

# PHYSIOLOGY OF BASAL GANGLIA AND REGULATORY MECHANISMS



**Dr Syed Shahid Habib**

*MBBS DSDM FCPS*

*Associate Professor*

*Dept. of Physiology*

*King Saud University*

# OBJECTIVES

*At the end of this lecture the students should be able to:-*

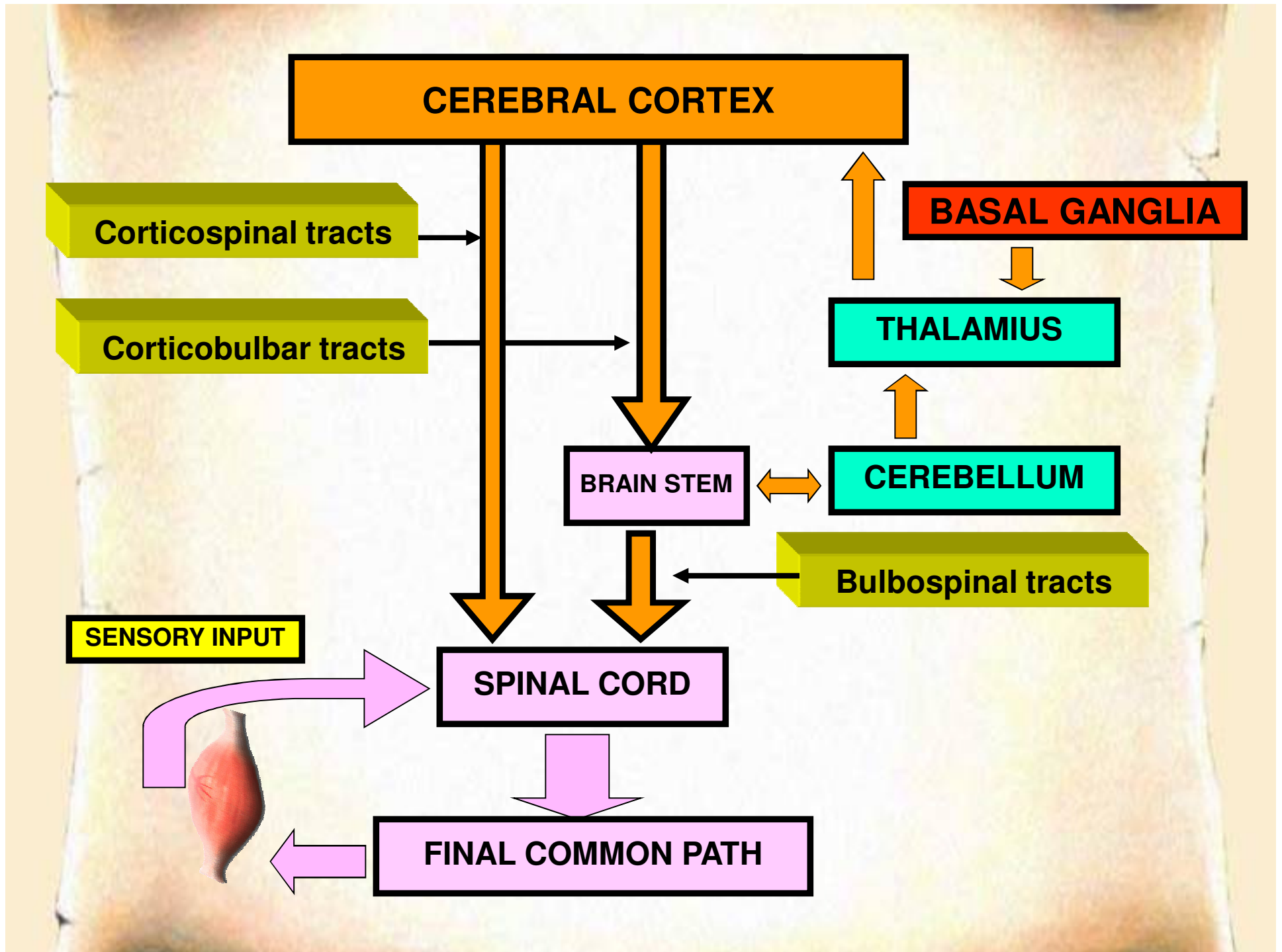
- *Appreciate different nuclei of basal ganglia*
- *Know different neurotransmitters that have a role in basal ganglia functions*
- *Appreciate general functions of basal ganglia*
- *Diagnose basal ganglia disorders*

The background of the slide is a close-up photograph of a book's cover, showing the texture of the paper and the binding. A bright yellow, irregularly shaped label is pasted onto the cover, containing the title text. A solid red horizontal line is positioned below the label.

# **OVERVIEW OF MOTOR ACTIVITY CONTROL**

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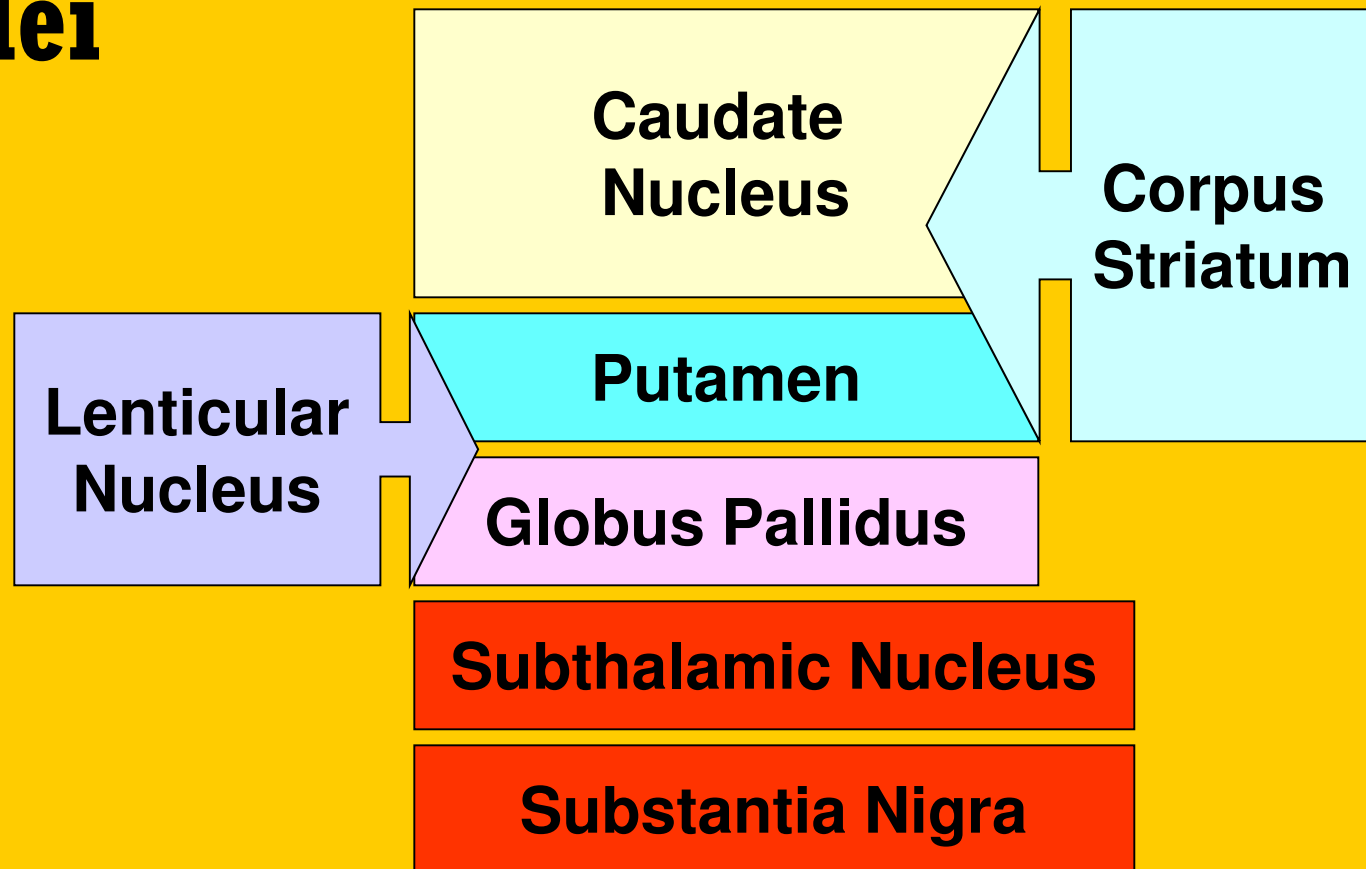


A scroll with a title label. The scroll is unrolled, showing a light beige, textured surface. It is held by four wooden rollers, one at each corner. In the center of the scroll, there is a yellow, pill-shaped label with a small notch on its left side. The label contains the text 'BASAL GANGLIA' in bold, purple, sans-serif capital letters. Below the label, the text 'COMPONENTS' and 'FUNCTIONAL ANATOMY' is written in bold, black, sans-serif capital letters, stacked vertically.

# **BASAL GANGLIA**

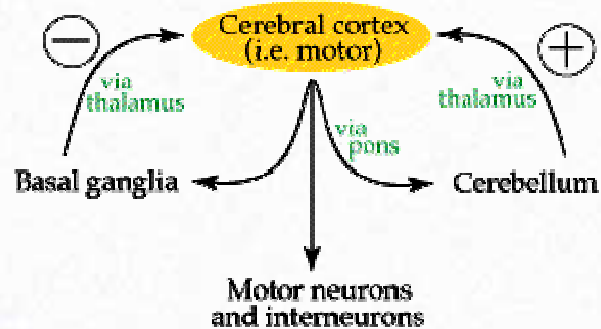
**COMPONENTS**  
**FUNCTIONAL ANATOMY**

# Basal Nuclei



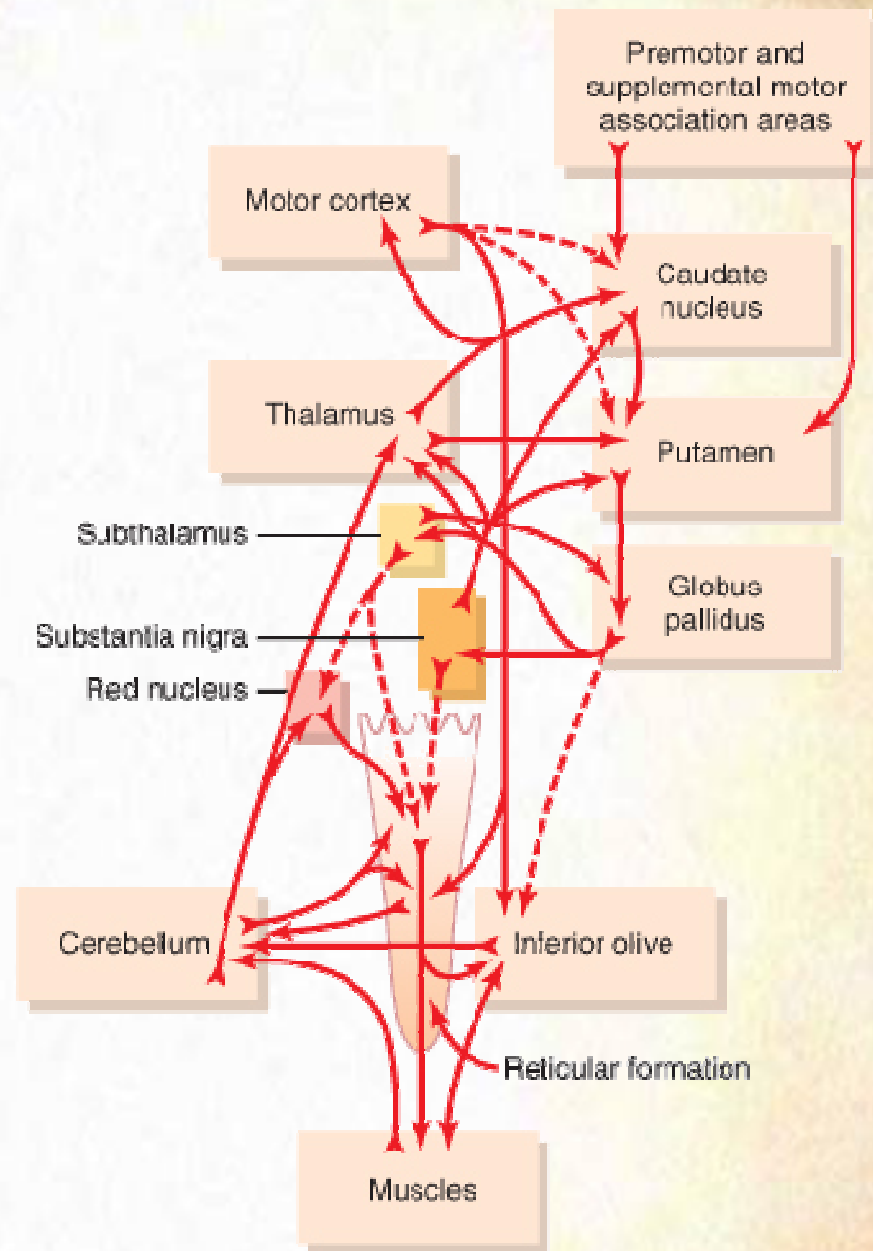
# BASAL GANGLIA

## CONNECTIONS





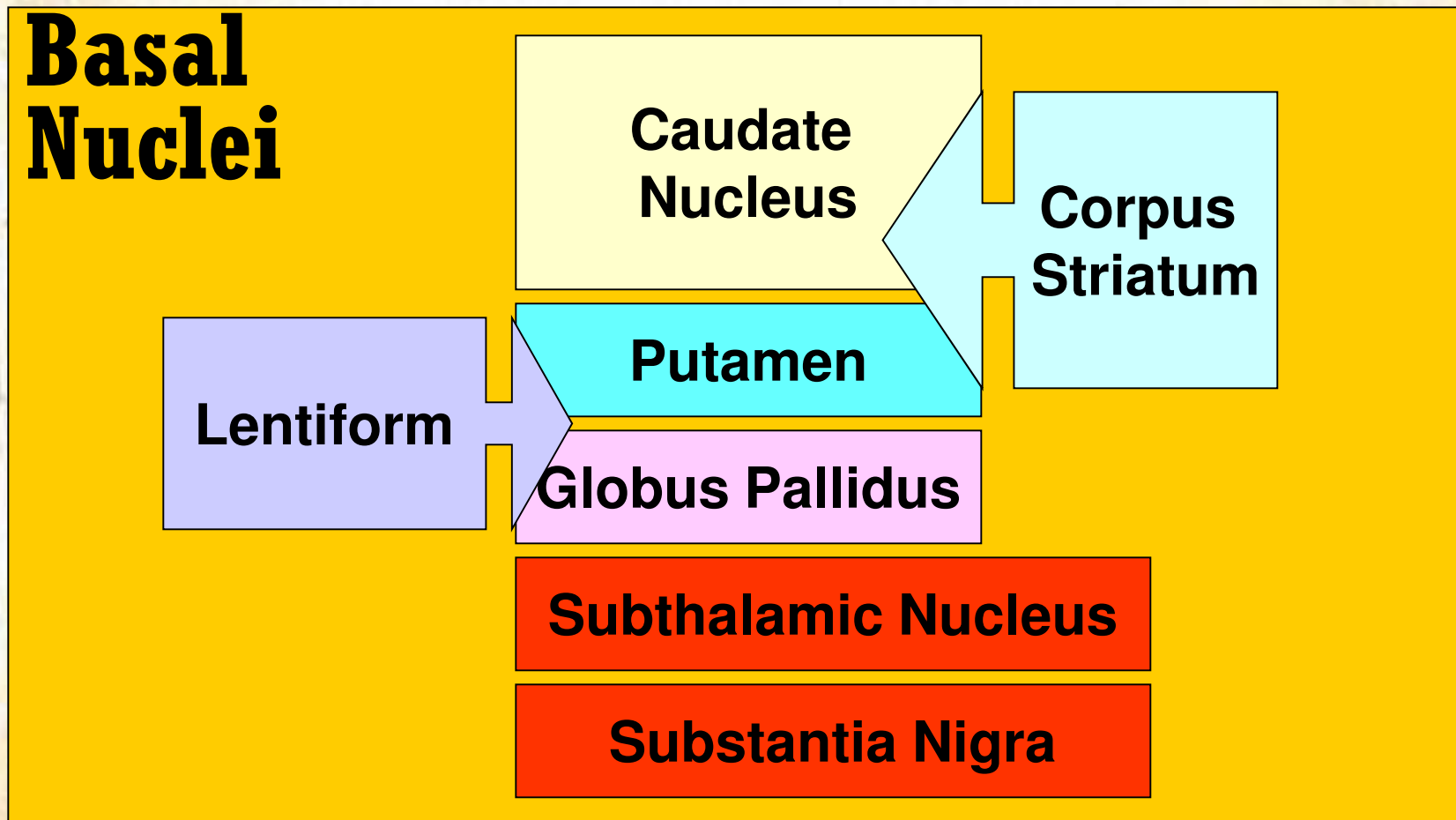
# Connections for Motor Control





### 3 Connections to remember

1. Main input to the basal ganglia
2. Main output from the basal ganglia
3. Connections between parts of basal ganglia

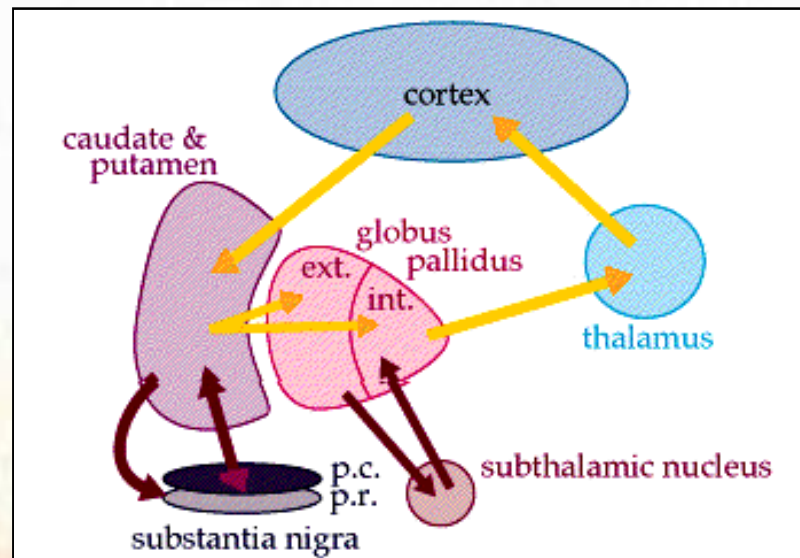


## MAIN INPUT TO THE BASAL GANGLIA

The comes from the cerebral cortex (motor area) and projects to the **NEOSTRIATUM**  
(a term for the caudate nucleus and putamen)

## THE MAIN OUTPUT

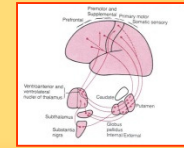
Is via the thalamus to the cerebral cortex  
(motor area)



# BASIC CIRCUITS OF BASAL GANGLIA

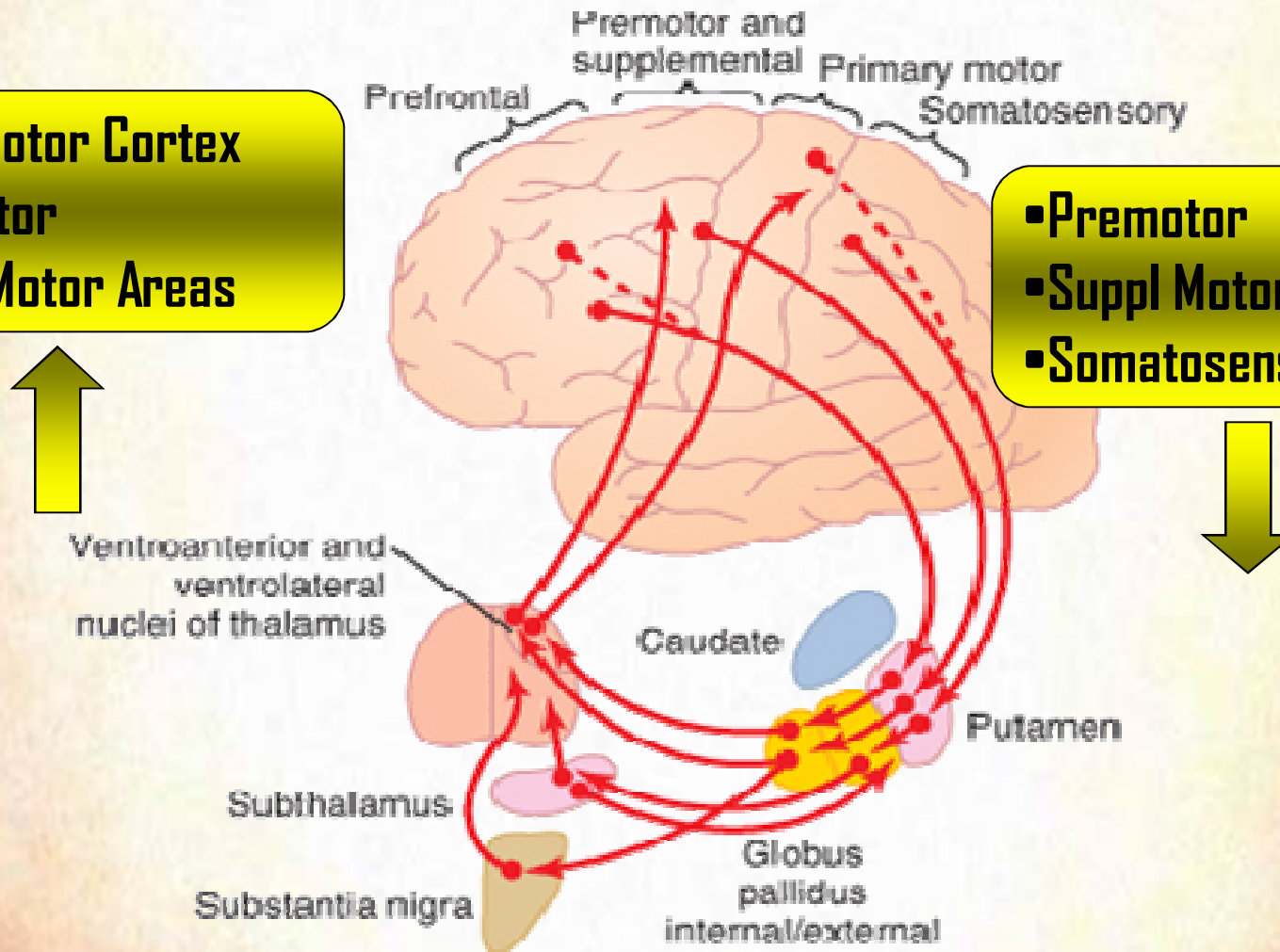
1. **Motor loop (putamen circuit)** concerned with learned movement.
2. **Cognitive loop (Caudate circuit)** concerned with cognitive control of sequences of motor pattern. Basically it is concerned with motor intentions.  
(Note: cognition means thinking process using sensory input with information already stored in memory.)
3. **Limbic loop** involved in giving motor expression to emotions like, smiling, aggressive or submissive posture.
4. **Occulomotor loop** concerned with voluntary eye movement [ saccadic movement]

# The Putamen Circuit



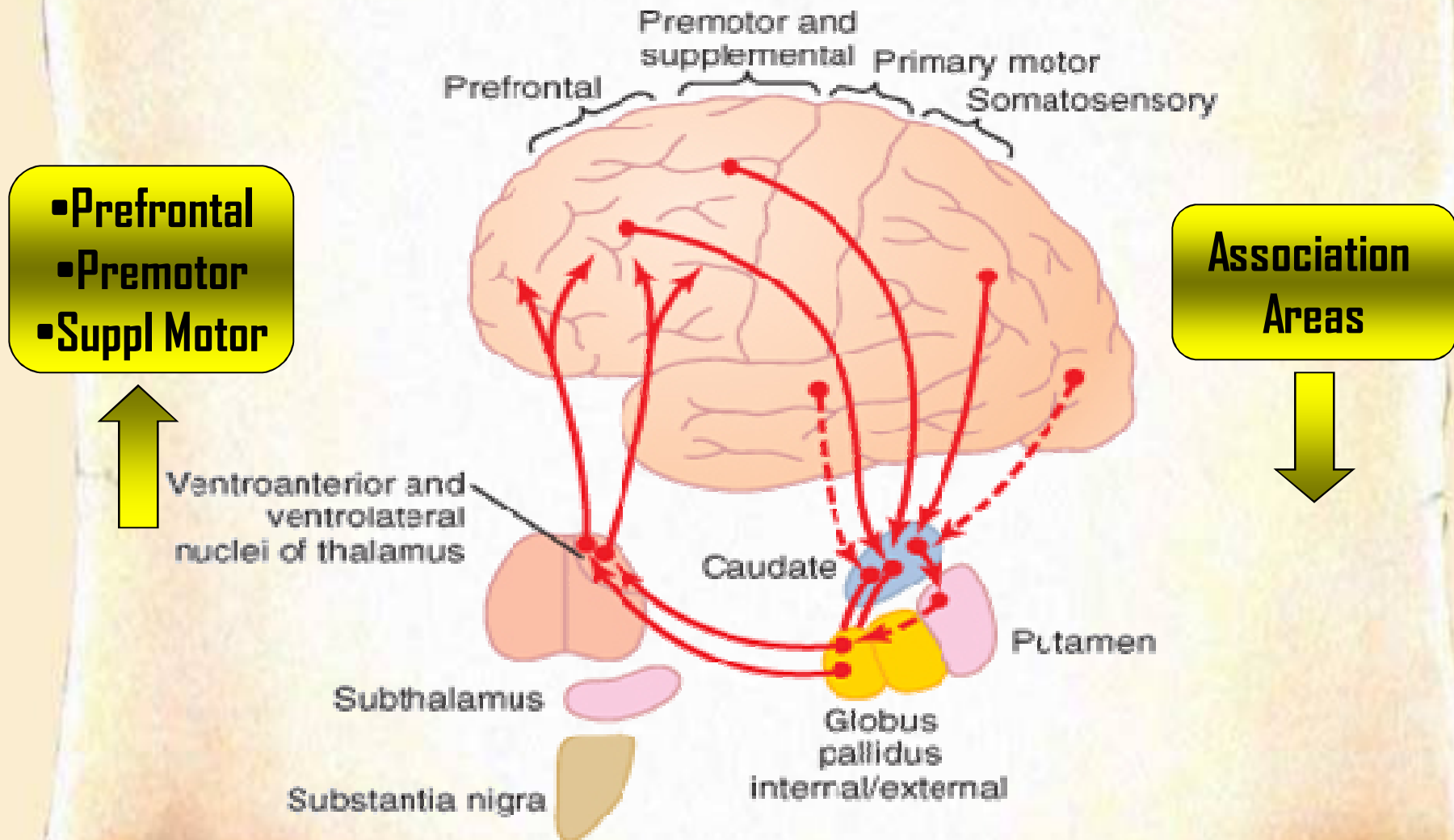
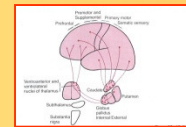
- Prim Motor Cortex
- Premotor
- Suppl Motor Areas

- Premotor
- Suppl Motor
- Somatosensory Cortex





# The Caudate Circuit



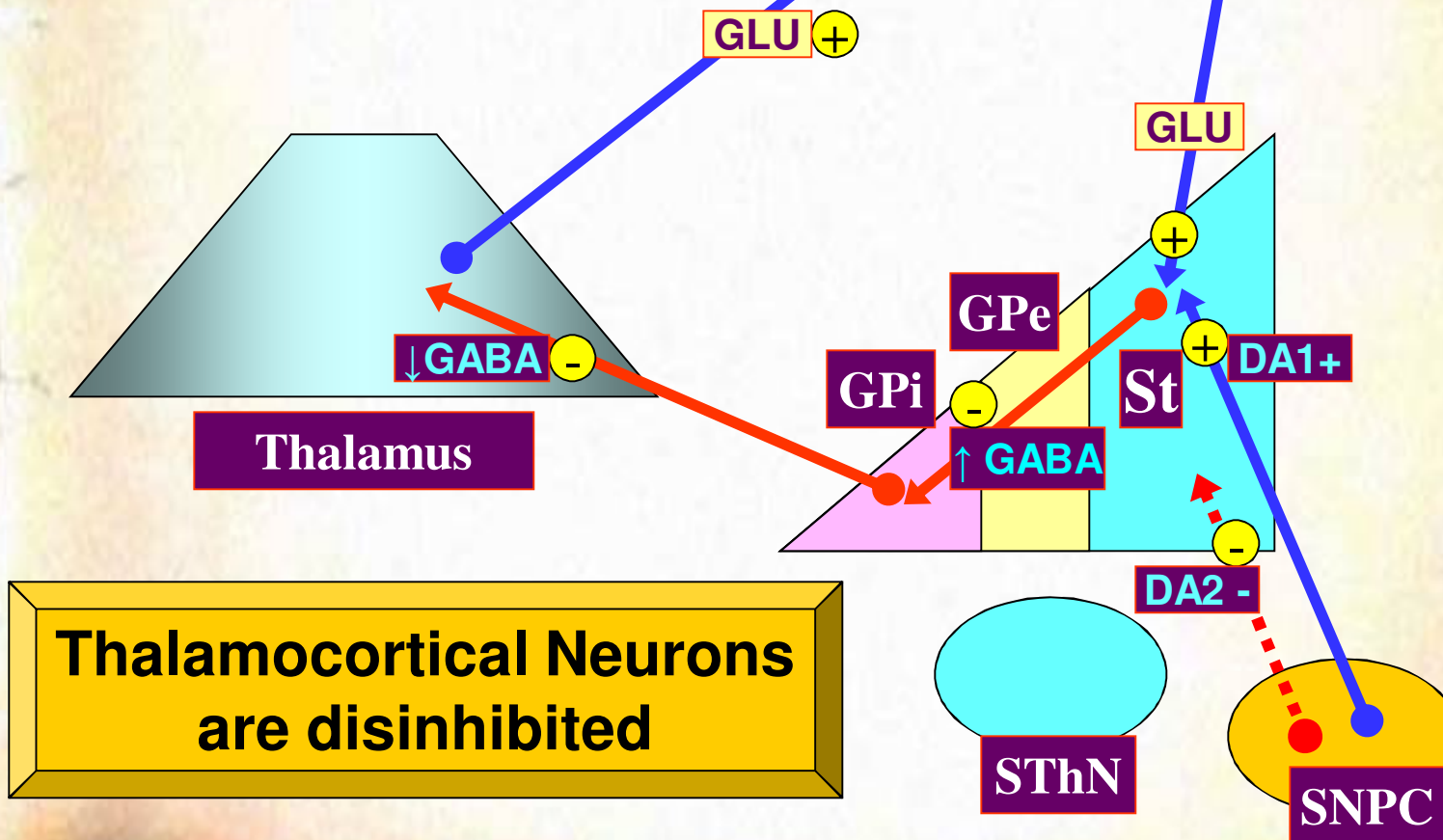


# **Basal Ganglial Pathways Direct and Indirect**

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## Direct Basal Ganglia Pathway

↑ MOTOR ACTIVITY



# Indirect Basal Ganglia Pathway

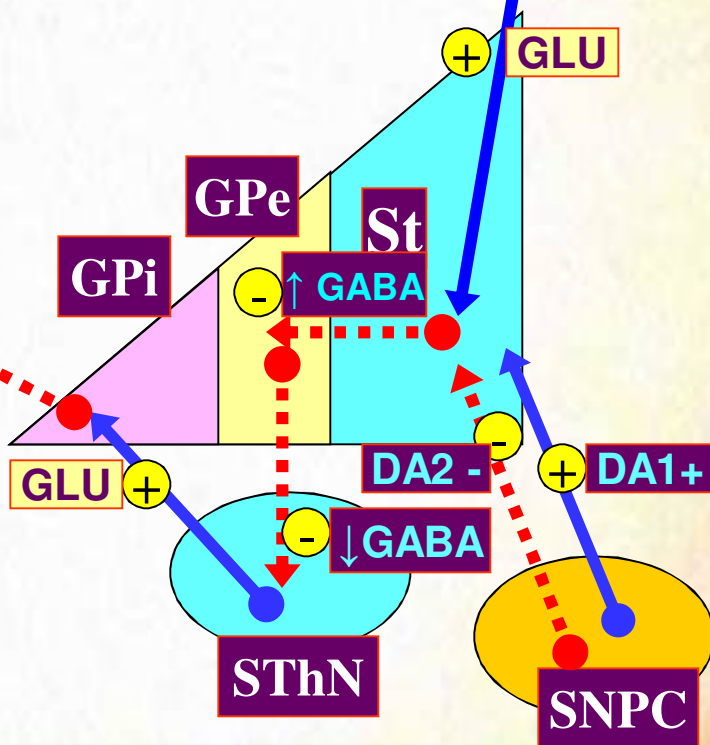
↓ MOTOR ACTIVITY

GLU +

↑ GABA -

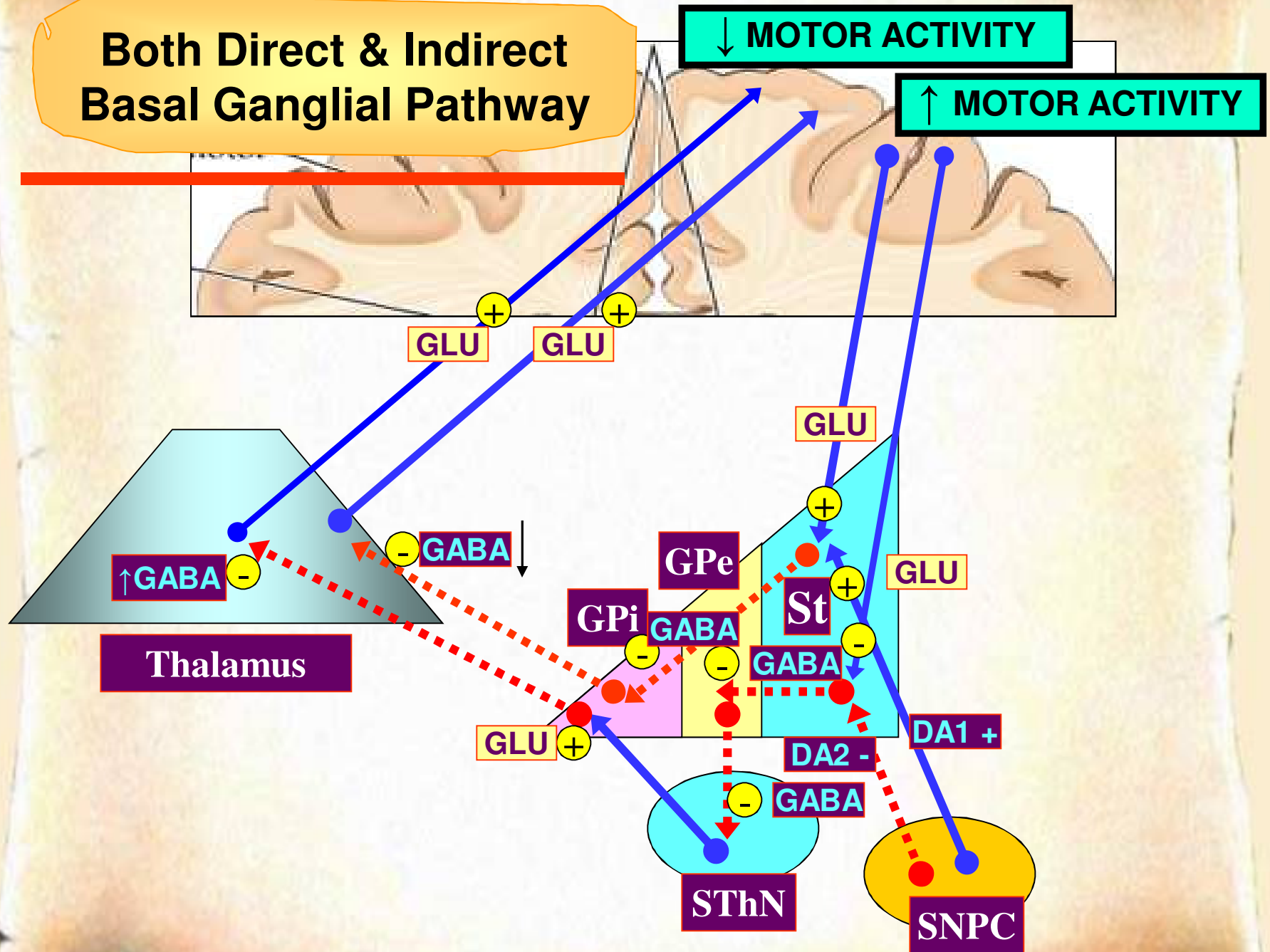
Thalamus

Subthalamic Neurons are disinhibited





# Both Direct & Indirect Basal Ganglia Pathway



# Metabolic characteristics

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- High Oxygen consumption .
- High Copper content in **Wilson's disease** (Copper intoxication):
- Autosomal Recessive
- Copper binding protein **Ceruloplasmin** is low
- Lenticular degeneration occurs

A scroll with a title and a list of functions. The scroll is unrolled, showing a title in a yellow box and a list of functions below it. The scroll is tied with wooden rings at the corners.

# **BASAL GANGLIA**

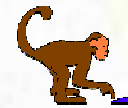
## **FUNCTIONS**

- **Control of movements**
- **Planning and programming of movements**
- **Cognition**

# The Putamen Circuit

## Executes Learned Patterns of Motor Activity

- Basal ganglia function in association with the corticospinal system to control *complex patterns of motor activity*.
- Examples are:
  - writing of letters of the alphabet.
  - cutting paper with scissors,
  - hammering nails,
  - shooting a basketball through a hoop,
  - passing a football,
  - throwing a baseball,
  - the movements of shoveling dirt,
  - most aspects of vocalization,
  - controlled movements of the eyes
  - virtually any other of our skilled movements, most of them performed subconsciously.





# **The Caudate Circuit**

## **Cognitive Control of Sequences of Motor Patterns**

- **Cognition means the thinking processes of the brain, using both sensory input to the brain plus information already stored in memory. Thoughts are generated in the mind by a process called cognitive control of motor activity.**
- **Example: A person seeing a lion approach and then responding instantaneously and automatically by (1) turning away from the lion, (2) beginning to run, and (3) even attempting to climb a tree.**
- **Thus, cognitive control of motor activity determines subconsciously, and within seconds, which patterns of movement will be used together to achieve a complex goal**



# The Caudate Circuit

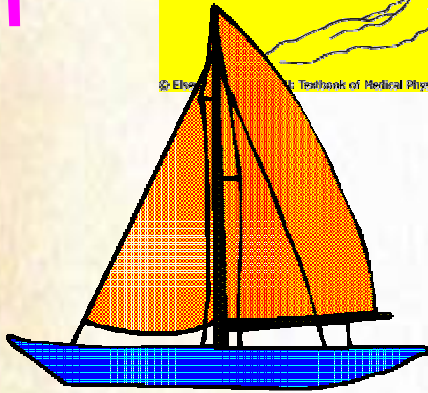
## Change the Timing and to Scale the Intensity of Movements

- Two important capabilities of the brain in controlling movement are
  - (1) to determine how rapidly the movement is to be performed and
  - (2) to control how large the movement will be.
- For instance, a person may write the letter "a" slowly or rapidly. Also, he or she may write a small "a" on a piece of paper or a large "a" on a chalkboard. Regardless of the choice, the proportional characteristics of the letter remain nearly the same

A



ON





A scroll with wooden rollers and a yellow title box.

# **BASAL GANGLIA**

## **DISORDERS**

**MOVEMENTS (ATAXIA Rate, Range, Force, Direction)**

**SPEECH**

**POSTURE**

**GAIT**

**MENTAL ACTIVITY**

**OTHERS**

# Movement Disorders

## Hyperkinetic

- Hemiballismus
- Huntington's Disease
- Athetosis



## Hypokinetic

- Parkinson's Disease
- Drug Induced (Neuroleptics, MPTP)

Movement Disorder	Features	Lesion
Chorea	Multiple quick, random movements, usually most prominent in the appendicular muscles	Atrophy of the <b>striatum</b> . Huntington Chorea
Athetosis	Slow writhing movements, which are usually more severe in the appendicular muscles	Diffuse hypermyelination of <b>corpus striatum and thalamus</b>
Hemiballismus	Wild flinging movements of half of the body	Hemorrhagic destruction of contralateral <b>subthalamic n.</b> Hypertensive patients
Parkinsonism	Pill rolling tremor of the fingers at rest, lead pipe rigidity and akinesia	Degeneration of <b>Substantia Nigra</b>