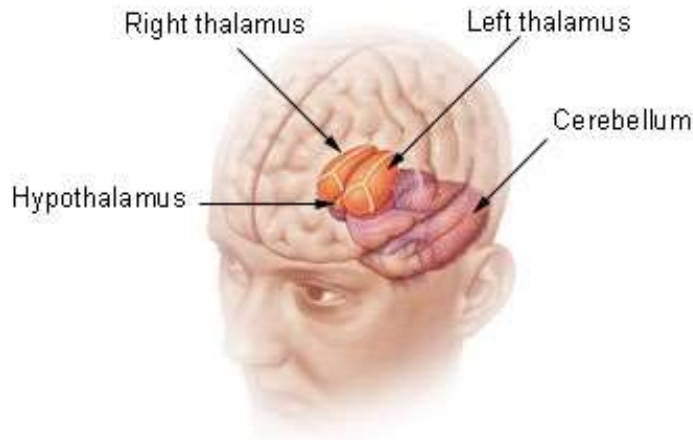


Diencephalon

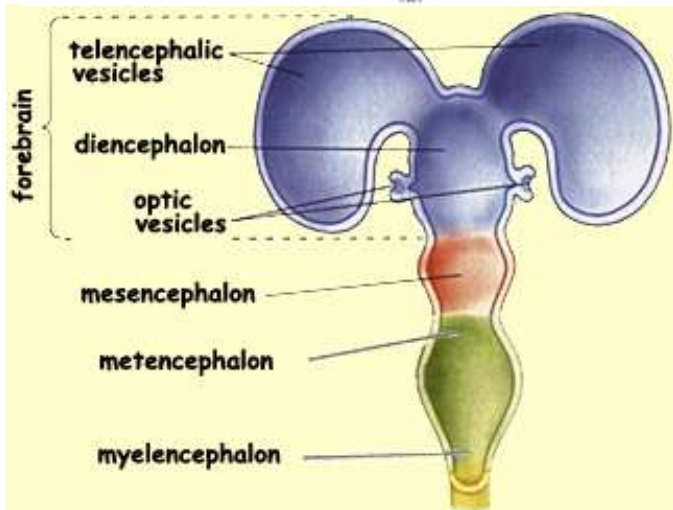
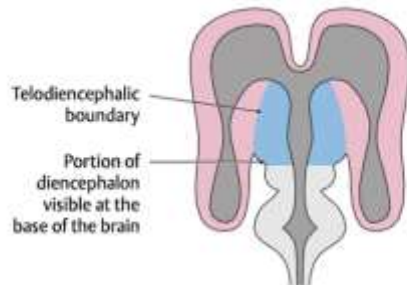
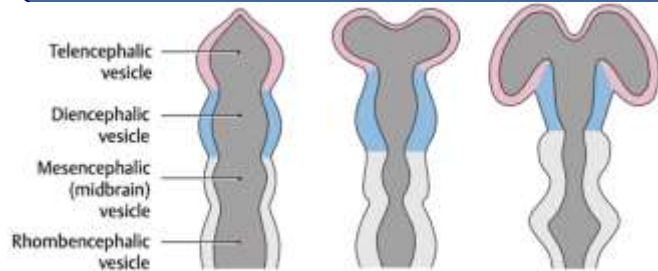


Diencephalon ("interbrain")

1. Diencephalon – regional organization and internal structure:
 - ✓ thalamus – topographic and nuclear organization
 - ✓ metathalamus – the geniculate bodies
 - ✓ epithalamus – pineal gland and habenula
 - ✓ subthalamus (ventral thalamus)
 - ✓ hypothalamus – divisions, nuclei and connections
2. Third ventricle
3. Brainstem reticular formation



Embryologic development



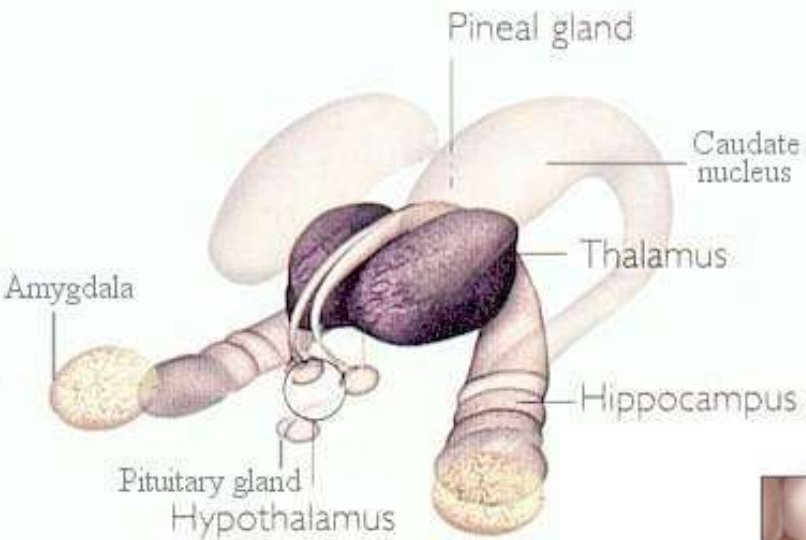
- Embryonic origin:
 - ✓ side walls of the ***prosencephalon (forebrain)***

- Location – at the midline of the brain:
 - ✓ caudally – *mesencephalon*
 - ✓ cranially – *telencephalon*

- Functions:
 - ✓ relay system between sensory input neurons and other parts of the brain
 - ✓ works in tandem with the limbic system



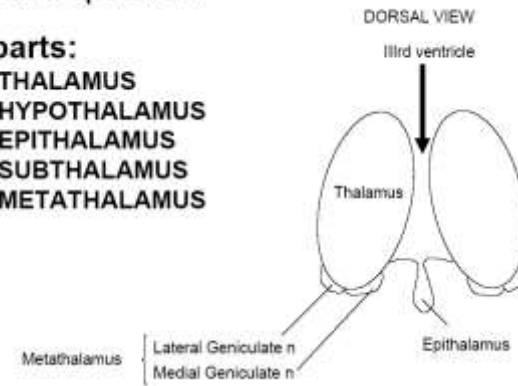
Diencephalon – gross structure and parts



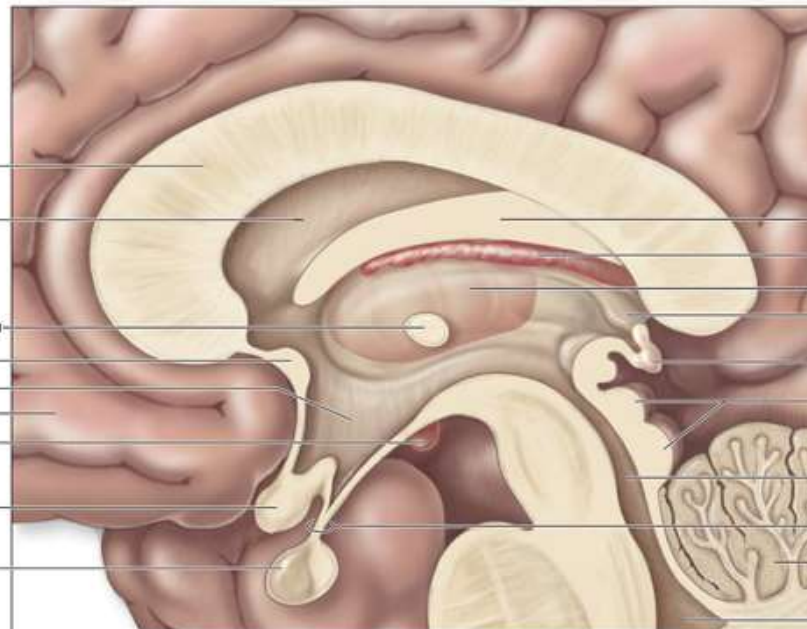
Diencephalon

5 parts:

1. THALAMUS
2. HYPOTHALAMUS
3. EPITHALAMUS
4. SUBTHALAMUS
5. METATHALAMUS



Corpus callosum
Septum pellucidum
Interthalamic adhesion
Anterior commissure
Hypothalamus
Frontal lobe
Mammillary body
Optic chiasm
Pituitary gland



Midsagittal section

Fornix
Choroid plexus in third ventricle
Thalamus
Habenular nucleus
Pineal gland
Part of the corpora quadrigemina
Mesencephalic aqueduct
Infundibulum
Cerebellum
Fourth ventricle

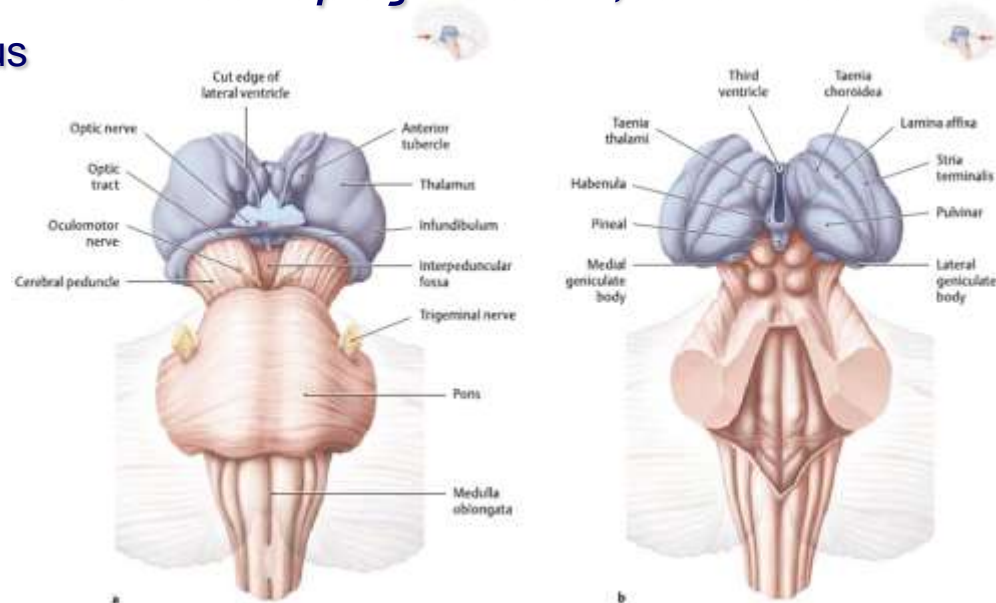
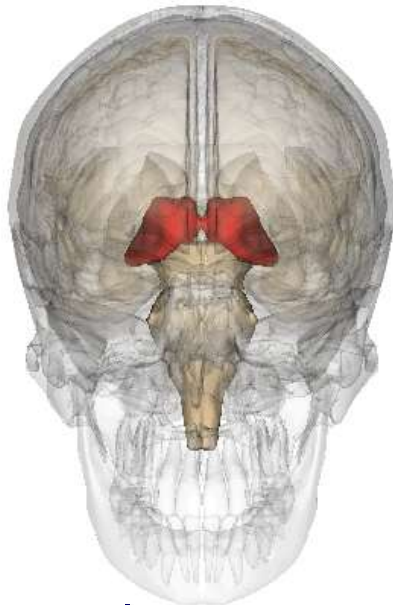
Epithalamus



Thalamus – external features

- two egg-shaped lobes of grey matter
 - ✓ third ventricle medially
 - ✓ hypothalamus ⇒ hypothalamic sulcus

Gr. θάλαμος = room, chamber

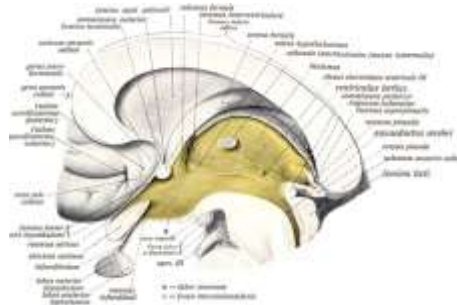


■ **Thalamus dorsalis:**

- ✓ rostral pole = *tuberculum anterius thalami*
- ✓ caudal pole = *pulvinar thalami* (“cushioned seat”)
- ✓ interthalamic adhesion
- ✓ *lamina affixa*
- ✓ *stria terminalis thalami*

■ nuclear complex – 2% of the total brain

- ✓ about 80% of diencephalic mass
 - ~30 mm long
 - ~20 mm wide
 - ~20 mm tall

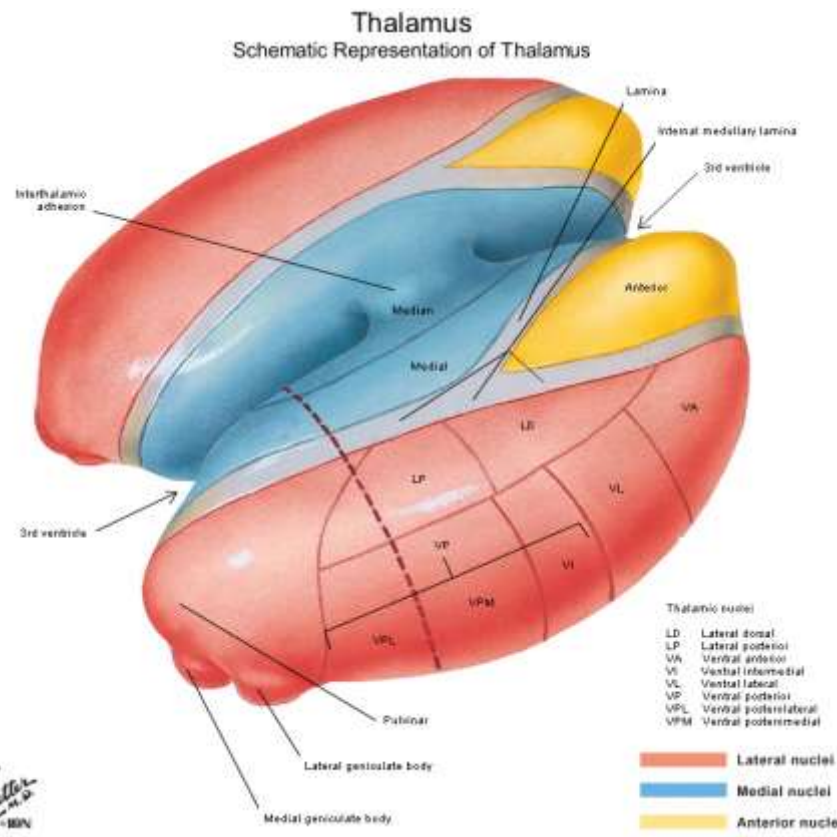
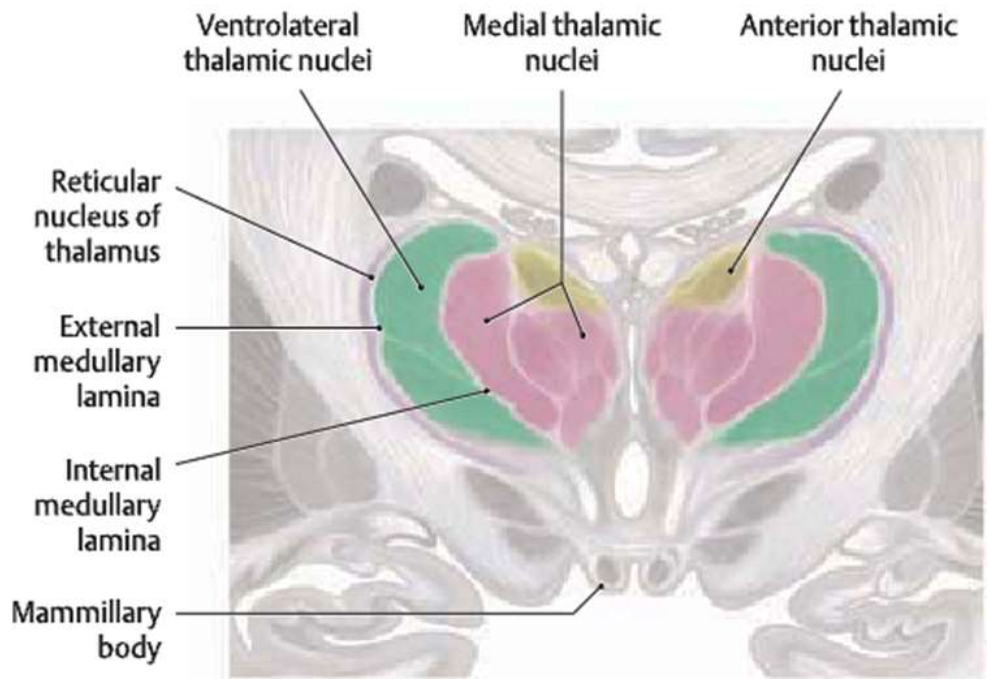




Thalamus – internal structure

- internal medullary lamina (medial) – Y-shaped:

- ⇒ three major nuclear masses:
 - ✓ anterior
 - ✓ medial
 - ✓ lateral nuclear groups

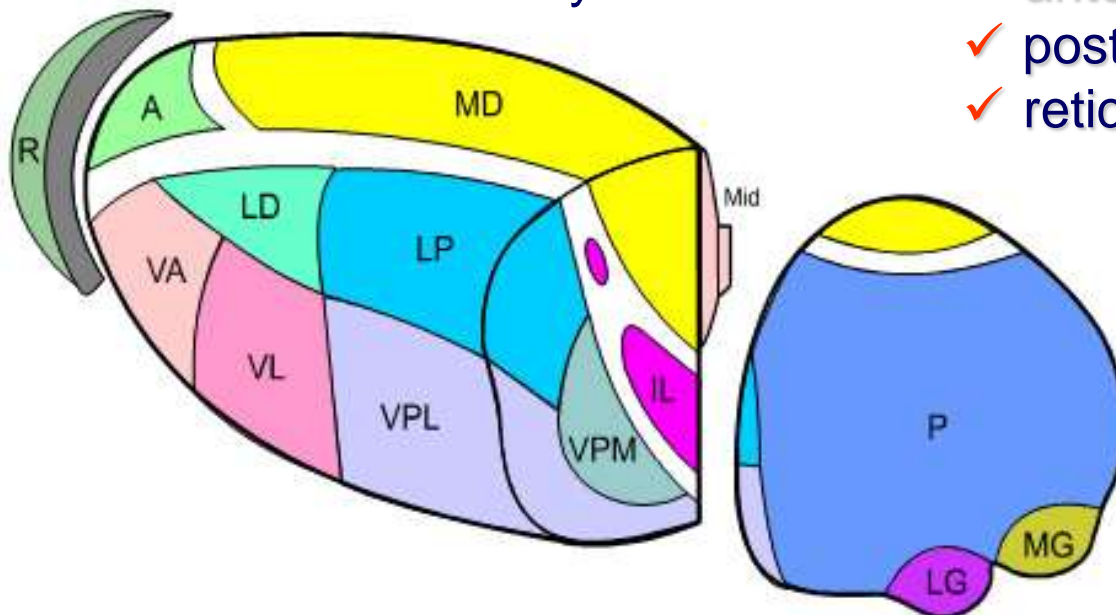


- external medullary lamina (lateral):
- ⇒ reticular nucleus of the thalamus

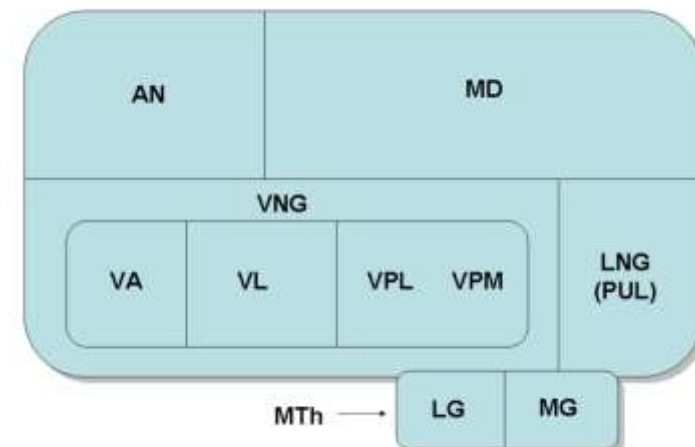


Thalamus – nuclear organization

- 50-60 distinct nuclei
- 5 functional nuclear groups:
 - ✓ sensory relay nuclei
 - ✓ motor relay nuclei
 - ✓ reticular system relay nuclei
 - ✓ limbic system relay nuclei
 - ✓ association relay nuclei
- 8 main anatomic nuclear groups:
 - ✓ intralaminar
 - ✓ ventral – anterior, lateral, posterior
 - ✓ lateral dorsal
 - ✓ medial
 - ✓ midline
 - ✓ anterior
 - ✓ posterior
 - ✓ reticular



Thalamic Nuclei (lateral view - MNG on other side)





Thalamic nuclei

o in internal medullary lamina:

■ intralaminar nuclear group:

✓ rostral intralaminar nuclei:

- central lateral nucleus, *nucleus centralis lateralis*
- central medial nucleus, *nucleus centralis medialis*
- paracentral nucleus, *nucleus paracentralis*

✓ caudal intralaminar nuclei:

- centromedian nucleus, *nucleus centromedianus*
- parafascicular nucleus, *nucleus parafascicularis*

o laterally from internal medullary lamina:

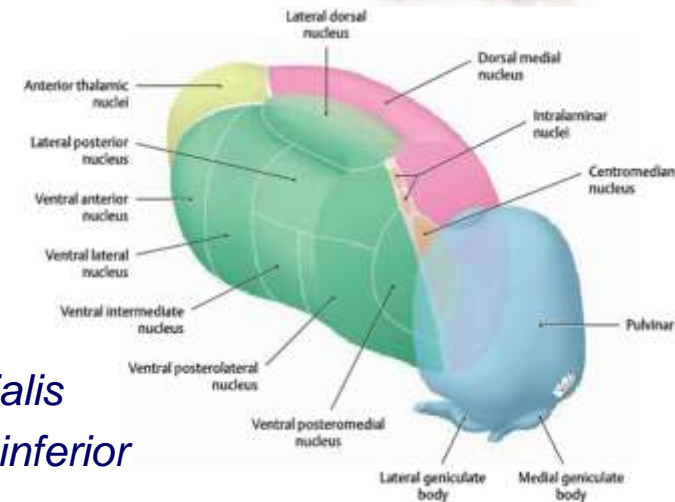
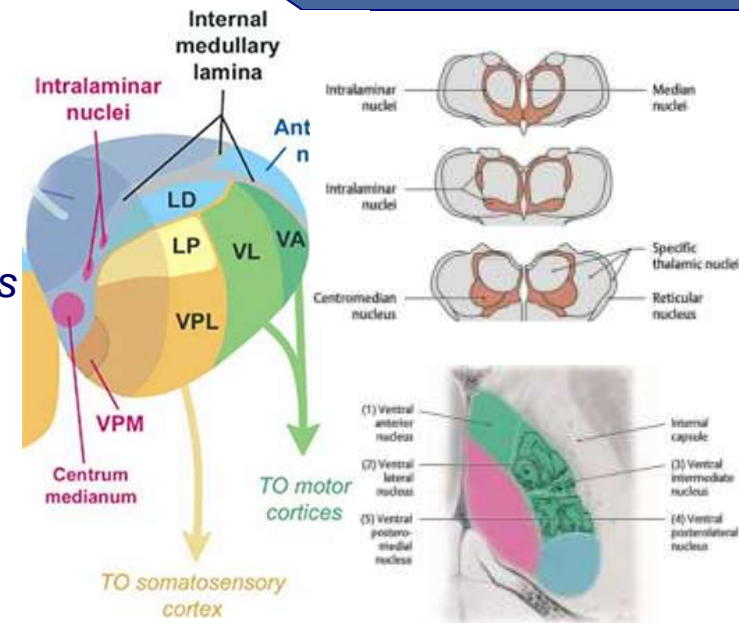
■ ventral nuclear group:

✓ ventral anterior nucleus, *nucleus ventralis anterior*

✓ ventral lateral nucleus, *nucleus ventralis lateralis*

✓ ventrobasal nuclei, *nuclei ventrobasales*:

- ventral posterior, *nucleus ventralis posterolateralis*
- ventral posteromedial, *nucleus ventralis posteromedialis*
- ventral posterior inferior, *nucleus ventralis posterior inferior*





Thalamic nuclei

■ medial nuclear group: (mediodorsal complex)

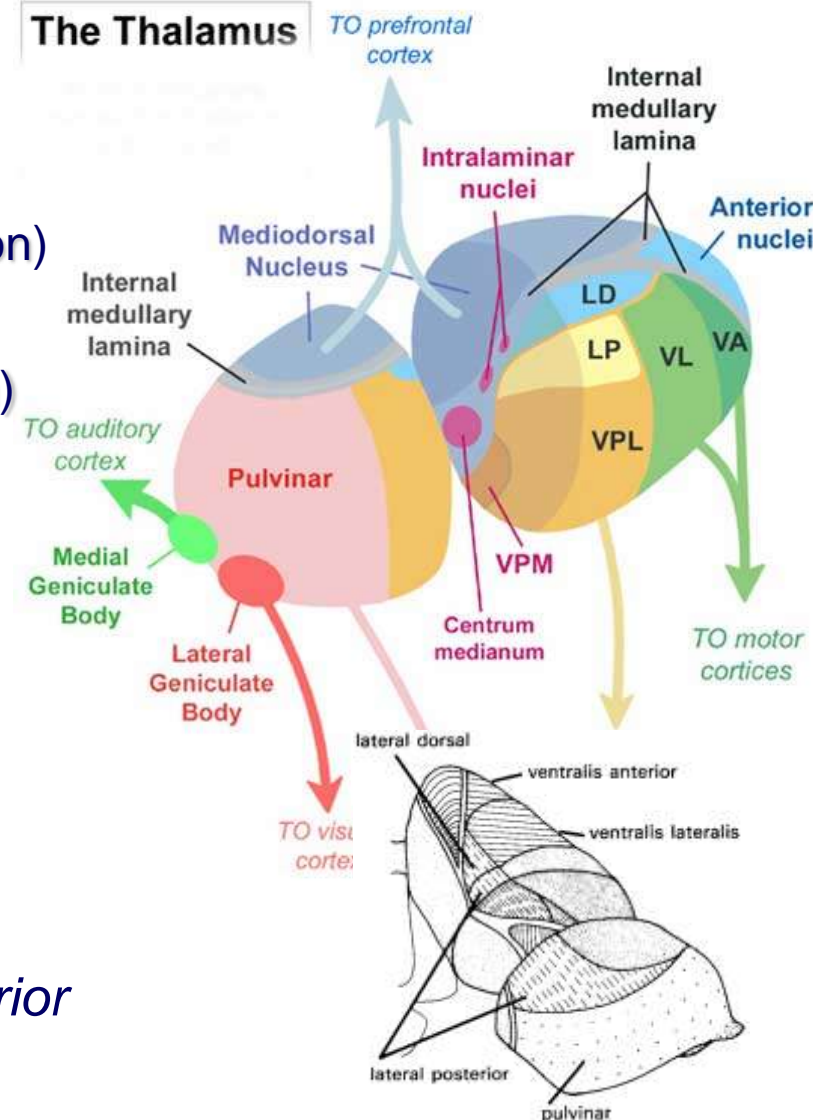
- ✓ mediodorsal nucleus, *nucleus mediodorsalis* (magnocellular portion)
 - ⇒ affects, emotion, behaviour
- ✓ medioventral nucleus (parvocellular portion) *nucleus medioventralis*

■ midline nuclear group:

- ✓ paratenial and paraventricular nuclei
 - ⇒ limbic system
 - ⇒ memory, awake and alert state

■ lateral nuclear group:

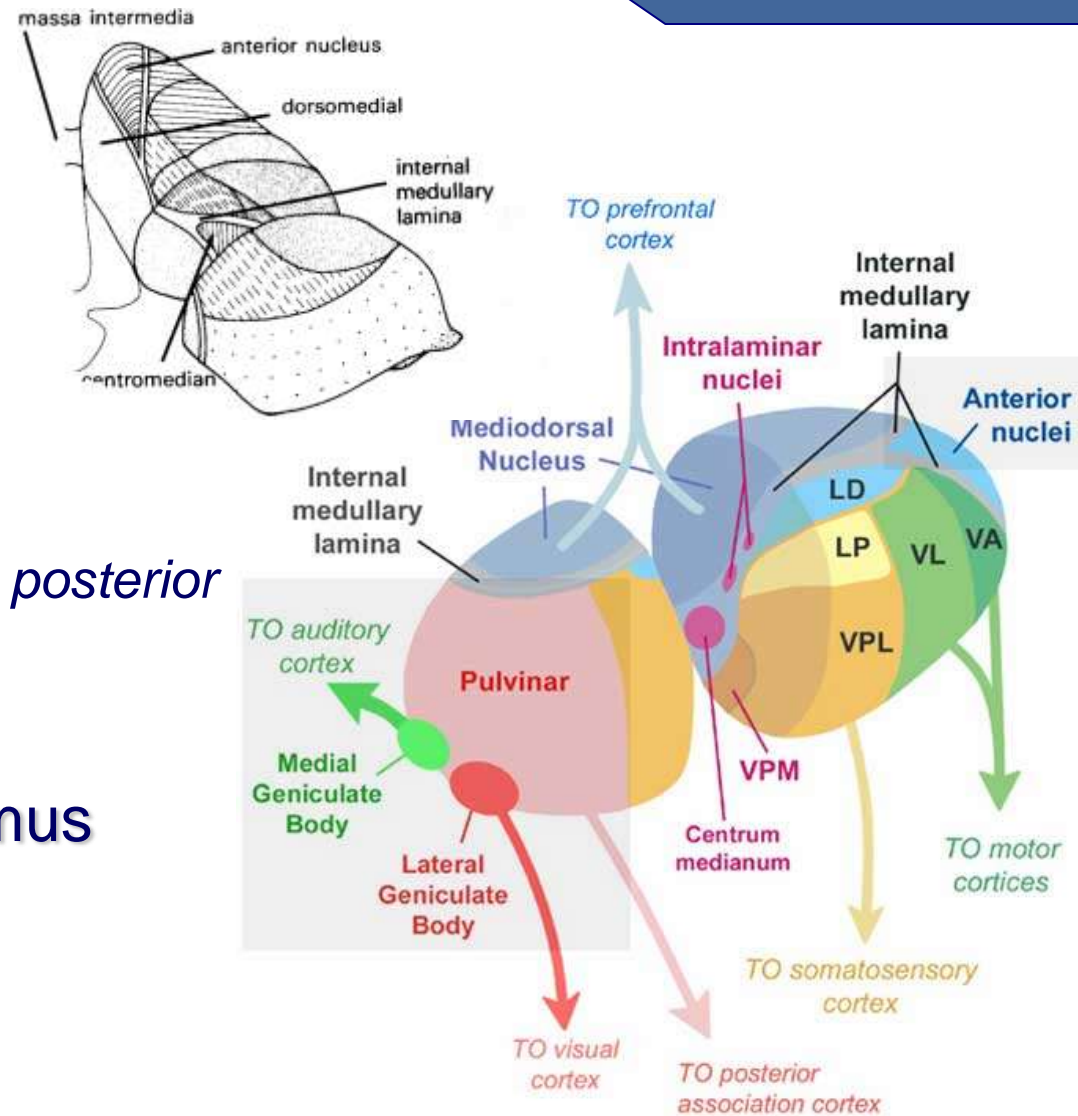
- ✓ lateral dorsal, *nucleus dorsalis lateralis*
- ✓ lateral posterior, *nucleus lateralis posterior*
- ✓ pulvinar, *nuclei pulvinares*





Thalamic nuclei

- anterior nuclear group:
 - ⇒ limbic system
 - ✓ *nucleus anterodorsalis*
 - ✓ *nucleus anteroventralis*
 - ✓ *nucleus anteromedialis*
- posterior nuclear group: (in ventral pulvinar)
 - ✓ posterior nucleus, *nucleus posterior*
 - ✓ suprageniculate nucleus
 - ✓ limitans nucleus
- reticular nucleus of thalamus
- geniculate nuclear group:
 - ✓ medial geniculate nucleus
 - ✓ lateral geniculate nucleus

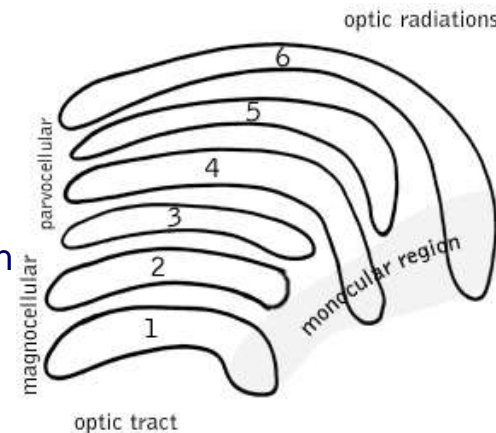
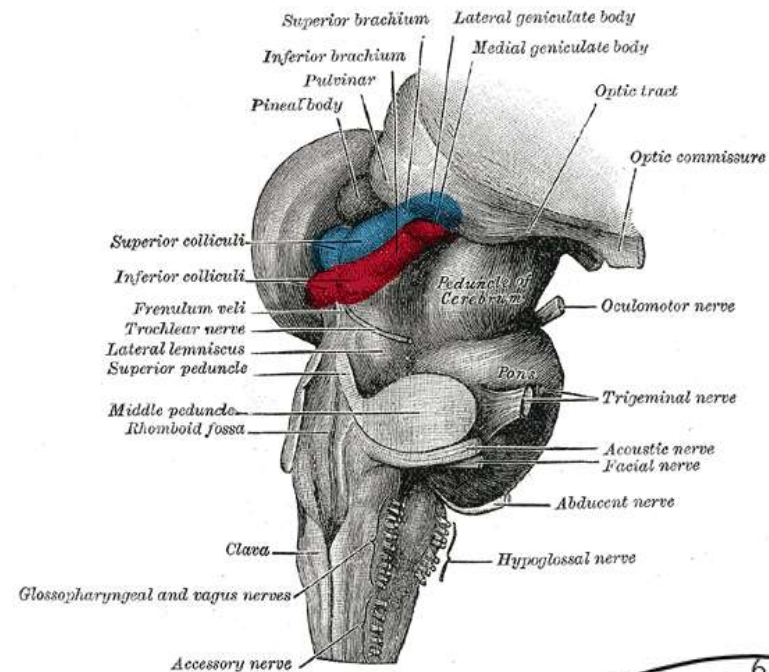
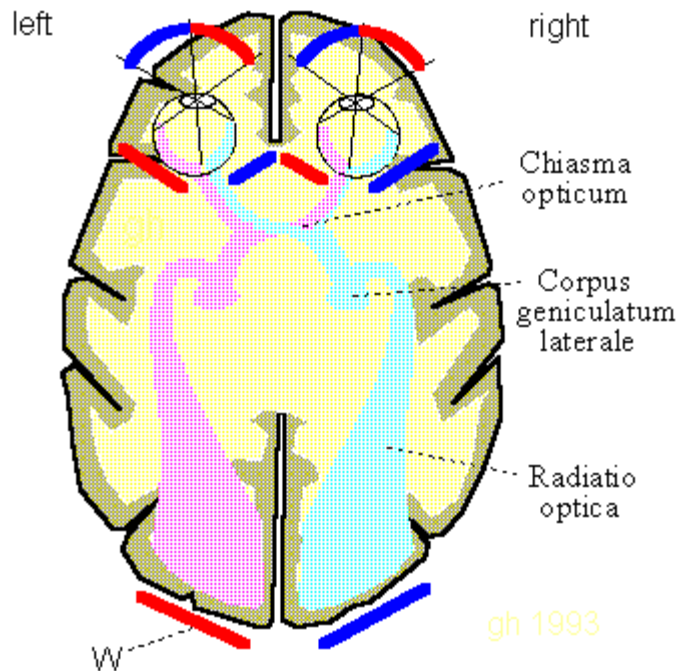




Metathalamus – geniculate bodies

- Medial geniculate body: subcortical acoustic center (thalamic relay)

✓ inferior colliculi ⇒ inferior brachium
 ⇒ acoustic radiation ⇒ auditory cortex



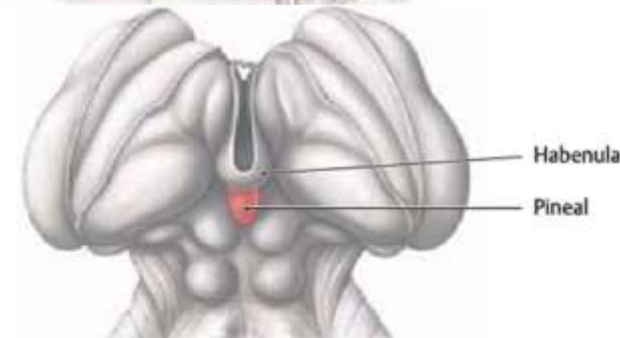
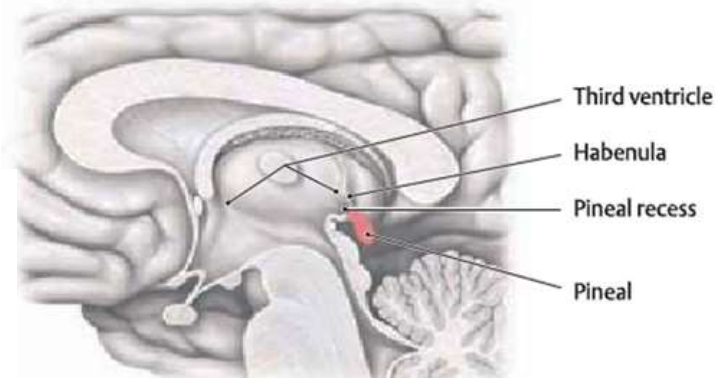
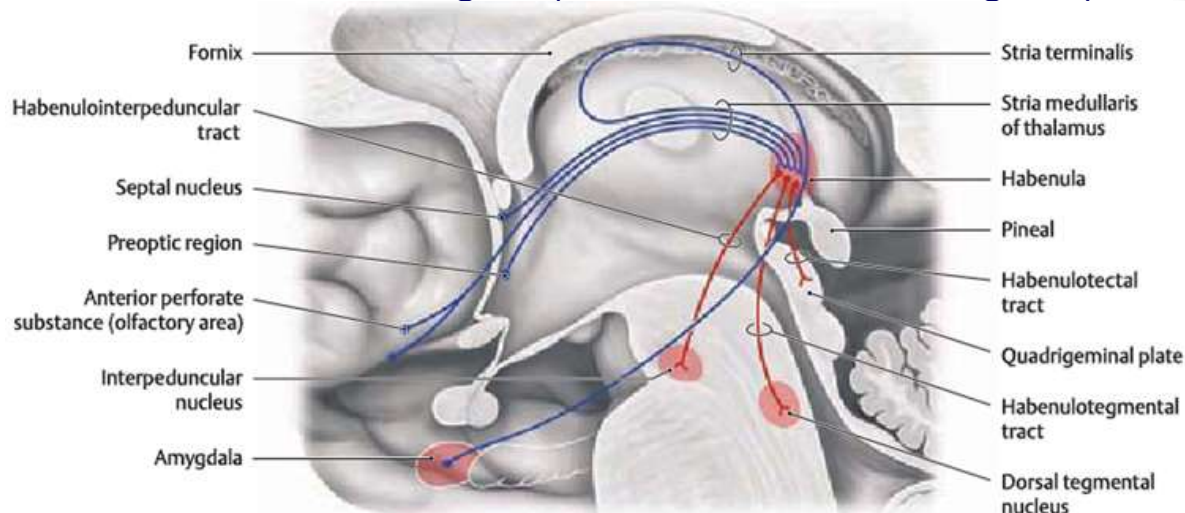
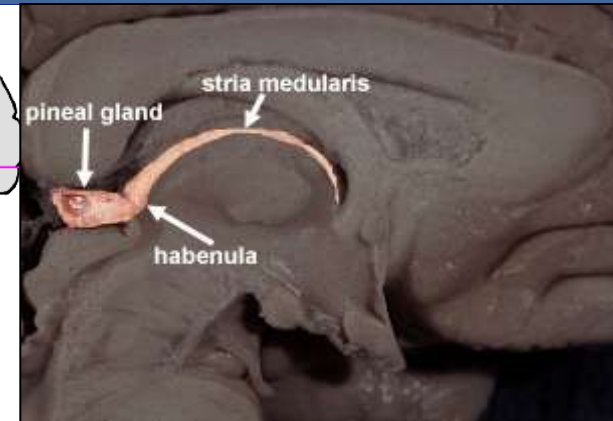
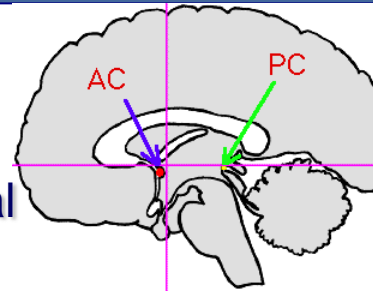
- Lateral geniculate body: primary processing center for visual information

✓ superior colliculi ⇒ brachium of superior colliculus
 ⇒ optic radiation ⇒ visual (striate) cortex

Epithalamus

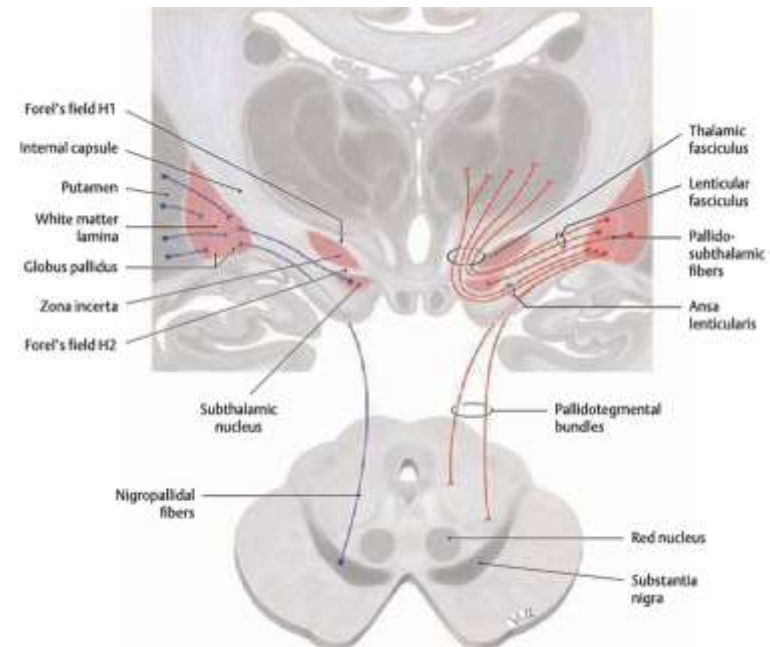
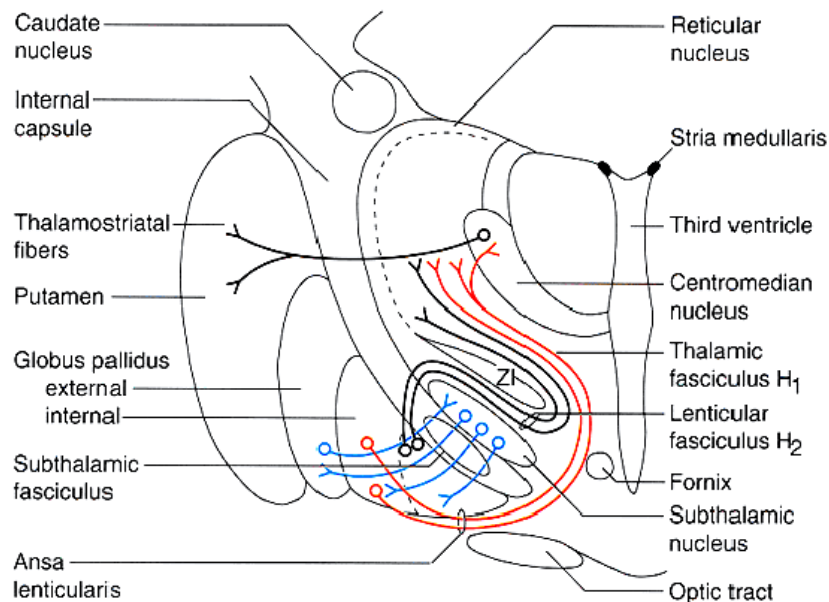
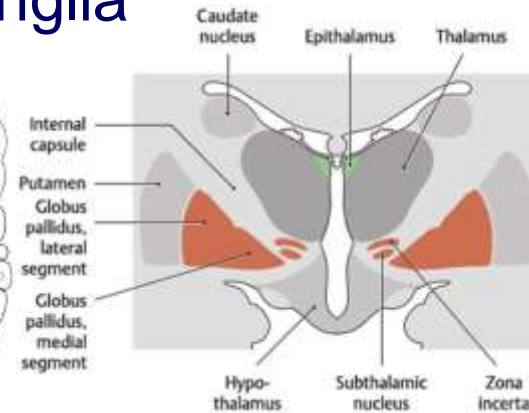
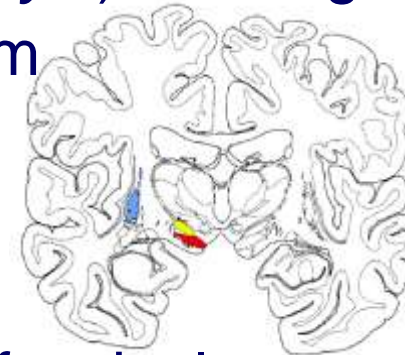


- *stria medullaris thalami*
- habenular trigone:
 - ✓ habenular nuclei, medial and lateral
- habenula
 - ✓ habenular commissure
- pineal gland, *corpus pineale (epiphysis)*
- posterior commissure
 - ✓ subfornical organ (circumventricular organs)



Subthalamus (ventral thalamus)

- subthalamic nucleus (*corpus Luysi*): basal ganglia
 - ✓ extrapyramidal motor system
- *zona incerta* – GABAergic neurons
- *nuclei campi perizonales* (H₁- and H₂-fields of *Forel*)
- *ansa lenticularis* and lenticular fasciculus

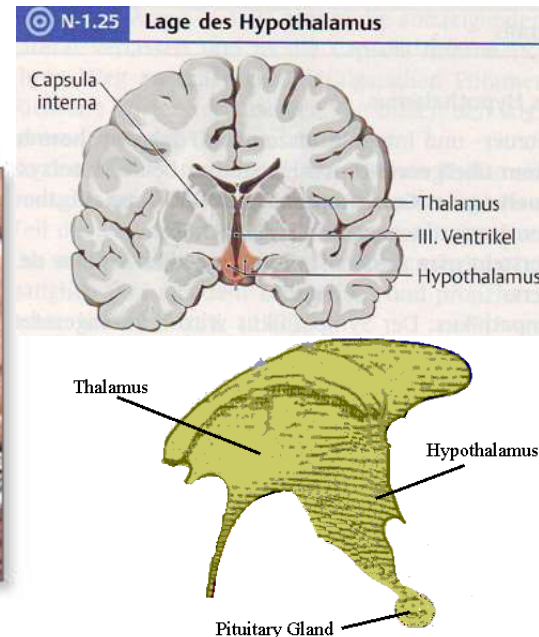
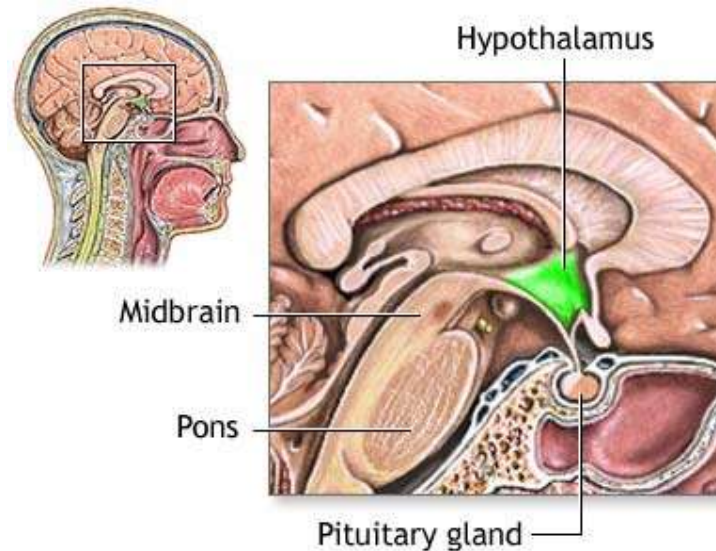
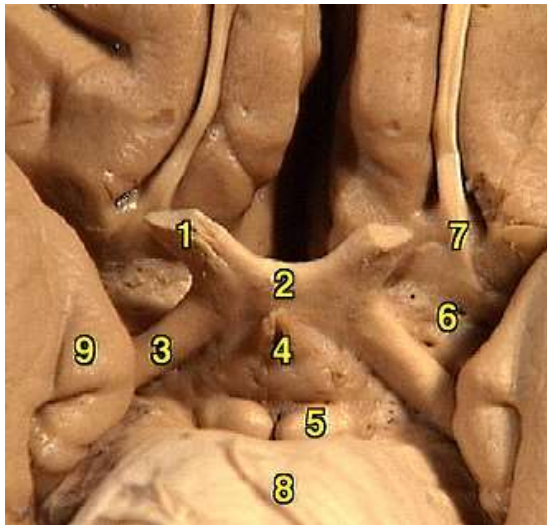
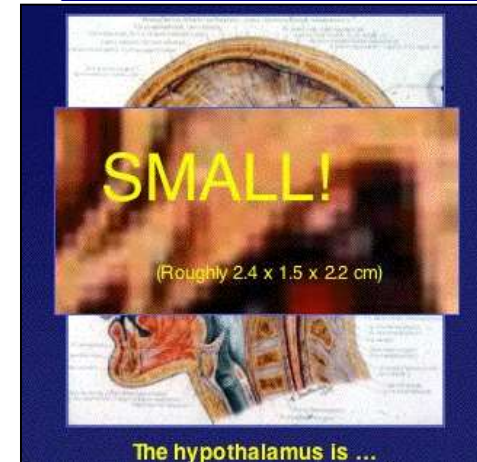




Hypothalamus – gross anatomy

Gr. ὑποθαλαμος = *hypo-*, cognate to Latin *sub-* "under"

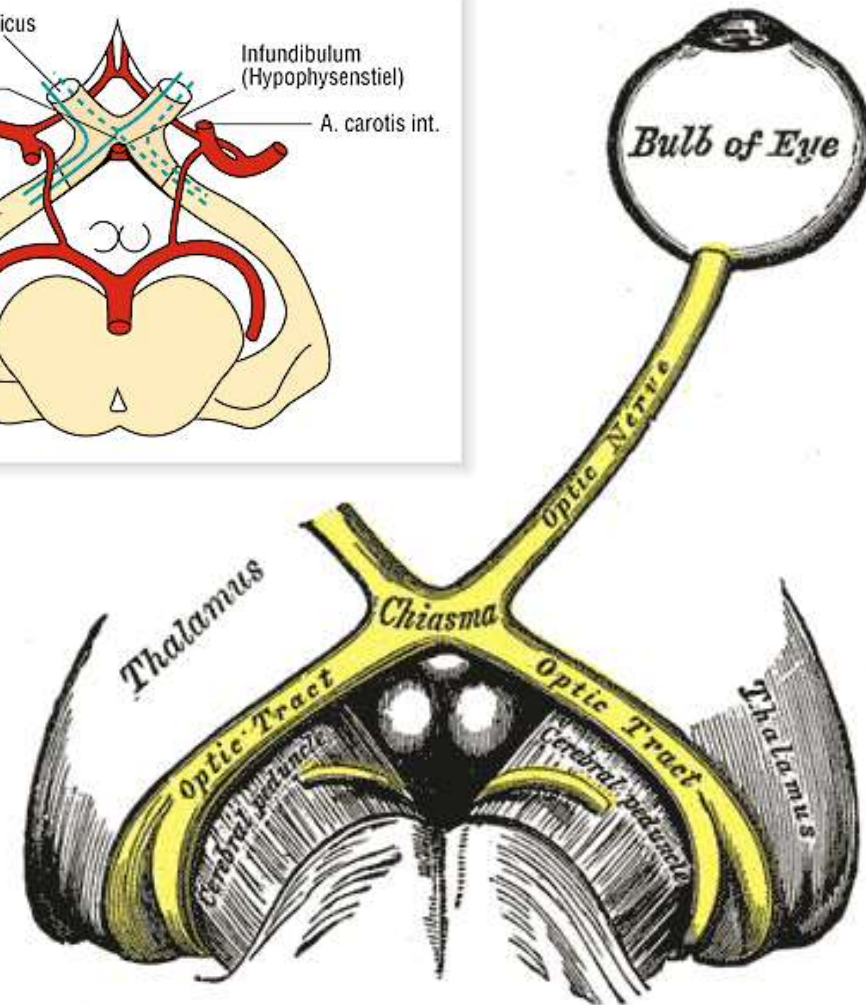
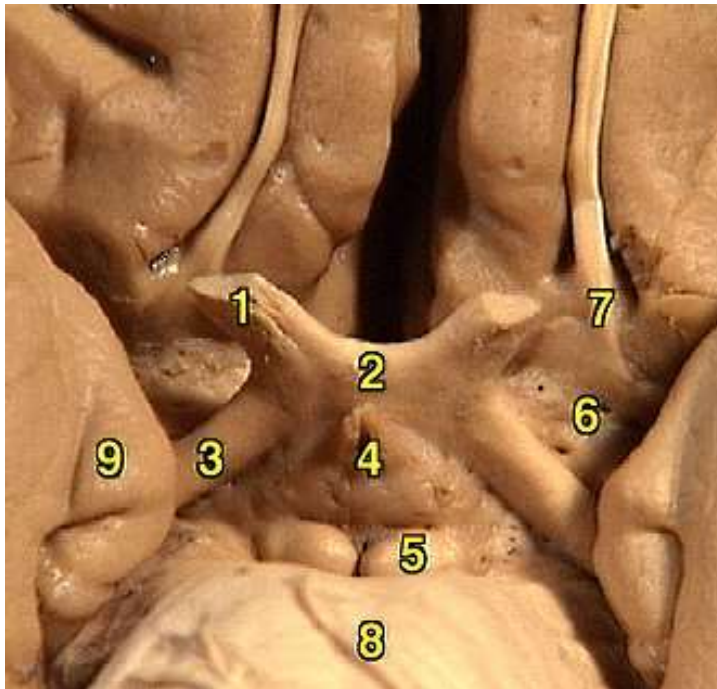
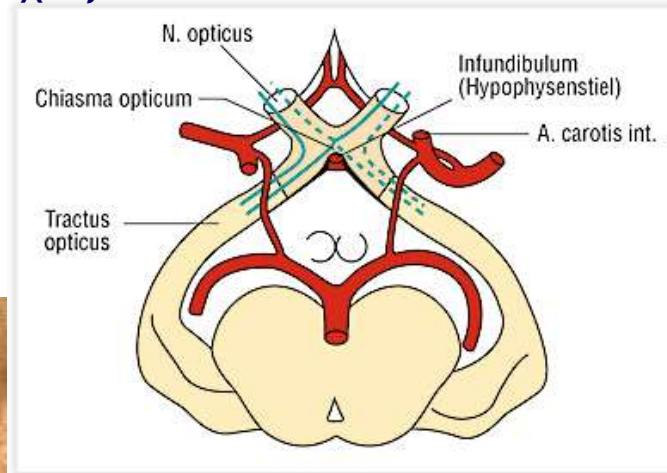
- ✓ most ventral portion of the diencephalon
- ✓ weight 4-5 g – less than 1% of the total human brain volume
- preoptic area, *area preoptica*
- optic chiasm, *chiasma opticum*
- *tuber cinereum*, median eminence
- infundibular tract, *infundibulum* ⇒ *hypophysis cerebri*
- mammillary bodies, *corpora mammillaria*





Optic chiasm and tract

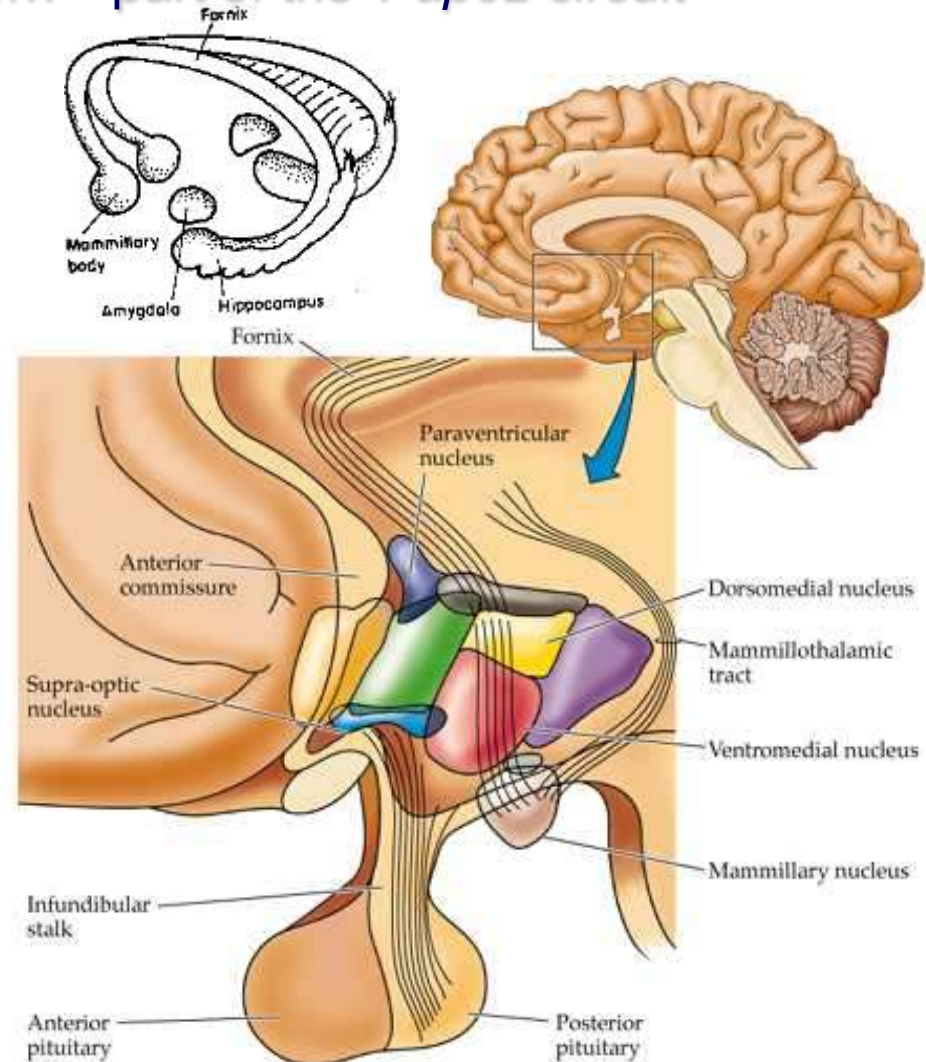
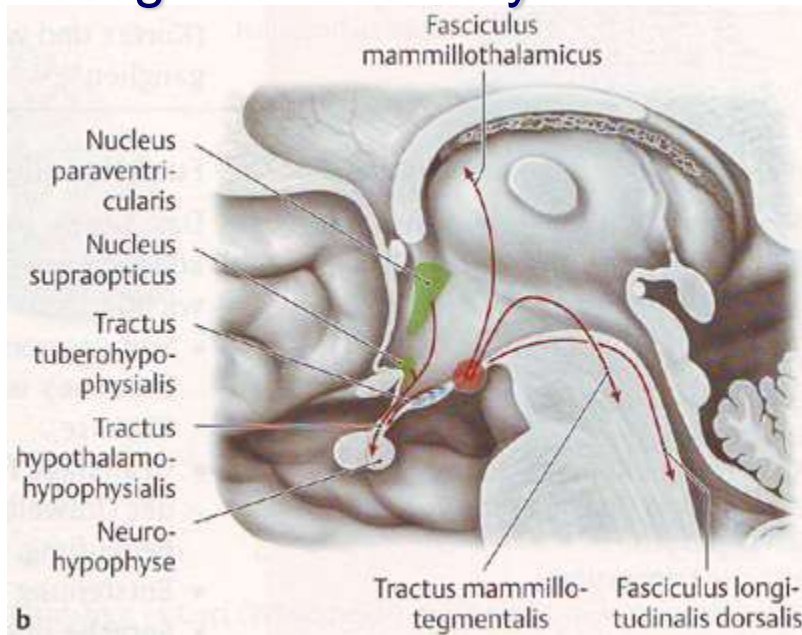
- ✓ part of the visual system
- ✓ Gr. χίασμα, "crossing", from the Greek χιαζω 'to mark with an X', after the Greek letter 'X', *chi*
- ✓ the part where CN II partially cross
- ✓ allows for parts of both eyes that attend to the right visual field to be processed in the left visual system in the brain, and vice versa





Mammillary bodies

- ✓ incorporated into the limbic system – part of the ‘Papez circuit’
- ✓ *fasciculus mamillothalamicus* (tract of *Vicq d’Azyr*)
- ✓ *fasciculus mamillo-tegmentalis*
- ✓ involved with the processing of recognition memory

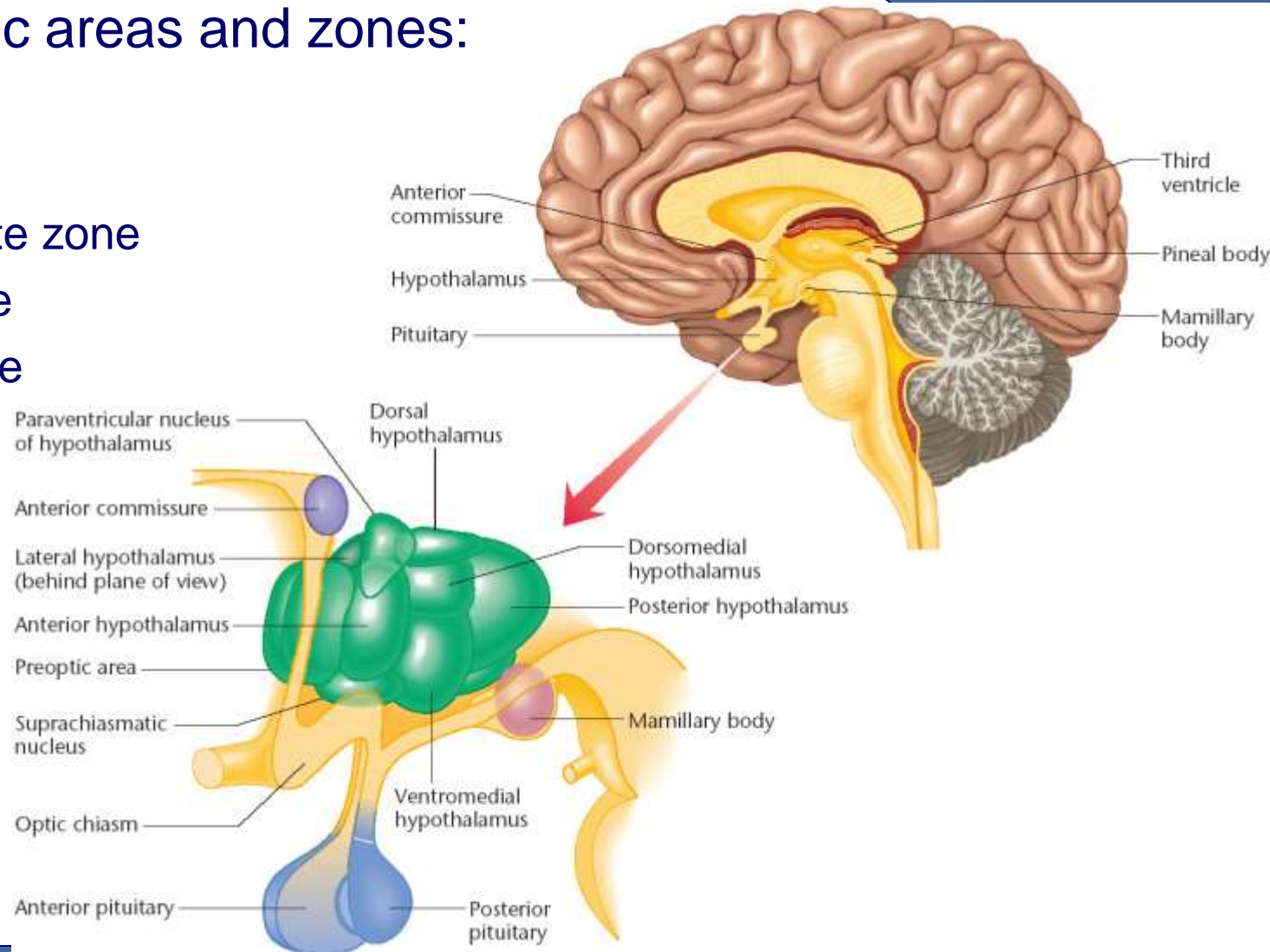




Hypothalamic divisions

hypothalamic areas and zones:

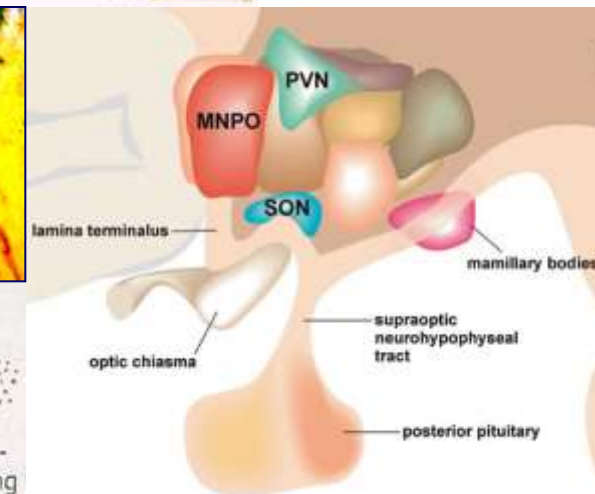
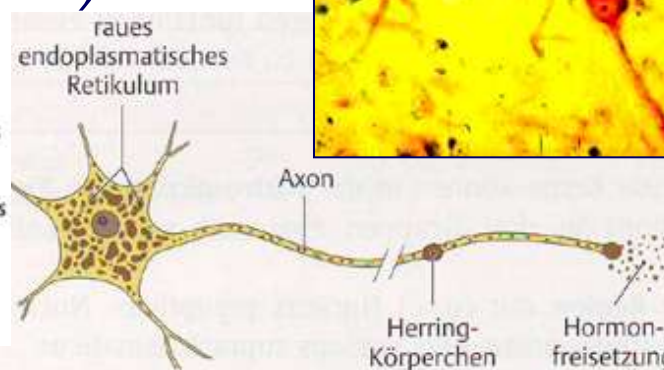
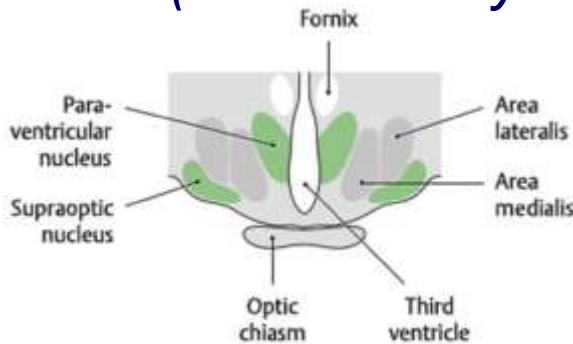
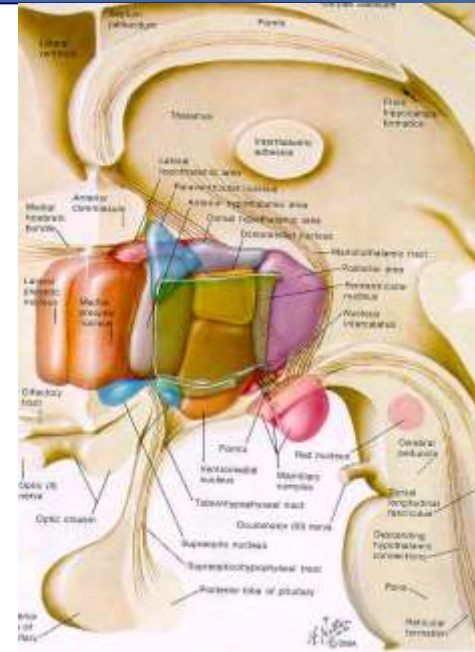
- ✓ rostral
- ✓ dorsal
- ✓ intermediate zone
- ✓ lateral zone
- ✓ medial zone
- ✓ posterior





Hypothalamic nuclei

- preoptic region:
 - ✓ preoptic periventricular nucleus
 - ✓ medial preoptic nucleus
 - ✓ lateral preoptic nucleus
- anterior hypothalamic region:
 - ✓ supraoptic nucleus
 - ⇒ *oxytocin, vasopressin (ADH)*
 - ✓ paraventricular nucleus
 - ✓ anterior hypothalamic nucleus
 - ✓ suprachiasmatic nucleus
 - ⇒ *endogenous brain clock (circadian rhythms)*





Hypothalamic nuclei

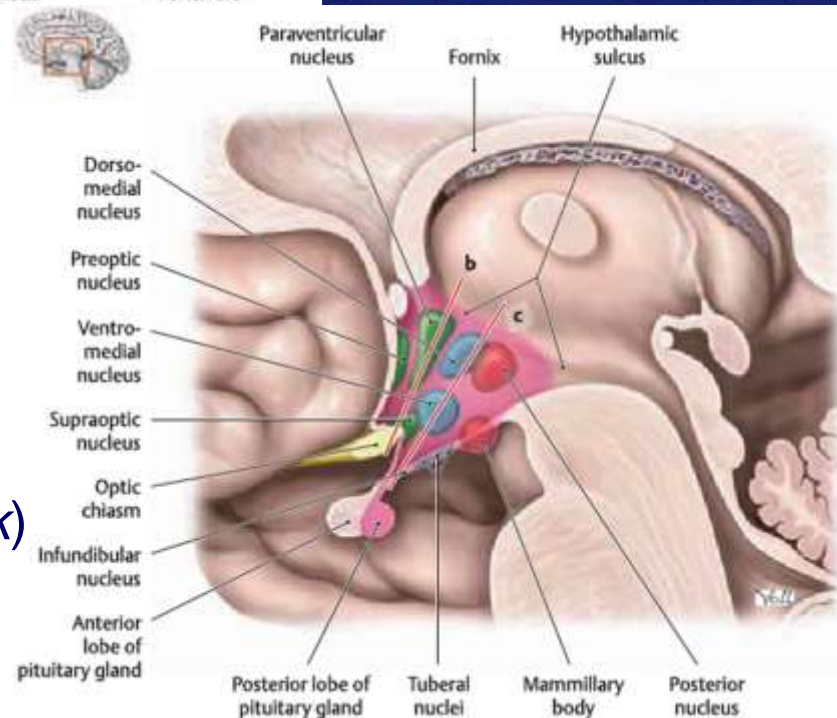
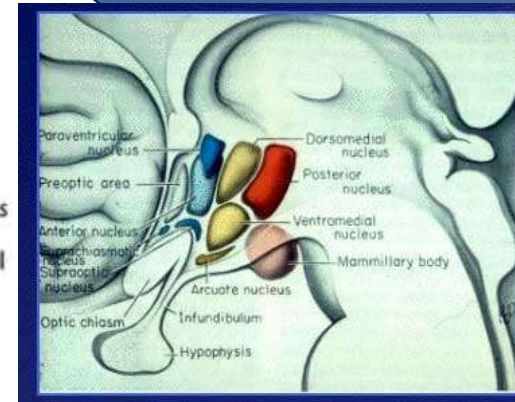
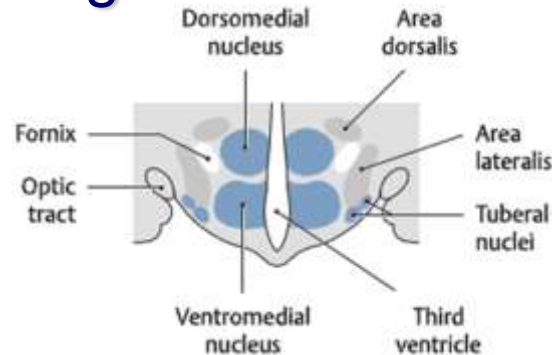
■ intermediate hypothalamic region:

- ✓ dorsomedial nucleus
- ✓ ventromedial nucleus
- ✓ tuberal nuclei, incl.

arcuate (infundibular) nucleus: A_{12}

■ posterior hypothalamic region:

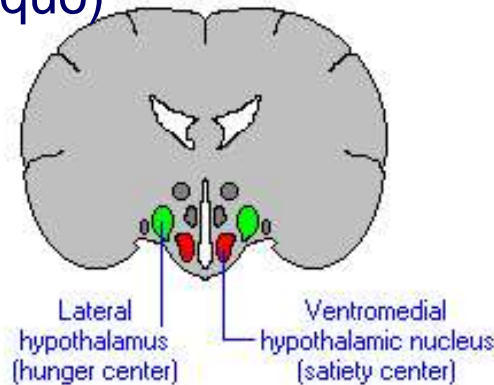
- ✓ medial mammillary nucleus
- ✓ lateral mammillary nucleus
- ✓ intermediate mammillary nucleus
(intercalated nucleus of *Le Gros Clark*)
- ✓ posterior hypothalamic nucleus





Hypothalamus – functional significance

- 0.5% of the total volume of human brain
- main function – homeostasis (maintaining the body's status quo)
- central control of:
 - ✓ visceral functions
 - ✓ endocrine effects – release/inhibiting factors
- neurosecretion:
 - ✓ pituitary hormones – oxytocin, vasopressin
- temperature regulation – dual thermostat
- instinctive and cyclic behaviors:
 - ✓ regulation of food (appetite) and water intake
 - ✓ control of sexual behavior and reproduction
 - ✓ biological clock (sleep-waking cycle)
 - ✓ expression of emotion, fear, rage, aversion, pleasure and reward

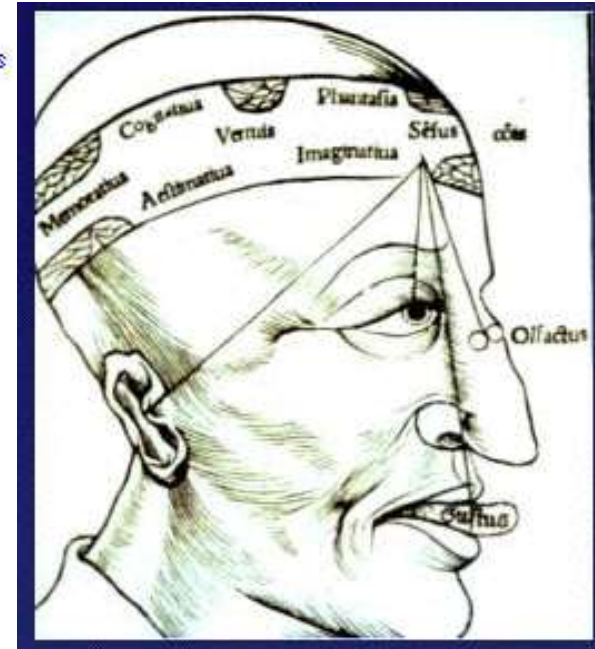


HYPOTHALMUS

Important Homeostatic Functions

Regulation of:

- | | |
|-----------------------------|-------------------------|
| - Temperature | - Circulatory volume/BP |
| - Food/water/intake | - Circadian rhythm |
| - Sleep/wakefulness | - Sexual behavior |
| - Defense/stress mechanisms | - Affective behavior |



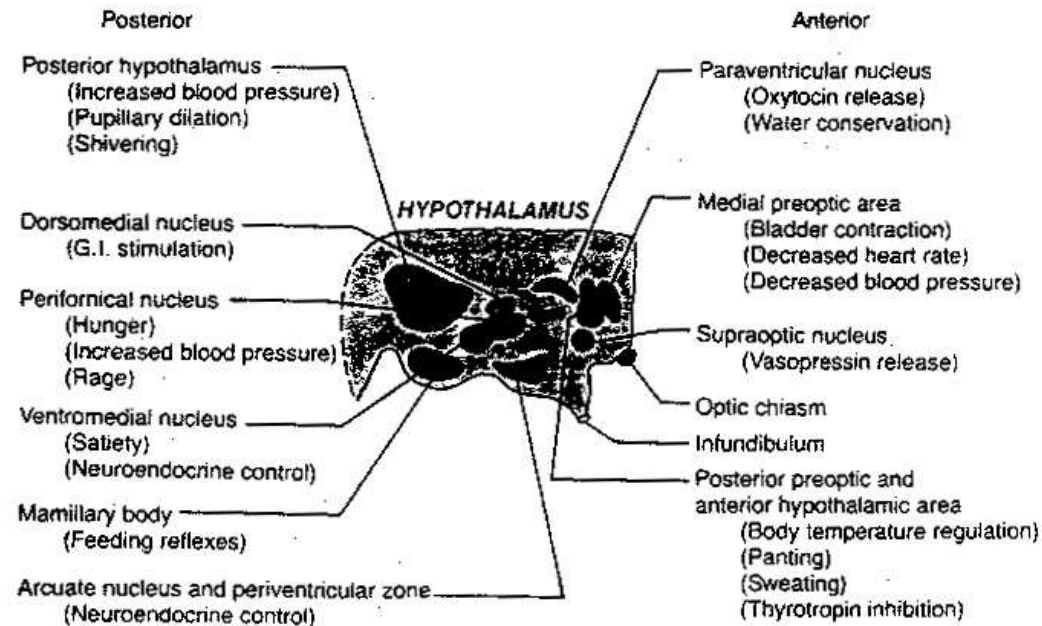


Hypothalamus – clinical significance

- numerous functional considerations

- in injury:

- ✓ sleepiness
- ✓ obesity
- ✓ diabetes insipidus
- ✓ adiposogenital dystrophy
- ✓ libido loss
- ✓ dysregulation of body temperature





Diencephalic syndrome

- Synonyms: diencephalic syndrome of emaciation, Russell's syndrome:



- ✓ hypothalamic tumors
- ✓ postnatal failure to thrive
- ✓ progressive emaciation (abnormal thinness)
- ✓ unusual eye position and sometimes blindness
- ✓ intense sleepiness
- ✓ amnesia
- ✓ euphoric appearance
- ✓ emesis (vomiting)

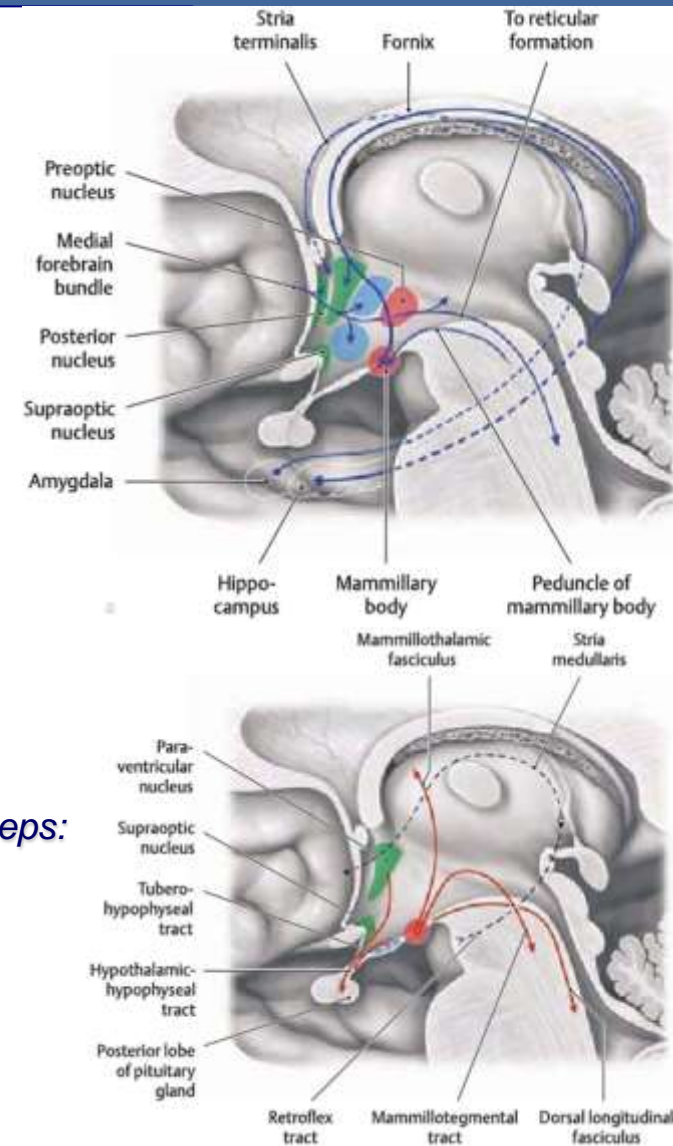


Diencephalic syndrome



Hypothalamic connections

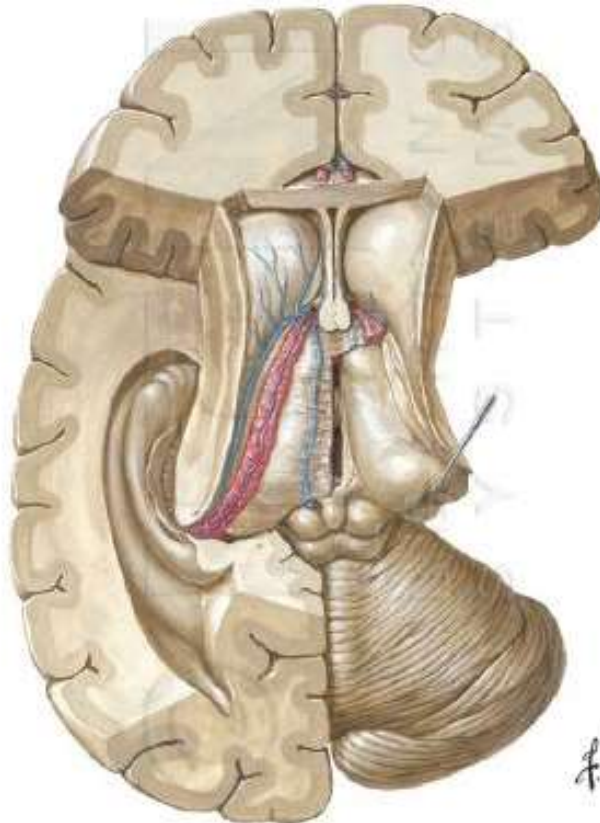
- Afferent connections:
 - ✓ corticohypothalamic fibers
 - ✓ limbic system –
 - hippocampo-hypothalamic afferents
 - amygdalo-hypothalamic fibers
 - septal region
 - piriform lobe
 - ✓ thalamus – periventricular nucleus, *zona incerta*
 - ✓ brainstem reticular formation –
 - dorsal longitudinal fasciculus (of Schütz)
 - mammillary peduncle
- Efferent connections:
 - ✓ medial forebrain bundle
 - ✓ hypothalamo-hypophysial – neurohypophysial
 - ✓ mammillary efferent fibers – *fasciculus mammillaris princeps*:
 - *fasciculus mamillothalamicus*
 - *fasciculus mamillo tegmentalis*
 - ✓ descending hypothalamic projections:
 - *n. tractus solitarii*, *n. dorsalis n. vagi*
 - laminae I and II of the spinal cord



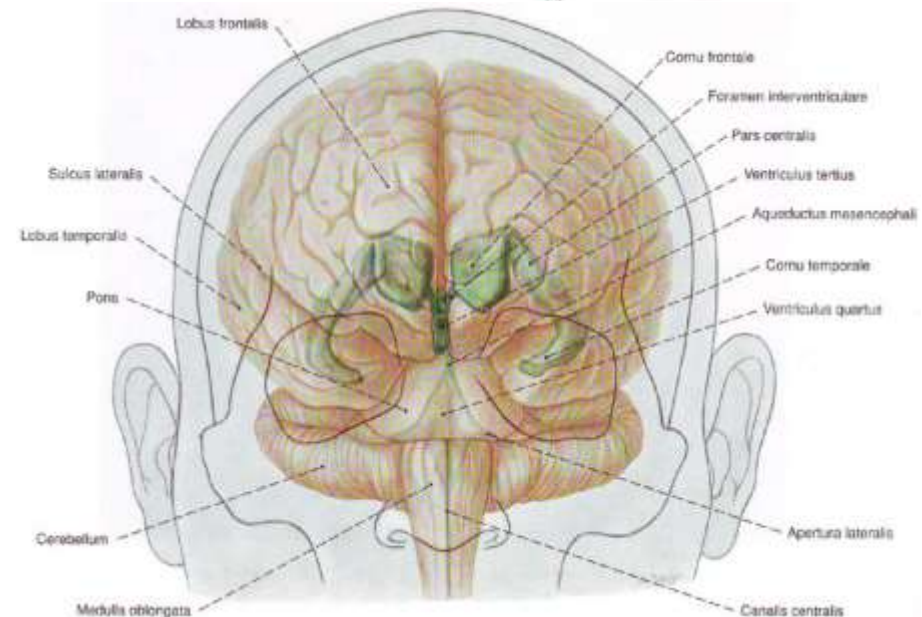
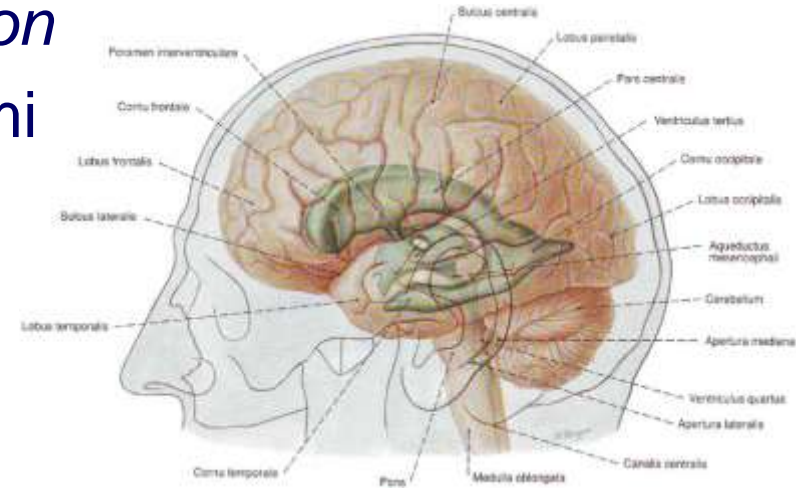


Third ventricle

- embryonic origin – *prosencephalon*
- location – between the two thalami (lateral walls) and hypothalamus



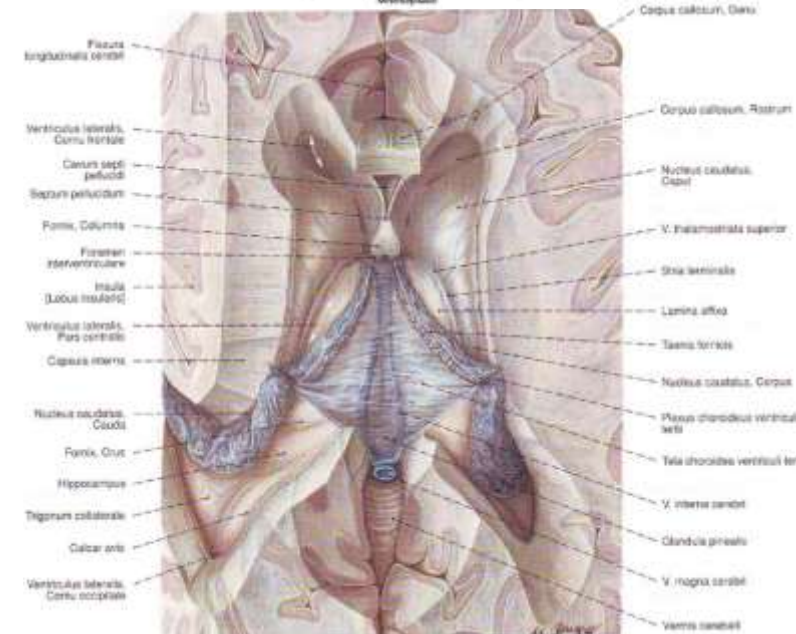
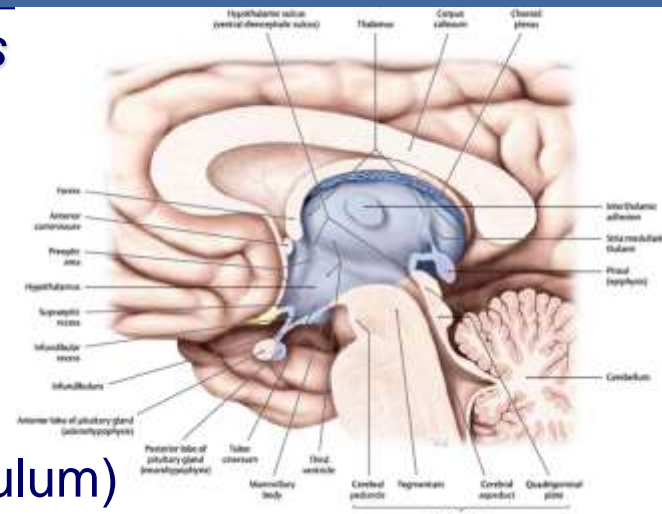
F. N. Lazarov
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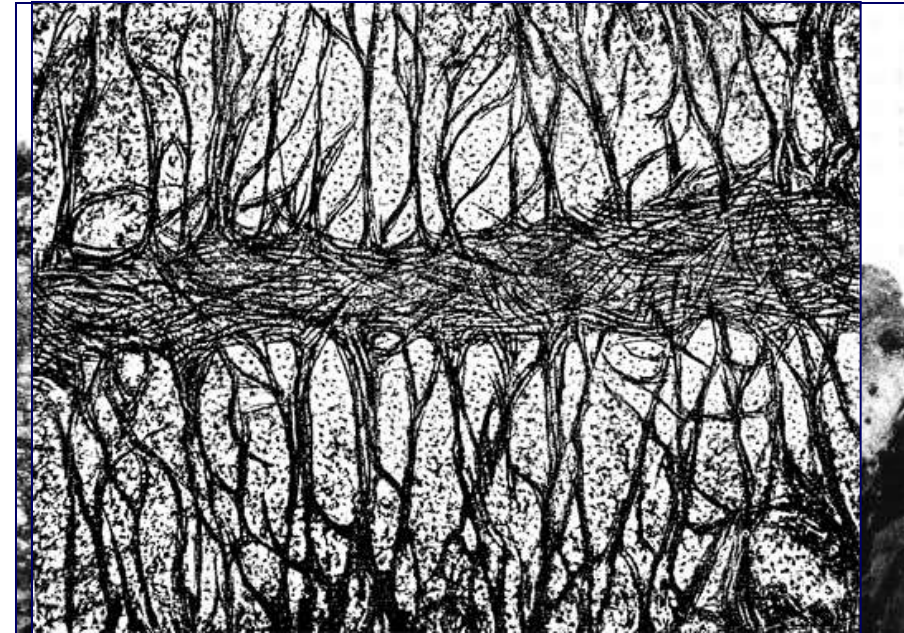
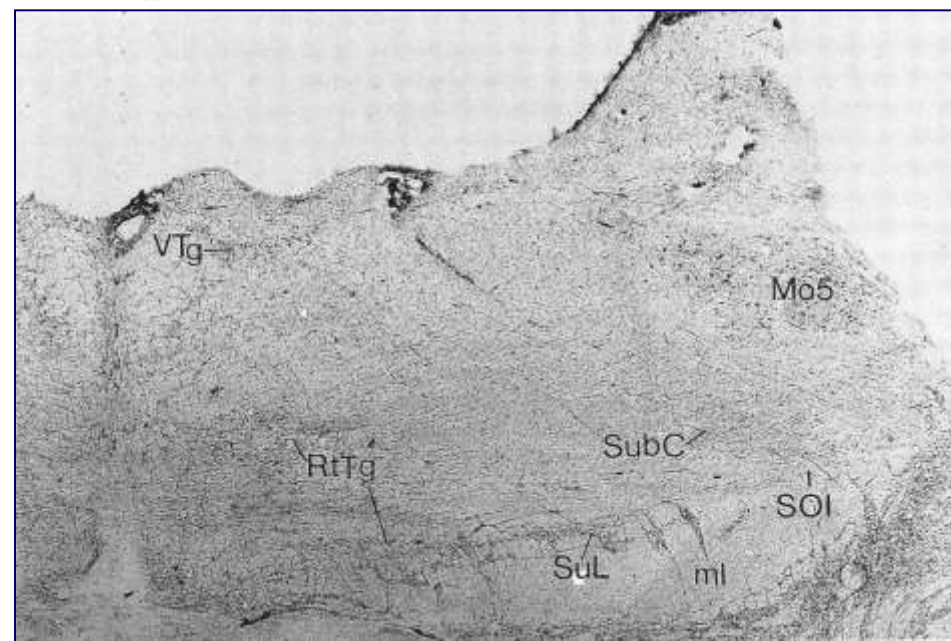
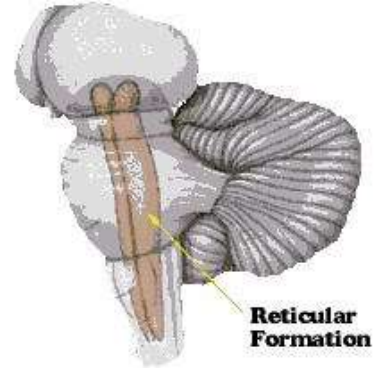


Third ventricle

- anterior boundary – *lamina terminalis*
anterior commissure
- posterior boundary –
posterior commissure
 - ✓ pineal recess ⇒ pineal gland
 - ✓ cerebral aqueduct
- floor – parts of the hypothalamus
(optic chiasma, tuber cinereum, infundibulum)
 - ✓ optic recess
 - ✓ infundibular recess
- roof – layer of ependyma, covered by
the *tela choroidea ventriculi tertii* ⇒
choroid plexus of the third ventricle
- communication with:
 - ✓ fourth ventricle –
cerebral aqueduct (of *Sylvius*)
 - ✓ lateral ventricles –
interventricular foramina (of *Monro*)



Reticular formation – terminology

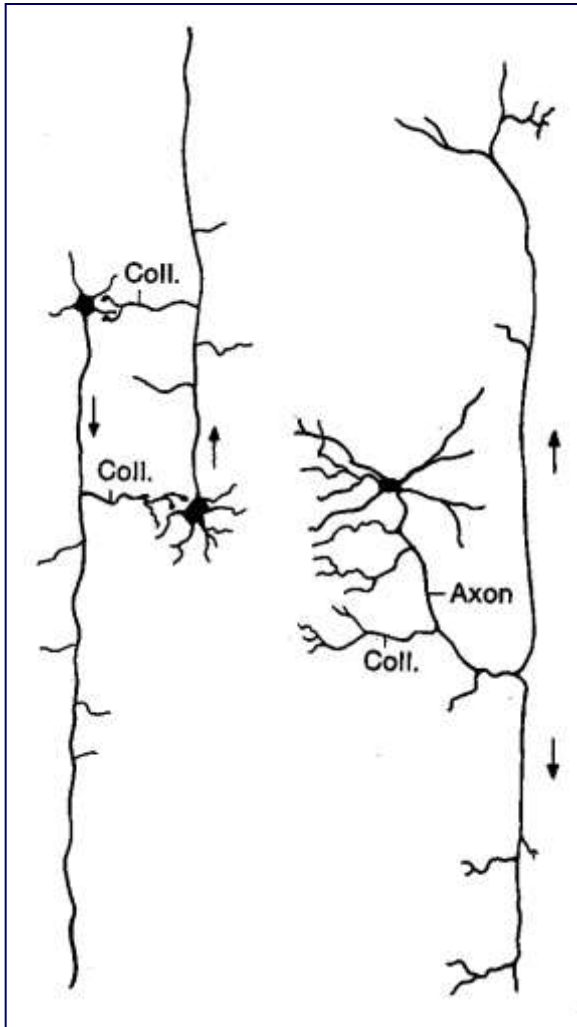


NB: *reticulum* means *netlike structure*

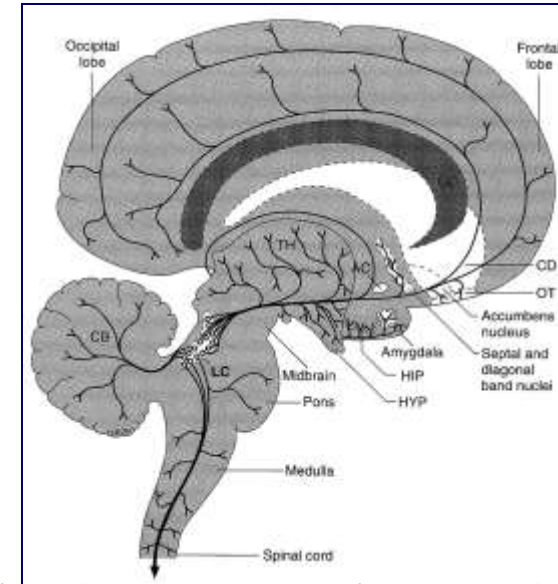
Why is the reticular formation a reticular formation? Because their fibers indeed build a net.



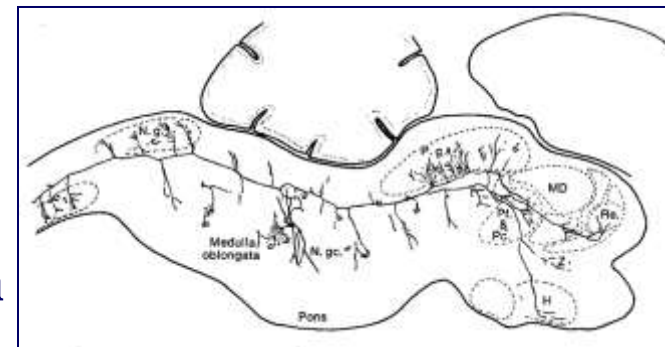
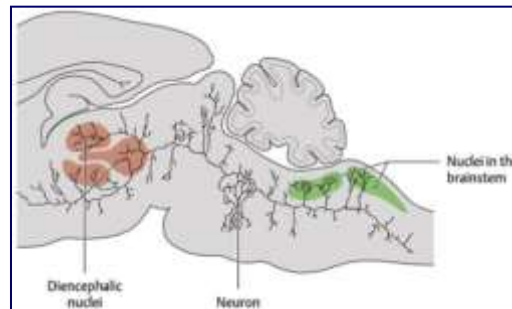
Reticular formation (RF) – general considerations



1. Brainstem RF proper
2. Spinal RF
3. Other RF-related brainstem areas
 - ✓ periaqueductal grey matter (PAG)
 - ✓ reticular activating system (RAS)
 - ✓ locus coeruleus



- ✓ Widespread distribution and extensive collateralization of reticular axons



- ✓ Typical neurons of the reticular formation – mostly interneurons



Brainstem RF proper – (>100 small) nuclei

Median (midline) column of reticular nuclei – **raphe nuclei** (serotonergic and peptidergic – enkephalin and β -endorphin):

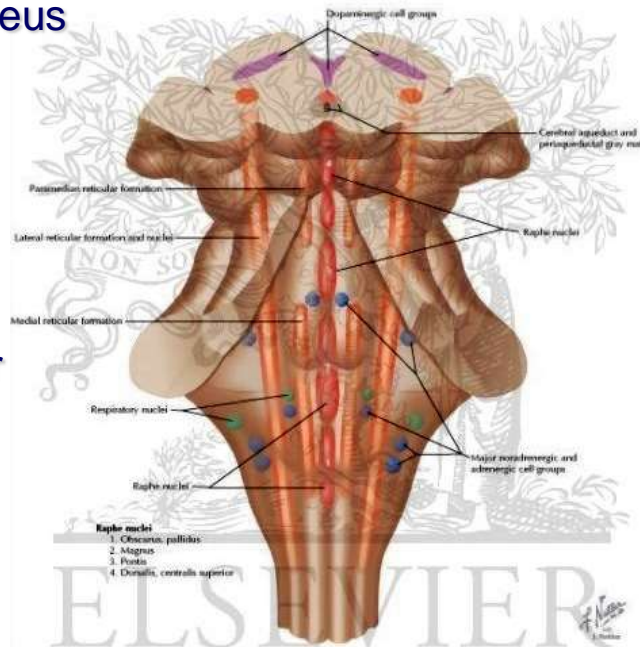
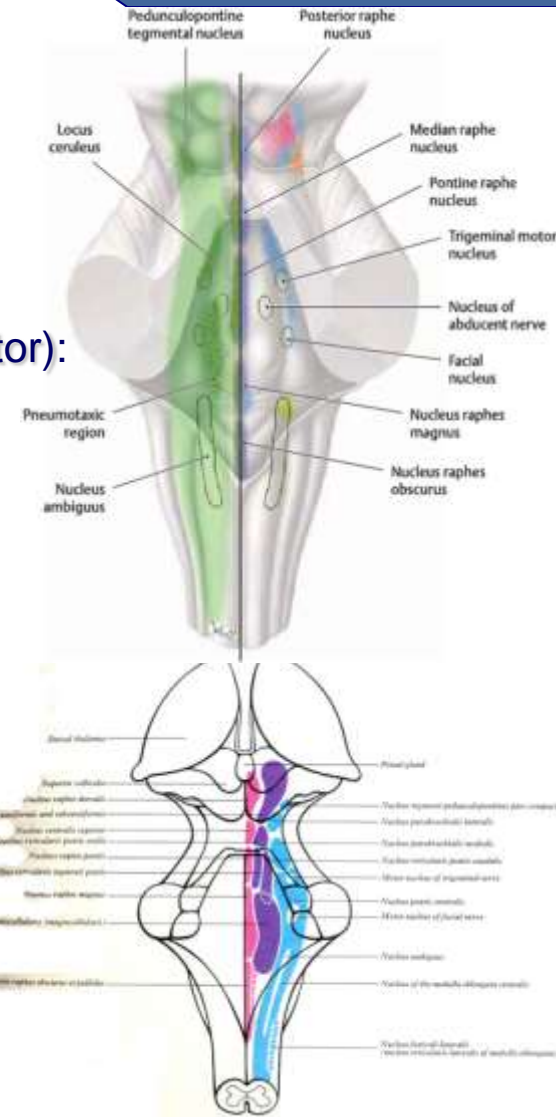
- ✓ *nucleus raphes obscurus et pallidus* in medulla
- ✓ *nucleus raphes magnus* in pons (peptidergic)
- ✓ *nucleus raphes centralis superior* and
- ✓ *nucleus raphes dorsalis* in midbrain

Medial (paramedian) column – magnocellular (efferent and motor):

- ✓ medullary gigantocellular (magnocellular) nucleus
- ✓ pontine gigantocellular nucleus
- ✓ *nucleus tegmenti pontis*
- ✓ *nucleus pontis caudalis*
- ✓ *nucleus pontis oralis*
- ✓ *nucleus cuneiformis*
- ✓ *nucleus subcuneiformis*

Lateral column – parvocellular (afferent and sensory):

- ✓ *nucleus pontis centralis*
- ✓ *nuclei parabrachiales*
- ✓ *nucleus tegmentalis pedunculopontinus*





Reticular formation – functions

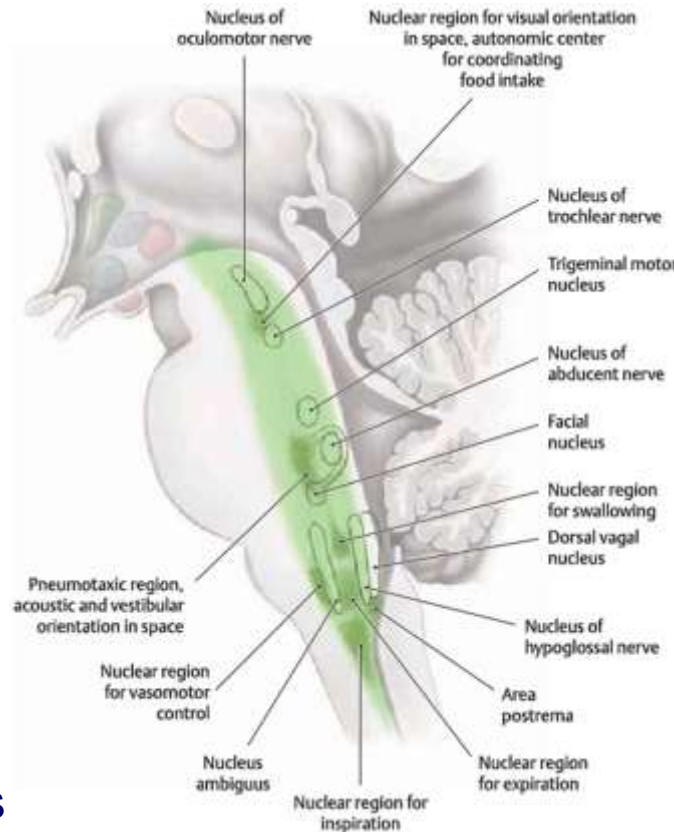
- controls ~25 specific behaviors:

- ✓ sleep
- ✓ walking
- ✓ eating
- ✓ urination&defecation
- ✓ sexual activity

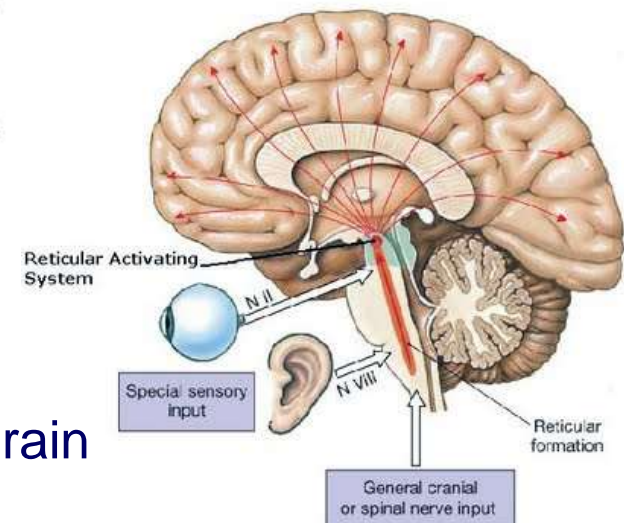
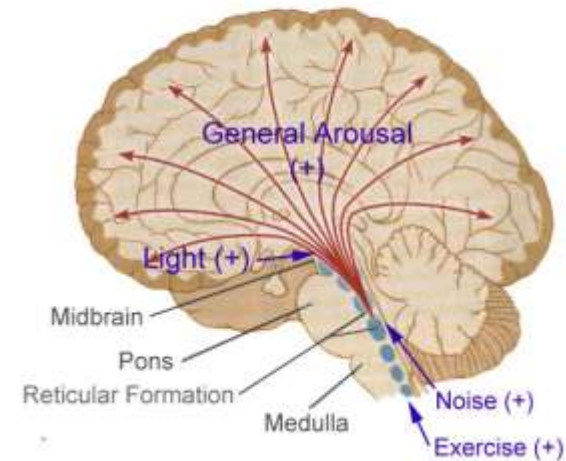
- additional functions:

- ✓ arousal
- ✓ attention
- ✓ cardiac reflexes
- ✓ motor functions
- ✓ regulates awareness
- ✓ relays nerve signals to the cerebral cortex

- one of the phylogenetically oldest portions of the brain

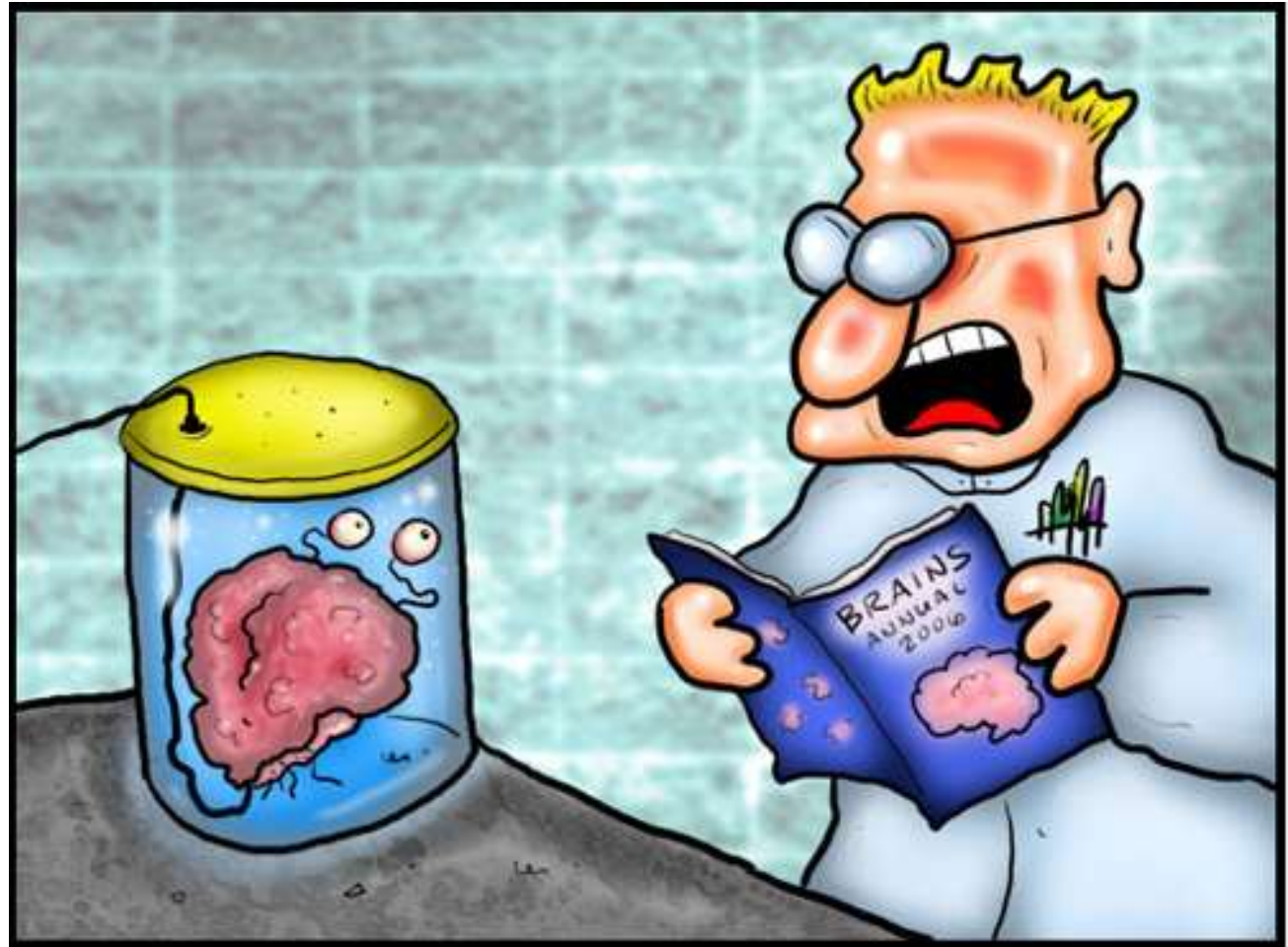


Reticular Activating System (RAS) determines the level of alertness





Thank you...



"Everything we thought we knew about the hypothalamus was wrong! Wrong, wrong, wrong!"