

CNS

Doctor 2021



Anatomy Sheet (4)

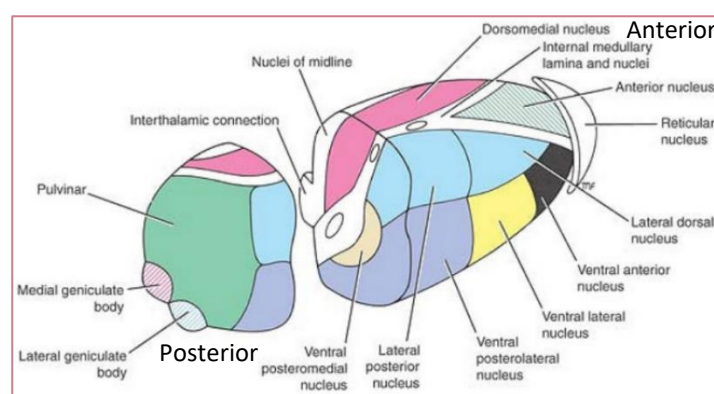
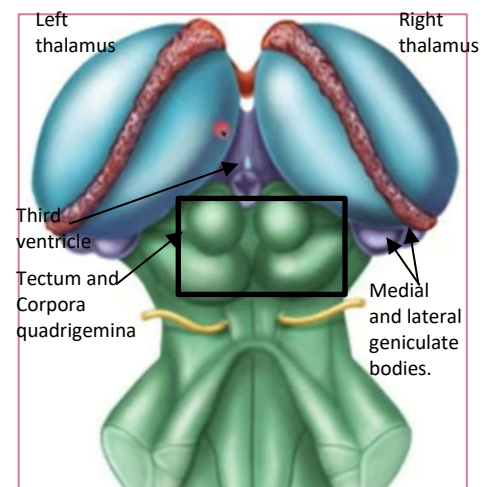
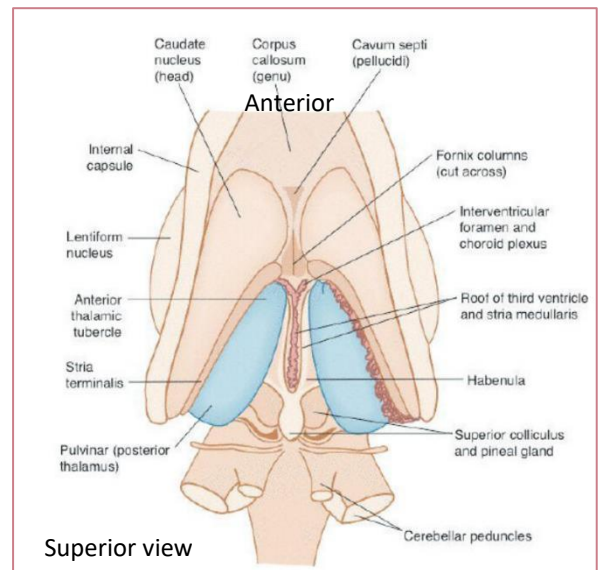
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THALAMUS

- Part of the diencephalon. (Remember: the forebrain is composed of 1- telencephalon (Cerebrum) and 2-diencephalon (Thalamus, hypothalamus, subthalamus and epithalamus)).
- **Large, ovoid, gray mass of nuclei**
- There are two thalami (Right and left), separated by the third ventricle (the cavity of the diencephalon where the CSF passes through it from the two lateral ventricles to the fourth ventricle).
- **The anterior end: narrow and rounded and forms the posterior boundary of the interventricular foramen** (foramen of Monro, which allows the CSF to pass from the lateral to the third ventricle).
- **The posterior end: Wider than the anterior end and expanded laterally to form the Pulvinar**, where you can find the geniculate bodies.
- **The inferior surface is continuous with the tegmentum of the midbrain** (Notice the picture, the thalamus is resting on the midbrain).
- **The medial surface of the thalamus forms part of the lateral wall of the third ventricle (interthalamic connection).**
- Sometimes, there is an interthalamic connection (gray matter), which passes through the space of the third ventricle and connects the two thalami together.
- Please keep referring to the following picture while you are studying the different parts of the Thalamus.



- **Stratum zonale: thin layer of white matter, covering thalamus on its superior surface.**
- **External medullary lamina: white matter on the lateral surface.**
- **Internal medullary lamina: vertical sheet of white matter (Y shape, one stem and two rami) which divides the thalamus into 3 parts:**
 - **Anterior part:** between the two rami.
 - **Medial part.**
 - **Lateral part.**
- We mentioned in previous lectures that the thalamus has a nickname which is the secretary of the cerebrum and this name arises from the fact that no fibers reach the cortex directly, they all pass by the thalamus especially that all the cell bodies of the 3rd order neurons for the sensory tract lie within it so it's a sensory (and motor) relay station-Olfaction is an exception-.
- Also, you must remember that as long as there are synapses within the thalamus then we have modulation-by dampening or amplification- for the arriving signals, it's not just a passage way.
- **(1) Anterior thalamic nuclei:**
 - **Location and connection: bordered by the limbs of the internal Lamina. Receives fibers from the mamillary bodies via the mammillothalamic tract and projects to the cingulate cortex of the Cerebrum**
 - **Function: limbic system, concerned with emotional tone and the mechanisms of recent memory.**
 - The Limbic system is composed of papez circuit, which includes anterior thalamic nucleus.
- **(2) Dorsomedial nucleus:**
 - **Location and connection: (Medial part) connections with:**
 - **The prefrontal cortex** (part of the limbic system)
 - **The hypothalamic nuclei** (part of the limbic system)
 - **All other groups of thalamic nuclei.**
 - **Function: integration of sensory information (somatic, visceral and olfactory information (emotional feelings))**

- The dorsomedial nucleus' connection with the prefrontal cortex and hypothalamic nuclei is responsible for the integration of emotions.

➤ **(3) Intralaminar nuclei:**

- **Location and connection: (within the internal medullary lamina) connections with:**
 - **Reticular formation:** also called the conscious mind, which keeps you awake. It is a group of nuclei that are found in the midline of the brainstem.
 - **The spinothalamic and trigeminothalamic tracts** (ascending tracts)
 - **Send efferent fibers to other thalamic nuclei**
- **Function: influence the levels of consciousness and alertness**

➤ **(4) Ventral anterior and Ventral lateral nuclei** (motor nuclei of the thalamus):

- **Location and connection: (lateral part) connections with** (all related to motor function):
 - **Reticular formation**
 - **Substantia nigra:** part of the basal nuclei functionally
 - **Corpus striatum**
 - **Premotor cortex**
 - **Other thalamic nuclei**
 - **Cerebellum** (fibers that pass between the cerebrum and cerebellum pass through these nuclei and we've already mentioned that we have fibers that move from the cerebrum to the cerebellum in the cerebro-ponto- cerebellum pathway then we have fibers that go back again in the dentothalamic pathway as an example and thus forming a loop. 'Remember: 1) Fibers should pass through the thalamus to reach the cerebrum, 2) We have four deep cerebellar nuclei: Dentate, Emboliform, Globose and fastigial'.
- **Function: Influences activity of motor cortex.**

➤ **(5) Ventral Posteromedial (VPM):**

- **Location: Lateral part**
- **Afferent connection: Trigeminal lemniscus** (a band of white matter – second order neurons - that transmit signals from the spinal and the main trigeminal nuclei about general sensations from the head and neck area to the thalamus then the VPM relays these signals to the cortex), **gustatory fibers** (transmit taste sensations from nucleus tractus solitarius which receives signals from three cranial nerves -7, 9, 10- then the 2nd order neurons project towards the VPM in the thalamus to go from there to the cortex).
- **Efferent connection: Primary Somatic sensory cortex** and primary gustatory cortex (area 43).
- **Function: Relays common sensations, Head & Neck**

➤ **(6) Ventral Posterolateral (VPL):**

- Larger than the VPM thalamic nucleus as it receives two lemnisci.
- **Location: Lateral part**
- **Afferent connection: Medial** (Posterior column) **and spinal lemnisci** (Spinothalamic)
- **Efferent connection: Primary Somatic sensory cortex**
- **Function: Relays common somatic sensations** from all over the body- except the head and area (trigeminal lemniscus).

➤ **(7) Lateral geniculate body:**

- **Location: undersurface of the pulvinar of the thalamus**
- **Afferent connection: Optic tract** (optic nerve is a misnomer, it is thought to be a projection of the diencephalon and since it's a part of the CNS, it must be called 'tract').
- **Efferent connection: Optic radiation** (part of the internal capsule) **to visual cortex of occipital lobe.**
- **Function: Visual information from opposite field of vision.**

➤ (8) Medial geniculate body:

- **Location:** posterior surface of the thalamus beneath the pulvinar
- **Afferent connection:** inferior colliculus receives both ears but predominantly from the opposite ear.
- Inferior colliculus receives signals from the lateral lemniscus pathway (Cochlea → vestibulocochlear nerve → enter the brainstem at the pontomedullary junction → synapse in the ventral and dorsal cochlear nuclei → cross the midline forming trapezoid bodies in the pons → ascend and form the lateral lemniscus → inferior colliculus for reflexes → MGB).
- **Efferent connection:** auditory cortex of the superior temporal gyrus.
- **Function:** Hearing

➤ (9) Reticular nucleus:

- **Location:** **Anteriorly**, between the external medullary lamina and the internal capsule
- **Afferent connection:** Cerebral cortex, reticular formation
- **Efferent connection:** other thalamic nuclei
- **Function:** cerebral cortex regulates thalamic activity since it is the only nucleus that **receives** fibers from the cortex.

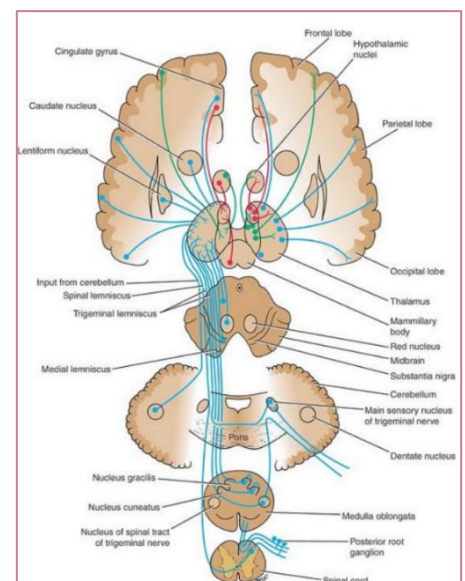
CONNECTIONS OF THALAMUS

➤ Every thalamic nucleus (except the reticular nucleus) sends axons to specific parts of the cerebral cortex and cerebral cortex sends reciprocal fibers back to the Thalamic nuclei

- Information received by the Thalamus is always shared with the cerebral cortex

➤ Sensory-motor axonal loops involving the cerebellum and the basal nuclei:

- **Cerebellar (globose emboliform) -rubro-thalamic-cortical-ponto-cerebellar Loop.**
- **Cortical-striatal-pallidal-thalamic-cortical Loop (Related to the basal nuclei).**



FUNCTIONS OF THALAMUS

- Relay station for all sensory information of all types (except smell).
 - VPL, VPM, MGB, LGB and Dorsomedial nucleus (The Dorsomedial can be considered as multimodal)
- Influences activity of motor Cortex (including direct and indirect loops)
 - VL, VA
- Influences levels of consciousness and alertness.
 - Intralaminar nuclei.
- Emotional tone, mechanisms of recent memory (limbic nuclei)
 - Anterior thalamic nuclei.

Functional Divisions

➤ Sensory nuclei

➤ Motor nuclei

➤ Intralaminar nuclei

➤ Limbic nuclei

➤ Multimodal nuclei

LESIONS OF THE THALAMUS

- Damage to VPM and VPL (Sensory):
 - Due to: usually thrombosis or hemorrhage of one of the arteries supplying the thalamus.
 - Symptoms: loss of all forms of sensation, including light touch, tactile localization and discrimination from the opposite side of the body
 - Vascular lesion of the thalamus may also involve the midbrain and internal capsule and produce extensive motor and sensory deficits. (Symptoms overshadowed: it is difficult to determine if the cause of symptoms is the damaged thalamus(gray matter) or the damaged internal capsule (White matter)).
 - To make the previous point sound clearer; if a light bulb goes off you won't be able to tell whether the bulb itself is damaged (thalamus) or the electric wire that supplies it is damaged 'internal capsule'.
- Dejerine–Roussy syndrome (thalamic Pain) (Sensory):
 - May occur as the patient is recovering from a thalamic infarct
 - Symptoms: Spontaneous pain occurs on the opposite side of the body (remember fibers decussation).

➤ **Abnormal Involuntary Movements (Motor):**

- **Due to: vascular lesions of the thalamus.**
- **Symptoms: Chorea (involuntary movements, the extremities and twitching of the face) and athetosis (slow, involuntary, convoluted, writhing movements of the fingers, hands and toes)**
- **Vascular lesion of the thalamus may also involve the neighboring caudate and lentiform nuclei (Symptoms overshadowed).**

➤ **Thalamic hand (Motor):**

- **The wrist is flexed, the metacarpophalangeal joints are flexed, and the interphalangeal joints are extended.**
- **Fingers can be moved but slowly.**
- **The reason behind this condition is still unknown.**



HYPOTHALAMUS

➤ **Part of the diencephalon.**

➤ **Below the thalamus.**

➤ **Floor and the inferior part of the lateral walls of 3rd ventricle.**

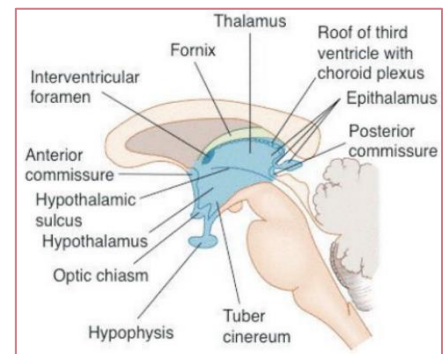
➤ The figure on the right is from a midsagittal section, notice the hypothalamic sulcus between the thalamus and the hypothalamus.

➤ Remember that the hypothalamus is a single structure, but it lies on the lateral walls of the 3rd ventricle from both the right and left sides because of its concavity.

➤ It is a small area (almost nail like) of gray matter, and functionally, it's part of three systems: the autonomic nervous systems, endocrine system - controls the pituitary which is the main gland of the system- and the limbic system -the thalamus is the major output pathway of this system-.

➤ **Boundaries:**

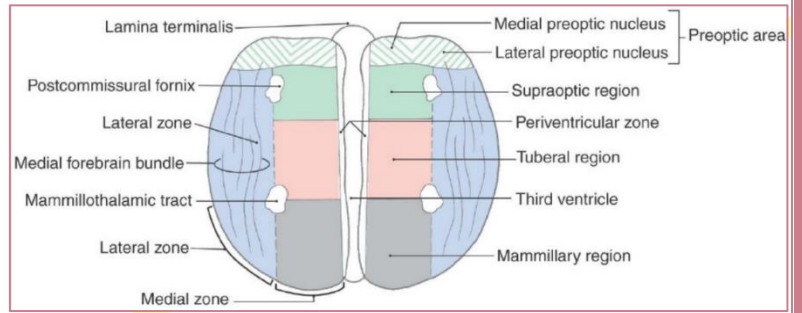
- **Anterior: lamina terminalis.**
- **Superior: hypothalamic sulcus.**
- **Lateral: internal capsule**-can't be seen on the above figure-
 - (It separates the thalamus and hypothalamus medially from the lentiform nucleus laterally).



- **Posterior:** posterior edge of the mammillary body.
- **Medial:** Cavity of third ventricle.

➤ **Divisions of Hypothalamus:**

➤ We have the cavity of the 3rd ventricle in the midline separating the right and left sides of the hypothalamus- Notice the following figure.



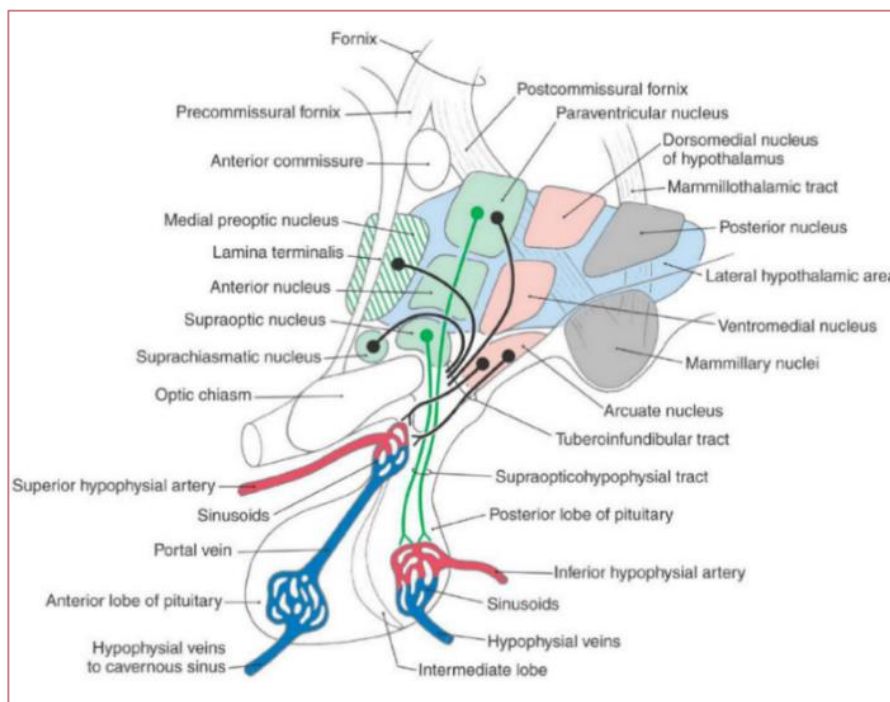
➤ It's divided into 4 zones, all of them being gray matter and each one has a specific function.

➤ It receives the fornix which is the bundle that carries input from the hippocampus to the hypothalamus allowing it to translate emotions to an autonomic response (eg. the body's response when you're sad is the production of tears).

- **Preoptic area:** Medial preoptic nucleus and Lateral preoptic nucleus.
- **Lateral zone:** Lateral hypothalamic nucleus and Tuberal nuclei.
- **Medial zone:** Supraoptic (chiasmatic) region, Tuberal region and Mammillary region.

Periventricular zone (closest to the midline).

➤ Please keep referring to the following picture while studying the different zones of the hypothalamus.



PREOPTIC AREA

1. Medial preoptic nucleus

- Manufacture gonadotropin-releasing hormone (GnRH).
- Tuberoinfundibular tract to capillaries of the hypophysial portal system.
 - A group of axons from multiple nuclei carry information to the hypophysial system in this tract-the release of the GnRH actually happens in the capillaries of this system- and the need for this system is due to the minute amount of hormones being released that can get diluted if released in the blood vessels of the systemic circulation, so since the hypophysial system provides a small area, we get higher hormonal concentrations in the blood and dilution is prevented allowing the hormones to produce a higher effect .
- GnRH causes the release of gonadotropins from Ant pituitary:
 - Luteinizing hormone (LH).
 - Follicle stimulating hormone (FSH).
 - These two hormones affect males and females differently.
- Sexually dimorphic nucleus.
 - Dimorphism is the difference between males and females in the same species and as you all know; the human beings have differences -considered very limited compared to the differences in animals- and this nucleus is believed to be bigger in size in males thus its's sexually dimorphic.

2. Lateral preoptic nucleus: ?? there's nothing clear about its function.

LATERAL ZONE

1. Lateral hypothalamic nucleus.

- Feeding center.
- Stimulation: promotes feeding (appetite).
- Destruction: attenuate feeding.
- This nucleus is activated in the case of hypoglycemia.

2. Tuberal nuclei.

- Via tuberoinfundibular tract influence releasing of:
 - **Thyrotropin-releasing hormone:** Thyrotropin enhances the thyroid gland to release T3 and T4

- Growth hormone-releasing hormone
- Growth hormone release-inhibiting hormone (Somatostatin).

➤ This nucleus acts to control the anterior pituitary similar to the medial preoptic nucleus.

MEDIAL ZONE

1. Supraoptic region:

- A. Supraoptic.
- B. Paraventricular
- C. Suprachiasmatic.
- D. Anterior nuclei.

- **Supraoptic and Paraventricular nuclei contain oxytocin and antidiuretic hormone (ADH) to the posterior pituitary by supraoptic- hypophysial tract.**
- Oxytocin (Responsible for the reinforce bonding between the infant and the mother as it is released during breast feeding) and ADH are synthesized in these two nuclei.
- **Suprachiasmatic nucleus** (as the name implies, it lies above the optic chiasm); **receives direct input from the retina and has a role in controlling the circadian rhythms** (24-hour cycles that regulate various processes in the body, including sleep, metabolism, and mental health).
- We said that this nucleus receives input from retina which allows is to know whether your surrounding is dark -night time mostly- or light - daytime- and accordingly it manages the circadian cycle.
- **Anterior nucleus: Maintenance of body temperature (cooling).**
- The anterior nucleus functions in thermoregulation and its main effect is the vasodilation of the blood vessels under the skin causing heat loss and sweating, which cools the body down, so it's activated when the weather is very hot.

2. Tuberal region:

A. Ventromedial nucleus: Satiety center.

- Satiety is the sense of fullness, so this nucleus works in a manner opposite to that of the lateral hypothalamic nucleus and if a lesion affected this nucleus, the patient's complain would be that he eats excessively, and yet, remains hungry.

B. Dorsomedial nucleus: Aggressive Behavior-Will be discussed at the end of the lecture-.

C. Arcuate nucleus:

➤ **Tuberoinfundibular tract** (directed towards the anterior pituitary) and **hypophysial Portal system**.

➤ Like the medial preoptic and tuberal nuclei; all three of them act on the anterior pituitary.

➤ **Neurons that contain releasing hormones**

- **Gonadotropin-releasing hormone.**
- **Growth hormone-releasing hormone.**
- **Prolactin release-inhibiting hormone.**

3. Mammillary region:

A. Medial mammillary nucleus:

➤ **Termination of fornix.**

- As we mentioned previously, the fornix is considered bundles of white matter that convey input from the hippocampus (floor of the inferior horn of the third ventricle) towards the hypothalamus, and its anterior column specifically attaches to the medial mammillary nucleus- The fornix is a very important part of the limbic system.

➤ **Origin of mammillothalamic tract** (extends from the mammillary body until it reaches the anterior **thalamic** nucleus).

B. Intermediate and Lateral mammillary nuclei:

➤ **Receive sensory input from the midbrain via mammillary peduncle.**

C. Posterior hypothalamic nucleus:

➤ **Maintenance of body temperature (heating).**

- The **posterior** hypothalamic nucleus works exactly opposite to the anterior hypothalamic nucleus; when the temperature drops, it causes the superficial vessels constrict reducing heat loss and it also helps in shivering-A mechanism that the body uses to generate heat.

PERIVENTRICULAR ZONE

- **Synthesize releasing hormones** (the same ones discussed in the arcuate nucleus).
- **Tuberoinfundibular tract to the hypophysial portal system.**
- **Very similar to arcuate nucleus.**
- ❖ **Effect of Stimulation or Lesion of the Hypothalamic Nuclei:**

NUCLEUS	STIMULATION OF	LESION OF
Suprachiasmatic nucleus	Adjusts the circadian clock phase	Abolishes circadian rhythms
Supraoptic or paraventricular nuclei	Increased blood volume, blood pressure, and metabolism	Diabetes insipidus
Lateral hypothalamic nucleus	Increased feeding	Decreased feeding
Ventromedial nucleus	Decreased feeding	Increased feeding
Dorsomedial nucleus	Sham rage	Decreased aggression and decreased feeding
Mammillary body	?	Short-term memory is not processed into long-term memory

- The table above summarizes what we already discussed about the nuclei, but in an experimental way (The experiments were conducted on animals mostly).
 1. Suprachiasmatic nucleus: It controls the circadian rhythm, so its stimulation adjusts the rhythm, however, the presence of a lesion causes a problem in the rhythm.
 2. Supraoptic or paraventricular nuclei: They manage oxytocin and ADH so when stimulated they increase blood pressure and metabolism because of the increase in ADH mainly. On the other hand, a lesion causes diabetes insipidus (The symptoms are like the ones of diabetes mellitus, hence the name) and this condition is associated with increased urination because of the decrease in ADH levels.
 3. Dorsomedial nucleus: Its stimulation leads to sham rage (A term that is usually used for animals) and a lesion results in decreased aggression and feeding (food and aggression are correlated in animals more than in

- humans because their food-seeking behavior when they are hungry is translated as aggression, but you -as a human- have more self-control).
4. Mammillary body: We still don't know how the stimulation affects the mammillary body, but we know that a lesion manipulates with the processing of short-term memory into long term memory -You'll understand this concept better when you study the limbic system lecture.

E-LEARNING QUESTIONS:

Which of the following thalamic nuclei is concerned with emotional tone and the mechanisms of recent memory?

- a) Anterior thalamic
- b) MGB
- c) LGB
- d) VPL
- e) Intralaminar

Answer: A

Which of the following thalamic nuclei receives gustatory fibers?

- a) VPL
- b) VPM
- c) MGB
- d) LGB
- e) VA and VL

Answer: B

Which of the following hypothalamic nuclei is sexually dimorphic nucleus?

- a) Medial preoptic nucleus
- b) Tuberal nuclei
- c) Suprachiasmatic nucleus
- d) Lateral hypothalamic nucleus
- e) Mammillary body

Answer: A

Which of the following thalamic nuclei is responsible for maintenance of body temperature (cooling)?

- a) Paraventricular nuclei
- b) Suprachiasmatic nucleus
- c) Dorsomedial nucleus
- d) Anterior nucleus
- e) Arcuate nucleus

Answer: D

GOOD LUCK :)

V2

➤ Page 12: The posterior hypothalamic nucleus; not the anterior one.