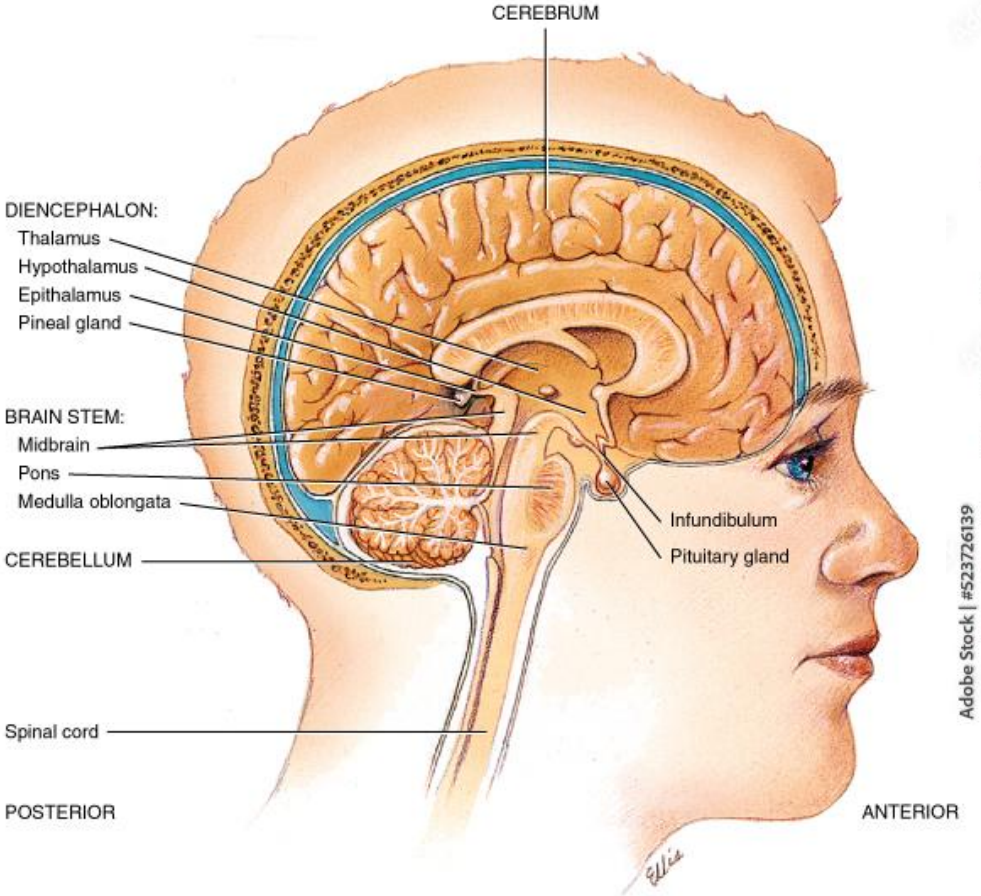
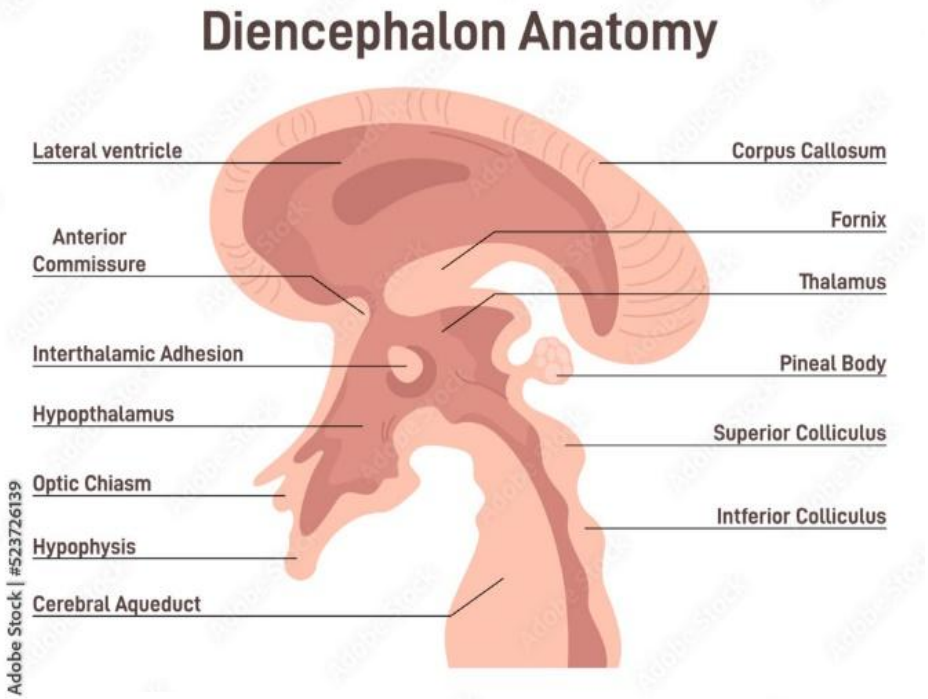
Diencephalon

Chien, 2025

Thalamus (丘腦): Cognition center, awareness and in the acquisition of knowledge
Subthalamus (底丘腦): control skeletal muscle movements and muscle tone
Hypothalamus (下視丘): Multiple functions (Autonomic, Neuroendocrine, etc.)
Epithalamus (上丘腦): Pineal (melatonin) Habenular nuclei (emotional responses to smells)



(a) Diagram of medial view of brain in sagittal section



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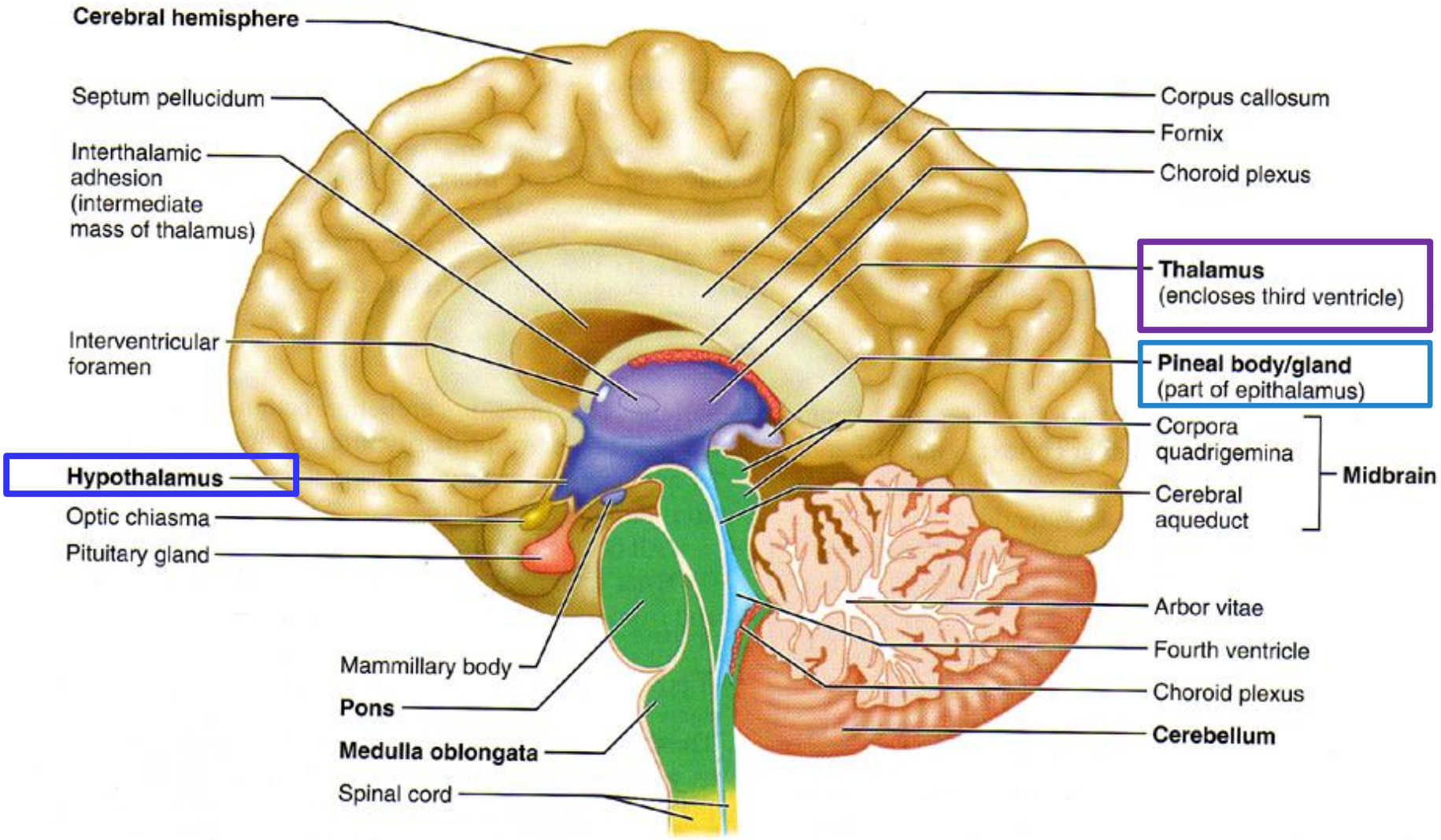
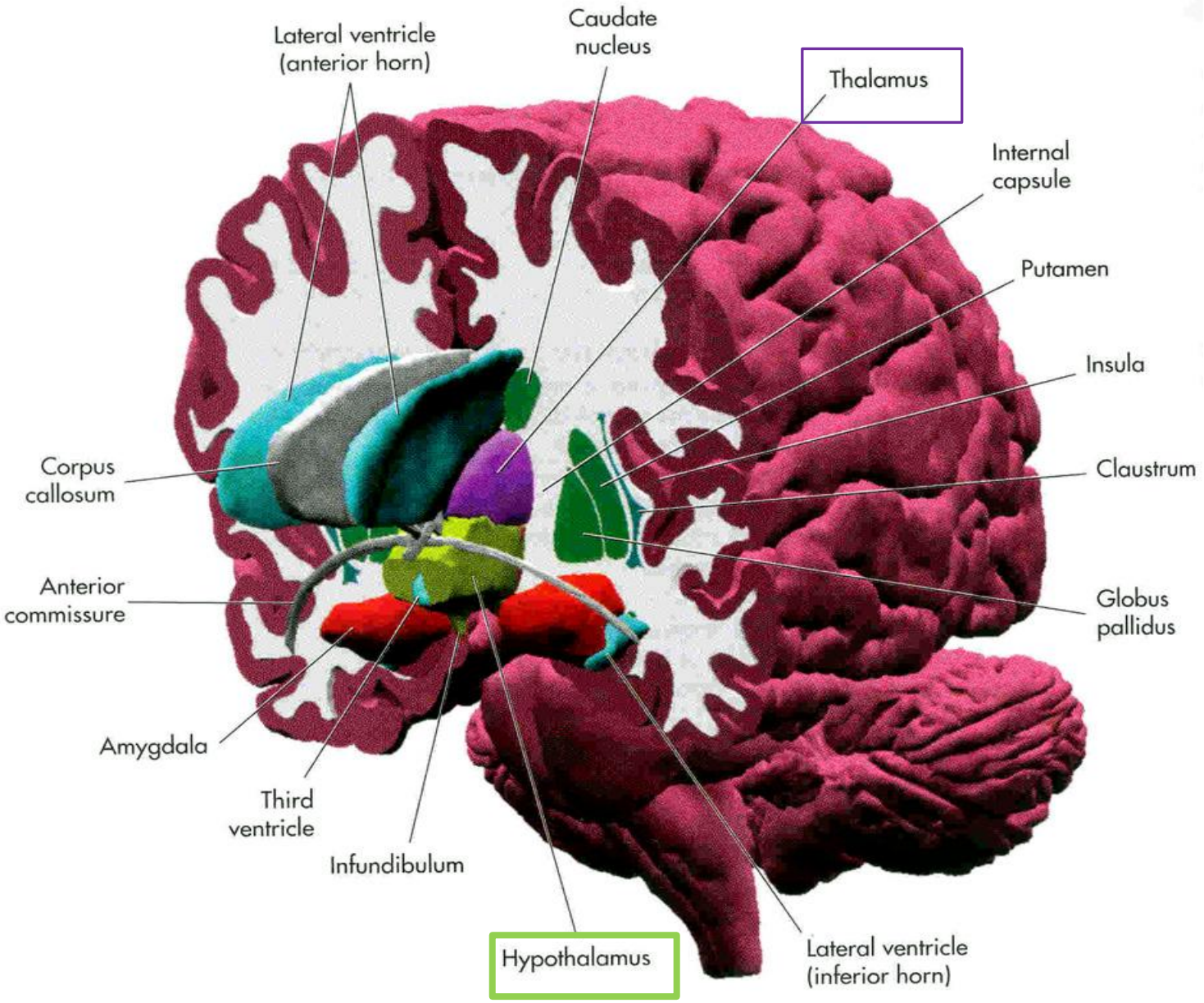
Diencephalon 間腦

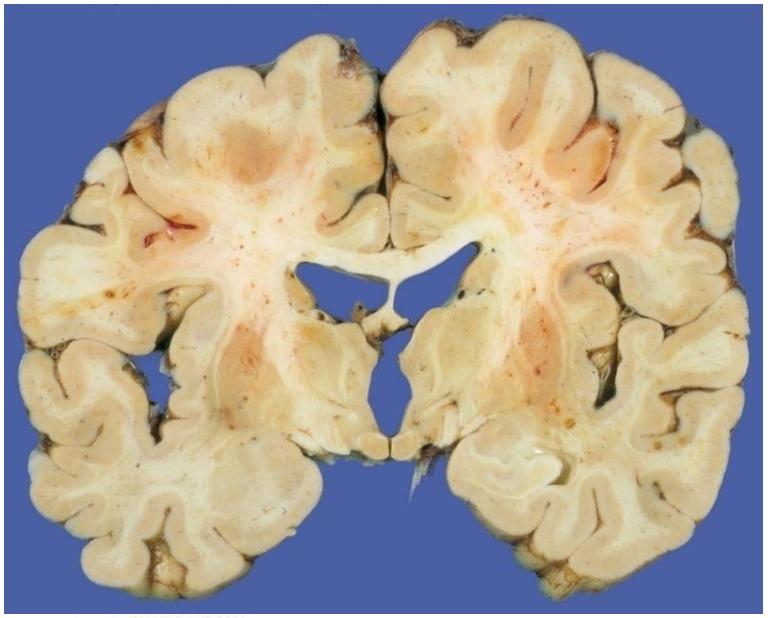


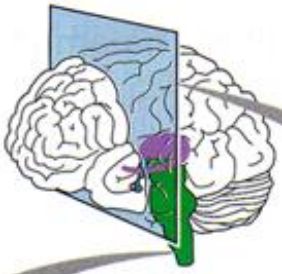
Diencephalon: Thalamus 丘腦 & Hypothalamus 下視丘 (下丘腦)

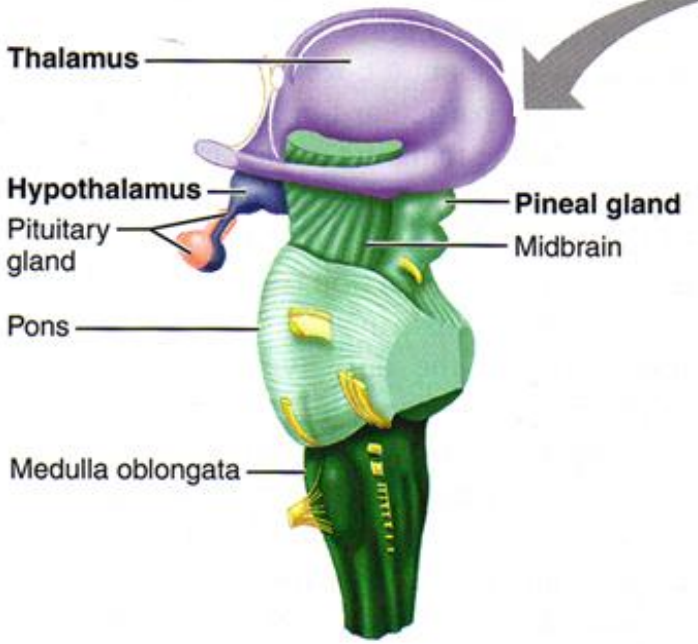


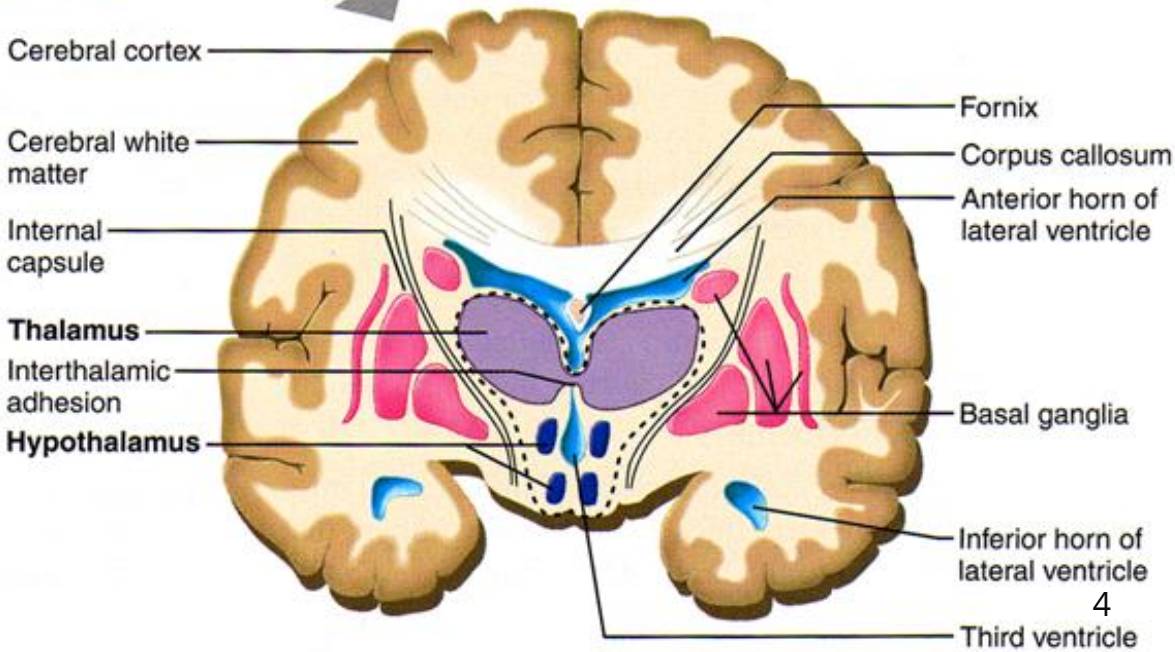
Thalamus 丘腦

- 1 inch long mass of gray mater in each half of brain
- Relay station for sensory information on way to cortex

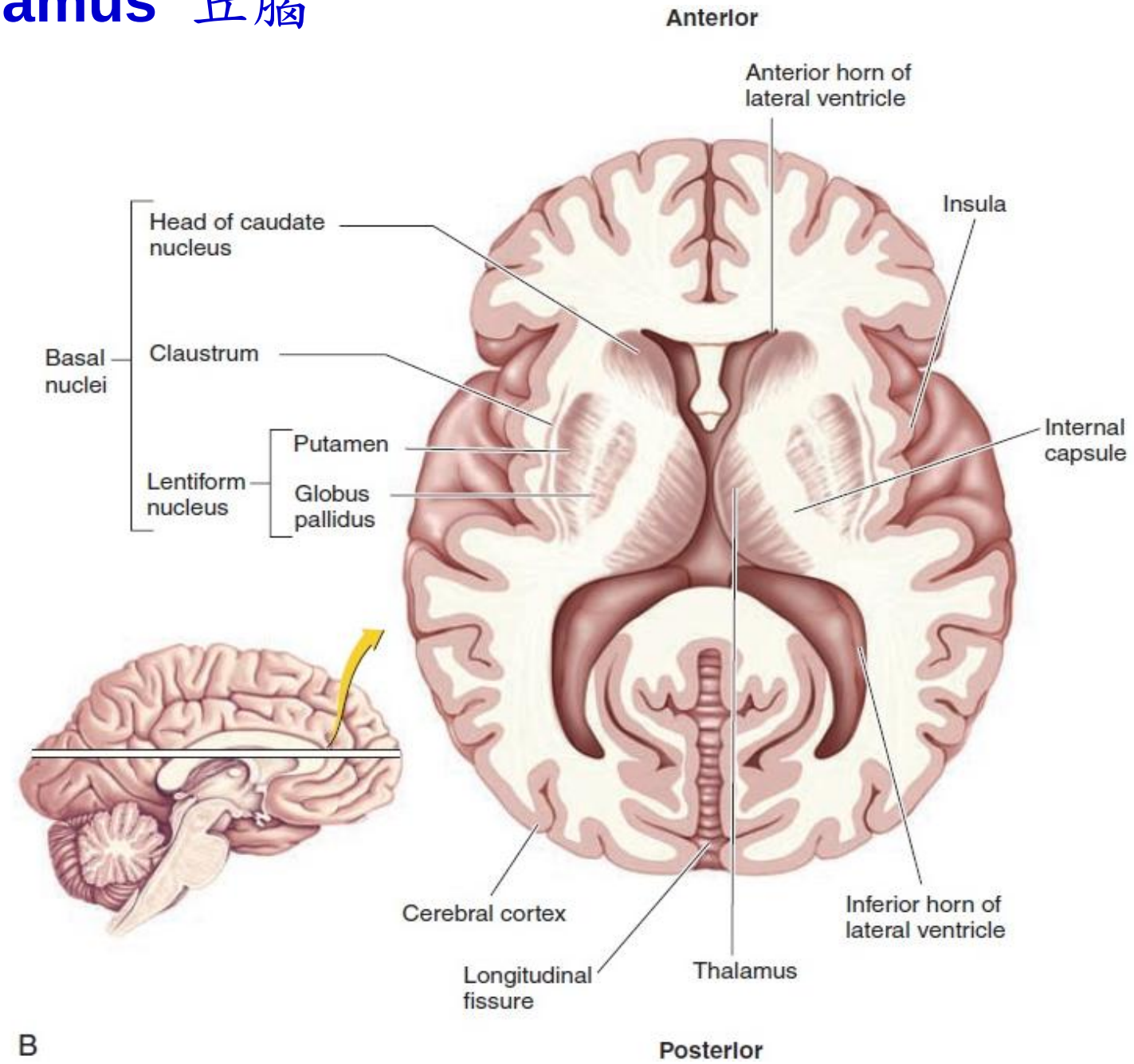




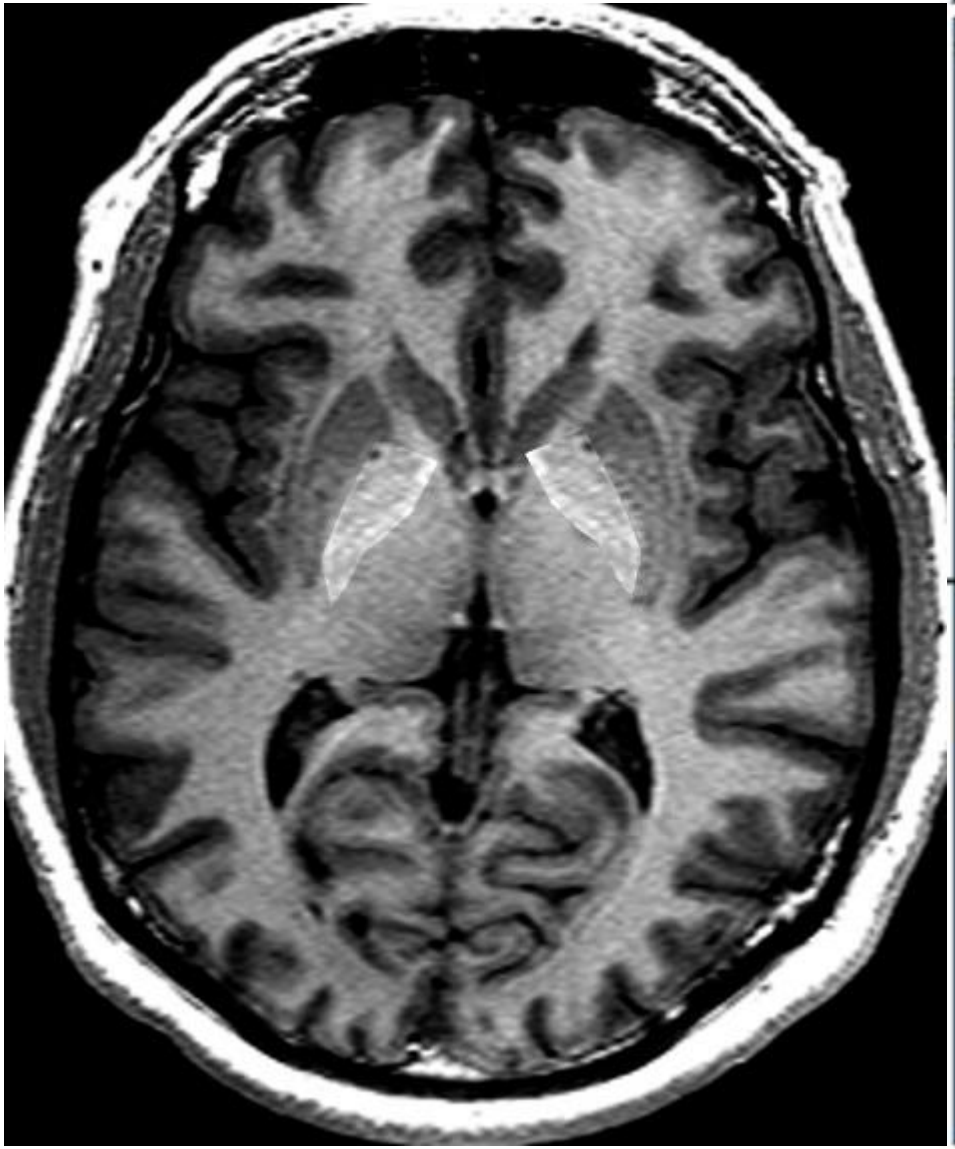


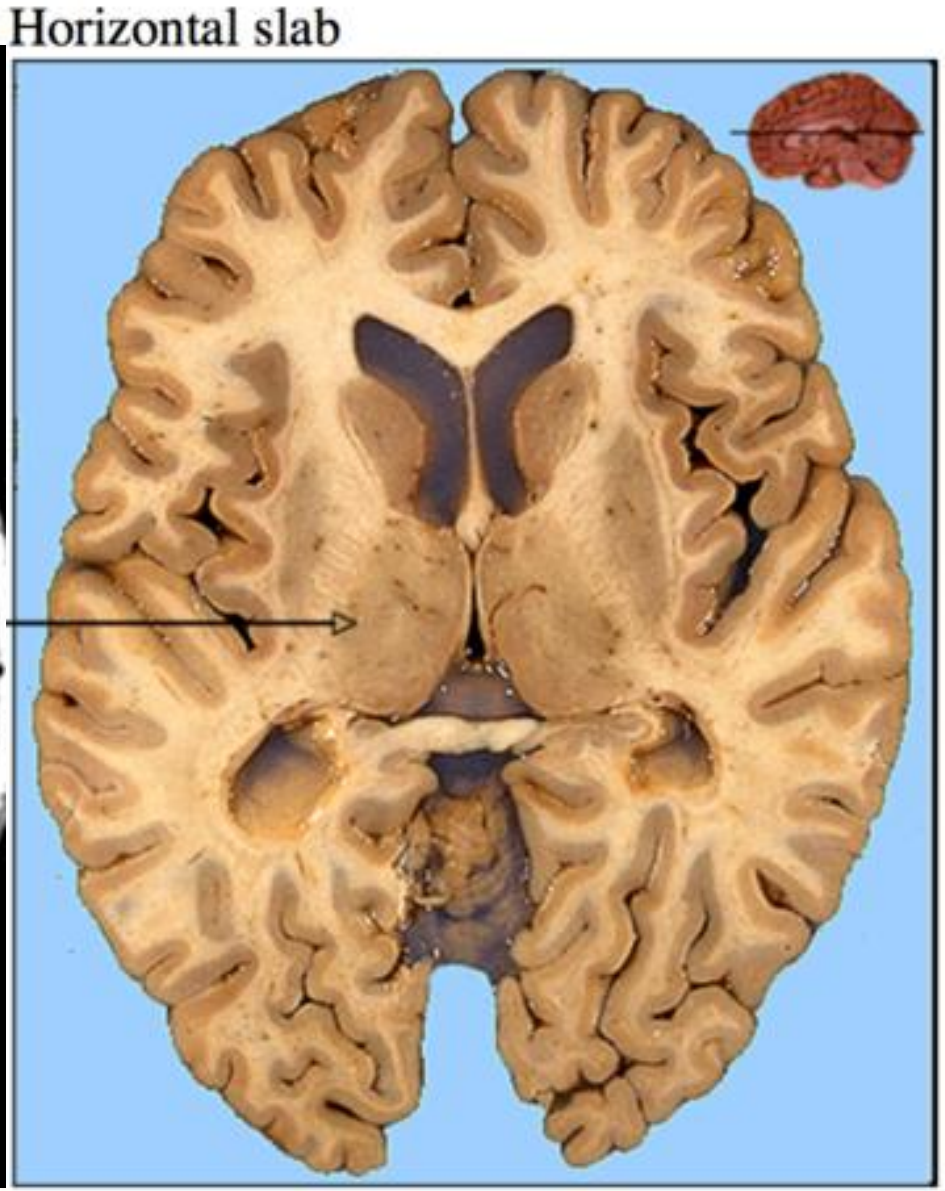


Thalamus 丘腦


Anterior
Anterior horn of lateral ventricle
Insula
Head of caudate nucleus
Basal nuclei
Claustrum
Putamen
Lentiform nucleus
Globus pallidus
Internal capsule
Cerebral cortex
Inferior horn of lateral ventricle
Longitudinal fissure
Thalamus
B
Posterior

Thalamus 丘腦





Thalamus 丘腦:

4/5 of the Diencephalon

Egg-shaped 3 cm x 1.5 cm

Internal medullary lamina:

1. Lateral nuclear mass

2. Medial nuclei

3. Anterior nuclei

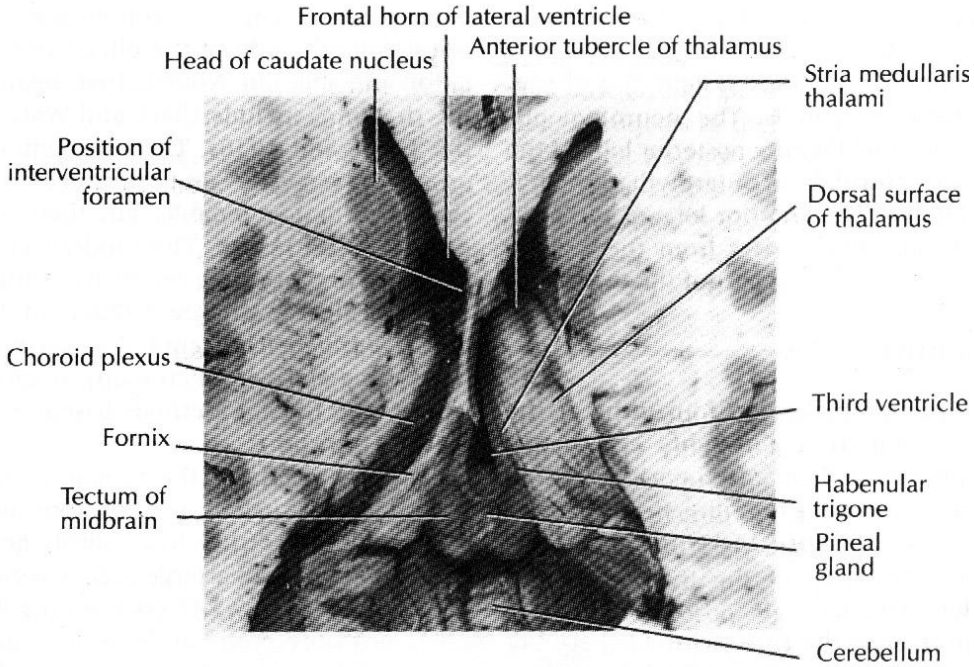
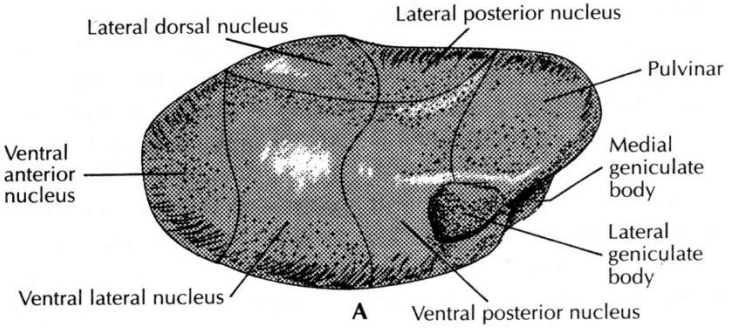
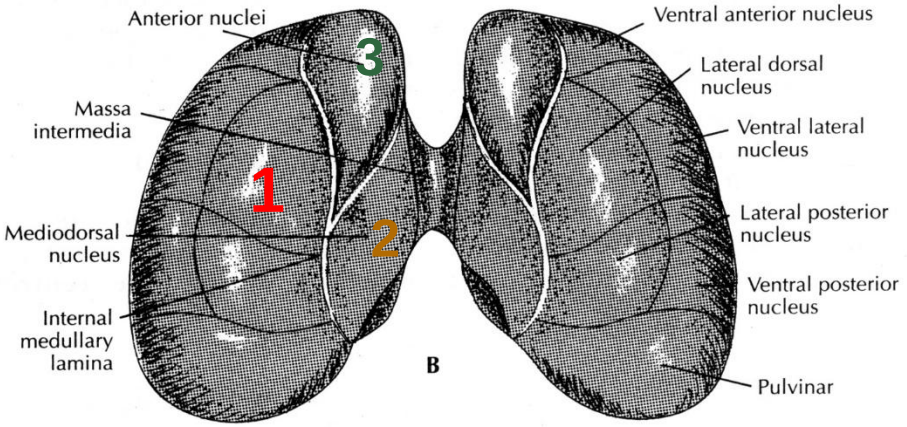


Figure 11-3. Dorsal aspect of the diencephalon, exposed by removing the corpus callosum. The fornix and the choroid plexus of the lateral ventricle have been removed on the right side. (×1)





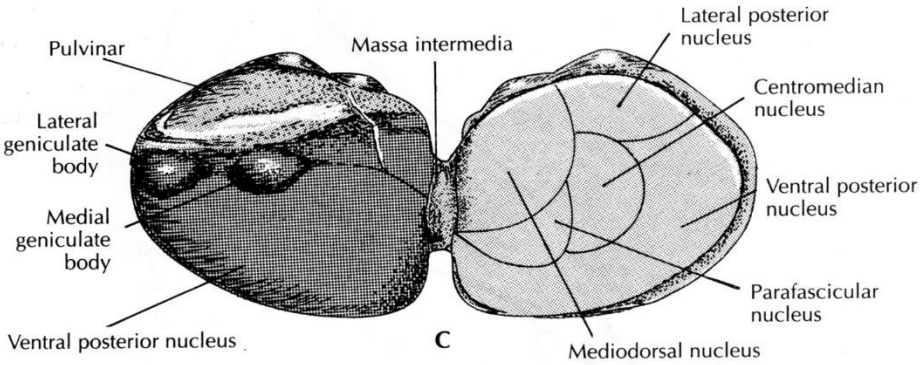
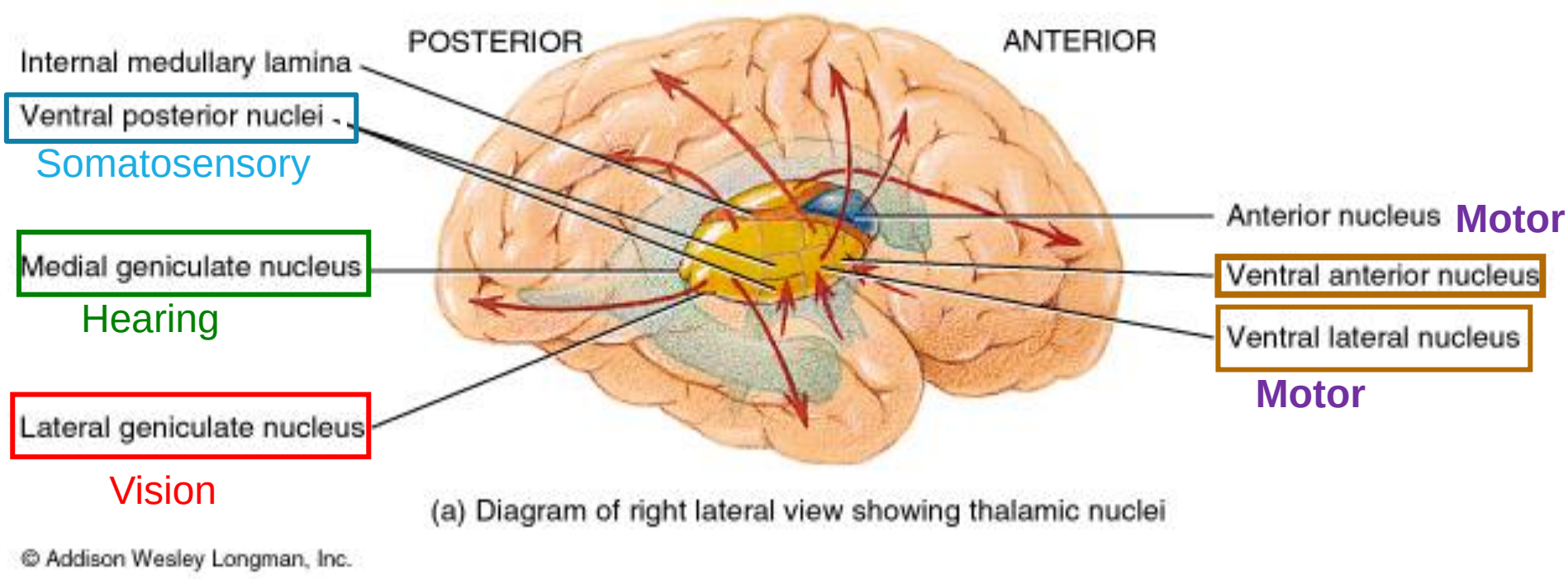


Figure 11-4. The thalami, showing positions of the larger nuclei. **(A)** Lateral view. **(B)** Dorsal view. **(C)** Posterior view, with the posterior half of the right thalamus cut away. *(From a model made by Dr. D.G. Montemurro)*

Thalamus:

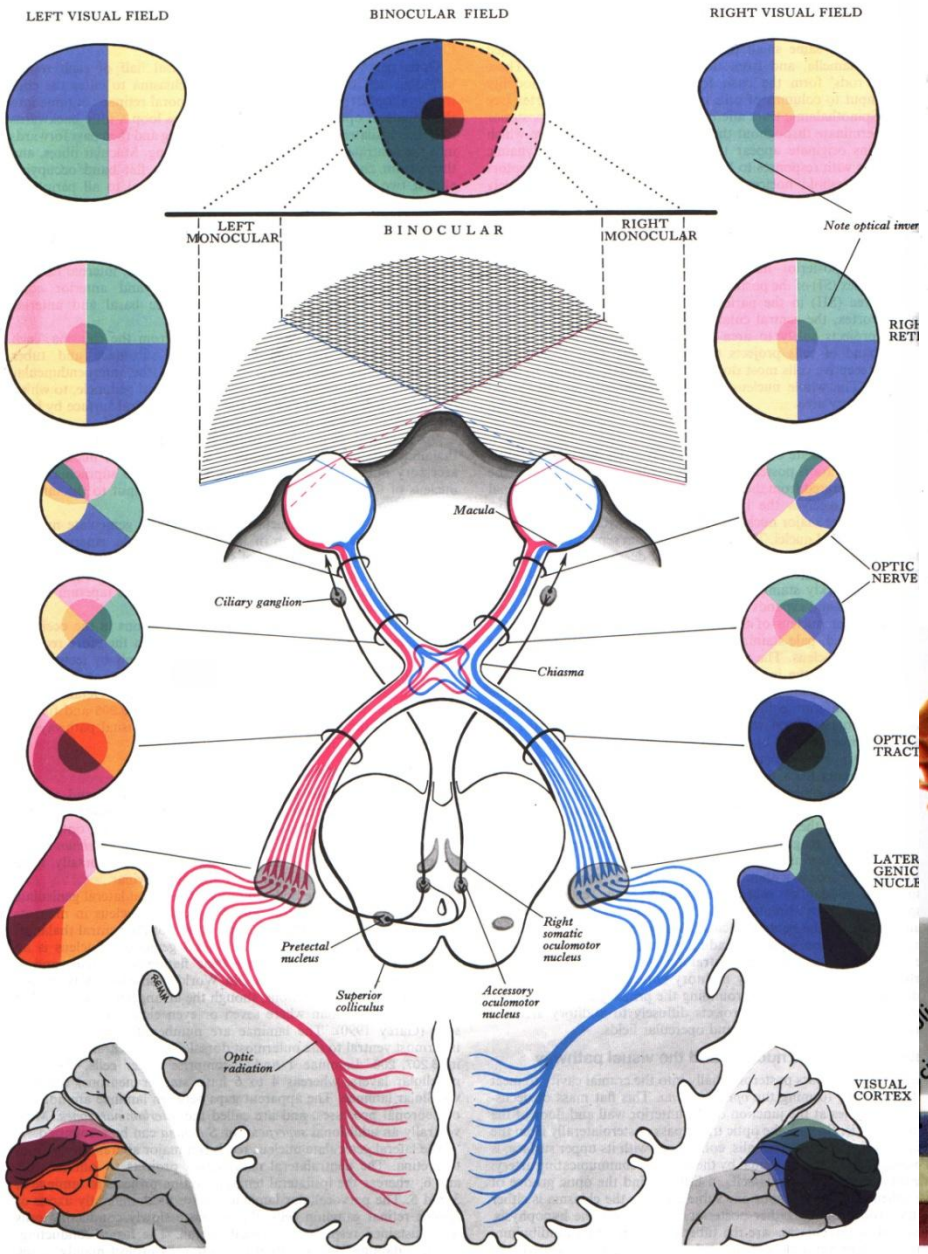
A. Relay nuclei: transmit ascending impulses to the cerebral cortex

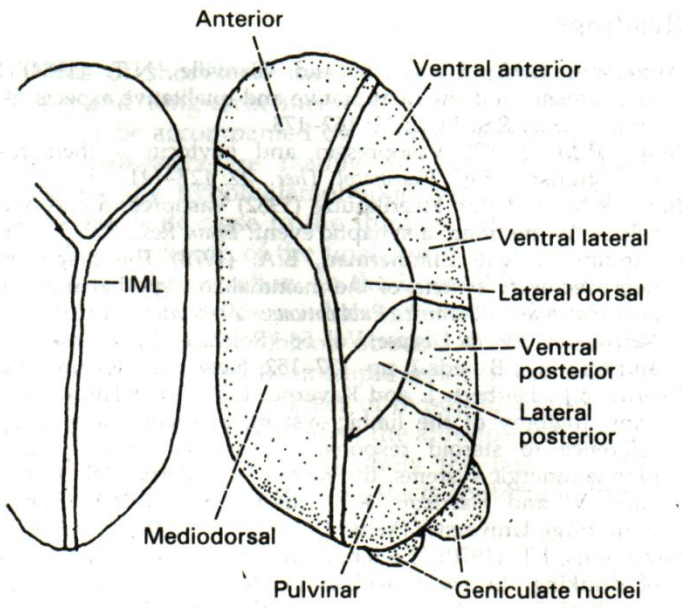
LGB (Vision), MGB (Hearing), VP (Somatosensory), VL, and VA (Motor)

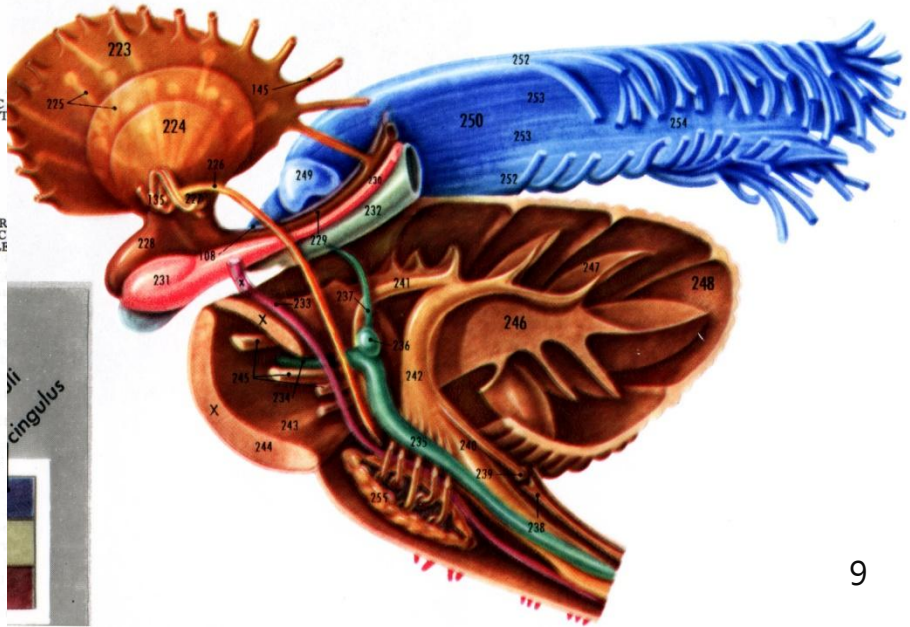


Lateral geniculate body (nucleus) (LGB)

Relay the visual impulses to the visual cortex over the geniculocalcarine tracts







Medial geniculate body (nucleus) (MGB)

Relay the auditory impulse to the anterior transverse temporal gyrus via the auditory radiations

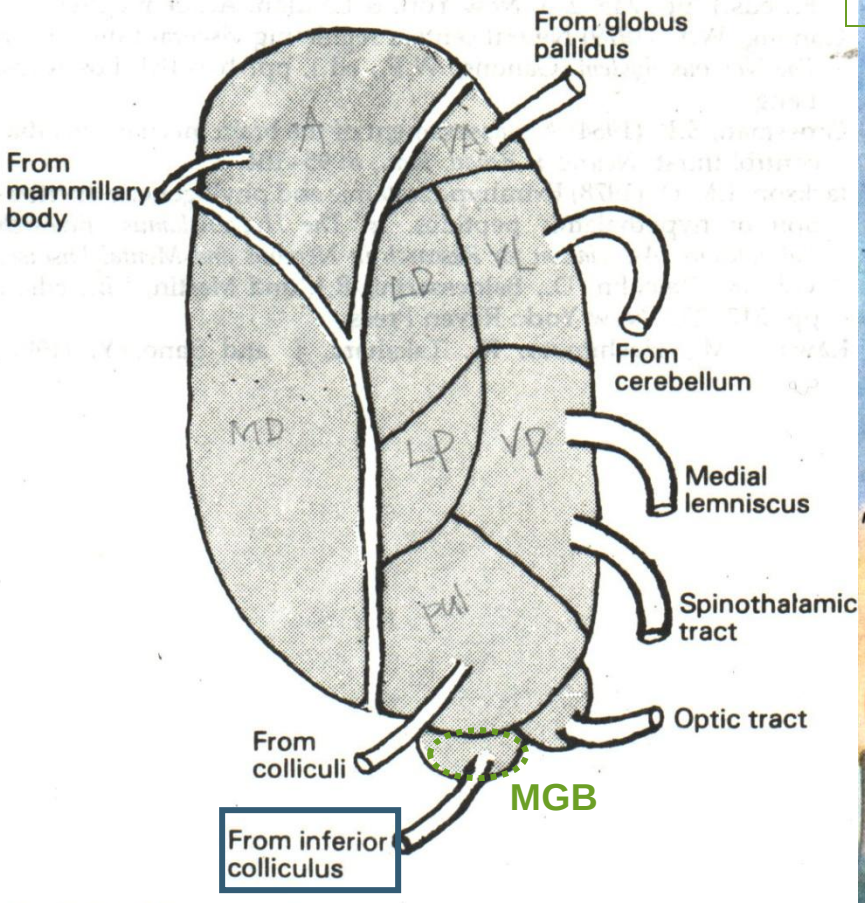
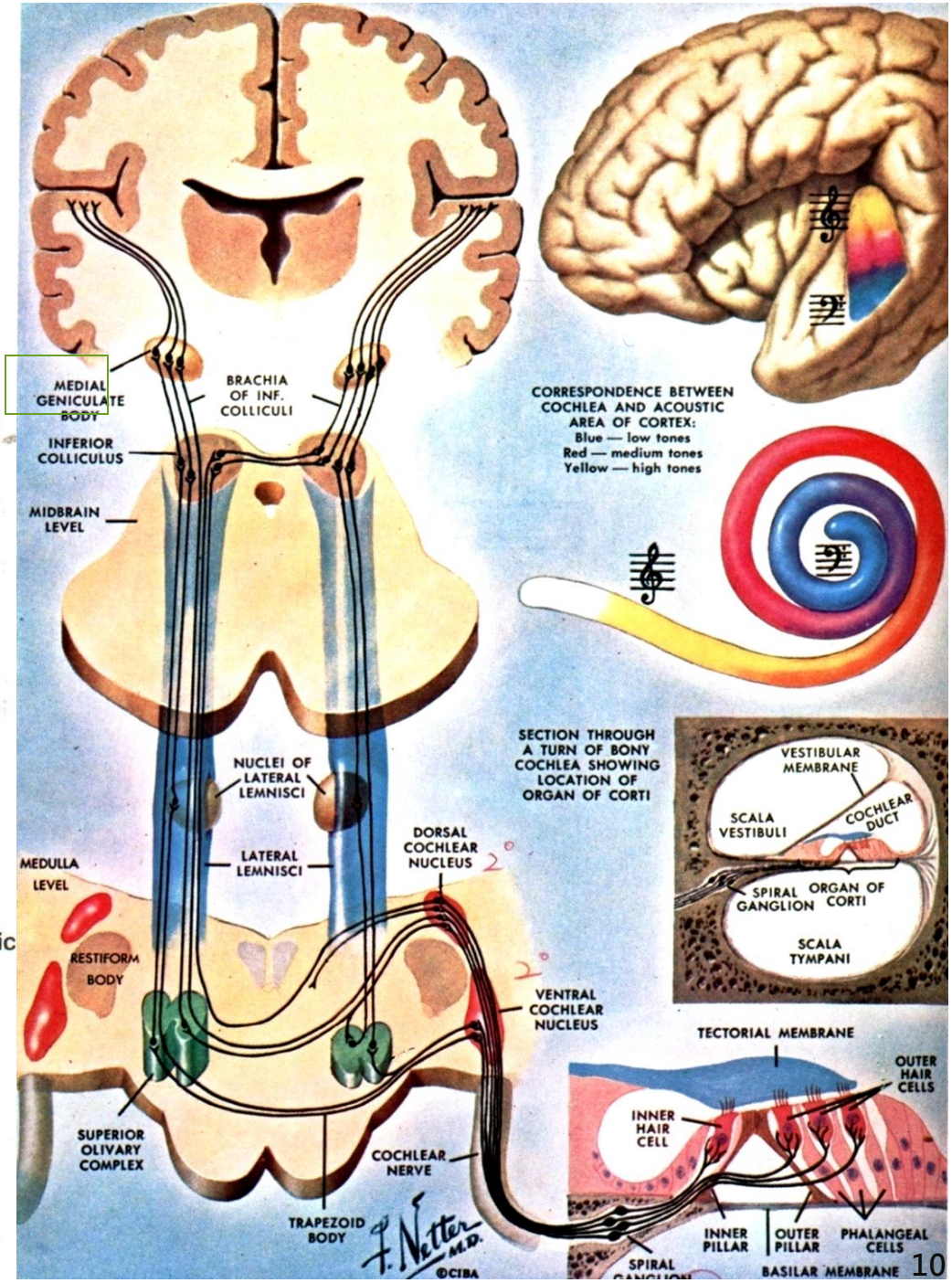


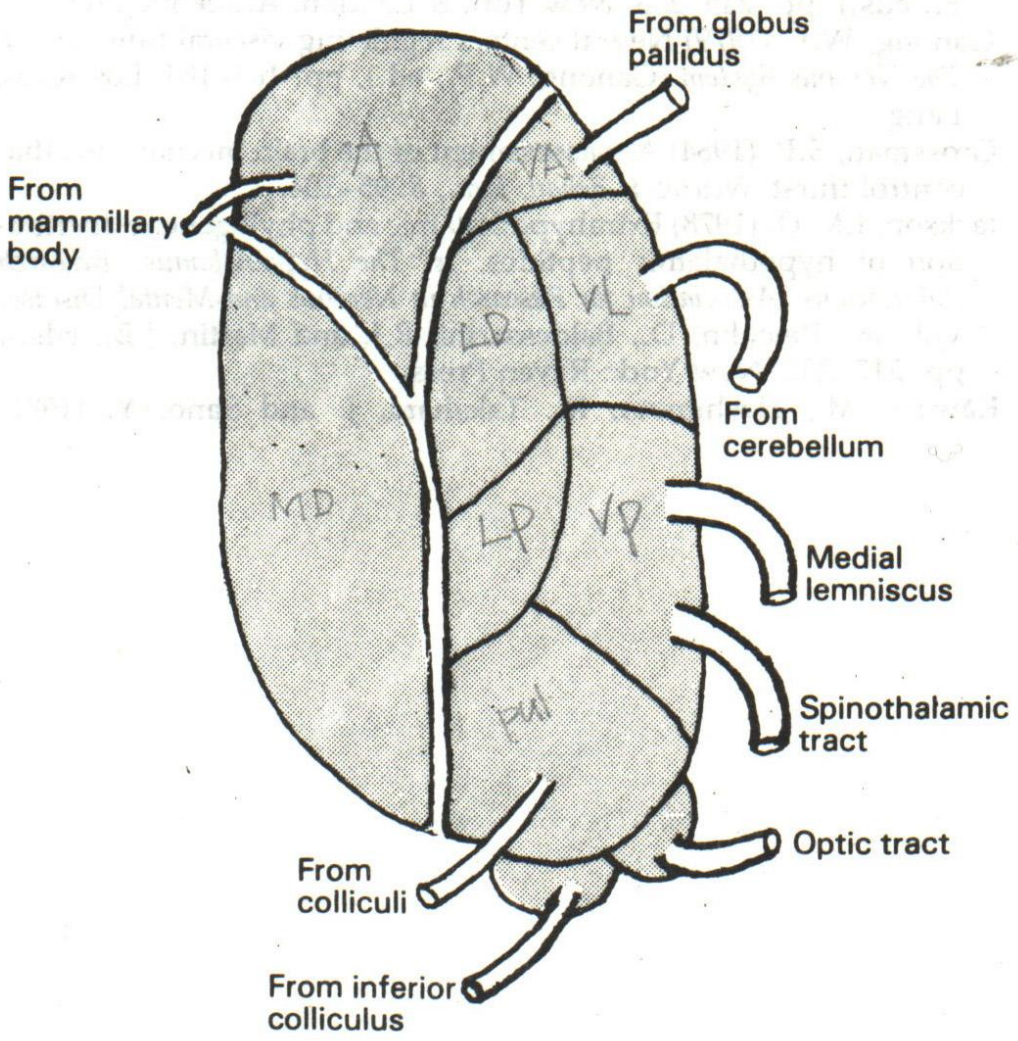
Fig. 17-2 Diagram indicating sources of input to the specific thalamic nuclei.



Ventral posterior nucleus (VP) (Somato-Sensory inputs)

Medial lemniscus, spinothalamic and the secondary trigeminal tracts synapse here

Ventroposterior medial nucleus (VPM) & Ventroposterior lateral nucleus (VPL)



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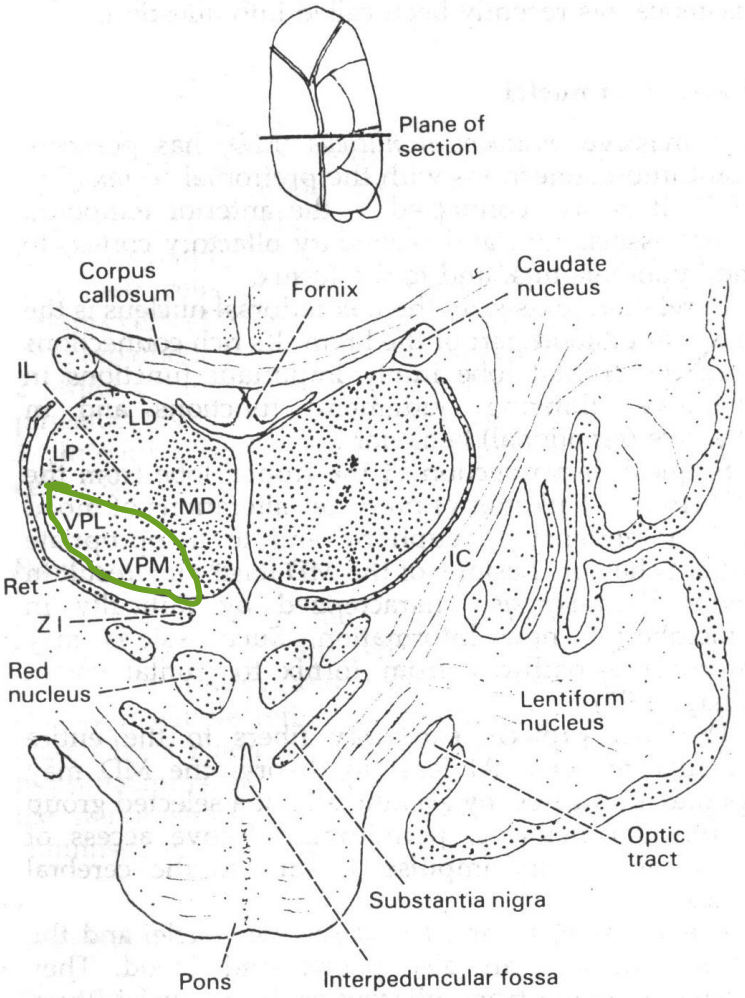


Fig. 17-4 Frontal section of brain base. IC, internal capsule; IL, internal medullary lamina; LD, lateral dorsal nucleus; LP, lateral posterior nucleus; MD, mediodorsal nucleus; Ret., reticular nucleus; S, subthalamic nucleus; VPL, ventroposterolateral nucleus; VPM, ventroposteromedial nucleus; ZI, zona incerta.

Ventroposterior medial nucleus (VPM)

from the secondary tracts of the face
Afferents: trigeminal and solitary nucleus
Efferents: somatosensory and gustatory cortex

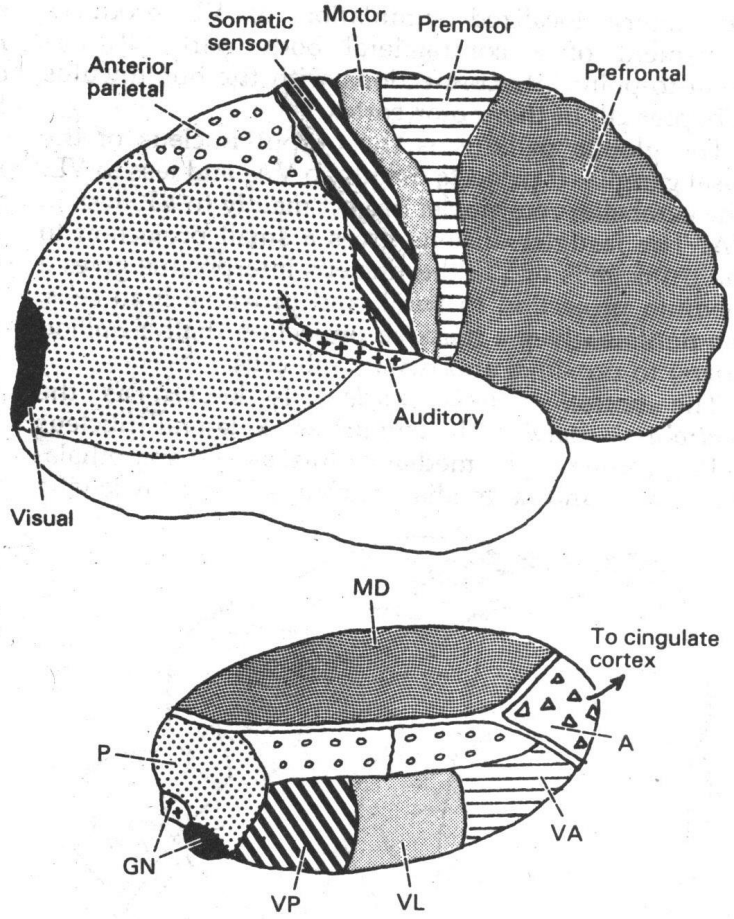
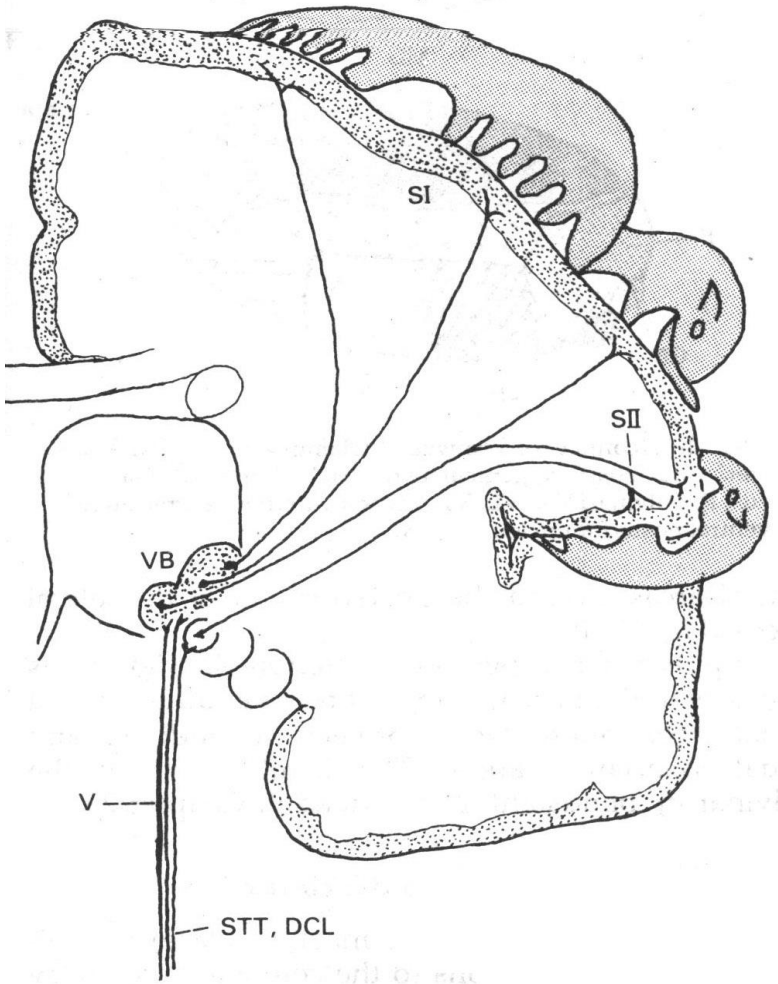
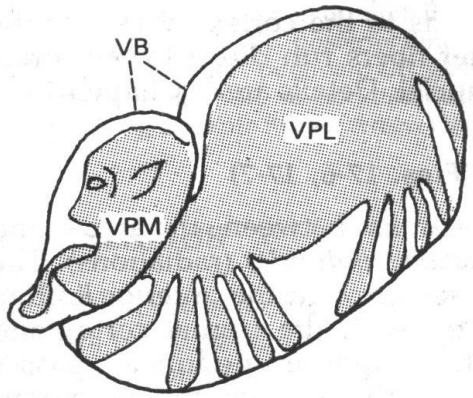


Fig. 17-5 Interconnections between thalamus and cerebral cortex. A, anterior nucleus; GN, geniculate nuclei; MD, mediodorsal nucleus; P, pulvinar; VA, VL, VP, ventral anterior, ventral lateral and ventral posterior nuclei.

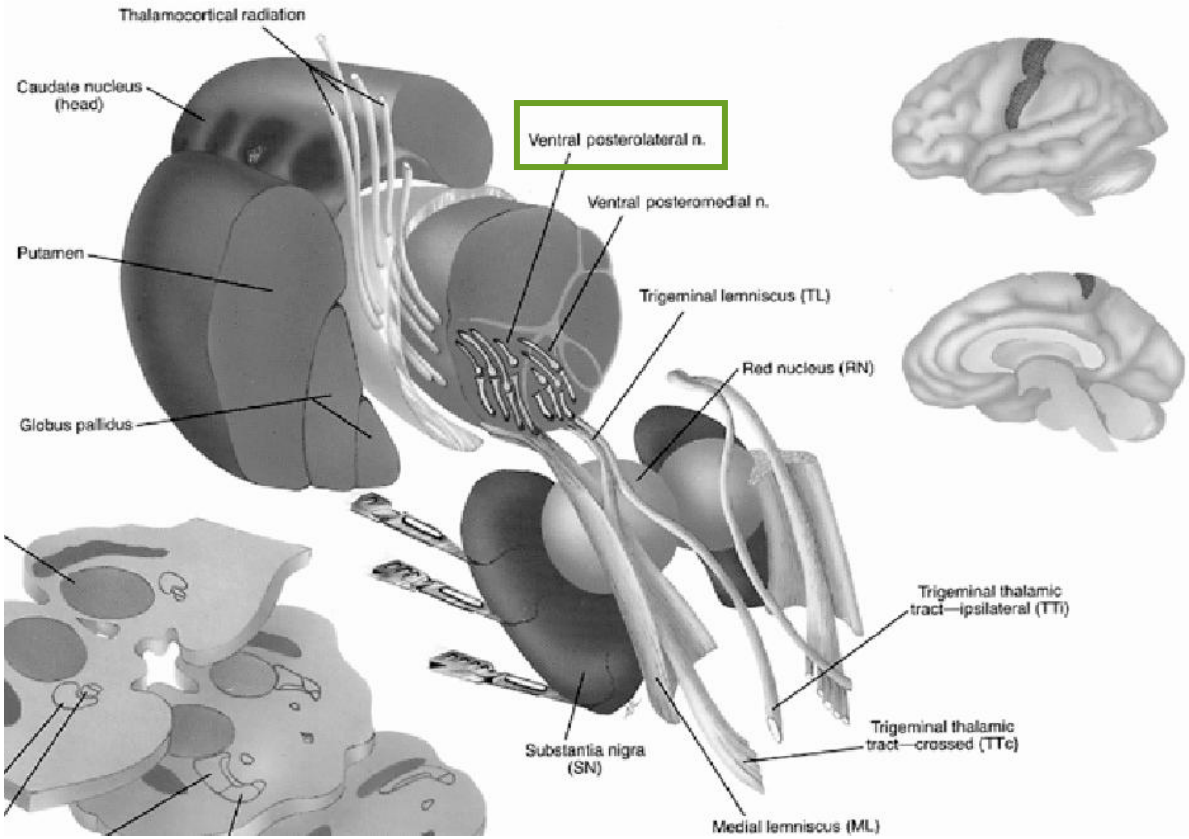


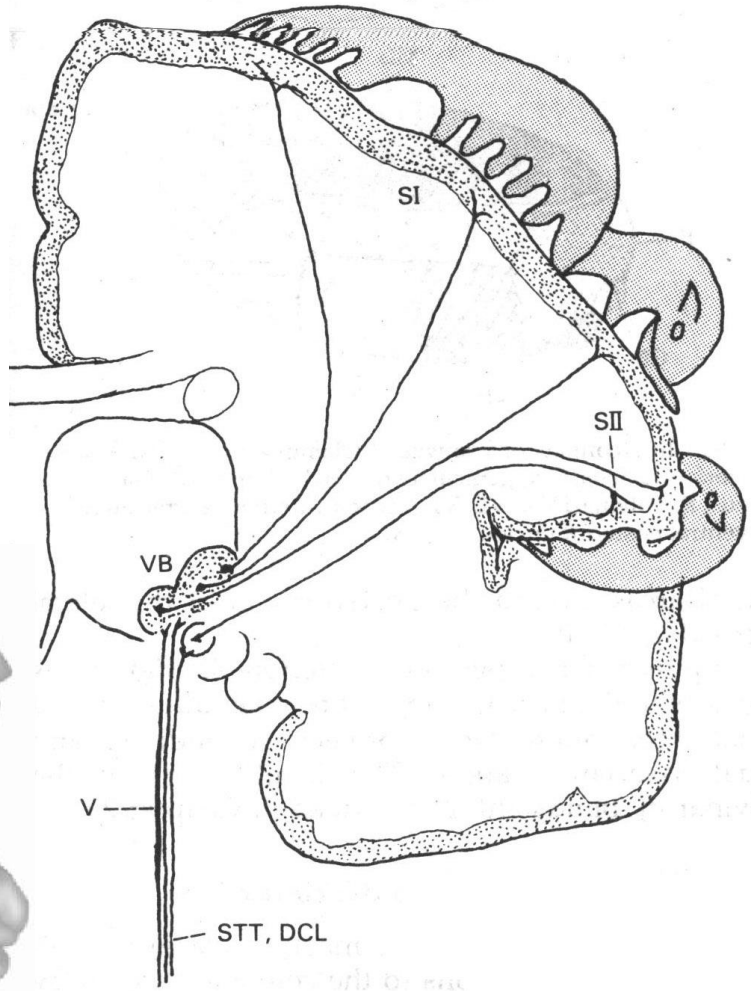


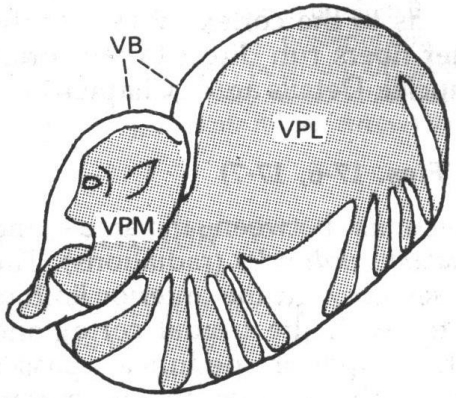
Ventroposterior lateral nucleus (VPL)

from the remainder of the body

Afferents from the Medial lemniscus, spinothalamic
Efferents to somatosensory areas of cortex





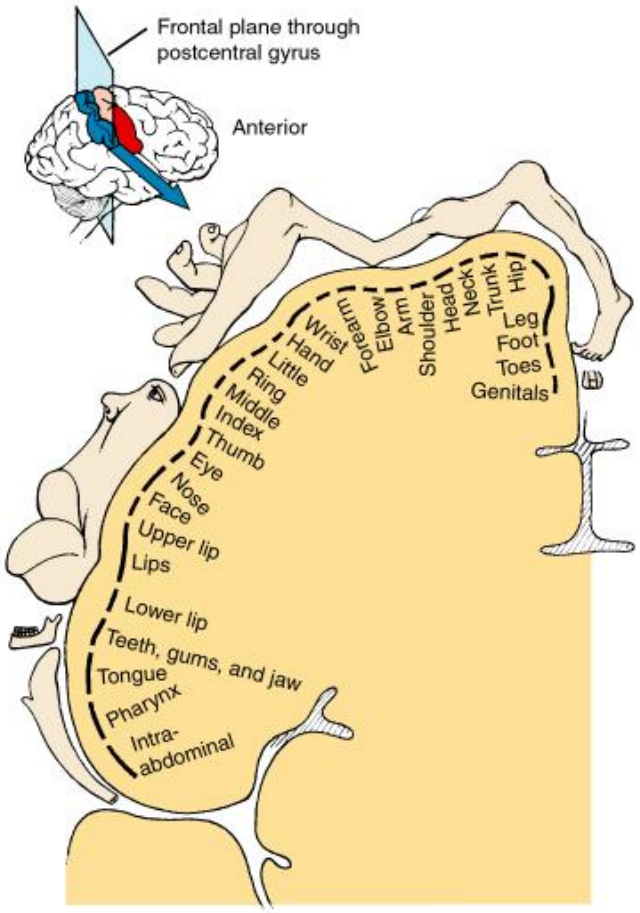


Thalamus丘腦:

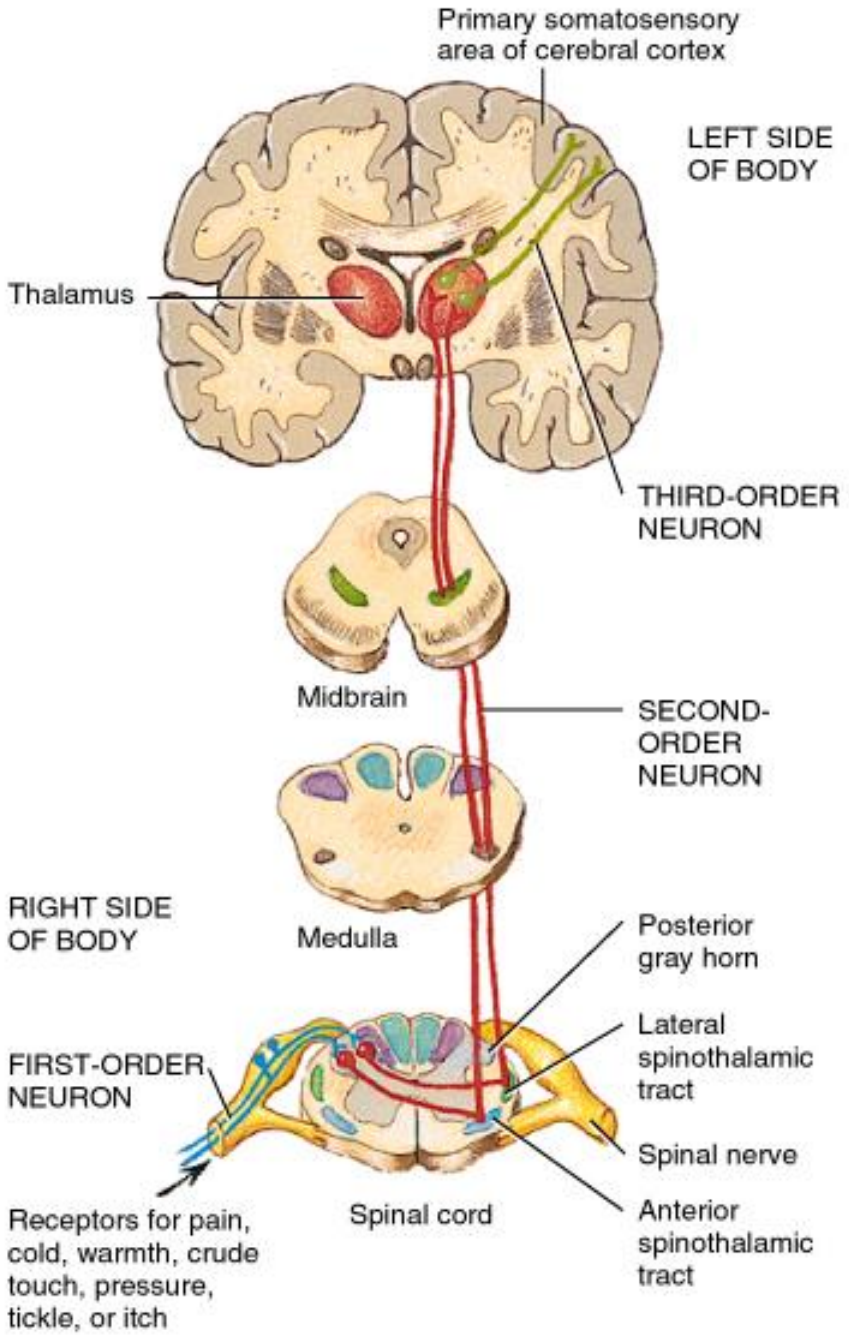
Principal relay station for sensory impulses from spinal cord to cortex

Spinothalamic tracts

(pain, temperature, and pressure)



(a) Frontal section of primary somatosensory area in right cerebral hemisphere



Ventral lateral nucleus (VL)

(motor function)

from the cerebellothalamic fiber via the superior cerebellar peduncle

To: Primary motor cortex

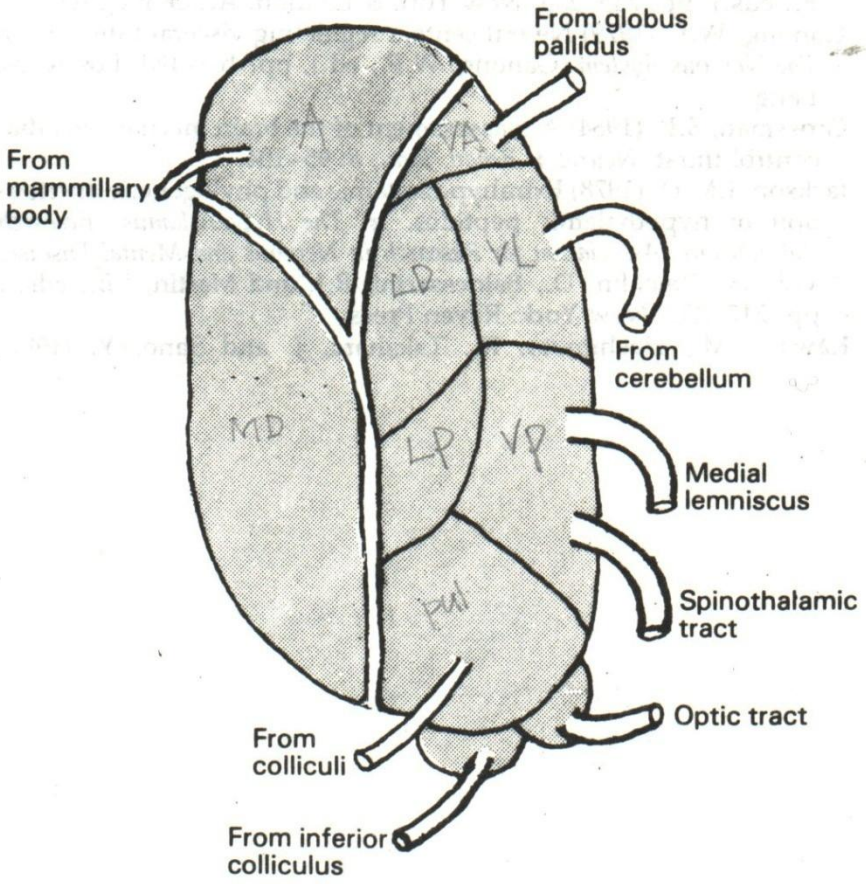


Fig. 17-2 Diagram indicating sources of input to the specific thalamic nuclei.

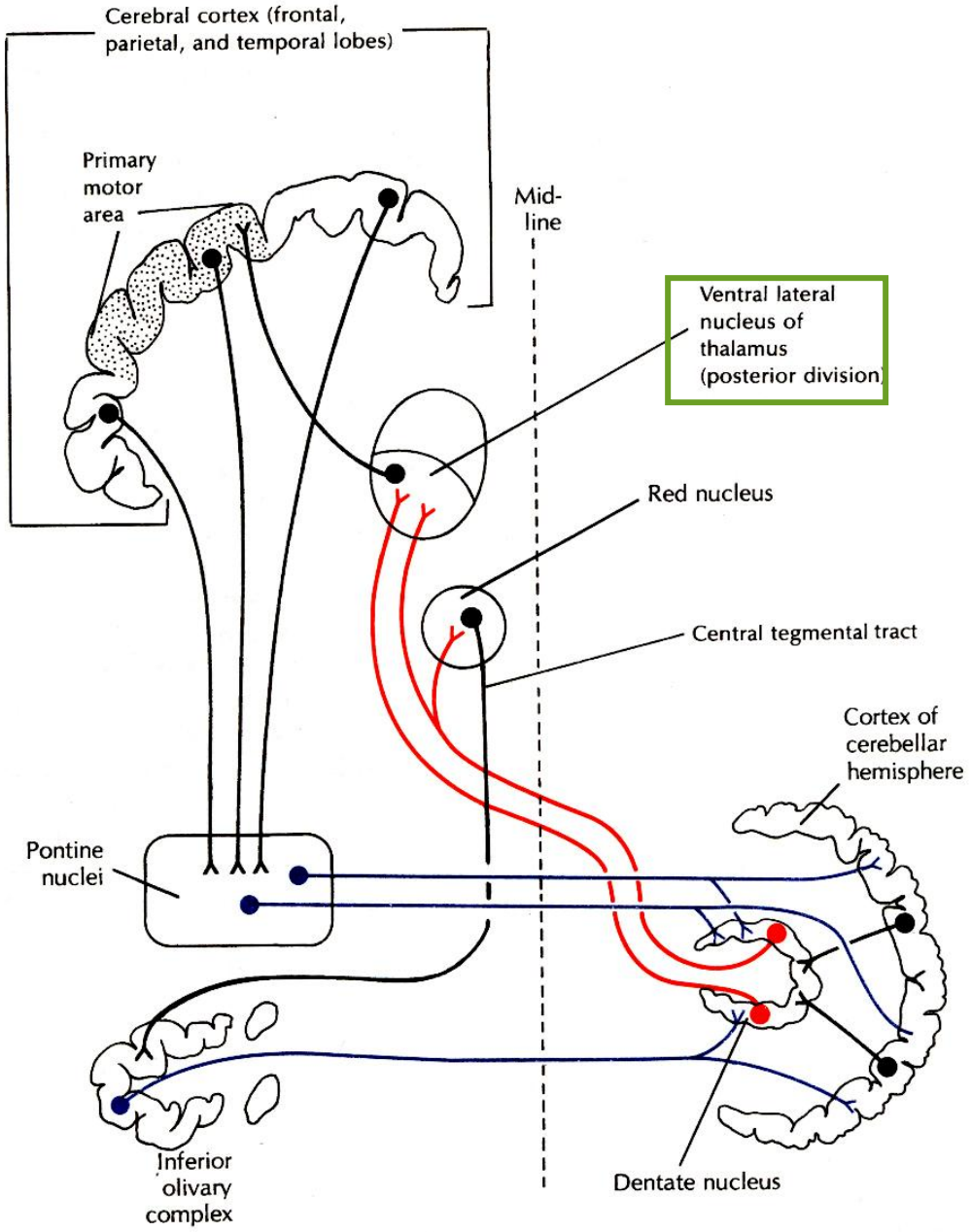
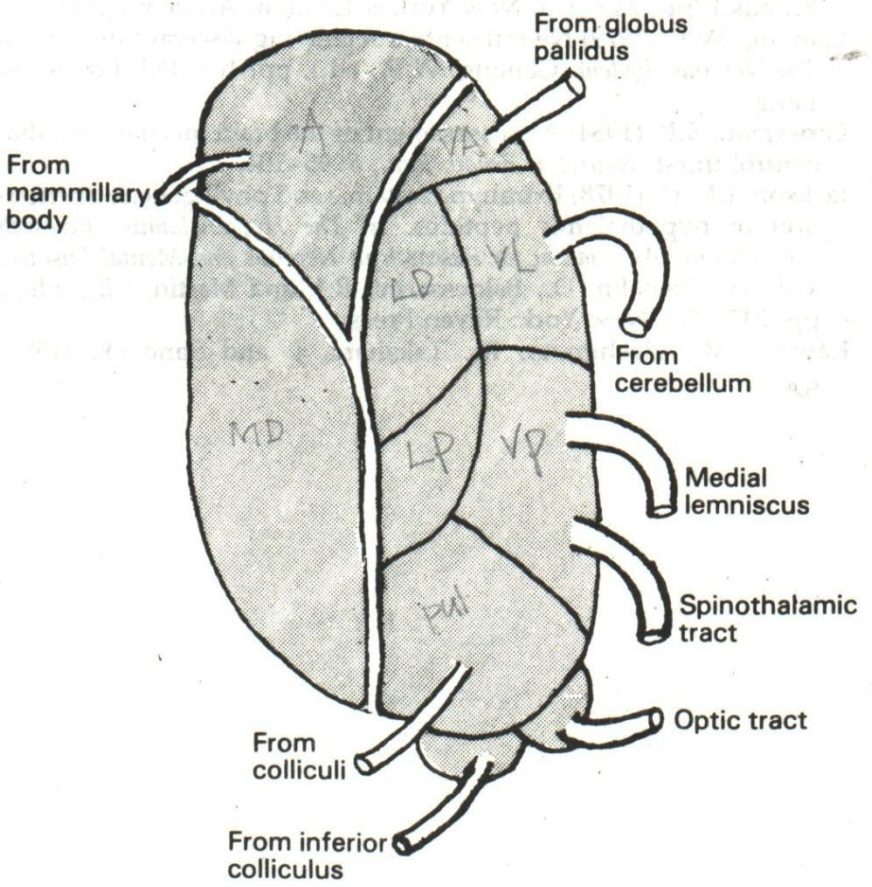


Figure 10-15. Connections of the pontocerebellum. Afferents to the cerebellum are *blue;* cerebellar efferents are *red;* other neurons are *black.*

Ventral anterior nucleus (VA) (motor function)

from the globus pallidus via the thalamic fasciculus
project to the cerebral cortex (premotor area)



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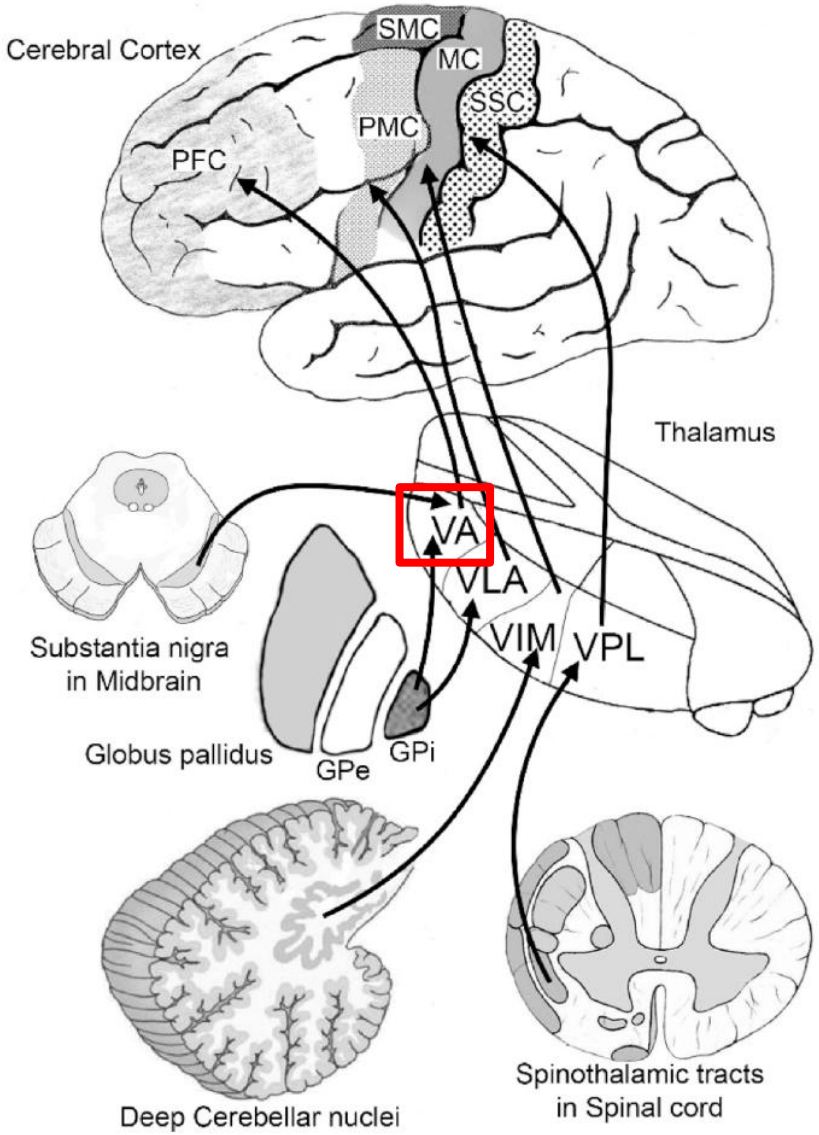
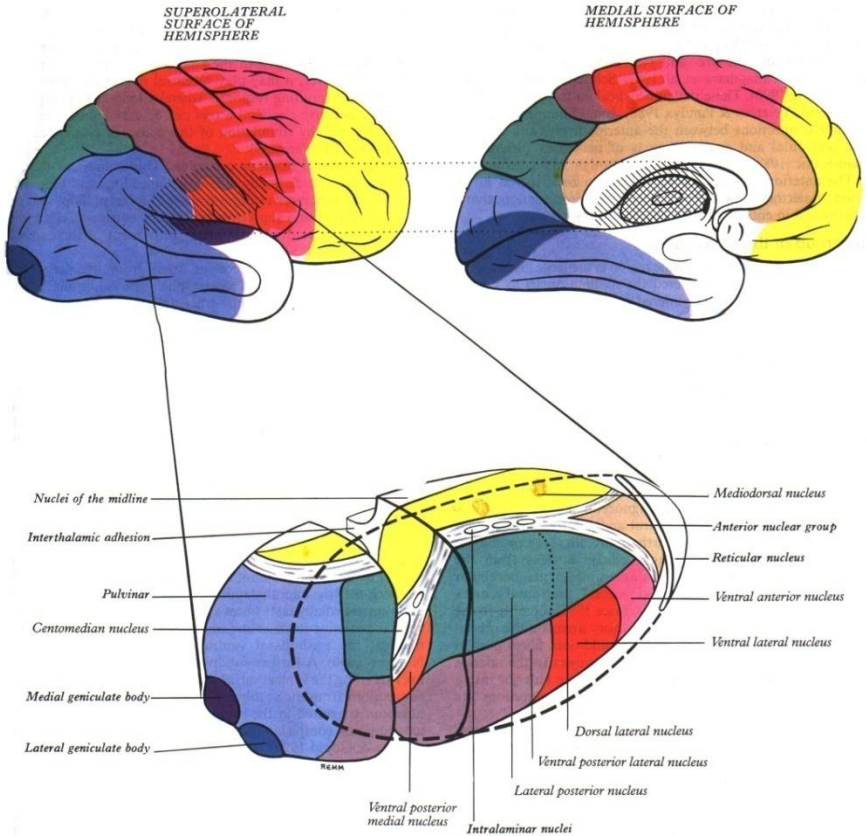


B. Association nuclei:

a two-way connection with the cerebral cortex; also interconnect with the other nuclei of the thalamus

1. Pulvinar (P) 枕核
2. Lateral nucleus (L)
3. Dorsomedial (mediodorsal) nucleus (DM or MD)
4. Anterior nucleus (A)



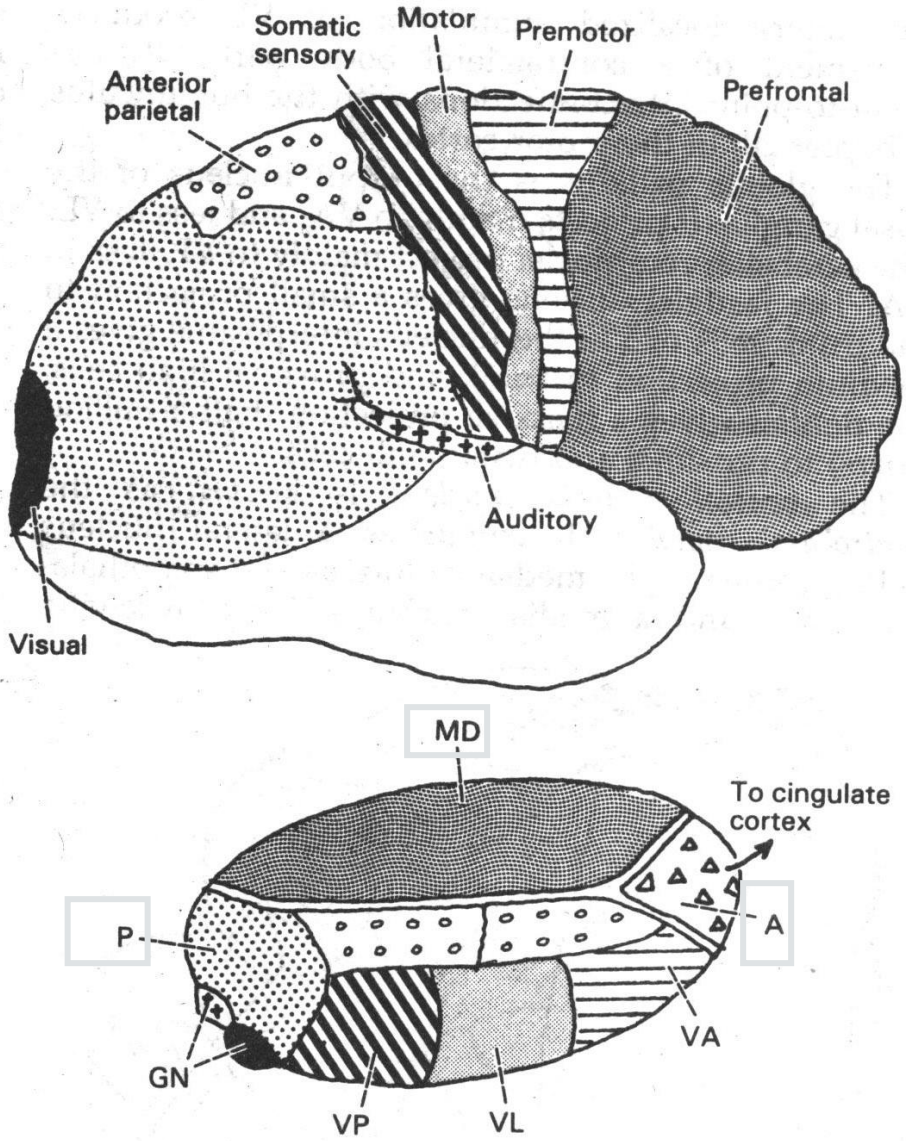
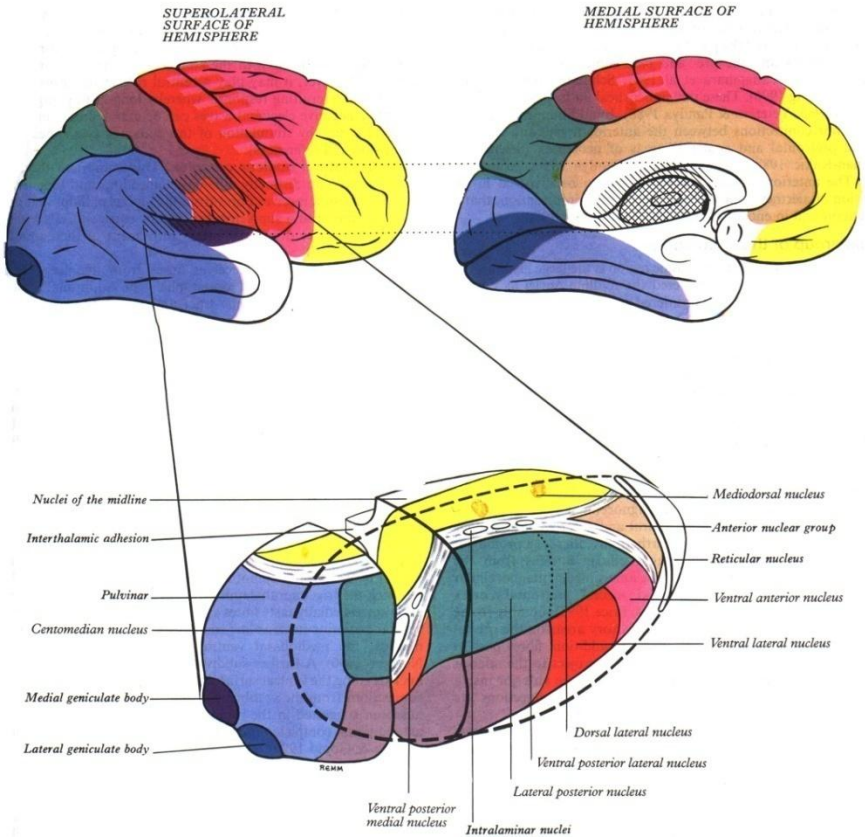


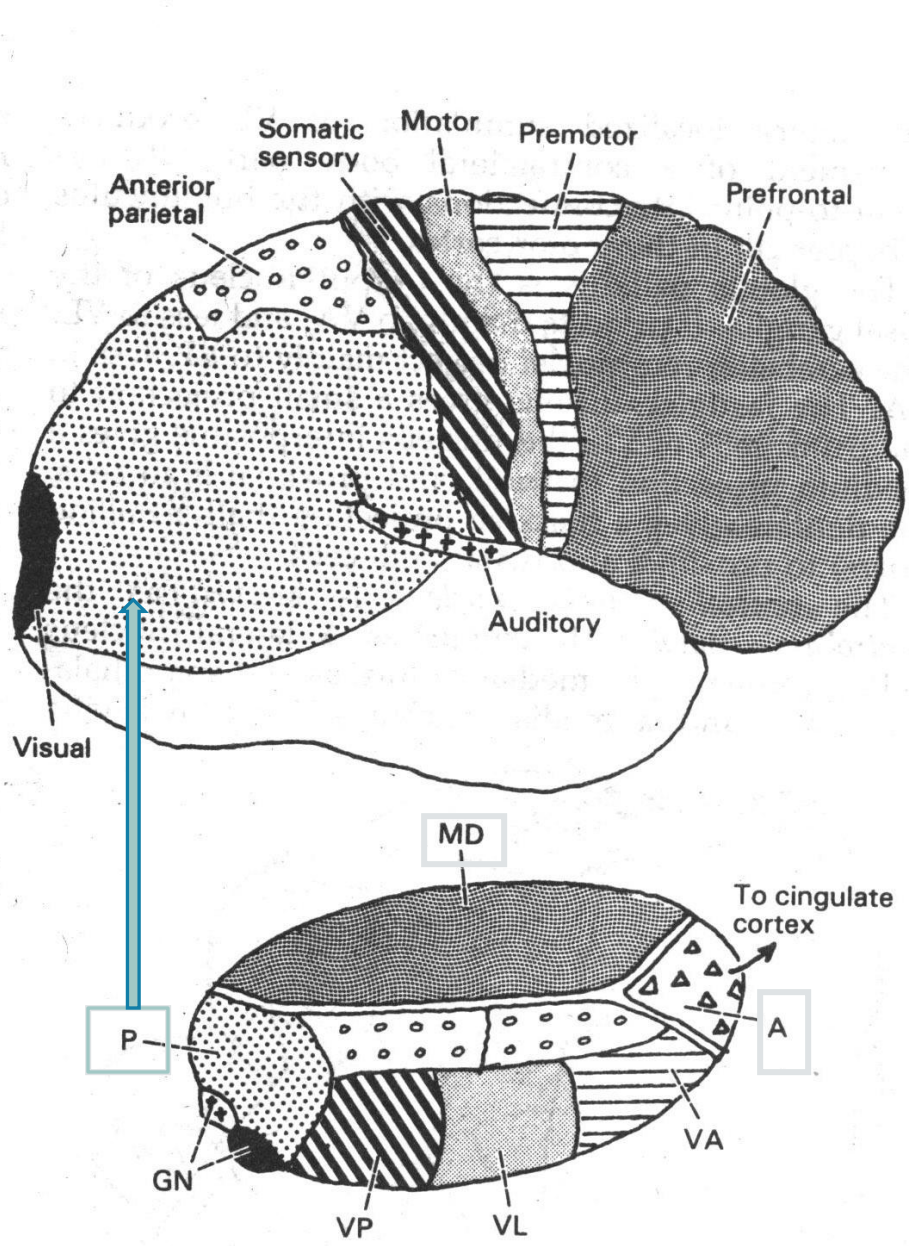
Fig. 17-5 Interconnections between thalamus and cerebral cortex. A, anterior nucleus; GN, geniculate nuclei; MD, mediodorsal nucleus; P, pulvinar; VA, VL, VP, ventral anterior, ventral lateral and ventral posterior nuclei.

Pulvinar (P)枕核:

(Vision associated function)

The pulvinar part is the most posterior region of the thalamus.





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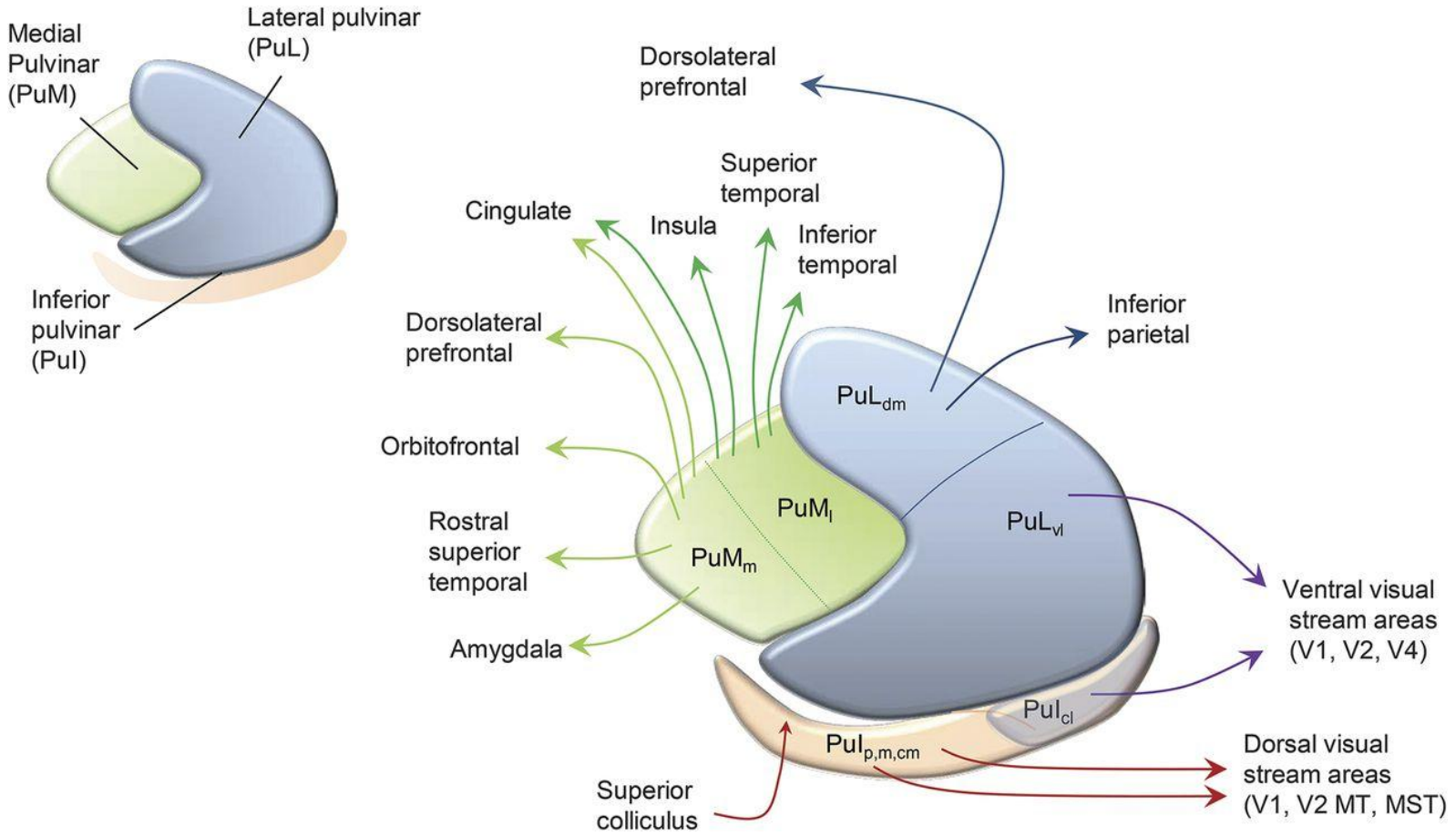
Pulvinar (PUL) (Vision associated function)

Connects reciprocally with a large association area of the parietal, temporal, and occipital cerebral cortex

Afferents from the superior colliculus

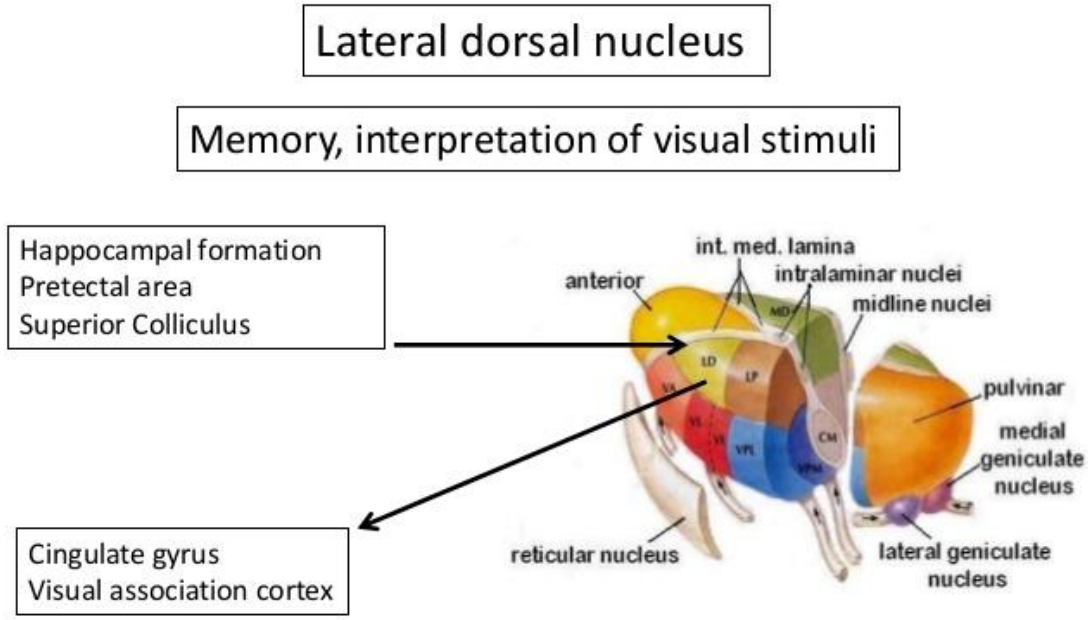
Efferents to the parietal-occipital-temporal association cortex

Lesions of the pulvinar can result in neglect syndromes and attentional deficits.



Lateral nuclei (LD+LP): reciprocally connect with the portion of the parietal lobe posterior to the postcentral gyrus

Lateral dorsal nucleus (LD):
to region of precuneus
•afferents: hippocampus (limbic system)
•efferents to the cingulate gyrus
emotion and behavior functions with visual stimuli



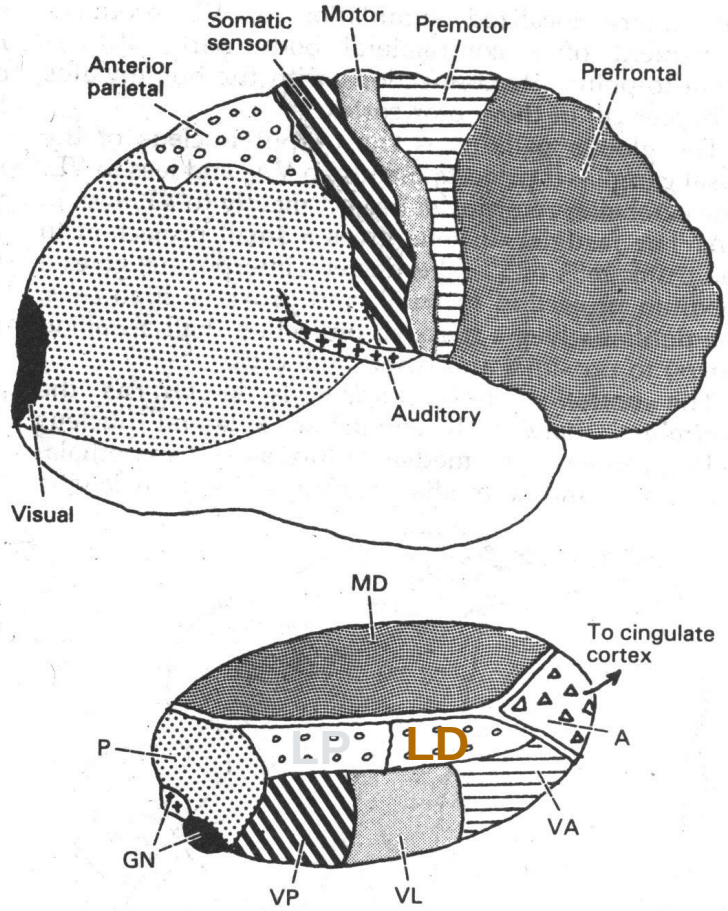


Fig. 17-5 Interconnections between thalamus and cerebral cortex. A, anterior nucleus; GN, geniculate nuclei; MD, mediodorsal nucleus; P, pulvinar; VA, VL, VP, ventral anterior, ventral lateral and ventral posterior nuclei.

Lateral posterior nucleus (LP):
to superior parietal lobule

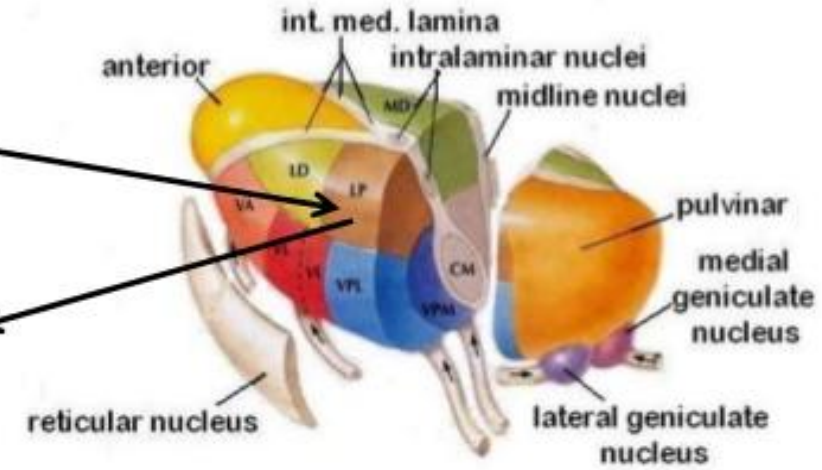
- afferents from the superior colliculus
- efferents to the parietal association cortex

Lateral posterior nucleus

Interpretation of visual & other sensory stimuli

Superior Colliculus

Parietal, temporal,& occipital association cortex

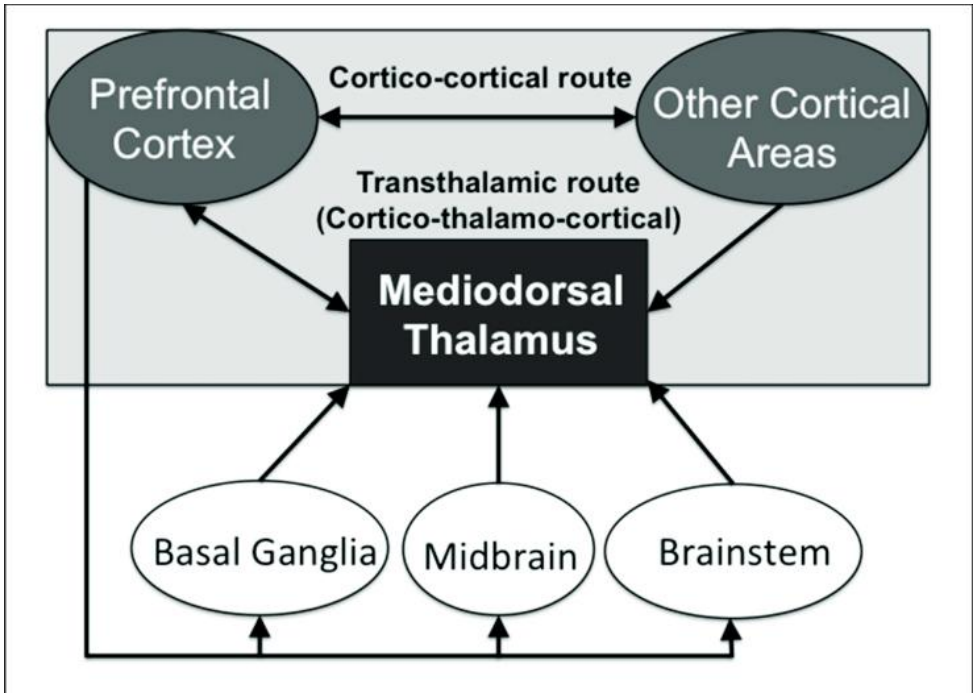


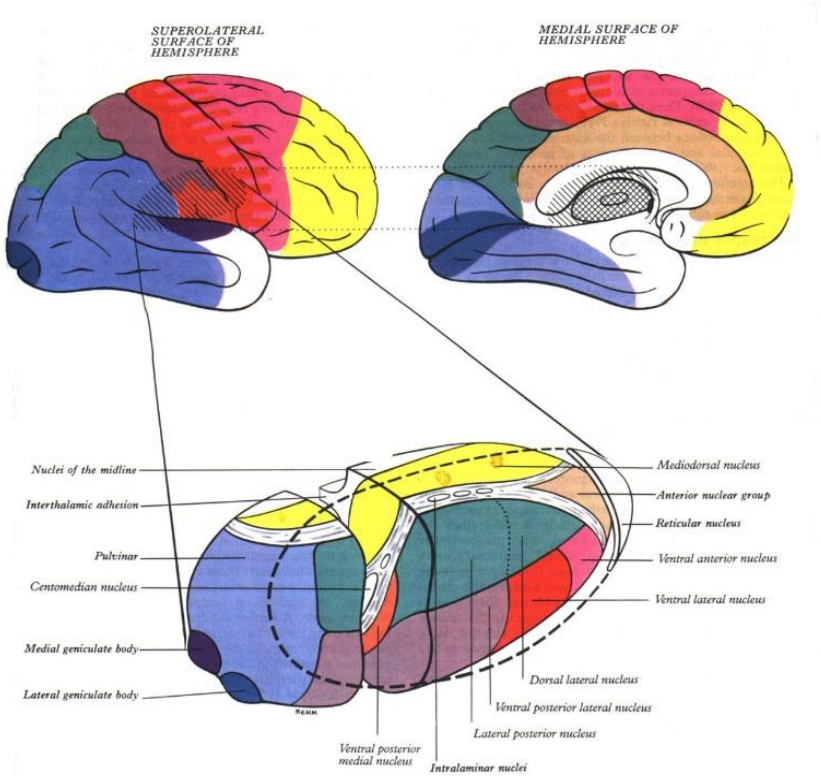
Dorsomedial (mediodorsal) nucleus (DM) (Emotional response, memory)

Reciprocally connect with a large portion of the frontal lobe which is rostral to the premotor area

- Afferent fibres - Prefrontal cortex, hypothalamus, other thalamic nuclei
- Efferent fibres - Prefrontal cortex (area 8,9,10 and 11) hypothalamus, other thalamic nuclei

- Function served:
  - The dorsomedial nucleus belongs to a neural system concerned with affective behavior, decision making and judgment, memory, and the integration of somatic and visceral activity.
  - The reciprocal connections between the prefrontal cortex and the dorsomedial nucleus can be interrupted surgically to relieve severe anxiety states and other psychiatric disorders.





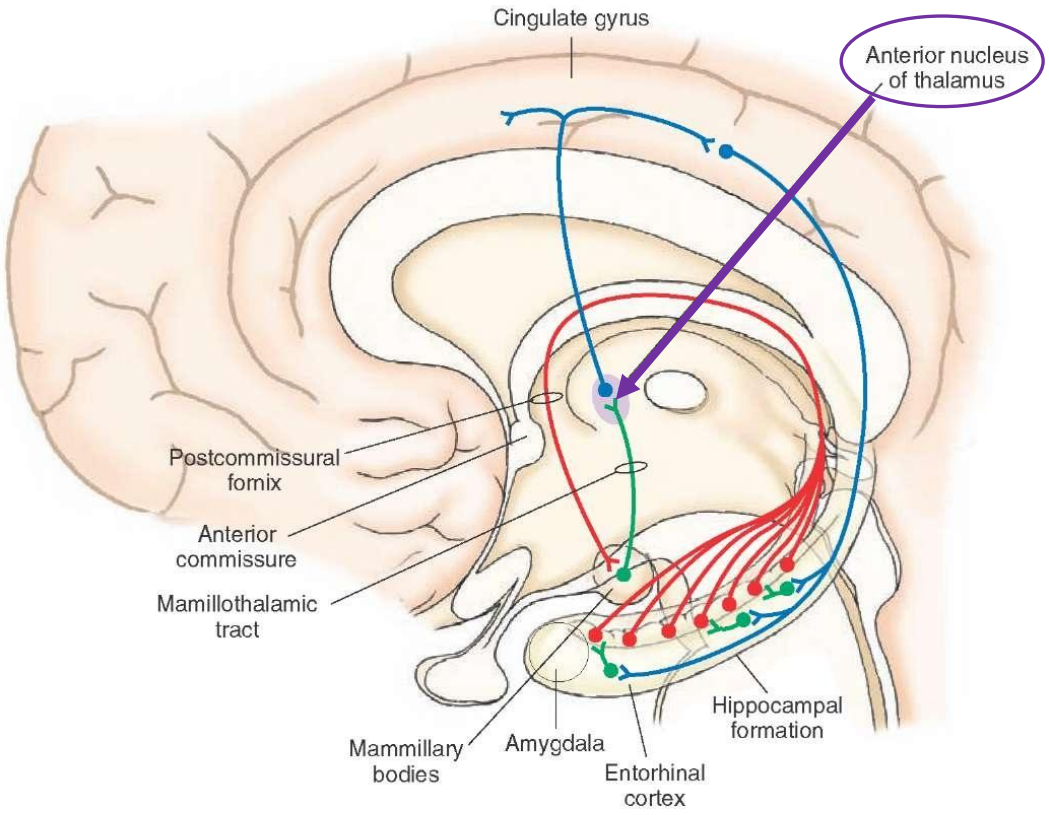
Anterior nucleus (A): located in the swollen anterior tubercle of the thalamus

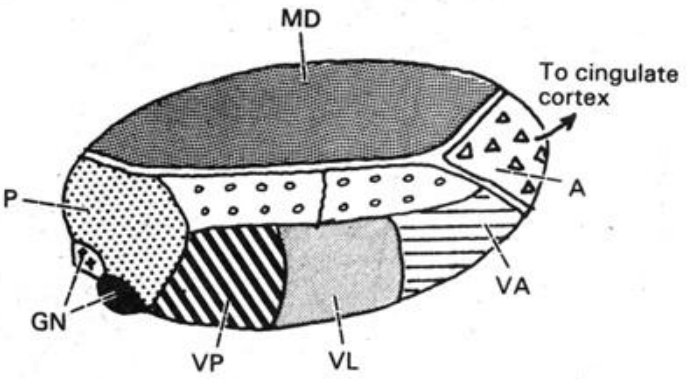
•Afferents from the mammillary body (memory and behavioral functions)

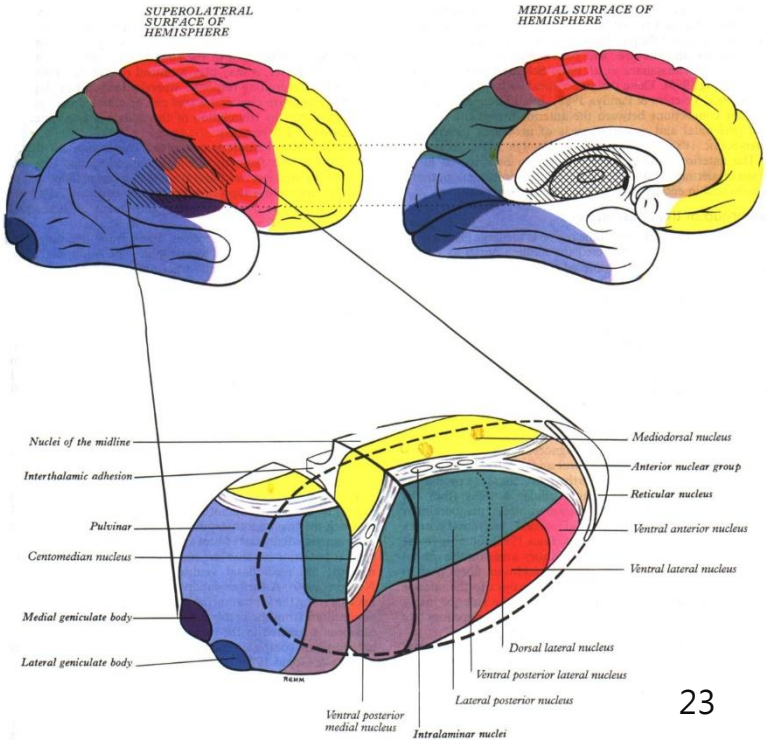
•Efferents to the cingulate gyrus

mammillothalamic tract terminates

reciprocal connections with the cingulate gyrus

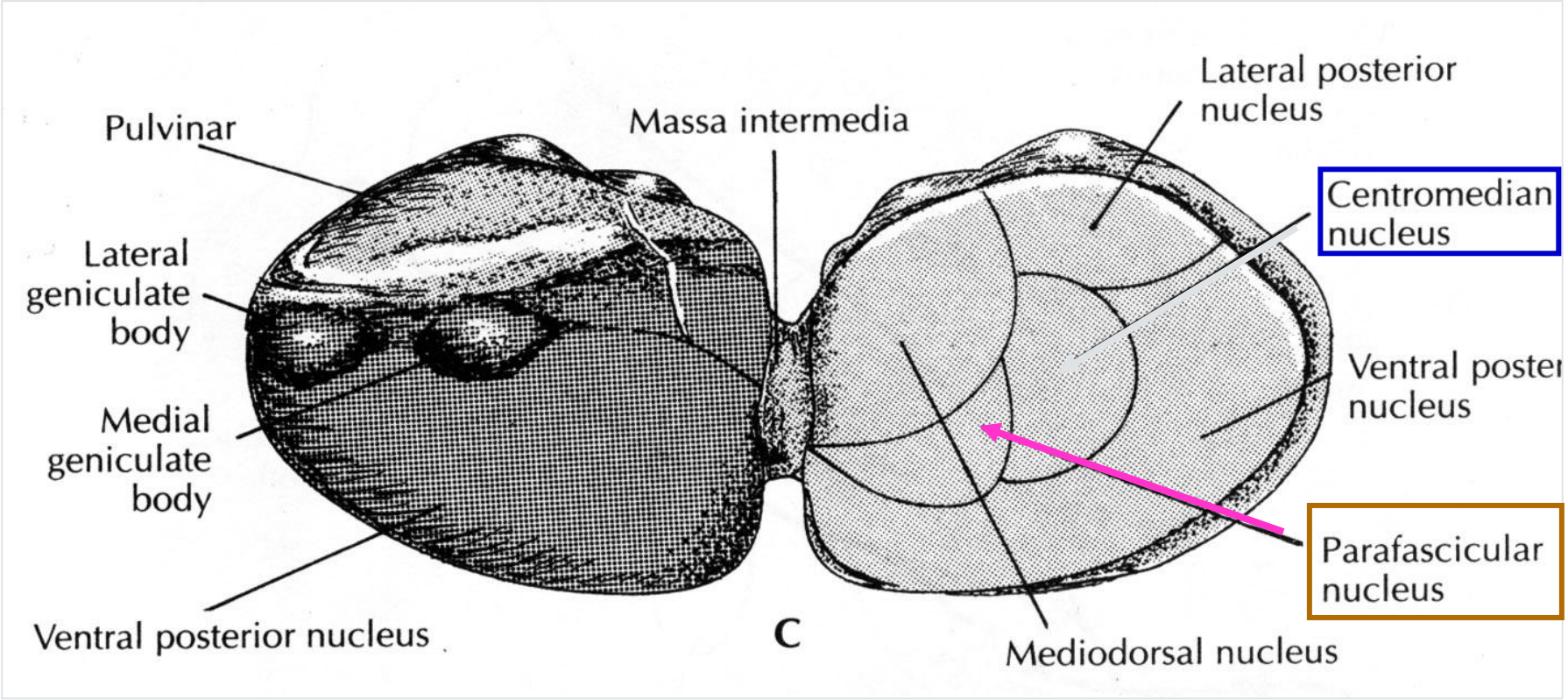






Intralaminar nuclei: the internal medullary lamina splits and encloses groups of cells (Arousal, awareness, and emotional pain responses)

1. Centromedian nucleus (CM): large, round nucleus located medial to the VPL/VPM
2. Parafascicular nucleus (PF): located medial to the centromedian nucleus



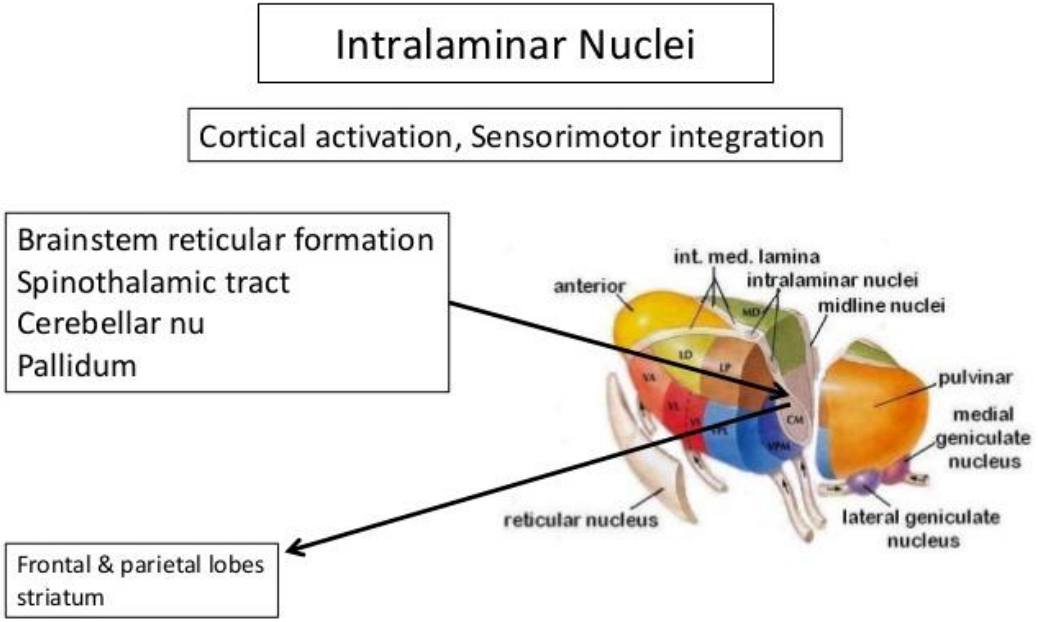
Intralaminar nuclei: the internal medullary lamina splits and encloses groups of cells (Arousal, awareness, and emotional pain responses)

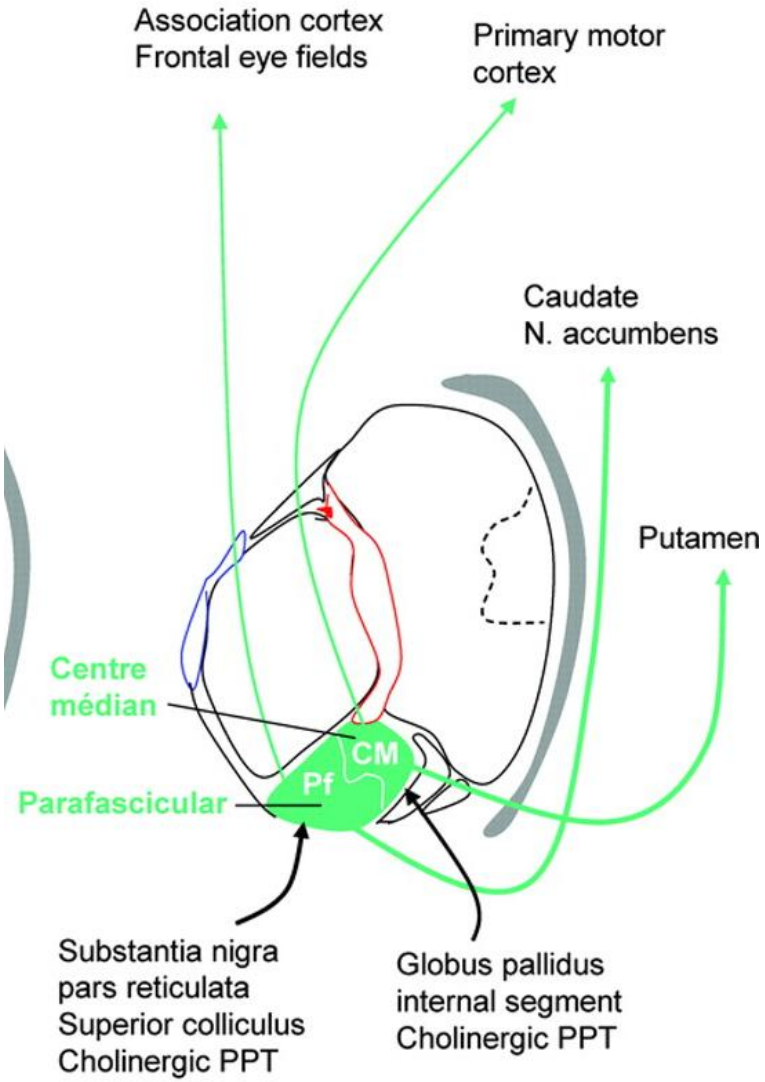
1. Centromedian nucleus (CM):

- afferents from the globus pallidus
- efferents to the Primary motor cortex, Putamen

2. Parafascicular nucleus (PF):

- afferents from the Substantia nigra, pars retculata, superior colliculus
- efferents to the Caudate, Association cortex Frontal eye fields





Diffuse conducting system:

is located in the internal lamina or on the extreme medial or lateral margins

Reticular nucleus:

1. covering the anterior (and lateral) surface of the thalamus
2. afferents from the thalamus and cerebral cortex
3. GABAergic efferents to the thalamus

Function: modulates the exchange of signals between thalamic nuclei and the cerebral cortex

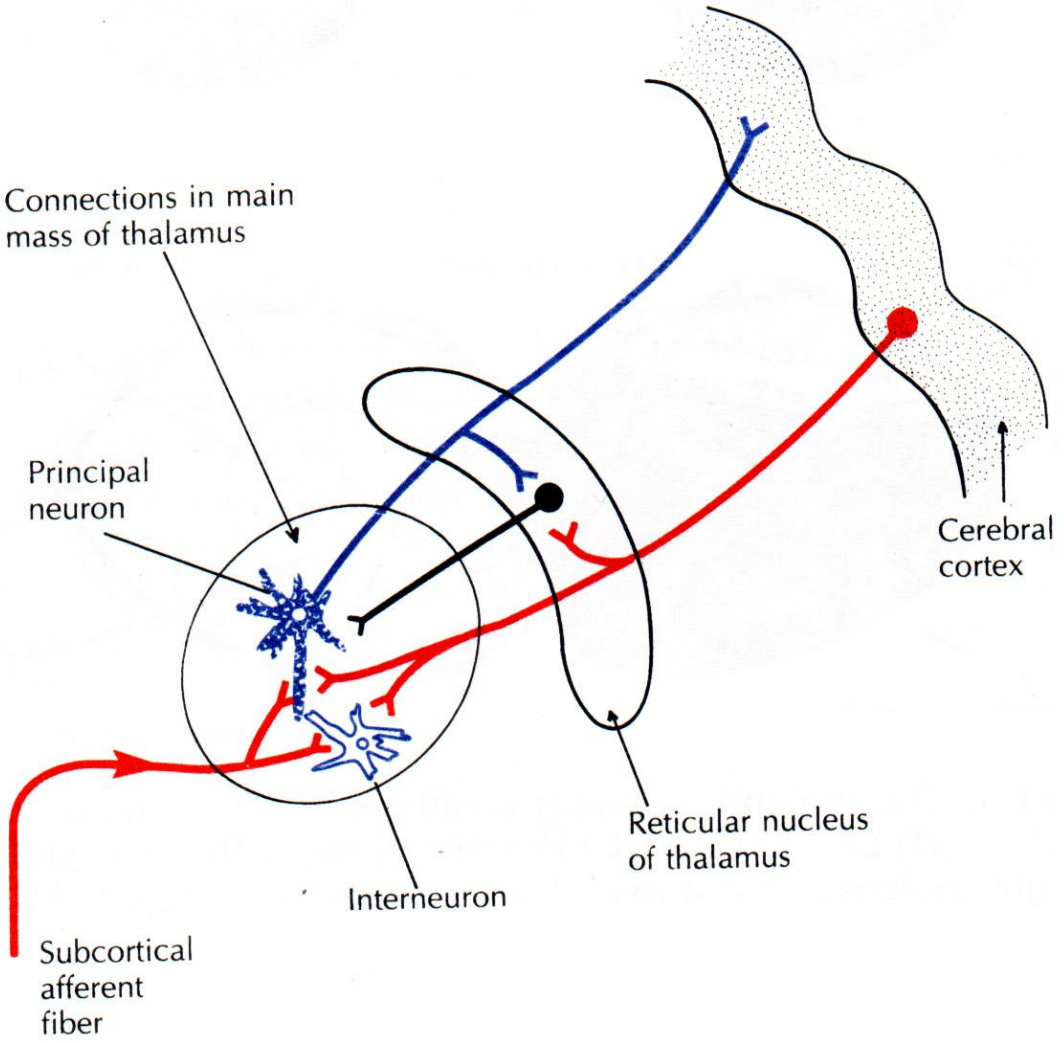
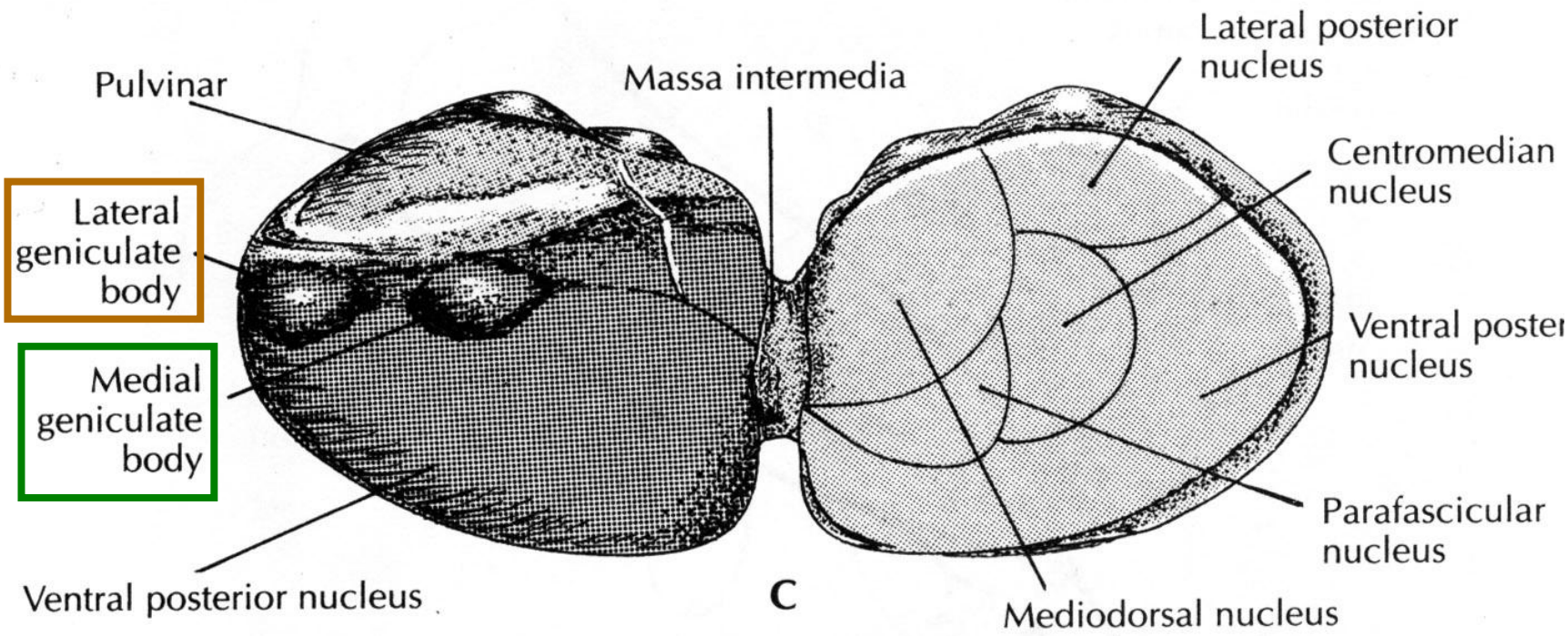


Figure 11-5. Scheme of neuronal connections of the thalamus.

Metathalamus (後丘腦)

A. Lateral geniculate body: receive the optic tract (Vision)
B. Medial geniculate body: receive the brachium of the inferior colliculus (Hearing)



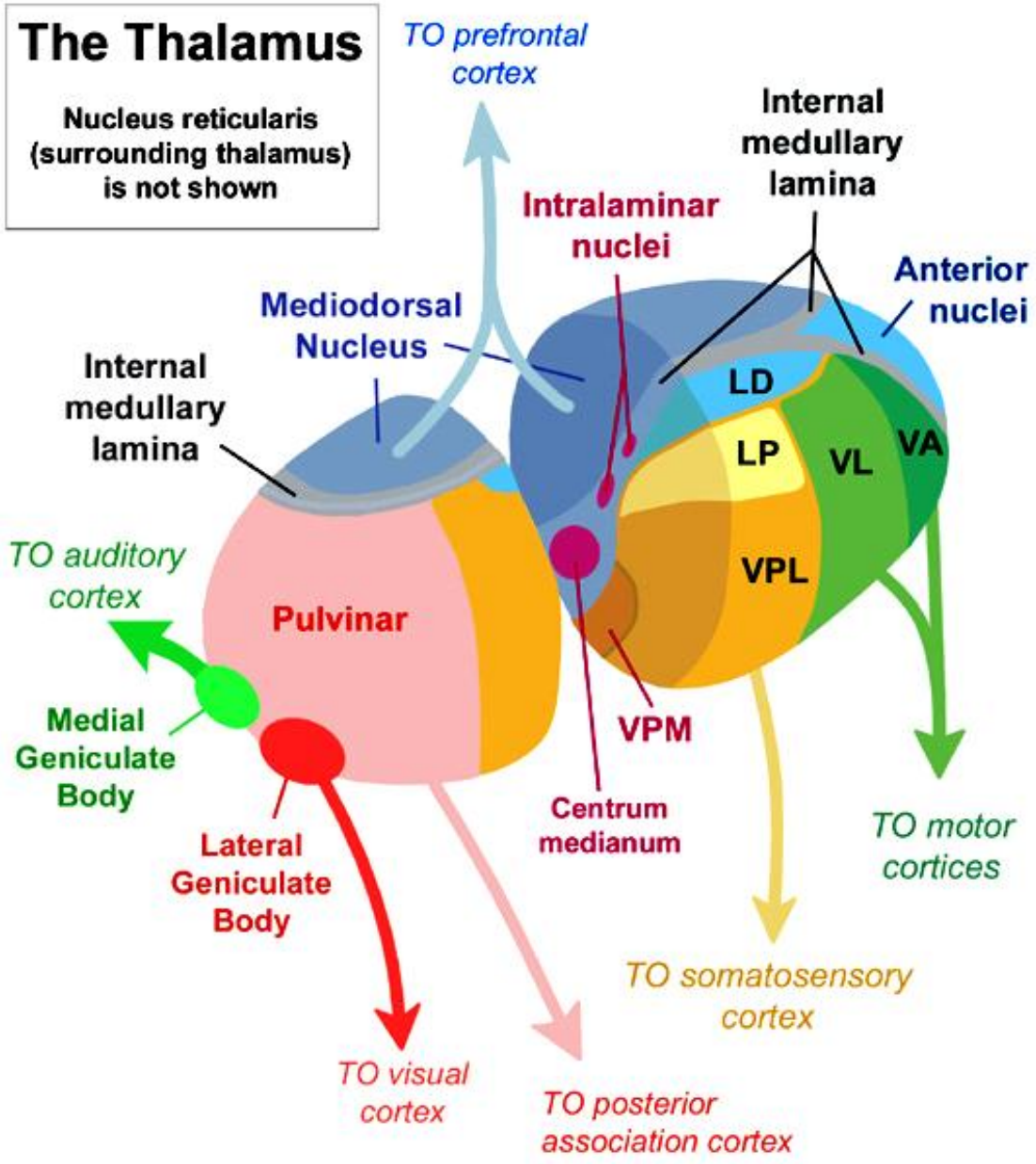
Summary of Thalamic Nuclei

Nuclei have different roles

1. relays auditory and visual impulses, taste and somatic sensations

2. receives impulses from cerebellum or basal ganglia

3. anterior nucleus concerned with emotions, memory and acquisition of knowledge (cognition)



Subthalamus 底丘腦

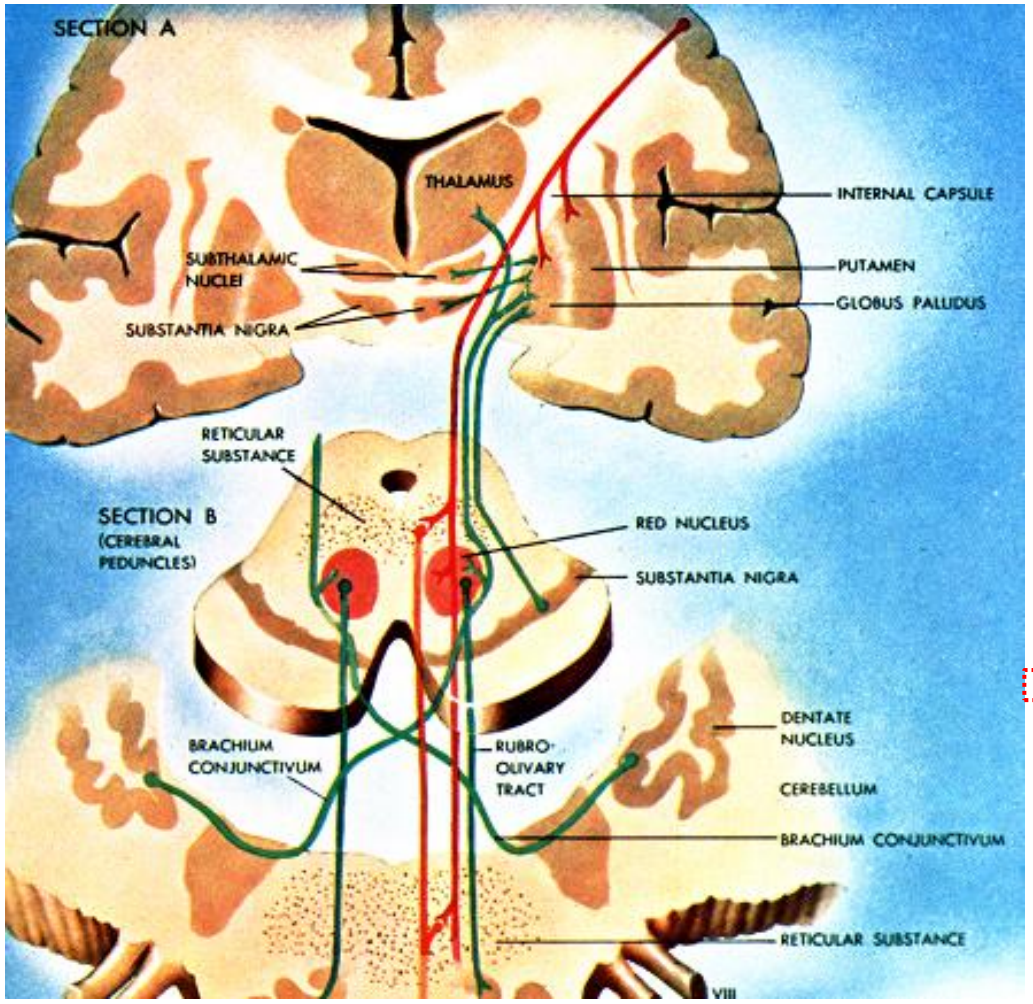
control skeletal muscle movements and muscle tone

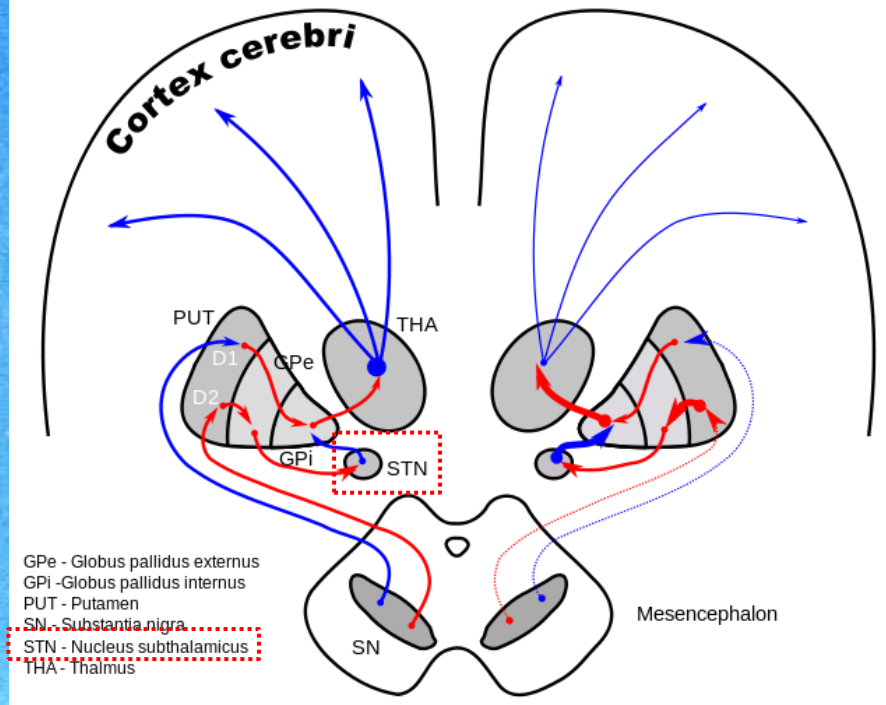
Motor cortex → subthalamic nuclei →red nuclei and substantia nigra

Subthalamic nuclei:

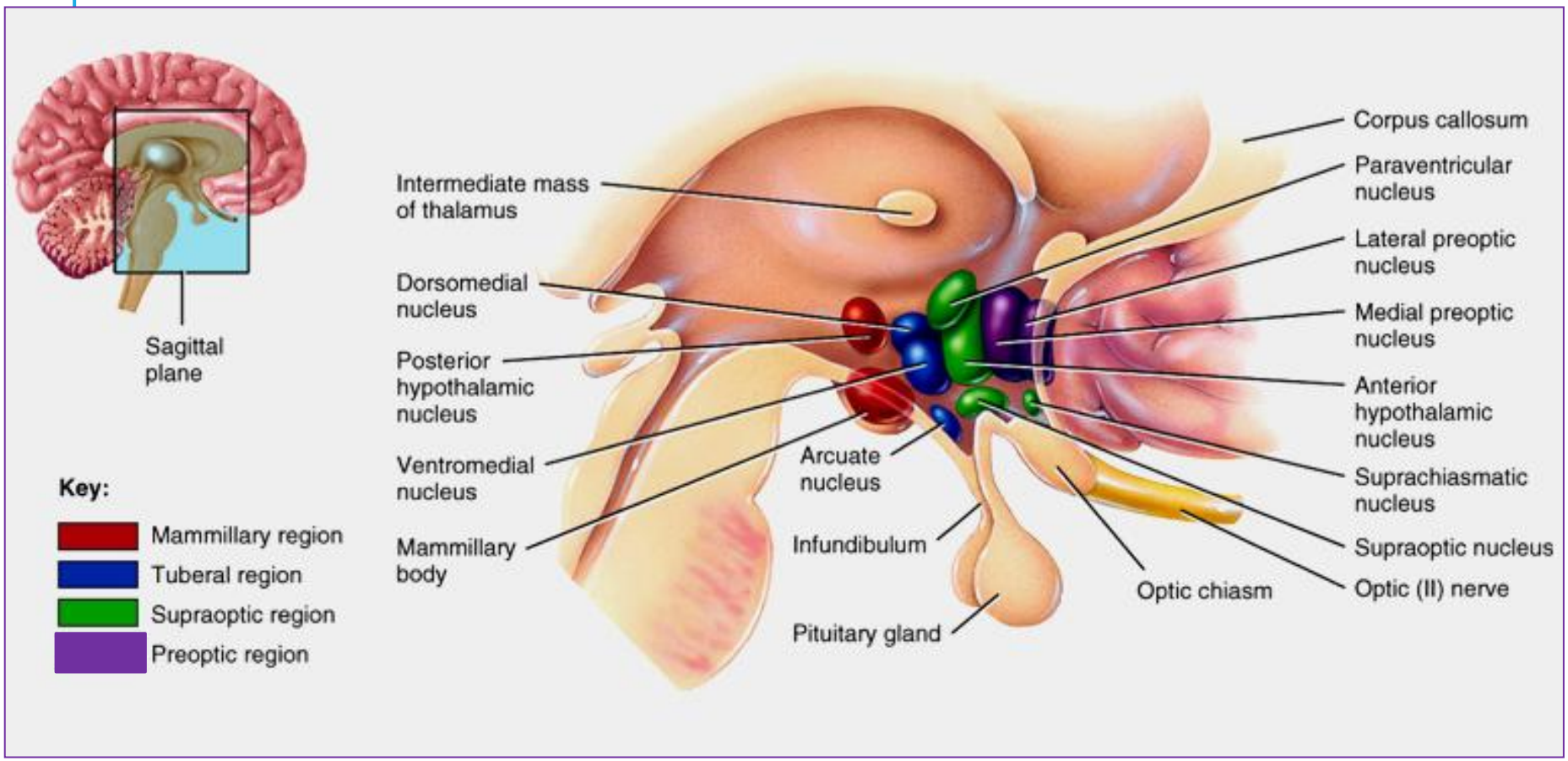
a. Replace the substantia nigra at the level of the lower border of the optic tract

b. Afferents from and efferents to the **globus pallidus**





HYPOTHALAMUS 下視丘:
DOZEN NUCLEI IN 4 MAJOR REGIONS



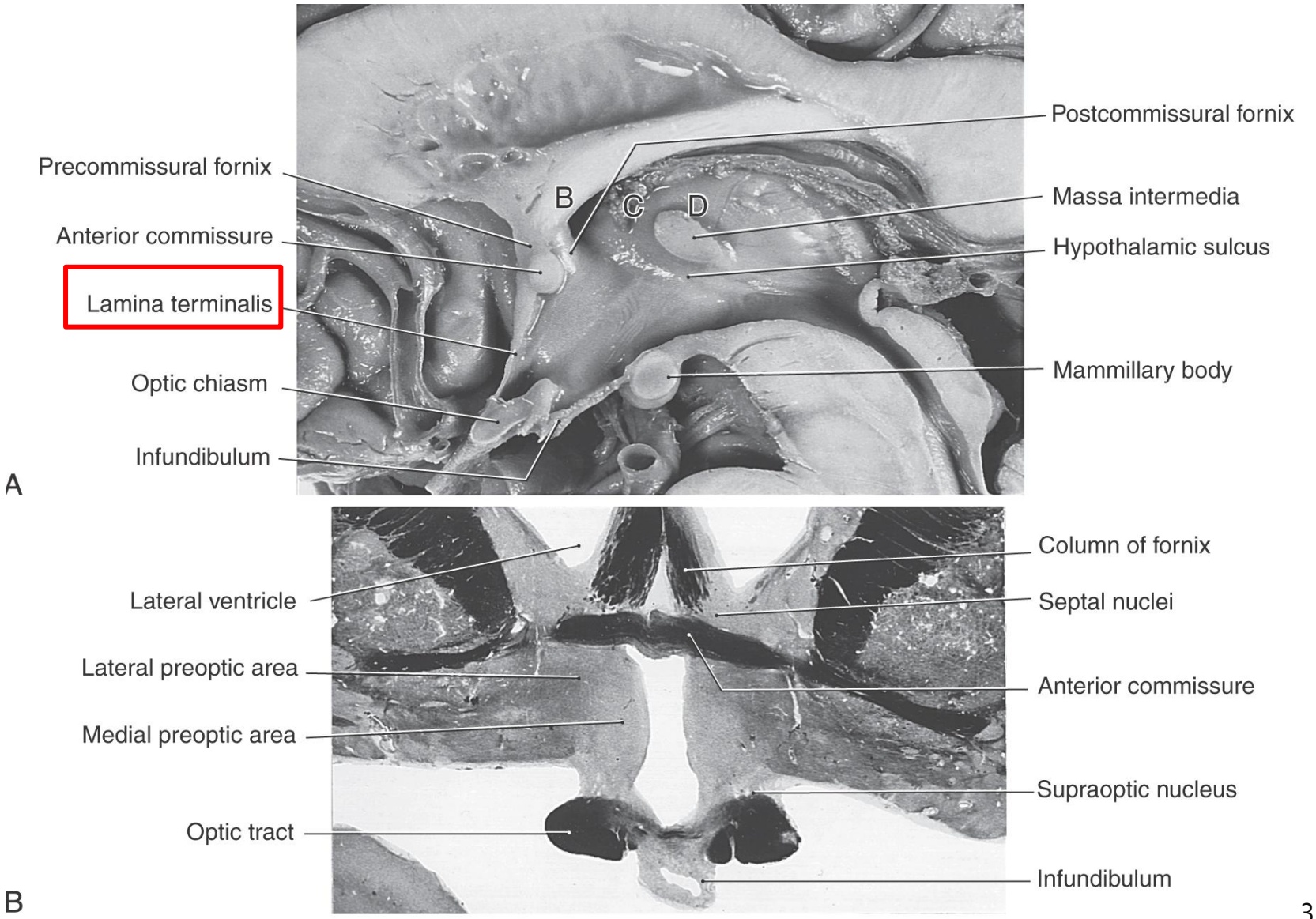
Major regulator of homeostasis

- receives somatic and visceral input, taste, smell & hearing information; monitors osmotic pressure, temperature of blood

Hypothalamus

A. Relationship

1. Anterior: lamina terminalis 終板



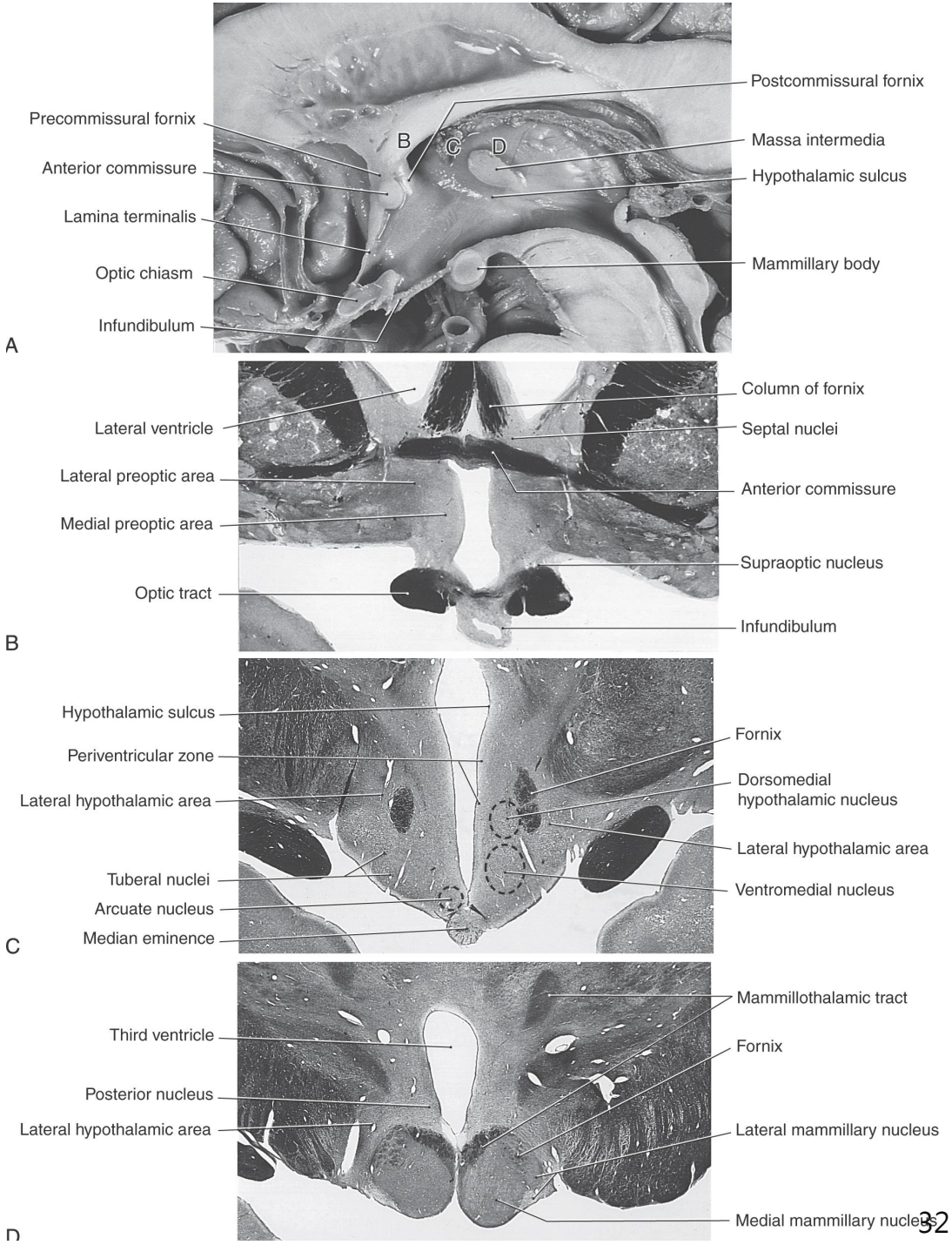
Hypothalamus

A. Relationship

2. Inferior: from front to back
   a. Optic chiasma
   b. Tuber cinereum 灰結節

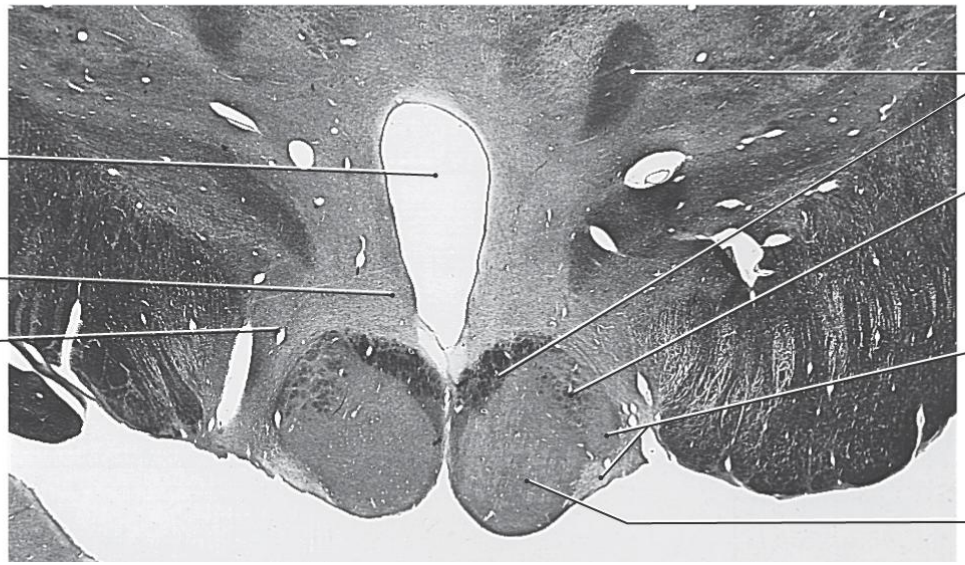
Infundibulum漏斗: connects the tuber cinereum and the pars nervosa of the hypophysis

   c. Mammillary bodies乳頭體



3. Medial: ventral to the hypothalamic sulcus

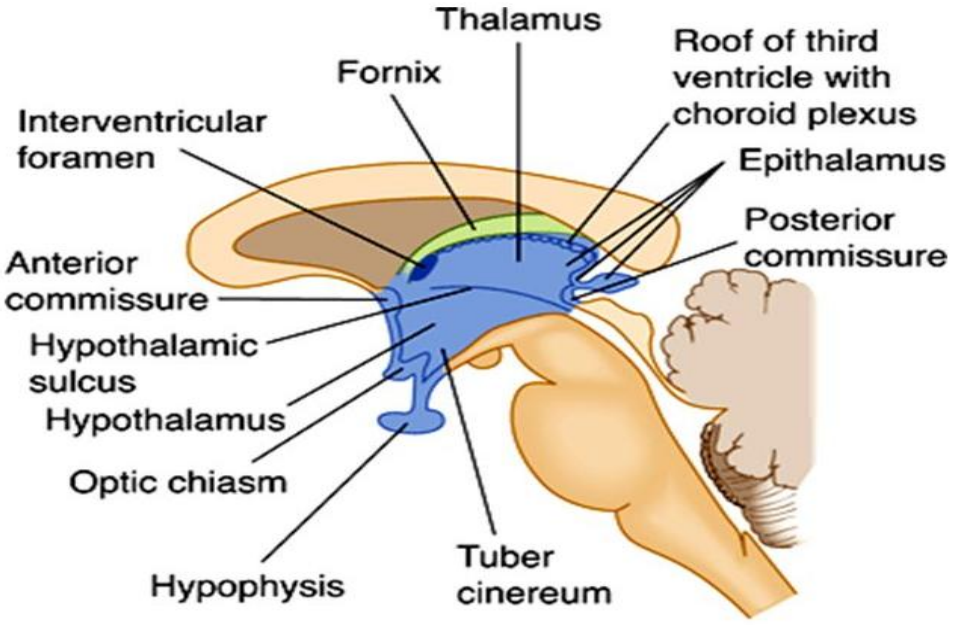
C



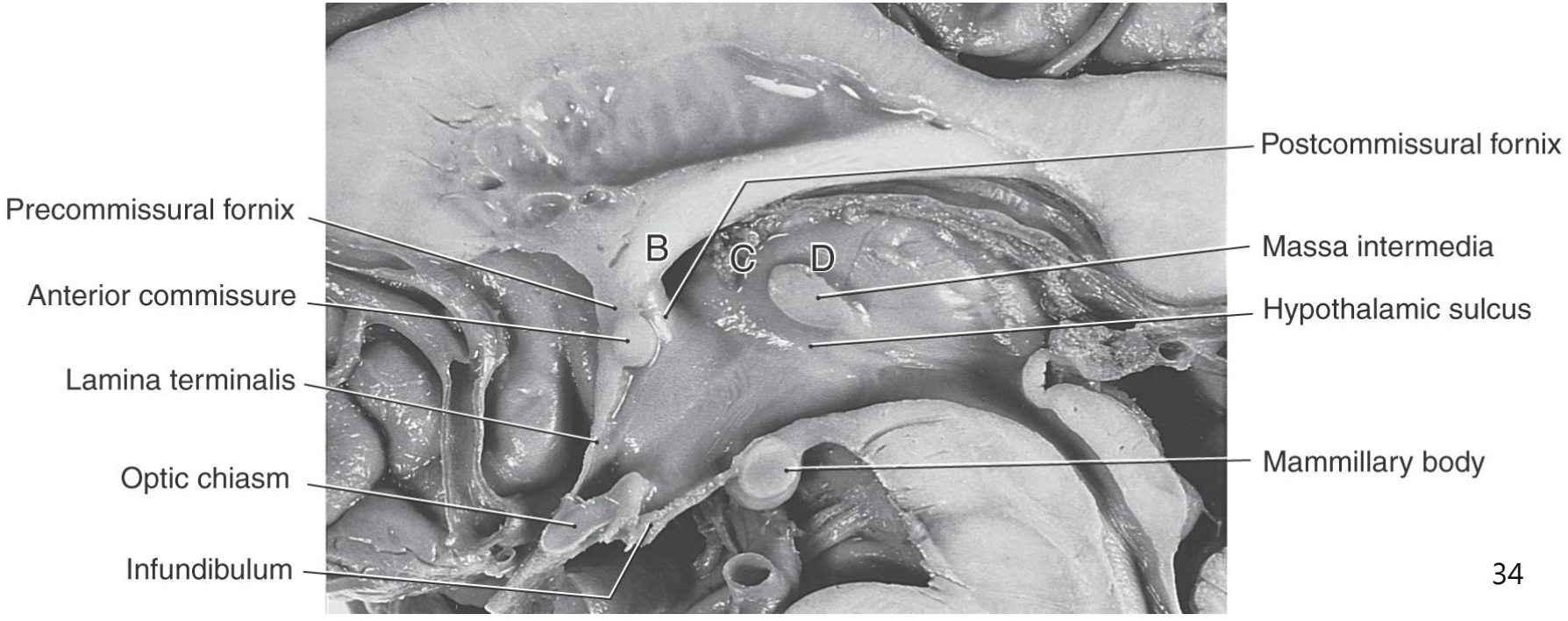
D

4. Superior

a. Anterior commissure
b. Fornix
c. Interventricular foramen



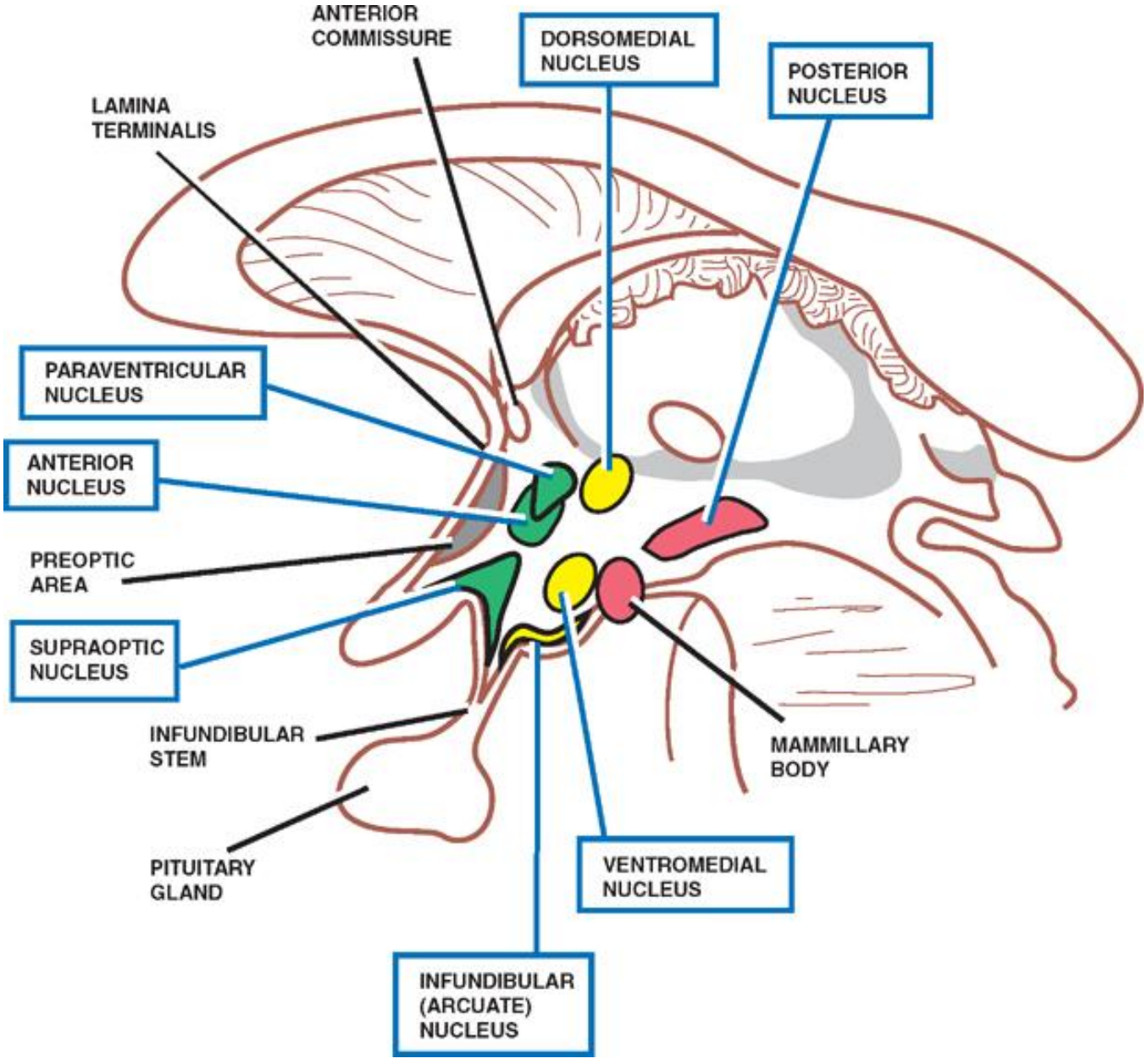
Source: Waxman SG: *Clinical Neuroanatomy, 26th Edition*: http://www.accessmedicine.com



A

Hypothalamus 下視丘:

Dozen nuclei in 4 major regions

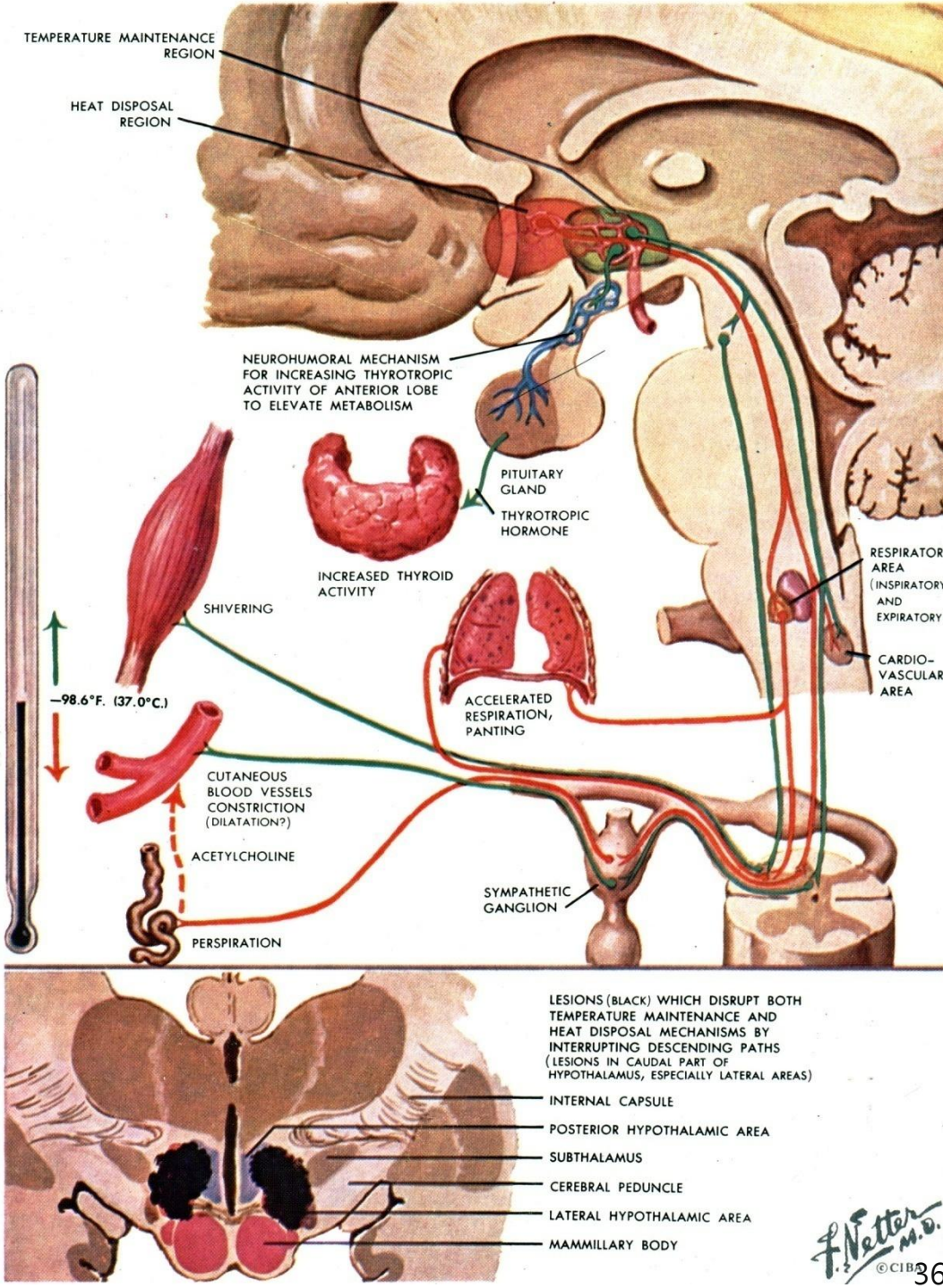


I. Preoptic region:

preoptic periventricular, medical and lateral preoptic nuclei:

regulated autonomic activities with the hypothalamus

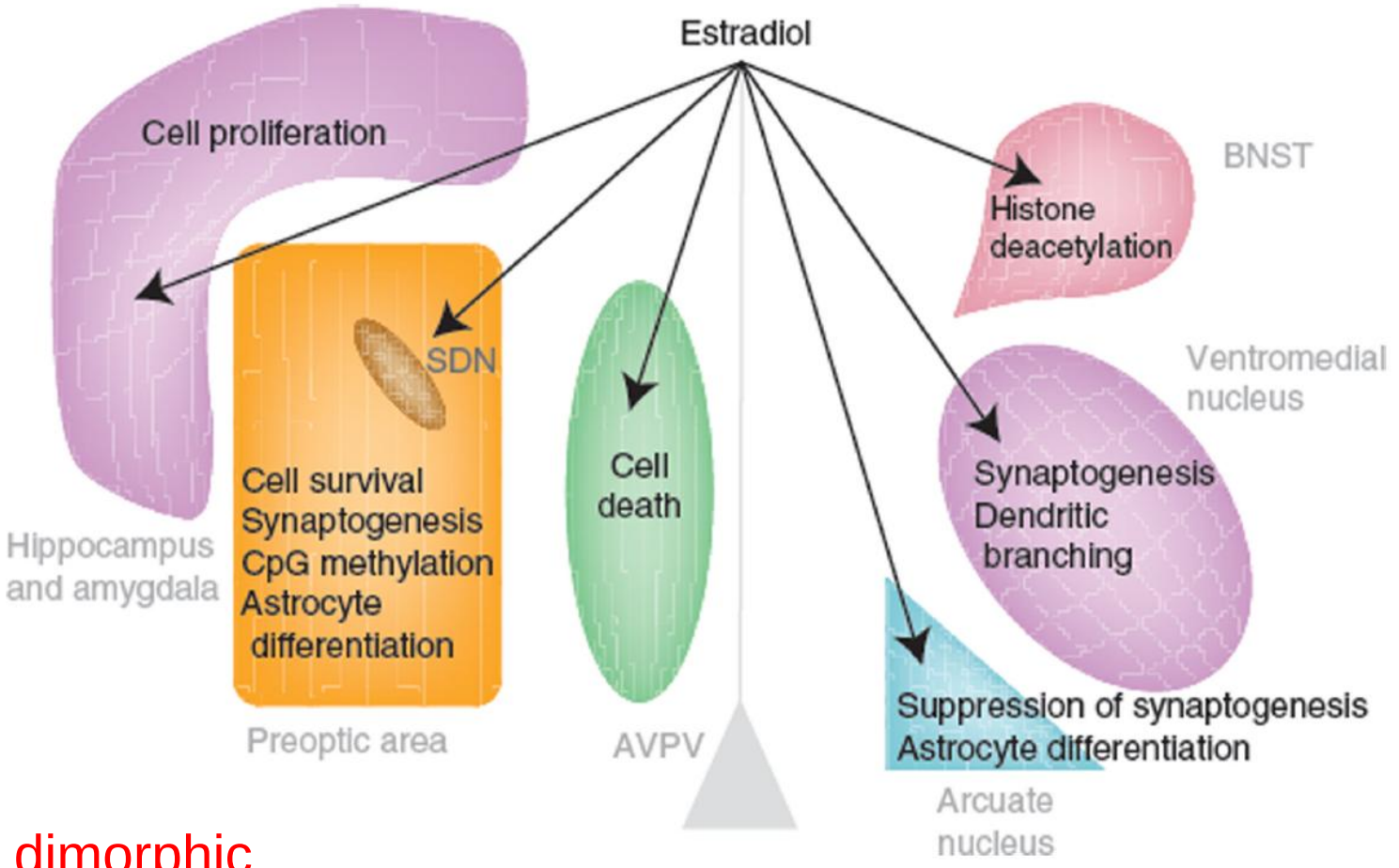
The **preoptic area** is responsible for thermoregulation and receives nervous stimulation from thermoreceptors in the skin, mucous membranes, and hypothalamus itself.



I. Preoptic region:

Nat Neurosci. 2011 June ; 14(6): 677–683. doi:10.1038/nn.2834.

Reframing sexual differentiation of the brain

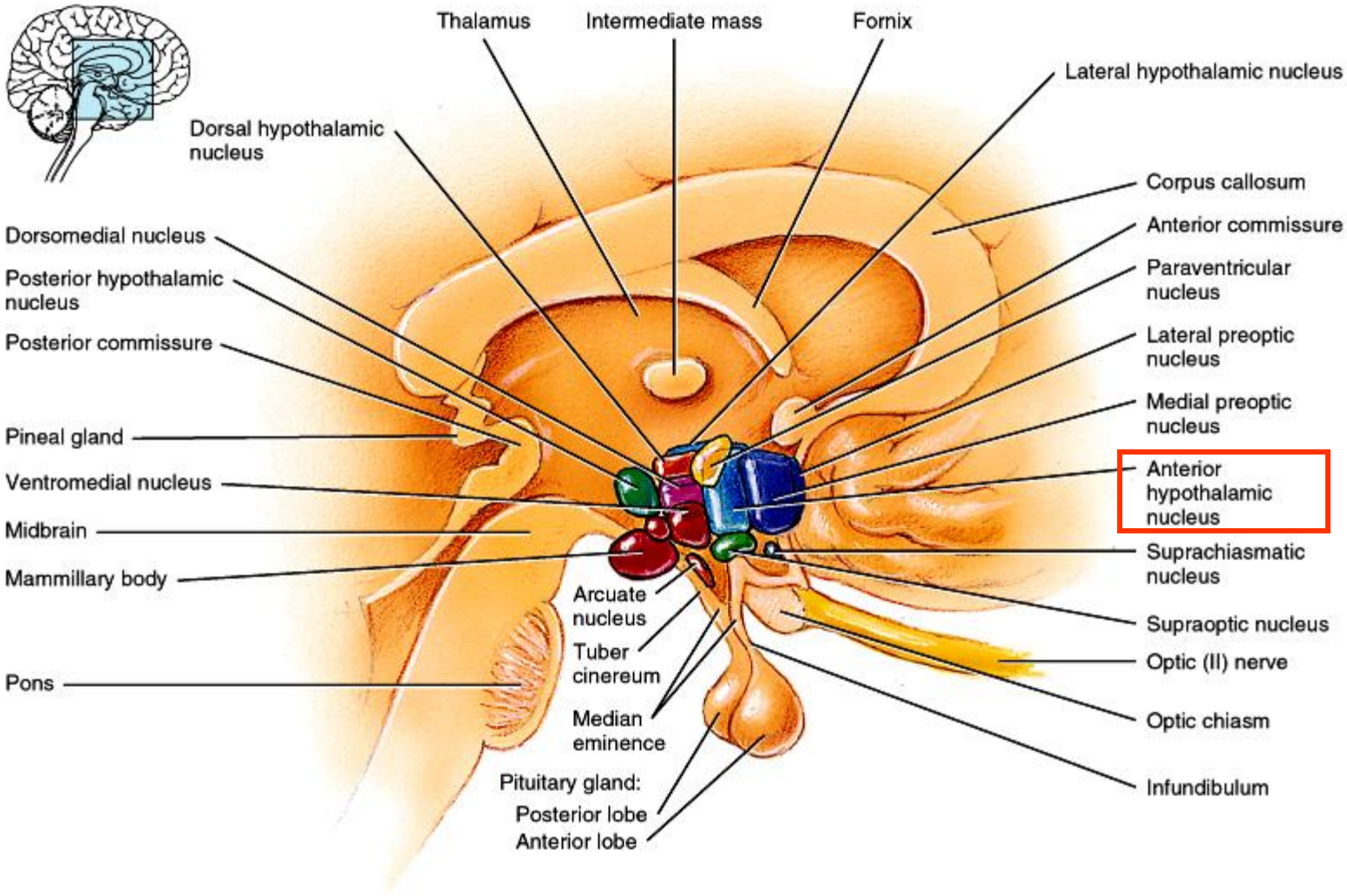


The sexually dimorphic nucleus (SDN) of the preoptic area (POA), is 3-5-fold larger in males

Figure 3.

Multiple mechanisms of estradiol-induced differentiation. In the rodent, estradiol is a masculinizing hormone, but it exerts multiple region-specific effects via distinct cellular mechanisms. Thus, during a perinatal sensitive period, the same hormone, estradiol, promotes cell survival, cell death and cell proliferation in separate brain regions. Estradiol also promotes the formation of new dendritic spine synapses in some brain regions while suppressing them in others. The enduring consequences of the organizational effects of estradiol may be mediated in part via epigenetic changes to the DNA and chromatin in processes that are region-specific, but are still poorly understood.

Anterior hypothalamic nucleus: parasympathetic function (Thermoregulation; panting; sweating; thyrotropin inhibition)



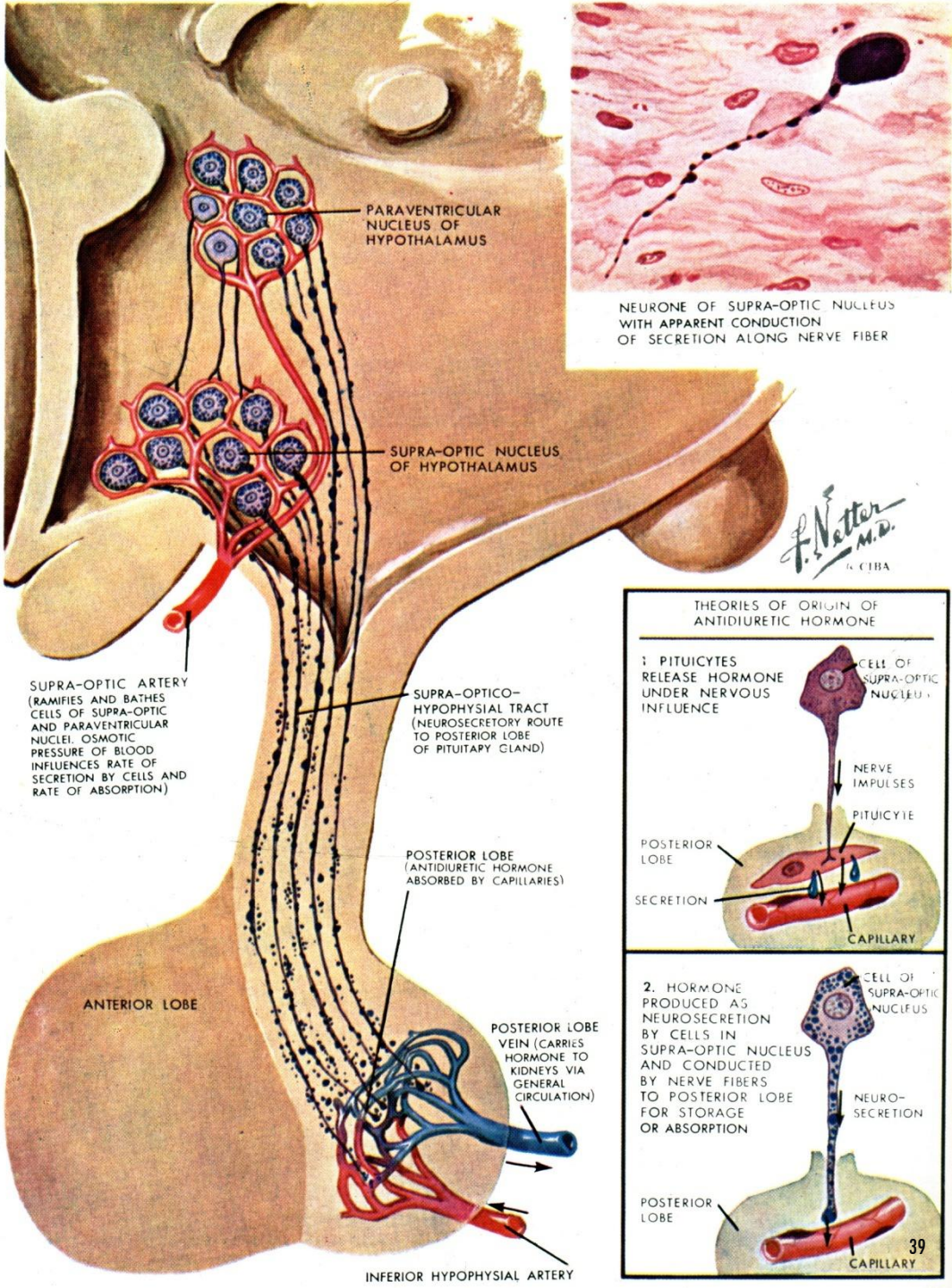
Sagittal section of brain showing hypothalamic nuclei

II. Supraoptic region:

paraventricular nucleus
→ supraopticohypophyseal tract

supraoptic nucleus→
supraopticohypophyseal tract → posterior pituitary

Neuroendocrine:
oxytocin release
vasopressin (ADH) release



III. Tuberal region:

3 parts; a ventral, a dorsal, and an intermediate

- dorsal area: scattered cells
  dorsomedial nucleus
  (GI stimulation)
  ventromedial nucleus (satiety
  neuroendocrine control)

Infundibular (arcuate) nuclei
LHRH release
FSH Releasing Factor

IV. Mammillary region:

2 parts

- posterior hypothalamic area:
  dorsal part
- mammilary nuclei: ventral part
  (relay stations in reflexes to the sense of smell).
- **posterior nuclei**
  (Increase blood pressure; pupillary dilation; Shivering)
  ***Sympathetic Function**

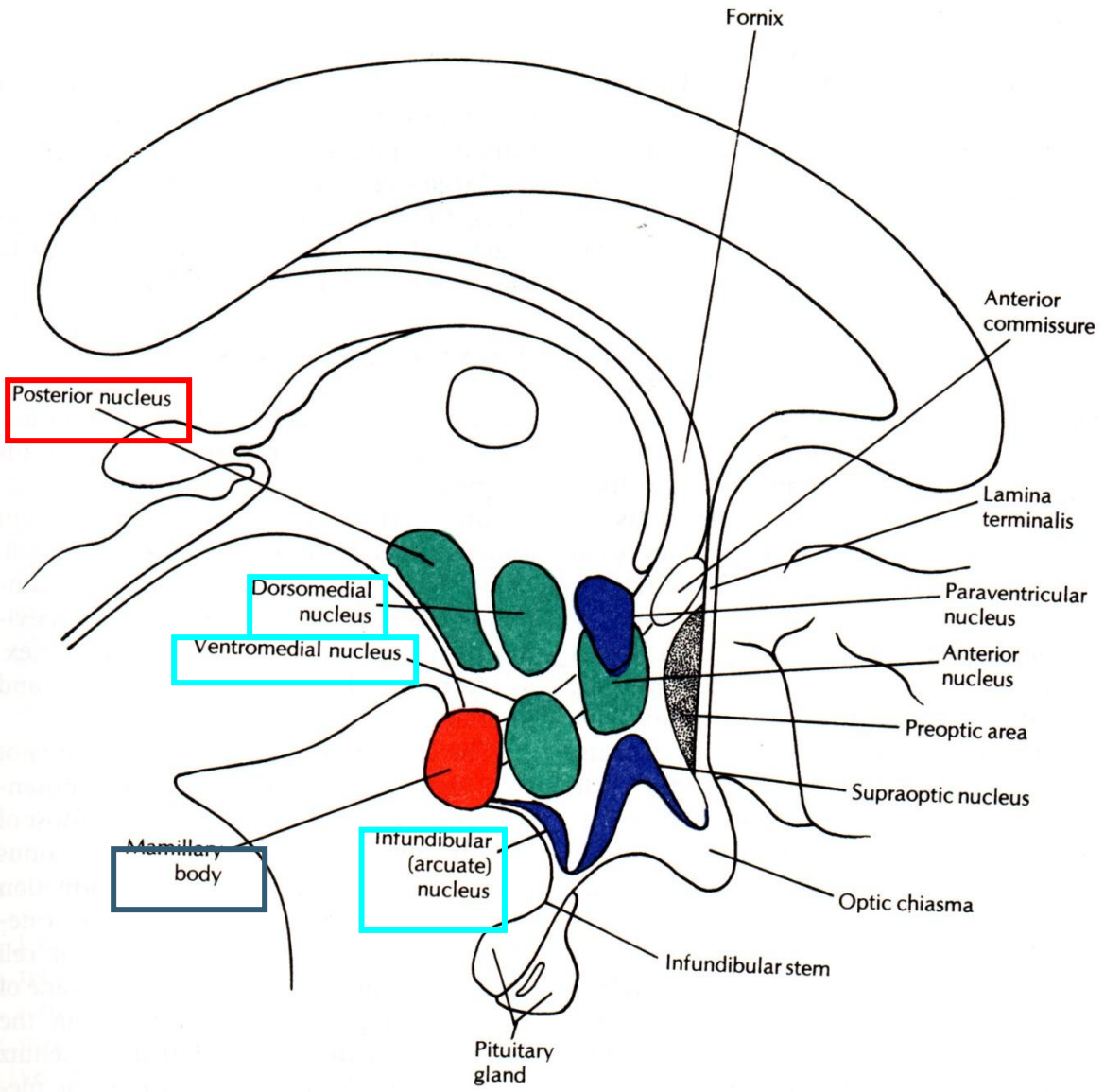
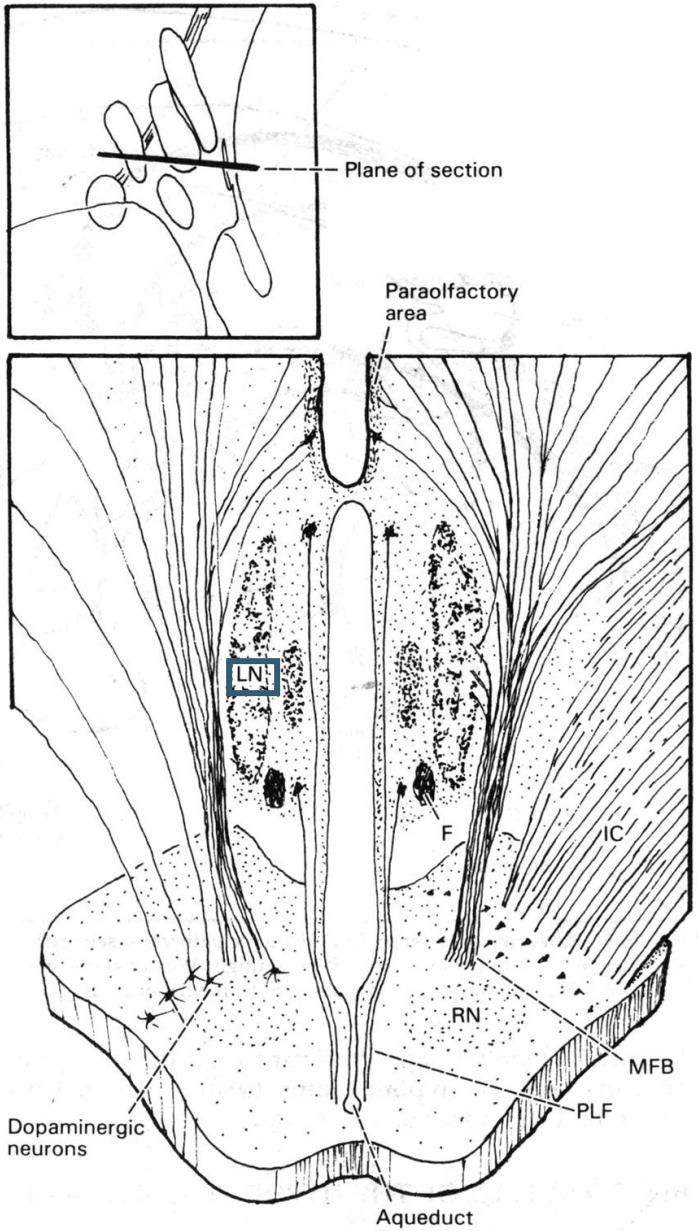


Figure 11-14. Nuclei in the medial zone of the hypothalamus.

Lateral portion: many longitudinal fibers
- lateral preoptic region: small anterior
- lateral hypothalamic area: large posterior



Hunger center 饑餓中樞
Thirst center 口渴中樞

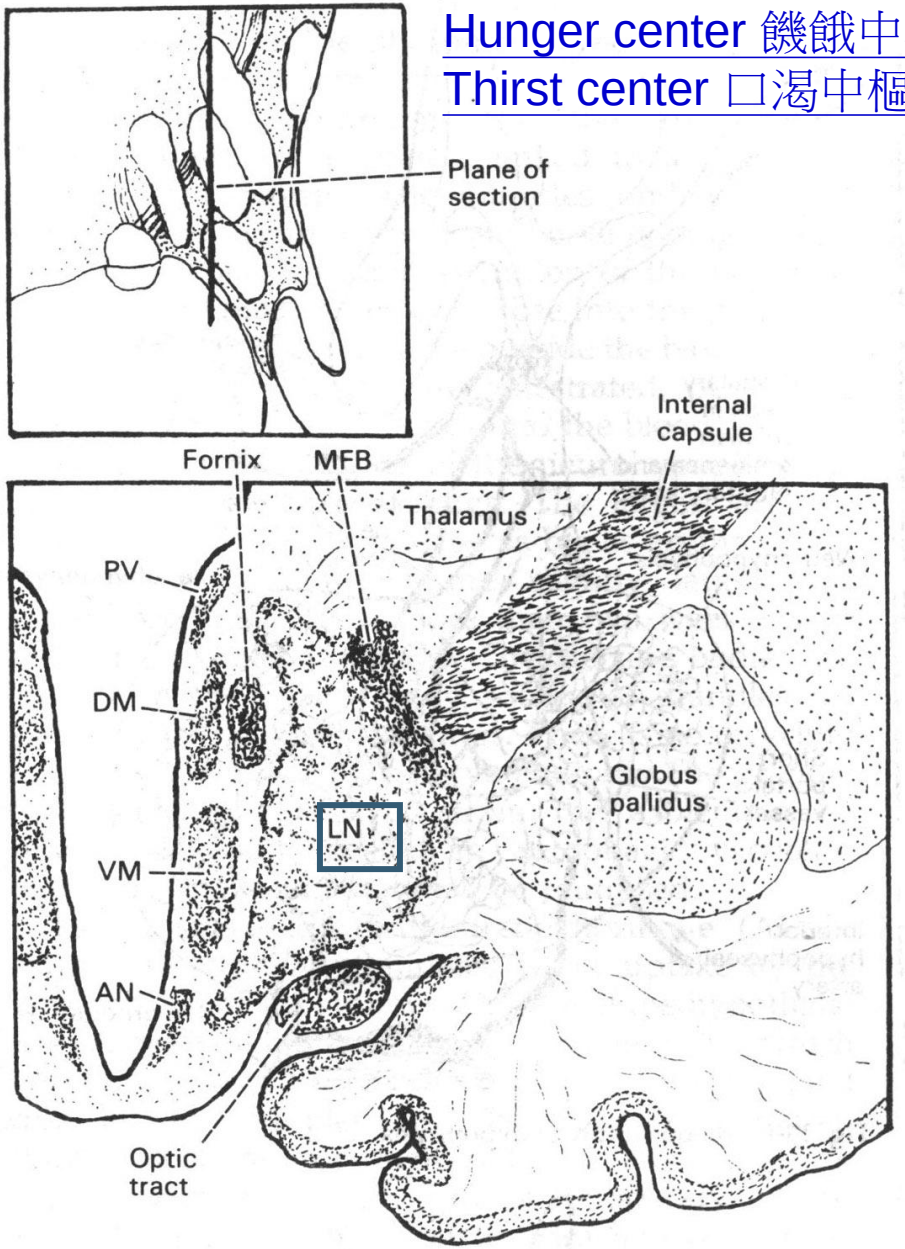


Fig. 16-3 Coronal section of hypothalamus. AN, arcuate nucleus; DM, dorsomedial nucleus; LN, lateral nucleus; MFB, medial forebrain bundle; PV, paraventricular nucleus; VM, ventromedial nucleus.

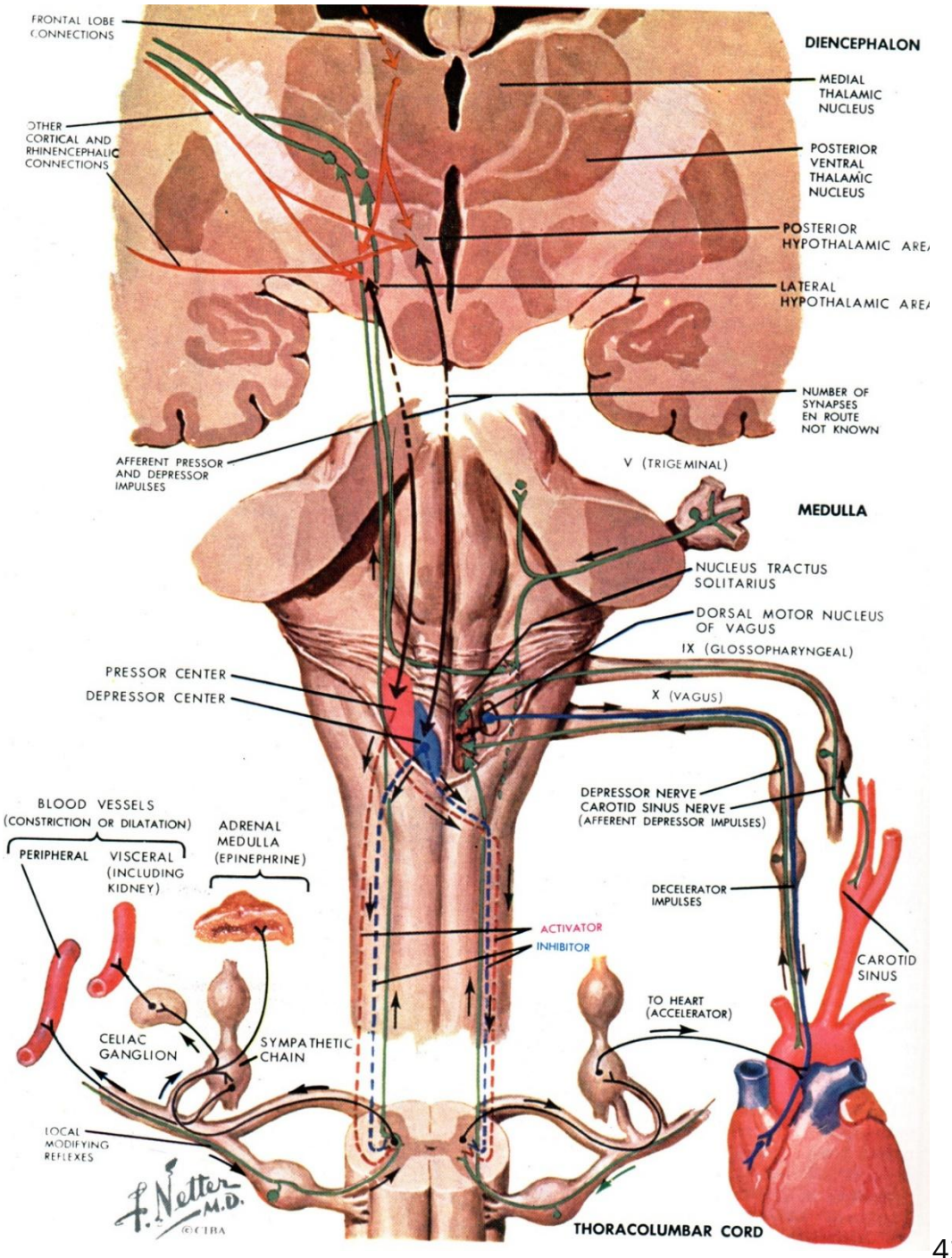
Functions of hypothalamus:

1. controls and integrates activities of the autonomic system

Anterior hypothalamic area (parasympathetic)

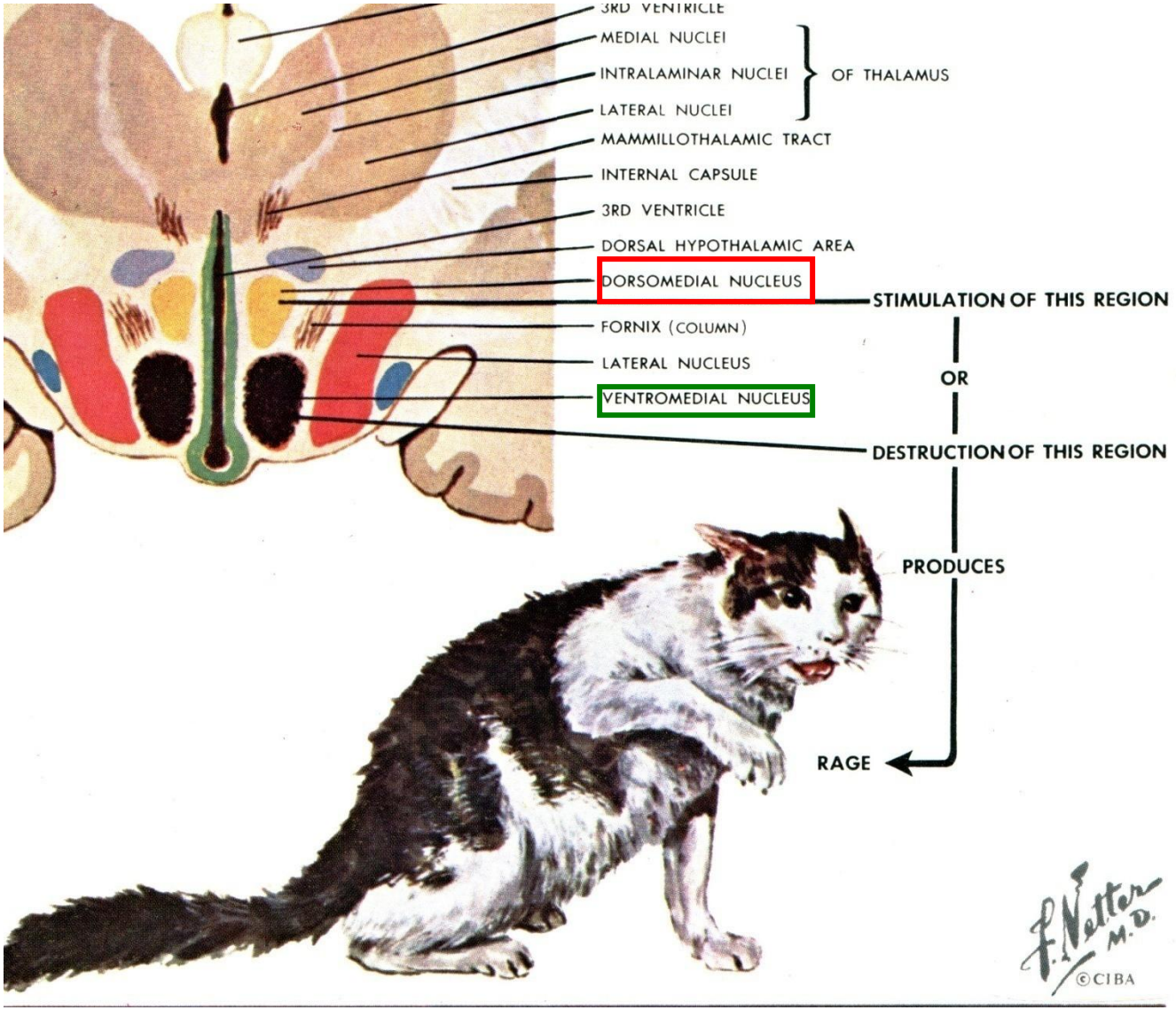
Posterior hypothalamic area (sympathetic)

Lateral hypothalamic area (thirst and hunger)



2. associated with feelings of rages and aggression.

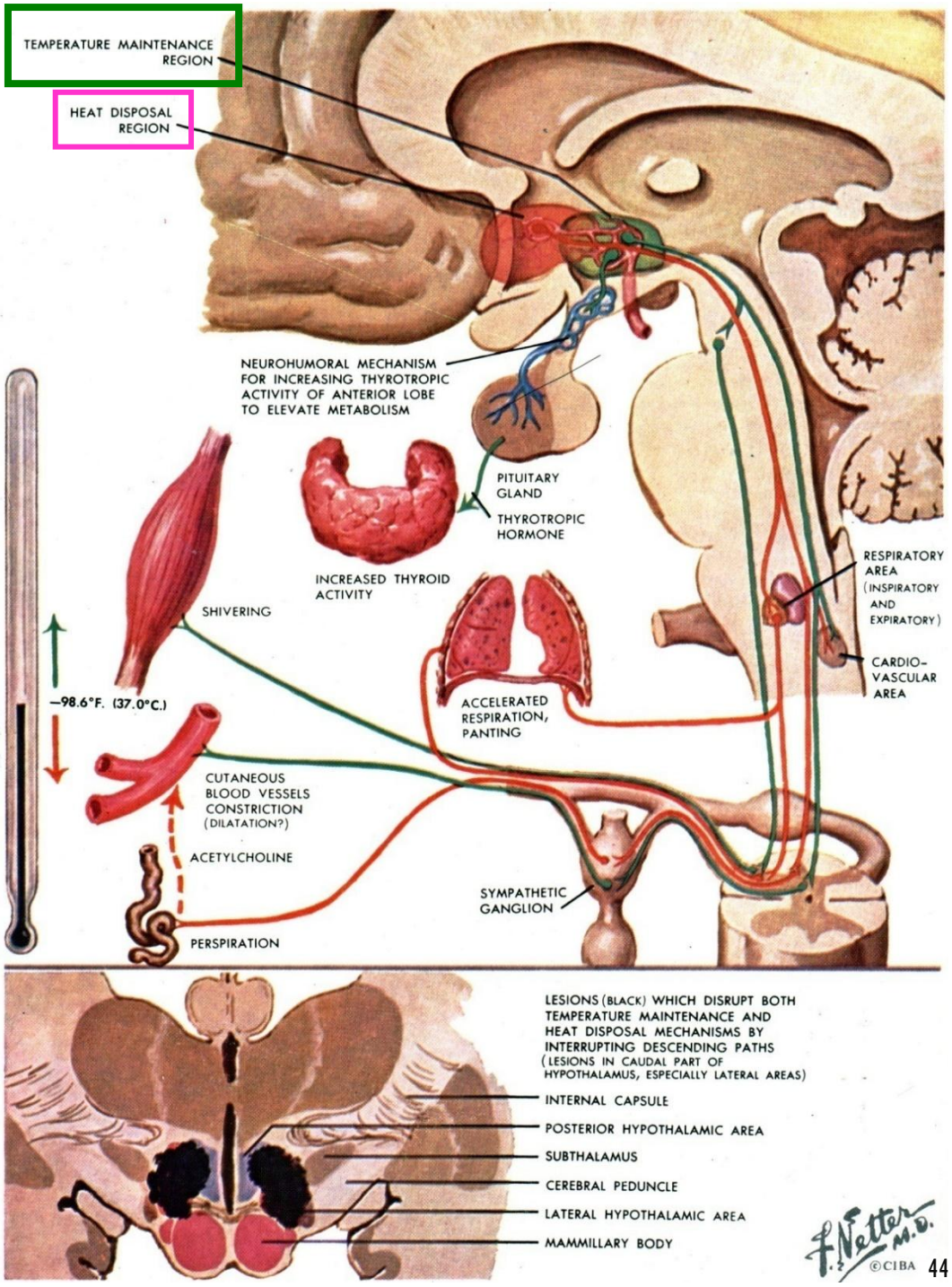
Dorsomedial nucleus (兇) vs. Ventromedial nucleus (善)



3. regulates the body temperature

Heat disposal region:
Anterior hypothalamic area
(parasympathetic)

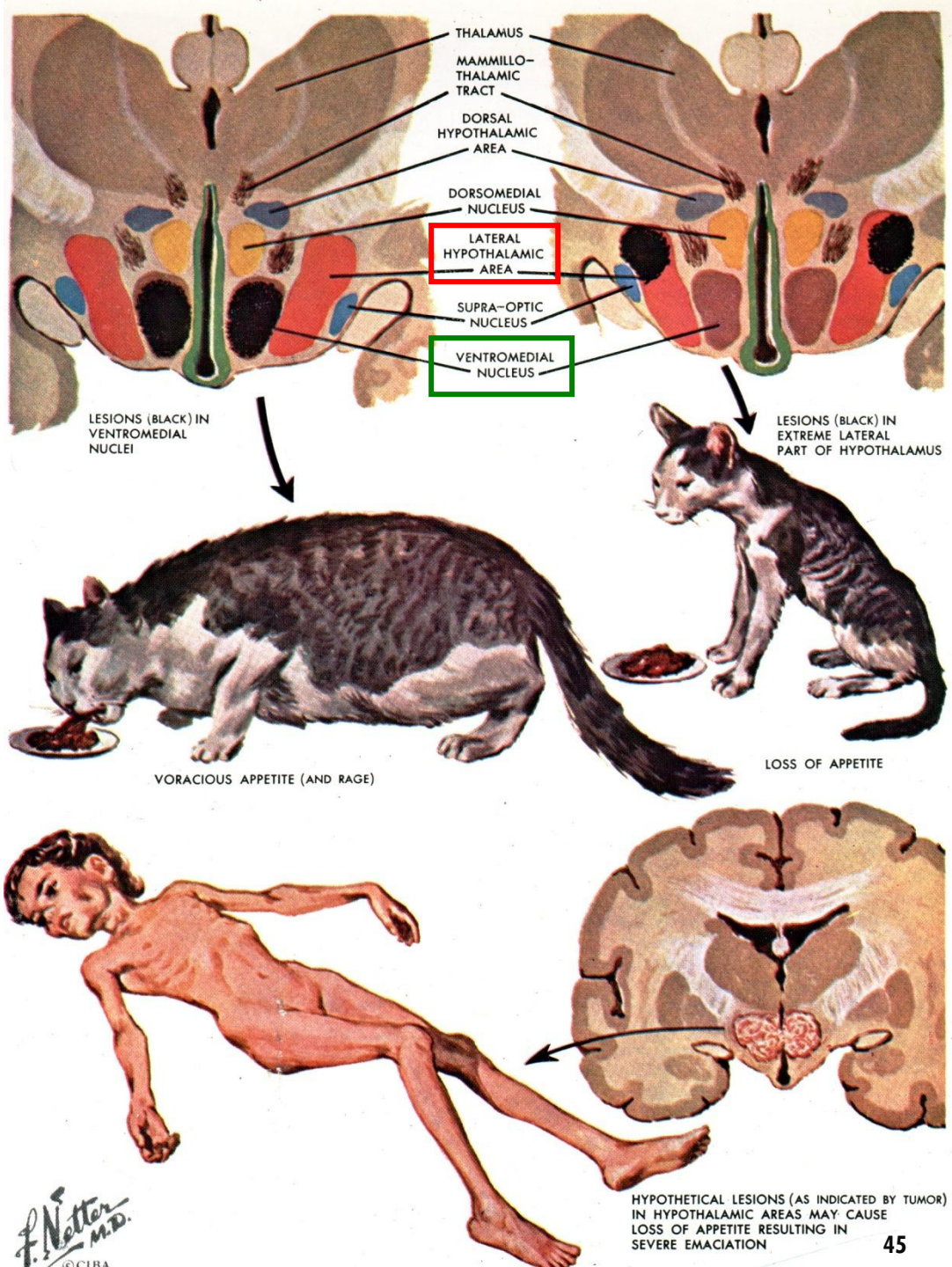
Temperature maintenance region:
Posterior hypothalamic area
(sympathetic)



4. regulate food intake: feeding (hunger) center & satiety center

feeding (hunger) center 饑餓中樞:
Lateral hypothalamic area

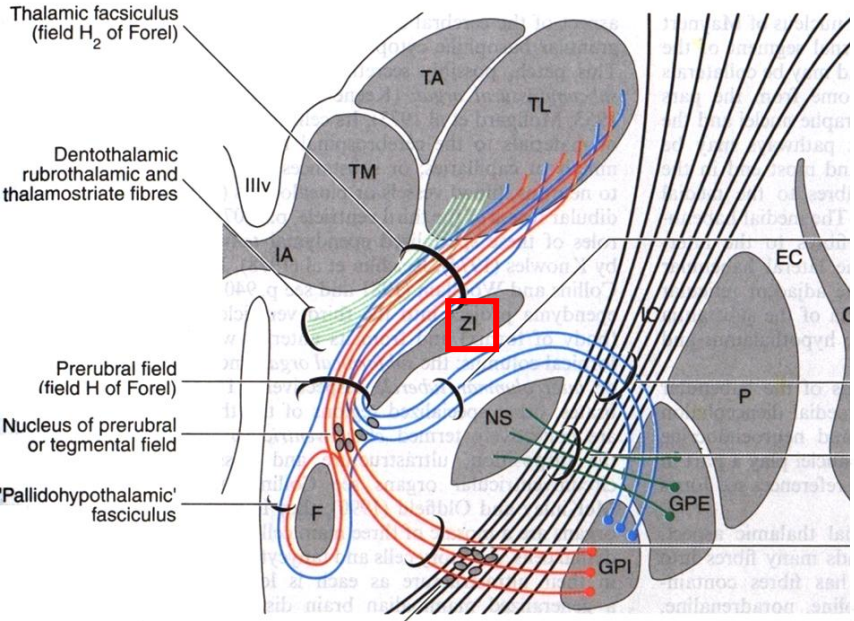
satiety center (飽足中樞):
Ventromedial nucleus (VM) (善)

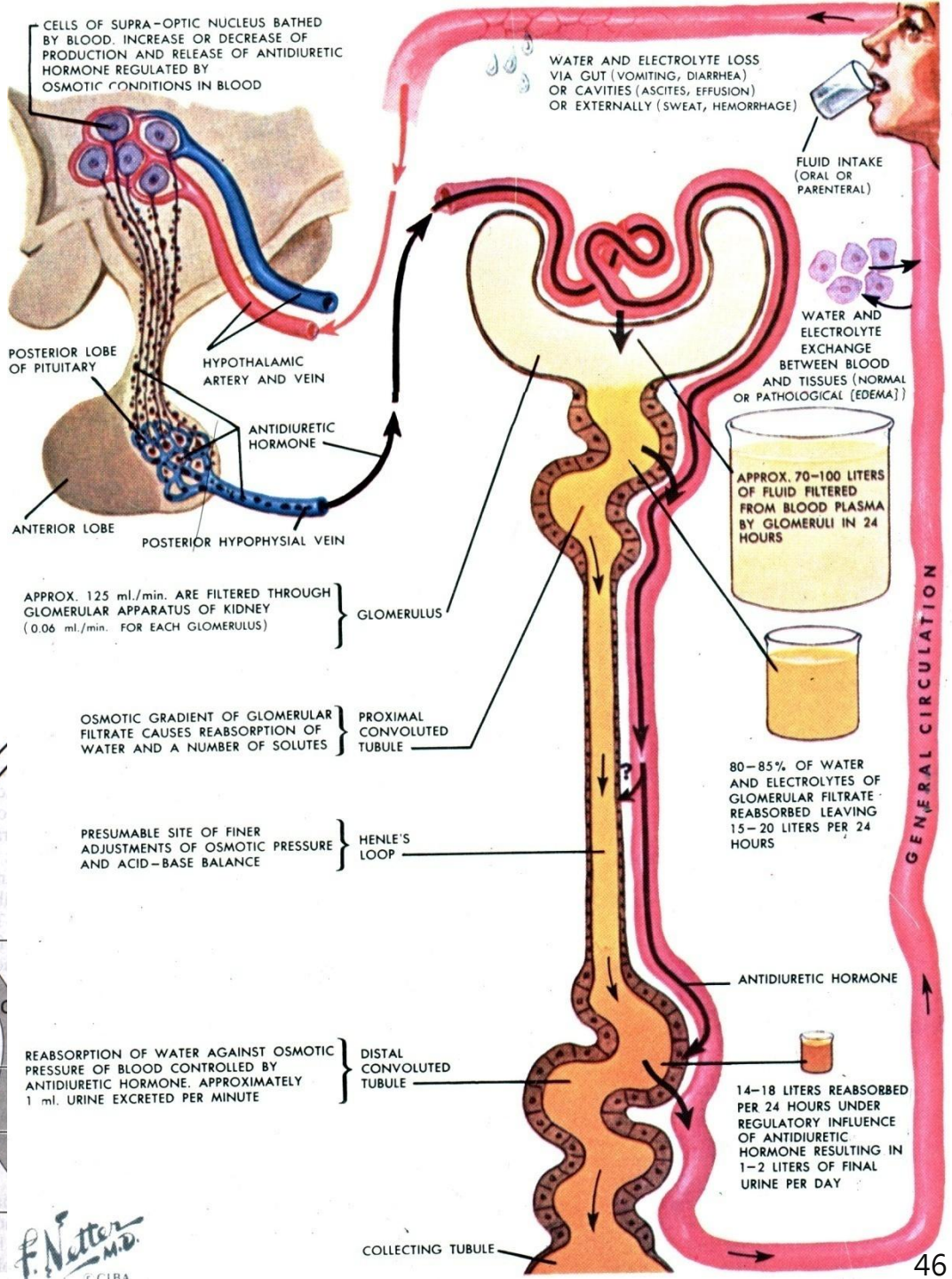


5. thirst center 口渴中樞: regulate osmotic pressure of extracellular fluid

paraventricular nucleus
supraoptic nucleus→
posterior pituitary (ADH)

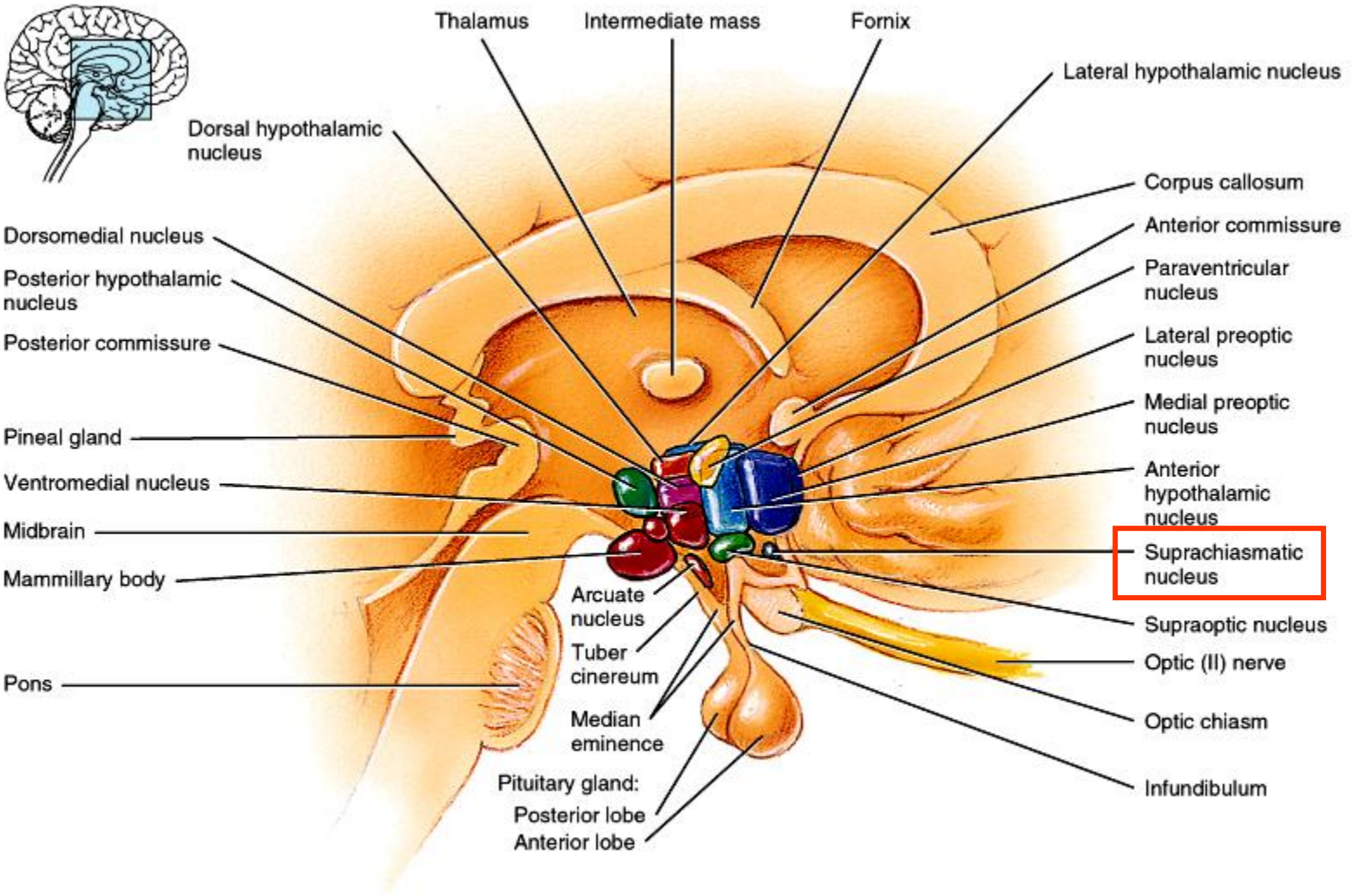
Note:
Zona incerta: regulation of drinking behavior





6. biological clock, maintains the waking state and sleep patterns

Suprachiasmatic nucleus



Sagittal section of brain showing hypothalamic nuclei

7. Endocrine functions:

tuber cinereum and infundibulum →pituitary gland

Median eminence正中隆起: ***Master of endocrine system**

hypothalamic regulating hormones→anterior pituitary

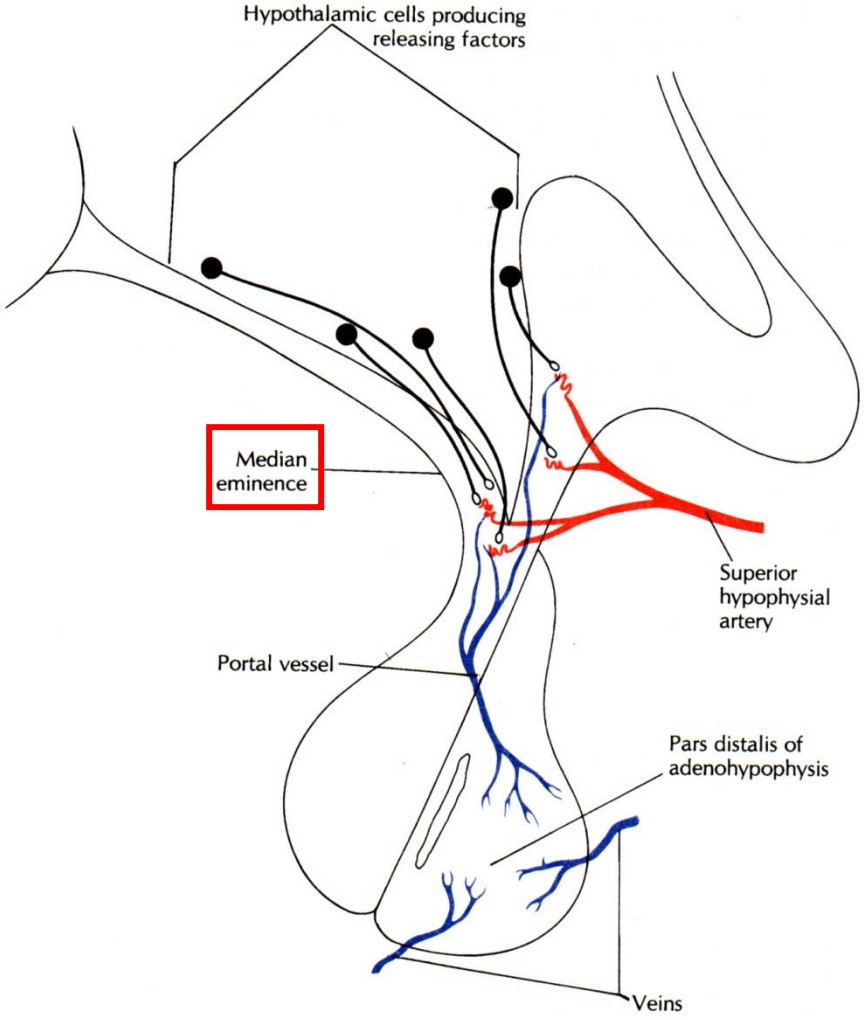


Figure 11-17. The pituitary portal system. Arteries are *red;* veins are *blue;* neurons that secrete releasing hormones are *black.*

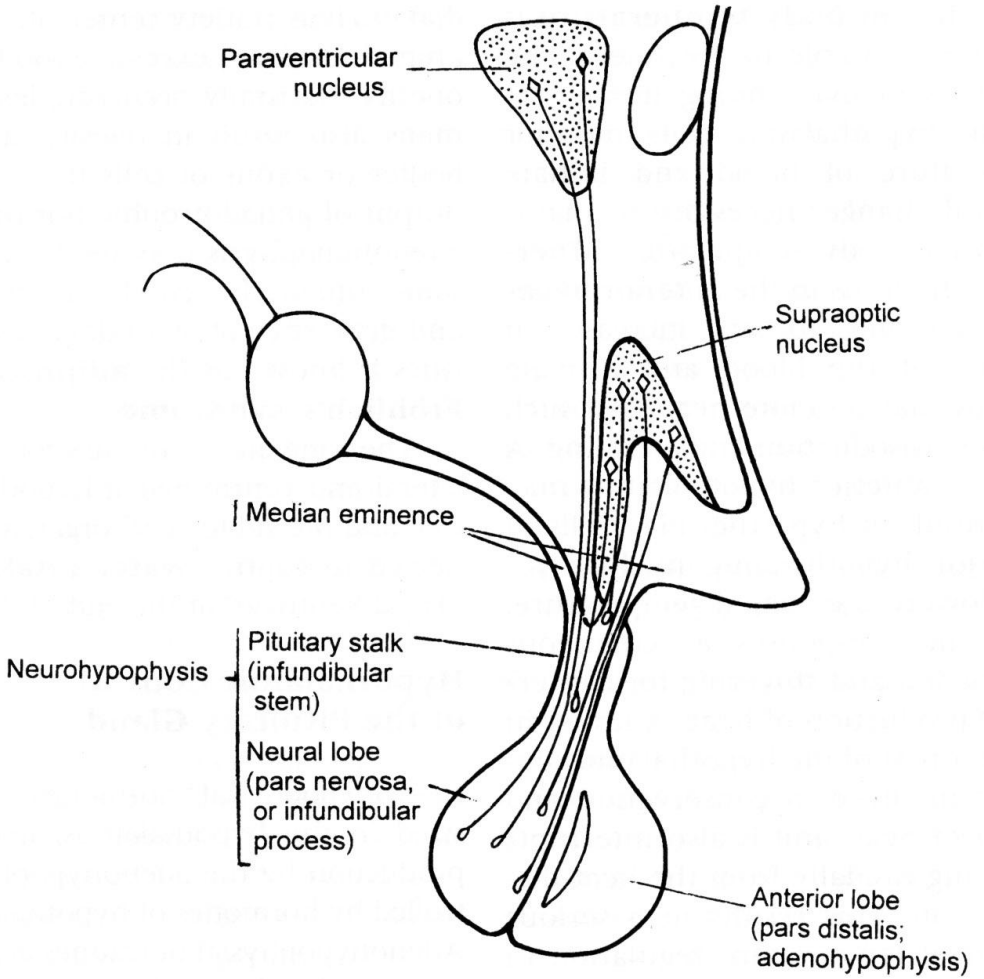


Figure 11-16. Hypothalamo-hypophysial tract and the parts of the neurohypophysis.

Hypothalamus: Autonomic, Neuroendocrine, Physiological responses

1. The hypothalamus is responsive to: Light: daylength and photoperiod for regulating circadian and seasonal rhythms (Biological clock: Suprachiasmatic nucleus)

2. Olfactory stimuli, including pheromones (Mammillary bodies, Habenular nuclei)

3. Autonomic nervous inputs (anterior and posterior hypothalamus): information arising in particular from the heart, the stomach, and the reproductive tract

4. Endocrine function: Blood-borne stimuli, including leptin, insulin, pituitary hormones, cytokines, plasma concentrations of glucose and osmolarity, etc.

Stress:

Invading microorganisms by increasing body temperature, resetting the body's thermostat upward.

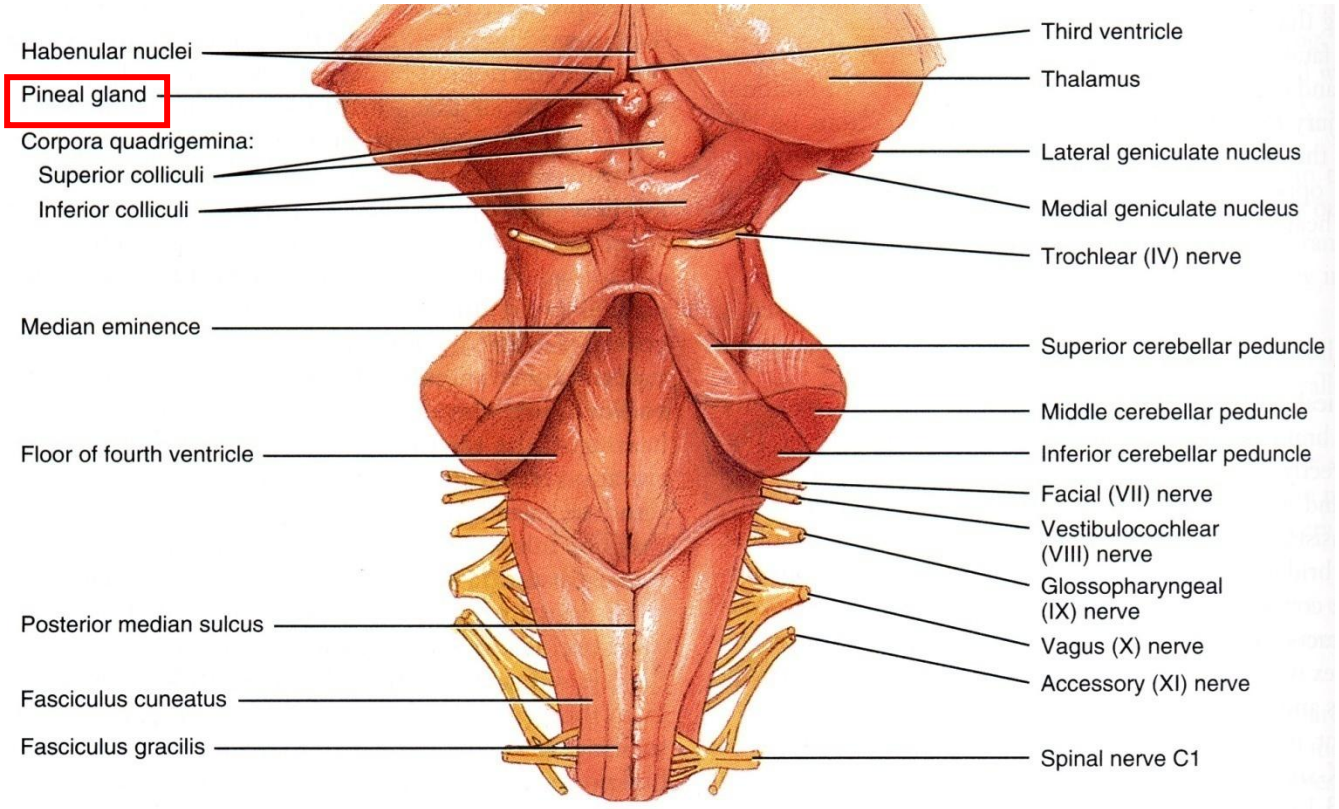
Summary of Hypothalamus

- Controls and integrates activities of the ANS which regulates smooth, cardiac muscle and glands
- Synthesizes regulatory hormones that control the anterior pituitary
- Contains cell bodies of axons that end in posterior pituitary where they secrete hormones
- Regulates rage, aggression, pain, pleasure & arousal
- Feeding, thirst & satiety centers
- Controls body temperature
- Regulates daily patterns of sleep

Epithalamus 上丘腦: The Old part of Diencephalon

A. Pineal body (epiphysis): No Neurons

1. Glia cells (astrocytes)
2. Parenchymal cells (pinealocytes)
3. Nerve fibers: serving primarily as the terminals of postganglionic sympathetic neurons from the Superior Cervical Ganglion (SCG)
4. Calcareous accumulations (brain sands)
5. Function: secretes melatonin (more in the darkness, promoting sleepiness)



Pineal gland (pineal body)

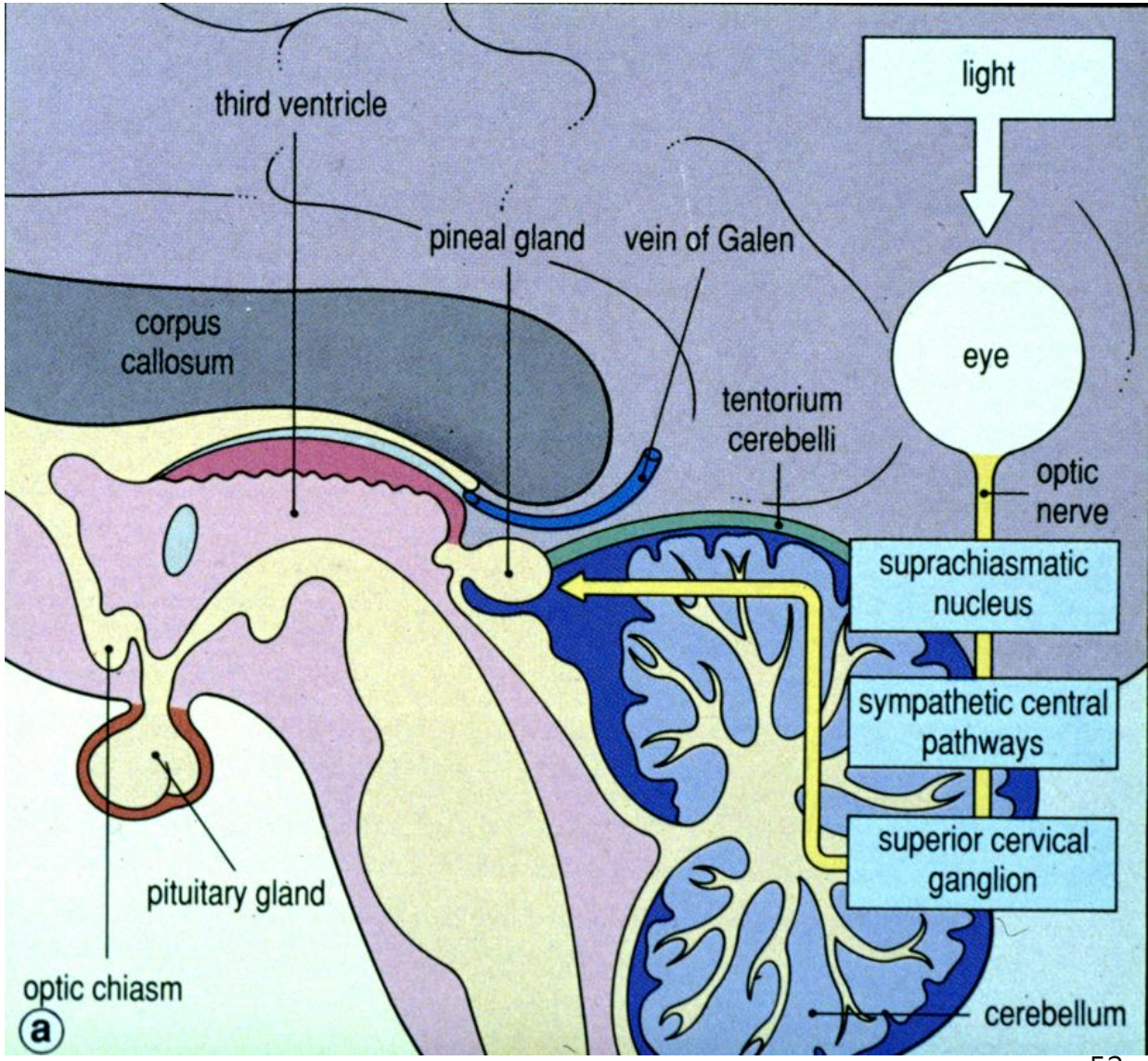
Biological clock？ → hypothalamus (suprachiasmatic nucleus)

Neuroendocrine transducer:

to convert a neuronal signal (such as light and dark) to a endocrine signal (shifting concentrations of hormone secretion)

Melatonin 松果腺素(退黑激素):
a derivative of **serotonin**; steady secretion of **melatonin** at night; inhibition of melatonin secretion by light

Circadian rhythm日周期節律

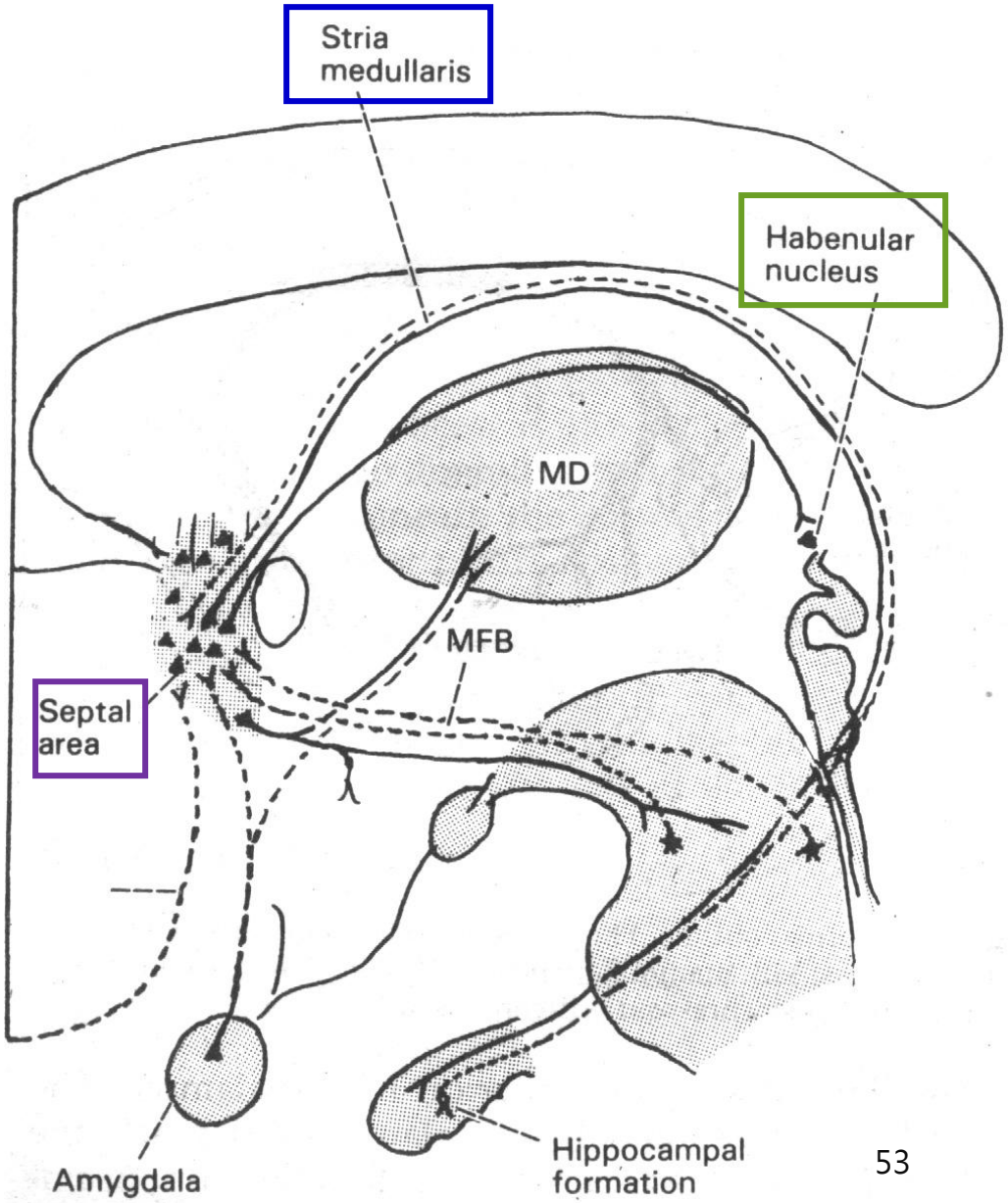


B. Habenular nuclei 韁核**:** in the dorsal margin of the base of the pineal body
olfaction (smell), especially emotional responses to smells

1. Habenulointerpeduncular tract:
conveys limbic output from the habenula to the midbrain reticular formation
- afferents from the septal area,
- efferents to the midbrain reticular formation

2. Stria medullaris:
a. form a small ridge on the dorsomedial margin thalamus
b. a route through which septal efferents reach the habenula

Extra-Functions of **Habenular nuclei** :
including pain processing, reproductive behavior, nutrition, sleep-wake cycles, stress responses, and learning.



C. Habenular commissure:
consists of stria medullaris fibers crossing over to the contralateral habenular nuclei
D. Posterior commissure: ventral to the base of the pineal body
1. Carries decussating fibers of the **superior colliculi** and pretectum (visual reflex)
2. Crossing fibers dealing with vertical eye movements and pupillary light reflex

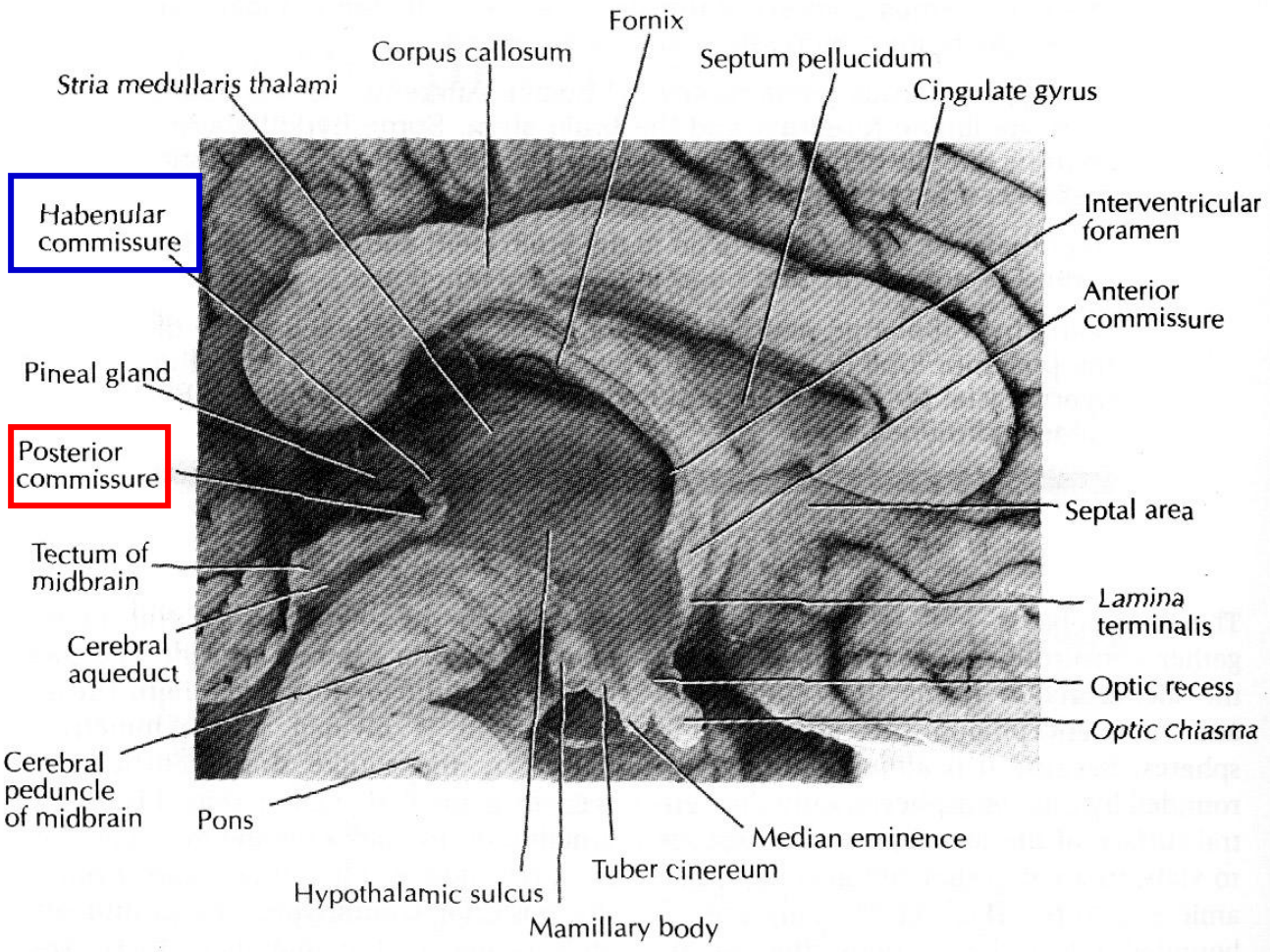


Figure 11-2. Central region of the brain in median section. (×1.25)

Summary of Diencephalon

Thalamus:
LGB: visual; MGB: auditory
VPM: somatosensory of head; VPL: Somatosensory of body
VL: cerebellar input, Motor; VA: Motor
Pulvinar (P): visual associated; Lateral nucleus (L): Limbic
Dorsomedial (DM): Emotional response, memory
Anterior nucleus (A): memory and behavioral functions
Intralaminar nuclei (CM, PF): Arousal, awareness & emotional responses

Subthalamus: control skeletal muscle movements and muscle tone
Zona incerta: Drinking behavior

Hypothalamus*: Autonomic, Neuroendocrine, Physiological responses

Epithalamus:
Pineal body: neuroendocrine, melatonin secretion
Habenular nuclei: emotional responses to smells