

CNS

ANATOMY



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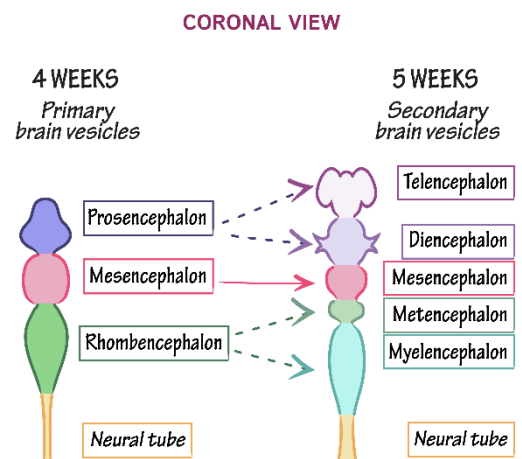
Diencephalon

In this lecture, we will

- Briefly mention the development of the CNS in embryo (which will be discussed in the next lecture).
- Study Diencephalon's derivatives
 - Thalamus
 - Hypothalamus
 - Subthalamus
 - Epithalamus
 - Metathalamus

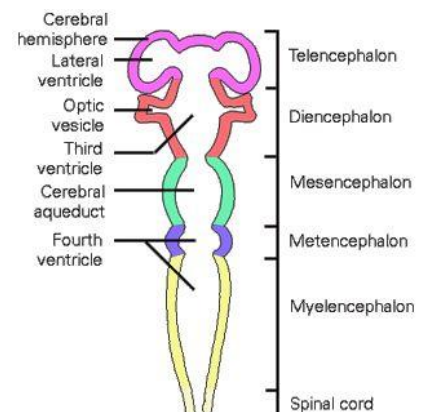
In this lecture, we will discuss the anatomy of the diencephalon. So, what is the diencephalon? If you remember in embryology when we said that the **neural tube** differentiates into **3 primary brain vesicles**, which include:

1. The Proximal/Forebrain vesicle (**prosencephalon**): As development continues, this primary vesicle gives rise to 2 **secondary brain vesicles (Telencephalon and Diencephalon)**.
Telencephalon eventually forms the **cerebral hemisphere** (Cerebral Cortex, Cerebral white matter & Basal Ganglia) and the **Diencephalon**, from which structures like the **thalamus, hypothalamus, subthalamus, epithalamus & metathalamus** are derived.
2. The middle/midbrain vesicle (**Mesencephalon**), which eventually forms the **midbrain**.
3. The distal/Hindbrain vesicle (**Rhombencephalon**), which differentiates into the **cerebellum** and parts of the brain stem (**pons and medulla**)



We must also be familiar with the cavities that we find within these vesicles (the figure beside makes your life much easier)

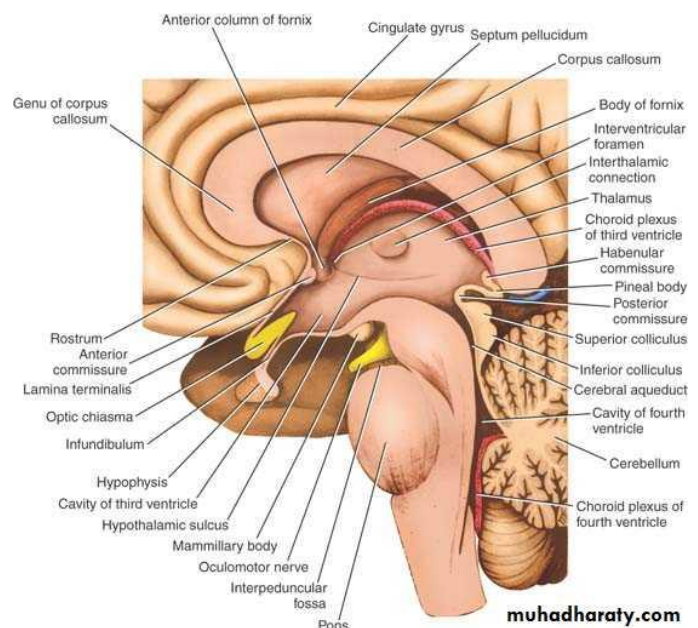
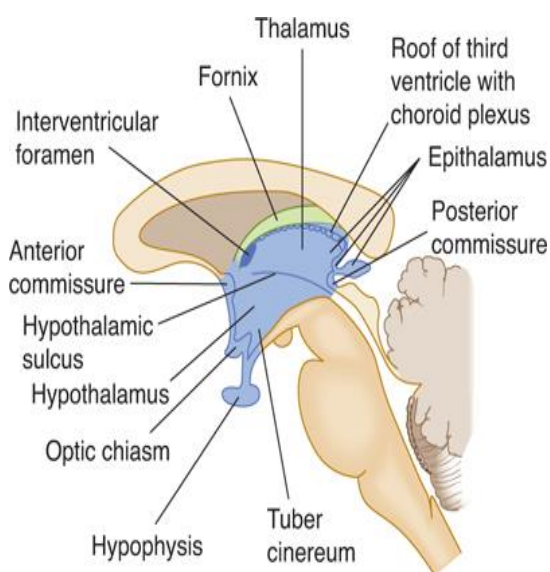
- The lateral ventricle forms the cavity that we find within the cerebral hemisphere.
- The 3rd ventricle forms the cavity that we find within the diencephalon.
- Cerebral aqueduct forms the cavity that we find within the mesencephalon.
- The 4th ventricle forms the cavity that we find within the rhombencephalon.



Medial Surface of Thalamus

By looking at a sagittal section of the diencephalon, we should identify the following:

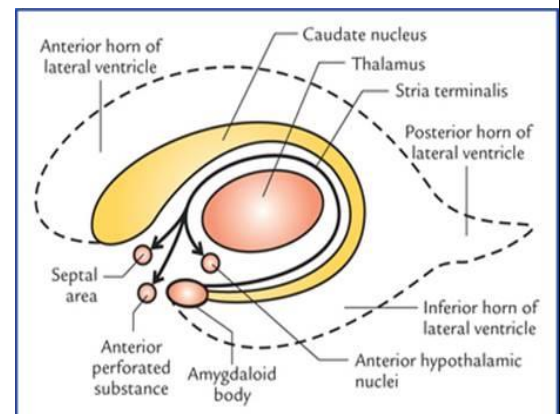
- 1) Corpus Callosum (Anterior to posterior => rostrum, genu, body, & splenium)
- 2) Fornix. Note that the Thalamus is separated from the fornix by a fissure which represents the choroidal plexus that secretes CSF, and which extends from this fissure to the lateral ventricle.
- 3) Septum pellucidum which encloses the cavity of lateral ventricle.
- 4) Thalamus
- 5) Hypothalamic nuclei (anteroinferior)
- 6) Midbrain, pons, and medulla lie below the thalamus.



Lateral Surface of Thalamus

By looking at a sagittal section of the lateral Surface of Diencephalon, we should identify the following:

1) The caudate nucleus along with the thalamus lie within the floor of the body of the Lateral ventricle. But how can we anatomically relate the thalamus to the caudate nucleus? Simply, the caudate nucleus is lateral to the thalamus. And the fissure which separates these 2 structures is the **stria terminalis** (refer to the figure beside), which is a connection of the limbic system between the anterior nucleus of the **hypothalamus** (and not the thalamus as mentioned by the doctor) and the amygdala.



2) **lentiform Nucleus:** More laterally you will find the lentiform nucleus, which is formed of

A. An outer part called putamen.

B. An inner part called globus pallidus (external and internal segments)

3) **internal capsule:** *Between the (thalamus+caudate nucleus) & Lentiform Nucleus, a structure known as internal capsule is found. It is the largest projection fibers that extend from the cerebral cortex downwards or carries a sensation through the sensory tracts from the spinal cord to area 3,1,2.*

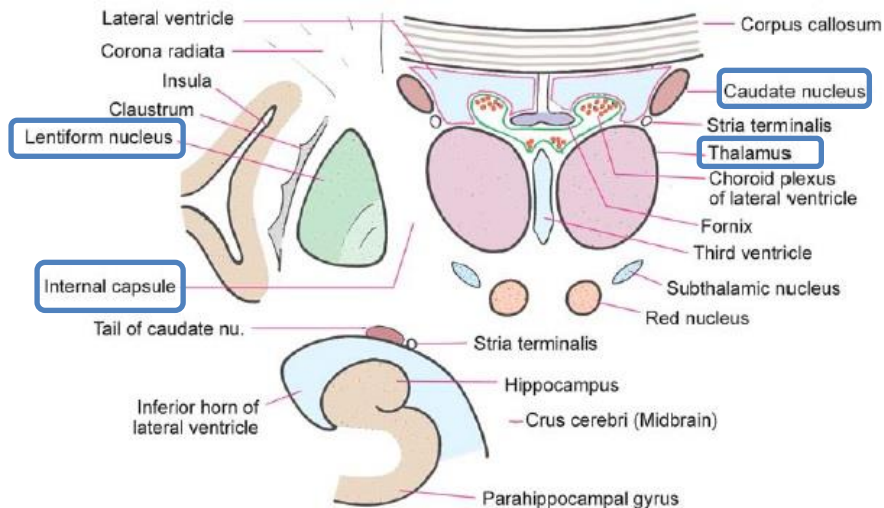
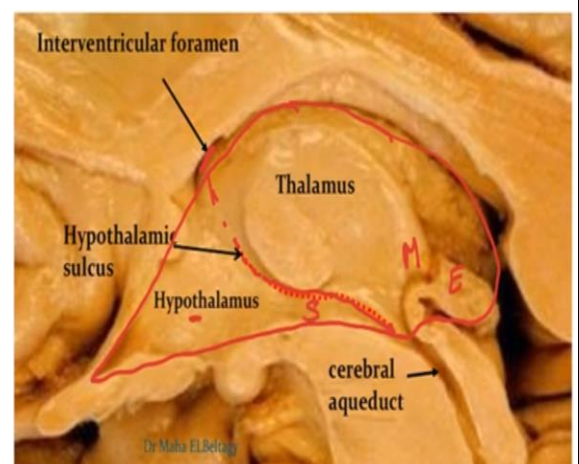


Fig. 13.2. Coronal section through the cerebrum to show structures related to the thalamus.

The Diencephalon

- The Diencephalon is located near the **midline** of the brain **above** the midbrain.
- Developed from the forebrain vesicle (**prosencephalon**).
- More **primitive** than the cerebral cortex and lies under it.
- Surrounds the third ventricle, which is interconnected with the lateral ventricle through foramen of Monro (aka. Interventricular Foramen) and downward with the fourth ventricle through the cerebral aqueduct that passes inside the substance of the midbrain.

- The cavity of the 3rd ventricle divides the diencephalon into 2 halves.
- Each half is divided by the hypothalamic sulcus (which extends from the interventricular foramen to the cerebral aqueduct) into ventral & dorsal parts.
- **Dorsal (posterosuperior) part** includes: - *Thalamus, Epithalamus & Metathalamus.*
- **Ventral (anteroinferior) part** includes: - *Hypothalamus & Subthalamus.*

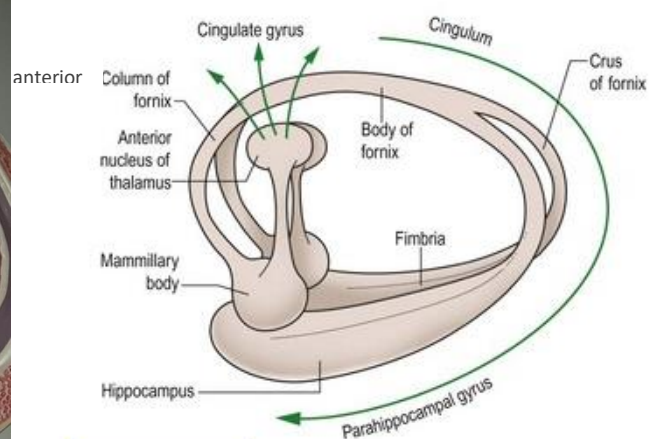
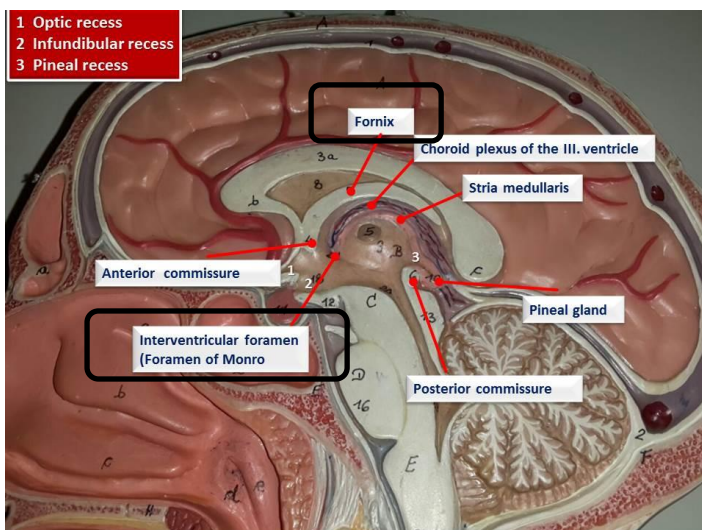


Thalamus

- It is a large egg-shaped mass of grey matter which forms the main sensory relay station for the cerebral cortex. So, most of the sensory information including vision, taste, touch and balance & etc. reach the thalamus and eventually are transmitted from there to their final destination in the cerebral cortex.
- The **thalamus** and **hypothalamus** form *part of the lateral wall* of the **third** ventricle
- The **thalamus** and **caudate nucleus** form *part of the floor of the body* of the **lateral** ventricle.
- The 2 thalami are connected by interthalamic adhesion.
- Shape and relations: Oval shape & has 2 ends:
 - ❖ **Anterior end:** narrow and forms the posterior boundary of the IVF.
 - ❖ **Posterior end:** Pulvinar overhanging the MGB and LGB.
- Also has 4 surfaces:
 - ❖ **Upper surface:** floor of body of lateral ventricle.
 - ❖ **Medial surface:** lateral wall of third ventricle
 - ❖ **Lateral surface:** caudate above & lentiform below separated from it by posterior limb of internal capsule.
 - ❖ **Lower surface:** hypothalamus anterior and subthalamus posterior

Notes:

- The professor mentioned the components of fornix 1) anterior column of the fornix 2) body of the fornix 3) crura or posterior column of the fornix. You can refer to the diagram below (right).
- The IVF lies posterior to the anterior column of the fornix. To be more specific, it actually lies between the anterior end of the thalamus and the anterior column of the fornix. You can refer to the diagram below (left).

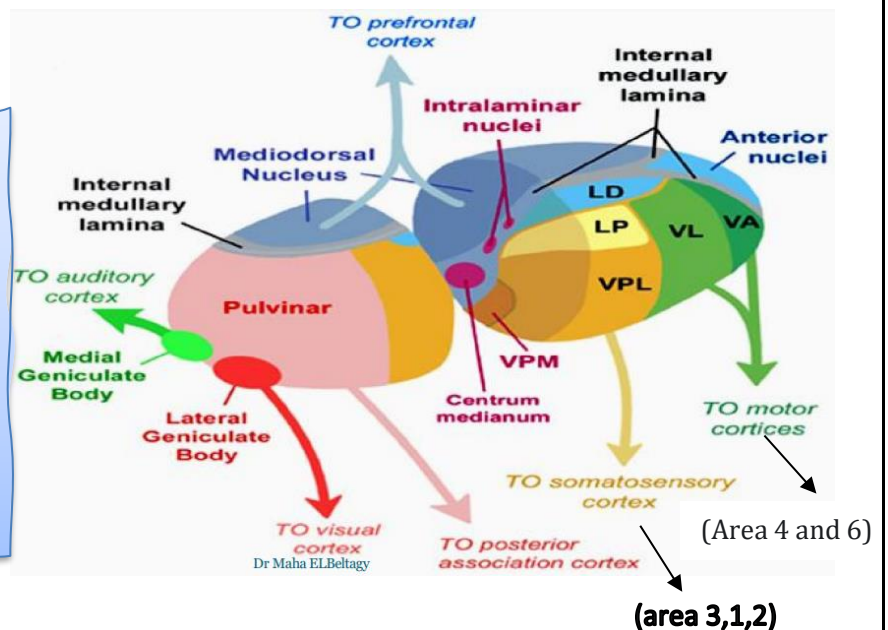


Classification of Thalamic Nuclei

- We all agree on the fact that thalami are bags full of nuclei. Based on this fact, scientists had to classify thalamic nuclei. So, what they did was that they divided these nuclei based on their relation to the **internal lamina** (which is a Y-shaped white matter found within the thalamus). This lamina divides thalamic nuclei into **Medial Nuclear Group** ① (those which lie medially to the Internal lamina), **lateral nuclear group** ② (those which are found lateral to the internal lamina), & **Anterior Nuclear Group** ③ (which is found between the 2 limbs of Y letter)
- The Group of nuclei which lie in the most posterior part of the thalamus (=the pulvinar) are called the **posterior nuclear group** ④. There, another group of nuclei, known as the **Metathalamic Nuclear Group** ⑤, exists. This group consists of the MGB and the LGB. We also have the **intralaminar nuclear group** ⑥ which run within the Y shaped internal lamina. Finally we have the **thalamic reticular nucleus** ⑦* which is found anterior to the anterior end of the thalamus (it is also found lateral to the thalamus) and is connected to the reticular formation of the brainstem.

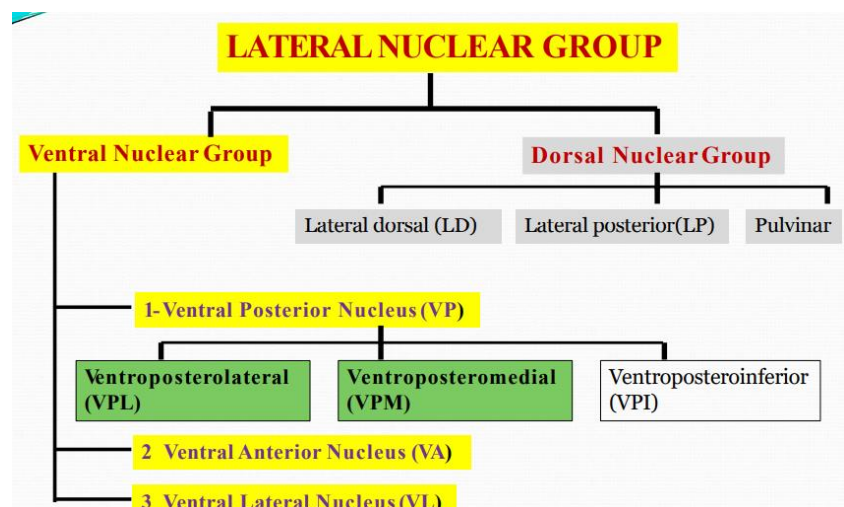
Notes:

1. Anterior nuclei send projections to the cingulate gyrus to form some connections with the limbic system.
2. You must be familiar with the figure beside as the professor almost read every single word.



Summary of Thalamic Connectivity and function

- **Sensory Input** general sensation, special sensation, taste, equilibrium, hearing, vision
- **Motor Input** cerebellum, basal ganglia
- **Reticular Formation**
- **Limbic System** mammillary nucleus & hippocampal formation.



We're required to know the details about certain nuclei (**the ones that are marked with a tick**) in this table.

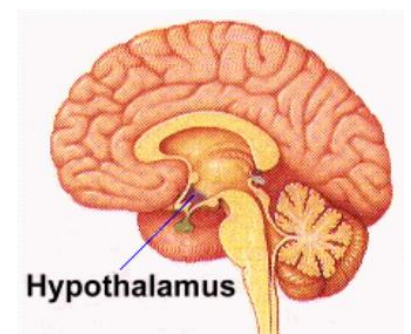
Nucleus	Afferent	Efferent	Function
Anterior ✓	Mammillothalamic tract, cingulate gyrus, hypothalamus ✓	Cingulate gyrus, hypothalamus ✓	Emotion and memory ✓
Dorsomedial	Prefrontal cortex, hypothalamus	Prefrontal cortex, hypothalamus	Integration of somatic, visceral, olfaction
LD & LP	Cerebral cortex	Cerebral cortex	unknown
VA ✓✓	Premotor cortex, BG	Premotor cortex, BG	Motor activity
VL ✓✓	Premotor cortex, cerebellum	Premotor cortex, cerebellum	Motor activity
VPM ✓✓	Trigeminal lemniscus	Area 3,1,2	general sensation
VPL ✓✓	Medial & spinal lemnisci	Area 3,1,2	general sensation
Intralaminar	Reticular formation	Cerebral cortex	Alertness
Reticular	Cerebral cortex	Other thalamic nuclei	Regulate thalamus
MGB ✓	Lateral lemniscus	Superior temporal gyrus	hearing
LGB ✓	Optic tract	Visual cortex (area 17)	Vision

Thalamic Radiations

- Thalamocortical fibers / Anterior thalamic radiation**
 - ❖ connect the anterior nucleus of thalamus to the frontal lobes and cingulate gyrus.
 - ❖ Ascend in the anterior limb of the internal capsule.
 - ❖ plays a vital role by connecting the thalamus to the limbic system
- sensory radiation / superior thalamic radiation**
 - ❖ from VP of thalamus to post central gyrus.
 - ❖ Ascend in the posterior half of the posterior limb of the internal capsule.
- optic radiation / posterior thalamic radiation**
 - ❖ From LGB to occipital lobe (visual cortex)
 - ❖ Retrolentiform part of the internal capsule.
- auditory radiation / Inferior thalamic radiation**
 - ❖ From MGB to the auditory area in the superior temporal lobe.
 - ❖ Sublentiform part of the internal capsule

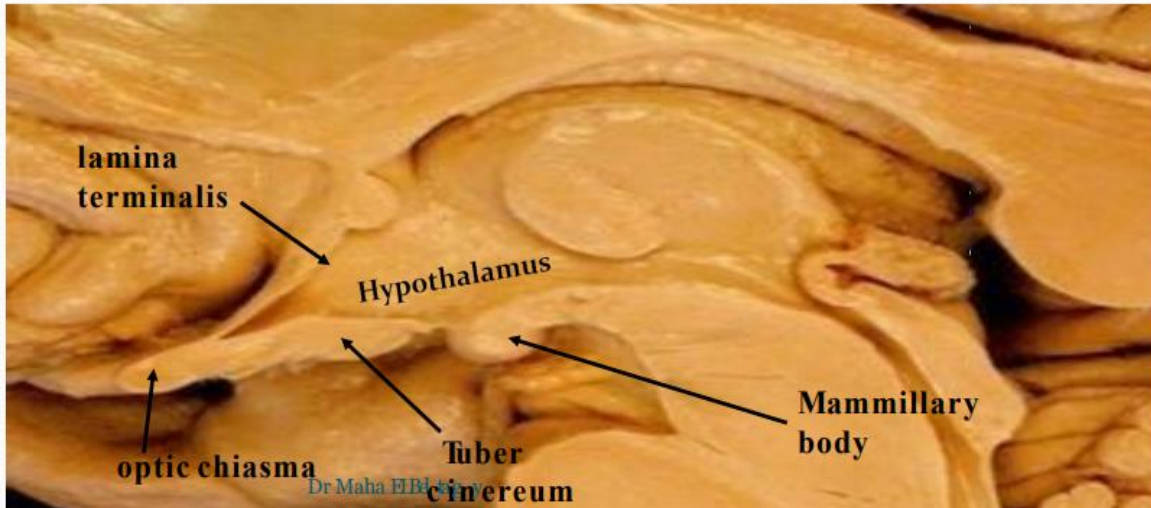
Hypothalamus

- Part of the Diencephalon.
- Extends from optic chiasma to the mammillary bodies.
- Forms the floor of the third ventricle.
- Hypothalamus has a preoptic area that anatomically extends from optic chiasma to lamina terminalis and anterior commissure.
- Bounded laterally by the internal capsule. which separates it from the caudate and lentiform nucleus.



Major constituents :

- Mammillary bodies. ← **Horizontal part (contents of interpeduncular fossa)**
- Tuber cinereum & infundibulum. ← **Horizontal part (contents of interpeduncular fossa)**
- Nervous tissue adjacent to optic chiasma ← **Vertical part**
- Preoptic region adjacent to lamina terminalis ← **Vertical part**



Notes on the figure above:

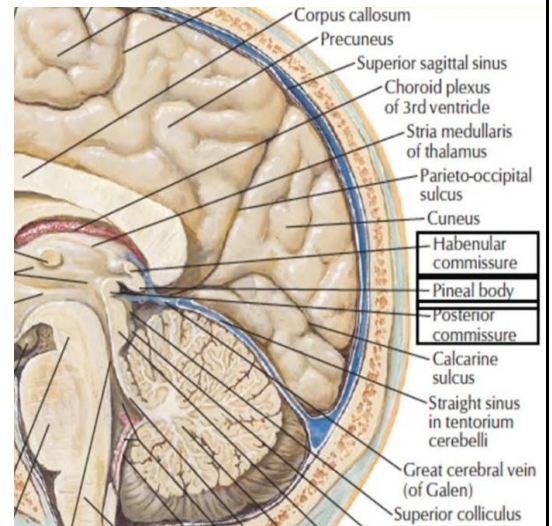
- The interpeduncular fossa lies on the inferior surface (floor) of the brain.
- Circle of Willis lies around the interpeduncular fossa. (will be discussed in the last lecture)
- 2 mamillary bodies (one on each side) exist.
- From the under surface of the tuber cinereum a hollow conical process, the infundibulum, projects downward attached to the posterior lobe of the pituitary gland to form the hypophyseal-hypothalamic portal circulation.

Functions of Hypothalamus

1. **Homeostasis** (food intake, water and electrolyte balance, temperature regulation and circadian rhythm). homeostasis is defined as the different mechanisms by which the body adjust its function. In a healthy individual, it is a healthy state that is maintained by the adjustment of the biochemical and physiological pathways. This is the **main** function of the hypothalamus.
2. **Endocrine control** (=regulation of hormones) via pituitary gland (Growth hormone, reproductive hormones like LH & FSH, stress hormones).
3. **Autonomic control** (sympathetic and parasympathetic responses).
4. **Limbic function** (memory and emotions).

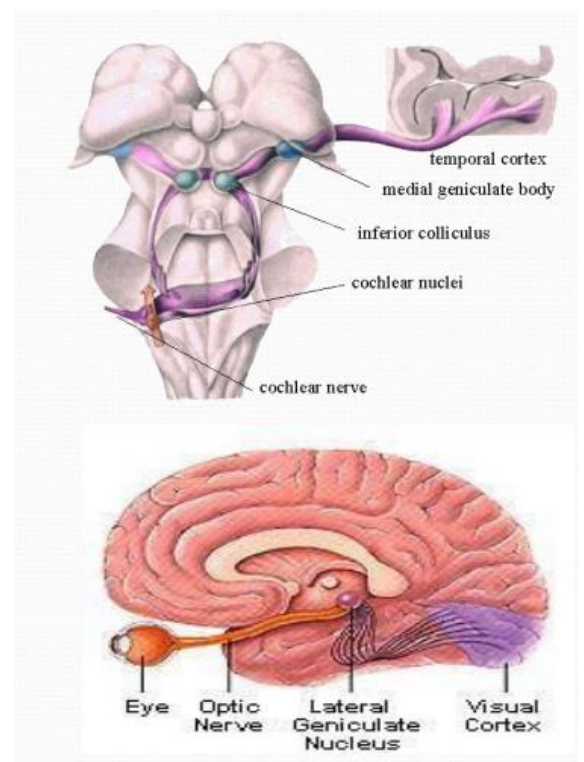
Epithalamus

- Formed by:
 - 1) **Habenular Nucleus:**
 - a. Medial Habenular Nucleus
 - b. Lateral Habenular Nucleus
 - 2) **Habenular Commissure**
 - 3) **Pineal Gland** (habenular commissure above and posterior commissure below)
- Functions:
 - 1) The epithalamus acts as a connection (through the habenular nuclei) between the limbic system and other parts of the brain. It also plays a vital role in the "smell pathway" through connecting the habenular nuclei and the amygdala.
 - 2) Secretion of melatonin by the pineal gland.
 - 3) Regulation of pituitary gland through hypothalamus (pineal gland).



Metathalamus (Geniculate Bodies)

- Placed under pulvinar of the thalamus.
- Made of:
 - 1- **Medial Geniculate Body (MGB):**
 - ❖ Gives efferent (auditory radiation) in Sublentiform part of the internal capsule to auditory area (area 41&42) in superior temporal gyrus.
 - ❖ Receives afferents from lateral lemniscus and inferior colliculus through inferior brachium.
 - 2- **Lateral Geniculate Body (LGB):**
 - ❖ Gives efferent (optic radiation) in retrolentiform part of internal capsule to visual center (area 17) in the occipital lobe 3rd order neuron in visual pathway.
 - ❖ Receives afferents from optic tract.



Subthalamus

- Connected to the basal nuclei (that is why it is considered the motor zone of diencephalon)
- Lies between the thalamus and the superior surface of the tegmentum of midbrain.
- Anatomically, it is made of **3 nuclei & 3 bundles**.

Subthalamic Nucleus

Substantia nigra and red nucleus in the midbrain

Zona incerta: (grey matter inside the subthalamus). Its connections project extensively over the brain from the cerebral cortex down into the spinal cord (plays role in controlling pain)