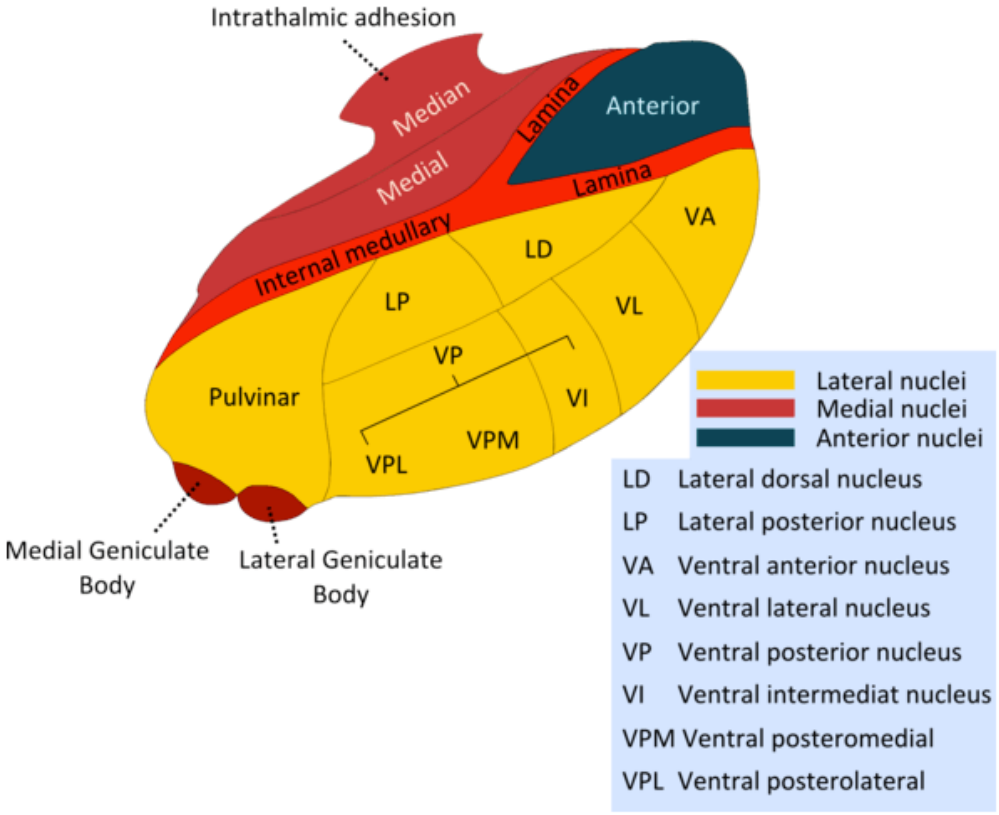
UNIVERSITY OF ZAMBIA
SCHOOL OF MEDICINE

- **HUMAN ANATOMY**

Topic: Thalamus



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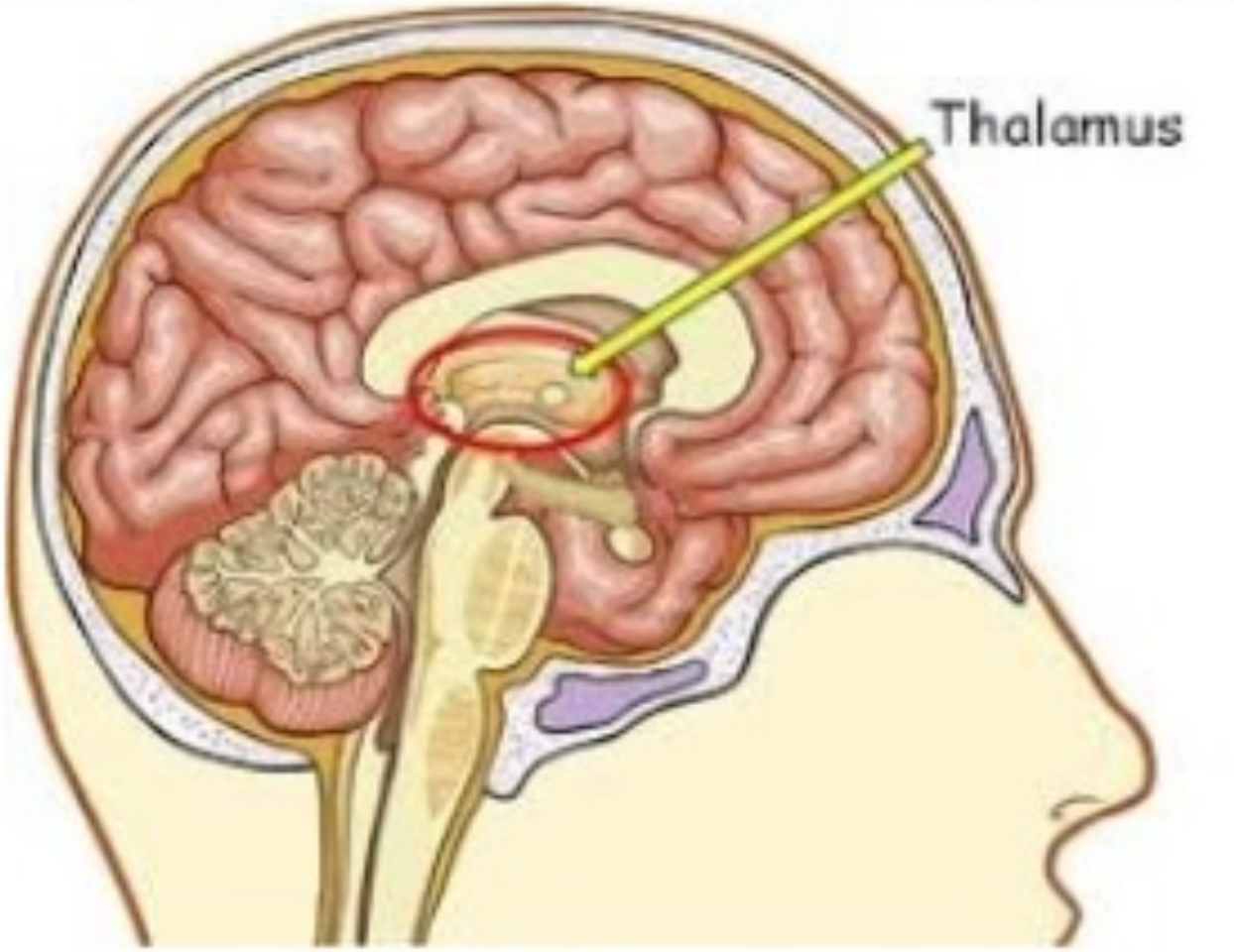
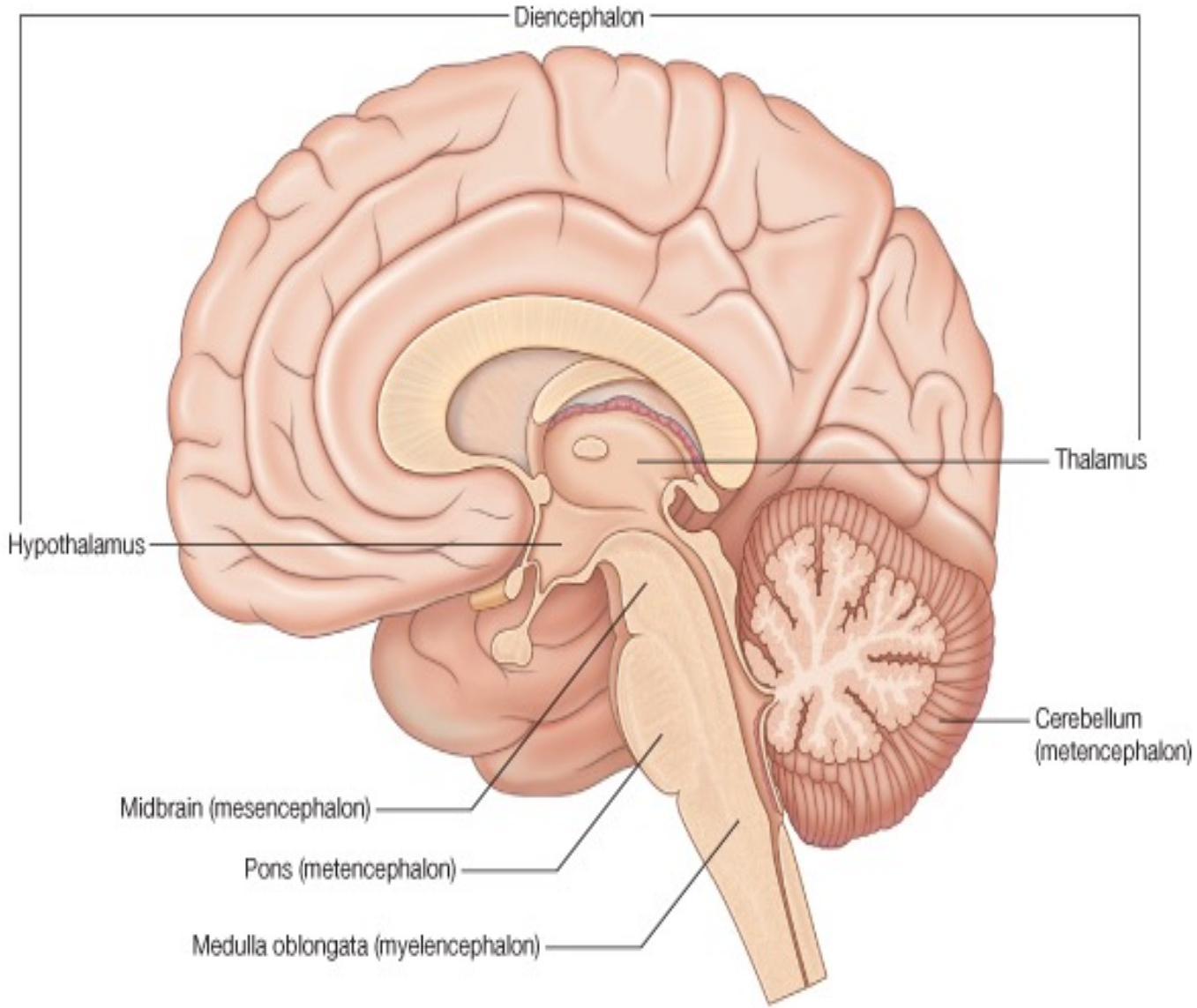
Introduction

- **Thalamus means ”inner chamber” or “bedroom” in Greek**
- Is an important processing station in the center of the brain
- **Nearly all pathways that project to the cerebral cortex do so via synaptic relays in the thalamus**
- The thalamus is often thought of as the major sensory relay station
- However, in addition to sensory information, the thalamus also conveys nearly all other inputs to the cortex including motor inputs from the cerebellum and basal ganglia, limbic inputs, widespread modulatory inputs involved in behavioural arousal and sleep-wake cycles and other inputs
- Some thalamic nuclei have specific topographical projections to restricted cortical areas while others project more diffusely

Introduction

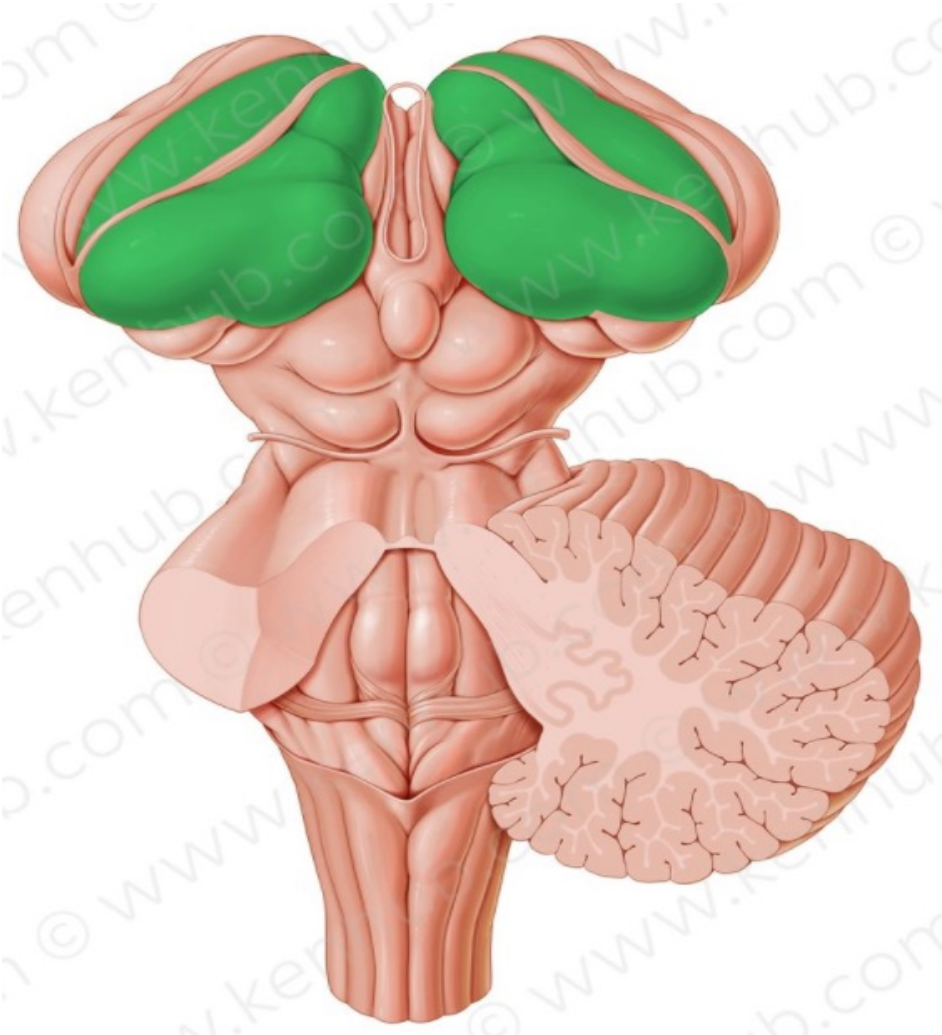




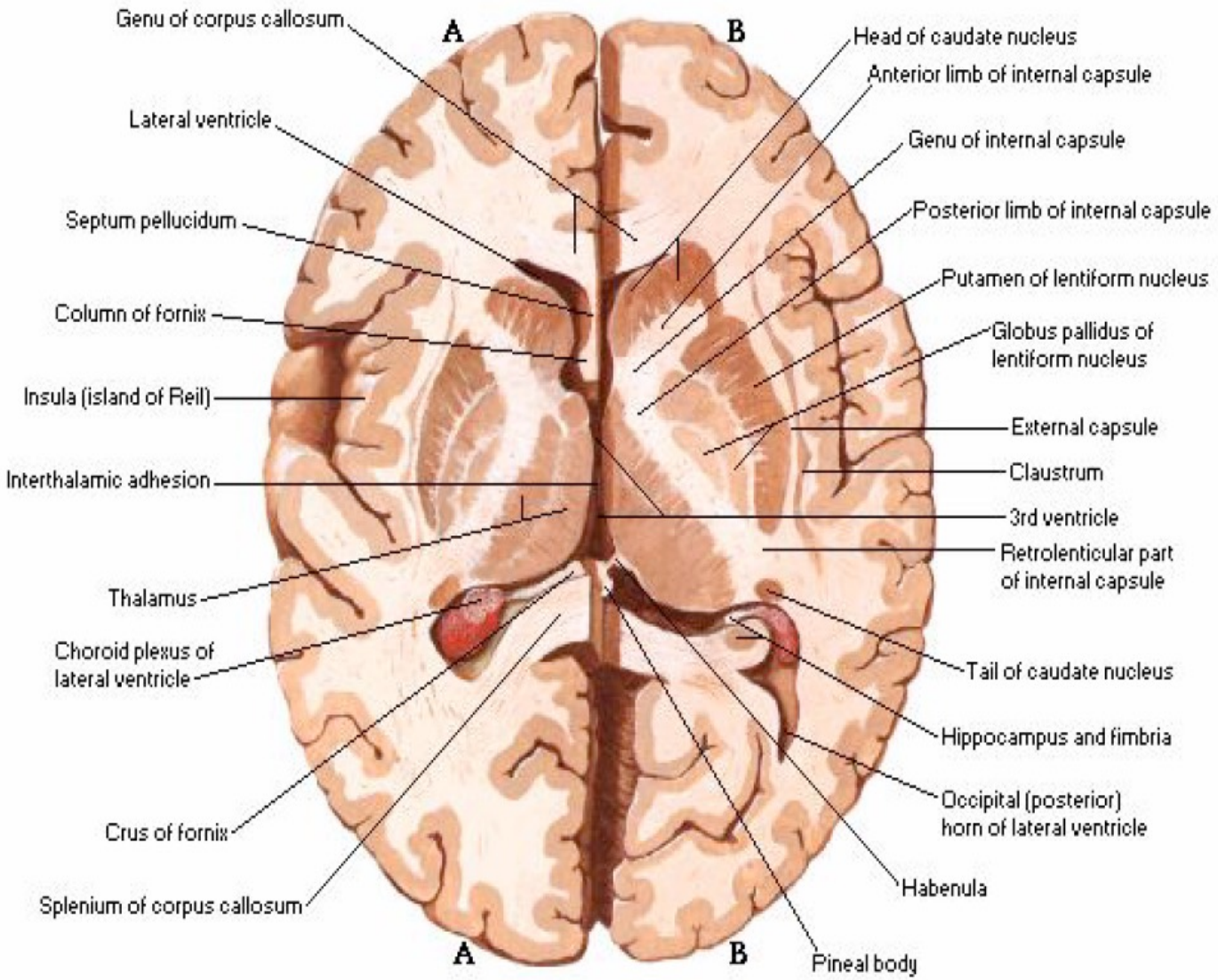
Introduction

- Thalamic nuclei typically receive dense reciprocal feedback connections from the cortical areas to which they project
- **In fact, corticothalamic projections outnumber thalamocortical projections**
- **The thalamus is part of the diencephalon together with the hypothalamus and epithalamus**
- Diencephalon is located just rostral to the midbrain
- Hypothalamus is located immediately beneath the thalamus
- The epithalamus consists of several small nuclei including the **habenula,** parts of the **pretectum** and the **pineal body**
- In horizontal sections, the thalami are visible as deep, gray matter structures shaped like eggs with their posterior ends angled outward forming an inverted V

Introduction



Horizontal Sections through Cerebrum

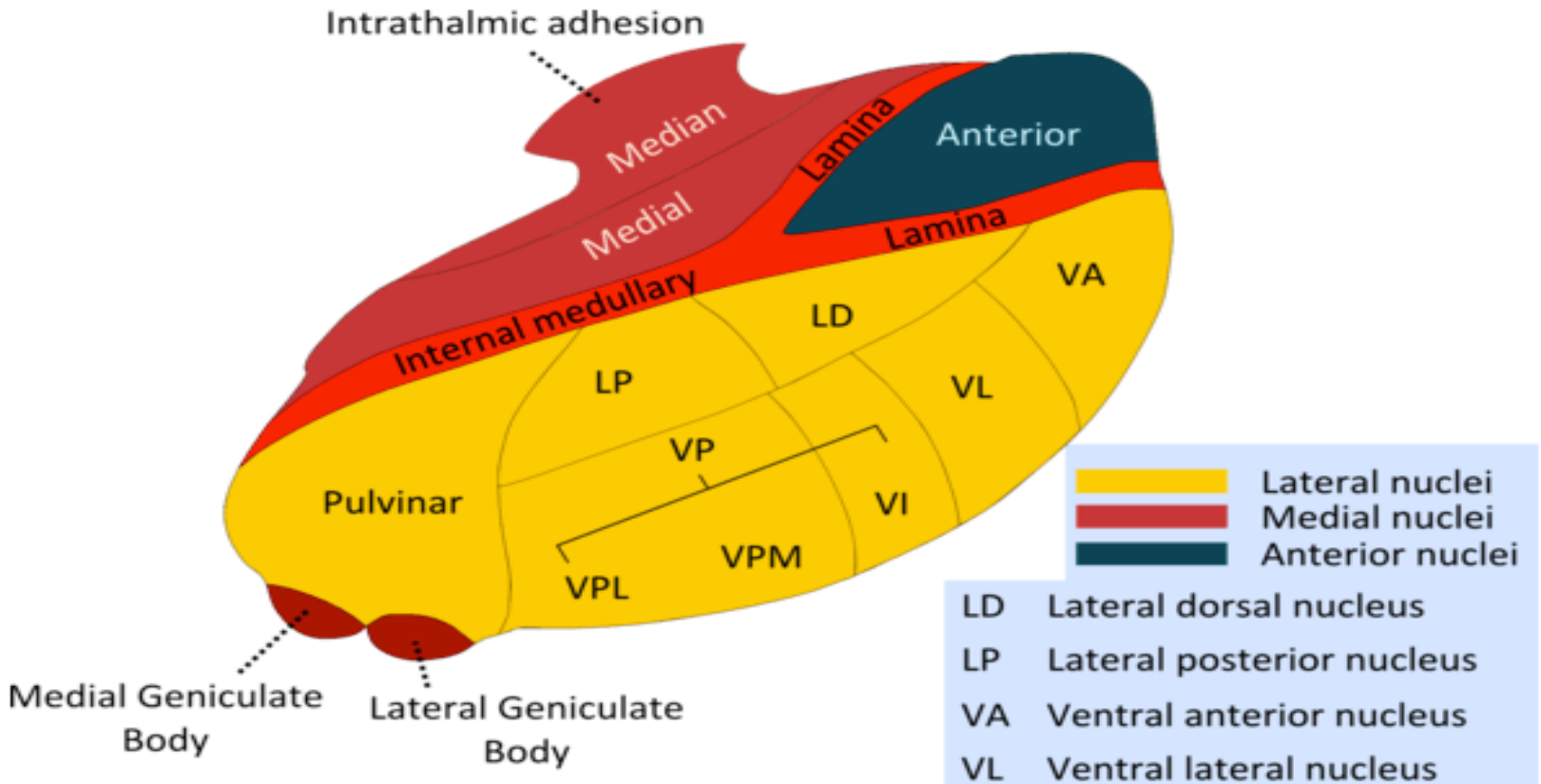


Introduction

- The thalamus is divided into a **medial nuclear group, lateral nuclear group and anterior nuclear group** by a Y-shaped white matter structure called the **internal medullary lamina**
- Nuclei located within the internal medullary lamina itself are called the **intra-laminar nuclei**
- The midline thalamic nuclei are an additional thin collection of nuclei lying adjacent to the third ventricle, several of which are continuous with and functionally very similar to the intra-laminar nuclei
- Finally, the thalamic reticular nucleus (to be distinguished from the reticular nuclei of brainstem) forms an extensive but thin sheet enveloping the lateral aspect of the thalamus
- The three main categories of thalamic nuclei are:

- **Relay nuclei**
- **Intra-laminar nuclei**
- **Reticular nuclei**

Thalamic Nuclei



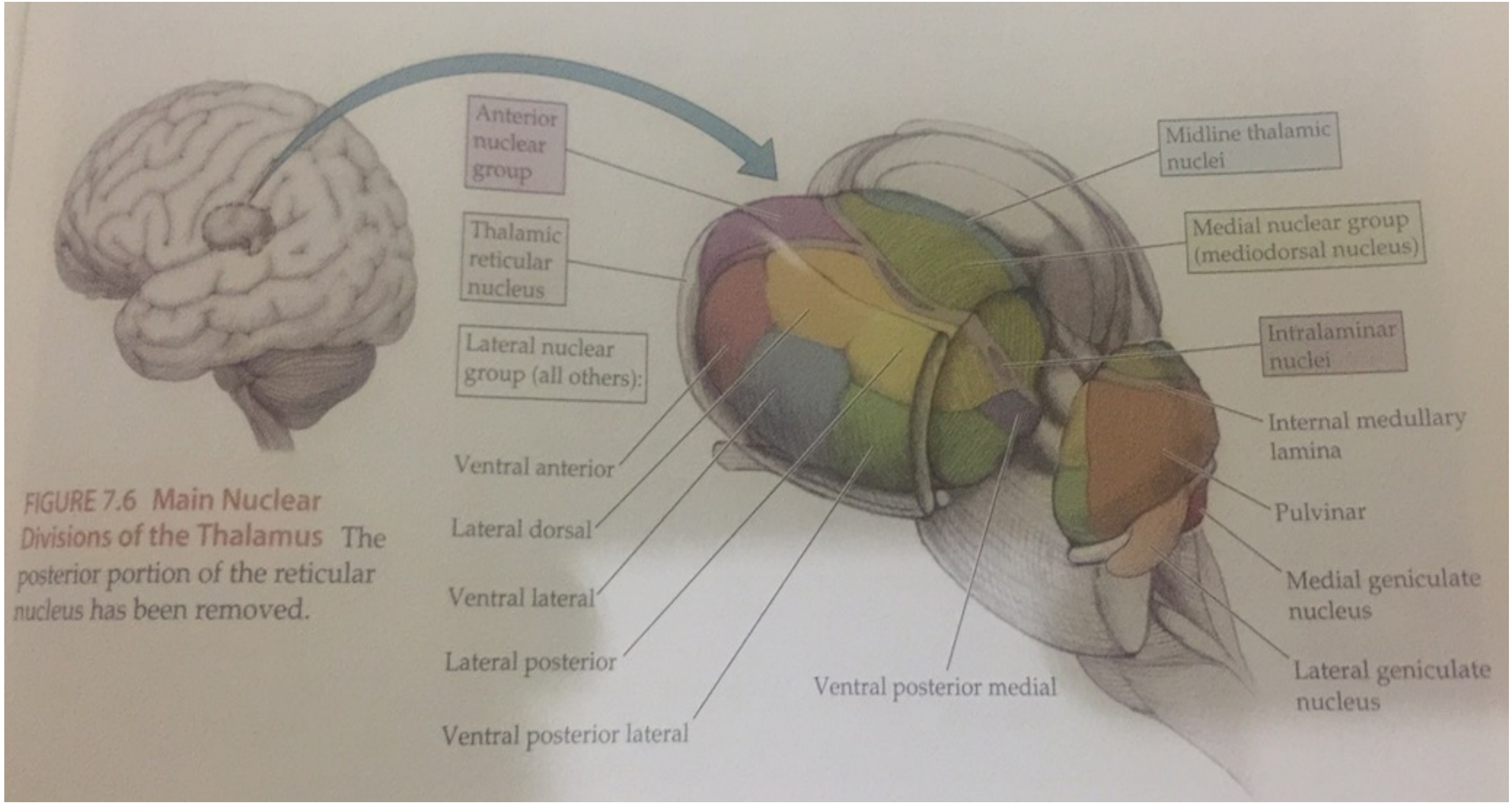


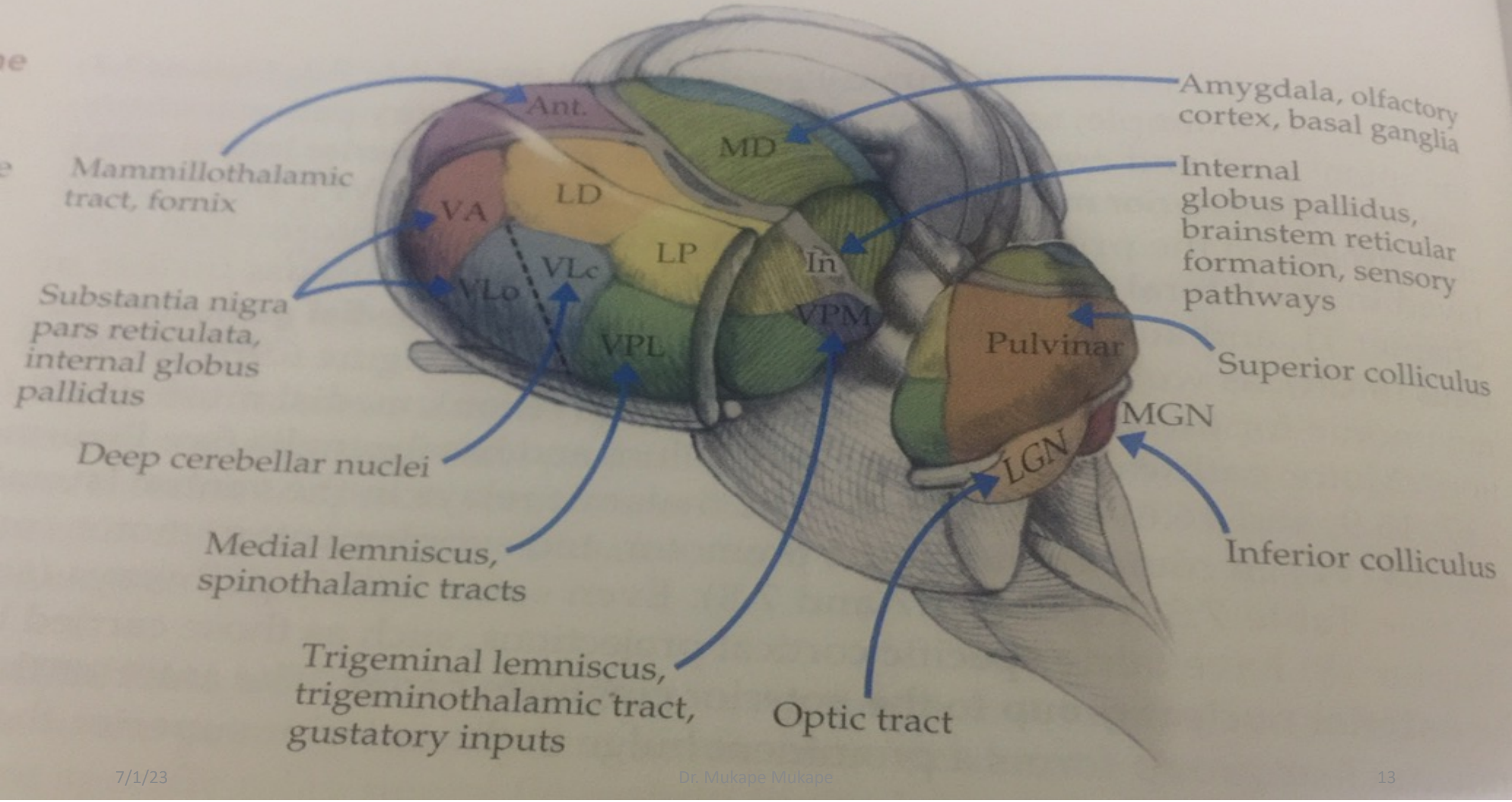
FIGURE 7.6 **Main Nuclear Divisions of the Thalamus** The posterior portion of the reticular nucleus has been removed.

Thalamic Nuclei (most well known and clinically important are highlighted in red)

Relay Nuclei	Intralaminar nuclei	Reticular Nucleus
Lateral nuclear group - **Ventral posterior lateral nucleus (VPL)** - **Ventral posteromedial nucleus (VPM)** - **Lateral geniculate nucleus (LGN)** - **Medial geniculate nucleus (MGN)** - **Ventral lateral nucleus (VL)** - **Ventral anterior nucleus (VA)** - **Pulvinar** - Lateral dorsal nucleus - Lateral posterior nucleus - Ventral medial nucleus	**Rostral intra-laminar nuclei** - Central medial nucleus - Paracentral nucleus - Central lateral nucleus	
Medial nuclear group - **Mediodorsal nucleus (MD**	Caudal intra-laminar nuclei - **Centromedian nucleus** - Parafascicular nucleus	
Anterior nuclear group - **Anterior nucleus** - Midline thalamic nuclei		

Clinically Important Nuclei and their Functions

Nucleus	Proposed Functions
Ventral posterior lateral nucleus (VPL)	Relays somatosensory spinal inputs to cortex
Ventral posteromedial nucleus (VPM)	Relays somatosensory cranial nerve inputs to cortex
Lateral geniculate nucleus (LGN)	Relays visual inputs to cortex
Medial geniculate nucleus (MGN)	Relays auditory inputs to cortex
Ventral lateral nucleus (VL)	Relays basal ganglia and cerebellar inputs to cortex
Ventral anterior nucleus (VA)	Relays basal ganglia and cerebellar inputs to cortex
Pulvinar	Behavioral orientation toward relevant visual and other stimuli
Mediodorsal nucleus (MD)	Limbic pathways, major relay to frontal cortex
Anterior nucleus	Limbic pathways
Centromedian nucleus	Motor relay for basal ganglia

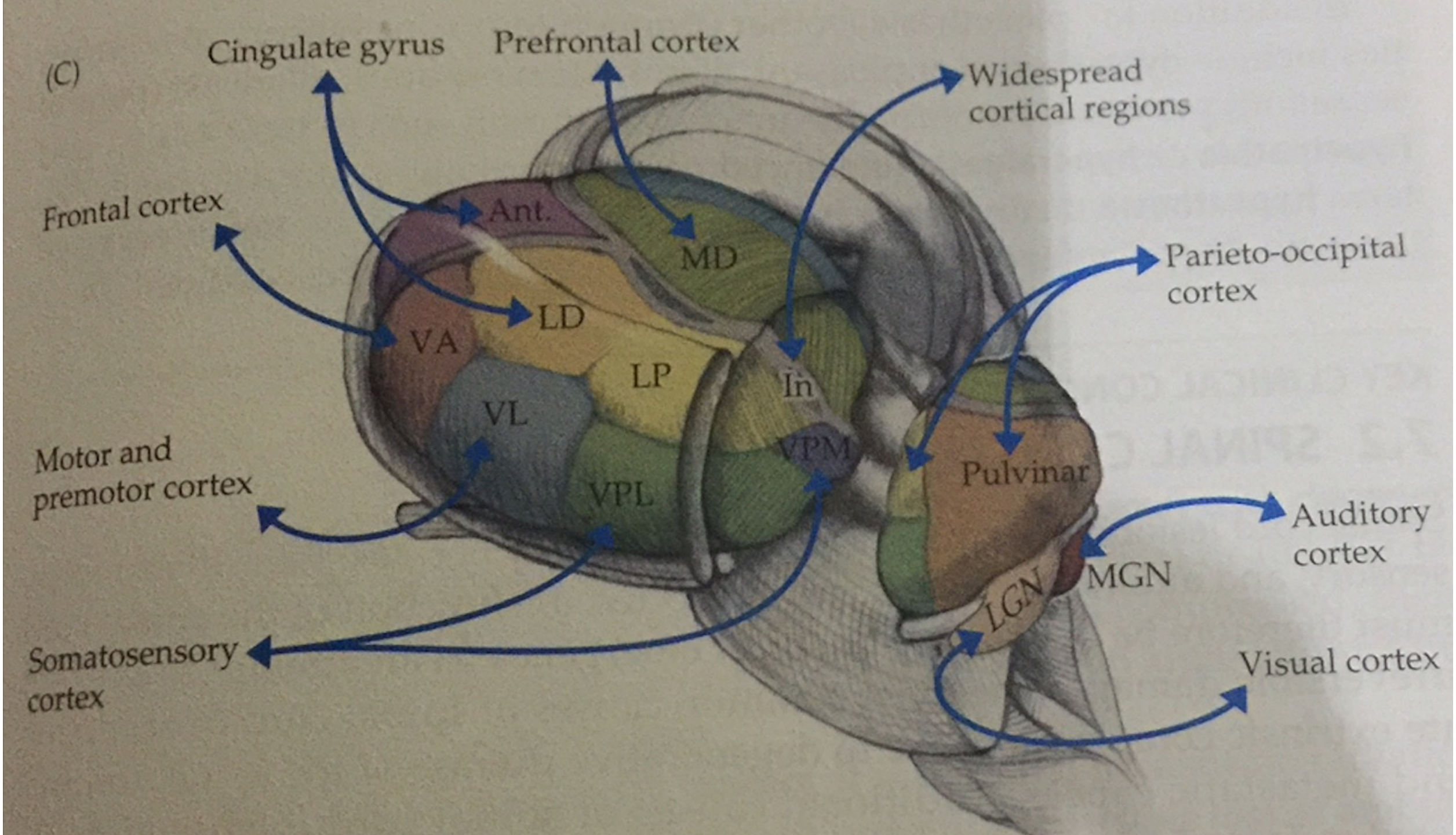

Ant.
MD
LD
VA
LP
VLc
VLo
In
VPM
VPL
Pulvinar
LGN
MGN
Mammillothalamic tract, fornix
Amygdala, olfactory cortex, basal ganglia
Internal globus pallidus, brainstem reticular formation, sensory pathways
Substantia nigra pars reticulata, internal globus pallidus
Superior colliculus
Deep cerebellar nuclei
Medial lemniscus, spinothalamic tracts
Inferior colliculus
Trigeminal lemniscus, trigeminothalamic tract, gustatory inputs
Optic tract

Relay Nuclei

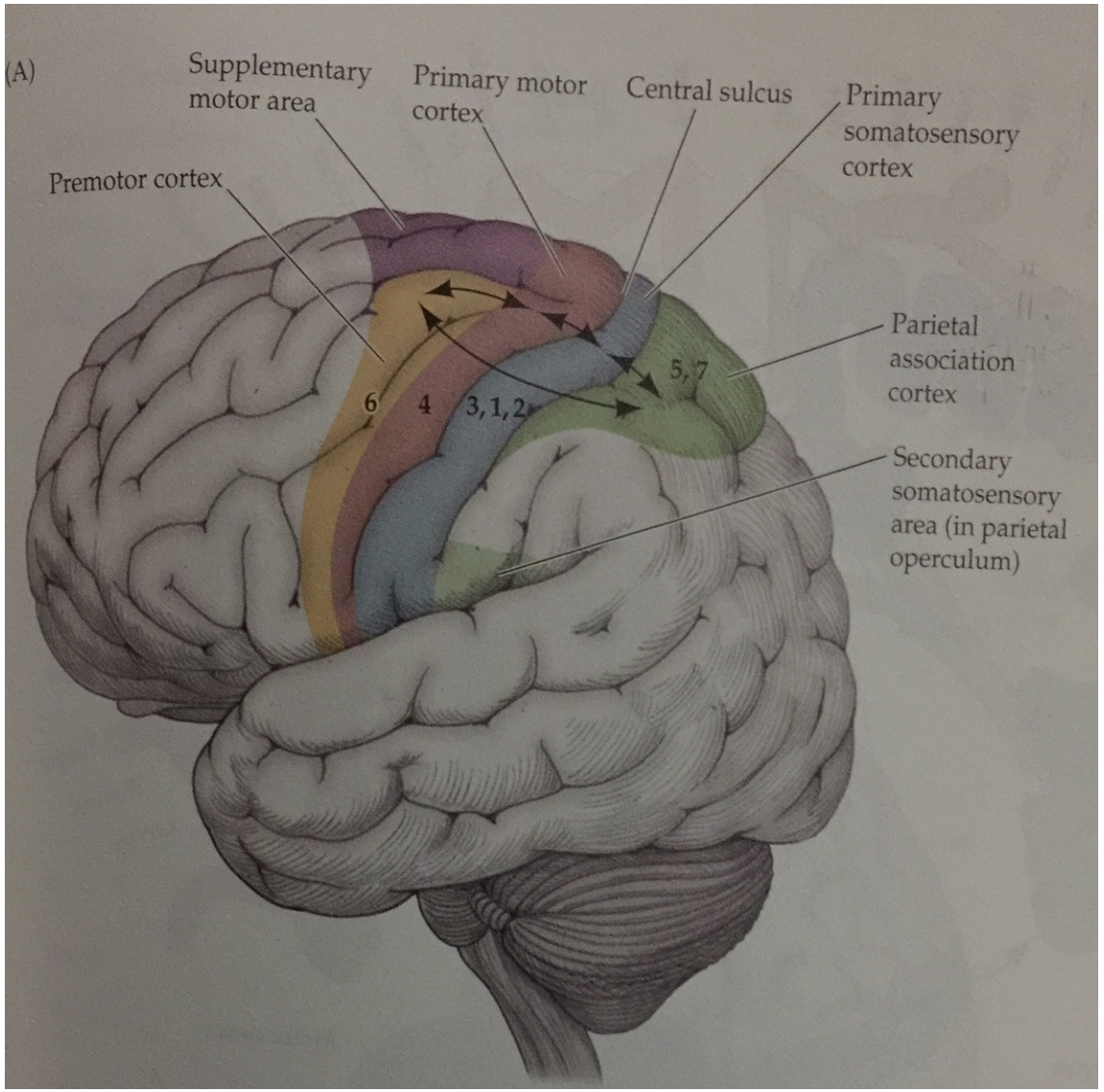
- Most of the thalamus is made up of relay nuclei
- These receive inputs from numerous pathways and then project to the cortex
- In addition, relay nuclei receive massive reciprocal connections back from the cortex
- **Projections of relay nuclei to the cortex may be fairly localised to specific cortical regions or more diffuse**

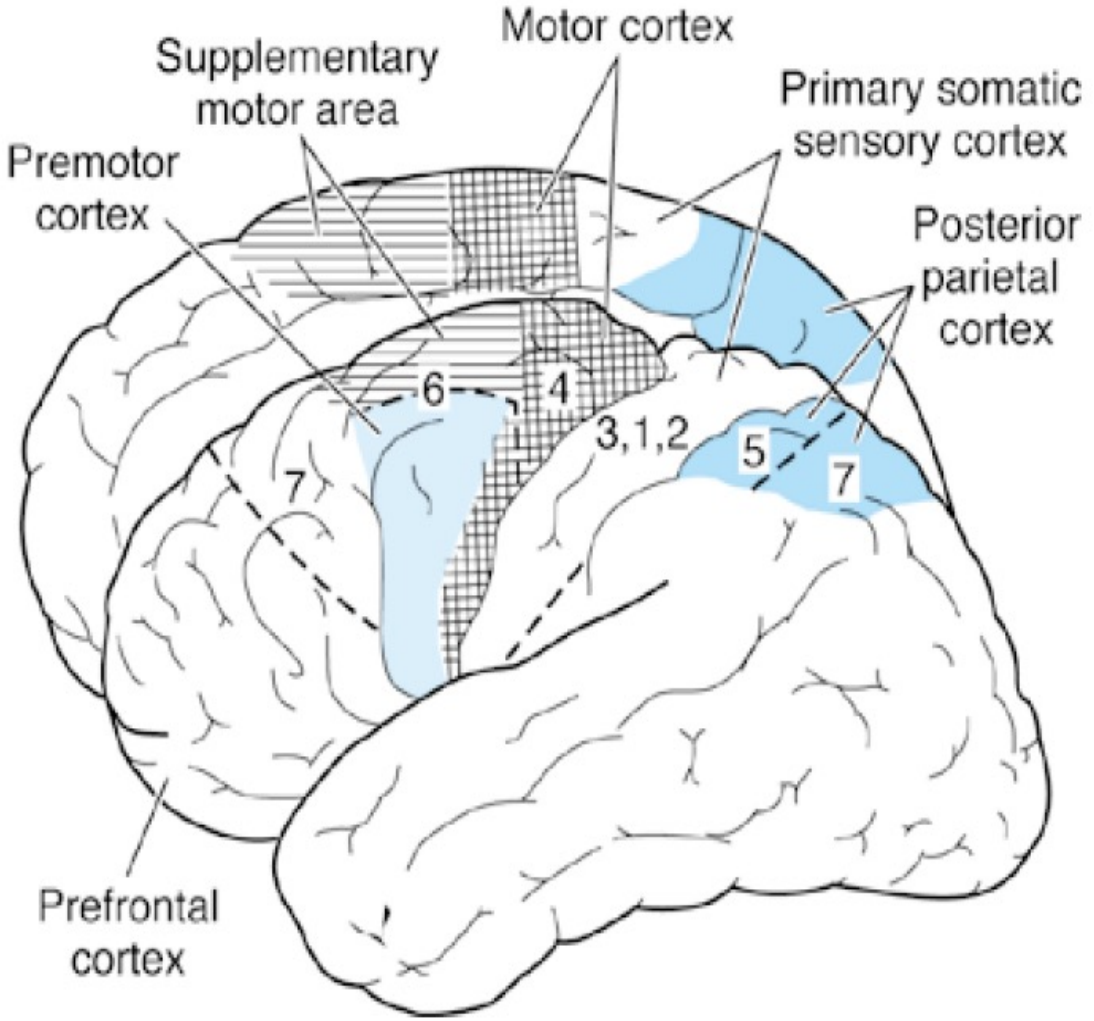
Specific Thalamic Relay Nuclei

- Among the thalamic relay nuclei, projections to the primary sensory and motor areas tend to be the most localised
- These specific relay nuclei lie mainly in the lateral thalamus
- All sensory modalities with the exception of olfaction have specific relays in the lateral thalamus en route to their primary cortical areas
- **For example, somatosensory pathways from spinal cord and cranial nerves relay in the ventral posterior lateral (VPL) and ventral posterior medial (VPM) nuclei respectively**
- The VPL and VPM in turn project to the primary somatosensory cortex
- **Visual information is relayed in the lateral geniculate nucleus (LGN) and auditory information in medial geniculate nucleus (MGN)**
- **Motor pathways leaving the cerebellum and basal ganglia also have specific thalamic relays in the ventral lateral nucleus (VL) en route to the motor, premotor and supplementary motor cortex**
- Even some limbic pathways have fairly specific cortical projections such as those carried by the anterior nuclear group to the anterior cingulate cortex
- The anterior nuclear group forms a prominent bulge in the anterior superior thalamus

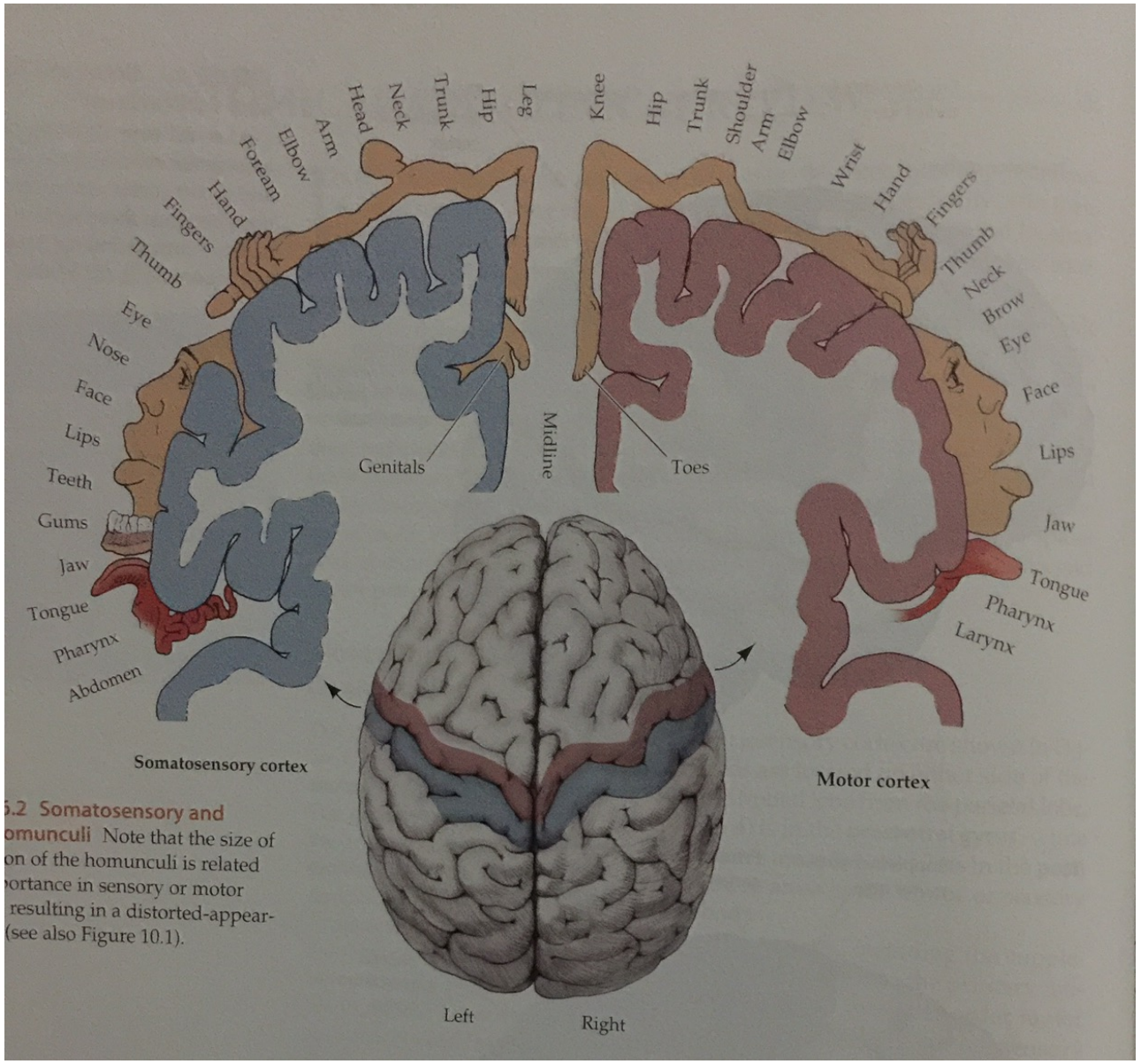

(C)
Cingulate gyrus
Prefrontal cortex
Widespread cortical regions
Frontal cortex
Ant.
MD
Parieto-occipital cortex
LD
VA
LP
In
VL
VPM
Pulvinar
Motor and premotor cortex
VPL
Auditory cortex
MGN
LGN
Somatosensory cortex
Visual cortex

Motor and Sensory Cortex



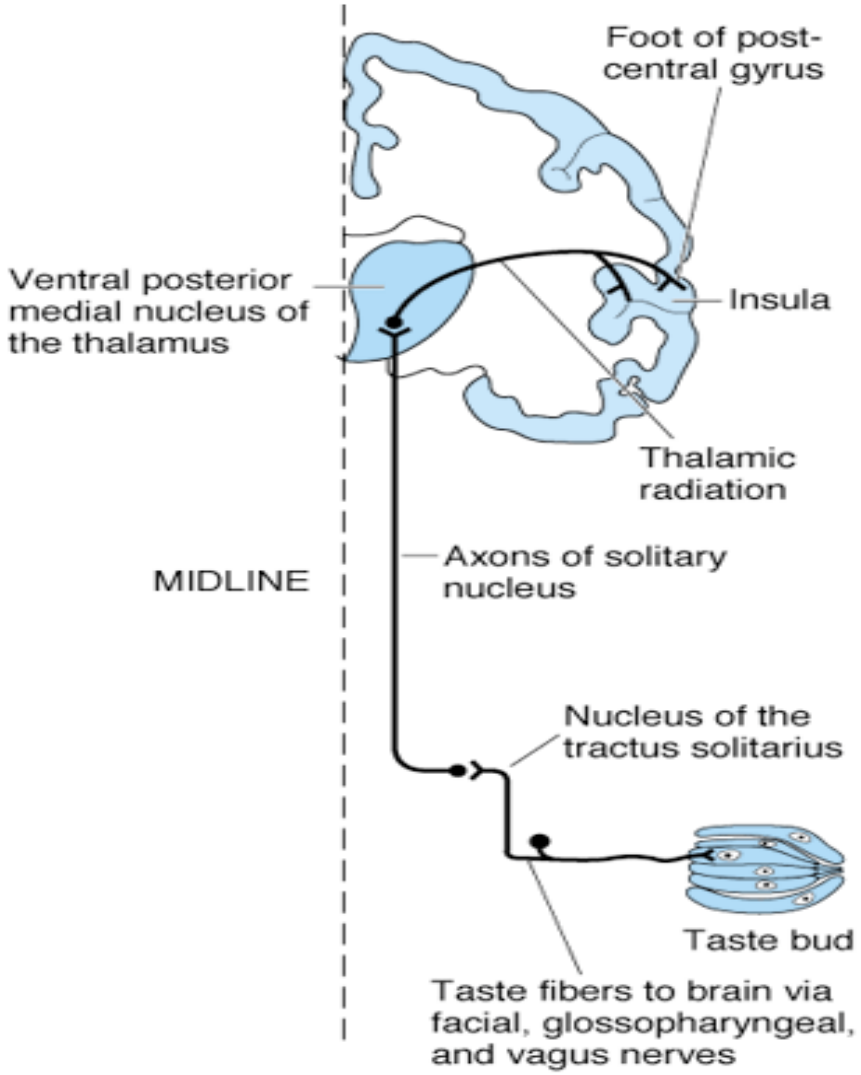


Motor and Somatosensory Homunculi



5.2 Somatosensory and omunculi Note that the size of on of the homunculi is related portance in sensory or motor resulting in a distorted-appear- (see also Figure 10.1).

Diagram of Taste Pathways



Non-specific Thalamic Relay Nuclei

- Many thalamic nuclei have more widespread cortical projections
- For example, visual and other sensory inputs to the pulvinar are relayed to large regions of the parietal, temporal and occipital association cortex involved in behavioural orientation towards relevant stimuli
- **The pulvinar (“couch” or ”cushion” in Latin) is a large, pillow-shaped nucleus that occupies most of the posterior thalamus**
- Diffuse relays of limbic inputs and other information involved in cognitive functions occur in the mediodorsal nucleus (MD) as well as in the midline and intra-laminar thalamic nuclei
- The MD sometimes called the dorsomedial nucleus, forms a large bulge lying medial to the internal medullary lamina, best seen in coronal sections
- The MD serves as the major thalamic relay nucleus for information travelling to the frontal association cortex

Intra-laminar Thalamic Nuclei

- Lie within the internal medullary lamina
- Like the relay nuclei, they receive inputs from numerous pathways and have reciprocal connections with the cortex
- They are sometimes classified along with other “non-specific” relay nuclei
- However, unlike relay nuclei, their main inputs and outputs are from the basal ganglia
- Intra-laminar nuclei can be divided into two functional regions:

- **Caudal intralaminar nuclei** which include the large centromedian nucleus and are involved mainly in basal ganglia circuitry
- **Rostral intralaminar nuclei** also have input and output connections with basal ganglia. In addition, the rostral group appear to have an important role in relaying inputs from ascending reticular activating system (ARAS) to the cortex, maintaining alert, conscious state

Reticular Nucleus

- Forms a thin sheet located just lateral to the rest of the thalamus and just medial to the internal capsule
- It should not be confused with the similarly named reticular formation located in the brainstem
- **This nucleus is the only nucleus of the thalamus that does not project to the cortex**
- Instead, it receives inputs mainly from other thalamic nuclei and the cortex and then projects back to the thalamus
- The reticular nucleus consists of almost pure population of inhibitory GABergic neurons
- This composition, together with its connections with the entire thalamus make it well suited to regulate thalamic activity

Reticular Nucleus

- In addition to cortical and thalamic inputs, other inputs to the reticular nucleus arising from the brainstem reticular activating systems and the basal forebrain may participate in modulating the state of alertness and attention

- In summary, the thalamus has a major reciprocal connections with all regions of the cerebral cortex

- It contains many different nuclei with different functions

- These nuclei convey information from other parts of the nervous system as well as from the periphery to the cortex

THE END