

# Overview of Basal Ganglion, Thalamus, Hypothalamus, Brainstem, and Spinal Cord – Neuroanatomy and MR Anatomy

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American Board of Pain Medicine

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Medical Director

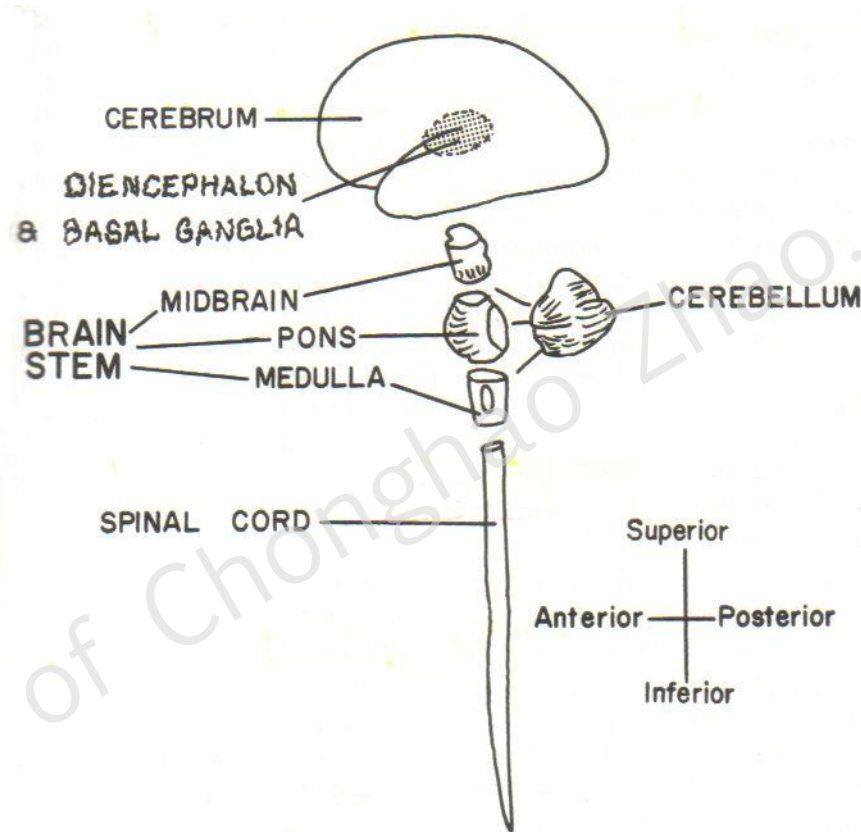


California Headache & Pain Center  
201 S. Buena Vista Street, # 238  
Burbank, CA 91505  
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1234 S. Garfield Avenue, # 205  
Alhambra, CA 91801\  
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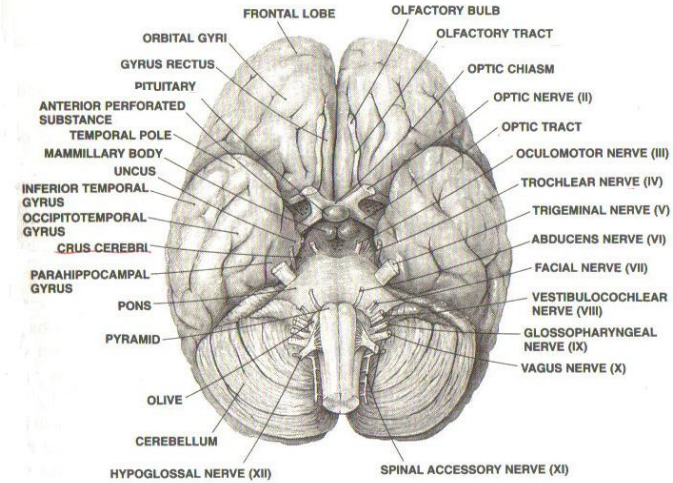
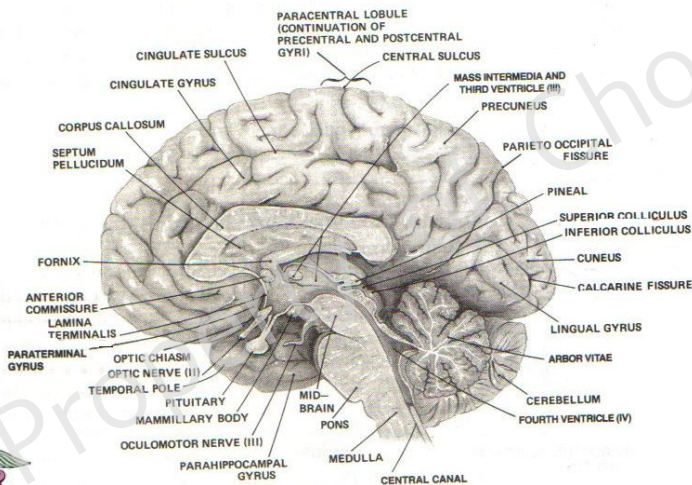
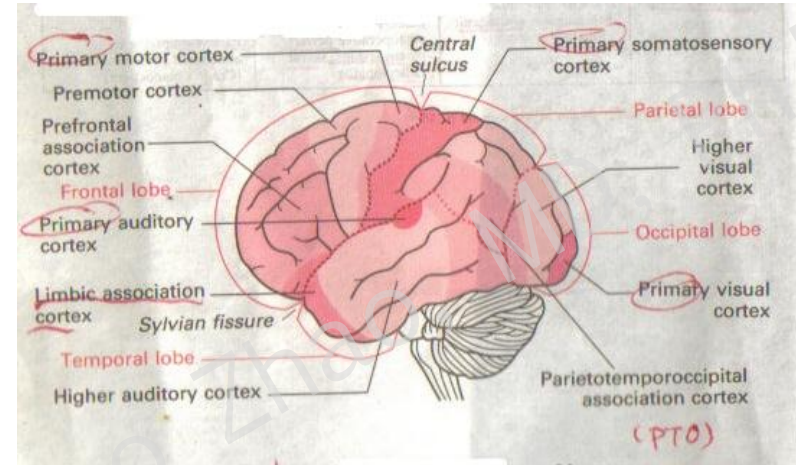
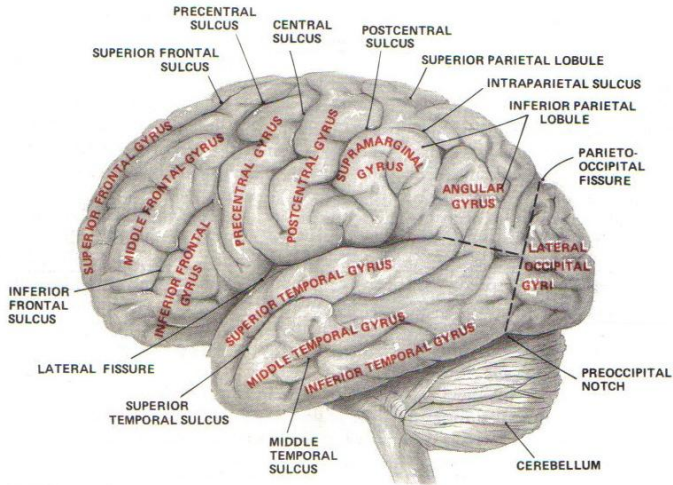
# Major Structures of Central Nervous System



\* Diencephalon: thalamus, hypothalamus, epithalamus, and subthalamus



# The Brain Anatomy and Function

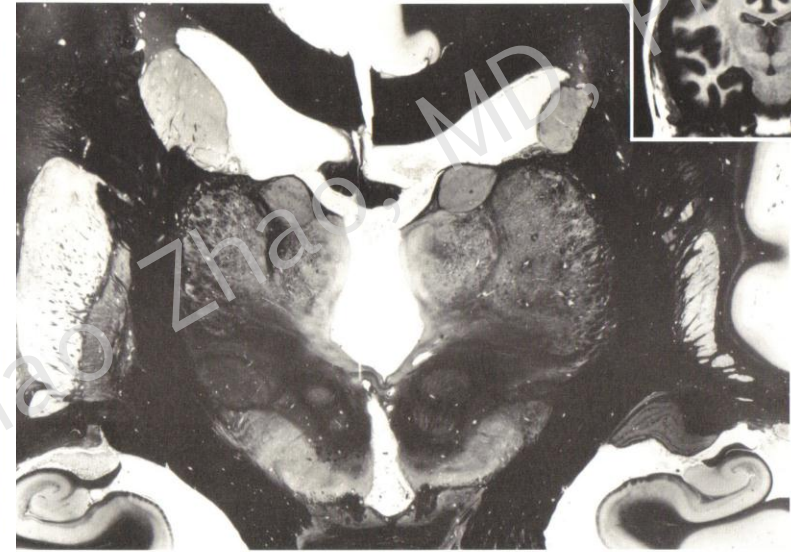
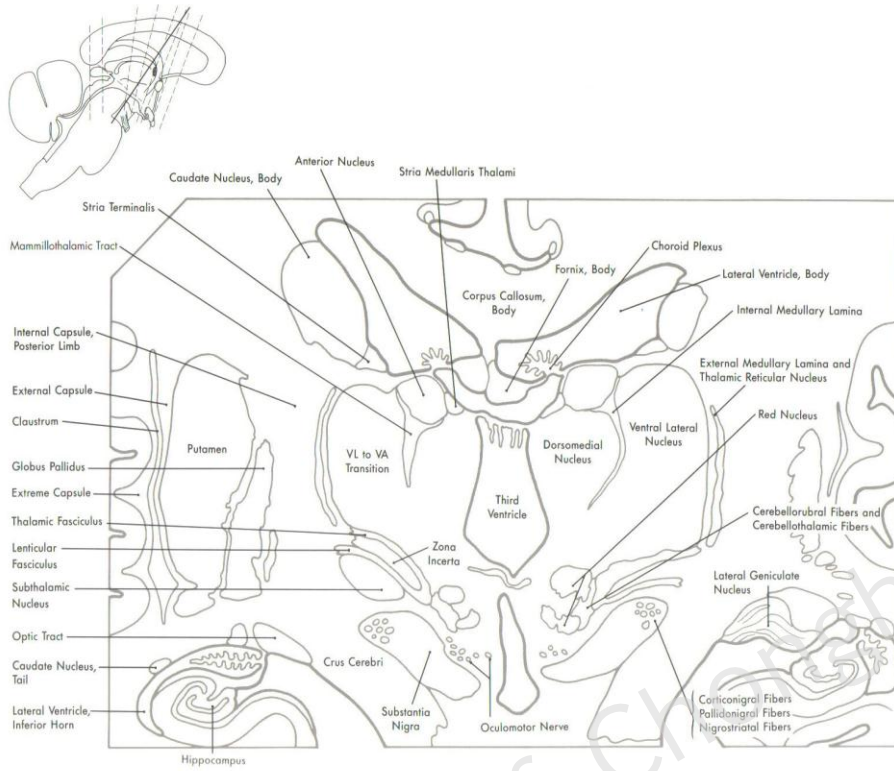


Berlit P. *Memorix of Neurology*. 1996.

Gilman S. & Newman SW. *Essentials of Clinical Neuroanatomy and Neurophysiology*. 1996



# Basal Ganglion and Thalamus



## BASAL GANGLIA NOMENCLATURE

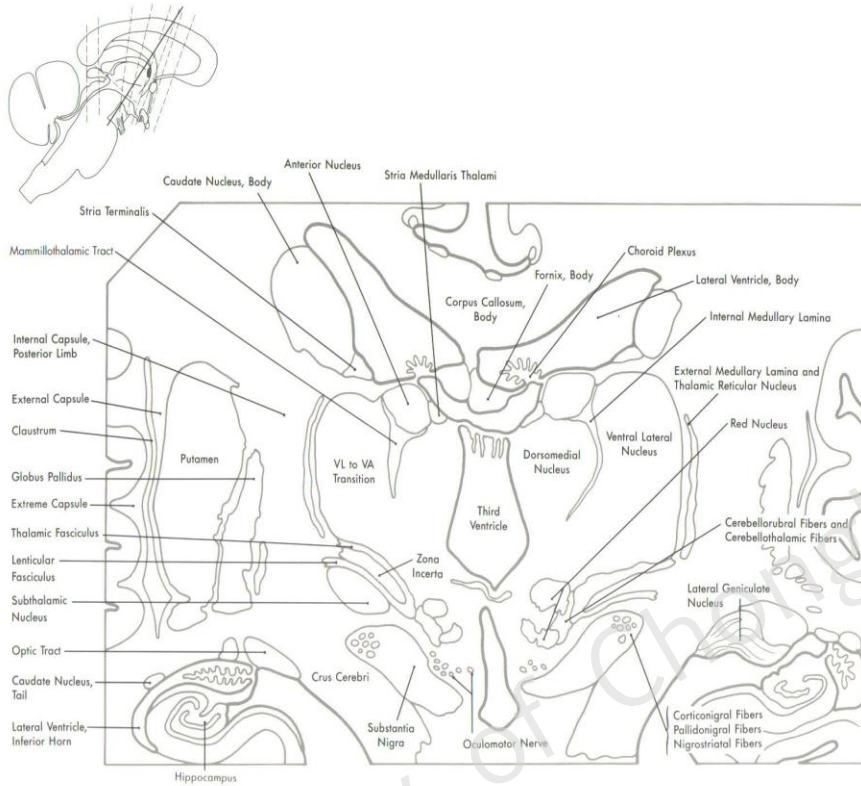
Term	Descriptive Terms		Synonym	Components
	Prefix	Suffix		
Striatum	Strio-	-striate	Neostriatum	Caudate nucleus and putamen
Pallidum	Pallido-	-pallidal	Paleostriatum	Globus pallidus
Lenticular nucleus				Putamen and globus pallidus
Corpus striatum				Caudate nucleus, putamen, and globus pallidus
Subthalamic nucleus	Subthalamo-	-subthalamic		
Substantia nigra	Nigro-	-nigral		( Pars compacta and pars reticularis )

Hanes DE. *Neuroanatomy, an atlas of structures, sections, and system*, 1995.

Gilman S & Newman SW. *Essential of clinical anatomy and physiology*, 1996.



# Basal Ganglion and Thalamus-MR View



Hanes DE. *Neuroanatomy, an atlas of structures, sections, and system*, 1995.



# Basal Ganglion Function and Disorder

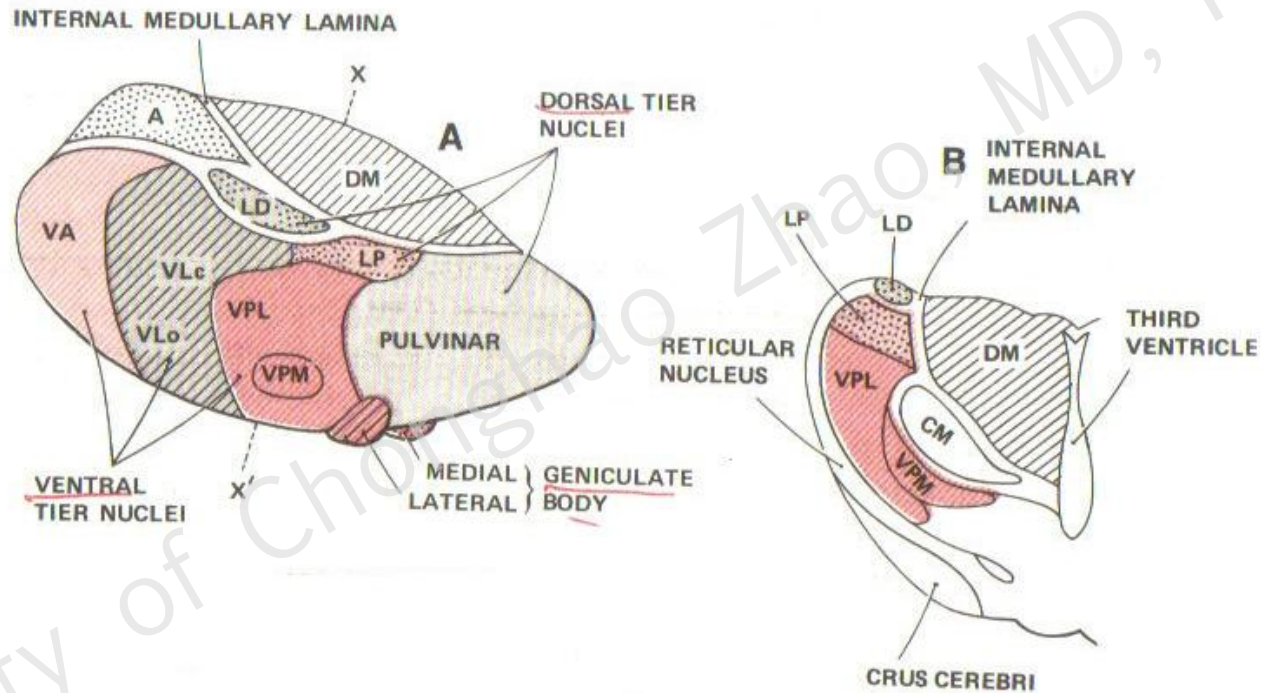
- Function: conversion of motor planning into movement pattern programming, e.g. strength, direction, speed, and amplitude of movement
- Example of disorders or symptoms:
  - Parkinson's disease: neuronal cell loss in Substantia Nigra and degeneration of nigrostriatal pathway. Symptoms of resting tremor, cogwheel rigidity, hypokinesia, impaired postural reflexes
  - Dystonia: putamen involved. Sustained twisting movements and postures.
  - Hemiballism: contralateral subthalamic nucleus. Irregular flailing and writhing movements of the limbs on one side of the body
  - Chorea: caudate nucleus. Irregular, random, jerky movements.



Berlit P. *Memorix of Neurology*. 1996.

Fahn S. et al. *Handbook of Movement Disorder*. 1997.

# Subdivision of Thalamus



Gilman S & Newman SW. *Essential of clinical anatomy and physiology*, 1996.

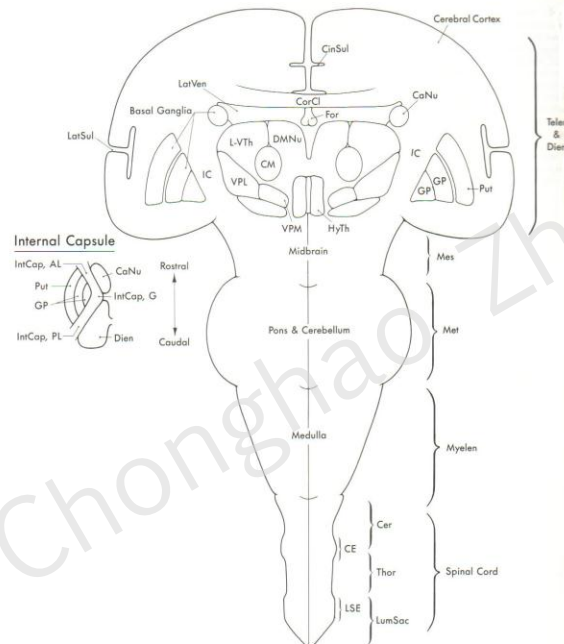
# Thalamus Function

- Anterior thalamic nucleus (A): Receives fibers from mammillothalamus tract and hippocampal formation, related to attention, memory, and learning.
- Centromedian nucleus (CM): receives fibers from GP, projects to putamen and caudate nucleus
- Ventral anterior nucleus (VA): Receives fibers from substantia nigra and globus pallidus, projects to premotor cortex and supplementary motor cortex.
- Ventral posterior nucleus complex (VP): receives fibers from medial lemniscus, the gustatory pathways, the secondary trigeminal tracts, and part of the spinothalamic system; projects to the postcentral gyrus areas 3,2,1 or primary somatosensory cortex. Regulate the somatosensory and taste function.
  - Ventral posteriorlateral nucleus (VPL): whole body sensory except the head
  - Ventral posteriormedial nucleus (VPM): sensory of the head, taste fibers from the nucleus of the solitary tract.
- Medial geniculate body (MGB): receives auditory impulses from inferior colliculus, projects to auditory cortex of the superior temporal gyrus.
- Lateral geniculate body (LGB): connected with optic radiations via geniculocalcarine tract and visual cortex.





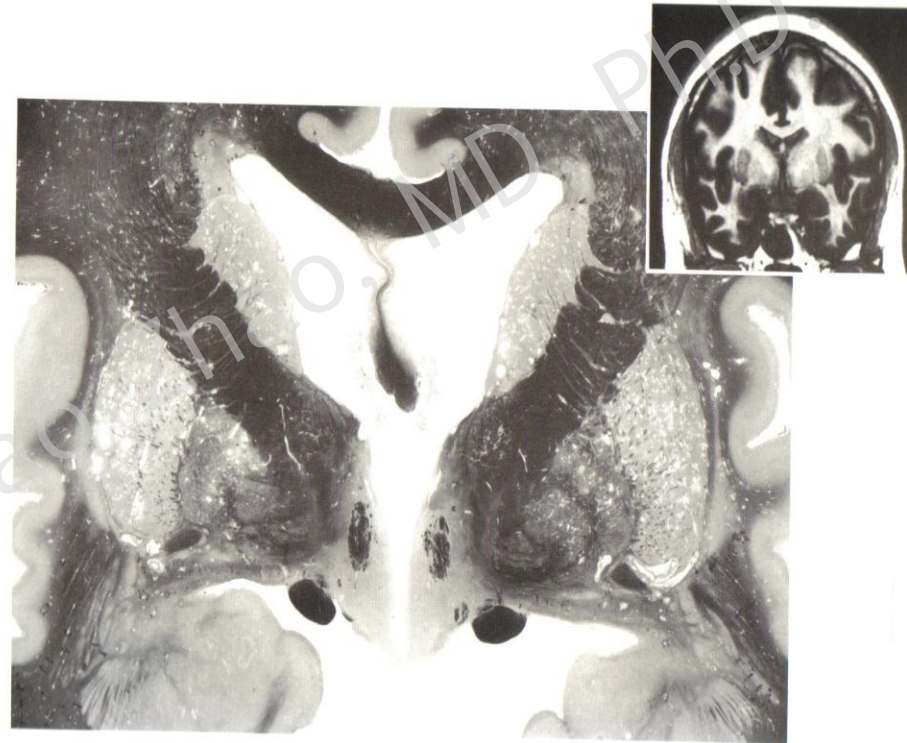
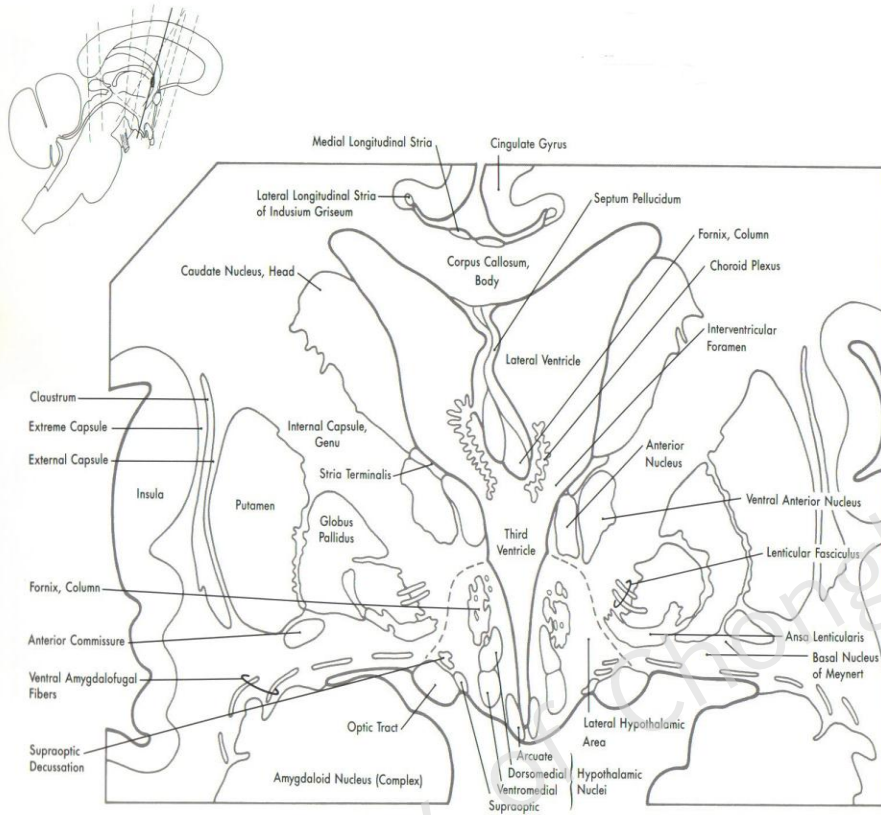
# Schematic View of Basal Ganglion, Thalamus, Hypothalamus



- Thalamic pain syndrome: e.g. tumor in the thalamus, causing a vague sense of pain without the ability to accurately localize it.
- Central Pain: involving the lesion of spinothalamic or trigeminothalamic tracts, resulting in spontaneous pain.
- Thalamic syndrome: e.g. stroke, combination of hemianesthesia with spontaneous pain and hemi



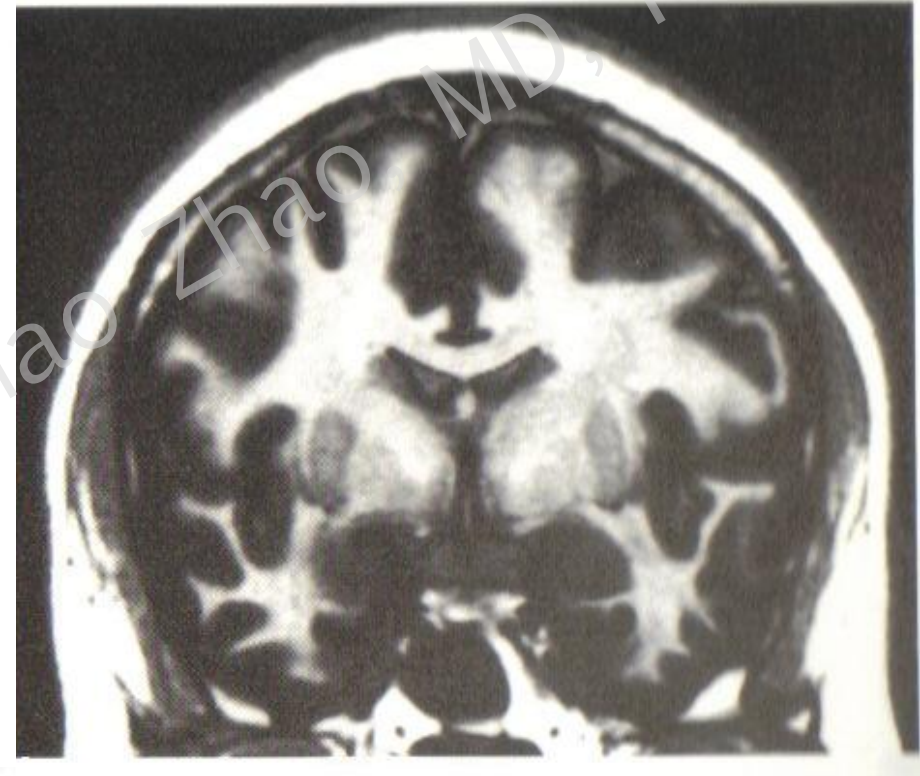
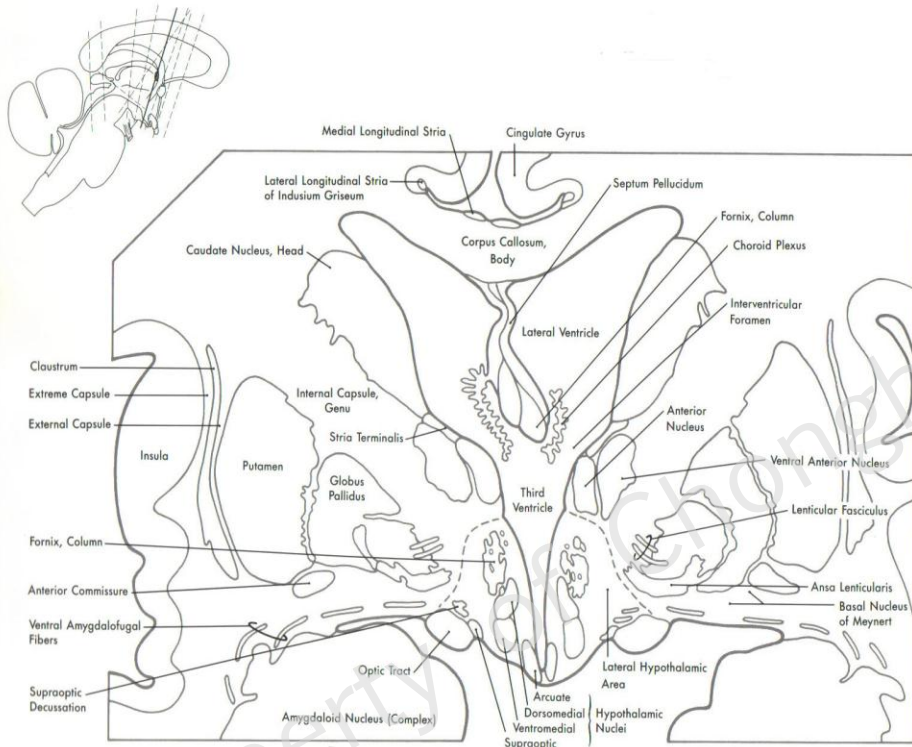
# Basal Ganglion, Thalamus, Hypothalamus



Hanes DE. *Neuroanatomy, an atlas of structures, sections, and system*, 1995.



# Basal Ganglion, Thalamus, Hypothalamus – MR View



# Hypothalamus Connections

- Hypothalamus:
  - forms the floor and ventral part of the walls of the 3rd ventricle.
  - Major nuclei:
    - Suprachiasmatic nucleus: dorsal to the optic chiasm, receives input from the retina
    - Supraoptic and paraventricular nuclei: terminate in the posterior pituitary, where they secrete oxytocin and vasopressin into the systemic circulation.
    - Arcuate nucleus: regulating the anterior pituitary function.
  - Major connections:
    - limbic system (stria terminalis, ventral amygdalofugal pathway, fornix)
    - Autonomic system: fibers from paraventricular nucleus and lateral hypothalamus descend through medial forebrain bundle to visceral sensory neurons (nucleus solitarius) and preganglionic parasympathetic nuclei in the brainstem (dorsal motor nucleus of the vagus and nucleus ambiguus) and to both sympathetic and parasympathetic cell groups in the spinal cord.
    - Reticular formation: to regulate the sleep-wakefulness rhythm.

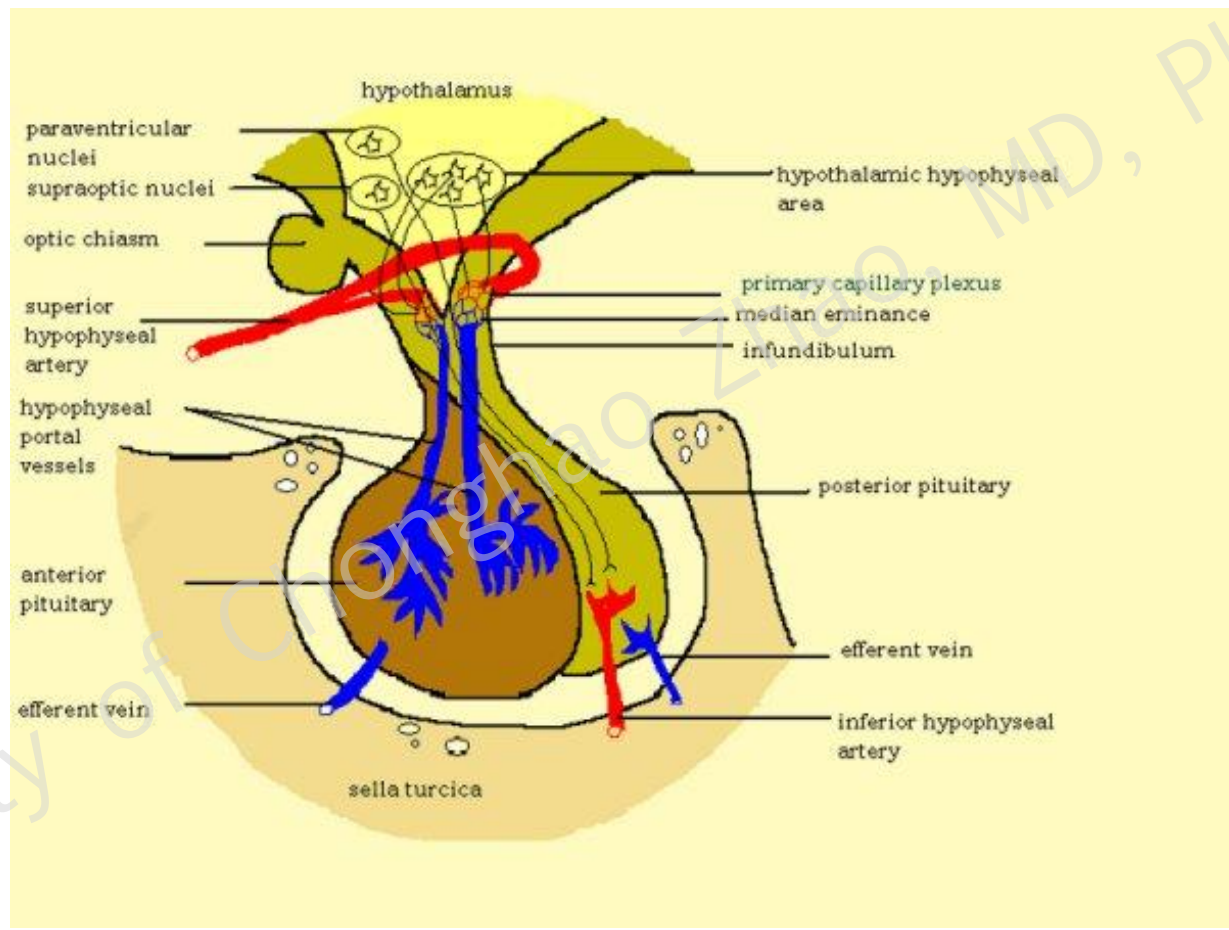


# Hypothalamus Function

- Endocrine: hypothalamic-pituitary relationships
  - Supraoptic and paraventricular nuclei: producing peptide hormones oxytocin and vasopressin, transported via hypothalamohypophyseal tract, and secreted from posterior pituitary (neurohypophysis)
- Reproductive physiology and behavior
  - Arcuate nucleus and other parts of the periventricular zone of the hypothalamus producing peptide-releasing or inhibiting hormone, transported to the anterior pituitary, stimulate the release of ACTH, TSH, FSH, LH, GH, prolactin; inhibit the release of GH (somatostatin), prolactin.
- Body temperature:
  - preoptic region and anterior hypothalamic area, integrate the autonomic reflexes (e.g. peripheral vasoconstriction, vasodilation and sweating), and somatic motor or behavioral response (e.g., shivering, seeking a warmer or cooler environment) to regulate body temperature at 37 ° C.
- Food intake:
  - Ventromedial nucleus: the satiety center, lesion of it causes obese due to overeating
  - Lateral hypothalamus: the feeding center for eating and drinking, lesion of it causes death due to lack of water and nourishment.
- Emotion:
  - Involving connection to cerebral cortex, amygdala or the hippocampal formation.
  - Regulating the autonomic discharge: acceleration of the heart rate, elevation of blood pressure, flushing or pallor of the skin, sweating, dryness of the mouth, disturbances of the gastrointestinal tract.



# Hypothalamus – Pituitary Axis



# Hypothalamus – Pituitary Axis

The diagram illustrates the hypothalamus and pituitary gland. The hypothalamus is shown at the top with several neurohormones (CHRH, TRH, LHRH, GHRH, PAH, GH/PIH) being released into the portal vessels. These vessels lead to the anterior lobe (adenohypophysis) and the posterior lobe (neurohypophysis). The anterior lobe releases ACTH, TSH, FSH, and LH. The posterior lobe releases GH and Prolactin. The pars intermedia is also shown.

The anterior lobe is site of formation and storage of 6 hormones: 4 messenger hormones that act on other endocrine glands:

- ACTH (→ adrenals: ↑ Cushing's syndrome, ↓ Addison's disease)
- TSH (→ thyroid: hyper-, hypothyroidism)
- FSH (→ gonads)
- LH (→ gonads)

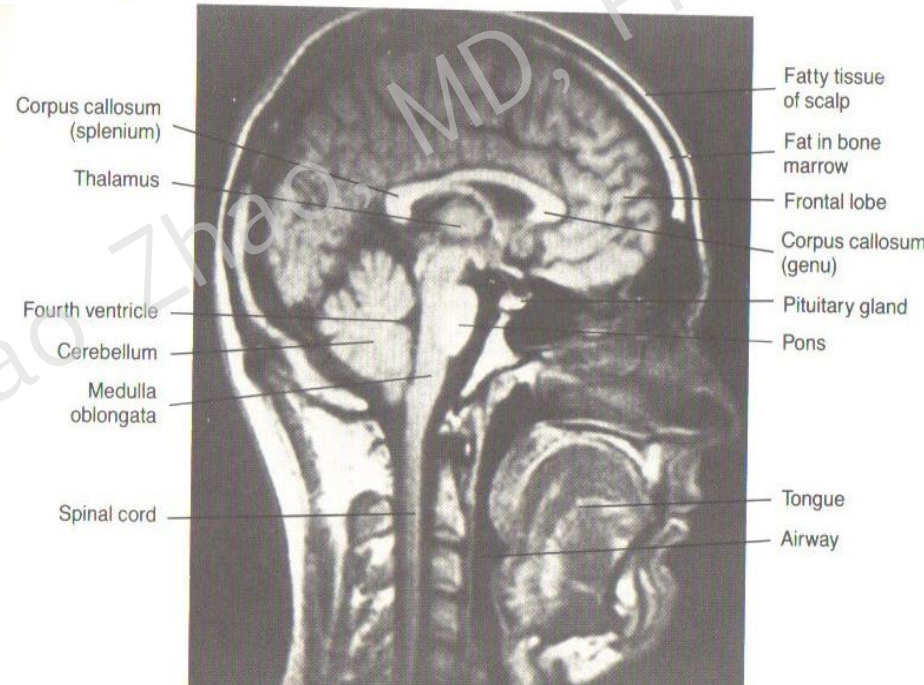
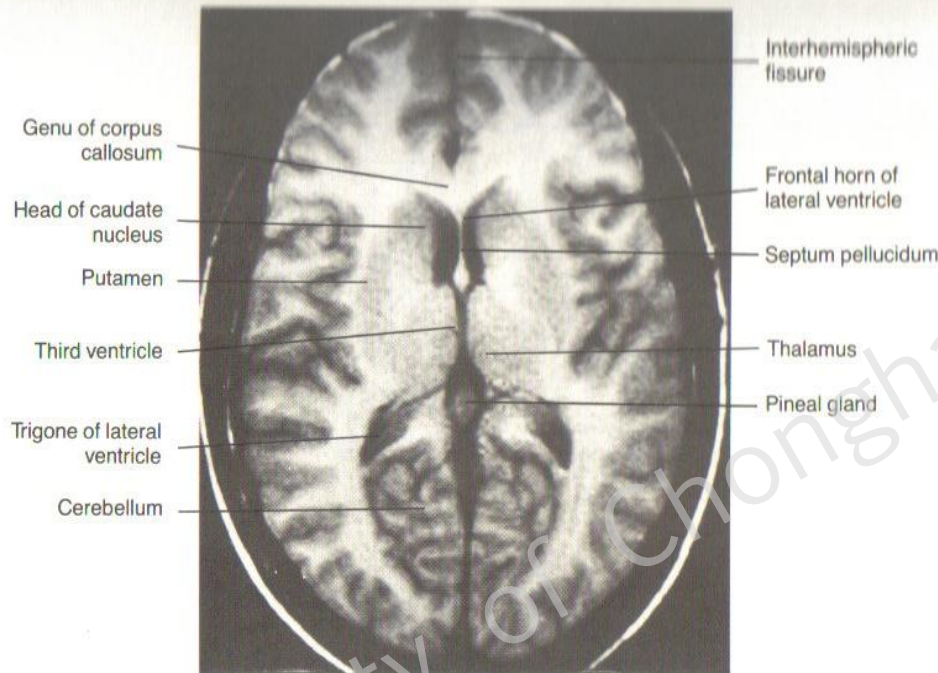
The two direct acting hormones act on other systems or whole organism:

- GH (→ all cells of body: ↑ gigantism or acromegaly)
- Prolactin (→ many cells: ↑ galactorrhoea, secondary amenorrhoea; impotence, gynaecomastia)

Control of release of all anterior lobe hormones is exclusively humoral via 6 hypothalamic neurohormones (table below)

ACTH: adrenocorticotrophic hormone (corticotrophin); TSH: thyroid stimulating hormone (thyrotrophin); FSH: follicle stimulating hormone; LH: luteinising hormone (both FSH and LH are gonadotrophins); GH: growth hormone, also STH: somatotrophic hormone (somatotropin)

# Cerebellum Anatomy and MR View



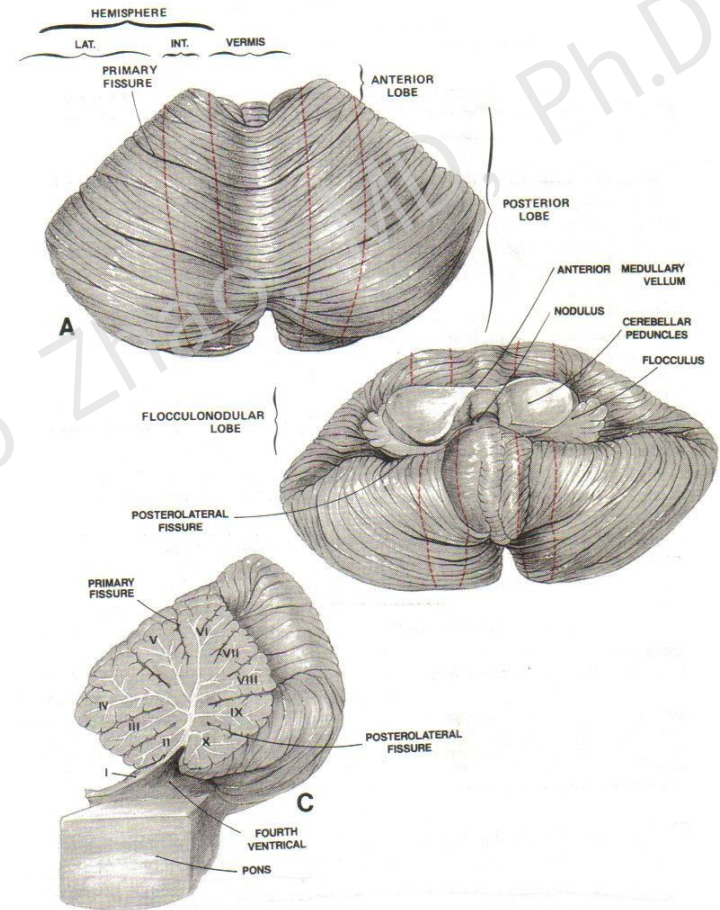
Squire LF & Novelline RA. *Fundamentals of Radiology*. 1988.



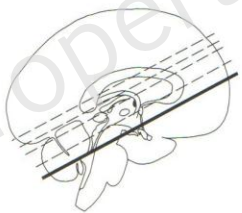
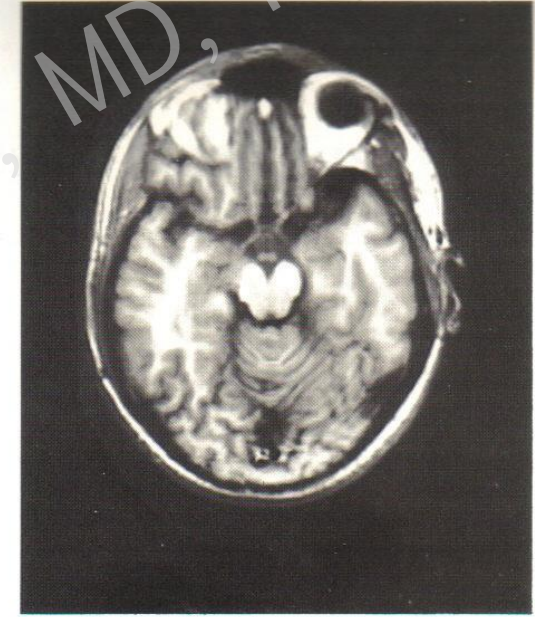
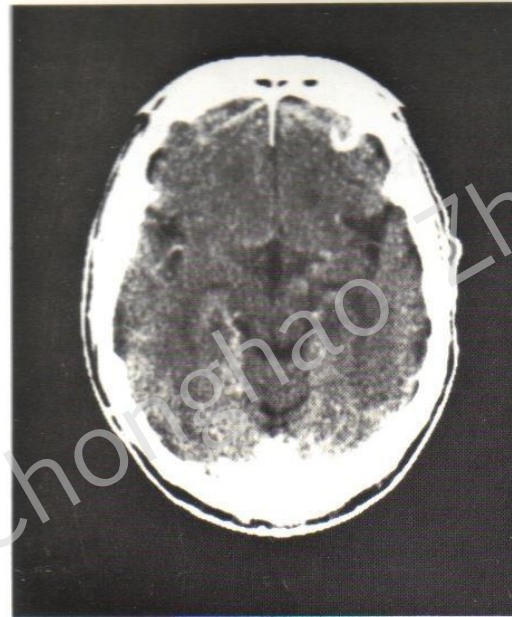
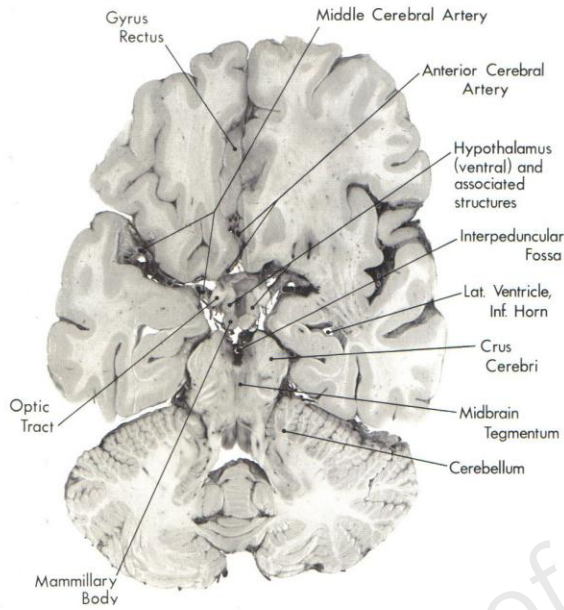


# Cerebellar Function

- Postural supporting (posture, tone, equilibration)
- Slower aimed movements and coordination with supportive postural measures
- Articulation, eye movement saccades, music performance, sport



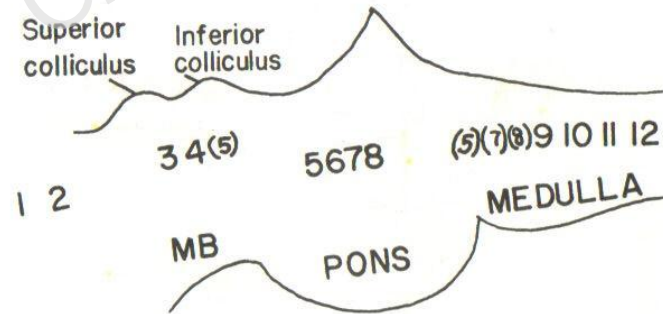
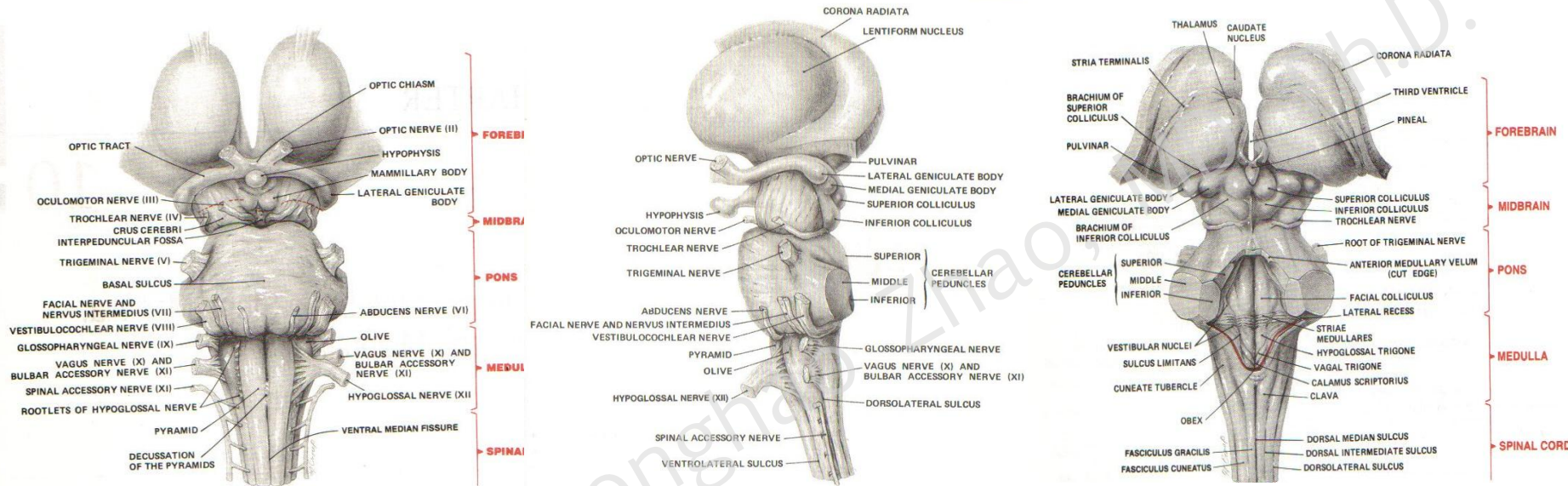
# Brainstem CT and MR View



Hanes DE. Neuroanatomy, an atlas of structures, sections, and system, 1995.



# Brainstem Anatomy

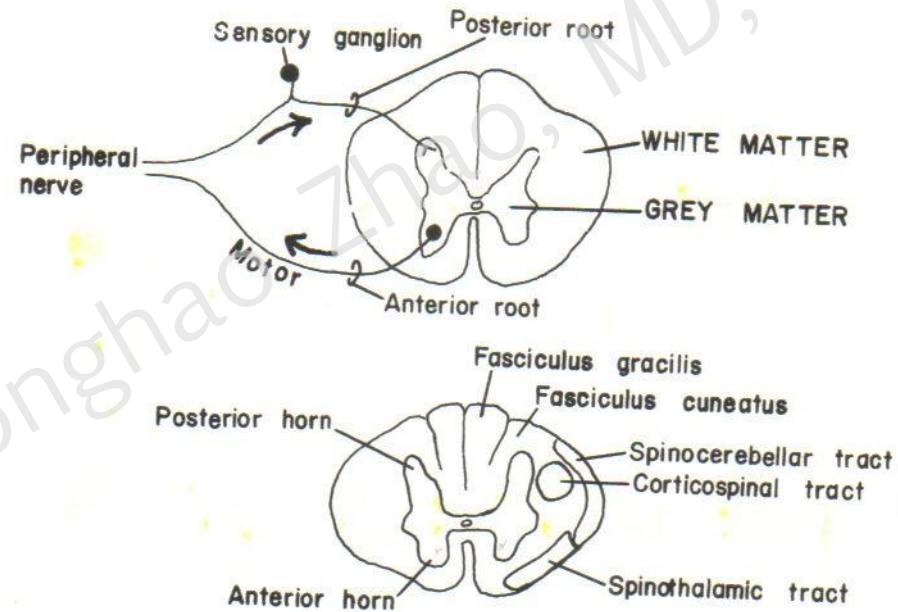
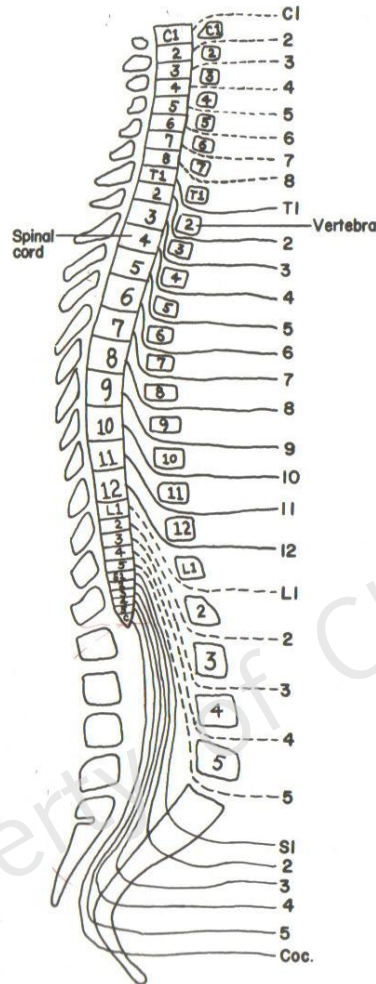


Goldberg S. *Clinical Neuroanatomy*, 1990.

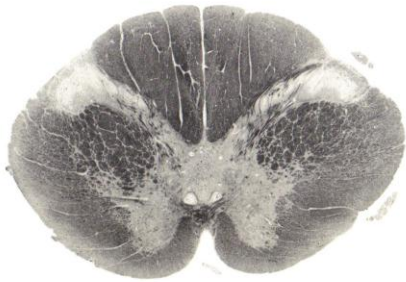
Gilman S. & Newman SW. *Essentials of Clinical Neuroanatomy and Neurophysiology*. 1996



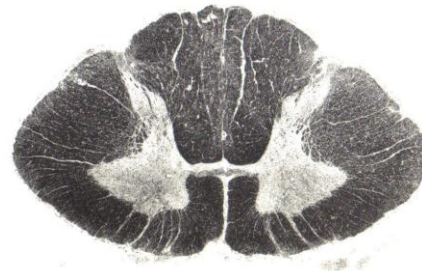
# Schematic View of Spinal Cord



# Spinal Cord Traverse Section



C1



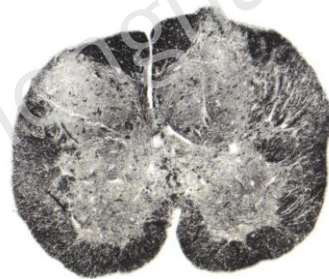
C7



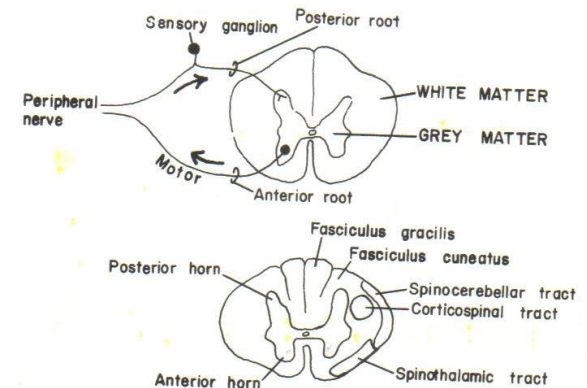
T4



L4



Sacral



Goldberg S. *Clinical Neuroanatomy*, 1990.

Hanes DE. *Neuroanatomy, an atlas of structures, sections, and system*, 1995.

# Spine Anatomy and MR Saggital View

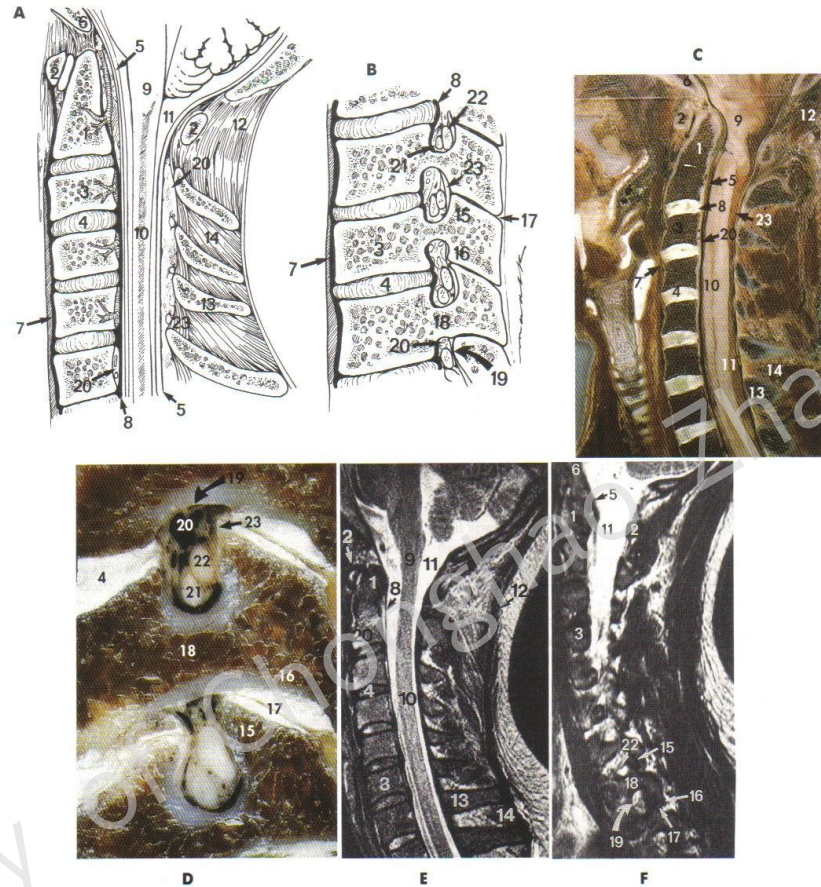


Fig. 19-6. Sagittal anatomy of the cervical spine and spinal cord. A and B, Anatomic drawings through the midline (A) and neural foramina (B). C and D, Cryomicrotome sections with midline anatomy (C) and close-up view of the neural foramen (D). E, Midline sagittal T2-weighted MR scan shows the cervical spine and spinal cord. F, More lateral scan shows the neural foramina and exiting roots. 1, Dens with odontoid process. 2, Cl. 3, Vertebral body. 4, Intervertebral disk. 5, Dura. 6, Clivus. 7, Anterior longitudinal ligament. 8, Posterior longitudinal ligament. 9, Cervicomedullary junction. 10, Cervical spinal cord with central gray matter. 11, Subarachnoid space. 12, Ligamentum nuchae. 13, Spinous process. 14, Interspinous ligament. 15, Superior articular facet. 16, Inferior articular facet. 17, Facet joint. 18, Pedicle. 19, Neural foramen. 20, Epidural veins and fat. 21, Anterior (ventral) roots. 22, Posterior roots and dorsal root ganglia. 23, Ligamentum flavum. (C and D, Courtesy V.M. Haughton.)

Osborn AG. *Diagnostic neuroradiology* 1994.