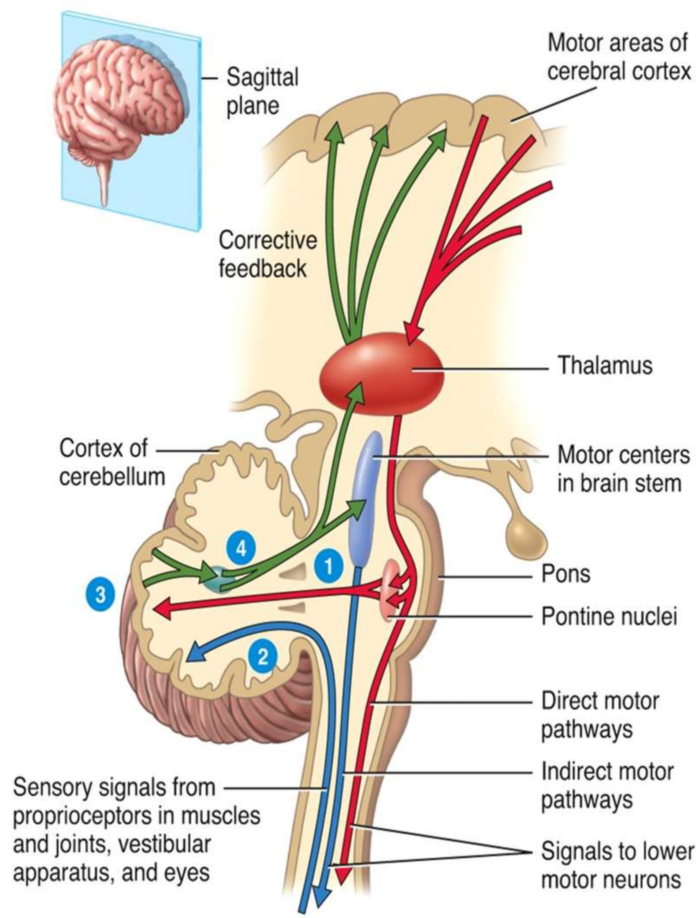
Chapter 14.6

Motor Control

(Review / Covered in Previous Slides)



Sagittal section through brain and spinal cord

Motor Control Is An Example of a Higher Brain Function

–Motor control describes how we control the contraction of our skeletal muscles

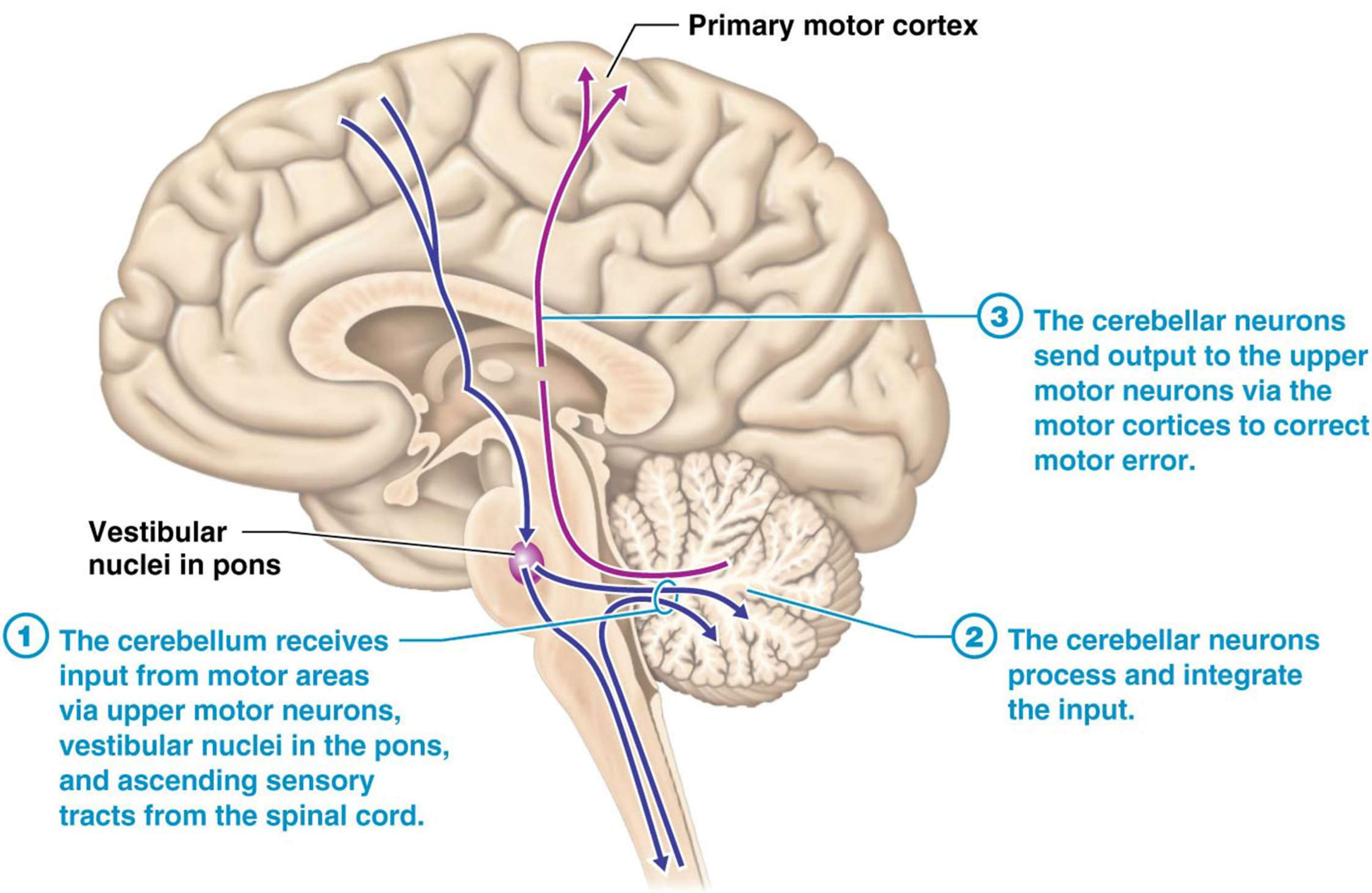
–Motor control requires the simultaneous bi-directional movement of action potentials between neural networks that interconnect the *cerebral cortex, basal nuclei, cerebellum, thalaus, and several other nuclei in the brain stem*

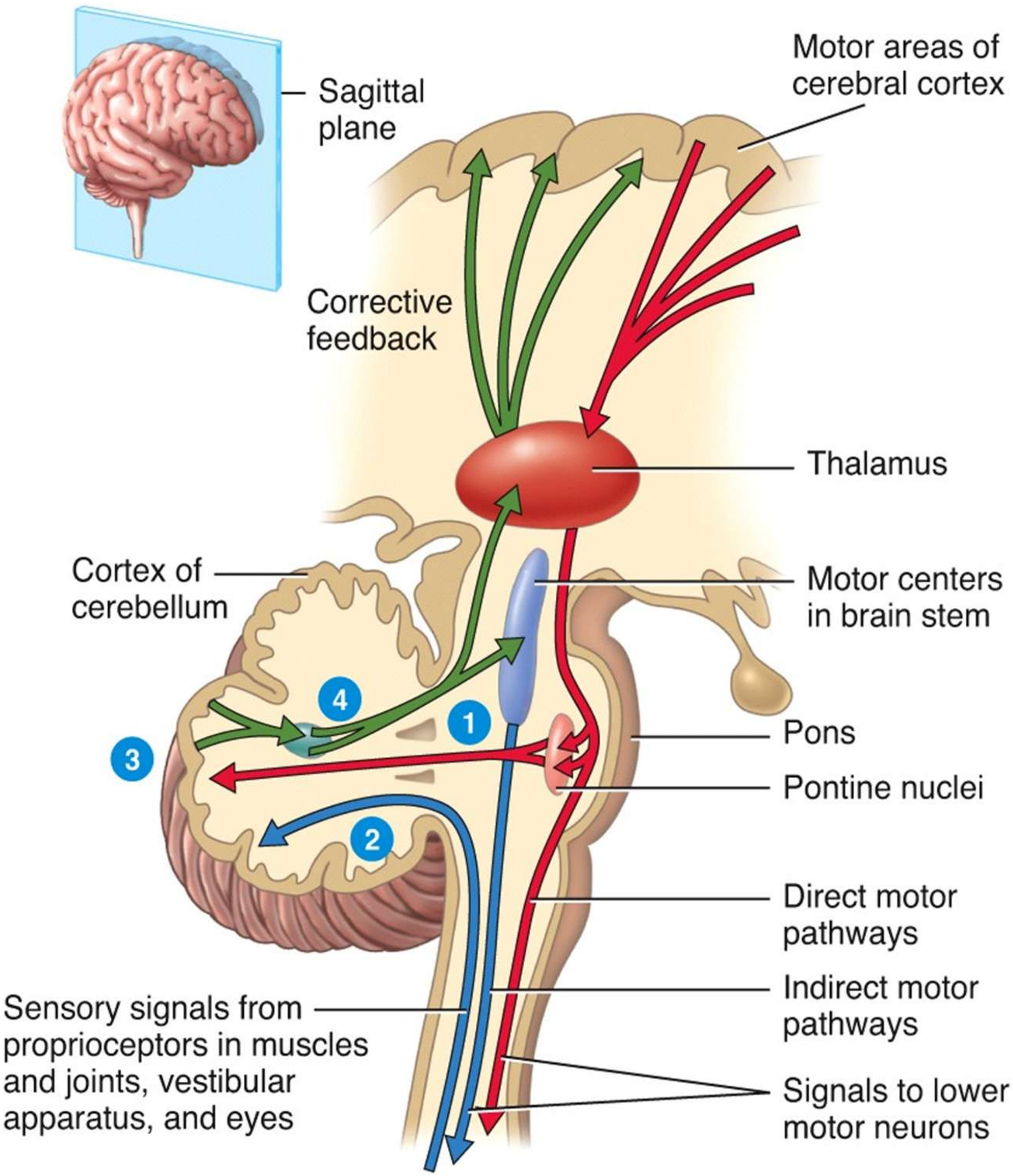
–Central pattern generators (also called local curcuit neurons) also play a role in regulating the sequential contraction of skeletal muscles

- These nuclei control groups of skeletal muscle (e.g. regulating the muscle contraction which occur during walking)
- CPG are located in the spinal cord's anterior horns

Cerebellum function in voluntary movement.

The cerebellum compares the intent with performance.





Sagittal section through brain and spinal cord

Intent VS Performance

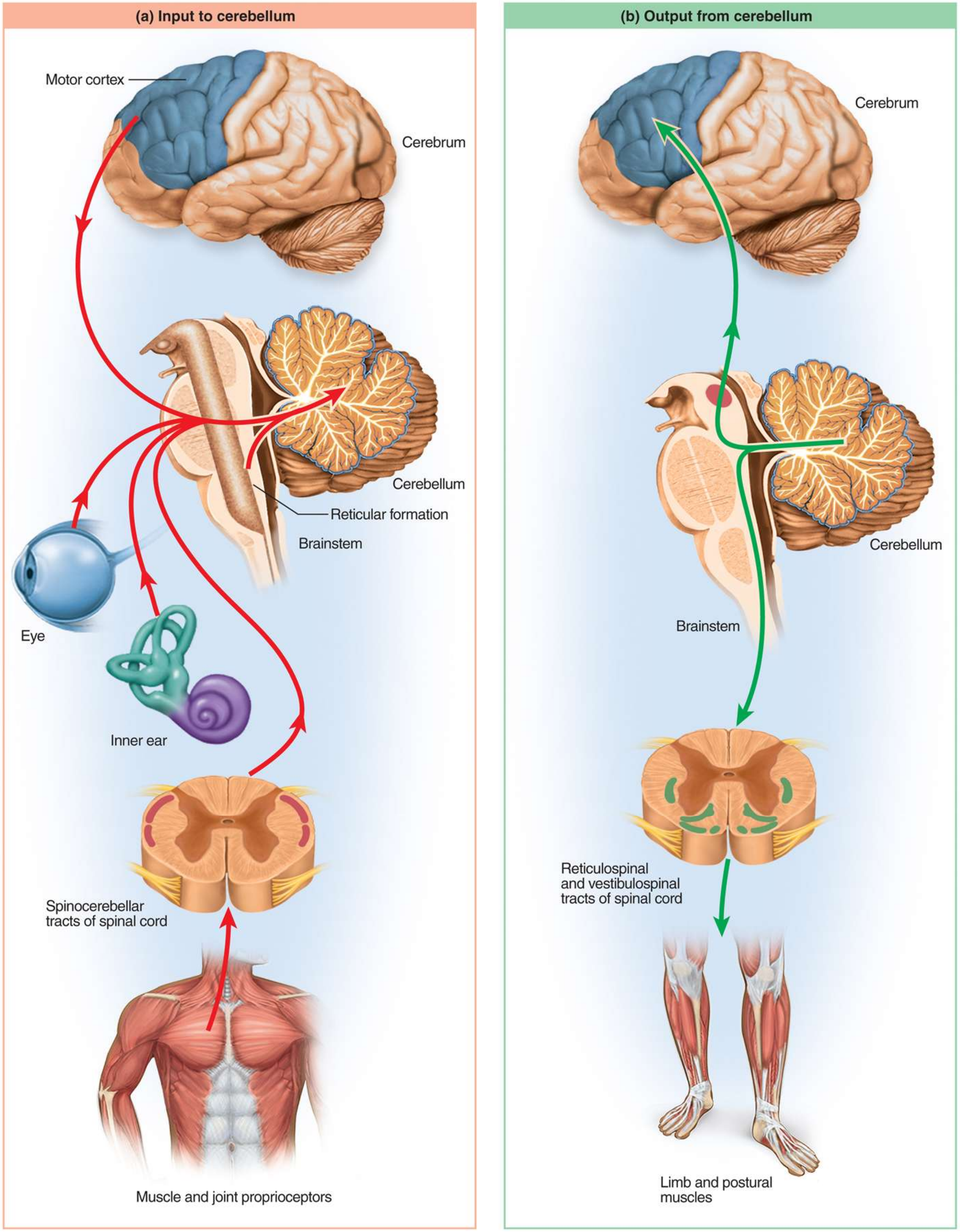
1 - Monitoring intentions for movement // get impulses from motor cortex and basal nuclei via pontine nuclei

2 – Monitoring actual movement

3 – Comparing command signal with sensory information

4 – Sending out corrective feedback // via thalamus to cerebral cortex upper motor neurons as well as to indirect UMN

These events occurs in the pyramidal pathway.



Input and Output of the Cerebellum

Note: motor control requires constant comparison by the cerebellum of stimuli not only from proprioceptors but also from other sensations (e.g. vision and equilibrium)

This explains in part why the cerebellum have so many neurons and each neuron has over 100,000 unique synapses!

Motor control is only of the many functions of the cerebellum, however. In general, all of the cerebellum's function involve "comparing" (e.g. time, texture, like sounding words, etc.)

Motor Control
Intent VS Performance

•The conscious thought to contract a skeletal muscle originates in the prefrontal cortex (i.e. executive function)

–prefrontal cortex starts an action potential that will eventually signal the precentral gyrus (i.e. motor strip send action potentials via UMN)

–before this happens, the pathway must transits through the motor association area, then to the basal ganglia then to the thalamus before it reaches the precentral gyrus (i.e. motor strip).

–prefrontal cortex is where we plan our behavior (the origin of our idea to move)

–motor association area = where we compile a program for the skeletal muscle contractions requested by the frontal cortex /// if a skeletal muscle even is often used then it is saved in the motor association area as a motor programs /// just like computer apps (eg. how to tie your shoes or typing your password)

–*Note: basal ganglia play a critical role in motor control /// we will study this later // Note: BG can take charge and control skeletal muscles when we lose conscious control of motor control // e.g . When you drive your car for a distance without awareness!*

More About Motor Control

•Learned motor programs are located in the motor association area. These local curcuit neurons may be destroyed by a stroke which would result in loss of function. These motor skills may be “relearned” with physical therapy.

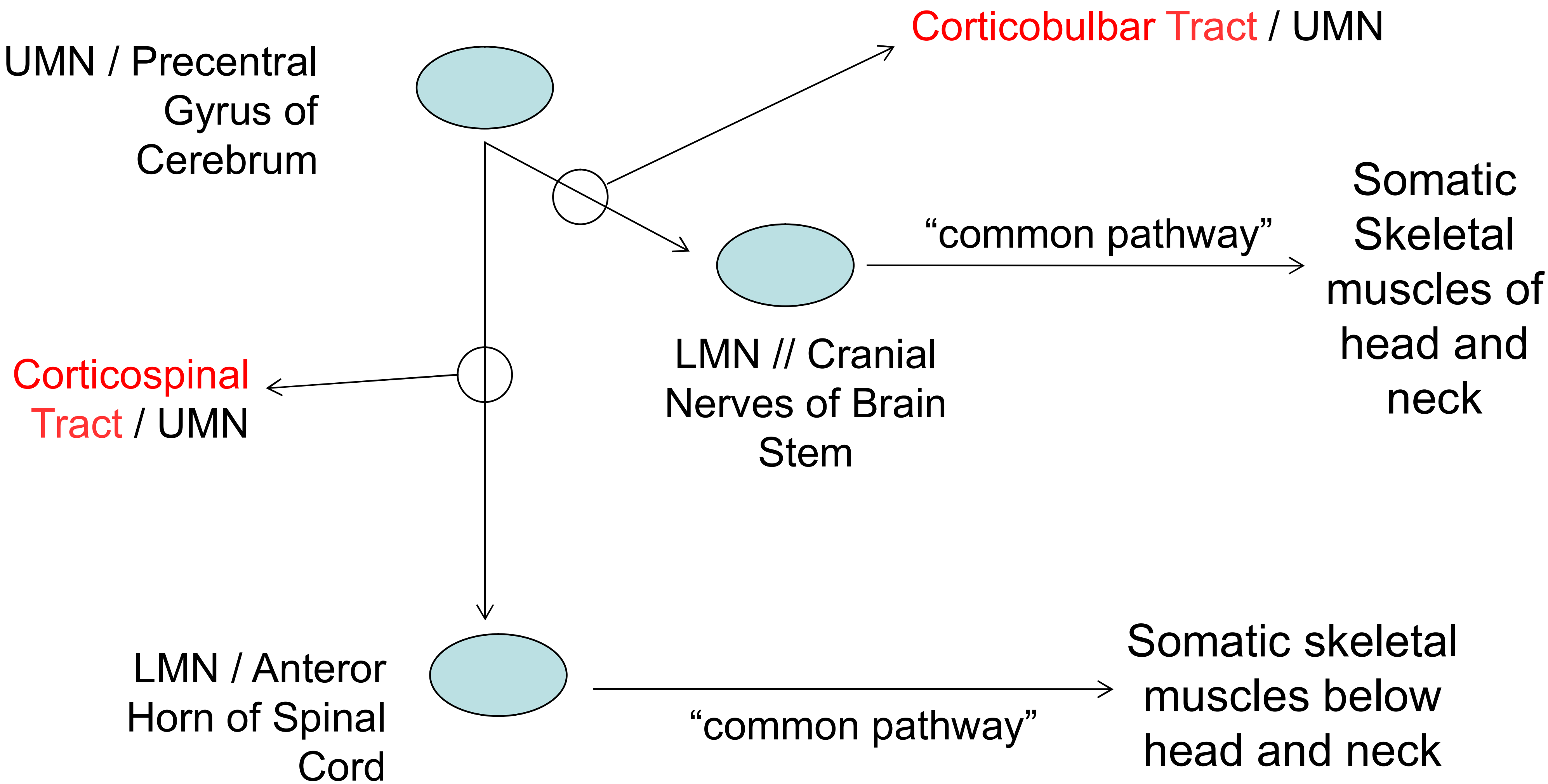
•Precentral Gyrus (Primary Motor Area) is where soma of the corticospinal tract originate (the upper motor neurons) /// these axons descend to synapse on lower motor neurons (soma in anterior horns of spinal cord) // LMN = common pathway to skeletal muscles

•Precentral Gyrus also has neurons which form the corticobulbar tract (also upper motor neurons) // they descend to synapse on motor nuclei in brain stem (cranial nerves) // these cranial nerves are the lower motor neurons that innervate skeletal muscles in head and neck

•Both CST & CBT synapse with LMN // LMN are the common pathway that connect CNS to skeletal muscles (see next slides)

Descending Direct Pathways

Pathways = Axon Tracts



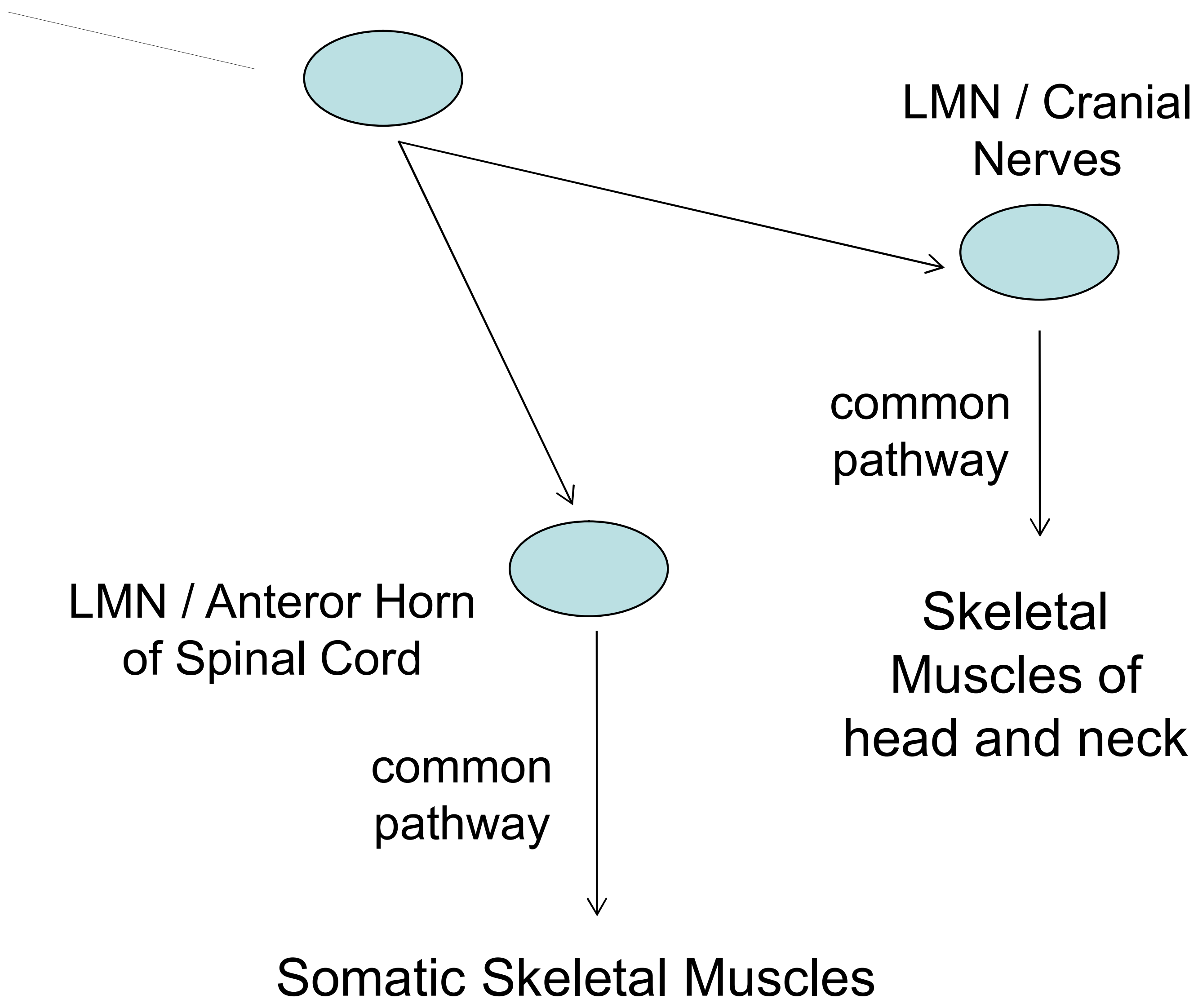
Descending Indirect Pathways

Pathways = Axon Tracts

UMN // These n**uclei originate in medulla oblongata**

1. tectospinal tract
2. vestibulospinal tract
3. rubriospinal tract
4. reticularspinal tract

Note: Nuclei #1 and #2 are responsible for reflexes from eyes and ears.



Basal Nuclei Functions

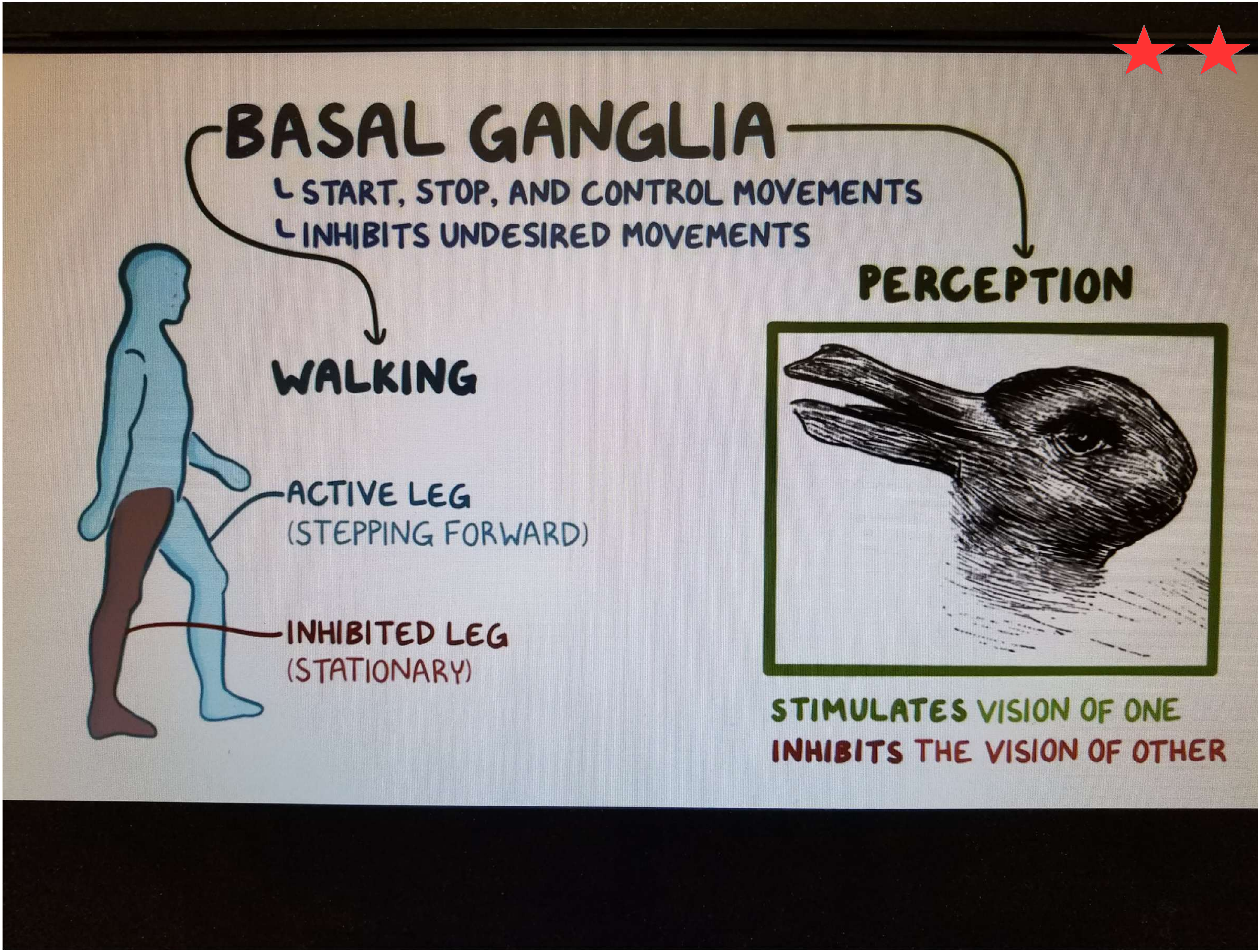
- Before the motor strip can send an action potential to an UPM, the motor association cortex directs the AP through the basal nuclei (BN).

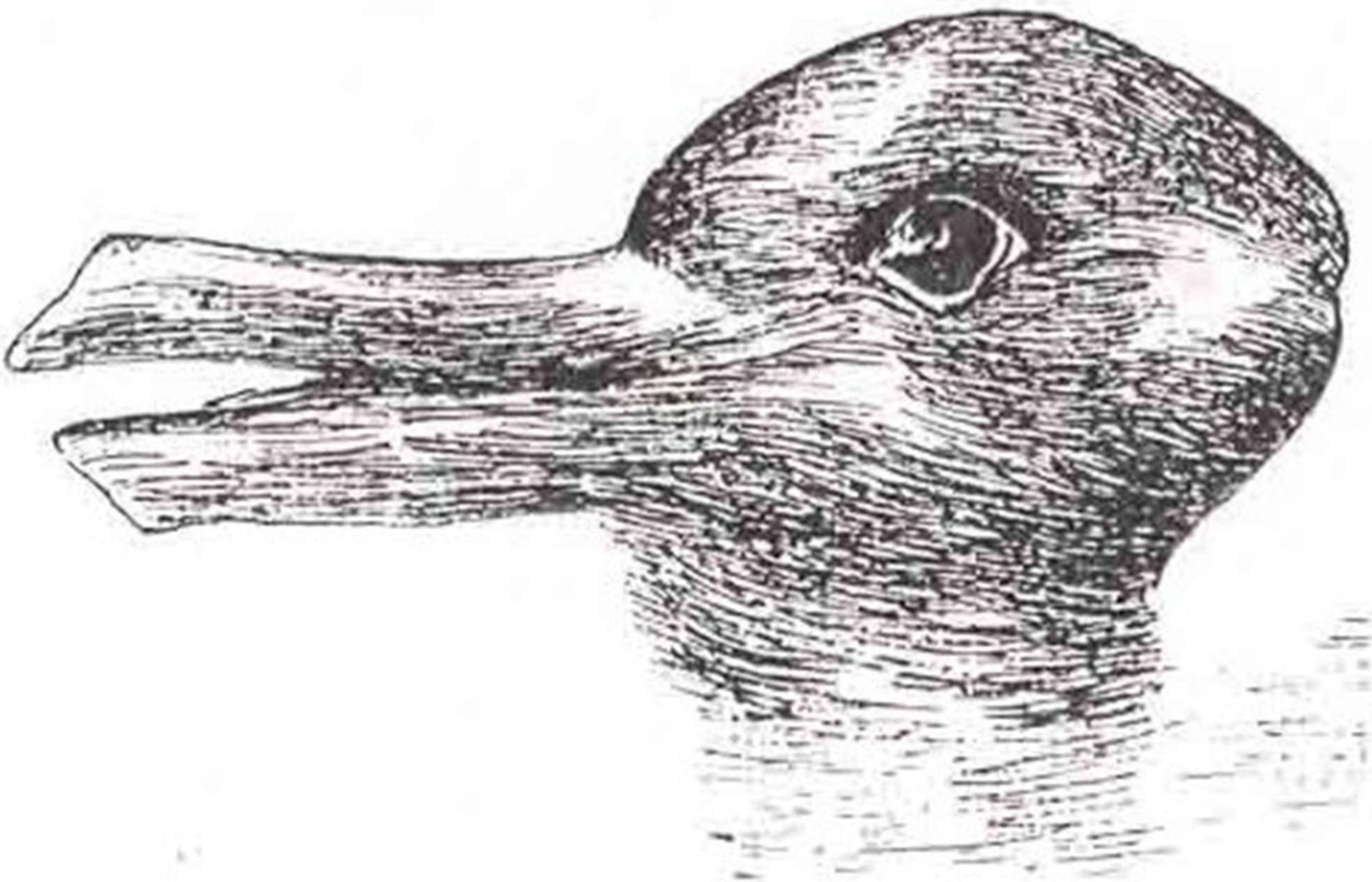
- BN is responsible for initiating a voluntary skeletal muscle contraction (BN direct pathway / excitation) while also preventing unwanted contraction (BN indirect pathway / inhibitory). The BN also plays a role in visual perception and other functions.

- Think about the rhythmic muscle contraction and relaxation that occurs when you walk. You must initiate and stop contractions, but you must also inhibit other skeletal muscle unwanted contractions

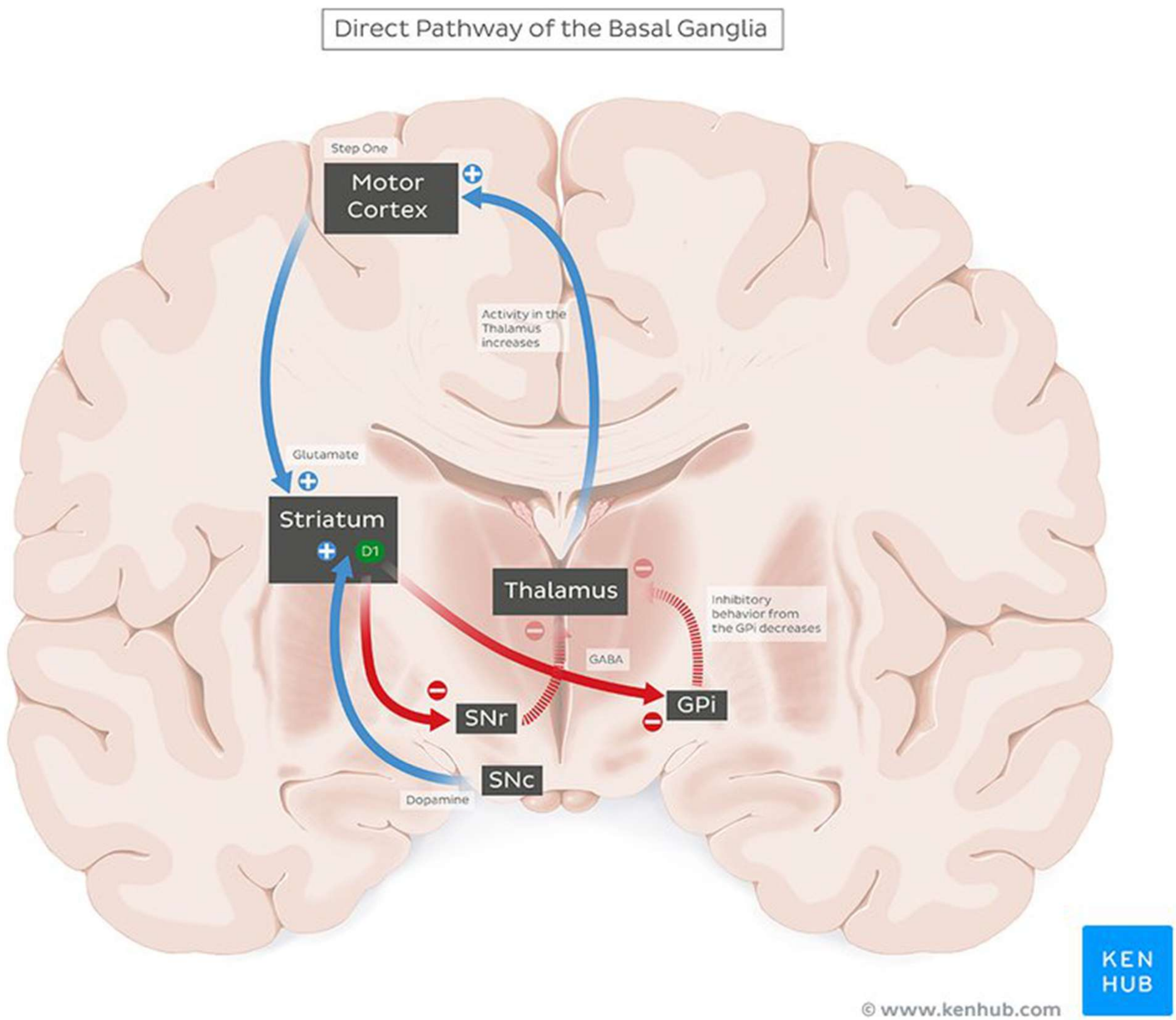
- Motor association area sends AP into striatum (cadate and putamen nuclei) // results in globus pallucidum passing AP through thalamus and eventually the AP arrives at the motor strip // the AP may now move down UMN to LMN and cause the skeletal muscle to contract.

- Basal nuclei also play a roll in vision. Perception is limited by BN so we can only see one image at a time (see next slide)


BASAL GANGLIA
START, STOP, AND CONTROL MOVEMENTS
INHIBITS UNDESIRED MOVEMENTS
WALKING
ACTIVE LEG
(STEPPING FORWARD)
INHIBITED LEG
(STATIONARY)
PERCEPTION
STIMULATES VISION OF ONE
INHIBITS THE VISION OF OTHER



The following slides examine the function of the the Basal Nuclei in greater detail. This information is not a learning objective for this class. If you are curious and want to know more about motor control then you may want to study these slides.



Direct Pathway of the Basal Ganglia
Step One
Motor Cortex
Activity in the Thalamus increases
Glutamate
Striatum
D1
Thalamus
Inhibitory behavior from the GPi decreases
GABA
SNr
GPi
SNc
Dopamine
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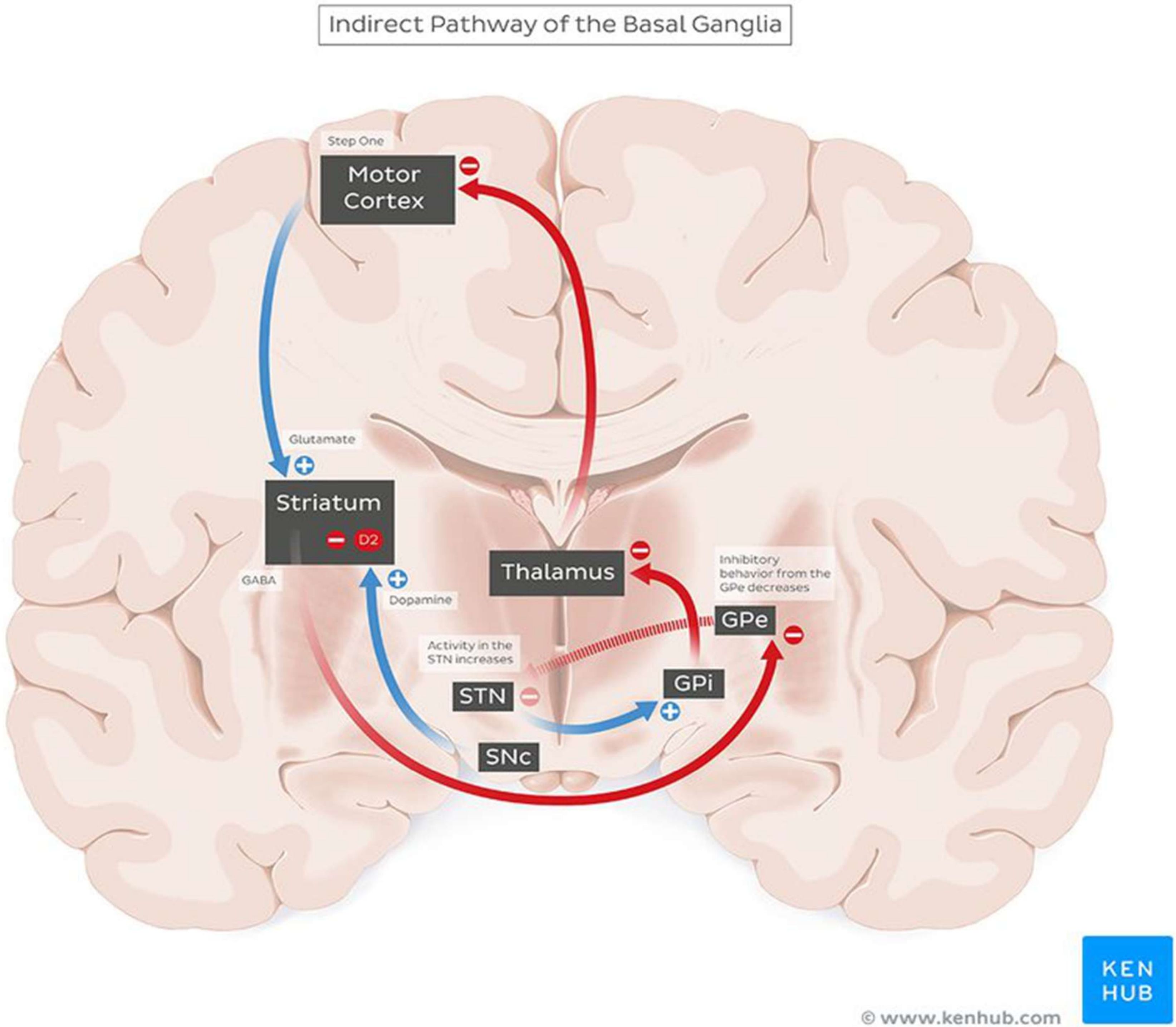

Indirect Pathway of the Basal Ganglia
Step One
Motor Cortex
Glutamate
Striatum
D2
GABA
Dopamine
Thalamus
Inhibitory behavior from the GPe decreases
GPe
Activity in the STN increases
STN
GPi
SNc
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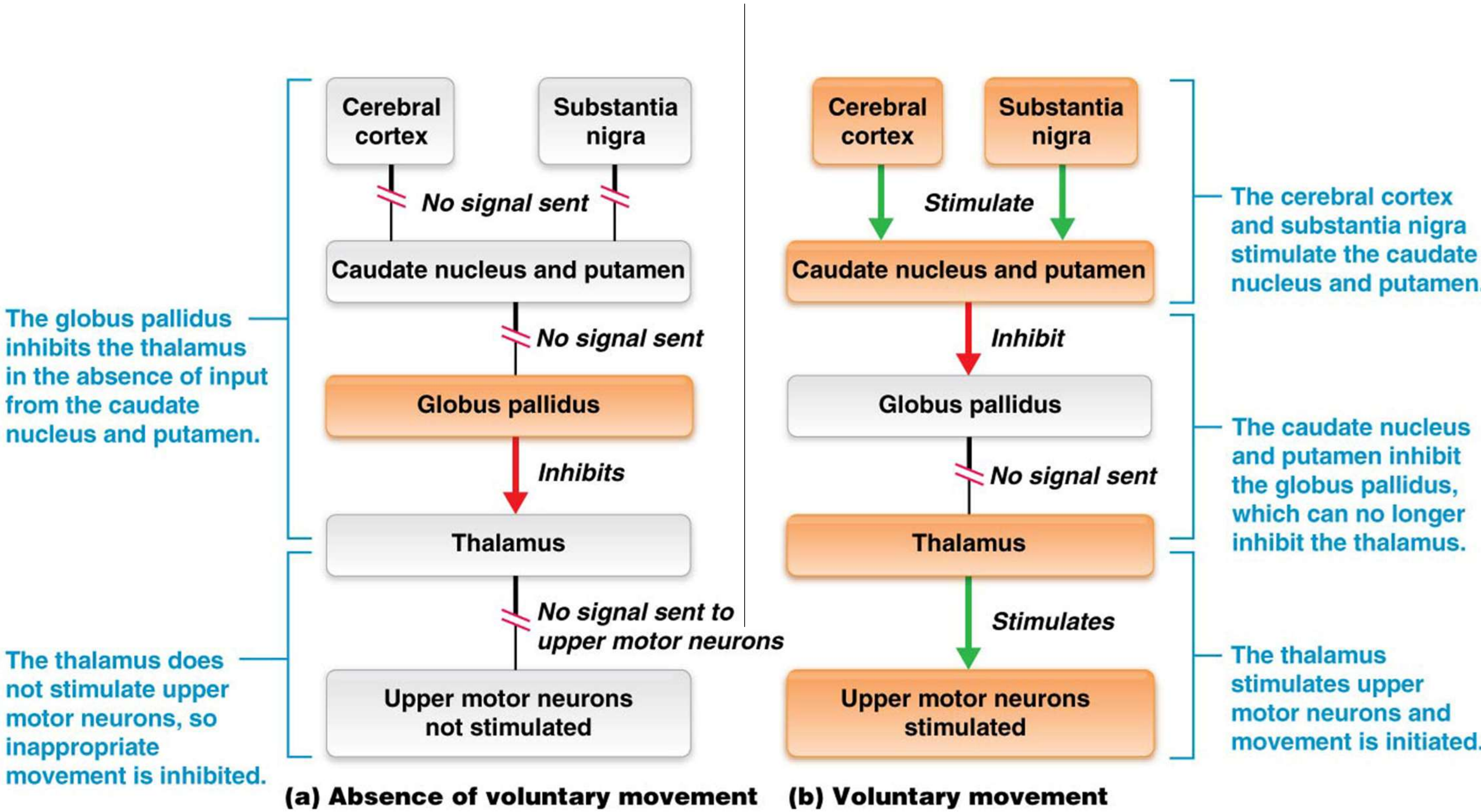
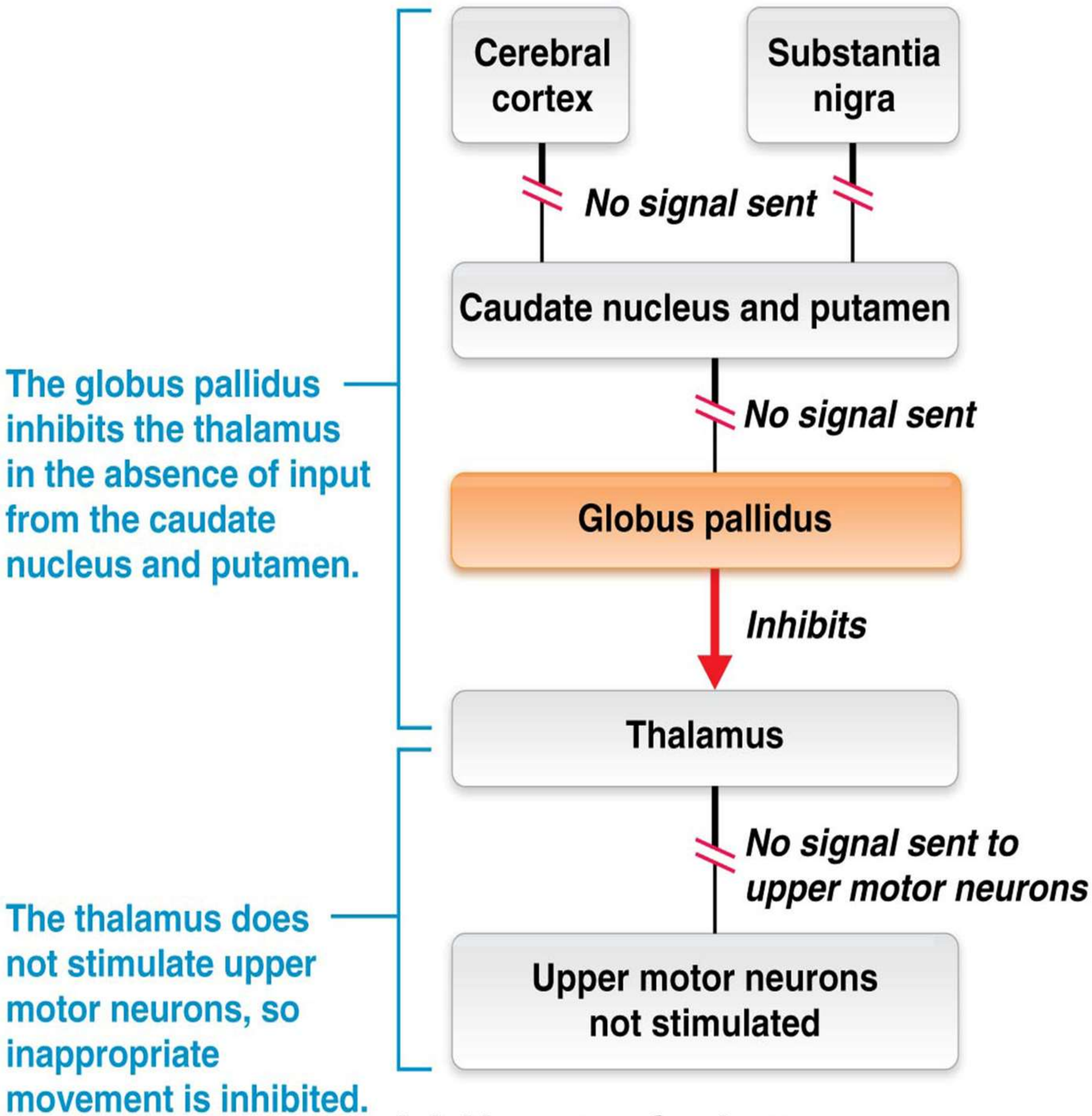
Role of the basal nuclei in voluntary movement.



Role of the basal nuclei in voluntary movement.

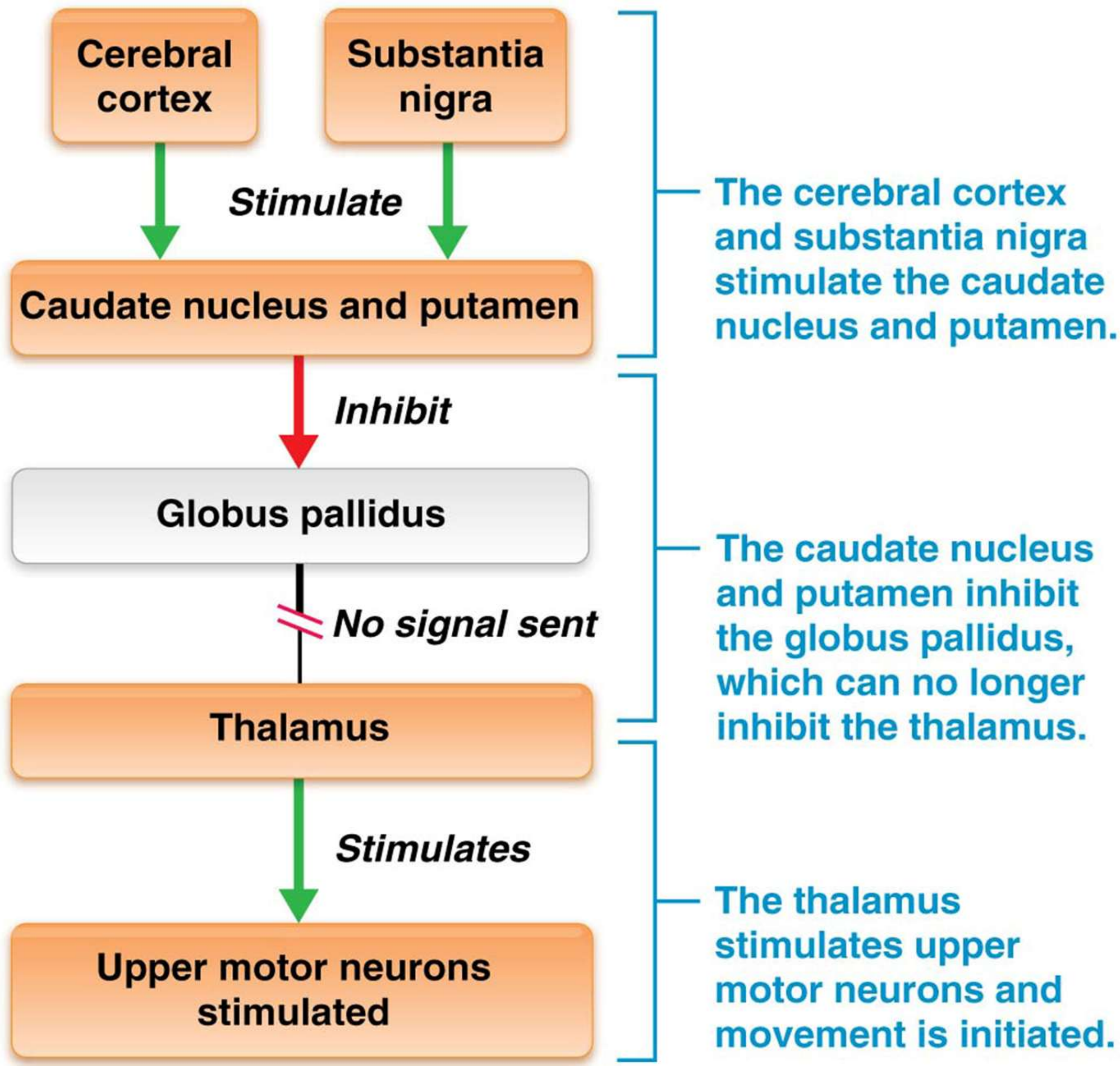


(a) Absence of voluntary movement

Role of the basal nuclei in voluntary movement.

Globus pallidus function is to prevents motor programs from reaching UMN by blocking the AP at the thalamus.

The motor programs are stored in the basal nuclei, cerebellum, and motor association areas.



(b) Voluntary movement

The Big Picture of CNS Control of Voluntary Movement.