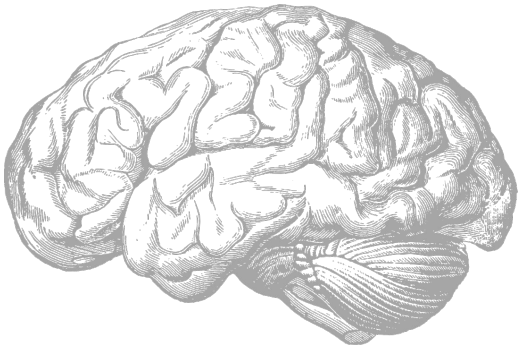
Anatomy of the Basal Ganglia and Connections

CNS Block



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The Editing File

Objectives

- **Define** "basal ganglia" and enumerate its **components.**
- Enumerate **parts of "Corpus Striatum"** and their important **relations.**
- **Describe the structure** of Caudate and Lentiform (Putamen & Globus Pallidus) nuclei.
- **Differentiate** between striatum & paleostriatum in term of connections.
- State briefly **functions & dysfunctions** of Corpus Striatum.

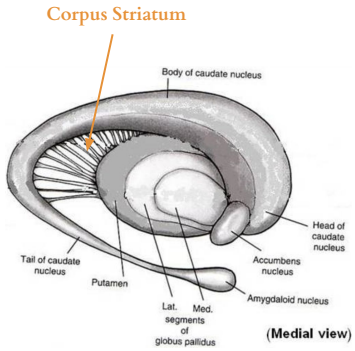
You can find Atlas by Clicking HERE!

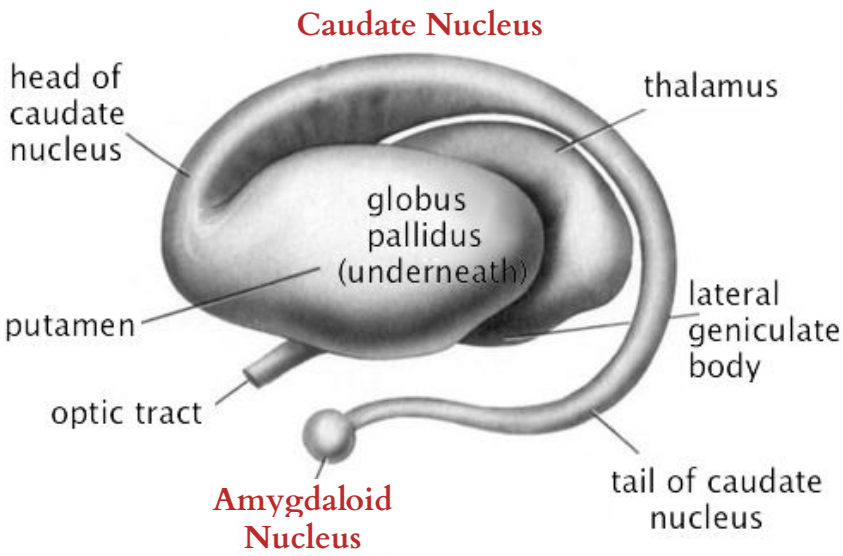
Basal Ganglia (Nuclei)

Definition

A group of nerve cells deeply situated in cerebral hemispheres.

Components

Caudate Nucleus	❖ **Caudate** & **Lentiform** nuclei are functionally related to each other & called "**Corpus Striatum**". ❖ A part of **extrapyramidal motor system**, it is principally involved in the control of posture and movements (primarily by inhibiting undesired motor functions).	
Lentiform Nucleus (Divided into Putamen and Globus Pallidus)	**Corpus Striatum:** Bands of grey matter pass from lentiform nucleus across the internal capsule to the caudate nucleus, giving the striated appearance, hence the name Corpus Striatum.	
Amygdaloid Nucleus (Part of the Limbic System)	❖ It is only **EMBRYOLOGICALLY** related to Corpus Striatum.	



Globus Pallidus + Putamen = Lentiform Nucleus

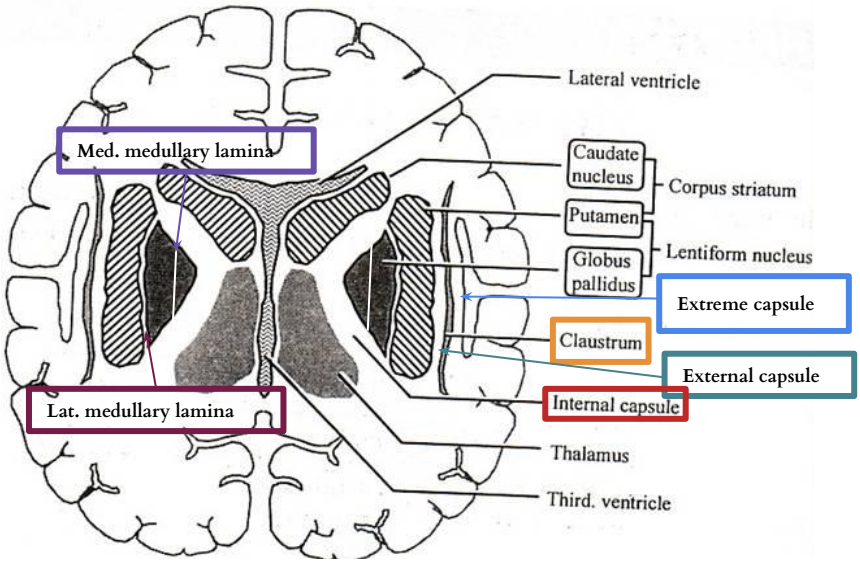
Dr. note: It's important to know that:
1- Putamen + Globus pallidus = lentiform nucleus.
2- Caudate nucleus + putamen = Neostriatum (striatum).
3- Caudate nucleus + lentiform nucleus = Corpus striatum.

Lentiform Nucleus

Shape

Three sided, **wedge-shaped** mass of grey matter, with a convex outer surface and an apex which lies against the **genu of the internal capsule.**

Divisions	**Putamen**	❖ Larger, darker lateral portion. ❖ It is more closely related to **Caudate nucleus** (regarding development, function & connections), and together constitute the **Neostriatum** (Neo=New) **or Striatum.** ❖ Separated from globus pallidus by a thin sheath of nerve fibers, the **lateral medullary lamina.** ❖ The white matter lateral to putamen is divided into two layers, by a sheath of grey matter, the **Claustrum**: **1- External capsule (Medial):** between the Claustrum and the **Putamen.** **2- Extreme capsule (Lateral):** between the Claustrum and the **Insula.**
	Globus Pallidus	❖ Smaller, lighter medial portion. ❖ It is the oldest part of corpus striatum and is called **Paleostriatum** (Paleo=قديم/عتيق) **or Pallidum.** ❖ Consists of two divisions: the **Lateral** & the **Medial segments**, separated by a thin sheath of nerve fibers, the **Medial Medullary lamina.** ❖ The medial segment is similar in cytology and connections with the **Pars reticulata of substantia nigra.**



Dr. note: From medial to lateral:

- Internal capsule
- Medial part of GP
- Medial medullary lamina
- Lateral part of GP
- Lateral medullary lamina
- Putamen
- External capsule
- Claustrum
- Extreme capsule
- Insula

- Gray matter
- White matter

Caudate Nucleus

MCQ

Shape

C-shaped mass of grey matter.

Components

Head

- Rounded in shape.
- Lies **anterior** to **thalamus** (in **frontal** lobe). you must know the lobe
- Completely separated from the putamen by the **internal capsule** **EXCEPT** rostrally where it is continuous with the putamen.

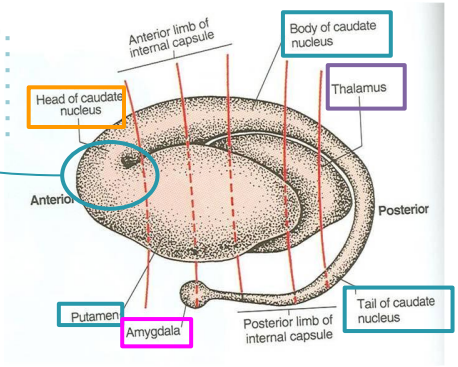
Body

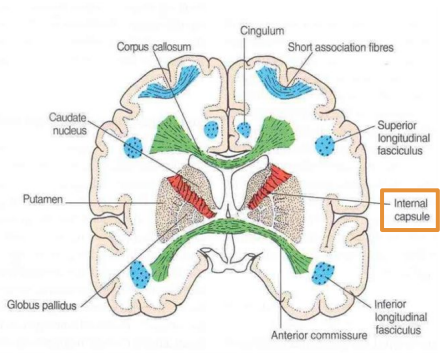
- Long & narrow.
- Extends **above** **thalamus** (in **parietal** lobe). you must know the lobe

Tail

- Long & tapering.
- Descends into **temporal** lobe. you must know the lobe
- Continuous with **Amygdaloid** Nucleus.

The rostral continuous part of the head with the putamen





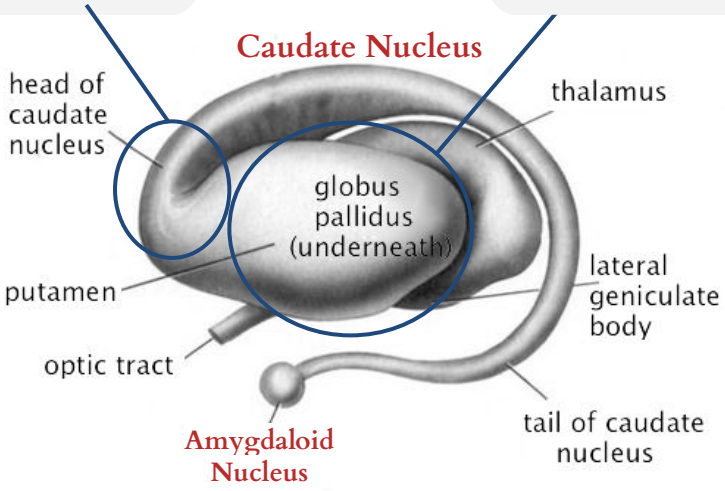
Important Relations of Corpus Striatum

Head of caudate

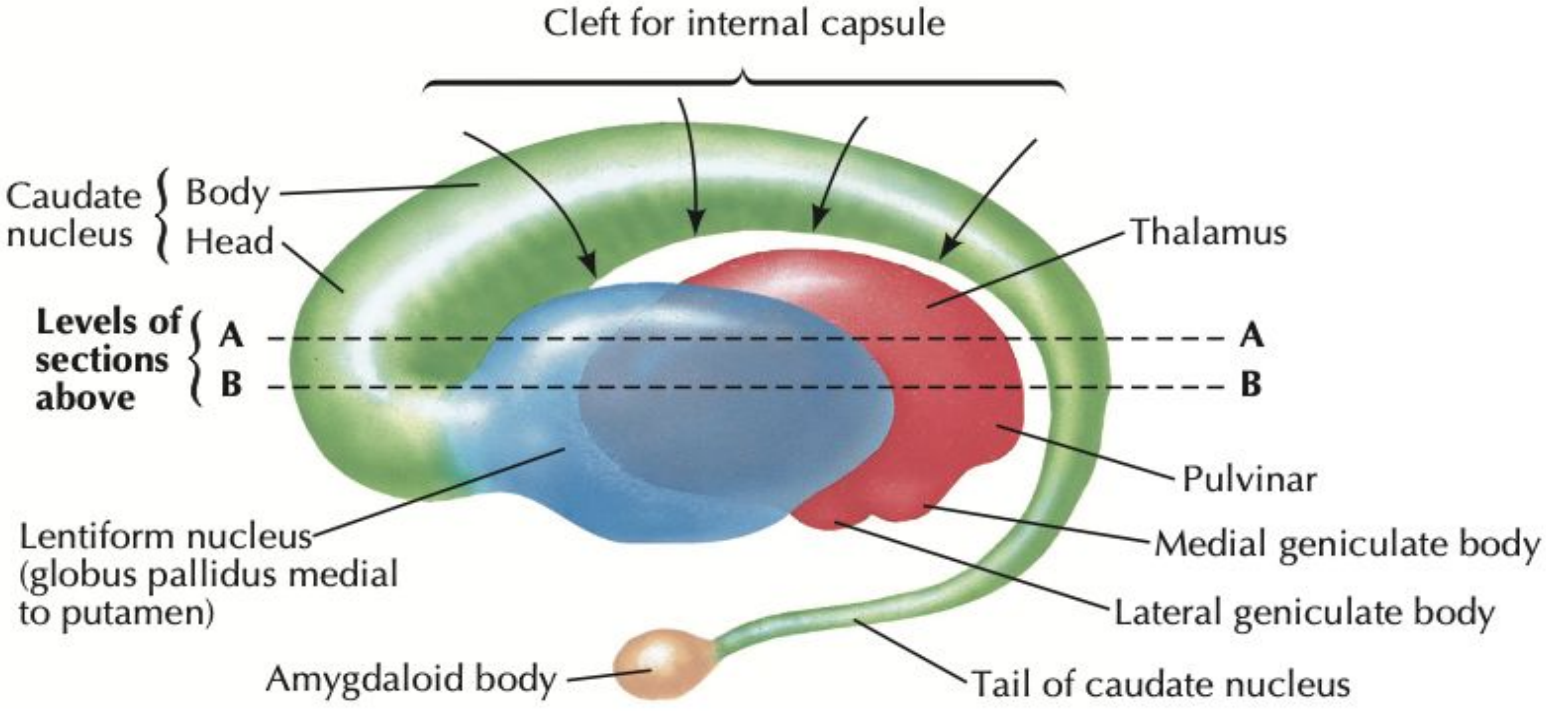
- **Anterior** to thalamus.
- **Medial** to Lentiform & separated from it by anterior limb of internal capsule.

Lentiform Nucleus

- **Lateral** to thalamus & separated from it by posterior limb of internal capsule.



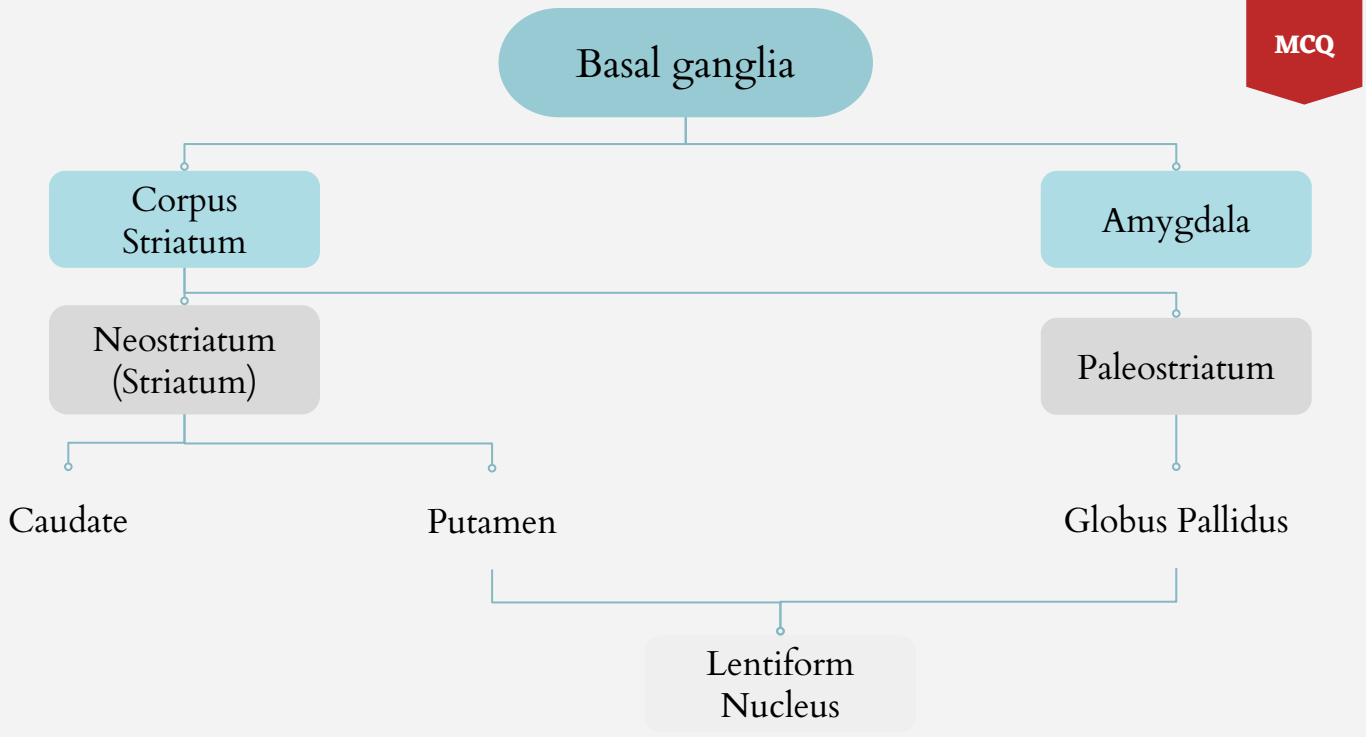
Extra for visualization



Interrelationship of thalamus, lentiform nucleus, caudate nucleus, and amygdaloid body (schema): left lateral view

Basal Ganglia

MCQ



Striatum

Female Slides

- The Input Portion of Corpus Striatum (Caudate and Putamen)
- The Output Portion Paleostriatum (Globus Pallidus) Medial segment of Globus Pallidus + Pars Reticulata of Substantia Nigra

Cerebral Cortex (Sensory & Motor) (Glutamate)

Thalamus (Intralaminar nuclei)

Pars **compacta** of Substantia Nigra (Dopamine)

Brain stem Strial Fibers (Serotonin)

Striatum
is the input portion of basal ganglia which receives projections from the overlying cerebral cortex.

Pars **Reticulata** of Substantia Nigra

Striatonigral Fibers

Striatopallidal Fibers

Lateral Segment of Globus Pallidus*

Medial Segment of Globus Pallidus**

→ Afferents
→ Efferents

*Connected to the Subthalamus by a tract (fibers) called: The subthalamic fasciculus

**Connected to the thalamus by thalamic fasciculus

Connection of corpus striatum

Afferent Fibers (Input):

Male Dr really really focused on the neurotransmitters

Corticostriate Fibers:
- From all parts of cerebral cortex (mostly from sensory- motor cortex) axons pass to caudate nucleus and putamen.
- **Glutamate is the neurotransmitter of this fibers.**

Thalamostriate Fibers:
- From intralaminar nuclei of thalamus axons pass to caudate nucleus and putamen.

Nigrostriate Fibers:
- Axons from **Substantia nigra** of midbrain (pars **compacta**) pass to caudate nucleus and putamen.
- **Dopamine is the neurotransmitter.**

Brainstem Strial Fibers:
- Ascending fibers from brain stem end in caudate nucleus & putamen.
- **Serotonin is the neurotransmitter.**
- It is believed that the last 2 groups are inhibitory in function.

Efferent Fibers (Output):

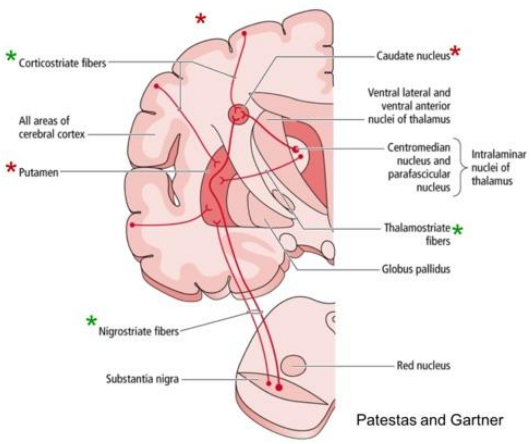
Striatopallidal Fibers:
- These fibers pass from striatum (caudate nucleus & putamen) to globus pallidus.
- Gamma-aminobutyric acid (**GABA**) is the neurotransmitter.

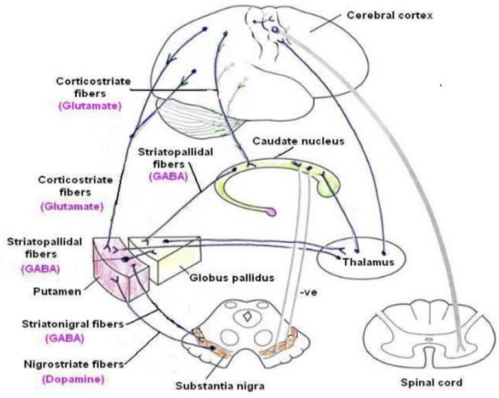
Striatonigral Fibers:
- These fibers pass from caudate nucleus & putamen to **Substantia nigra** (pars **reticulata**).
- Some fibers use **GABA** as a neurotransmitter, and others use **substance p.**
(a neuropeptide that **causes pain,** it works as a neurotransmitter to excite most cellular processes).

Fibers connecting substantia nigra to the striatum:

1- **AFFERENT:** Pars **Compacta**

2- **EFFERENT:** Pars **Reticulata**





Corpus Striatum Function

The corpus striatum **assists** in regulation of voluntary movement and learning of motor skills as they:

➥ **Facilitate** behavior and movement that are required and appropriate.
➥ **Inhibit** unwanted or inappropriate movement.

Basal Ganglia Function

الحركة التي تنتج من الـ cerebral cortex تكون غير منظمة و jerky، عشان كذا الـ extrapyramidal system خصوصًا basal ganglia وظيفتها التنظيم.

1. Control of movement
2. Planning and programming of movement
3. Cognition

Introduction to Function of Basal Nuclei

Just for knowledge

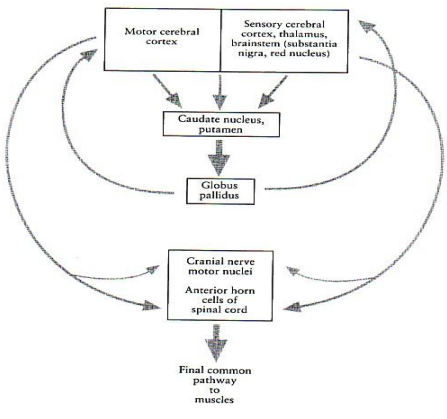
- Basically the activity of basal nuclei begins by information received from:
1- sensory cortex 2- thalamus 3- substantia nigra 4- red nucleus
according to thoughts of mind.

- These information is integrated within striatum and channeled within globus pallidus and outflow back to motor areas of cerebral cortex, and other motor areas in brain stem.

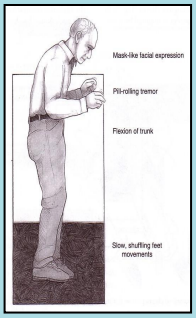
- Thus the basal nuclei can control muscular movement through its effect on cerebral cortex, so basal nuclei assist in regulation of voluntary movement and learning of motor skills.

Functions of Basal Ganglia

➥ **Design of plans**, which convert thoughts and ideas into motor actions: to produce a coordinated organized purposeful movement. e.g. dressing.
➥ **Determining the timing and scale of movement:** to what extent the movement will be fast, and how long it will last.
➥ **Storage of motor programs of familiar motor actions:** e.g. signature.

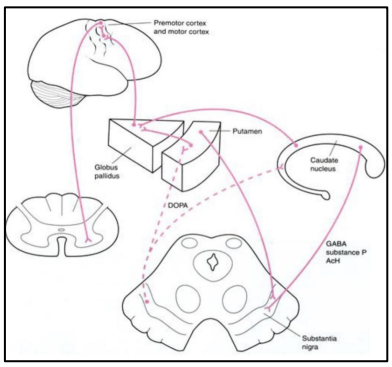


Parkinsonism

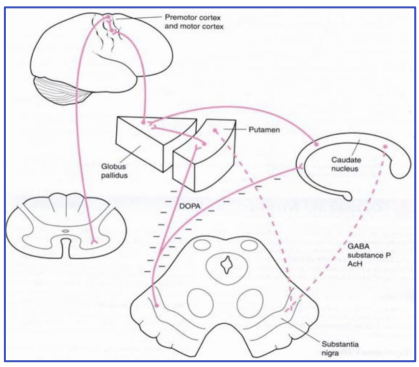
Parkinson's disease, Paralysis Agitans		
Lesion	Neuronal degeneration in substantia nigra leading to reduction of dopamine within corpus striatum.	
Features 	**Dyskinesia:**	
	It means abnormal motor control or abnormal involuntary movements as:	
	Tremors	- Pill-rolling, involuntary, rhythmic, oscillating movements. - It occurs during rest, hence it is called **Static** (resting) **Tremors**.
	Rigidity	- It occurs in both flexors and extensors, but more in flexors, giving flexion attitude. - It is called **lead pipe rigidity**.
	Mask face	- Low volume, slow, monotonous speech,
	Bradykinesia	- Slow movement. - Abnormal gait: shuffling gait.

Parkinson's disease Vs. Huntington's disease

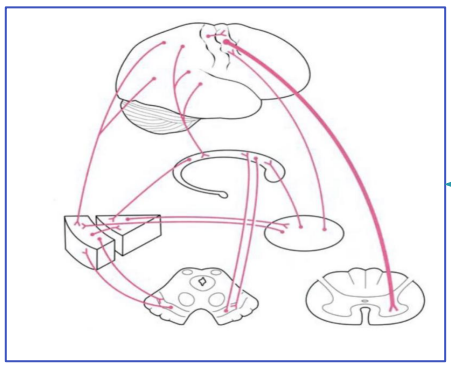
Parkinson's Disease	Huntington's Disease
Degeneration of inhibitory pathways between Substantia Nigra & Corpus Striatum.	
Main Connections between Cortex, Basal Nuclei, Thalamic Nuclei, Brainstem & Spinal Cord.	



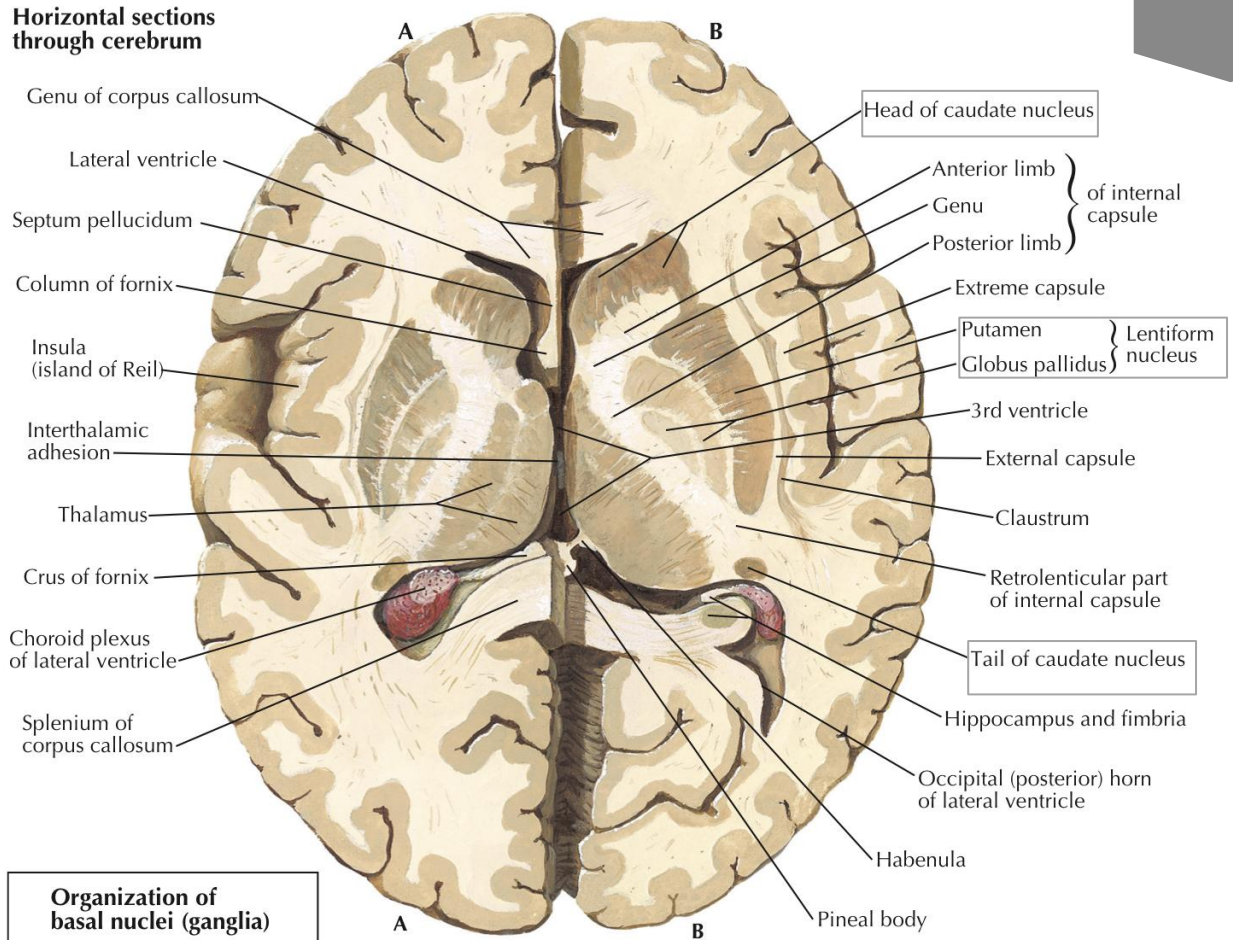
Parkinson's disease



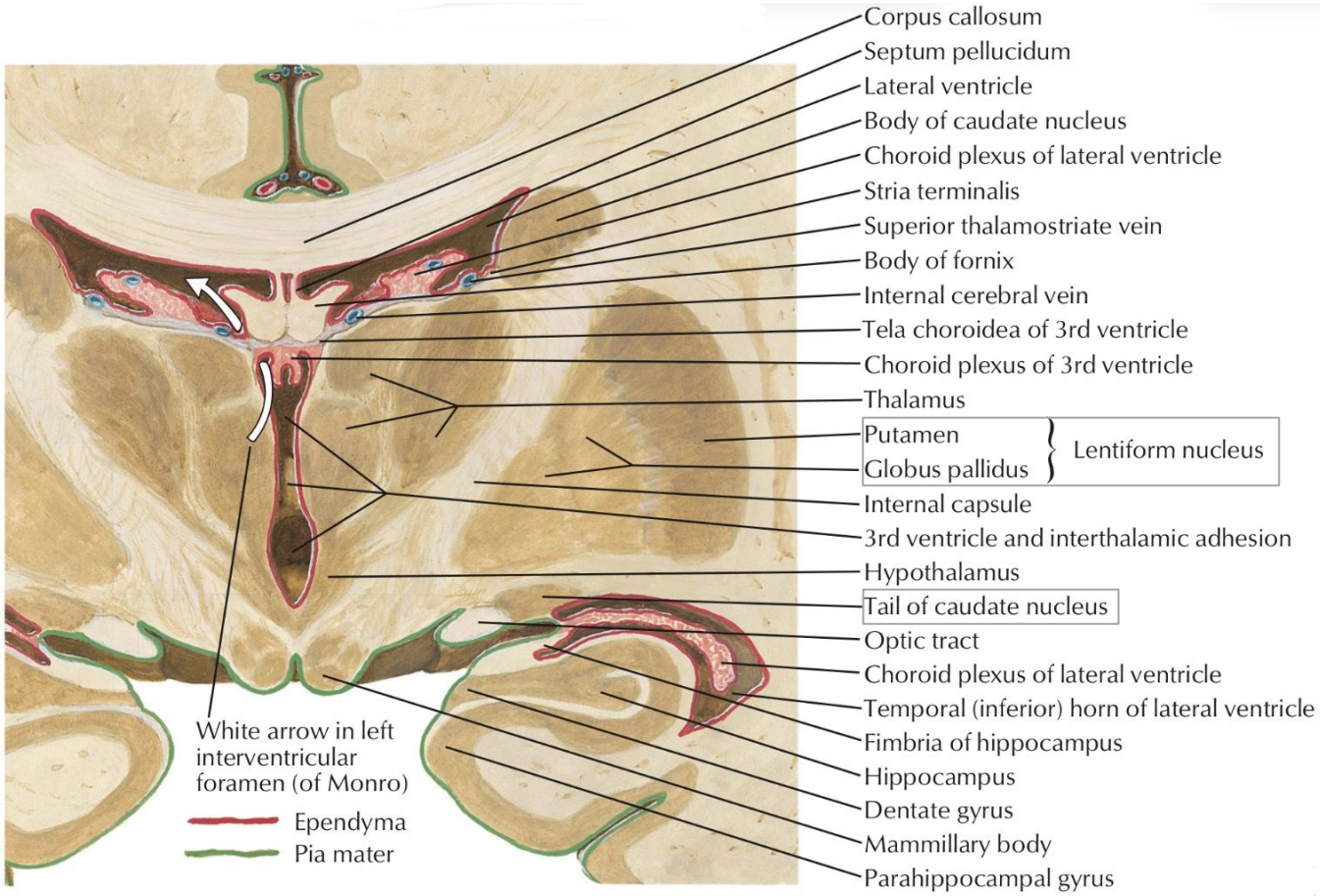
Huntington's disease



Horizontal sections through cerebrum



Organization of basal nuclei (ganglia)



Coronal section of brain: posterior view

MCQs

Q1. If a patient is recently diagnosed as parkinson's disease; where is the most likely site of lesion? Female Slides			
A. Thalamus	**B.** Spinal cord	**C.** Substantia nigra	**D.** Crus cerebri
Q2. Which of the following structures is not considered to be part of the basal ganglia?			
A. Caudate nucleus	**B.** Dentate nucleus	**C.** Substantia nigra	**D.** Globus pallidus
Q3. Which of the basal ganglia nuclei receives direct cortical input?			
A. Claustrum and amygdala	**B.** Globus pallidus internal and substantia nigra	**C.** Caudate and putamen (striatum)	**D.** Subthalamic nucleus
Q4. Which of the following neurotransmitters is used by the axons of substantia nigra neurons that project to the caudate and putamen?			
A. GABA	**B.** Dopamine	**C.** Serotonin	**D.** Norepinephrine
Q5. Within the direct pathway, the cerebral cortex directly excites which structure?			
A. The striatum	**B.** The thalamus	**C.** The globus pallidus external	**D.** The subthalamic nucleus
Q6. Dopamine is produced and released by which structure, most notably?			
A. Putamen	**B.** Globus pallidus	**C.** Substantia nigra reticulata	**D.** Substantia nigra compacta

A1. C A2. B A3. C A4. B A5. A A6. D

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