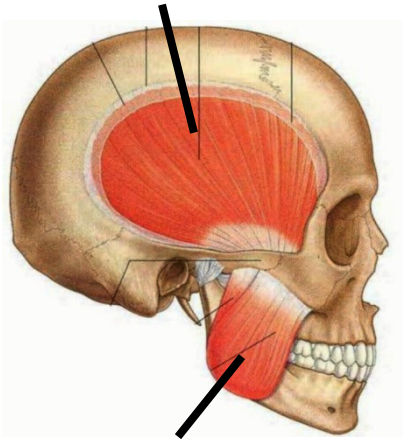
TAP DOWN ON CHIN





STRETCH MUSCLES THAT CLOSE MOUTH (ELEVATE MANDIBLE)

TEMPORALIS



TEST FUNCTION OF TRIGEMINAL NERVE (V3)

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