

Nervous System (II)

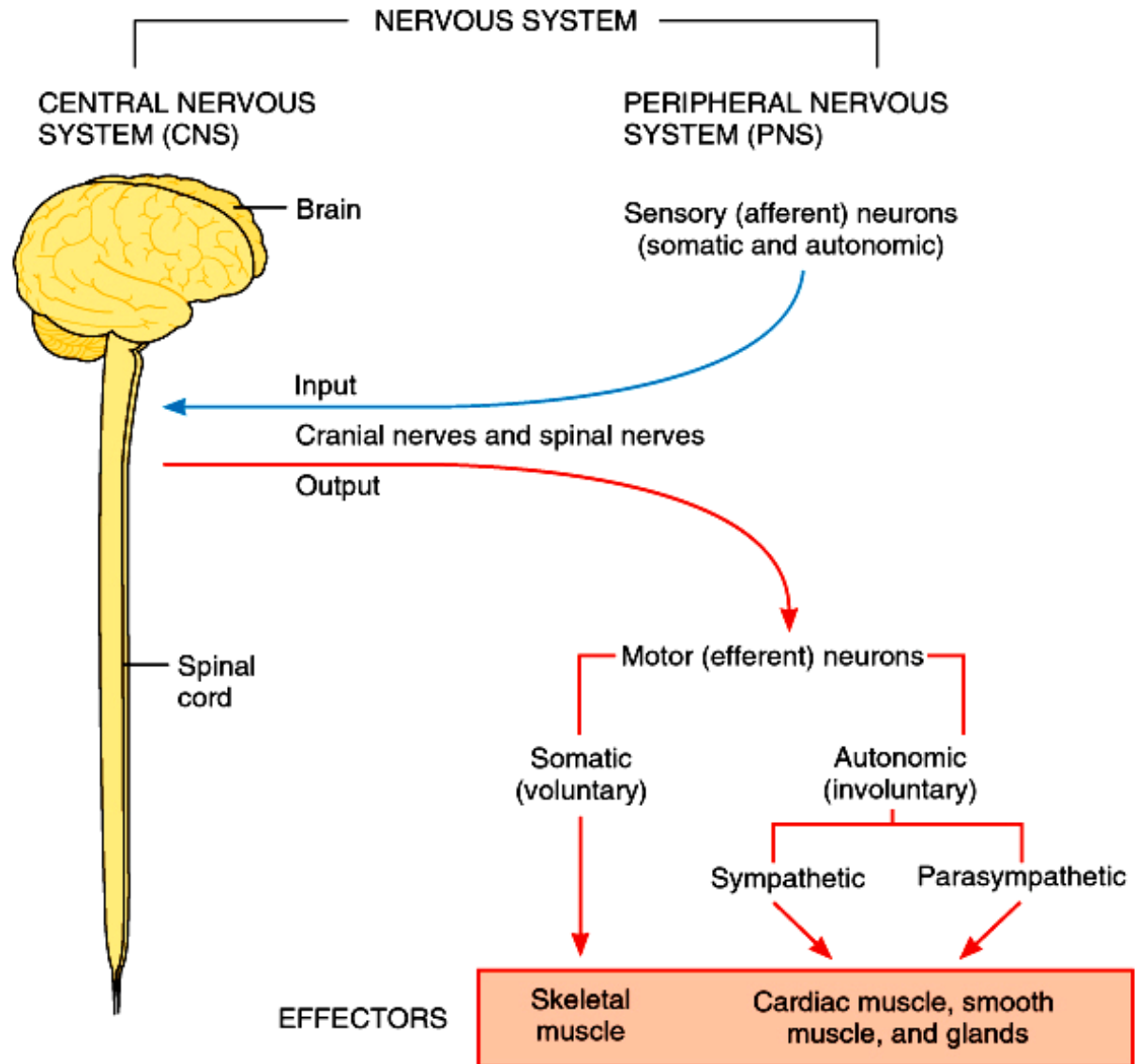
Chien, 2025

- 中樞神經系統

The Brain

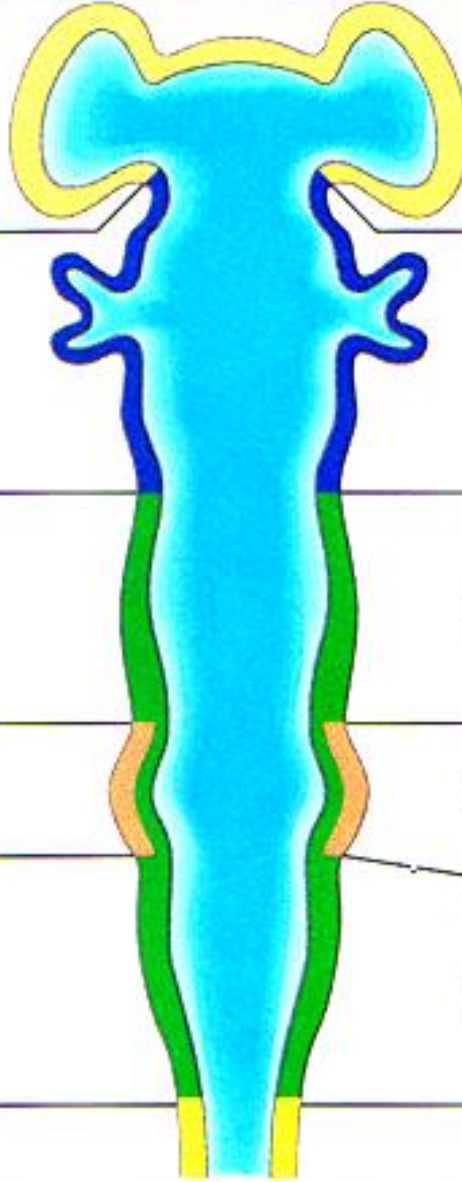
- 自主神經系統

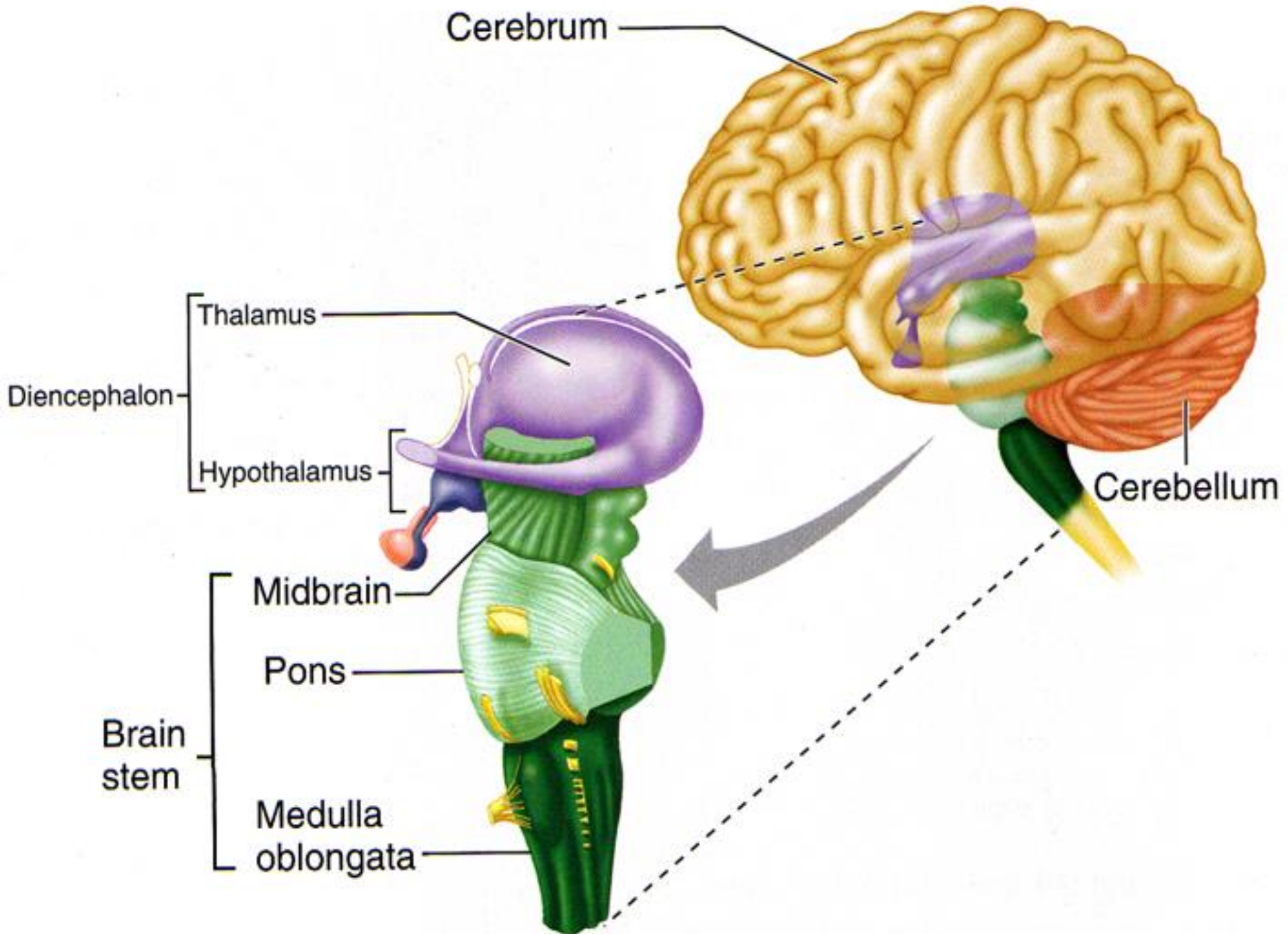
- Autonomic Nervous System (Next week)



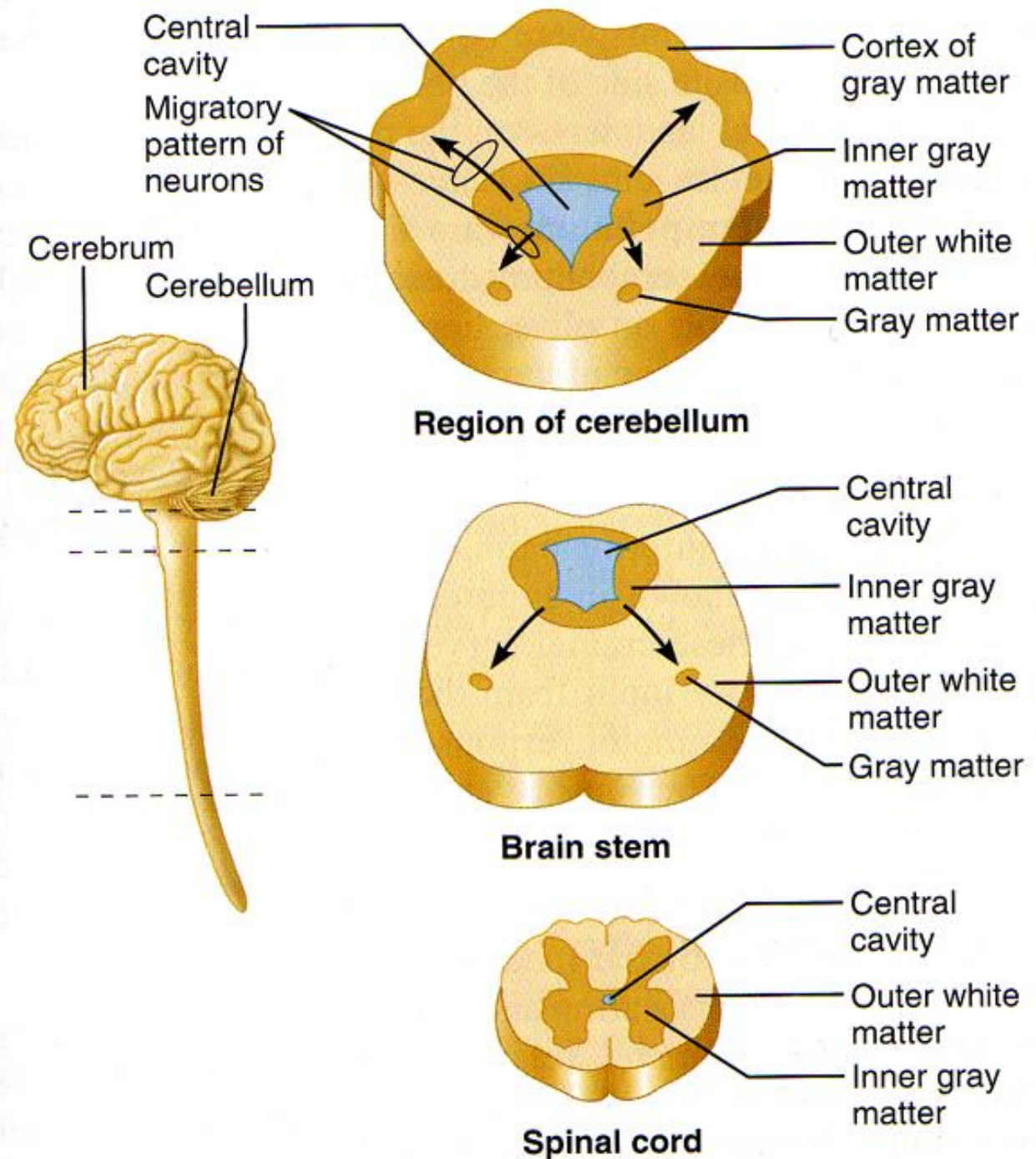
The Brain

- Principal parts of the brain
- Protective coverings of the brain
- Cerebrospinal fluid 腦脊髓液
- Brain stem & Cerebellum 腦幹及小腦
- Diencephalon 間腦
- Cerebrum 大腦
- Cranial Nerves (Next week)

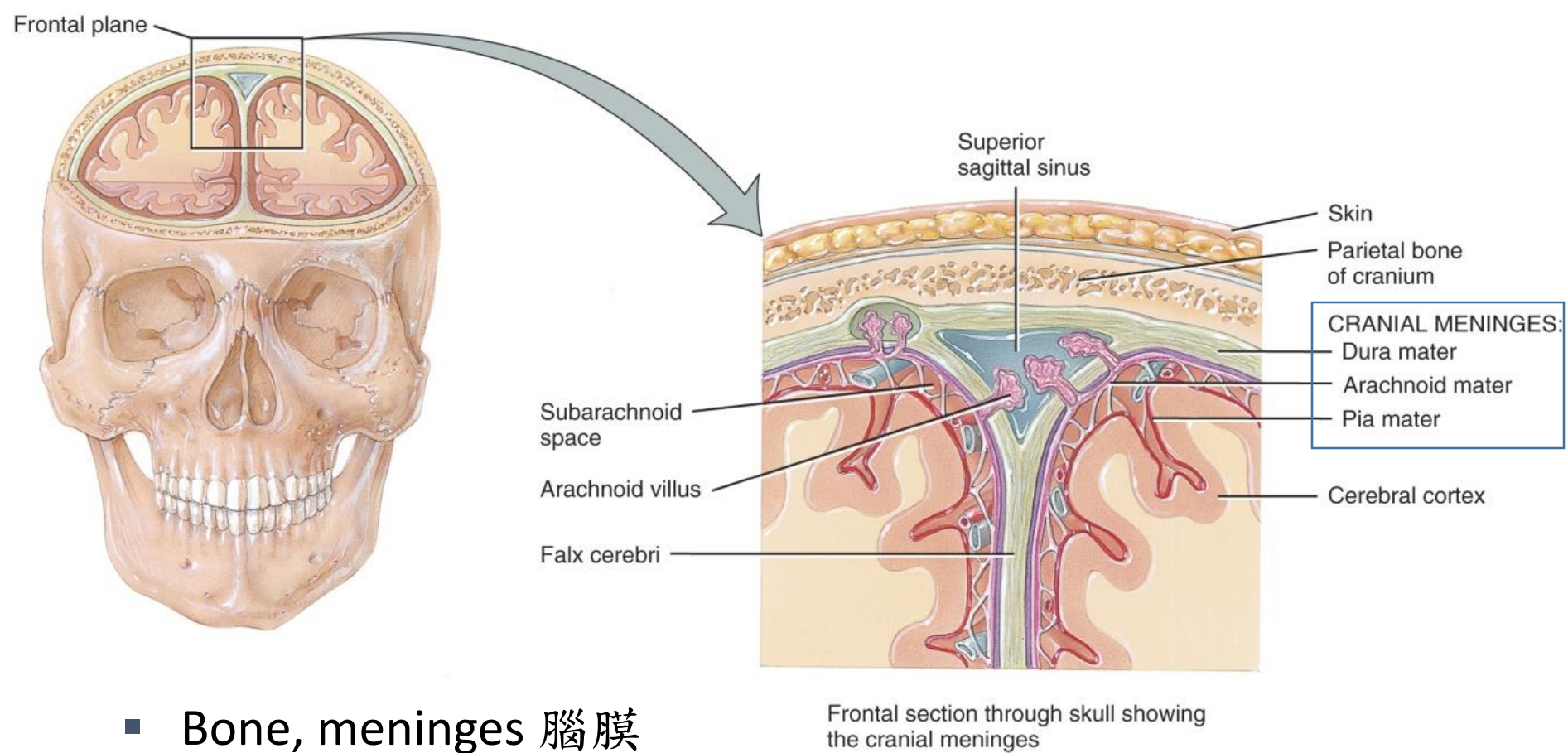
(c) Secondary brain vesicles	(d) Adult brain structures	(e) Adult neural canal regions
 Telencephalon	Cerebrum: Cerebral hemispheres (cortex, basal ganglia)	Lateral ventricles
Diencephalon	Diencephalon (thalamus, hypothalamus)	Third ventricle
Mesencephalon	Brain stem: midbrain	Cerebral aqueduct
Metencephalon	Brain stem: pons	Fourth ventricle
Myelencephalon	Cerebellum	
	Brain stem: medulla oblongata	Central canal
	Spinal cord	



Gray matter and white matter of the CNS



Protective coverings of the brain



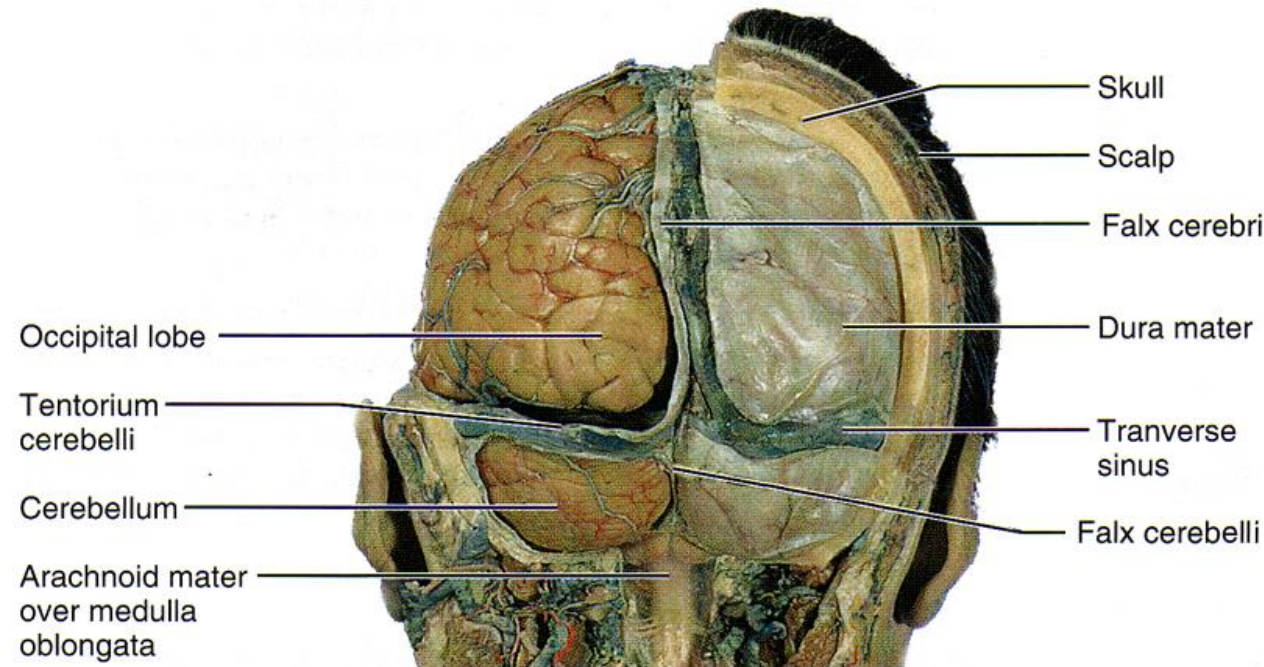
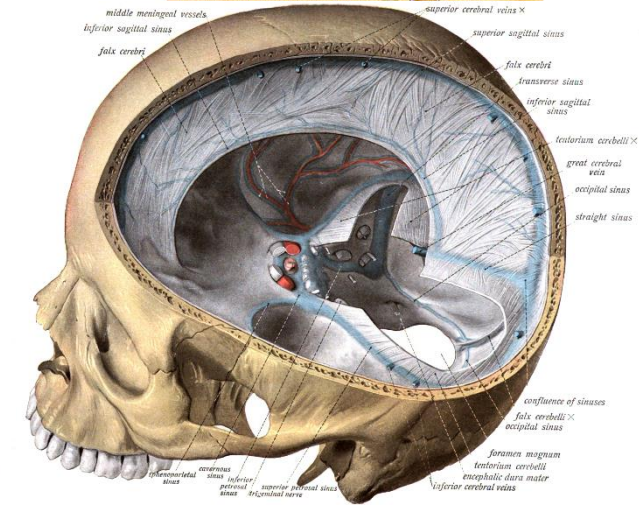
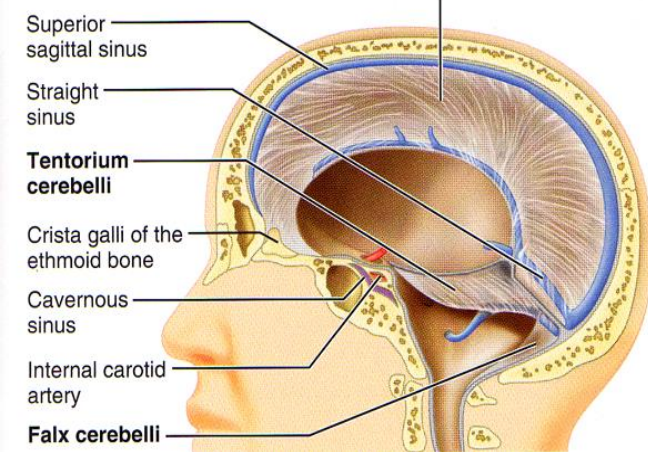
- Bone, meninges 腦膜
- Meninges same as around the spinal cord
- Dura mater extensions

Dura mater extensions

falx cerebri 大腦鐮

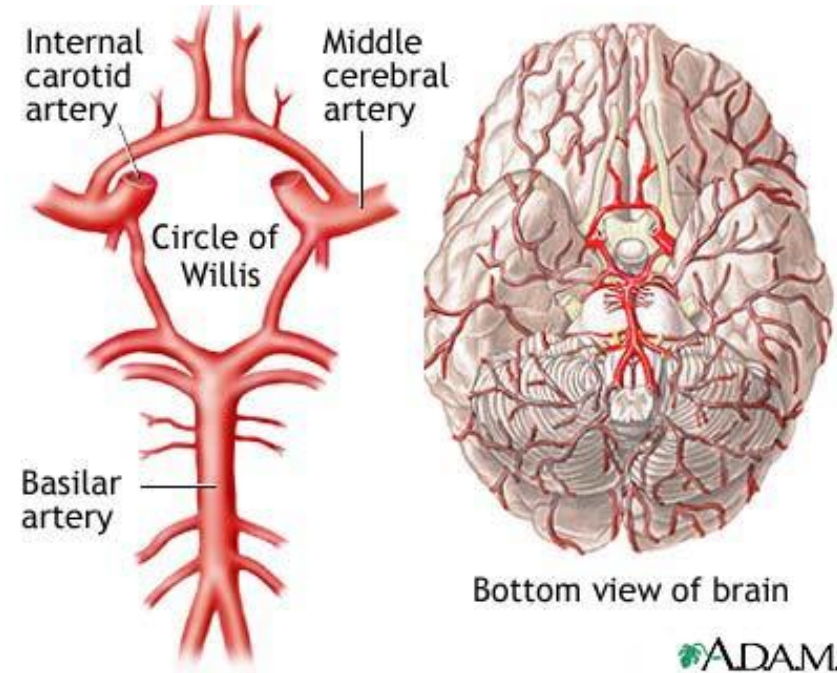
tentorium cerebelli 小腦天幕

falx cerebelli 小腦鐮



Blood Supply to Brain

- Arterial blood supply is branches from circle of Willis on base of brain
- Vessels on surface of brain --
--penetrate tissue

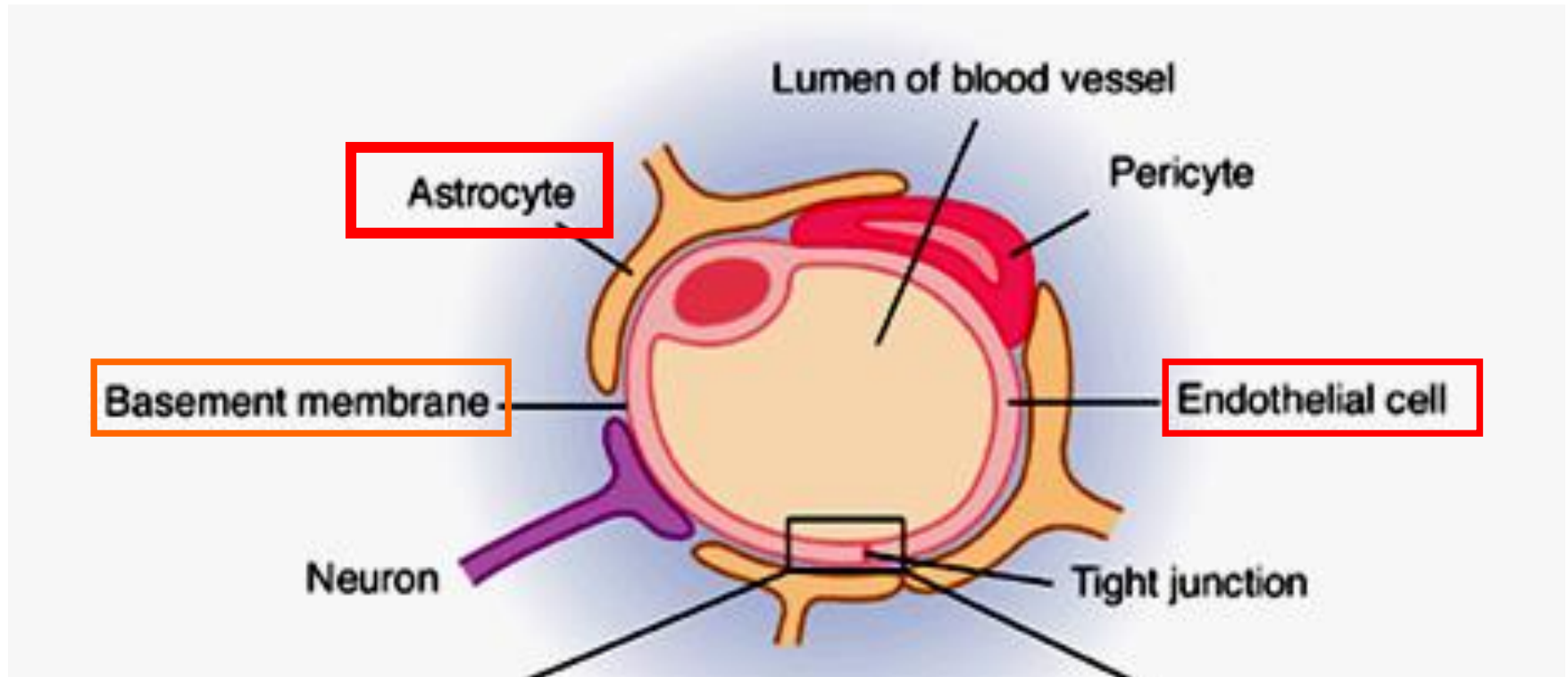


- Uses 20% of our bodies oxygen & glucose needs
 - blood flow to an area increases with activity in that area
 - deprivation of O₂ for 4 min does permanent injury

Blood-Brain Barrier (BBB) 血管腦障壁

protects cells from some toxins and pathogens

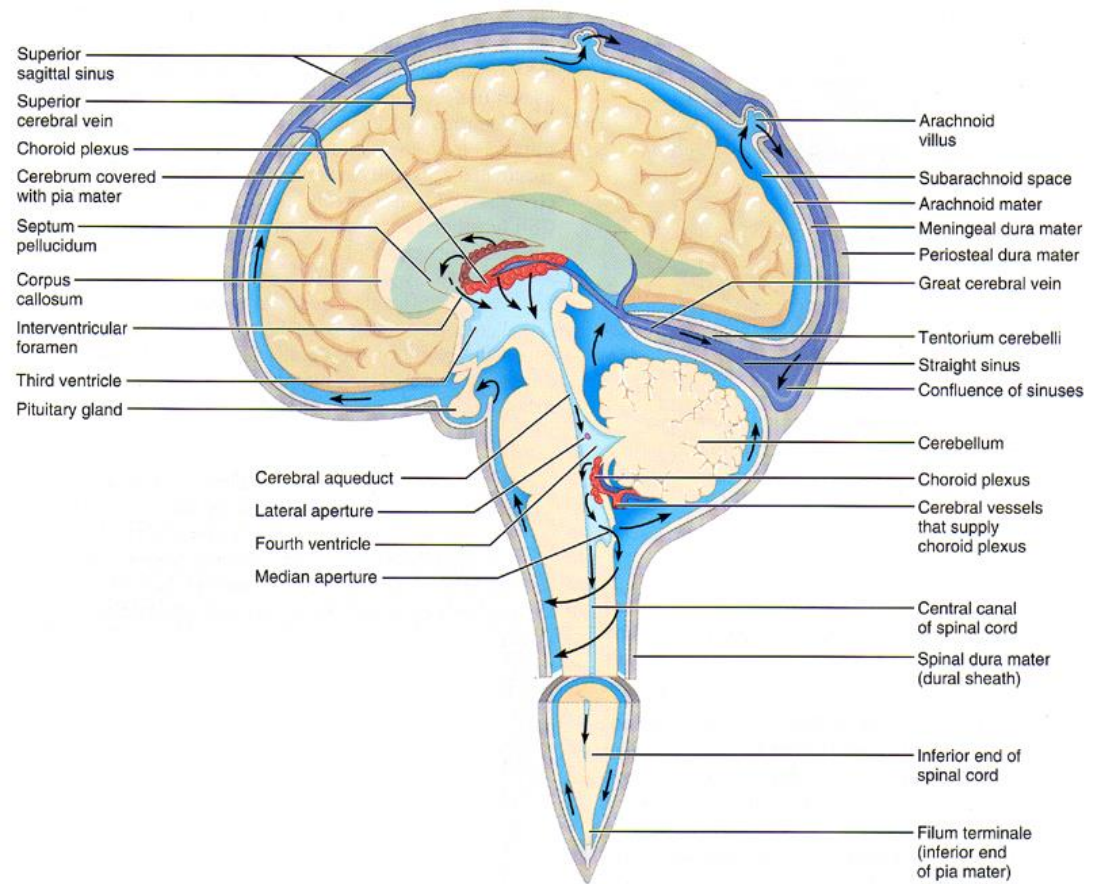
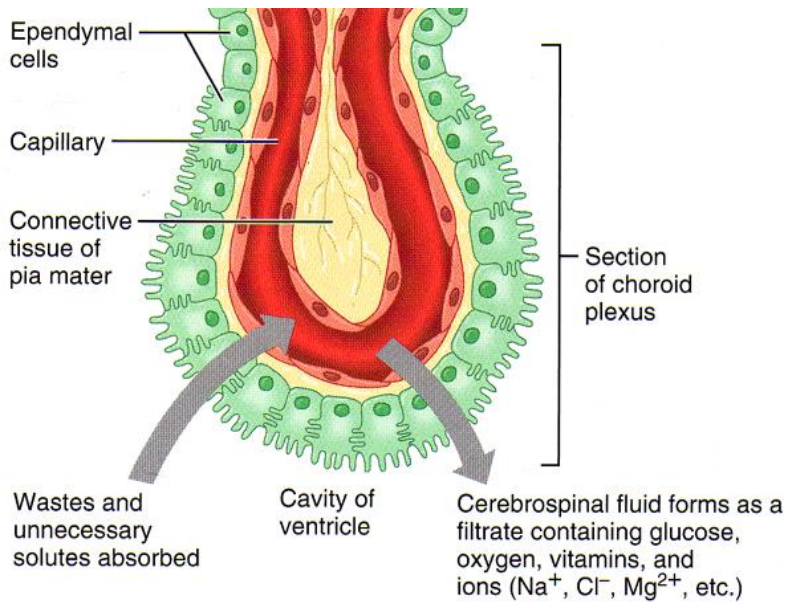
- tight junctions seal together epithelial cells, continuous basement membrane, **astrocyte processes** covering capillaries



Cerebrospinal fluid (CSF)腦脊髓液

- 80-150 ml (3-5oz)
- Clear liquid containing glucose, proteins, & ions
- Functions
 - mechanical protection
 - floats brain & softens impact with bony walls
 - chemical protection
 - optimal ionic concentrations for action potentials
 - circulation
 - nutrients and waste products to and from bloodstream

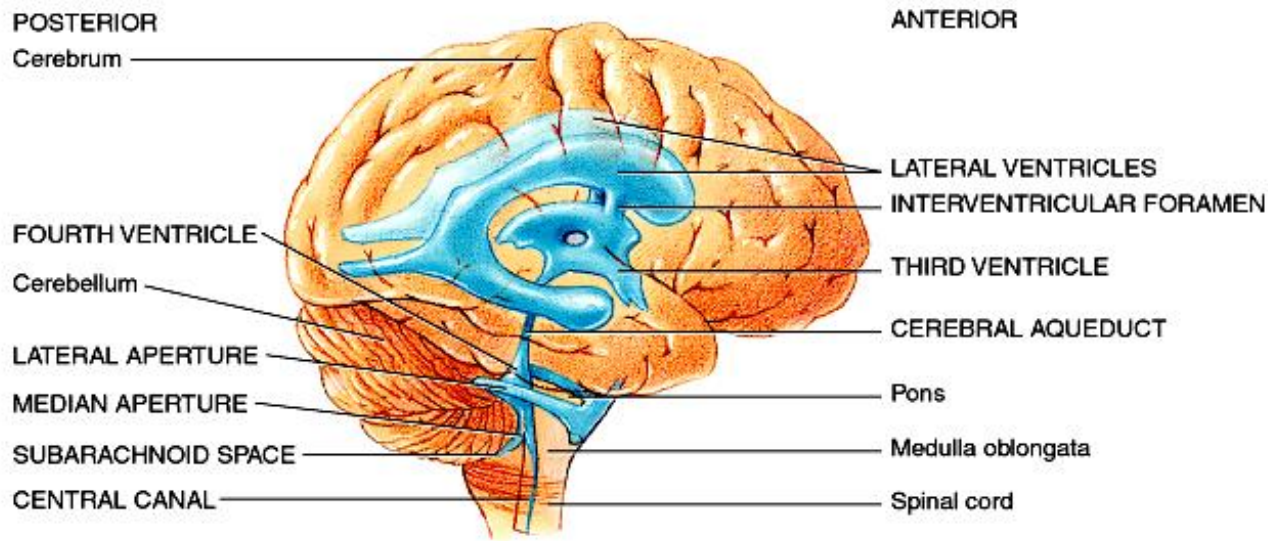
Origin of CSF: Choroid plexus 脈絡叢



- Choroid plexus 脈絡叢
= capillaries covered by ependymal cells

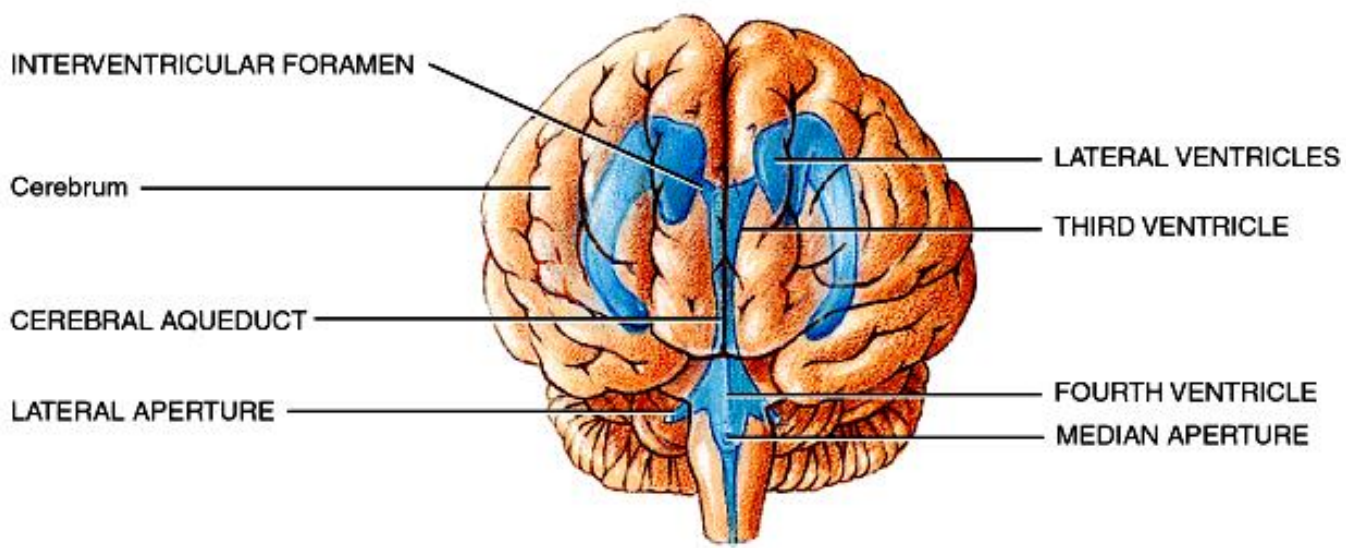
- 2 lateral ventricles, one within each cerebral hemisphere
- roof of 3rd ventricle
- fourth ventricle

Brain Ventricles



(a) Right lateral view of brain

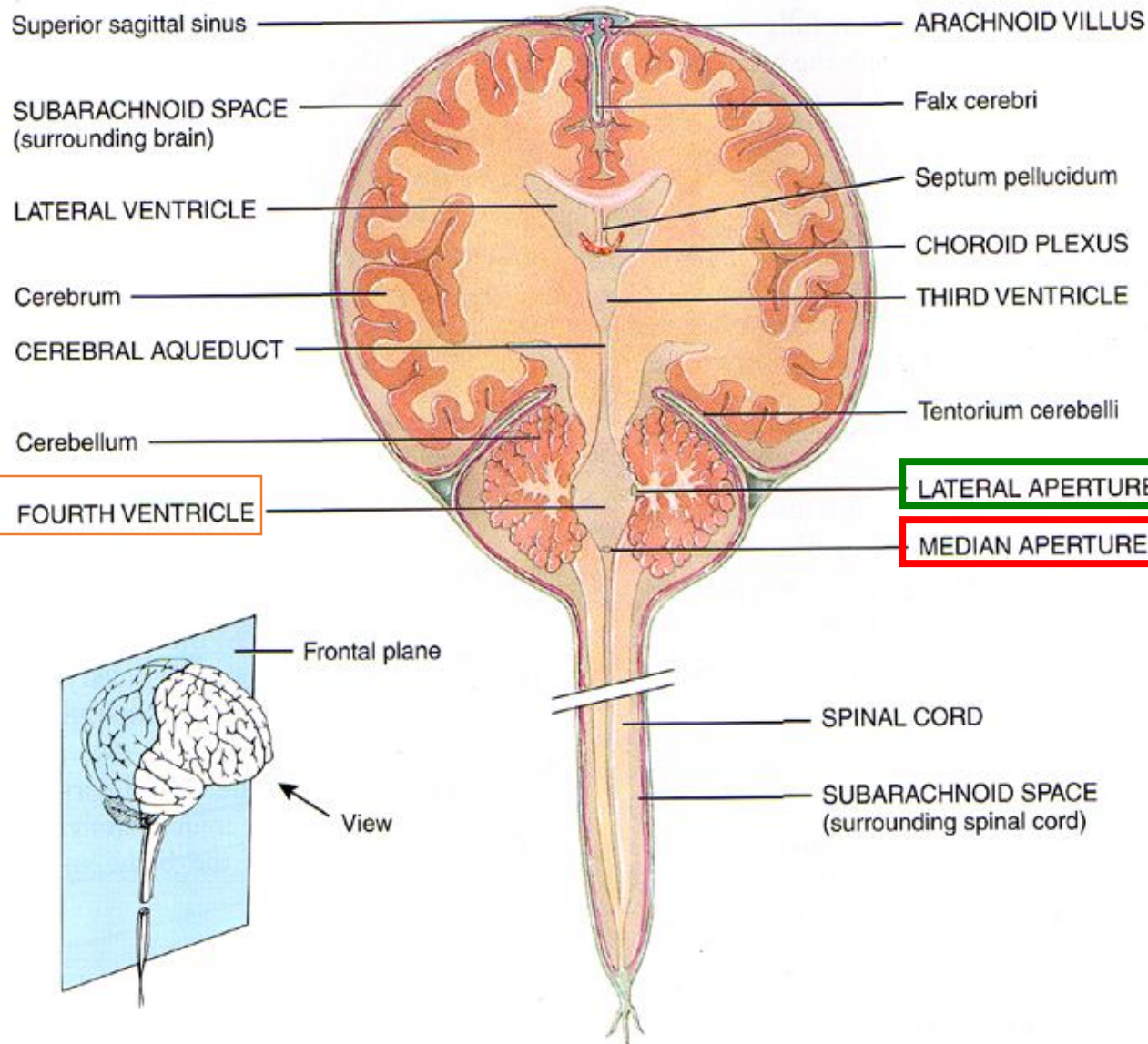
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(b) Anterior view of brain

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Drainage of CSF from Ventricles



2 lateral apertures
1 median aperture
allow CSF to exit
from the interior
of the brain

Flow of CSF

Lateral ventricles
(choroid plexuses)

→ **interventricular foramen**

→ **3rd Ventricle**

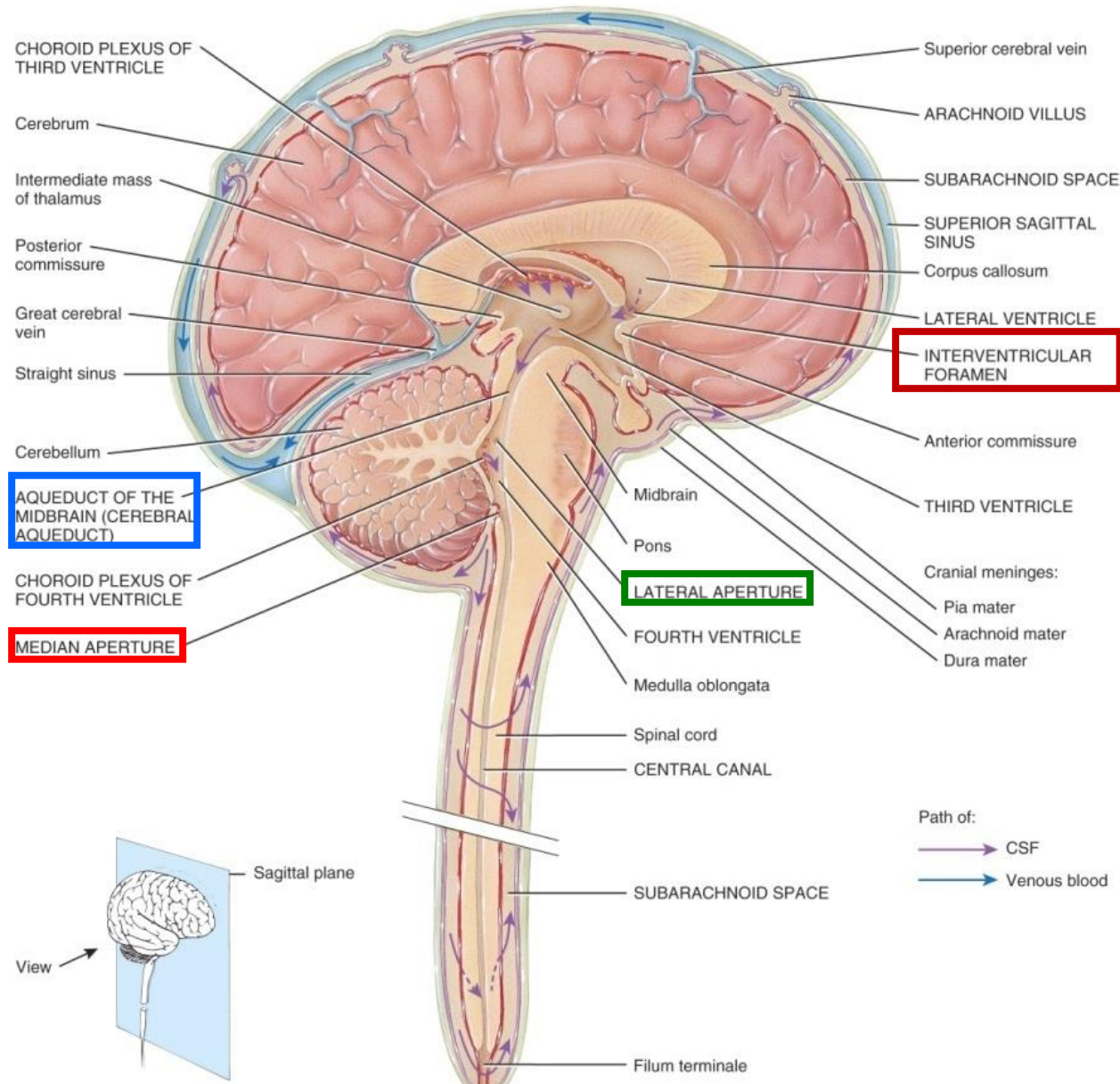
→ **cerebral aqueduct**

→ **Fourth ventricle**

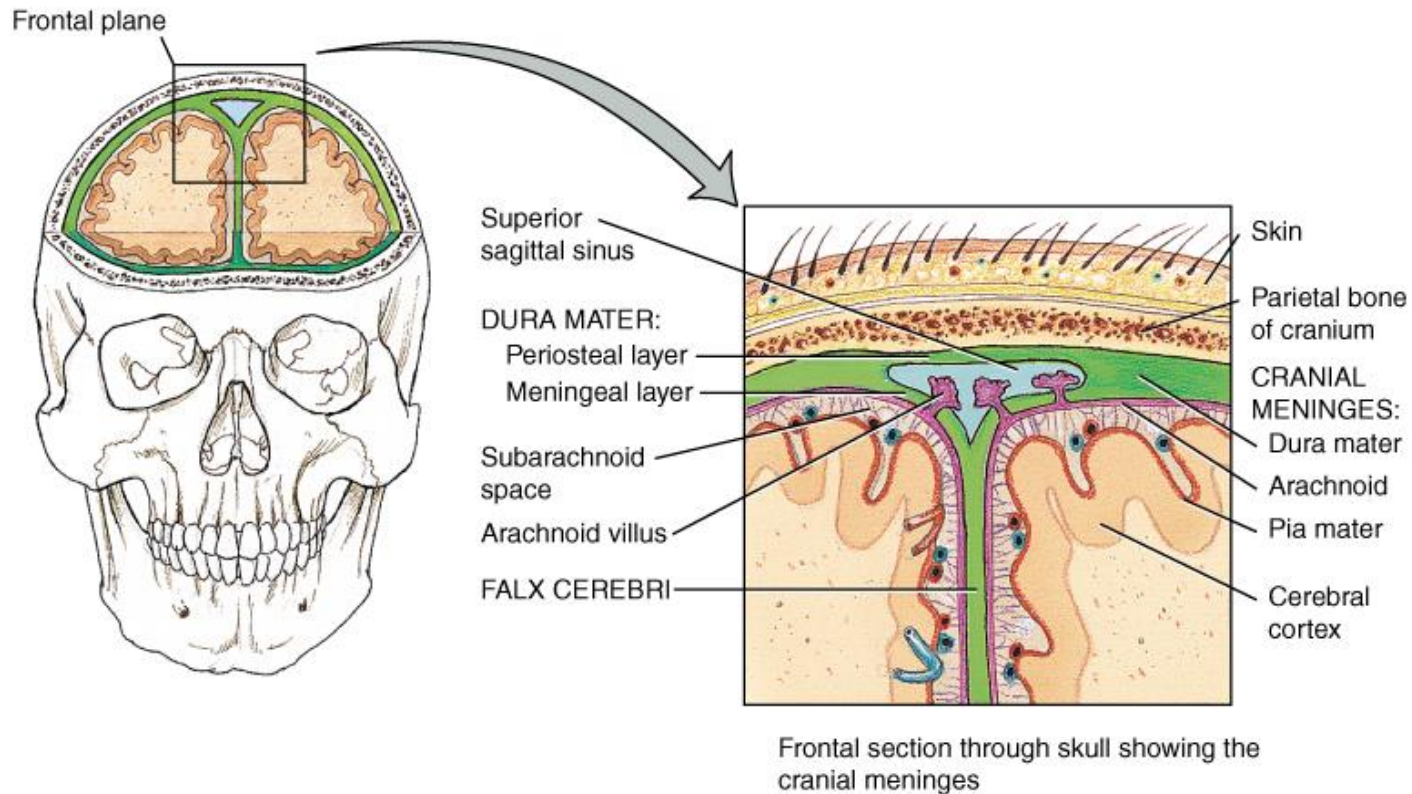
→ **1 median aperture**
2 lateral apertures

→ **central canal of spinal cord**

→ **subarachnoid space**



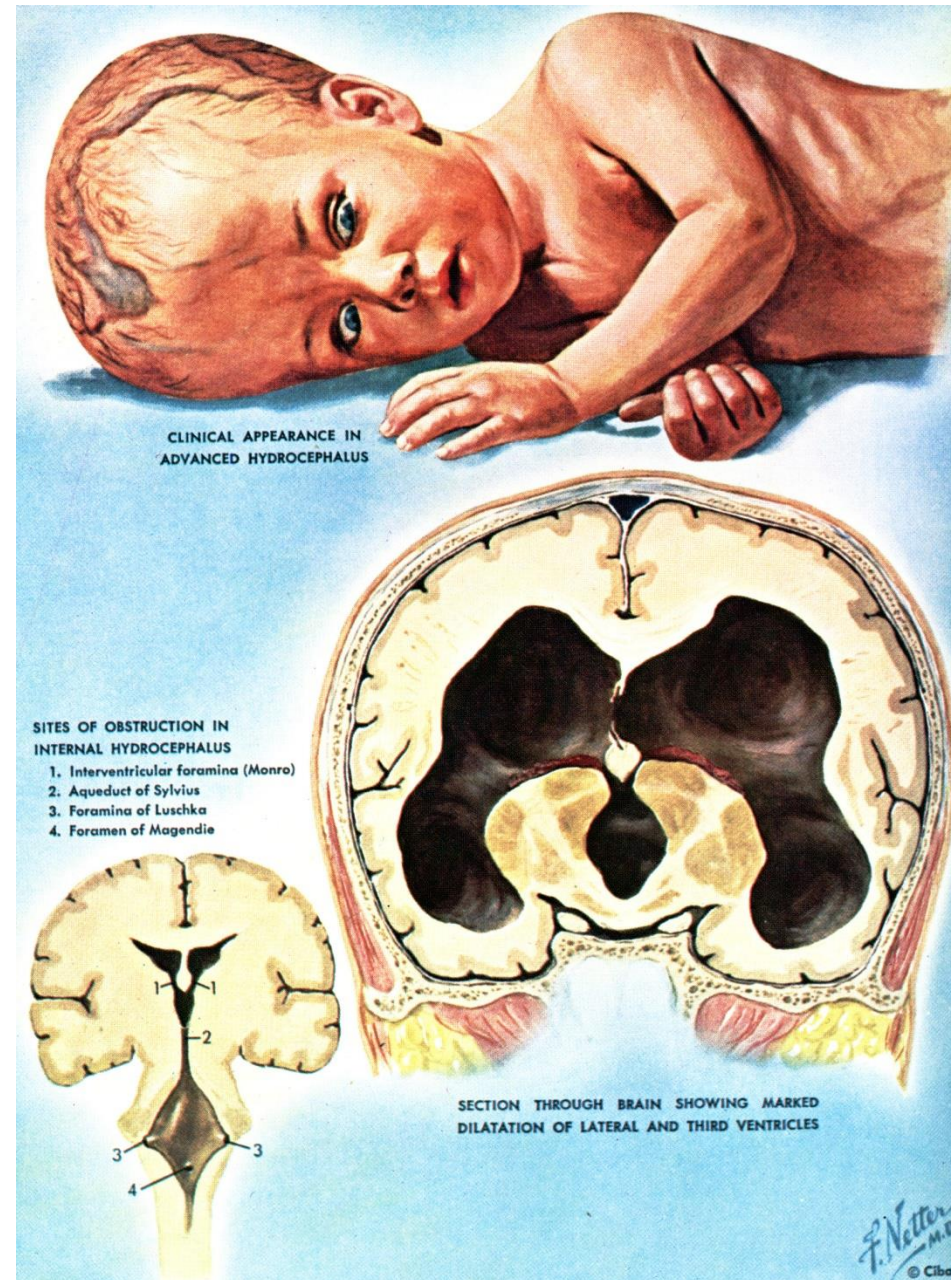
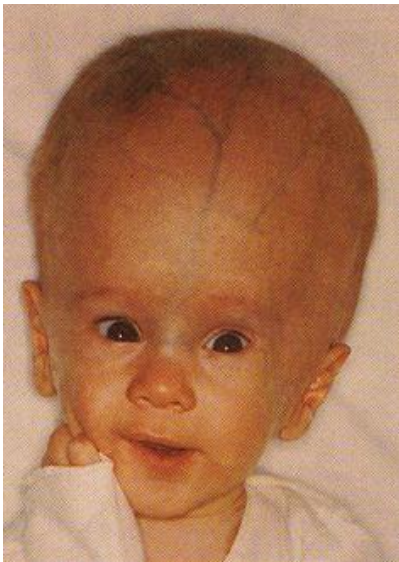
Re-absorption of CSF: into superior sagittal sinus (arachnoid villi)



- Reabsorbed through arachnoid villi
 - grapelike clusters of arachnoid penetrate dural venous sinus
- 20 ml/hour reabsorption rate = same as production rate

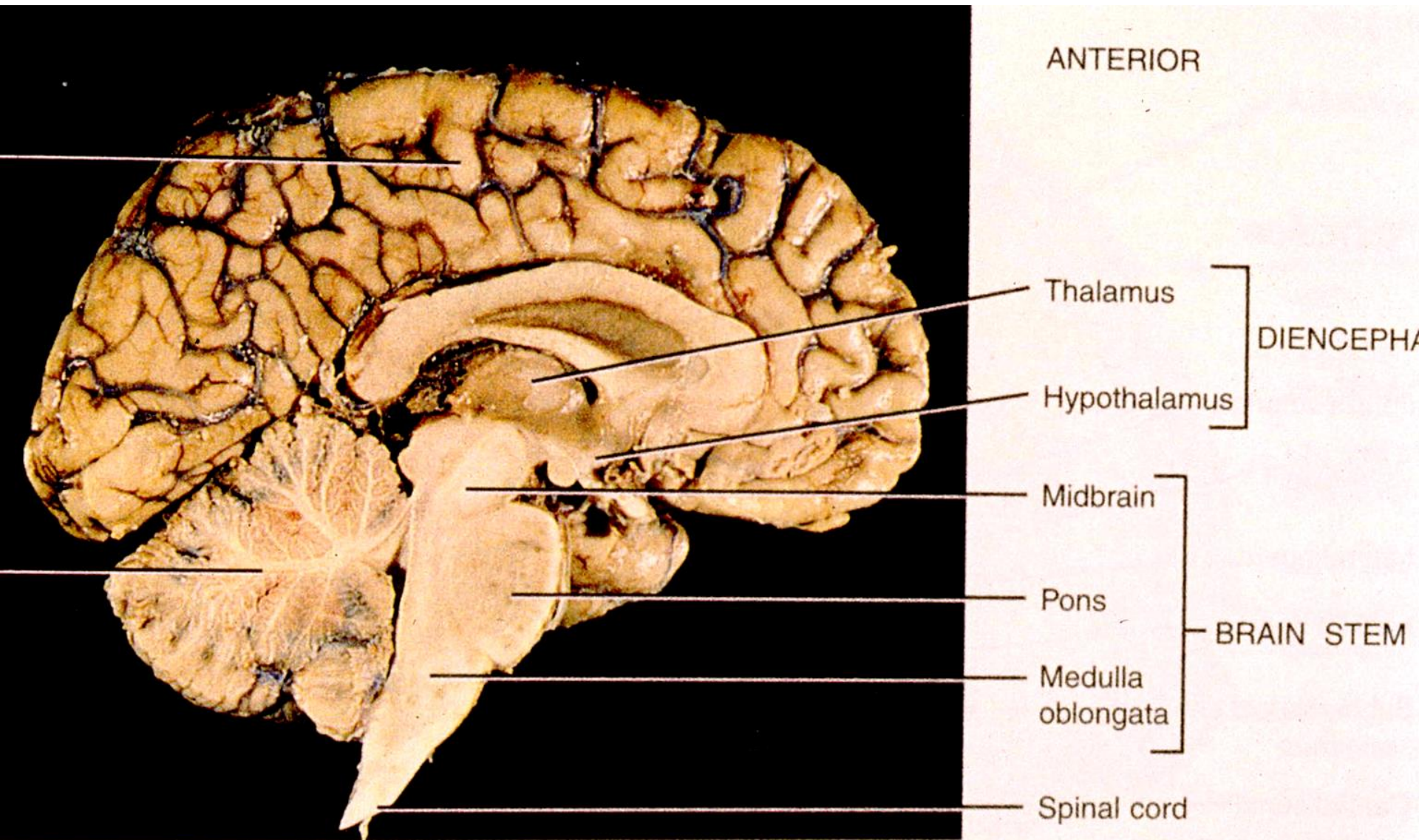
Hydrocephalus 水腦症

- Blockage of drainage of CSF (tumor, inflammation, developmental malformation, meningitis, hemorrhage or injury)
- Continued production cause an increase in pressure --- hydrocephalus



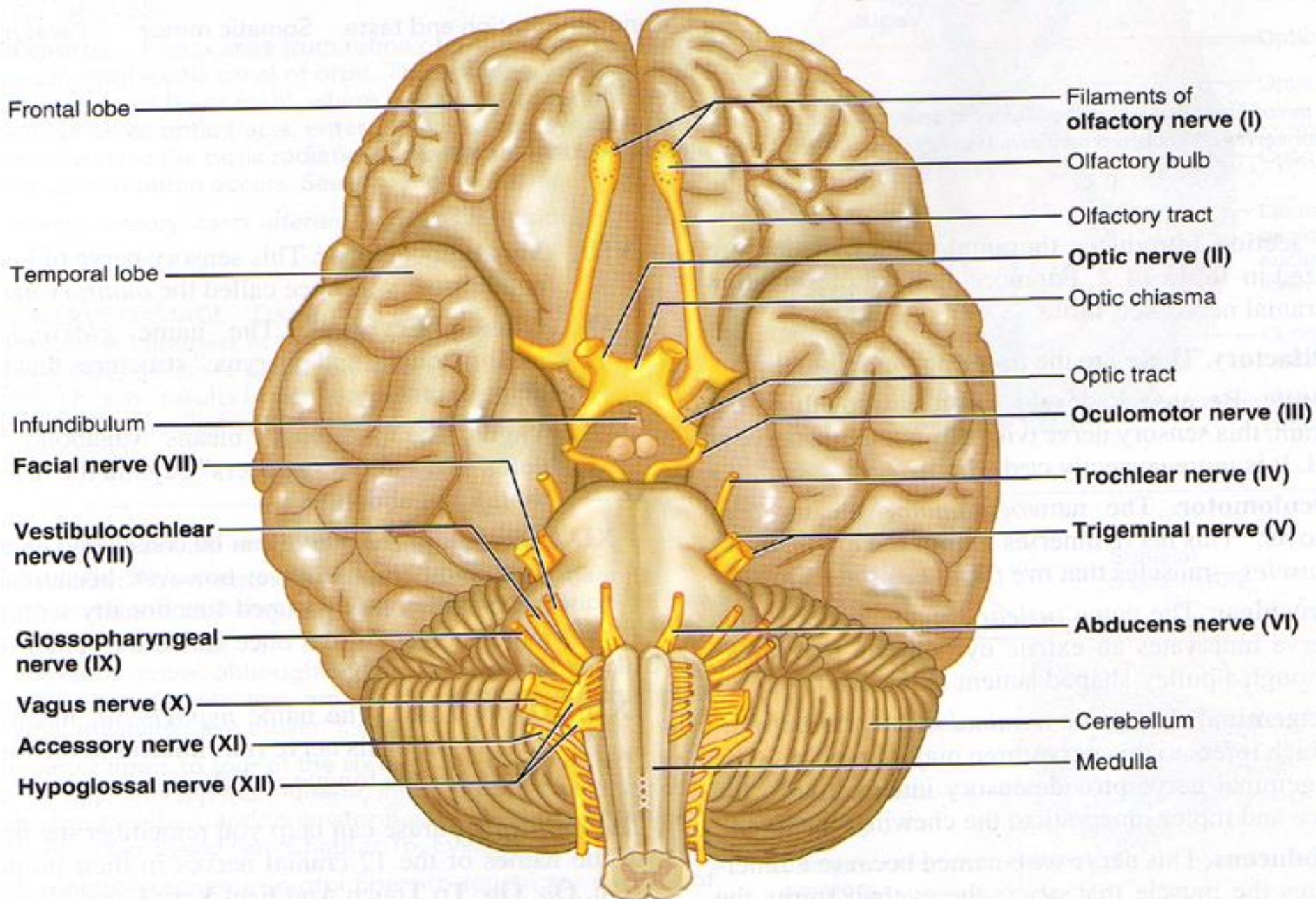
Brain Stem 腦幹

Medulla Oblongata 延腦 Pons 橋腦 Midbrain 中腦

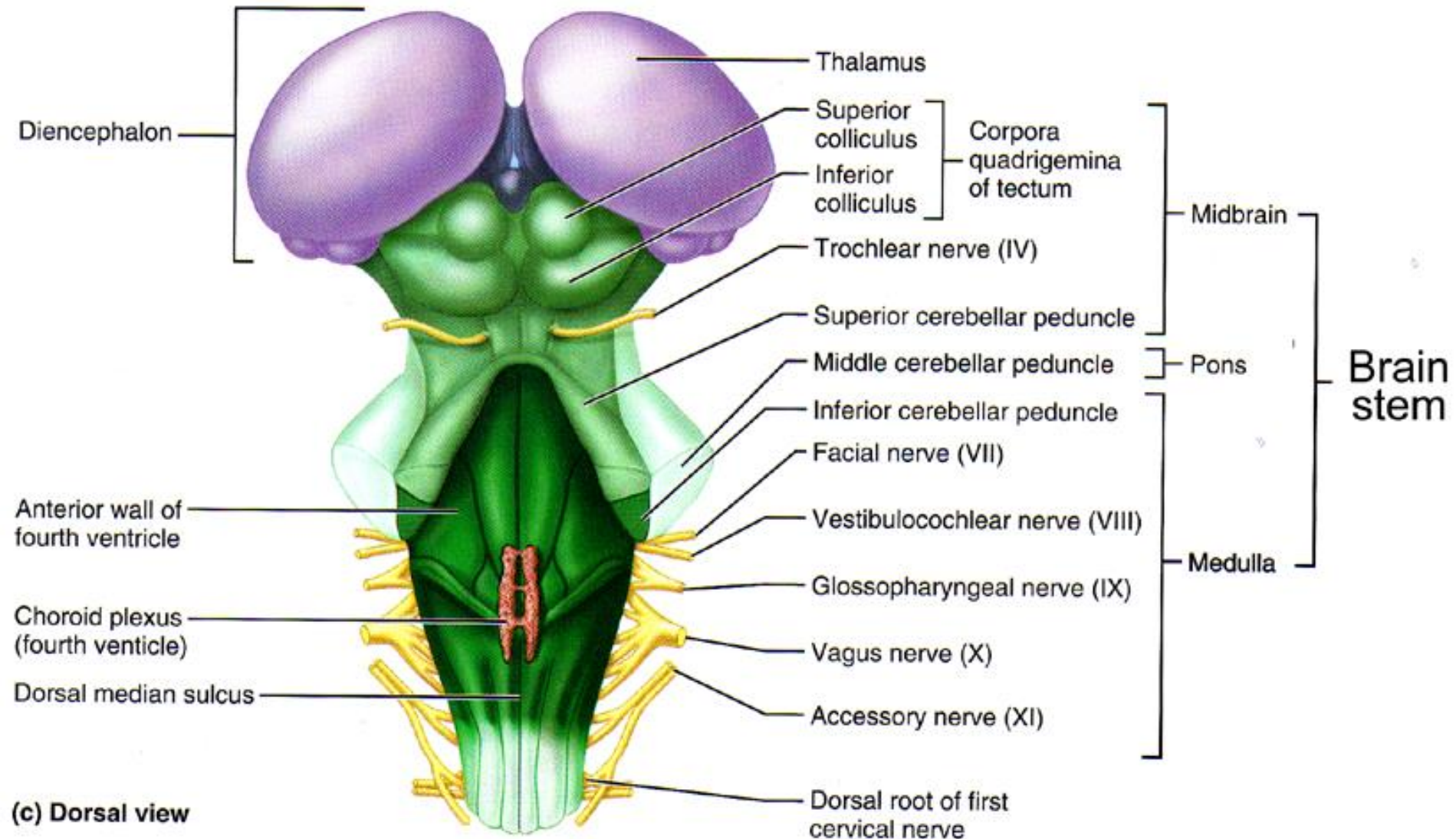


(b) Medial aspect of brain in sagittal section

Brain stem (腦幹)

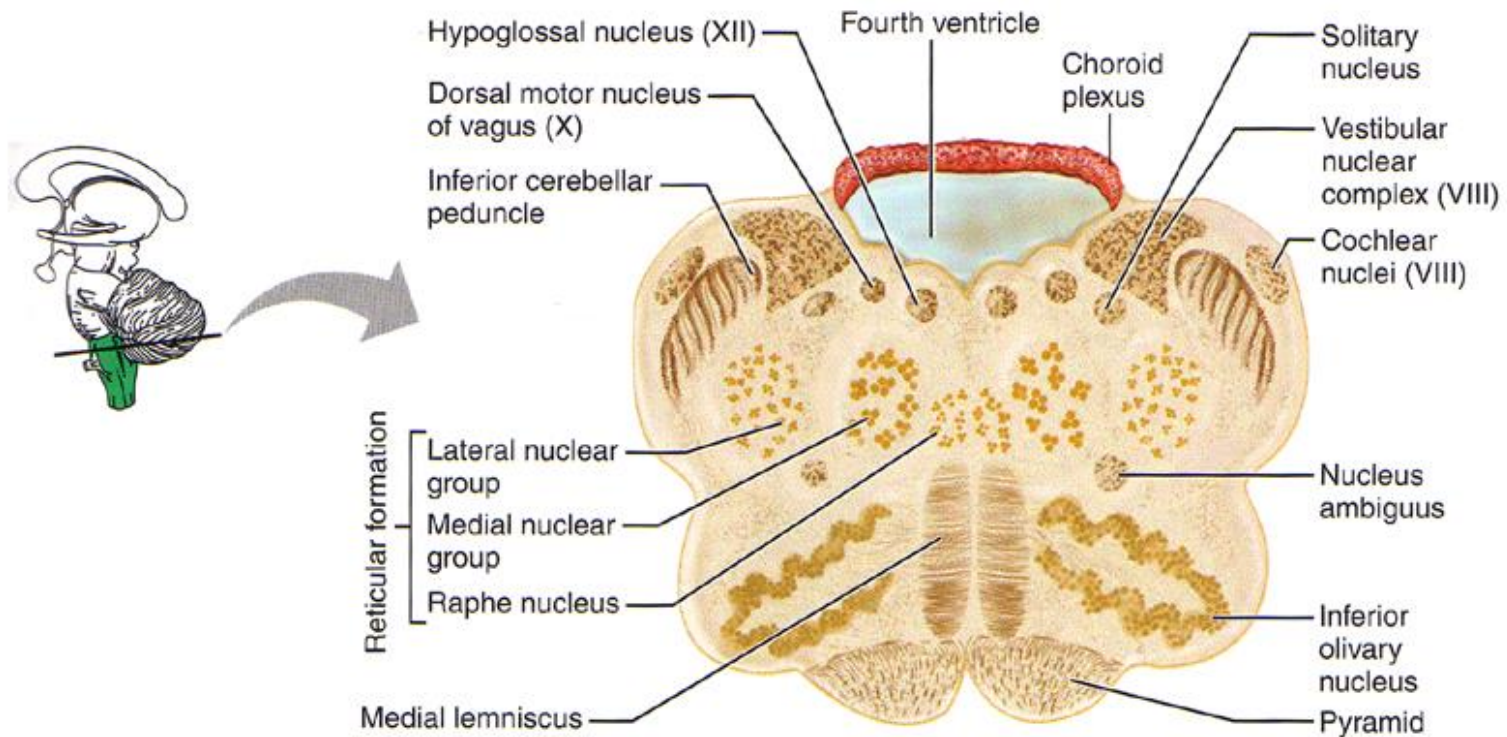


Brainstem and Cranial nerves



(c) Dorsal view

Medulla Oblongata (延腦): 生命中樞



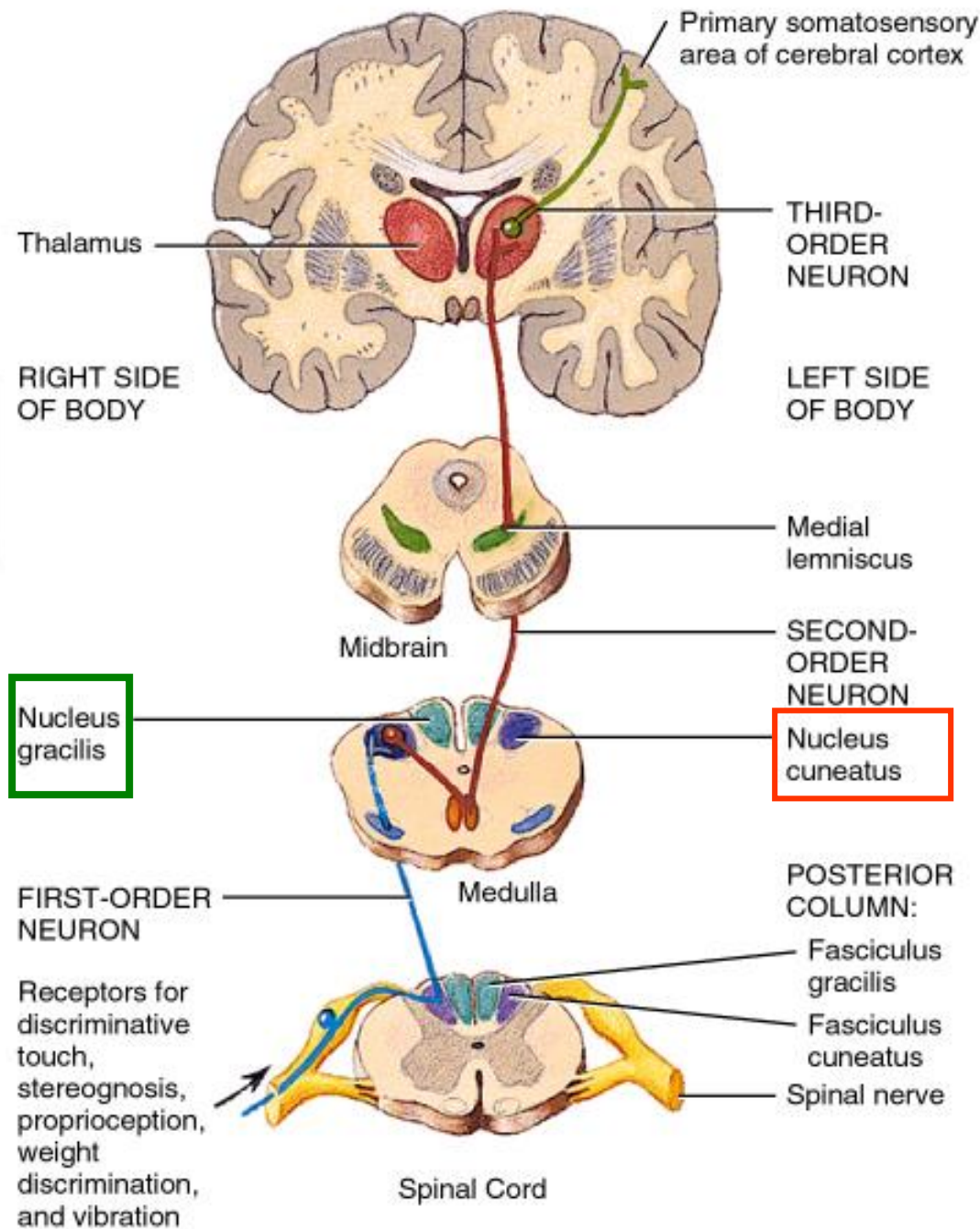
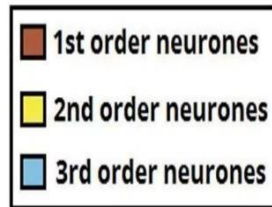
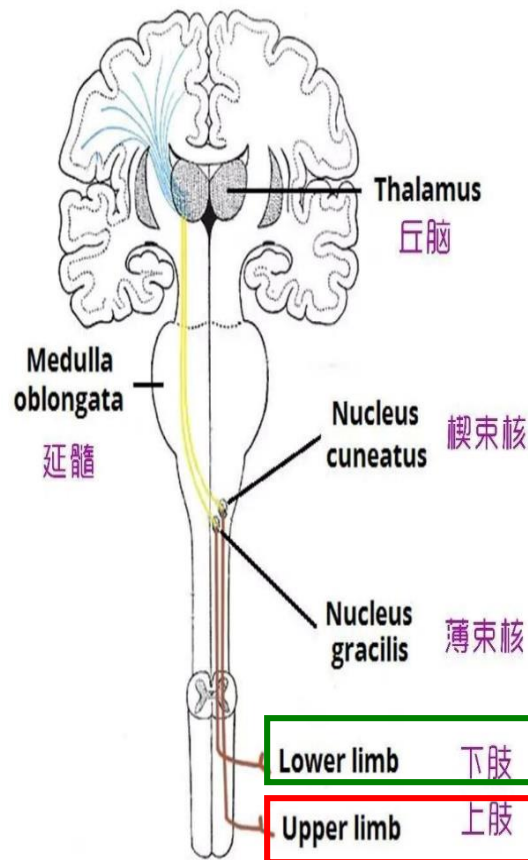
- Continuation of spinal cord
- Ascending sensory tracts
- Descending motor tracts
- Nuclei of 5 cranial nerves
- **Cardiovascular center**
- **Respiratory center**
- **Information in & out of cerebellum**
- **Reflex centers for coughing, sneezing, swallowing etc.**

Sensory nuclei: 體感覺

Nucleus cuneatus 楔狀核 (上肢)

Nucleus gracilis 薄束核 (下肢)

在延腦交叉到對側



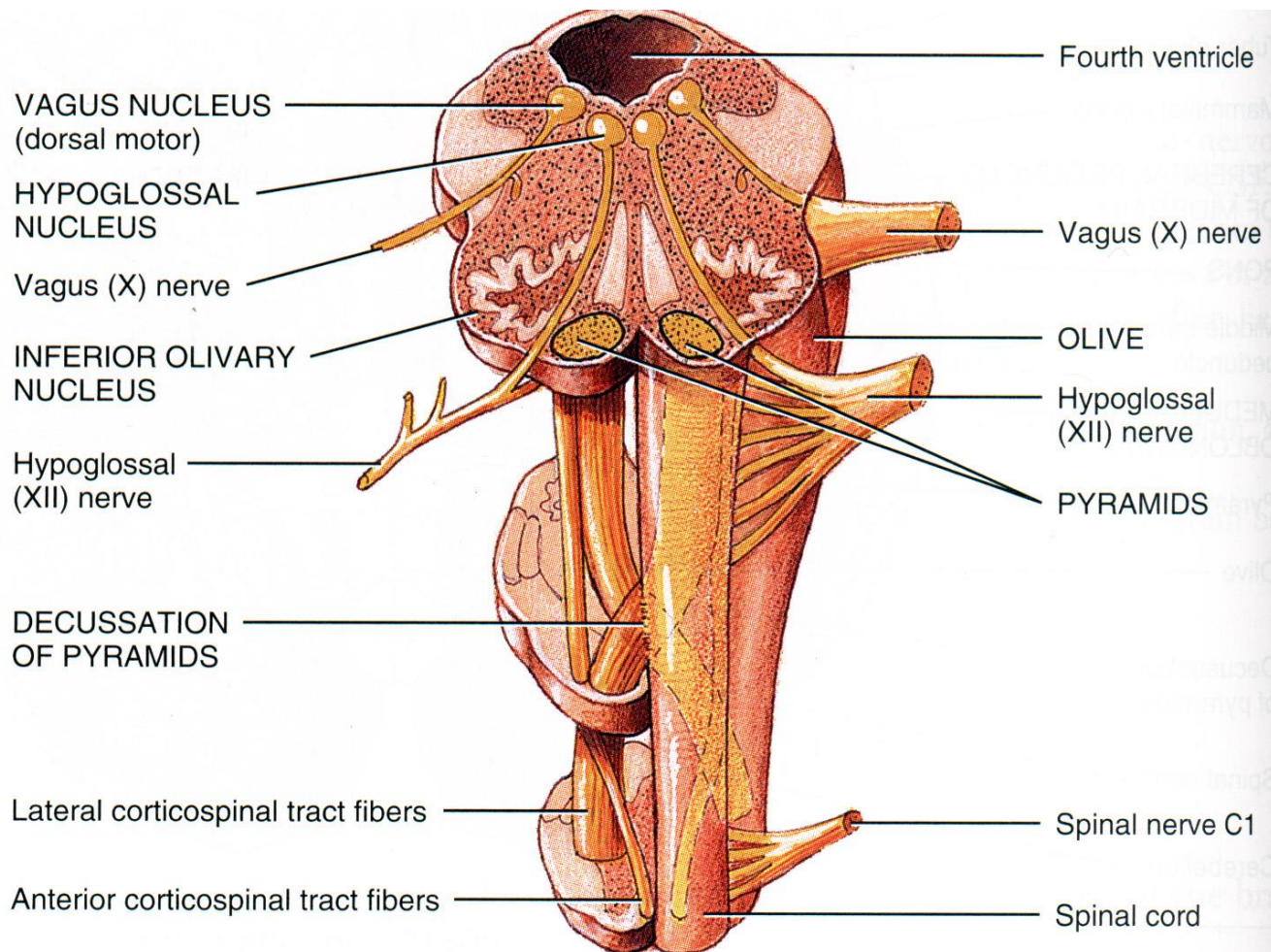
Autonomic functions of Medulla Oblongata 延腦 :

1. Cardiovascular center:

regulates the rate and force of heartbeat and blood vessels diameter

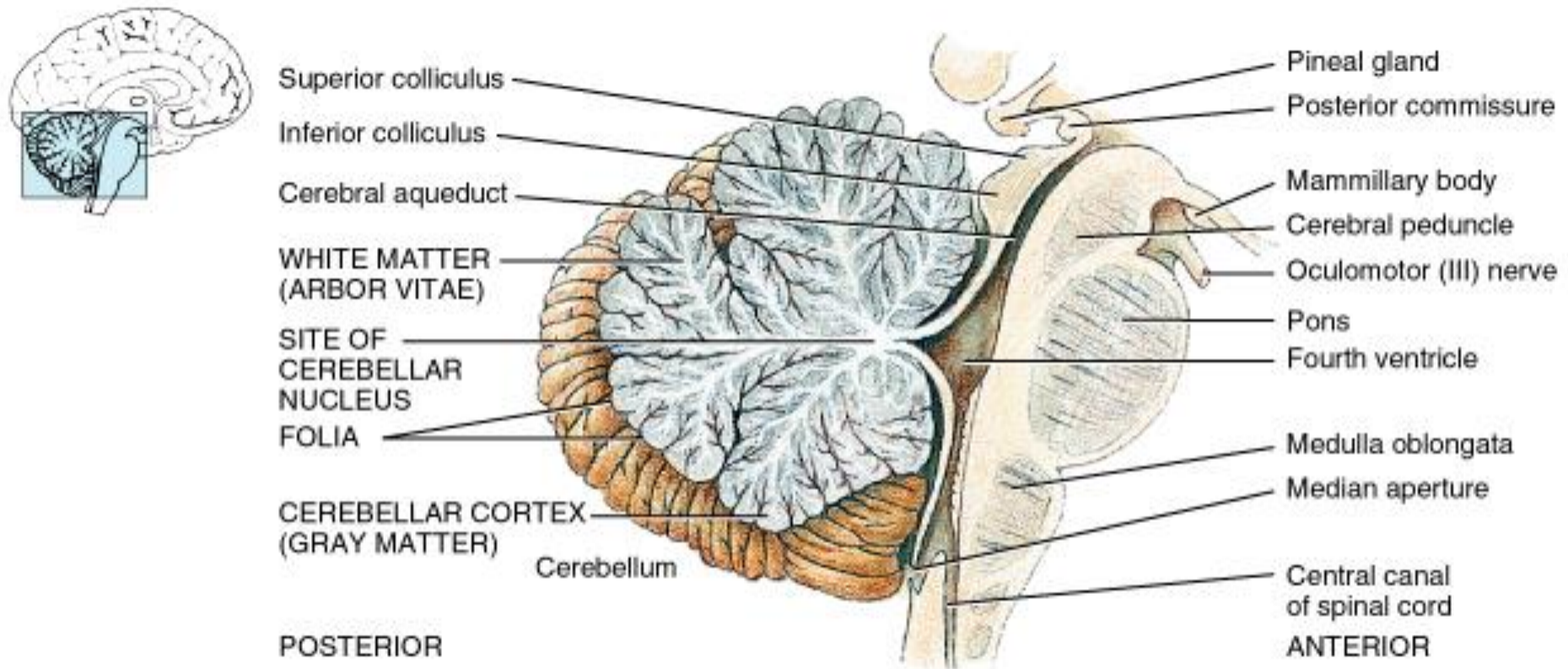
2. Medullary rhythmicity area of the Respiratory center

*Centers for Swallowing, Vomiting, Coughing, Sneezing, and Hiccuping



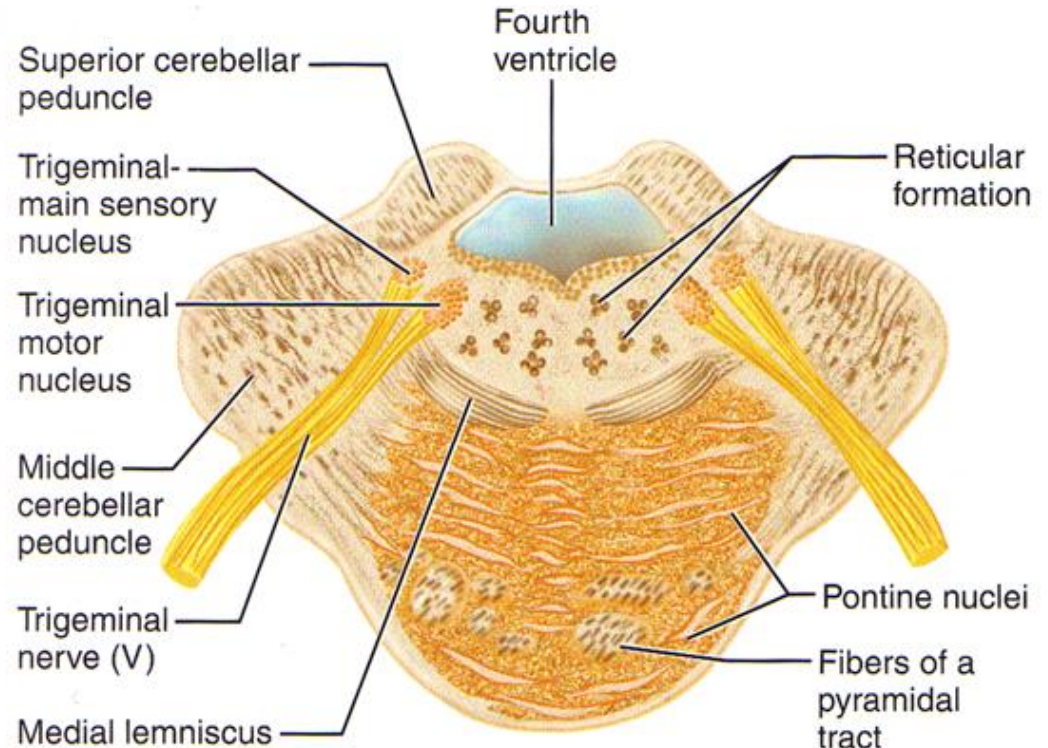
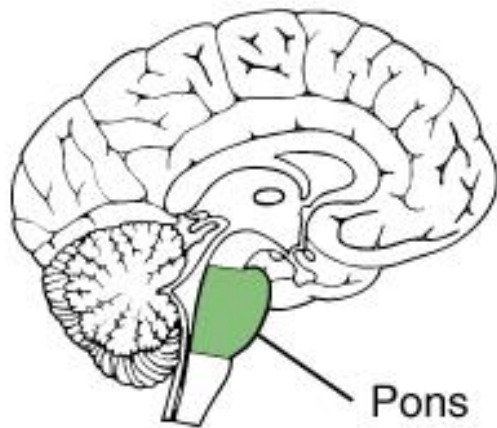
Pons 橋腦

Middle cerebellar peduncles 中小腦腳 → cerebellum



(c) Midsagittal section of cerebellum and brain stem

Pons



- One inch long
- White fiber tracts ascend and descend
- **Pneumotaxic area 呼吸調節區 & apneustic areas 長吸區** help control breathing

Pons 橋腦

Nuclei for cranial nerves:

1. trigeminal nerves (V)
2. abducens nerves (VI)
3. facial nerves (VII)
4. vestibulocochlear nerves (VIII) for equilibrium

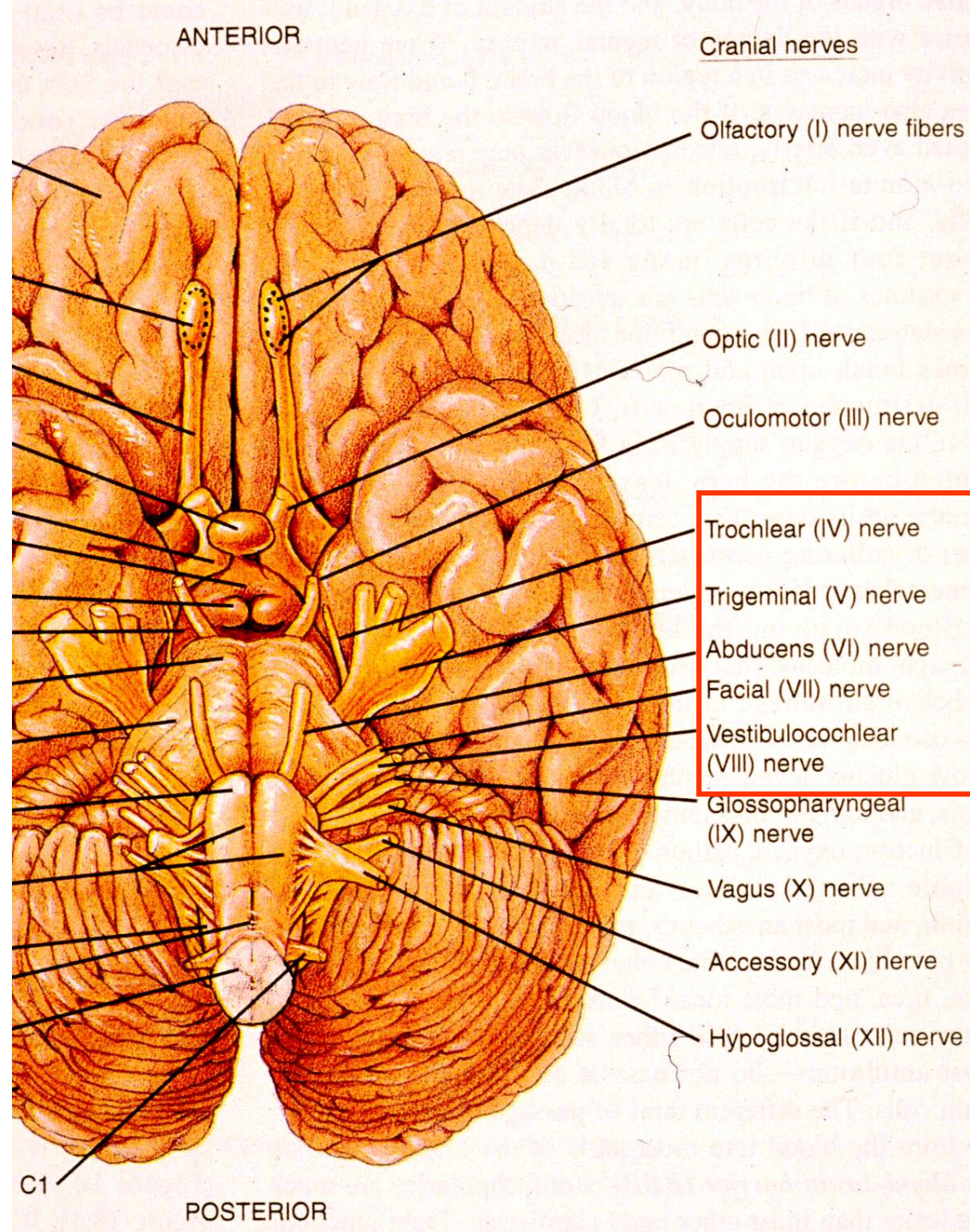
***Pneumotaxic area**

呼吸調節區

apneustic area 長吸區

(+ **medullary rhythmicity area**)

→ **control the respiration**



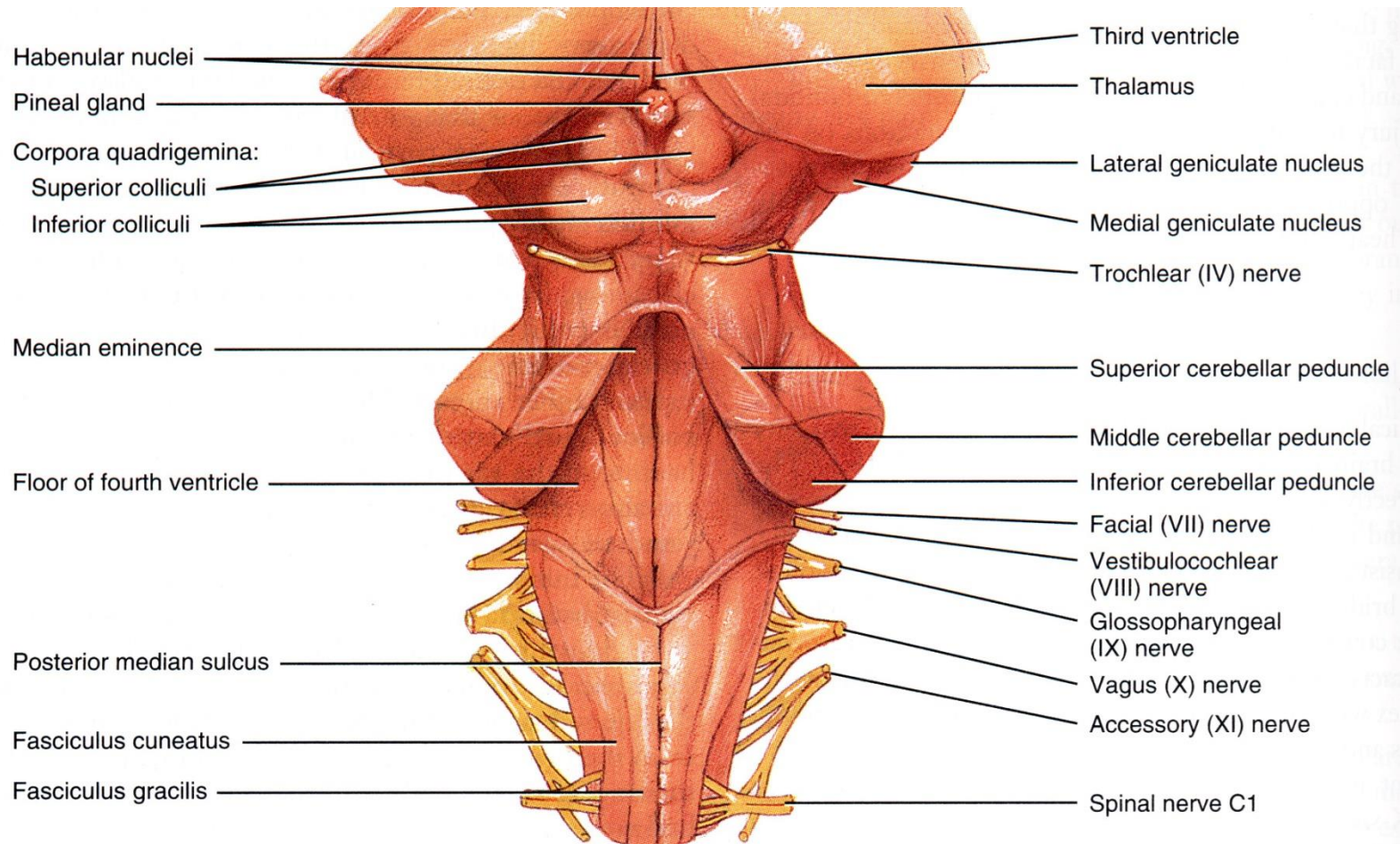
Midbrain中腦

Superior cerebellar peduncles 上小腦腳 → cerebellum

Tectum:頂蓋

Superior colliculi 上丘: reflex centers for the movements of eyes, head, and neck in response to **visual** and other stimuli.

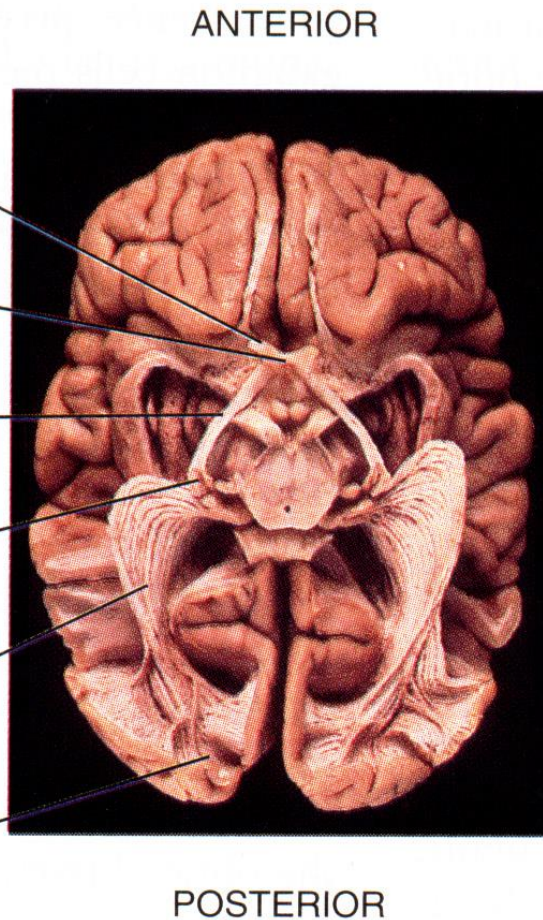
Inferior colliculi 下丘: reflex centers for the movements of the head and neck in response to **auditory** stimuli.



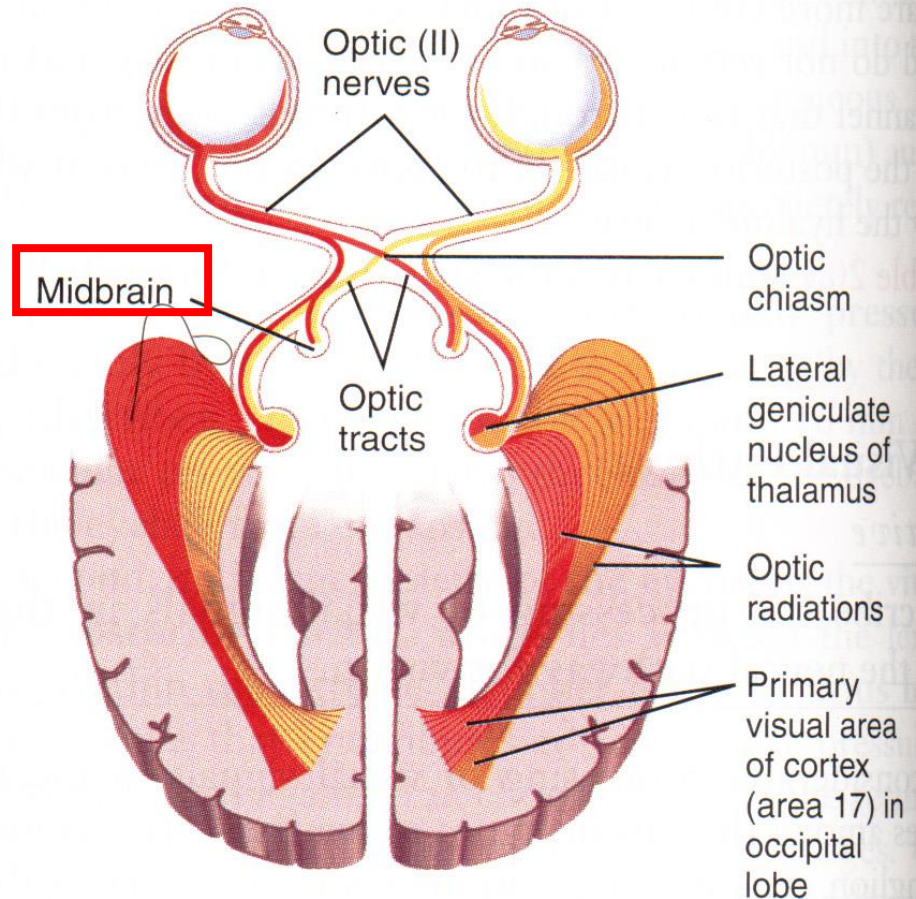
2. Optic nerves 視神經

Visual pathway:

Optic (II) nerve
↓
Optic chiasm
↓
Optic tract
↓
Lateral geniculate nucleus of thalamus
↓
Optic radiations
↓
Primary visual area of cortex (area 17) in occipital lobe

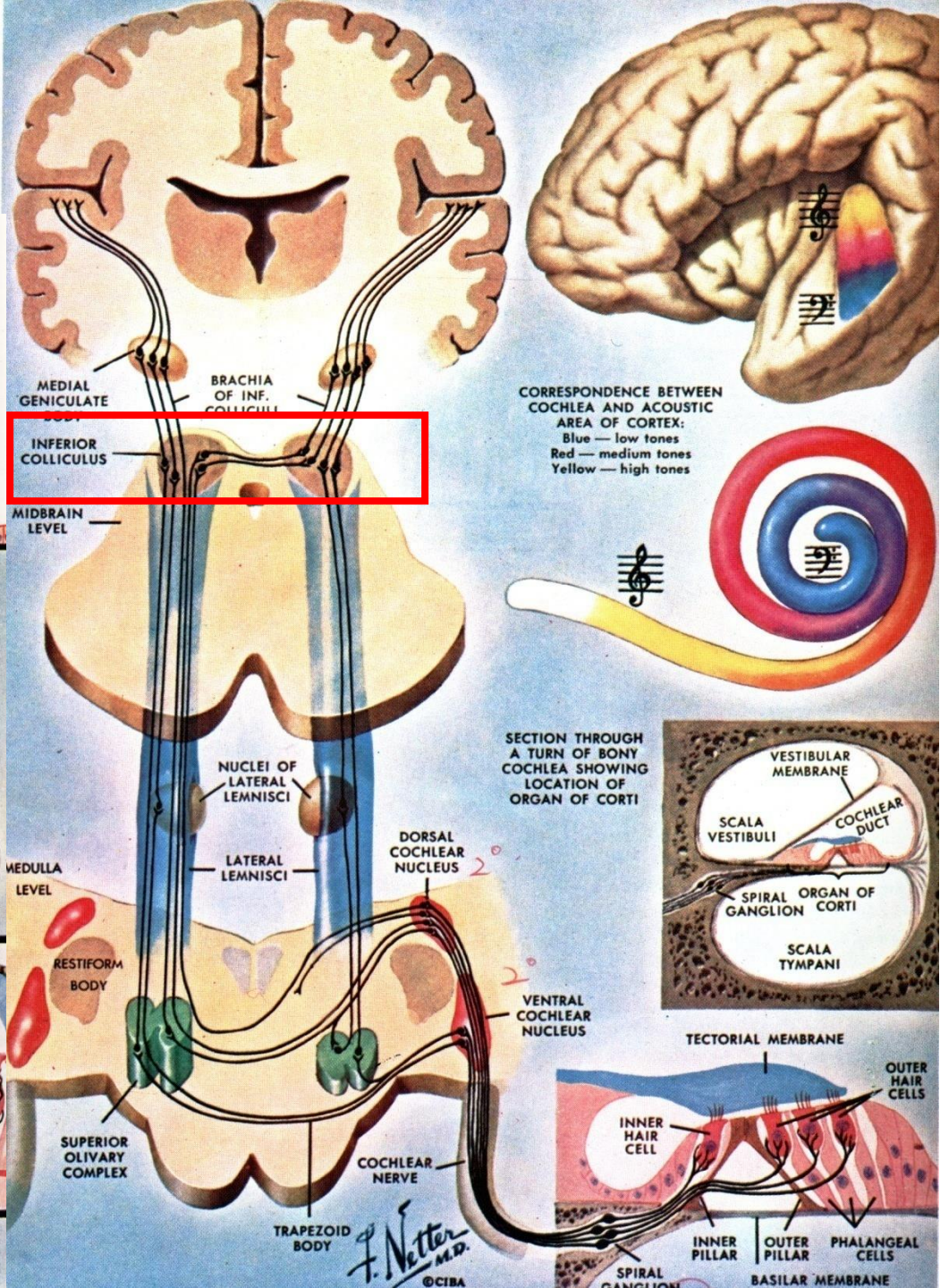
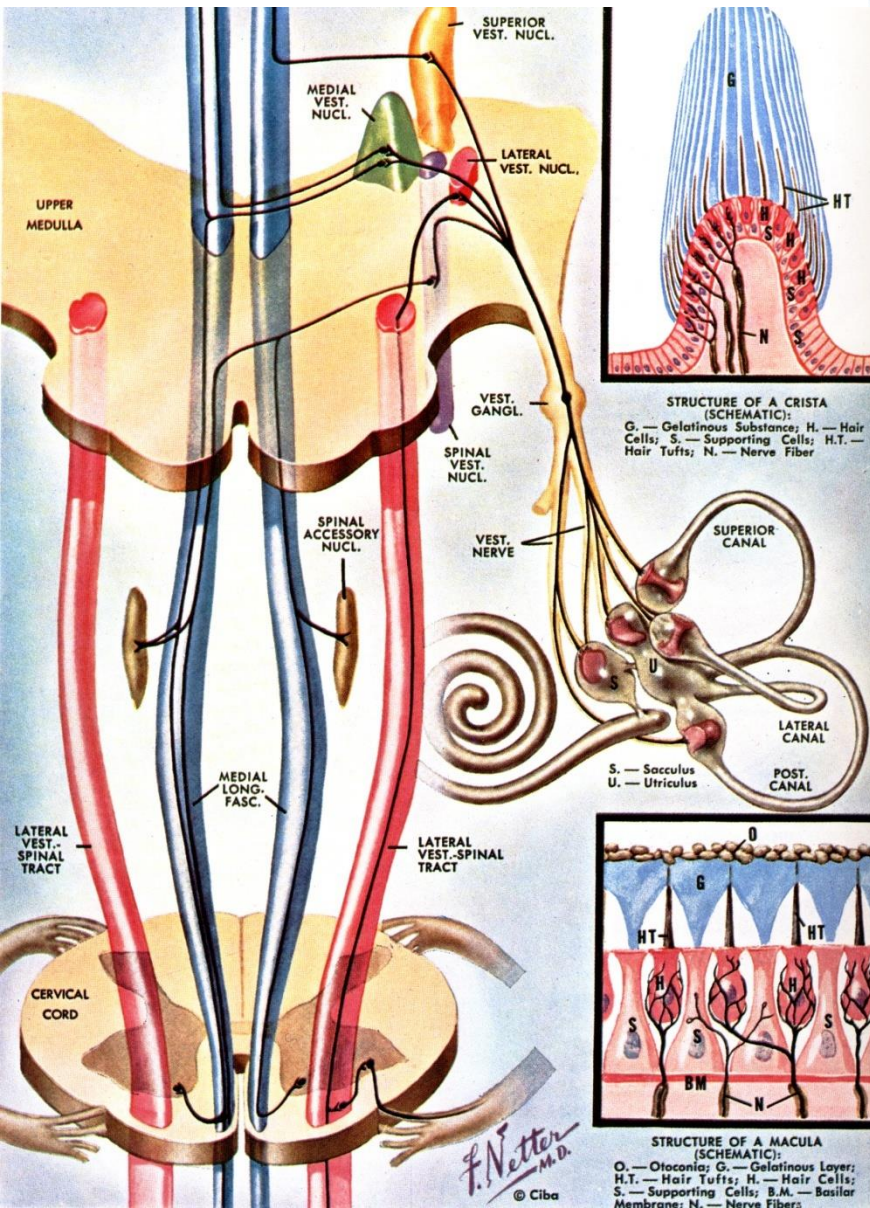


(a) Inferior view

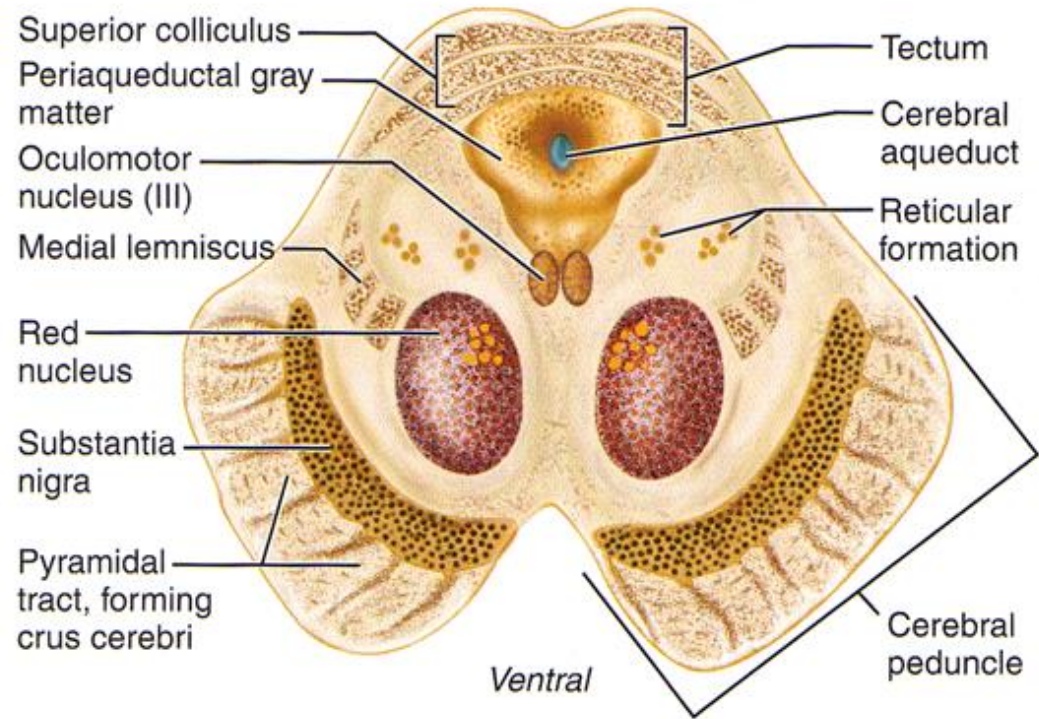
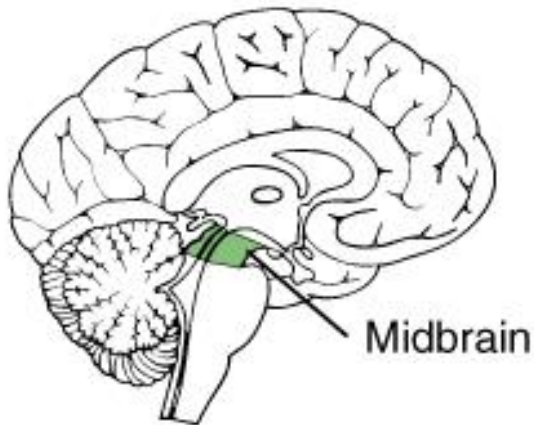


(b) Superior view of transverse section through eyeballs and brain

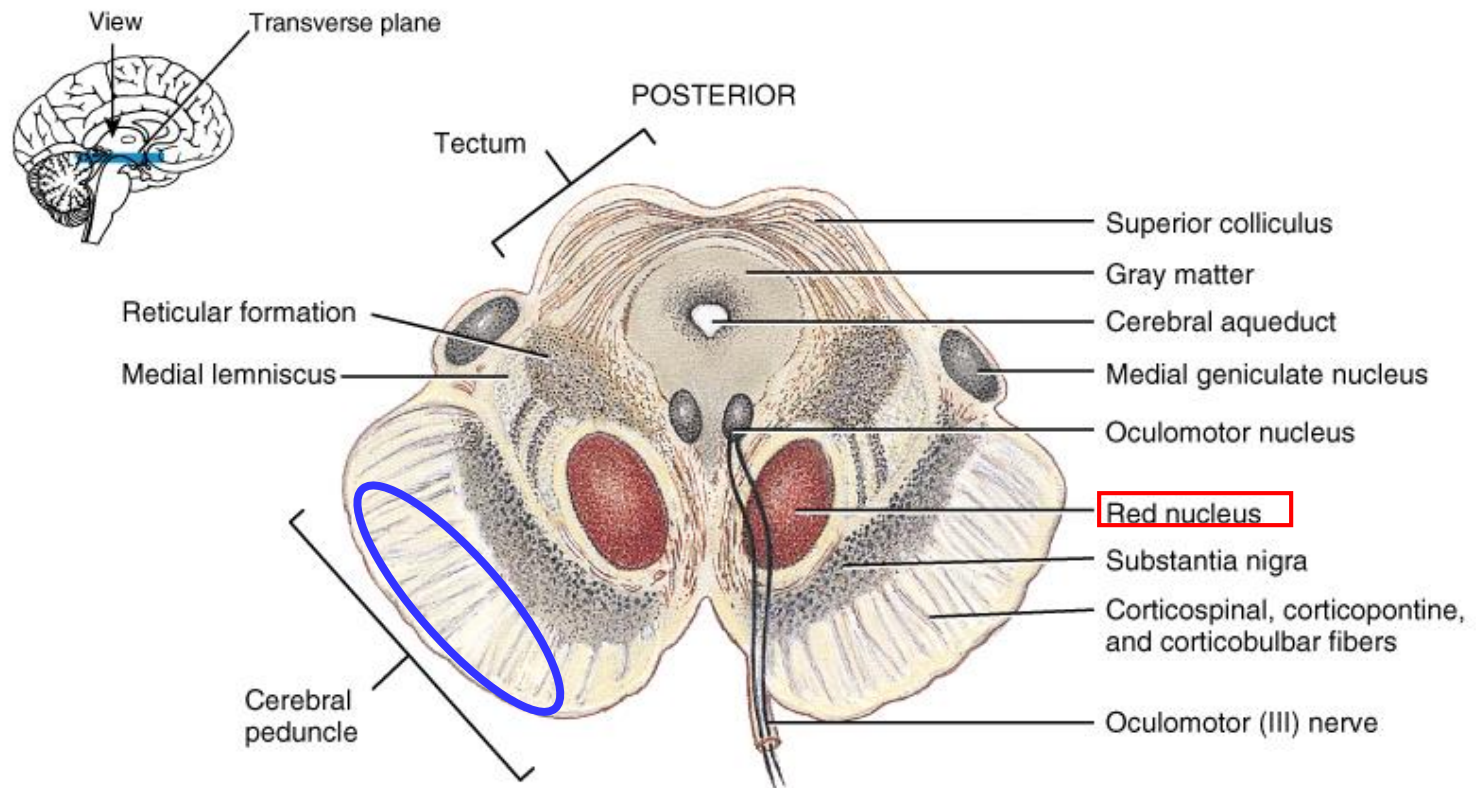
8. Vestibulocochlear nerves 前庭耳蜗神經



Midbrain

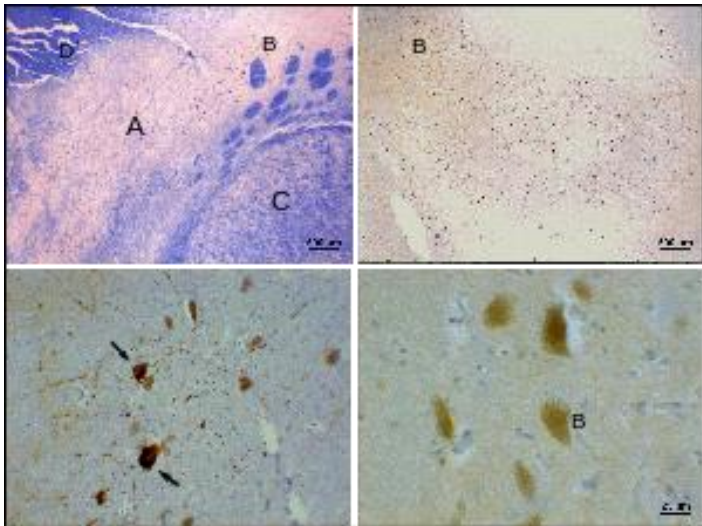
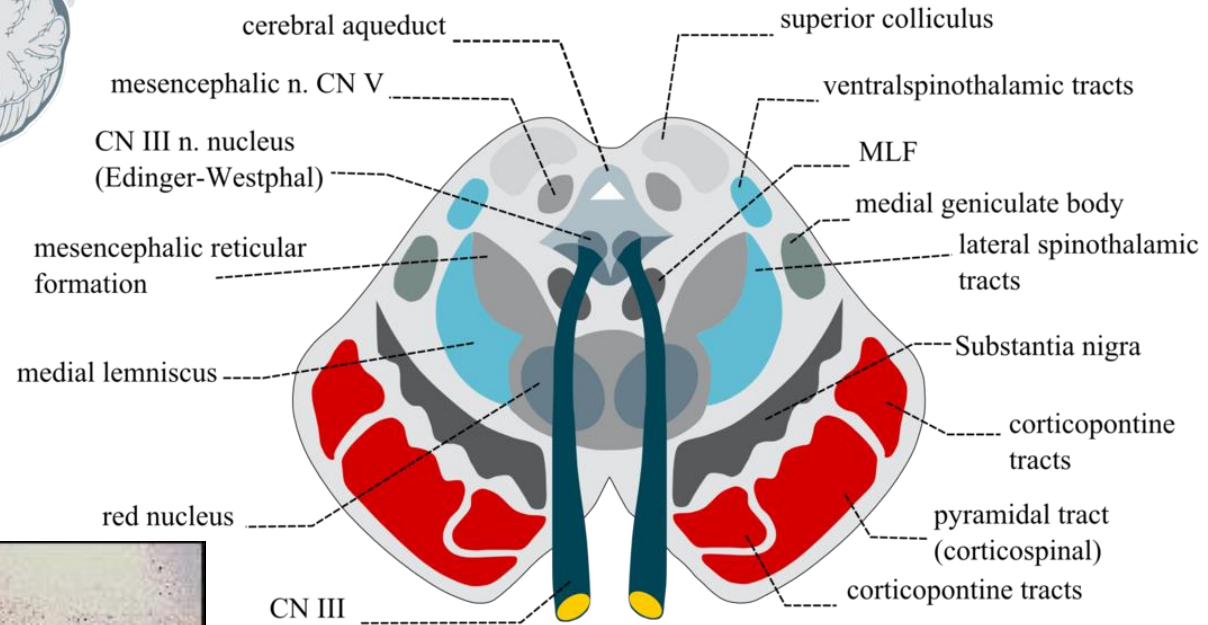


- One inch in length
- Extends from pons to diencephalon
- Cerebral aqueduct connects 3rd ventricle above to 4th ventricle below



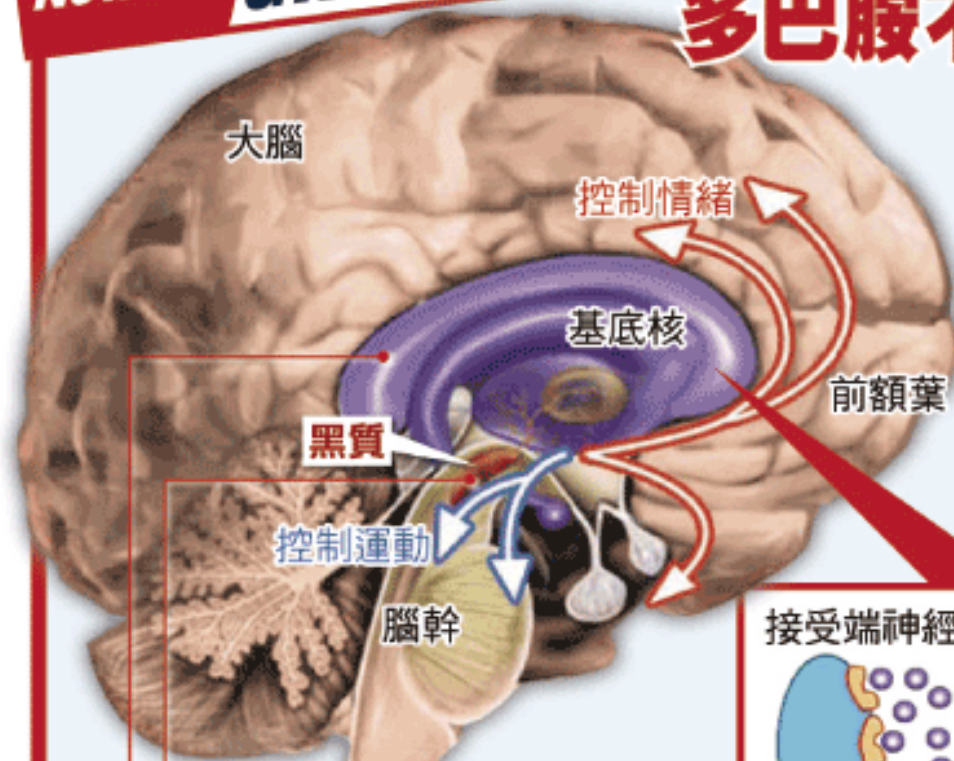
- **Cerebral peduncles**---clusters of motor & sensory fibers
- **Substantia nigra** 黑質-helps controls subconscious muscle activity
- **Red nucleus** 紅核-- rich blood supply & iron-containing pigment
 - cortex & cerebellum coordinate muscular movements by sending information here from the cortex and cerebellum

Parkinson's disease is a neurodegenerative disease characterized, in part, by the death of dopaminergic neurons in the **substantia nigra** 黑質.



Substantia nigra with loss of cells and Lewy body pathology

多巴胺不足 神經傳導失調



帕金森症源於人體無法製造足夠多巴胺，使神經傳導失調，以致肢體不協調、四肢顫抖或情緒異常等症狀。帕金森症治療藥物多巴胺促進劑，可補充人體不足之多巴胺，但也會因個人體質不同引發精神異常、性慾過盛等副作用。

藥物替代多巴胺

多巴胺功能

- 1 大腦黑質製造神經傳導物質多巴胺，並送至基底核
- 2 基底核將大腦命令傳遞至腦幹、脊髓以協調身體動作；同時傳至前額葉產生情緒反應
- 3 患者因多巴胺濃度不足，基底核失常，出現肢體不協調或憂鬱等症狀

接受端神經元

傳送端神經元



常人

多巴胺濃度
正常



病患

製造多巴胺細胞退化，使多巴胺濃度不足



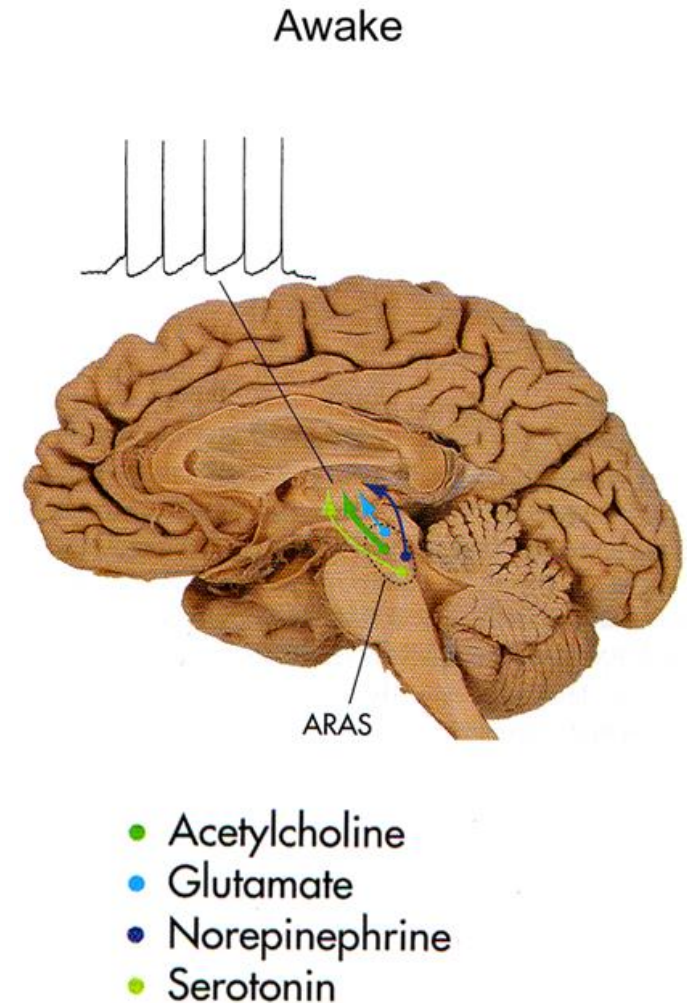
用藥後

促進劑成分類似多巴胺，人體可直接接受

Reticular Formation

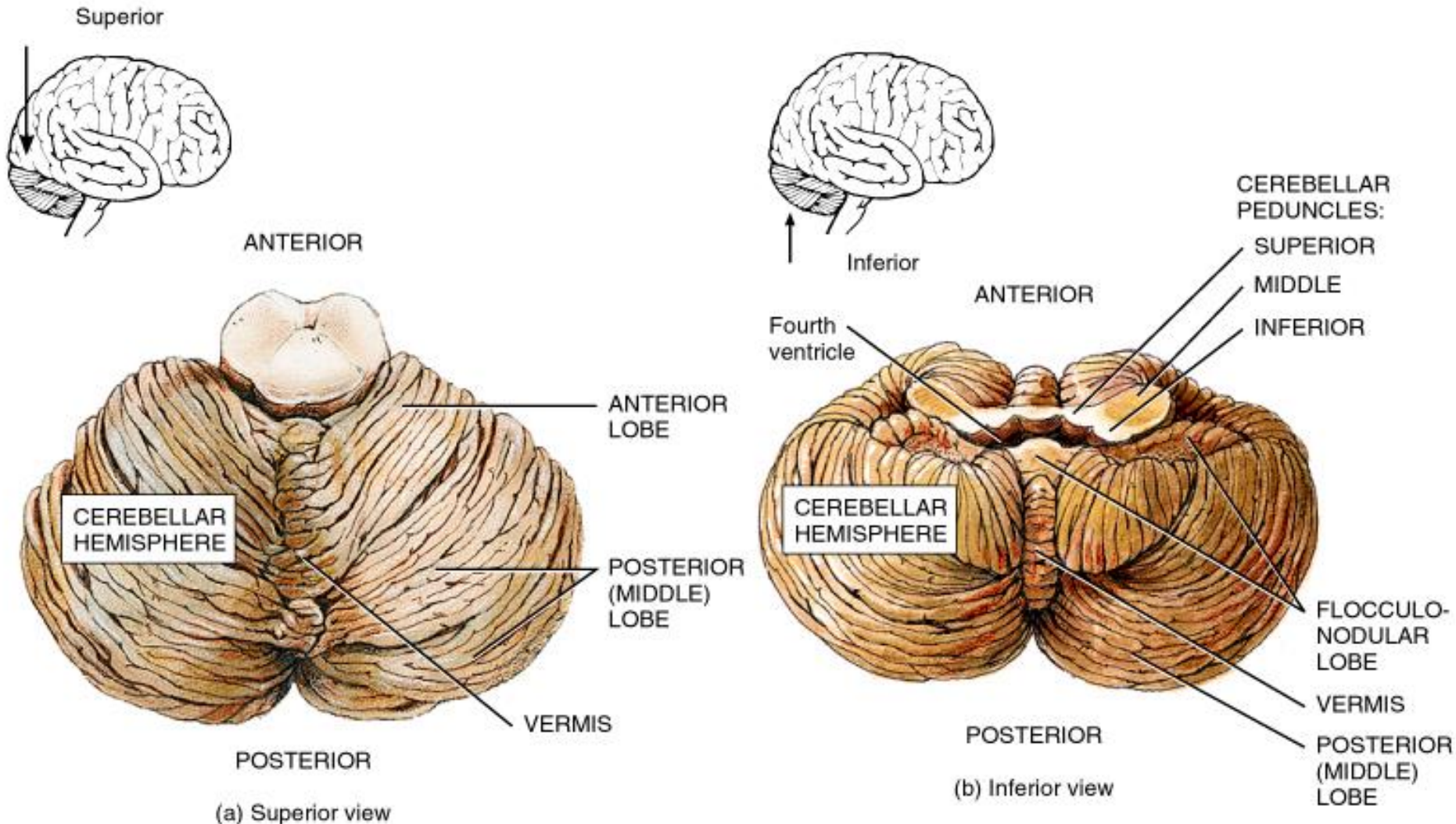
網狀結構

- Scattered nuclei in medulla, pons & midbrain
- Reticular activating system
 - alerts cerebral cortex to sensory signals (sound of alarm, flash light, smoke or intruder) to awaken from sleep
 - maintains consciousness & helps keep you awake with stimuli from ears, eyes, skin and muscles
- Motor function is involvement with maintaining muscle tone



Cerebellum 小腦

Functions: Coordinating skilled movements; regulate posture and balance
All skilled motor activities, from catching basketball to dancing

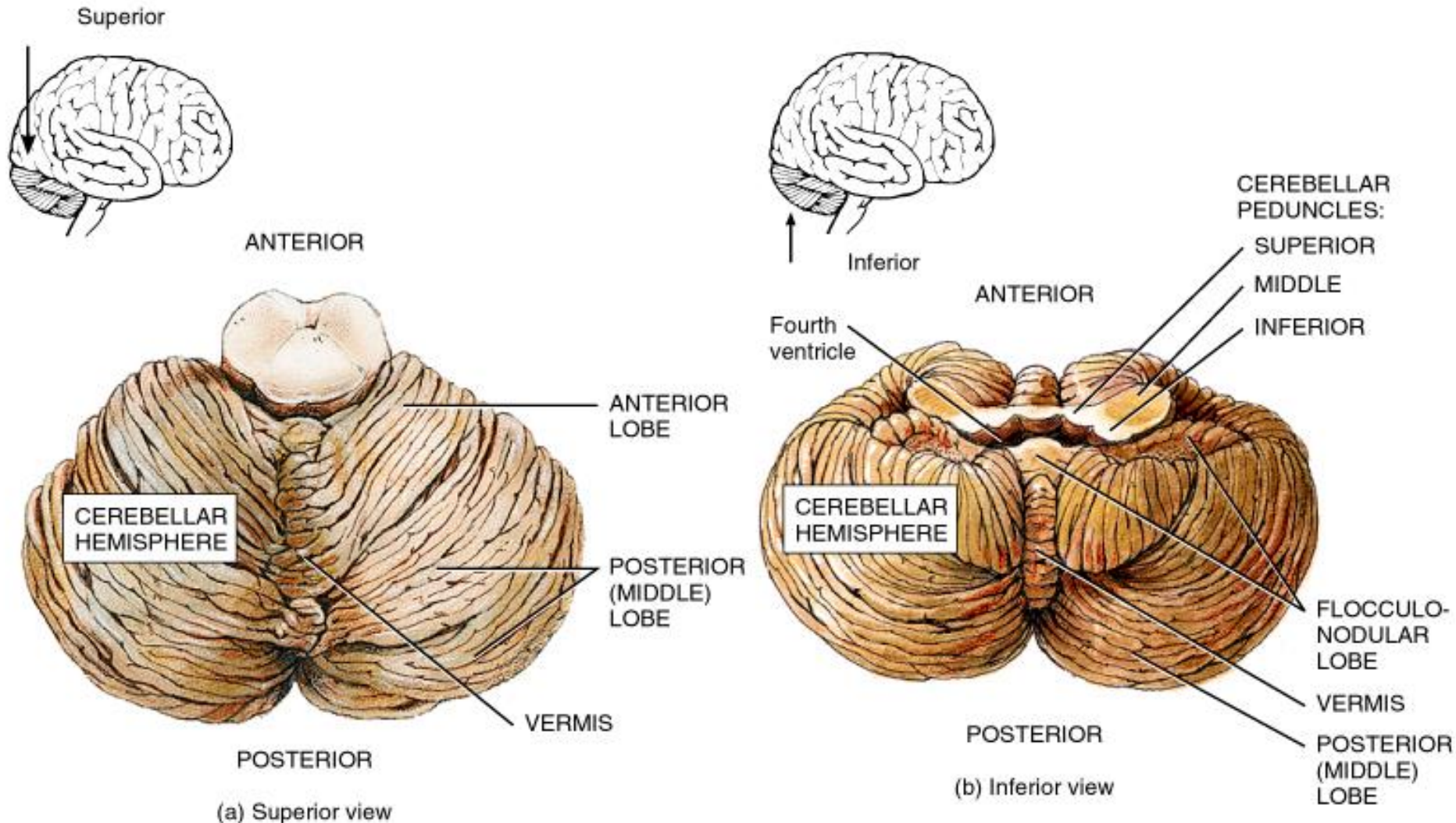


Cerebellar hemispheres and vermis 蚓部

Anterior and Posterior lobes: subconscious movements of skeletal muscles

Flocculonodular lobe 小葉結葉: the sense of equilibrium

Cerebellar hemispheres cortex 小腦半球皮質 (folia 小腦葉): Skilled movements

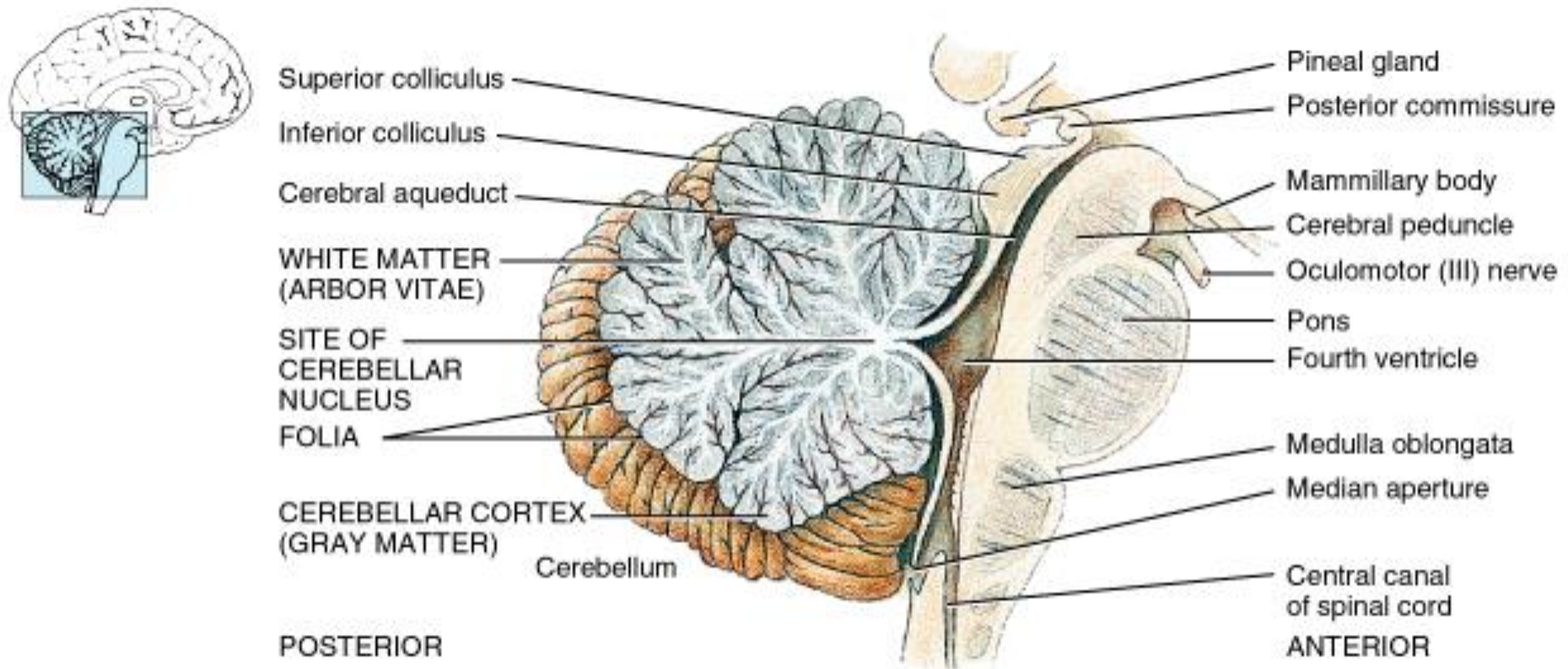


Cerebellar Peduncles 小腦腳

Inferior cerebellar peduncles: medulla oblongata and spinal cord

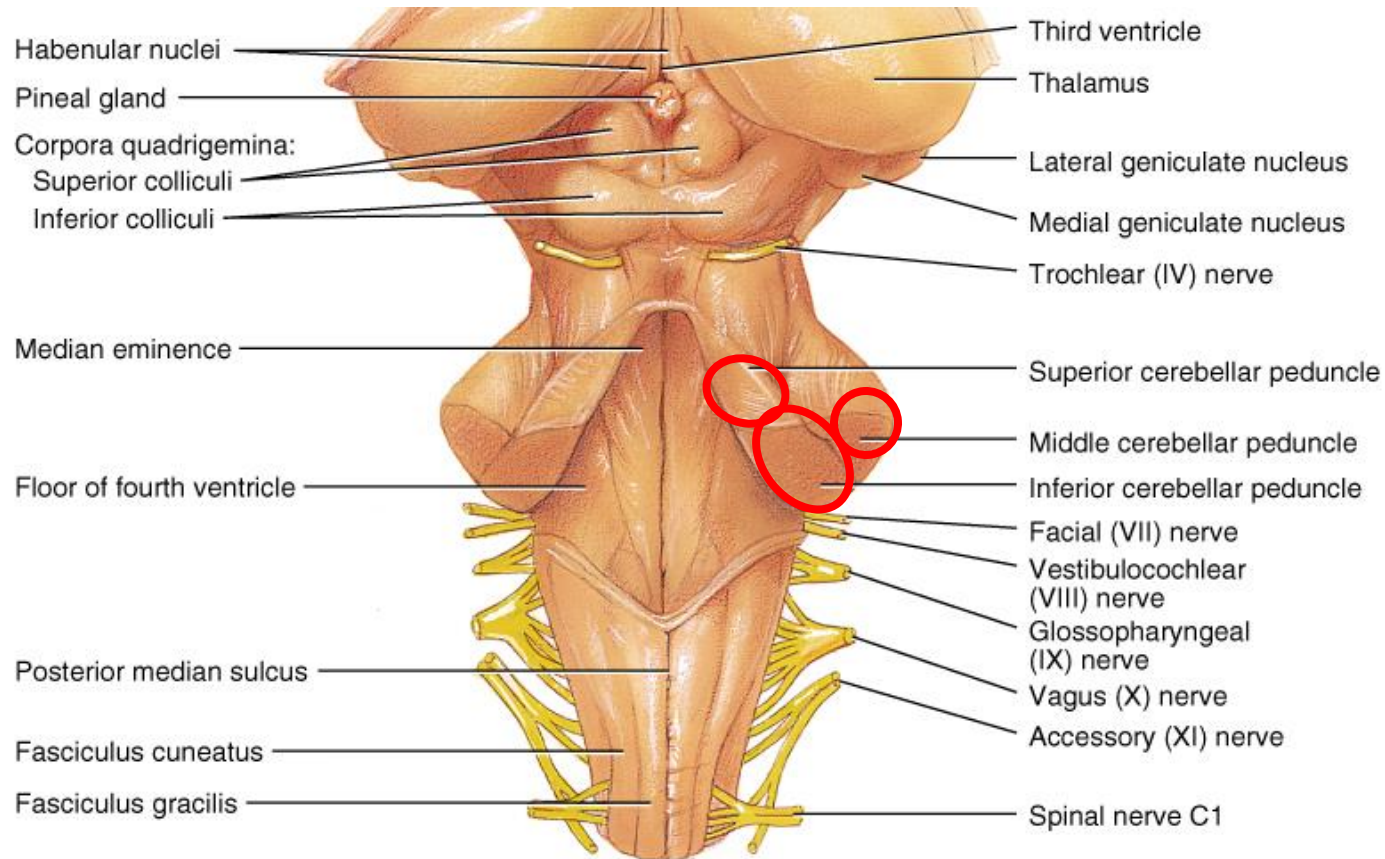
Middle cerebellar peduncles: pons (sensory input from pons)

Superior cerebellar peduncles: midbrain (motor output to midbrain)



(c) Midsagittal section of cerebellum and brain stem

Cerebellar Peduncles 小腦腳

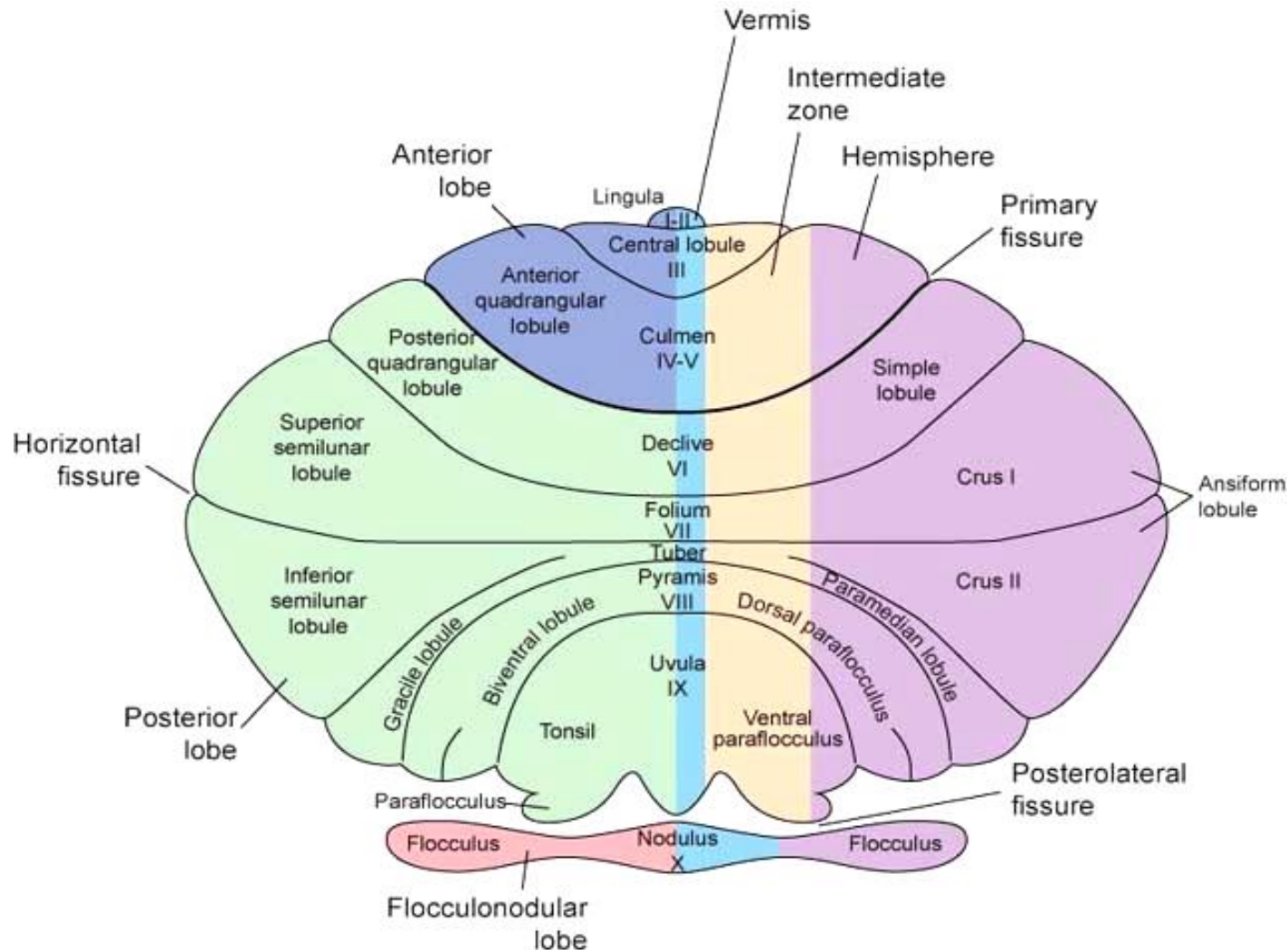


- Superior, middle & inferior peduncles attach to brainstem
 - **inferior** carries sensory information from spinal cord
 - **middle** carries fibers from the pons
 - **superior** carries motor fibers that extend to red nucleus

Cerebellar Functions: Motor learning and Cognitive functions

1. Lateral Hemispheres: Planning Movements

2. Intermediate zones: Adjusting limb movement
3. Vermis: Postural adjustments
4. Flocculus and Vermis: Eyes movements



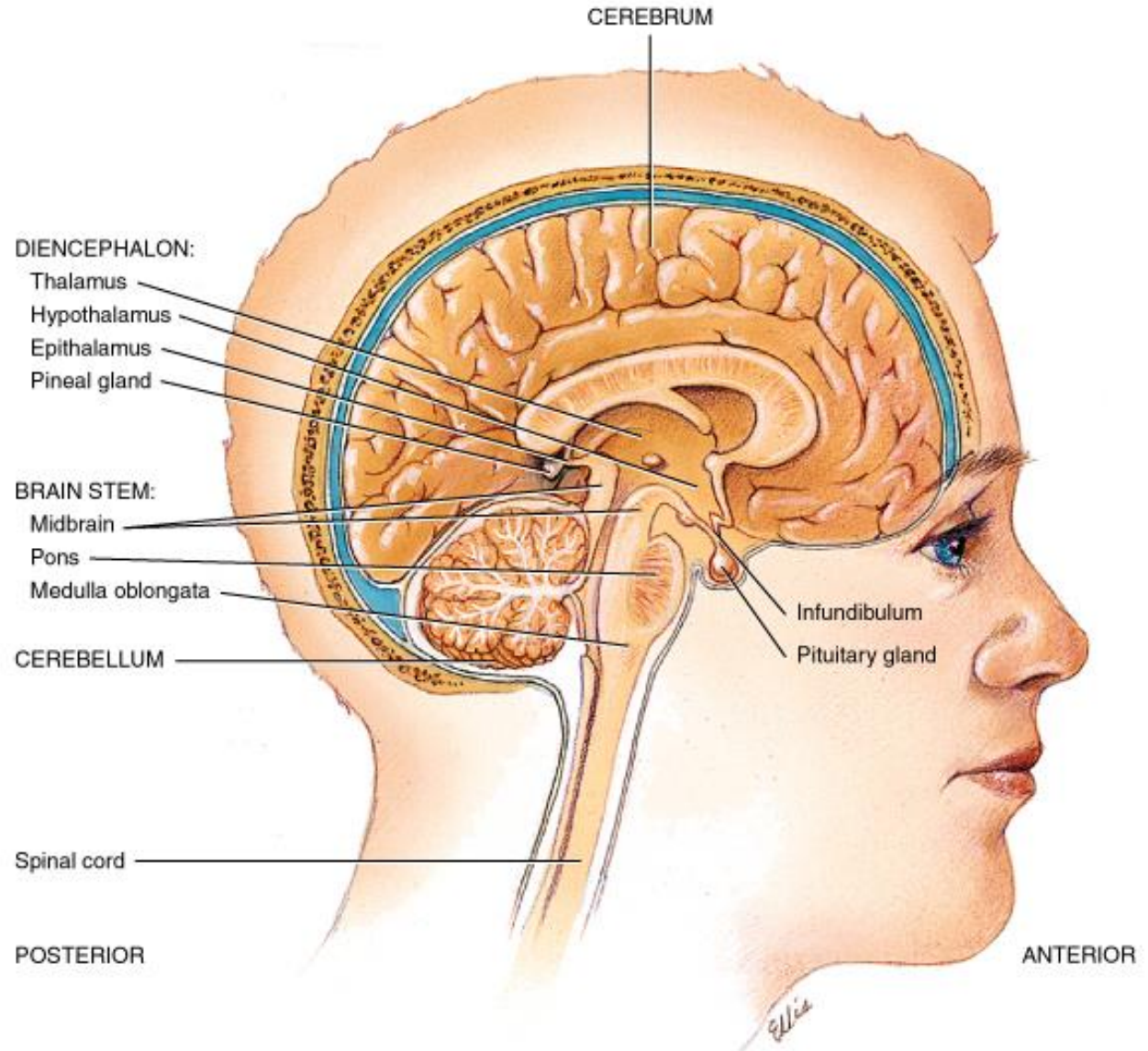
Diencephalon 間腦

Epithalamus 上視丘

Thalamus 丘腦

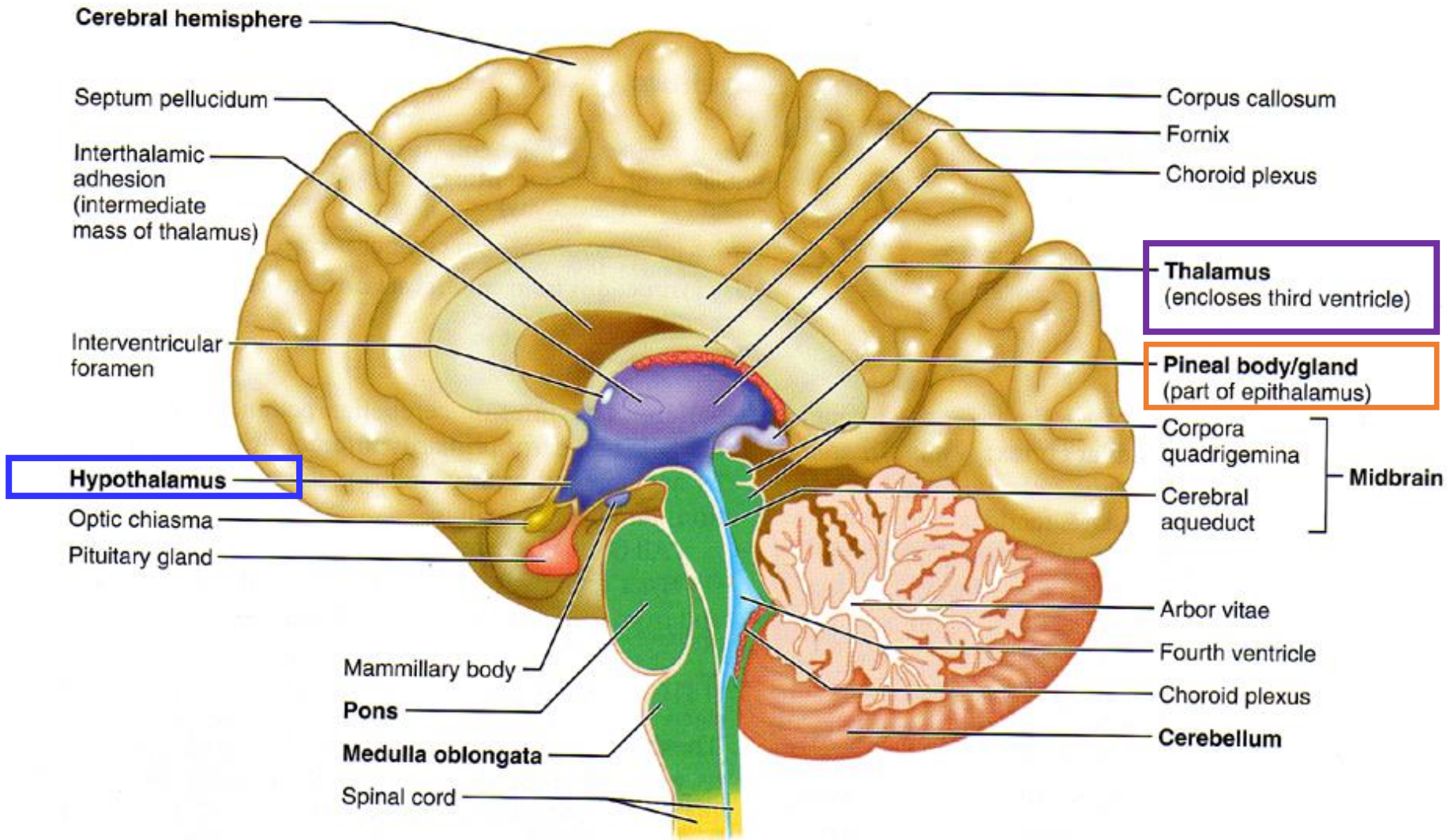
Subthalamus 底丘腦

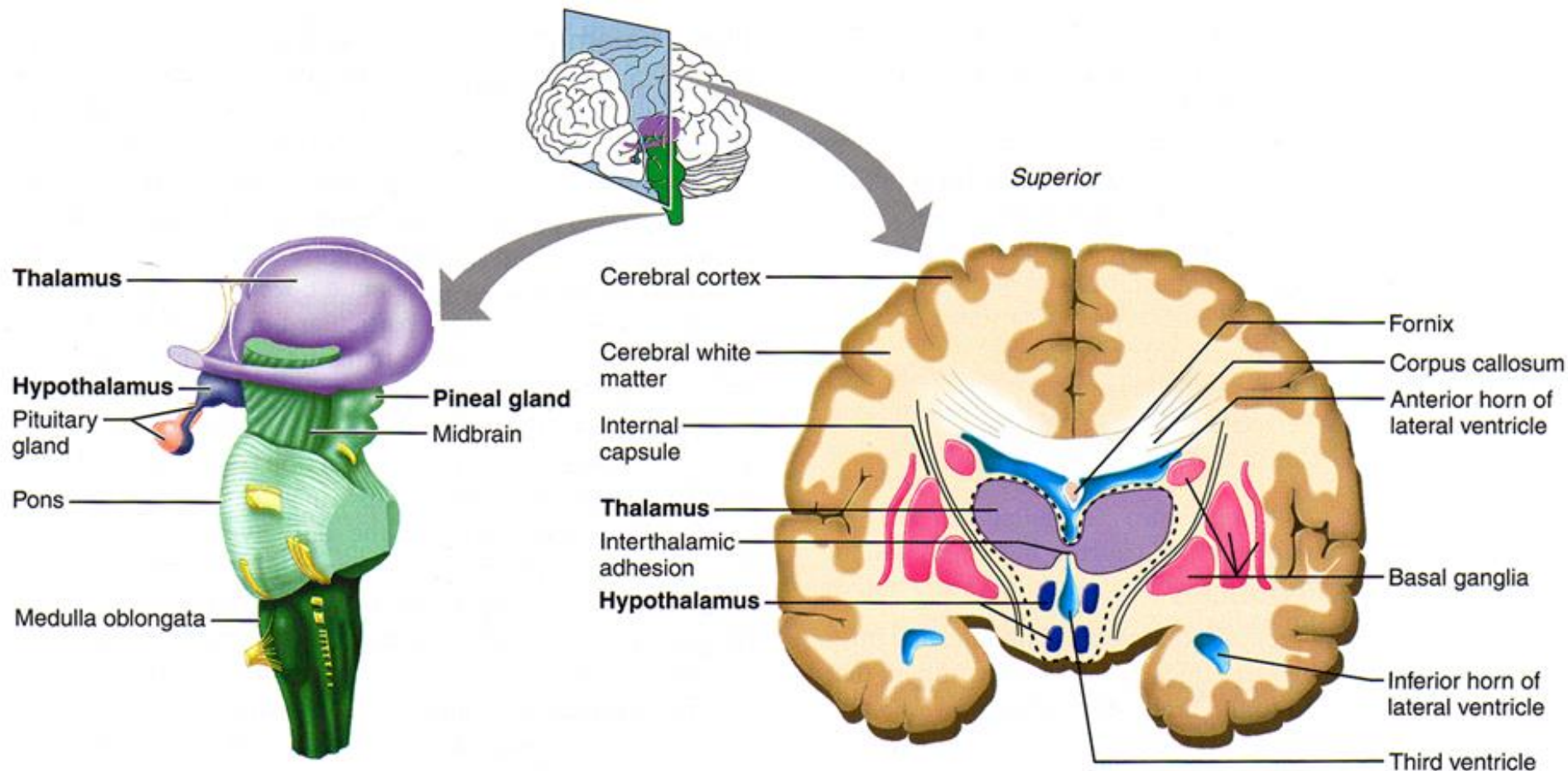
Hypothalamus 下視丘



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

Diencephalon 間腦



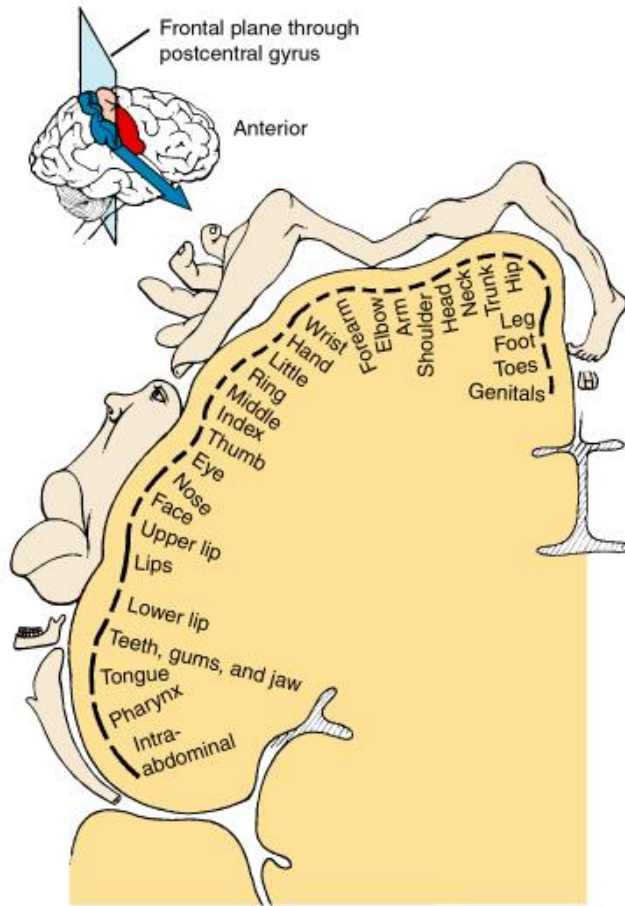


- 1 inch long mass of gray mater in each half of brain (connected across the 3rd ventricle by intermediate mass)
- Relay station for sensory information on way to cortex
- Crude perception of some sensations

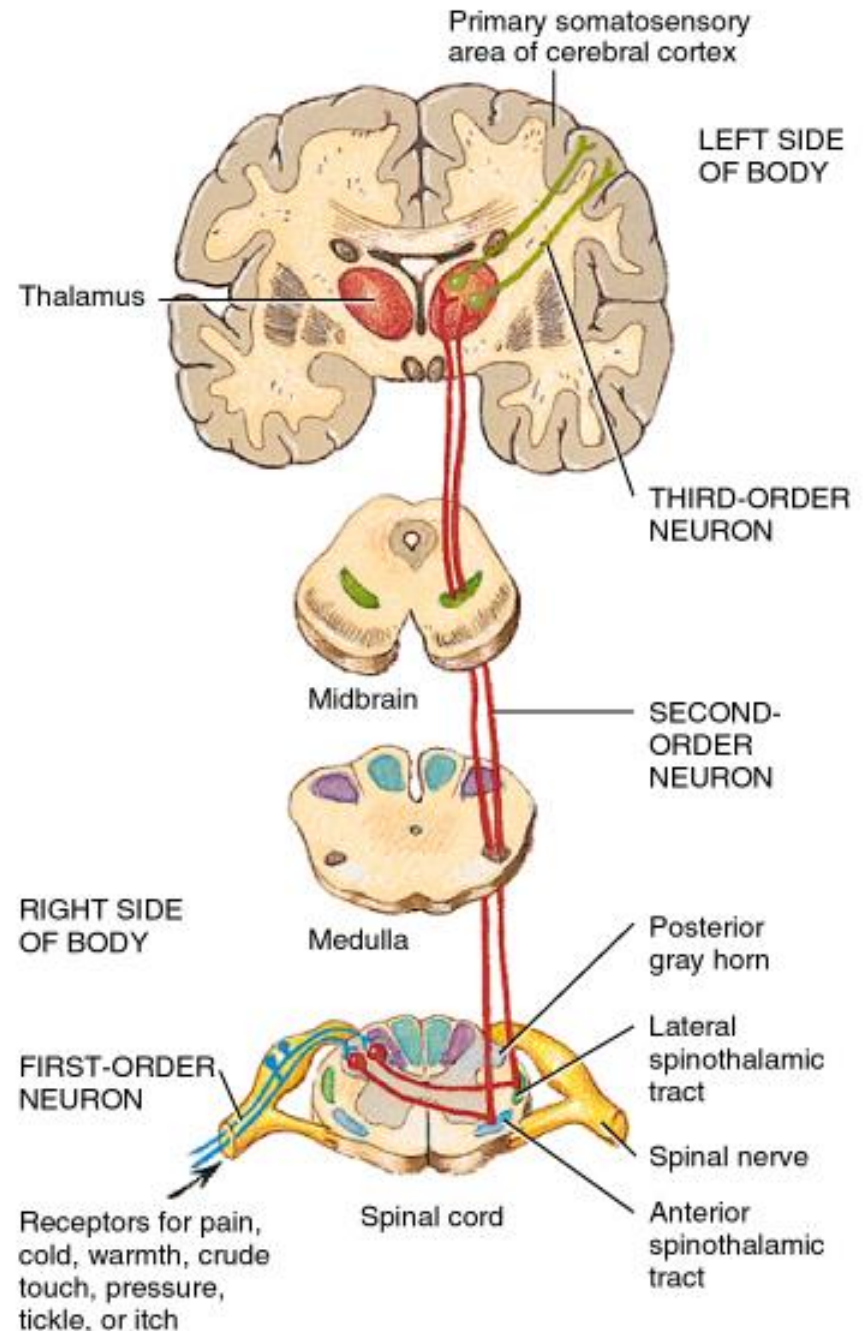
Thalamus 丘腦:

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



Thalamus 丘腦:

***Medial geniculate nucleus** 內膝狀核: **hearing**

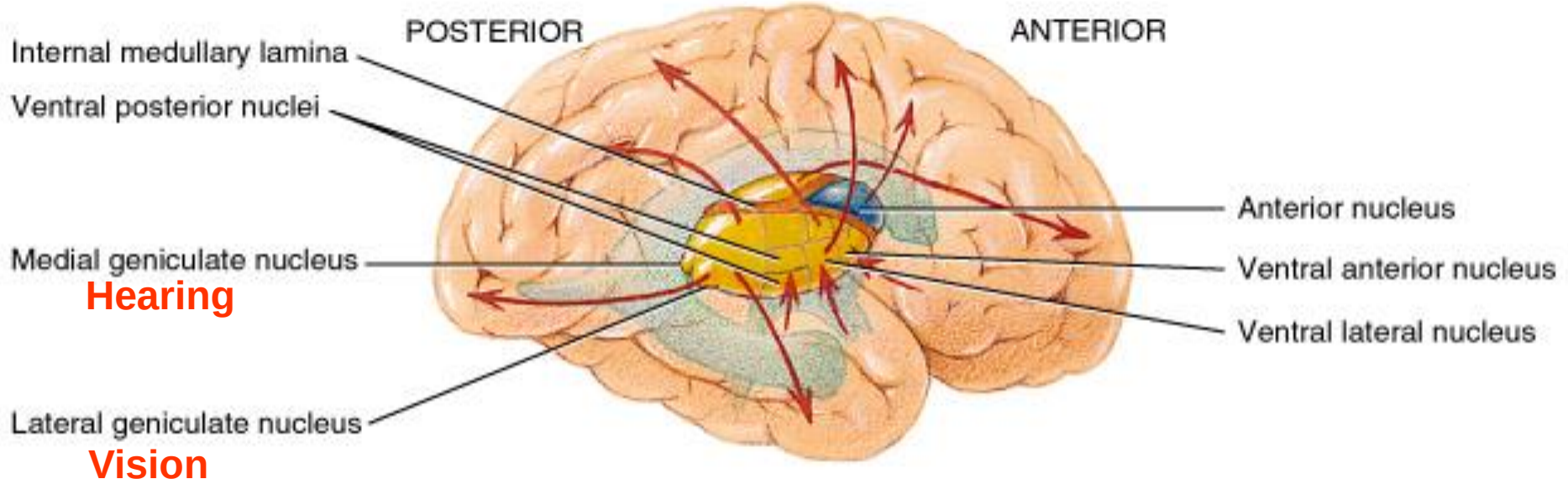
***Lateral geniculate nucleus** 外膝狀核: **vision**

***Ventral posterior nucleus**: taste and somatic sensations such as touch, pressure, vibration, heat, cold and pain)

***Anterior nucleus**: emotions and memory

***Ventral lateral nucleus and Ventral anterior nucleus**: voluntary motor actions and arousal

Cognition center 認知中心: awareness and in the acquisition of knowledge



(a) Diagram of right lateral view showing thalamic nuclei

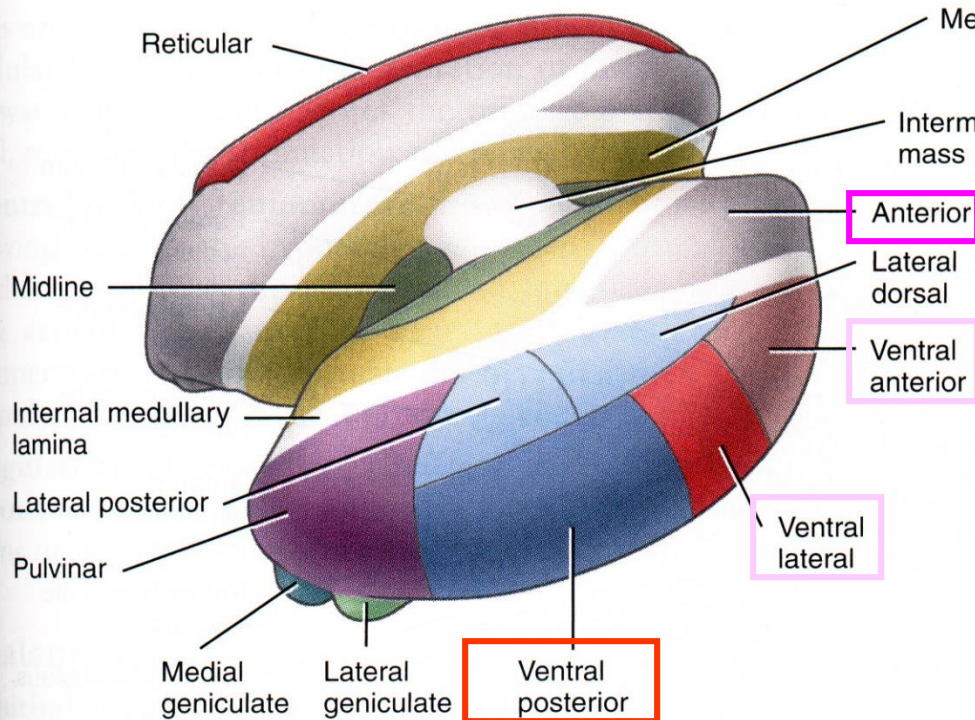
Thalamus 丘腦:

***Ventral posterior nucleus**: taste and somatic sensations such as touch, pressure, vibration, heat, cold and pain)

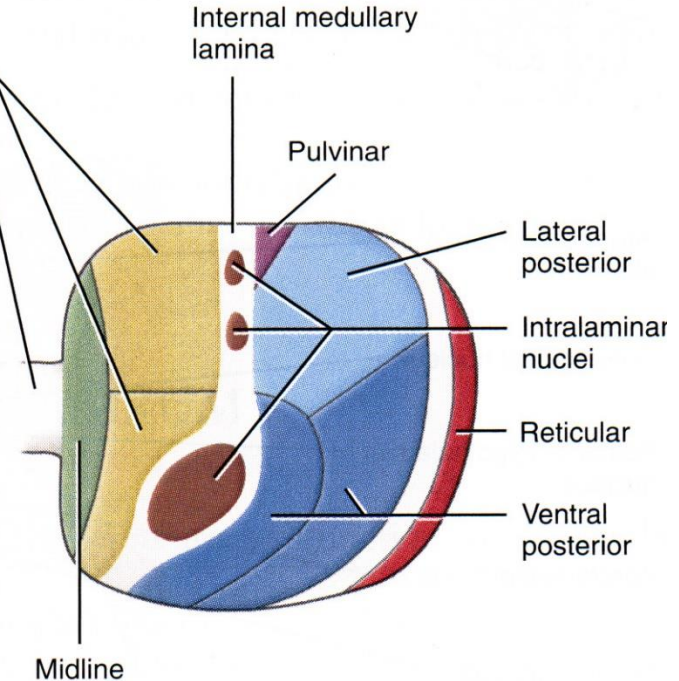
***Anterior nucleus**: emotions and memory

***Ventral lateral nucleus and Ventral anterior nucleus**: voluntary motor actions and arousal

Cognition center 認知中心: awareness and in the acquisition of knowledge



(d) Superolateral view of thalamus showing locations of thalamic nuclei (reticular nucleus is shown on the left side only; all other nuclei are shown on the right side)

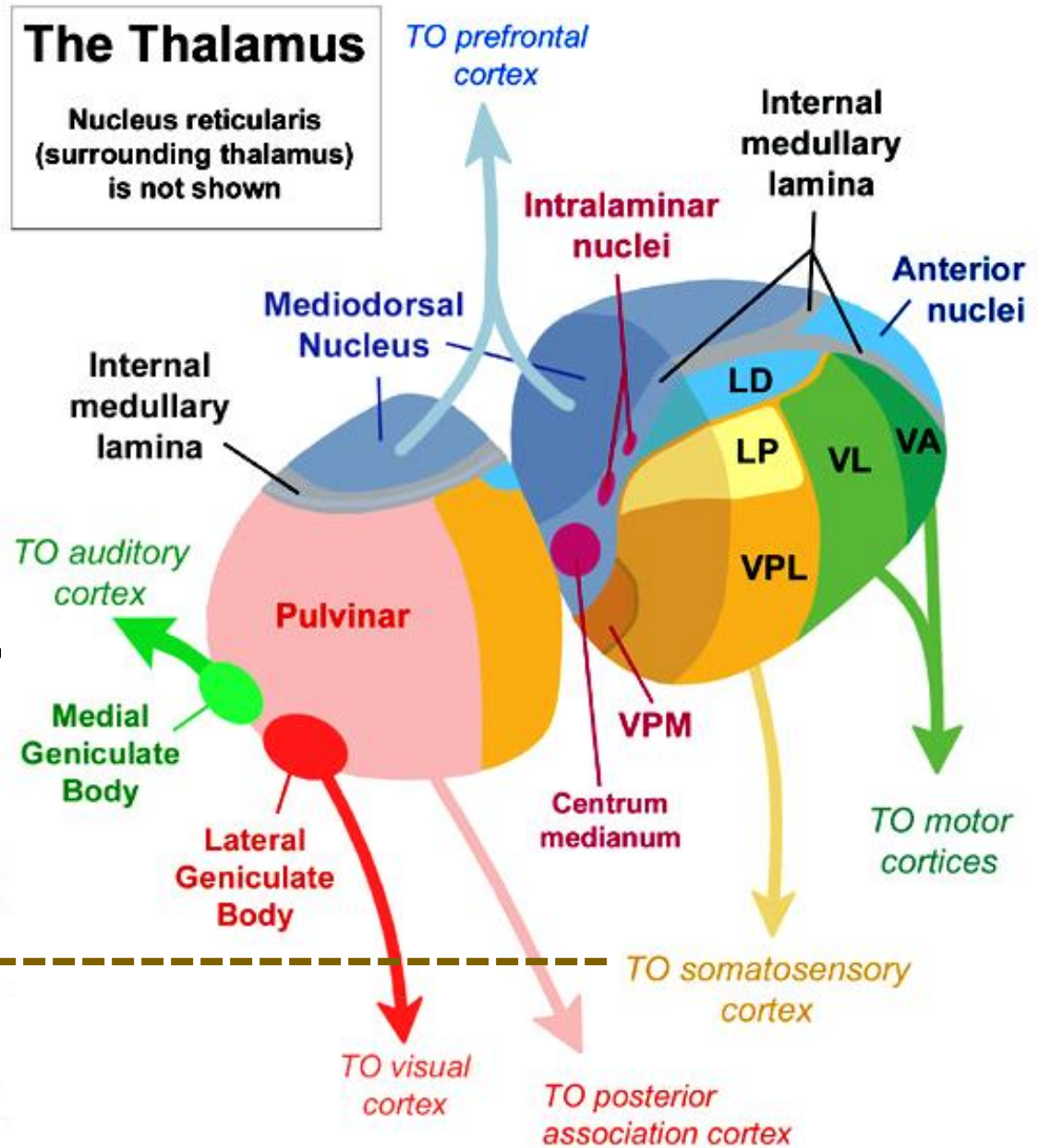
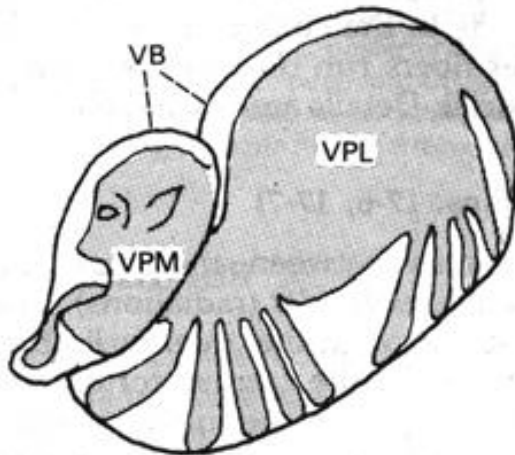


(e) Transverse section of right side of thalamus showing locations of thalamic nuclei

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:

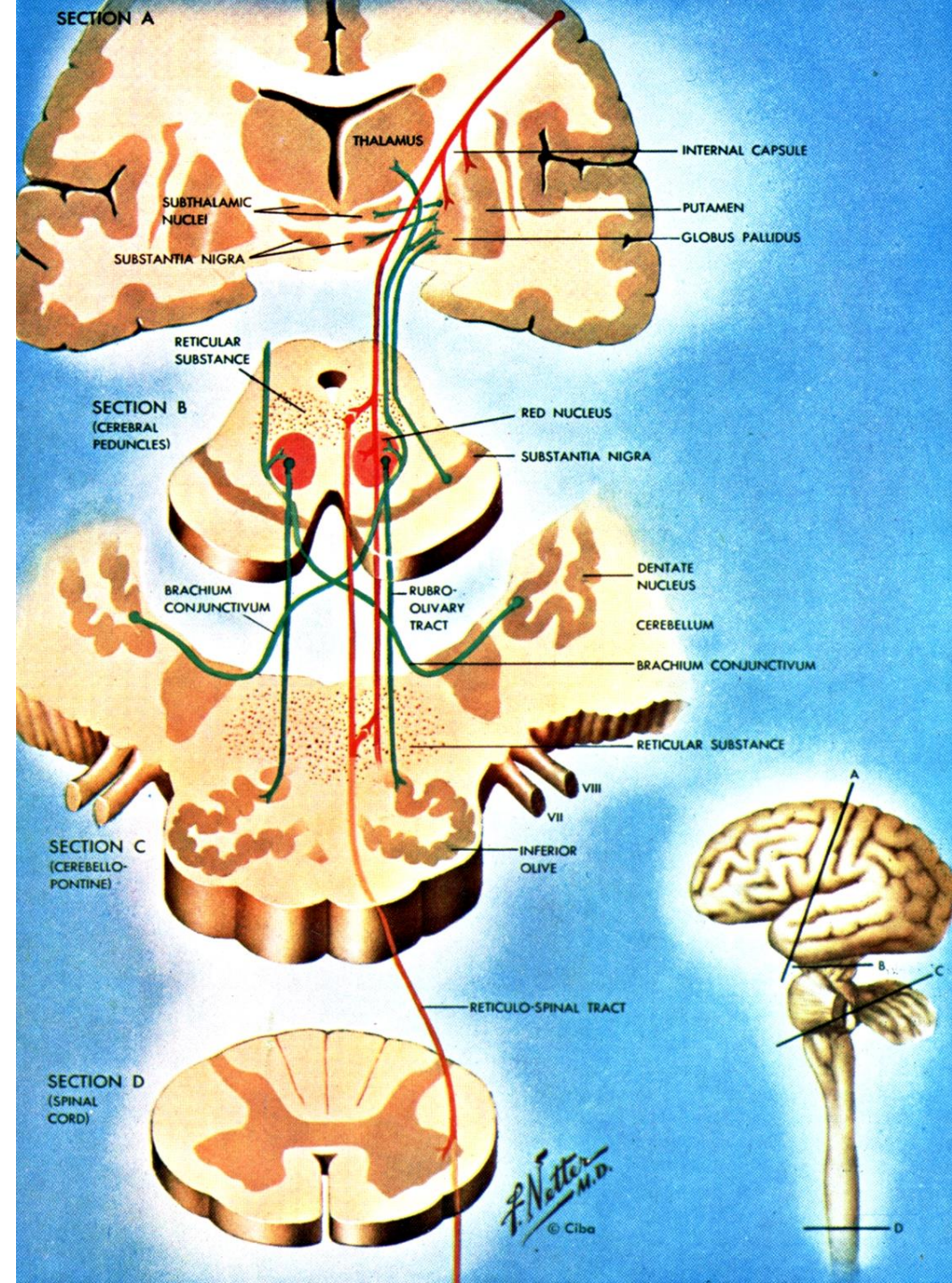
control skeletal muscle

movements and muscle tone

Motor cortex

→ subthalamic nuclei

→ red nuclei and substantia nigra



Hypothalamus 下視丘

mammillary region 乳頭區: mammillary bodies and posterior hypothalamic nucleus

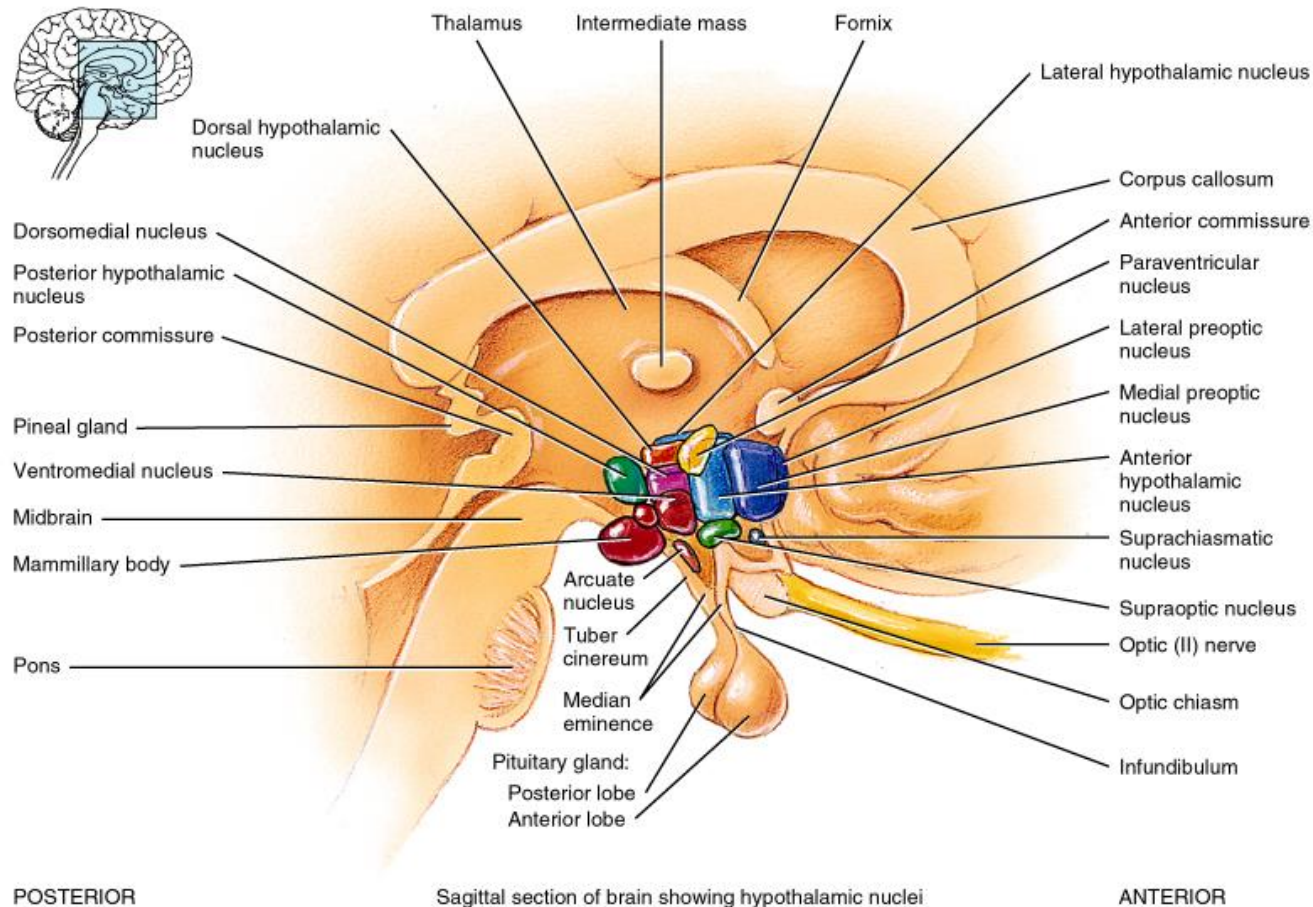
mammillary bodies 乳頭體: relay stations in reflexes to the sense of smell.

tuberal region 管區: dorsomedial, ventromedial and arcuate nuclei

tuber cinereum 灰管 and infundibulum 漏斗 → pituitary gland

Median eminence 正中隆起: *Master of endocrine system

hypothalamic regulating hormones → anterior pituitary



POSTERIOR

© Addison Wesley Longman, Inc.

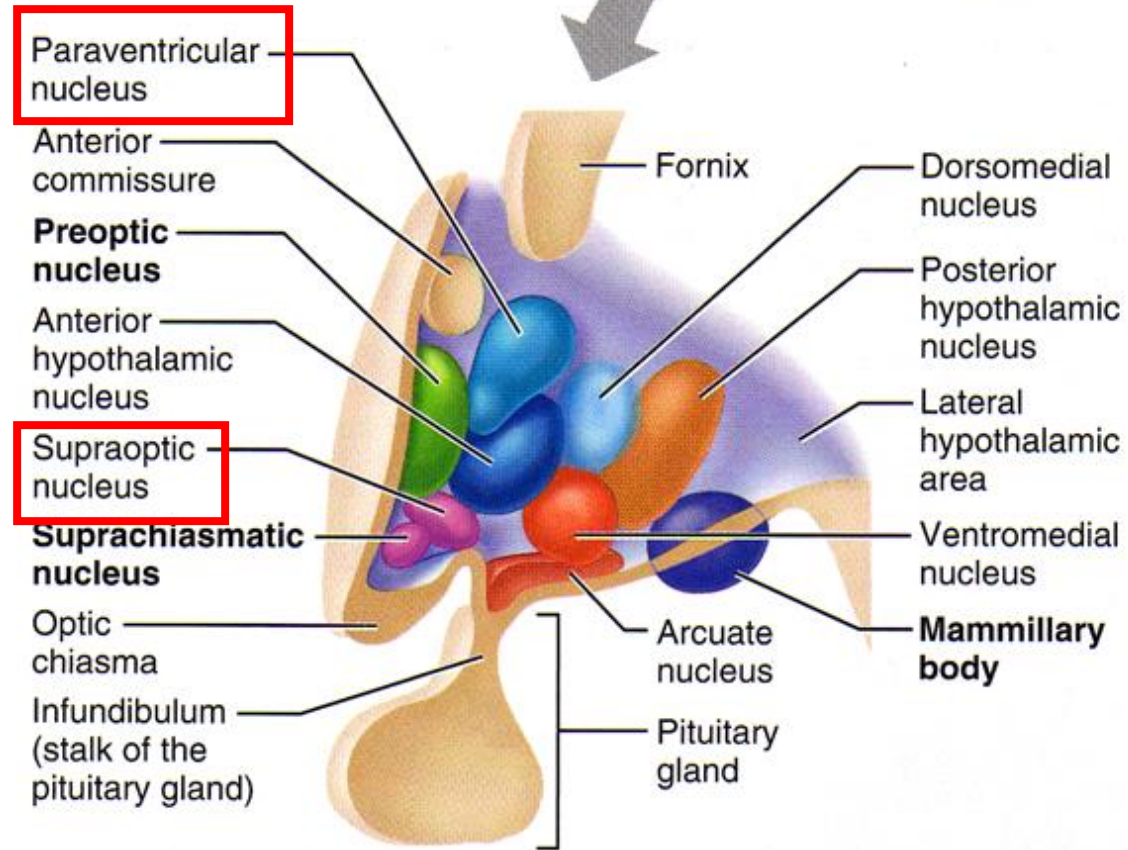
Sagittal section of brain showing hypothalamic nuclei

ANTERIOR

Hypothalamus

- Dozen or so nuclei in 4 major regions

- **Paraventricular nu. & supraoptic nu.** send axons through the infundibulum into posterior lobe of the pituitary gland



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

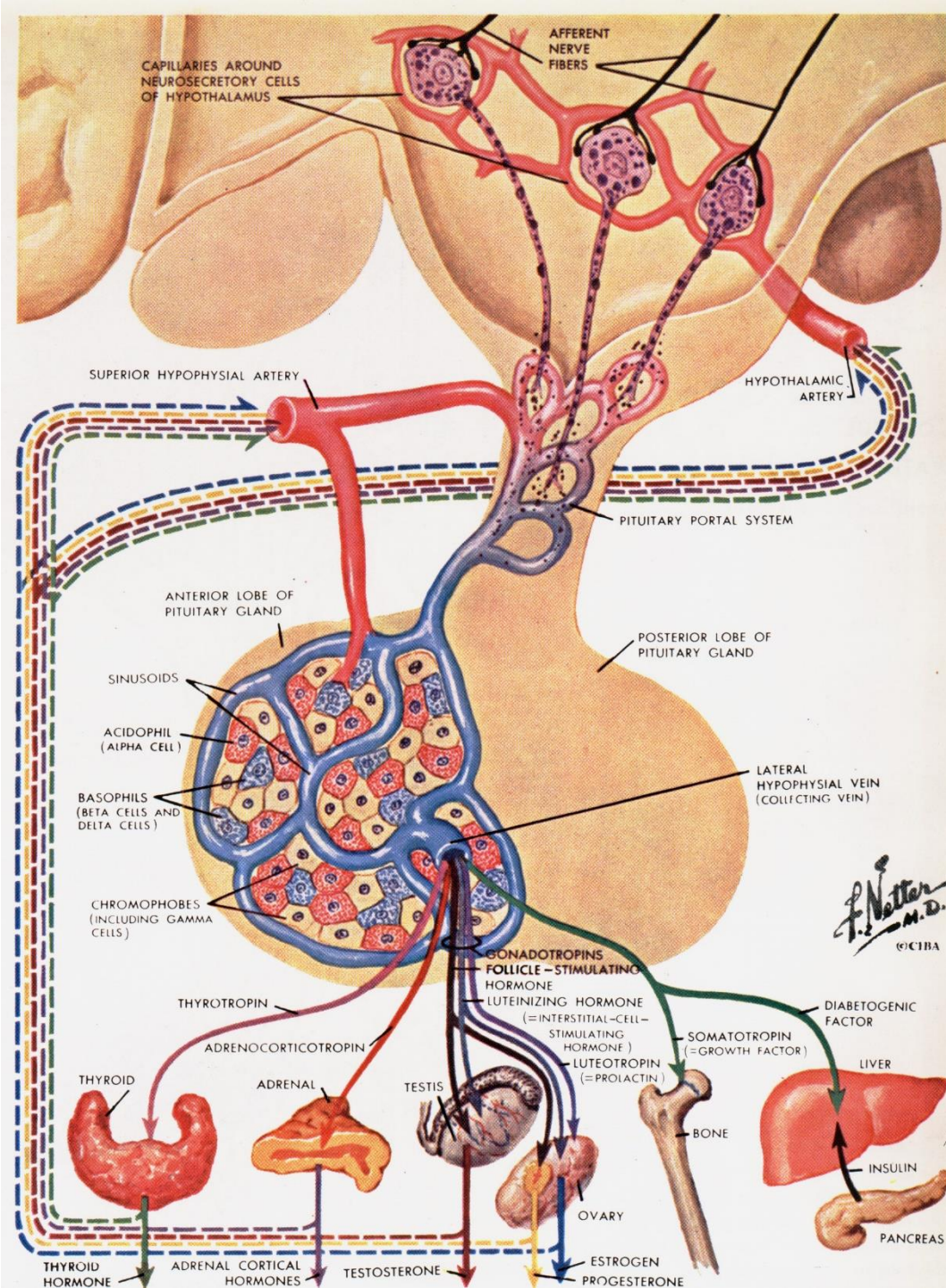
Tuberal region 管區:

dorsomedial, ventromedial and arcuate nuclei

tuber cinereum 灰管 and
infundibulum 漏斗
→ pituitary gland

Median eminence 正中隆起:

***Master of endocrine system**
hypothalamic regulating
hormones → anterior pituitary



Supraoptic region 視束上區:

Paraventricular nucleus 側室核

→ supraopticohypophyseal tract

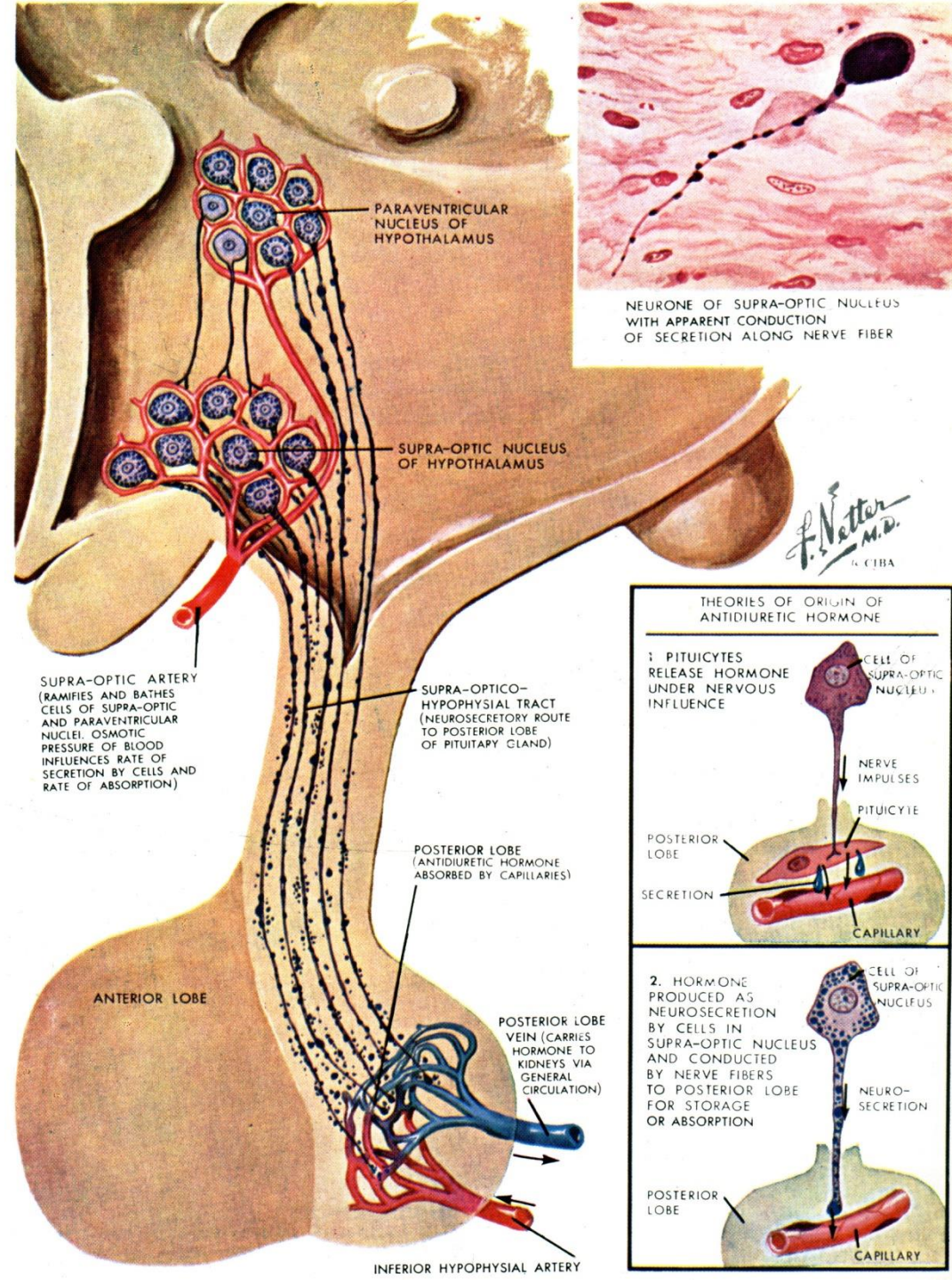
Supraoptic nucleus 視束上核

→ supraopticohypophyseal tract → posterior pituitary

Neuroendocrine:

1. oxytocin 催產素

2. vasopressin 抗利尿激素 (antidiuretic hormone, ADH)



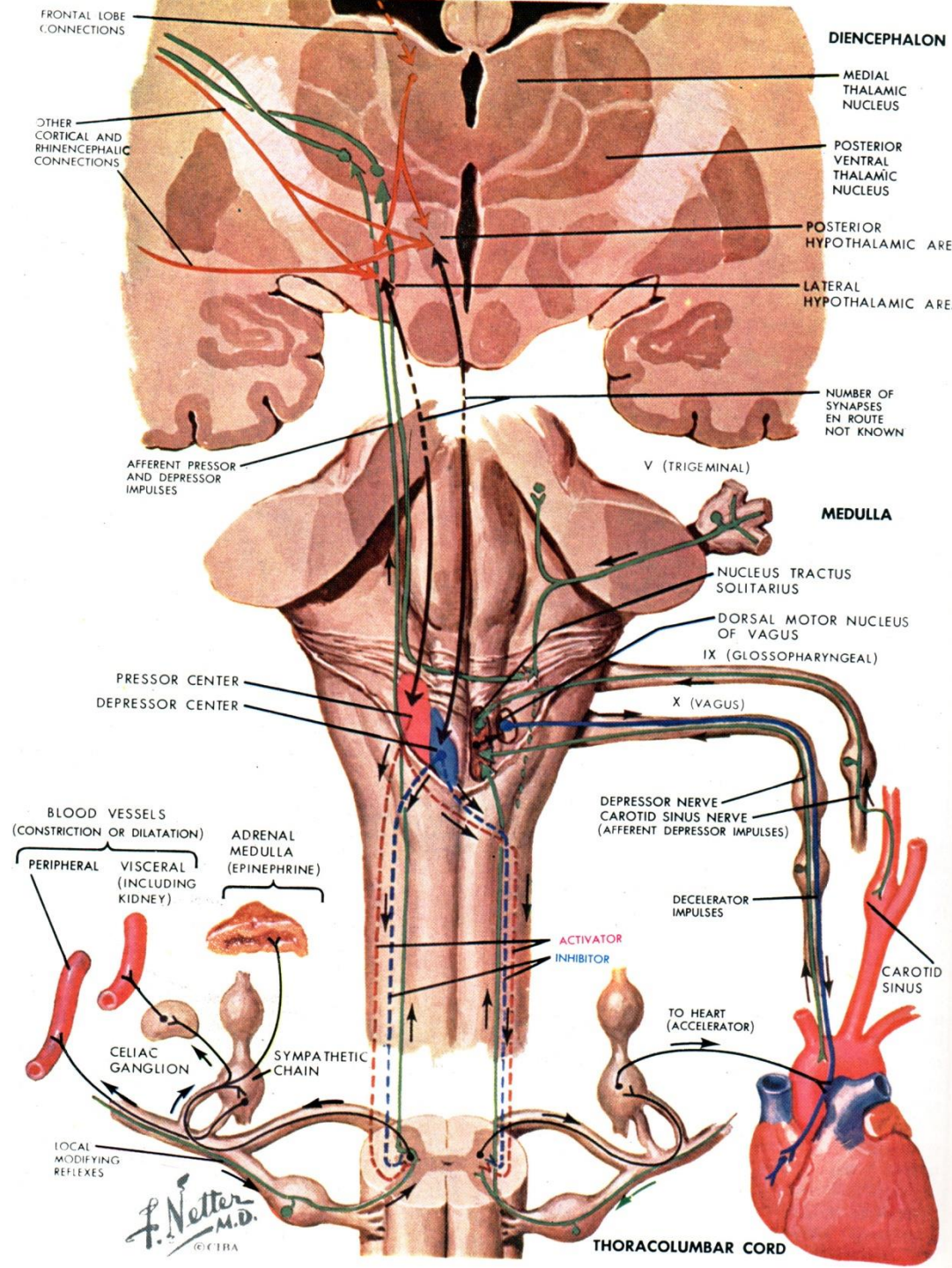
Functions of hypothalamus:

1. controls and integrates activities of the autonomic system

Anterior hypothalamic area
(parasympathetic)

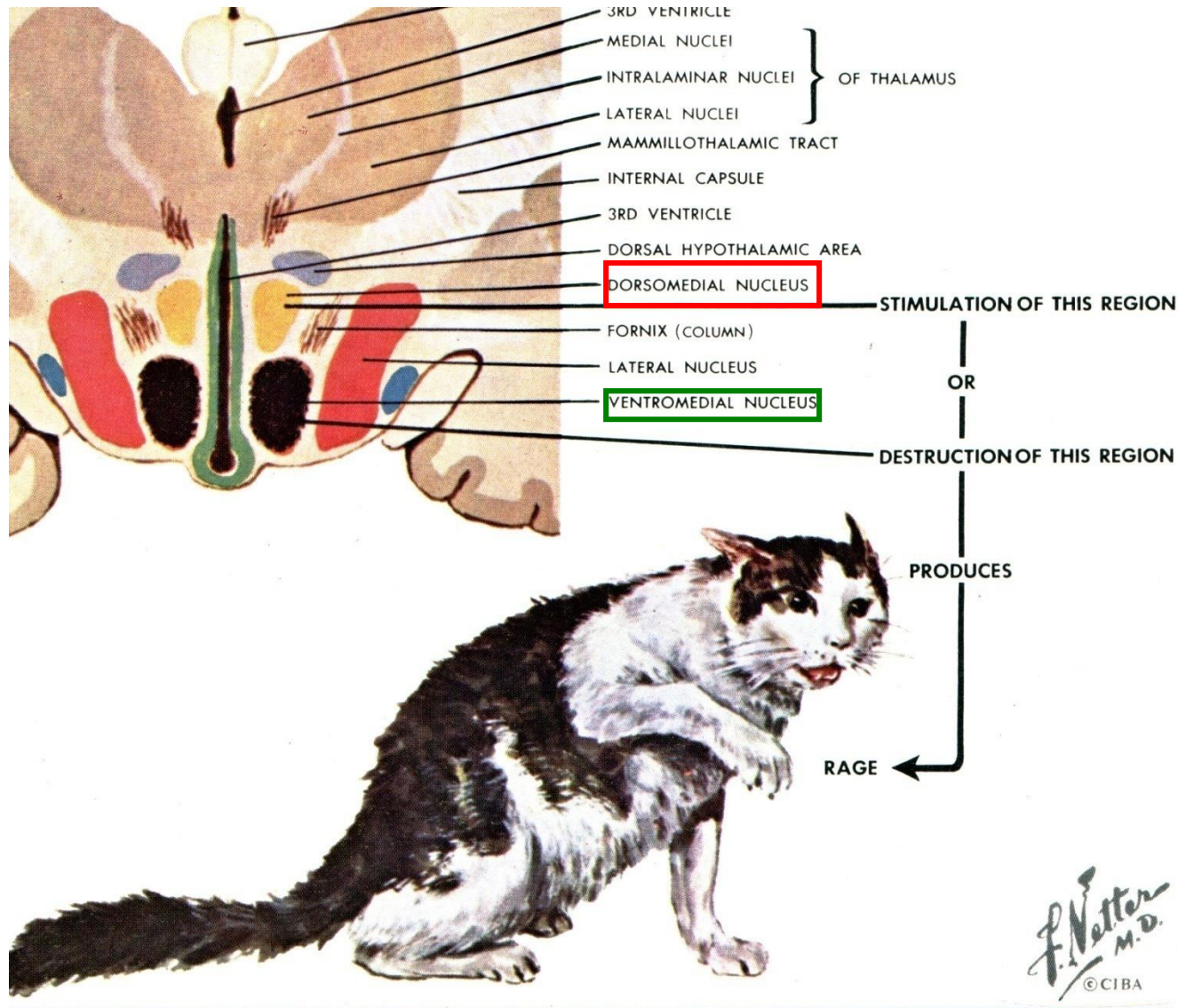
Posterior hypothalamic area
(sympathetic)

Lateral hypothalamic area
(thirst and hunger)



2. associated with feelings of rages and aggression.

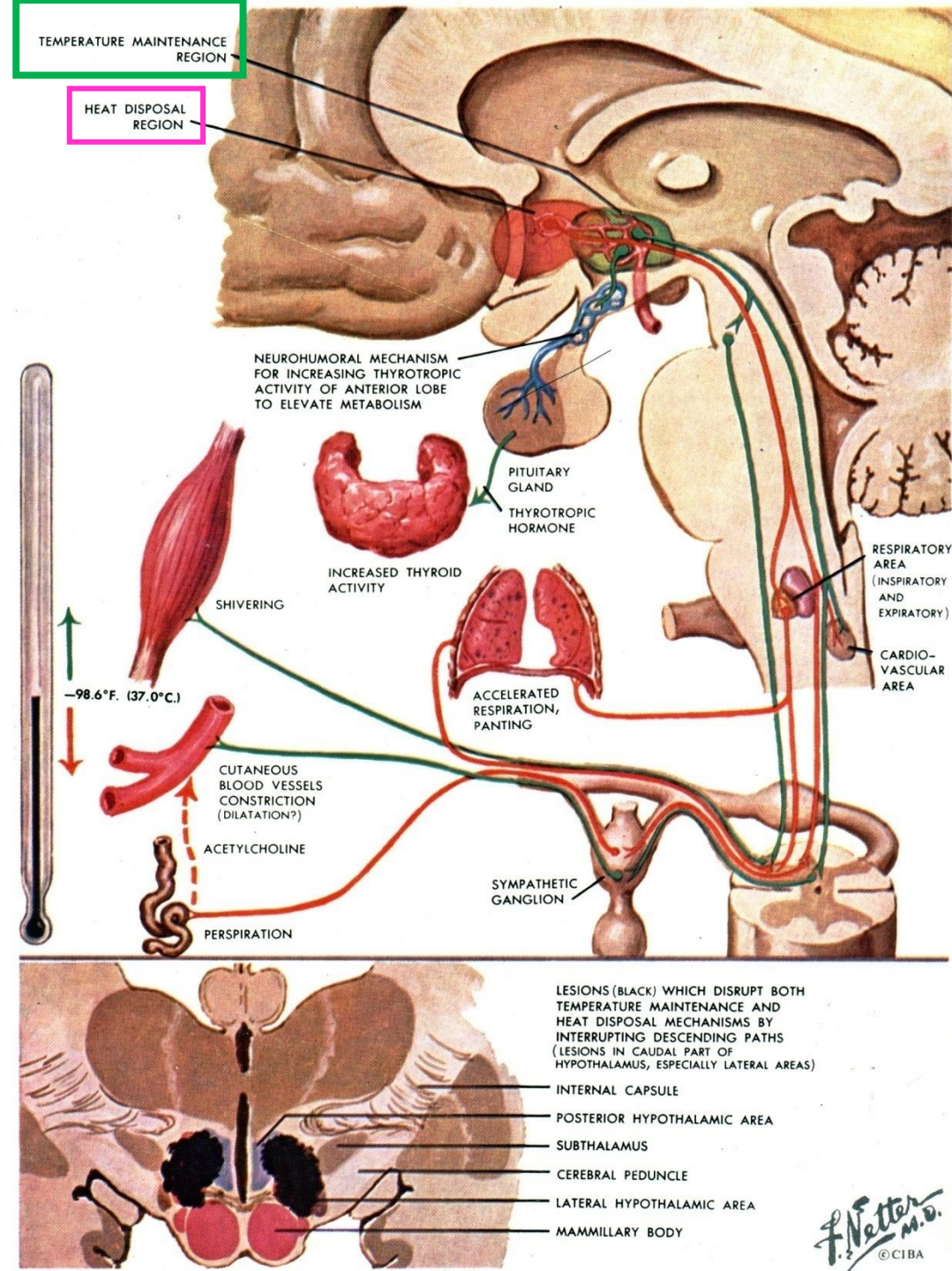
Dorsomedial nucleus (兇) vs. Ventromedial nucleus (善)



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

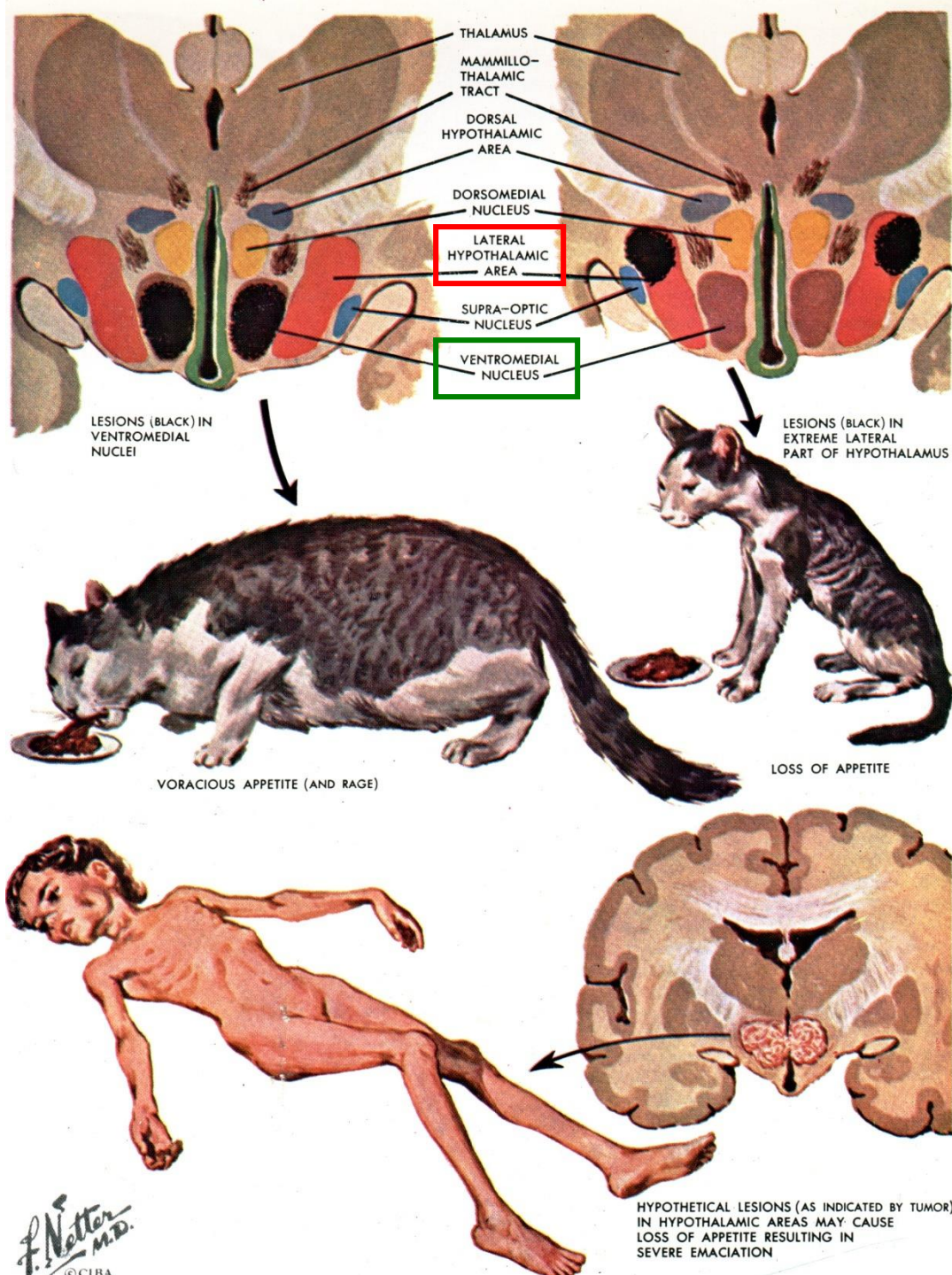
feeding (hunger) center

饑餓中樞:

Lateral hypothalamic area

satiety center (飽足中樞):

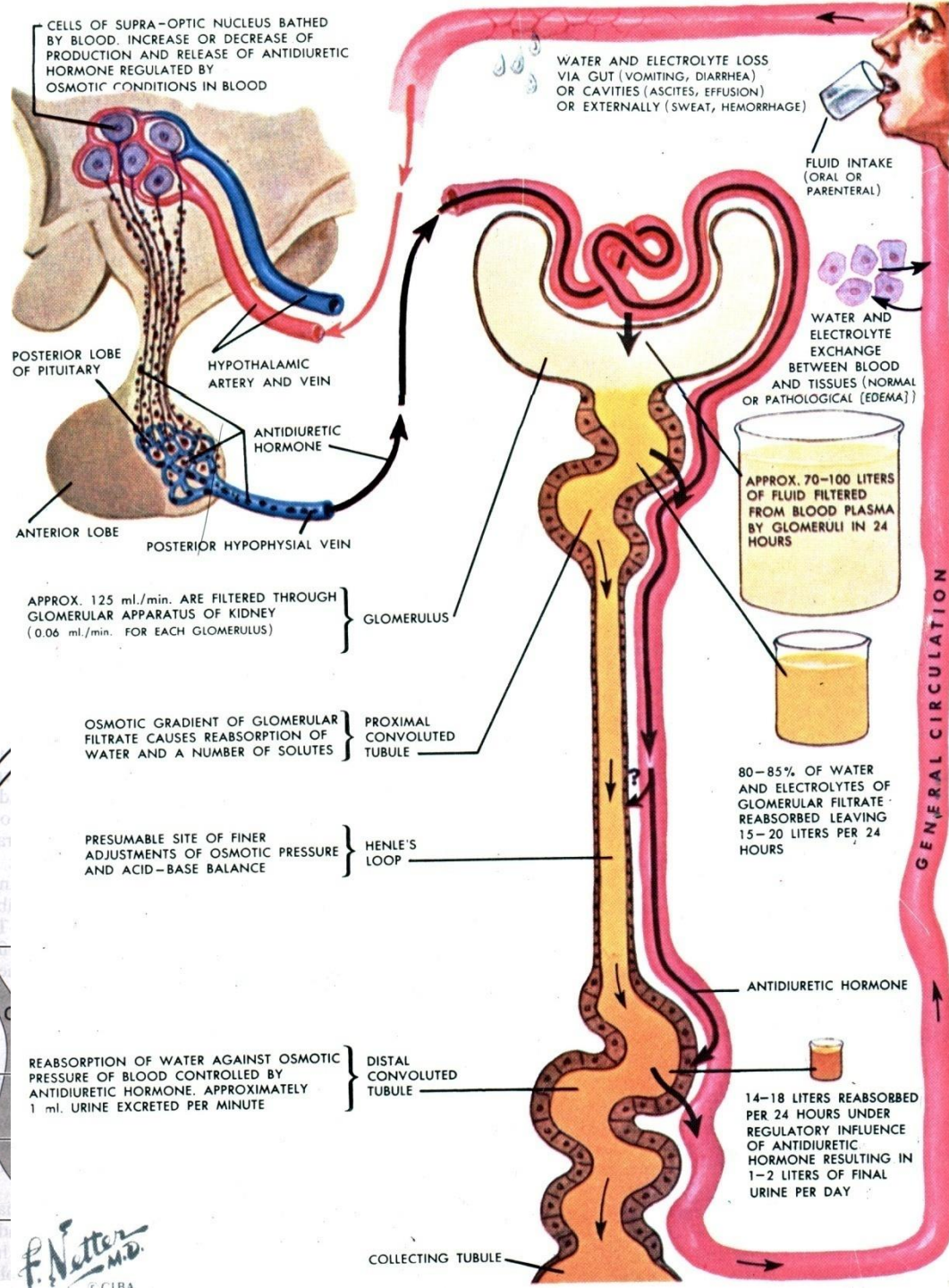
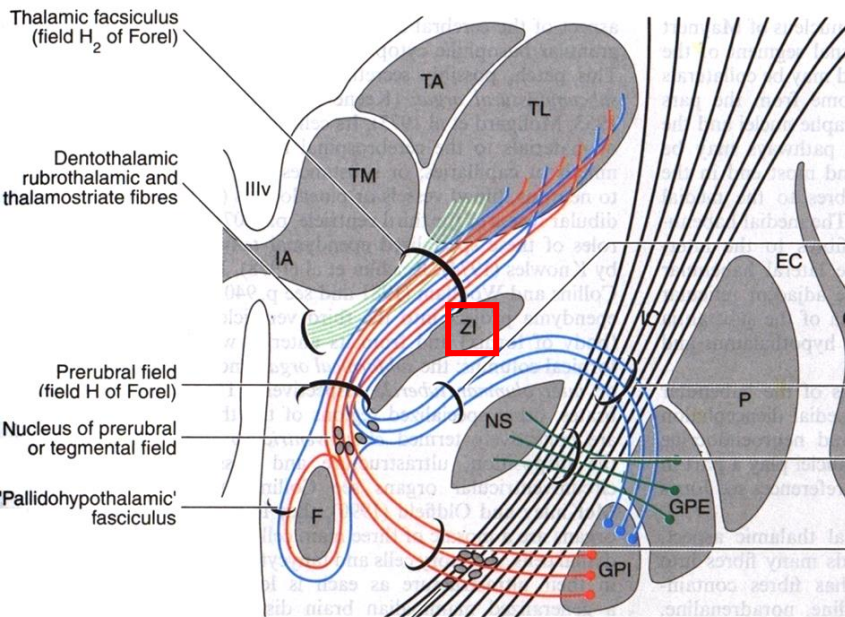
Ventromedial nucleus (VM)
(善)



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

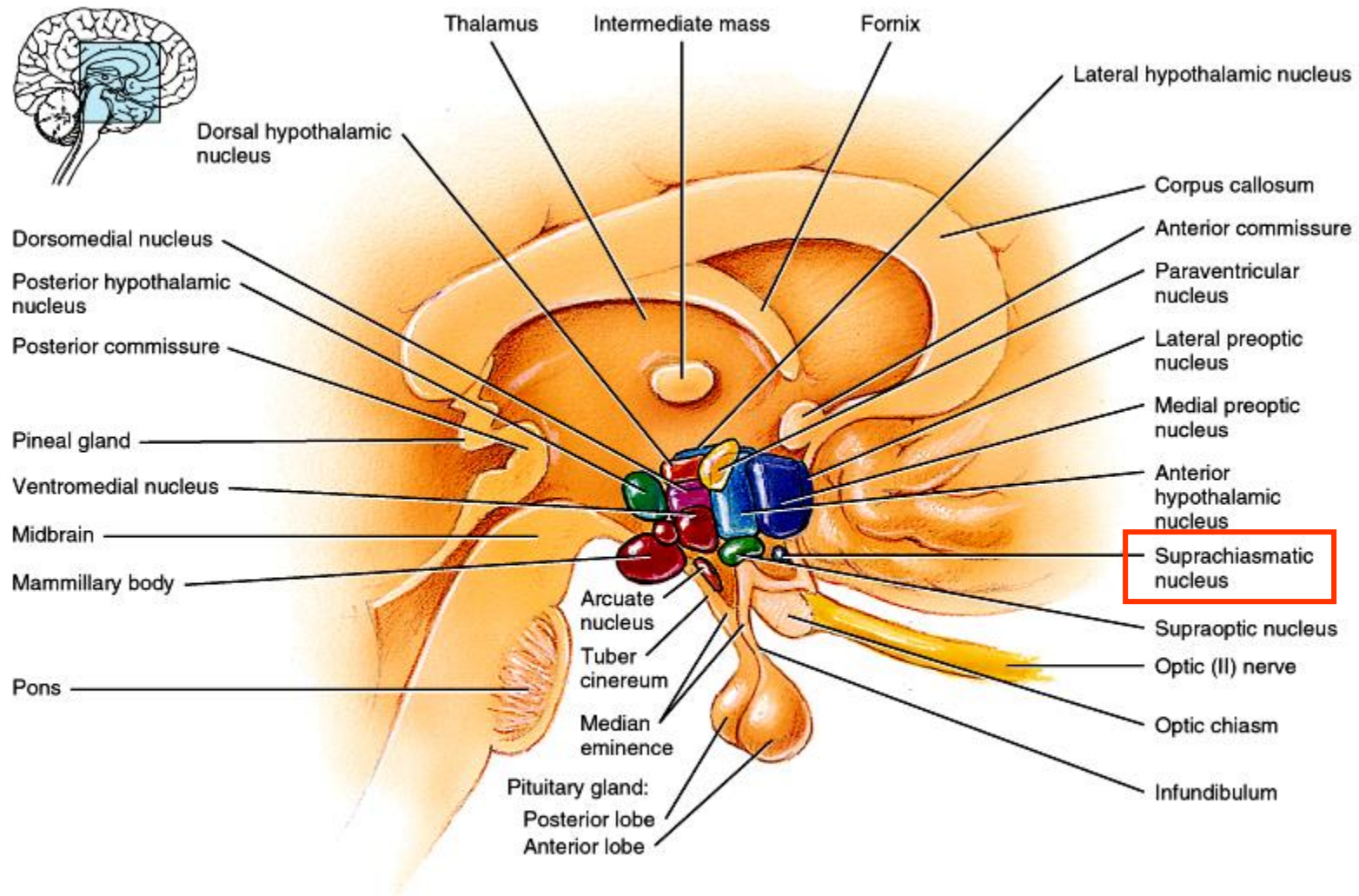
paraventricular nucleus
supraoptic nucleus →
posterior pituitary (ADH)

Zona incerta: regulation of
drinking behavior



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

Suprachiasmatic nucleus



POSTERIOR

Sagittal section of brain showing hypothalamic nuclei

ANTERIOR

7. Endocrine functions:

tuber cinereum and infundibulum → pituitary gland

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

hypothalamic regulating hormones → anterior pituitary

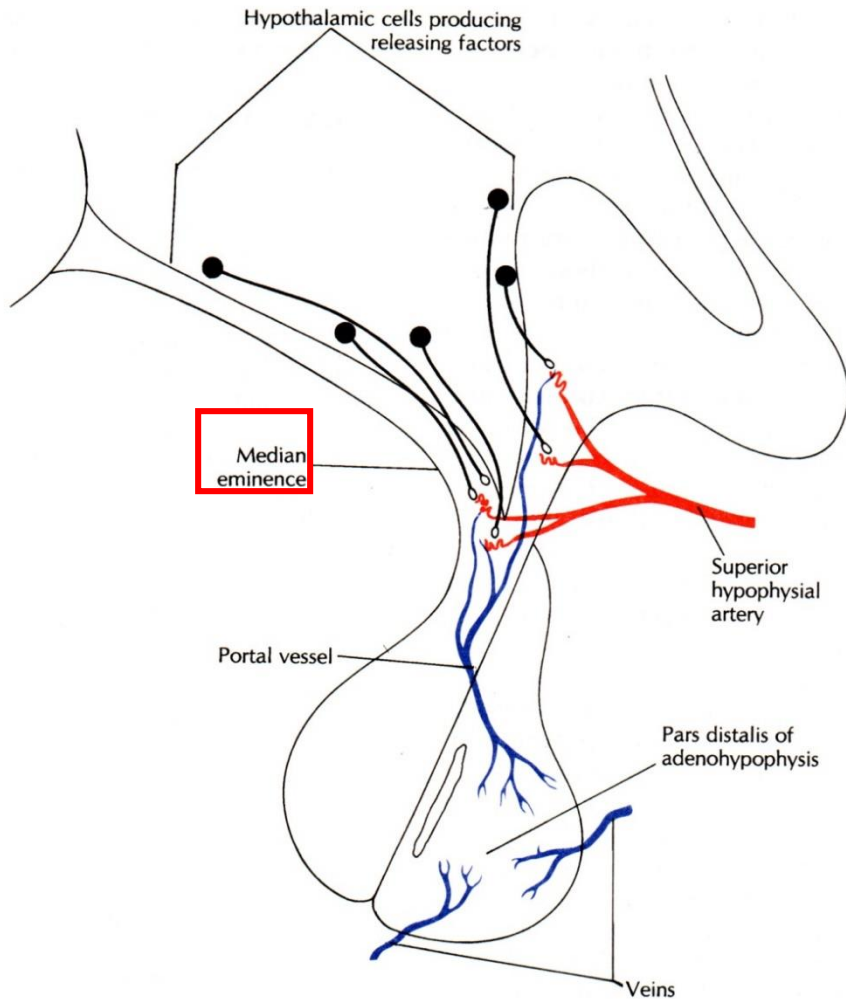


Figure 11-17. The pituitary portal system. Arteries are red; veins are blue; neurons that secrete releasing hormones are black.

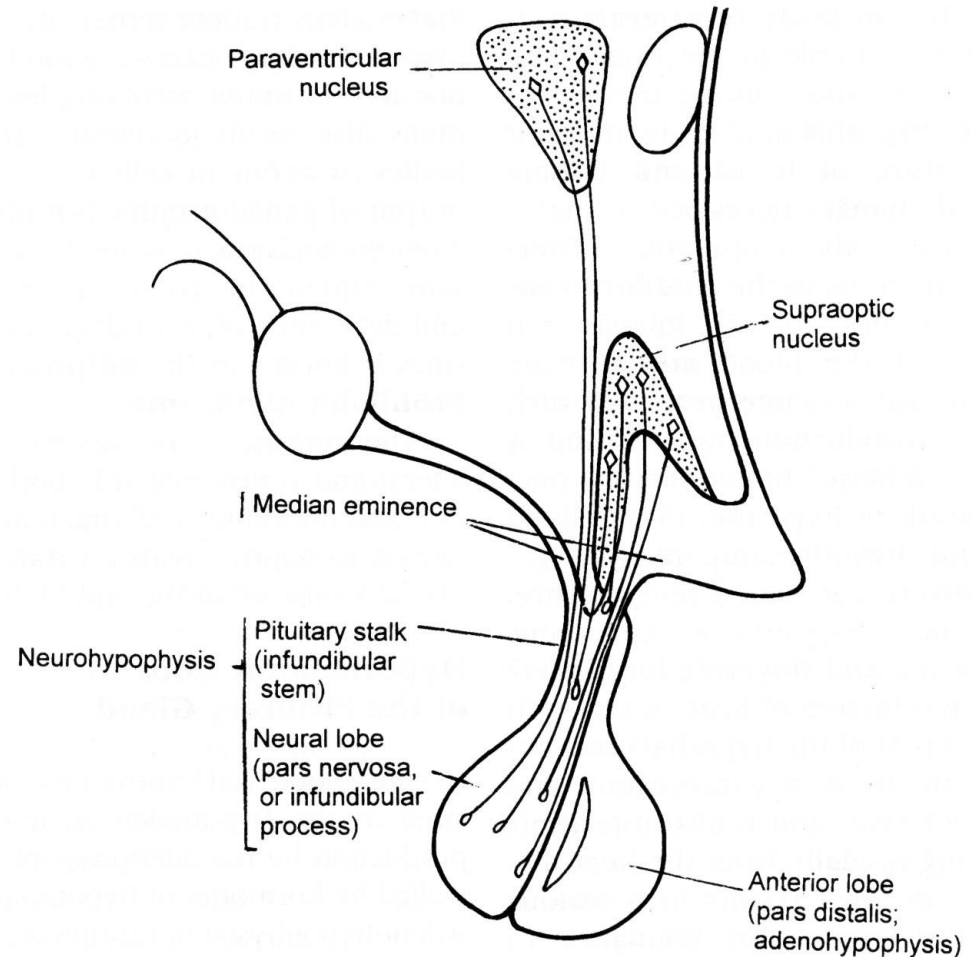


Figure 11-16. Hypothalamo-hypophyseal tract and the parts of the neurohypophysis.

Summary of the Functions 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

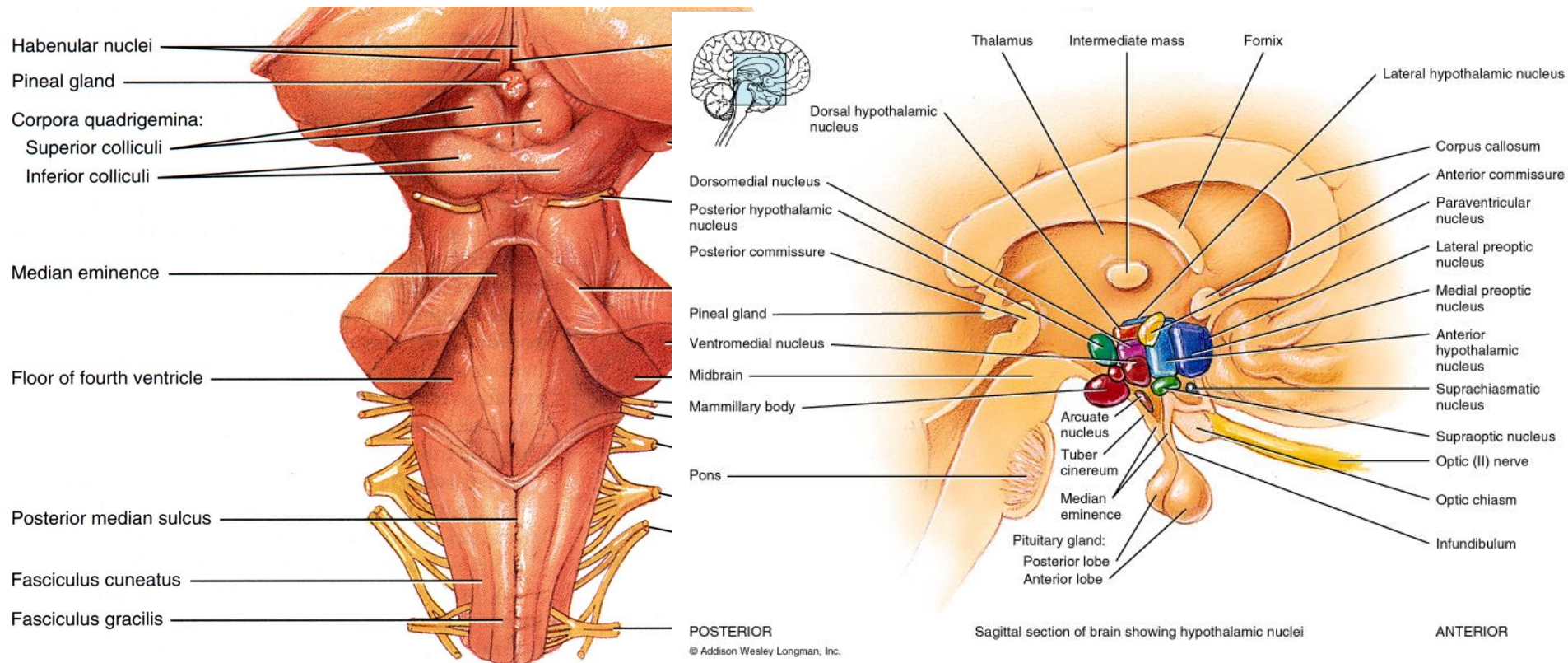
Epithalamus 上視丘:

Pineal gland 松果體:

secretes **melatonin** (more in the darkness, promoting sleepiness)

Habenular nuclei 韁核:

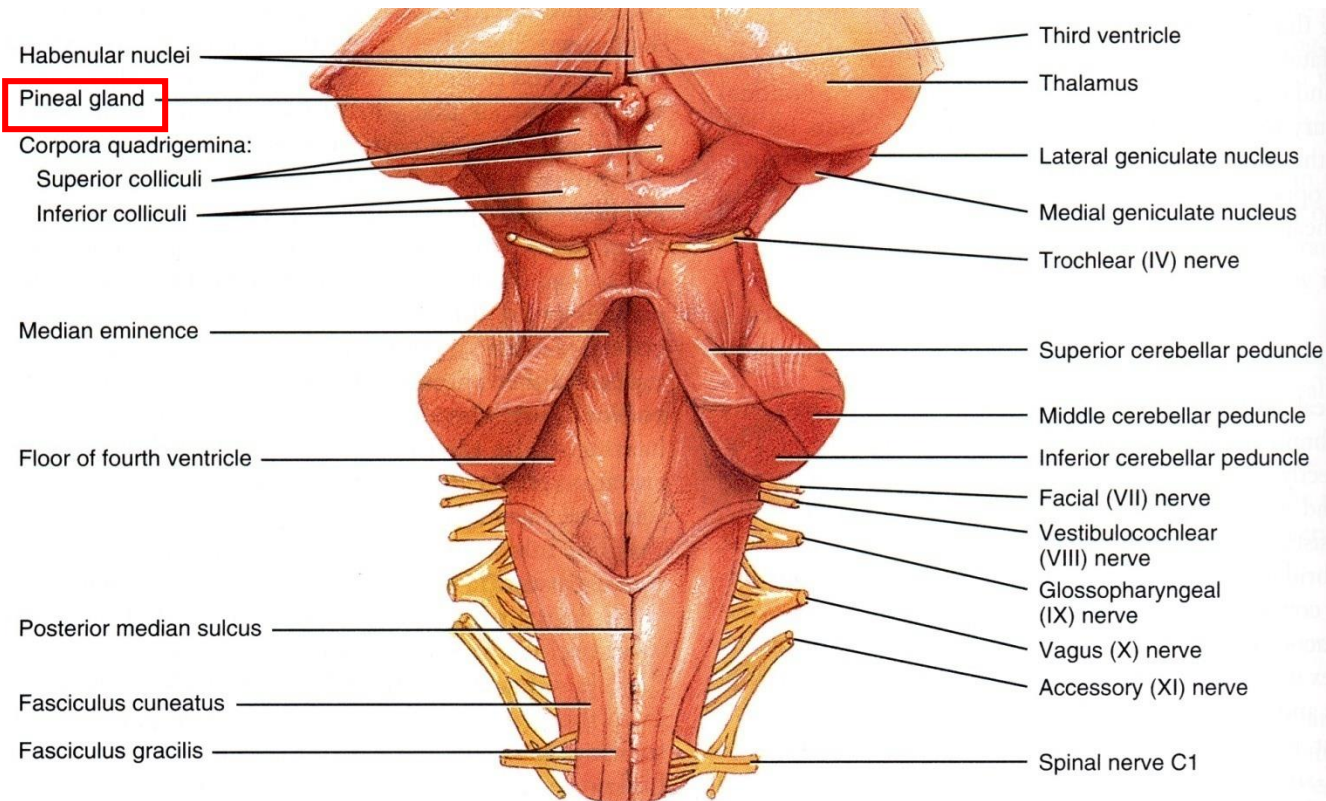
olfaction (smell), especially **emotional responses to smells**



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)



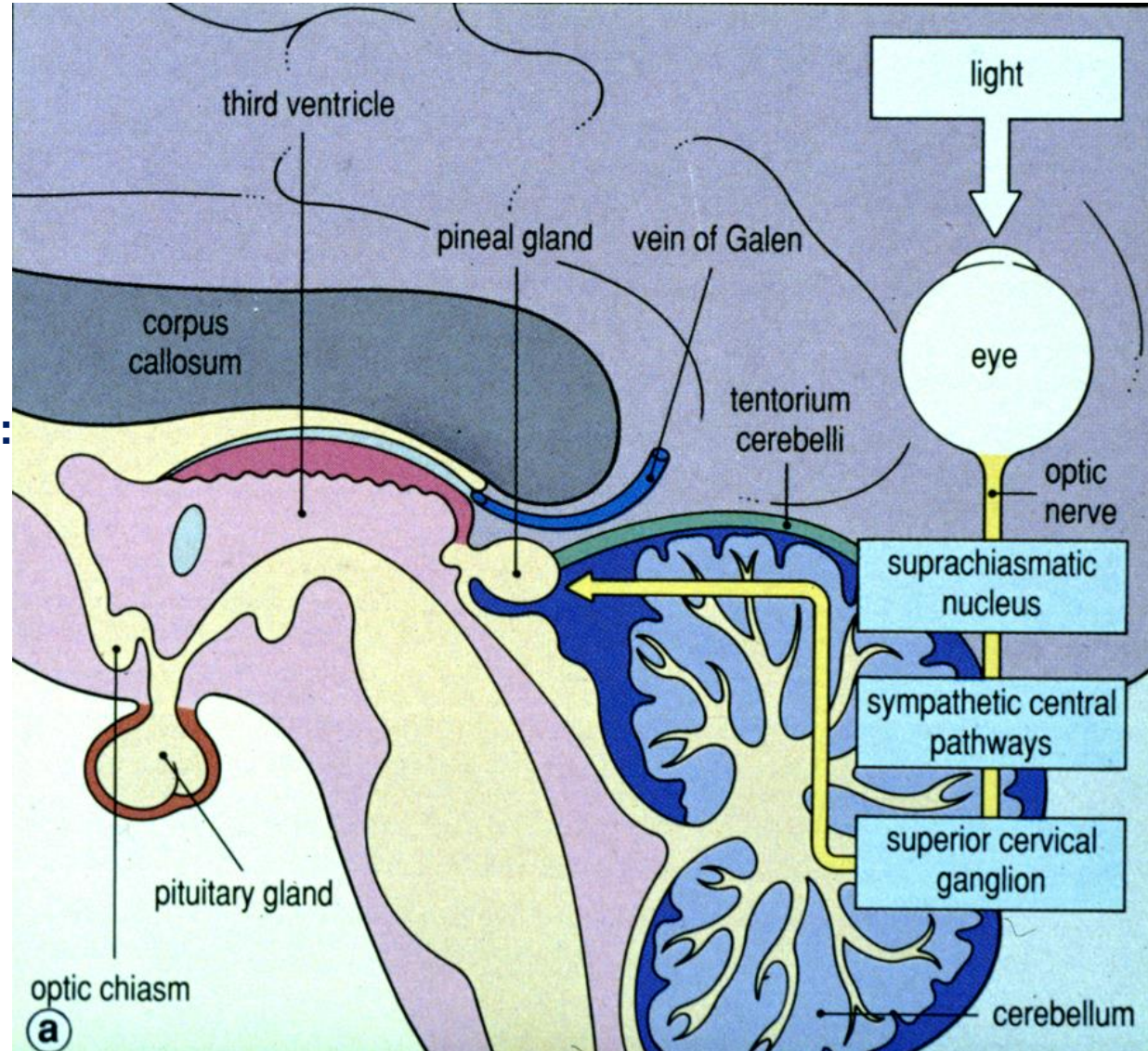
Pineal gland (pineal body)

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(褪黑激素):
a derivative of **serotonin**;
steady secretion of **melatonin**
at night; inhibition of melatonin
secretion by light

Circadian rhythm 日周期節律



Cerebrum 大腦

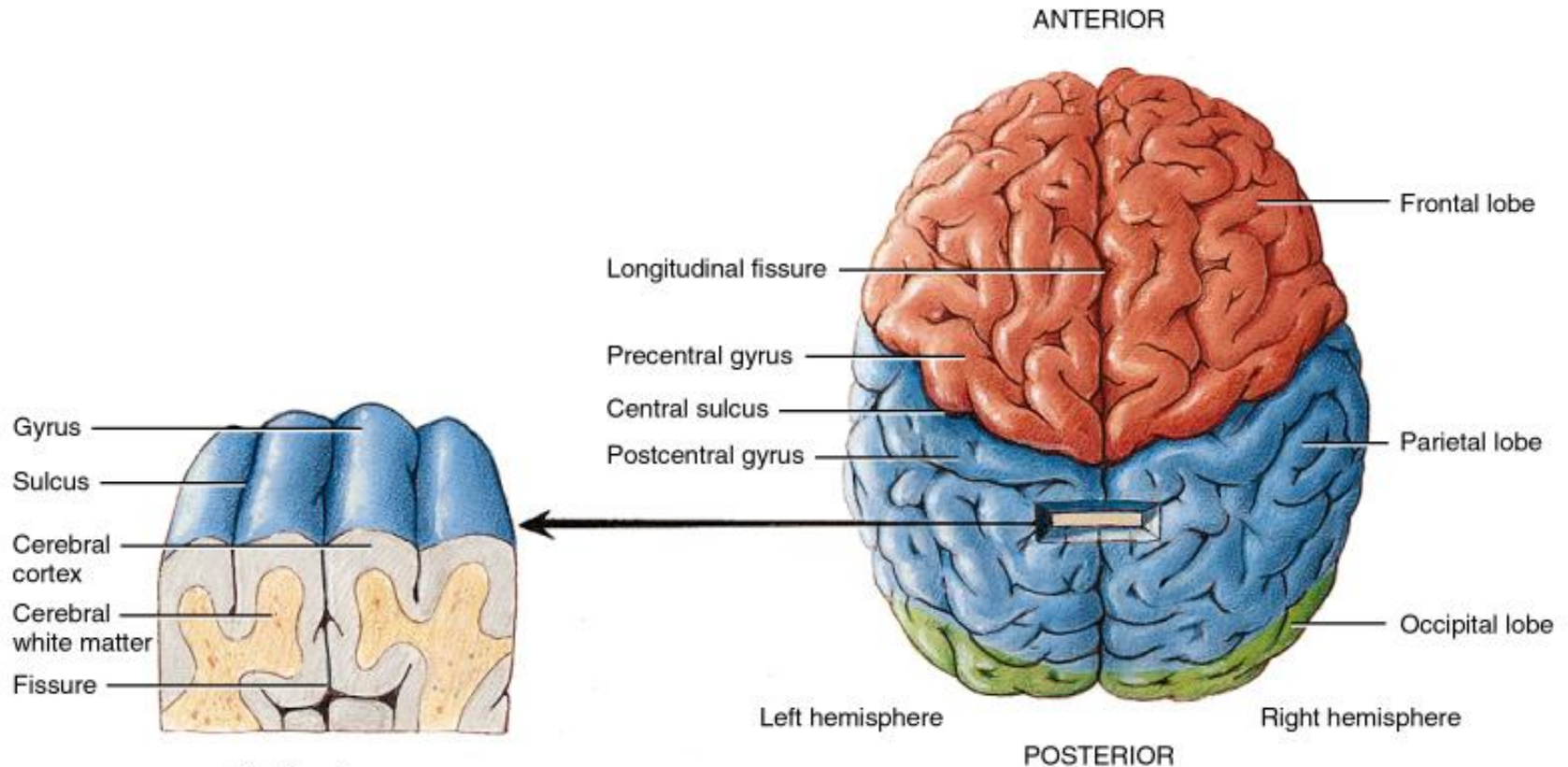
The surface of cerebrum (gray matter) → cerebral cortex

Gyrus (gyri): folds 腦迴

Fissures 裂: deepest grooves between folds

*Longitudinal fissure (cerebral hemispheres)

Sulcus (sulci) 溝: shallower grooves



Details of a gyrus, sulcus, and fissure

(a) Diagram of superior view

Five lobes

(A) Lateral view

Frontal lobe

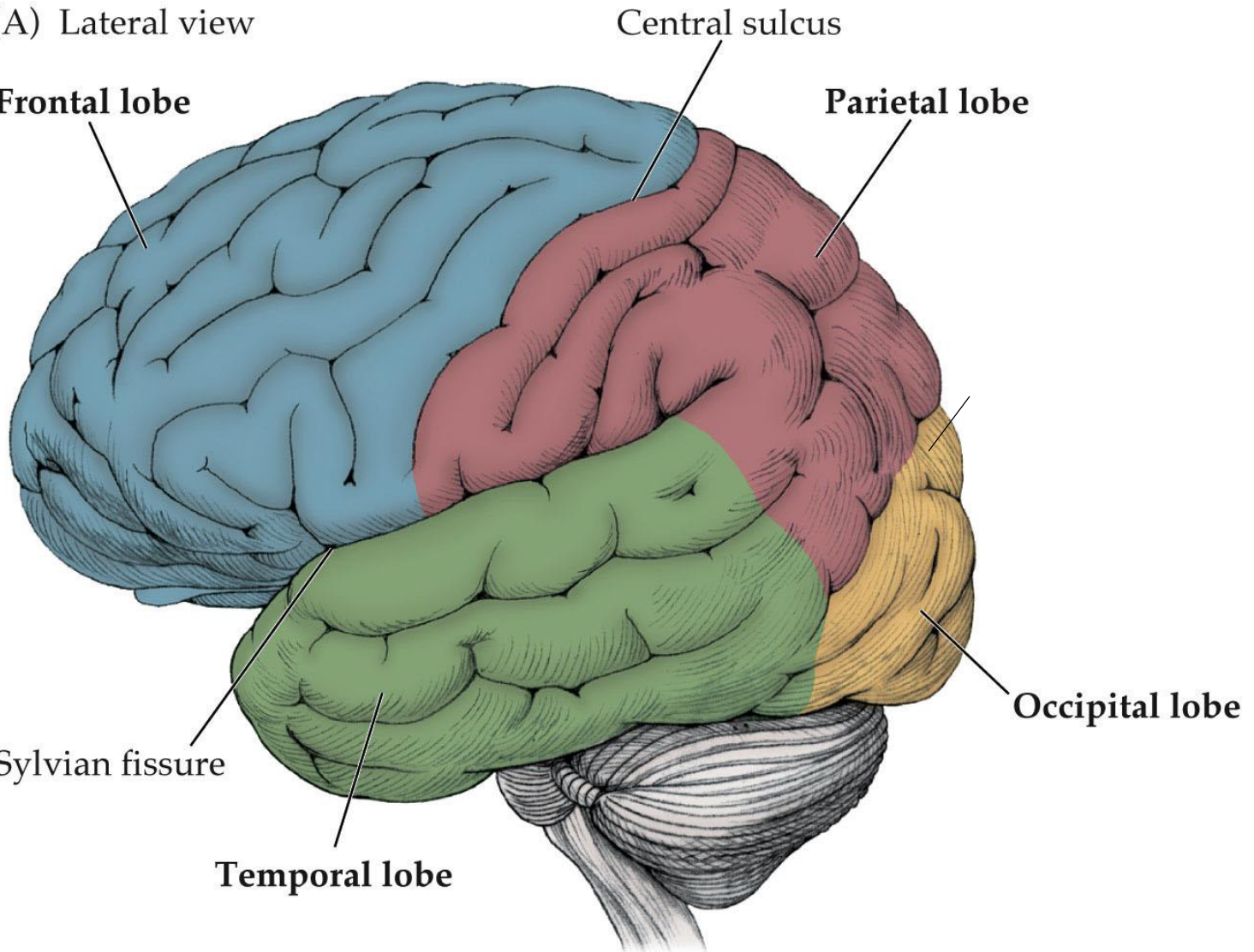
Central sulcus

Parietal lobe

Sylvian fissure

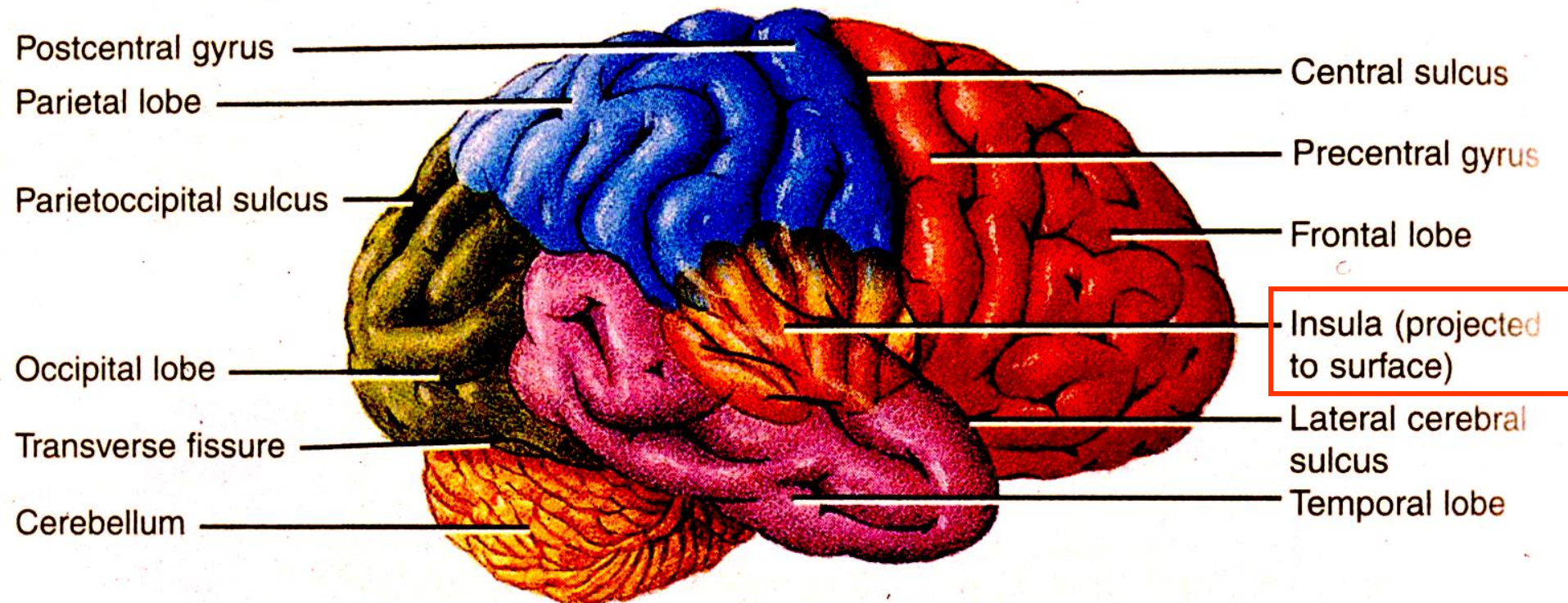
Temporal lobe

Occipital lobe



Lobes: Frontal, Parietal, Temporal, and Occipital Lobes

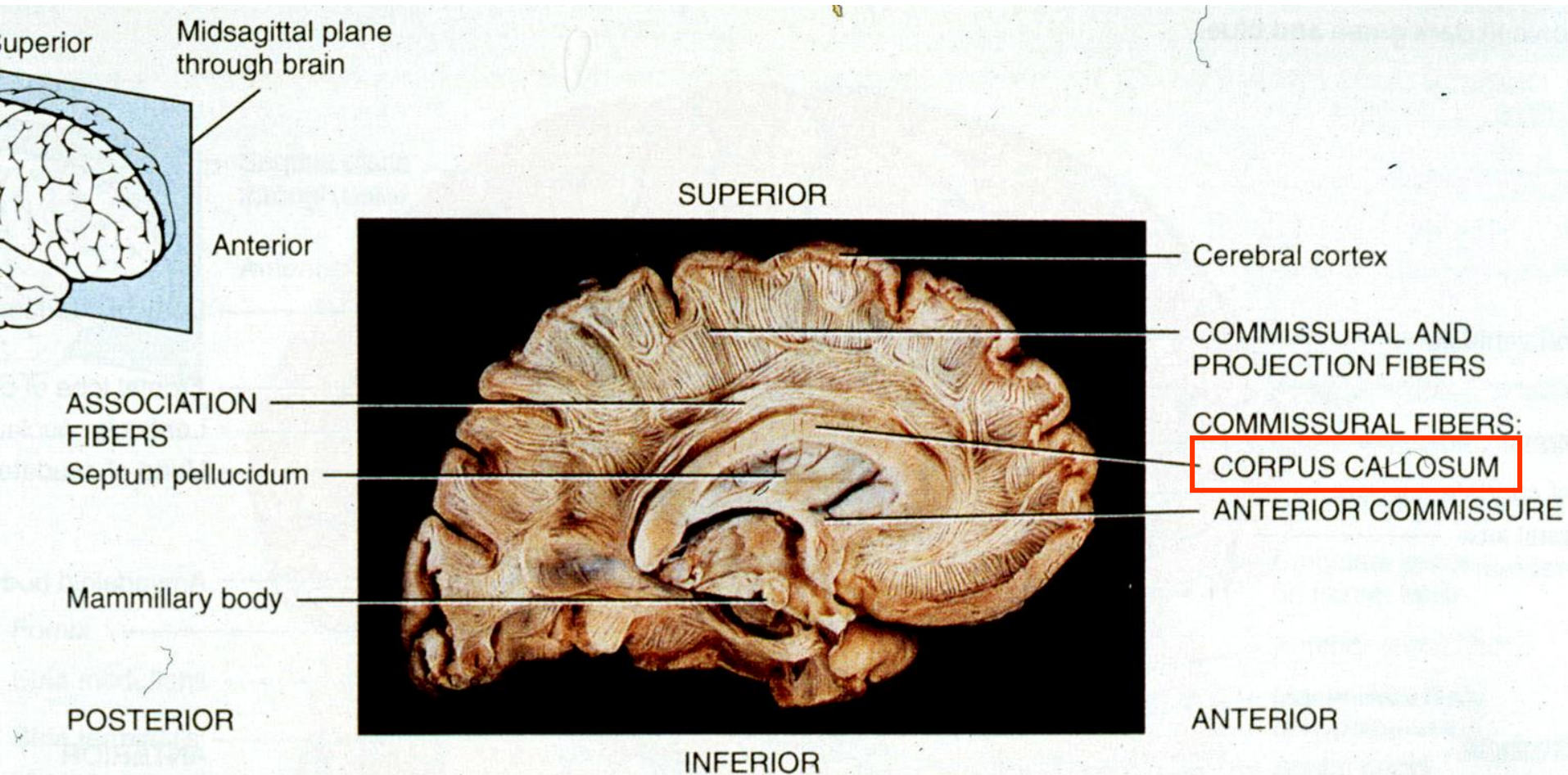
***Insula** 腦島: lies deep within the lateral cerebral fissure, deep to the parietal, frontal and temporal lobes.



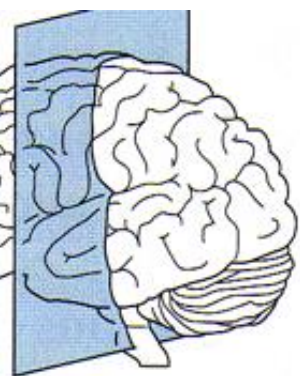
(d) Right lateral view

Cerebrum 大腦

Corpus callosum 胼胝體: transverse fibers (white matter) connected hemispheres



Medial view of white matter tracts revealed by scooping out gray matter from a midsagittal section



Corpus callosum
(commissural
fibers)

Corona
radiata

Caudate

Putamen

Globus pallidus

Internal
capsule

Subthalamic
nucleus

Projection
fibers

Decussation
of pyramids

Longitudinal
fissure

Gray matter

White matter

Lateral
ventricle

Fornix

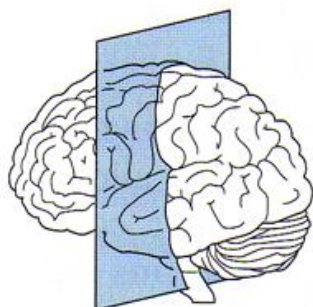
Third
ventricle

Thalamus

Pons

Medulla
oblongata

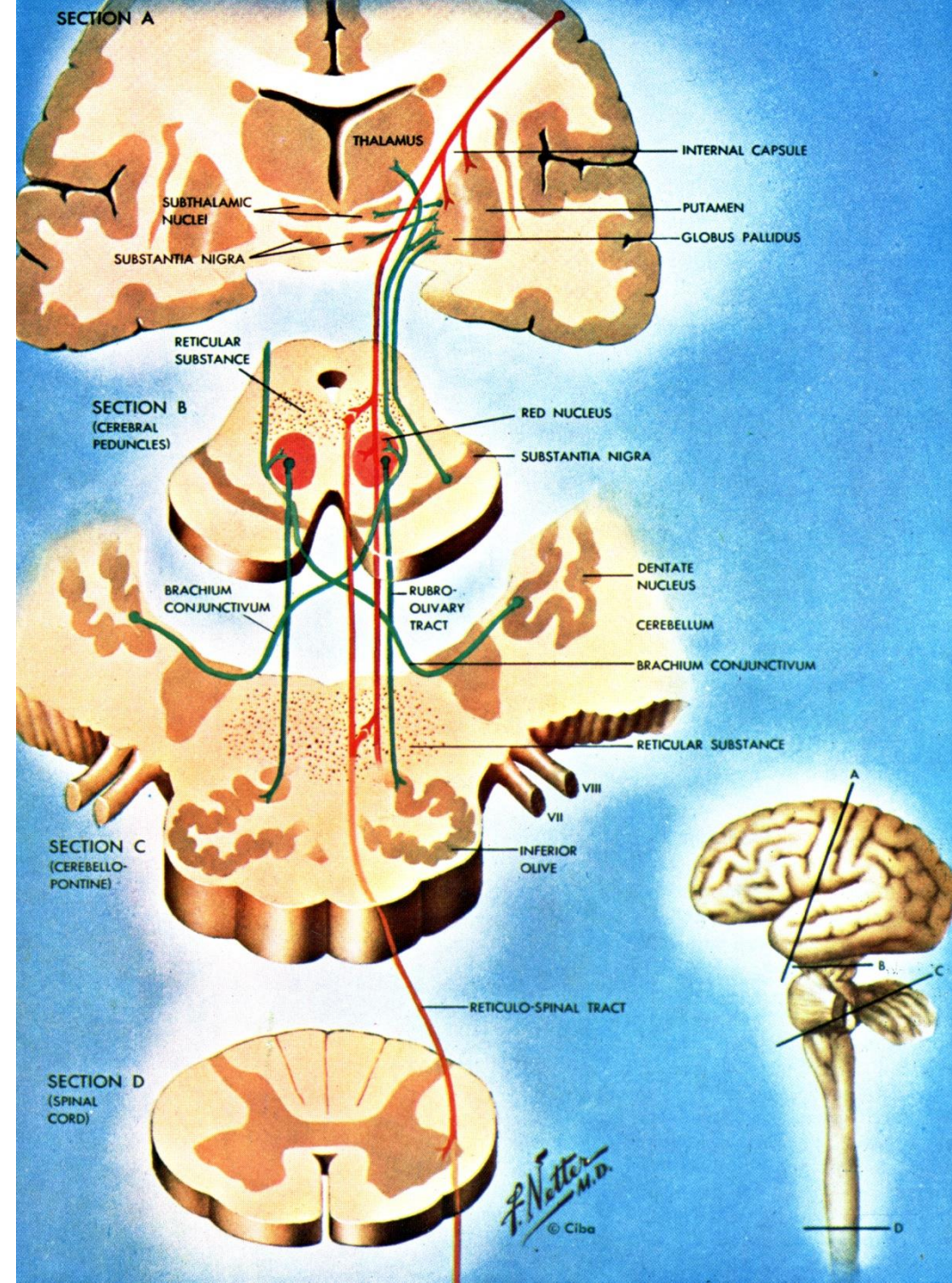
Basal ganglia



Basal Ganglia 基底核:

(substantia nigra, red nuclei, and subthalamic nuclei)

Functions: motor control for fine body movements

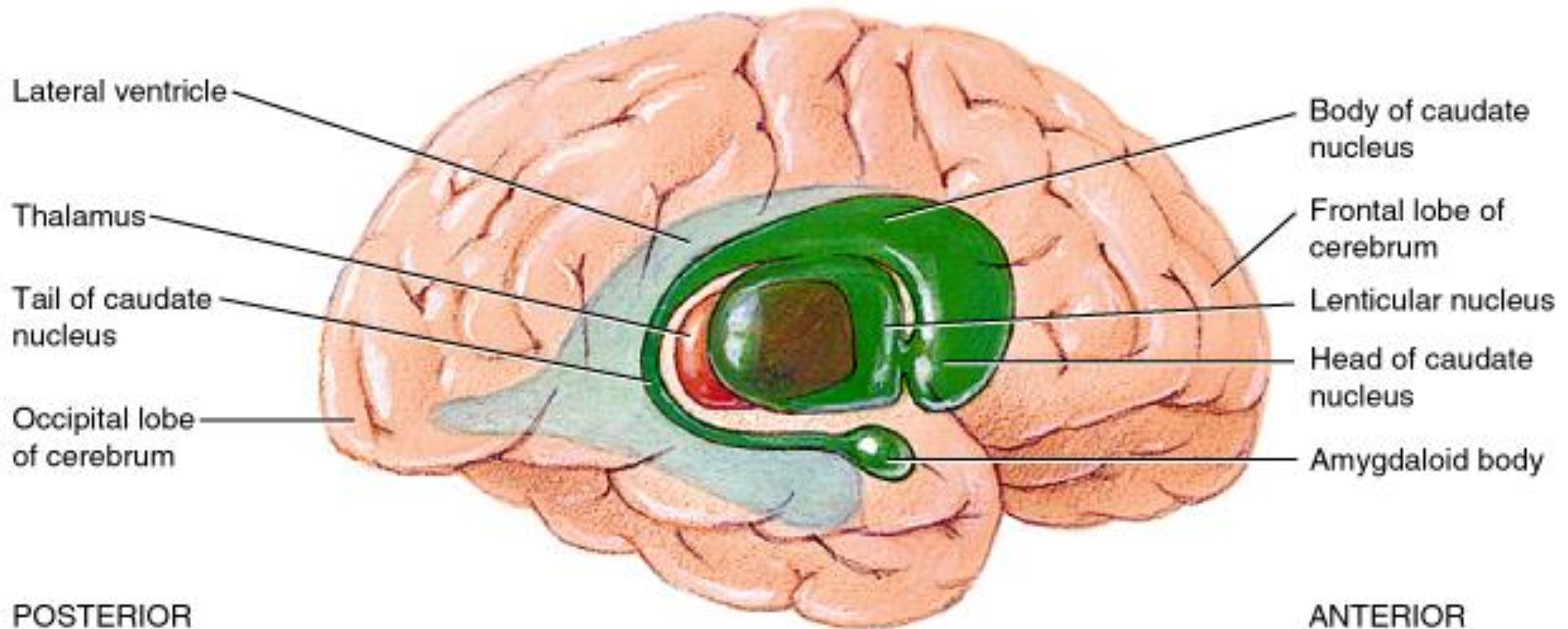


Corpus striatum 紋狀體:

*Caudate nucleus 尾狀核: head, body and tail → amygdaloid body

Lenticular nucleus 豆狀核: *Putamen 殼狀核

*Control the large automatic movements of skeletal muscles, such as swinging the arms while walking

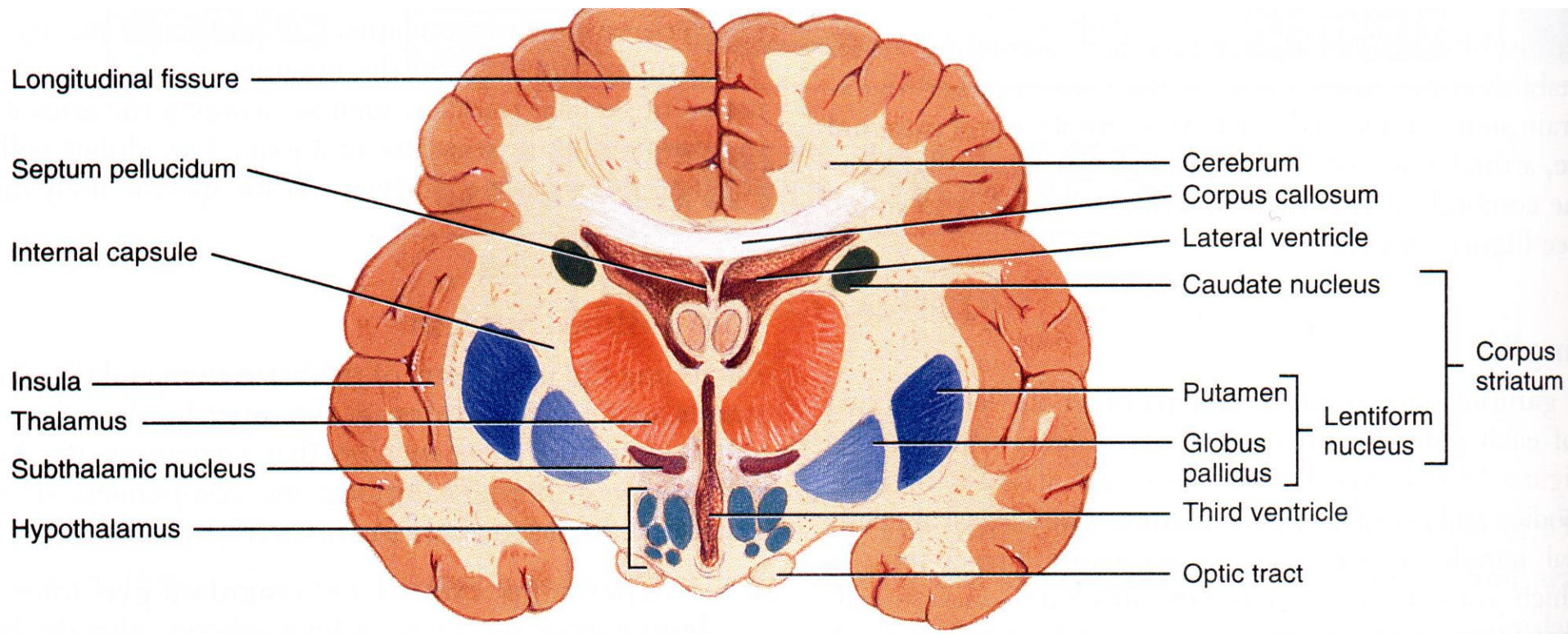


(a) Diagram of lateral view of right side of brain

Corpus striatum 紋狀體:

Globus pallidus 蒼白球: regulation of muscle tone required for specific body movements

Stroke → Basal ganglia: paralysis of the side of the body **opposite to the damage**

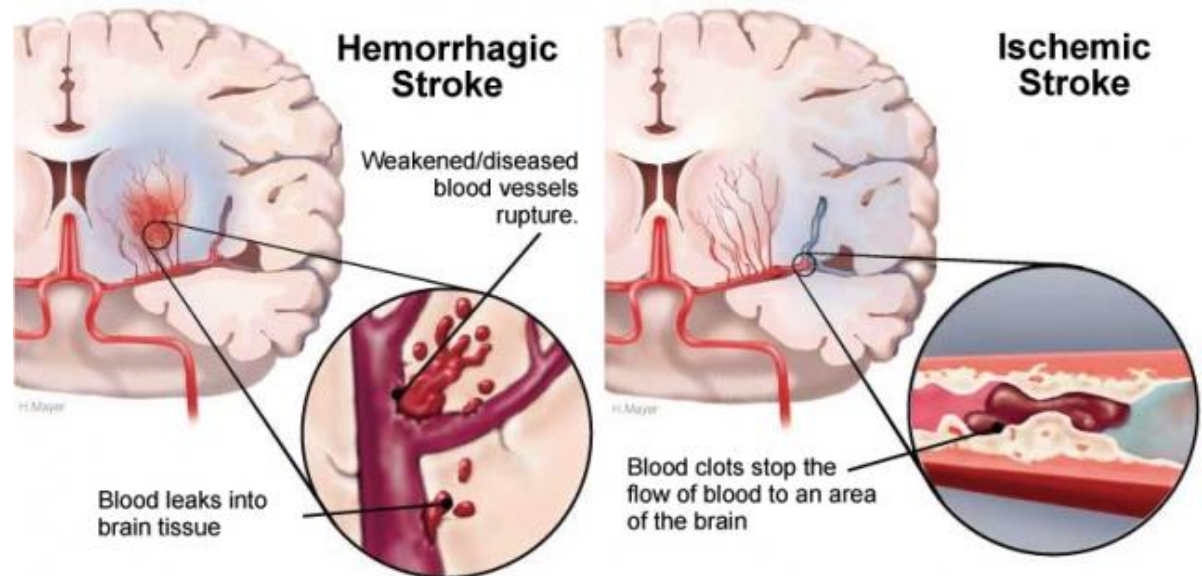
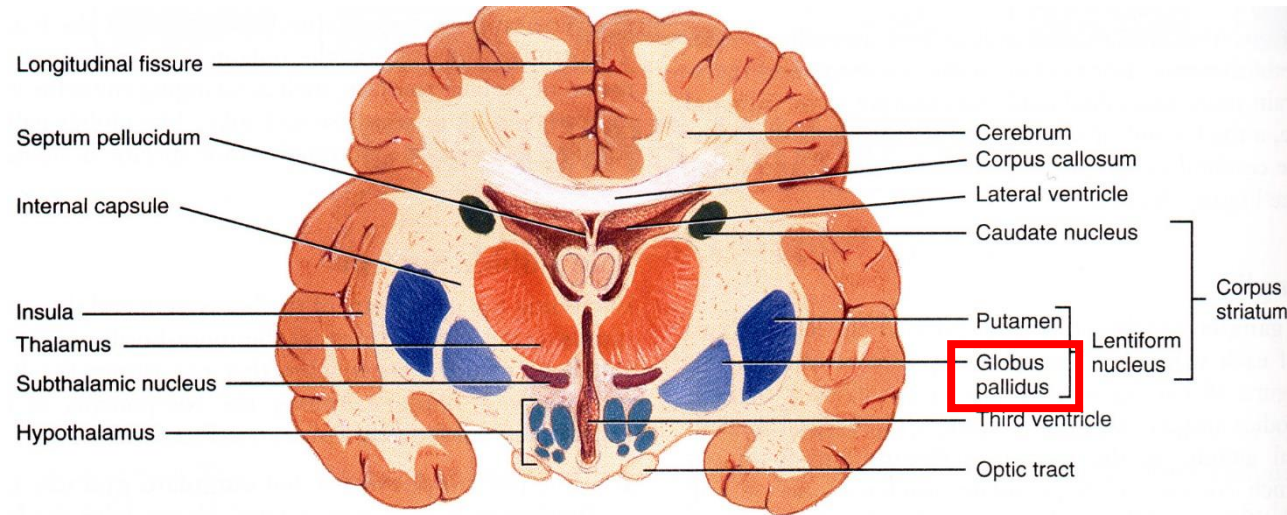


Corpus striatum

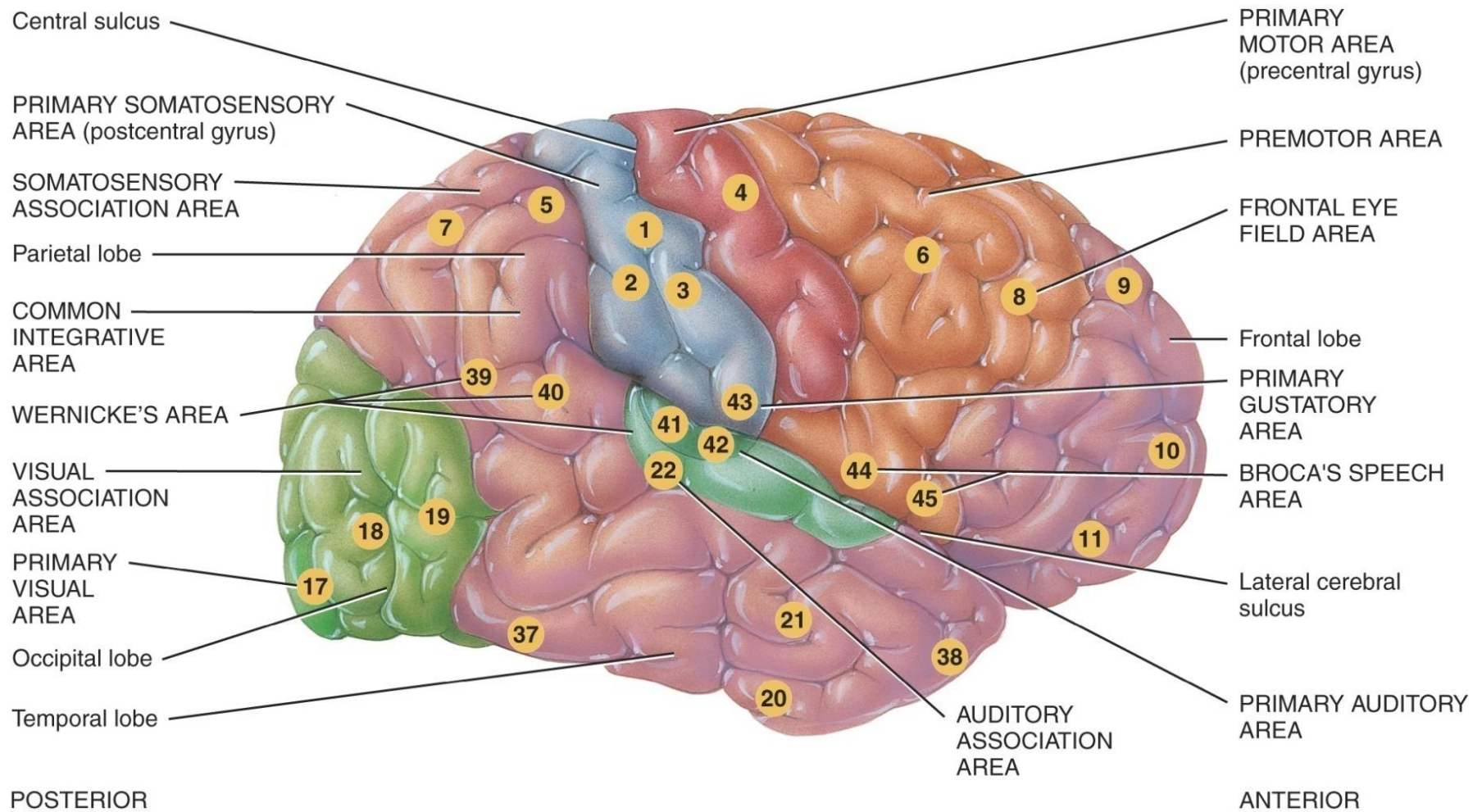
紋狀體:

Globus pallidus 蒼白球:
regulation of muscle
tone required for
specific body
movements

Stroke 中風 → Basal
ganglia: paralysis of
the side of the body
opposite to the damage



Functional organization of the cerebral cortex



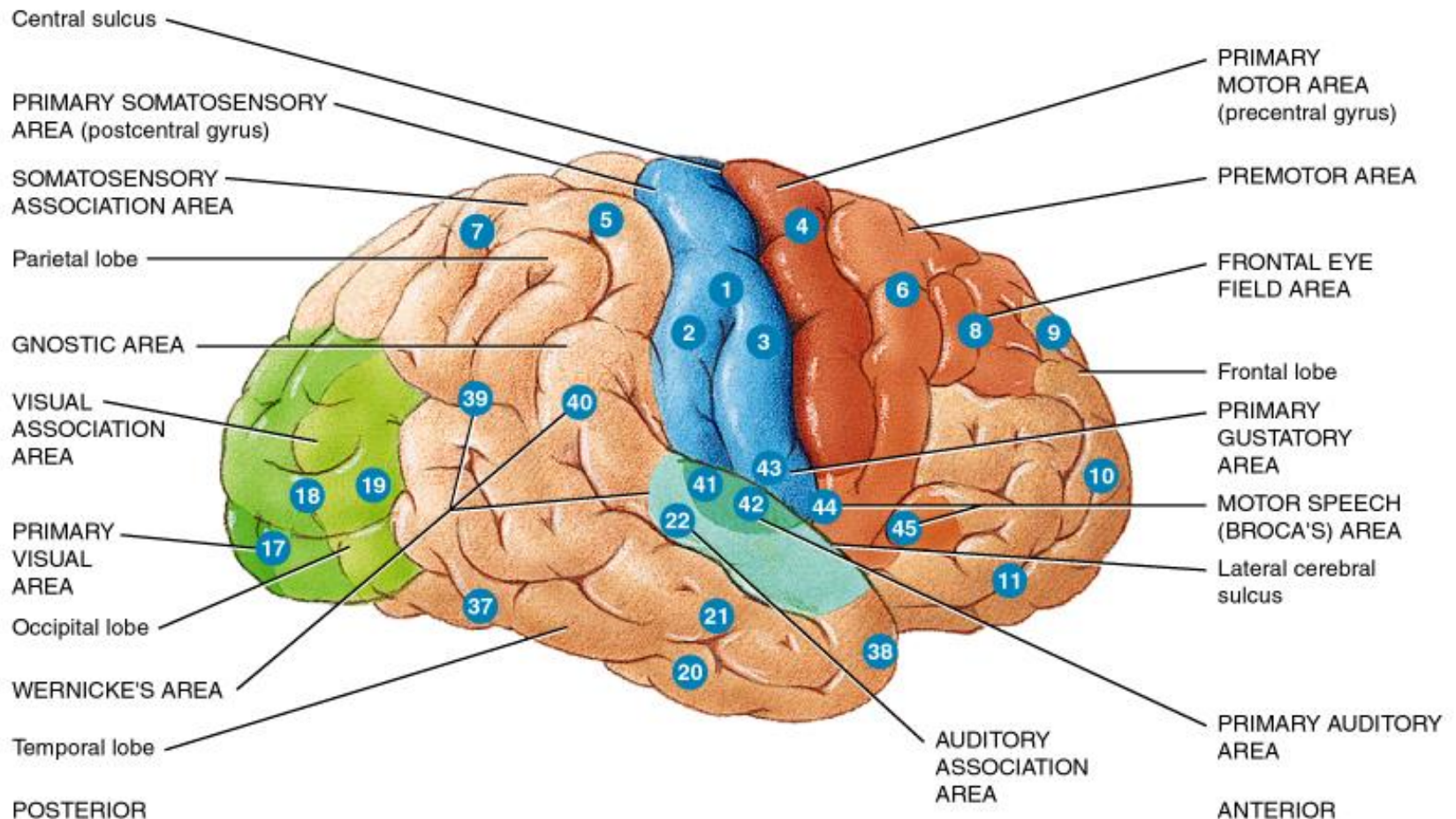
Brodmann's map of the cerebral cortex, first published in 1909

Functional Areas of the Cerebral Cortex

Sensory areas

Primary somatosensory area (#1, #2, #3): postcentral gyrus of frontal lobe

Primary visual area (#17): medial surface of occipital lobe



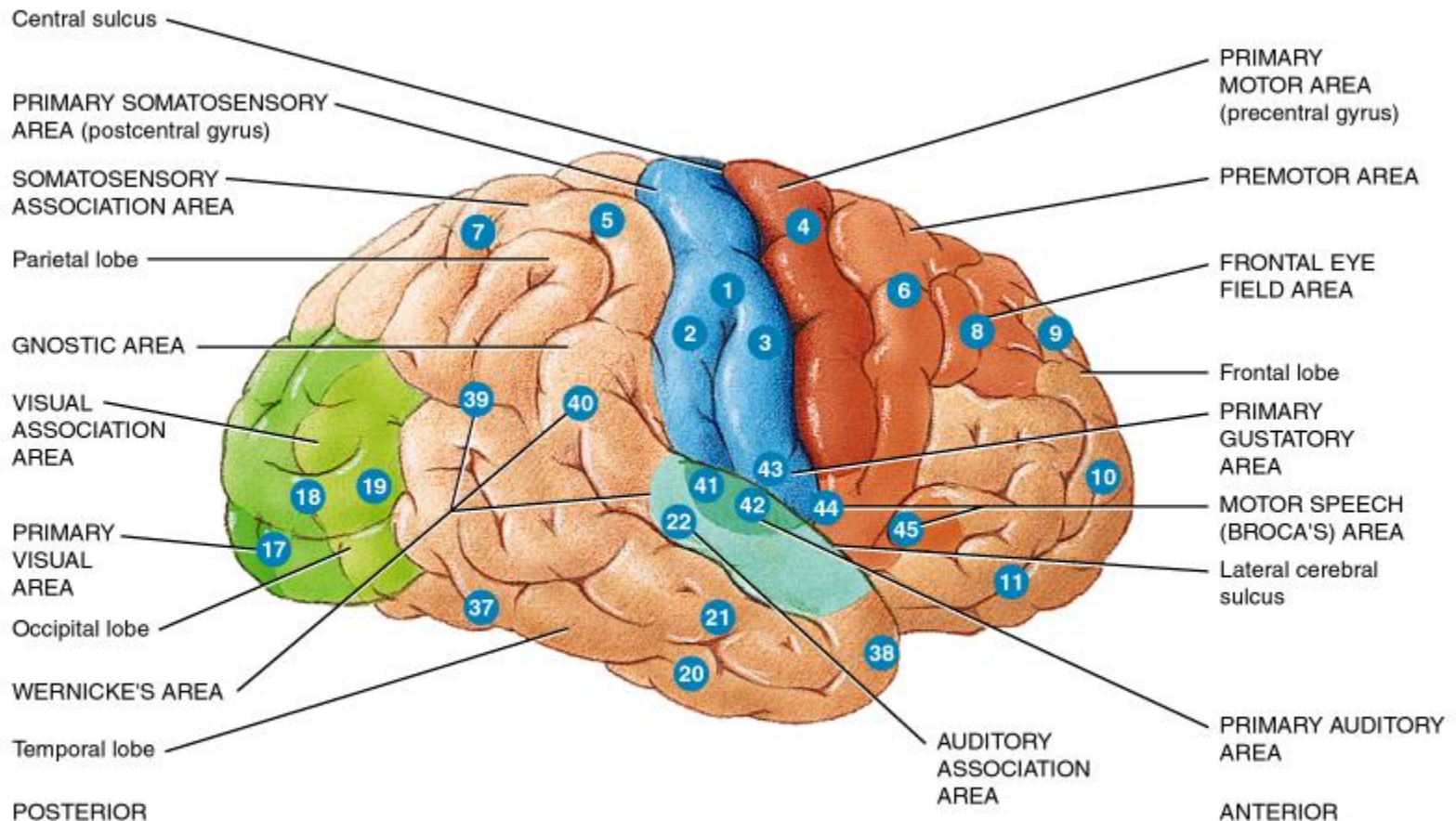
Lateral view of right cerebral hemisphere

Sensory areas

Primary auditory area (# 41 and # 42): superior part of temporal lobe

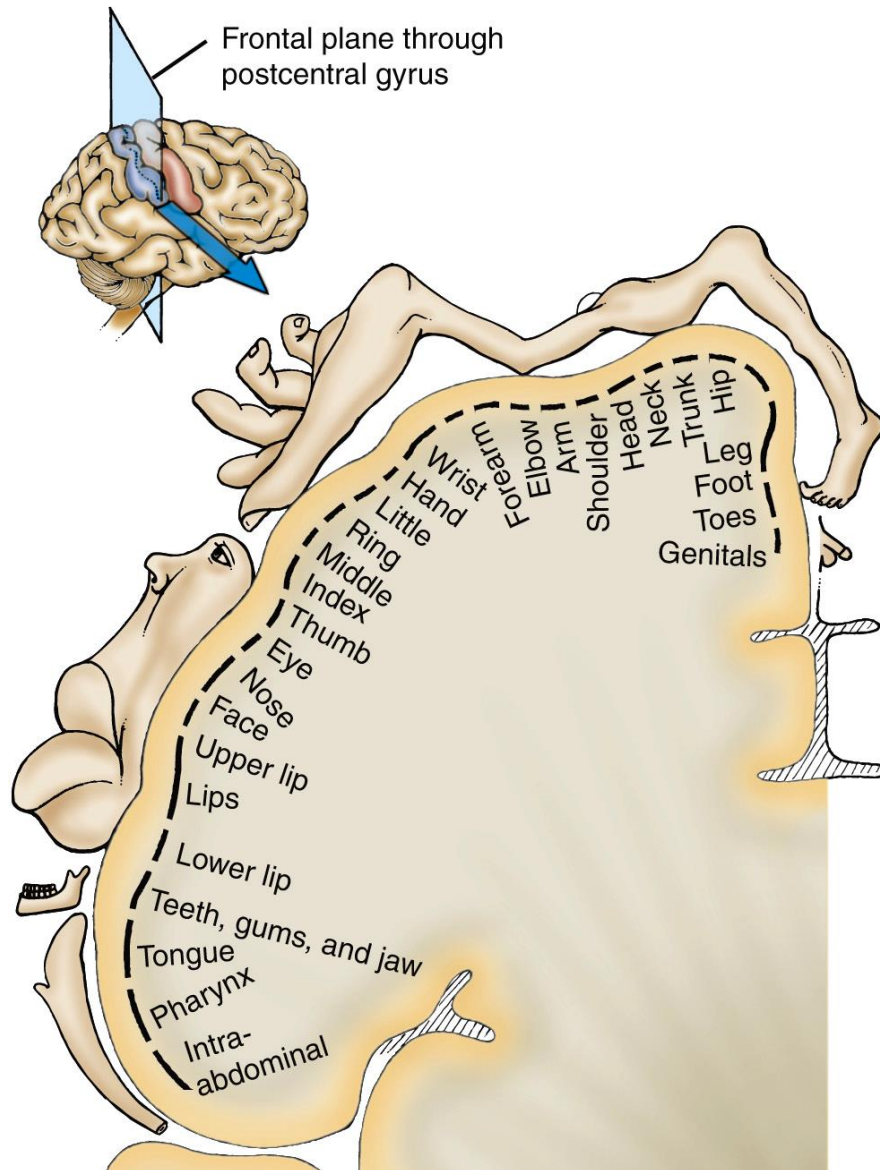
Primary gustatory area (# 43): the base of the postcentral gyrus superior to the lateral cerebral sulcus in the parietal lobe

Primary olfactory area (# 28): temporal lobe



Lateral view of right cerebral hemisphere

Somatosensory Map

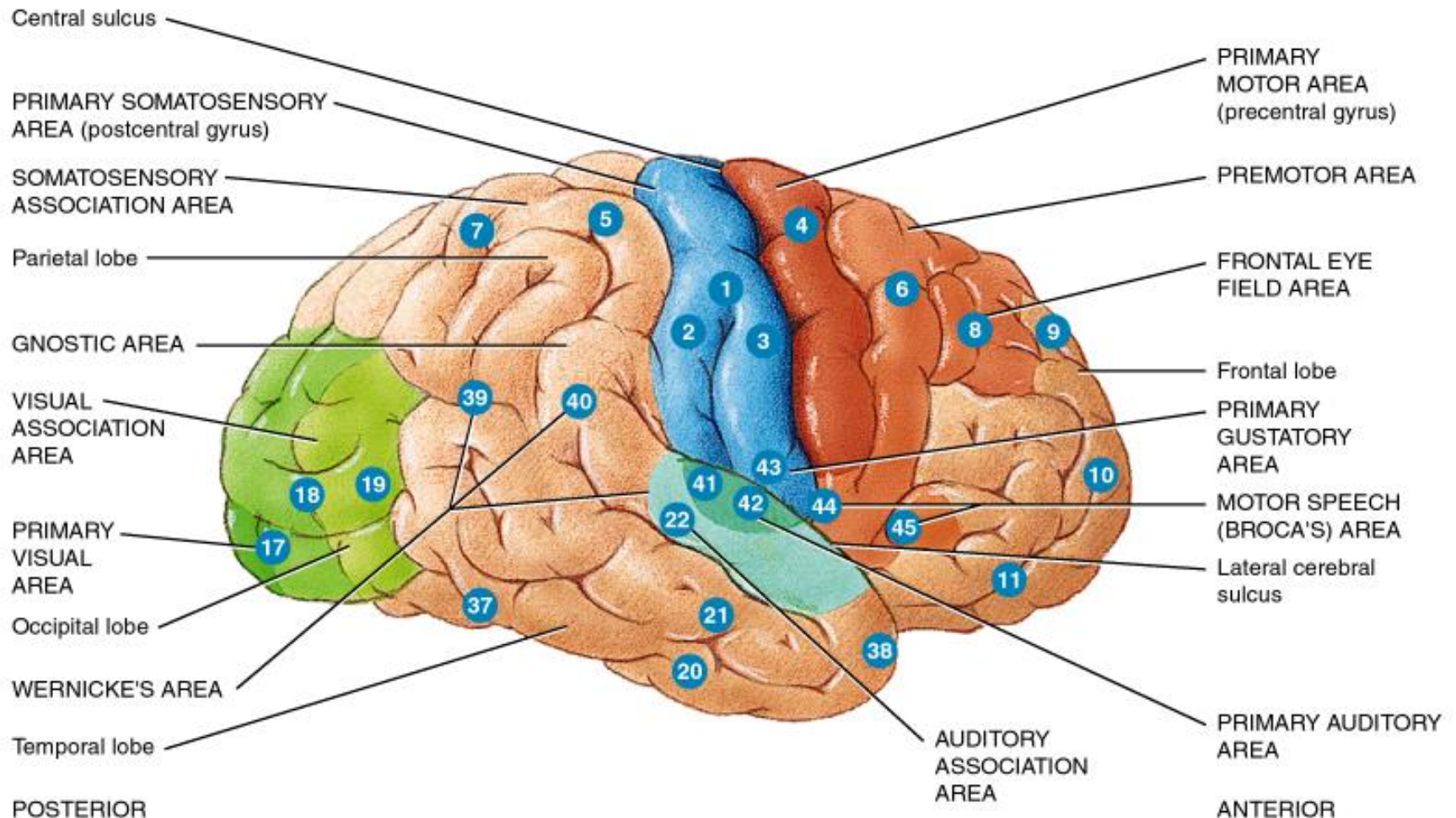


Sensory homunculus

2. Motor areas

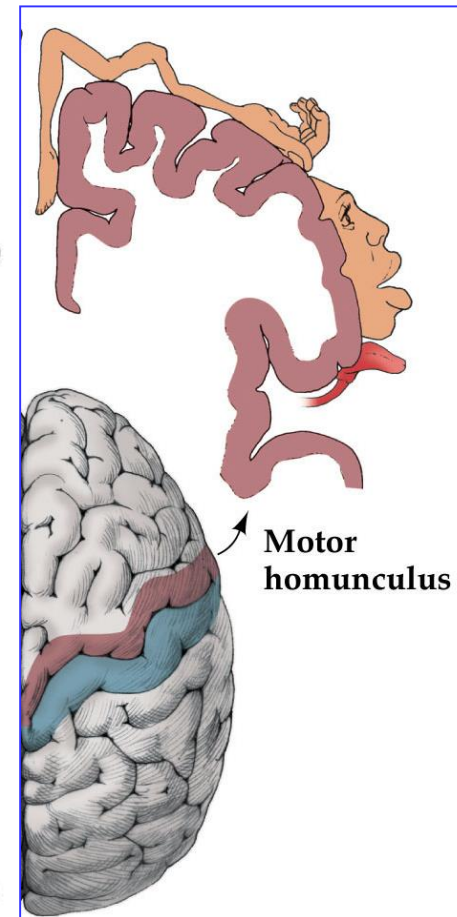
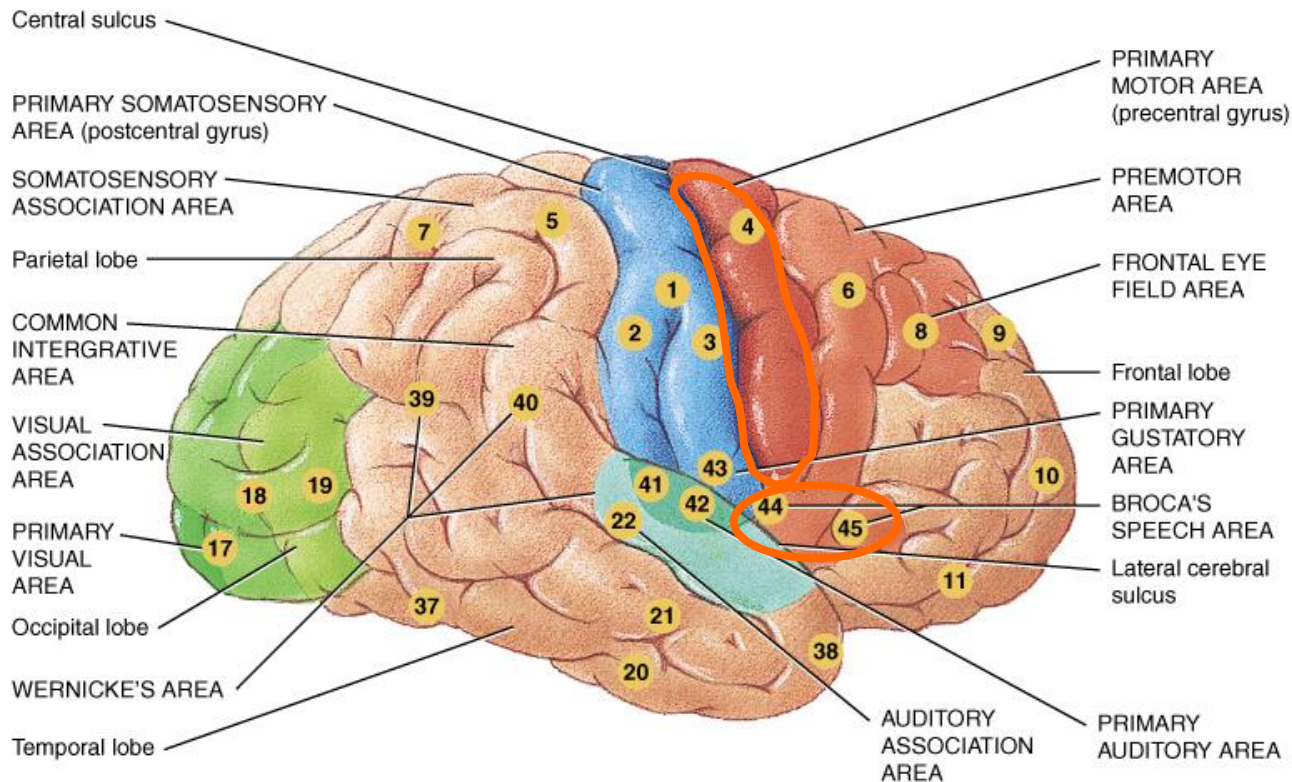
Primary motor area (# 4): precentral gyrus of frontal lobe

Motor speech area (# 44 and # 45; Broca's area): *On the left frontal lobe



Lateral view of right cerebral hemisphere

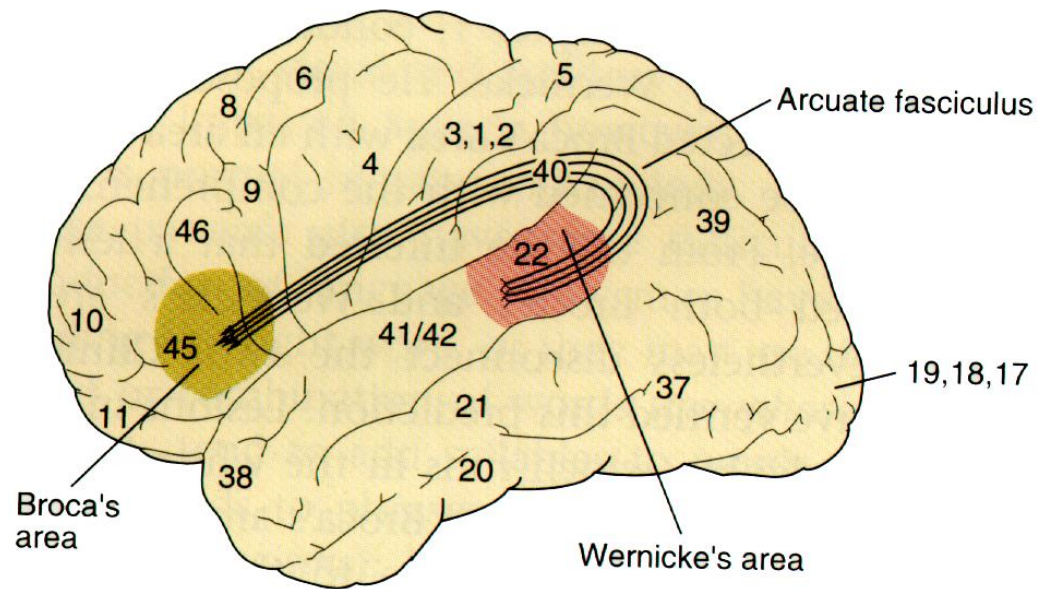
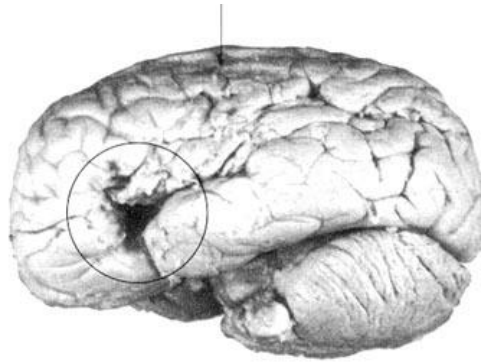
Motor Areas of Cerebral Cortex



- Voluntary motor initiation
 - Primary motor area = 4 = precentral gyrus
 - controls voluntary contractions of skeletal muscles on other side
 - Motor speech area = 44 = Broca's area
 - production of speech -- control of tongue & airway

Language

Language areas are located in the left cerebral hemisphere of most people



Expressive (Motor) speech area (Broca's area)

Receptive (Sensory) language area (Wernicke's area)

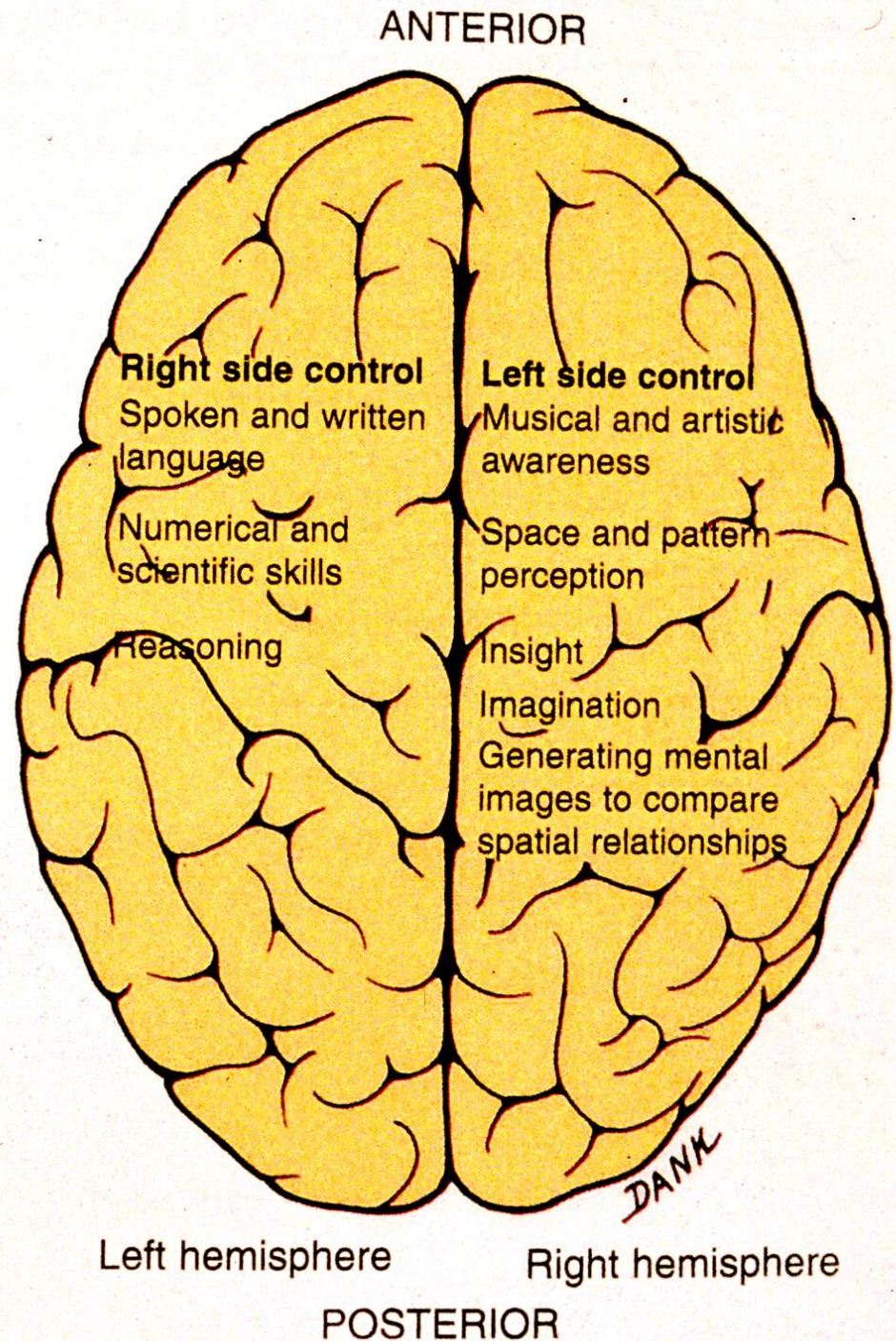
Lateralization of the cerebral cortex

Left hemisphere:

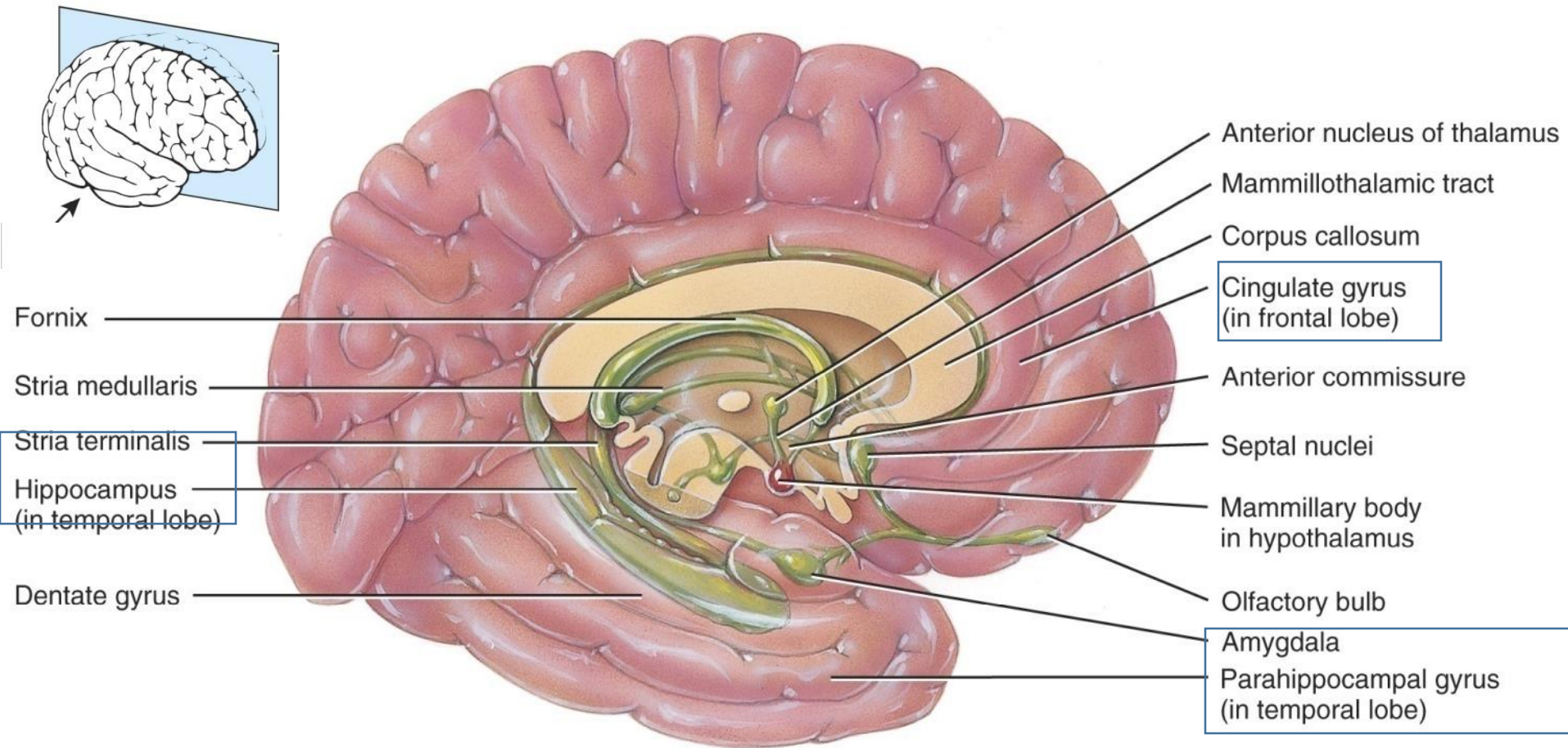
1. control of muscles on right side of body
2. Spoken and written language
3. Numerical and scientific skills
4. Reasoning

Right hemisphere:

1. control of muscles on left side of body
2. Musical and artistic awareness
3. Space and pattern perception
4. Insight
5. Imagination
6. Generating mental images to compare spatial relationships



Cerebrum: limbic system (**Emotional Brain**) 邊緣系統



- Parahippocampal & cingulate gyri & hippocampus
- Emotional brain--intense pleasure & intense pain
- Strong emotions increase efficiency of memory

Limbic System (Emotional Brain) 邊緣系統

1. Limbic lobe: parahippocampal and cingulate gyri

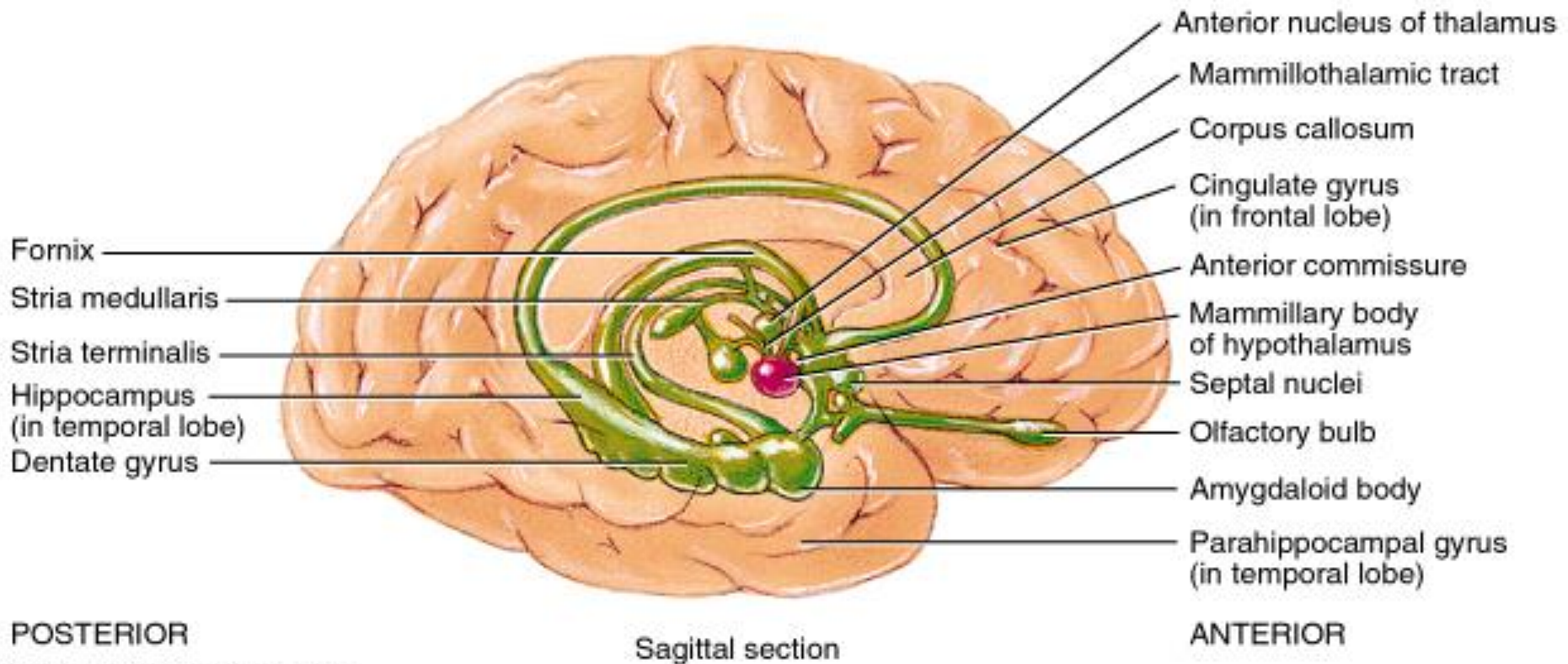
Hippocampus 海馬: memory

2. Dentate gyrus 齒狀迴

3. Amygdaloid body 杏仁核

4. Septal nuclei 中隔核

5. Mammillary body of the hypothalamus



Limbic System (Emotional Brain) 邊緣系統

6. Anterior nucleus of the thalamus

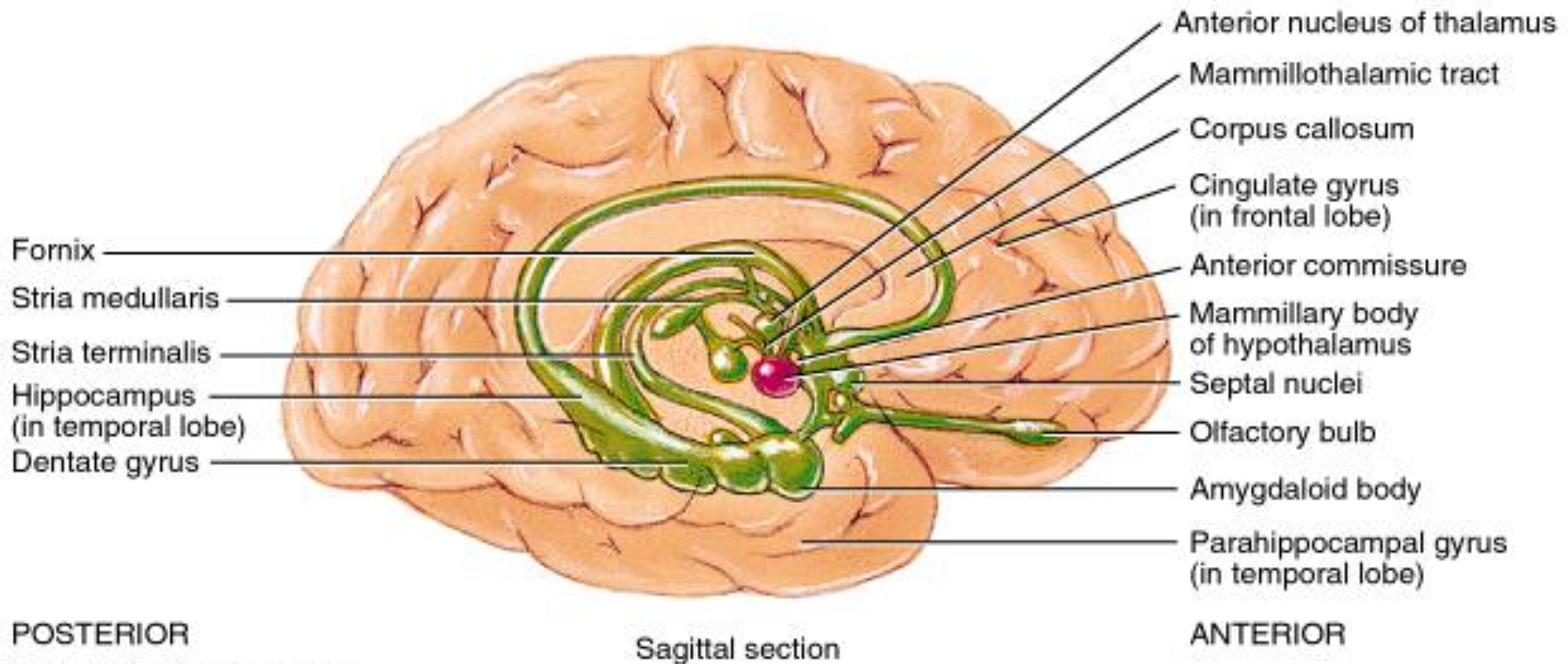
7. Olfactory bulbs

8. Fornix 穹隆:

white matter tracts connect the hippocampus to the hypothalamus

Stria terminalis 終紋, stria medullaris 髓紋, and mammillothalamic tracts.

Emotions: pain, pleasure, anger, rage, fear, sorrow, sexual feelings, docility, and affection



The Brain

- Principal parts of the brain
- Protective coverings of the brain
- Cerebrospinal fluid 腦脊髓液
- Brain stem & Cerebellum 腦幹及小腦
- Diencephalon 間腦
- Cerebrum 大腦
- **Cranial Nerves** (Next week)

Autonomic Nervous System & Special Senses (Next week)