BASAL GANGLIA AND CONTROL OF MOTOR FUNCTIONS

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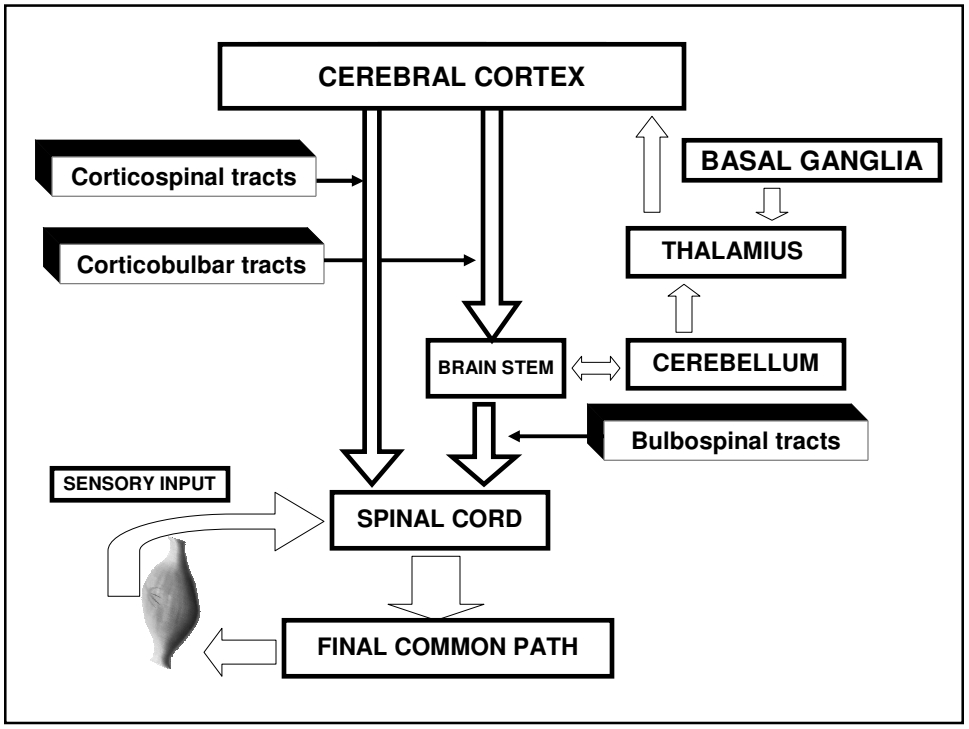
OBJECTIVES

TO UNDERSTAND

- COMPONENTS
- FUNCTIONAL ANATOMY
- CONNECTIONS
- FUNCTIONS
- DISORDERS

OF BASAL GANGLIA



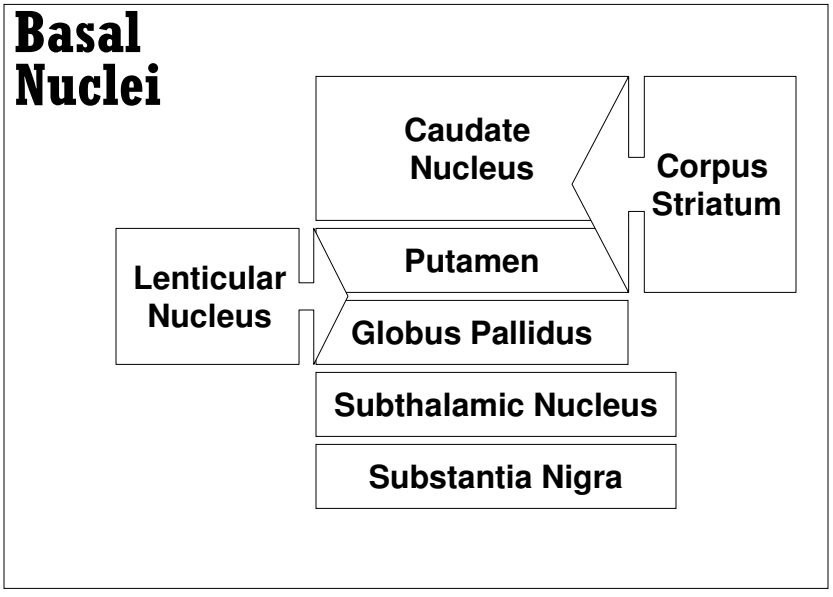
BASAL GANGLIA

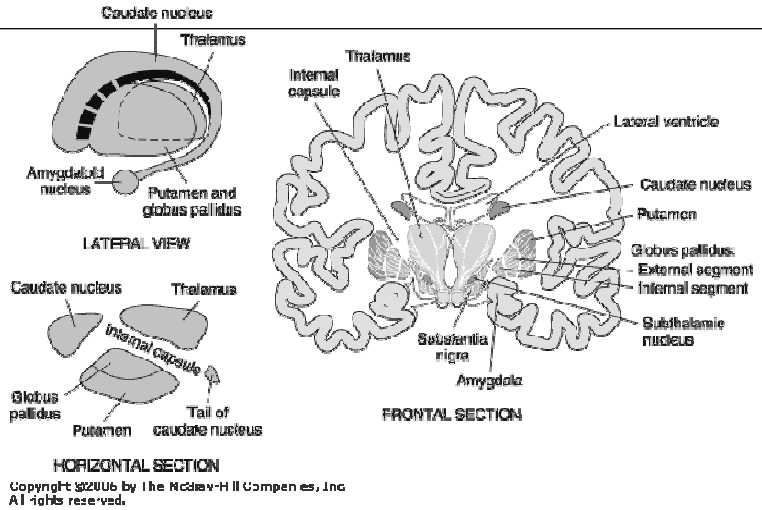
COMPONENTS
FUNCTIONAL ANATOMY

BASAL GANGLIA

THE BASAL GANGLIA ARE MASSES OF GREY MATTER MADE OF CELL BODIES LYING DEEP INSIDE THE WHITE MATTER OF THE CEREBRUM, AND MAKES UP PART OF THE MIDBRAIN.

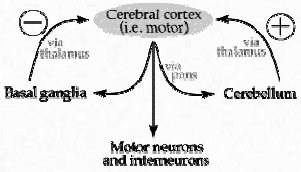
An upper mass is called the caudate nucleus, is separated from a lower mass, the lentiform nucleus. The lentiform nucleus consists of the putamen and the globus pallidus. Other nuclei include the substantia nigra and subthalamic nucleus.



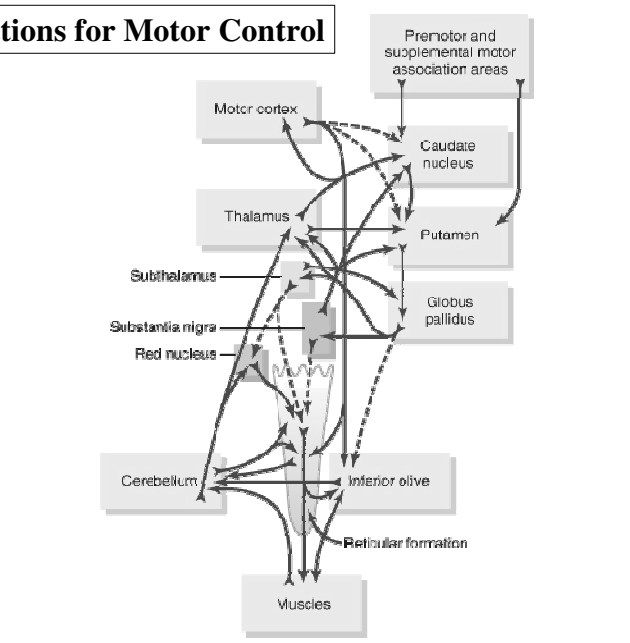


BASAL GANGLIA

CONNECTIONS

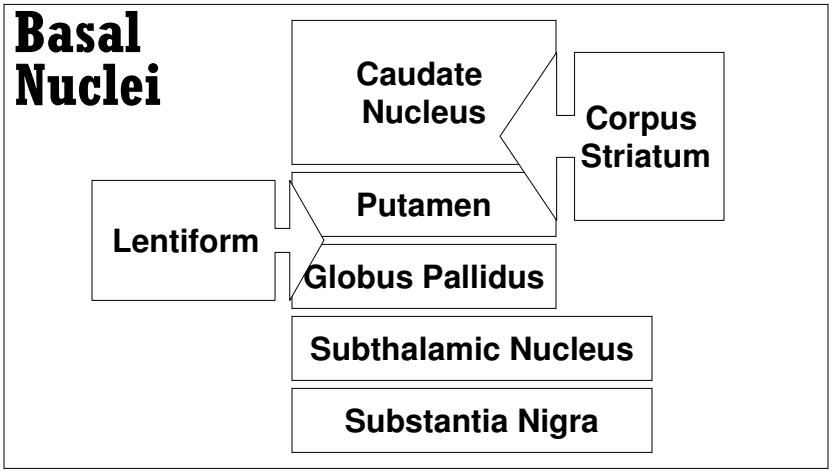


Connections for Motor Control



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

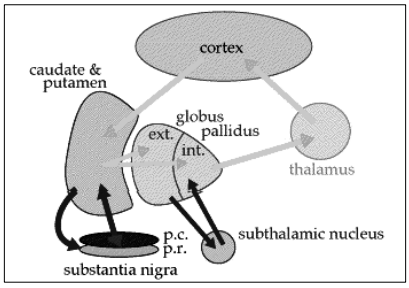
The comes from the cerebral cortex (motor area) and projects to the NEOSTRIATUM

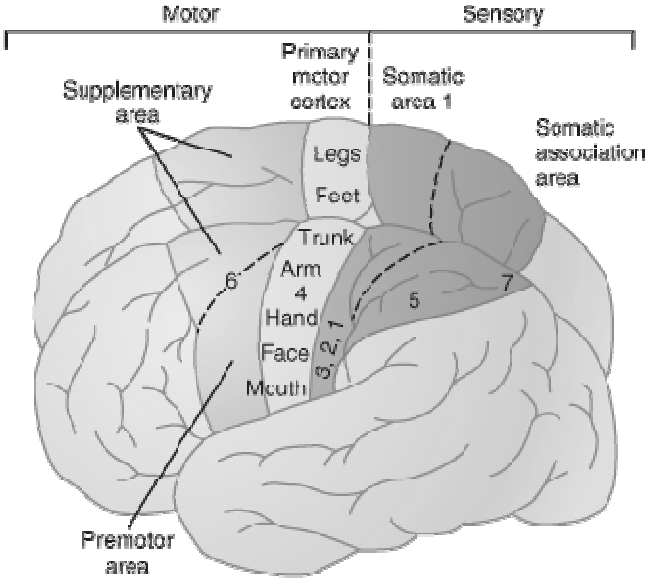
(a term for the caudate nucleus and putamen)

THE MAIN OUTPUT

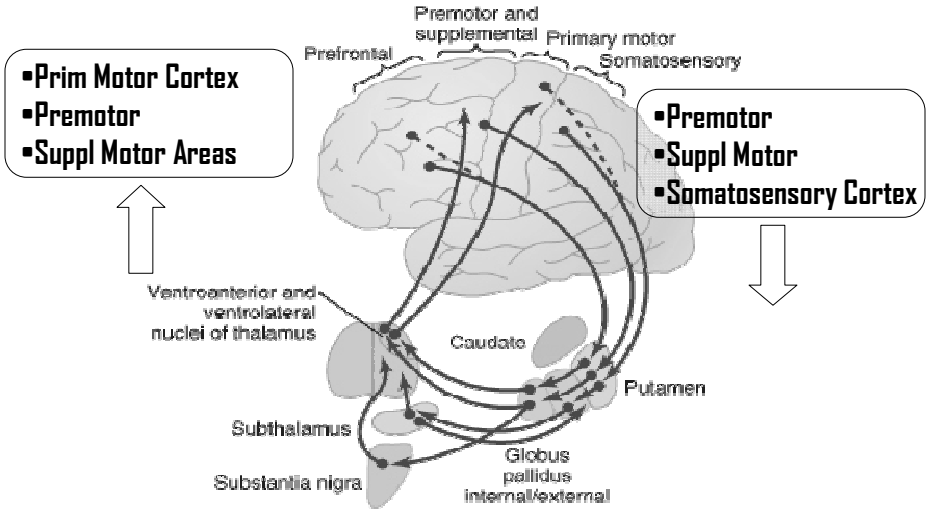
Is via the thalamus to the cerebral cortex

(motor area)

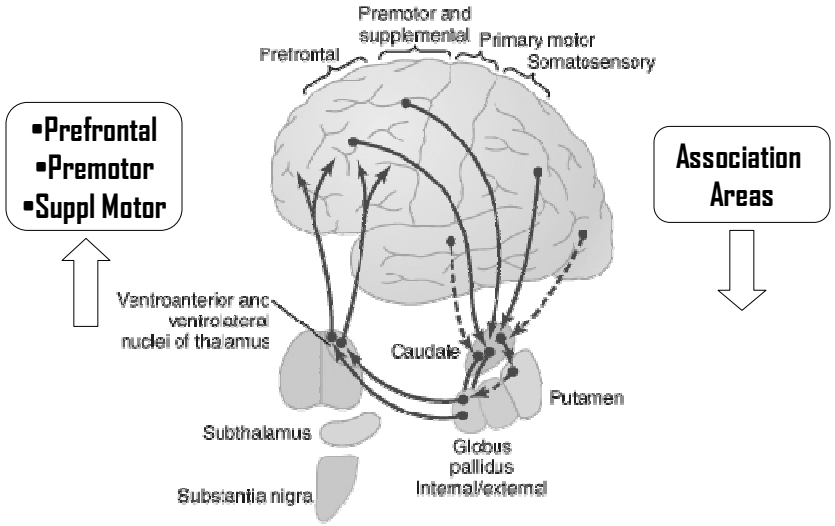




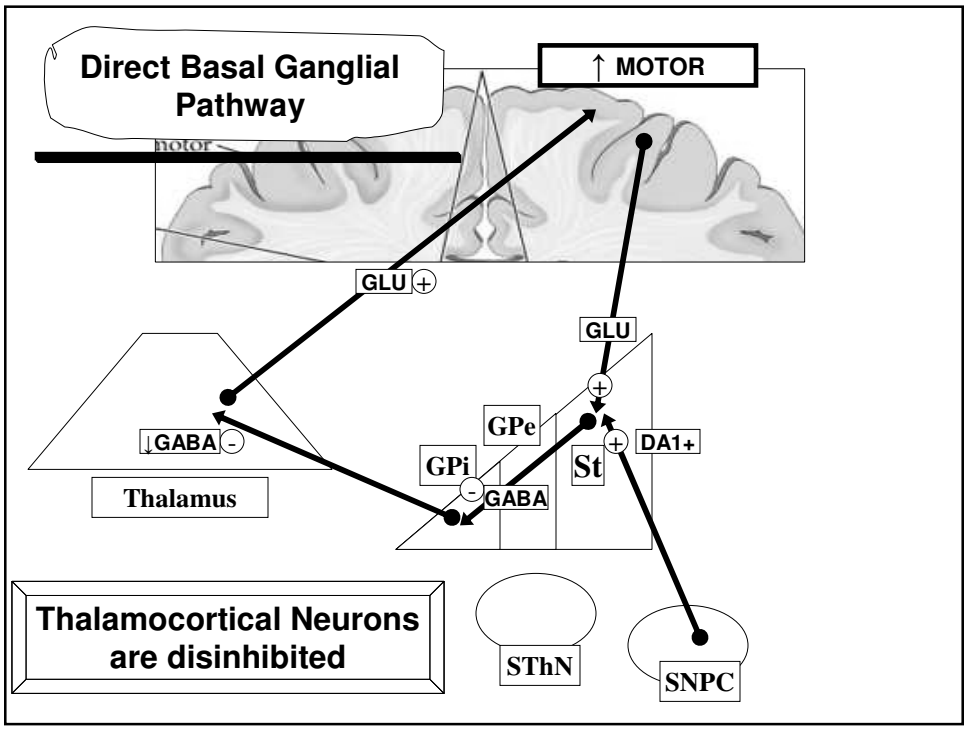
The Putamen Circuit

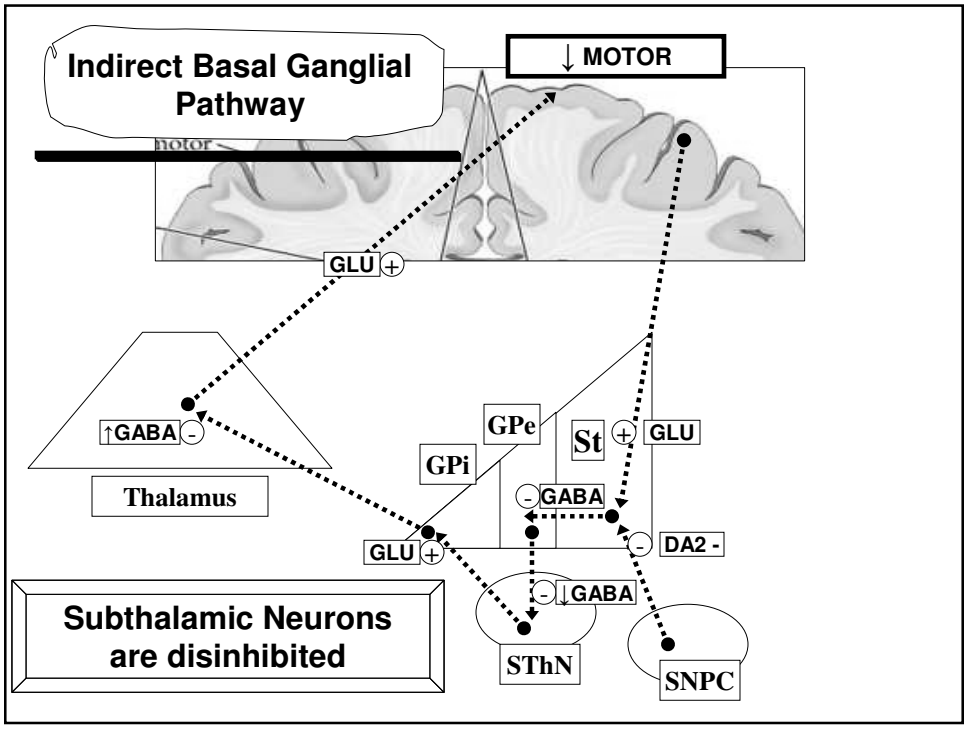


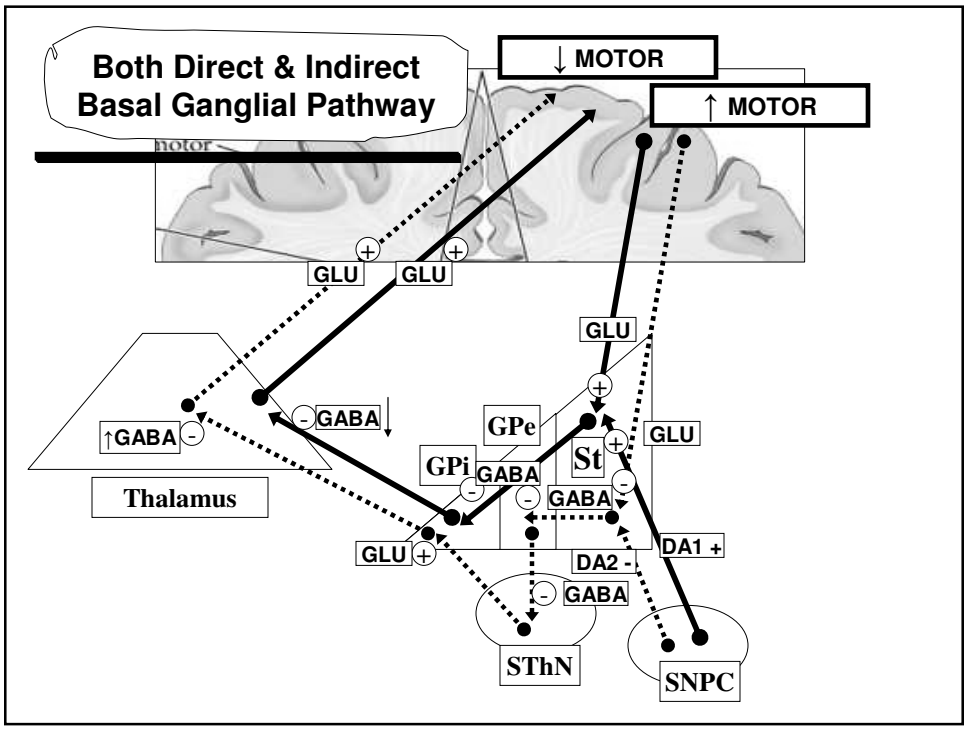
The Caudate Circuit



Basal Ganglial Pathways Loops




Indirect Basal Ganglial Pathway
↓ MOTOR
GLU
↑GABA
Thalamus
GPe
GPi
St
GLU
GABA
DA2 -
GLU
↓GABA
Subthalamic Neurons are disinhibited
SThN
SNPC


Both Direct & Indirect Basal Ganglial Pathway
↓ MOTOR
↑ MOTOR
GLU
GLU
GLU
↑GABA
GABA
Thalamus
GPe
GPi
St
GLU
GABA
GABA
GABA
GLU
DA2 -
DA1 +
GABA
SThN
SNPC

Metabolic characteristics

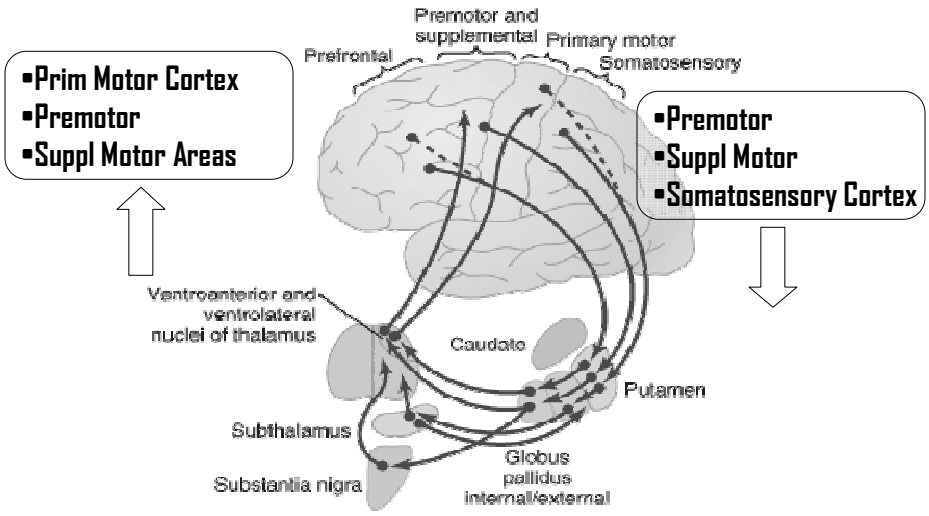
- High Oxygen consumption .
- High Copper content in Wilson's disease (Copper intoxication):
- Autosomal Recessive
- Copper binding protein Ceruloplasmin is low
- Lenticular degeneration occurs

BASAL GANGLIA

FUNCTIONS

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

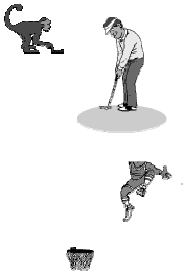
The Putamen Circuit



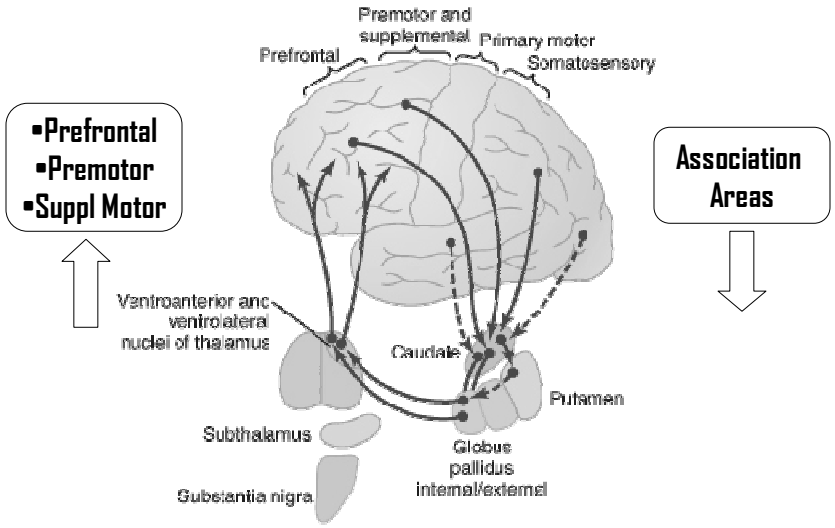
The Putamen Circuit

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



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**

Movement Disorders

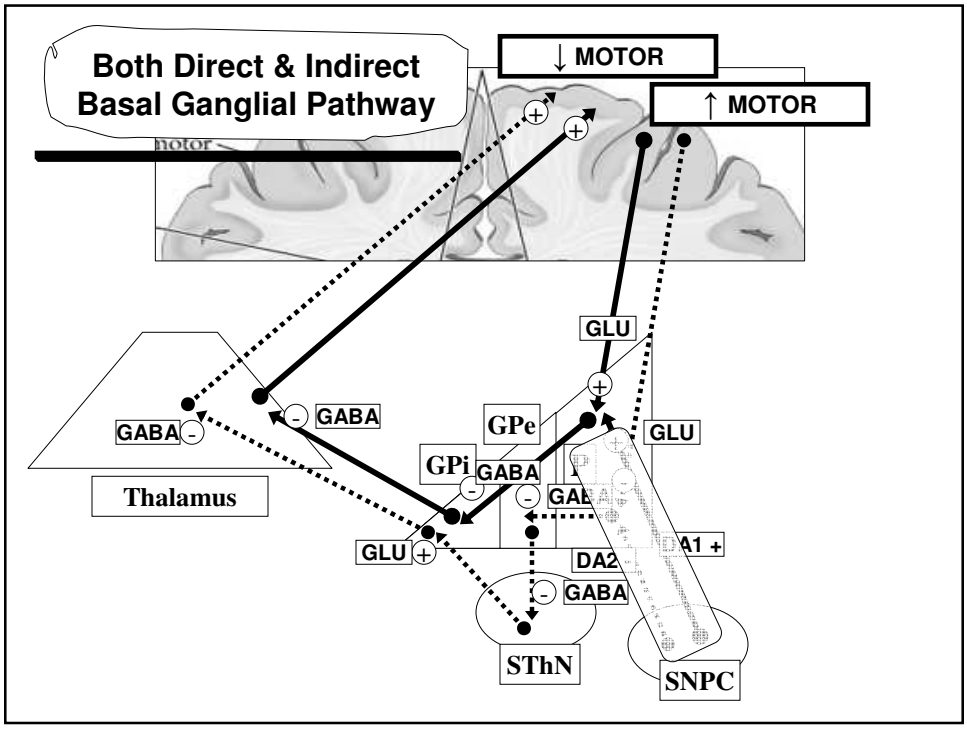
Hyperkinetic
- **Hemiballismus**
- **Huntington's Disease**
- **Athetosis**

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

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

Parkinson's Disease

- **Described by James Parkinson**
- **Degeneration of dopaminergic nigrostriatal neurons (60-80 %).**
- **Phenthiazines (tranquilizers drugs) .**
- **Methyl-Phenyl-Tetrahydro-Pyridine (MPTP). The oxidant MPP+ is toxic to SN.**
- **Five cardinal features**
  - **Tremor**
  - **Rigidity**
  - **Akinesia & Bradykinesia**
  - **Postural Changes**
  - **Speech Changes**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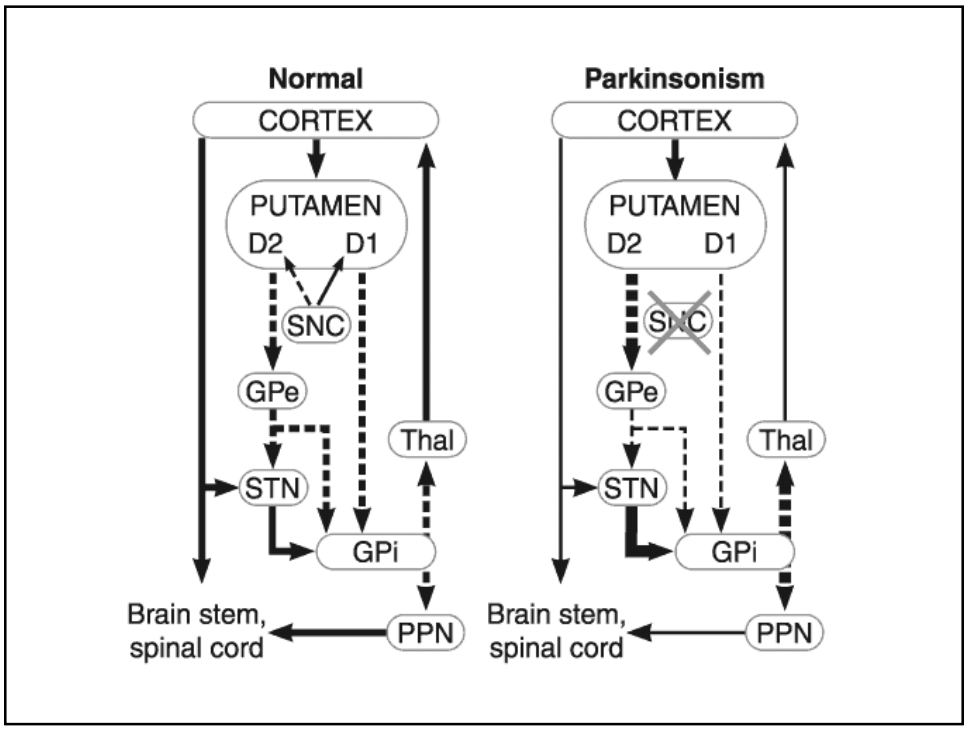
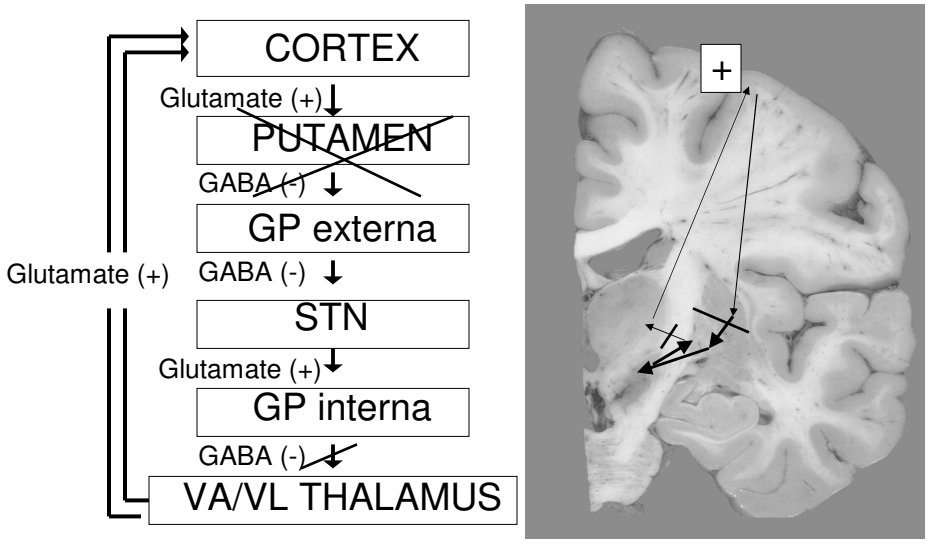
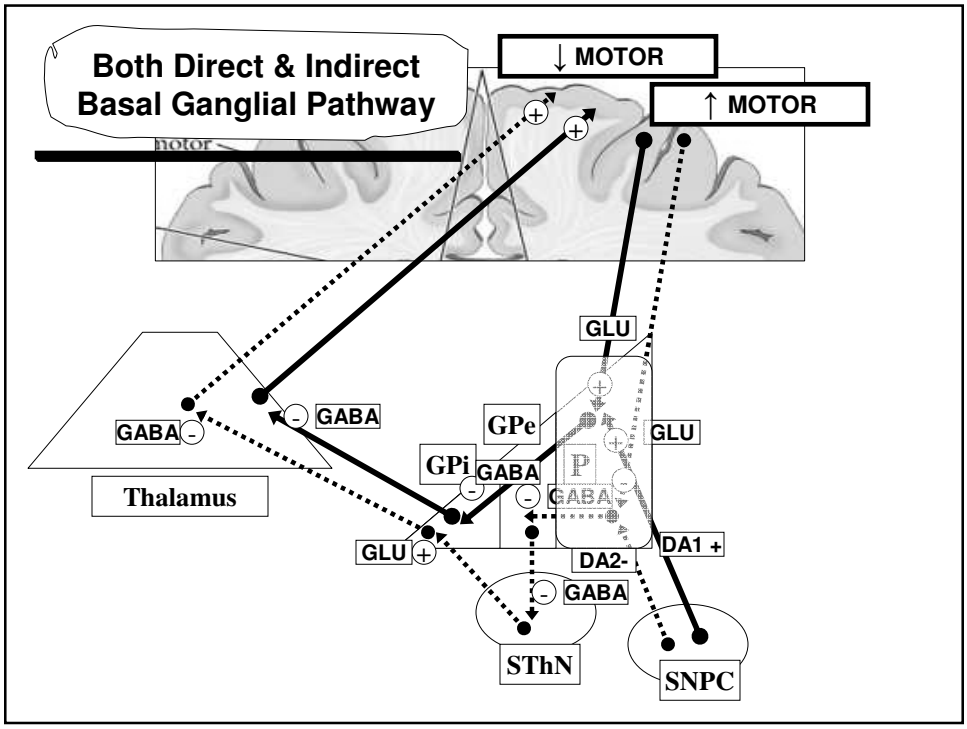

Normal
CORTEX
PUTAMEN
D2
D1
SNC
GPe
Thal
STN
GPi
Brain stem,
spinal cord
PPN
Parkinsonism
CORTEX
PUTAMEN
D2
D1
GPe
Thal
STN
GPi
Brain stem,
spinal cord
PPN

PARKINSON'S DISEASE

- **RESTING TREMORS**
- **RIGIDITY LEAD PIPE & COG WHEEL**
- **MONOTONUS** | **SLURRED** | **ANARTHRIA**
- **ABSENCE OF ASSOCIATED UNCONCIOUS MOVEMENTS(SWINGING OF ARMS DURING WALKING .**
- **FACIAL EXPRESSION IS MASKED**
- **SIMIAN POSTURE**
- **SWEATING**

Huntington's Disease

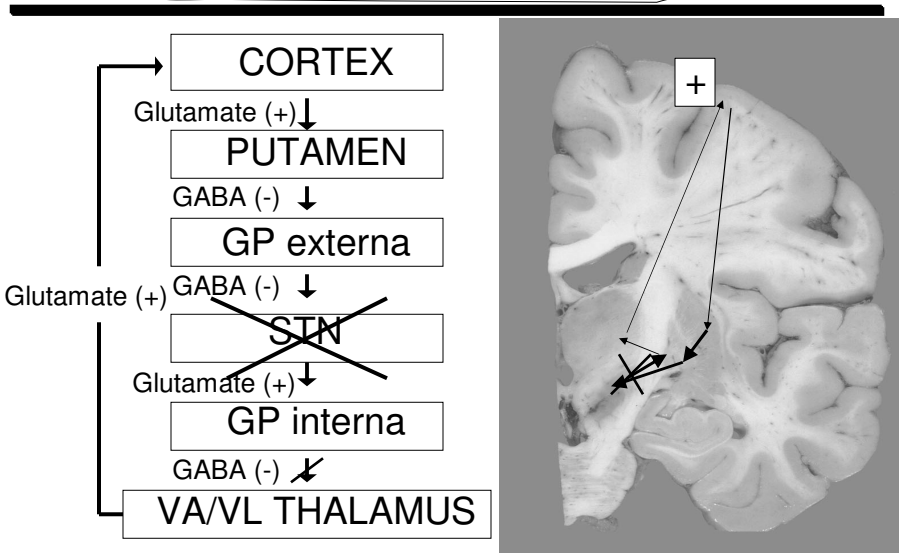


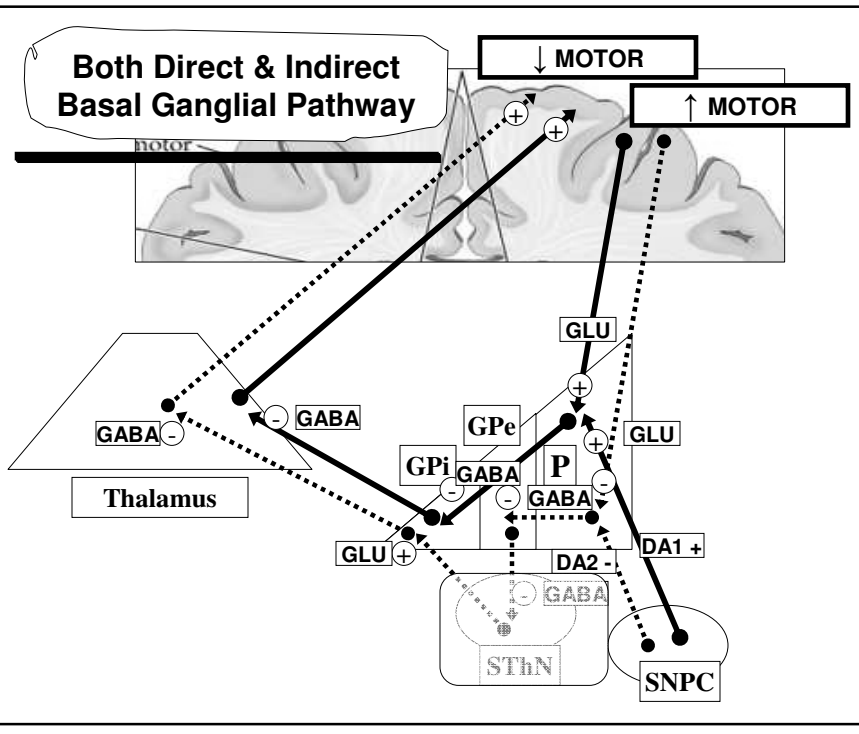


Huntington's Disease

- Hereditory , autosomal dominant
- Rare onset at 30-40s as early as 20s
- Disease of caudate & putamen.
- Early, Jerky movement of hands toward end of reaching an object
- Later, hyperkinetic choreiform movements appear and gradually increase until they incapacitate the patient
- Slurred speech and incomprehensive
- Progressive Dementia
- Loss of GABA nergic neurons

Hemiballismus





Hemiballismus

- **Injury usually to STN**
- **Decreased inhibition (Indirect Pathway)**
- **Characterized by uncontrolled flinging**
- **TX: Dopamine Antagonist**