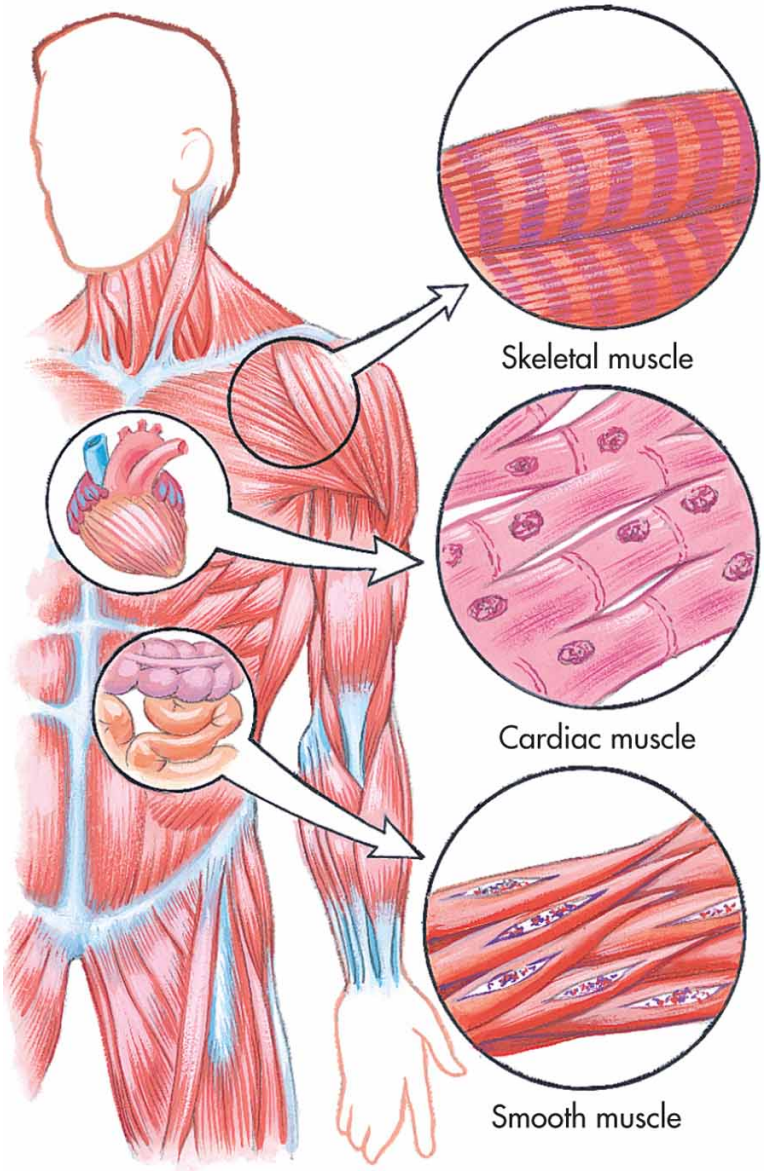
Lecture 7

Motor Processes

Cogs17 * UCSD

Three Types of Muscles



Striate (Skeletal) Muscle
Connected to Tendons to Bones
Voluntary movements

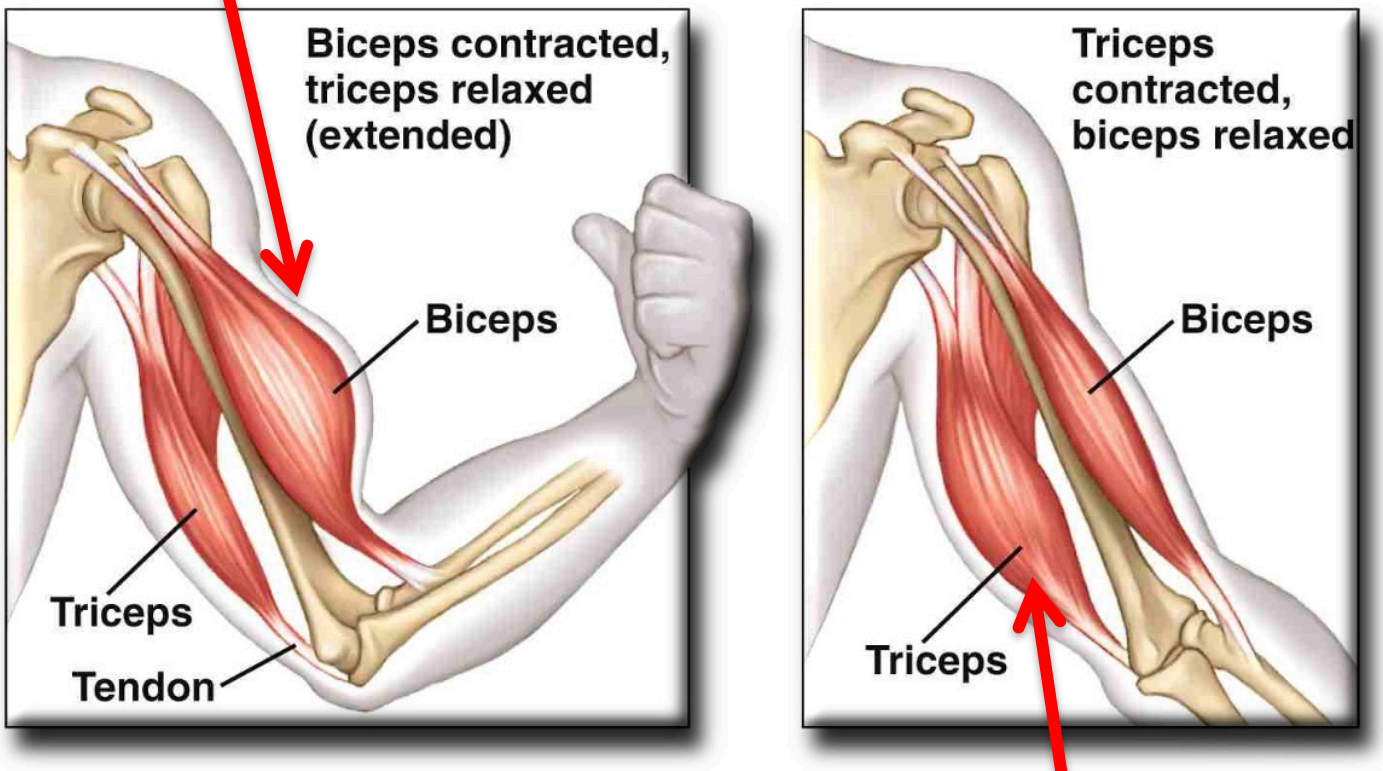
Cardiac (Heart) Muscle
Has endogenous rhythm of activity,
modified by neurons

Smooth (Organ) Muscle
Can sustain contraction,
Mostly autonomically controlled

Skeletal Muscles

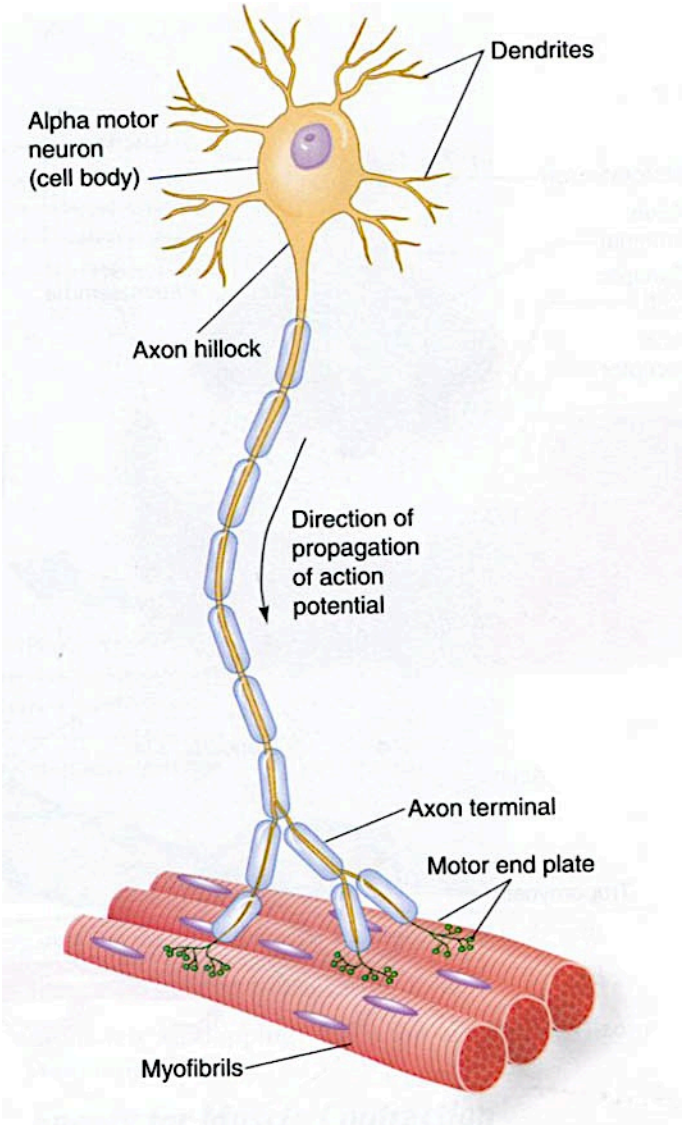
Come in "Antagonistic Pairs"

For each "**FLEXOR**" muscle, that moves bones toward body



There is a corresponding "**EXTENSOR**" muscle, that moves same bones away from body

Neuro-Muscular Junction



Motor Neurons

(α or Alpha Neurons)

release **Acytelcholine**

onto muscle fibers

Fiber responds like a Neuron would!

Na+ gates open, Na+ enters cell

Change in polarity opens Ca++ gates

Ca++ enters cell…

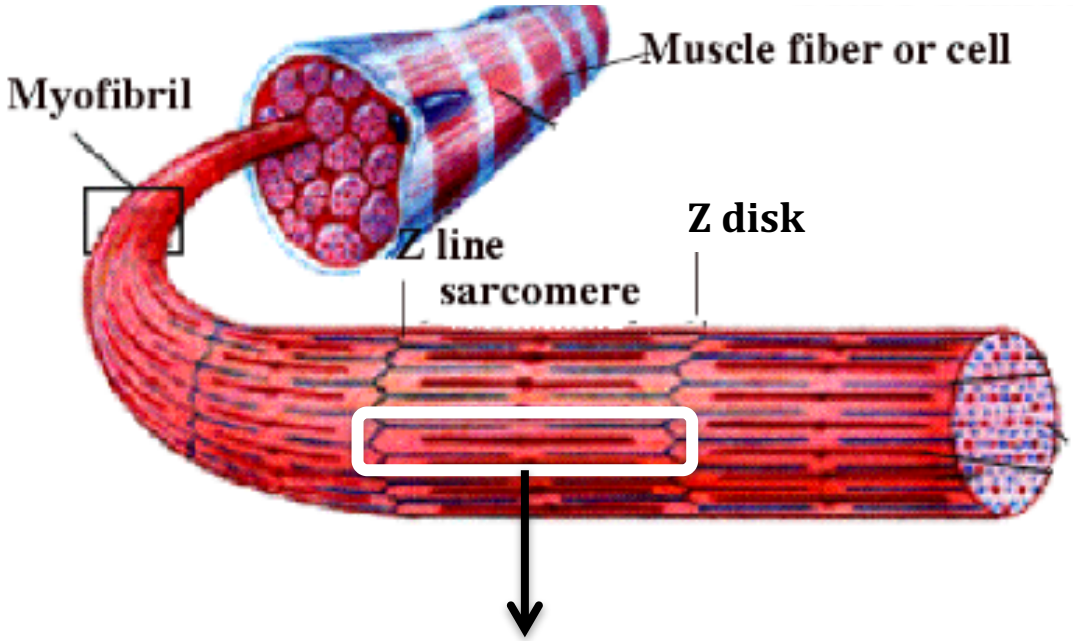
BUT

instead of causing release of neurotransmitter,

Ca++ activates **Sarcomeres**

to <u>contract</u> the muscle

Sarcomere Contractile Unit in Skeletal Muscles

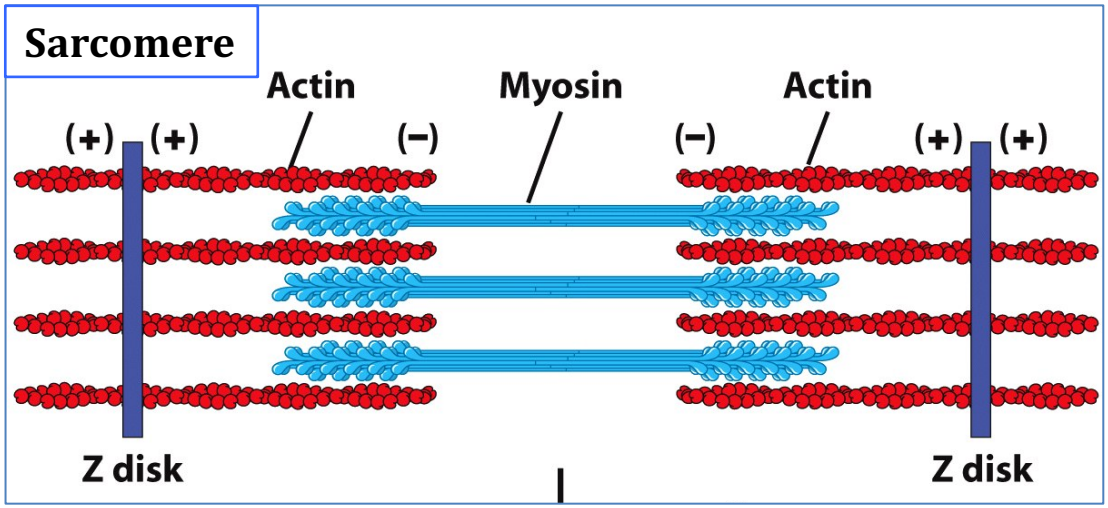


Two key proteins involved:

Actin

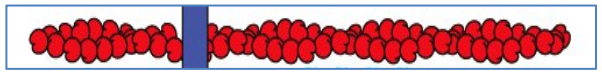
and

Myosin



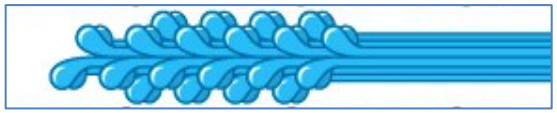
Sarcomere Contractile Unit in Skeletal Muscles

ACTIN coil



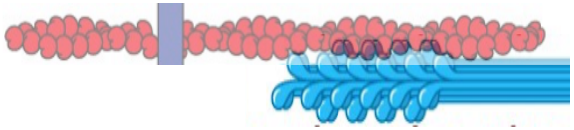
Secured to muscle at Z Disk

MYOSIN

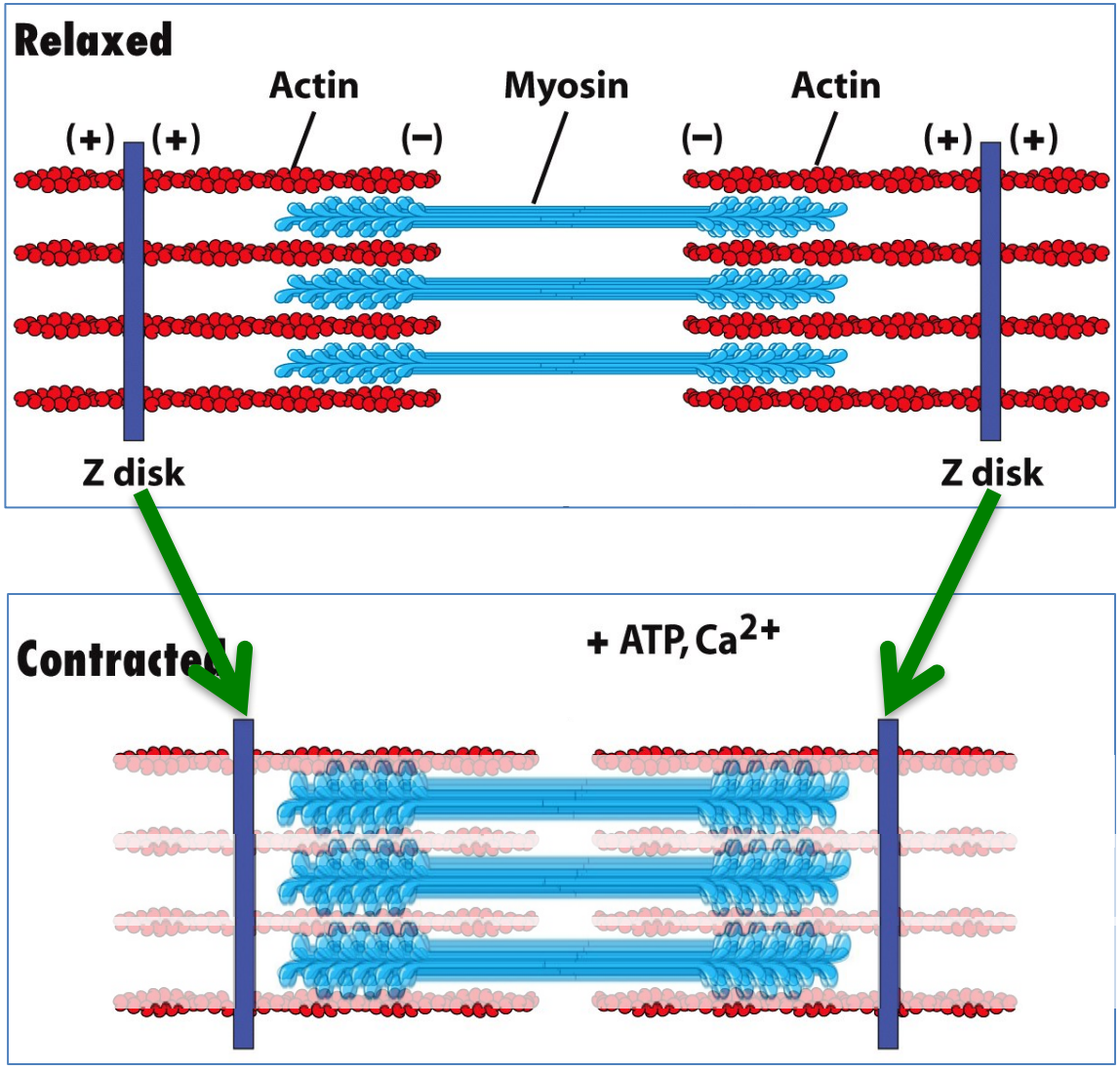


Cross-Bridges

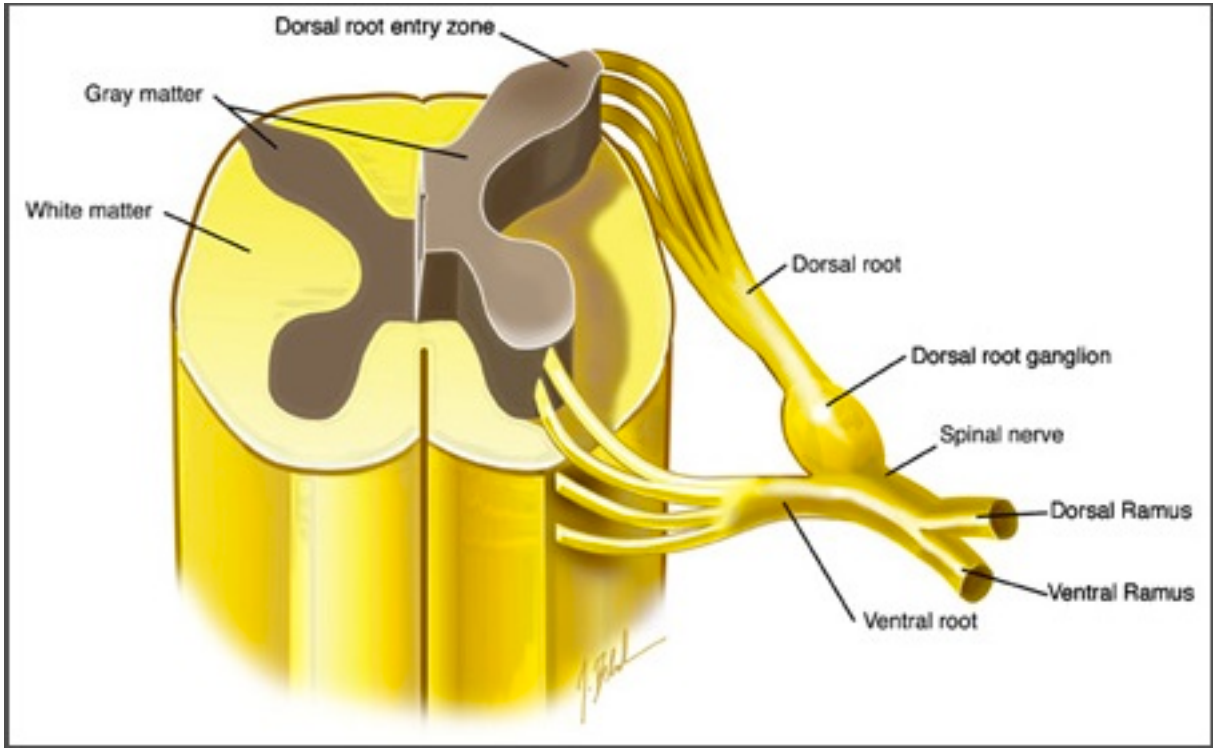
When Ca++ enters
muscle cells,
Cross Bridges activated



They 'row' into pairs of
Actin coils
pulling them closer together

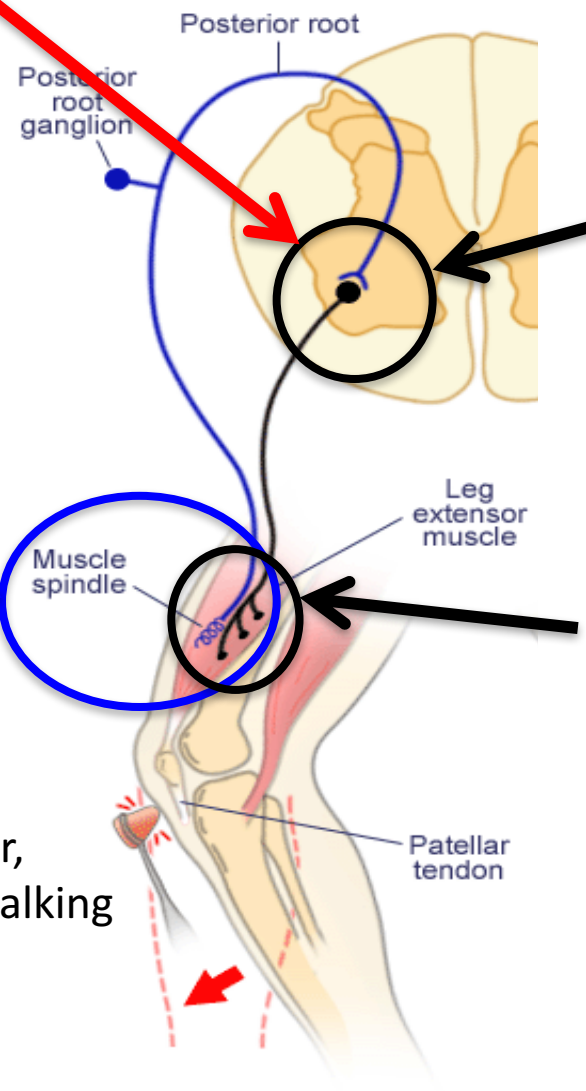


Spinal Reflexes Simple Circuits



Stretch Reflex

This is the *ONLY* one-synapse reflex



Muscle Spindle
(A Proprioceptor)
in muscle detects
passive stretch of muscle

Muscle Spindle
<u>excites</u>
Motor Neuron
In Spinal Cord

Motor Neuron
stimulates <u>same muscle</u> to
contract,
counters passive stretch

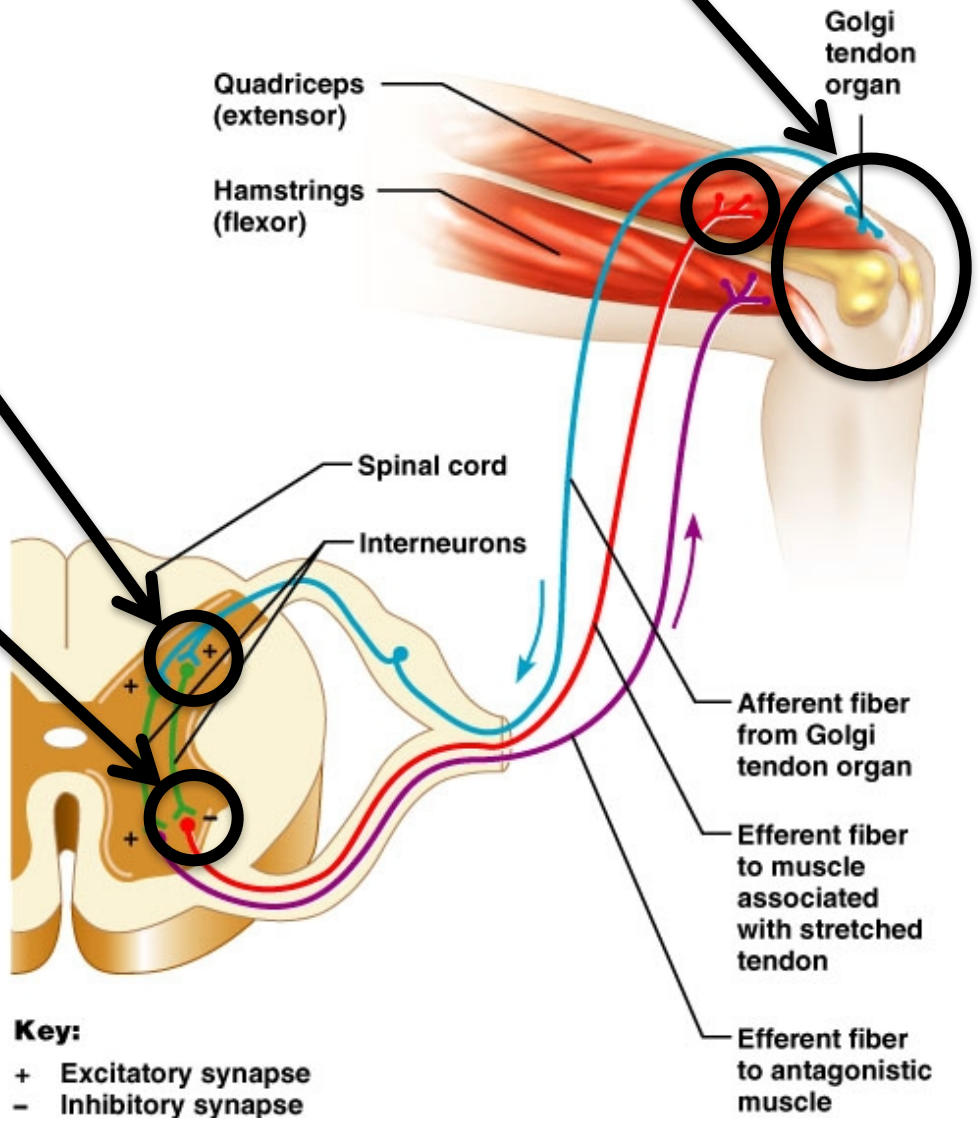
...as from doctor's hammer,
or from shift of weight while walking

Golgi Reflex

Over-contracting muscle pulls so hard on tendon that the **Golgi Tendon Organ** (a Proprioceptor) signals the Spinal Cord…

activates an ***Inhibitory*** **Inter-Neuron** in Spinal Cord that…

inhibits **Motor Neuron** to original muscle, reducing contraction



Golgi Reflex

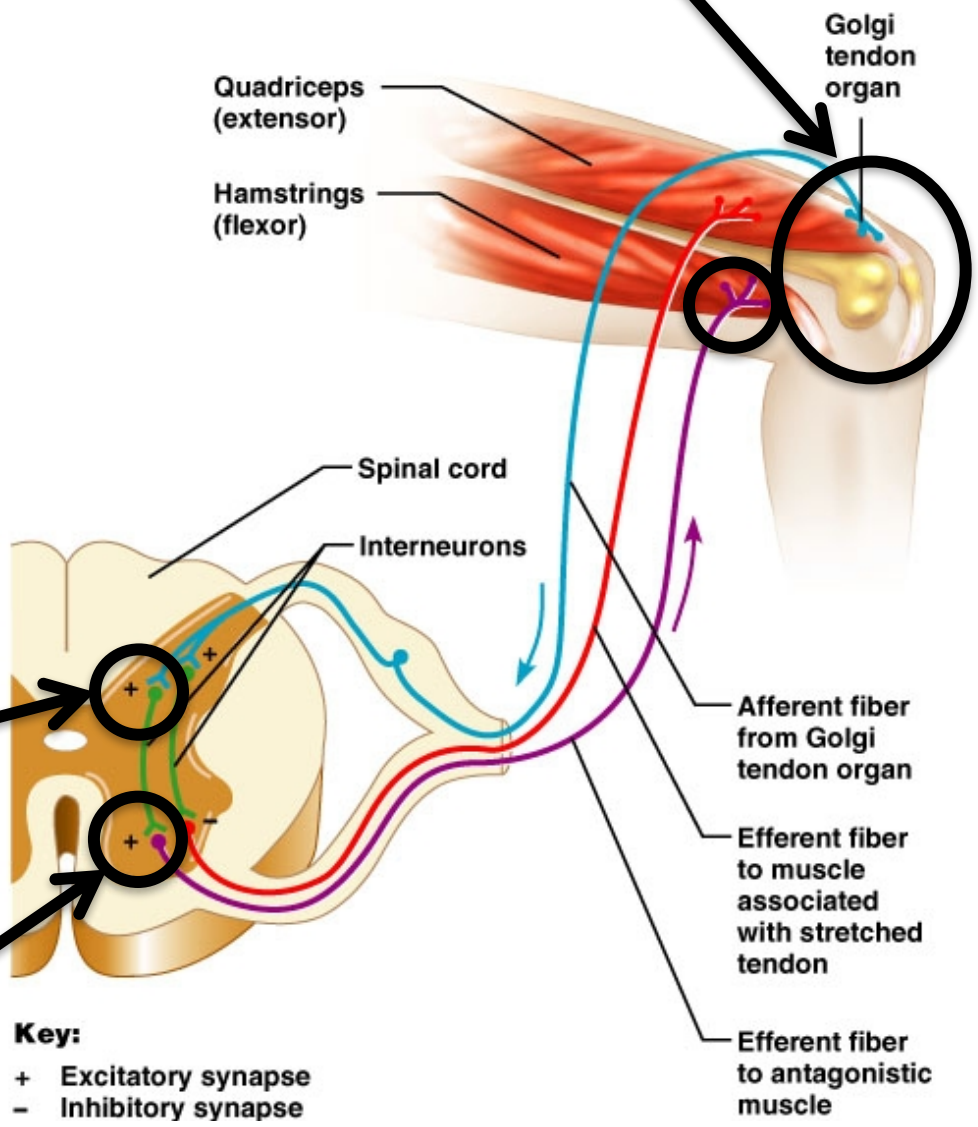
Over-contracting muscle
pulls so hard on tendon, that the
Golgi Tendon Organ
(a Proprioceptor)
signals Spinal Cord

activates an
***Inhibitory* Inter-Neuron**
in Spinal Cord that

inhibits
Motor Neuron
to original muscle,
reducing contraction

Golgi Tendon Organ
also activates an
***Excitatory* Inter-Neuron**
in Spinal Cord that

excites
Motor Neuron
to Antagonistic muscle,
increasing its contraction,
which decreases original's contraction

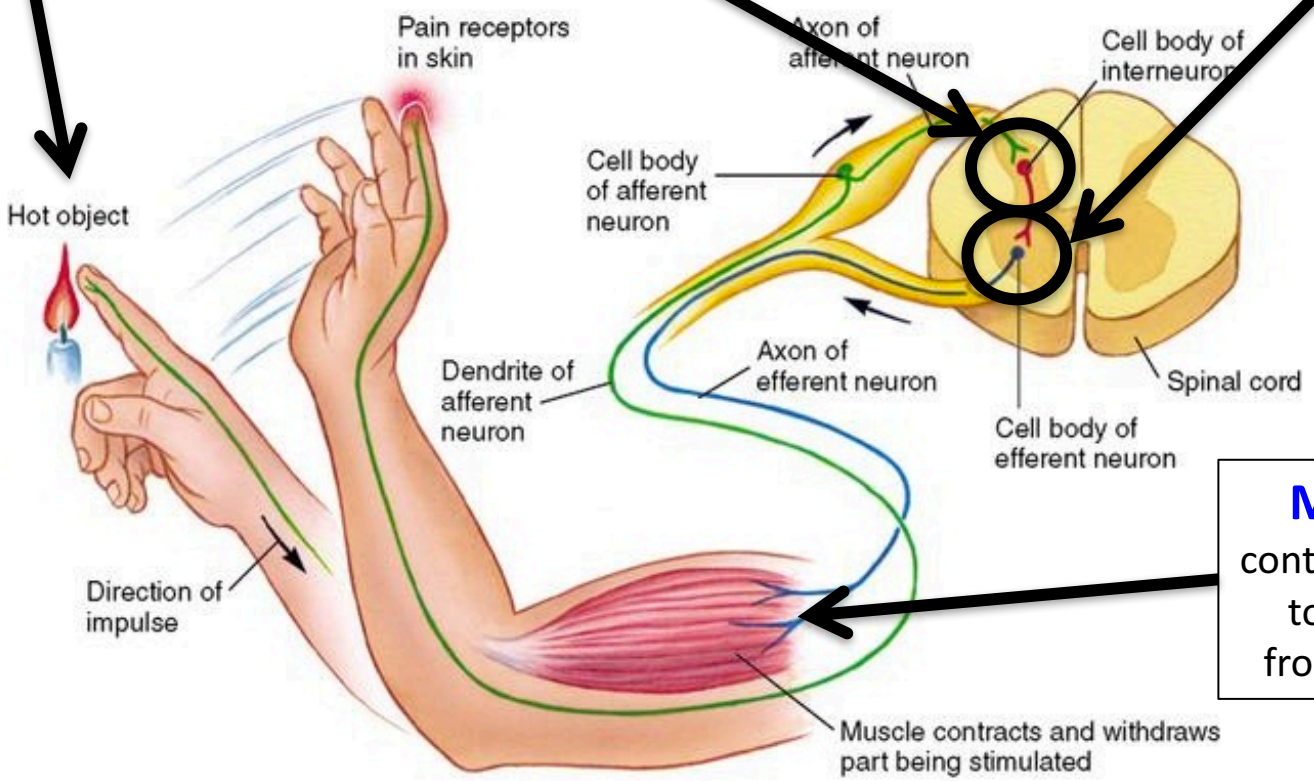


Pain Withdrawal Reflex

Nociceptor
(Pain Receptor)
detects
noxious stimulus

Nociceptor
synapses in Spinal Cord on
Excitatory Inter-Neuron

Excitatory Inter-Neuron
excites
Motor Neuron



Motor Neuron
contracts a flexor muscle
to pull sensor away
from noxious stimulus

Scratch Reflex

A Cerebellar Reflex

Like the human
"Raspberry"
(Tongue/Lip vibration)

Oscillator Circuit

Such circuits can be reflexive OR controlled
(e.g. clapping)

Infant Reflexes

A Cerebellar Reflex

Babkin Reflex

Press palms,
fingers grasp
& mouth opens

A vestigial attempt
to cling to fur

Infant Reflexes

A Cerebellar Reflex

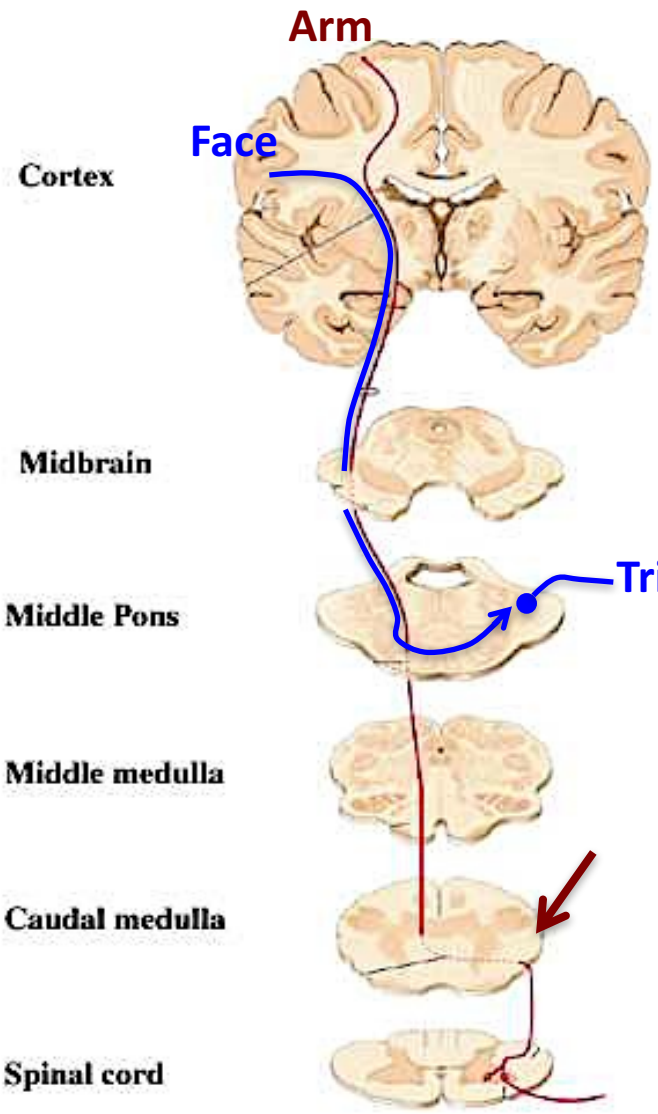
Rooting Reflex

Touch cheek,
head turns &
infant suckles

Can reappear in VERY drunk adults, if cerebellum suppressed by alcohol

Cortico-Spinal (Pyramidal) Tracts

For control of voluntary motion, on contralateral side of body



Cortico-Spinal Pathway
from Motor Cortex

Corticobulbar Tract
for face movements

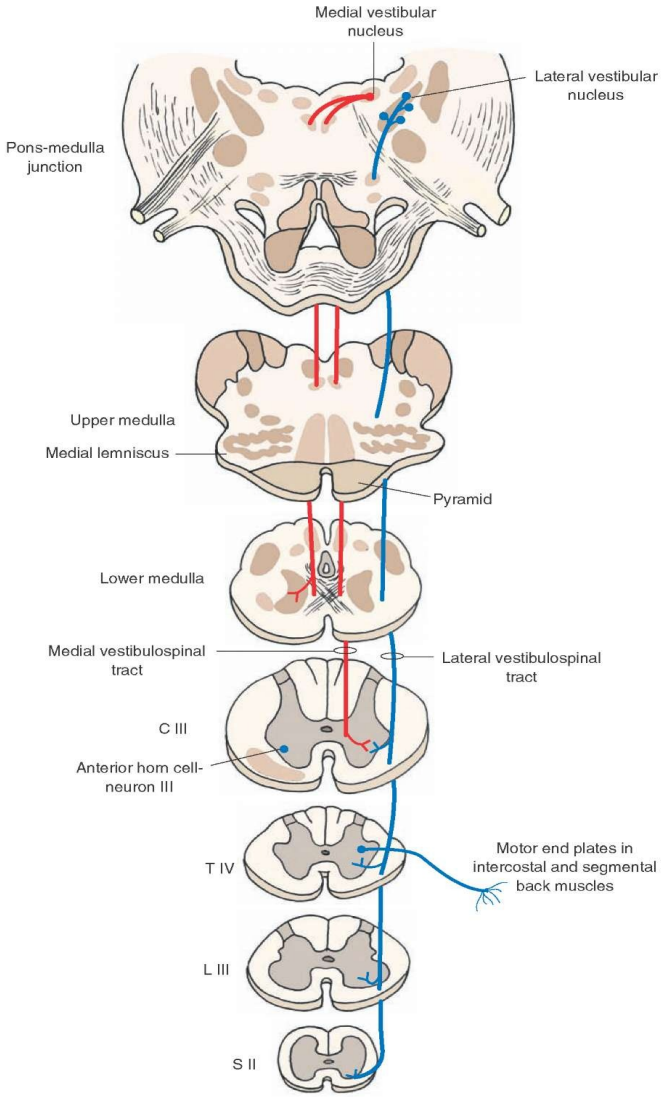
Crosses over in the **Pons**

Trigeminal Nerve
to face

Most fibers cross to
Contralateral Spinal Cord
in Medulla

Activates motor neurons to contralateral skeletal muscles

Ventro-Medial Tracts



Bilateral and Ipsi-Lateral

Primarily for control of posture,
neck, shoulders & trunk,
where one side cannot
move separately from the other

Includes circuits for WALKING,
since two sides must be
in tight coordination

Make multiple connections in
Tectum, Vestibular Nucleus, Reticular Formation,
integrating with sensory & arousal systems

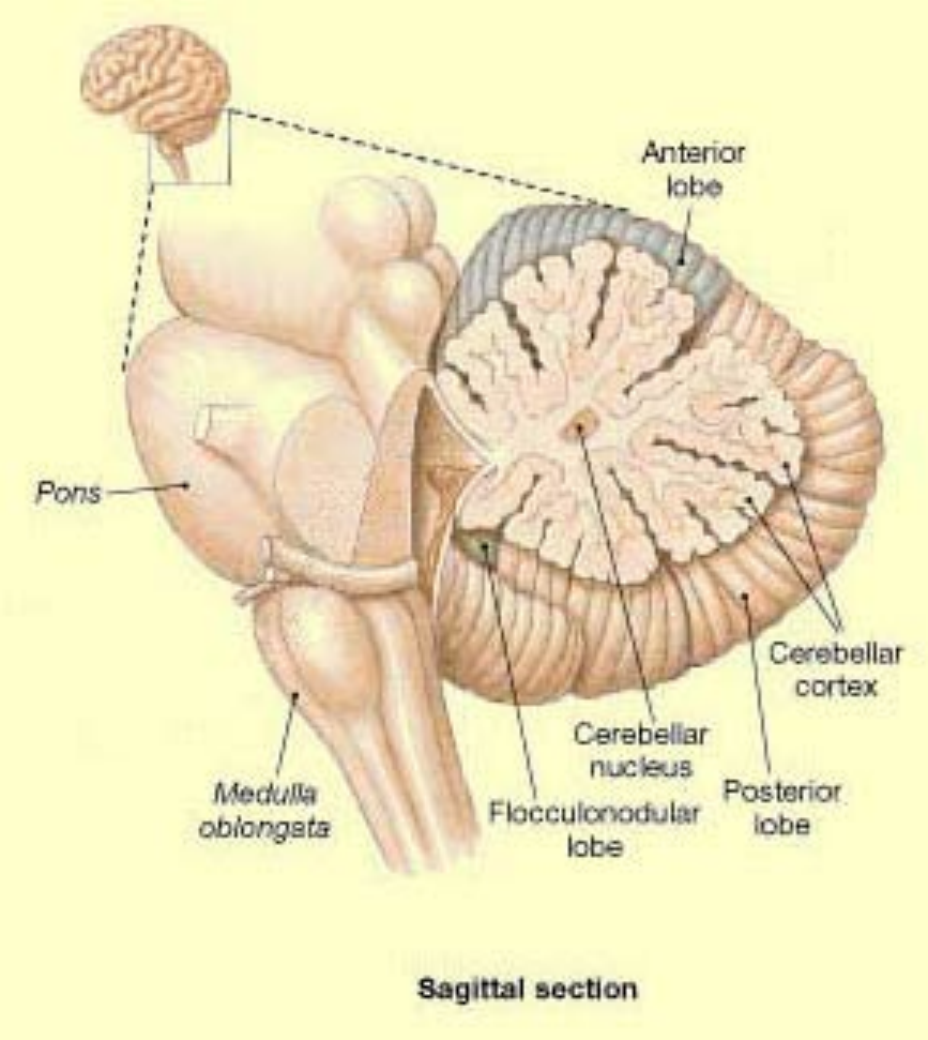
Cerebellum

Cerebellum

MNEMONIC:

Sarah the ballerina
has a hell of a cerebellum!

Cerebellum



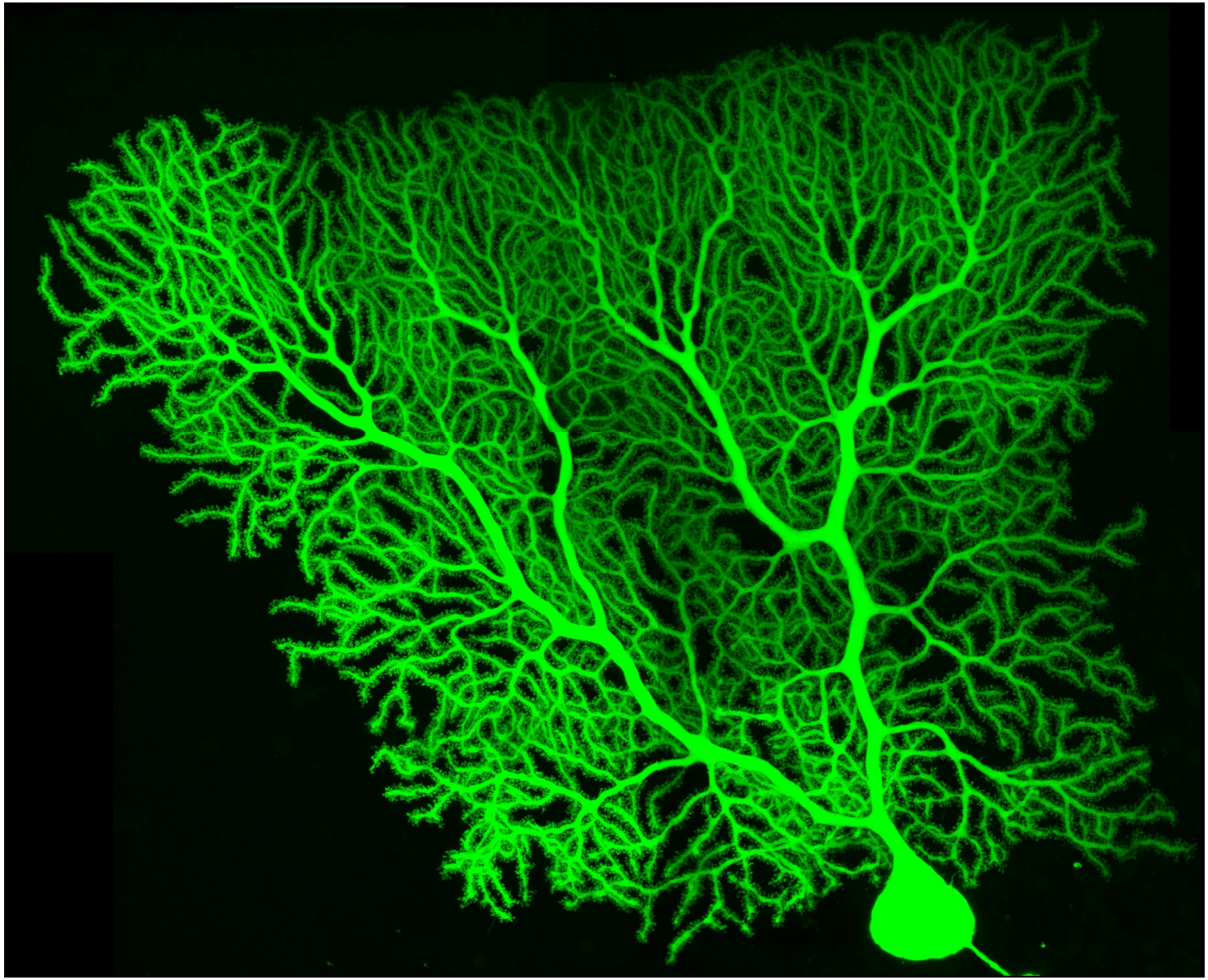
For rapid, well-coordinated movements requiring precise **timing**

Include preprogramed (like Saccades) and learned-through-practice behaviors...

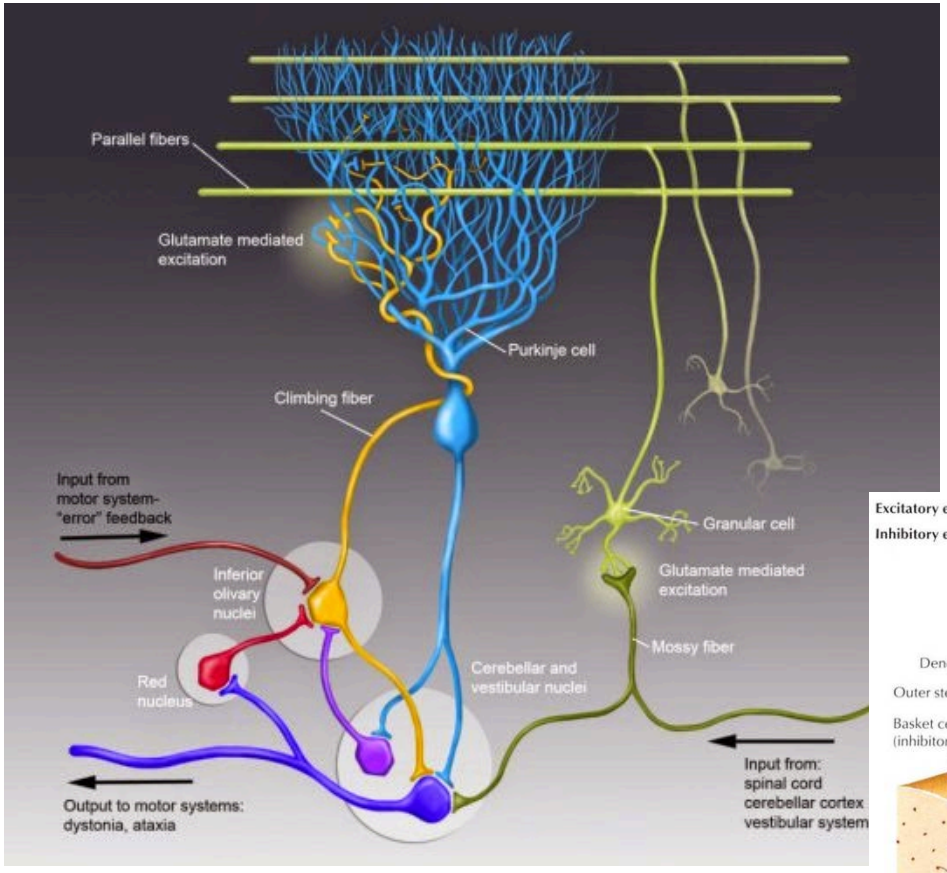
...including shifts of **Attention**

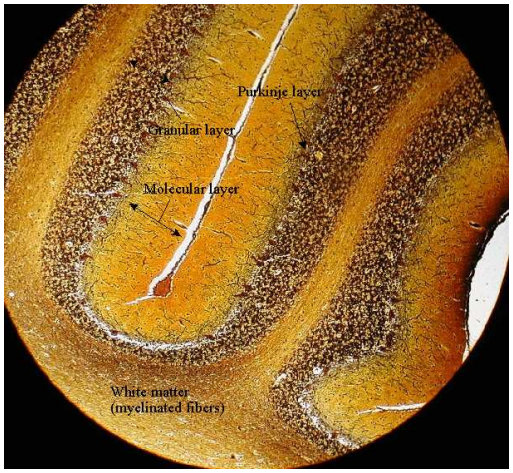
Depend on **real-time Sensori-Motor feedback**

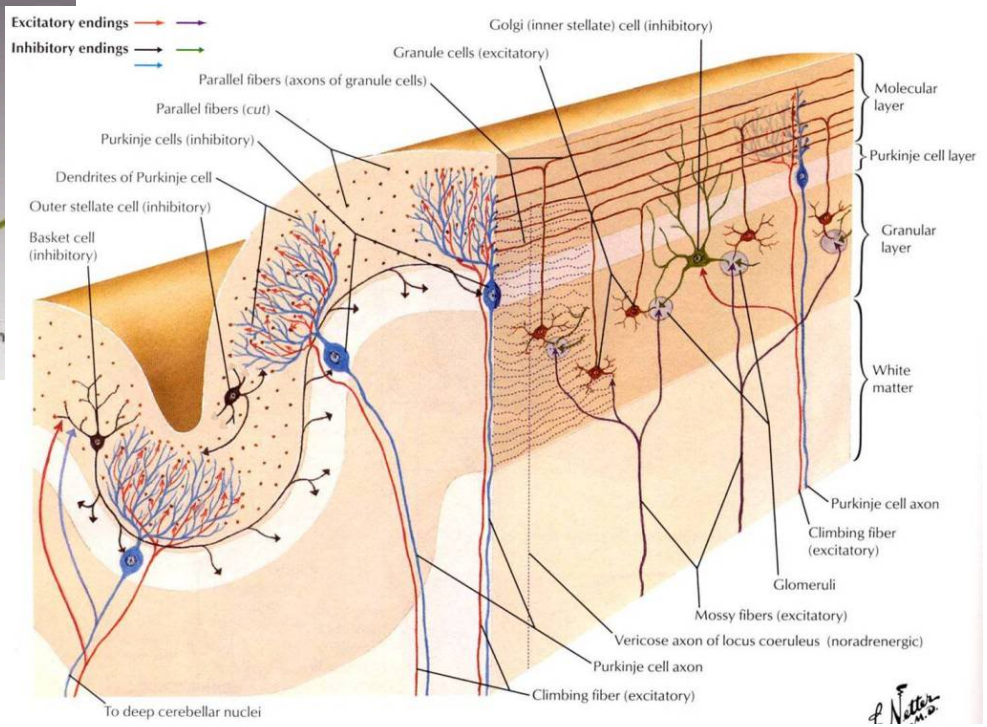
Purkinje Cell



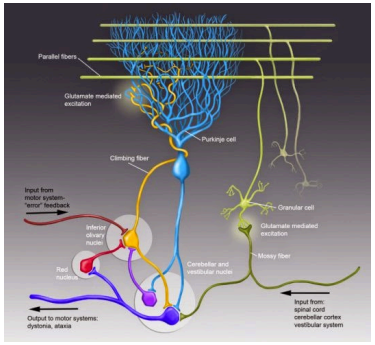
Cerebellar Circuits







~50 Billion cells
in Cerebellum alone!



Cerebellar Circuits

This circuit codes TIME as DISTANCE signals travel

Purkinjes correspond to different muscle groups

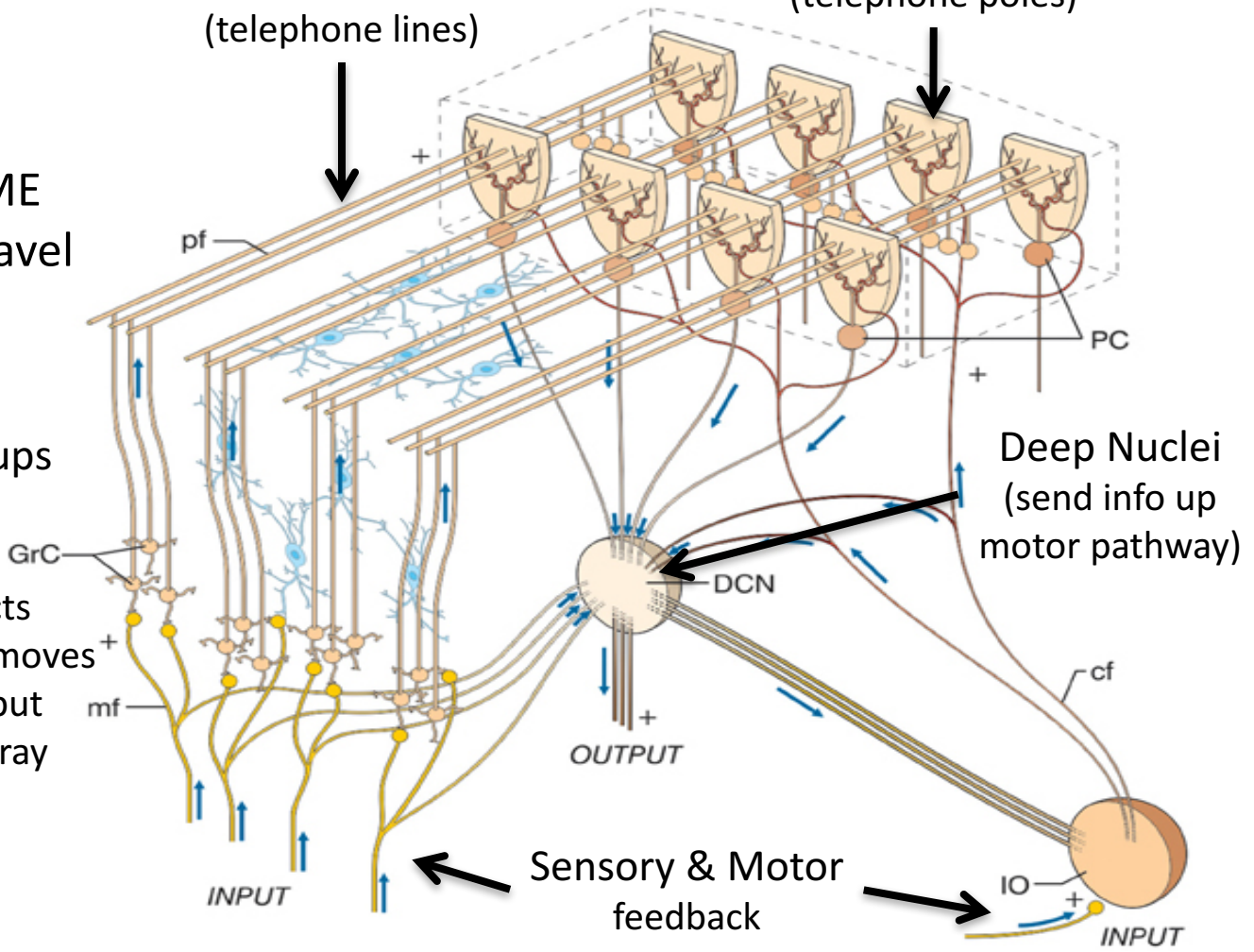
Activity along parallel tracts <u>represent timing</u> of different moves by changes in Purkinje output at <u>different places</u> along array

Parallel Fibers (telephone lines)

Purkinje Cells (telephone poles)

Deep Nuclei (send info up motor pathway)

Sensory & Motor feedback



Sobriety Test for Cerebellum Function

Smooth ballistic motion of hand to face

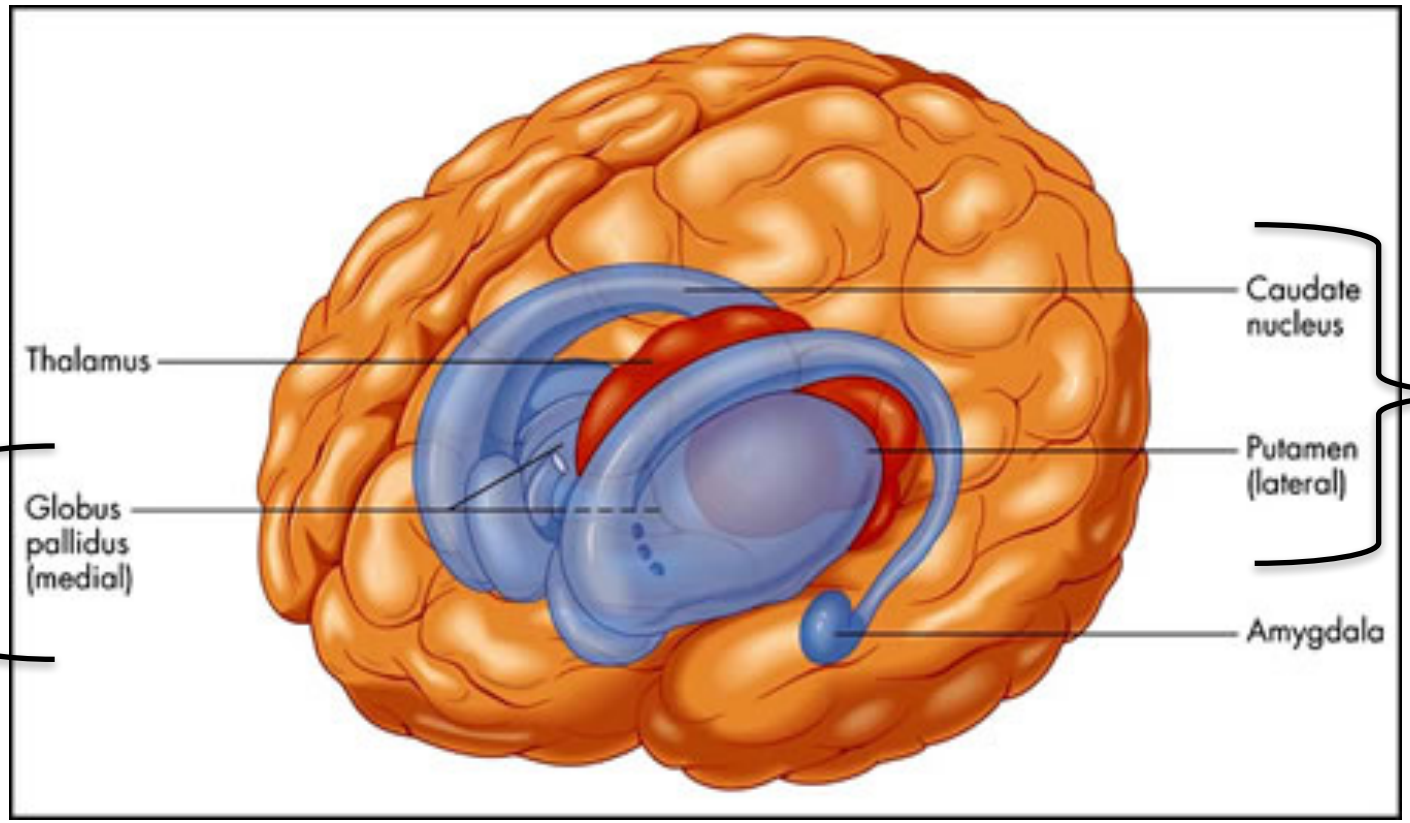
Walking a straight line, requires balance
(integration of vestibular input)

Cerebellum is particularly
sensitive to Alcohol poisoning,
impairing execution of these actions

Basal Ganglia

Organizes activity into **TASKS**

A "**Re-entrant System**" that keeps track of status of "sub-goals"



G.P.
(Output)

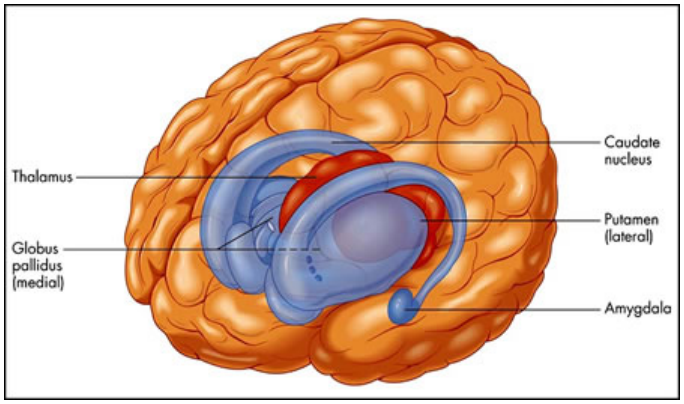
Striatum
(Input)

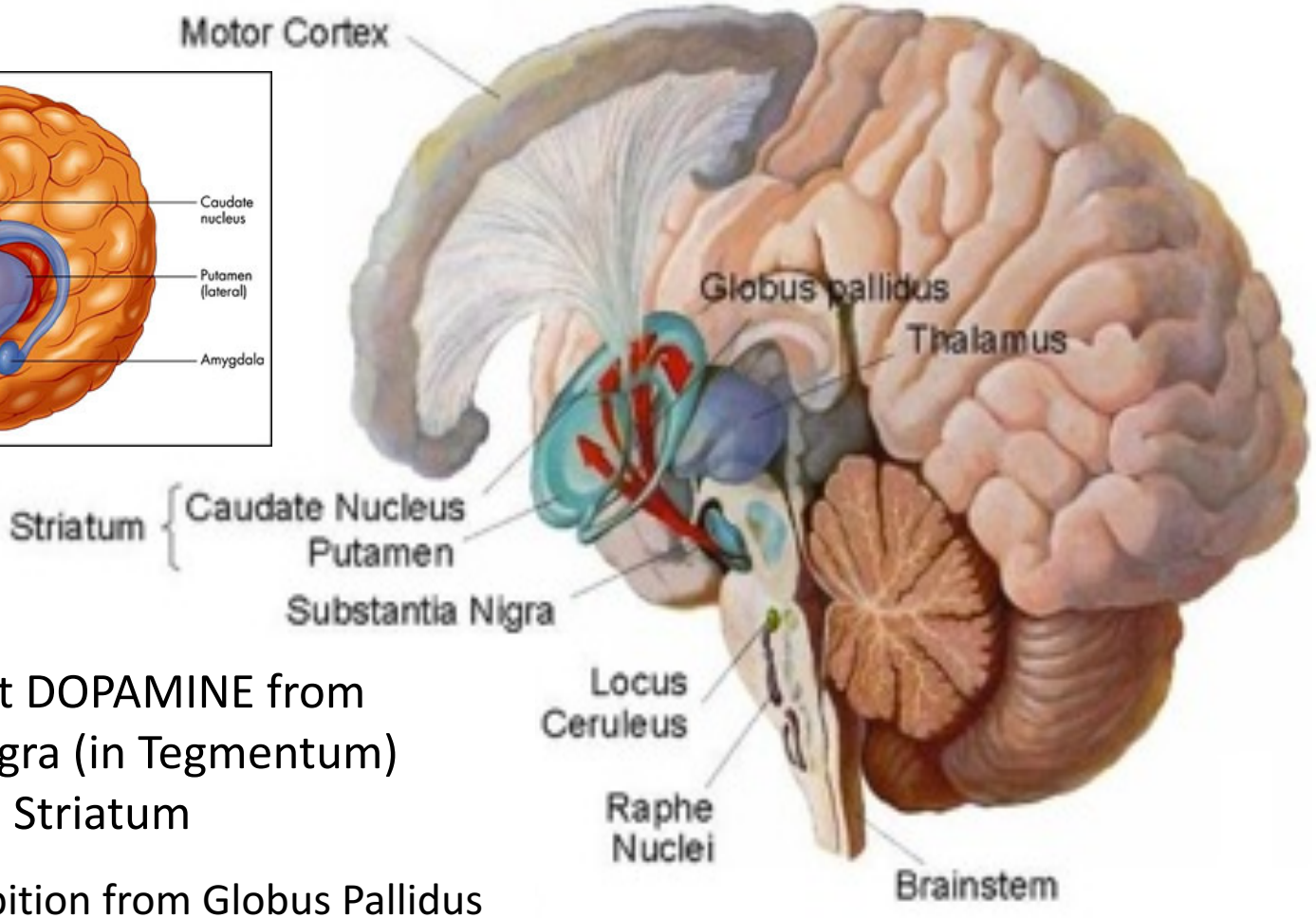
"**Automates**" complex sequential process (e.g. driving)

"**Selects**" what's appropriate when

Pathologies include (OCD) Obsessive Compulsive Disorder,
Attention Deficit Disorders (ADD) & Parkinson's disease

Brain Regions Affected by Parkinson's Disease





Insufficient DOPAMINE from Sustantia Nigra (in Tegmentum) to Striatum

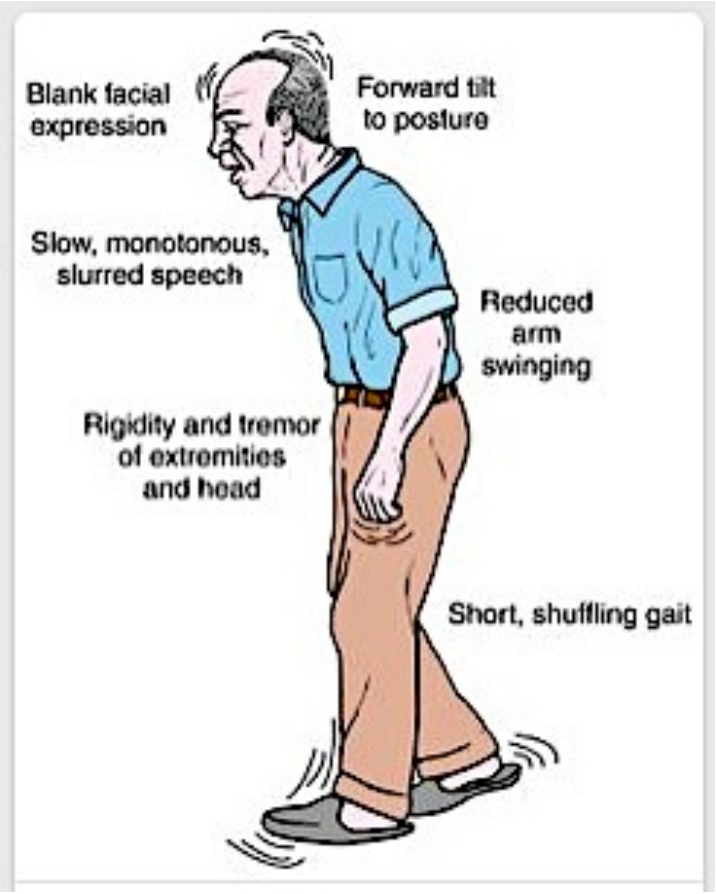
>> Greater inhibition from Globus Pallidus to motor nucleus (VLP) of Thalmus

Produces tremors, difficulty with smooth execution, cognitive deficits, eventually paralysis & death

Parkinsons' Disease

Treated with "**L-Dopa**", a dopamine precursor
that crosses blood-brain barrier

But many side effects, since
Dopamine so widespread & multi-functioned in brain



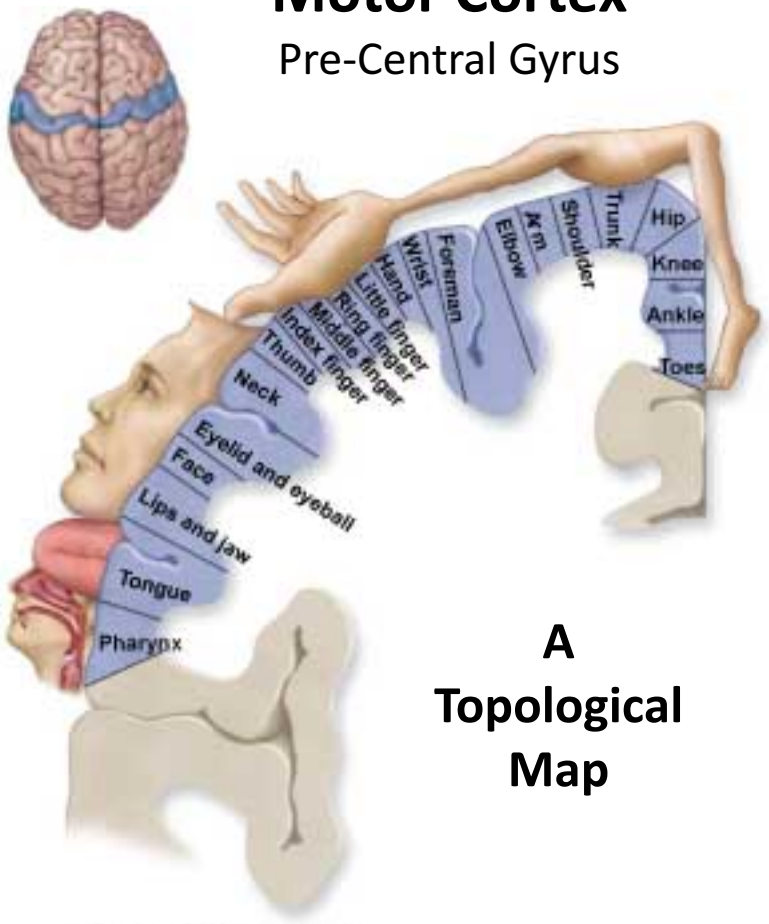
Can be caused by
head trauma

But also traced to
environmental
toxins!

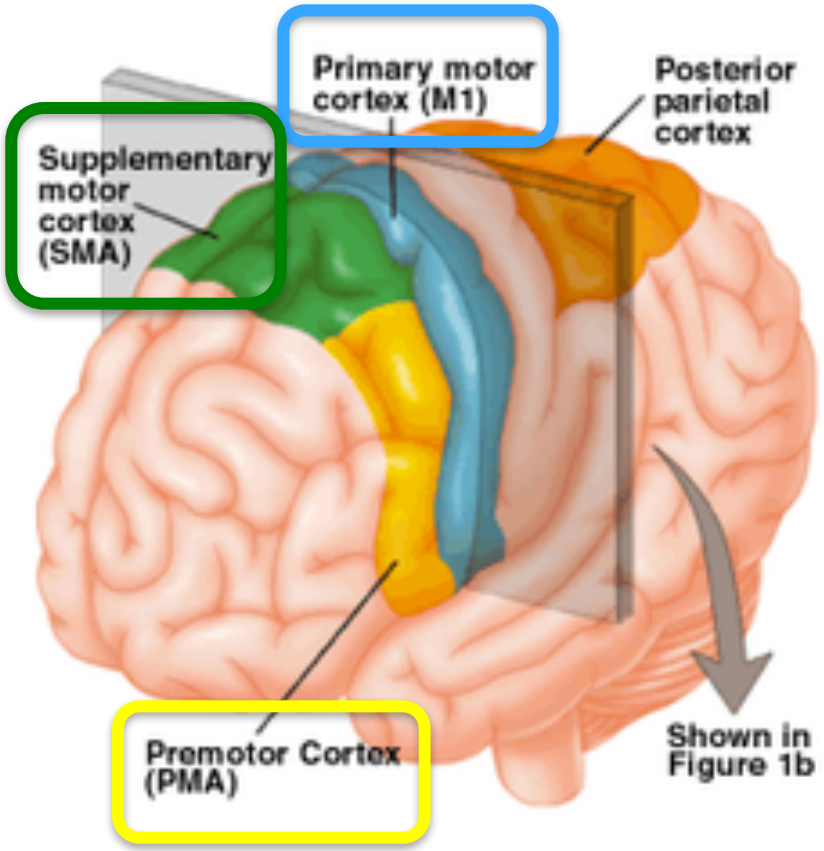
Motor Cortex

Motor Cortex

Pre-Central Gyrus



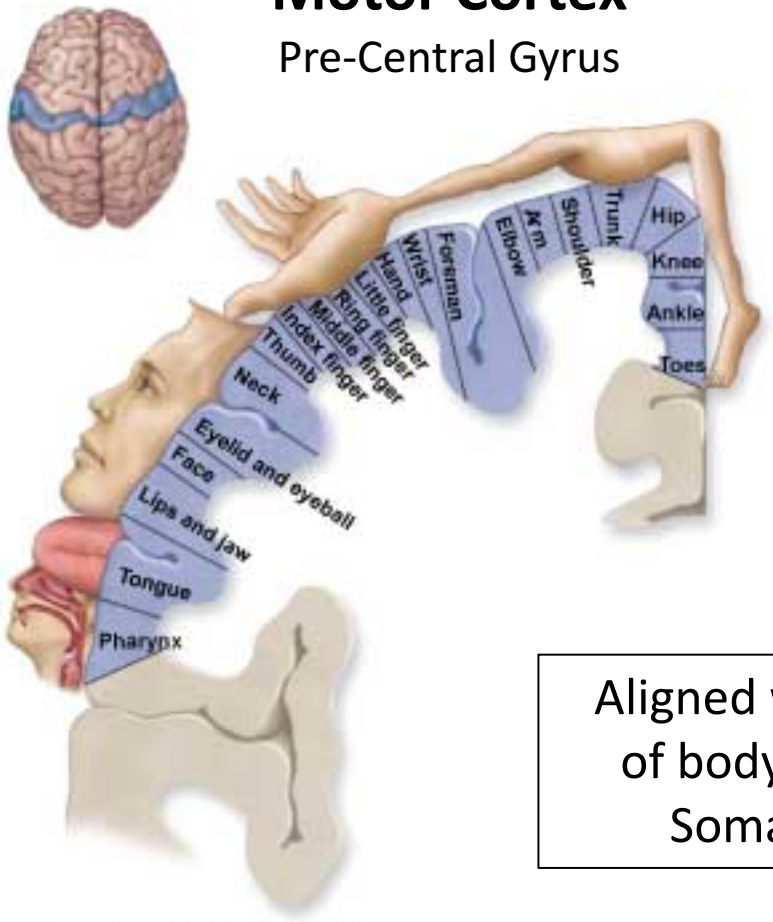
A Topological Map



Topological Cortical Maps

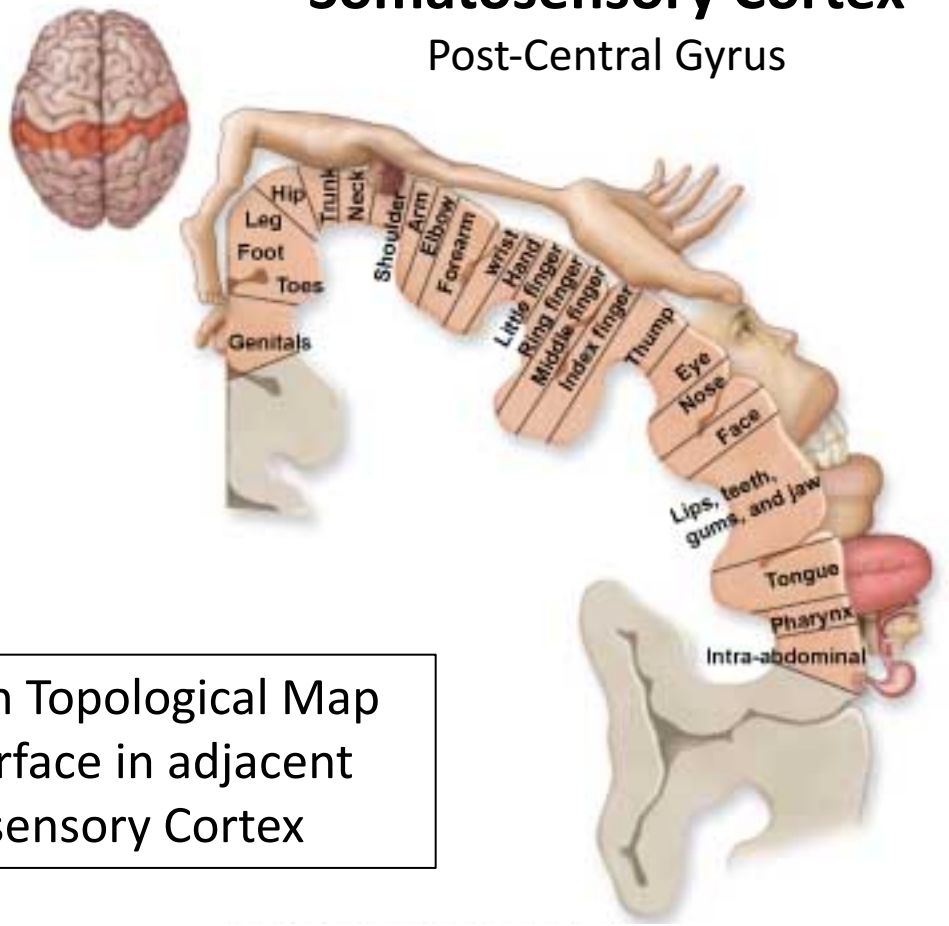
Motor Cortex

Pre-Central Gyrus



Somatosensory Cortex

Post-Central Gyrus



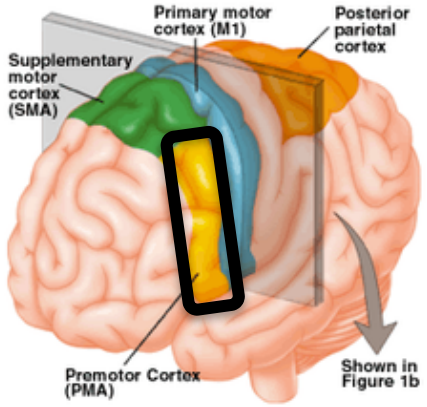
Aligned with Topological Map of body surface in adjacent Somatosensory Cortex

Motor Humunculus

Note that HANDS
are particularly magnified
even compared to
Somatosensory map

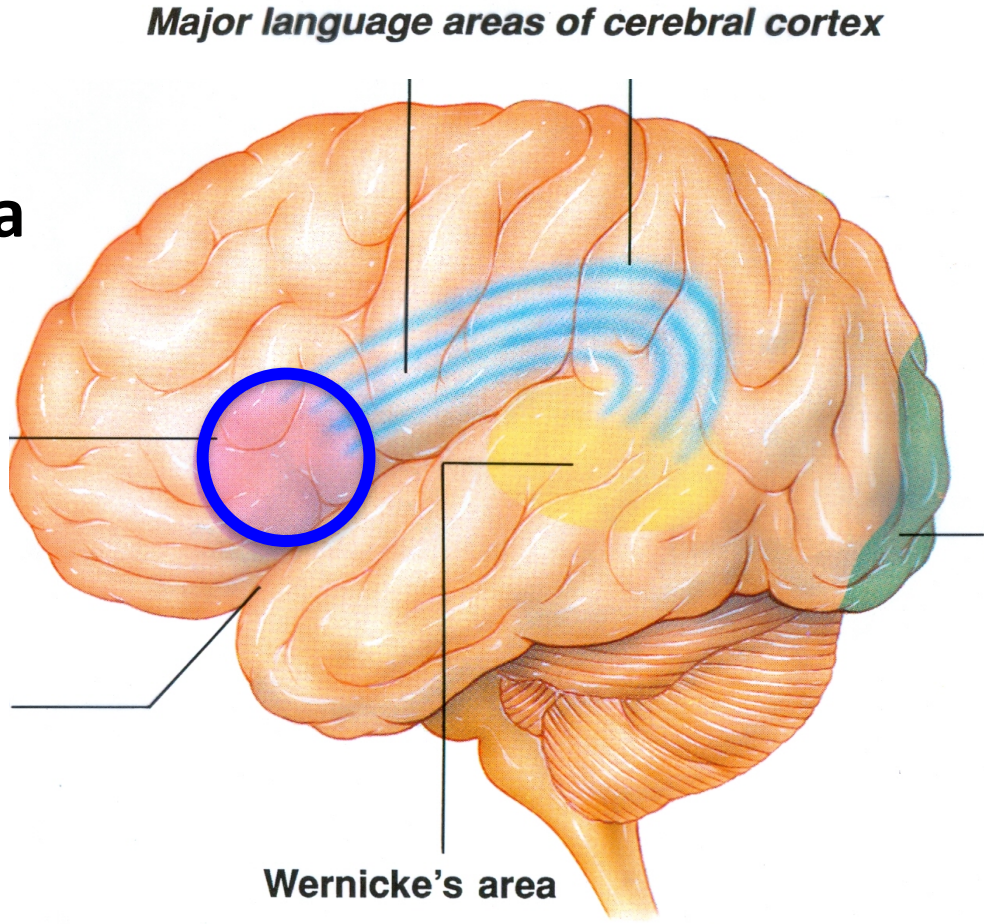
Pre-Motor Cortex

Prepare to act; Planning



Broca's Area

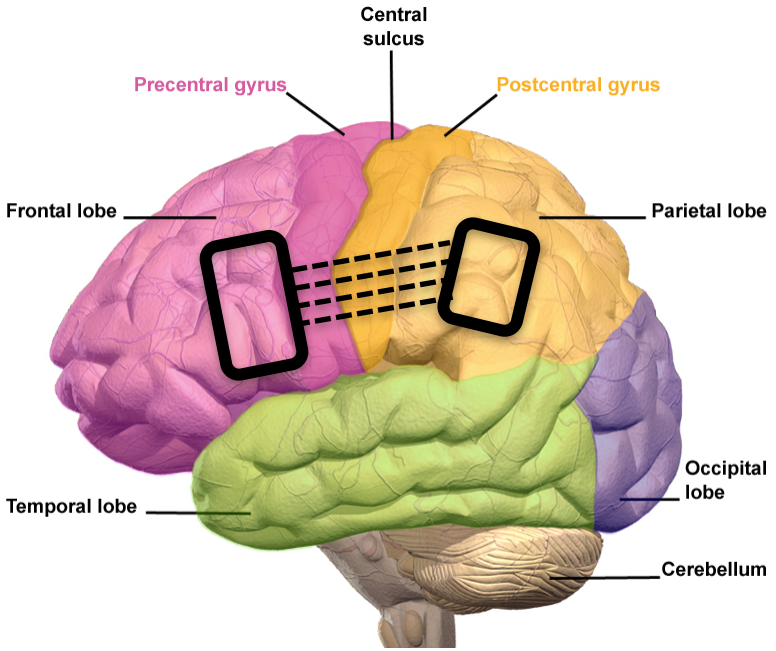
Prepare to Speak



Mirror Cell System

"Mirror Cells" respond when subject <u>sees/feels self</u> performing familiar act

Same cells respond when subject <u>sees another</u> perform that act



Integrated with activity of Mirror Cells in Parietal Lobe

Simulation of observed action