Neurons for the SLP: How our Nervous System Communicates

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Outline

- Review of the Basal Ganglia
- Neuroanatomy Review
  - Nervous System
  - Neurons
- Neuronal Communication at the Cellular Level
- Neuronal Communication at the System Level
  - Motor System
- Clinical Application: Basal Ganglia

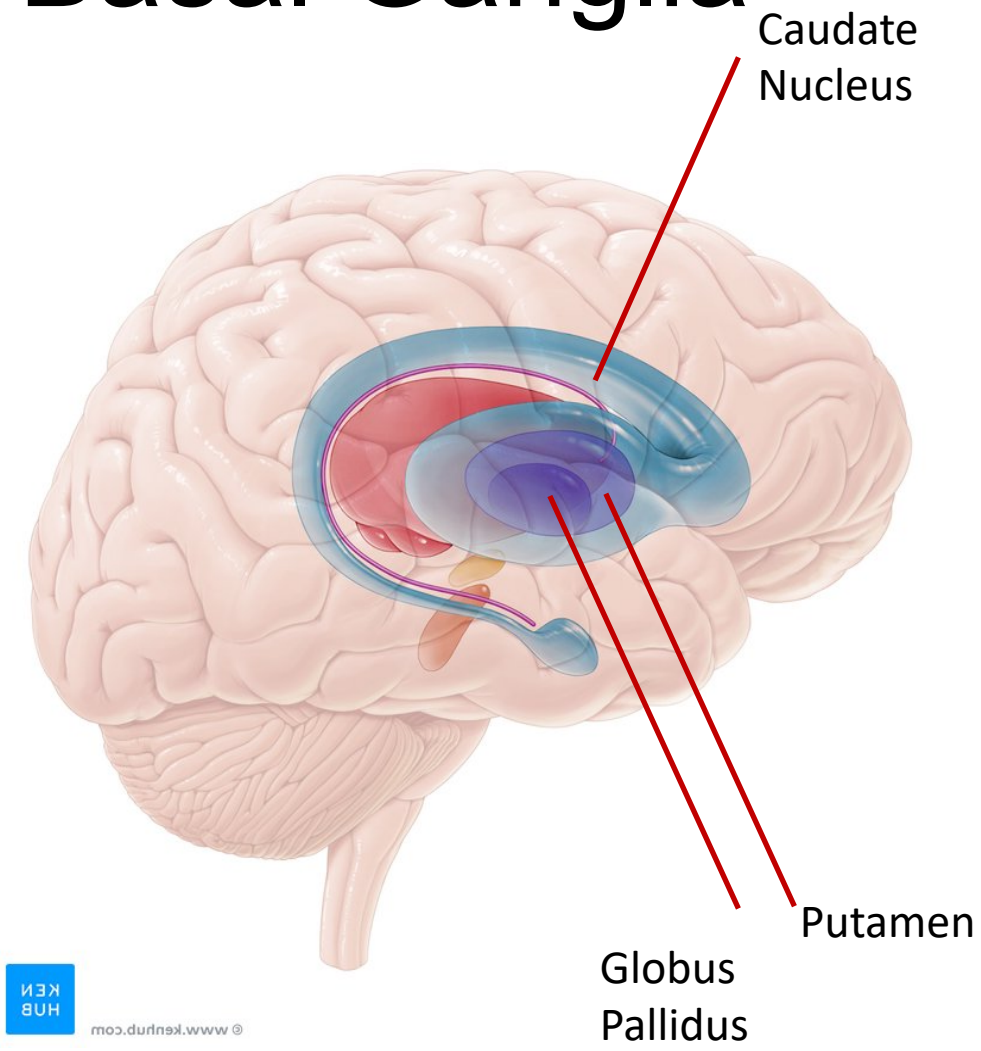
Learning Objectives

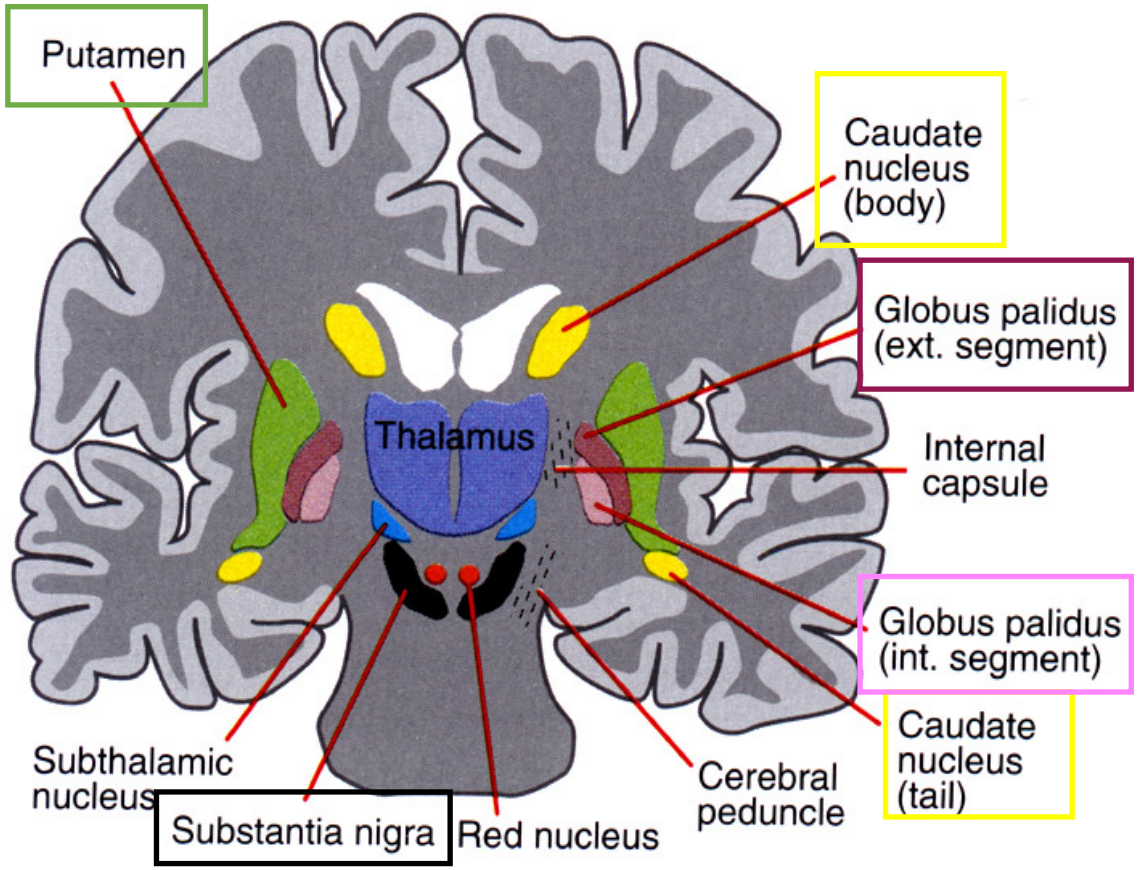
- Describe how neuronal anatomy relates to brain structures, including:
  - Gray and White Matter
  - Cortical and Subcortical
- Identify the parts and functions of a neuron
- Explain how neurons communicate at the cellular and system level

What word comes to mind when you hear *Basal Ganglia*?

Basal Ganglia

Movement, Mood, Emotions, Learning, and Cognition





Basal Ganglia – Motor Function

Initiating and Maintaining Smooth Movement

Parkinson's Disease

- Hypokinetic Dysarthria
- Resting tremor
- Akinesia: impairment in the initiation of movement
- Bradykinesia: reduction in the velocity & amplitude of movement

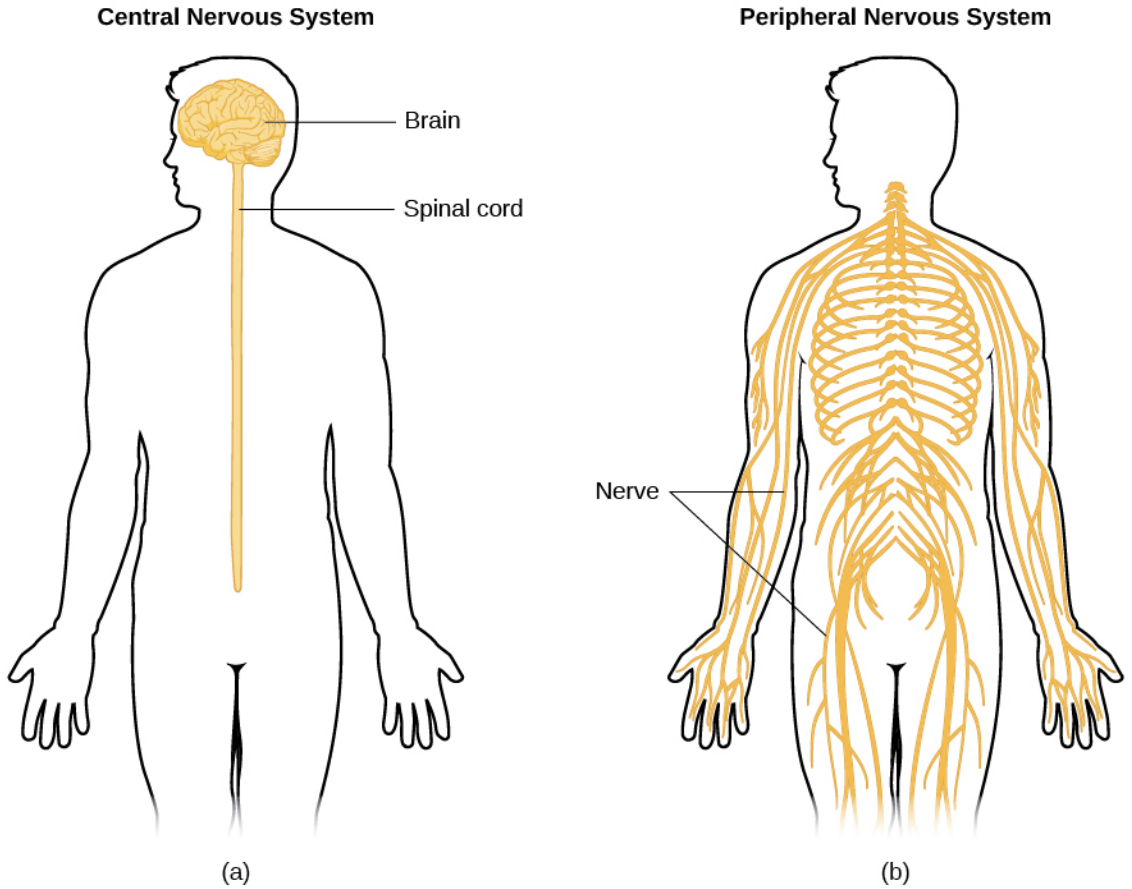
Huntington's Disease

- Hyperkinetic Dysarthria
- Ballismus: uncontrolled flinging (ballistic) movements
- Choreiform movements: generalized irregular dance-like movements of the limbs
- Athetoid movements: continuous writhing of the distal portions of the extremities

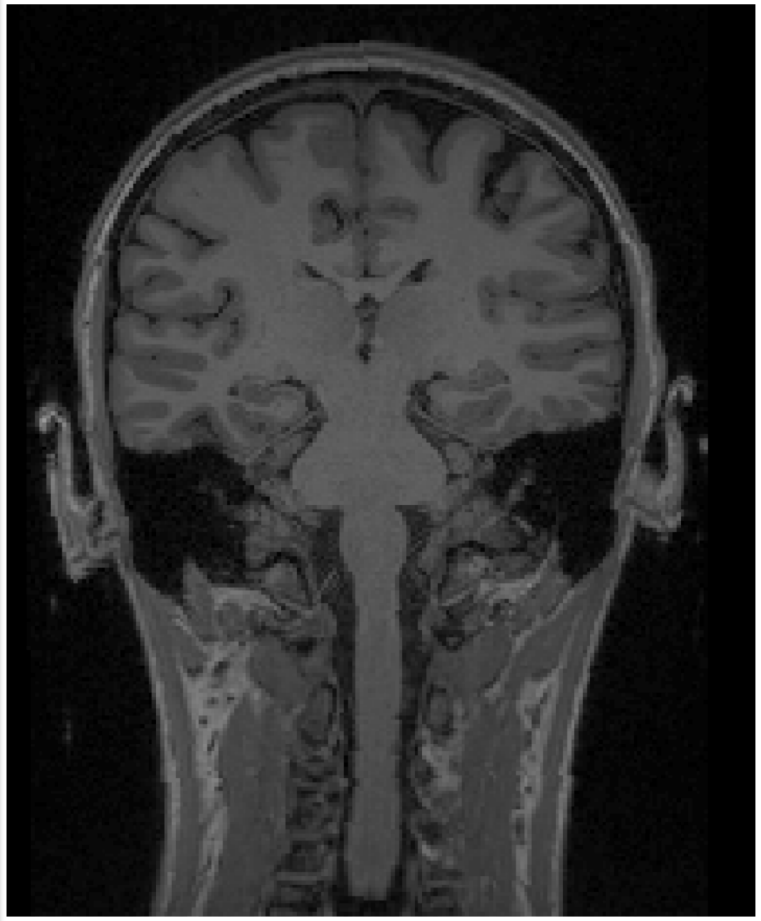
Anatomy Review

Central and Peripheral Nervous System

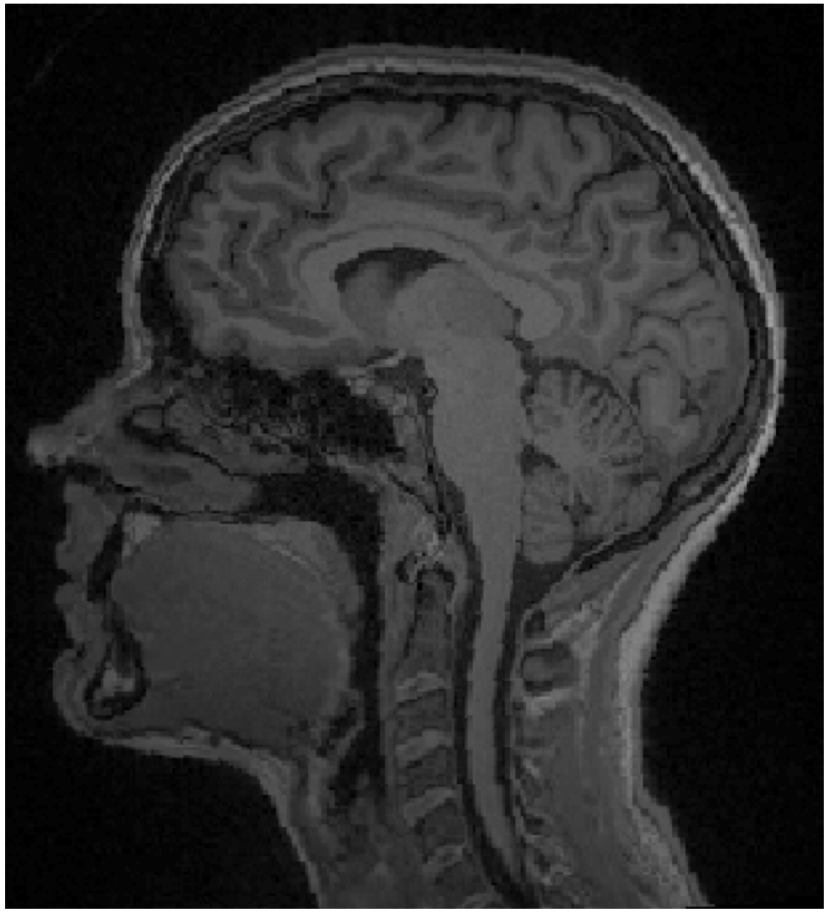
- Central Nervous System
  - Brain
  - Cerebellum
  - Brainstem
  - Spinal Cord
- Peripheral Nervous System
  - Connects the body (skin, muscles) to the Brain and Spinal Cord
  - Cranial Nerves!



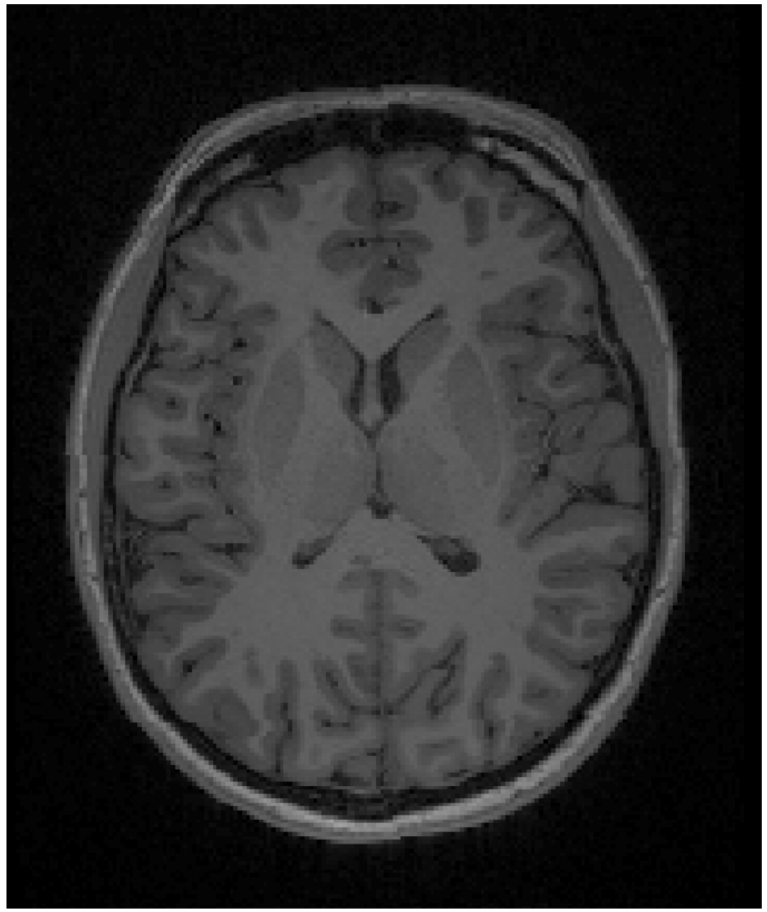
Gray Matter vs. White Matter in the Brain



Coronal View

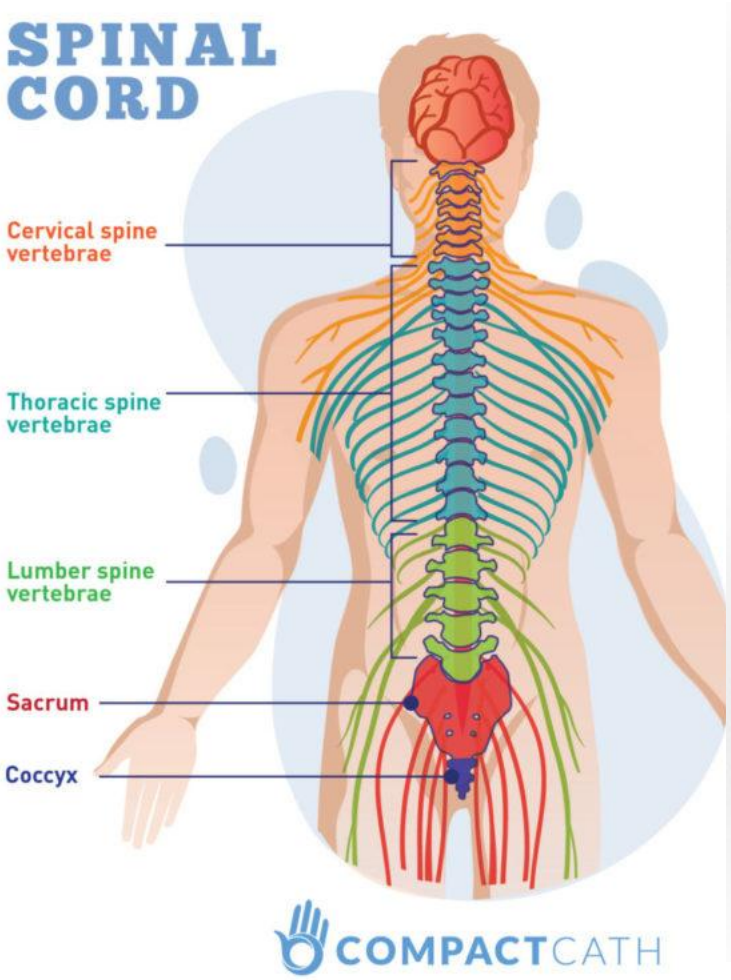


Sagittal View

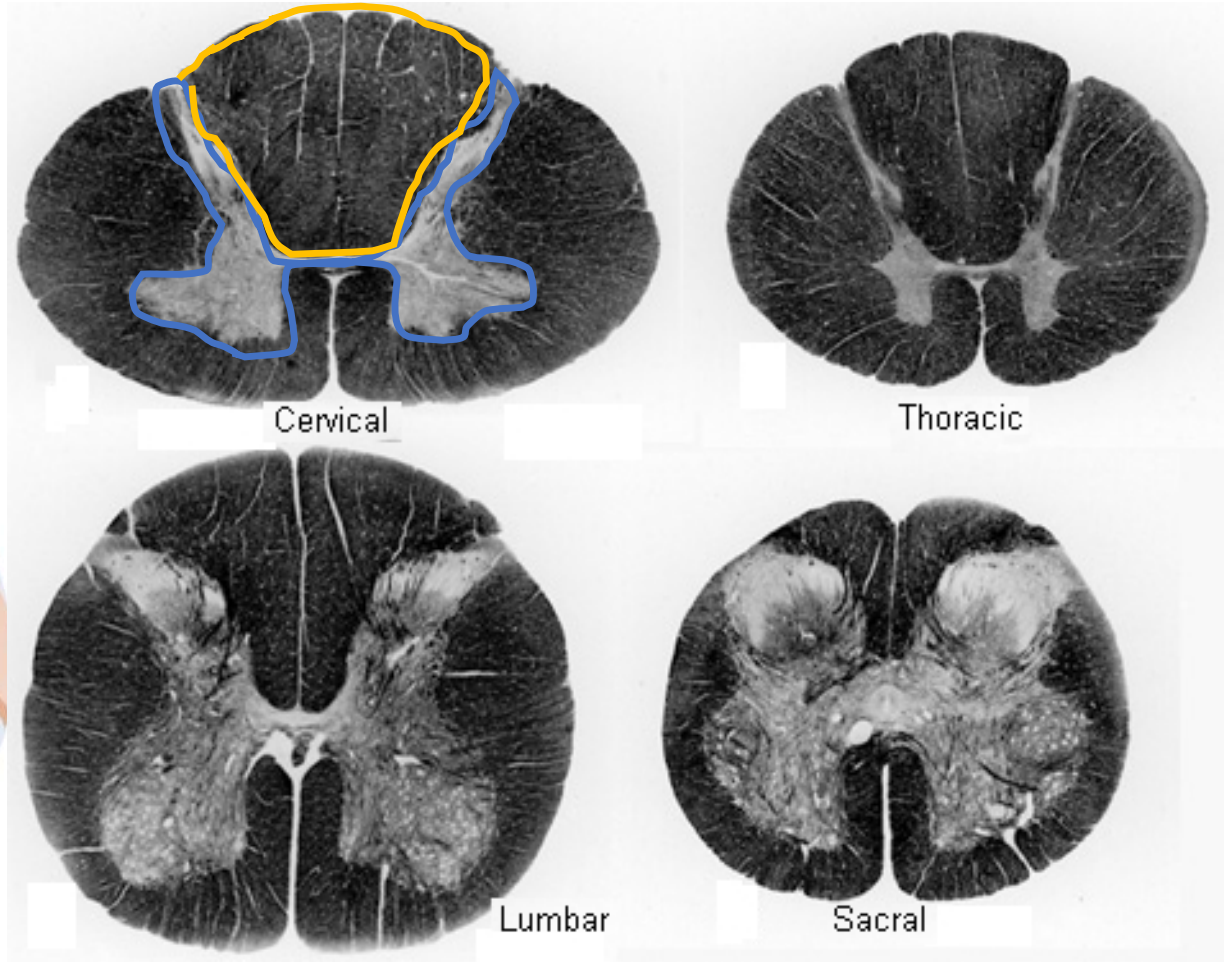


Axial View

Gray vs. White Matter in the Spinal Cord



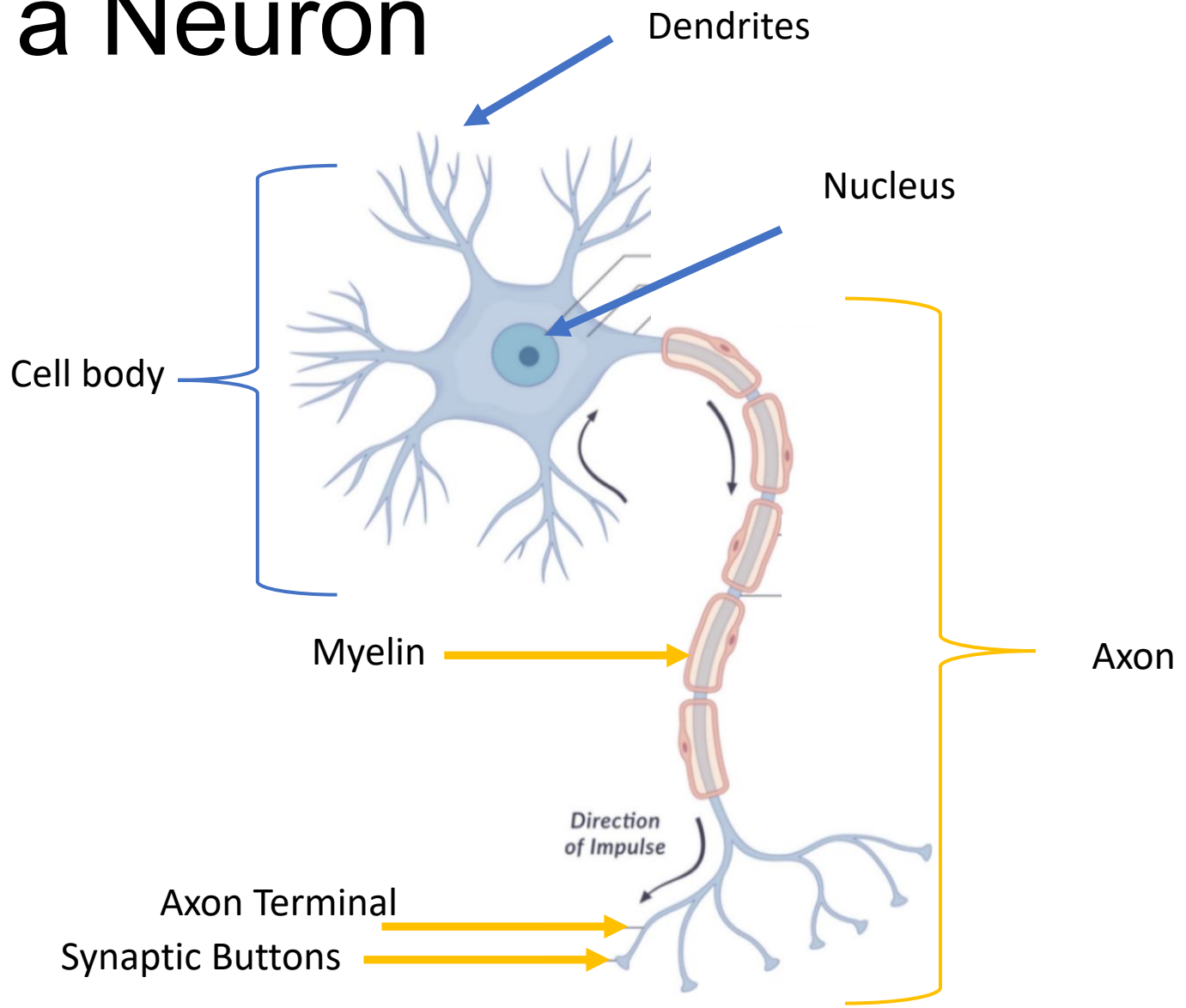
Dorsal (toward the back)



Ventral (toward the belly)

- Gray Matter
- White Matter
- NOTE: White Matter is Stained **black**

Parts of a Neuron

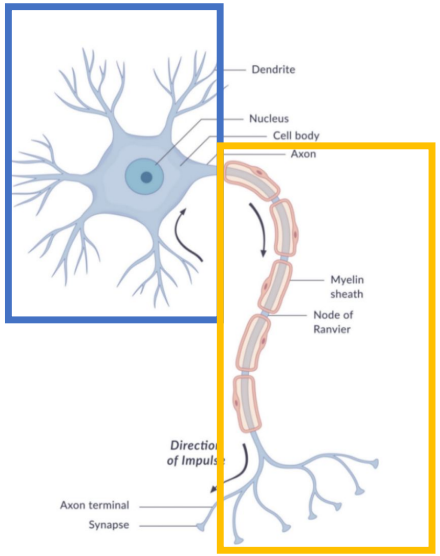


Neurons can be up to 3 ft long!

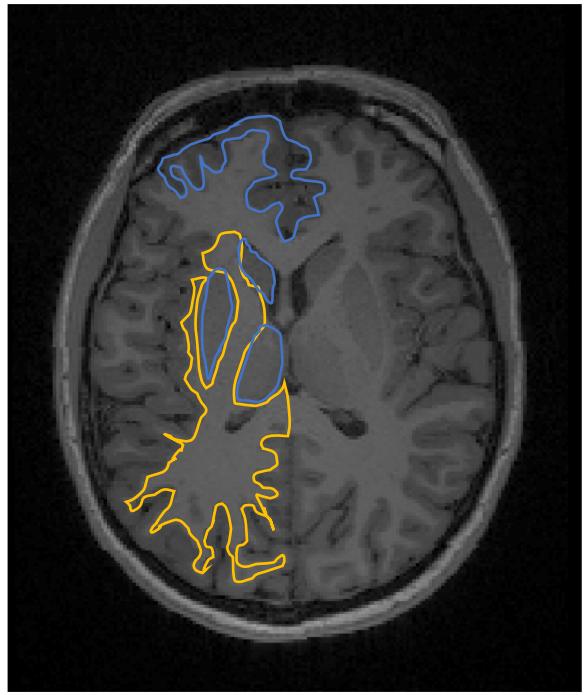
There are 2 neurons between your brain and a muscle!

Let's make a connection!

- **Grey Matter** = comprised of neuronal cell bodies
- **White Matter** = comprised on neuronal cell axons



- The **cortex** is the outermost layer of the brain, made up of cell bodies.
- The **subcortical** region of the brain has both.
  - White Matter = Tracts
  - Gray Matter = Nuclei (*usually*)
    - **Nuclei** = typically, clusters of cell bodies in the CNS
    - **Ganglia** = typically, clusters of cell bodies in the PNS



Neuronal Communication - Cellular Level

Cell Body

Dendrites = contain receptors that can bind Neurotransmitters

Nucleus = contains DNA

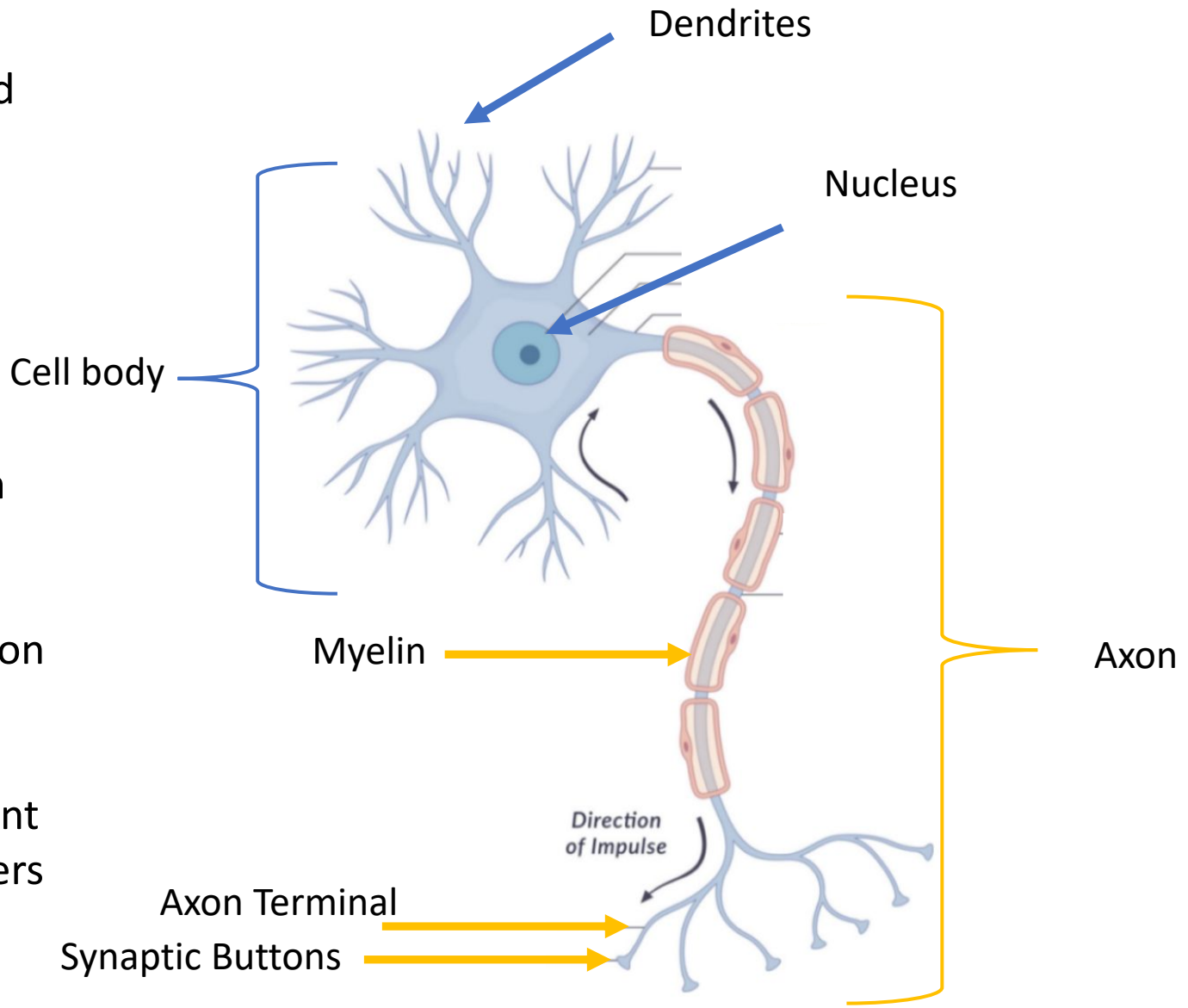
Axon

Axon = conducts electrical message (action potential)

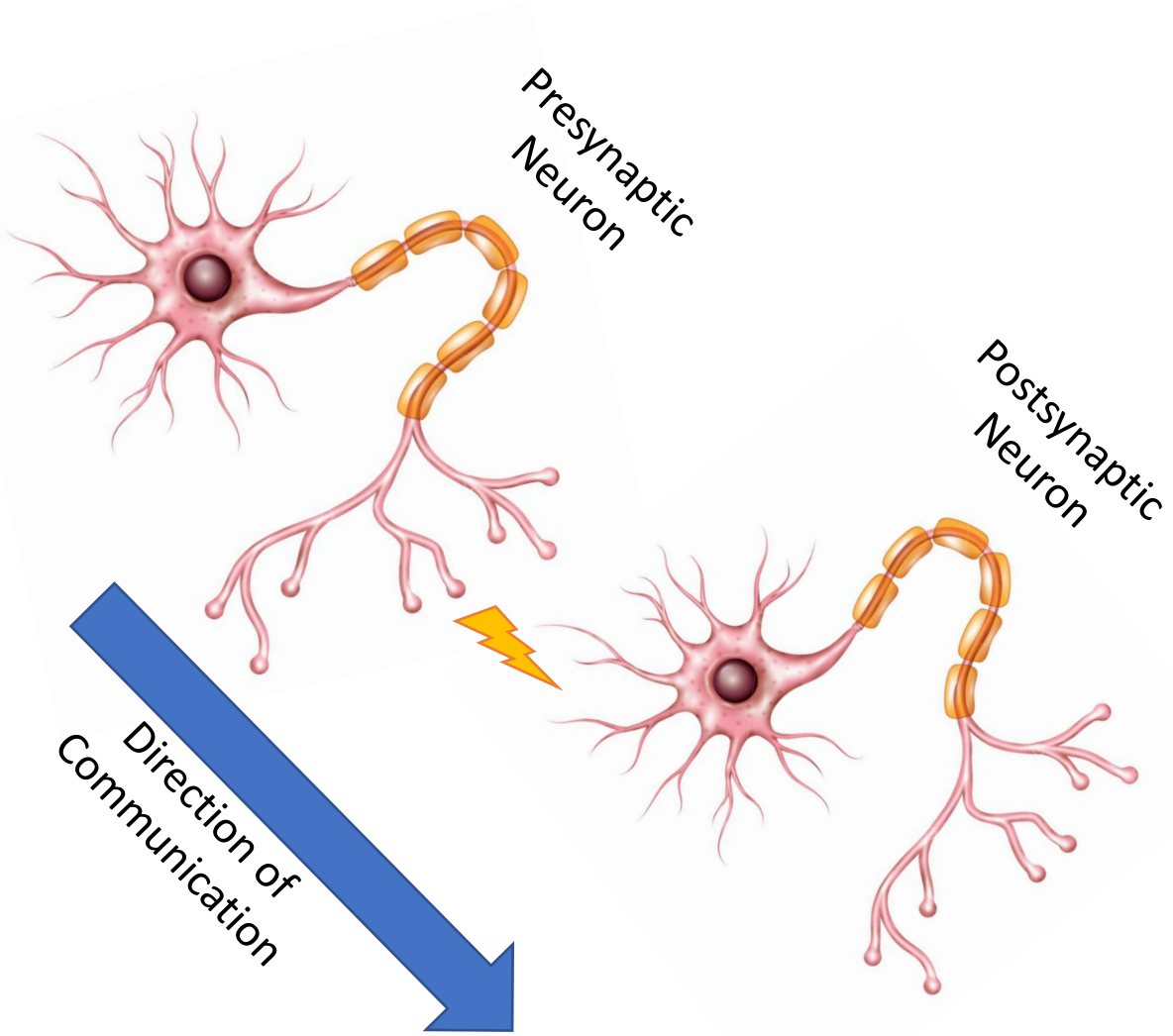
Myelin = speeds up conduction of the action potential

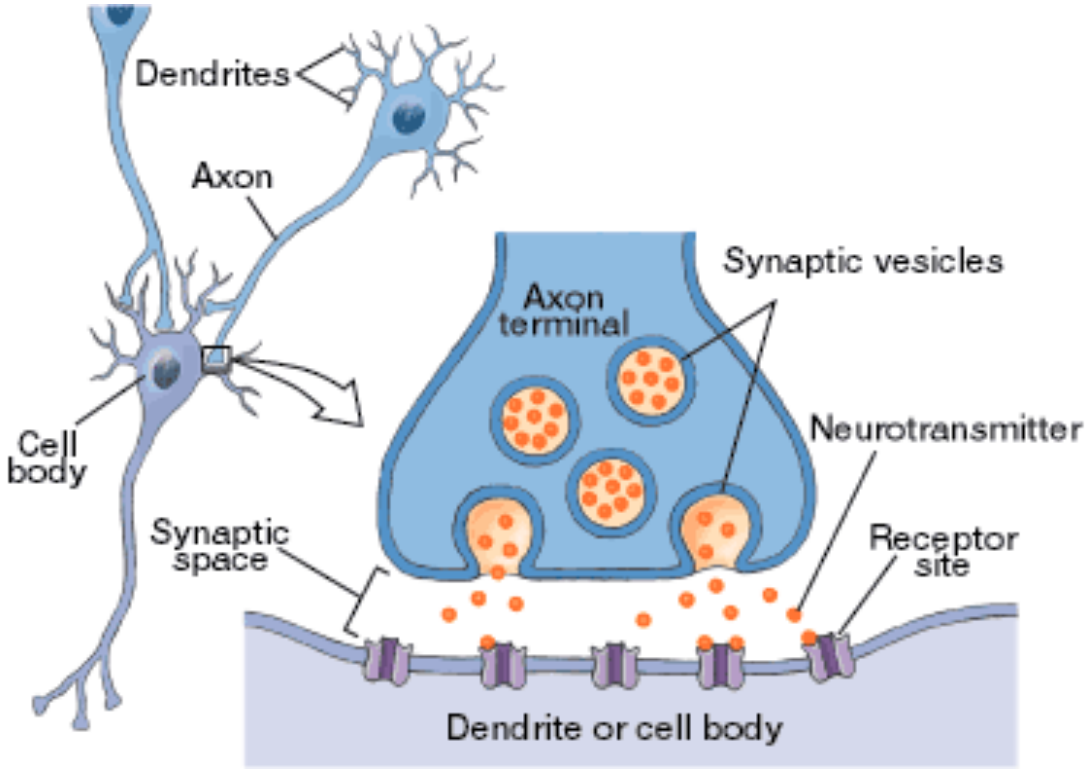
Axon Terminal = contains proteins important for creating and packaging neurotransmitters

Synaptic Buttons = binds synaptic vesicles for release of Neurotransmitters



Neuronal Communication: The Synapse





What is a Neurotransmitter?

Definition

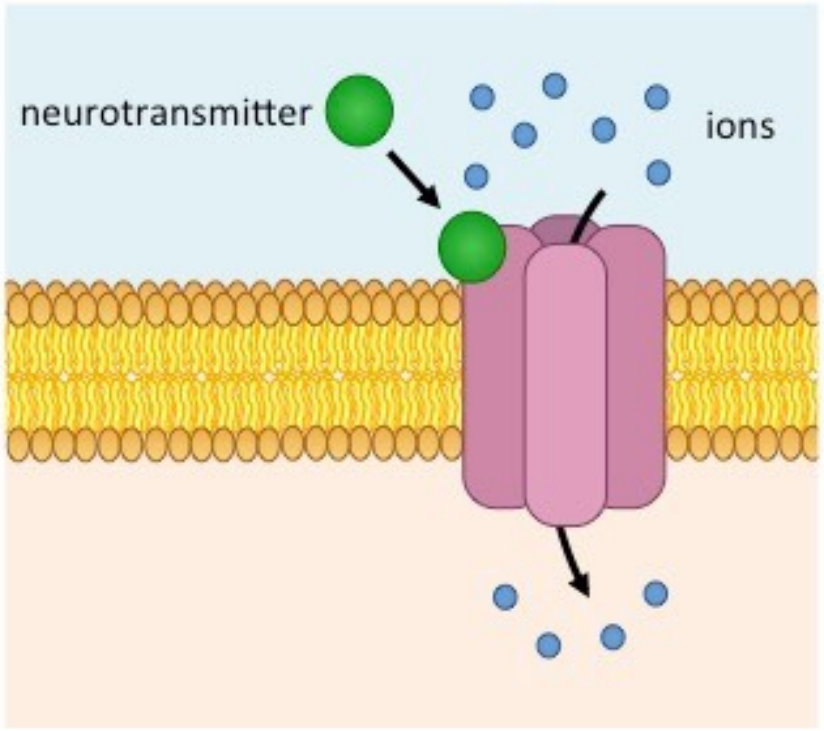
- Molecules that are:
  - Synthesized within a neuron
  - Packaged w/in vesicles
  - Released from axon
  - Activate Receptors
  - Removed or Recycled

Examples

- Dopamine
- Serotonin
- Acetylcholine
- Glutamate = excitatory
- GABA = inhibitory

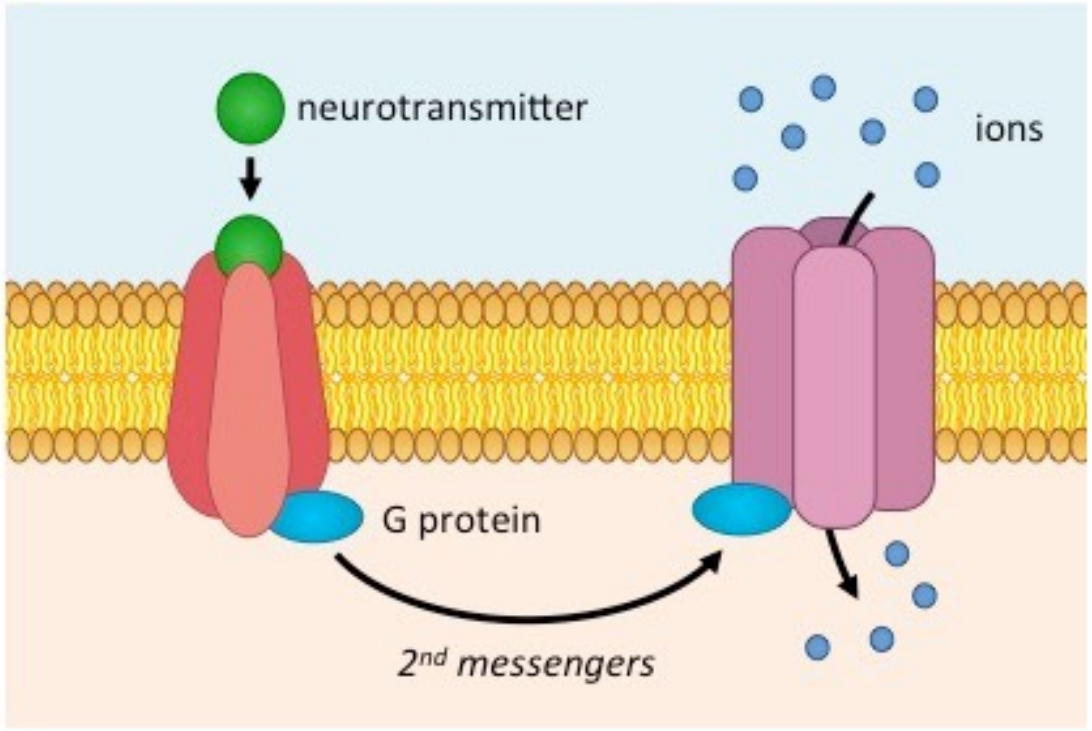
Types of Receptors

Channel



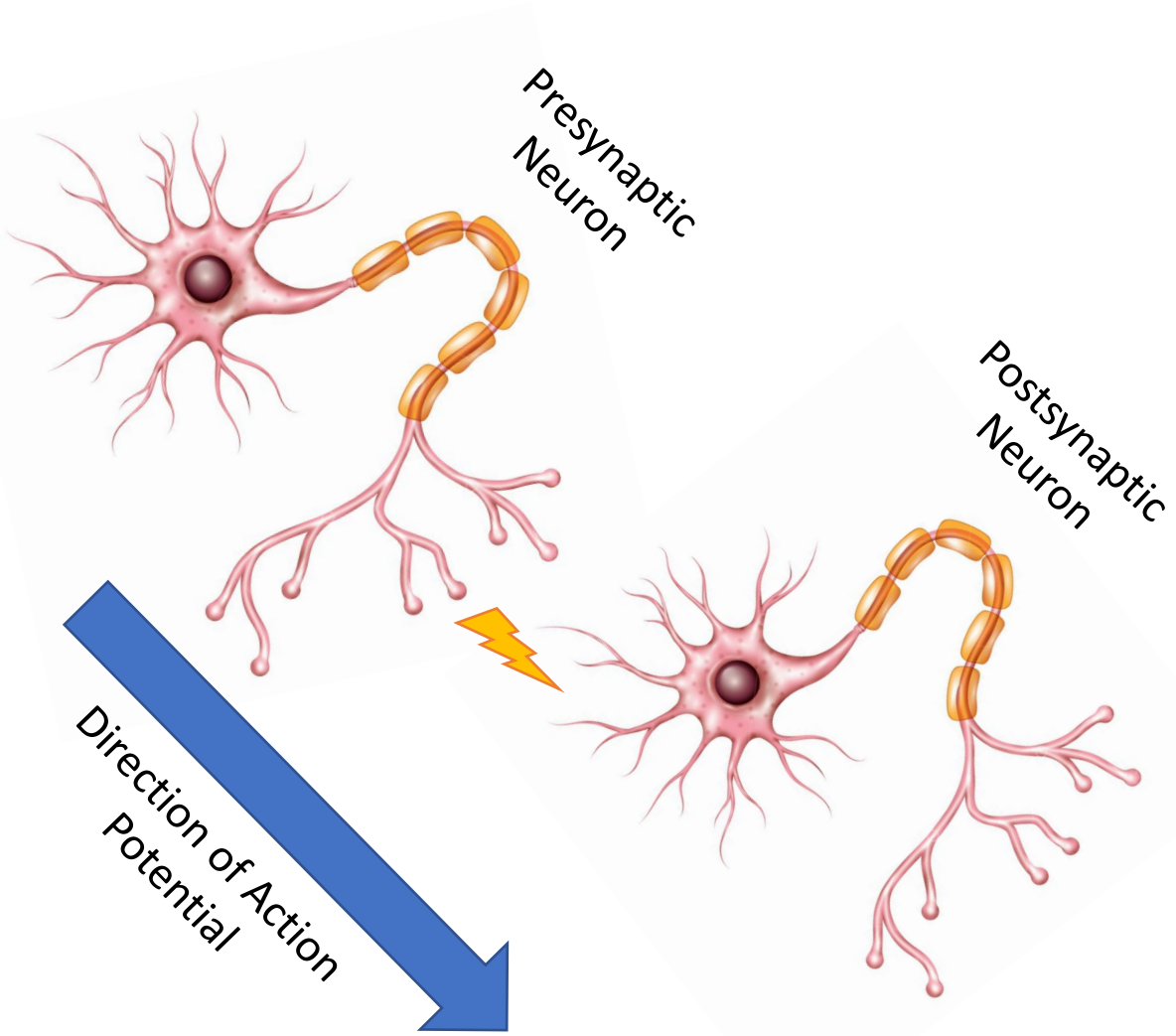
Neurotransmitter binds directly to channel protein and mediates the flow of ions across the membrane for a brief time

G-Protein Coupled Receptor

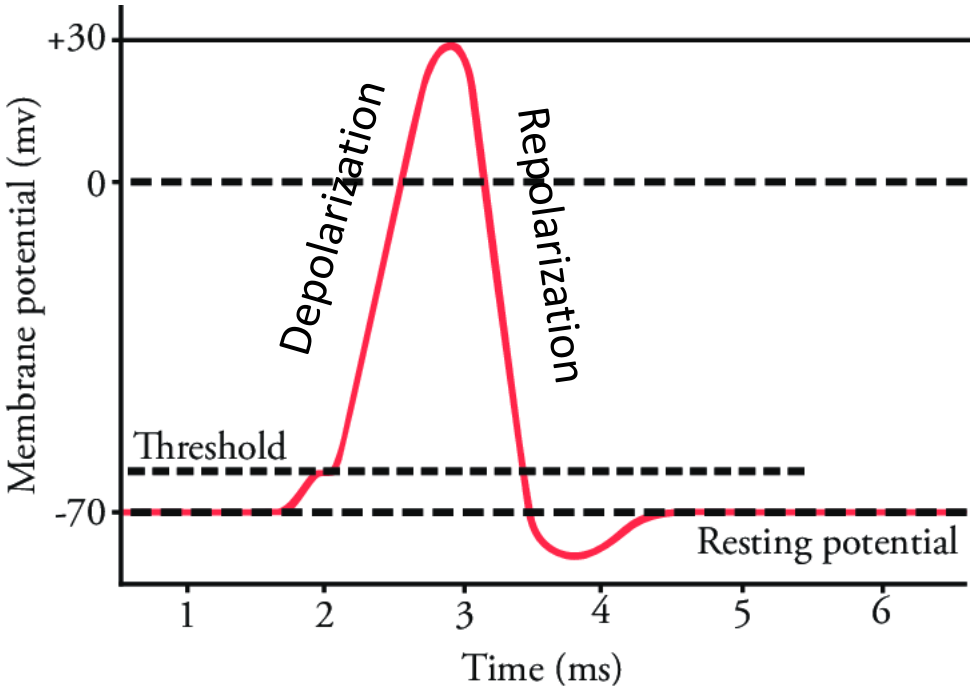


Neurotransmitter binds to G protein-coupled receptor and activates a second messenger system – mediating the opening of ion channels for a longer period of time

Neuronal Communication: The Action Potential

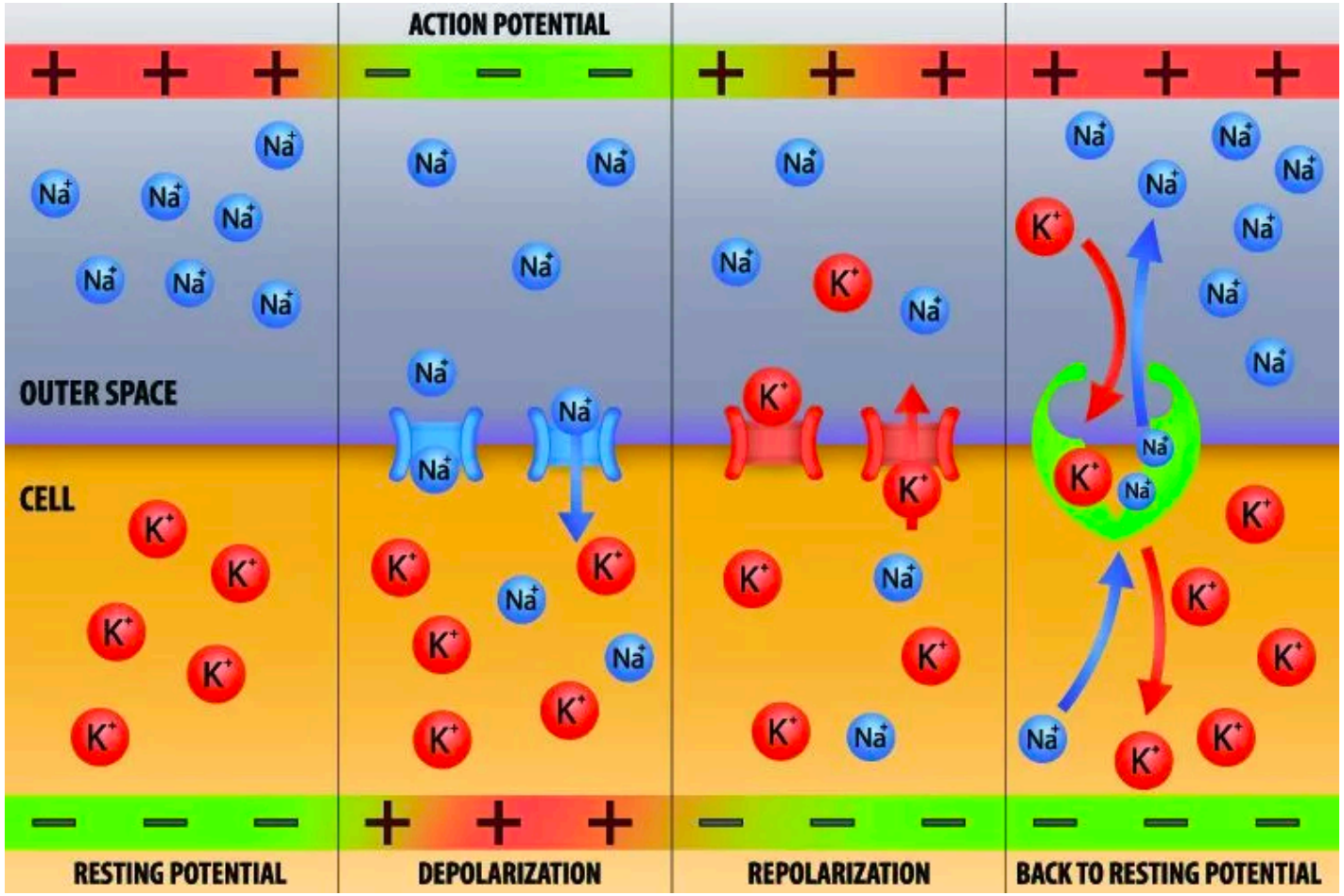


What happens in a Synapse?



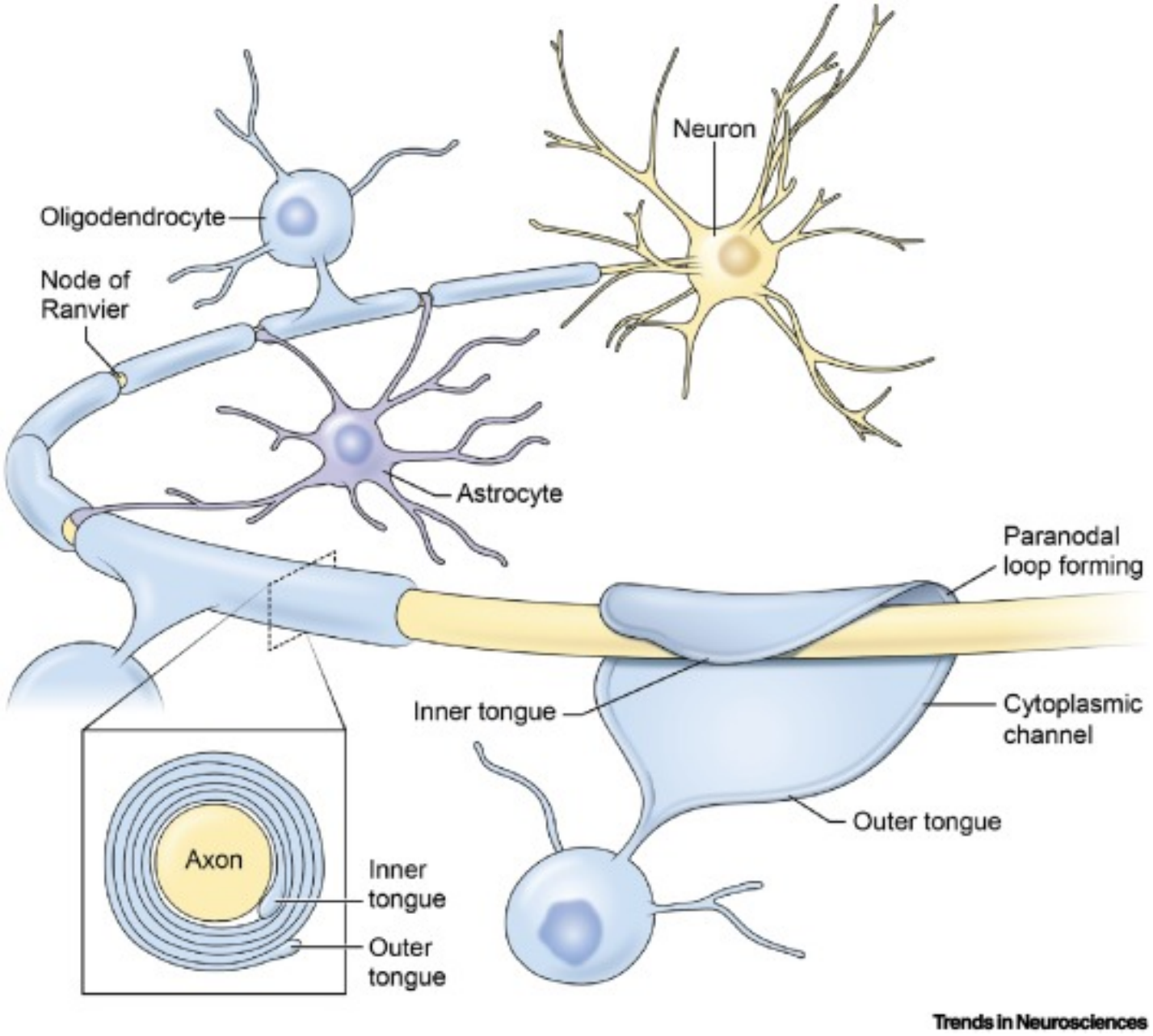
Neuronal Communication: The Action Potential

- Intracellular space is Negative at rest
- NTs can have an excitatory or inhibitory effect
  - Action Potential = excitatory effect



The Role of Myelin

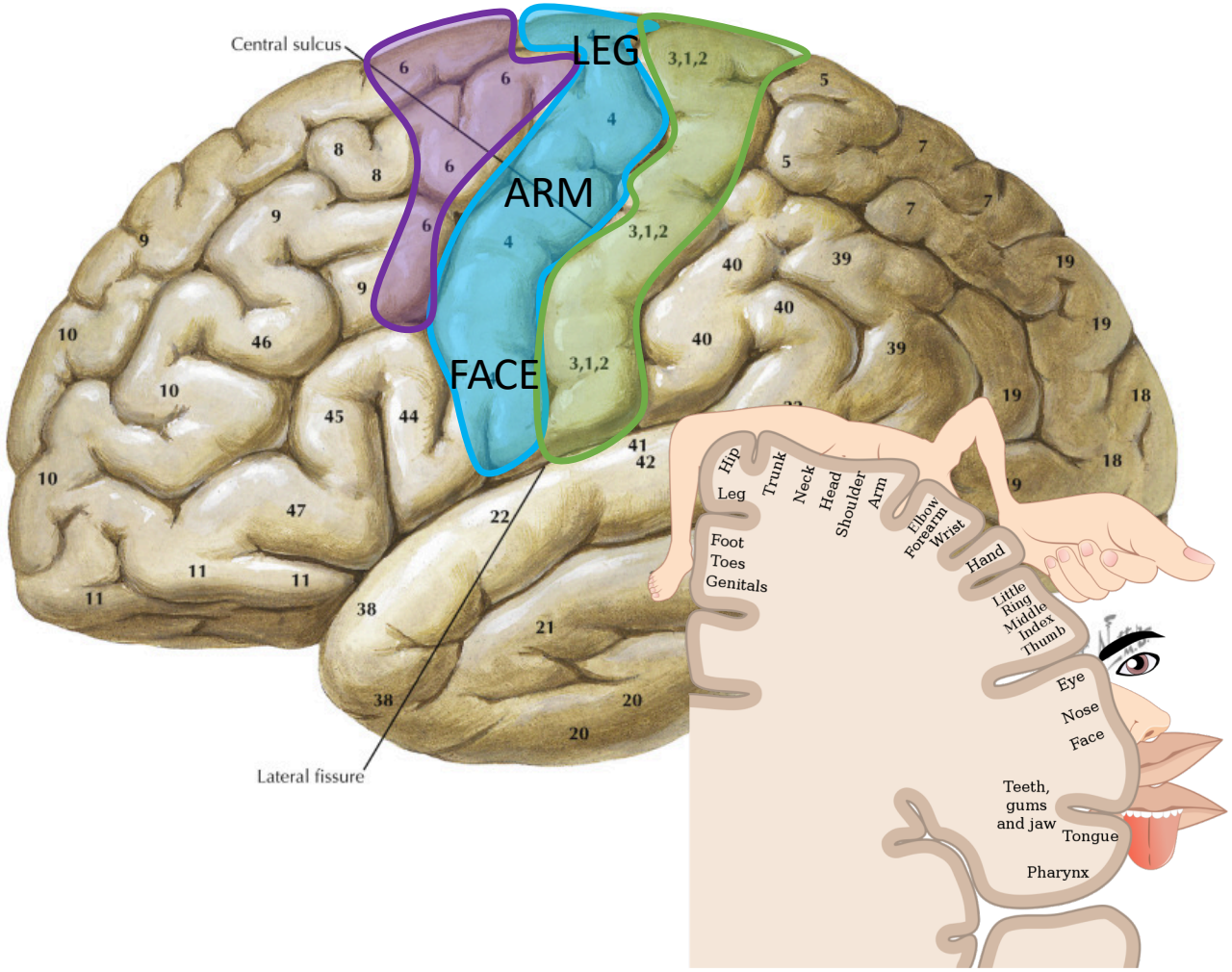
- Myelin is created by other cells
  - CNS: Oligodendrocytes
  - PNS: Schwann Cells
- Myelin creates saltatory conduction
- This speeds up the neural signal



Neuronal Communication - System Level

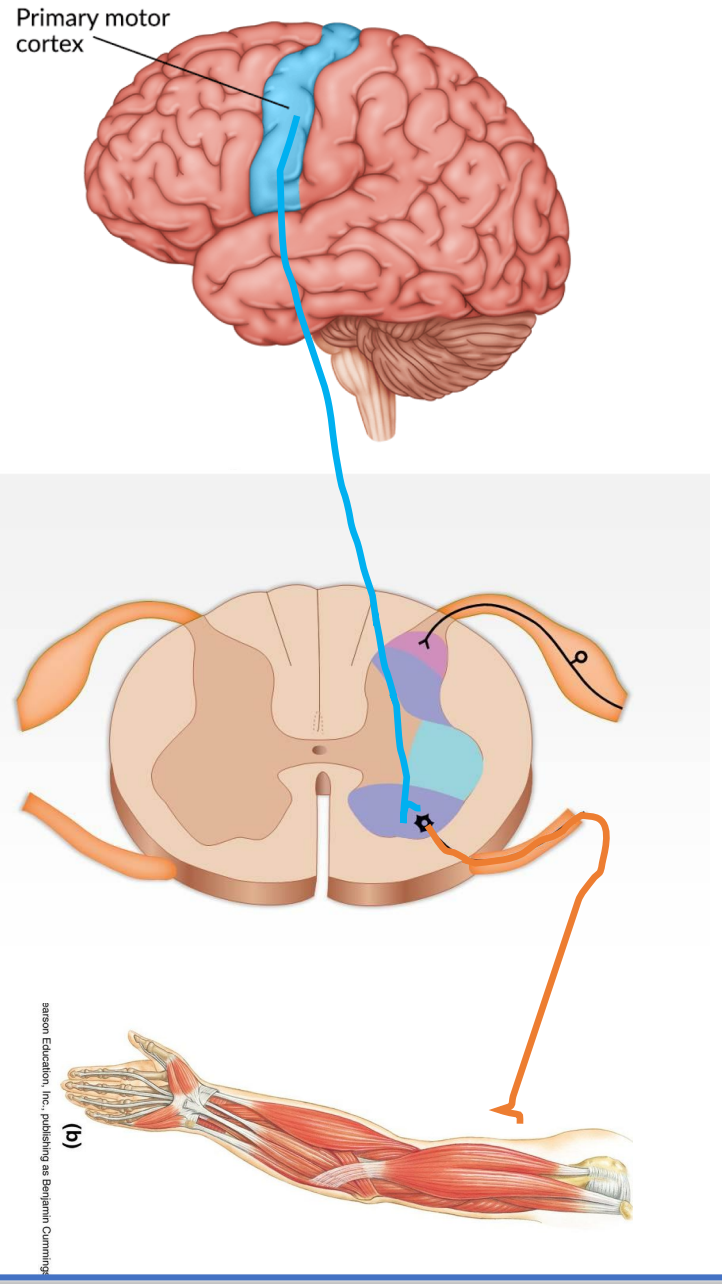
Messaging in the Motor System

- **Primary Motor Cortex**
  - Voluntary Movement (Force, extent, direction, speed)
- **Supplementary and Pre- Motor Area**
  - Motor planning of complex sequences
- **Primary Sensory Cortex**
  - Provides sensory/proprioceptive feedback for movement



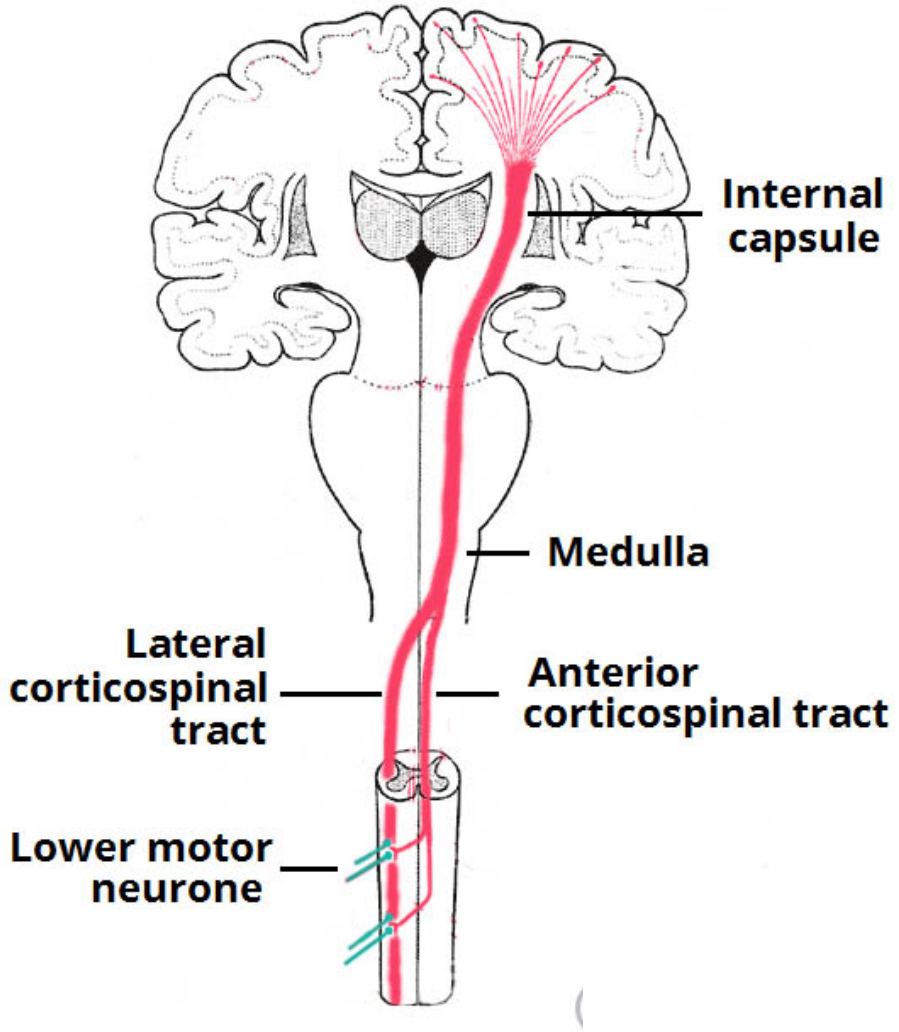
Motor Neurons

- **Upper motor neurons (UMN)** = cell bodies located in the brain and synapse with a lower motor neuron
  - Fully located in the CNS
  - Damage = spasticity, hypertonia
- **Lower motor neurons (LMN)** = cell body located in the spinal cord, synapses onto the muscle
  - Directly responsible for stimulating the target muscle
  - Cell bodies in the CNS, but axons in the PNS
  - Damage = Flaccidity, hypotonia



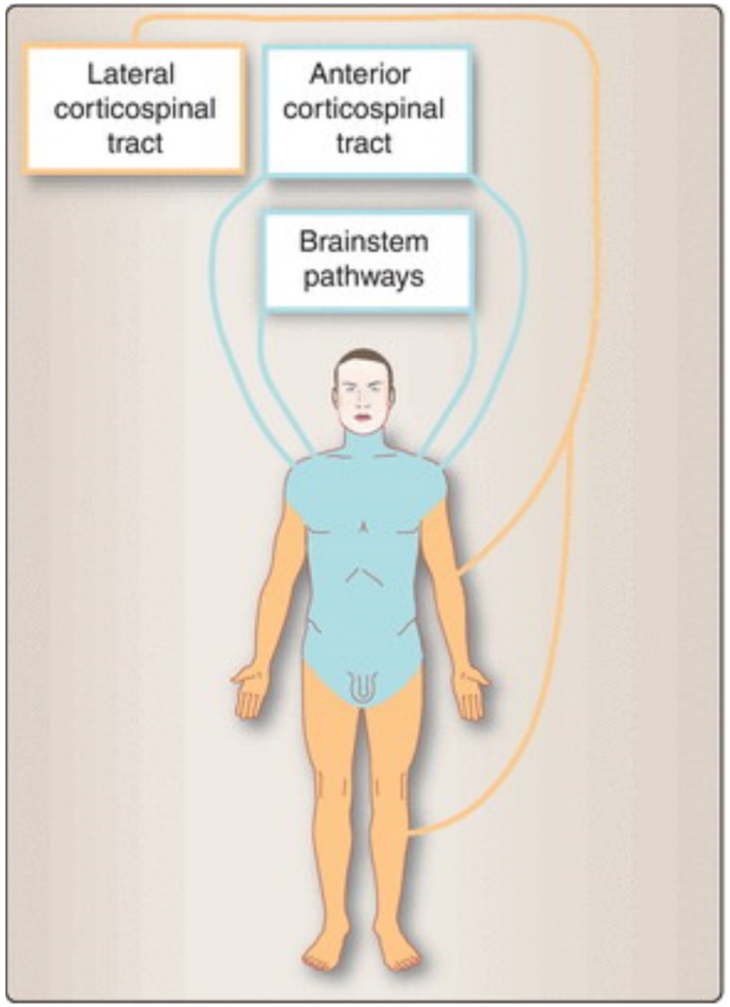
Motor Pathways

- Corticospinal Tract (2 segments)
  - Innervates our Trunk and Limbs
  - Pathway: Primary Motor Cortex→corona radiata→internal capsule→brainstem (crosses in medulla)→ventro/lateral spinal cord



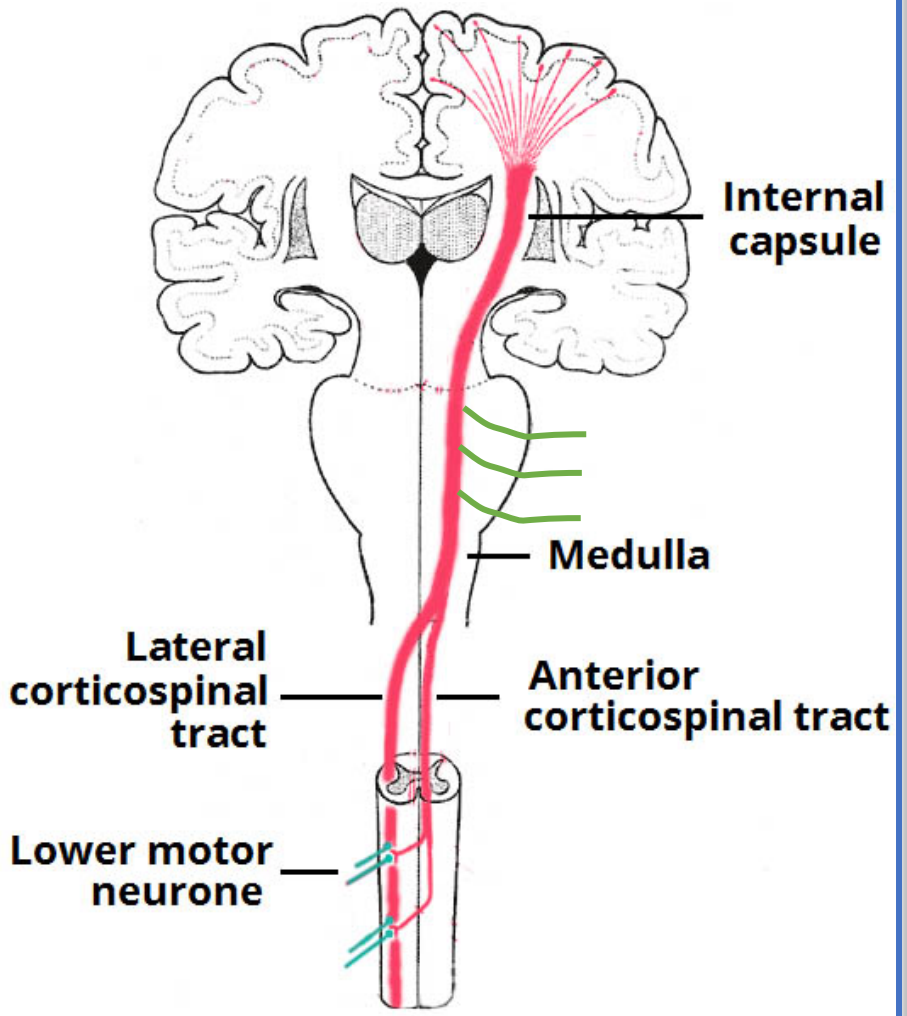
Motor Pathways

- Corticospinal Tract (2 segments)
  - Pathway: Primary Motor Cortex→corona radiata→internal capsule→brainstem (crosses in medulla)→ventro/lateral spinal cord
  - Lateral Tract: contralateral limb movements
  - Ventral Tract: bilateral innervation for trunk and neck



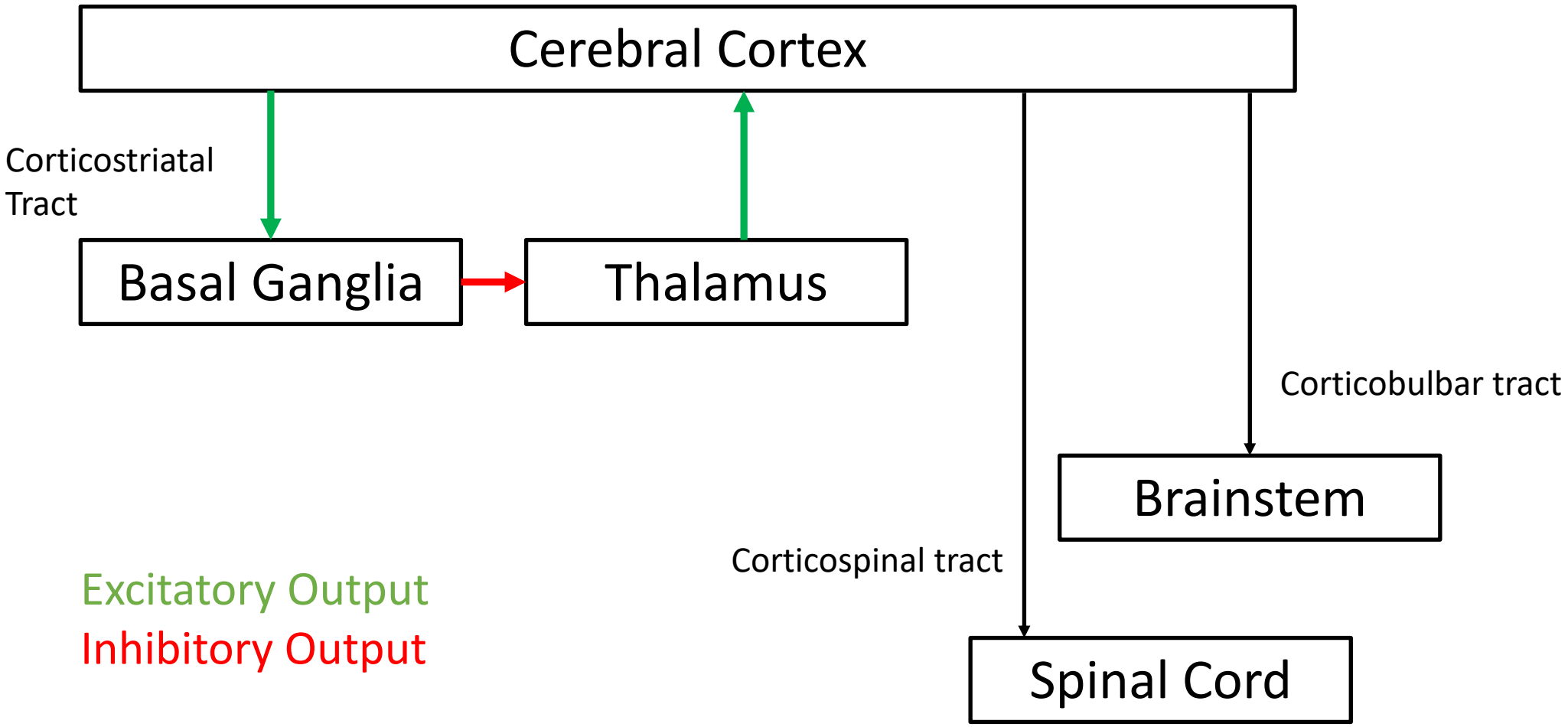
Motor Pathways

- Corticobulbar Tract
  - Innervate Face & Neck
  - Pathway: Primary Motor Cortex→corona radiata→internal capsule→cranial nerves in midbrai pons, and medulla→Head and Neck
- Both receive input from the Corticostriatal pathway (Basal Ganglia!)

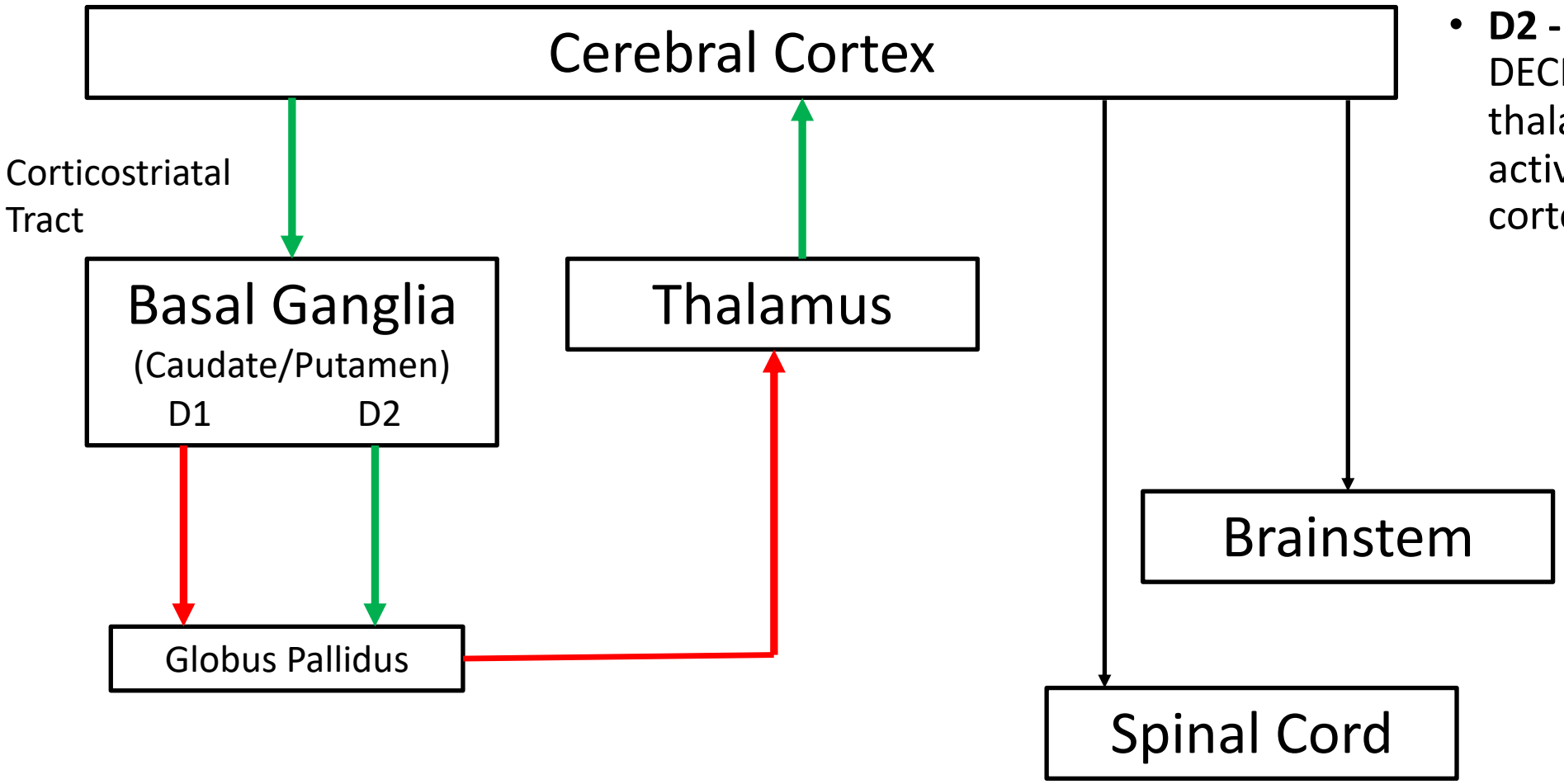


Clinical Application: Basal Ganglia Disorders

Basal Ganglia

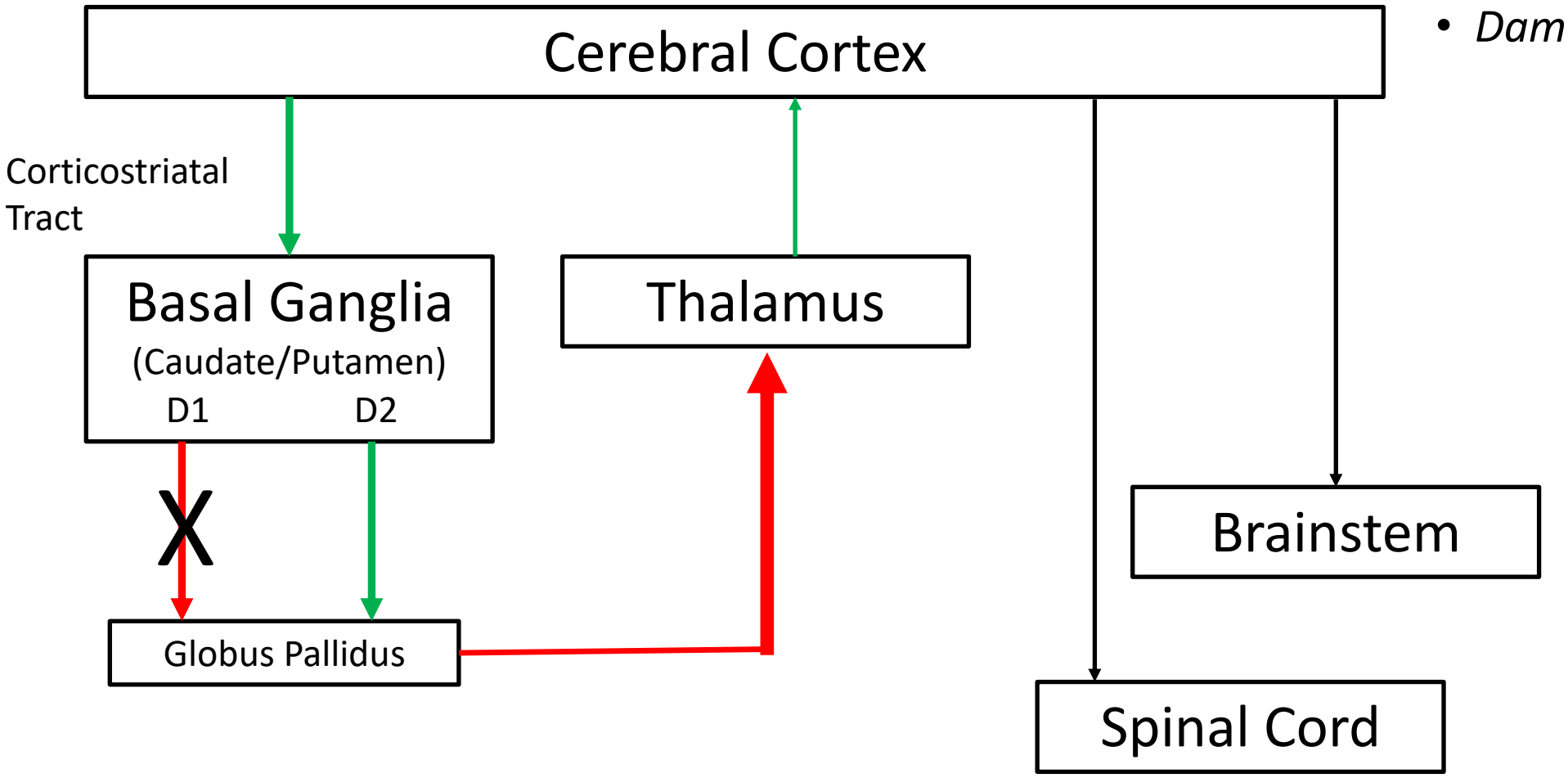


Basal Ganglia



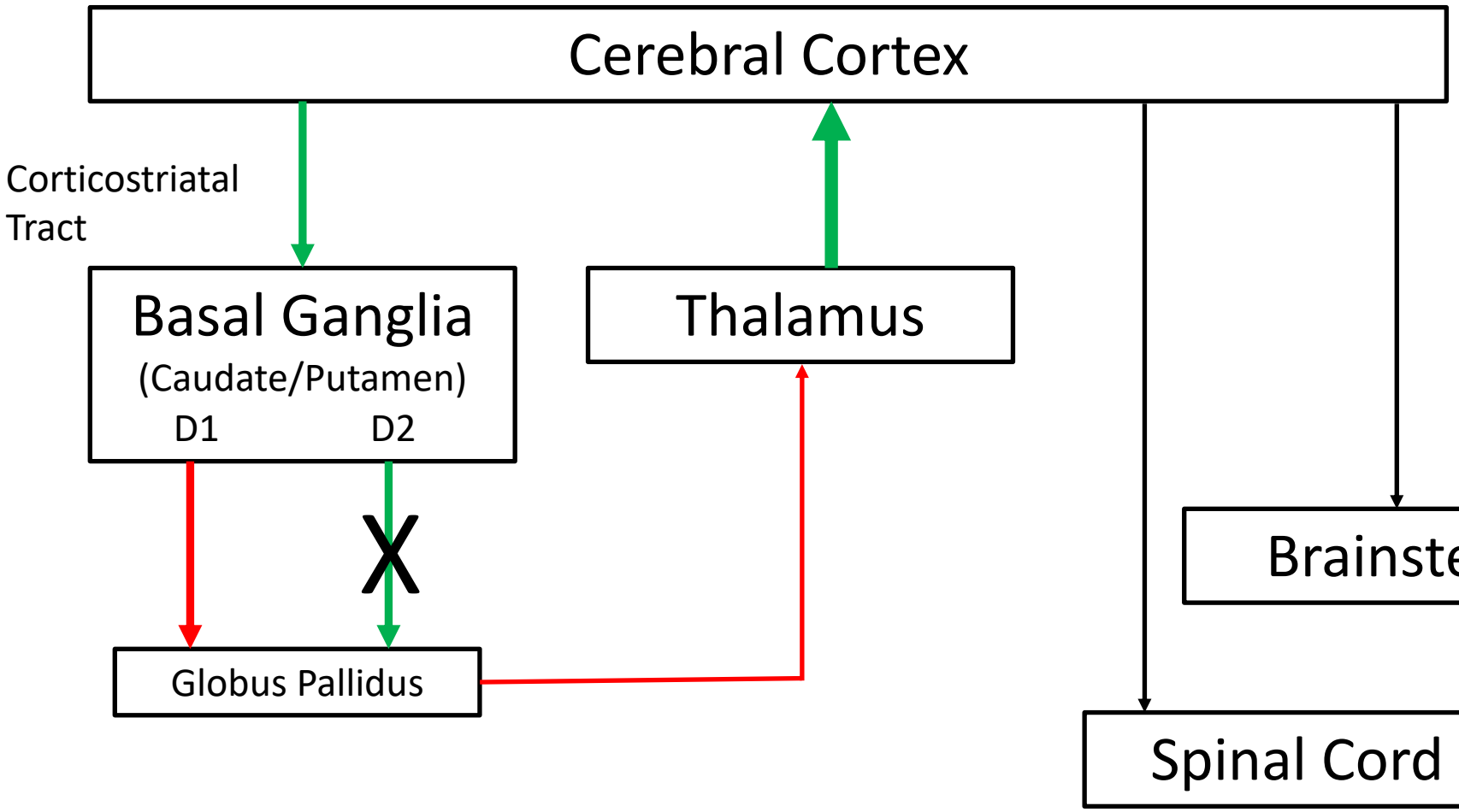
- **D1 - DIRECT pathway:** INCREASE activity to the thalamus & EXCITATION of the cerebral cortex.
- **D2 - INDIRECT pathway:** DECREASE activity of thalamus & DECREASE activity of the cerebral cortex.

Basal Ganglia



- **D1 - DIRECT pathway:** INCREASE activity to the thalamus & EXCITATION of the cerebral cortex.
- *Damage = hypokinesia*

Basal Ganglia



- **D2 - INDIRECT pathway:** DECREASE activity of thalamus & DECREASE activity of the cerebral cortex.
- *Damage = hyperkinesia*

Pharmacological Treatments Target Dopamine Levels

Treatment for Parkinson's

- Levodopa (L-Dopa)
  - Enzyme converts it into dopamine
- Carbidopa
  - Prevents L-Dopa from being broken down before it reaches the brain

Treatment for Huntington's

- Xenazine (tetrabenazine)
  - Prevents uptake into synaptic vesicles
  - Leads to depletion of dopamine in the neuron

Thank you for listening!
Questions?