Dr. P. SHARMILA BHANU,
Associate Professor of Anatomy

All the day-to-day activities like

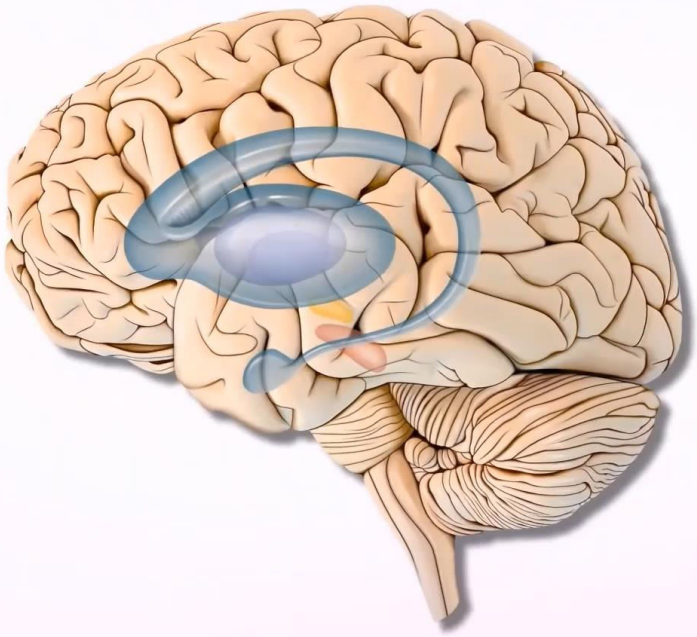
Walking

Writing

Having cup of tea

And many other functions

are governed and controlled by a specialized group of nuclei/ganglia, called



Anatomy of

BASAL GANGLIA

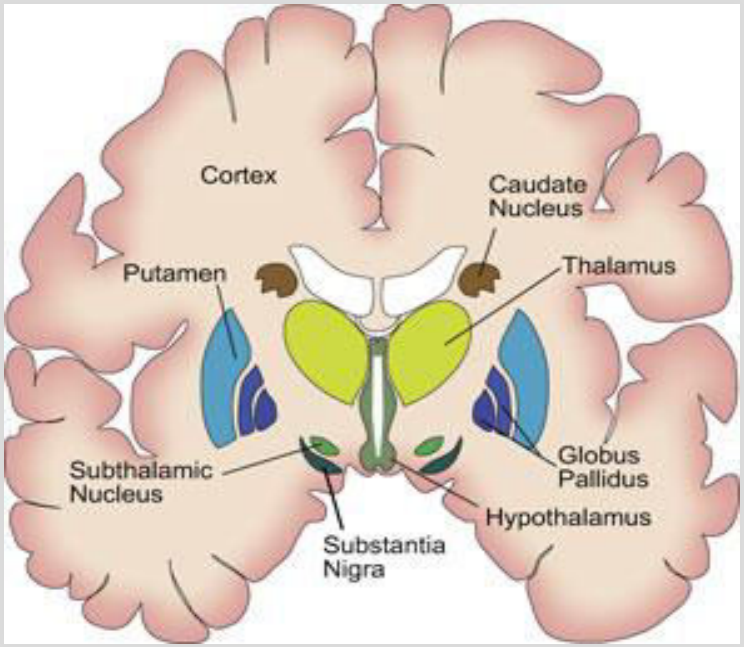
- ***Basal ganglia*** are a set of subcortical nuclei that receive inputs from the entire cerebral cortex and send outputs via the thalamus to different frontal cortical areas.
- It is part of extra pyramidal system
- Several parallel and segregated ***cortico-striatal-thalamo-cortical*** loops serve a role in selecting desirable actions and suppressing undesirable ones.

- **BG contribute to a number of processes, including**
  - ***Planning*, *decision-making***
  - ***Action selection*, *learning***
  - ***Sequencing*, and the *initiation and timing of movement*.**

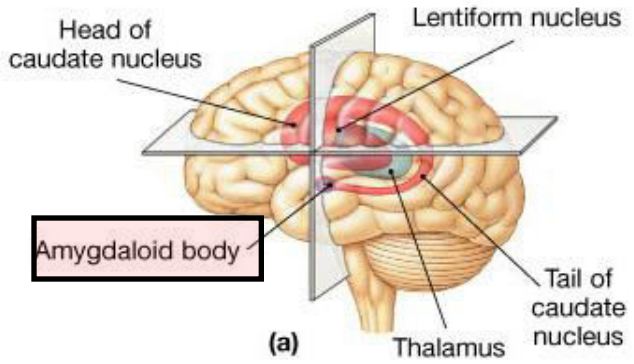
Components of Basal Ganglia (BG)

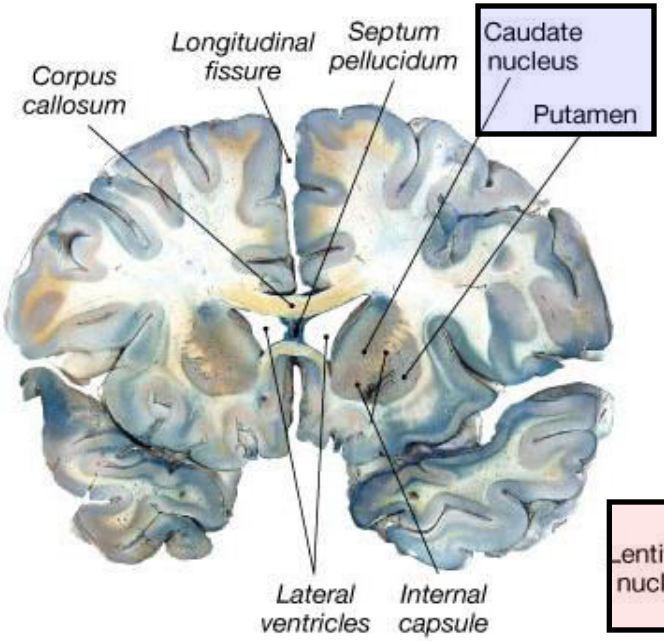
1. Corpus striatum
2. Claustrum
3. Amygdaloid body
4. Sub-thalamic nucleus
5. Substantia nigra

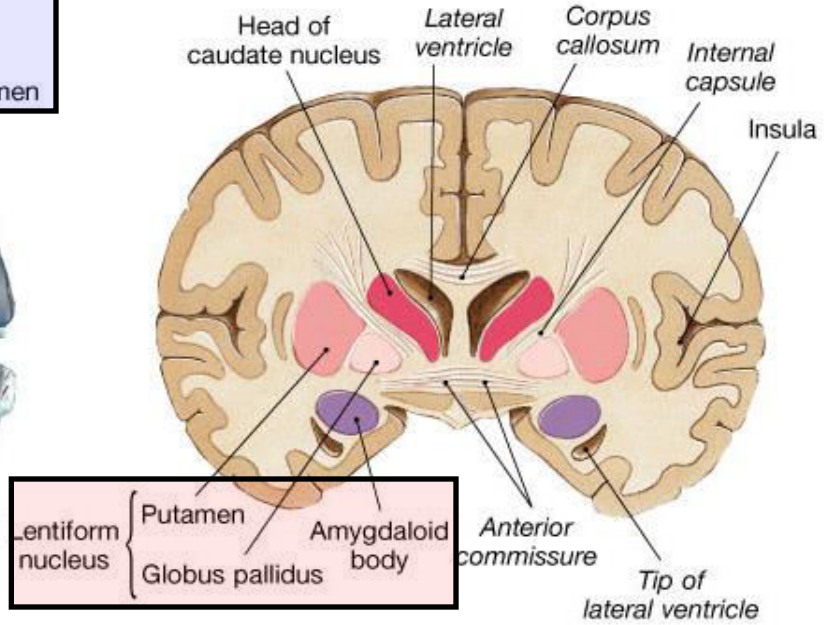
1. Caudate nucleus
2. Lentiform nucleus
   1. Globus Pallidus
   2. Putamen



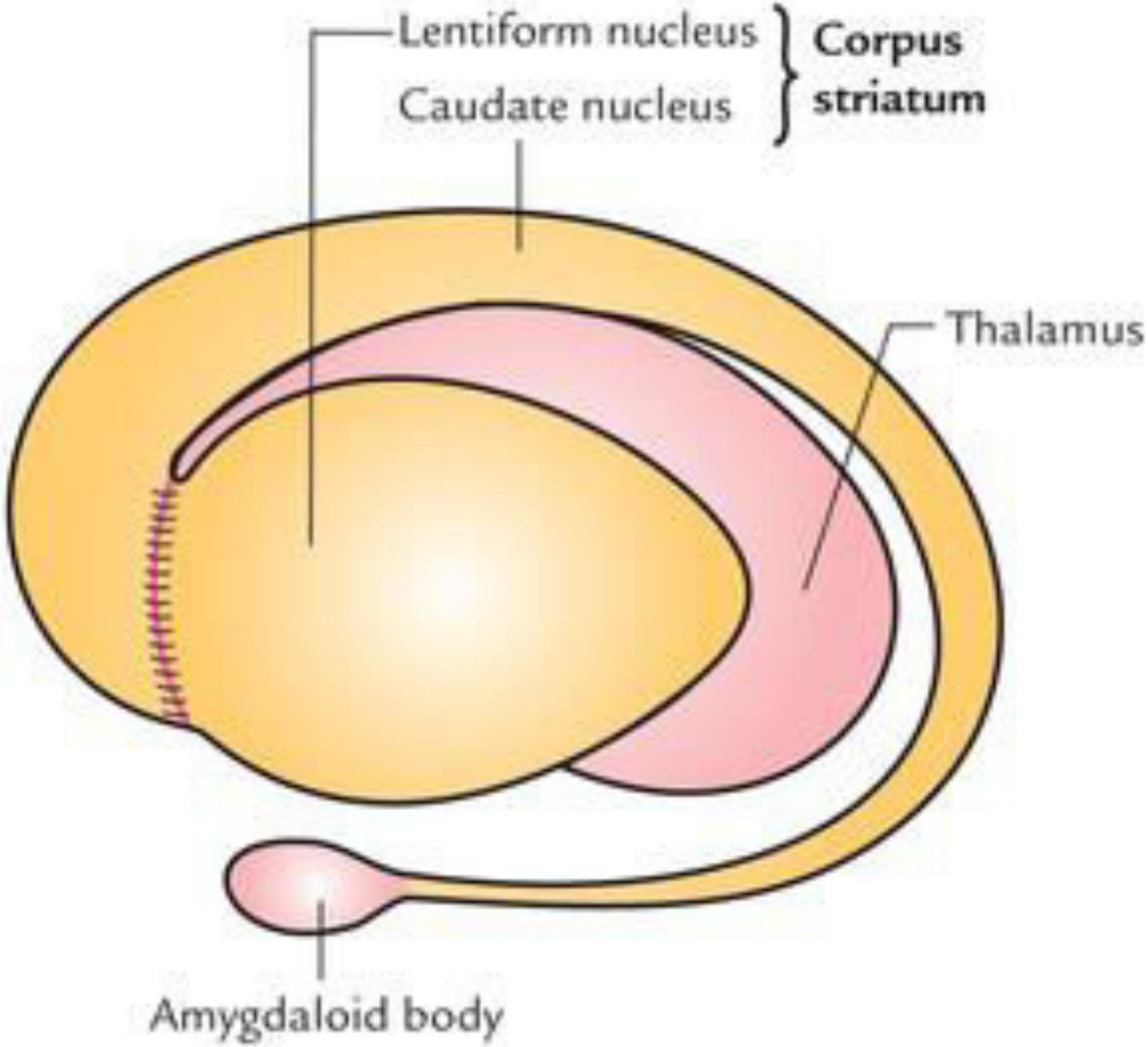
CORONAL SECTION

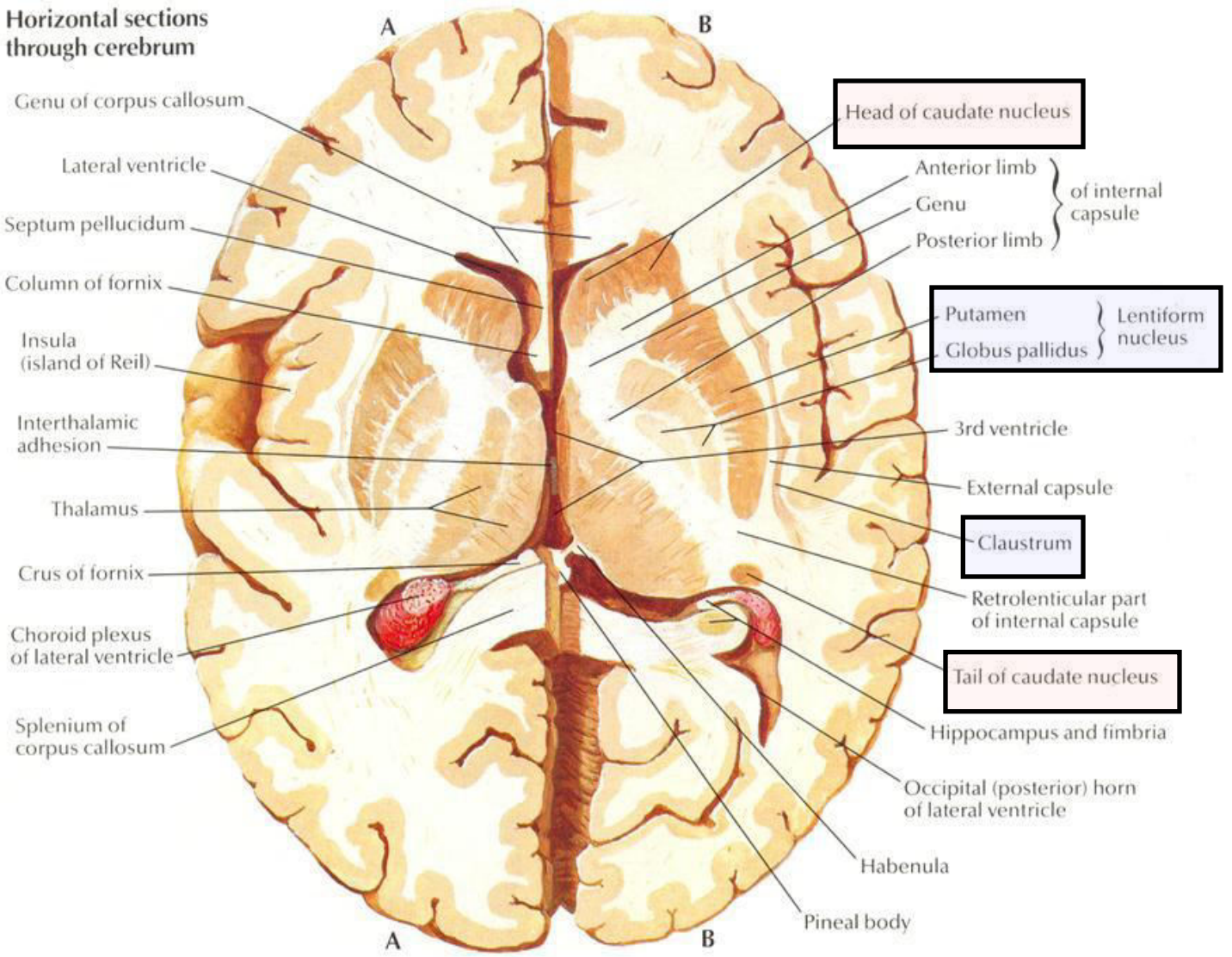






- Corpus striatum is divided almost by the fibers of internal capsule into medial part CAUDATE NUCLEUS and lateral part LENTIFORM NUCLEUS


Lentiform nucleus
Caudate nucleus
Corpus striatum
Thalamus
Amygdaloid body



LOWER LEVEL SECTION

HIGHER LEVEL SECTION

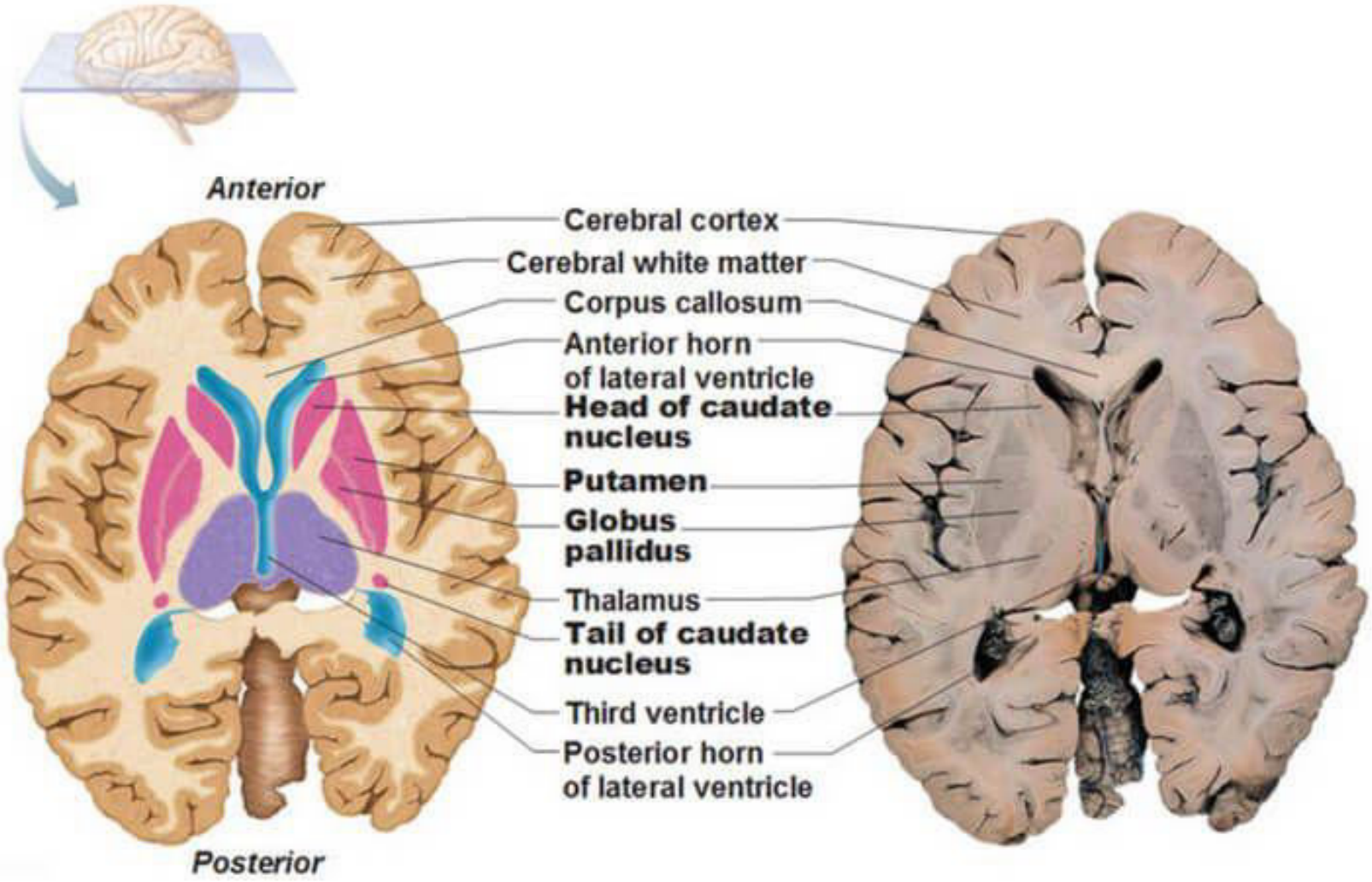
CAUDATE NUCLEUS

- Intra-ventricular part of striatum
- “C” shaped, arched mass of grey matter
- Divided into 3 parts
  - Head
  - Body
  - Tail

- **HEAD** – massive rounded projection; forms the floor of the anterior horn of lateral ventricle

Relations

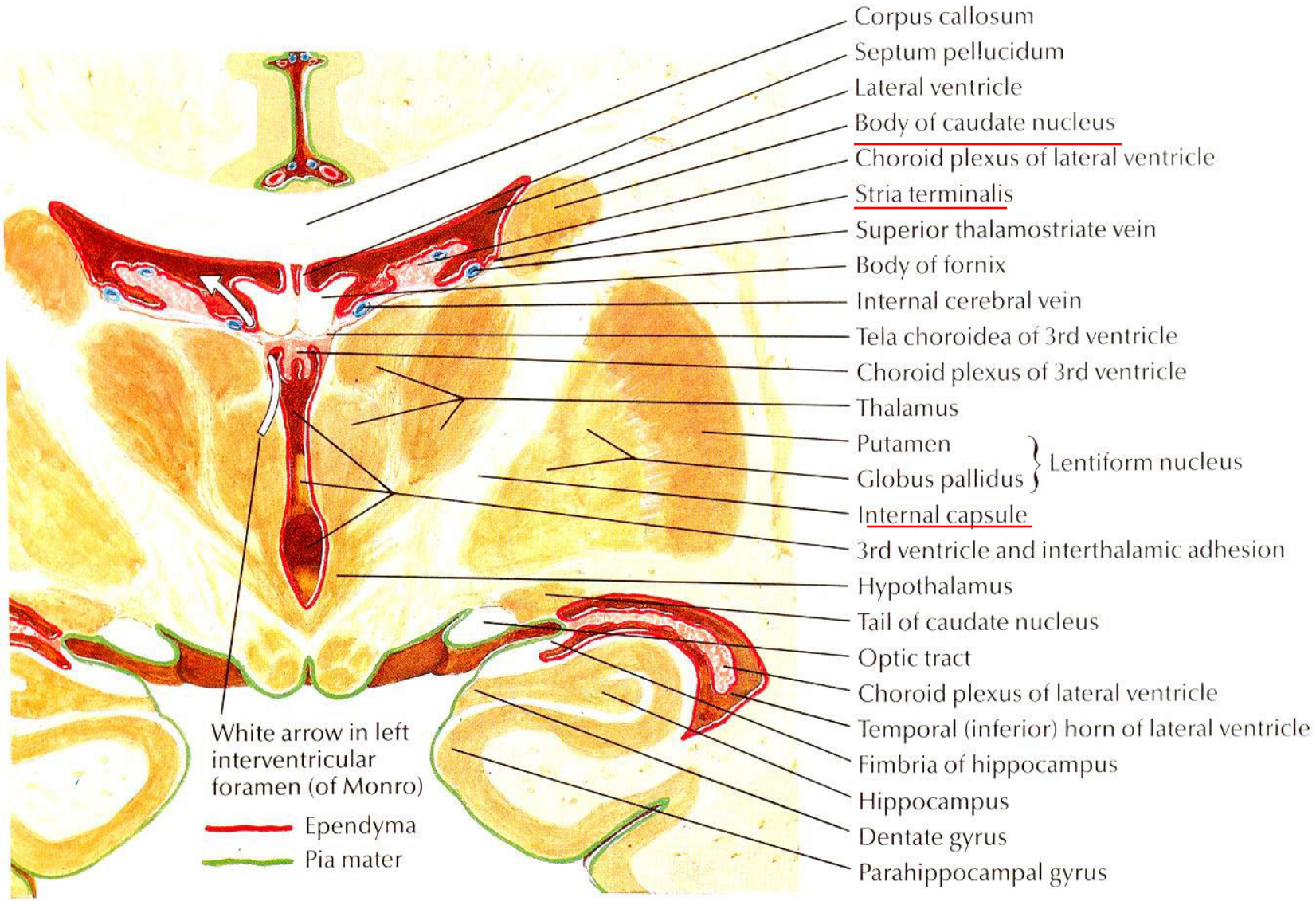
- **Superior** – corpus callosum
- **Lateral** – anterior limb of internal capsule and lentiform nucleus
- **Posterior** – body of caudate nucleus
- **Medial** – Striae terminalis


Anterior
Posterior
Cerebral cortex
Cerebral white matter
Corpus callosum
Anterior horn of lateral ventricle
Head of caudate nucleus
Putamen
Globus pallidus
Thalamus
Tail of caudate nucleus
Third ventricle
Posterior horn of lateral ventricle

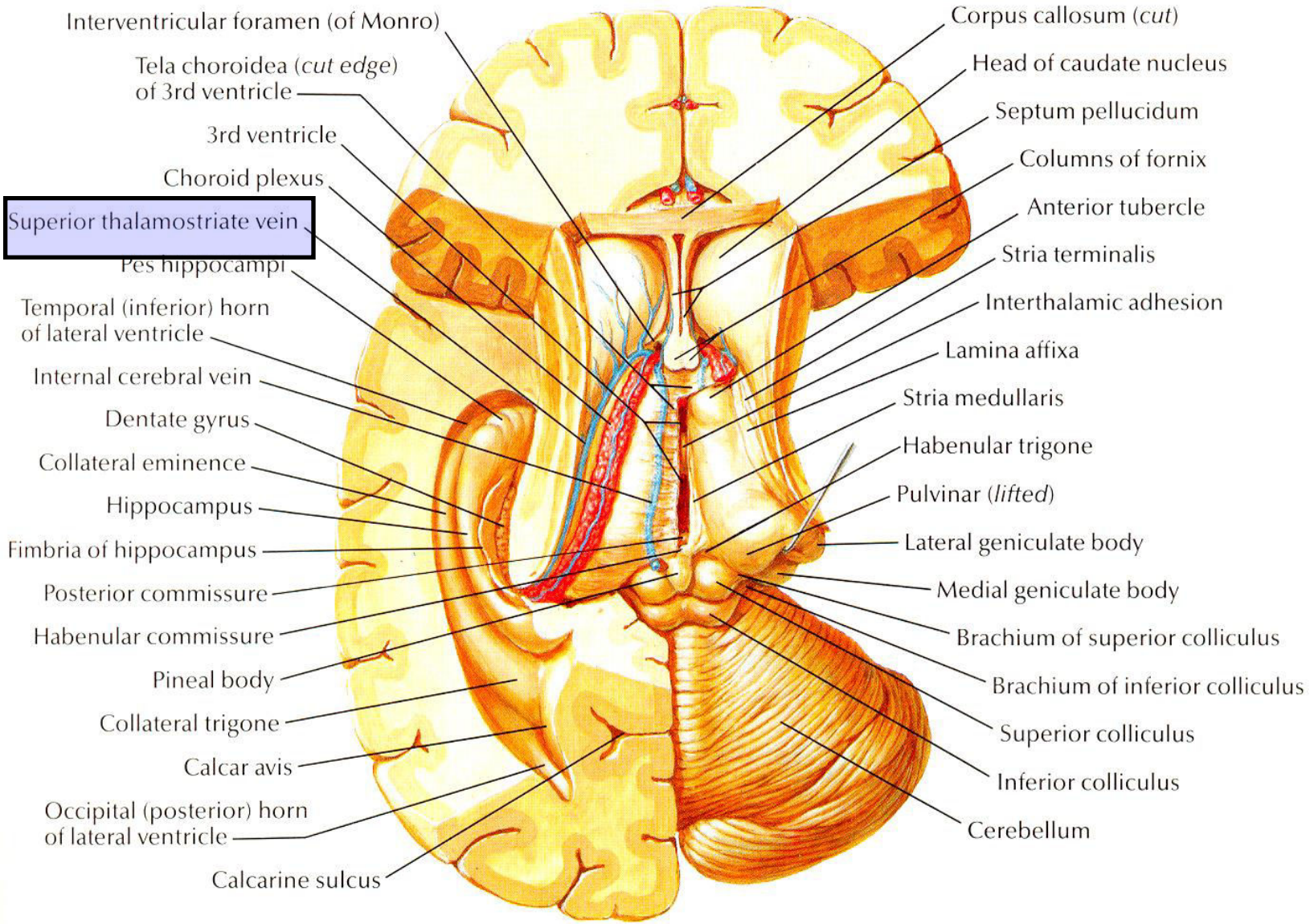
- **BODY** – narrow portion; forms the floor of body of lateral ventricle and ends into tail

Relations

- ***Medial*** – covered by ependyma; thalamostriate vein, Striae terminalis and thalamus
- ***Lateral*** – fronto-occipital fasciculus and corona radiata
- ***Posterior*** – continuous with the tail



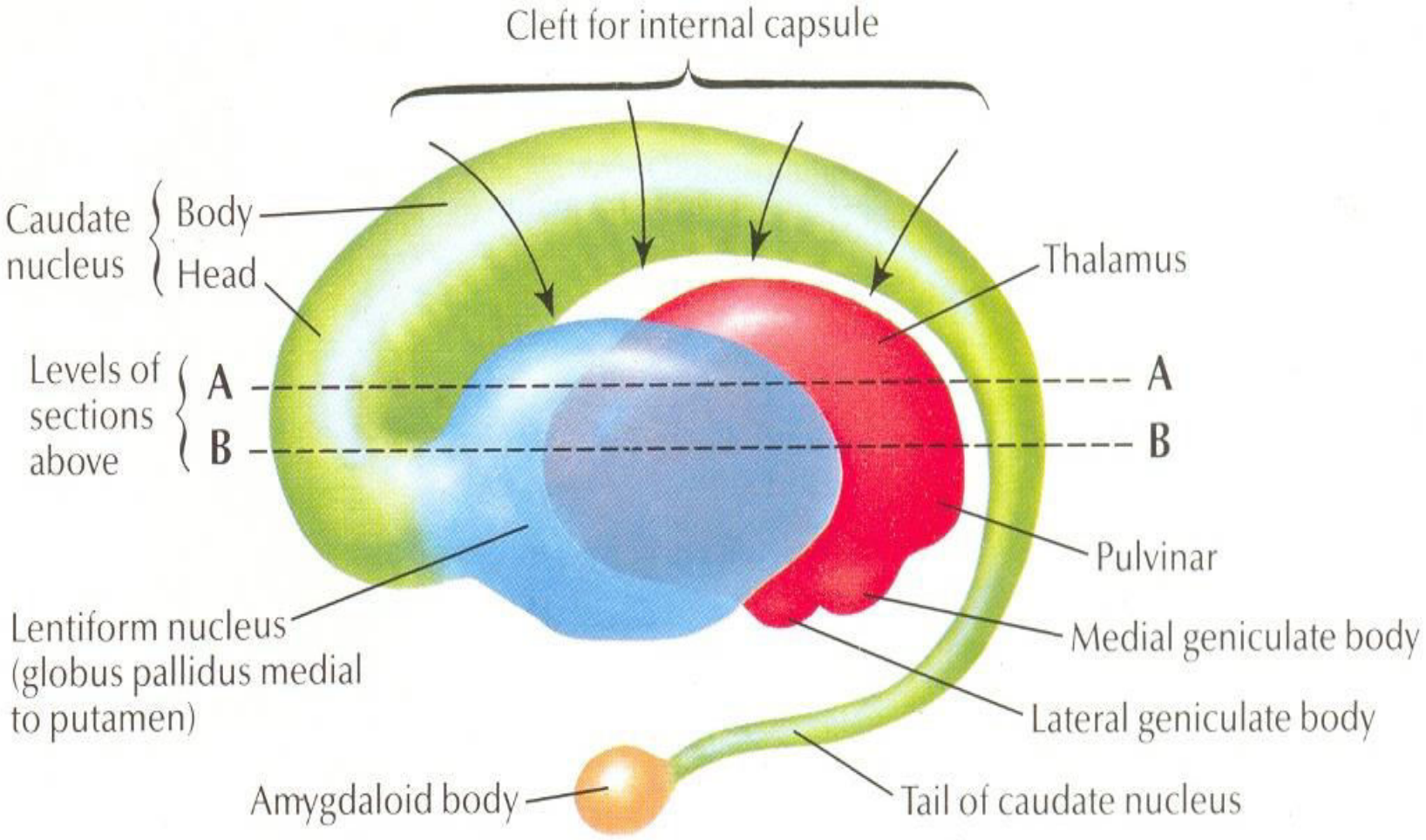
Coronal section of brain: posterior view


Interventricular foramen (of Monro)
Tela choroidea (*cut edge*) of 3rd ventricle
3rd ventricle
Choroid plexus
Superior thalamostriate vein
Pes hippocampi
Temporal (inferior) horn of lateral ventricle
Internal cerebral vein
Dentate gyrus
Collateral eminence
Hippocampus
Fimbria of hippocampus
Posterior commissure
Habenular commissure
Pineal body
Collateral trigone
Calcar avis
Occipital (posterior) horn of lateral ventricle
Calcarine sulcus
Corpus callosum (*cut*)
Head of caudate nucleus
Septum pellucidum
Columns of fornix
Anterior tubercle
Stria terminalis
Interthalamic adhesion
Lamina affixa
Stria medullaris
Habenular trigone
Pulvinar (*lifted*)
Lateral geniculate body
Medial geniculate body
Brachium of superior colliculus
Brachium of inferior colliculus
Superior colliculus
Inferior colliculus
Cerebellum

- **TAIL –forms the roof of the inferior horn of lateral ventricle with stria terminalis on its medial side. Anteriorly continuous with the amygdaloid nucleus**

STRUCTURE OF CAUDATE NUCLEUS

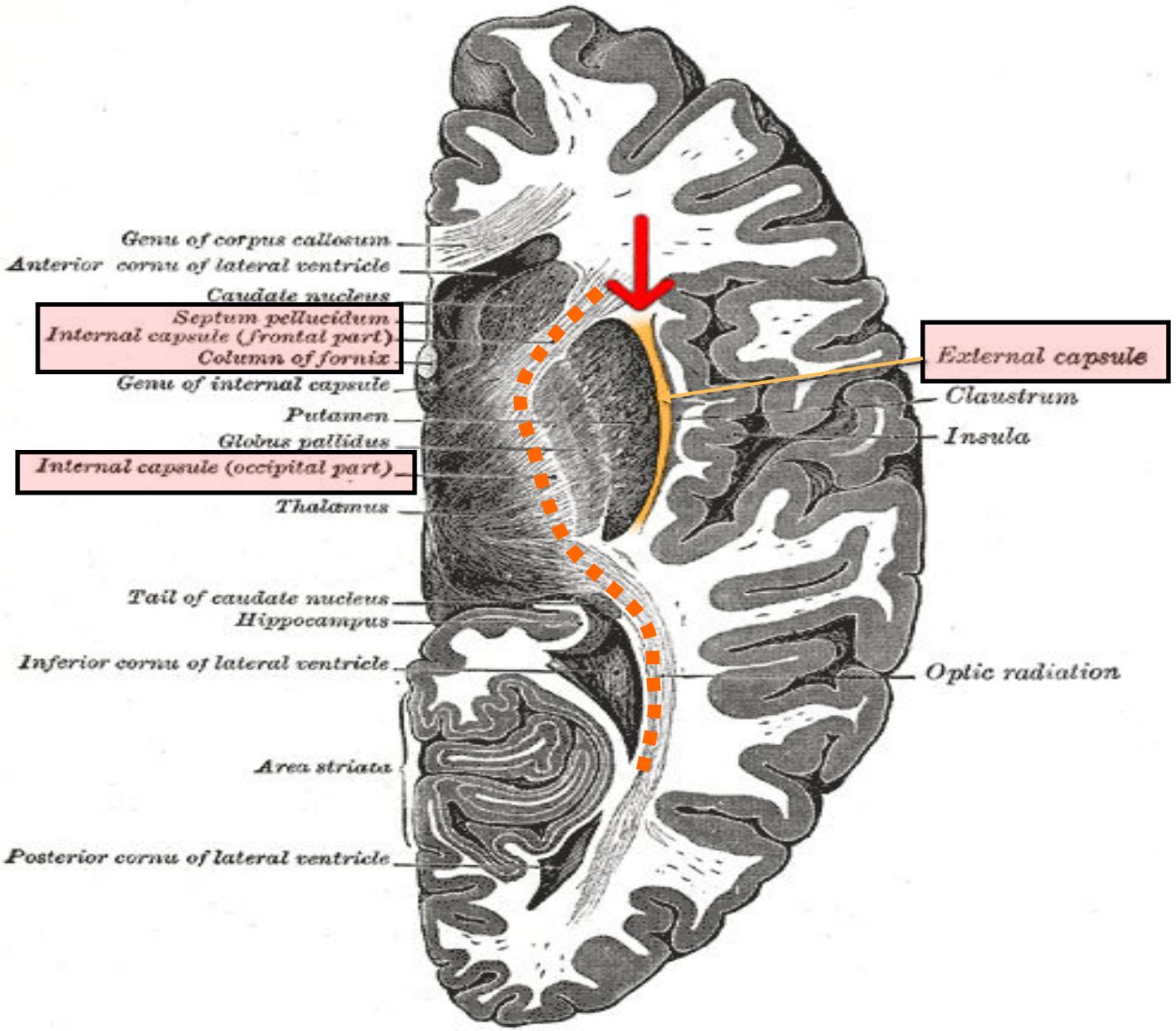
- **Contains mostly small stellate cells which receive the afferent striated fibers.**
- **Contains few large cells whose axons end in globus pallidus and substantia nigra.**



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

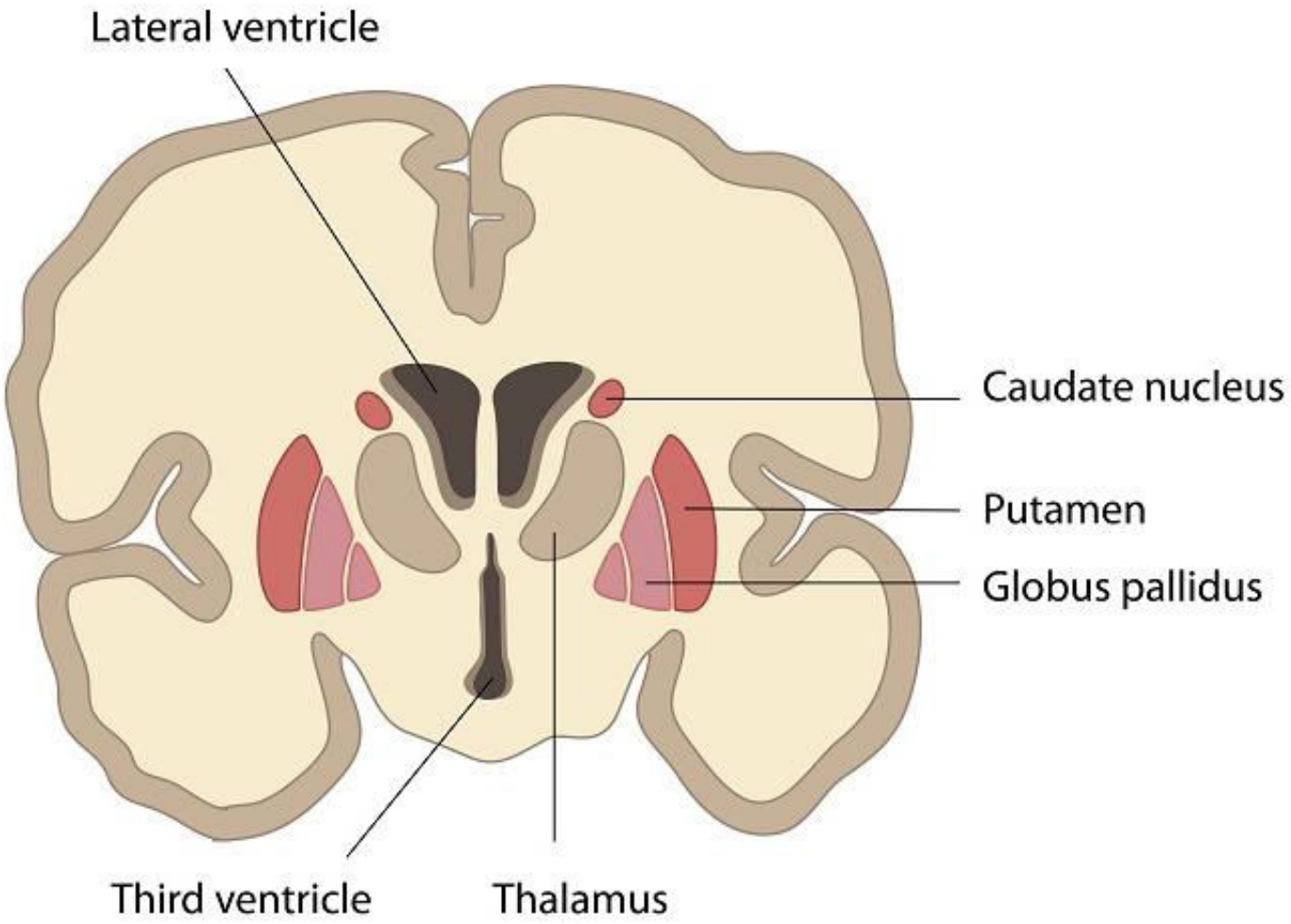
LENTIFORM NUCLEUS

- Extra-ventricular part of striatum
- Biconvex lens shaped
- It has
  - *Lateral surface* – convex related to external capsule – thin sheet of white matter
  - *Medial surface* – convex related to internal capsule (limbs and genu)
  - *Inferior surface* – related to sub-lentiform part of internal capsule


Genu of corpus callosum
Anterior cornu of lateral ventricle
Caudate nucleus
Septum pellucidum
Internal capsule (frontal part)
Column of fornix
Genu of internal capsule
Putamen
Globus pallidus
Internal capsule (occipital part)
Thalamus
Tail of caudate nucleus
Hippocampus
Inferior cornu of lateral ventricle
Area striata
Posterior cornu of lateral ventricle
External capsule
Claustrum
Insula
Optic radiation

PARTS OF LENTIFORM NUCLEUS (LN)

- **External medullary lamina (*thin layer of white matter*) divides the LN into medial smaller GLOBUS PALLIDUS *(paleostriatum)* and lateral larger PUTAMEN *(neostriatum)***


Lateral ventricle
Caudate nucleus
Putamen
Globus pallidus
Third ventricle
Thalamus

CONNECTIONS OF CORPUS STRIATUM

Afferent connections

- **Cortico-striate fibers** from ipsilateral cerebral cortex reach the striatum through internal and external capsules
- **Thalamo-striate fibers** from medial-dorsal, intralaminar and midline nuclei of thalamus; reaches mostly to caudate nucleus and remaining pass to putamen via internal capsule
- **Nigro-striatal fibers** from substantia nigra to caudate and putamen (dopaminergic)

CONNECTIONS OF CORPUS STRIATUM

Efferent connections

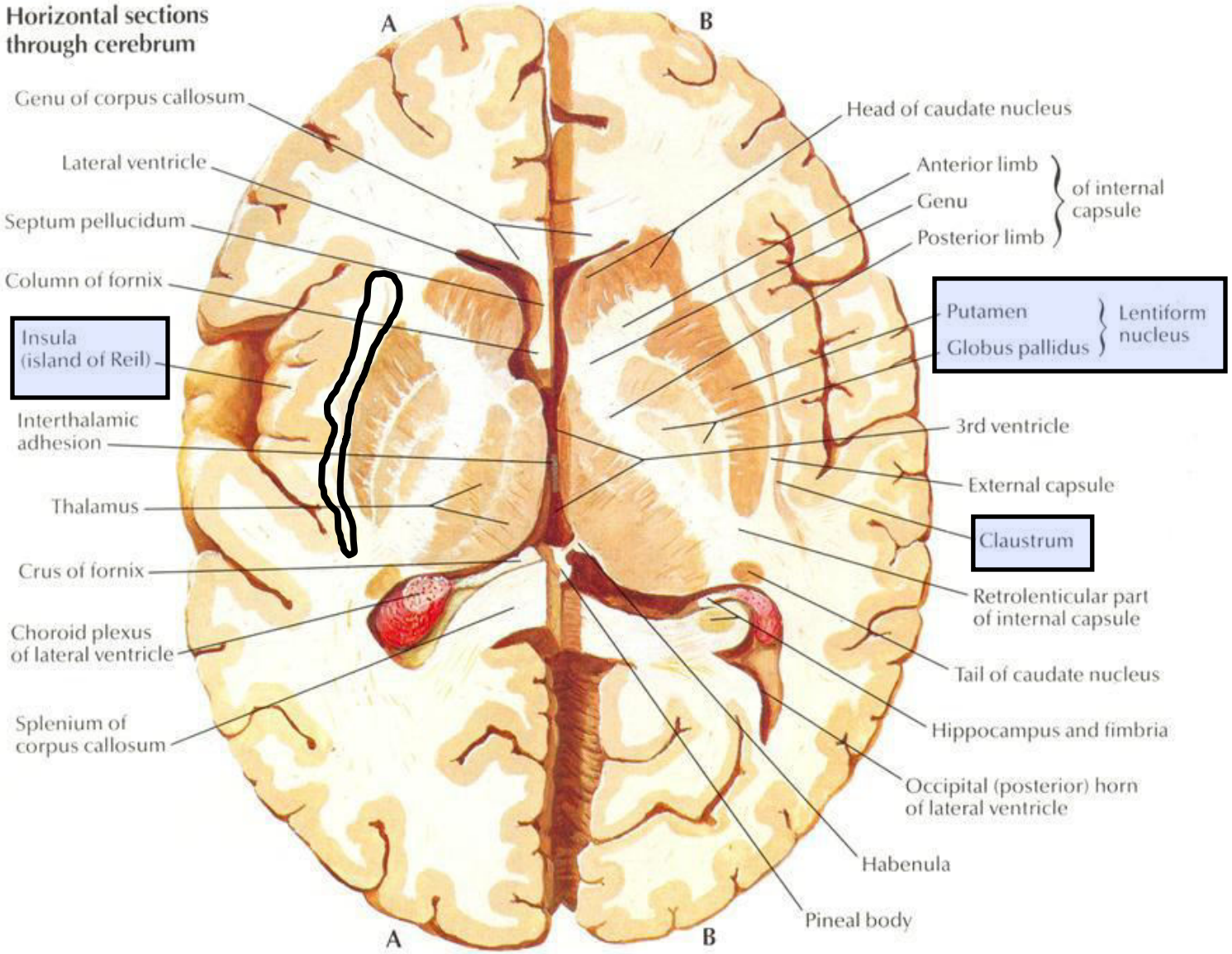
- Globus pallidus is main efferent component of striatum; to thalamus, dentate nucleus and rubral (red) nucleus of midbrain
- Some fibers from GP also pass to substantia nigra (Pallido-nigral fibers)

FUNCTIONS OF CORPUS STRIATUM

- Essential for muscle tone, quality of movement, posture and locomotion.
- Controls the automatic associated movements. E.g. Swinging of arms during walking
- Smoothening the voluntary motor activities of body without any jerk

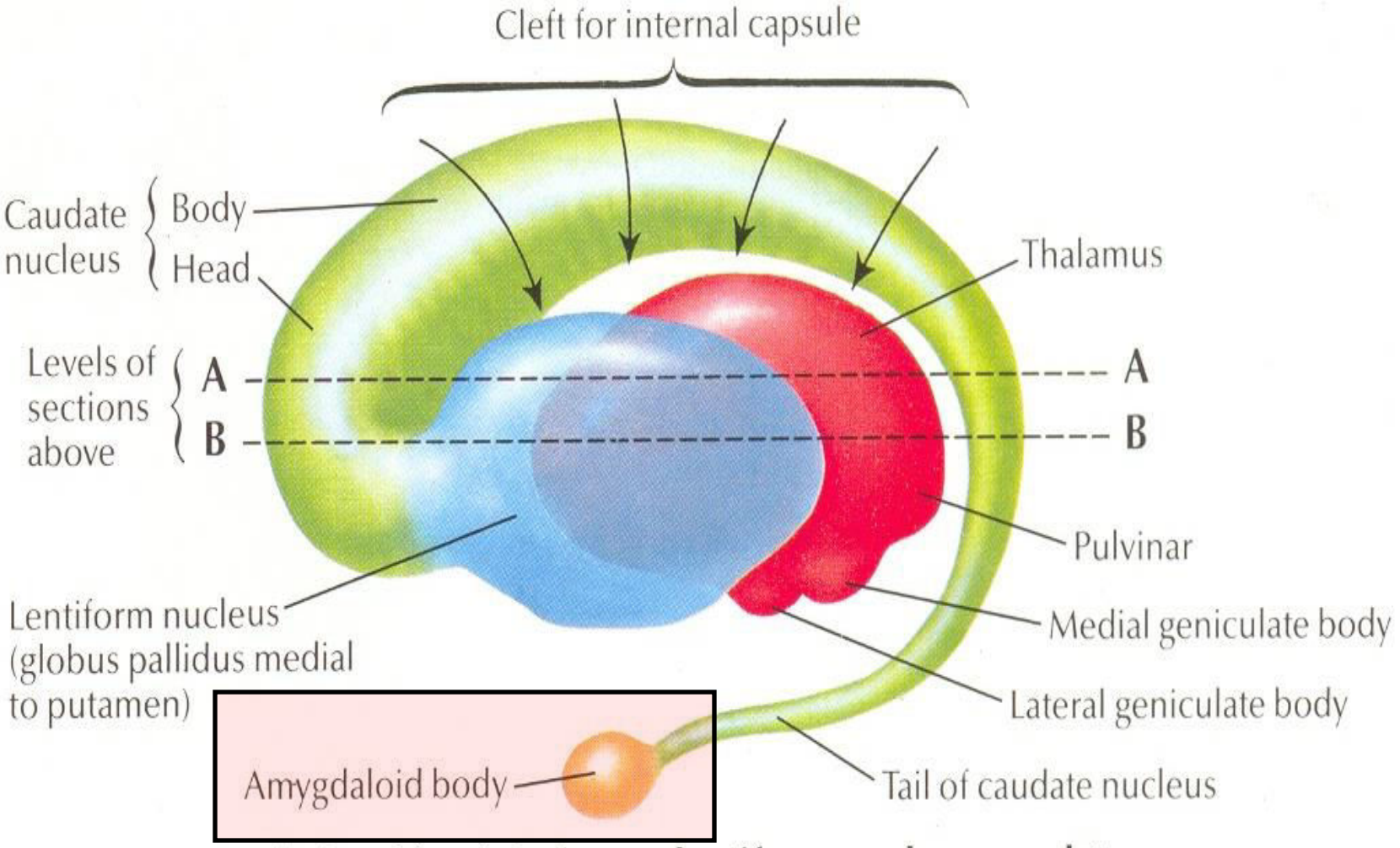
CLAUSTRUM

- Saucer-shaped mass of grey matter situated between the putamen and insula
- Considered as detached part of insula
- Neurons of claustrum acts as inter-neurons
- Precise neuronal mapping is not achieved in humans, but in animals (monkeys & cats), these are projected into visual cortex (Tanne-Gariepy et al. 2002)
- Connections and functions are not known clearly


Horizontal sections through cerebrum
A
B
Genu of corpus callosum
Lateral ventricle
Septum pellucidum
Column of fornix
Insula (island of Reil)
Interthalamic adhesion
Thalamus
Crus of fornix
Choroid plexus of lateral ventricle
Splenium of corpus callosum
Head of caudate nucleus
Anterior limb
Genu
Posterior limb
of internal capsule
Putamen
Globus pallidus
Lentiform nucleus
3rd ventricle
External capsule
Claustrum
Retrolenticular part of internal capsule
Tail of caudate nucleus
Hippocampus and fimbria
Occipital (posterior) horn of lateral ventricle
Habenula
Pineal body
A
B

AMYGDALOID BODY

- Almond shaped mass of grey matter in temporal lobe
- Lies anterosuperior to tip of inferior horn of lateral ventricle and situated deep to uncus
- Developmentally related to BG but functionally it is included in the limbic system and shares its functions.
- Posteriorly, AB becomes continuous with the tail of caudate nucleus and stria terminalis



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

CONNECTIONS OF AB

Afferent connections

- From primary olfactory regions to AB

Efferent connections

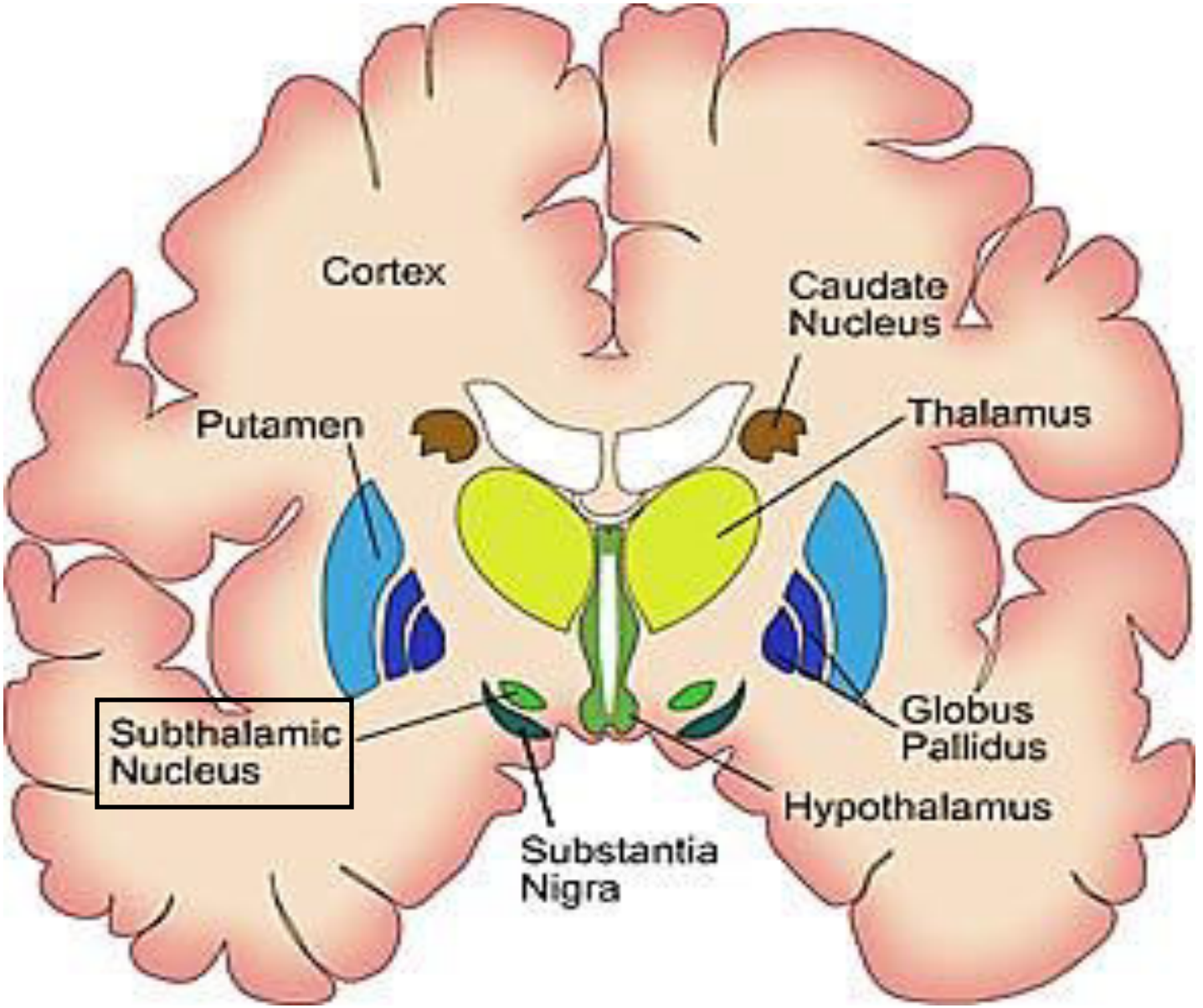
- From AB to Stria terminalis; hypothalamus and habenular nucleus

FUNCTIONS OF AB

- Plays important role in controlling the somatic responses
- It is believed that it plays an important role in smell mediated sexual behaviour
- Stimulation of AB produces excitability, fear and rage
- So bilateral damage of AB reduces fear and increases sexual activity

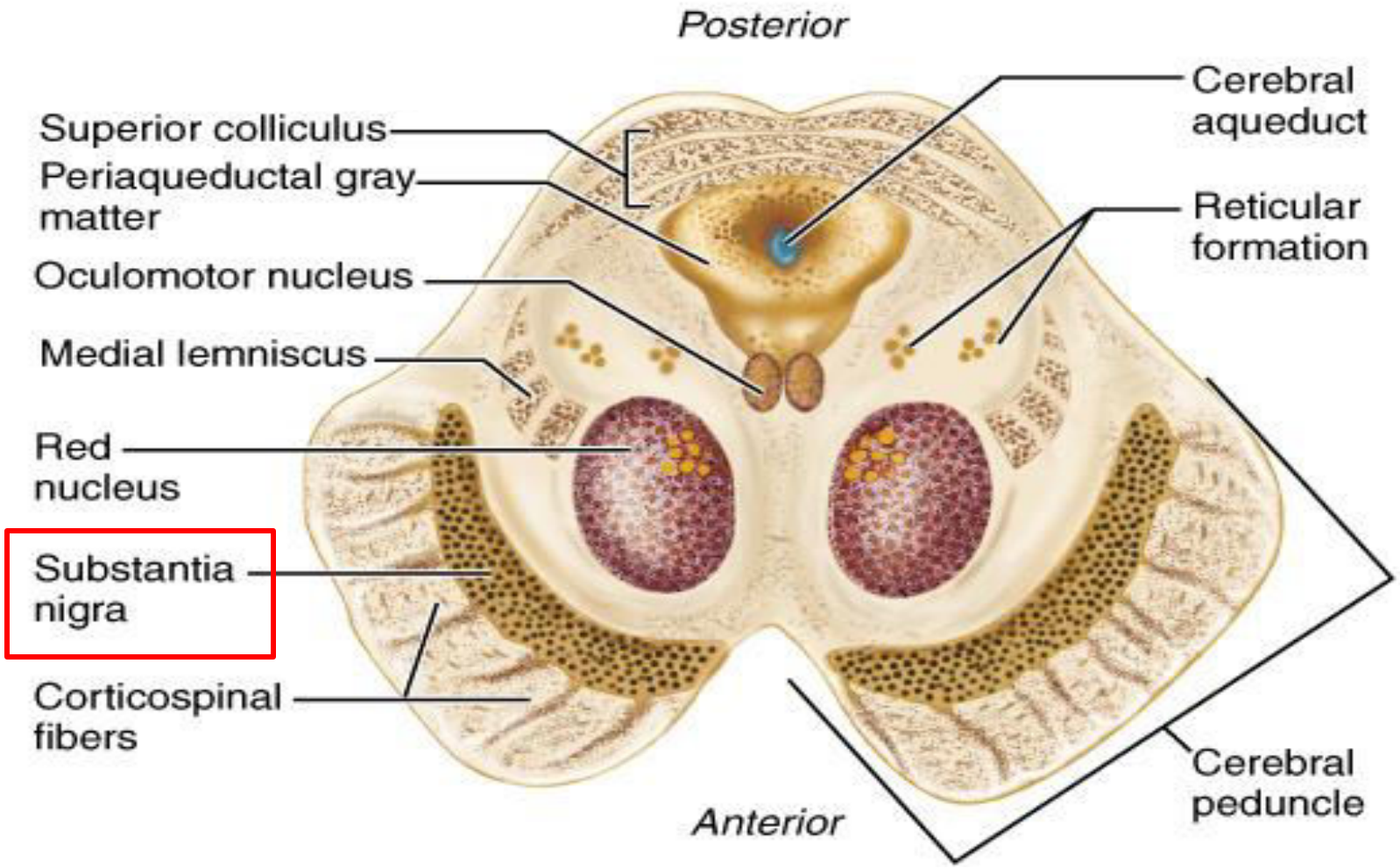
SUB-THALAMIC NUCLEUS (STN)

- Small nucleus in the ventral part of the diencephalon
- Located caudal to lateral half of thalamus and inferomedial to Globus Pallidus (GP)
- STN & GP are interconnected by subthalamic fasciculus which traverses the internal capsule


Cortex
Caudate Nucleus
Putamen
Thalamus
Subthalamic Nucleus
Globus Pallidus
Hypothalamus
Substantia Nigra

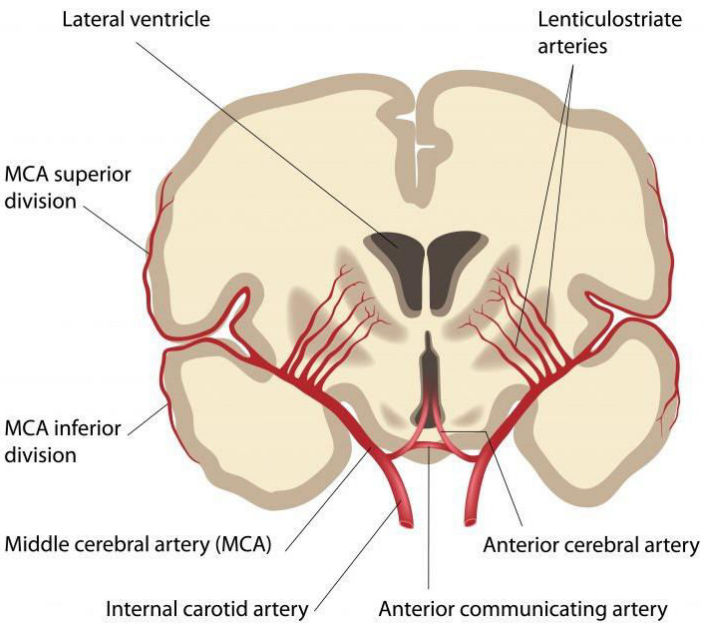
SUBSTANTIA NIGRA

- Blackish brown pigmented lamina of grey matter between the crus cerebri and tegmentum.
- Presents throughout the length of MB
- Contains the *Dopaminergic multipolar neurons
- Divided into lateral and medial part by traversed fibers of oculomotor nerve
- SN having connections with corpus striatum (caudate and putamen nucleus), red nucleus and reticular formation


Posterior
Superior colliculus
Periaqueductal gray matter
Oculomotor nucleus
Medial lemniscus
Red nucleus
Substantia nigra
Corticospinal fibers
Cerebral aqueduct
Reticular formation
Cerebral peduncle
Anterior

Vasculature to BG

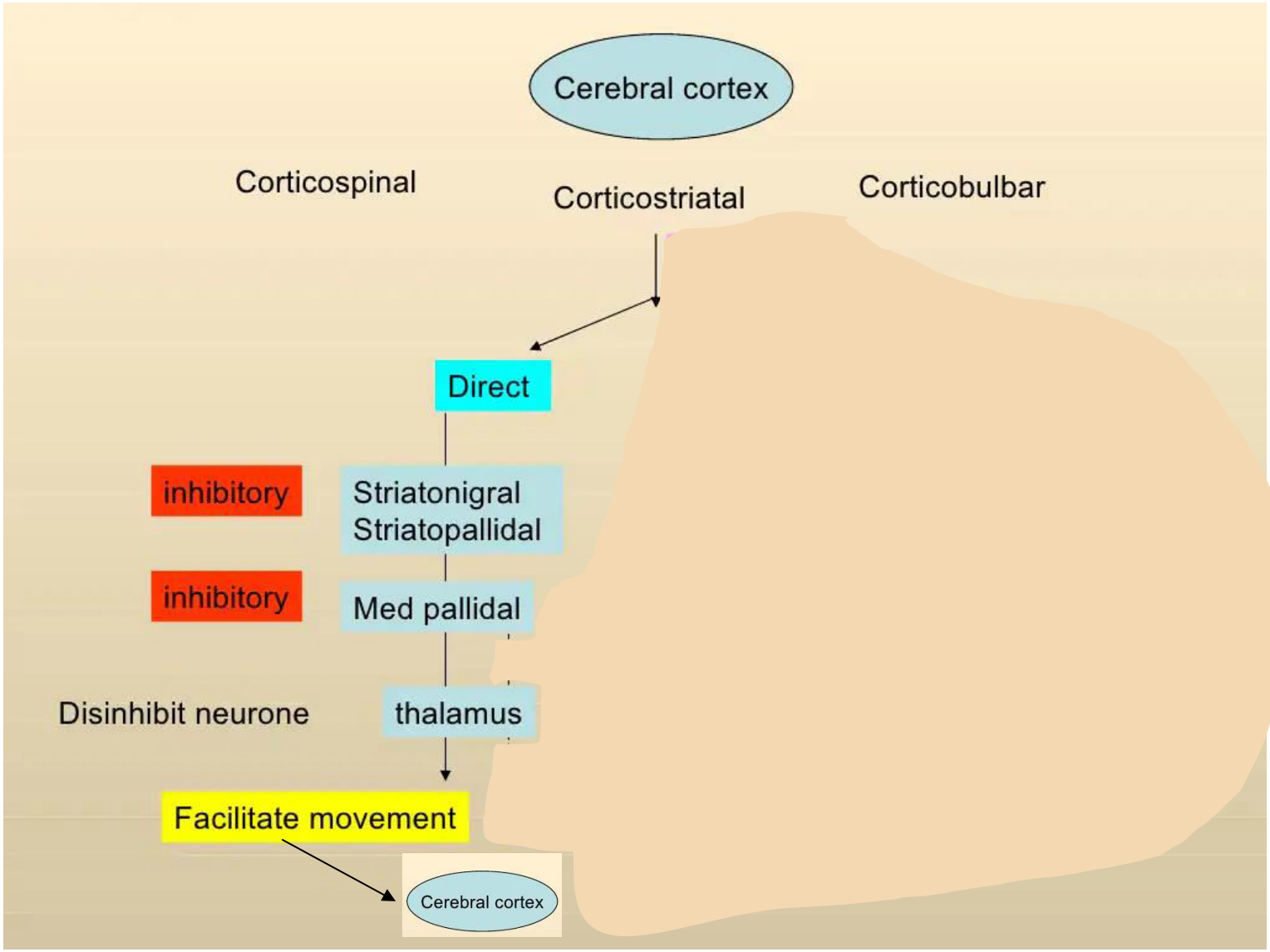
1. Middle cerebral artery via lenticulostriate branches
2. Anterior cerebral and anterior choroidal arteries – supply caudate nucleus, largest branch medial striate artery of Heubner
3. Posterior cerebral and posterior comm. arteries supply substantia nigra and subthalamic nucleus



FUNCTIONS OF BASAL GANGLIA

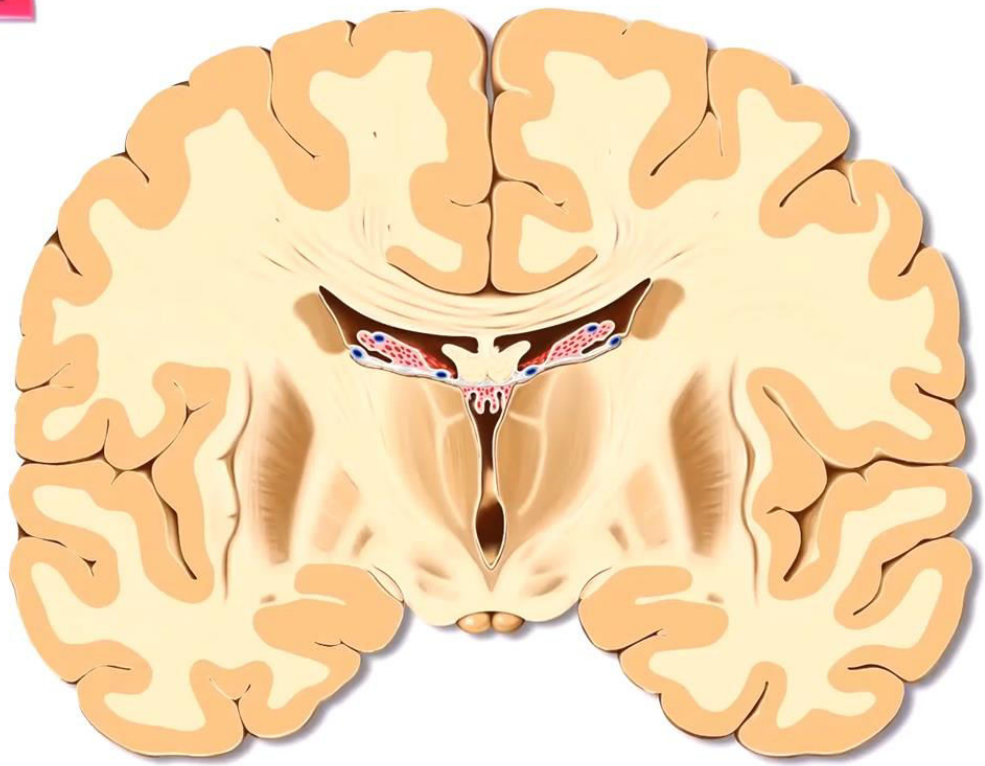
1. Concerned with planning and programming of voluntary movements
2. Determine how rapidly movement is to be performed and how large the movement must be
3. Decrease muscle tone and inhibit unwanted muscular activity
4. Regulate muscle tone for smoothening the voluntary motor activities of the body
5. Control group of movements for emotional expression

1. **Facilitates required & appropriate movements**
2. **Inhibit unwanted & inappropriate**
3. **The *deficits* tend to fall into one of two categories:**
    1. **The presence of extraneous/unwanted movements**
    2. **An absence or difficulty with intended movements**


Cerebral cortex
Corticospinal
Corticostriatal
Corticobulbar
Direct
inhibitory
Striatonigral
Striatopallidal
inhibitory
Med pallidal
Disinhibit neurone
thalamus
Facilitate movement
Cerebral cortex

Basal ganglia

Direct pathwa



Basal ganglia

Indirect pathway

MEDVIZZ

- **The balance between the cerebellum and the BG allows smooth, coordinated movement, and a disturbance in either system will show up as movement disorders.**

DISORDERS OF BASAL GANGLIA

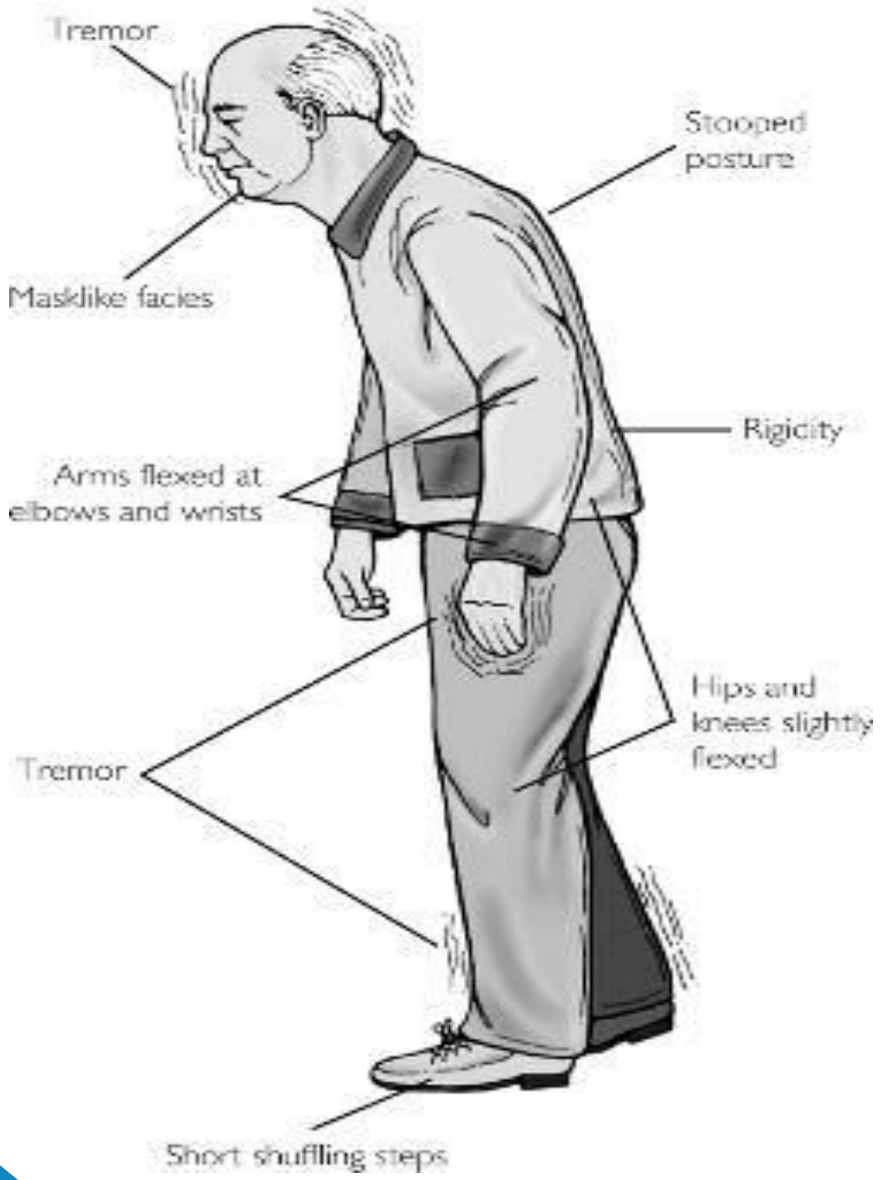
- Lesion of BG result in various forms of unwanted involuntary movements and disturbance in muscle tone.
- These disorders include Parkinsonism, Chorea, Athetosis and Ballismus

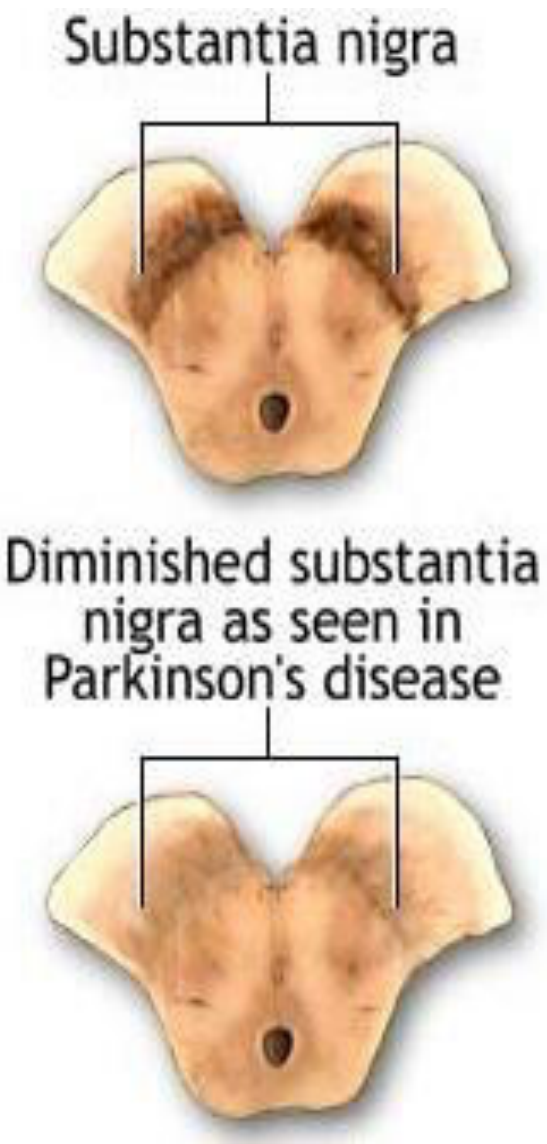
CLINICAL SYNDROMES IN LESION OF BG

- Parkinsonism – lesion is in globus pallidus
- Chorea – lesion is in caudate nucleus
- Athetosis – lesion is outer segment of putamen
- Ballismus – lesion in subthalamic nucleus

- **Parkinsonism (Parkinson's disease/PD)** – usually occurs after 50 years of age due to deficiency of dopamine in corpus striatum following a lesion in substantia nigra or nigrostriatal fibers.

- Dopamine causes inhibition of cells within the corpus striatum. The neurological changes in the parkinsonism appear to be a release phenomenon due to lack of inhibitory influences following dopamine deficiency


Tremor
Stooped posture
Masklike facies
Rigidity
Arms flexed at elbows and wrists
Hips and knees slightly flexed
Tremor
Short shuffling steps


Substantia nigra
Diminished substantia nigra as seen in Parkinson's disease

PD named after JAMES PARKINSON, who made a detailed description of this disease in his essay entitled “AN ESSAY ON THE SHAKING PALSY” in 1817

Characteristic features of Parkinsonism

- **Resting tremors** – slight shaking of hands when person is not performing a task. The tremors diminish with the movement and are exaggerated by emotional excitation
- **Rigidity** – due to joint stiffness and increased muscle tone; limb is passively moved
- **Bradykinesia** – slowness of movement; difficulty in execution of movement with planning and initiation
- **Postural instability** – impaired balance and falls

Cont……

- Memory problems
- Daytime somnolence
- Dermatitis
- Urinary incontinence
- Altered sexual function
- Gastric dysmotility and constipation
- Ophthalmological abnormalities – decreased blink; less tear film leads irritation of eye
- Reduce sense of smell
- Paresthesias

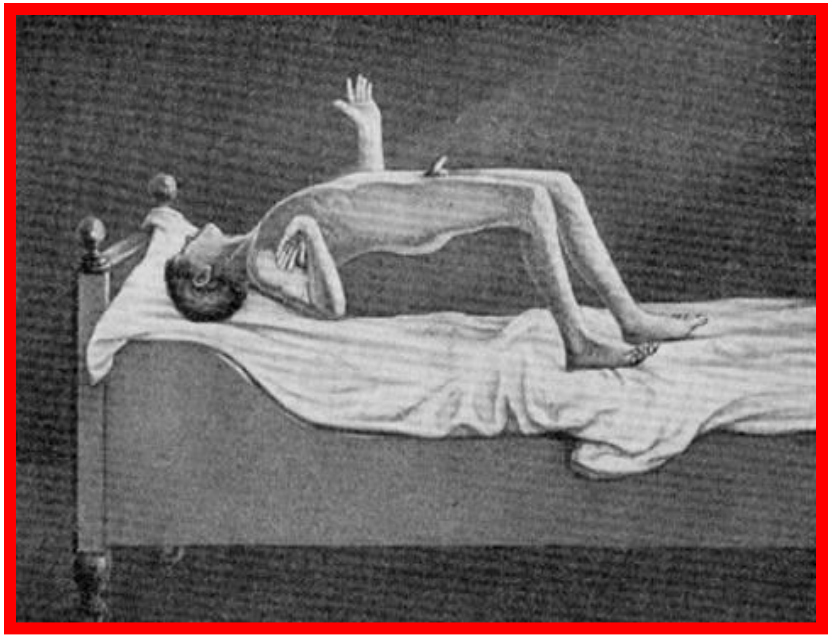
Treatment

- Administration of L-dopa, precursor of dopamine

- Implantation of fetal dopamine containing neurons (fetal stem cells from substantia nigra)

CHOREA

- Characterized by quick, jerky irregular purposeless involuntary movements
- Involve primarily in tongue, face and limbs




ALLConverter.org

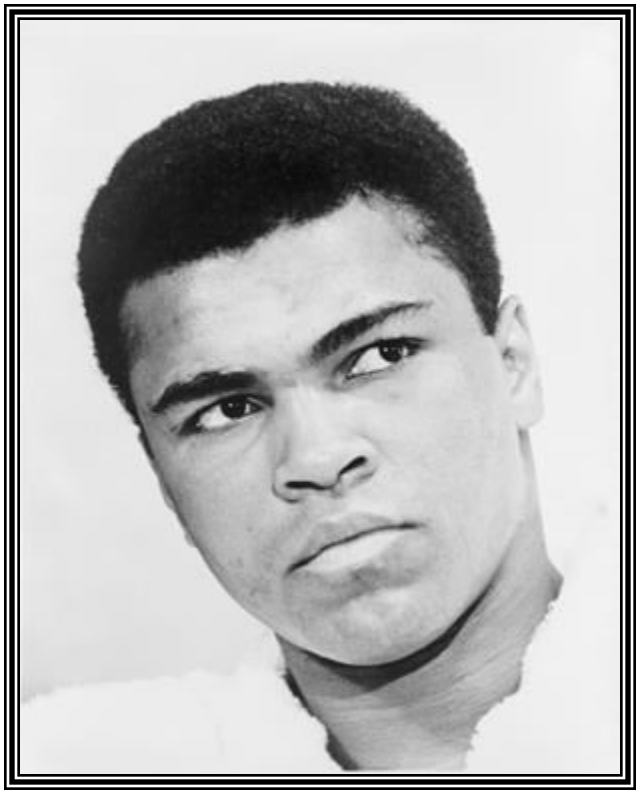
ATHETOSIS

- Slow sinuous movements
- Commonly involved in distal segments of limbs

BALLISMUS

- Due to lesion of blood vessels supplying subthalamic nucleus
- Characterized by violent irregular movement of trunk, girdles and proximal extremities
- Limbs suddenly flies in all directions out of control

- If restricted to one limb – **Monoballismus**
- If both upper and lower limbs on contralateral lesion of subthalamic nuclei - **Hemiballismus**



Muhammad Ali also called 'The Greatest Ali' (1942), American boxer and 3 time World Heavyweight Champion, failed only in initial 3 out of 54 matches. Retired in 1984 due to 'PD'

PARKINSON'S DISEASE

Resting tremor

PARKINSON'S DISEASE

Bradykinesia – slowness of movement

https://www.youtube.com/watch?v=TB6sbV4Jdno

Thanks to

Common Academic Programme Organizer, NMCGH

Dr. K. Asha Latha, Professor & Head, Anatomy Department

Dr. L. Hema, Moderator

Dr. P. SHARMILA BHANU,

Associate Professor of Anatomy

NARAYANA MEDICAL COLLEGE

Thank you All ☺