

BASAL GANGLIA

- The basal ganglia are among the most complex and least understood structures in the mammalian forebrain.
- The definition of basal ganglia is subject to some variation, but key structures include the corpus striatum (Caudate nucleus, putamen and globus pallidus), subthalamic nucleus and the substantia nigra.
- Interconnect through the telencephalon, diencephalon and midbrain.
- The neostriatum consist of the caudate nucleus and putamen.
- Separate in primate but united in rodents.
- Input of BG.
- Globus pallidus 2 segment.

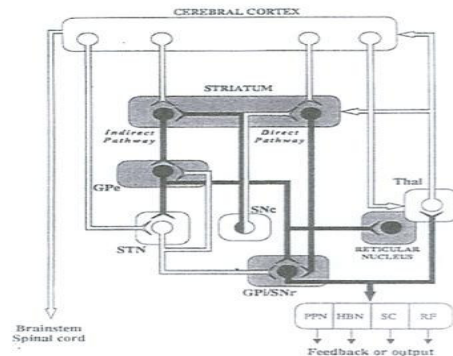


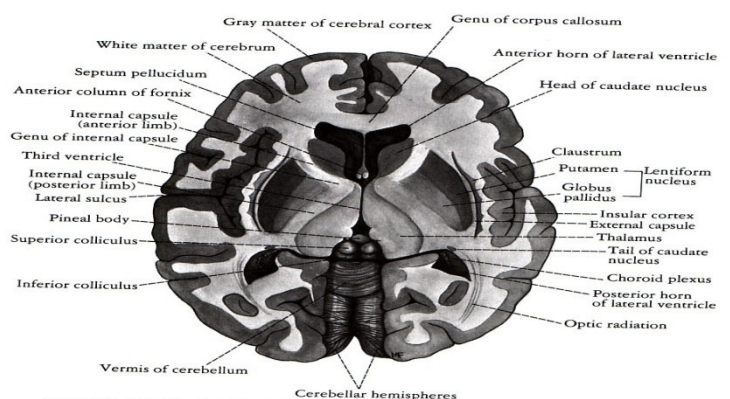
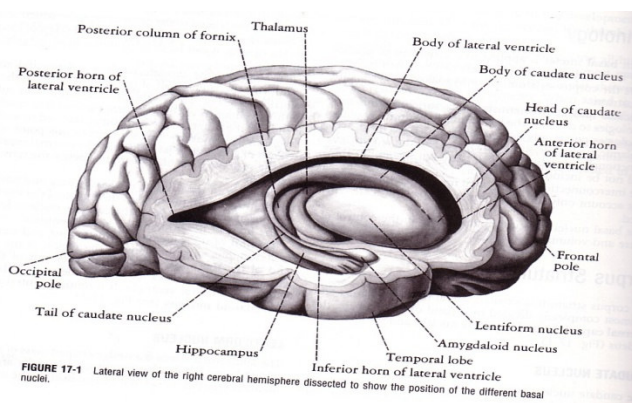
Figure 1.1 An updated version of the basal ganglia circuitry originally represented by Alexander and Crutcher (1986), showing the connectivity of the direct and indirect pathways of the basal ganglia. Inhibitory projections are shown as filled arrows, excitatory projections as open arrows. Gpe = external segment of the globus pallidus; SNc = substantia nigra pars compacta; SNr = substantia nigra pars reticulata; STN = subthalamic nucleus; Thal = thalamus; PPN = pedunculopontine tegmental nucleus; HBN = lateral habenular nucleus; SC = superior colliculus; and RF = reticular formation.

DEFINITION :

- It is a collection of grey matter deeply situated in each cerebral hemisphere.
- They play an important role in the control of posture and voluntary movement.
- They are part of extrapyramidal system.

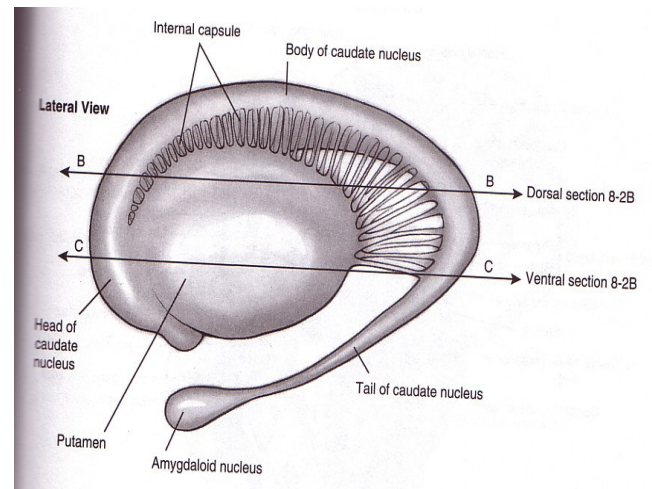
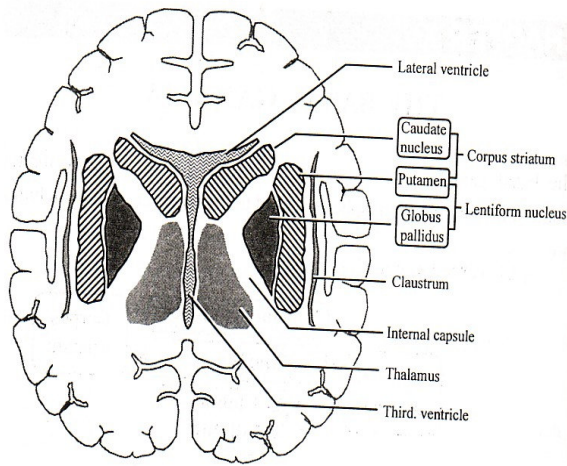
DIVISION :

1. **Corpus striatum** : which is divided by internal capsule into : **Caudate nucleus & Lentiform Nucleus.**
 2. **Amygdaloid body.**
 3. **Clastrum.**
- NB. The subthalamic nucleus (in diencephalon) & Substantia nigra & red nucleus (in midbrain) are functionally in close relation with basal ganglia but they should not be included with them.



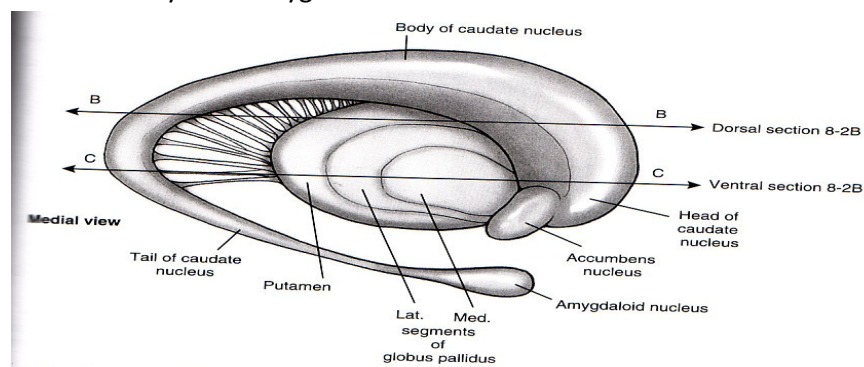
CORPUS STRIATUM :

- Lies lateral to Thalamus.
- It is divided completely by internal capsule into caudate nucleus and Lentiform nucleus.
- 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.



CAUDATE NUCLEUS :

- Large C-shaped or comma-shaped mass of grey matter.
- Lies in close relation to lateral ventricle.
- It has a Head, Body, and Tail.
- Head (anterior) : Large, & rounded and forms the lateral wall of anterior horn of lateral ventricle.
 - It is continuous inferiorly with putamen of lentiform Nucleus.
- Body : Long & narrow continuous with head at the interventricular foramen.
 - It forms part of the floor of body of lateral ventricle.
- Tail : Long & narrow, and lies in the roof of inferior horn of lateral ventricle.
 - It is connected anteriorly with Amygdaloid nucleus.



LENTIFORM NUCLEUS :

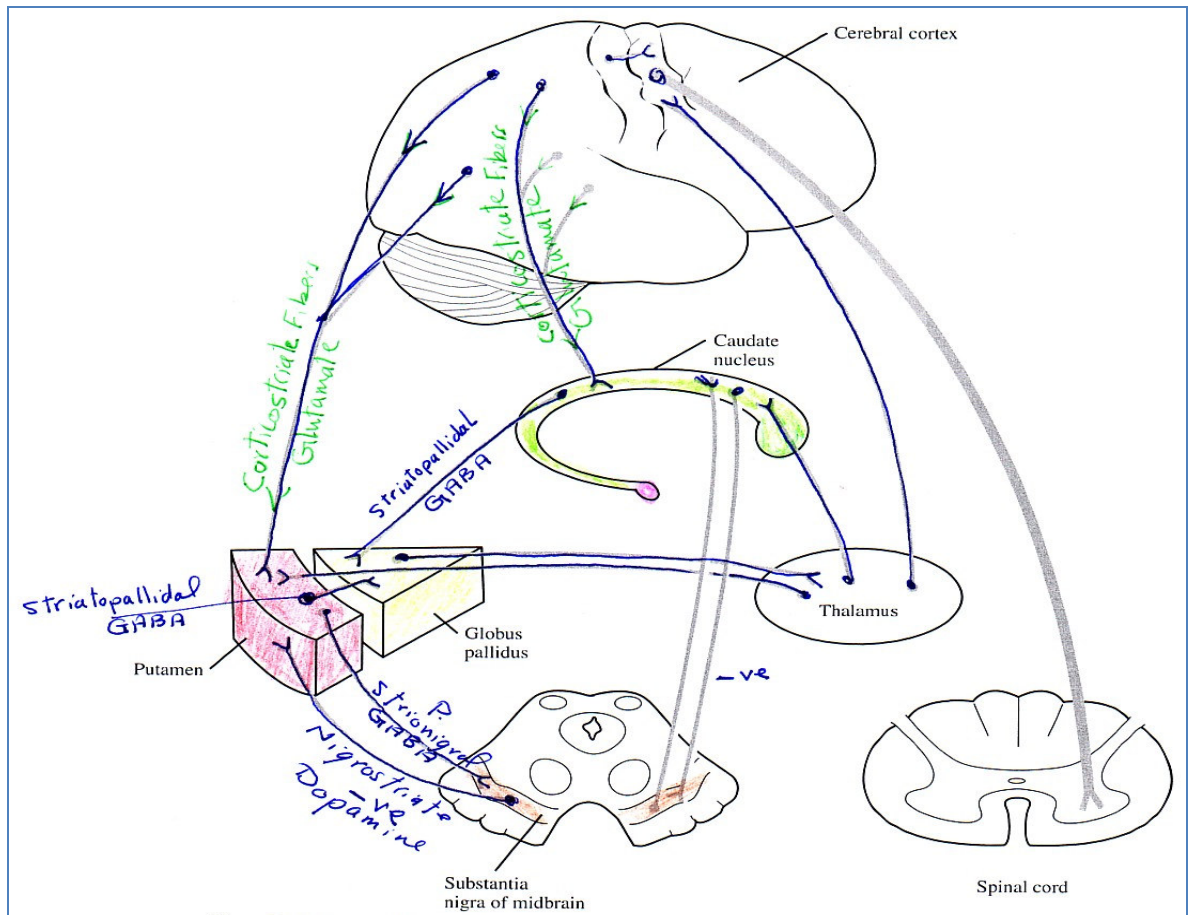
- It is a mass of grey matter wedge-shaped or (biconvex lens).
- It has 2 capsules, external capsule laterally & internal capsule medially.
- Internal capsule separates between lentiform nucleus laterally & caudate nucleus and thalamus medially.
- External capsule separates between lentiform nucleus and Claustrum.
- It is divided into Putamen & globus pallidus.
 - **Putamen** : Larger darker lateral portion.
 - **Globus pallidus** : Smaller, lighter medial portion.
- Inferiorly putamen is continuous with the head of caudate nucleus.

AMYGDALOID NUCLEUS :

- Almond-shaped small mass of grey matter lies in temporal lobe close to the Uncus.
- Lies Anterosuperior to inferior horn of lateral ventricle.
- It is connected to the tail of caudate nucleus.
- It is the smell center & part of limbic system.
- **Clastrum** : Thin sheet of gray matter which lies lateral to external capsule & medial to the **Insula**.

CONNECTION OF CORPUS STRIATUM :

- **Afferent Fibers (Input) :**
 1. 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.
 2. Thalamostriate Fibers : From intralaminar nuclei of thalamus axons pass to caudate nucleus and putamen.
 3. Nigrostriate Fibers : Axons from Substantia nigra of midbrain pass to caudate nucleus and putamen.
 - Neurotransmitter is **Dopamine**.
 4. Brain stem 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) :**
 1. **Striatopallidal fibers :**
 - These fibers pass from corpus striatum (caudate nucleus & putamen) to globus pallidus.
 - Gamma-aminobutyric acid (**GABA**) is the neurotransmitter.
 2. **Strionigral fibers :**
 - These fibers pass from caudate nucleus & putamen to Substantia nigra.
 - Some fibers use **GABA** as a neurotransmitter, and others use **substance P**.

INTRODUCTION TO FUNCTION OF BASAL NUCLEI :

- Basically the activity of basal nuclei begins by information received from sensory cortex, thalamus, substantia nigra, and red nucleus, according to thoughts of mind.
- These information is integrated within corpus 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, the basal nuclei assist in regulation of voluntary movement and learning of motor skills.

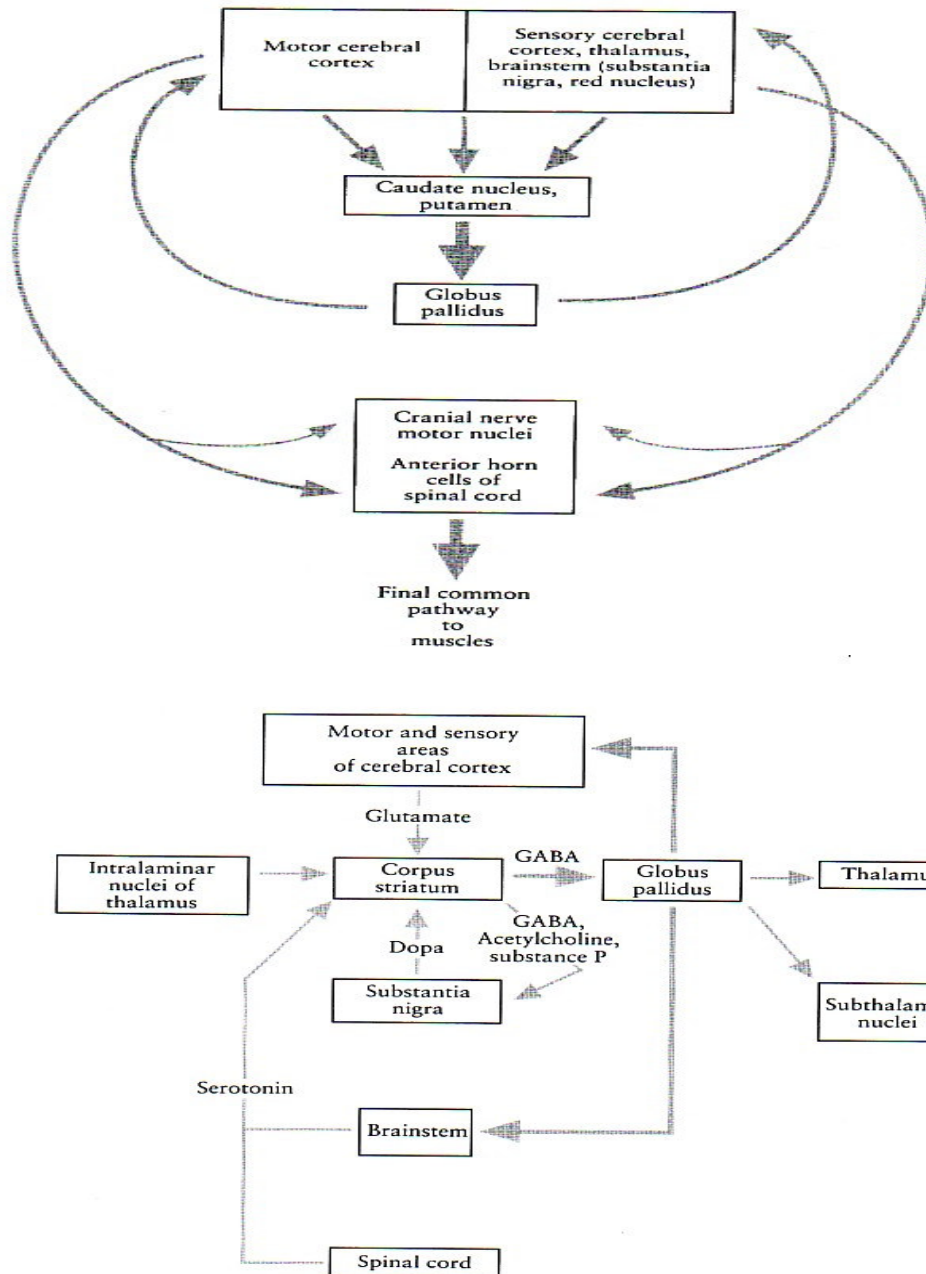


Figure 13-4 Basal nuclei pathways, showing the known neurotransmitters.

FUNCTIONS OF BASAL GANGLIA :

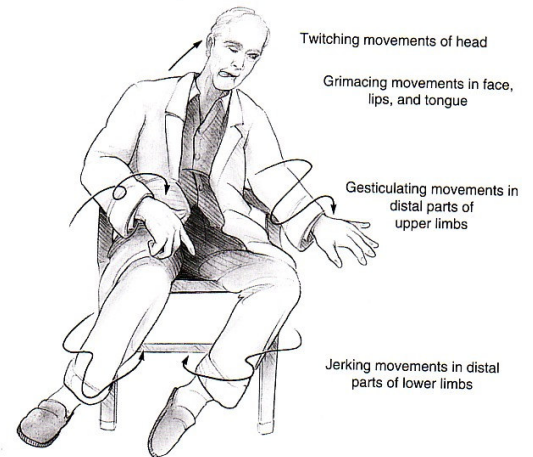
1. **Design of plans**, which convert thoughts and ideas into motor actions : to produce a coordinated organized purposeful movement. e.g. dressing.
2. **Determining the timing and scale of movement** : to what extent the movement will be fast, and how long it will last.
3. **Storage of motor programs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

MANIFESTATION OF LESION OF BASAL GANGLIA :

1. Involuntary movement during rest : Chorea, athetosis, hemiballismus, and tremor.
2. Changes in muscle tone.

a) Chorea : (Dance)

- Lesion : in caudate N.
- Features : Involuntary, quick, Jerky, irregular, non-repetitive and purposeless movement.
- e.g. Swift grimaces, and sudden movement of head or limb.
- Types : **Sydenham** (rheumatic fever) *more in female*, **Huntington's**, (hereditary), chorea Gravidarum, or chorea of contraceptive pills.



Huntington's Chorea

b) Athetosis : (Greek= Not fixed).

- Lesion : Putamen & Globus pallidus.
- Features : Involuntary, slow, sinuous, writhing movements involving distal part of limb (hand).

c) Hemiballismus : (Greek= Jumping).

- Lesion : Subthalamus.
- Features : Sudden, involuntary, spasmodic movements that involves one limb or one side of the body (Limb suddenly flies about in all directions out of control).

PARKINSONISM (PARKINSON'S DISEASE, PARALYSIS AGITANS) :

- Lesion : Neuronal degeneration in substantia nigra leading to reduction of dopamine within corpus striatum.
- Features :
 1. **Tremors : Pill-rolling**, involuntary, rhythmic, oscillating movements.
 - It occurs during waking time during rest, it is called static tremors.
 2. **Rigidity** : It occurs in both flexors, and extensors, but more in flexors giving flexion attitude.
 - It is called **lead pipe rigidity**.
 3. **Akinesia** : it means lack of movement; Absence of swinging arm during walking, mask face, low- volume slow monotonous speech, and shuffling gait.

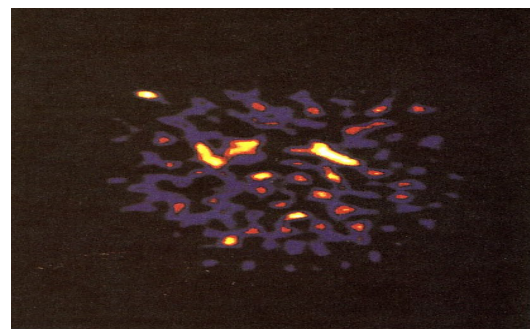
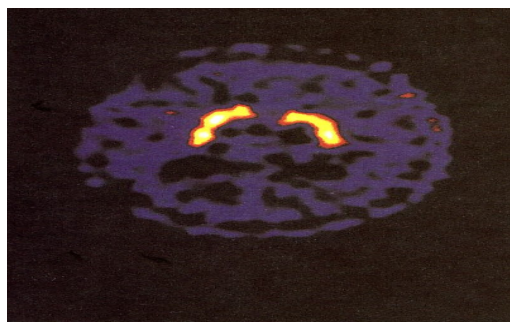
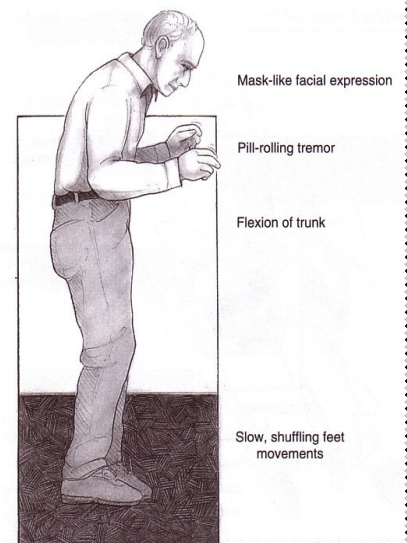


FIGURE 17-6 Axial (horizontal) PET scans of (A) a normal brain and (B) the brain of a patient with early Parkinson's disease, following the injection of 18-fluoro-6-L-dopa. The normal-brain image shows large amounts of the compound (yellow areas) distributed throughout the corpus striatum in both cerebral hemispheres. In the patient with Parkinson's disease the brain image shows that the total amount of the compound is low and it is unevenly distributed in the corpus striatum. (Courtesy Dr. Holley Day.)

NOTES

TOPOGRAPHICAL ANATOMY OF THE CORPUS STRIATUM :

- The corpus striatum includes : 1. the **caudate nucleus**, 2. **Putamen**, and 3. **globus pallidus**.
- These structures are primarily concerned with the control of posture and movement.
- Topographically, the putamen and globus pallidus constitute the **lentiform nucleus**.
- Functionally, the caudate nucleus and putamen form a single entity, the **neostriatum (striatum)**, while the globus pallidus forms the paleostriatum.
- The caudate nucleus lies in the wall of the lateral ventricle.
- The largest part, or head, of the caudate lies medial to the internal capsule and forms a prominent bulge in the lateral wall of the anterior horn of the ventricle.
- The curved, tapering tail of the caudate nucleus follows the curvature of the lateral ventricle into the temporal lobe.
- The putamen and globus pallidus lie lateral to the internal capsule, deep to the cortex of the insula.

CONNECTIONS OF THE STRIATUM :

- The caudate nucleus and putamen are the 'input' regions of the **corpus striatum**.
- They receive **afferents** from the cerebral cortex, *intralaminar thalamic nuclei* and the *pars compacta* of the substantia nigra.
- **Efferent** fibres are directed to the globus pallidus and the pars reticulata of the substantia nigra.

CONNECTIONS OF THE GLOBUS PALLIDUS :

- The globus pallidus consists of two segments : medial (internal) and lateral (external).
- The medial segment shares many similarities with the pars reticulata of the substantia nigra and, together, these two structures are regarded as the 'output' regions of the corpus striatum.
- The globus pallidus receives **afferent** fibres from the striatum and the subthalamic nucleus.
- The **lateral** segment of the *globus pallidus* projects to the *subthalamic nucleus*.
- The **medial** segment of the *globus pallidus* projects primarily to the *thalamus* (ventral anterior, ventral lateral and centromedian nuclei).
- The thalamus in turn sends fibres to the motor areas of the *frontal lobe*.

SELF QUIZ

1- Regarding the basal ganglia, all of the following are true EXCEPT :

- a. Corpus Striatum is divided into caudate nucleus & Lentiform nucleus.
- b. Lentoform Nucleus is divided into Putamen & globus pallidus.
- c. Amygdaloid Nucleus It is connected to the tail of caudate nucleus.
- d. Claustrum lies medial to the Insula.
- e. All of the above.

2- Regarding Caudate nucleus, all of the following are true EXCEPT :

- a. Large C-shaped.
- b. Lies in close relation to lateral ventricle.
- c. The Head of Caudate nucleus continuous posteriorly with putamen of lentiform Nucleus.
- d. It is connected anteriorly with Amygdaloid nucleus.
- e. The head forms the lateral wall of anterior horn of lateral ventricle.

3- Regarding Afferent fibers of Corpus Striatum, all of the following are true EXCEPT :

- a. Corticostriate use Glutamate as a neurotransmitter.
- b. Thalamostriate Fiber passes to caudate nucleus and putamen.
- c. Nigrostriate Fibers use Dopamine as a neurotransmitter.
- d. Striatopallidal fibers use (GABA) as a neurotransmitter.
- e. Brain stem Strial Fibers use Serotonin as a neurotransmitter.

4- Which of the following pairs are NOT true :

- a. Chorea : Lesion in caudate N.
- b. Athetosis : Putamen & Globus pallidus.
- c. Hemiballismus : Lesion in Subthalamus.
- d. Parkinson's disease : Reduction of dopamine within corpus striatum.
- e. None of the above.

1. a	2. c	3. d	4. e
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THE END

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