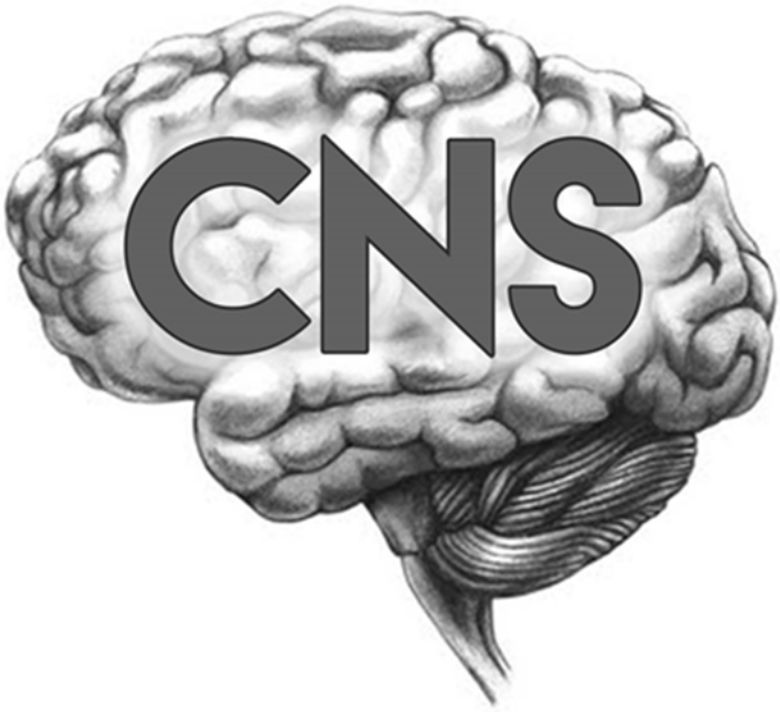


PHYSIOLOGY

○ Sheet ☑ Slide ○ Handout

Number

4

Subject

Basal ganglia physiololgy

Doctor

Faisal Mohammed

Date: **00/00/2016**

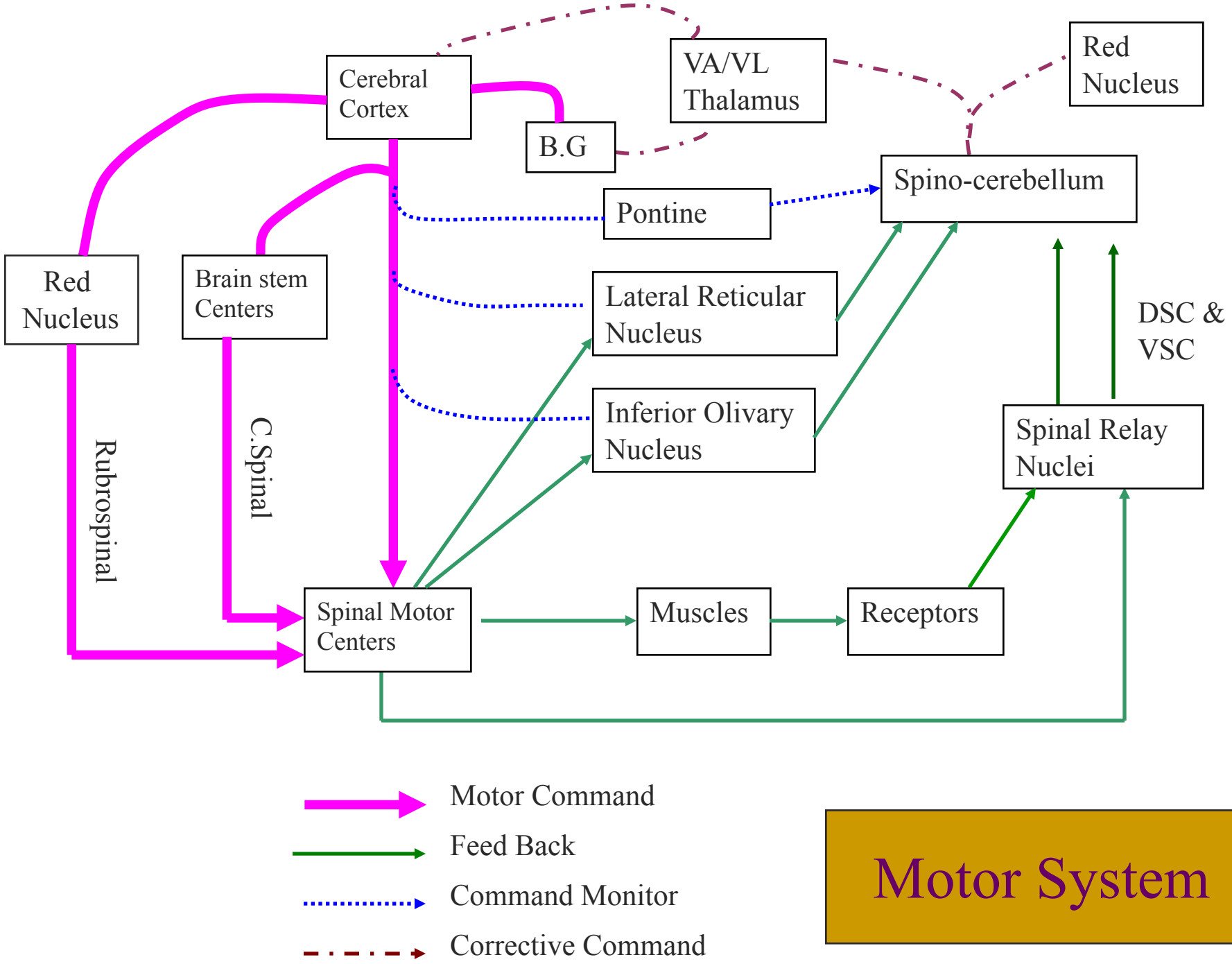
Price:

Basal Ganglia and Motor Control

Faisal I. Mohammed, MD, PhD

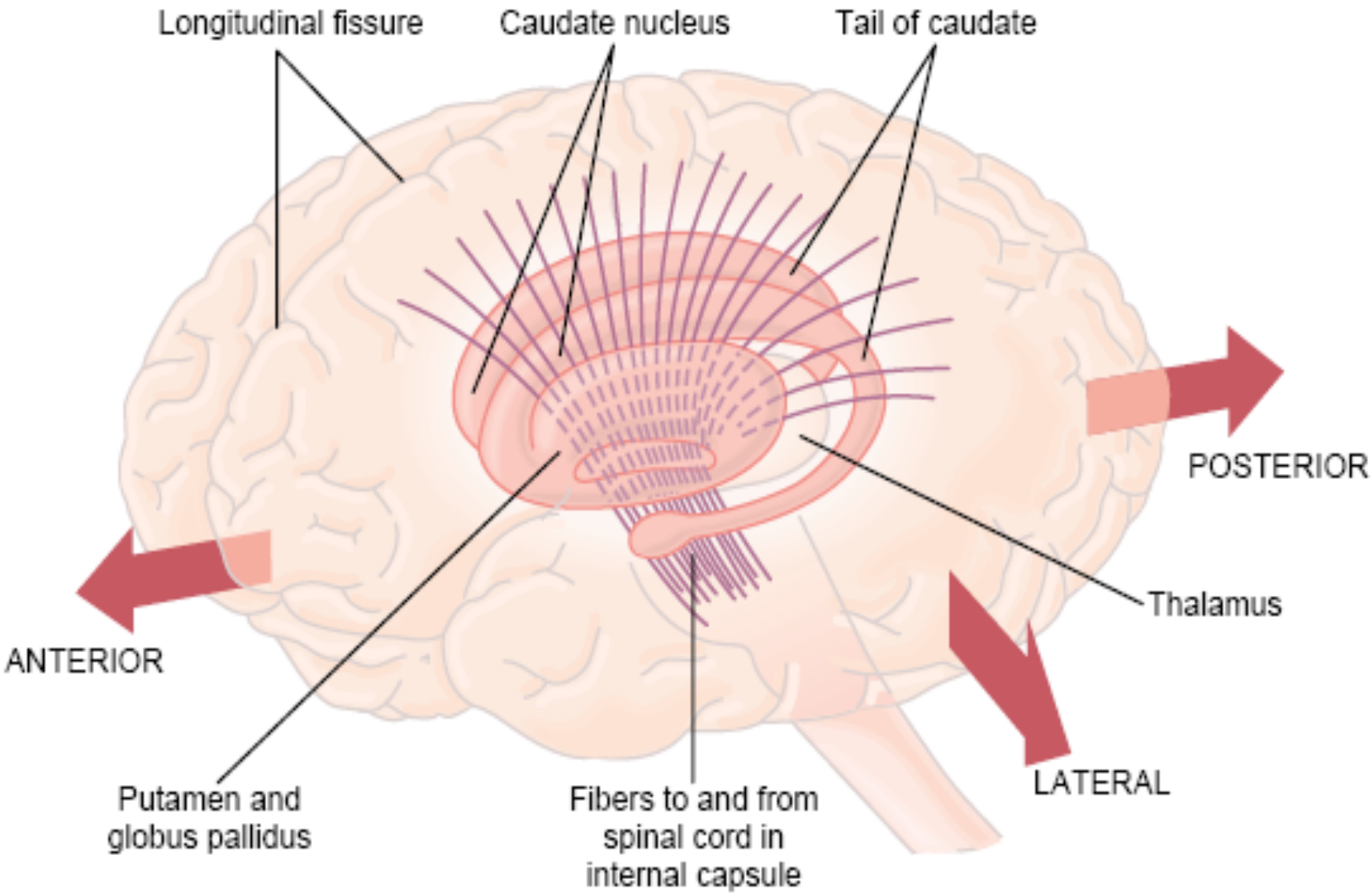
Objectives

- ☺ Recognize the basal ganglia system and name its parts
- ☺ Describe how the basal ganglia system works toward control of motor movements
- ☺ Identify basal ganglia abnormalities

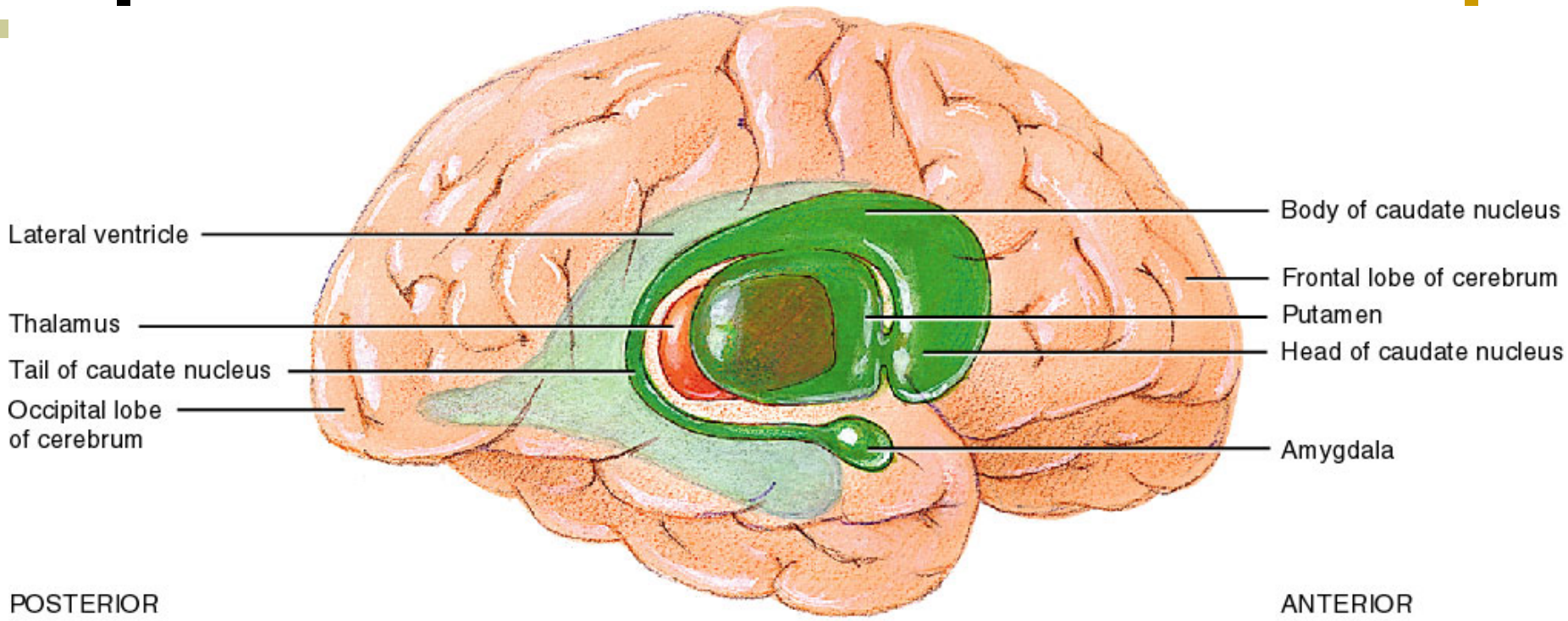

Cerebral Cortex
VA/VL Thalamus
Red Nucleus
B.G
Spino-cerebellum
Pontine
Red Nucleus
Brain stem Centers
Lateral Reticular Nucleus
DSC & VSC
Inferior Olivary Nucleus
Spinal Relay Nuclei
Rubrospinal
C.Spinal
Spinal Motor Centers
Muscles
Receptors
Motor Command
Feed Back
Command Monitor
Corrective Command
Motor System

Basal Ganglia System

- Consist of Four Nuclei
- striatum
  - caudate and putamen
- globus pallidus
- substantia nigra
- subthalamus


Longitudinal fissure
Caudate nucleus
Tail of caudate
POSTERIOR
ANTERIOR
Thalamus
LATERAL
Putamen and
globus pallidus
Fibers to and from
spinal cord in
internal capsule

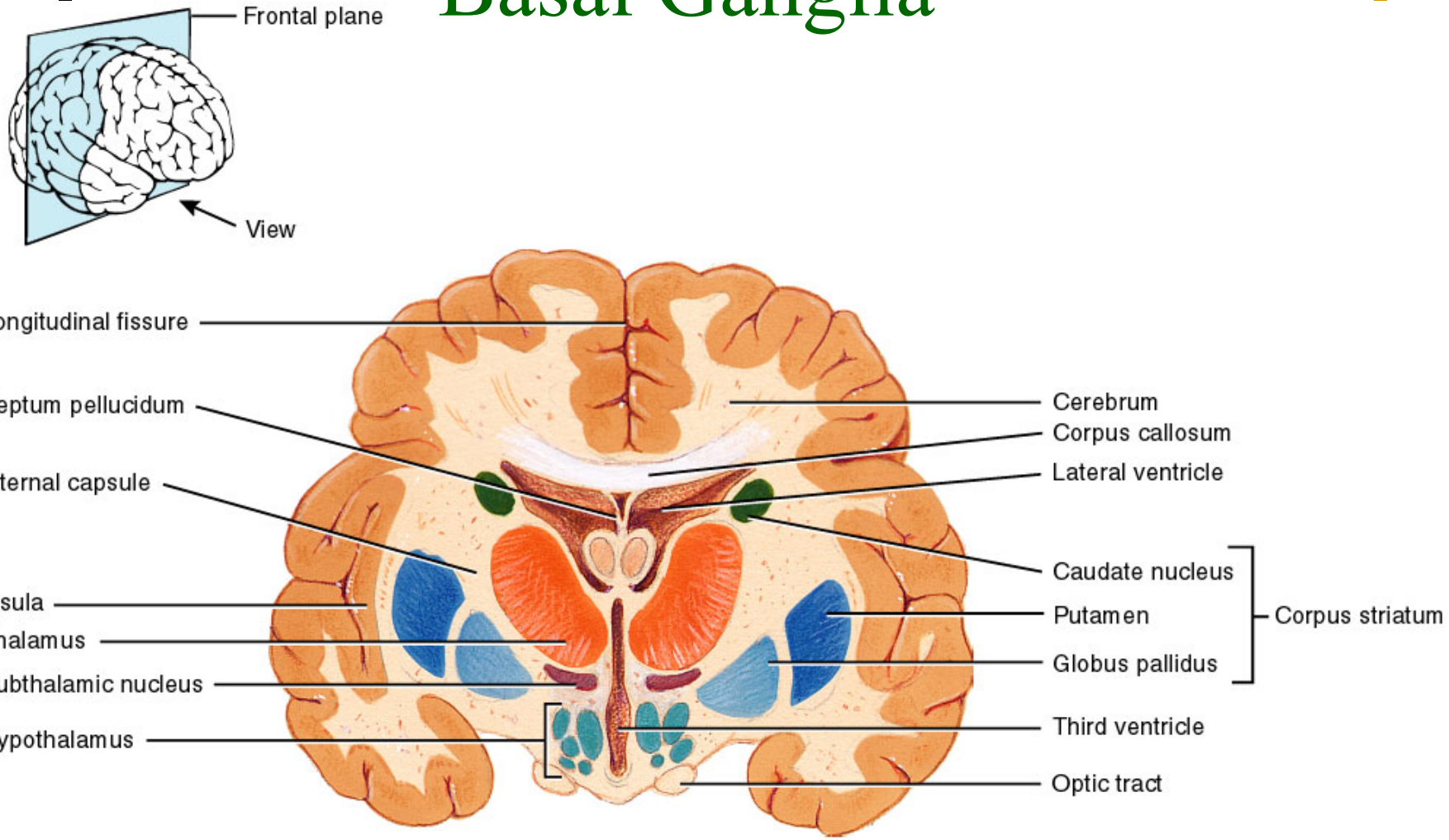
Basal Ganglia



(a) Lateral view of right side of brain

14.13a

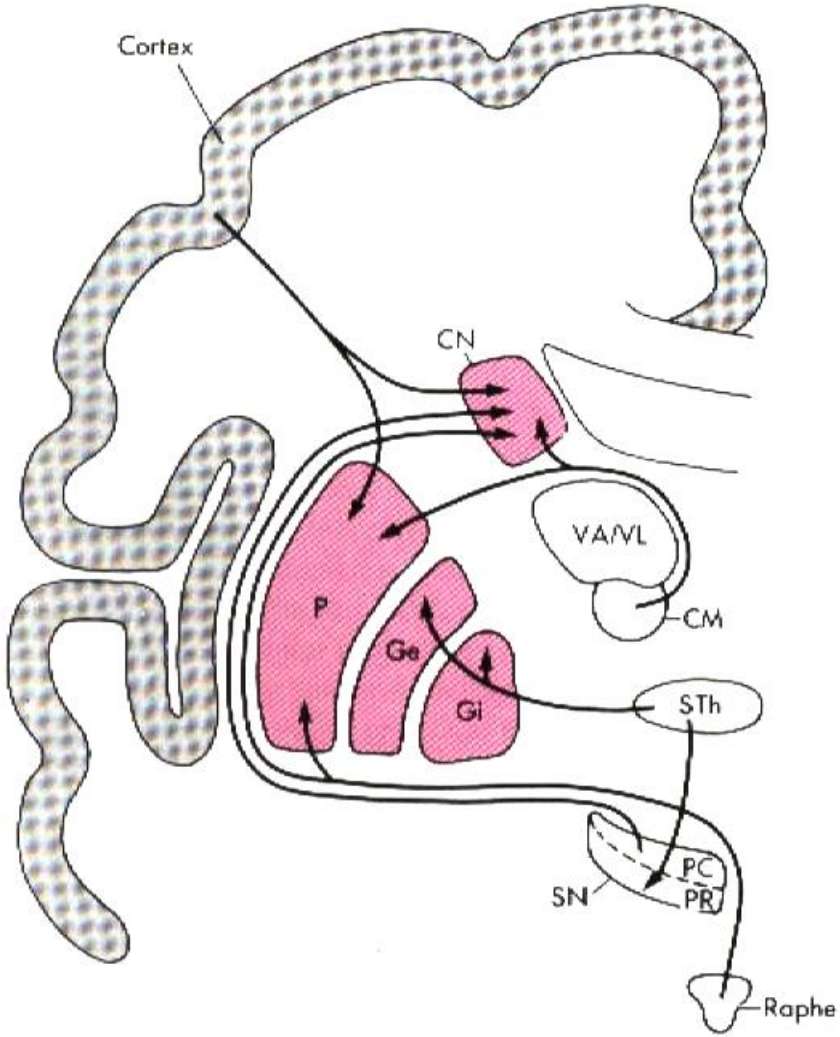
Basal Ganglia

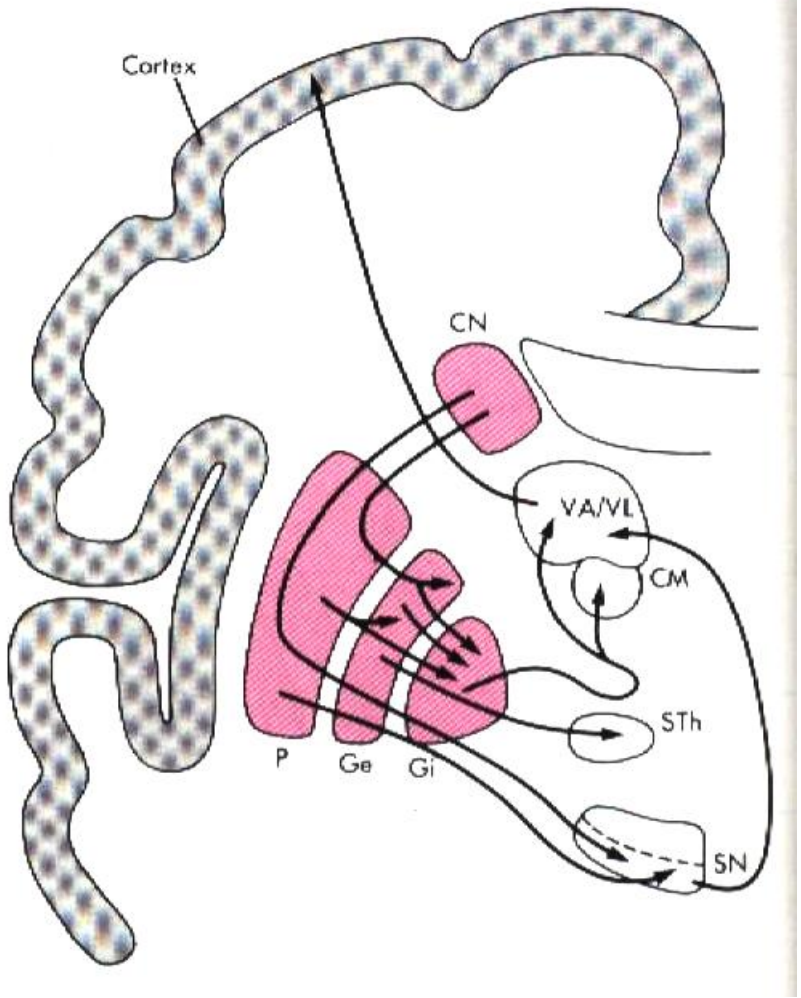


(b) Anterior view of frontal section

14.13b

Basal ganglia Afferents and Efferents





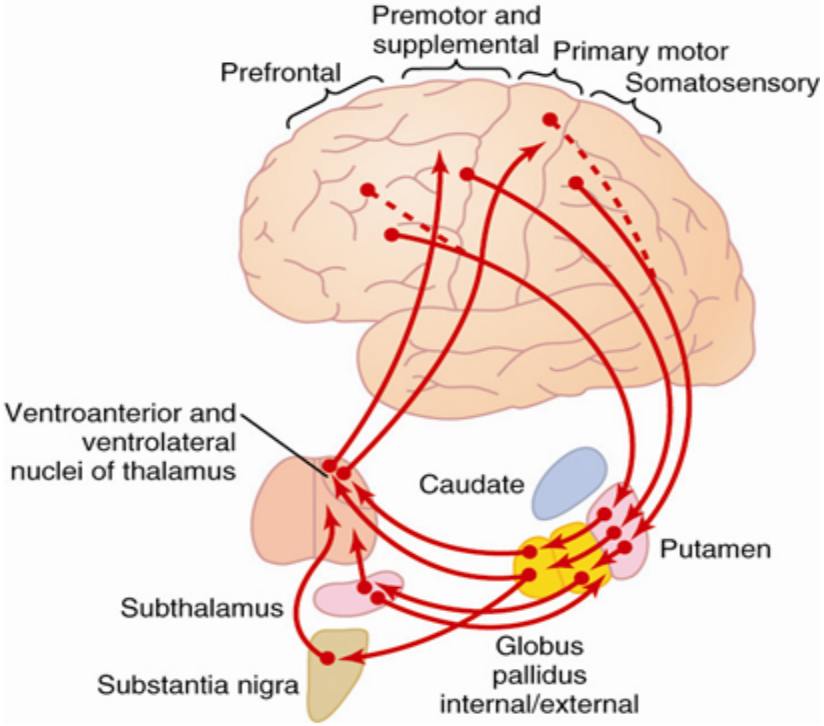
Basal ganglia Afferents

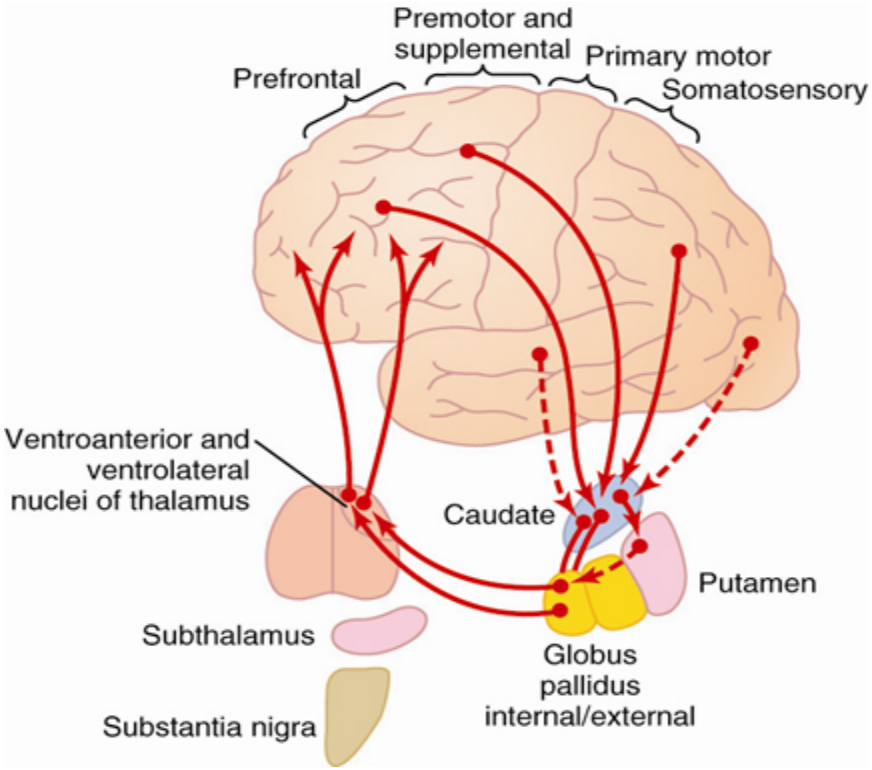
- Afferents:
  - Cerebral cortex to caudate and putamen
  - Substantia nigra pars compacta to putamen and caudate
  - Subthalamic nucleus to globus pallidus and to substantia nigra pars reticulata
  - Centromedial nucleus of the thalamus to putamen and caudate
  - Raphe magnus nucleus to putamen and caudate

Basal ganglia Efferents

- Effetrents:
  - Putamen and caudate to globus pallidus
  - Putamen and caudate to substantia nigra pars reticularis
  - Globus pallidus to subthalmic nucleus
  - Globus pallidus to ventroanterio and ventrolateral nuclei of the thalamus

The basal ganglia are the principle subcortical components of a family of parallel circuits linking the thalamus with the cerebral cortex





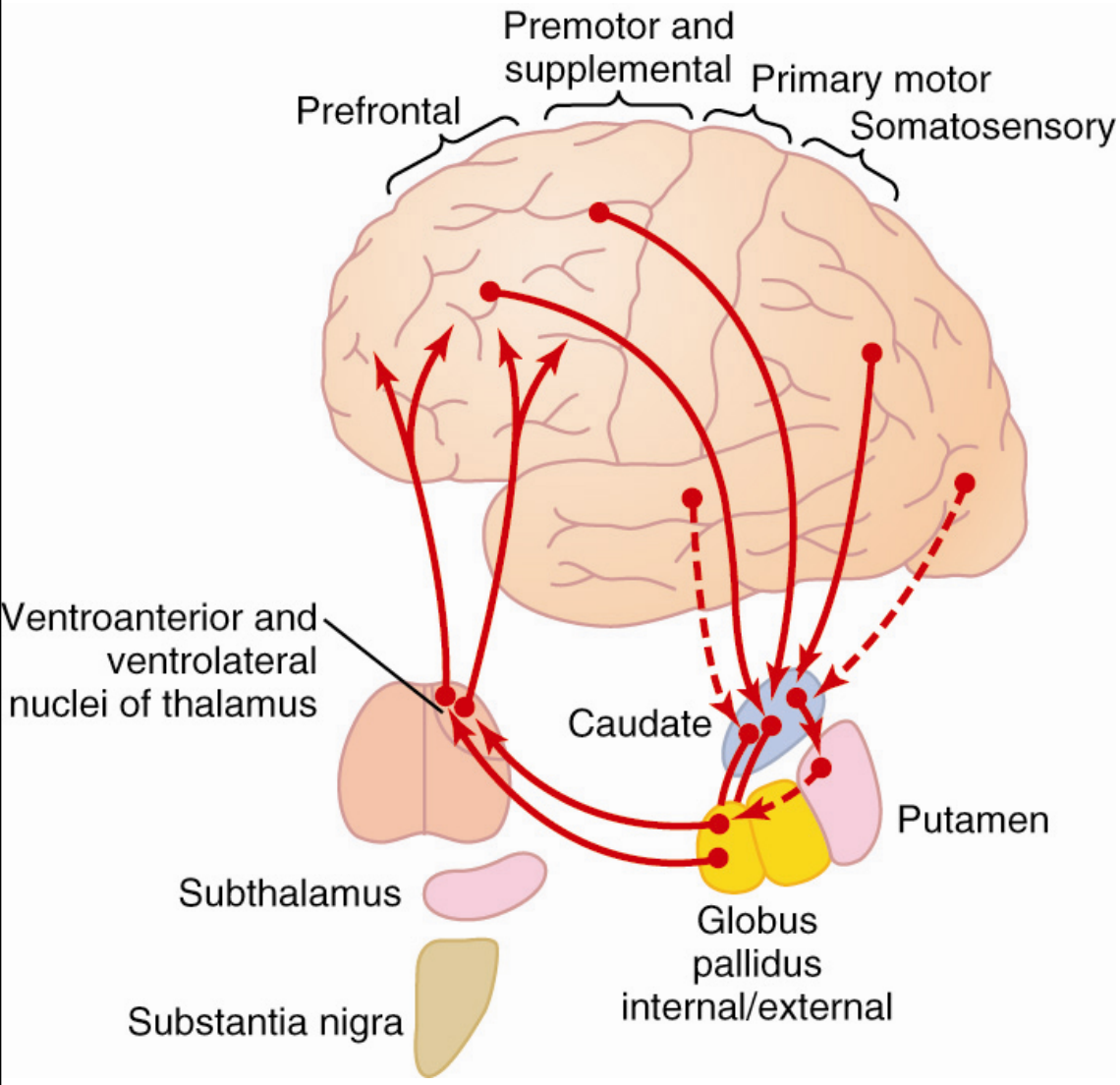
Motor Function of the Basal Ganglia

- control of ***complex patterns*** of motor activity
  - writing
  - using scissors
  - throwing balls
  - shoveling dirt
  - some aspects of vocalization

Function of the Basal Ganglia?

- not much is known about the specific functions of each of these structures
- thought to function in ***timing and scaling*** of motion and in the **initiation of motion**
- most information comes from the result of damage to these structures and the resulting clinical abnormality

Caudate Circuit

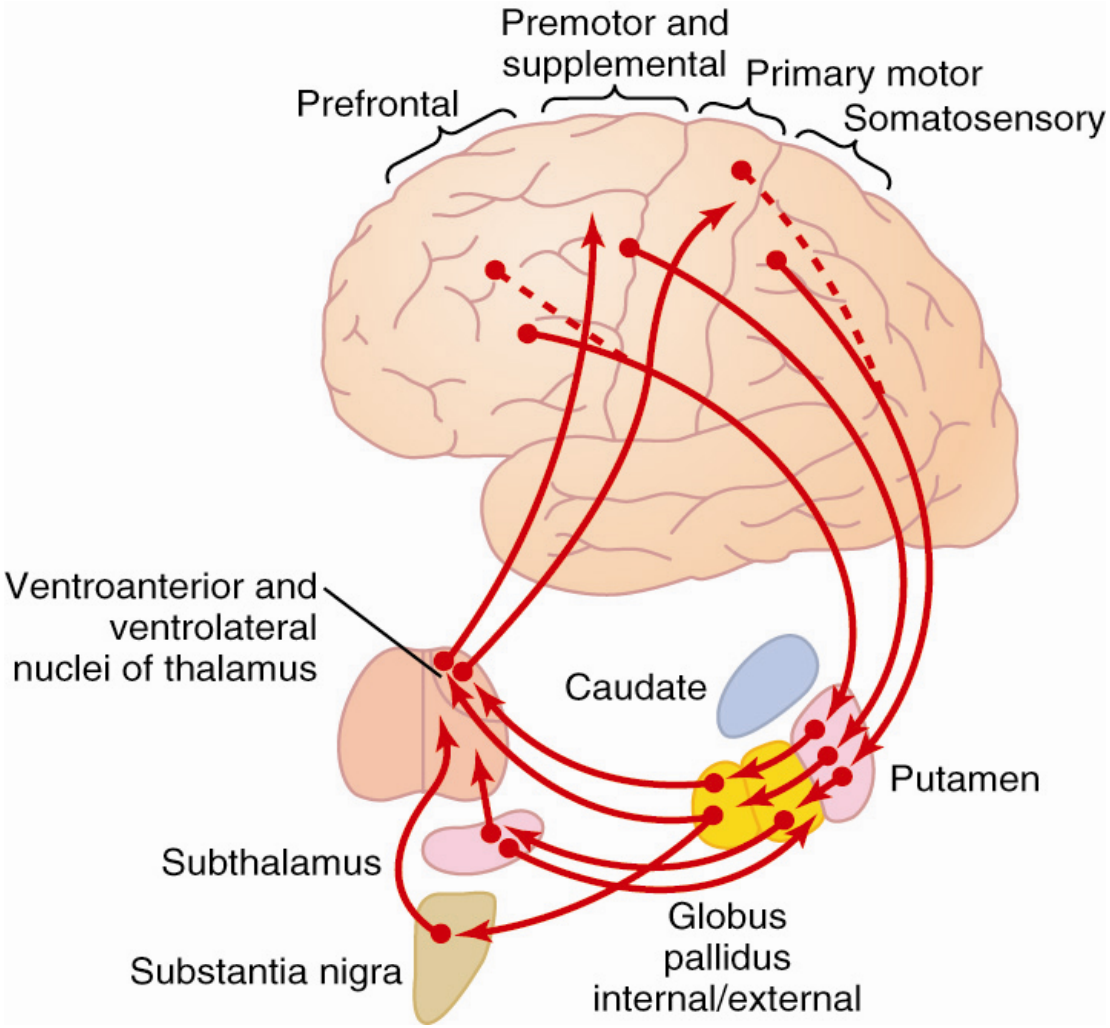


Caudate extends into all lobes of the cortex and receives a large input from association areas of the cortex

Mostly projects to globus pallidus, no fibers to sub-thalamus

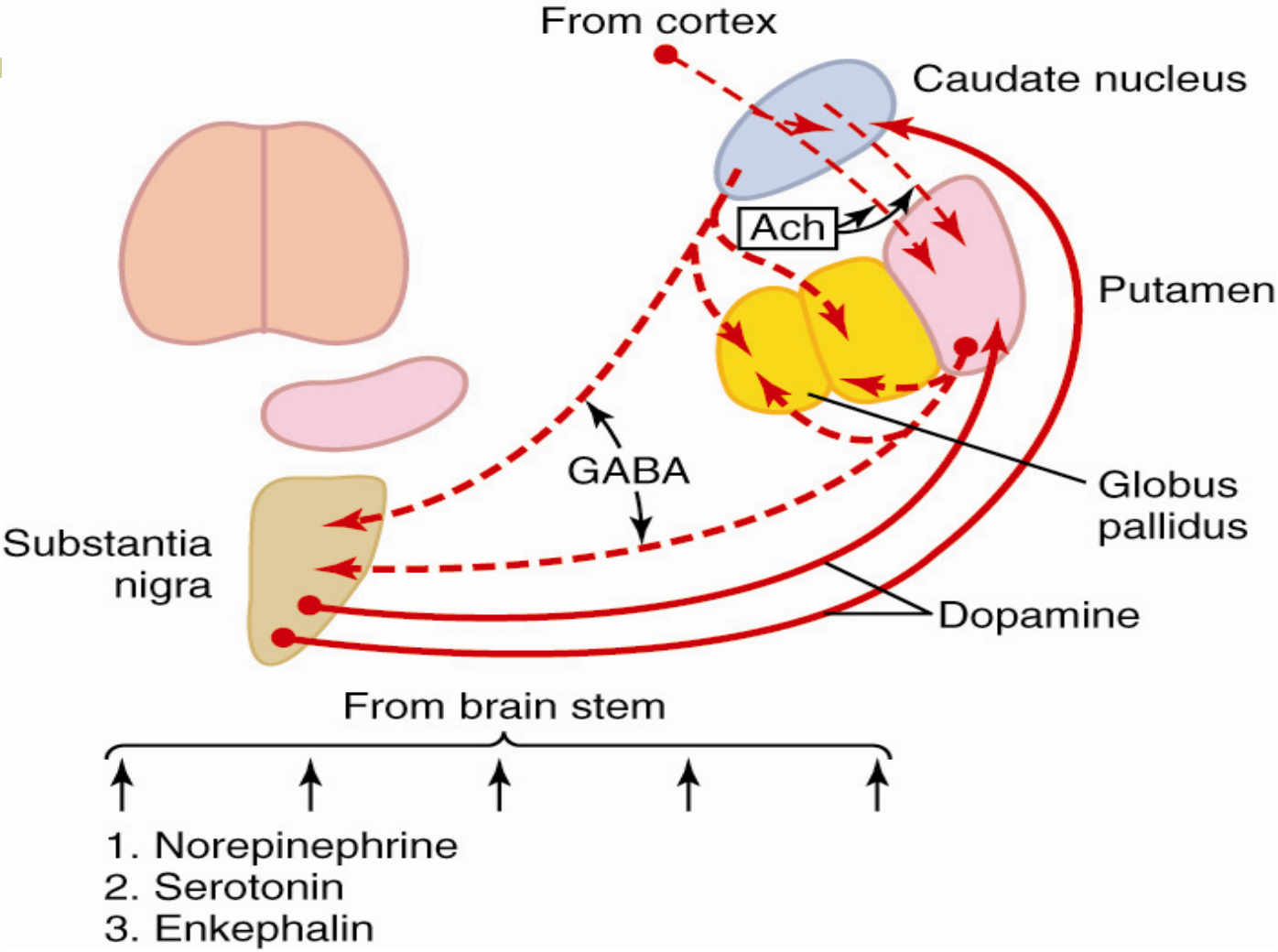
Most motor actions occur as a result of a **sequence of thoughts**. Caudate circuit may play a role in the **cognitive control of motor functions**

Putamen Circuit

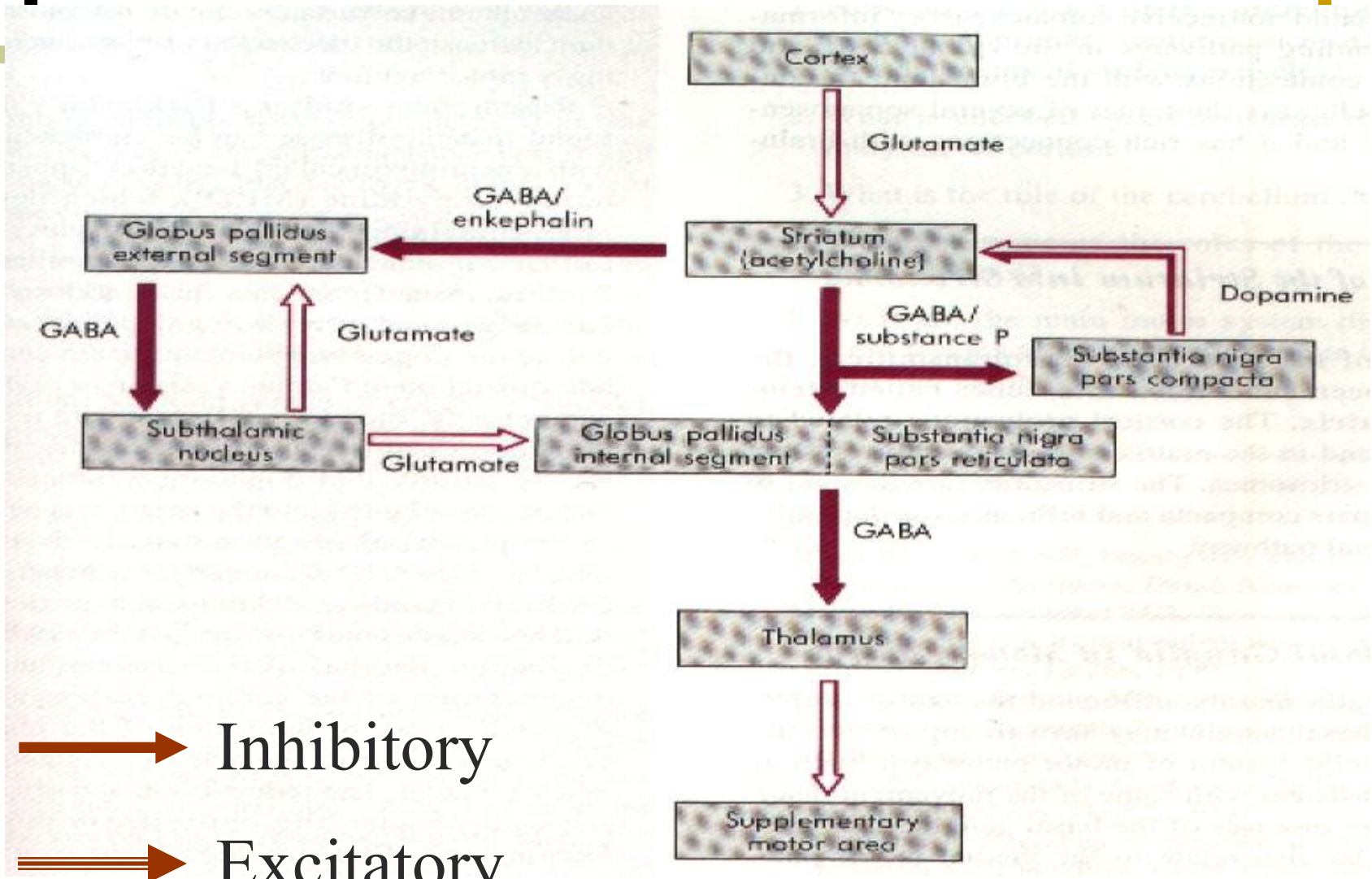


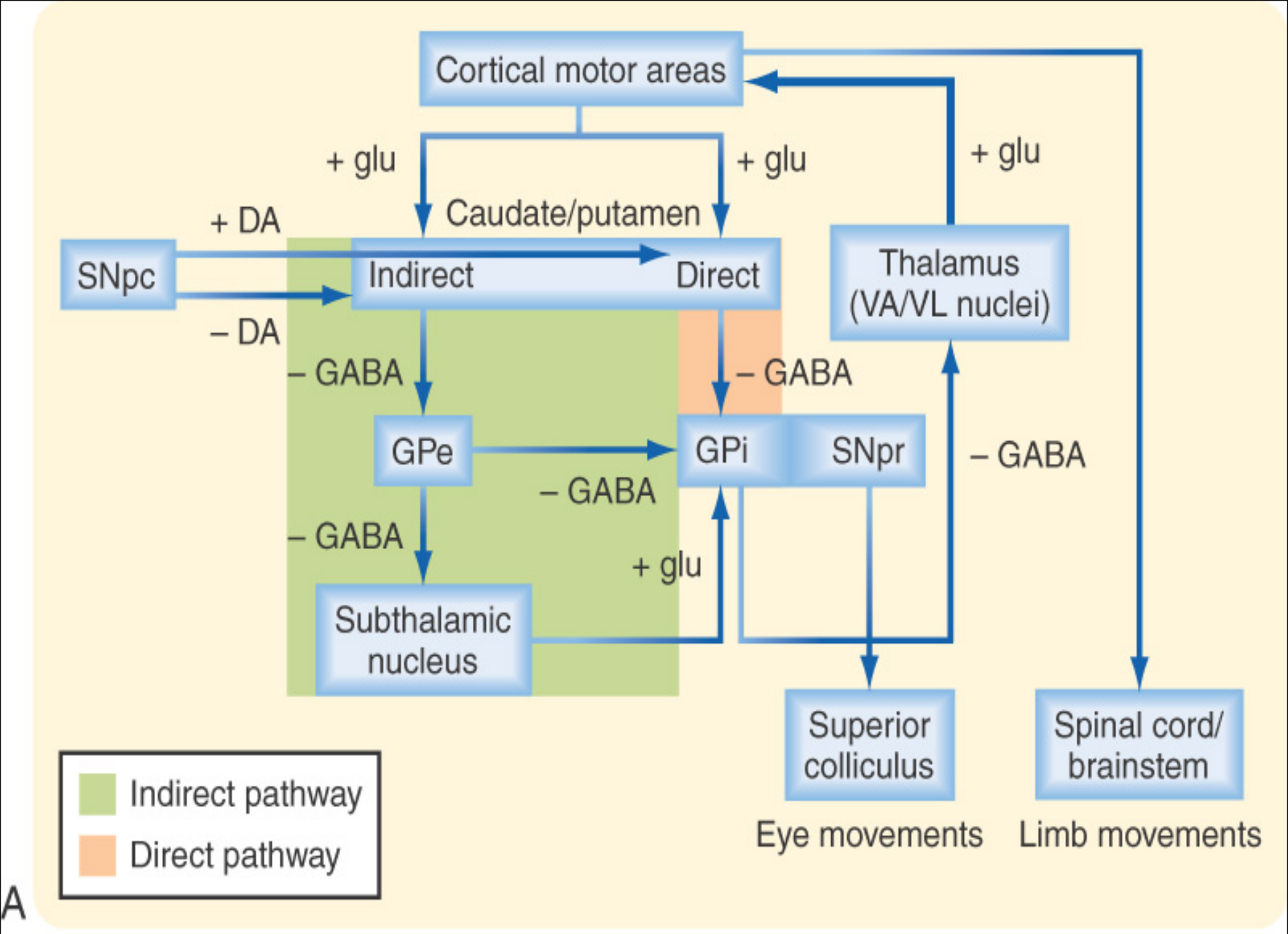
Mostly from premotor and supplemental motor cortex to putamen then back to motor cortex.

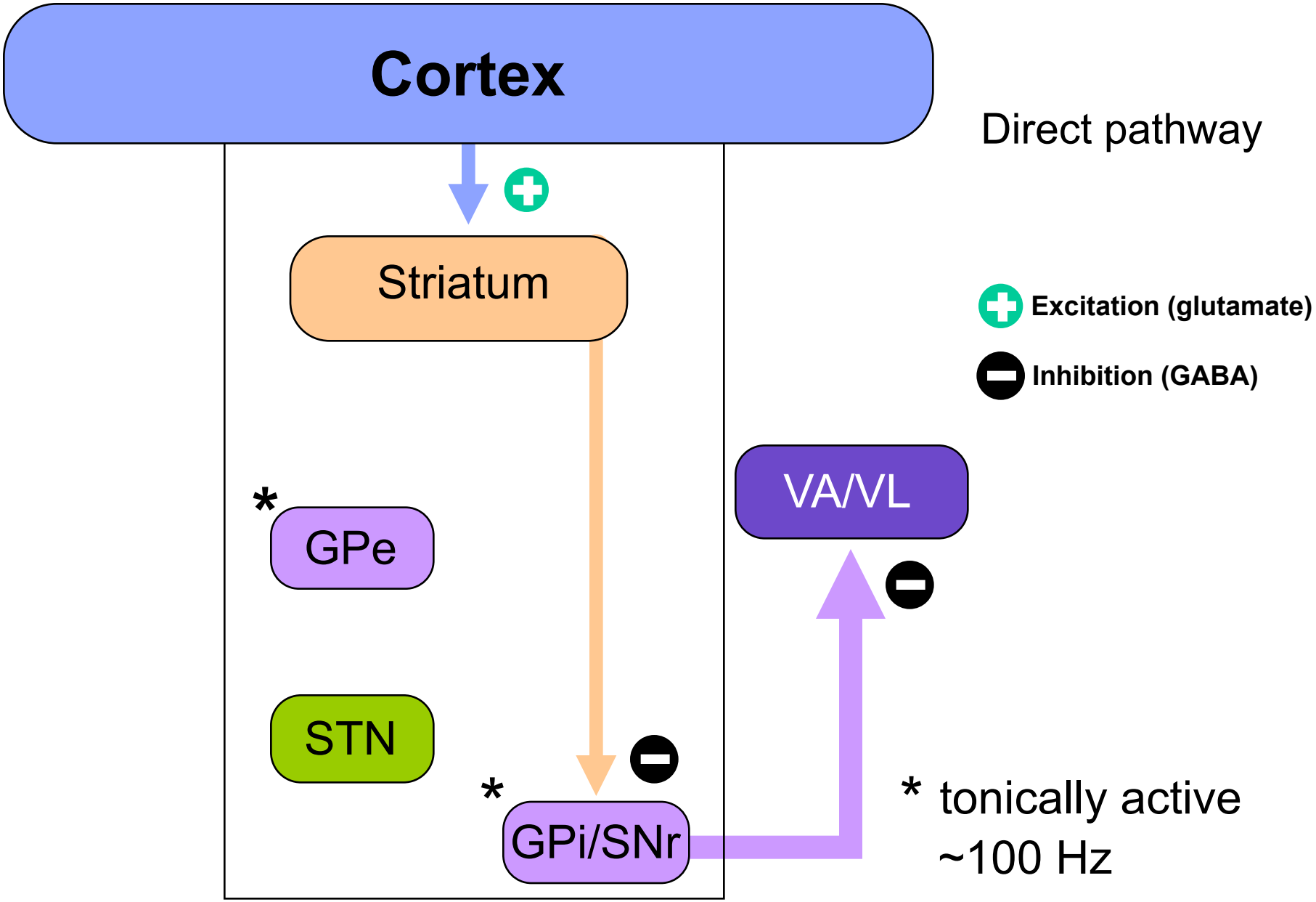
Neurotransmitters in the Basal Ganglia

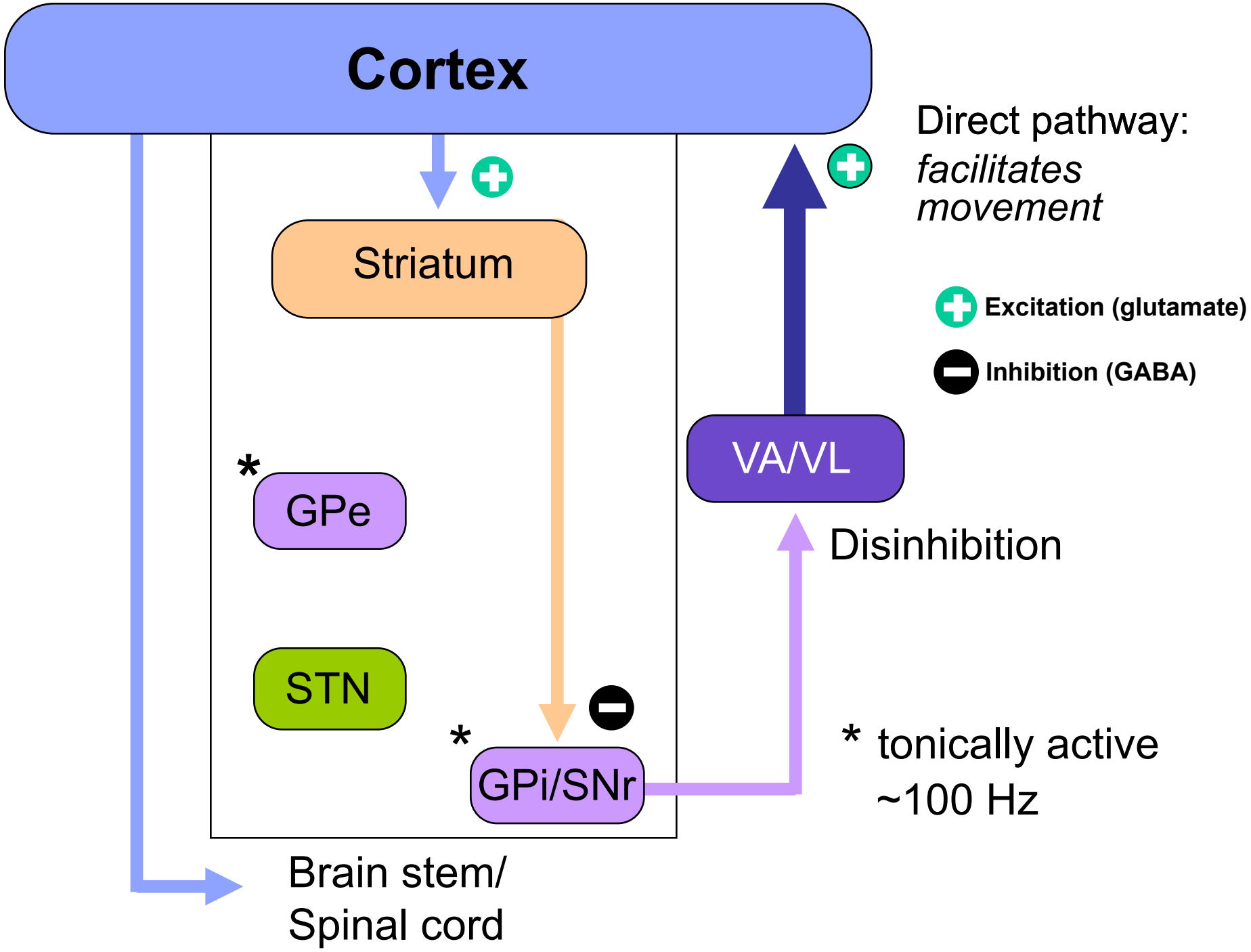


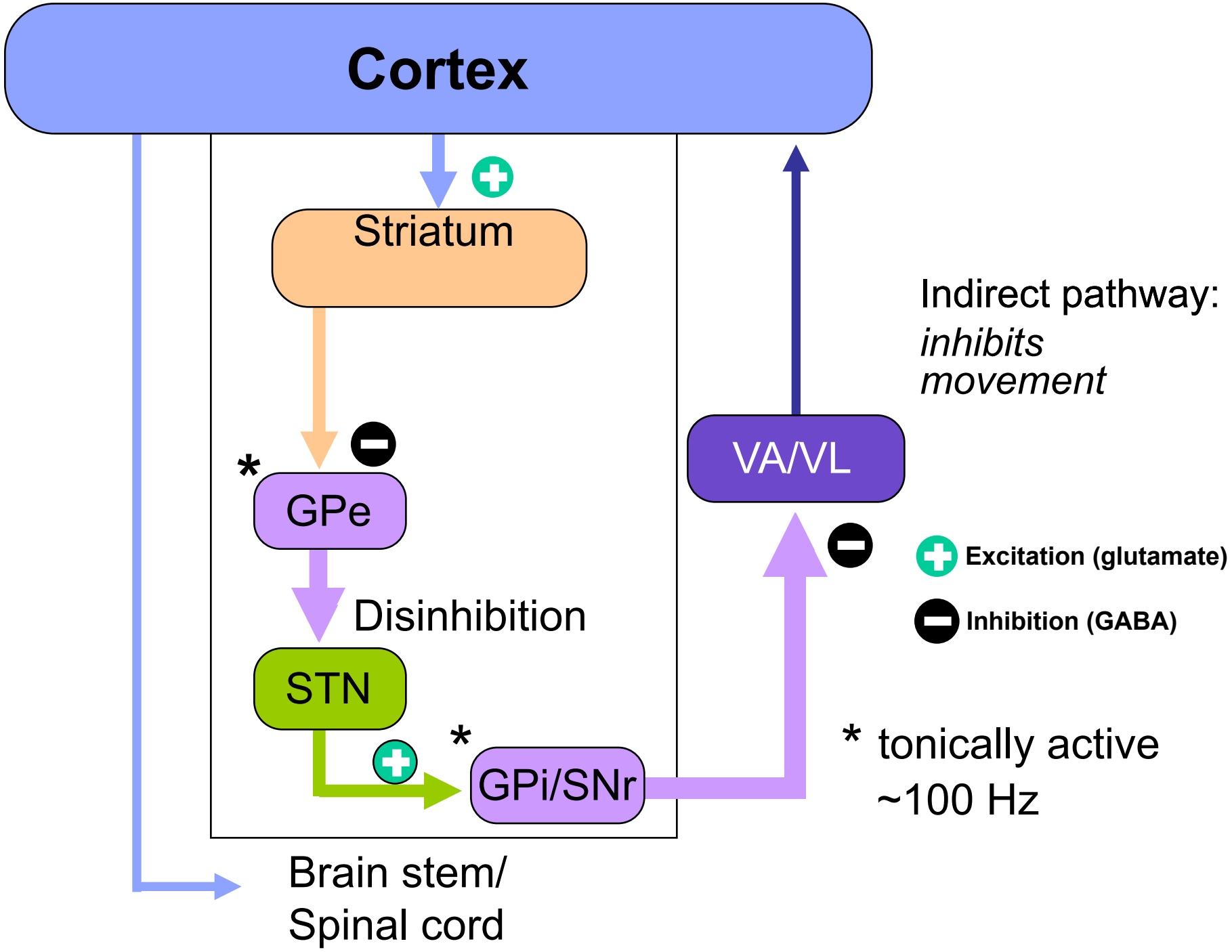
Basal Ganglia circuits and Neurotransmitters

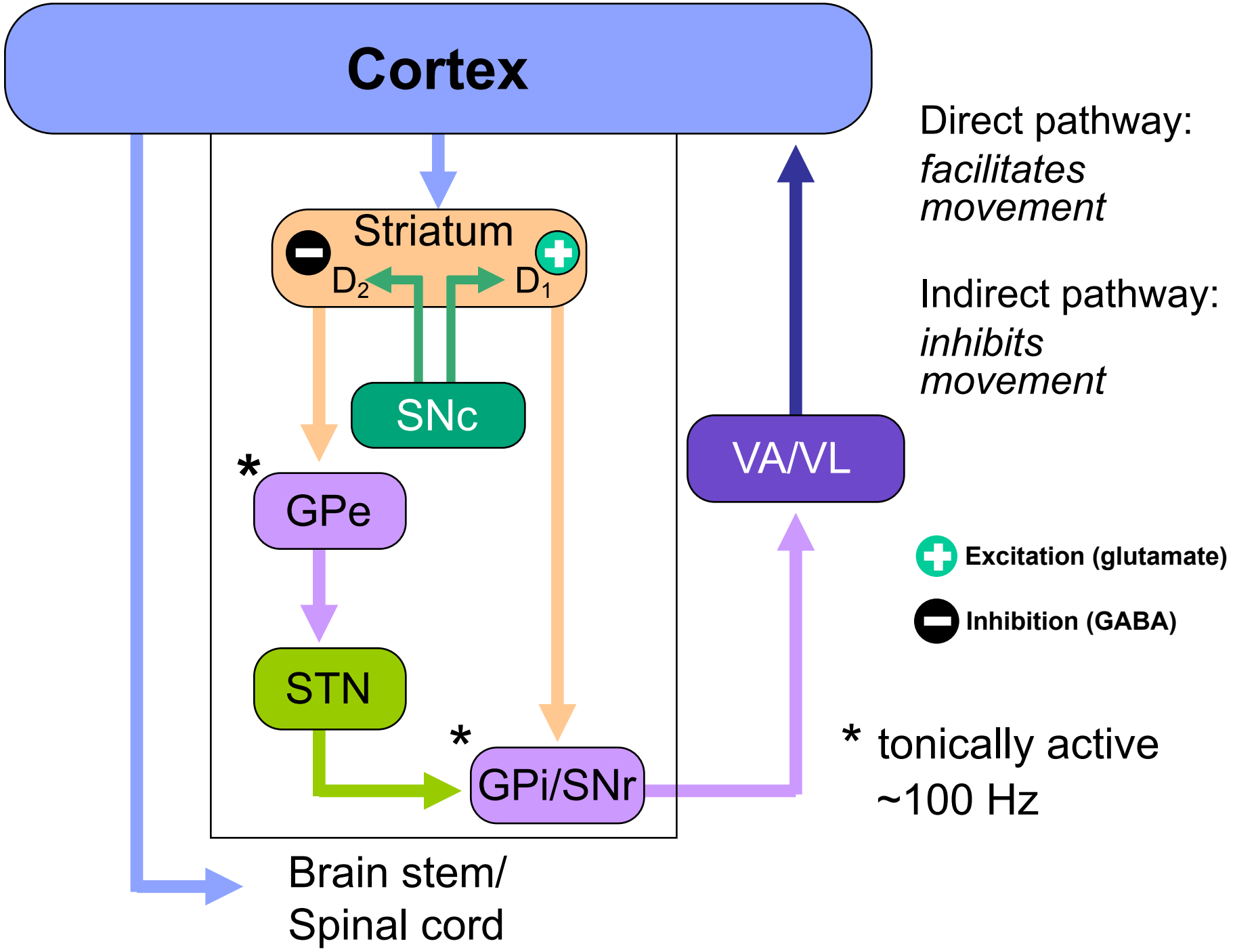




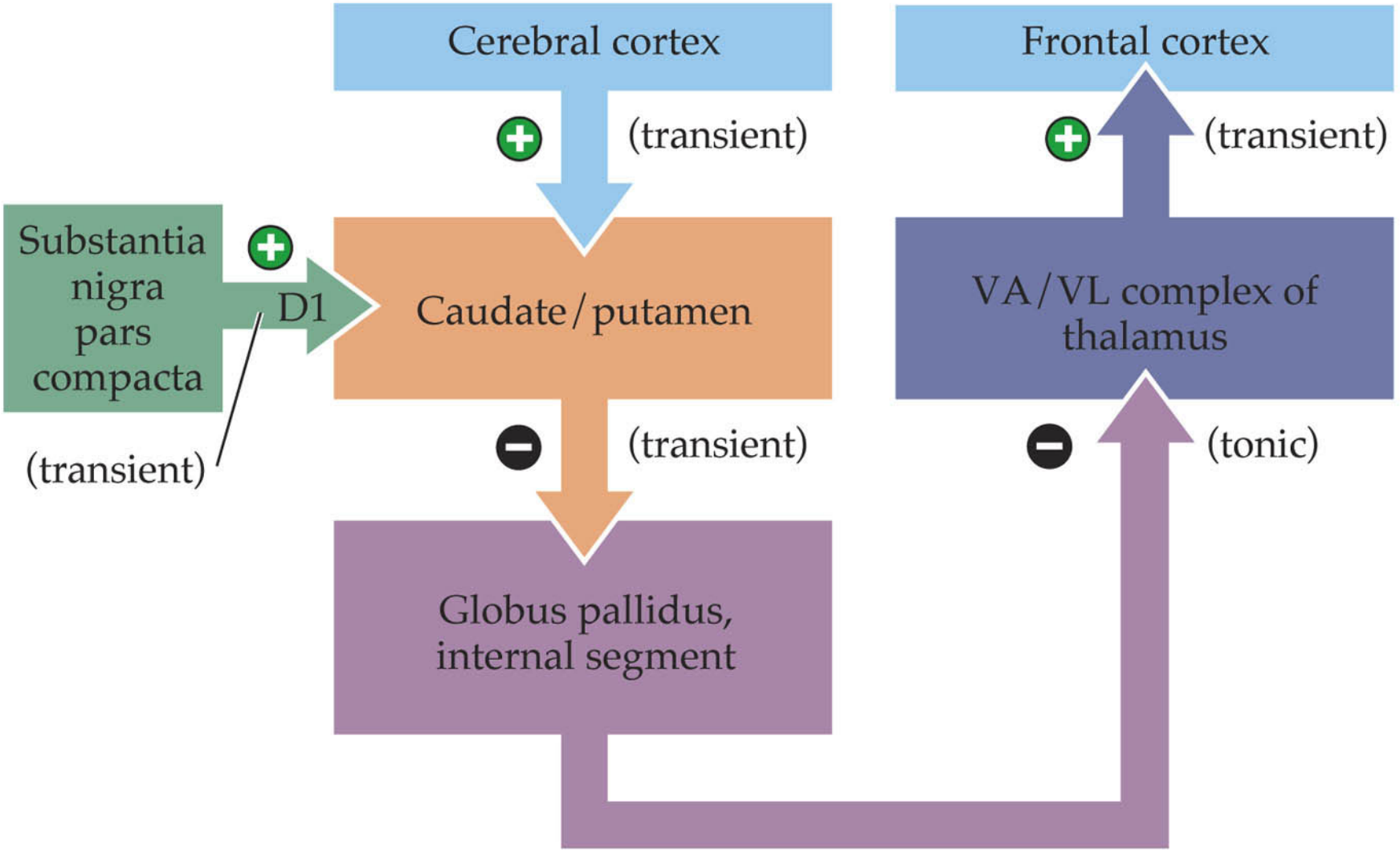

Cortex
Direct pathway
Striatum
Excitation (glutamate)
Inhibition (GABA)
VA/VL
*
GPe
STN
*
GPi/SNr
* tonically active
~100 Hz


Cortex
Striatum
GPe
STN
GPi/SNr
VA/VL
Brain stem/
Spinal cord
Direct pathway:
facilitates
movement
Excitation (glutamate)
Inhibition (GABA)
Disinhibition
* tonically active
~100 Hz

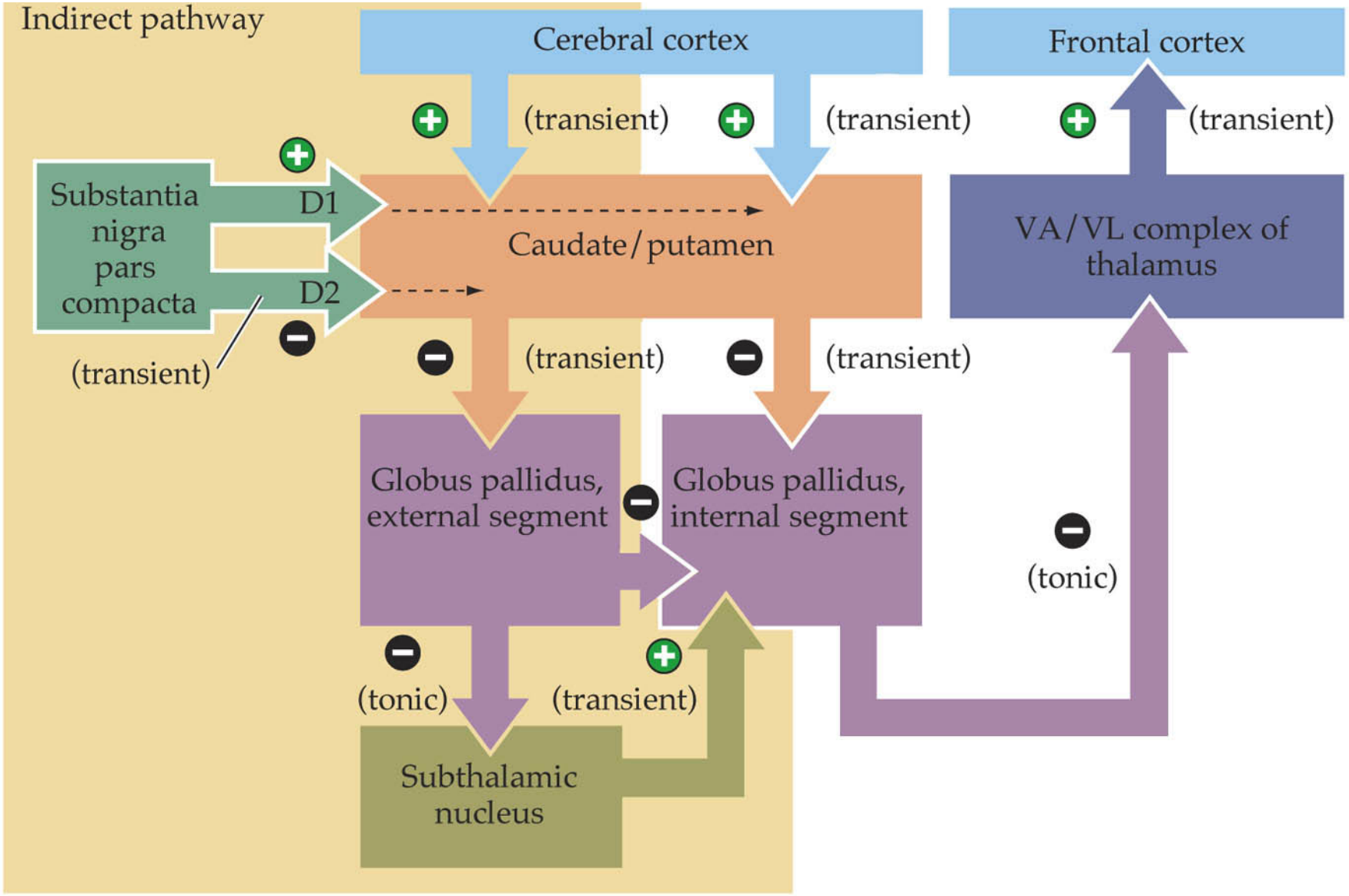

Cortex
Striatum
GPe
Disinhibition
STN
GPi/SNr
VA/VL
Brain stem/
Spinal cord
Indirect pathway:
inhibits
movement
Excitation (glutamate)
Inhibition (GABA)
* tonically active
~100 Hz


Cortex
Striatum
D2
D1
SNc
*
GPe
STN
*
GPi/SNr
VA/VL
Brain stem/
Spinal cord
Direct pathway:
facilitates
movement
Indirect pathway:
inhibits
movement
Excitation (glutamate)
Inhibition (GABA)
* tonically active
~100 Hz

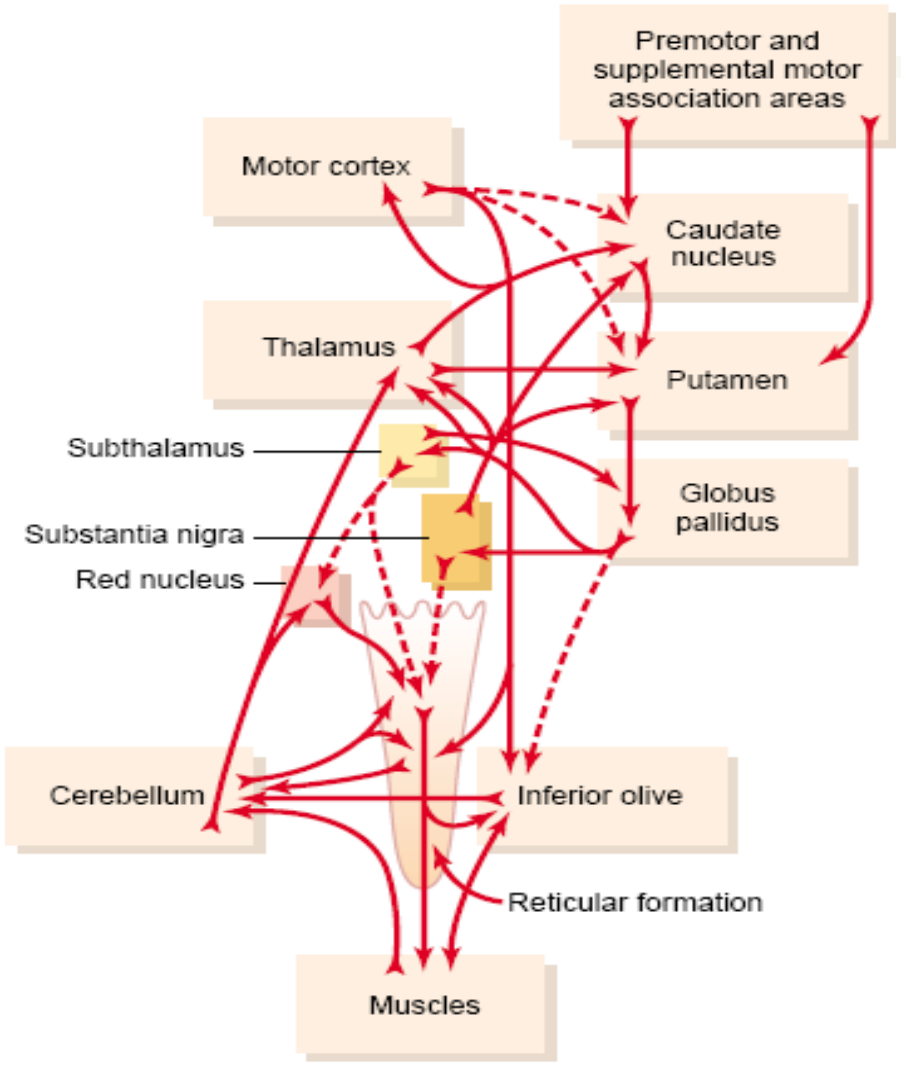
Direct pathway



Direct and indirect pathways



Motor control of the Basal Ganglia



Motor behavior is determined by the balance between direct/indirect striatal outputs

Hypokinetic disorders

- **insufficient direct** pathway output
- **excess indirect** pathway output

Hyperkinetic disorders

- **excess direct** pathway output
- **insufficient indirect** pathway output

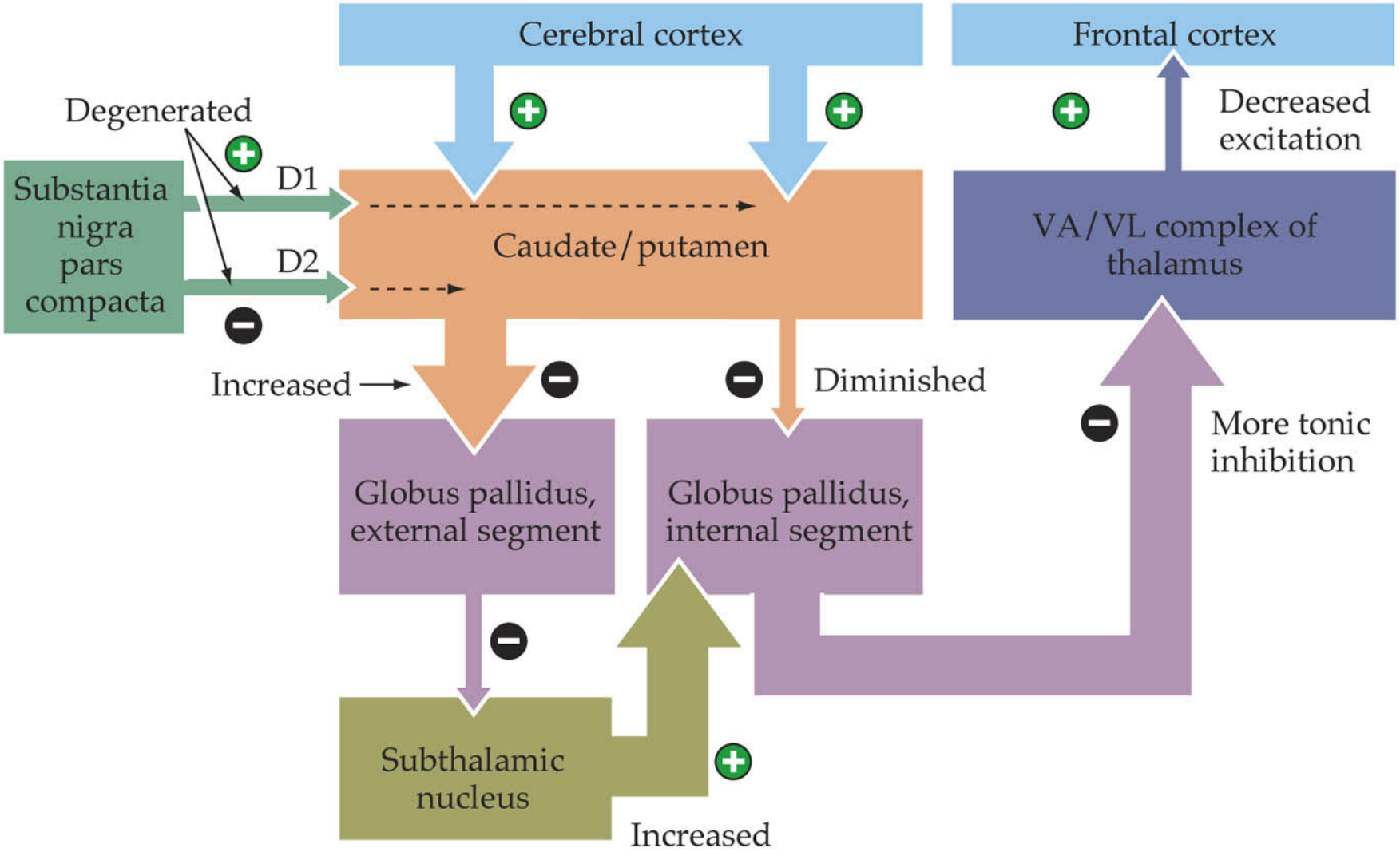
Lesions of Basal Ganglia

- Globus pallidus
  - athetosis - spontaneous writhing movements of the hand, arm, neck, and face
- Putamen
  - chorea – involuntary flicking movements of the hands, face, and shoulders
- Substantia nigra
  - Parkinson's disease - rigidity, resting tremor and akinesia (bradykinesia)
  - loss of dopaminergic input from substantia nigra to the caudate and putamen

Lesions of Basal Ganglia

- Subthalamus
  - hemiballismus - sudden flailing movements of the entire limb
- Caudate nucleus and Putamen
  - Huntington's chorea - loss of GABA containing neurons to globus pallidus and substantia nigra
- All signs and symptoms of basal ganglia diseases are contralateral to the lesion in contrast to cerebellar lesions which are ipsilateral

Parkinson's disease



Parkinson's disease

Symptoms

Motoric

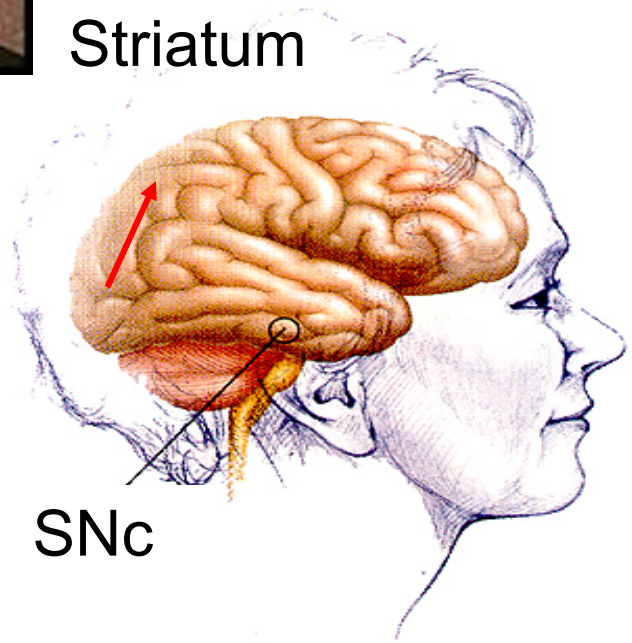
- Tremor (~4-5 Hz, resting)
- Bradykinesia
- Rigidity
- Loss of postural reflexes

Depression

Dementia

Parkinson's disease

Mohammed Ali



Pathophysiology

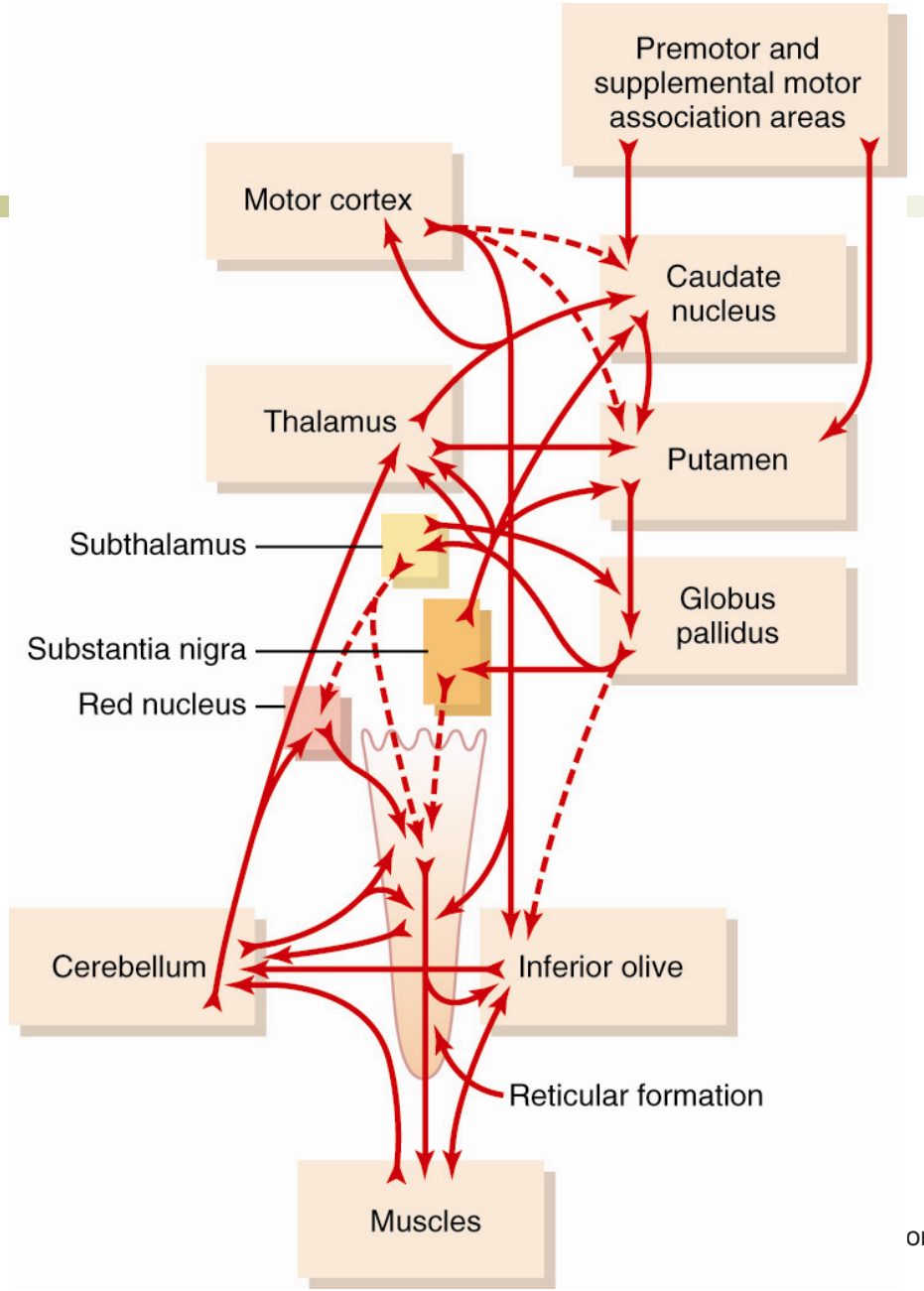
- Primary: loss of nigrostriatal DA projection

Integration of Motor Control

- Spinal cord level
  - preprogramming of patterns of movement of all muscles (i.e., withdrawal reflex, walking movements, etc.).
- Brainstem level
  - maintains equilibrium by adjusting axial tone
- Cortical level
  - issues commands to set into motion the patterns available in the spinal cord
  - controls the intensity and modifies the timing

Integration of Motor Control (cont'd)

- Cerebellum
  - function with all levels of control to adjust cord motor activity, equilibrium, and planning of motor activity
- Basal ganglia
  - functions to assist cortex in executing subconscious but learned patterns of movement, and to plan sequential patterns to accomplish a purposeful task



Overall scheme for integration of motor function

Thank You