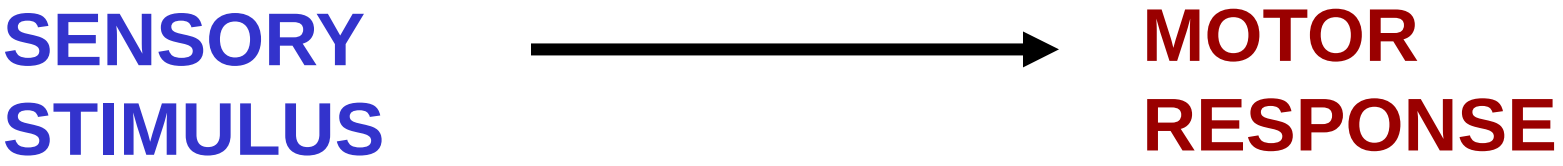
SPINAL REFLEXES



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

TYPICAL REFLEX

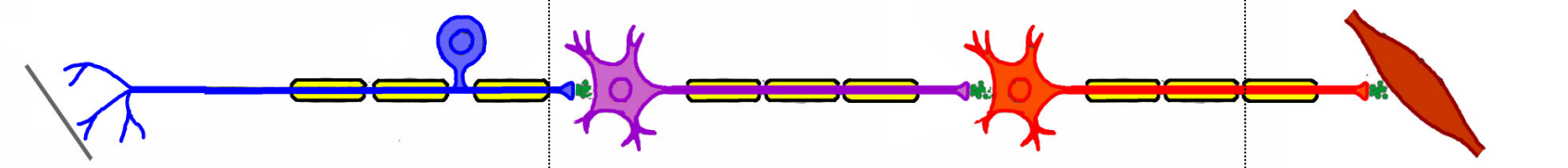
AFFERENT ARM OF REFLEX

SENSORY STIMULUS

in Central Nervous System

EFFERENT ARM OF REFLEX

MOTOR RESPONSE



STIMULUS

SENSORY NEURON

INTERNEURON

MOTOR NEURON

MUSCLE

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

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

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

For reflex to occur, all elements must be functional:

If absent, diagnose where pathway is interrupted.

If abnormal, diagnose where pathway is compromised.

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

D. EVALUATING REFLEXES

TABLE 21-8 Scoring Deep Tendon Reflexes

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

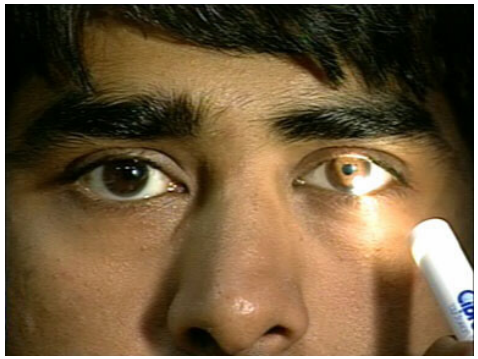
NOTE: DEEP TENDON REFLEX = STRETCH REFLEX

Reflex is evaluated according to:

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

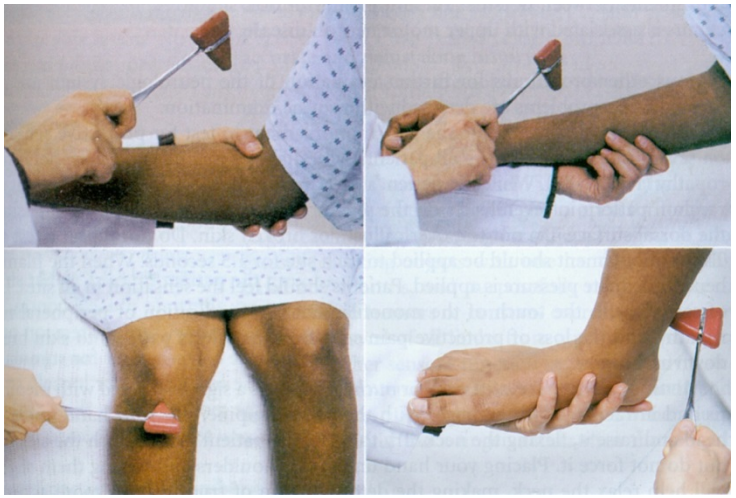
Hyper-reflexia = enhanced reflexes; in some disease processes, damage can enhance reflex responses
Clonus = series of abnormal, rapid alternating contractions and relaxations of muscle produced by single stimulus

E. SOME REFLEXES ARE PROTECTIVE AND CONSTANT



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

F. SOME REFLEXES ARE CONSTANT UNDER SAME CIRCUMSTANCES



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

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

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

PALMAR GRASP

MORO REFLEX - arm extend

STEPPING 'REFLEX' - actually eliciting a motor pattern

PLANTAR GRASP

PLACING REFLEX

TONIC NECK REFLEX - extend ipsilateral arm flex opposite arm

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

II. CLASSIC SPINAL REFLEXES

Three basic reflexes:

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

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

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

TERMINOLOGY

IN DESCRIBING A REFLEX:

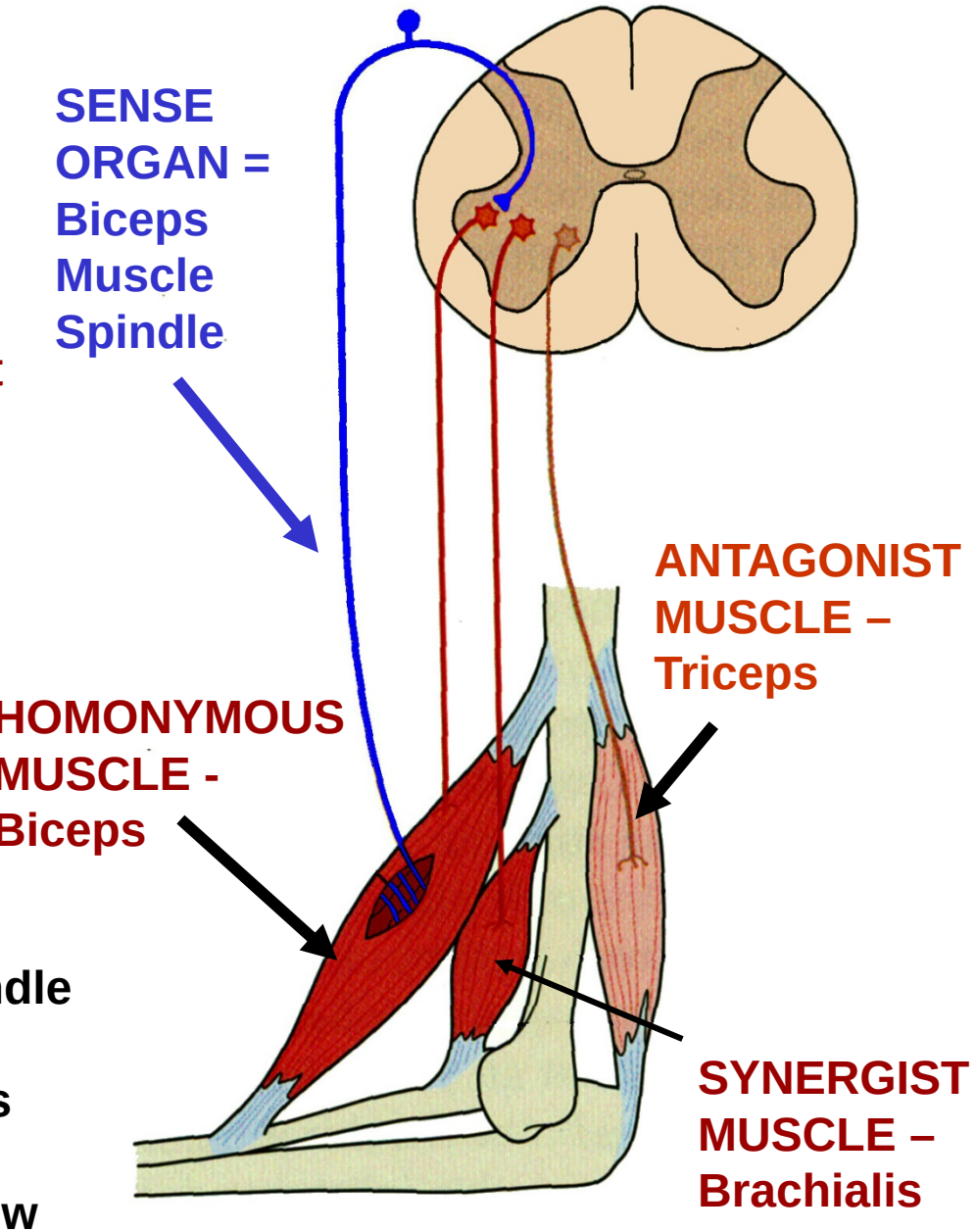
HOMONYMOUS MUSCLE = muscle that contains sense organ

SYNERGIST MUSCLE = muscle that produces similar action

ANTAGONIST MUSCLE = muscle that produces opposite action

CONTRALATERAL MUSCLE = muscle of opposite arm or leg

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

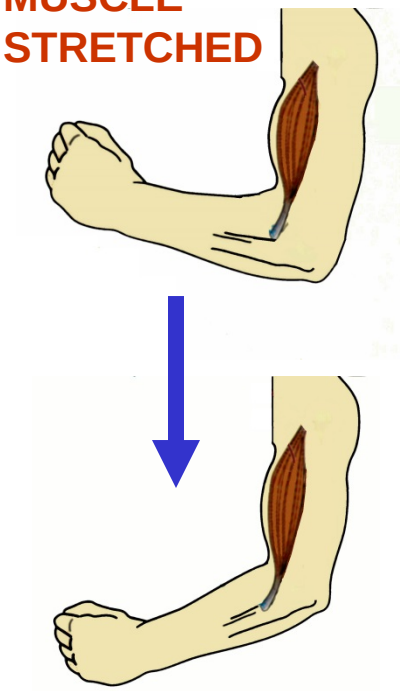


A. STRETCH REFLEX

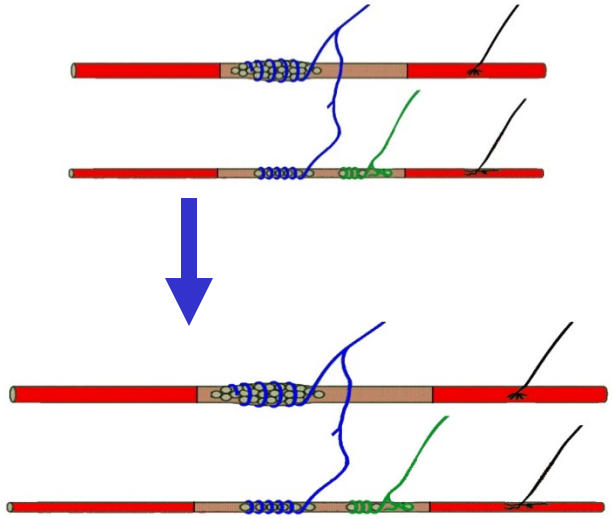
STIMULUS

RESPONSE

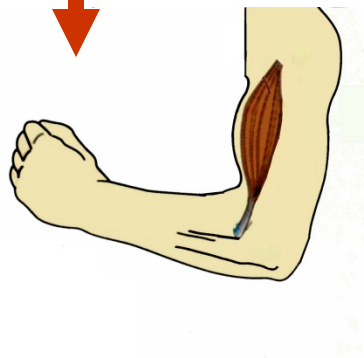
BICEPS MUSCLE STRETCHED



BICEPS MUSCLE SPINDLE



BICEPS MUSCLE CONTRACTS

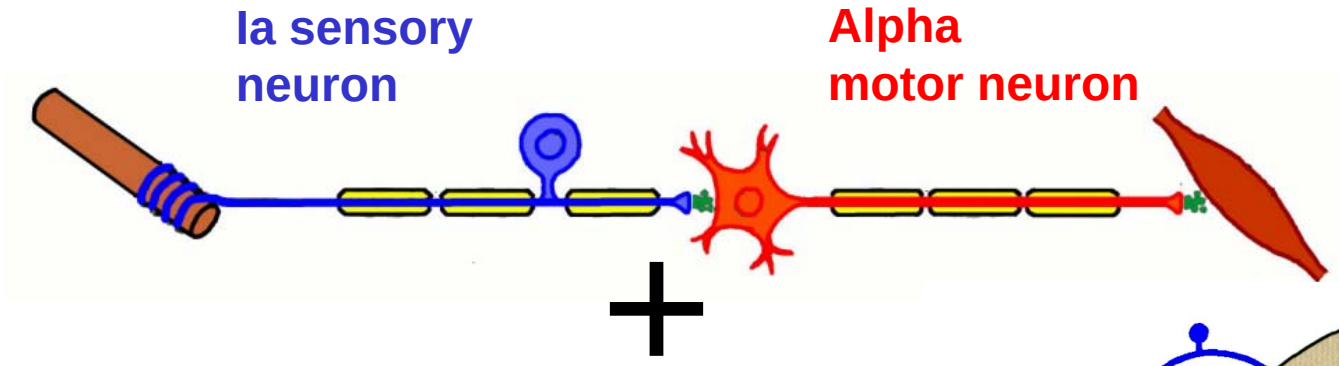


1) Stimulus - <u>fast stretch</u> of muscle

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

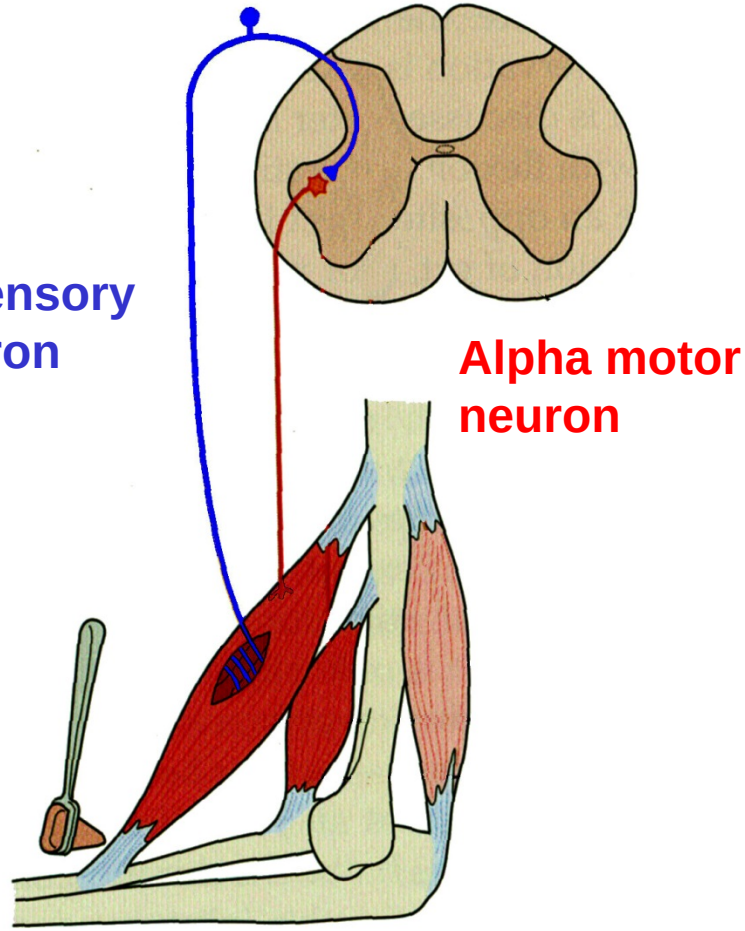
3) Primary response - muscle that is stretched <u>contracts rapidly</u>

SYNAPSES: MONOSYNAPTIC CONNECTION



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

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



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

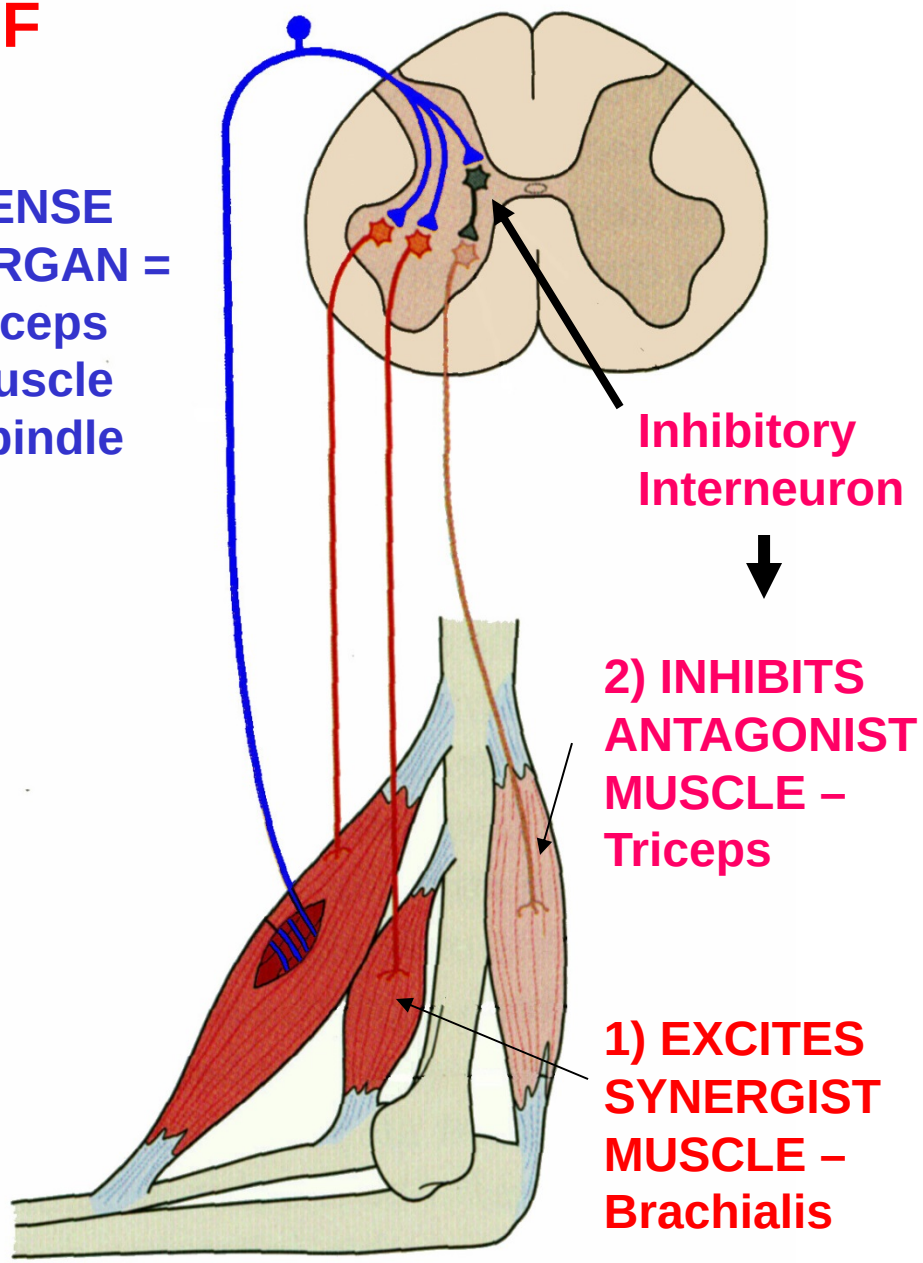
OTHER COMPONENTS OF STRETCH REFLEX

**

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

**

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

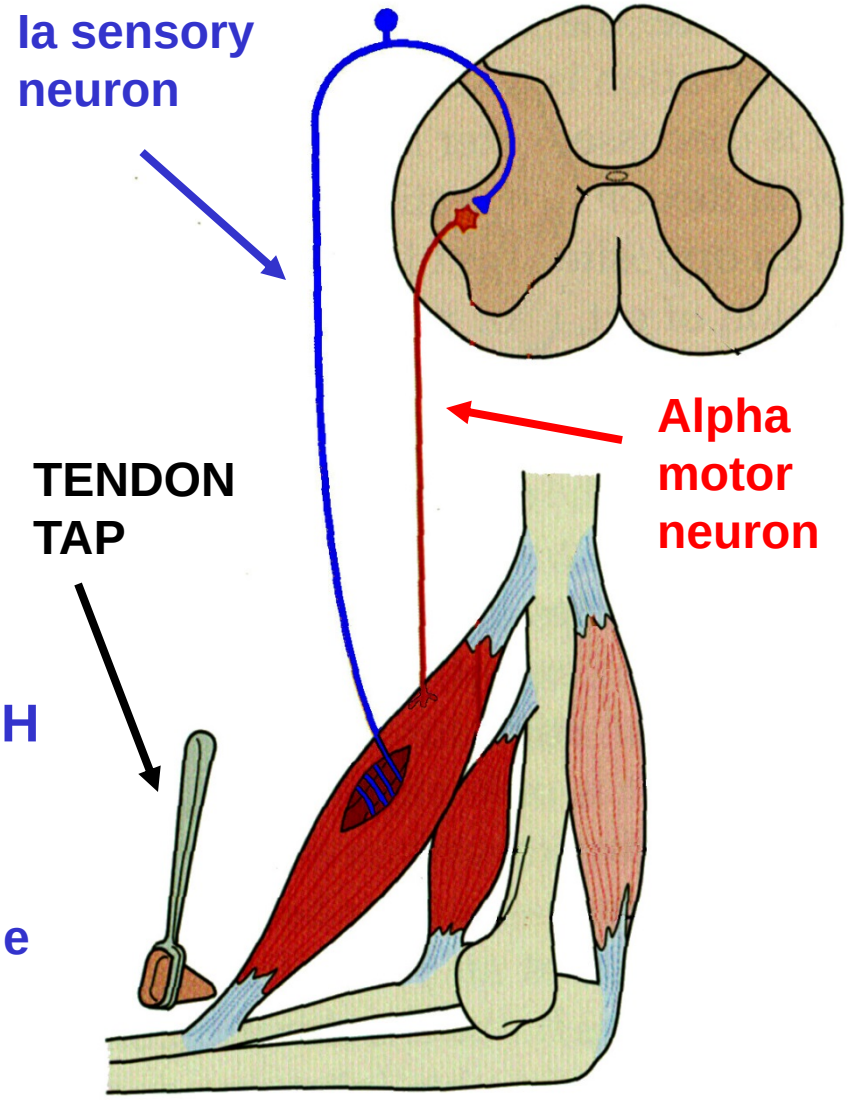


MUSCLE TONUS

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

CLINICAL TESTING OF STRETCH REFLEX: TENDON TAP

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

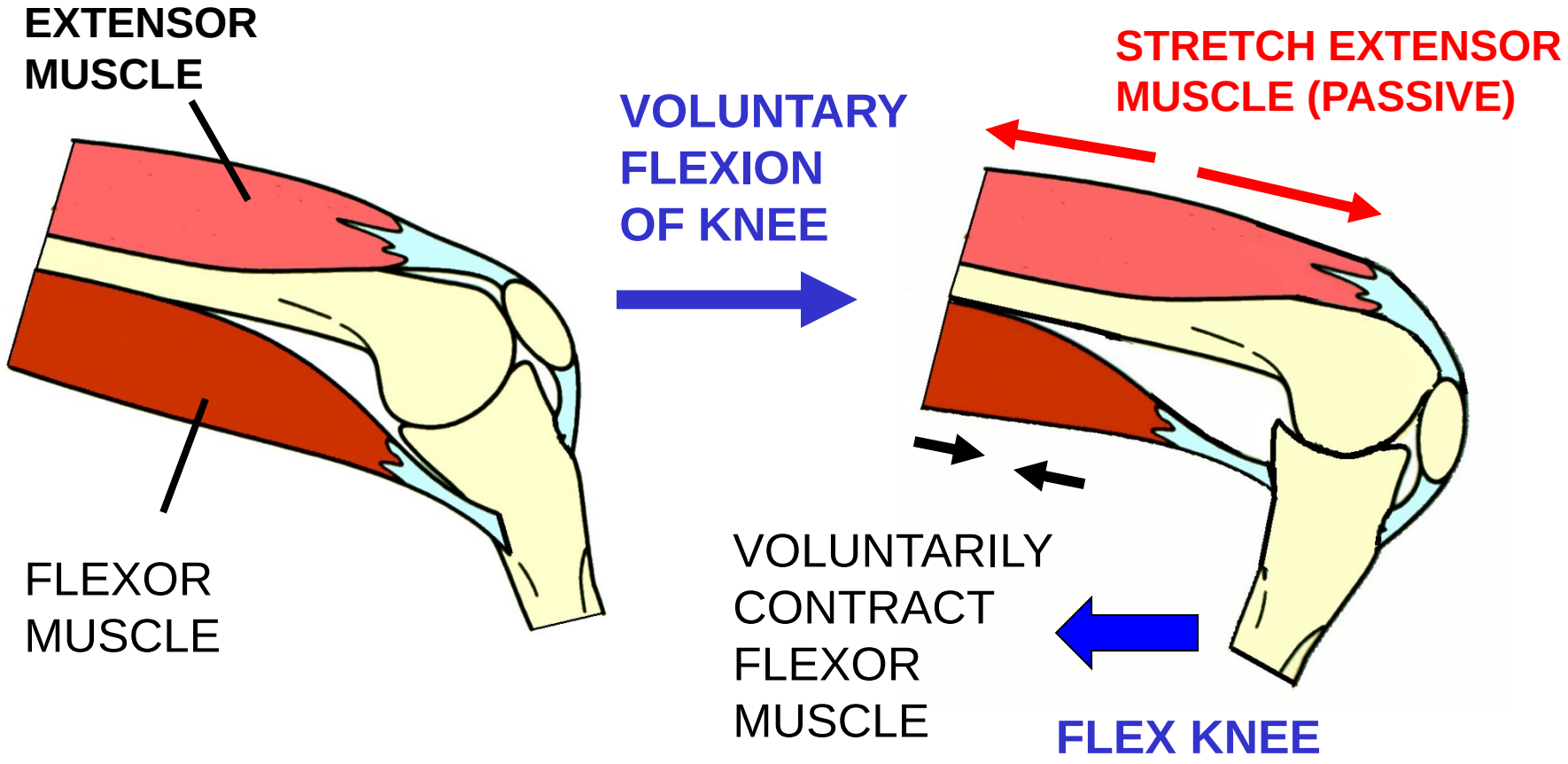


Spasticity/Rigity – Increased tonus occurs after Upper Motor Neuron Lesion (ex. stroke); due to loss of modulation of reflex

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

used by permission of Paul D. Larsen, M.D., University of Nebraska Medical Center; http://library.med.utah.edu/neurologicexam

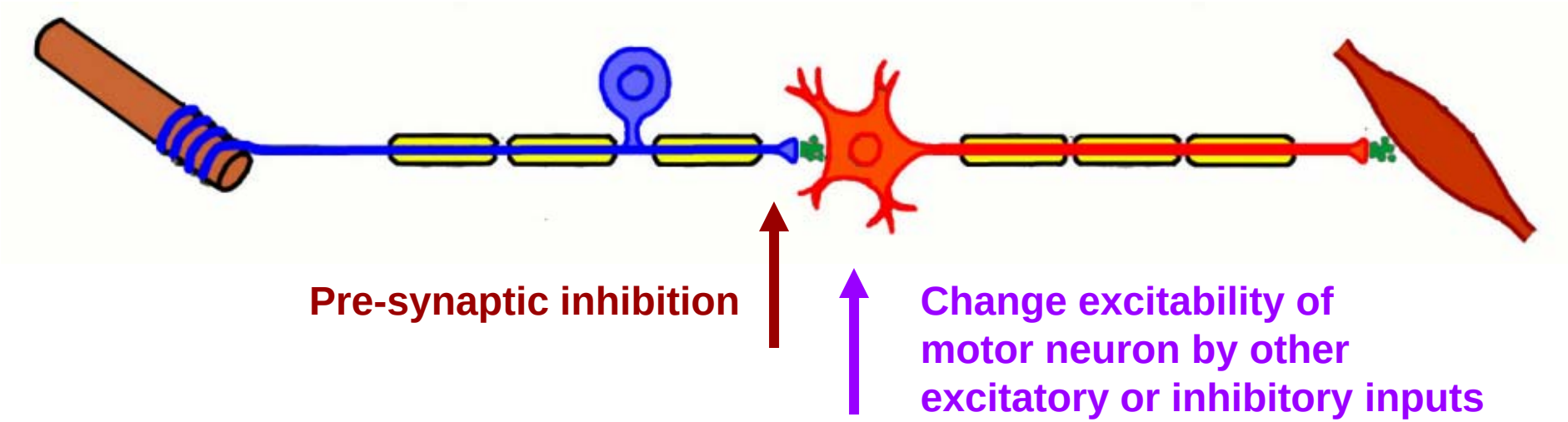
REFLEXES MUST BE MODIFIED DURING VOLUNTARY MOVEMENTS



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

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

MODIFICATION OF REFLEXES: MECHANISMS



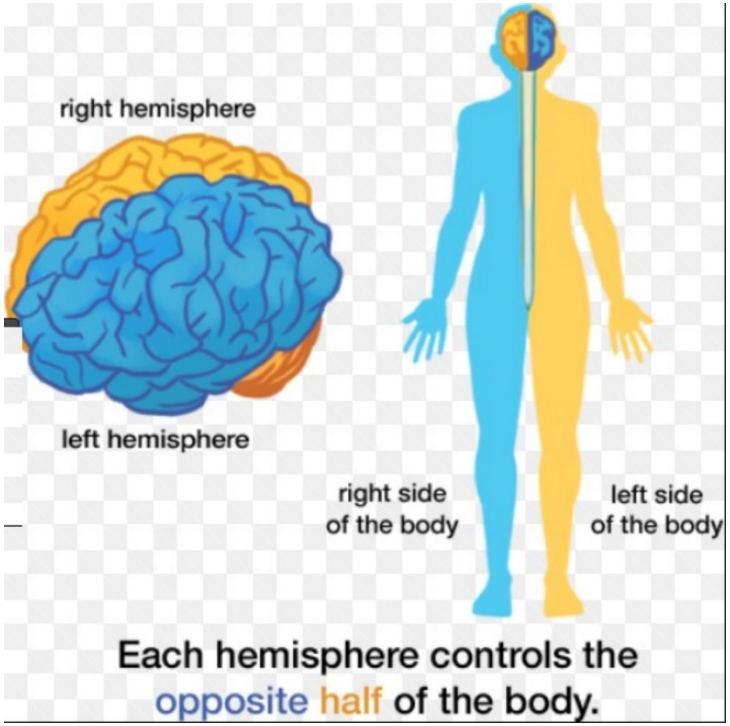
1- Reflexes can be modulated by

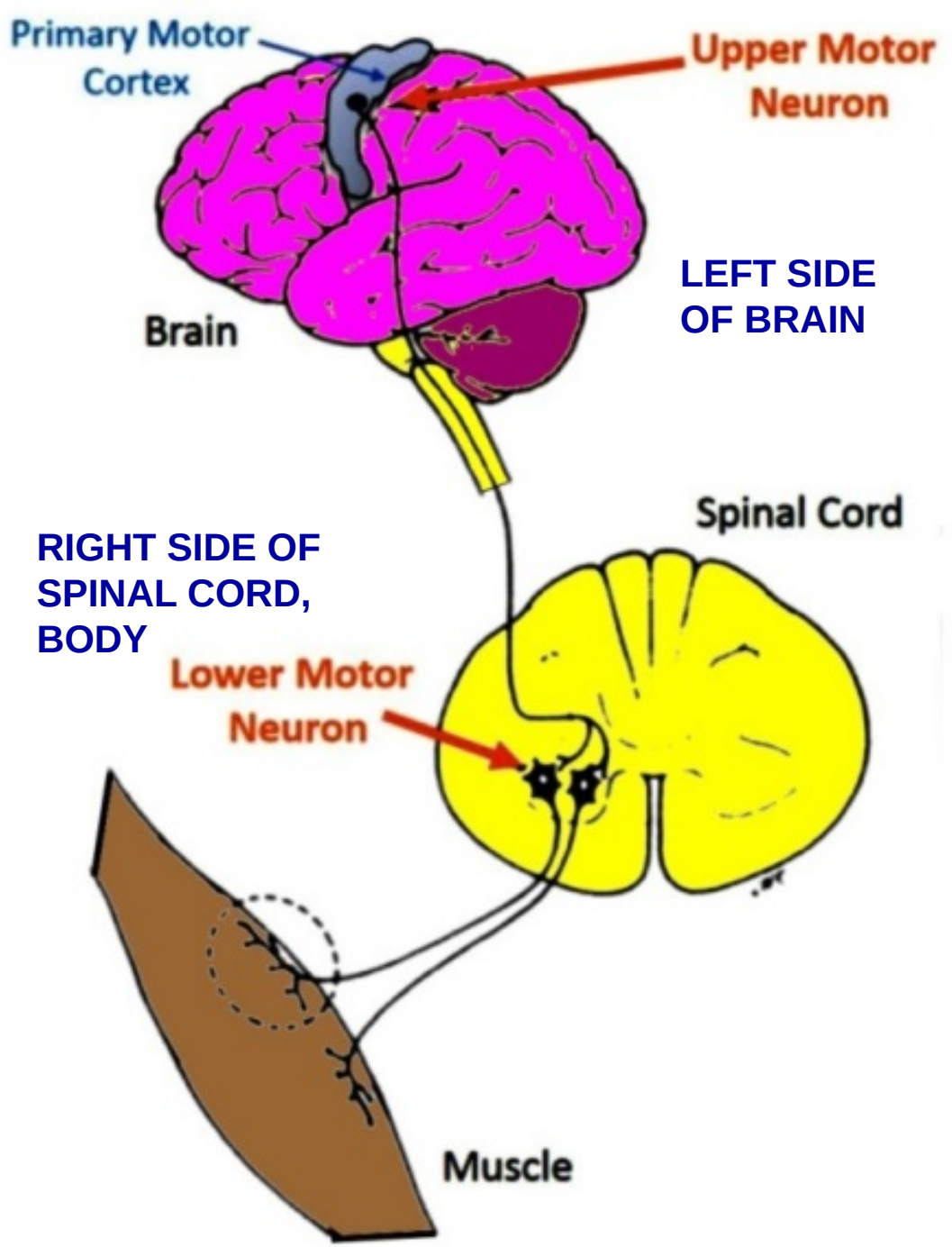
1) Gamma motor neurons – change muscle spindle sensitivity

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

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

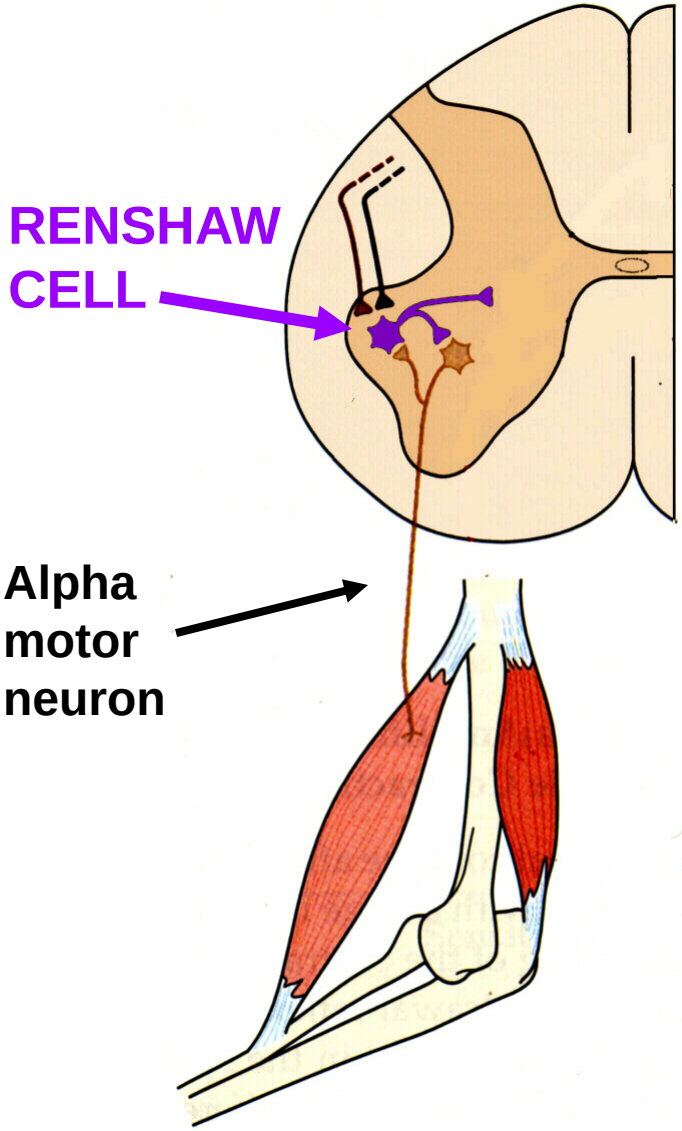
UPPER VS LOWER MOTOR NEURON

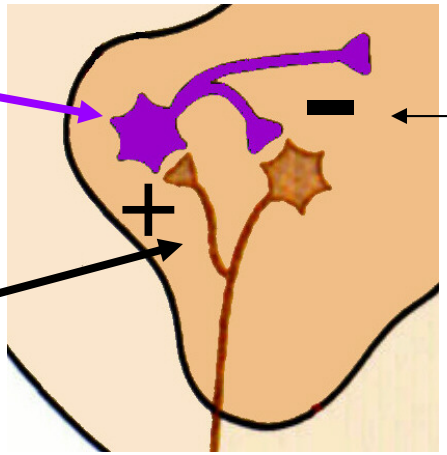




HYPERREFLEXIA: INCREASED STRETCH REFLEX ON ONE SIDE [**used by permission of Paul D. Larsen, M.D., University of Nebraska Medical Center; http://library.med.utah.edu/neurologicexam]**

ACTIVITIES OF MOTOR NEURONS CAN BE MODULATED BY RENSHAW CELLS



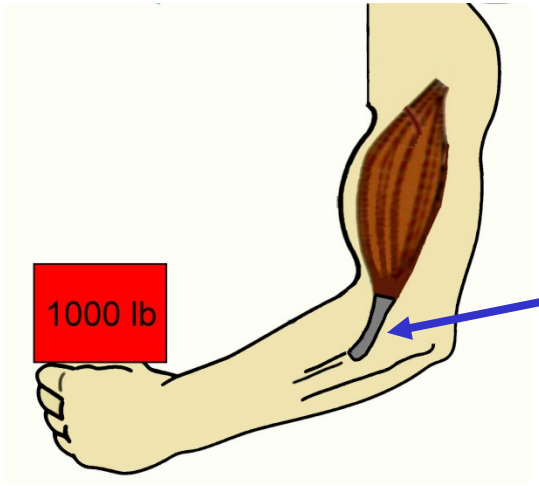


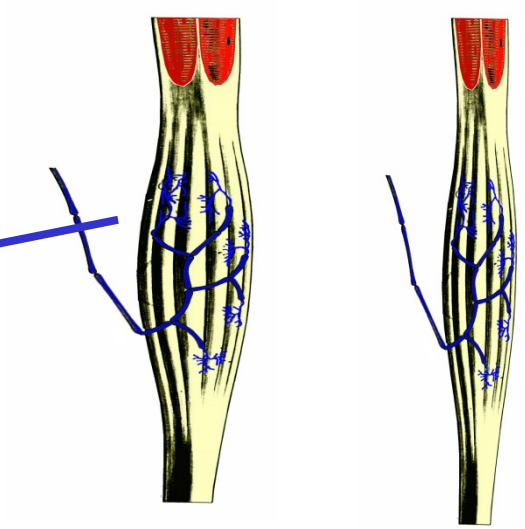
Axons of Alpha motor neurons have branches that synapse in central nervous system; these branches are called Recurrent Branches.

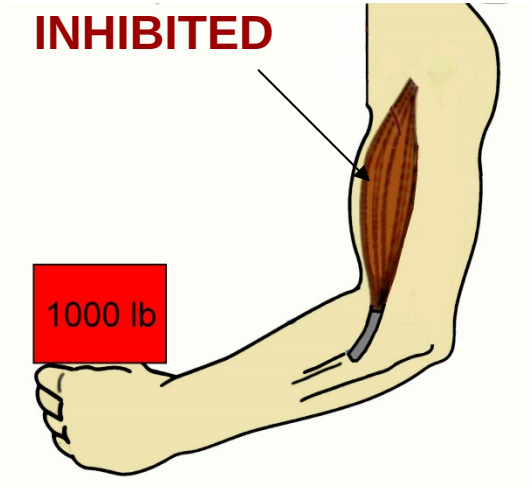
Renshaw cells are interneurons that receive excitatory inputs from Recurrent branches of motor neurons and make inhibitory synapses upon the same motor neurons
These circuits can limit motor neuron firing; inhibition can dampen or reduce reflexes

Camillo Golgi (1843-1926)

B. AUTOGENIC INHIBITION





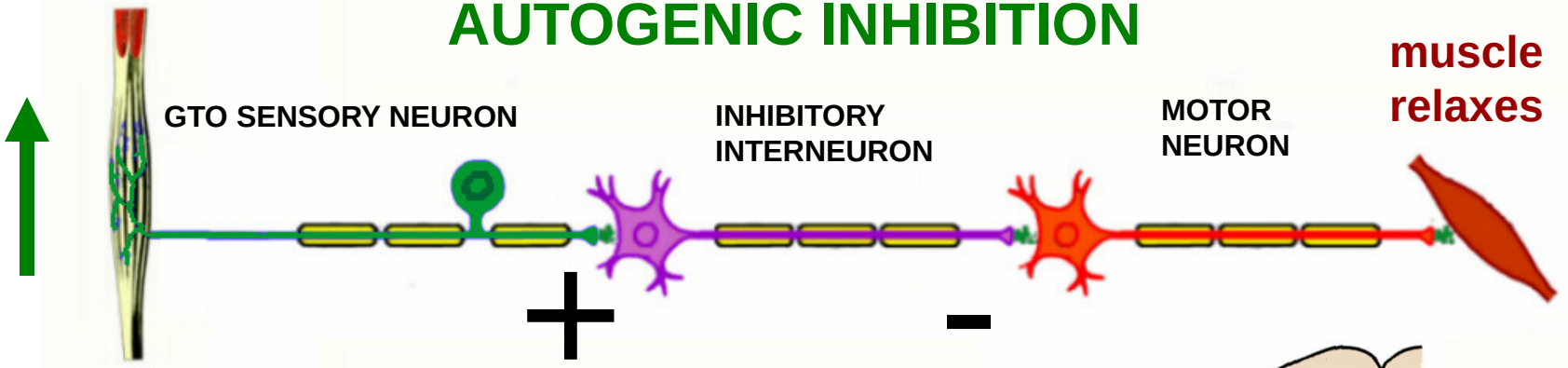


1) Stimulus - <u>Large force</u> exerted on muscle tendon

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

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

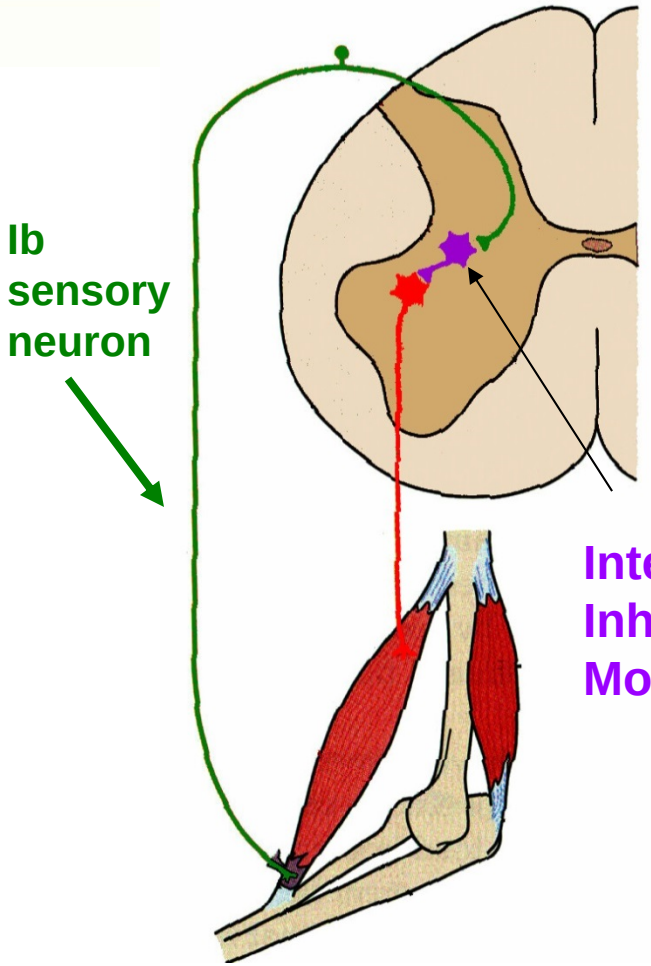
AUTOGENIC INHIBITION



PRIMARY RESPONSE
Synapses - polysynaptic

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

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



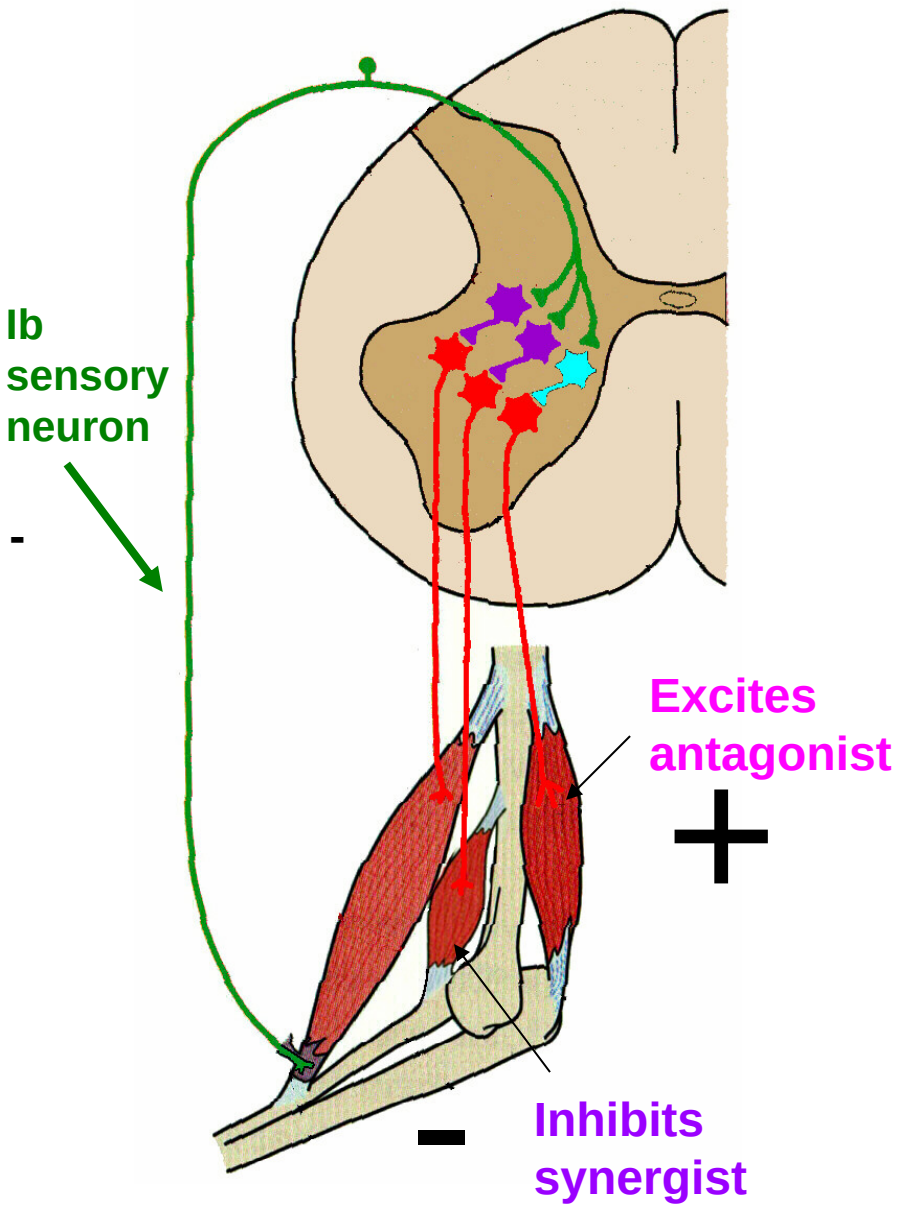
AUTOGENIC INHIBITION

Other effects

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

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

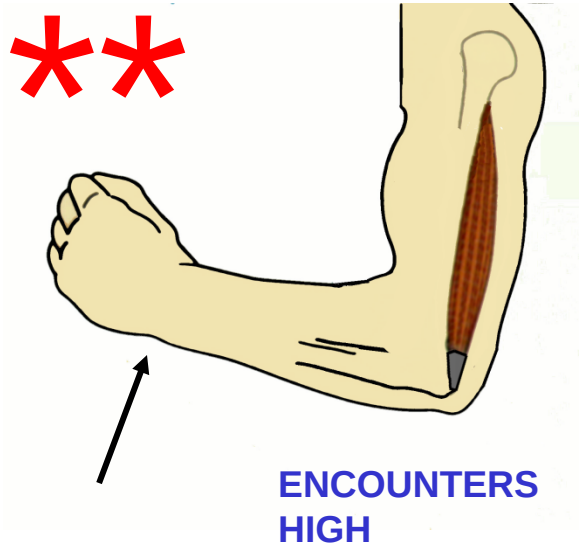
CLASPED KNIFE REFLEX: in Upper motor neuron lesions, tonus increases, resistance to stretch increases; if sufficient force is applied, limb resistance suddenly decreases (like pocket knife snapping shut)



CLASPED KNIFE REFLEX: is an example of Autogenic inhibition.

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

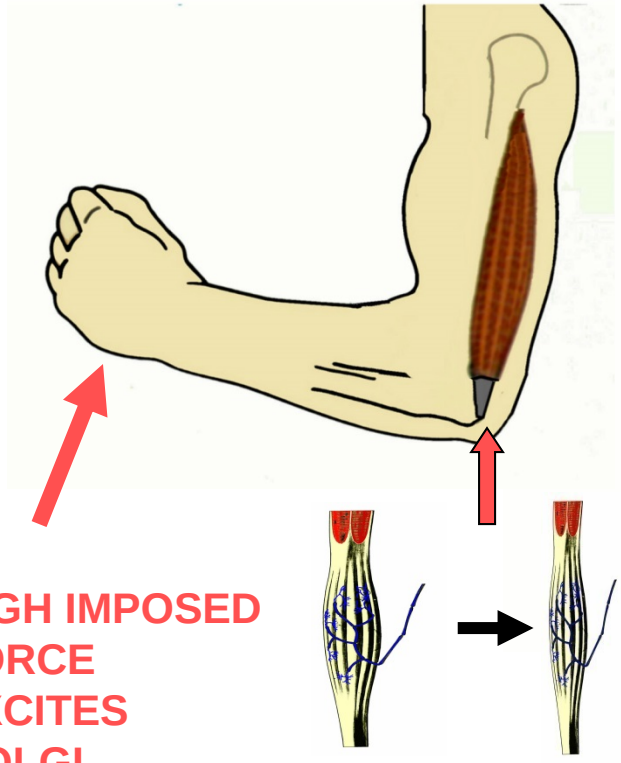
1) PHYSICIAN TRIES TO FLEX ELBOW JOINT OF PATIENT WITH UPPER MOTOR NEURON LESION



PHYSICIAN HOLDS WRIST AND PUSHES HERE AFTER TELLING PATIENT TO RELAX

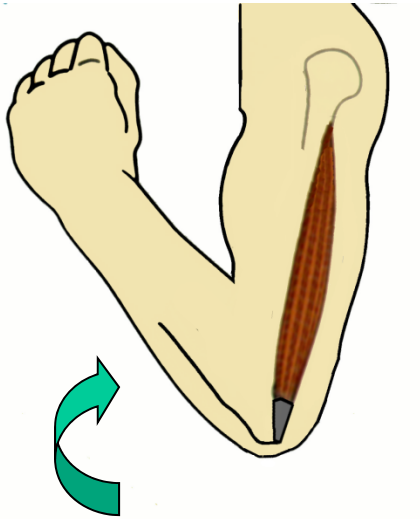
ENCOUNTERS HIGH RESISTANCE DUE TO HIGH TONUS IN TRICEPS AND HIGH STRETCH REFLEXES

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



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

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



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

CLASPED KNIFE REFLEX

AUTOGENIC INHIBITION AND FORCE REGULATION

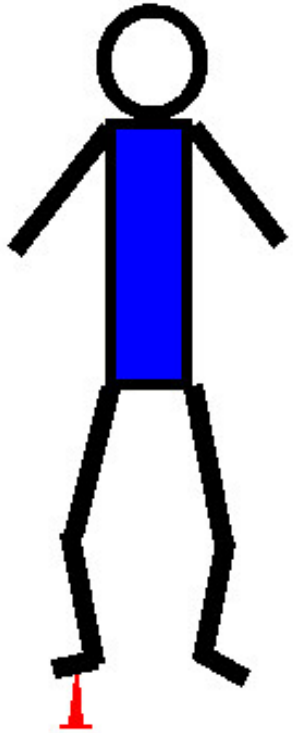
1- Regulating muscle tension - forces developed by contractions of muscles are automatically controlled so that they do not cause damage to tendons (ex. lifting heavy object).

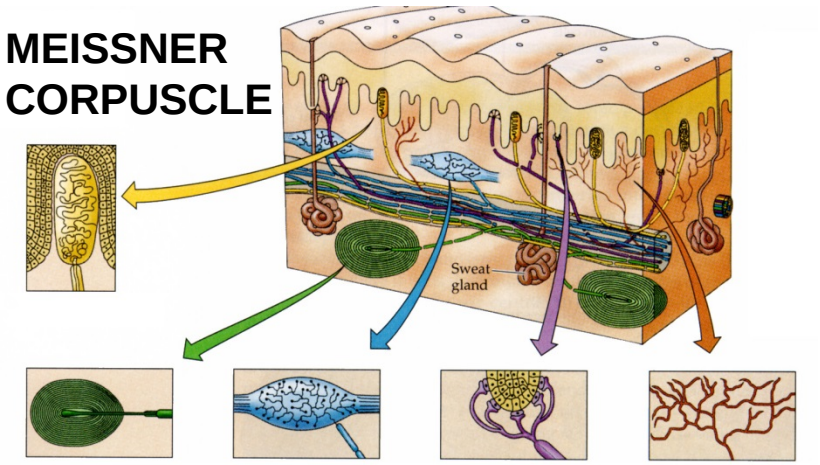
2- Regulation of force during other behavior is more complex (ex. walking) –

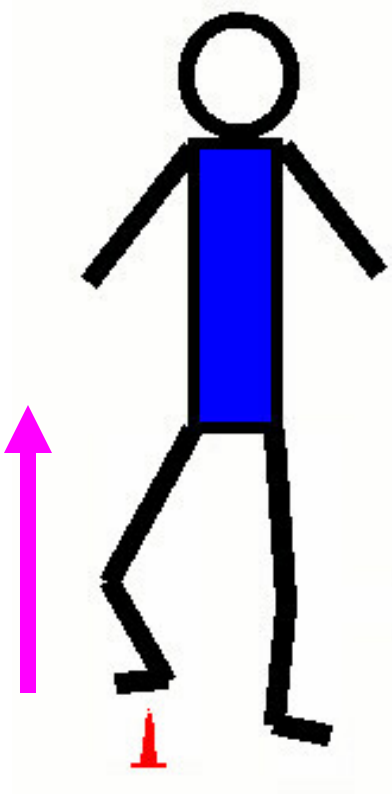
Connections for autogenic inhibition may be inactivated during walking

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

C. FLEXOR REFLEX





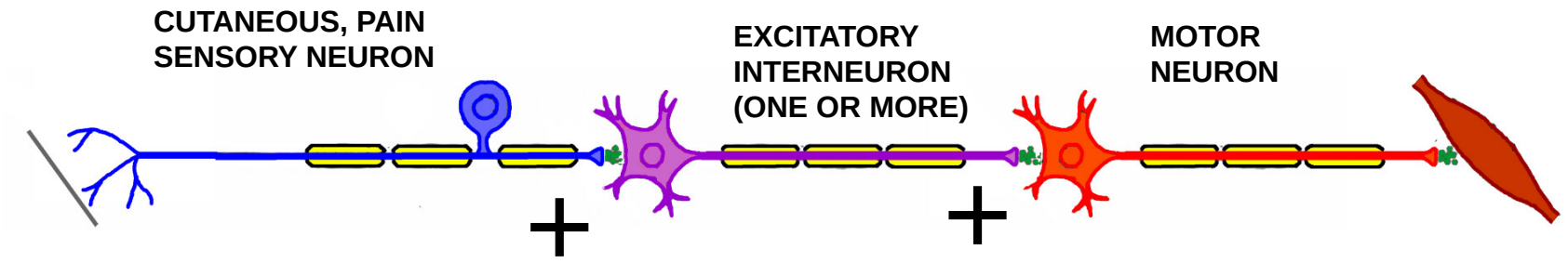


1) Stimulus - painful or noxious stimulus (stepping on nail)

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

3) Primary response - Protective withdrawal of limb

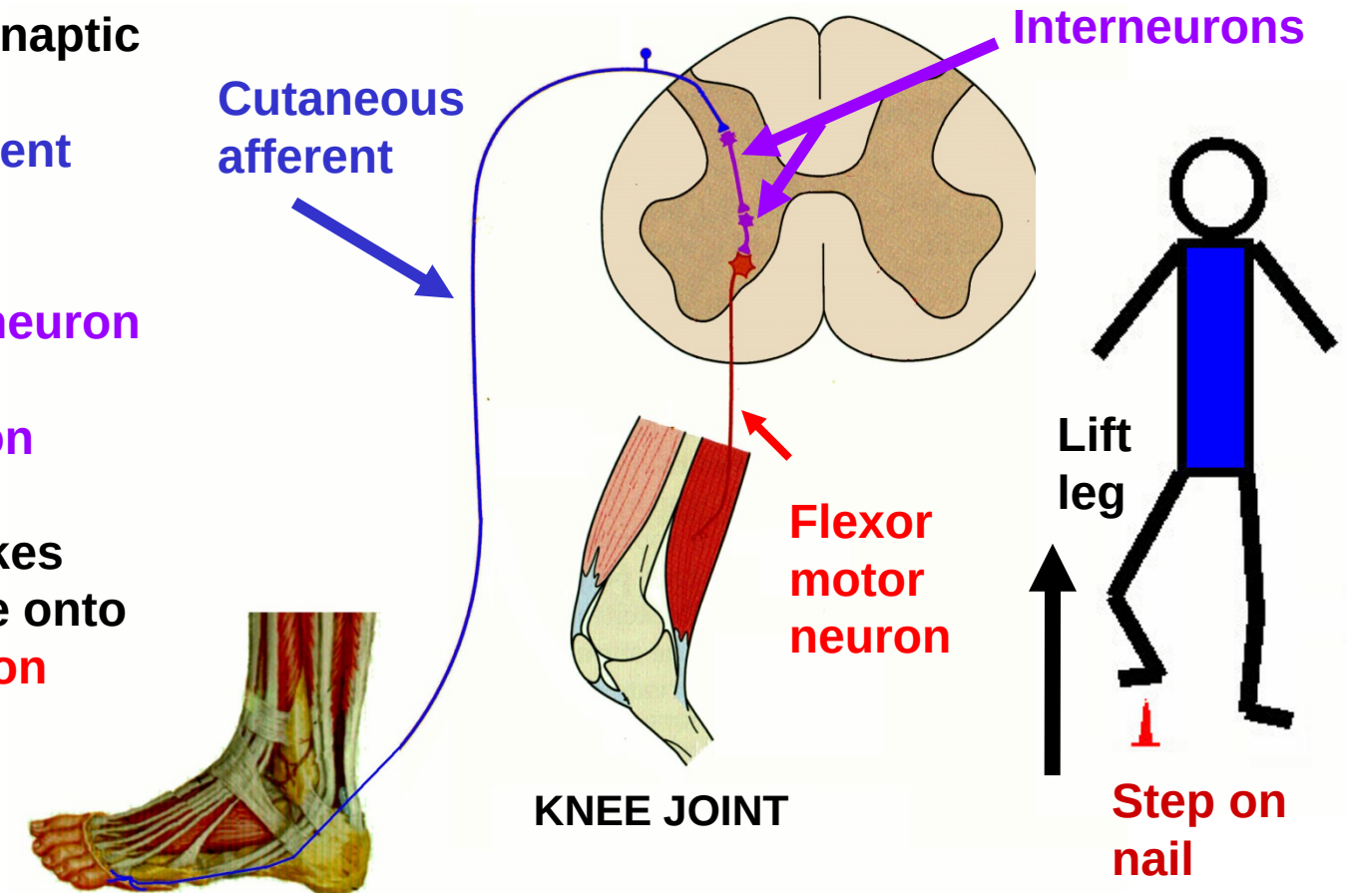
FLEXOR REFLEX: PATHWAYS



Synapses - Polysynaptic

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

2) Interneuron makes excitatory synapse onto Flexor motor neuron



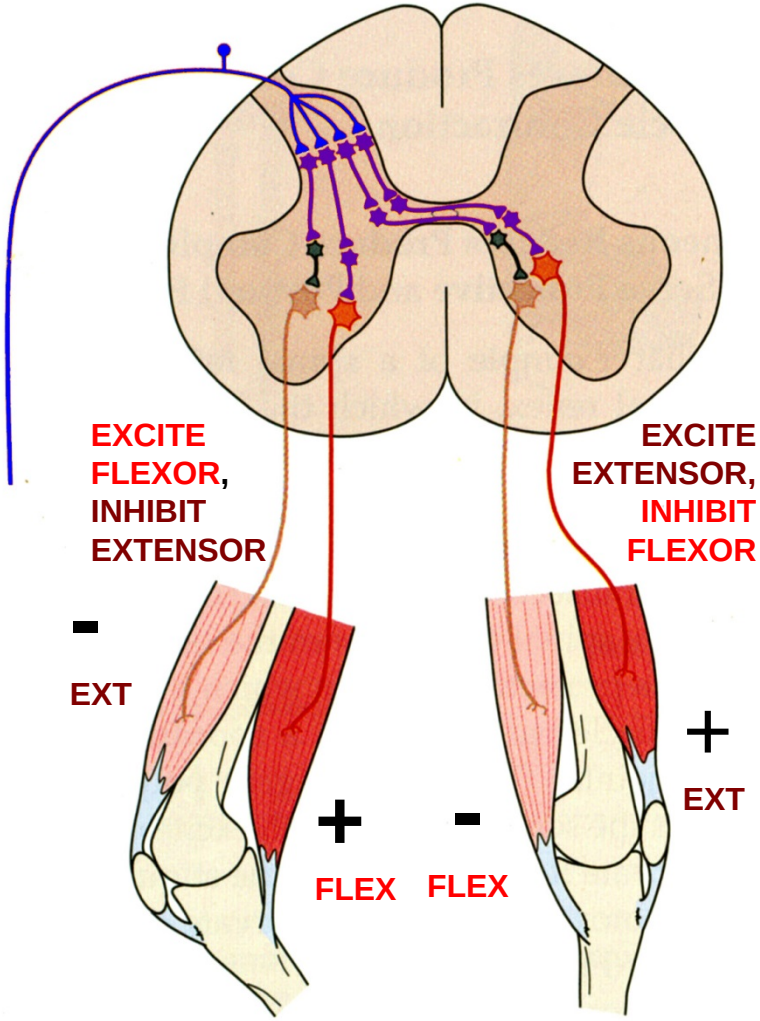
FLEXOR REFLEX: OTHER EFFECTS
ALL ARE POLYSYNAPTIC BY INTERNEURONS

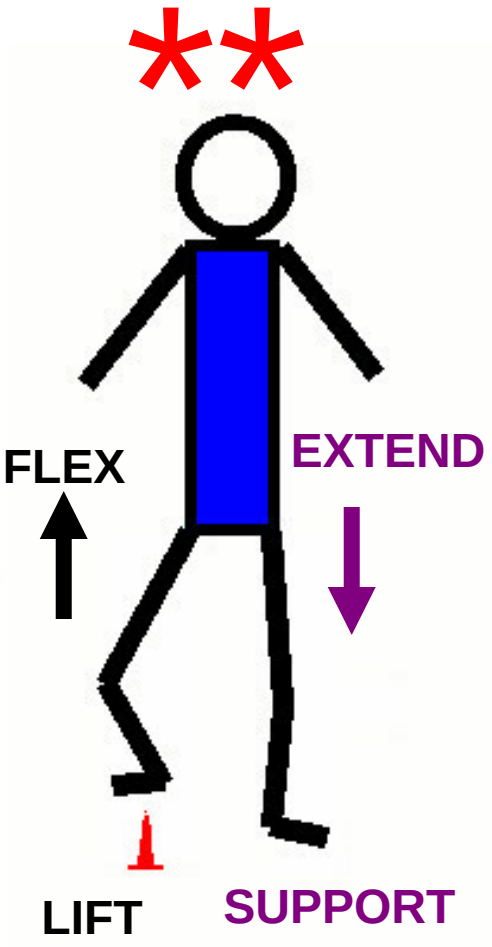
1) Excite synergist muscles - excite other flexors in same leg (other joints)

2) Inhibit antagonist muscles - inhibit Extensors in same leg

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

**





FUNCTION: OTHER LEG PROVIDES SUPPORT WHEN FIRST LEG IS LIFTED

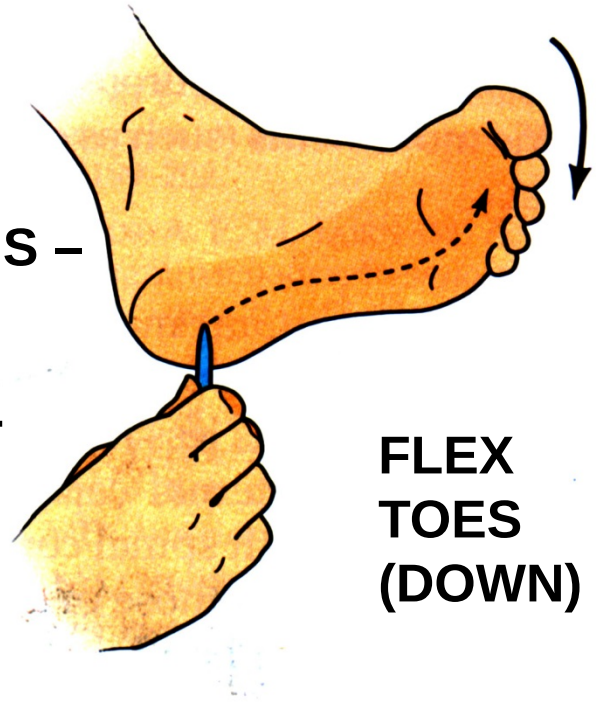
REFLEXES ARE MODULATED: SOME FLEXOR REFLEXES CAN CHANGE AFTER LESIONS, DISEASE PROCESSES

**

NORMAL RESPONSE

**

BABINSKI SIGN – (EXTENSOR PLANTAR RESPONSE)



STIMULUS – TO SKIN OF SOLE OF FOOT

FLEX TOES (DOWN)

EXTEND BIG TOE, FANNING (ABDUCTION) OF OTHER TOES

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

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

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

** 1. PUPILLARY LIGHT REFLEX - II TO III

AFFERENT ARM OF REFLEX

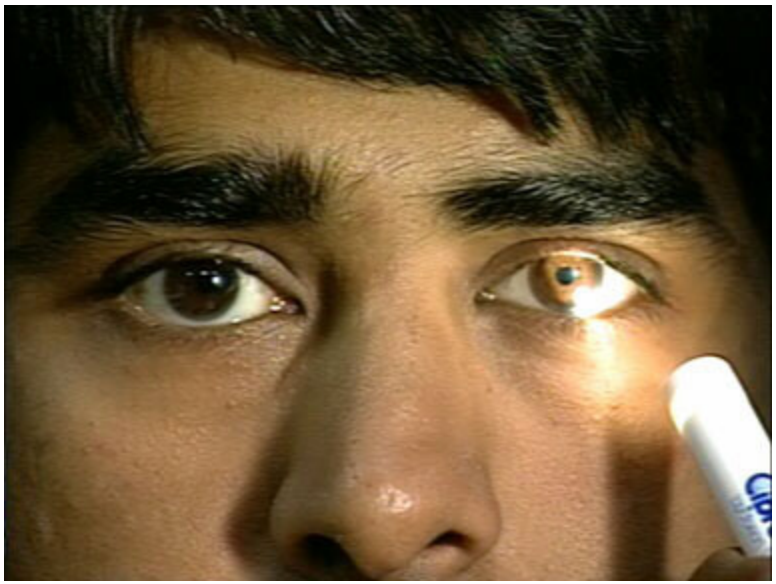
SENSORY STIMULUS

LIGHT IN EYE

EFFERENT ARM OF REFLEX

MOTOR RESPONSE

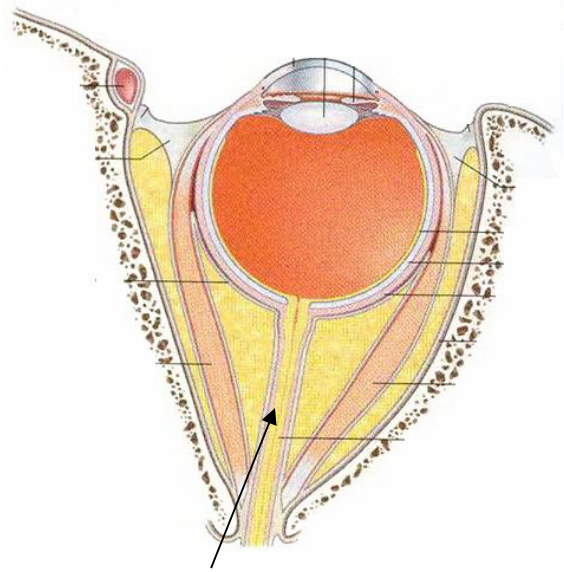
CONSTRICT PUPIL



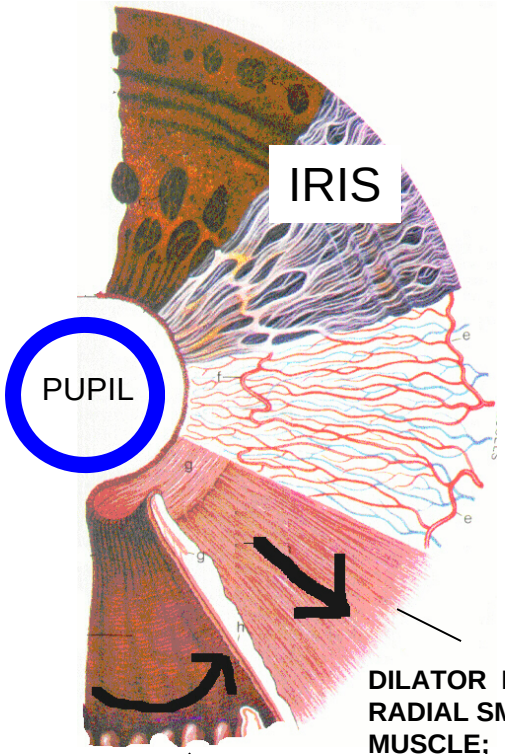
PUPILLARY LIGHT REFLEX

CN II - OPTIC NERVE - DETECTS LIGHT

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

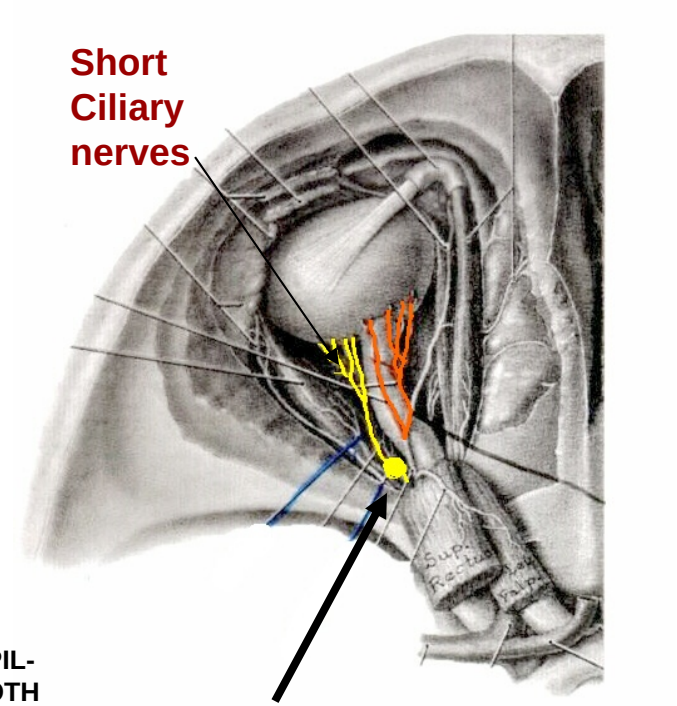


OPTIC NERVE - CN II VISION



DILATOR PUPIL- RADIAL SMOOTH MUSCLE; SYMPATHETICS

CONSTRICTOR PUPIL- CIRCULAR SMOOTH MUSCLE; PARASYMPATHETICS - CN III



Ciliary Ganglion of CN III

PUPILLARY LIGHT REFLEX

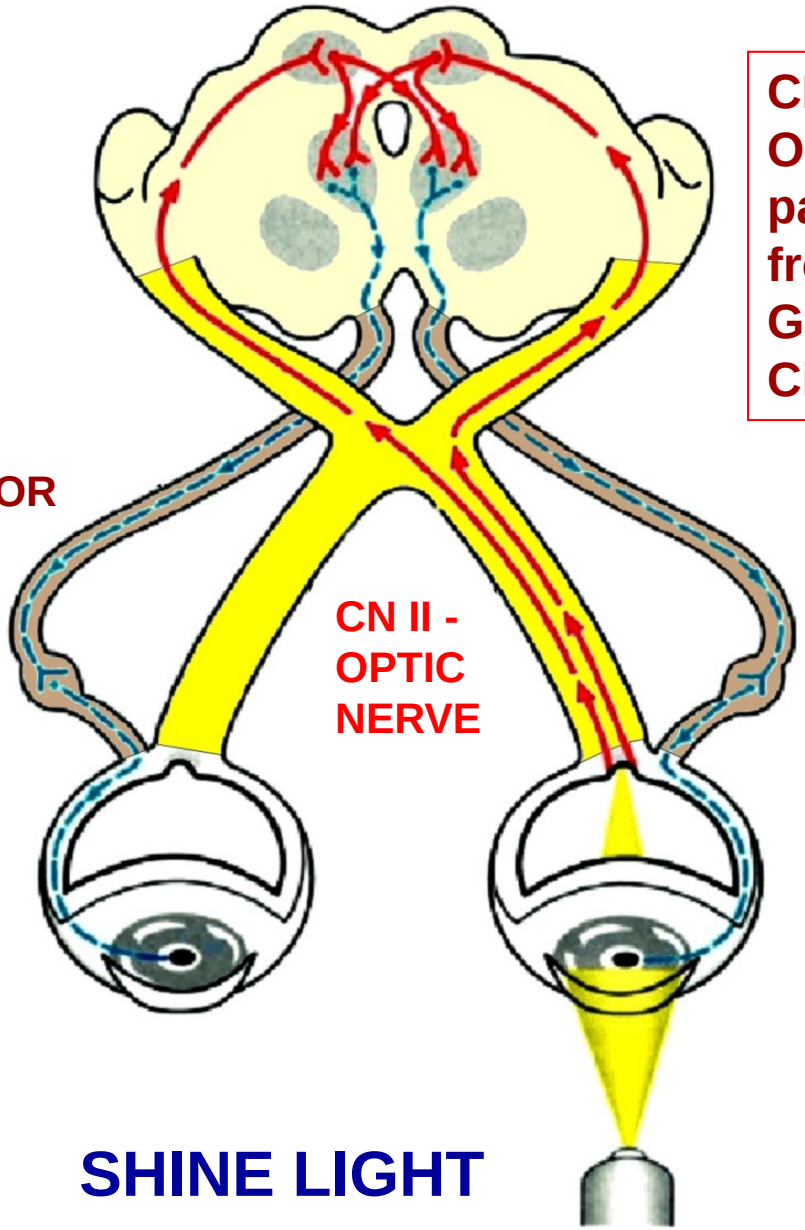
CN II - OPTIC NERVE - DETECTS LIGHT

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

CN III - OCULOMOTOR

CN III - OCULOMOTOR

CN II - OPTIC NERVE



CONSENSUAL REFLEX – PUPIL CONSTRICTS IN OPPOSITE EYE

DIRECT REFLEX – PUPIL CONSTRICTS IN SAME EYE

SHINE LIGHT

2. CORNEAL REFLEX - V TO VII

AFFERENT ARM OF REFLEX

SENSORY STIMULUS

TOUCH CORNEA

TRIGEMINAL - V1 - LONG CILIARY NERVES TO CORNEA

EFFERENT ARM OF REFLEX

MOTOR RESPONSE

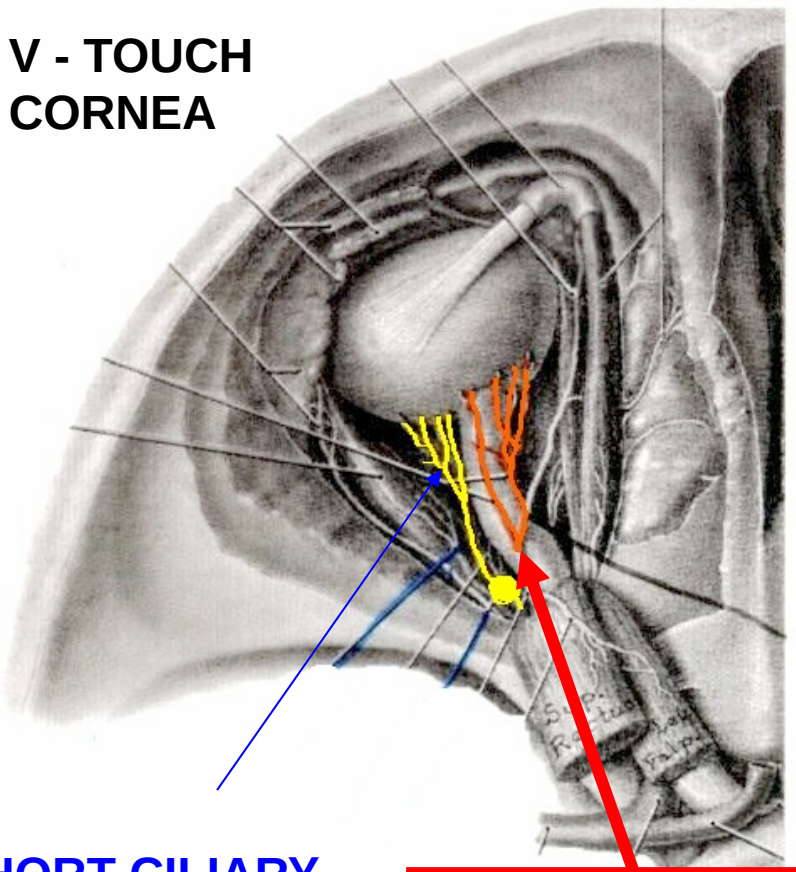
CLOSE EYELID

FACIAL - VII - MOTOR TO ORBICULARIS OCULI (SVE)

CORNEAL REFLEX - V to VII

**

V - TOUCH CORNEA



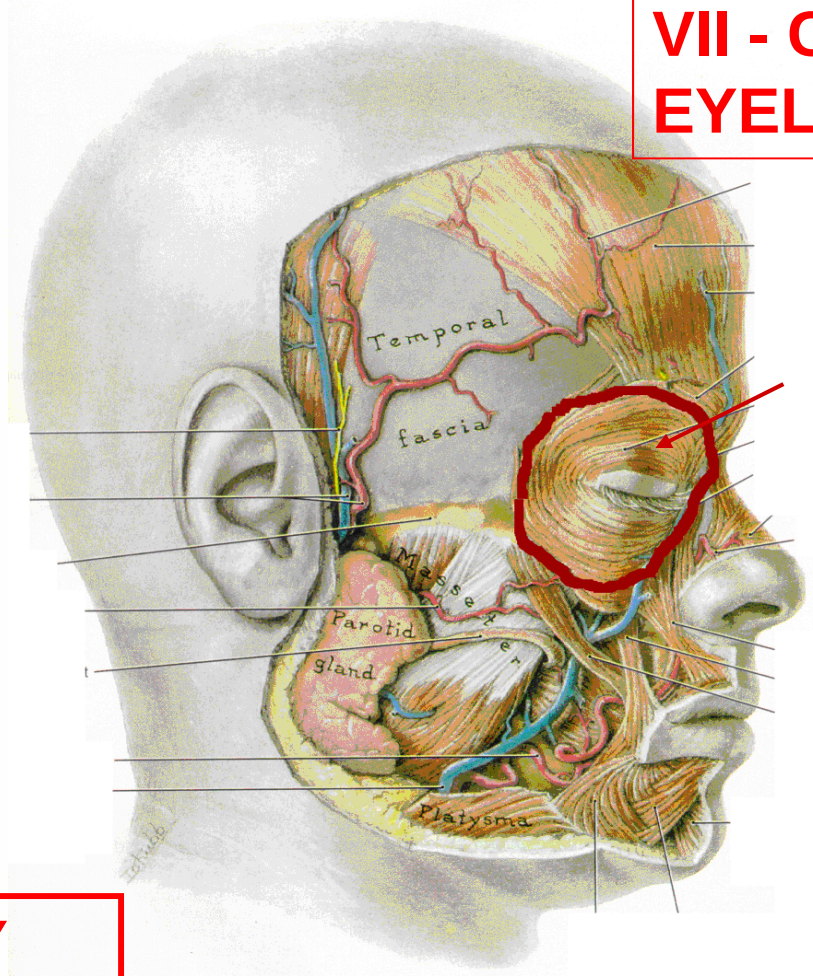
SHORT CILIARY NERVES (III),

CILIARY GANGLION

PARASYMPATHETIC

LONG CILIARY NERVES (V1) - SOMATIC SENSORY TO CORNEA

VII - CLOSE EYELID



ORBICU-LARIS OCULI M.

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

3. GAG REFLEX - IX to X **

AFFERENT ARM OF REFLEX

SENSORY STIMULUS

TOUCH ORO-PHARYNX

EFFERENT ARM OF REFLEX

MOTOR RESPONSE

PATIENT GAGS - CONTRACT PHARYNGEAL MUSCLES

GAG REFLEX

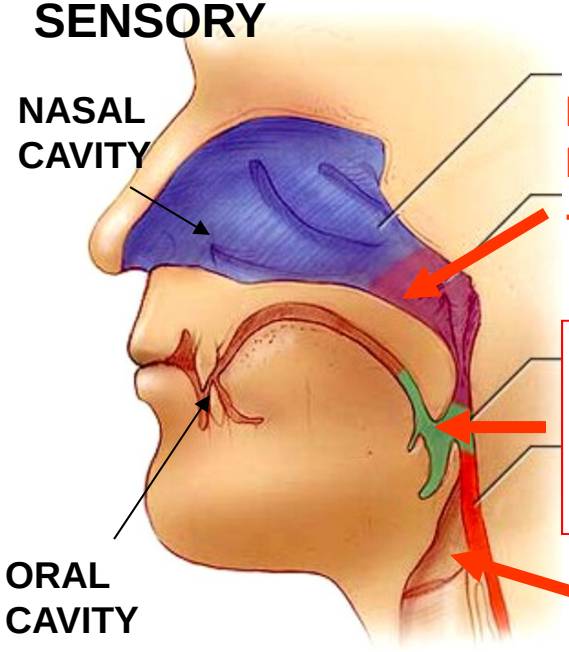
CRANIAL NERVES LECTURE

IX - SENSORY INNERVATION TO OROPHARYNX

All Pharynx is Visceral Sensory In 3 Cranial Nerves

SOMATIC SENSORY

VISCERAL SENSORY

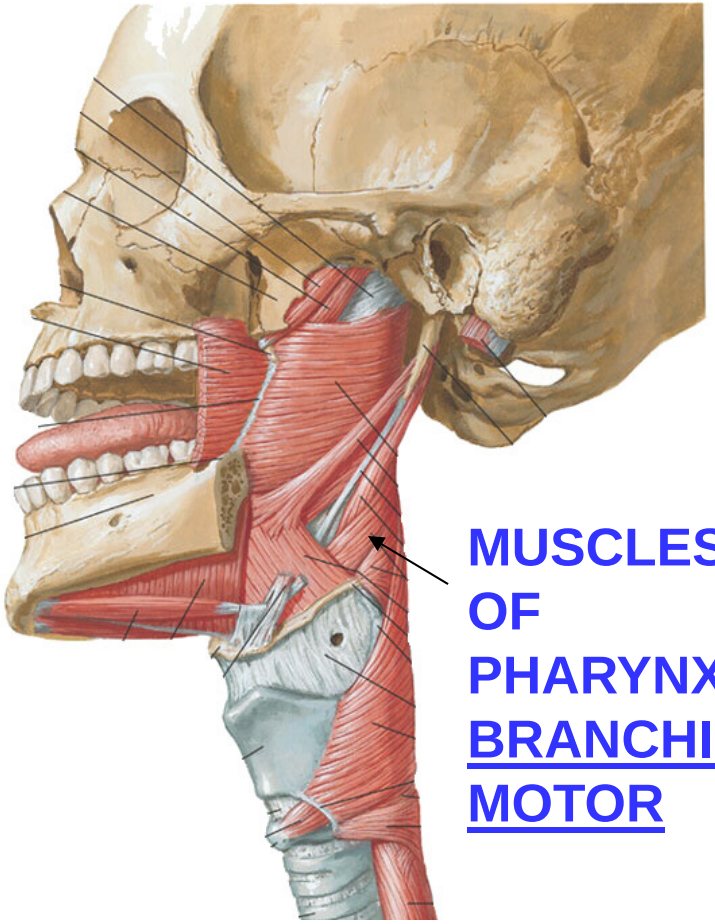


NASO-PHARYNX - VII

ORO-PHARYNX - IX

LARYNGO-PHARYNX - X

X - INNERVATES ALL MUSCLES OF PHARYNX (except Stylopharyngeus)



MUSCLES OF PHARYNX - BRANCHIO-MOTOR

**

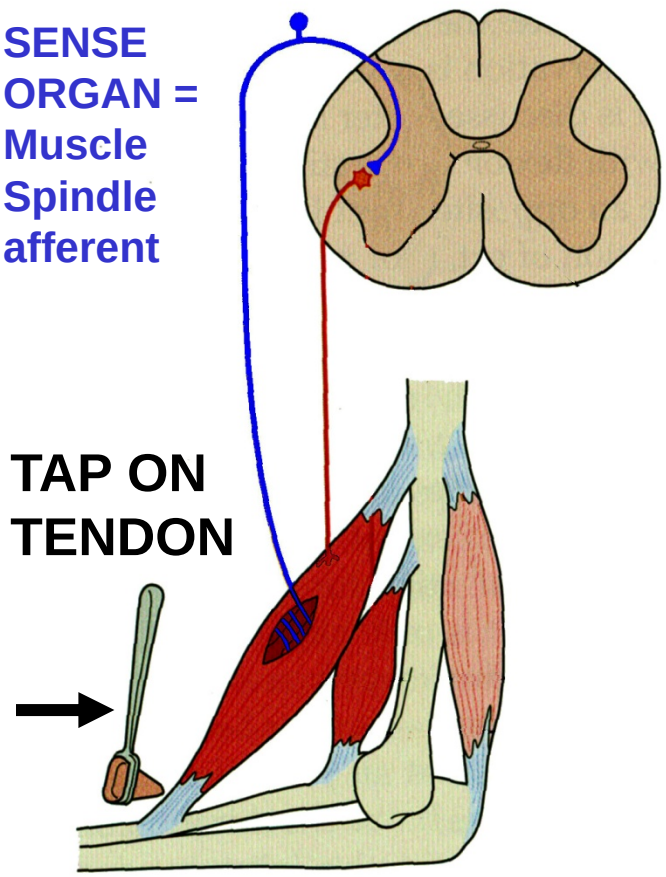
IX AND X - LEAVE MEDULLA, EXIT BY JUGULAR FORAMEN - CAN DIAGNOSE DAMAGE IN BRAINSTEM BY TESTING REFLEXES

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

STRETCH REFLEX

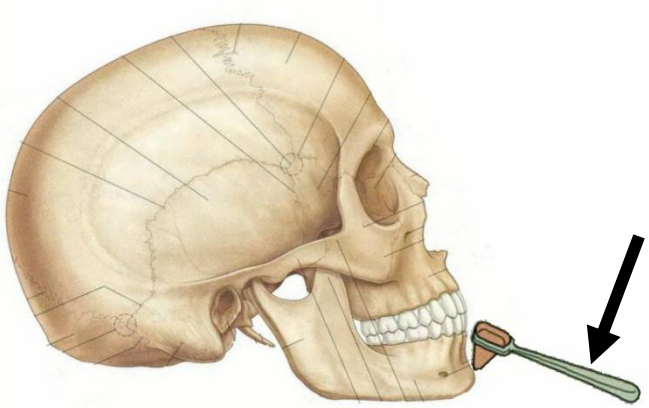
SENSE ORGAN = Muscle Spindle afferent

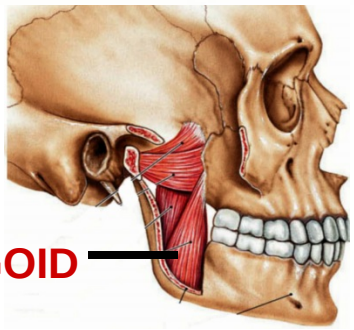
TAP ON TENDON



STRETCH REFLEX IN MUSCLES OF MASTICATION

TAP DOWN ON CHIN

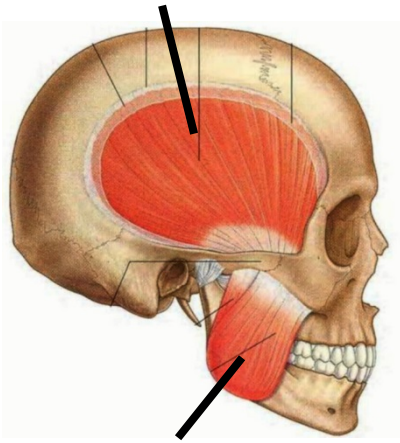




MEDIAL PTERYGOID

STRETCH MUSCLES THAT CLOSE MOUTH (ELEVATE MANDIBLE)

TEMPORALIS



MASSETER

TEST FUNCTION OF TRIGEMINAL NERVE (V3)

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

PALMAR GRASP

MORO REFLEX - arm extend

STEPPING 'REFLEX' - actually eliciting motor pattern

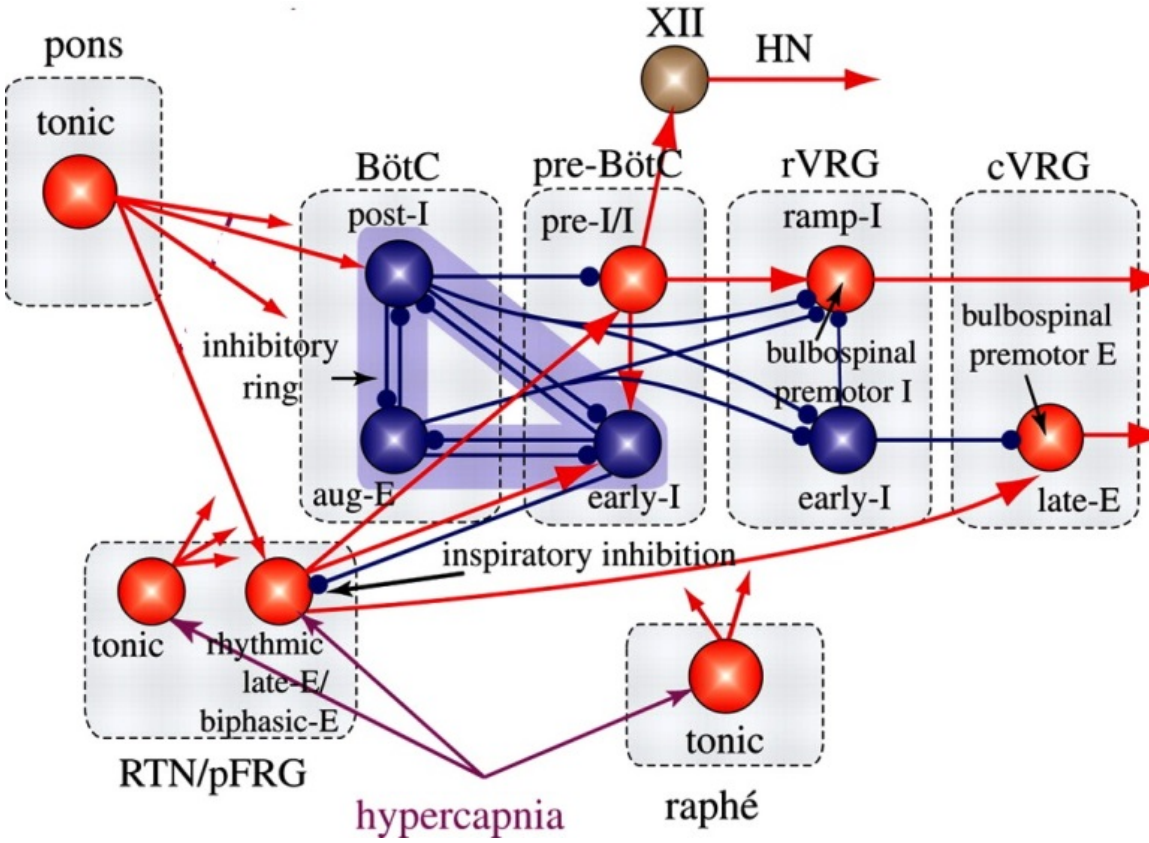
PLANTAR GRASP

PLACING REFLEX

TONIC NECK REFLEX - extend ipsilateral arm, flex opposite arm

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

Neurons in Brainstem (Pons and Medulla) that generate Respiration



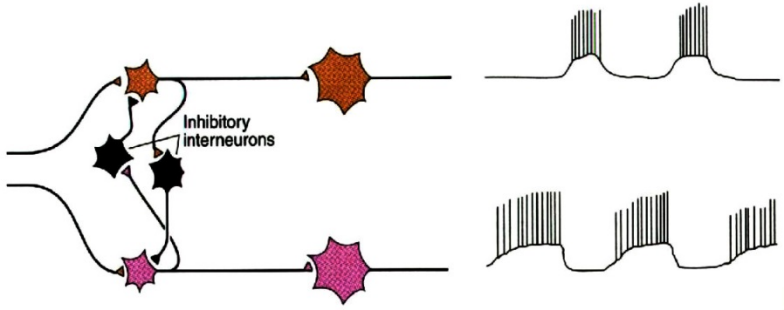
PN - Phrenic nerve inspiration

AbN - nerves to Abdominal muscles expiration

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

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

PATTERN GENERATOR - see Dr. Grover's lecture



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

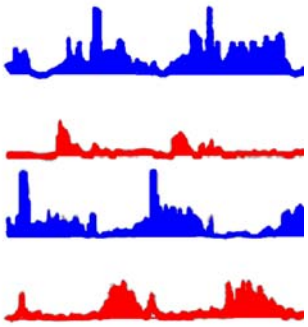
TREADMILL WALKING WITH WEIGHT SUPPORTED

Christopher Reeve

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

Note: Goo-Goo Person

MUSCLE ACTIVITIES IN WALKING ARE SIMILAR TO ADULT



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

Stepping 'reflex' probably represents activation of pattern generating neurons

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

SUMMARY OF SPINAL, CRANIAL NERVE REFLEXES

SPINAL REFLEXES AND DISORDERS

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

REFLEXES OF CRANIAL NERVES

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