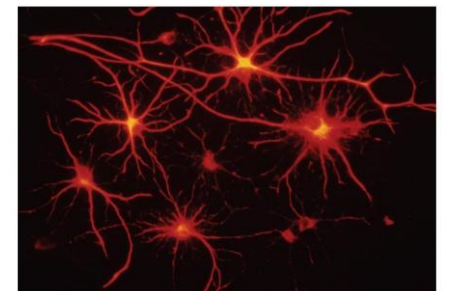


Chapter 6 中樞及周邊神經系統

- ✓6-1 神經系統的組成
- ✓6-2 大腦
- ✓6-3 間腦
- ✓6-4 腦幹
- ✓6-5 小腦
- ✓6-6 脊髓(p.185-187)
- ✓6-7 周邊神經系統(p.190-193)

Central Nervous System

- CNS: **brain** and **spinal cord**
- CNS (1.5 kg) comprises **2%** of body weight
- Necessary for the maintenance of homeostasis and respond to the environment
- It receives **15-20%** of the total blood flow to the body per minute (high metabolic rate)
- Adult brain contains **10^{11} neurons** (100 billion) and **10^{14} synapses** (100 trillion)
- Responsible for everything we perceive, do, feel, and think
- **Neurogenesis** (the formation of new brain cells from stem cells) in adult brains within the hippocampus



Physical Support of the CNS

● Bone

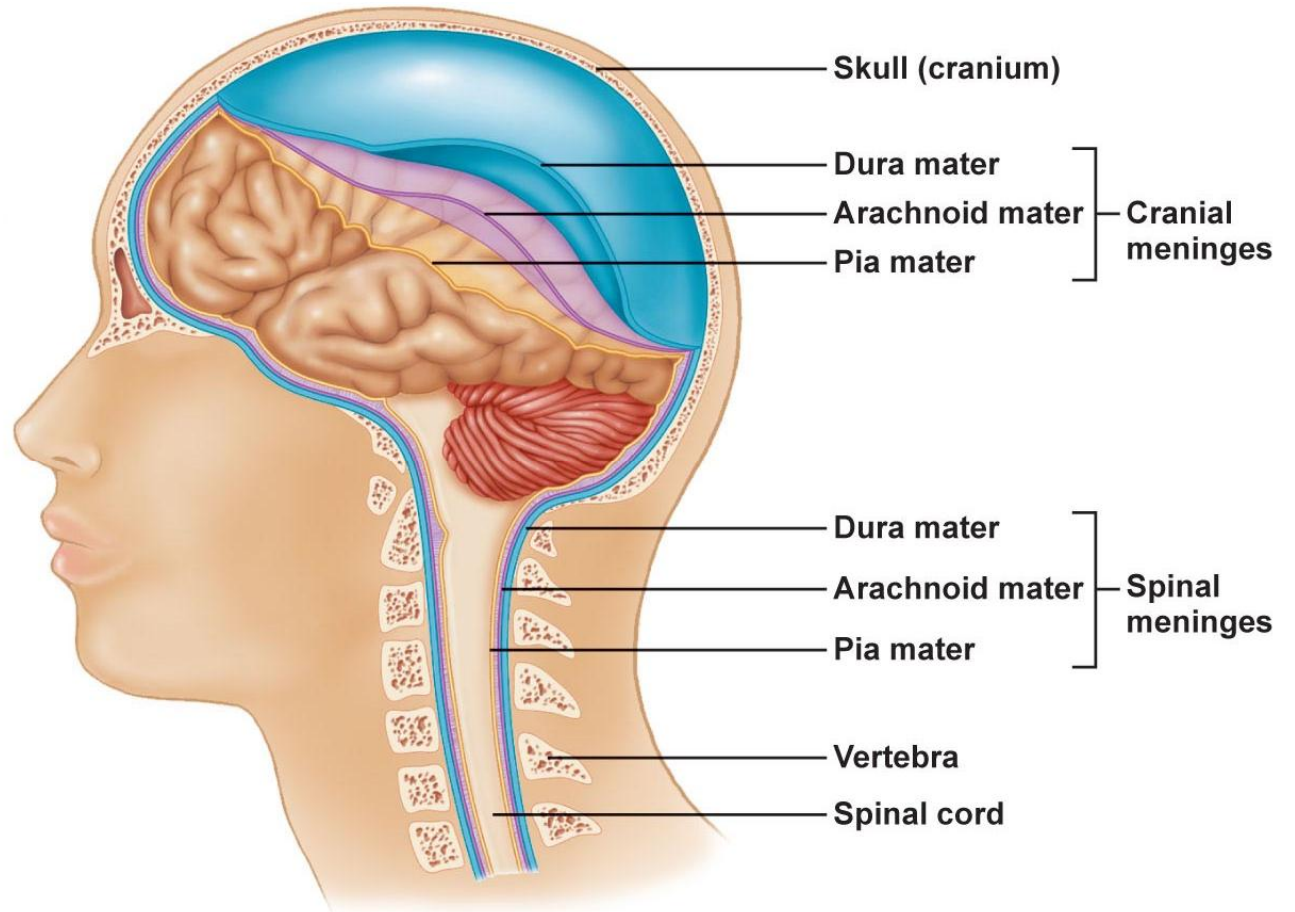
- Cranium
- Vertebrae

● Meninges

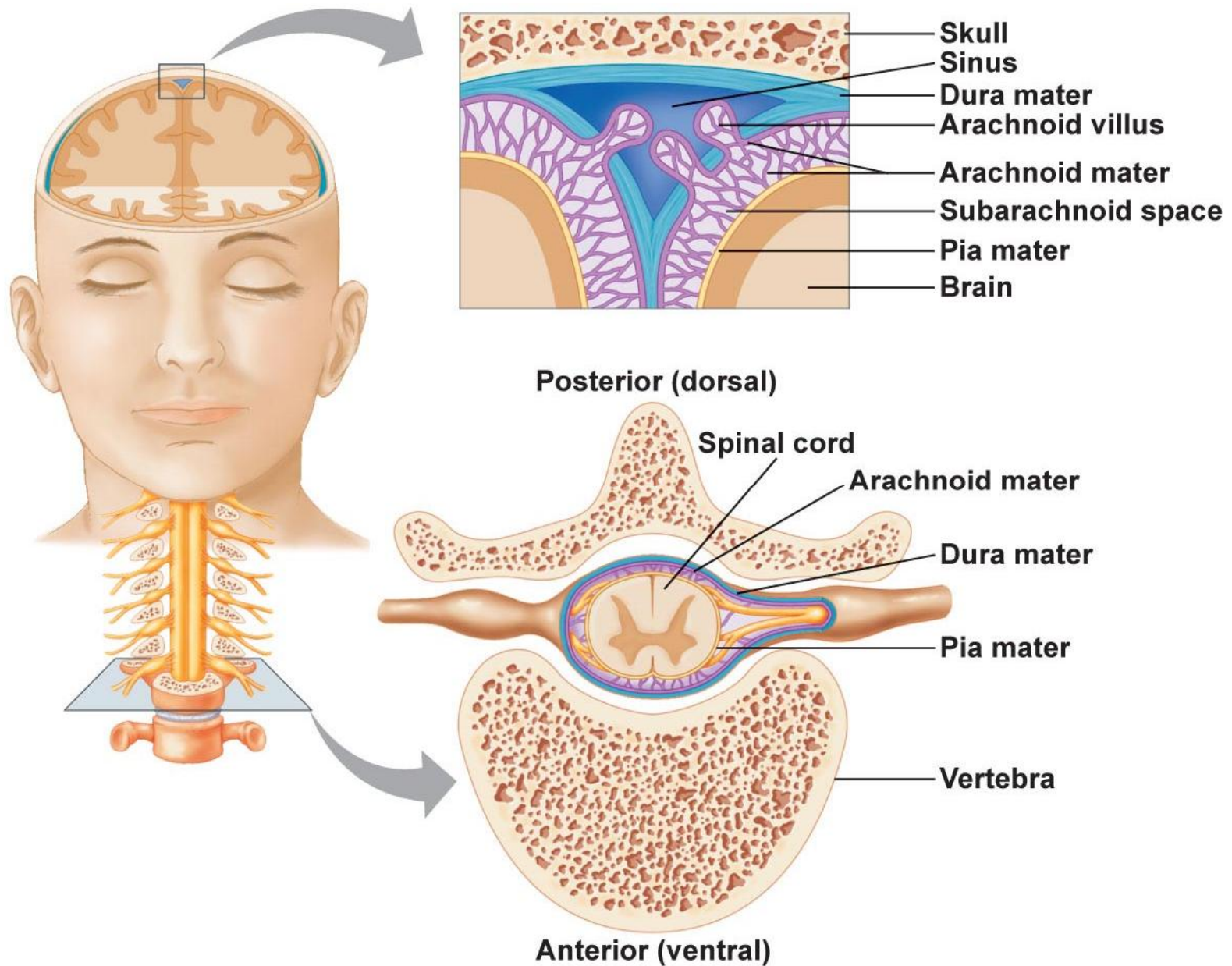
- Dura mater
- Arachnoid mater
- Pia mater

● Cerebrospinal fluid

● BBB



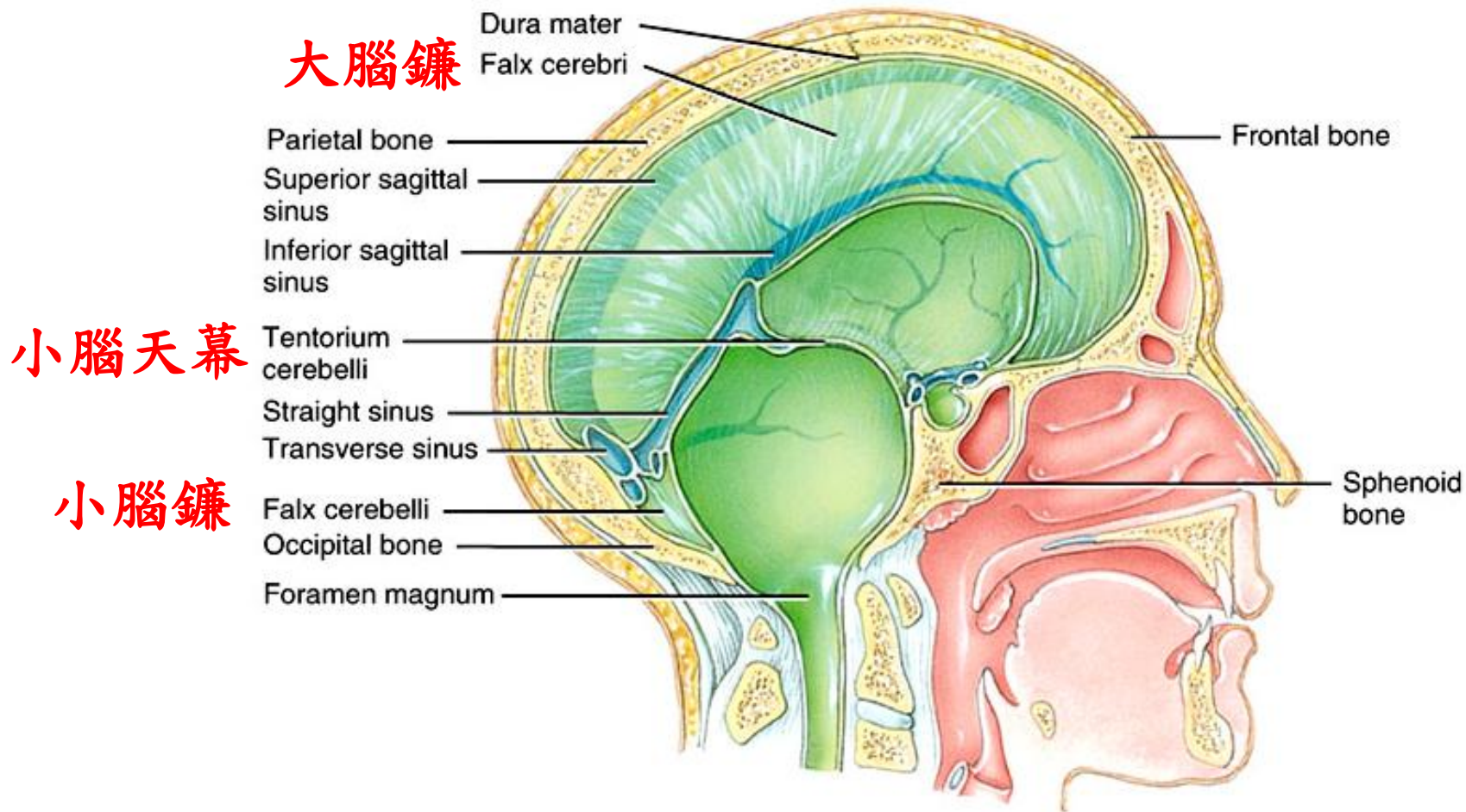
Meninges



(b)

● Three extensions of the **dura mater**:

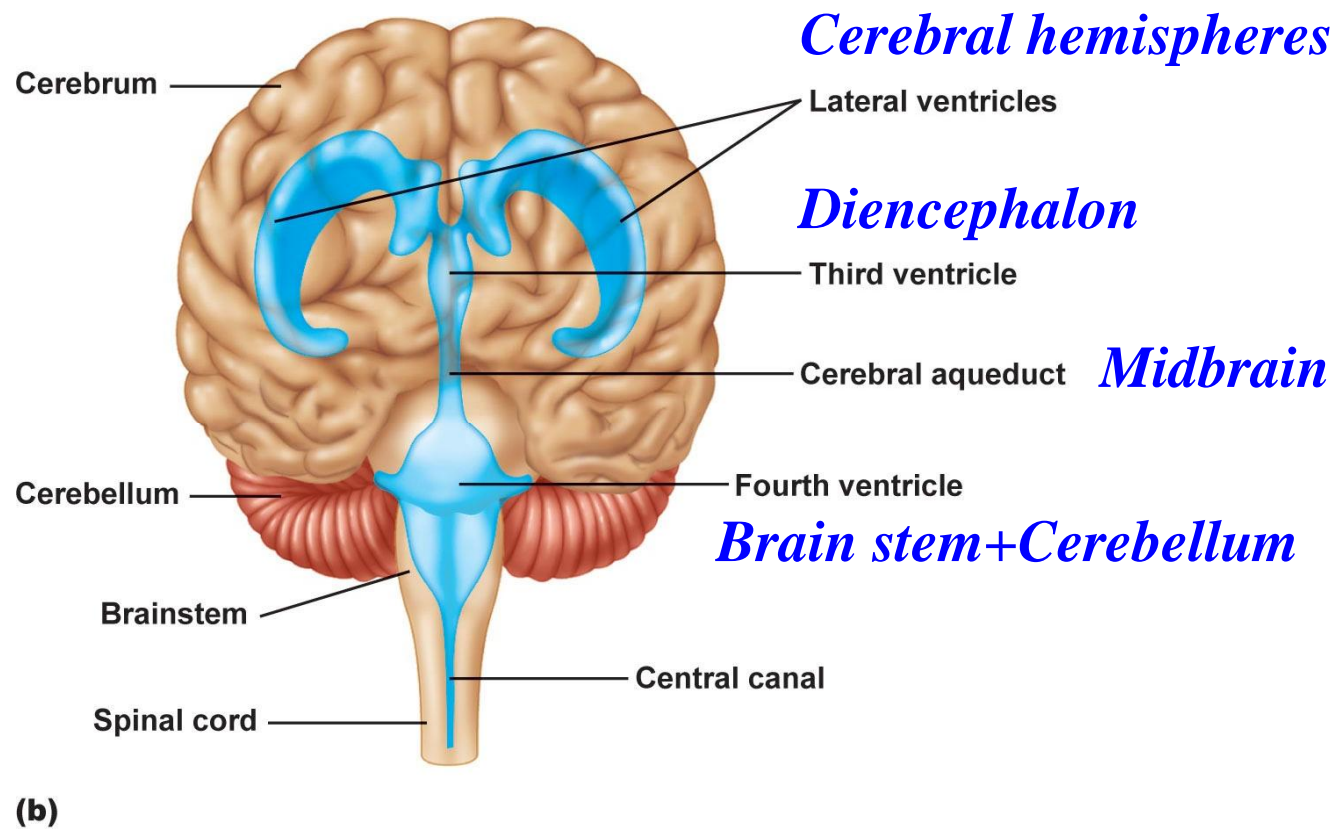
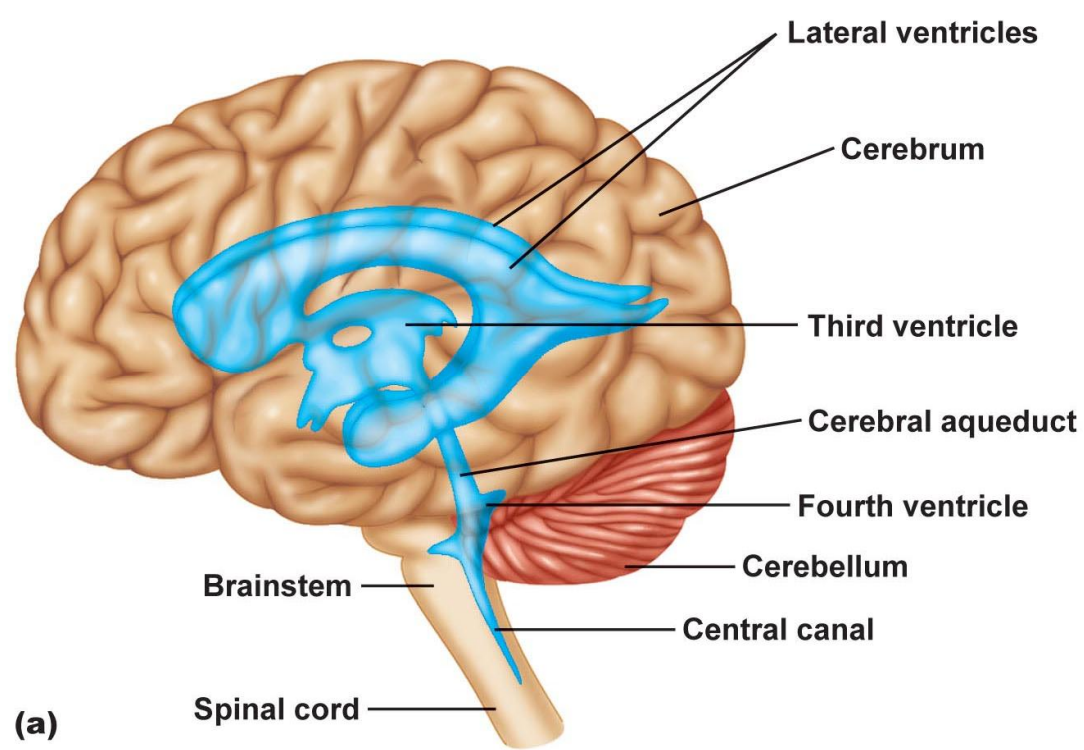
1. **Falx cerebri** (大腦鐮) separate the two cerebral hemispheres
2. **Falx cerebelli** (小腦鐮) separate the two cerebellar hemispheres
3. **Tentorium cerebelli** (小腦天幕) separate the cerebrum from the cerebellum

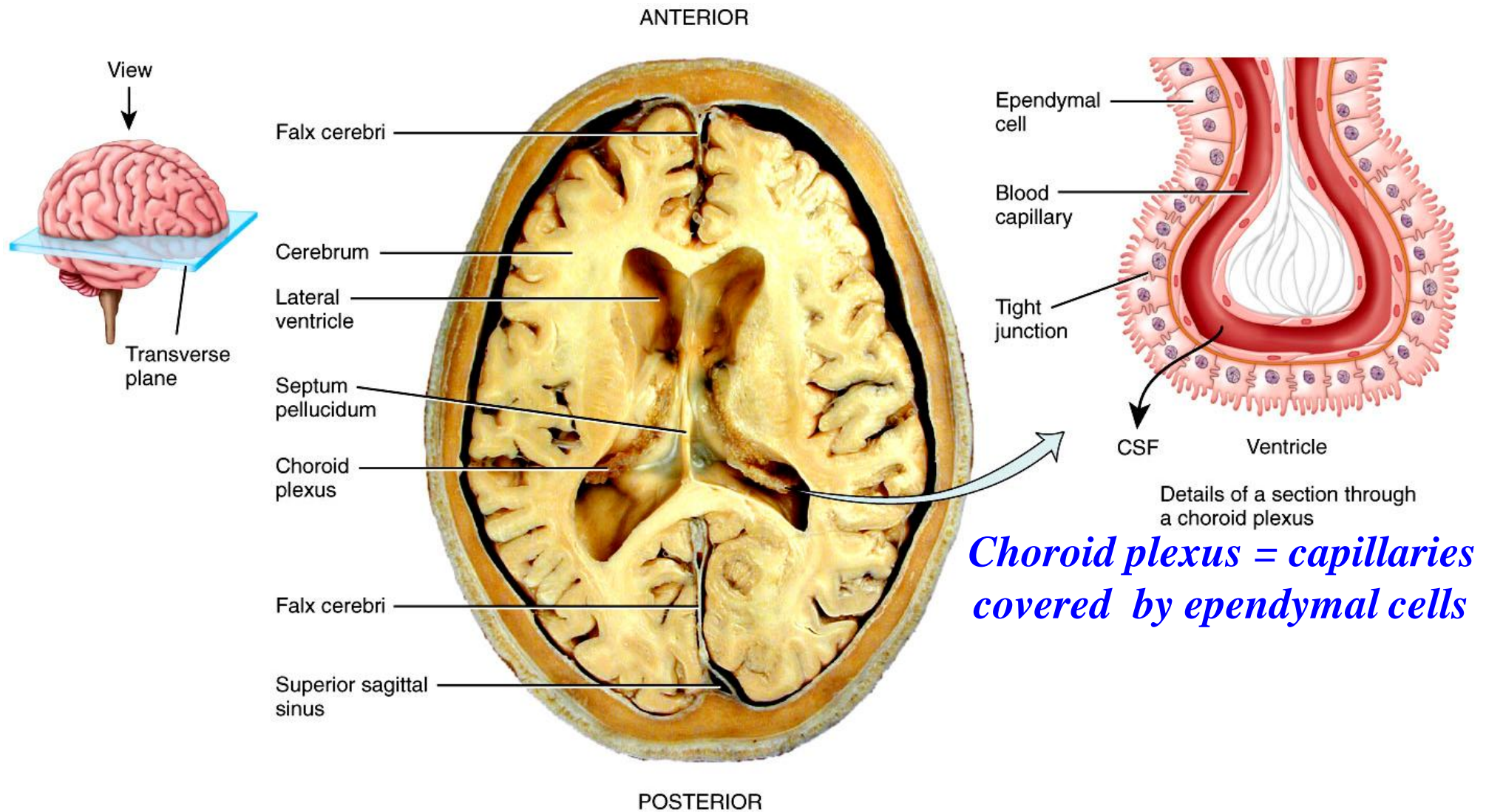


(b) Sagittal section of extensions of the dura mater

Cerebrospinal Fluid (CSF)

- Clear watery fluid bathing the CNS
- Secreted by **ependymal cells of the choroid plexus**
 - Circulates to **subarachnoid space** and **ventricles**
 - Reabsorbed by **arachnoid villi**
- **Locations** of choroid plexus
 - 2 lateral ventricles, one within each cerebral hemisphere
 - roof of 3rd ventricle
 - fourth ventricle
- **Functions**
 - Absorbs shock and protects the brain and the spinal cord
 - Maintains stable interstitial fluid environment





(a) Superior view of transverse section of brain showing choroid plexuses

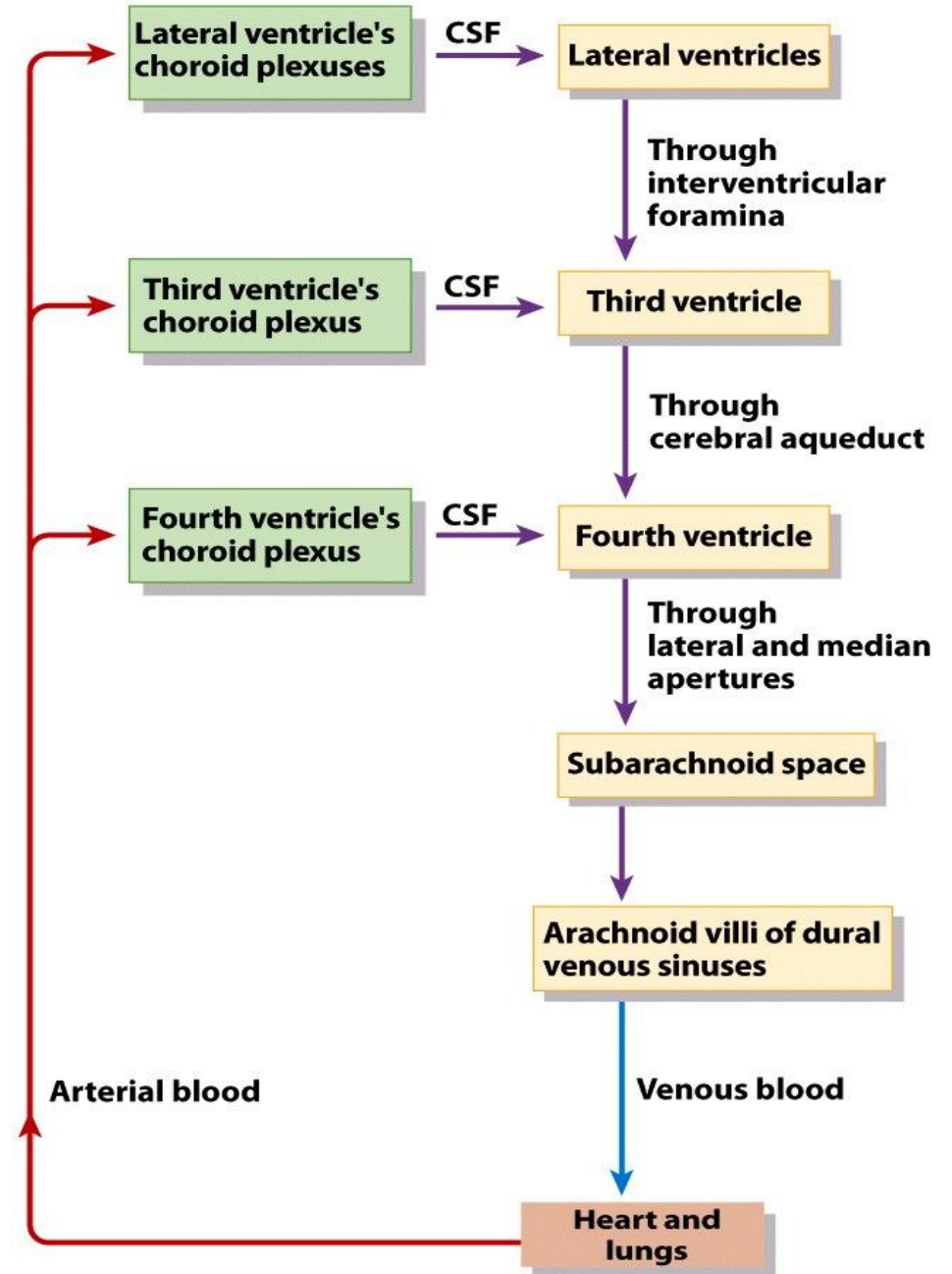
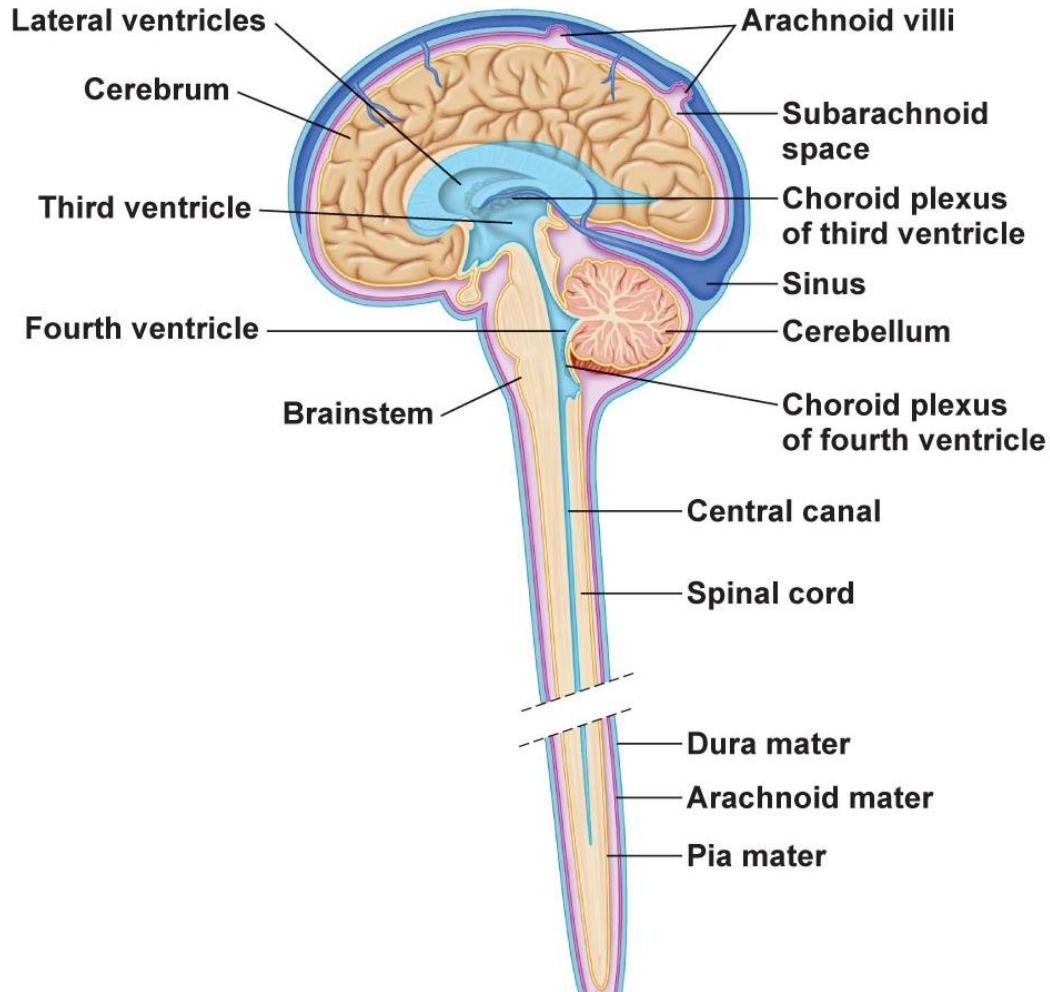
- **Total volume of CSF = 125–150 mL (10 mmHg)**
- **Choroid plexus produces 400–500 mL/day**
- **Recycled three times a day**

Compositions of Plasma and CSF

	Plasma	CSF
Glucose (mg/dL)	80–100	45–80
Proteins (mg/dL)	7000	15–45
Sodium (mM)	145	149
Potassium (mM)	4	3.1
Chloride (mM)	103	129
Calcium (mM)	2.5	2.1

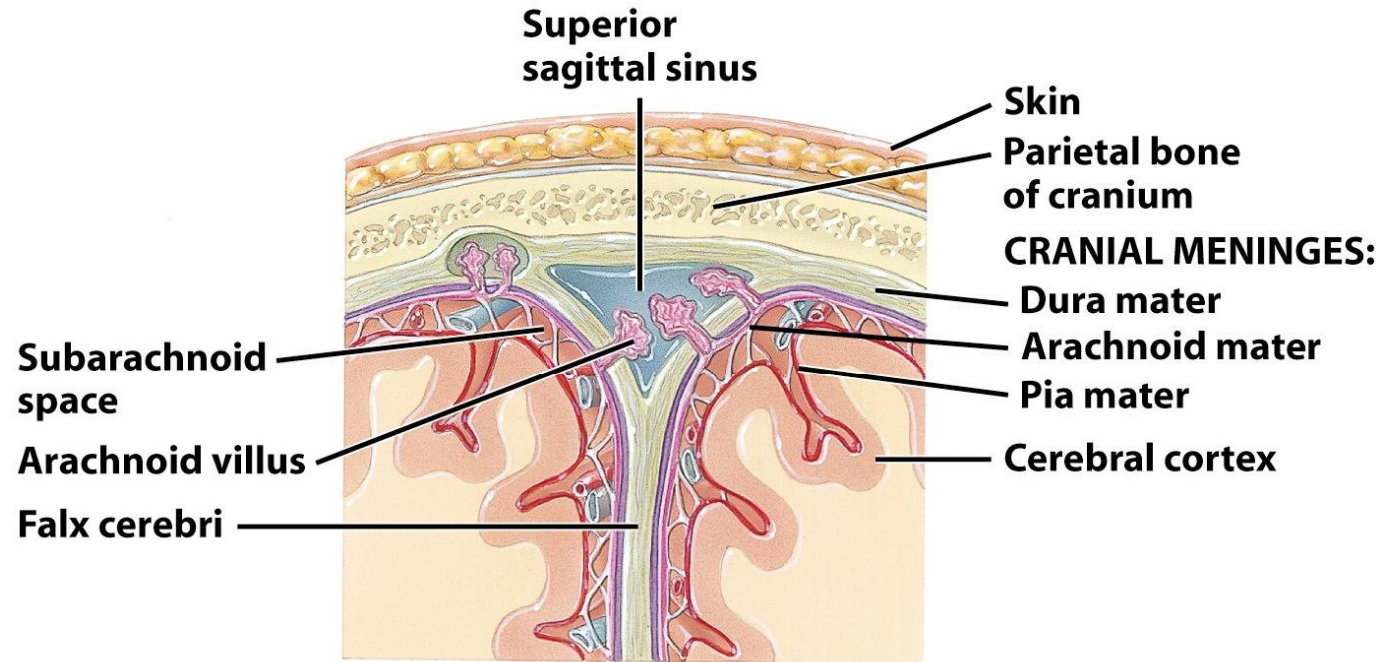
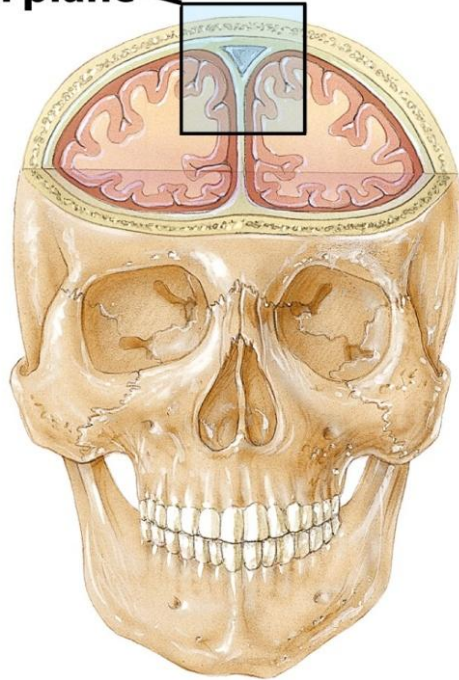
*CSF levels vary based on sampling site.

Flow of CSF



Reabsorption of CSF

Frontal plane



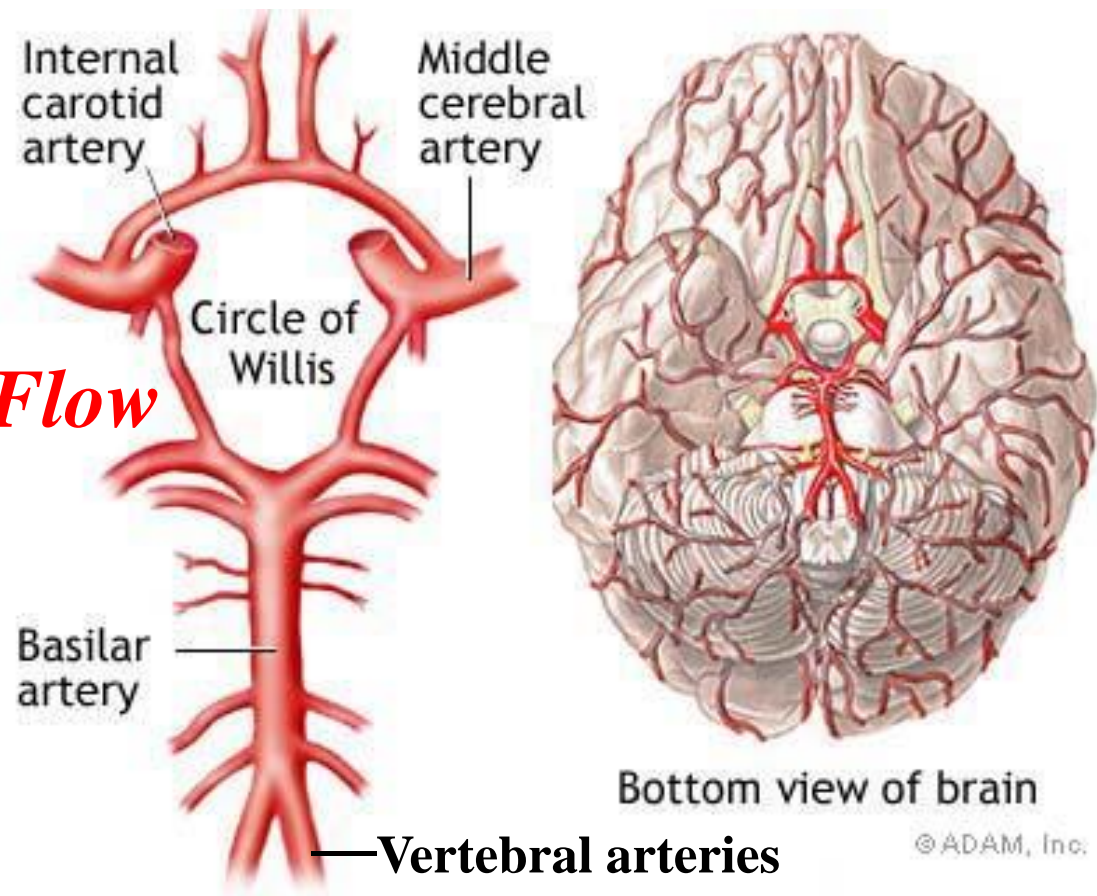
Frontal section through skull showing the cranial meninges

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

Brain Blood Flow and the Blood-Brain Barrier

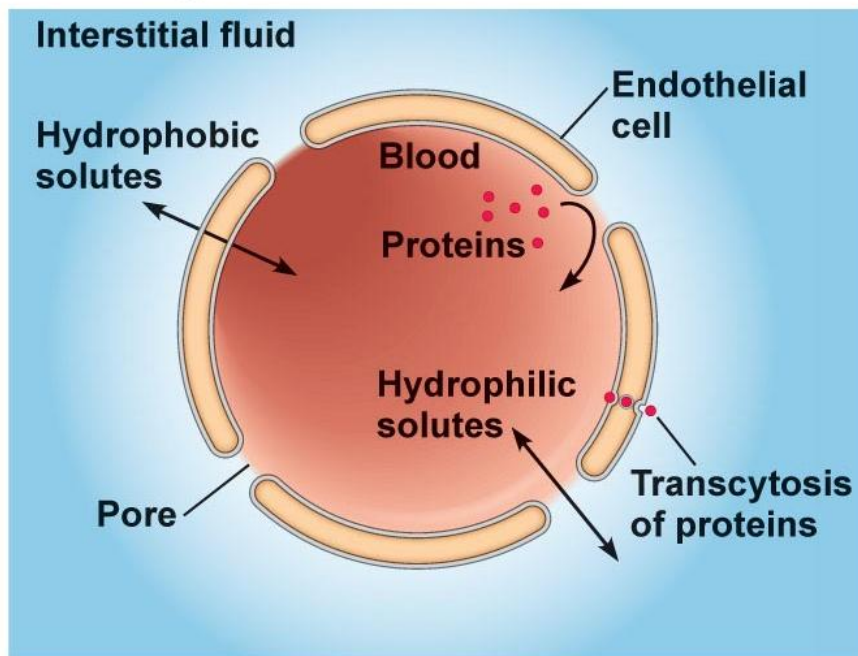
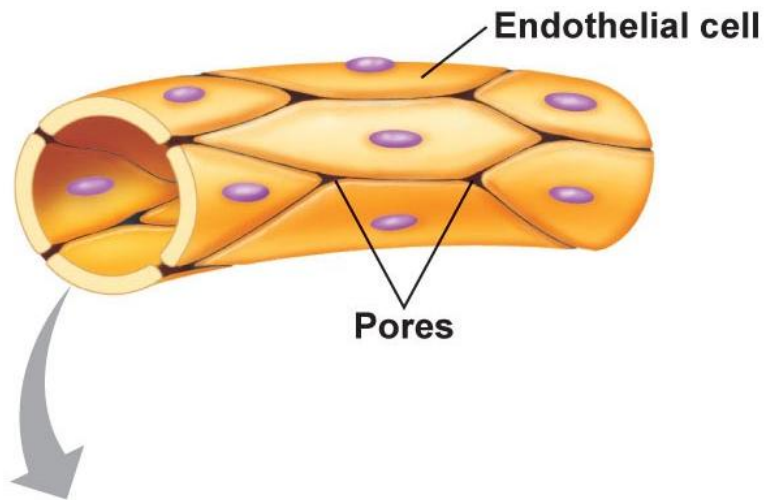
- Brain receives approximately **20%** of the total blood supply (high metabolic rate- aerobic glycolysis)
 - Brain uses **20%** of **oxygen** consumed by body at rest
 - Brain uses **50%** of **glucose** consumed by body at rest
 - No glycogen stores and fatty acids not used for energy
- Internal carotid and vertebral arteries --connect through the **Circle of Willis** (loops around the brainstem at the base of the brain) carry blood to the brain.
- Internal jugular veins return blood from the brain.
- **Blood-brain barrier (BBB)** protects brain from harmful substances

Brain Blood Flow

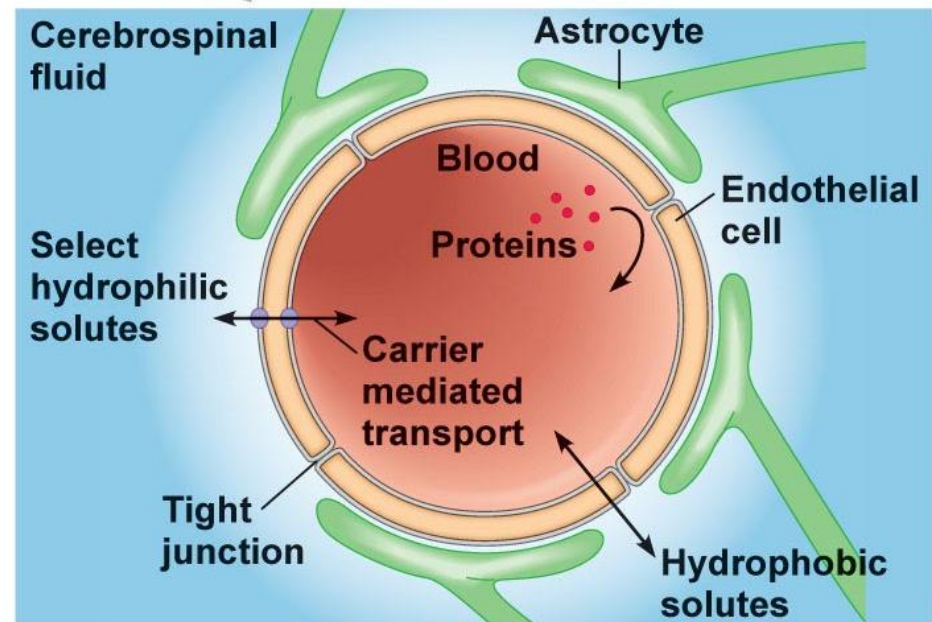
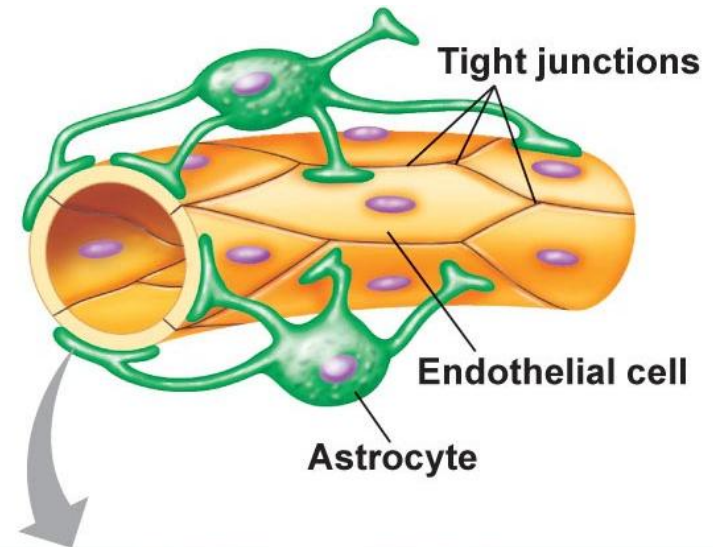


- **The internal carotid arteries** supply blood to the **anterior 3/5 of cerebrum**, except for parts of the temporal and occipital lobes
- **The vertebral arteries** travel along the spinal column and they join to form a single **basilar artery= vertebrobasilar arteries**, which supply blood to the **posterior 2/5 of the cerebrum**, part of the cerebellum, and the brain stem

Blood-Brain Barrier



(a) Typical capillary



(b) Brain capillary

Clinical Application:

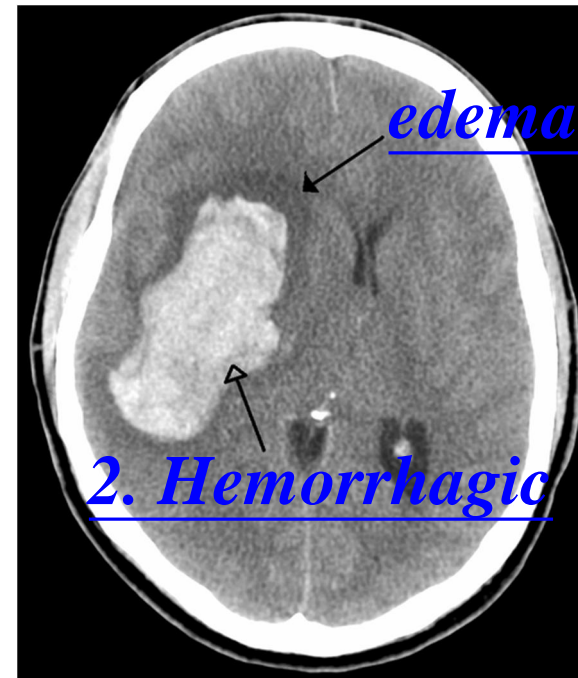
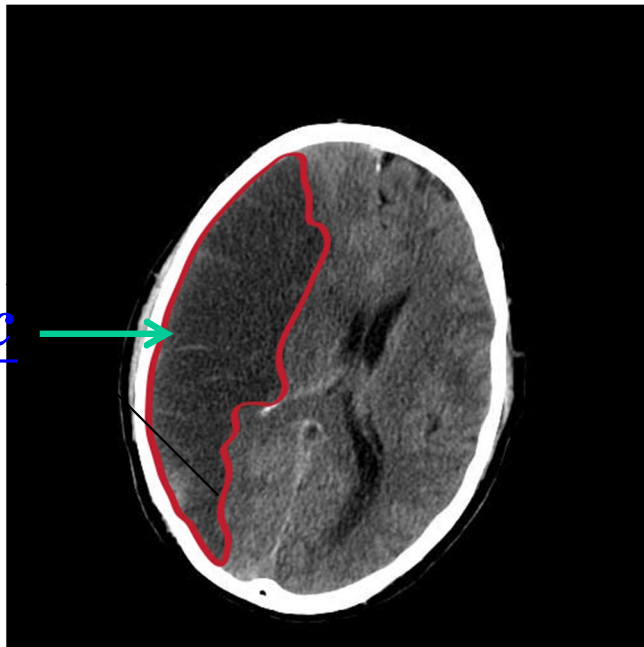
Stroke = Cerebrovascular Accident (CVA)

- Decreased brain blood supply (ischemia) caused by **blockage** (thrombosis, arterial embolism), or a **hemorrhage** (leakage of blood)

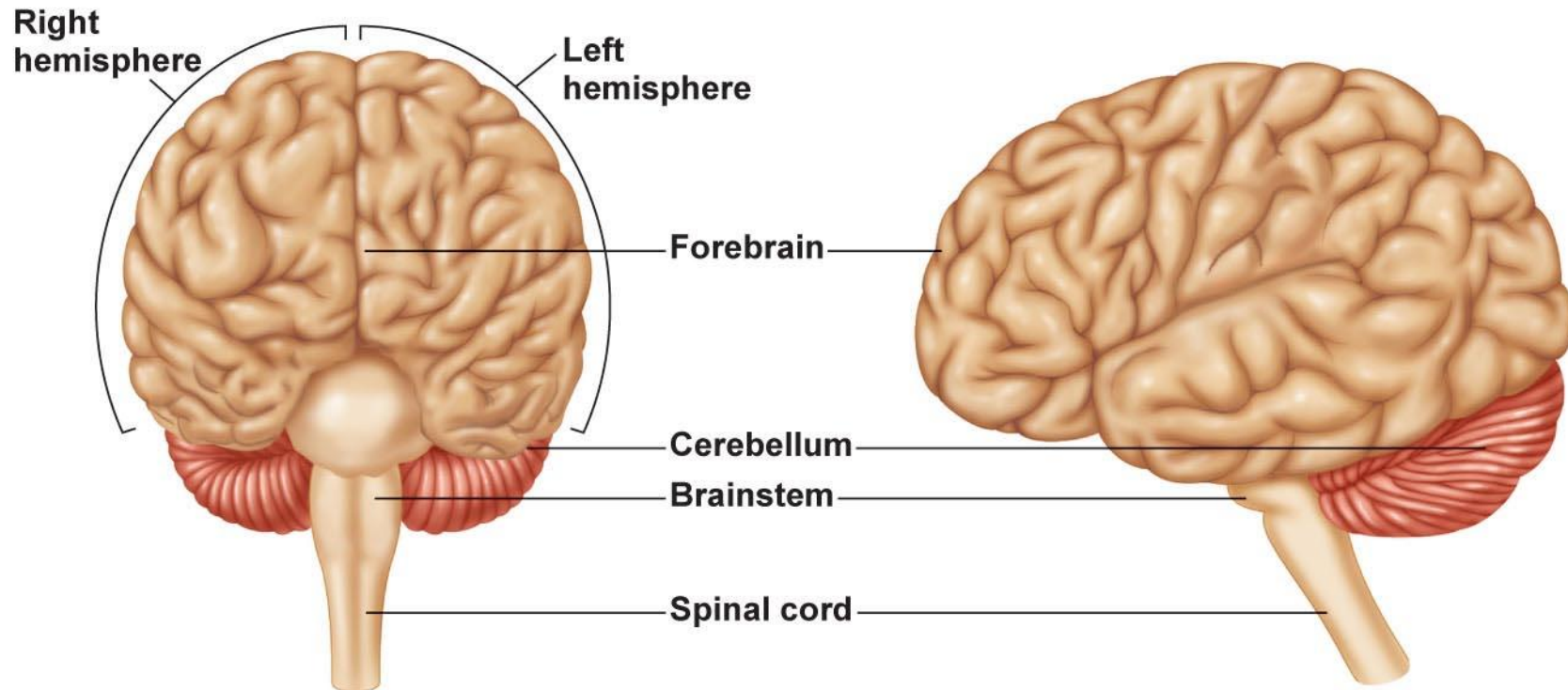
1. Ischemic stroke: Occlusion of cerebral blood vessel

2. Hemorrhagic stroke: Hemorrhage from cerebral blood vessel

*1. Ischemic
infarct*



Major Parts of the Brain



(a) External anterior view

(b) External lateral view (left hemisphere)

1. Forebrain

大腦(cerebrum)

--Cerebral cortex & Basal nuclei

間腦(diencephalon)

--Thalamus & Hypothalamus

2. Brainstem

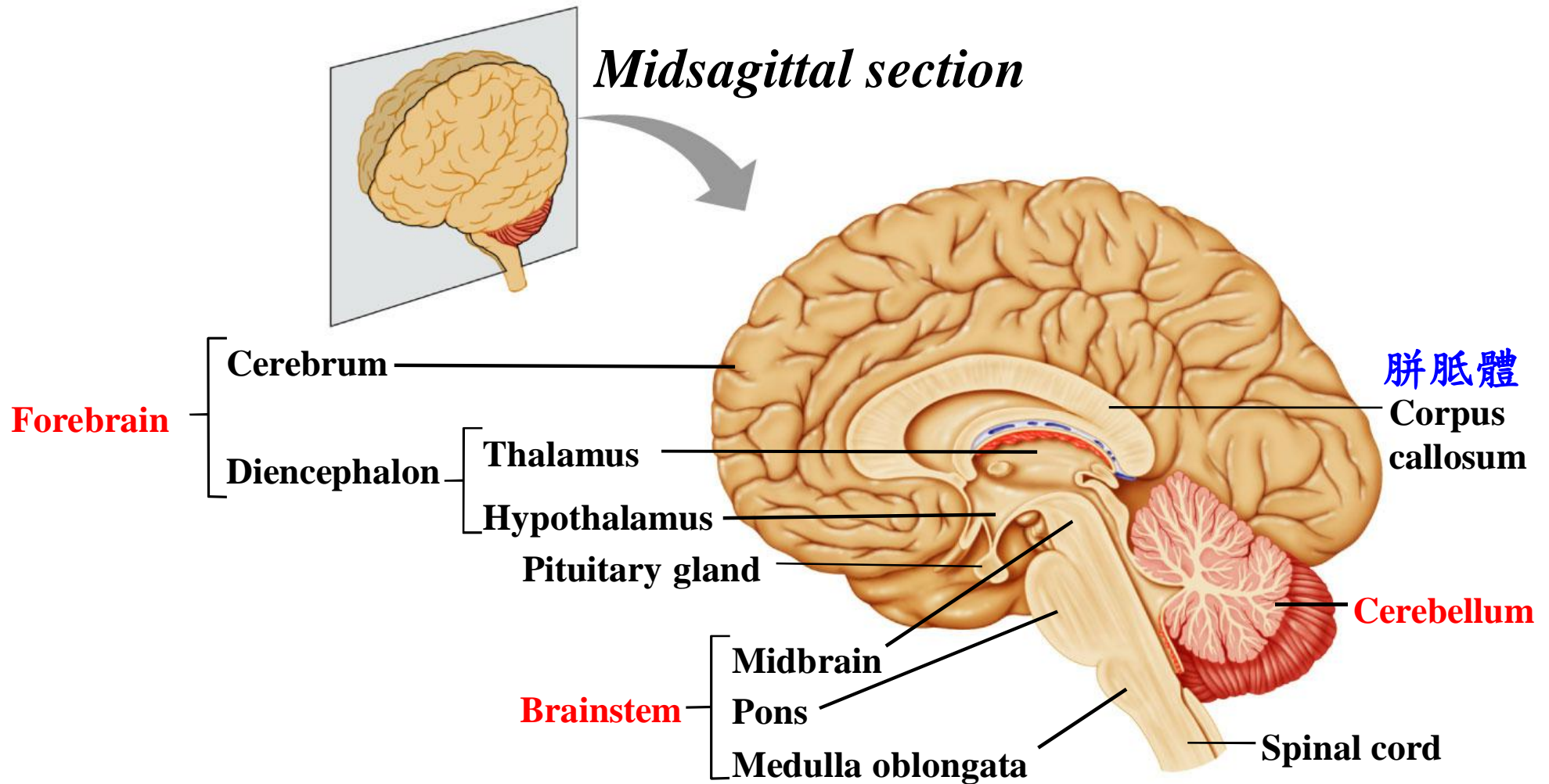
中腦(midbrain)

橋腦(pons)

延腦(medulla)

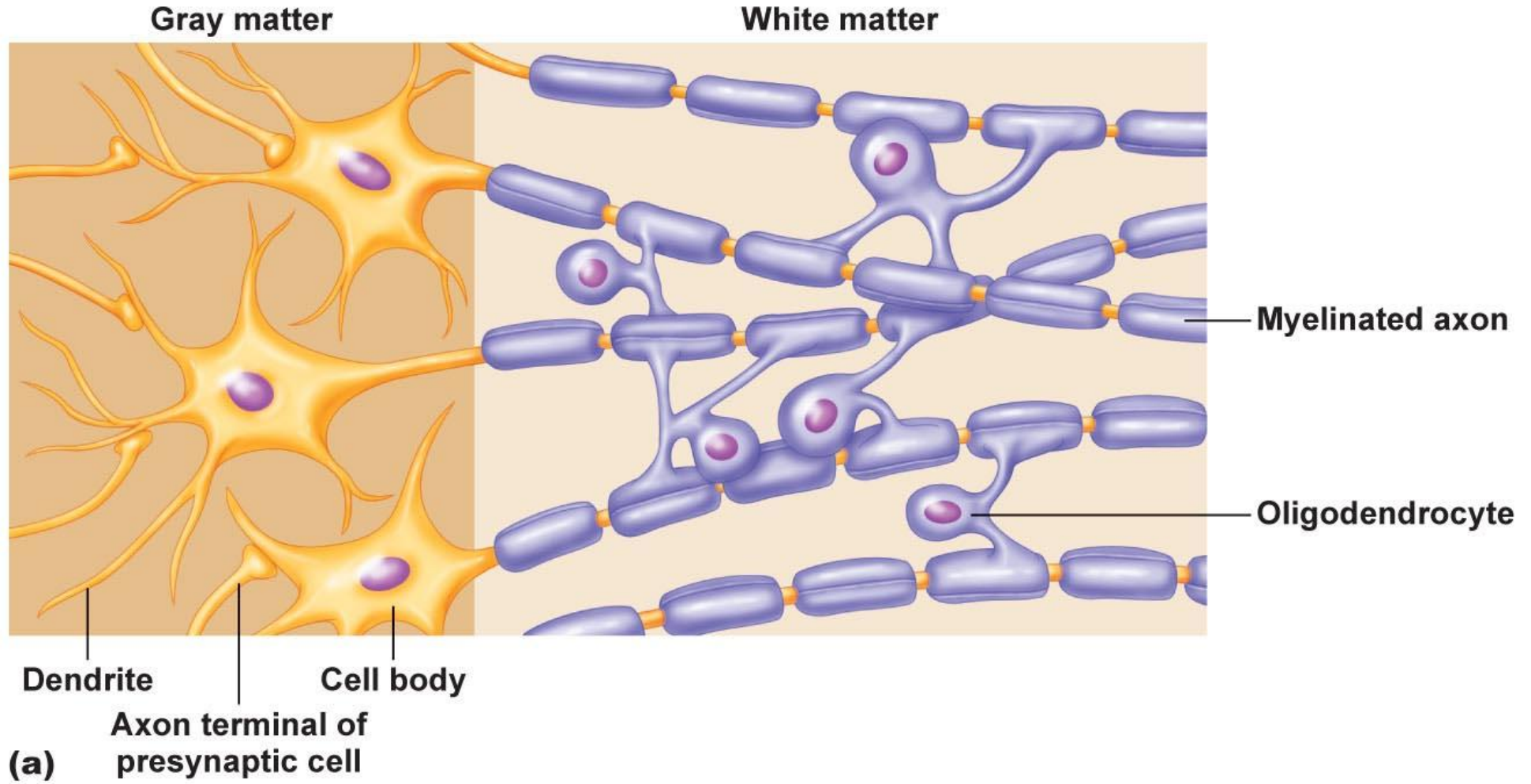
3. Cerebellum

Major Parts of the Brain

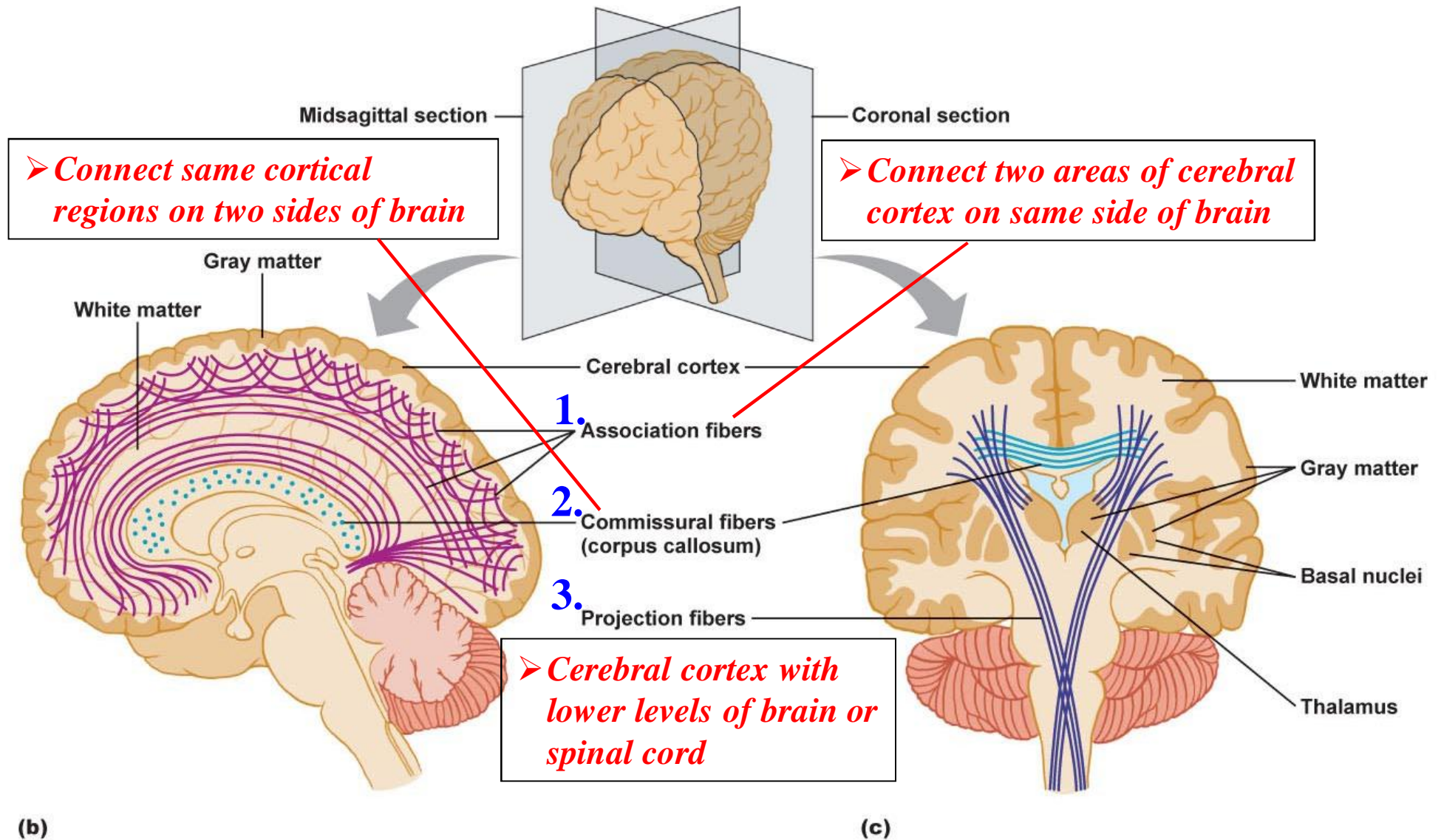


➤ *Pons+medulla+cerebellum= Hindbrain*

CNS: Gray and White Matter



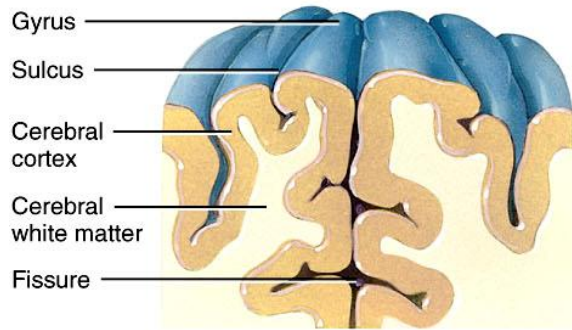
White Matter in Brain



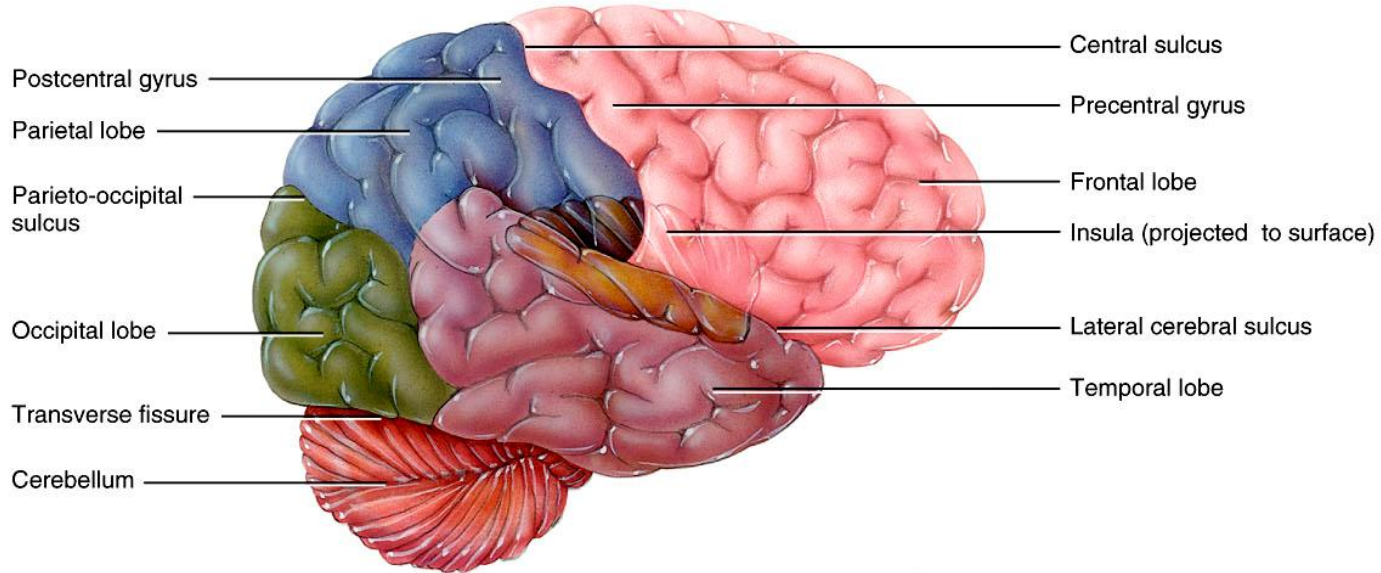
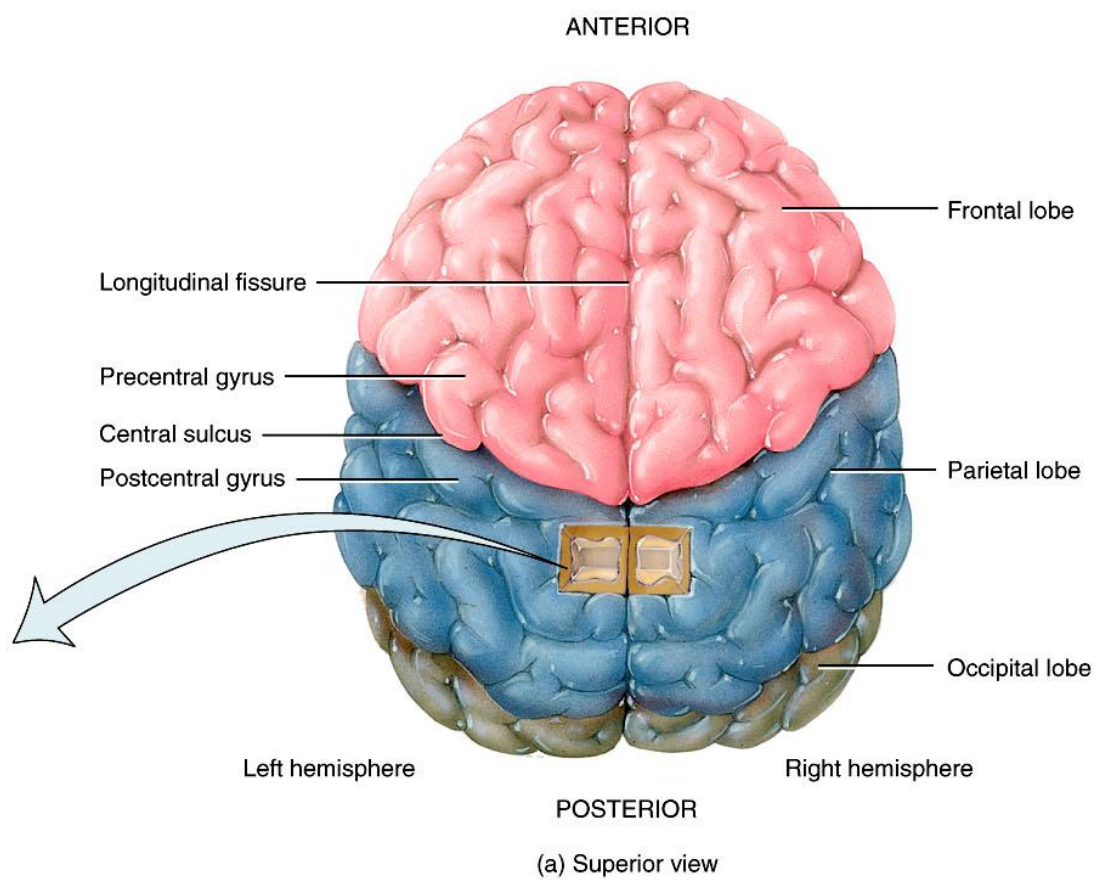
Cerebrum

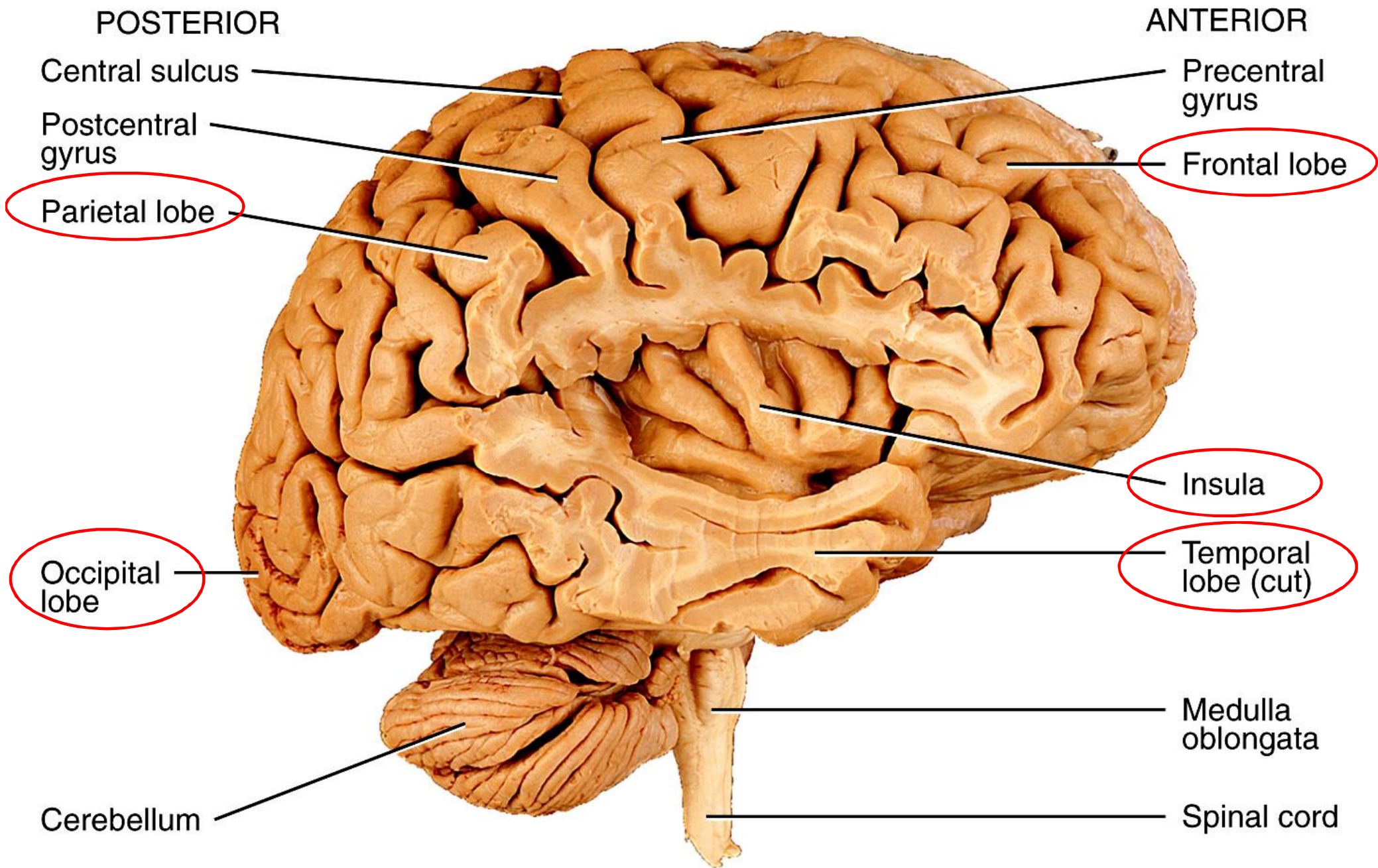
- The *cerebrum* is the largest part of the brain
 - The surface layer, the **cerebral cortex**, is 2-4 mm thick and is composed of **gray matter**
 - The cortex contains *gyri* (腦回), deep grooves called *fissures* (腦裂), and shallower *sulci* (腦溝)
- Beneath the cortex lies the cerebral **white matter**, tracts that connect parts of the brain with itself and other parts of the nervous system.
- The cerebrum is nearly separated into right and left halves, called *hemispheres*, by the longitudinal fissure.
 - Internally it remains connected by the *corpus callosum*, a bundle of transverse white fibers
- Functions: responsible for **higher mental functions**, **motor coordination and balance & coordination of eye and body movements**

Cerebrum



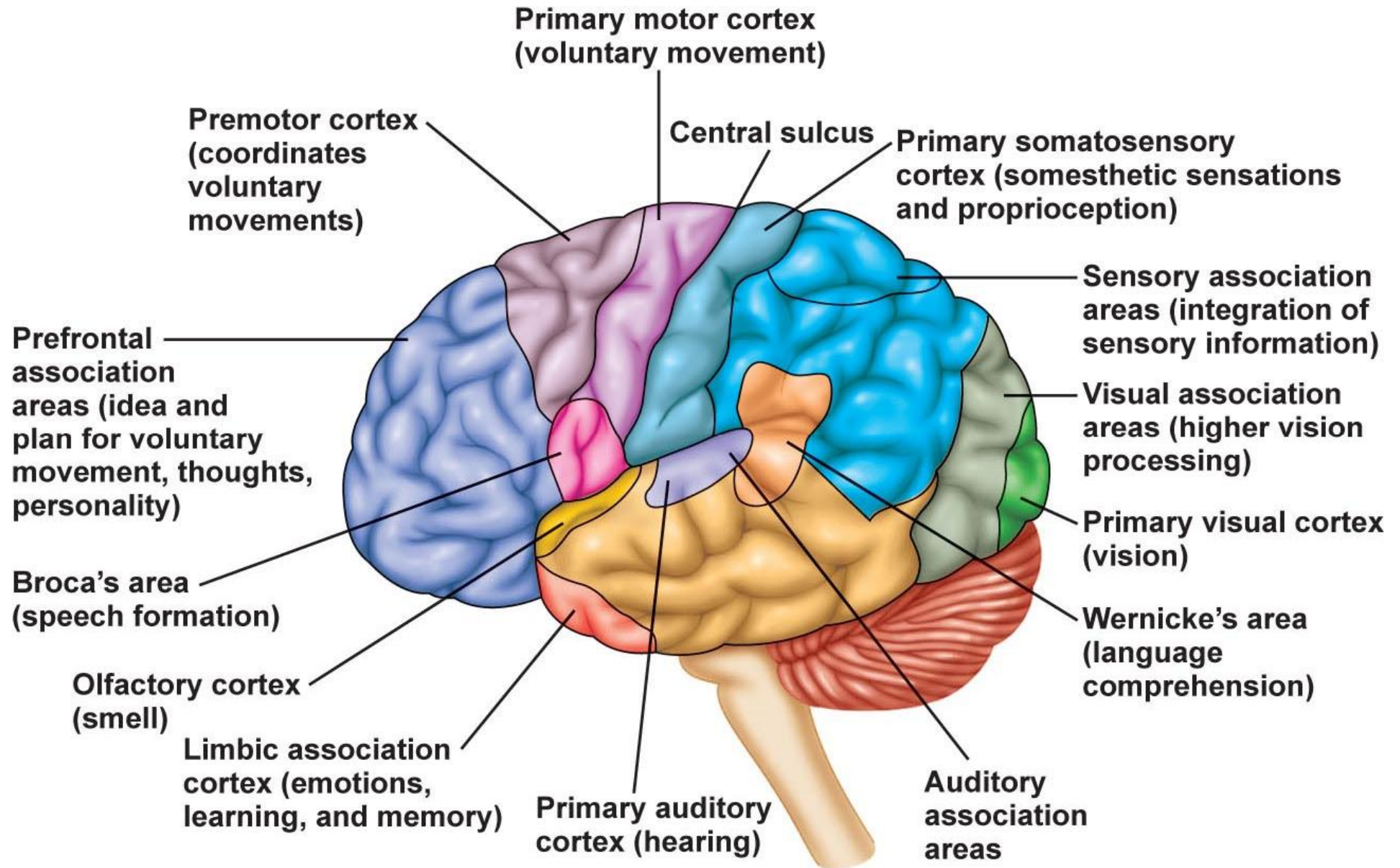
Details of a gyrus, sulcus, and fissure





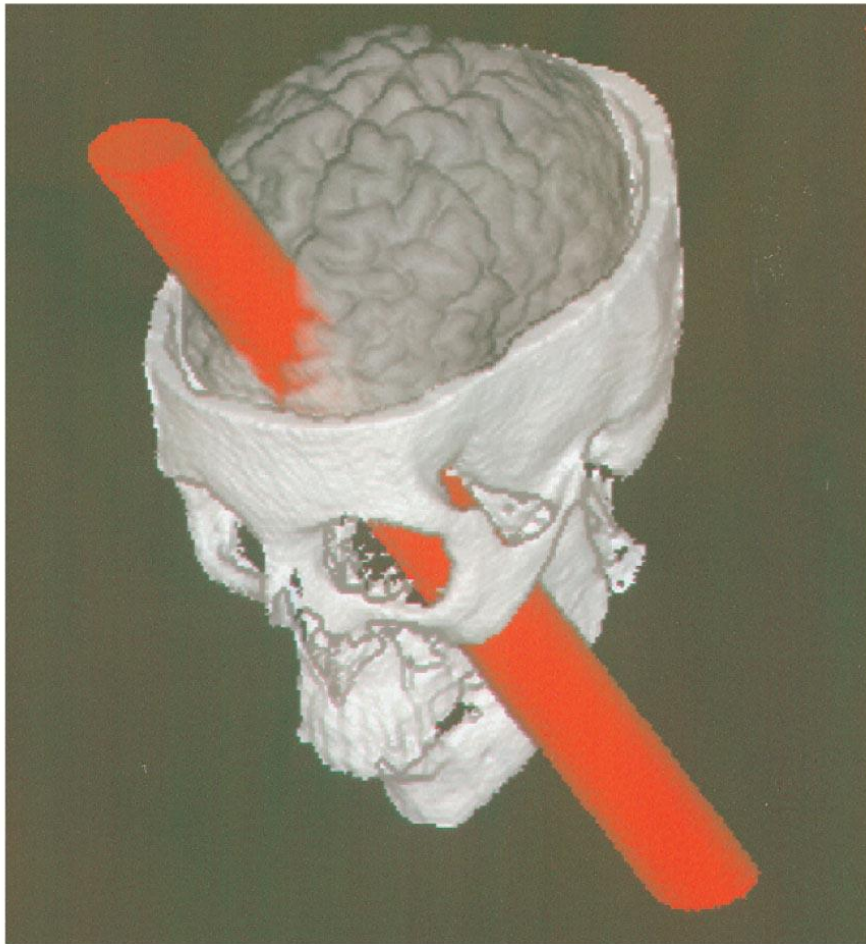
(c) Right lateral view with temporal lobe cut away

Functional Areas of Cerebrum

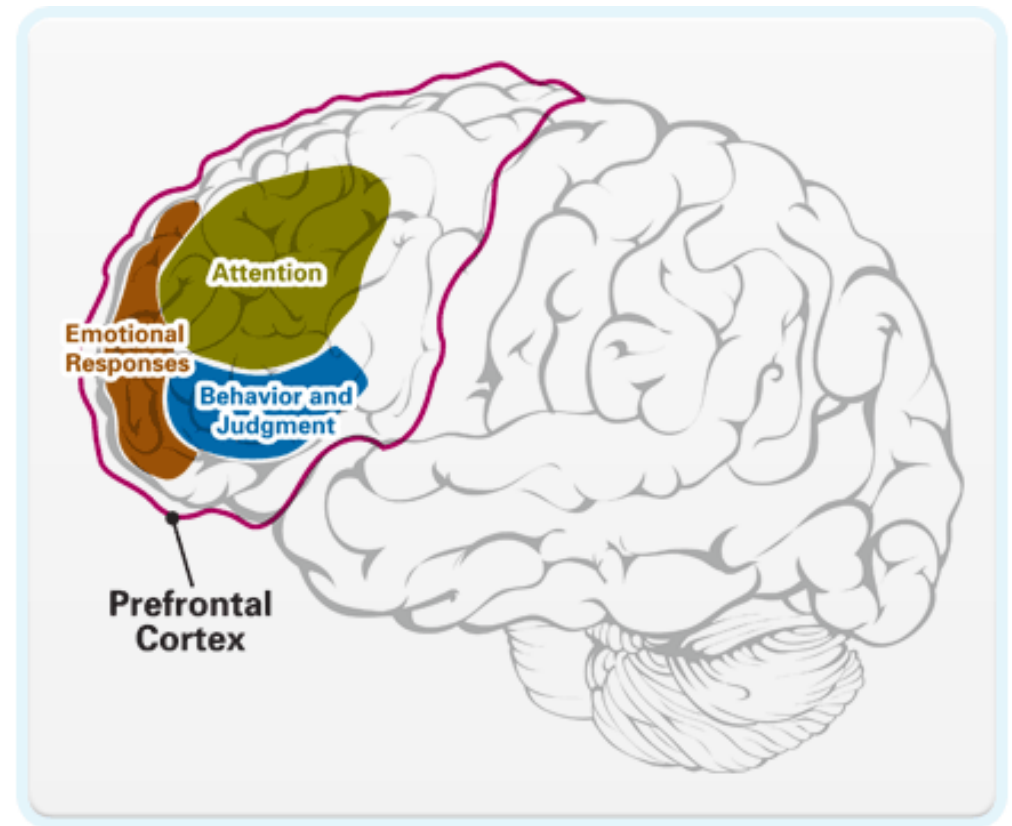


Prefrontal Association Cortex:

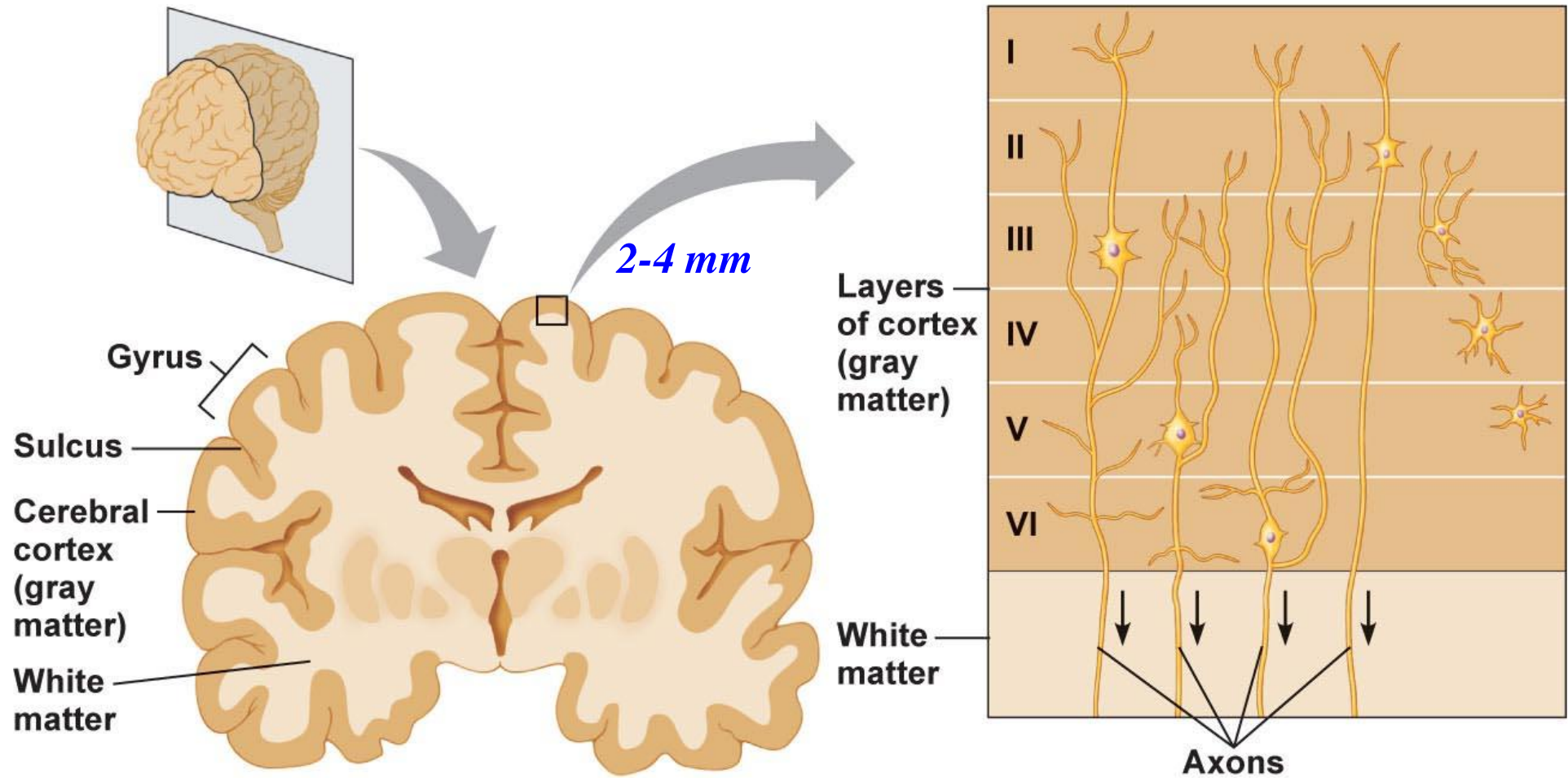
Personality



Phineas Gage accident

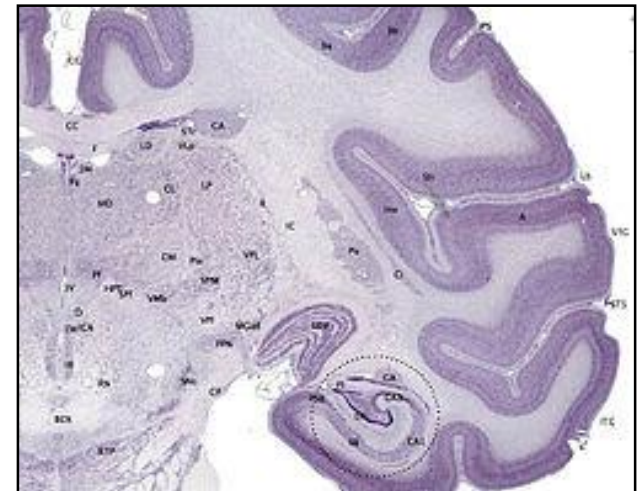


Layers of the Cerebral Cortex



Cerebral Cortex

- Outermost portion of cerebrum
- Thin convoluted layer of gray matter
- **Highest level of neural processing**
 - *Perception of environment*
 - *Formulate ideas*
 - *Recall past events*
 - *Command body movement*
 - *Complex integrating center*



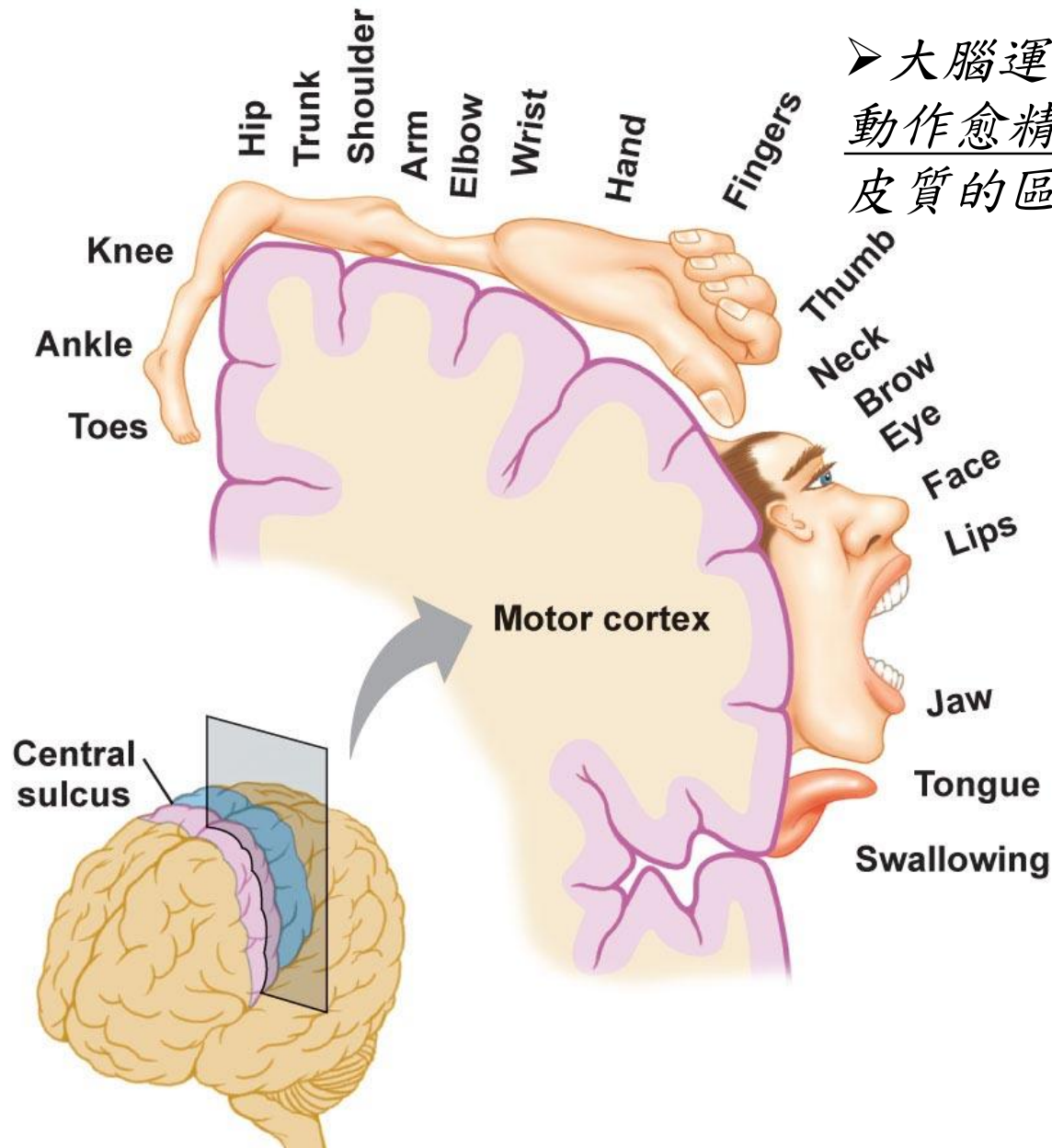
Topographical Organization

若將身體各部位依據其在運動或體感覺皮質上的
對應位置及**面積大小**予以排列組合
所呈現的圖像如同一個身體各部位比例被扭曲的小人

- Areas mapped according to function
- Characteristic of **cerebral cortex**
- Primary motor cortex
 - In frontal lobe
 - Motor homunculus (運動小人)**
- Primary somatosensory cortex
 - In parietal lobe
 - Sensory homunculus (感覺小人)**

Topographical Organization:

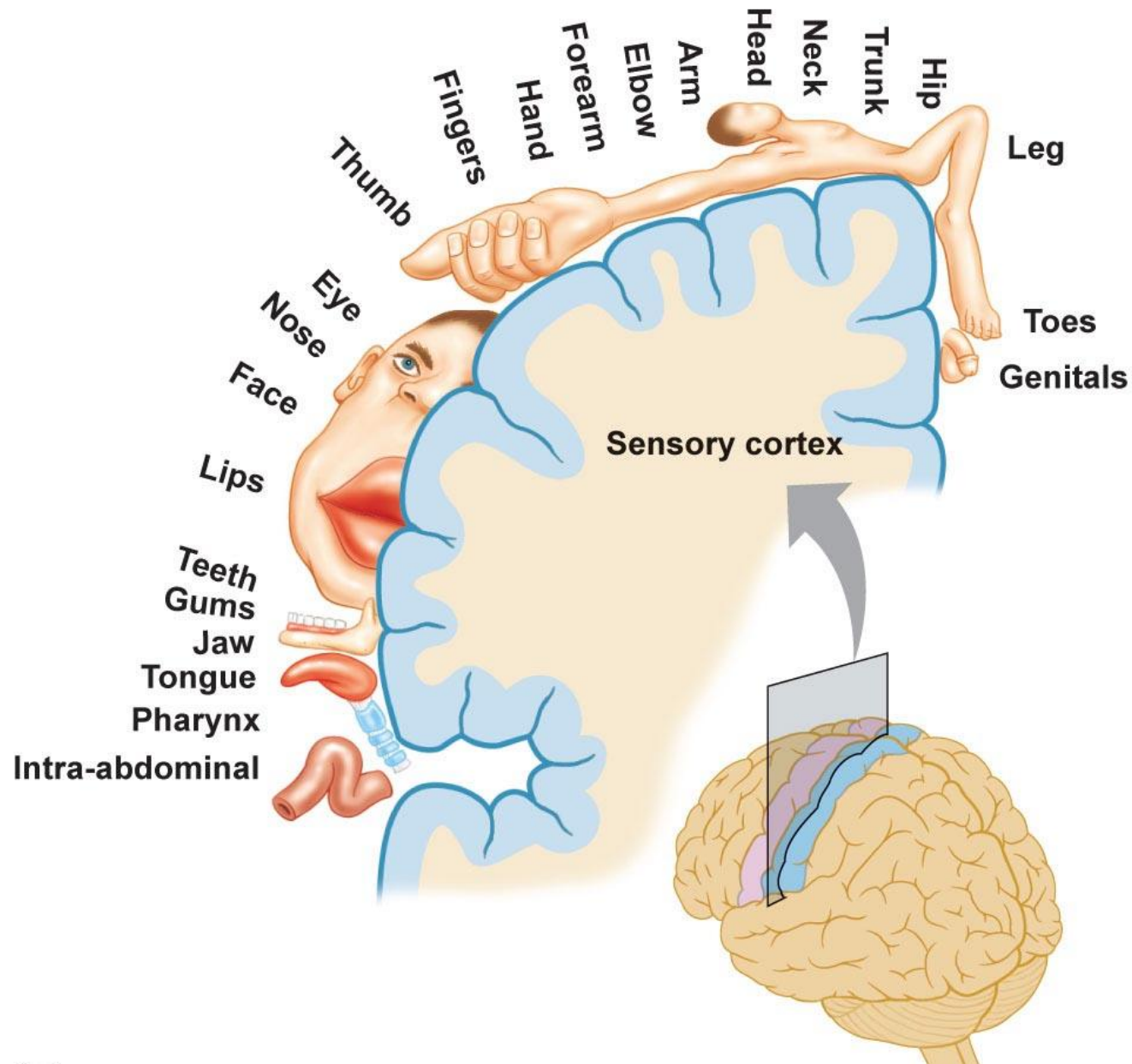
Motor Homunculus



➤ 大腦運動區支配對側肢體，動作愈精細或愈隨意，所佔皮質的區域愈大

Topographical Organization:

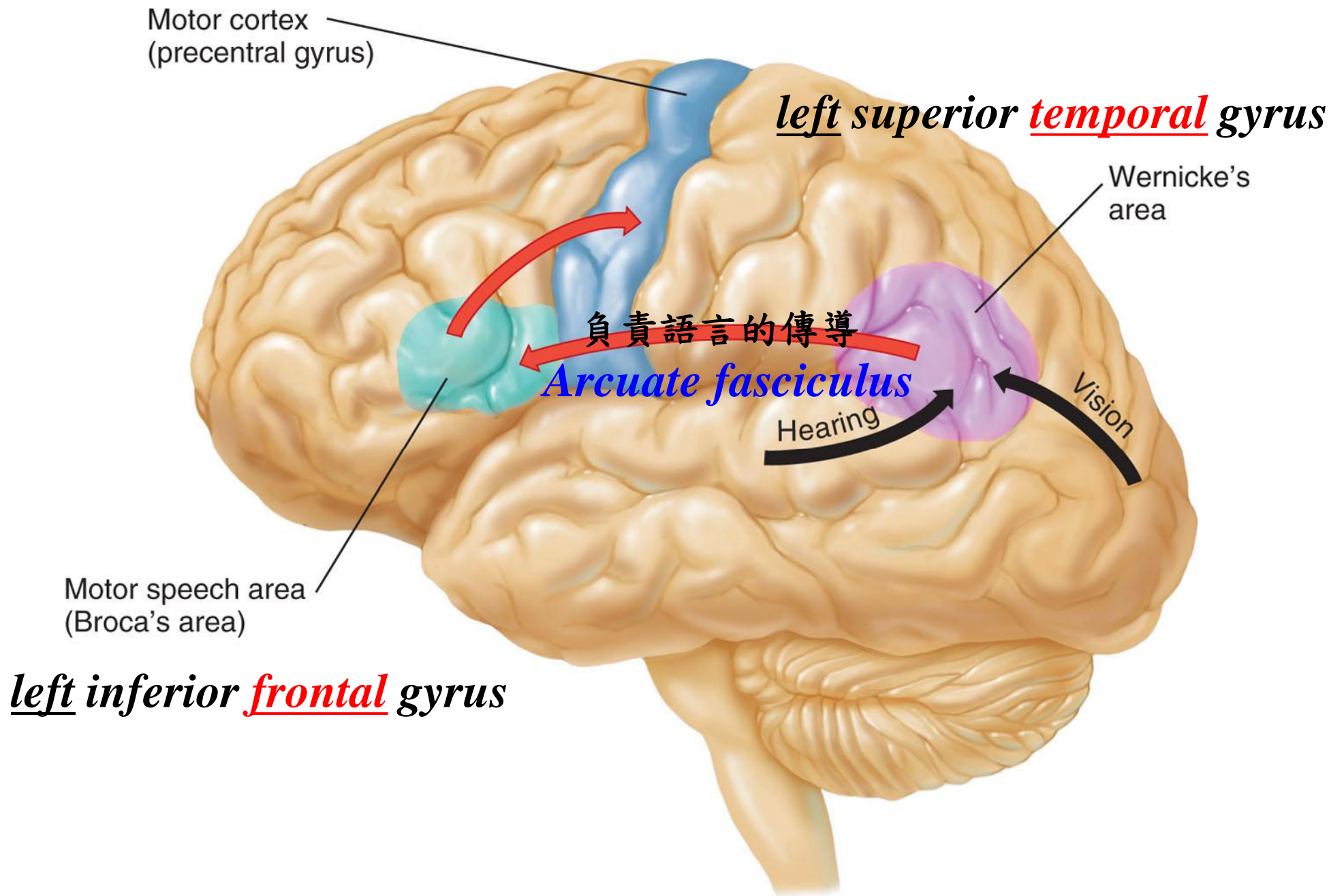
Sensory Homunculus



Integrated CNS Function:

Language

- Most of the knowledge of how the brain controls language has come from studying people with speech problems called **aphasias**
- Two areas are identified as important :
 - Broca's area (left inferior **frontal** gyrus)
 - Wernicke's area (left superior **temporal** gyrus)



失語症(Aphasia)

1. 理解性的失語症(感覺=流利型失語症)

是顳葉沃爾克氏區受損，此類病人答非所問，閱讀和理解能力有困難。雖看得到別人寫的東西卻無法看懂；雖聽的到別人說的話卻無法聽懂，病人說話相當流利但毫無意義。

2. 表達性的失語症(運動=非流利型失語症)

是額葉伯羅夫氏區受損，此病人可以完全聽懂別人說的話，但當病人要嘗試說話時舌頭肌肉雖可以正常控制，但因嘴部運動和呼吸無法協調，所以口吃或言語遲緩而且較不清晰。

3. 傳導性的失語症

是弓狀束受損，語言的接受和表達是正常，但無法複誦和朗讀，因為它是連接沃爾尼克氏區和伯羅夫氏區的神經路線。

Hemispheric Lateralization

● Sensory pathways cross

--Right brain perceives left input

--Left brain perceives right input

● Motor pathways cross

--Right brain controls muscles on left

--Left brain controls muscles on right

Hemispheric Lateralization

Functional Differences Between the Two Cerebral Hemispheres

LEFT HEMISPHERE FUNCTIONS

Receives somatic sensory signals from and controls muscles on right side of body.

Reasoning.

Numerical and scientific skills.

Ability to use and understand sign language.

Spoken and written language.

RIGHT HEMISPHERE FUNCTIONS

Receives somatic sensory signals from and controls muscles on left side of body.

Musical and artistic awareness.

Space and pattern perception.

Recognition of faces and emotional content of facial expressions.

Generating emotional content of language.

Generating mental images to compare spatial relationships.

Identifying and discriminating among odors.

左腦 (理性)

邏輯

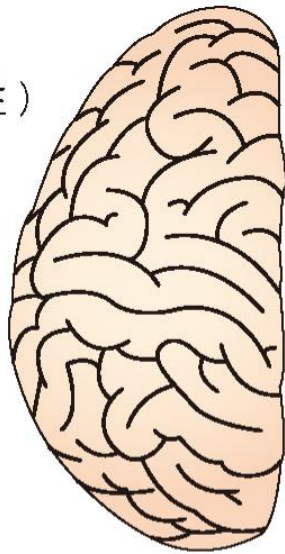
語言

數學

文字

推理

分析



右腦 (感性)

圖畫

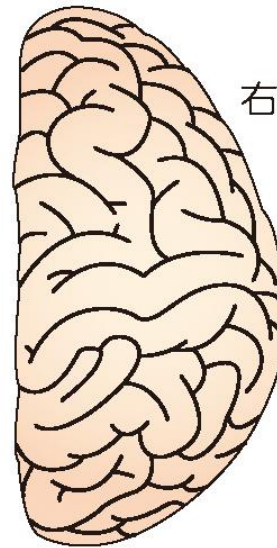
音樂

韻律

情感

想像

創意



Visualizing Brain Function

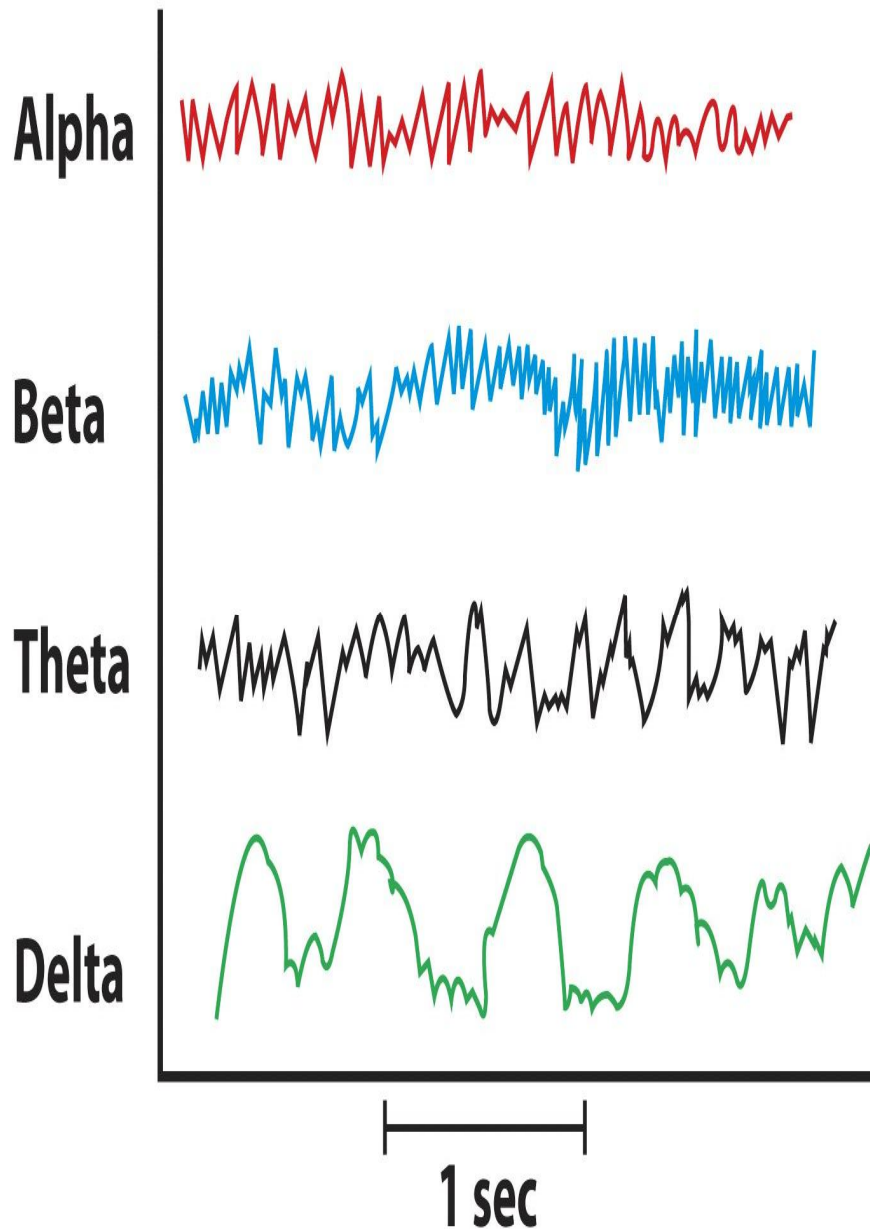
Abbreviation	Technique Name	Principle Behind Technique
EEG	Electroencephalogram	Neuronal activity is measured as maps with scalp electrodes.
fMRI	Functional magnetic resonance imaging	Increased neuronal activity increases cerebral blood flow and oxygen consumption in local areas. This is detected by effects of changes in blood oxyhemoglobin/deoxyhemoglobin ratios.
MEG	Magnetoencephalogram	Neuronal magnetic activity is measured using magnetic coils and mathematical plots.
PET	Positron emission tomography	Increased neuronal activity increases cerebral blood flow and metabolite consumption in local areas. This is measured using radioactively labeled deoxyglucose.
SPECT	Single photon emission computed tomography	Increased neuronal activity increases cerebral blood flow. This is measured using emitters of single photons, such as technetium.
CT	Computerized tomography	A number of x-ray beams are sent through the brain or other body region and are sensed by numerous detectors; a computer uses this information to produce images that appear as slices through the brain.

Source: Burkhart Bromm "Brain images of pain." *News in Physiological Sciences* 16 (Feb. 2001): 244–249.

Visualizing Brain Function

- **Electroencephalogram (**EEG**):** Electrodes on the scalp detect **synaptic potentials** produced by cell bodies and dendrites in the **cerebral cortex**
- Four patterns are usually seen:
 1. **Alpha waves:** active, relaxed brain. Seen most in frontal and parietal lobes
 2. **Beta waves:** produced with visual stimulation and mental activity. Seen most in frontal lobe
 3. **Theta waves:** seen during sleep; most from occipital and temporal lobes
 4. **Delta waves:** also seen in sleep, from all over the cerebrum

EEG



α 波(8 ~ 13 Hz)-- 頂葉和枕葉最明顯

又稱鬆懈波，一個人閉起眼睛但頭腦卻很清醒(身體放鬆的狀態心情愉快)

β 波(13 ~ 25 Hz)-- 在額葉最明顯

波形最快速、振幅小、頻率高，又稱忙碌波。有視覺刺激時閉起眼睛，突然張開看到某些事物或一個人開始想到某些事情或者去注意某些事情(大腦從事心智活動如閱讀、傾聽等)

θ 波(4 ~ 8 Hz)-- 顳葉與枕葉

又稱欲睡波，新生嬰兒的腦波

嚴重精神壓力或精神病的成人(利用 θ 波來測定精神疾病發作的前兆)

δ 波(<4 Hz)-- 所有大腦皮質

又稱沉睡波，正常成人睡覺時或在嬰兒清醒時以及成人在清醒時測得(表示你腦部有損傷或腦細胞受到傷害)

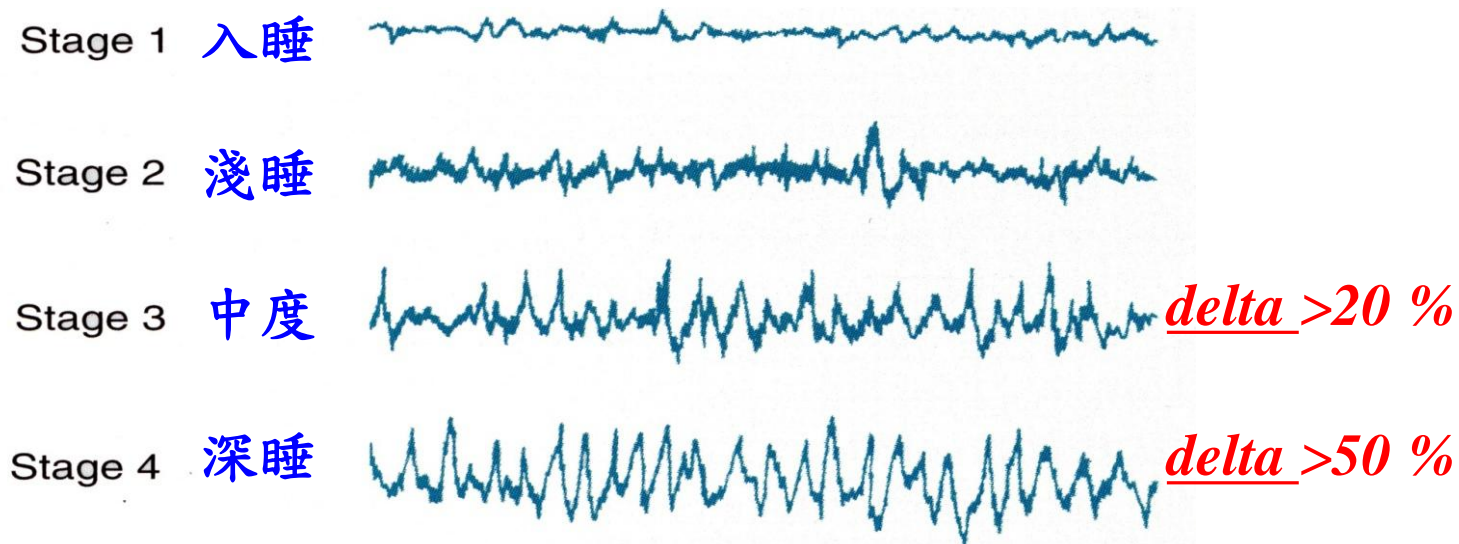
EEG of Sleep

● Two recognized categories:

--**REM (paradoxical sleep):** rapid eye movement; state when dreams occur. Theta waves are seen here.



--**Non-REM (resting sleep):** divided into four stages, determined by EEG waves seen. Stages 3 and 4 are often called slow-wave sleep, characterized by delta waves



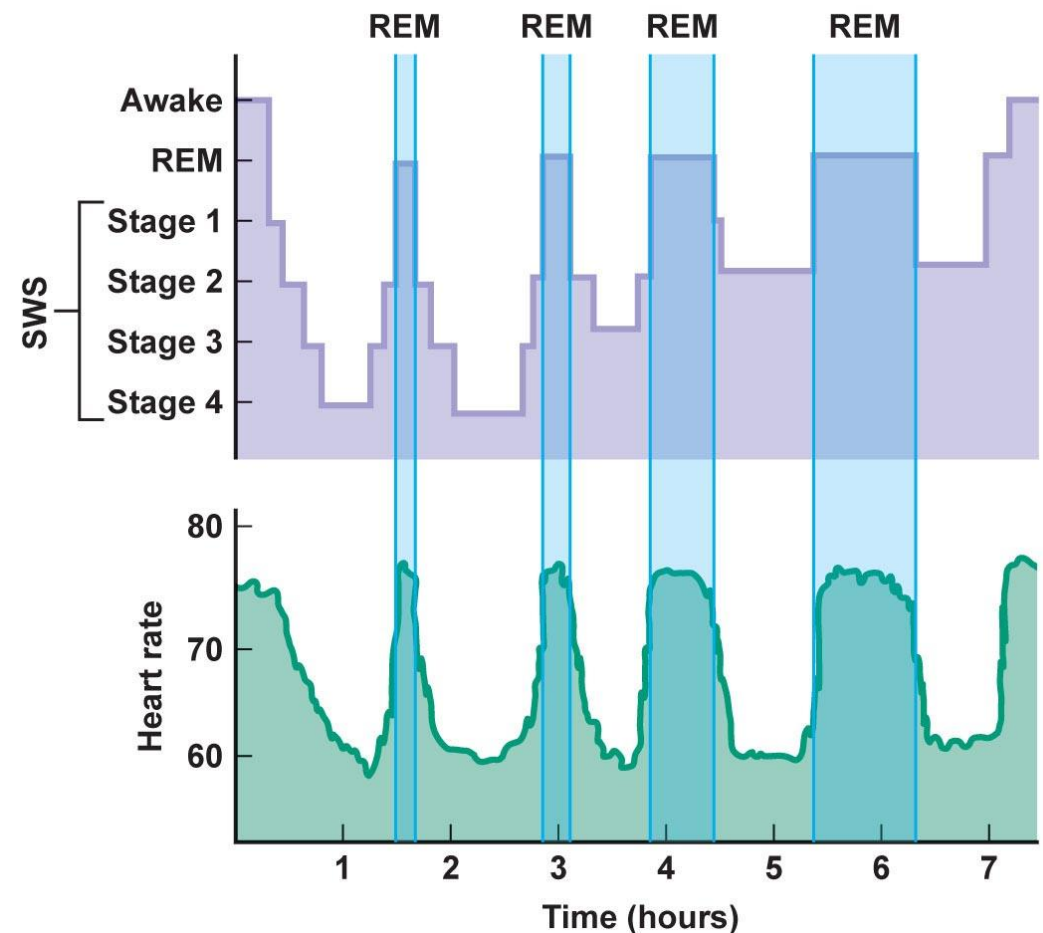
Integrated CNS Function:

Sleep

- When people first fall asleep, they enter non-REM sleep and progress through the four stages (30 min)
- Next, a person ascends back up the stages of non-REM sleep to REM sleep (60 min)
- This cycle repeats every **90 minutes**, and most people go through 4-5 per night
- If allowed to awaken naturally, people usually do so during REM sleep

Theories on purpose of sleep

- Lets **body and brain rest**
- Enhances **memory and learning**
- Adequate **immune system function**



REM Sleep

腦波圖出現去同步化(*desynchronized*)
快波和陣發性的眼球快速運動為特徵

- Some brain regions are more active during REM sleep than during the waking state
- The **limbic system** (involved in emotion) is very active during REM sleep
- Breathing and heart rate may be very **irregular**

Non-REM Sleep

腦波圖呈現**同步化(synchronized)**慢波為特徵

- As you fall asleep, neurons decrease their firing rates, decreasing blood flow and energy metabolism
- Breathing and heart rate are very **regular**
- Non-REM sleep may allow **repair** of metabolic damage done to cells by free radicals and allows time for the neuroplasticity mechanisms needed to **store memories**

Non-REM Sleep & REM Sleep

	Slow-wave sleep	REM sleep
<i>EEG</i>	Slow; medium to high amplitude	Fast; low amplitude
<i>Movement</i>	Moderate muscle tone; some movement, as in shifting position	Little tone; no movement (paralysis) of postural muscles, twitches of distal muscles
<i>Heart and respiration rates</i>	Decreased relative to rest while awake	Increased relative to rest while awake
<i>Dreams</i>	Rare, logical, not detailed	Common, vivid, illogical
<i>Rapid eye movements</i>	Rare	Frequent
<i>CNS site of induction</i>	Forebrain	Pons

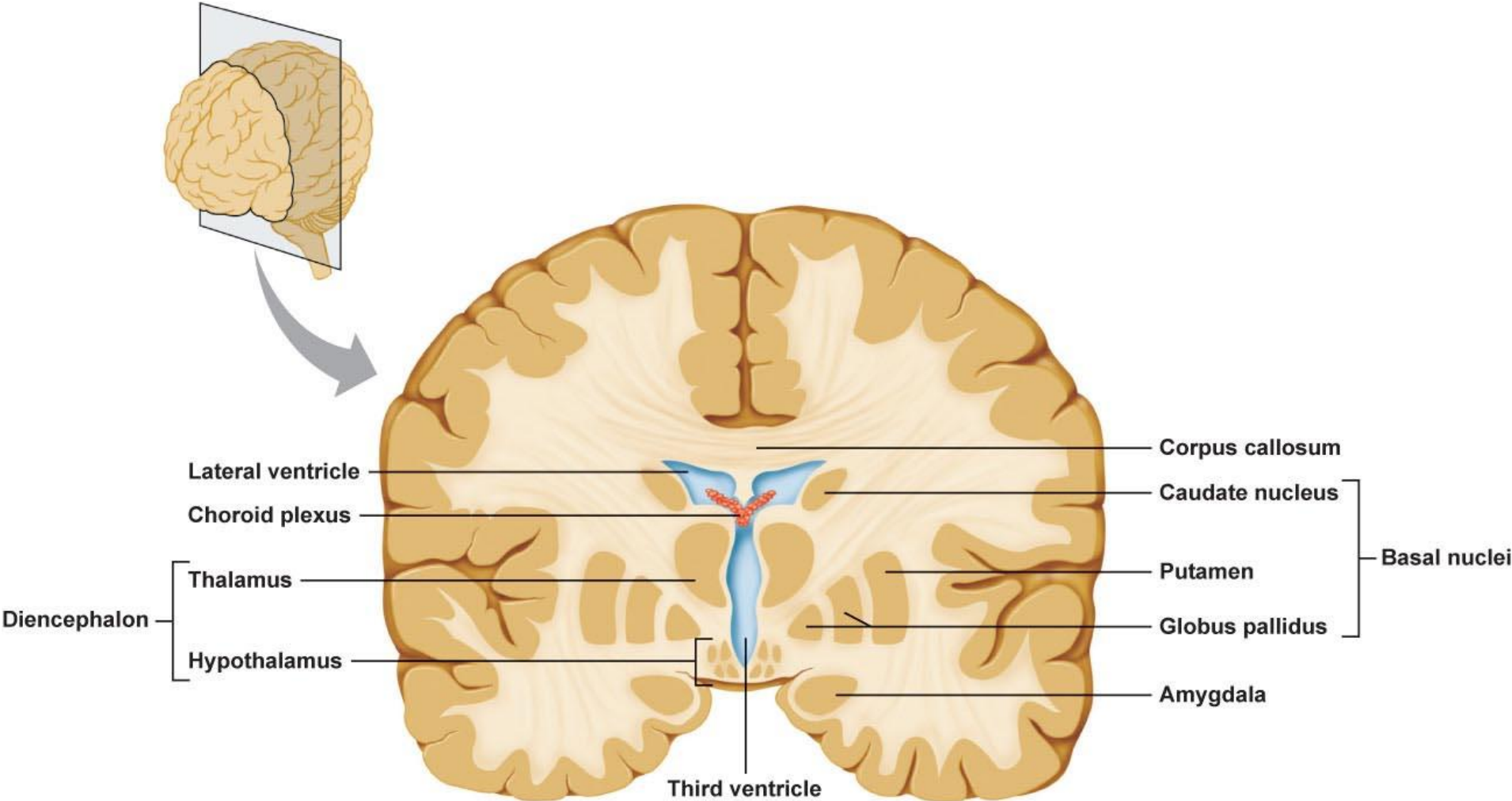


失眠症及嗜睡症 (Insomnia and Sleepiness)

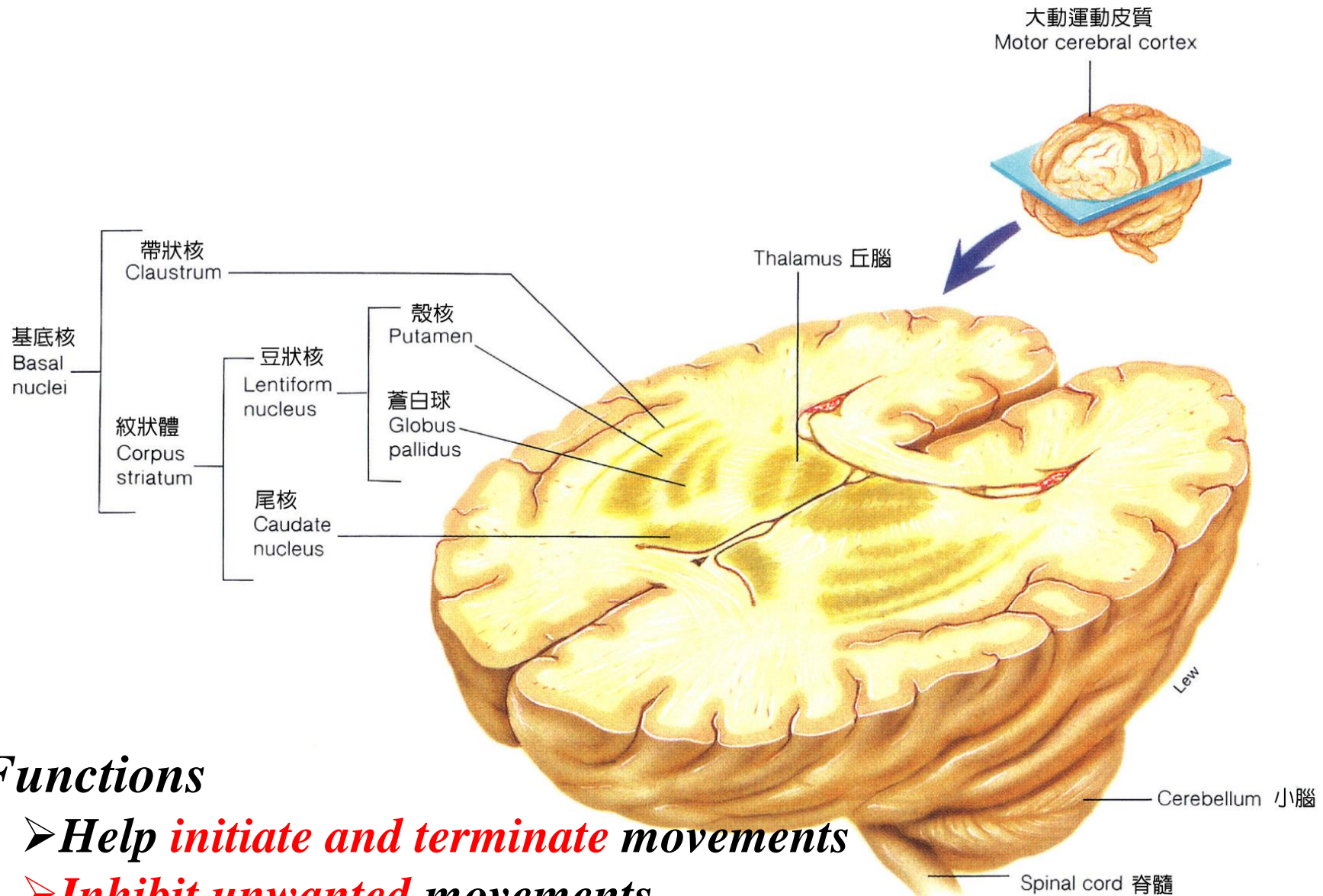
失眠症是指無法進入或維持整夜的睡眠。臨床表現為不易入睡，或睡後易醒，醒後無法再入睡等，並造成日間精神不振、反應遲鈍，影響身心健康及工作、學習和生活。臨床上依病程時間的長短可分為短暫性失眠（小於一週），短期性失眠（一週至一個月），和慢性失眠（大於一個月）。短暫性及短期性失眠常因時差、環境變化、壓力等造成；慢性失眠的原因則較為複雜，可能與生活不規律、身體或心理疾病有關。

嗜睡症是一種神經性疾病，能引起不可抑制性睡眠的發生。臨床表現為一天到晚想睡覺，這些睡眠可以發生在任何時間，甚至是在一些不適當的場合，例如說話、吃飯或駕車時，但最常發生在不活動或單調、重複性的活動階段。嗜睡症的病因尚未完全清楚，可能與基因、環境因素及某些中樞神經疾病有關，例如腦幹中的睡眠覺醒中樞功能出問題，或睡眠週期不規則等。

Subcortical Nuclei = Cerebral Nuclei (Gray Matter)



Basal Nuclei



● *Functions*

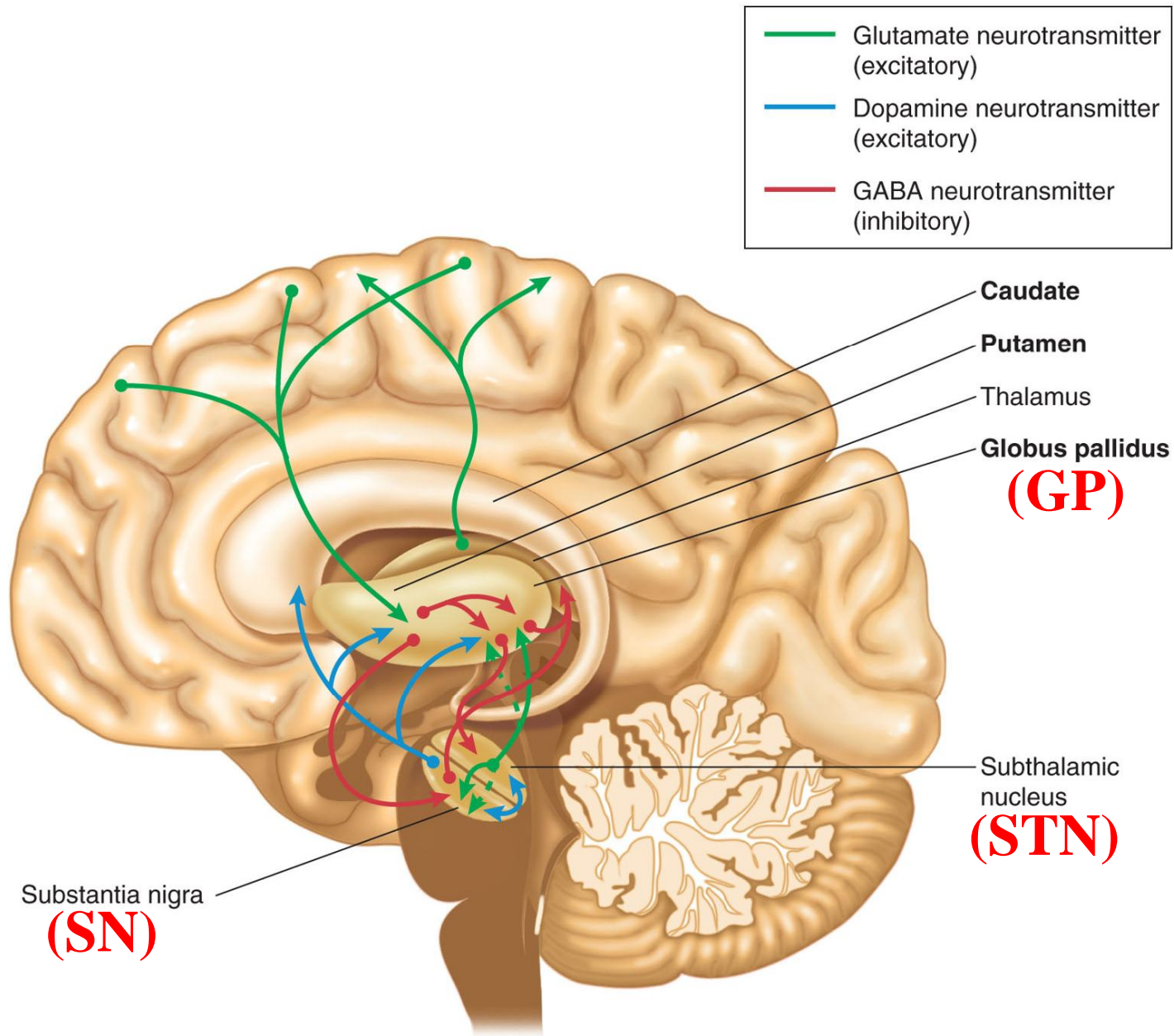
- *Help initiate and terminate movements*
- *Inhibit unwanted movements*
- *Selecting purposeful movements*
- *Regulate muscle tone and postural support*

Basal Nuclei: Corpus Striatum

- The neurons from motor regions of the frontal lobe release **glutamate** (stimulatory) on the putamen. The putamen then releases **GABA** (inhibitory) on other regions of the basal nuclei
- The globus pallidus sends **GABA**-releasing (inhibitory) neurons to the thalamus, which sends **glutamate**-excitatory axons to the motor cortex of the cerebrum.
- This completes a **motor circuit**. This circuit stimulates appropriate movements and inhibits unwanted movement

Motor cortex → Putamen → Globus pallidus → Thalamus → Motor cortex

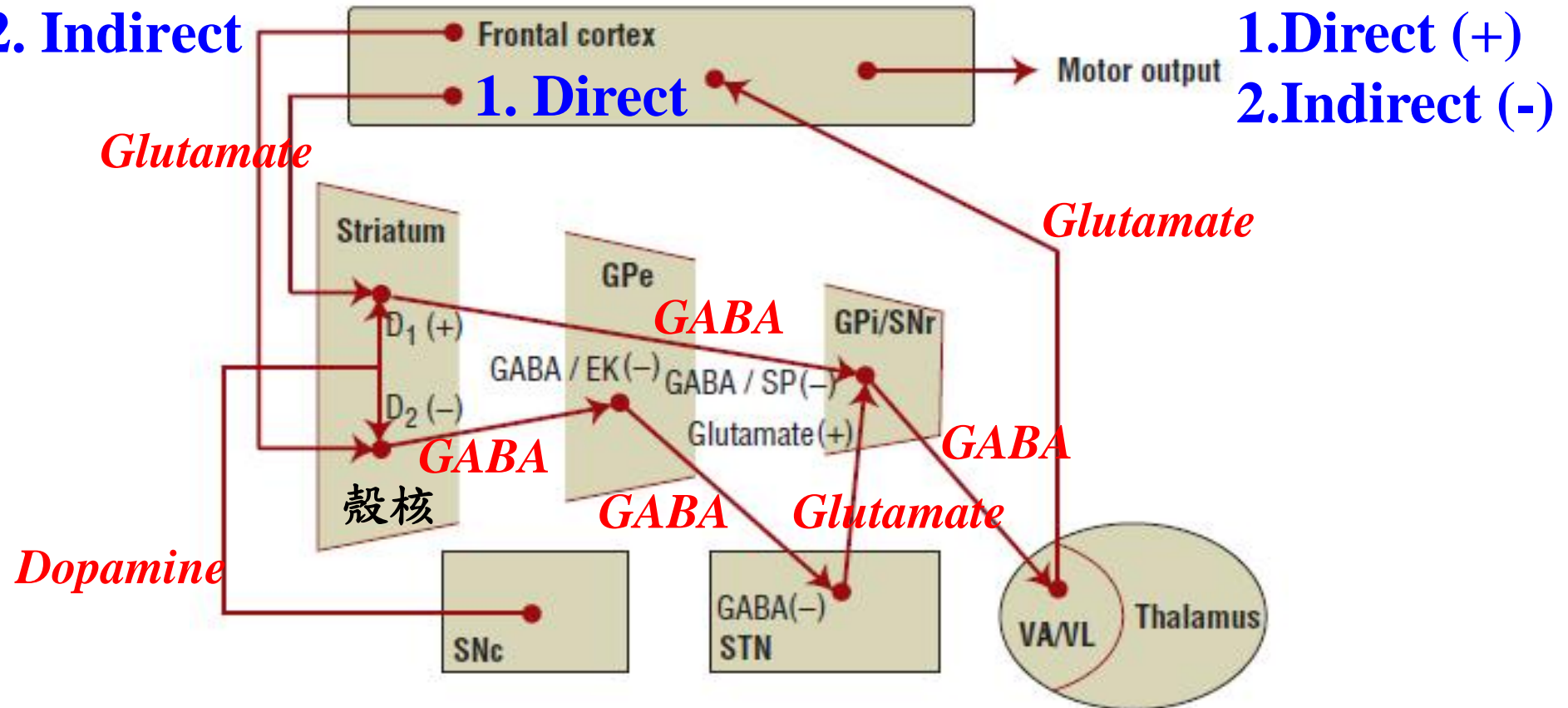
Basal Nuclei-Thalamocortical Circuit (Motor Circuit)



Basal Nuclei-Thalamocortical Circuit

(Normal Balance of Motor Circuit)

2. Indirect



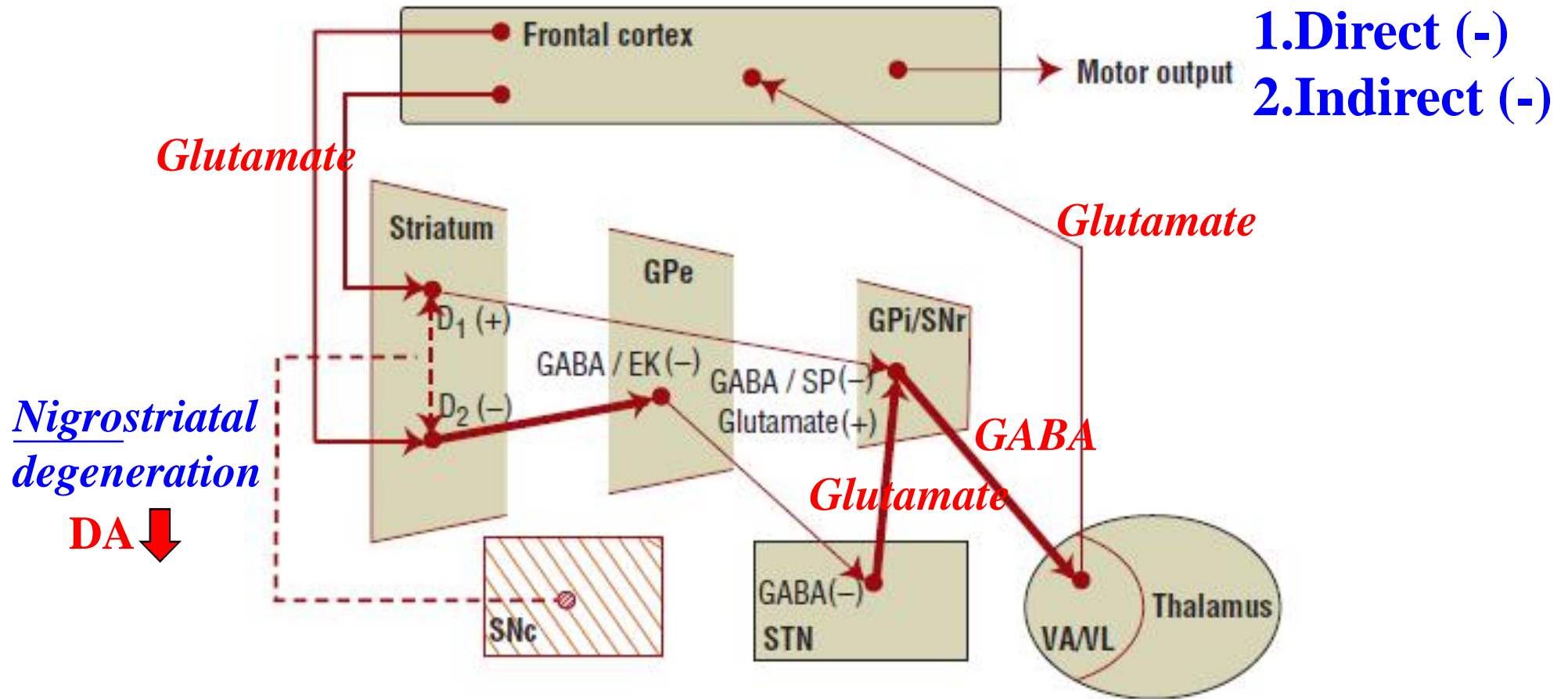
- GPe, globus pallidus externa; 蒼白球外核
- GPi, globus pallidus interna; 蒼白球內核
- SNc, substantia nigra pars compacta; 黑質體緻密部
- SNr, substantia nigra pars reticulata; 黑質體網狀部
- STN, subthalamic nucleus; 視丘下核
- VA, ventroanterior nuclei of the thalamus; 視丘腹前側核
- VL, ventrolateral nuclei of the thalamus 視丘腹外側核

Motor Circuit

路徑名稱	路徑的組成 (+表興奮性輸出， -表抑制性輸出)	抑制性 連接的 個數	機能描述	多巴胺受體 類型
直接	大腦皮質+ →紋狀體(殼核)- →內蒼白球/黑質 (GPi/SNr)- →視丘+ →大腦皮質	2 (偶)	大腦皮質的活動激活紋狀體神經元， 進而抑制內蒼白球的自發發放。由於 蒼白球的神經元對視丘的作用是抑制 性的，這一效應實際上削弱了視丘所 受到的抑制性輸入。這一過程成為 「去抑制」(disinhibition)	D1 (興奮性)
間接	大腦皮質+ →紋狀體(殼核)- →外蒼白球(GPe)- →丘腦下核(STN)+ →內蒼白球/黑質 (GPi/SNr)- →視丘+ →大腦皮質	3 (奇)	與直接通路不同，由於間接路徑中抑 制性突觸的個數為奇數，紋狀體神經 元細胞的激活對視丘產生抑制效應。	D2 (抑制性)

Abnormal Balance of Motor Circuit

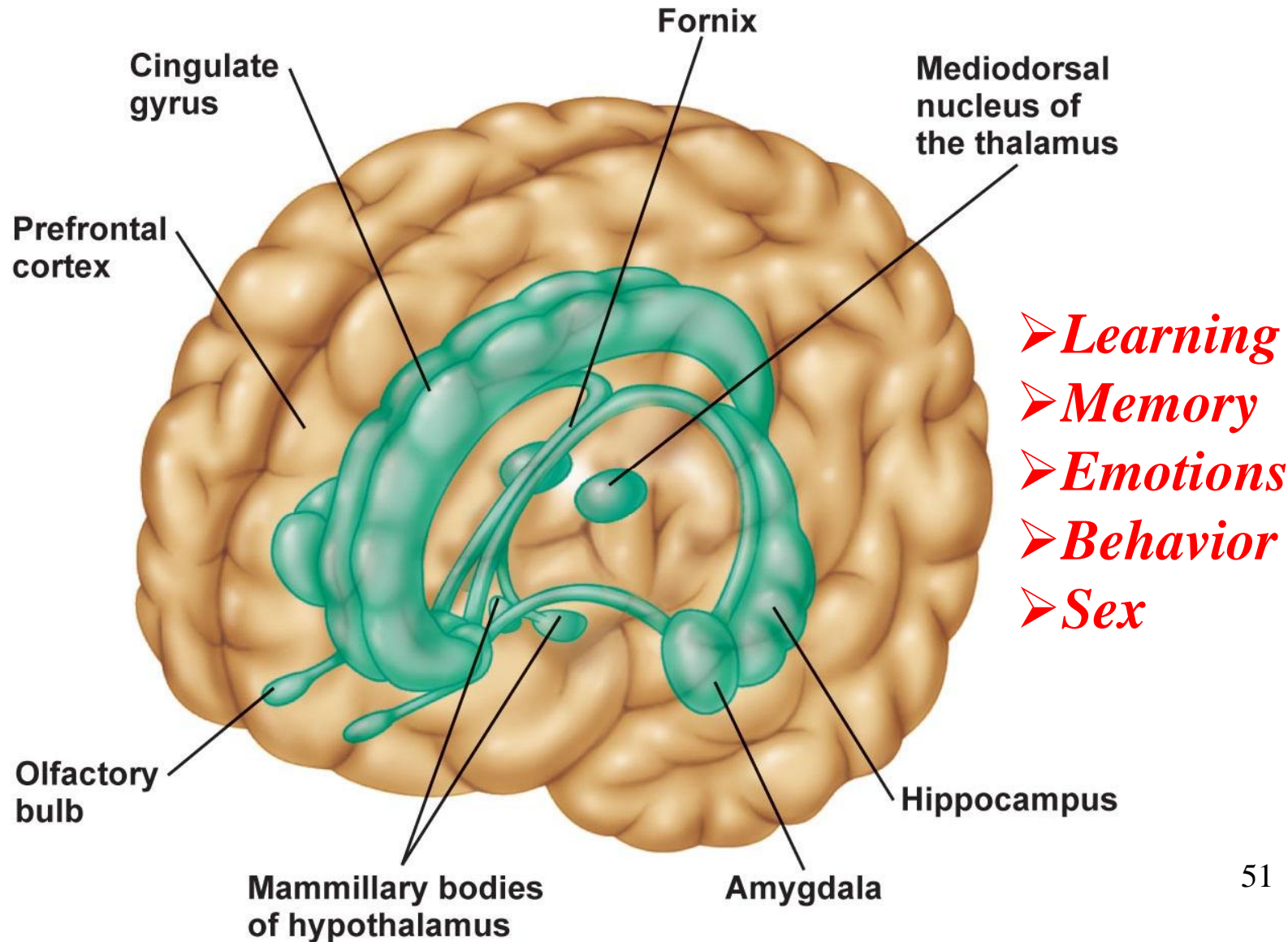
Nigrostriatal Degeneration--*Parkinson Disease*



- GPI, globus pallidus interna; 蒼白球內核
- SNc, substantia nigra pars compacta; 黑質體緻密部
- SNr, substantia nigra pars reticulata; 黑質體網狀部
- STN, subthalamic nucleus; 視丘下核
- VA, ventroanterior nuclei of the thalamus; 視丘腹前側核
- VL, ventrolateral nuclei of the thalamus 視丘腹外側核

Limbic System= Smell Brain

Group of brain regions (gray matter) responsible for emotional drives (Emotional Brain)



Limbic System

- The fornix connects the hippocampus to the hypothalamus, which sends neurons to the thalamus
- The thalamus sends neurons to the cingulate gyrus, which sends neurons to the hippocampus, completing the circuit (**Papez**)
- There are few synaptic connections between the limbic system and the cerebral cortex, which is why it is **hard to control your emotions**

Emotions & Motivation

主觀心情與外顯身體反應

● Amygdala

- Fear
- Aggression
- Anxiety

● Hypothalamus

- Anger
- Fear
- Aggression
- Goal-directed behaviors

● Midbrain

● Cerebral cortex

● Limbic system

將行為導向特定目的的能力

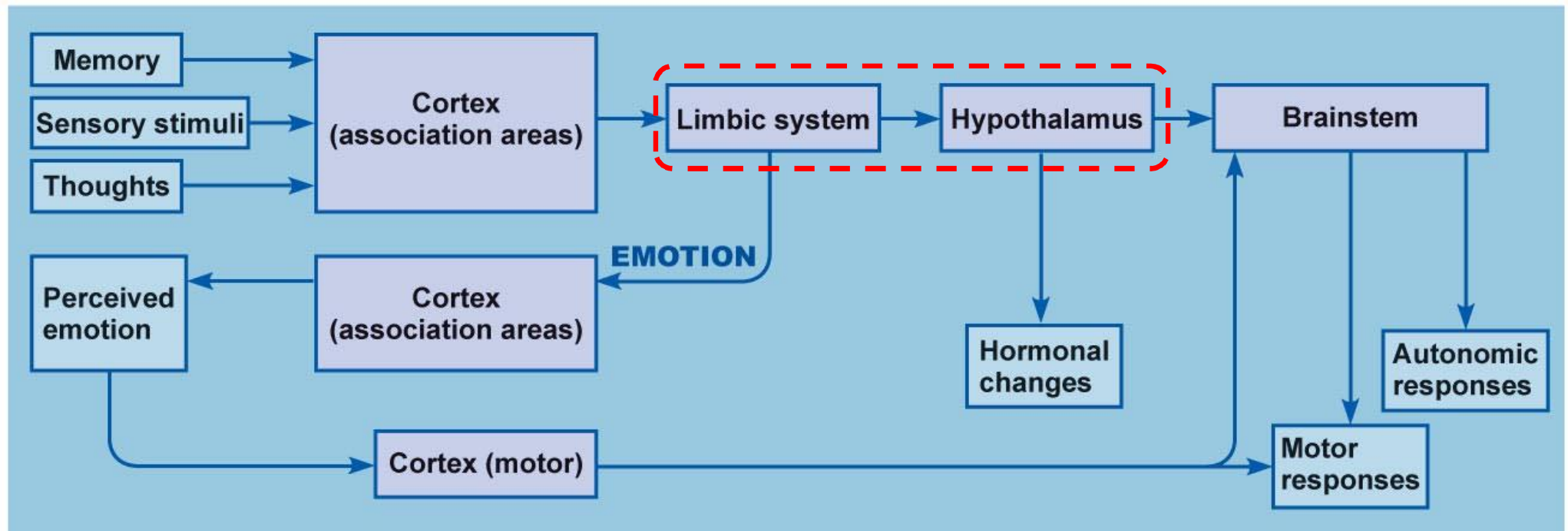
● Motivation = drive

- Physiological
- Emotions

● Pleasure

- Strong motivating emotion
- Pleasure centers contain **dopamine or 5-HT**
(Depression)
- Pleasure can be addictive

Integrated CNS Function: Emotions and Motivation



Integrated CNS Function:

Learning and Memory

- Learning (**Acquisition** of new information) & Memory (**Retention** of information, skills, or thoughts)
- Studies of people with **amnesia** reveal that areas of the temporal lobe, hippocampus (neural stem cells), caudate nucleus, and dorsomedial thalamus are involved in memory
- The **amygdala** is important in learning fear responses
- The **prefrontal cortex** may be involved in working memory—very short-term memory



失憶症 (amnesia) 是一種記憶混亂的疾病。簡單來說，就是喪失記憶。失憶症可因大腦遭受創傷、疾病，或使用某些藥物而造成，也可由心理創傷所引起。失憶症可分為順行性和逆行性兩種。順行性失憶症 (anterograde amnesia) 表現為不能保留新近獲得的訊息，多見於慢性酒精中毒患者。其發生機制可能是由於訊息儲存障礙。逆行性失憶症 (retrograde amnesia) 表現為不能回憶腦功能障礙發生前一段時間內的事件，多見於腦震盪、電休克後。其發生機制可能是記憶的訊息提取機制發生紊亂。

Types of Learning

- 非聯合型學習 (Non-associative learning) 是一種簡單的學習方式，不需要在刺激和反應之間建立某種明確的聯繫。
- 聯合型學習 (Associative learning) 是指兩個刺激在時間上很靠近並重複發生，最後在腦內逐漸形成某種聯繫的學習方式。
 - 古典式條件反射 (classical conditioning reflex):
被動學習
 - 操作式條件反射 (operant conditioning reflex):
主動學習

Types of Memory

根據記憶的儲存和提取方式分為兩類

1. 陳述性=外顯記憶(declarative memory = explicit)

有意識下

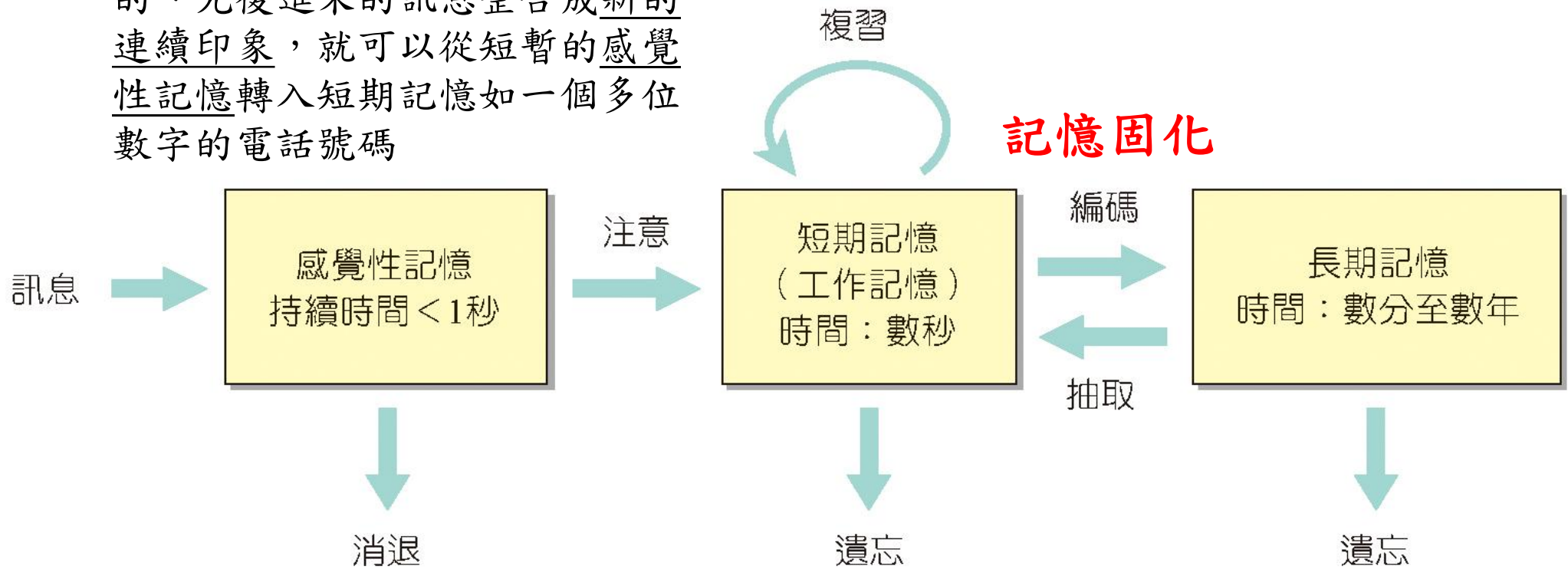
- 陳述性記憶(以言語表達的記憶)是對事實(語意)或事件(情節)的記憶(知道是什麼)。
- 陳述性記憶的獲得和回憶均依賴於認知過程，包括評價、比較和推理等。
- 陳述性記憶易於形成，幾乎不需要訓練即可形成，並能用語言表達出來，但容易遺忘。

2. 非陳述性(程序性)=內隱記憶(nondeclarative memory=implicit)無意識下

- 是對技能或技巧性動作的記憶(知道如何做)，例如我們對學習游泳、騎自行車、演奏樂器等技能的記憶。
- 非陳述性記憶的形成或讀出不依賴於意識和認知過程，而是在重複多次的練習中逐漸形成的，且難以用語言表達出來，但一旦形成後則不容易遺忘。

Processes of Memory

對訊息進行加工處理，把不連續的、先後進來的訊息整合成新的連續印象，就可以從短暫的感覺性記憶轉入短期記憶如一個多位數字的電話號碼



• 圖 6-16 陳述性記憶過程示意圖。

如自己的名字及每天都使用的技能和操作等，經過長年累月的運用，是不容易遺忘

Memory

- **Short-term memory:** recent events; transferred to long-term memory through process of **memory consolidation**
 - Memory consolidation occurs in the **medial temporal lobe ex. hippocampus**, and **amygdala**
 - Sleep** is needed for optimum memory consolidation
- **Long-term memory:** requires actual structural change

Categories of Memory

Memory Category	Major Brain Regions Involved	Length of Memory Storage	Examples
Episodic memory (explicit, declarative)	<u>Medial temporal lobes</u> , thalamus, fornix, <u>prefrontal cortex</u>	Minutes to years	<u>Remembering what</u> you had for breakfast, and what vacation you took last summer
Semantic memory (explicit, declarative)	<u>Inferior temporal lobes</u>	Minutes to years	<u>Knowing facts</u> such as what city is the capital, your mother's maiden name, and the different uses of a hammer and a saw
Procedural memory (explicit or implicit; nondeclarative)	<u>Basal ganglia, cerebellum, supplementary motor areas</u>	Minutes to years	<u>Knowing how to</u> shift gears in a car and how to tie your shoelaces
Working memory	Words and numbers: <u>prefrontal cortex</u> , Broca's area, Wernicke's area Spatial: <u>prefrontal cortex</u> , visual association areas	Seconds to minutes	<u>Words and numbers</u> : keeping a new phone number in your head until you dial it <u>Spatial</u> : mentally following a route

Source: Modified from: Budson, Andrew E. and Bruce H. Price. "Memory dysfunction." *New England Journal of Medicine* 352 (2005): 692–698.

● Long-term memory can be classified into:

--**Nondeclarative (implicit)**: memory of simple skills,
how to do things

--**Declarative (explicit)**: memory of things that can be verbalized

1. **Semantic** (語意): **facts** (對已知事實的記憶)
2. **Episodic** (情節): **events** (對事件發生的回憶)

Categories of Memory

特徵	短期記憶	長期記憶
在獲取新資訊後的儲存時間	立刻	較長；必須從短期記憶經由合併轉成長期記憶；資訊經由短期記憶方式被練習或是循環而增強
維持時間	持續幾秒到幾小時	持續幾天到幾年
儲存能力	被限制	非常大
恢復時間（記憶）	快速恢復	慢慢恢復；除非有意念去刻意遺忘記憶，則可快速恢復
無恢復能力（遺忘）	永遠忘記；記憶快速地逐漸消失除非合併到長期記憶	通常只有短暫想不起來；相對穩定的記憶路徑
儲存機制	與既存突觸功能（如改變所釋出神經傳導物質的量）的瞬時修飾有關	存在神經元包括相對永遠的功能與結構改變，正如新突觸的形成；新合成的蛋白質扮演重要角色

Mechanisms of Learning & Memory

(一) 學習和記憶的腦功能定位

--學習和記憶在腦內有一定的功能定位，不同種類的記憶在腦內有各自的代表區，如海馬回與空間位置的學習和記憶有關。

(二) 神經生理學機制

--突觸傳遞的可塑性改變可能是學習和記憶的神經生理學基礎。突觸傳遞的可塑性(plasticity)是指突觸的反覆活動所引致突觸傳遞效率的增強或減弱。

(三) 神經生物化學機制

--較長期的記憶有賴於腦內蛋白質的合成，並且中樞神經的神經傳遞物質(ex ACh, Glu, GABA, NO, etc.)也與學習記憶有關。

(四) 神經解剖學機制

--長期記憶可能與突觸形態的改變有關，例如突觸面積的增大和數目的增加、新突觸聯繫的建立等。

Synaptic Changes in Memory

● 長期增益現象(long-term potentiation, LTP)

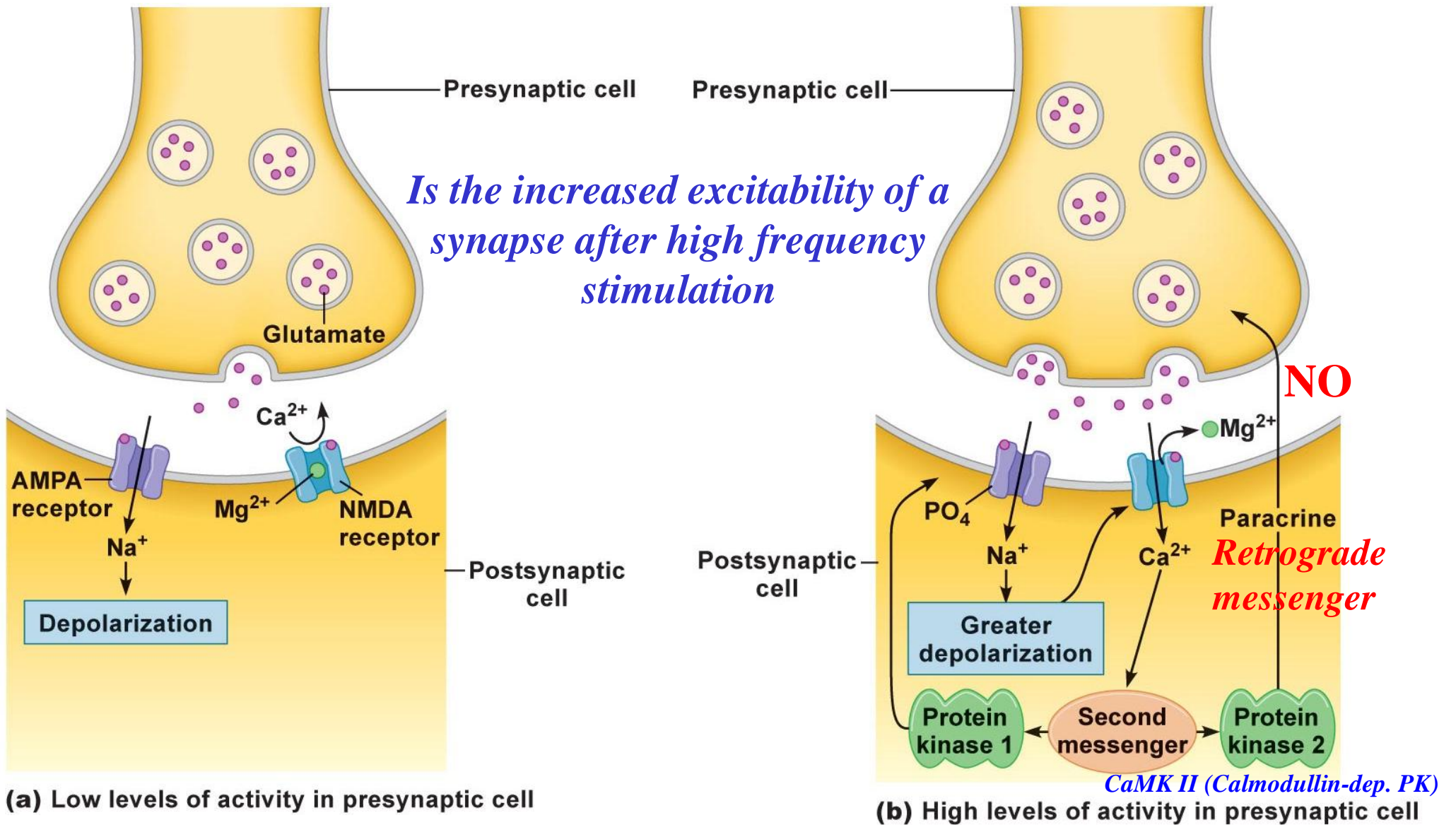
--是指突觸前神經元(glutamate)在受到短時間的高頻刺激後，突觸後神經元由於 Ca^{2+} 濃度顯著增加，引起快速形成且持續性的突觸後電位增強，持續時間可達幾小時、幾天甚至幾週。

● 長期抑制現象(long-term depression, LTD)

--是指突觸傳遞效率的長時間降低，亦由 Ca^{2+} 進入突觸後神經元所引起。

--但 LTD 是由突觸後神經元 Ca^{2+} 濃度輕度增加所引起，而 LTP 的產生則需要 Ca^{2+} 濃度顯著增加。

Long-term Potentiation (LTP)



Emotions and Memory

- Emotions sometimes strengthen and other times weaken memory formation
 - If the memory has an emotional component, the **amygdala** is involved in memory formation
 - Stress** impairs memory formation in the **hippocampus** and working memory function of the **prefrontal cortex**
 - Posttraumatic stress disorder may result in **hippocampal atrophy**
- The **amygdala** and **hippocampus** have receptors for stress hormones, such as **cortisol**
 - It is thought that cortisol may strengthen emotional memory formation via the **amygdala** but weaken **hippocampal** memory formation and memory retrieval

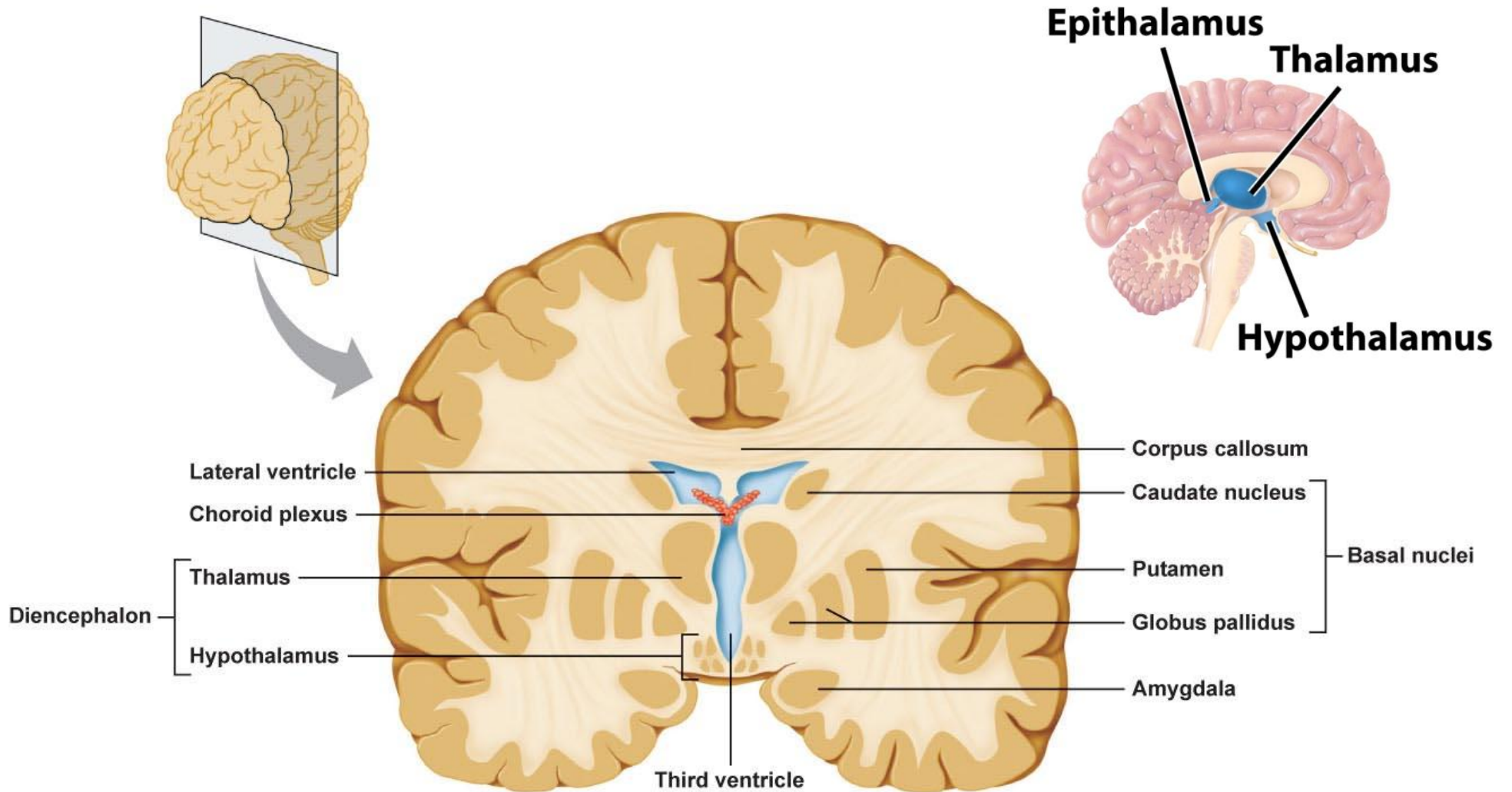
Prefrontal Cortex



- **Orbitofrontal cortex**: is a prefrontal cortex region in the frontal lobes in the brain which is involved in the cognitive processing of decision-making
- Ability to consciously experience **pleasure and reward (addictive behavior)**; receives input from all the senses and the **limbic system**
 - Damage here results in severe impulsive behavior
- **Lateral prefrontal area**: motivation, sexual desire, and cognitive functions

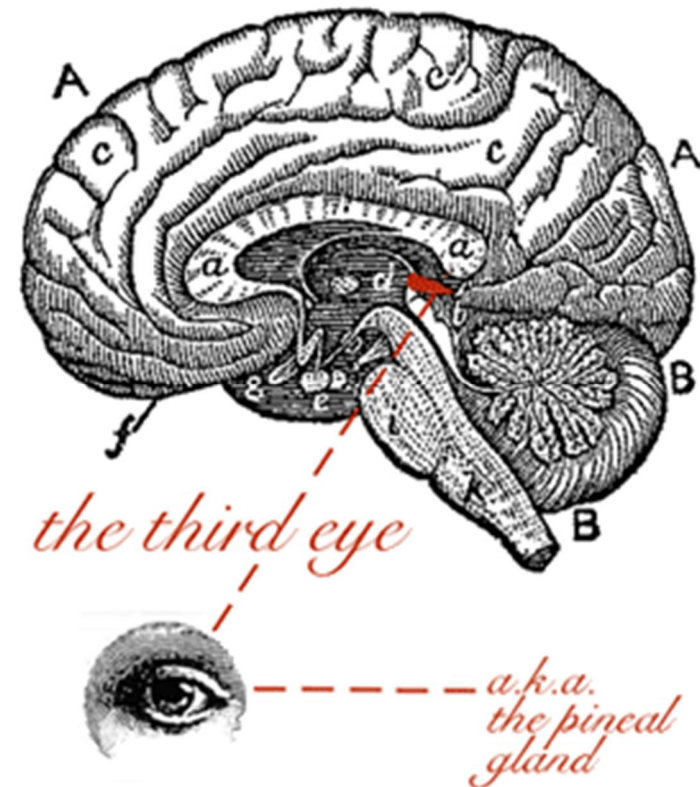
Diencephalon

Part of the forebrain that includes the *epithalamus*, *thalamus*, *hypothalamus*, and part of the *pituitary gland*



Diencephalon: **Epithalamus**

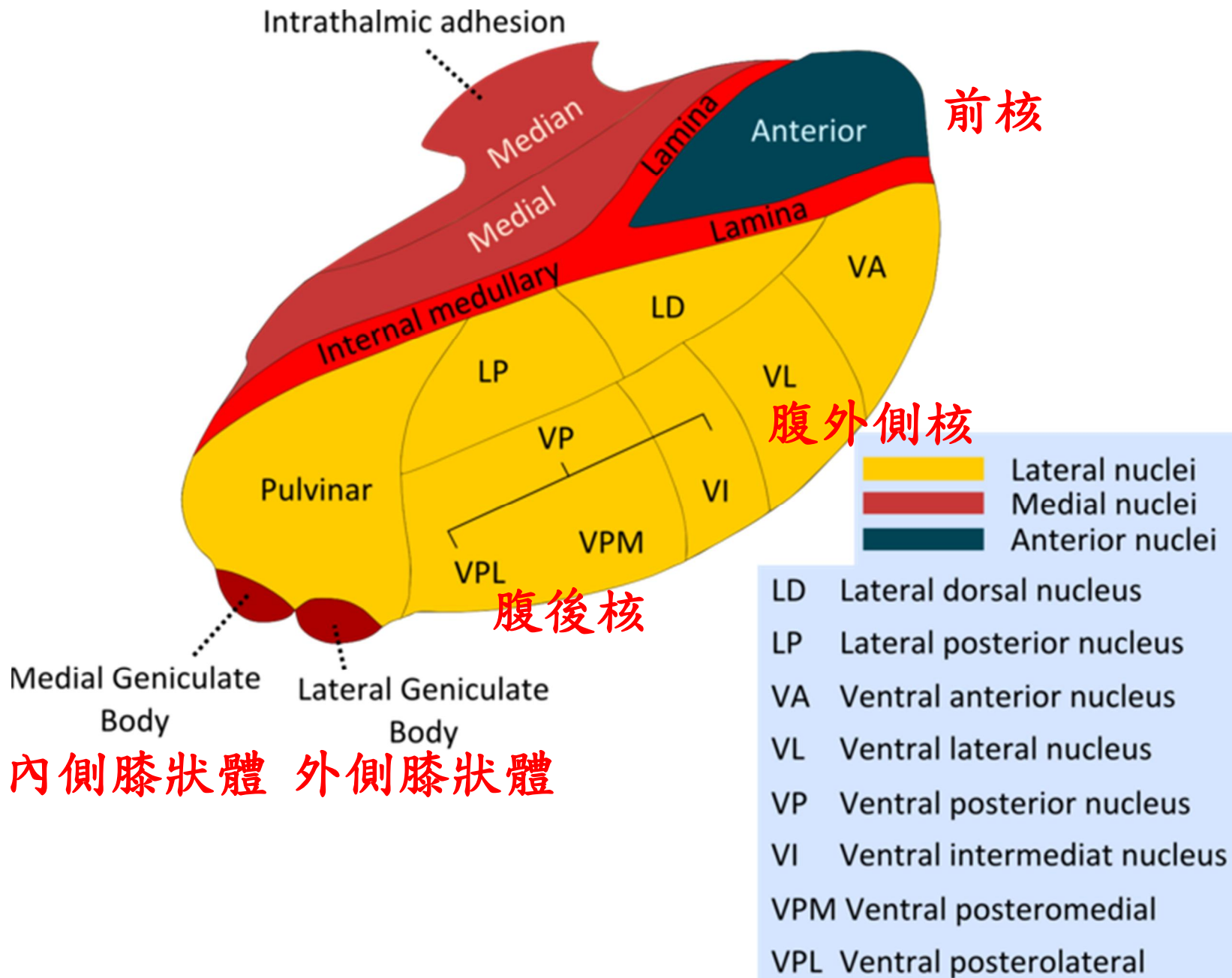
- Contains the **choroid plexus** over the third ventricle where cerebrospinal fluid is produced
- Also contains the **pineal gland**, which secretes the hormone **melatonin** that helps regulate circadian rhythms (24-hour cycle)
- **Inh. GnRH** (reproduction)



Diencephalon: **Thalamus**

- 成對的卵形灰質團塊，佔**4/5**的間腦區域。
- 位於大腦半球側腦室下方，且構成第三腦室大部分的內壁。
- 由20多個神經核組成，是所有感覺訊息(**嗅覺**除外)傳入大腦皮質前的**轉換站**(relay center)。
- 某些感覺衝動如粗觸覺、壓覺、痛覺、冷熱覺的解釋中樞，並參與情感、喚醒或警惕的機制。
- 在體運動系統中，與基底核、小腦有連接，參與運動的控制及協調。

Diencephalon: **Thalamus**



Diencephalon: **Thalamus**

1. 聽覺的傳導：

耳蝸所接收的聽覺訊息，會傳到視丘的**內側膝狀體**(medial geniculate nucleus)，然後再傳至位於顳葉的聽覺皮質。

2. 視覺傳導：

視覺訊息經由視神經傳到視丘的**外側膝狀體**(lateral geniculate nucleus)，然後再投射至位於枕葉的視覺皮質。

3. 一般感覺及味覺的傳導：

由視丘的腹後核(ventral posterior nucleus)負責，將對側身體傳來的感覺投射至大腦皮質感覺區。

Diencephalon: **Thalamus**

4. 隨意動作：

由小腦及大腦基底核傳來的隨意動作的訊息，會傳至視丘的腹外側核(ventral lateral nucleus)，再投射至大腦皮質前運動區。

5. 記憶及情緒：

視丘的前核(anterior nucleus) 與邊緣系統有關。

6. 初步詮釋一般感覺：

對一般感覺如痛覺、溫覺、粗觸覺及壓覺等作初步的詮釋，之後再傳到體感覺皮質區做完整的詮釋。

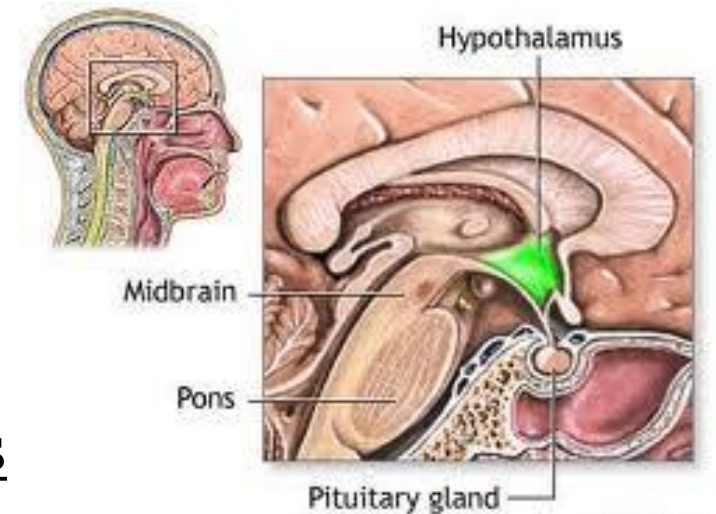
7. 參與喚醒或警醒的機制(過濾不必要之訊息)

Diencephalon: **Hypothalamus**

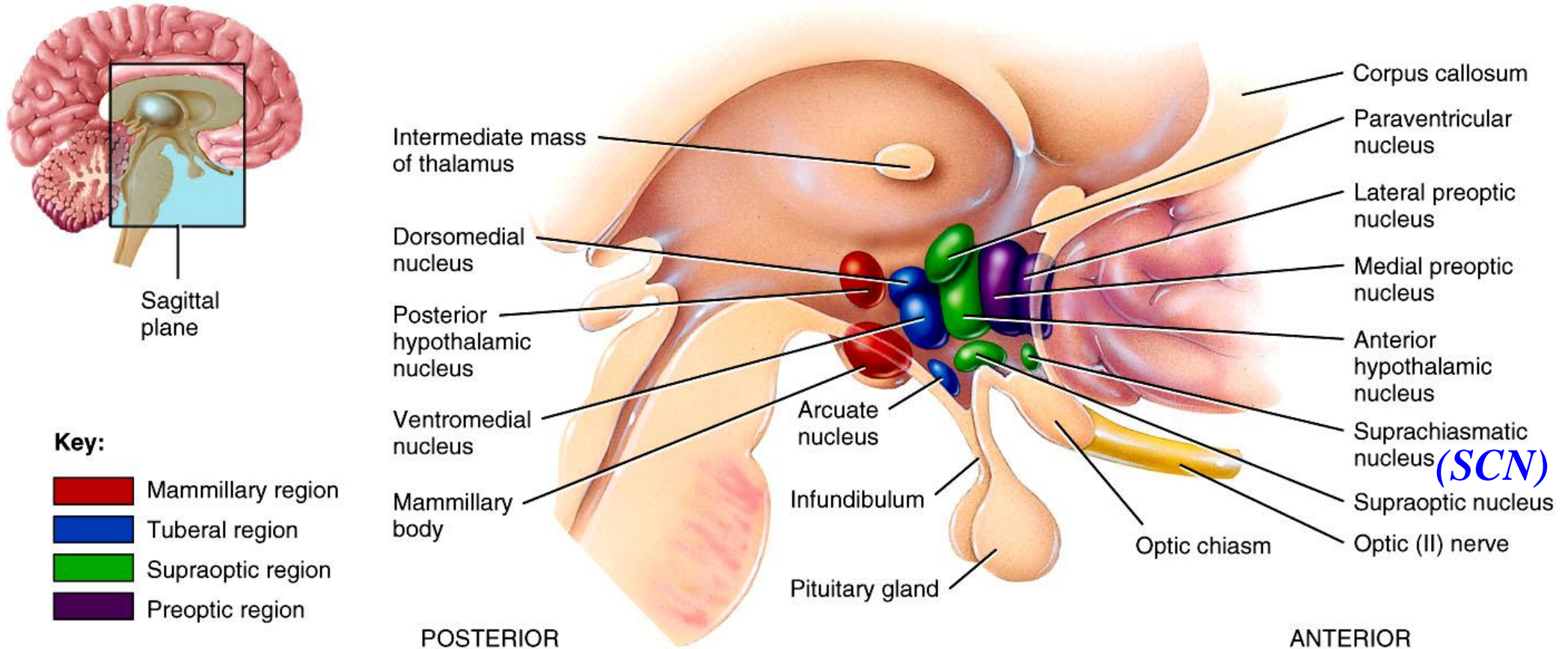
- **Integrating Center** for maintaining homeostasis and regulating the autonomic and endocrine system

- **Contains centers for:**

- Hunger/satiety and thirst
- Regulation of body temperature
- Regulation of sleep and wakefulness
- Regulation of cardiovascular functions
- Sexual arousal and performance
- Emotions of fear, anger, pain, and pleasure
- Control of the endocrine system
- Circadian rhythms (**biological clock**)
 - Suprachiasmatic nucleus (SCN)
 - Pineal gland



Hypothalamus



➤ **Lateral region (VLN):** *hunger (food intake)*

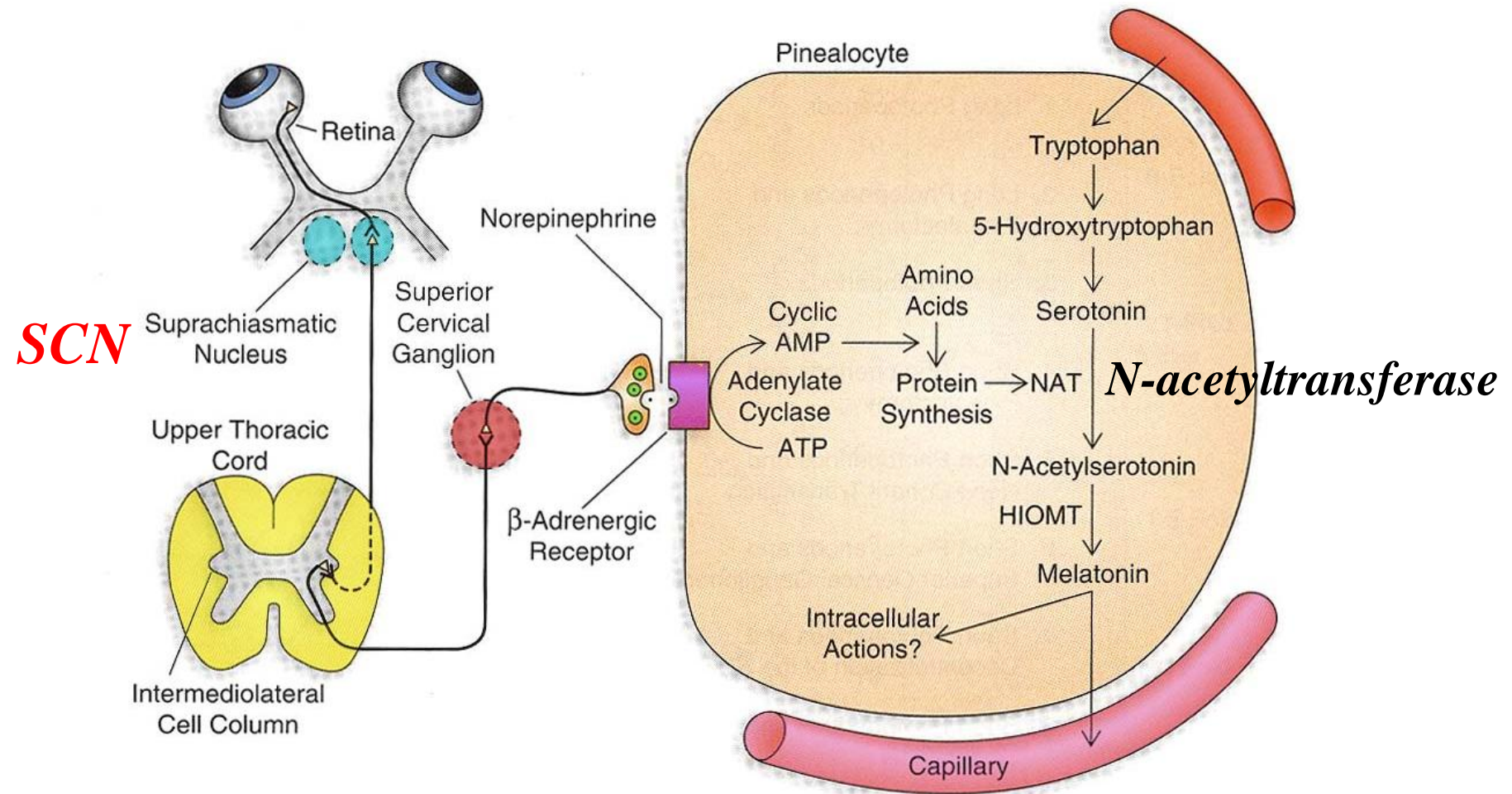
➤ **Medial region (VMN):** *satiety*

➤ **Preoptic-anterior:** *shivering, hyperventilation, vasodilation, sweating*

➤ **Supraoptic (SON):** *produces antidiuretic hormone (ADH), which helps control urine formation*

➤ **Paraventricular (PVN):** *produces the hormone oxytocin, which stimulates childbirth*

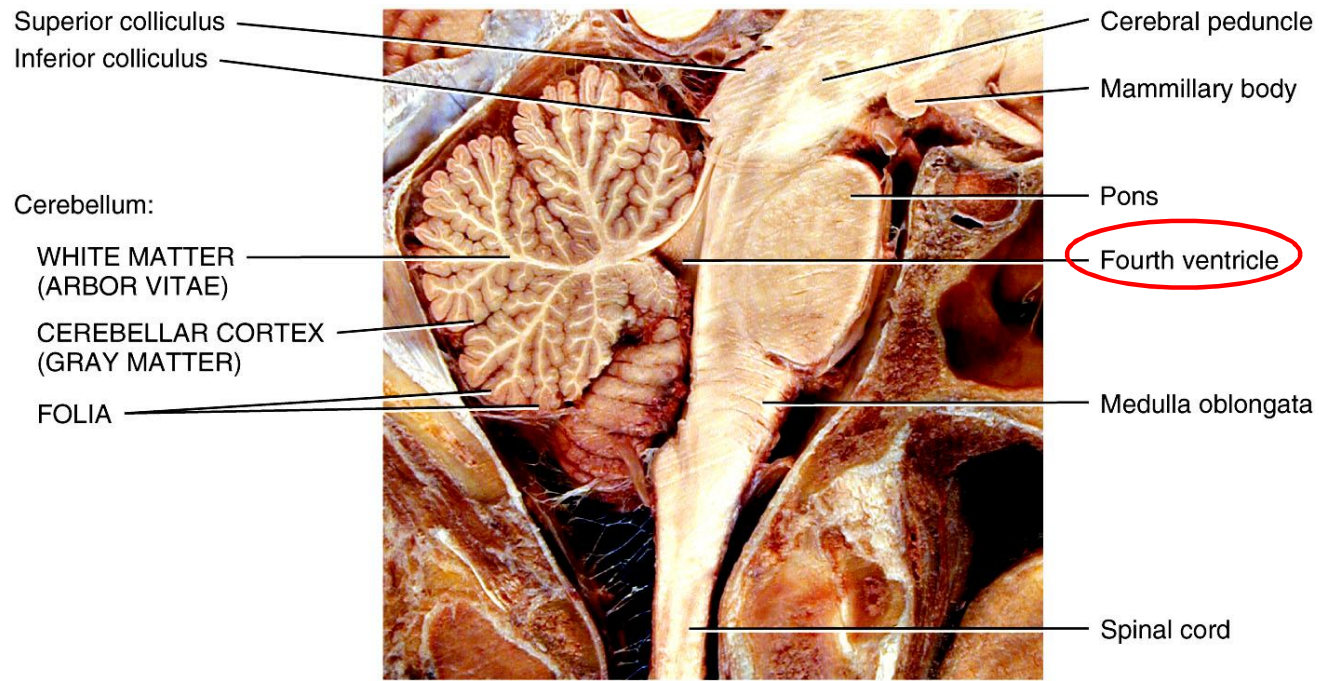
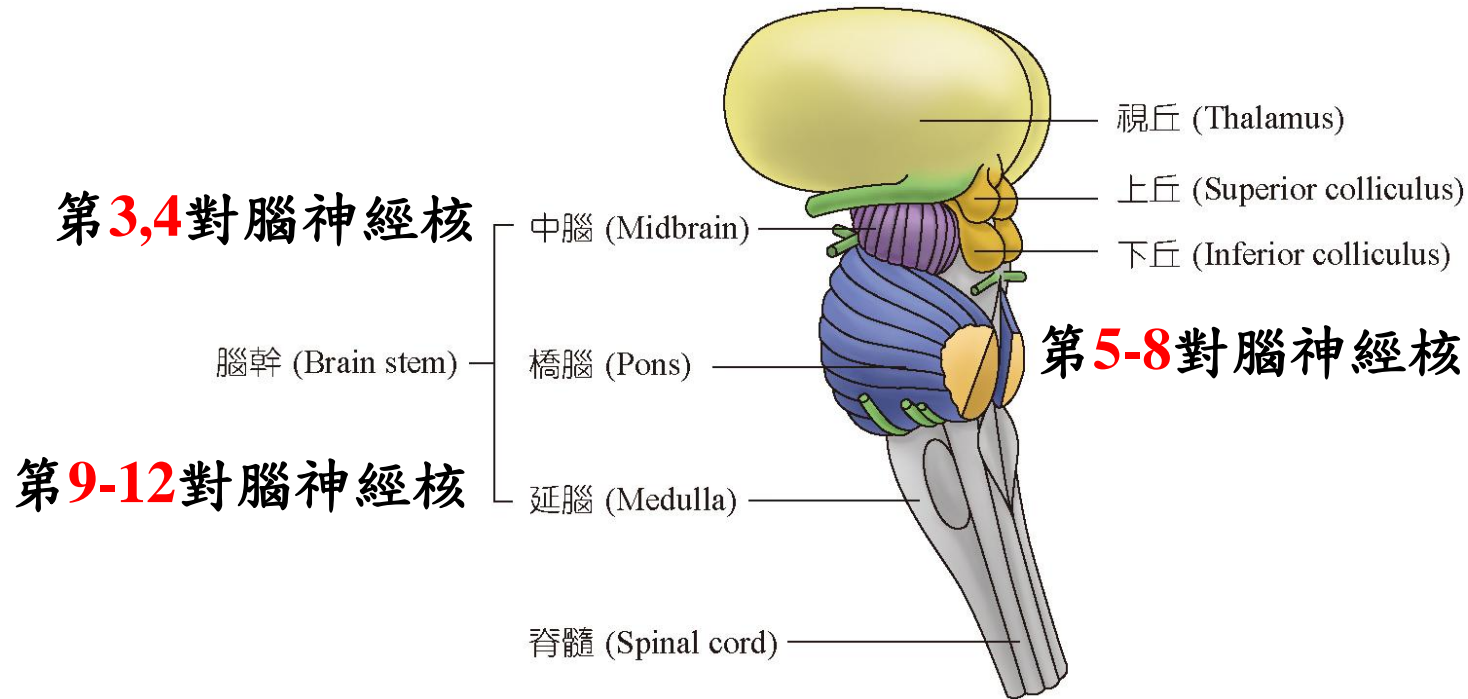
Regulation of Circadian Rhythms



- **Suprachiasmatic nuclei (SCN):** contain about 20,000 “clock cells” with activity that **oscillates every 24 hours**
- Controls the secretion of **melatonin** from the pineal gland

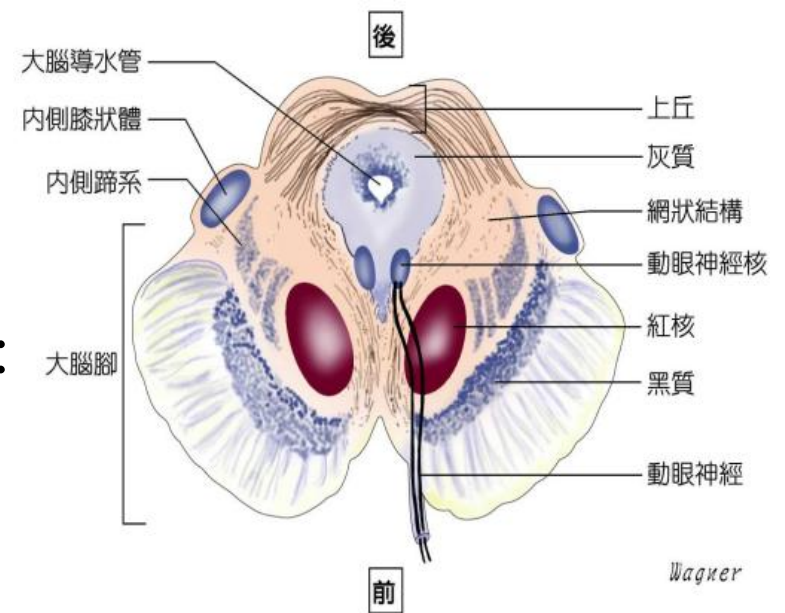
HIOMT: hydroxyindole-O-methyltransferase

Brainstem

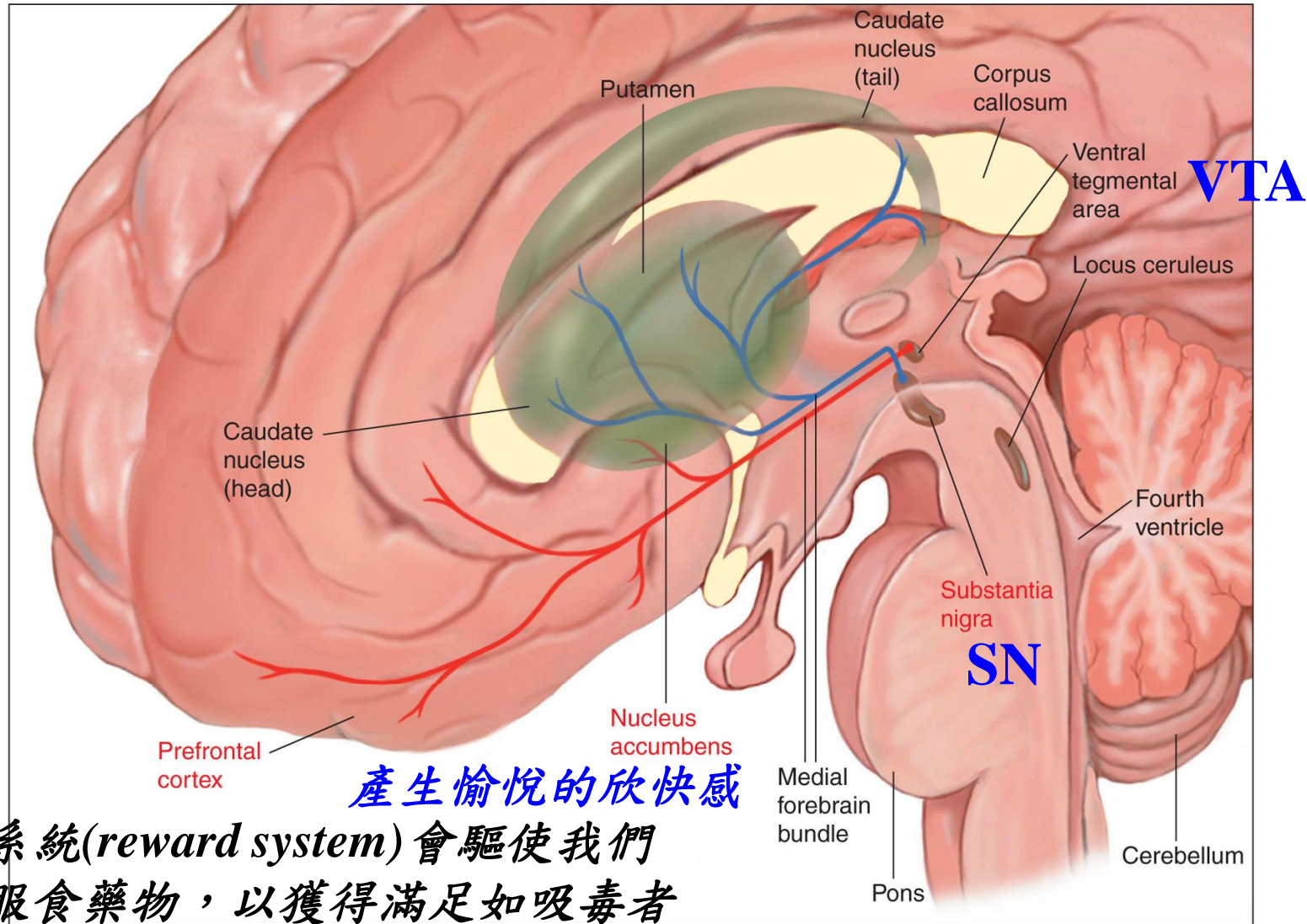


Midbrain

- Also called the **mesencephalon**. Includes:
 - Superior colliculi**: **visual** reflexes
 - Inferior colliculi**: **auditory** reflexes
 - Cerebral peduncles**: connects the cerebrum and spinal cord
 - Red nucleus**: connects the cerebrum and cerebellum; involved in motor coordination
 - Substantia nigra (SN)**: important part of the motor circuit; part of the **dopaminergic nigrostriatal system**
- **Ventral tegmental area (VTA)腹側蓋區**: Part of **the dopaminergic mesolimbic system** that sends neurons to the limbic system and nucleus accumbens (依核) in the forebrain
 - Involved in the behavioral reward system and has been implicated in addiction and psychiatric disturbances



Dopaminergic Pathways



➤ 報償系統(reward system)會驅使我們不斷服食藥物，以獲得滿足如吸毒者

產生愉悅的欣快感

Corpus striatum

Mesolimbic dopamine system

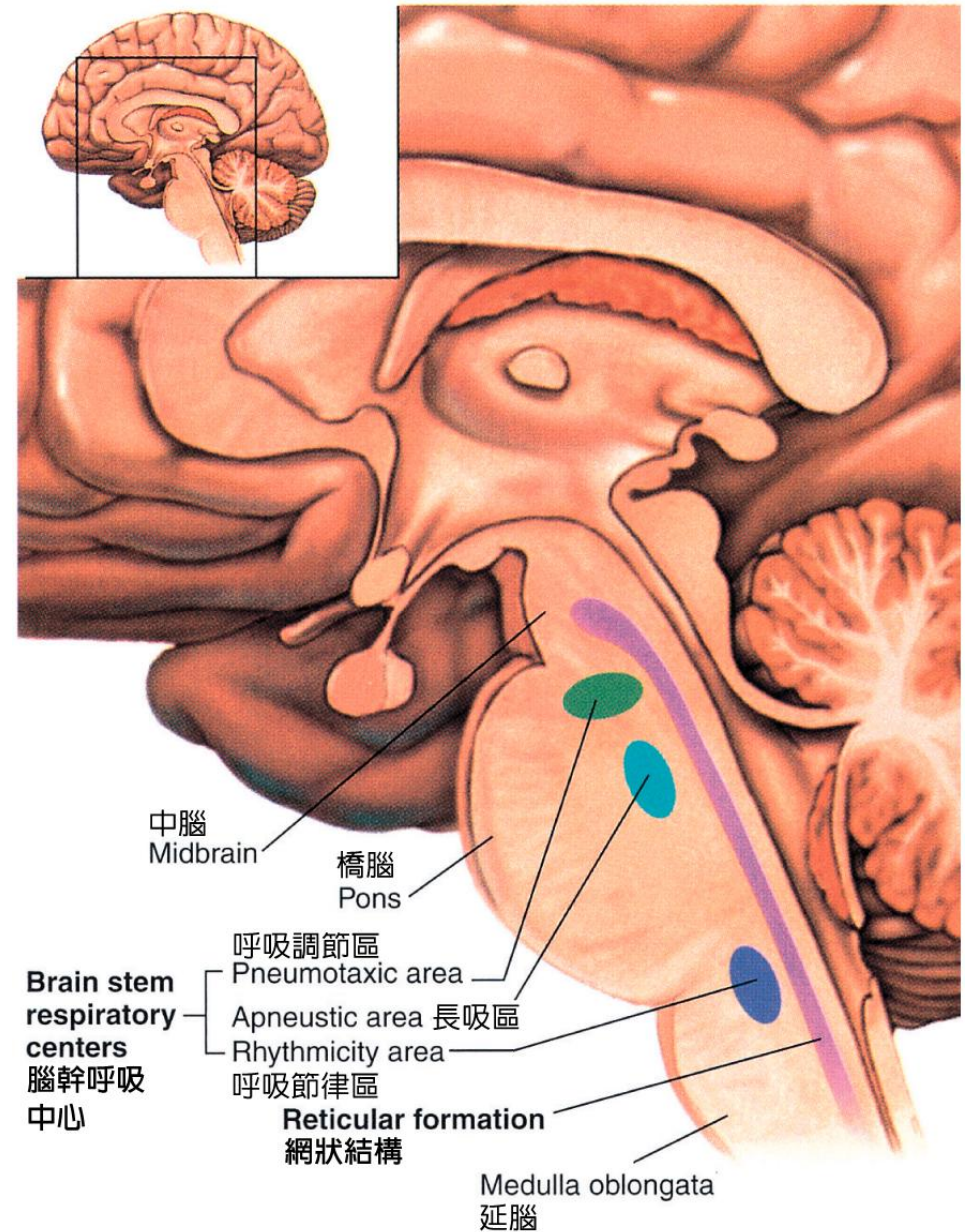
Nigrostriatal dopamine system

情緒性回饋感

運動控制

Pons

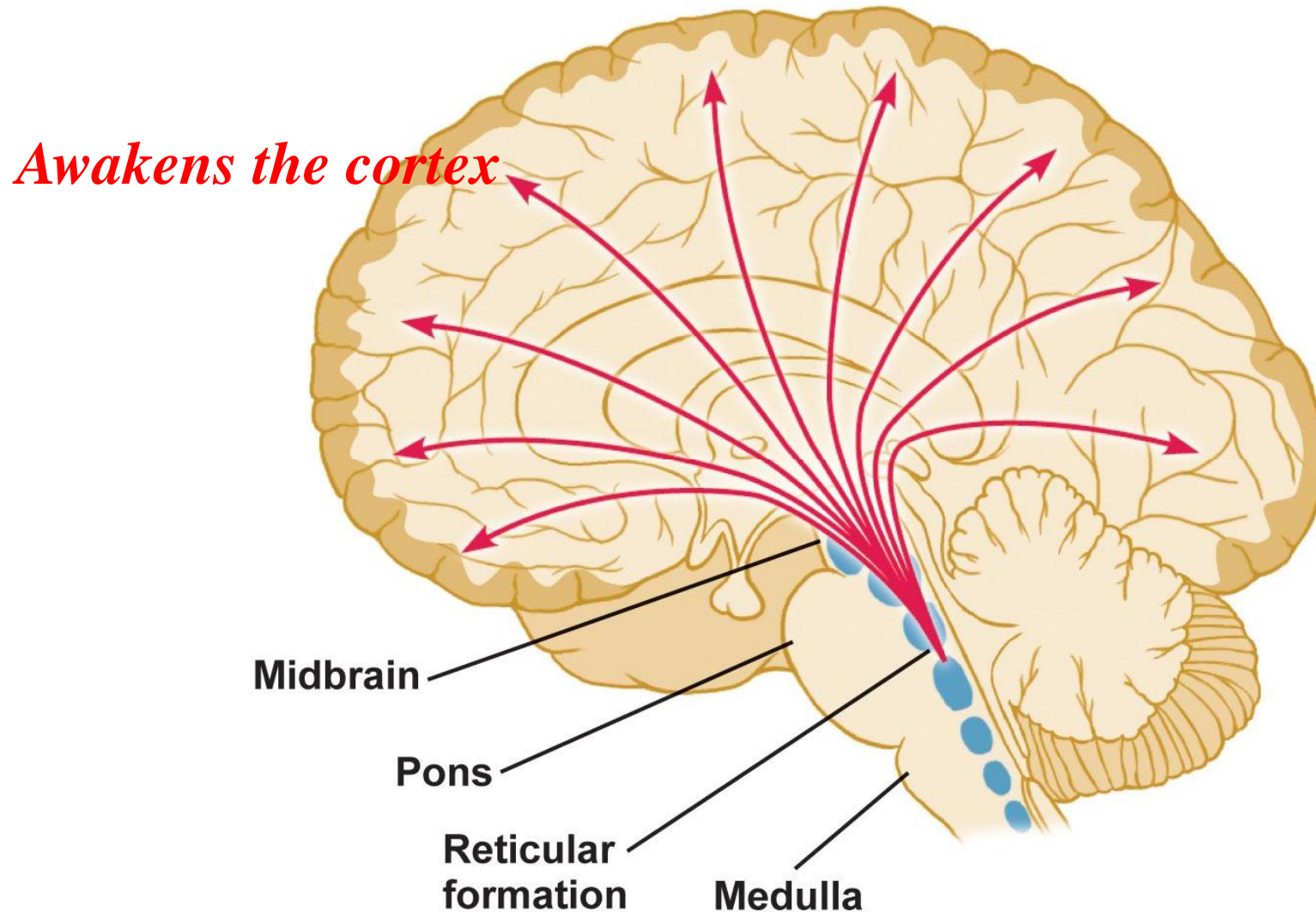
- **Hindbrain=**
Pons+medulla+cerebellum
- The pons houses sensory and motor tracts heading from/to the spinal cord
- Connects the brainstem and cerebellum
 - The **V-VIII** nerves arise from the pons
 - Two respiratory control centers** are found here:
 - **Apneustic center**
 - **Pneumotaxic center**



Medulla Oblongata

- All ascending and descending tracts between the brain and spinal cord pass through the **medulla**
 - Tracts cross sides in the **pyramids (motor pathways)**
 - Cranial nerves **IX-XII** come off the medulla
- Contains nuclei required for regulation of breathing and cardiovascular response = **Vital centers**
 - Vasomotor center* controls blood vessel diameter
 - Cardiac control center* controls heart rate
 - Respiratory rhythmicity center* helps areas in the pons control breathing
- **Swallowing, vomiting, coughing, sneezing** and **hiccups reflex centers (autonomic reflex centers)**

Reticular Formation

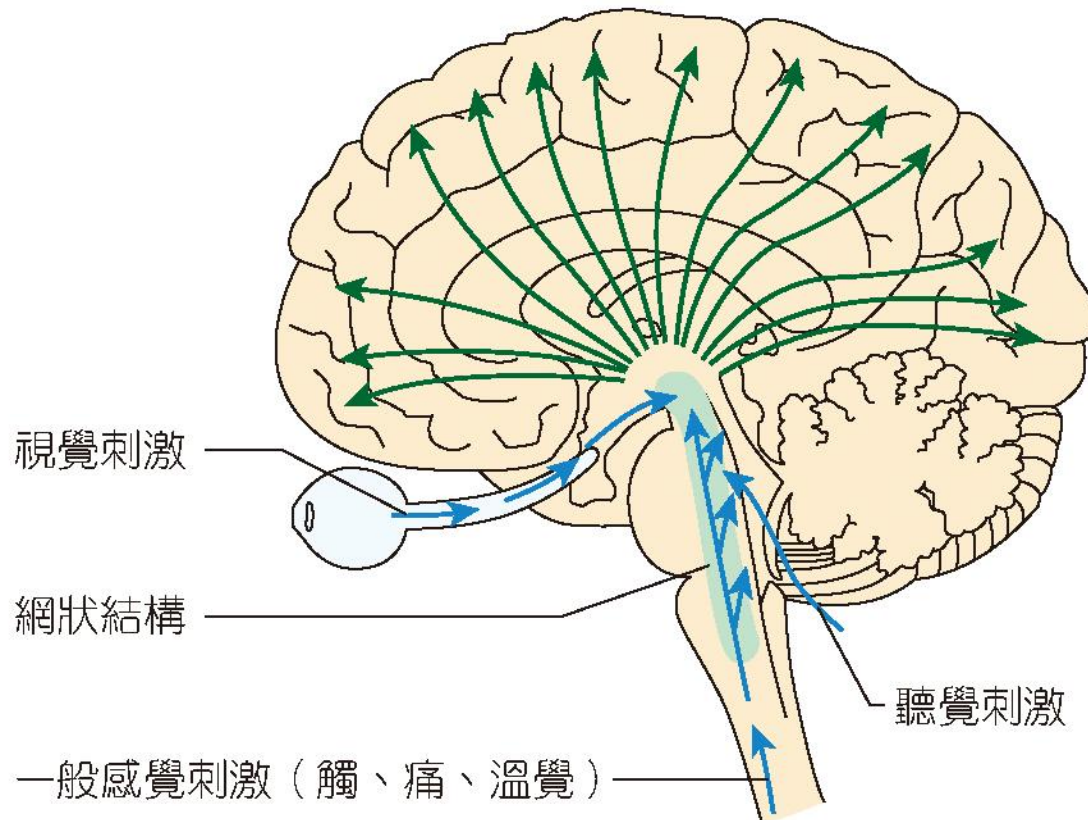


- A region in the **brainstem** that is involved in regulating the **sleep-wake cycle** and **filtering incoming stimuli** to discriminate irrelevant background stimuli

Reticular Activating System (RAS)

Ascending Activation: Awakens the cortex

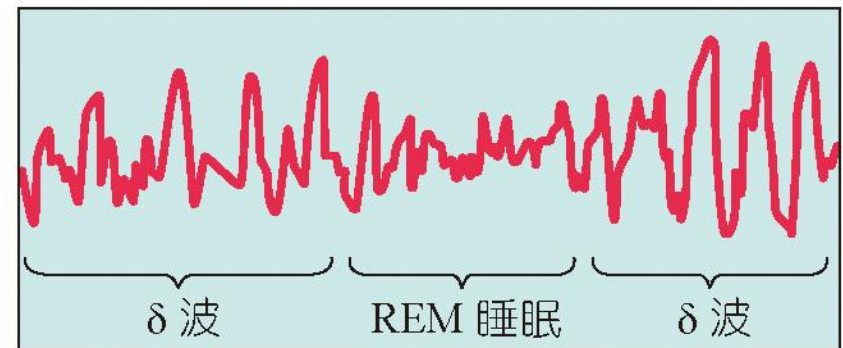
- To fall asleep, we must tune out sensory stimuli (*inh. RAS*)
When awake, we are alert to sensory stimuli (*sti. RAS*)
- This depends on the activation and inhibition of the RAS



清醒狀態 (β 波)



睡眠狀態



Descending Function: Maintain muscle tone

Sleep-Wake Neurotransmitters

● Awake state

--Acetylcholine

- Pons
- Sti. RAS
- Mimicked by **nicotine**

--Norepinephrine and dopamine

- Hypothalamus and basal forebrain
- Sti. RAS
- Mimicked by **amphetamines** and **cocaine**

● Sleep state

--Adenosine

- Non-REM sleep induced by forebrain
- Blocked by **caffeine**

--Acetylcholine

- REM sleep
- Pons

--GABA

- Hypothalamus
- Inh. RAS
- Mimicked by **sedative-hypnotics, anesthetics, alc.**

Cerebellum

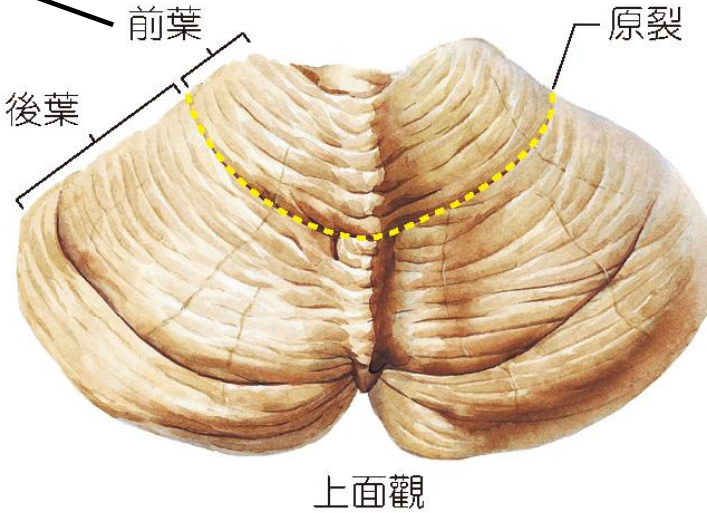
- 小腦是腦的第二大部分
- 位於延腦及橋腦的後方，在大腦枕葉的下方
- 小腦可分左右兩個小腦半球和中間的蚓狀部
- 每一個小腦半球分為前葉、後葉與小葉小結葉

接受來自脊髓的本體感覺和皮膚感覺的資訊 (a)

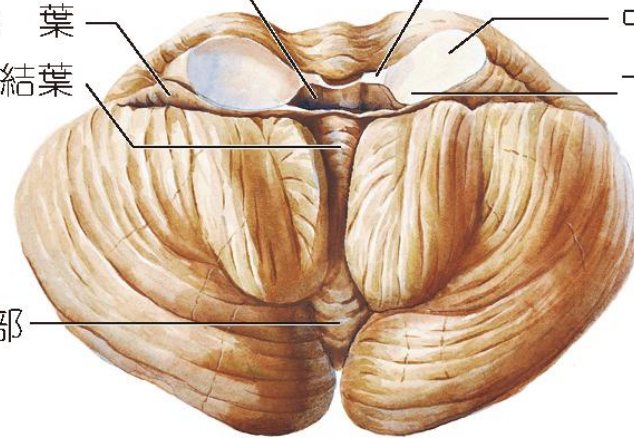
參與骨骼肌的下意識動作

在進化上出現最早，主要與前庭神經和前庭神經核密切聯繫，與平衡有關 (b)

接受來自脊髓的本體感覺和皮膚感覺的資訊



第四腦室
小葉
小結葉



連接中腦及小腦

連接橋腦及小腦，是大腦皮質的運動纖維經橋腦傳入小腦的路徑

連接延腦及小腦，是延腦和脊髓傳入小腦的路徑

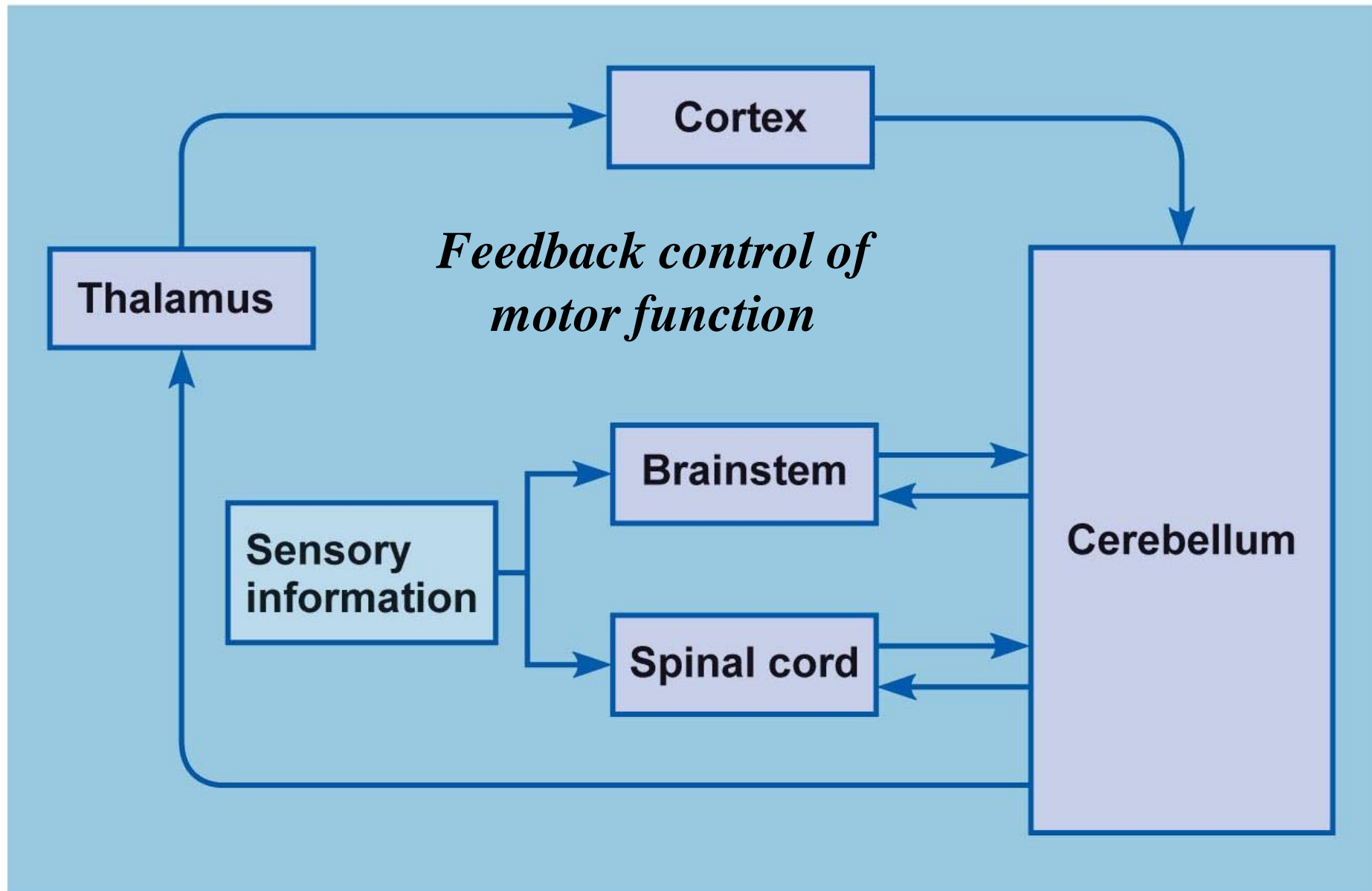
下面觀

Cerebellum

- 小腦的主要功能包括**維持身體平衡**、**調節肌肉張力**及**協調隨意動作**。
- 小腦可接受平衡覺(來自內耳半規管)、本體感覺(來自肌肉及關節)、視覺、聽覺、皮膚感覺等感覺傳入，並加以訊號整合，藉以調整維持身體平衡的肌肉的收縮及調節肌肉張力。
- 在運動時，小腦可提供時間資訊給大腦皮質及脊髓，使動作以正確的順序及時機執行。
- 負責動作協調，控制動作的速度、力量及方向等，使動作平滑流暢並終止於適當的位置。例如使用手指碰觸鼻子、將食物放進嘴巴或藉由觸覺找尋皮包中的鑰匙等，均需要小腦予以協調。
- 與動作的學習及記憶有關。若因飲酒過量造成小腦損傷，則曾經學習過之動作將無法再啟動，因此每次做動作時將會視為新動作再學習一次，故常會產生動作不協調表現如運動失調症(ataxia)。

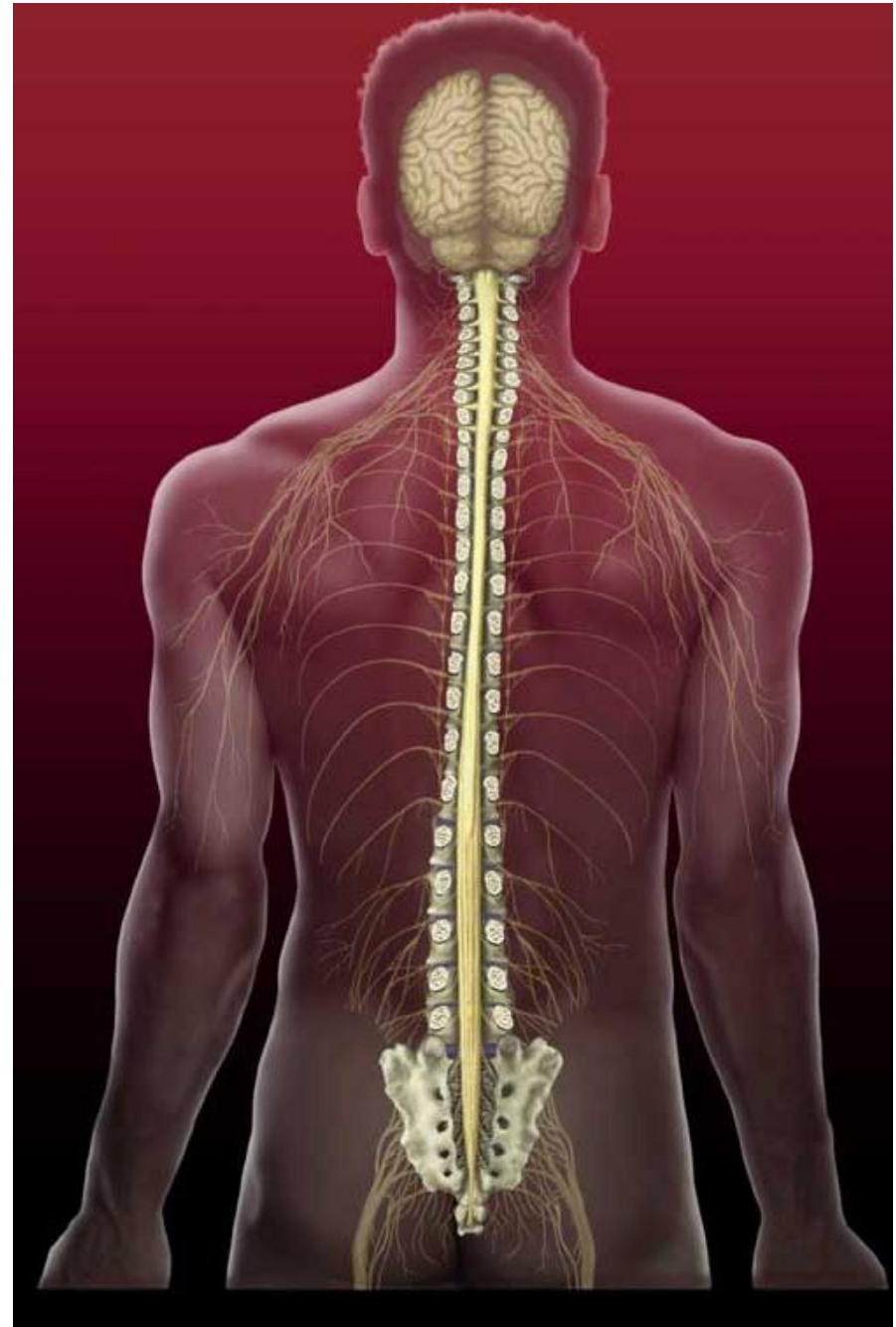
Cerebellum

Cerebellum Critical to Motor Coordination



External Anatomy of Spinal Cord

- The *spinal cord* begins as a continuation of the medulla oblongata
- Terminates at about the L2 in an adult and at L4 in newborn
- Main pathway for information connecting the brain and peripheral nervous system
- Integrating center of reflex
- Flattened cylinder
- 42-45 cm long & 1-1.4 cm diameter, and is enlarged in the cervical and lumbar regions



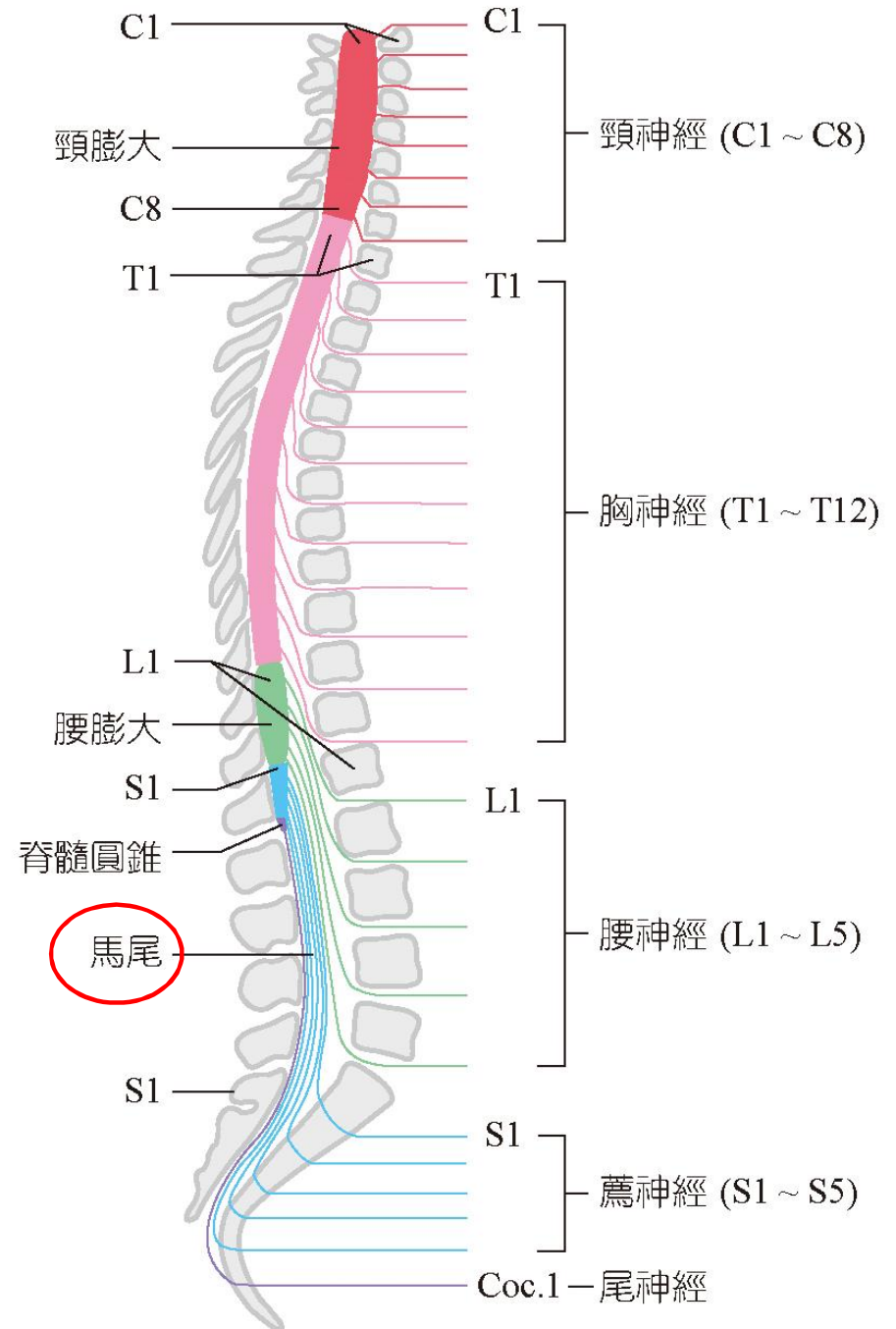
External Anatomy of Spinal Cord

1. 頸膨大(cervical enlargement)：

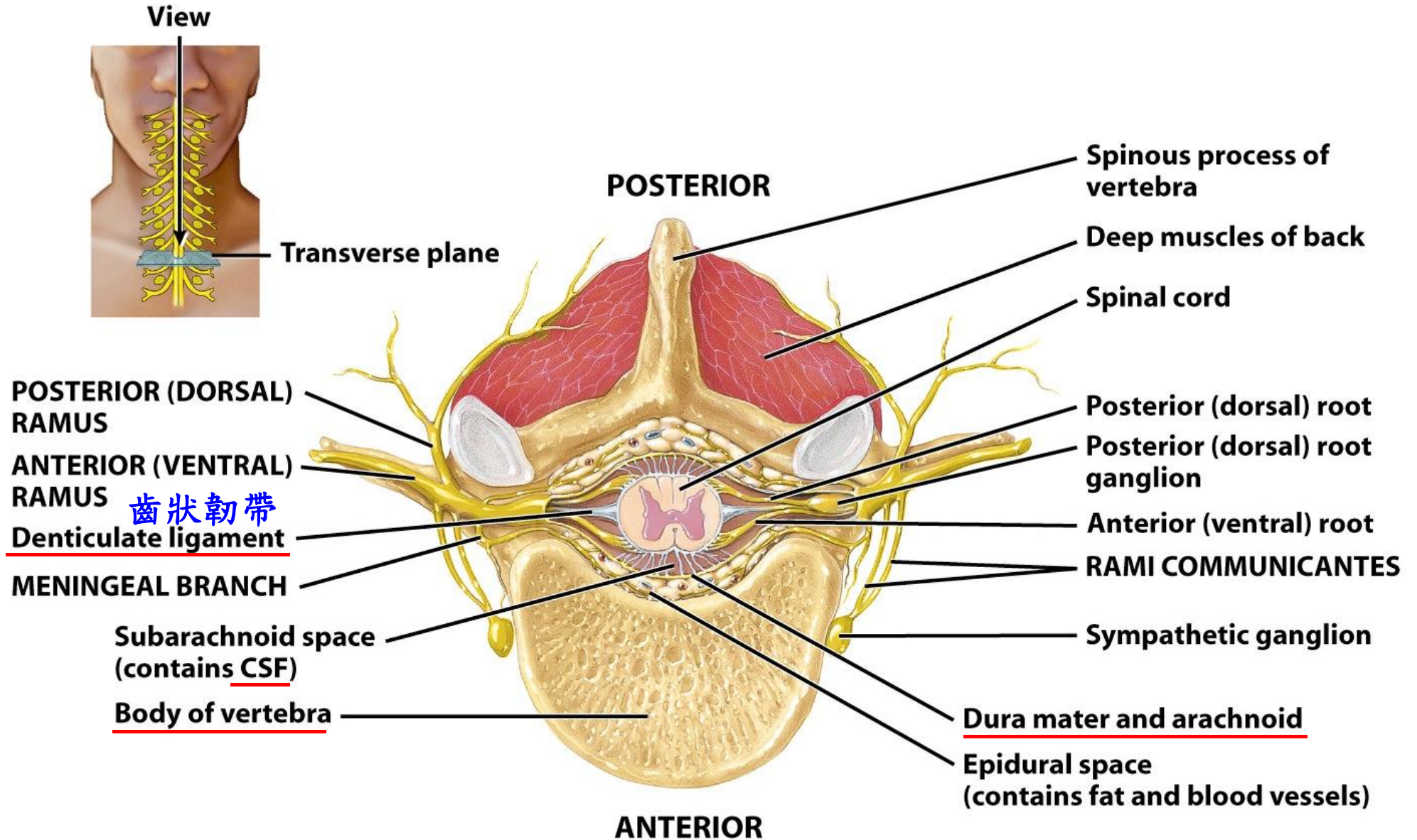
自頸髓第4節到胸髓第1節；
相當於臂神經叢發出的節段，
支配上肢。

2. 腰膨大(lumbar enlargement)：

自腰髓第2節至薦髓第3節；
相當於發出腰薦神經叢的節段，
支配下肢。

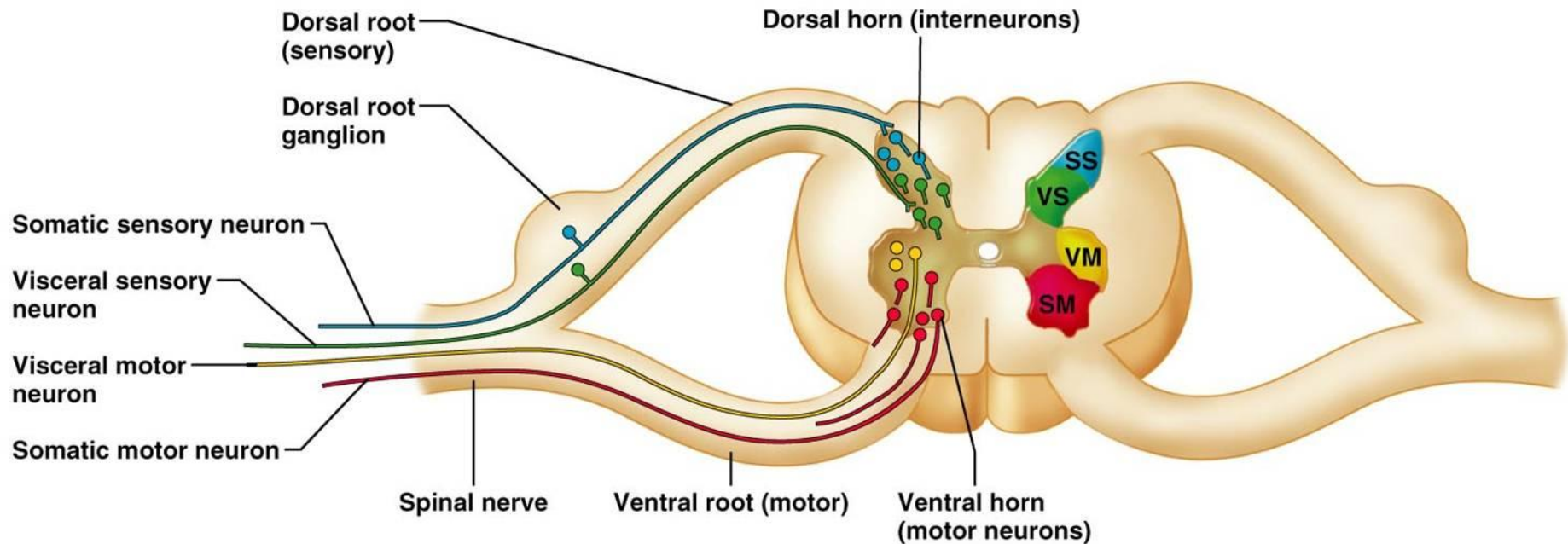


Spinal Cord Protection

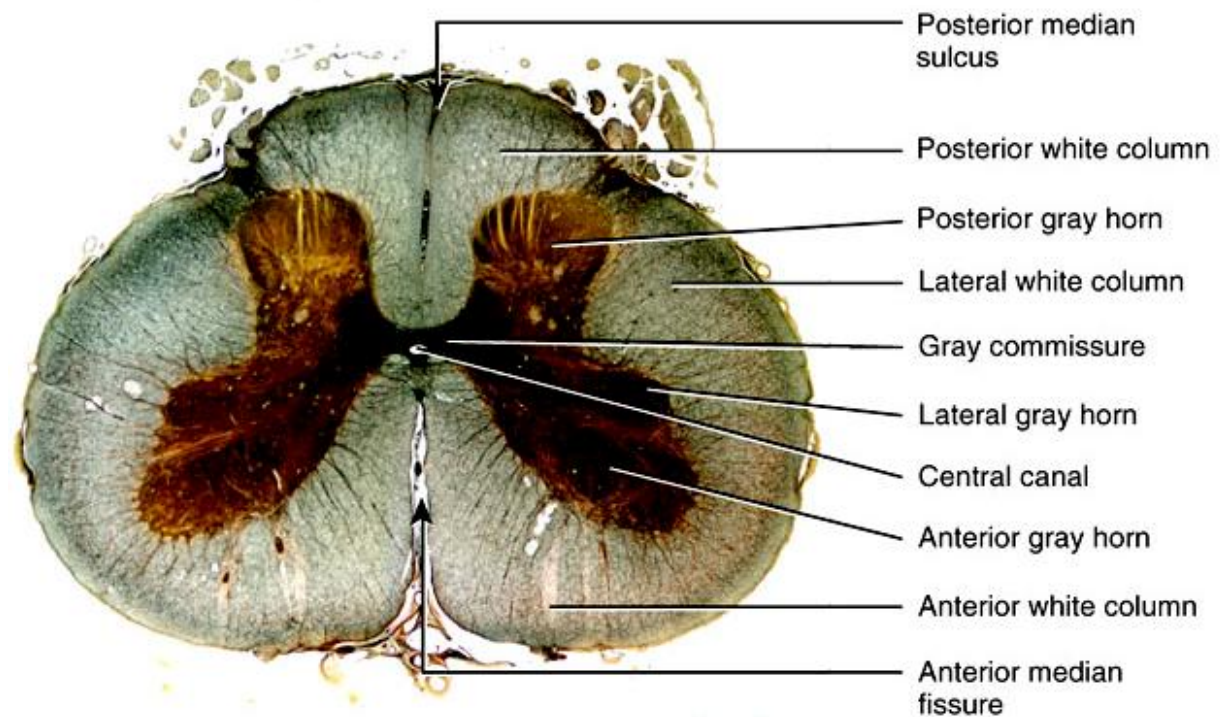


➤ By the *vertebral column, meninges, CSF, and vertebral ligaments*

Internal Anatomy of Spinal Cord



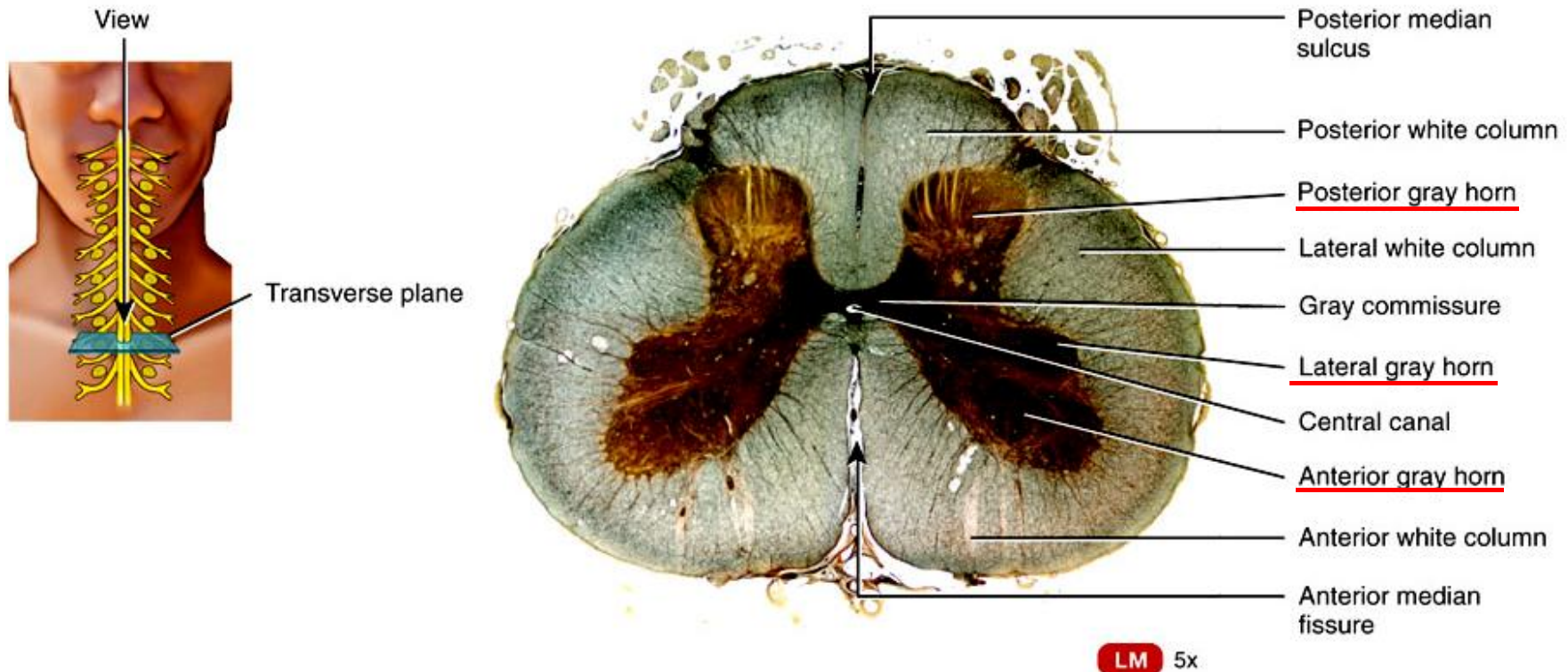
- **Dorsal (posterior) root** is incoming **sensory** fibers
 --**dorsal root ganglion** (swelling) = cell bodies of sensory nerves
- **Ventral (anterior) root** is outgoing **motor** fibers



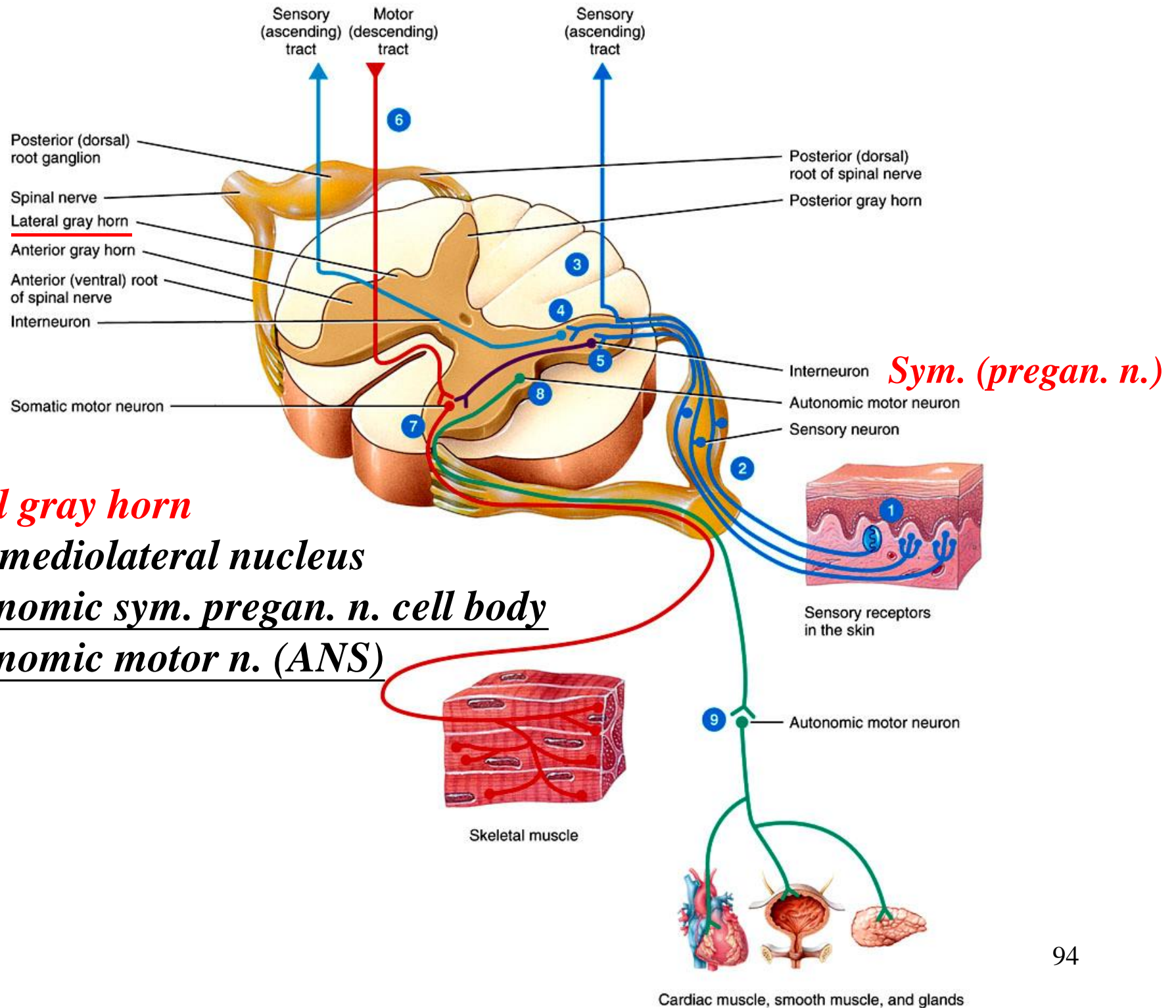
Gray Matter & White Matter

- **Gray matter** is shaped like the letter H or a butterfly
 - contains neuron cell bodies, unmyelinated axons & dendrites
 - paired **dorsal** and **ventral gray horns**
 - lateral horns** only present in thoracic spinal cord
 - gray commissure** crosses the midline
- **Central canal** is continuous with **4th ventricle** of brain
- **White matter** is composed of ascending (sensory) and descending (motor) fiber (axon) tracts

Gray Matter & White Matter



- The **gray matter** is divided into *horns*, which contain cell bodies of neurons
- The **white matter** is divided into *columns*
 - Each column (**spinal tract**) contains distinct bundles of nerve axons that have a common origin or destination and carry similar information
 - These bundles are called *tracts*



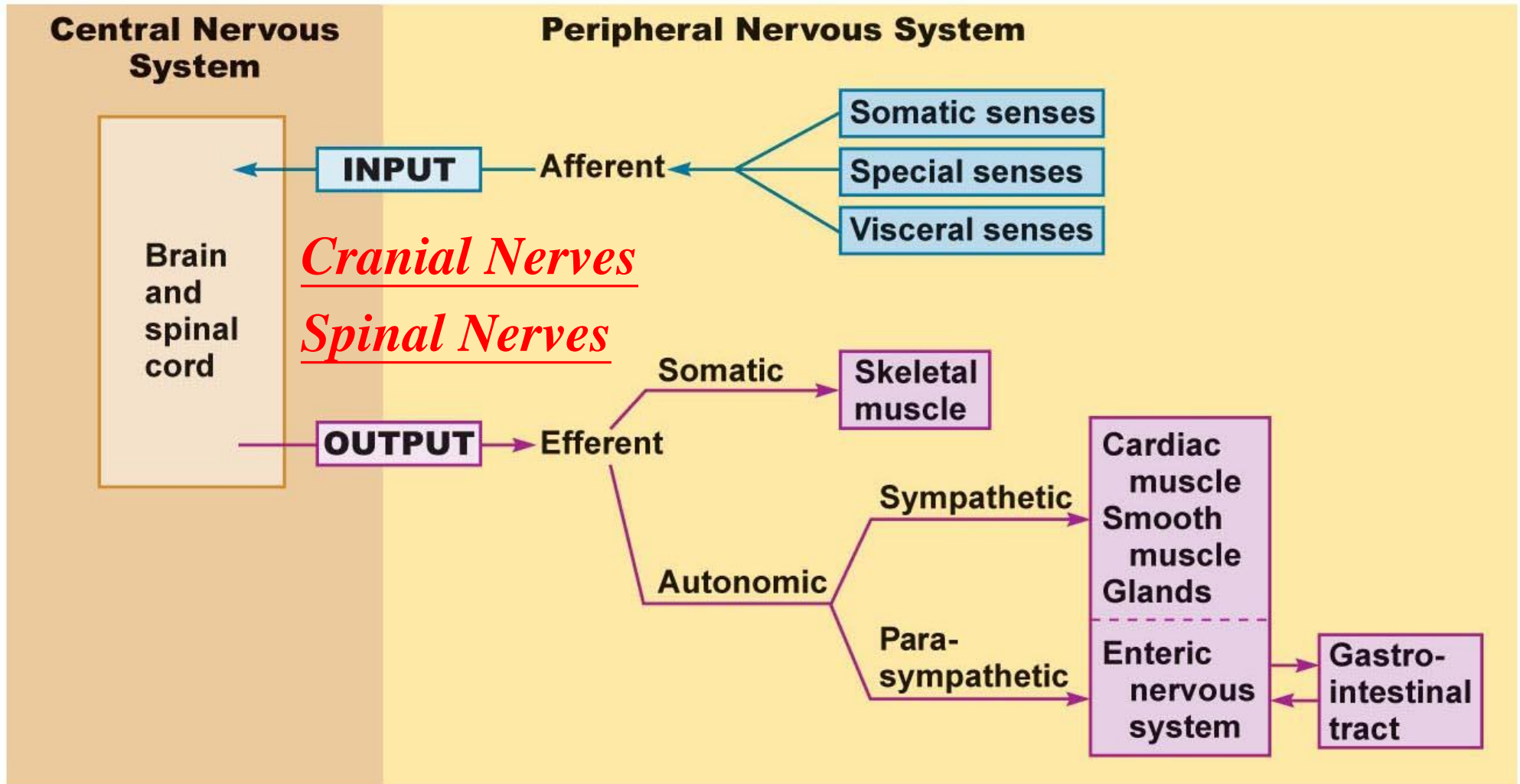
➤ **Lateral gray horn**

= *intermediolateral nucleus*

= *autonomic sym. pregan. n. cell body*

= *autonomic motor n. (ANS)*

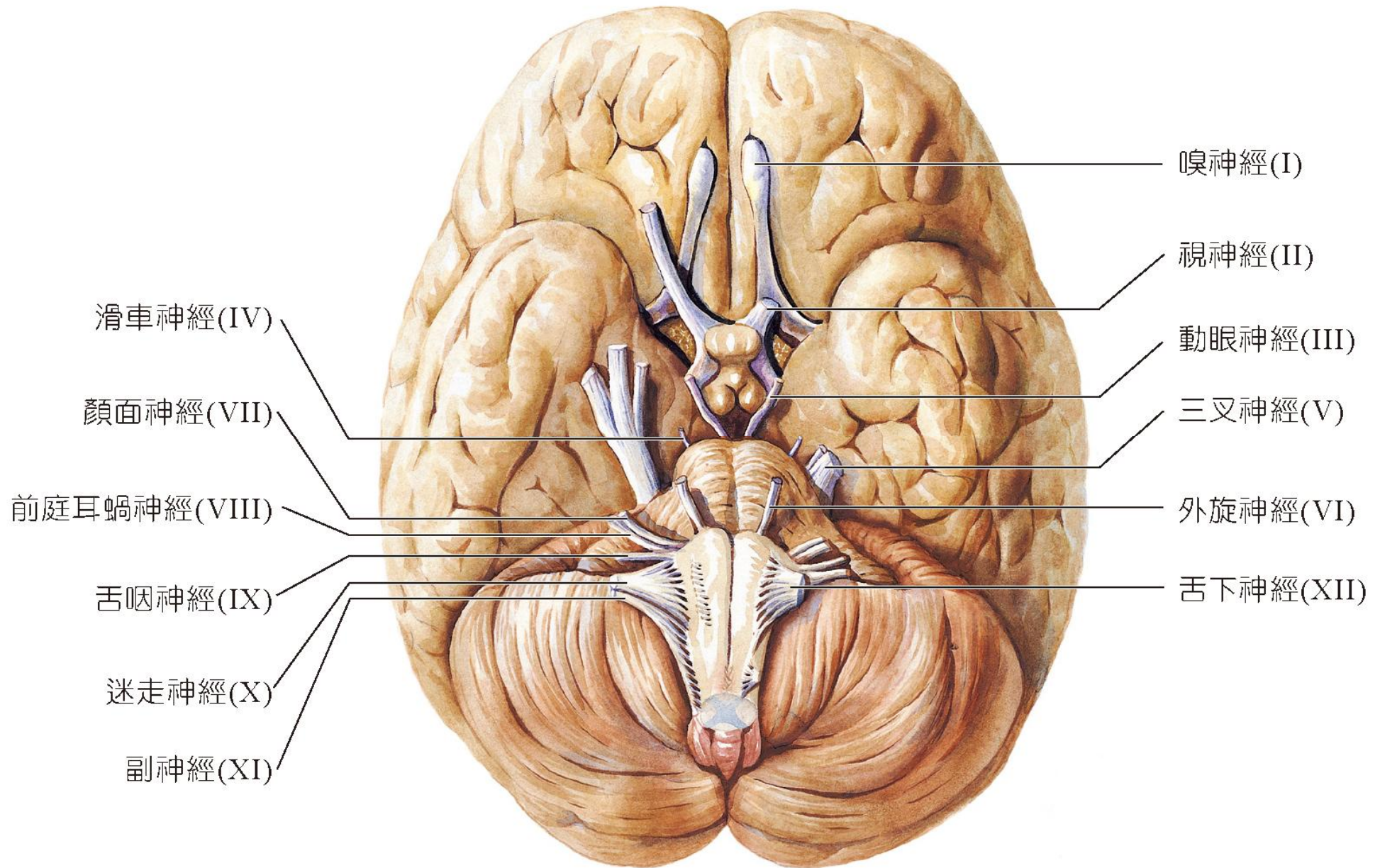
Peripheral Nervous System



Cranial Nerves

- Part of the **PNS**
- Nerves that arise directly from nuclei in the brain
- **Twelve pairs**
- Most are mixed nerves with both sensory and motor neurons
- Those associated with vision, olfaction, and hearing are **sensory only**
 - Cell bodies of these neurons are not in the brain but in ganglia located near the sensory organ

Cranial Nerves: 12 Pairs

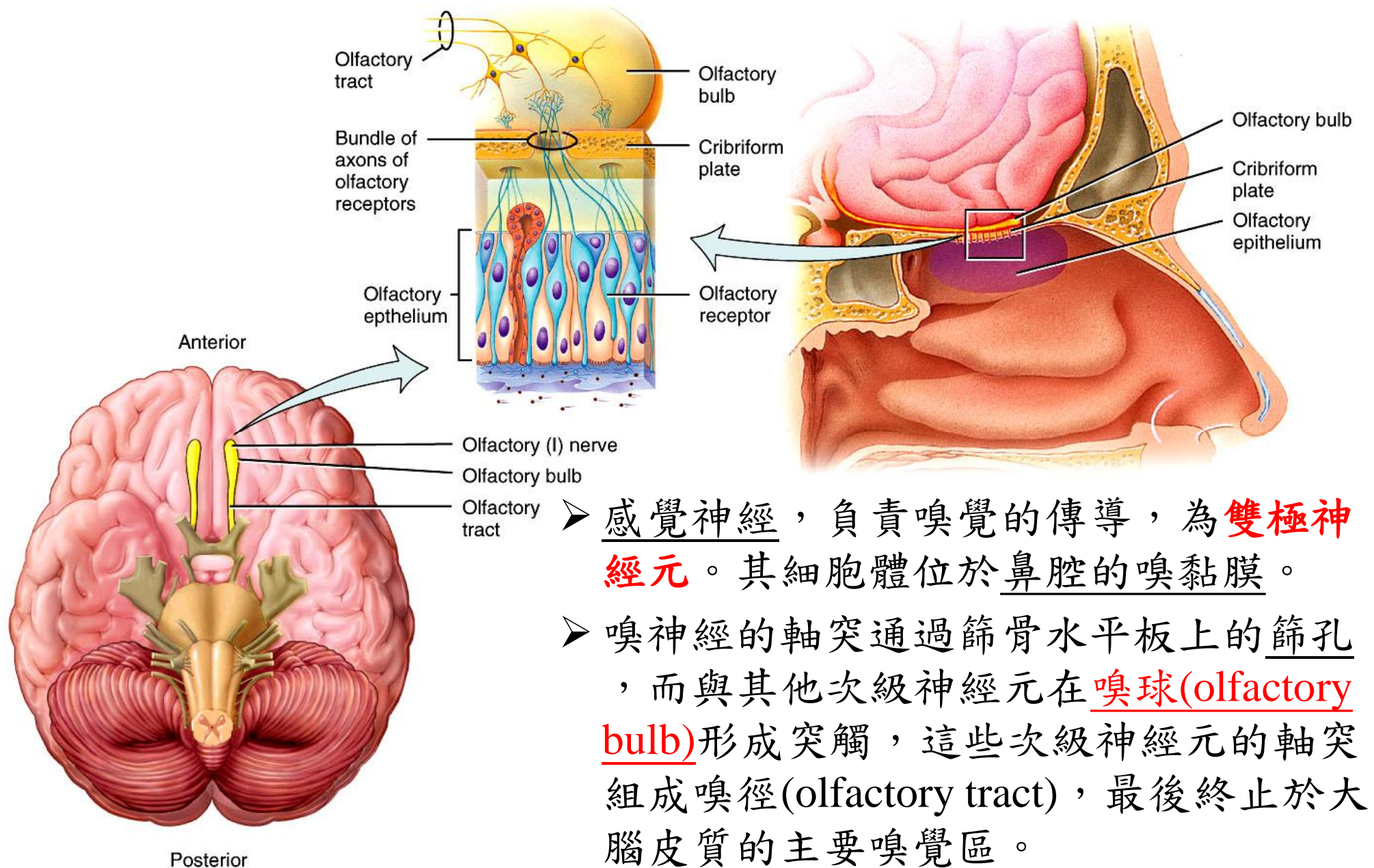


Cranial Nerves

名稱	組成	功能
I 嗅神經	感覺	傳導嗅覺訊息
II 視神經	感覺	傳導視覺訊息
III 動眼神經	運動	支配提上瞼肌及眼球外在肌（不包含外直肌及上斜肌）；支配控制瞳孔括約肌與水晶體睫狀肌
	感覺：本體感覺	由其運動纖維支配的肌肉傳來的本體感覺
IV 滑車神經	運動	控制眼球上斜肌的運動
	感覺：本體感覺	傳導眼球上斜肌的本體感覺
V 三叉神經		
眼支 (ophthalmic division)	感覺	角膜、鼻皮膚、前額及頭皮的感覺
上頷支 (maxillary division)	感覺	鼻黏膜、上排齒及牙齦、腭、上唇及臉頰皮膚的感覺
下頷支 (mandibular division)	感覺	顳部、舌頭、下排齒及牙齦、下巴及下頷皮膚的感覺
	運動	支配咀嚼肌及可拉緊鼓膜的肌肉
	感覺：本體感覺	咀嚼肌的本體感覺
VI 外旋神經	運動	支配眼球外直肌
	感覺：本體感覺	眼球外直肌的本體感覺

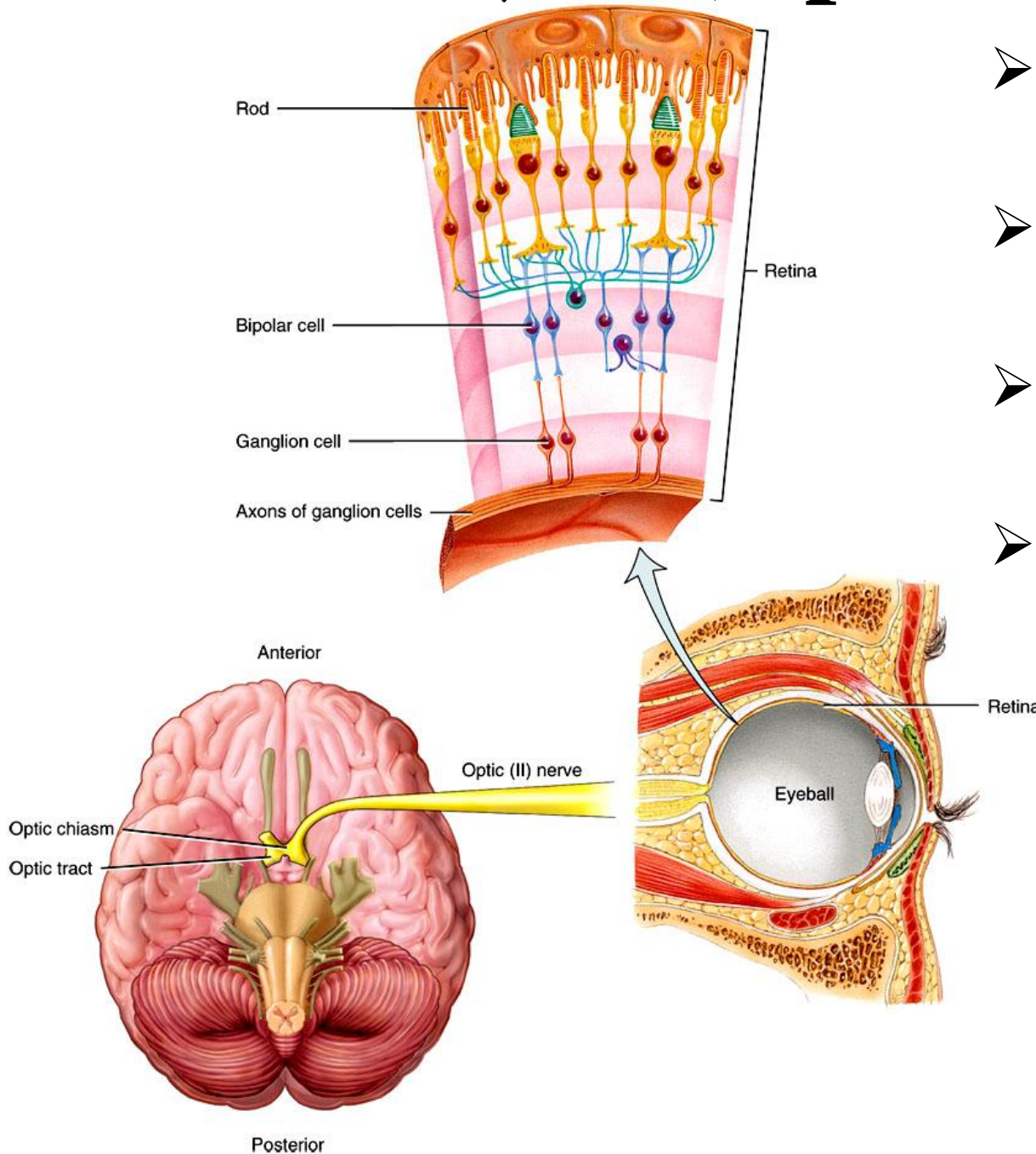
VII 顏面神經	運動	支配臉部表情肌及可拉緊鐙骨的肌肉
	運動：副交感神經	使淚腺分泌淚液，舌下及頷下腺唾液腺的分泌
	感覺	舌前 2/3 味蕾、鼻及腭的感覺
	感覺：本體感覺	面部表情肌的本體感覺
VIII 前庭耳蝸神經	感覺	與平衡感及聽覺有關的感覺
IX 舌咽神經	運動	支配吞嚥所使用的咽部肌肉
	感覺：本體感覺	咽部肌肉的本體感覺
	感覺	舌後 1/3 味蕾、咽、中耳腔及頸動脈竇的感覺
	運動：副交感神經	腮腺唾液腺分泌
X 迷走神經	運動	咽部（吞嚥）及喉部（發音）肌肉的收縮
	感覺：本體感覺	內臟肌肉的本體感覺
	感覺	舌後味蕾、耳廓感覺及總體臟器的感覺
	運動：副交感神經	許多內臟功能的調節
XI 副神經	運動	咽部動作；軟腭 控制頭部、頸部及肩膀的斜方肌和胸鎖乳突肌
	感覺：本體感覺	移動頭部、頸部及肩膀的肌肉的本體感覺
XII 舌下神經	運動	舌頭內、外肌及舌下肌
	感覺：本體感覺	舌頭肌肉的本體感覺

嗅神經 (Olfactory Nerve): I



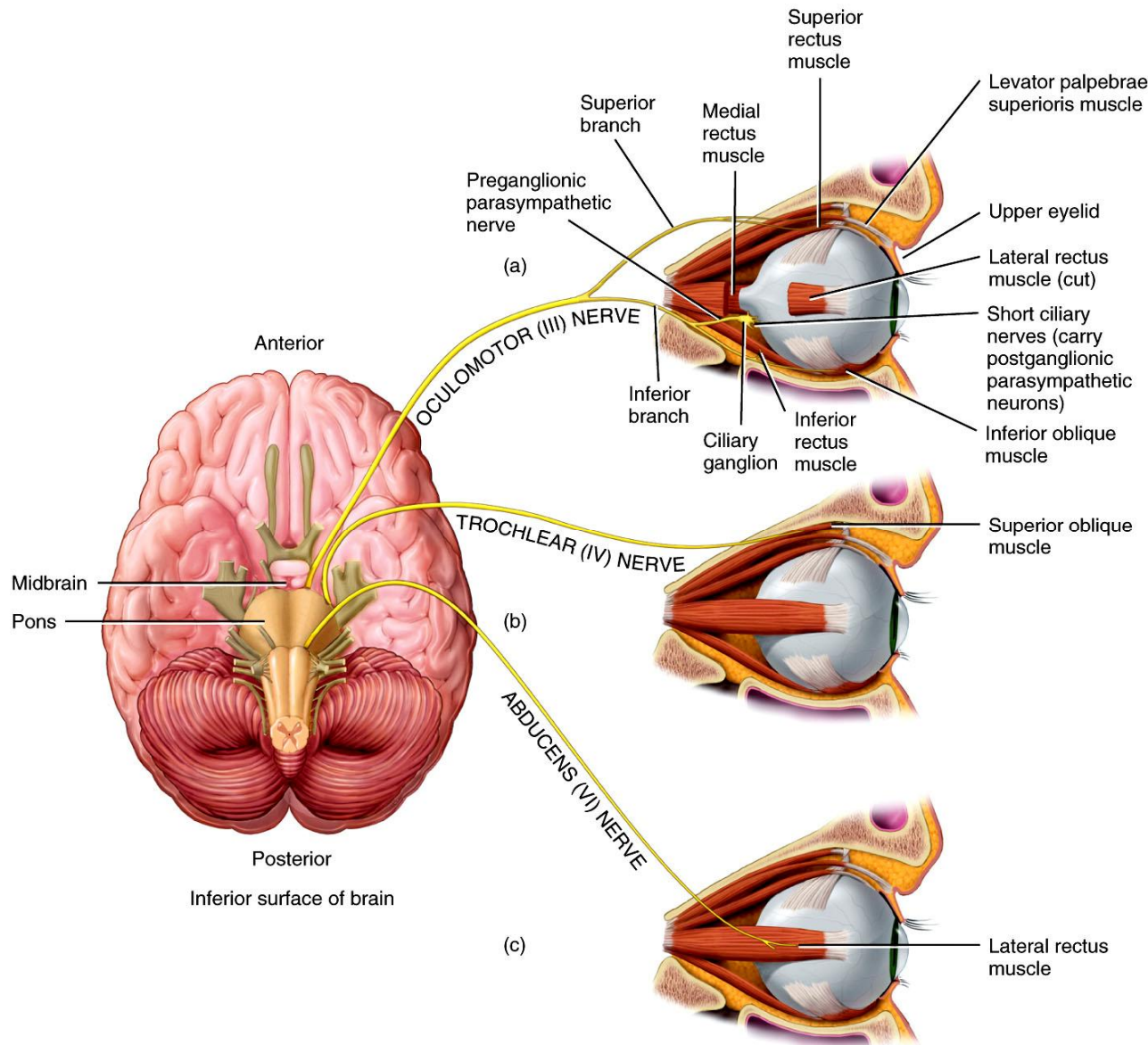
- 感覺神經，負責嗅覺的傳導，為**雙極神經元**。其細胞體位於鼻腔的嗅黏膜。
- 嗅神經的軸突通過篩骨水平板上的篩孔，而與其他次級神經元在嗅球(olfactory bulb)形成突觸，這些次級神經元的軸突組成嗅徑(olfactory tract)，最後終止於大腦皮質的主要嗅覺區。

視神經 (Optic Nerve): II



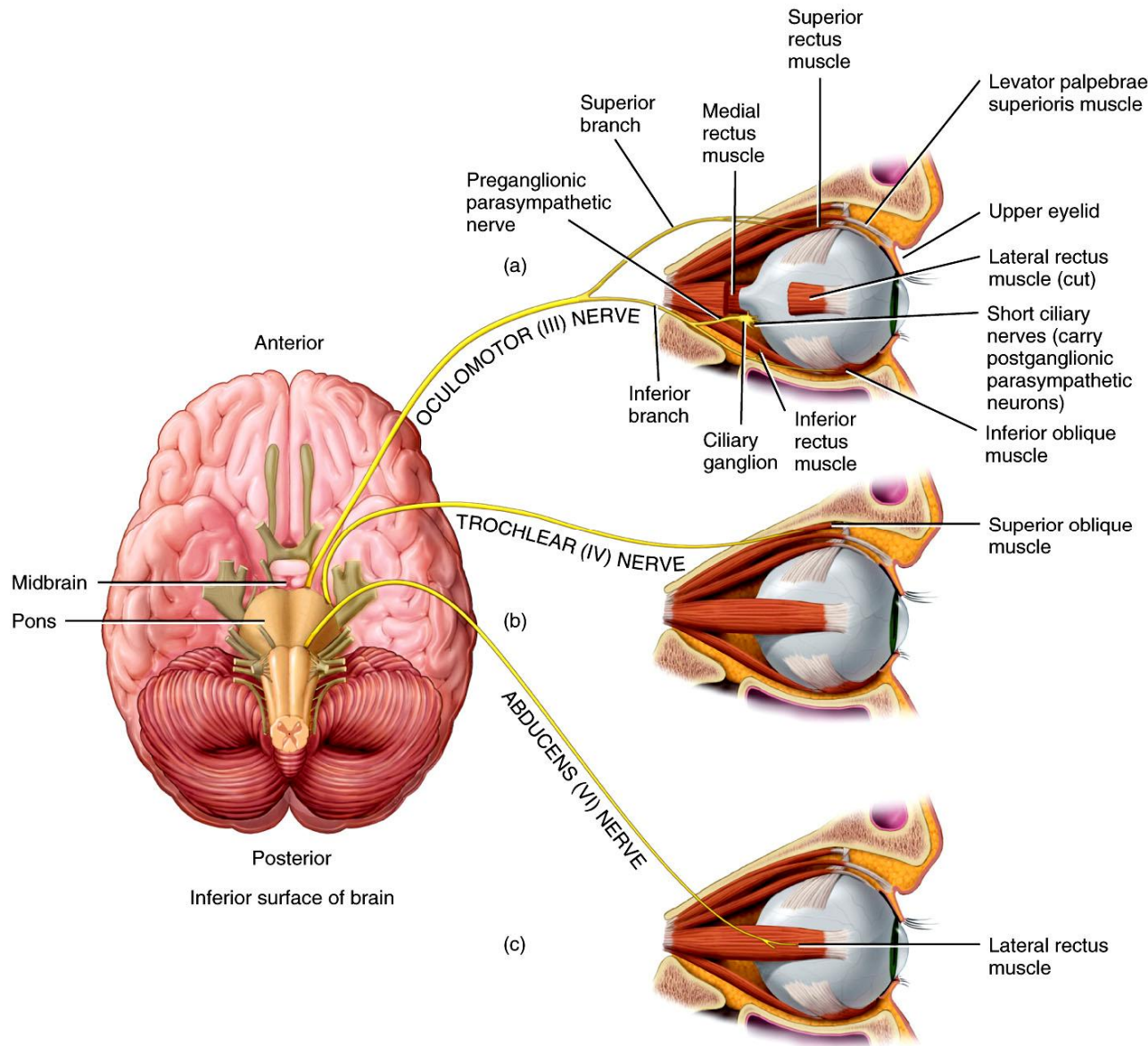
- 感覺神經，傳導視覺的神經衝動。
- 視神經是由視網膜之神經節細胞的軸突聚集而成。
- 視覺的神經衝動發生於視網膜上的**桿細胞**及**錐細胞**。
- 視覺傳遞路徑為：桿細胞、錐細胞 → 雙極神經元 (bipolar cells) → 節神經元 → 視神經 (通過視神經孔) → 視交叉 → 視徑 → 視丘的**外側膝狀體 (lateral geniculate body)** → 視放射 → 大腦皮質主要視覺區。

動眼神經 (Oculomotor Nerve): III



- 混合神經。
- 運動神經纖維：分佈到眼球外在肌（上直肌、下直肌、內直肌、下斜肌）及提上眼瞼肌。本體接受器則位於眼球外在肌。
- 副交感神經纖維：控制虹膜的環狀肌（瞳孔的大小）及睫狀肌（看遠近），支配瞳孔反射及負責水晶體的調節。
- 動眼神經的上、下枝皆通過眶上裂而離開顱腔，進入眼眶。

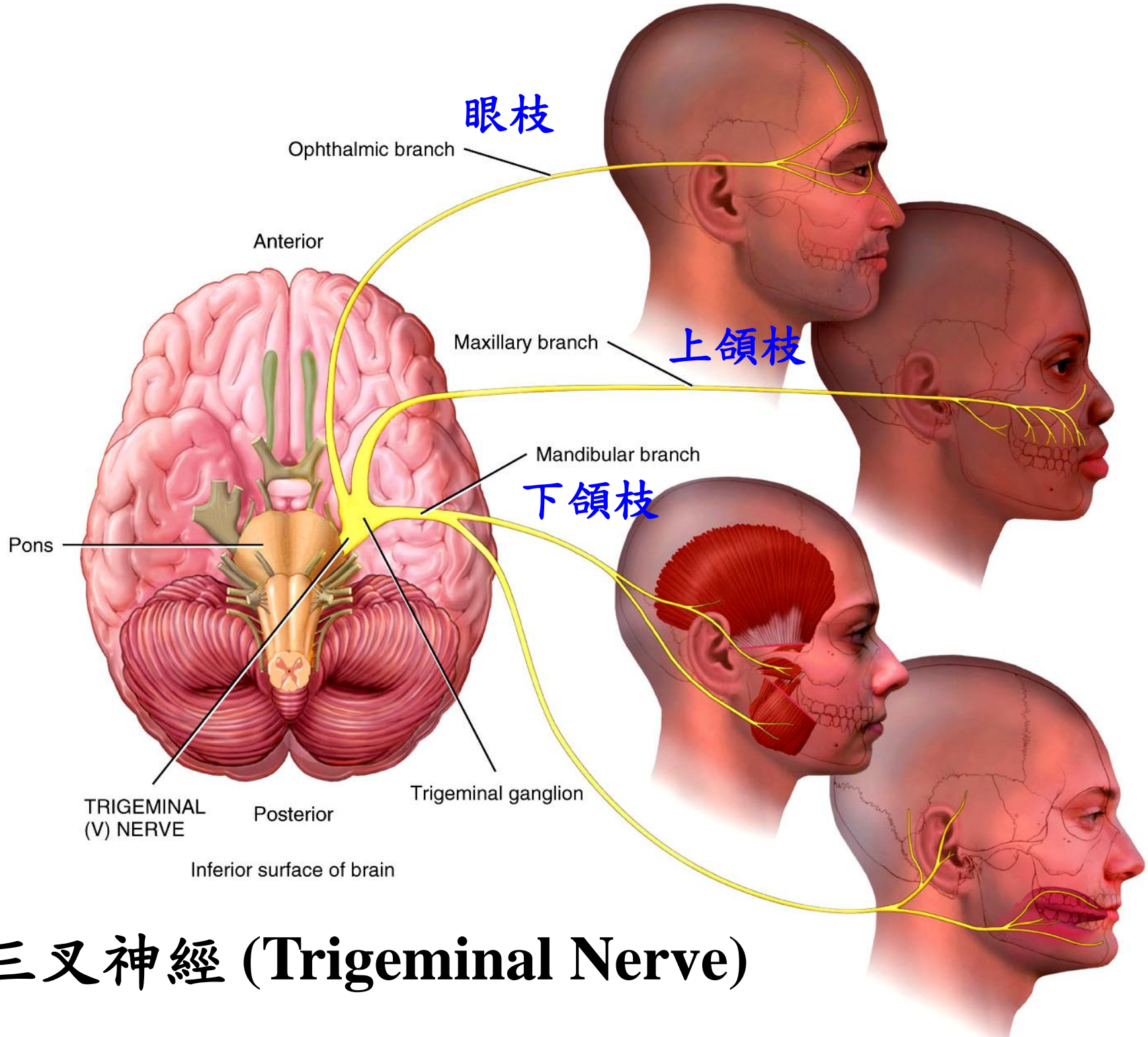
滑車神經 (Trochlear Nerve): IV



- 混合神經，由中腦背側發出，是腦神經中最小者。
- 其本體感覺及運動纖維都位於上斜肌。
- 它能控制眼球的運動。
- 滑車神經通過眶上裂。

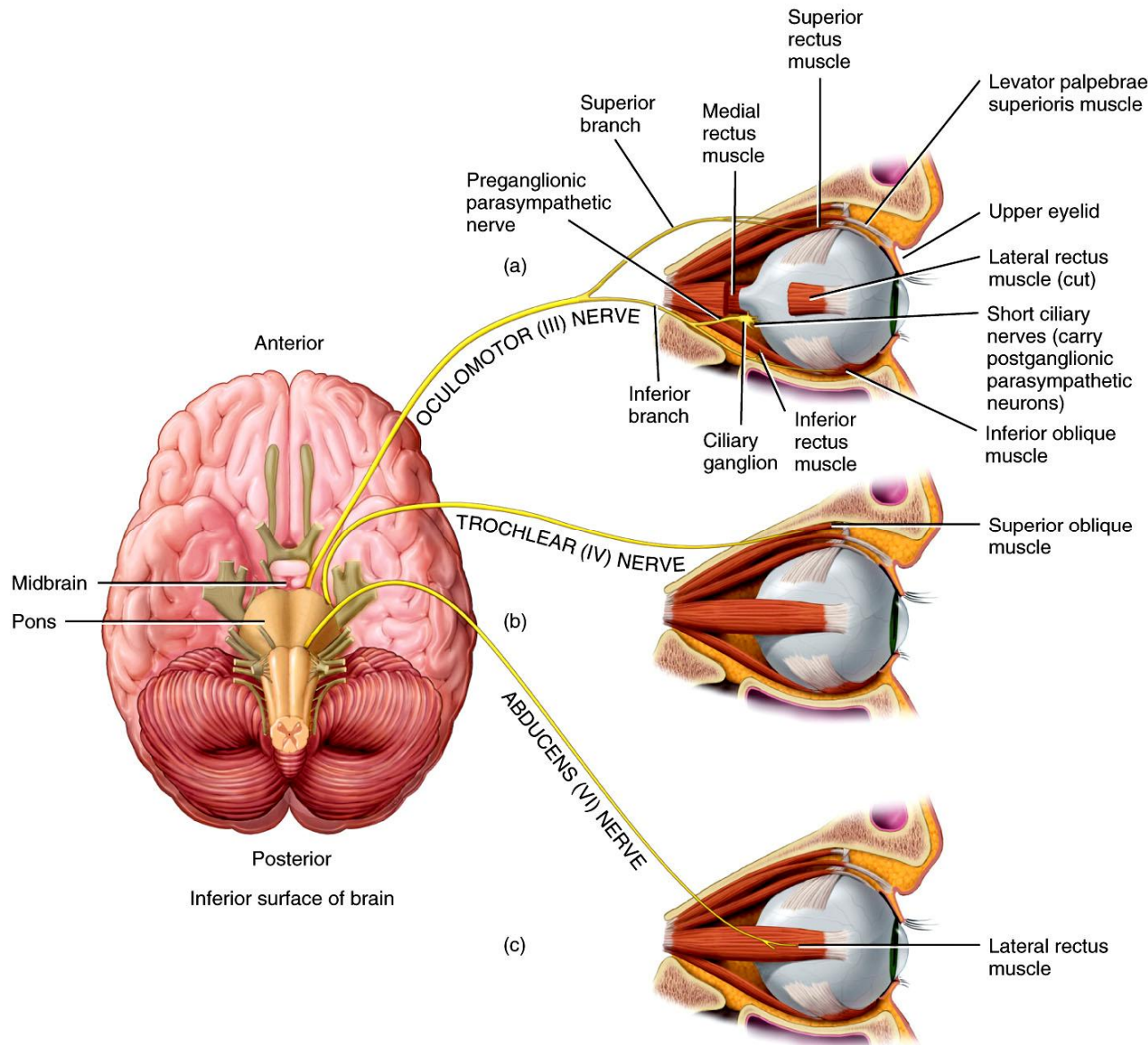
三叉神經 (Trigeminal Nerve): V

- 混合神經，是腦神經中最粗大者，但非最長。三叉神經因為有三個分枝而得名，此三個分枝者為：
 - 眼枝 (ophthalmic branch)：是感覺神經，通過眶上裂，分佈眼白、額頭、頭皮、上眼瞼、鼻腔上部的感覺。
 - 上頷枝 (maxillary branch)：是感覺神經，通過圓孔 (foramen rotundum)；分佈到顴骨、上齒槽及口。
 - 下頷枝 (mandibular branch)：是混合神經，通過卵圓孔 (foramen ovale)，分佈到下頷與下齒槽的感覺以及咀嚼肌的運動。
- 三叉神經的感覺部分傳送臉部與觸、溫、痛覺有關的衝動，細胞體位於三叉神經節=半月神經節，終止於橋腦的三叉神經核 (main sensory nucleus)。
- 與頭部、臉部的感覺、咀嚼肌之運動及鼓膜之緊張有關。



三叉神經 (Trigeminal Nerve)

外旋神經 (Abducens Nerve): VI



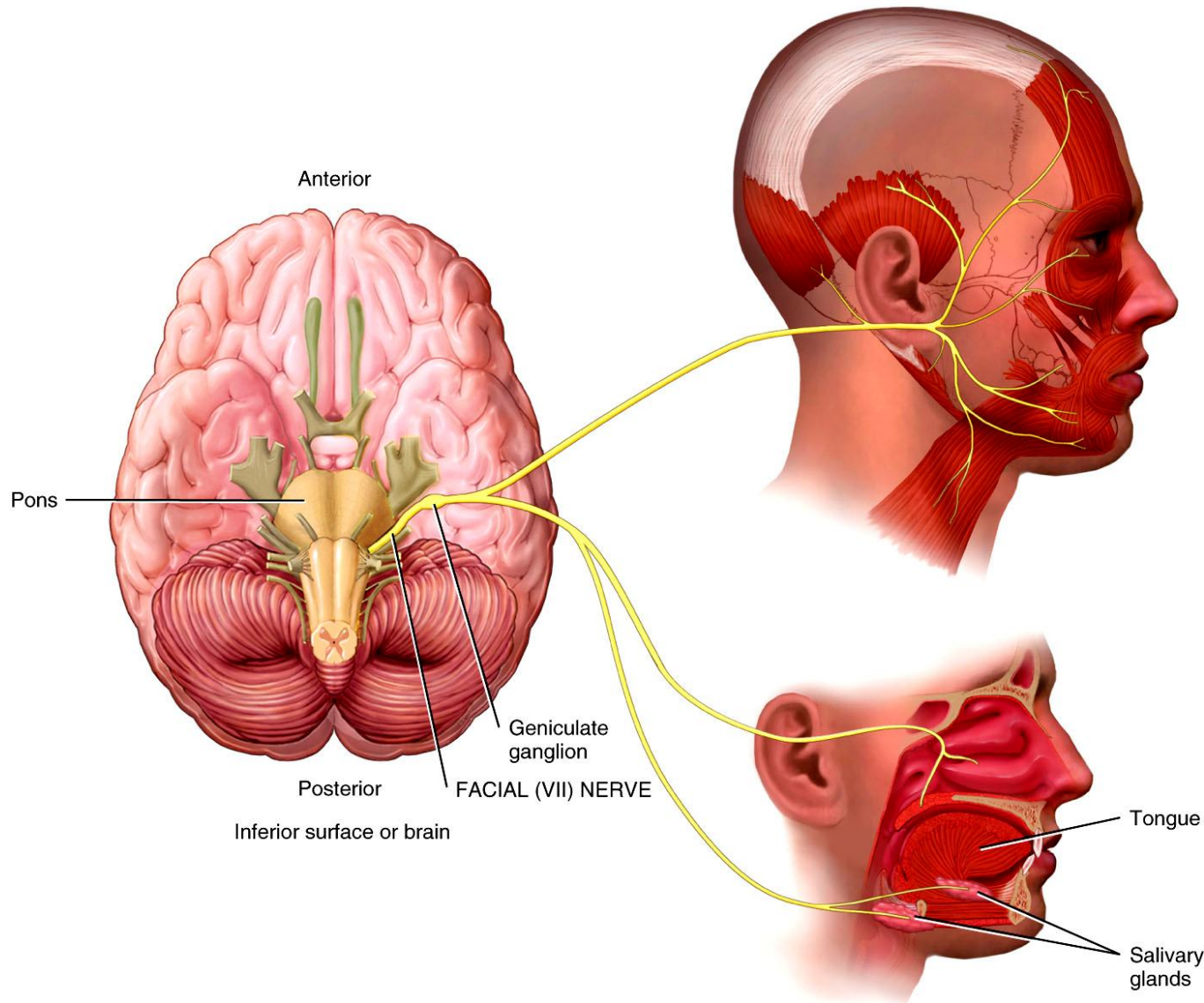
➤ 混合神經。其本體感覺及運動神經纖維都位於眼球之外直肌。

➤ 它通過眶上裂，為腦神經中顱腔內爬行距離最遠的神經。損傷會造成內斜視。

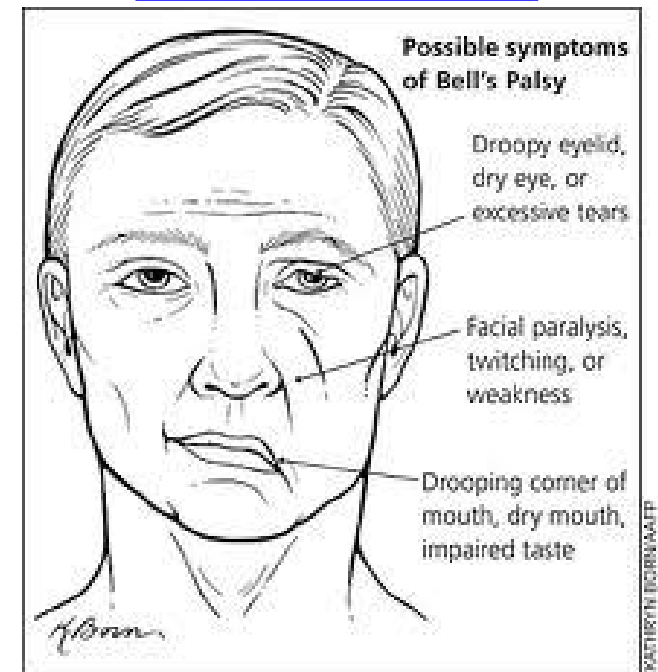
顏面神經 (Facial Nerve): VII

- 混合神經。
- 其運動部分負責**臉部表情肌**（除睜眼外）的所有動作。
◦ 分佈到臉部、頭部的淺層表情肌。
- 感覺神經纖維（味覺）之接受器位於**舌前三分之二的味蕾**。
- **副交感神經纖維**：控制唾液腺包括頷下腺(submaxillary gland)及舌下腺(sublingual gland)的分泌。
- 顏面神經也包含有支配淚腺的副交感神經纖維。
- 顏面神經的感覺神經與副交感神經穿過顳骨岩部的內耳道，支配臉部表情的運動神經則經莖乳突孔(stylomastoid foramen)離開顳骨。
- 顏面神經受損會造成口角歪斜，稱**顏面神經麻痺**或Bell's麻痺。

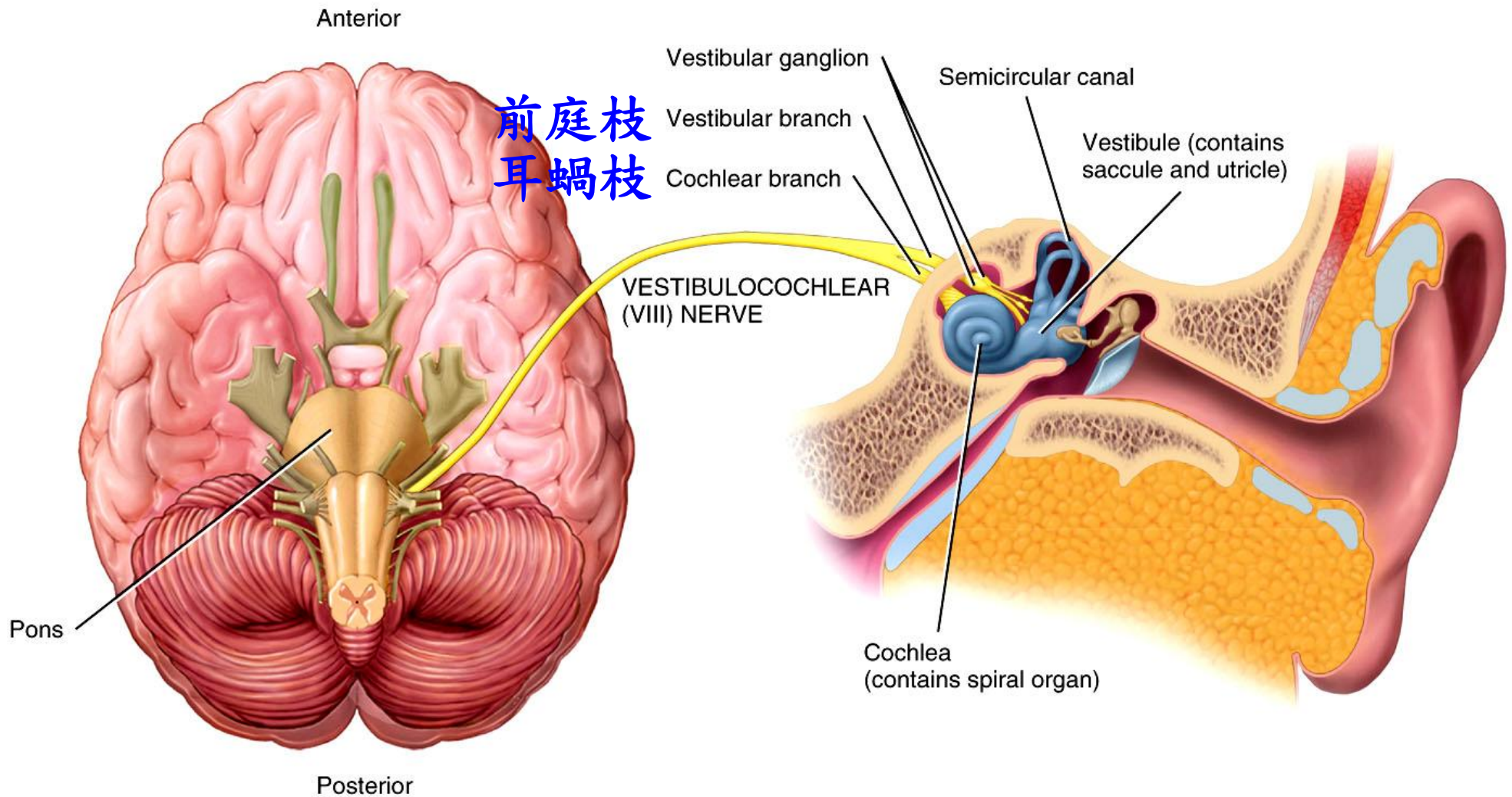
顏面神經 (Facial Nerve): VII



Bell's Palsy



前庭耳蝸神經 (Vestibulocochlear Nerve): VIII

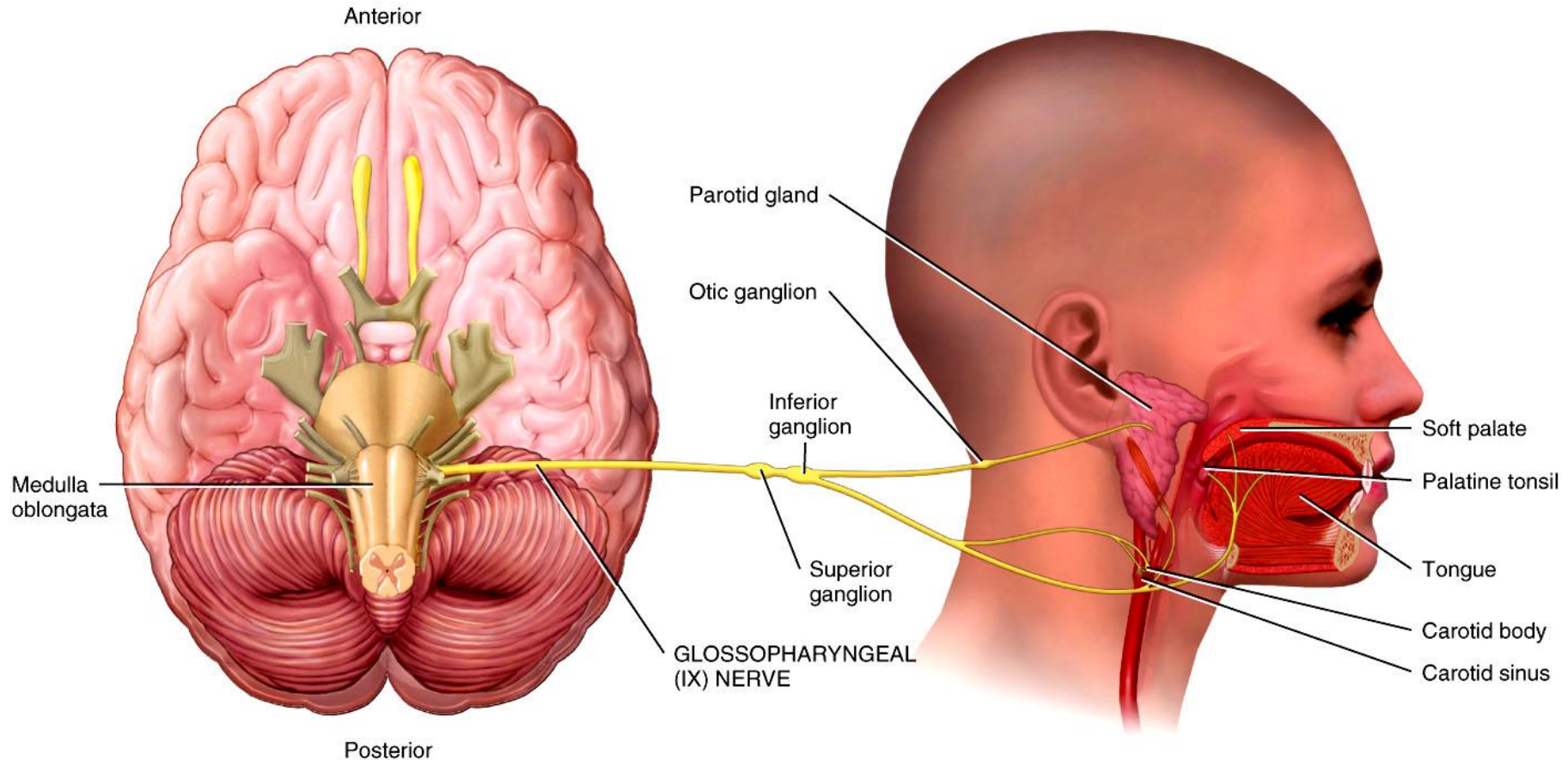


➤ 感覺神經，經內耳道分佈到內耳，它有兩個分枝：

--前庭枝：來自半規管、球囊及橢圓囊，與平衡有關

--耳蝸枝：來自內耳耳蝸內的柯蒂氏器 (organ of Corti)，負責聽覺傳導

舌咽神經 (Glossopharyngeal Nerve): IX



➤ 混合神經，舌咽神經經頸靜脈孔離開顱骨：

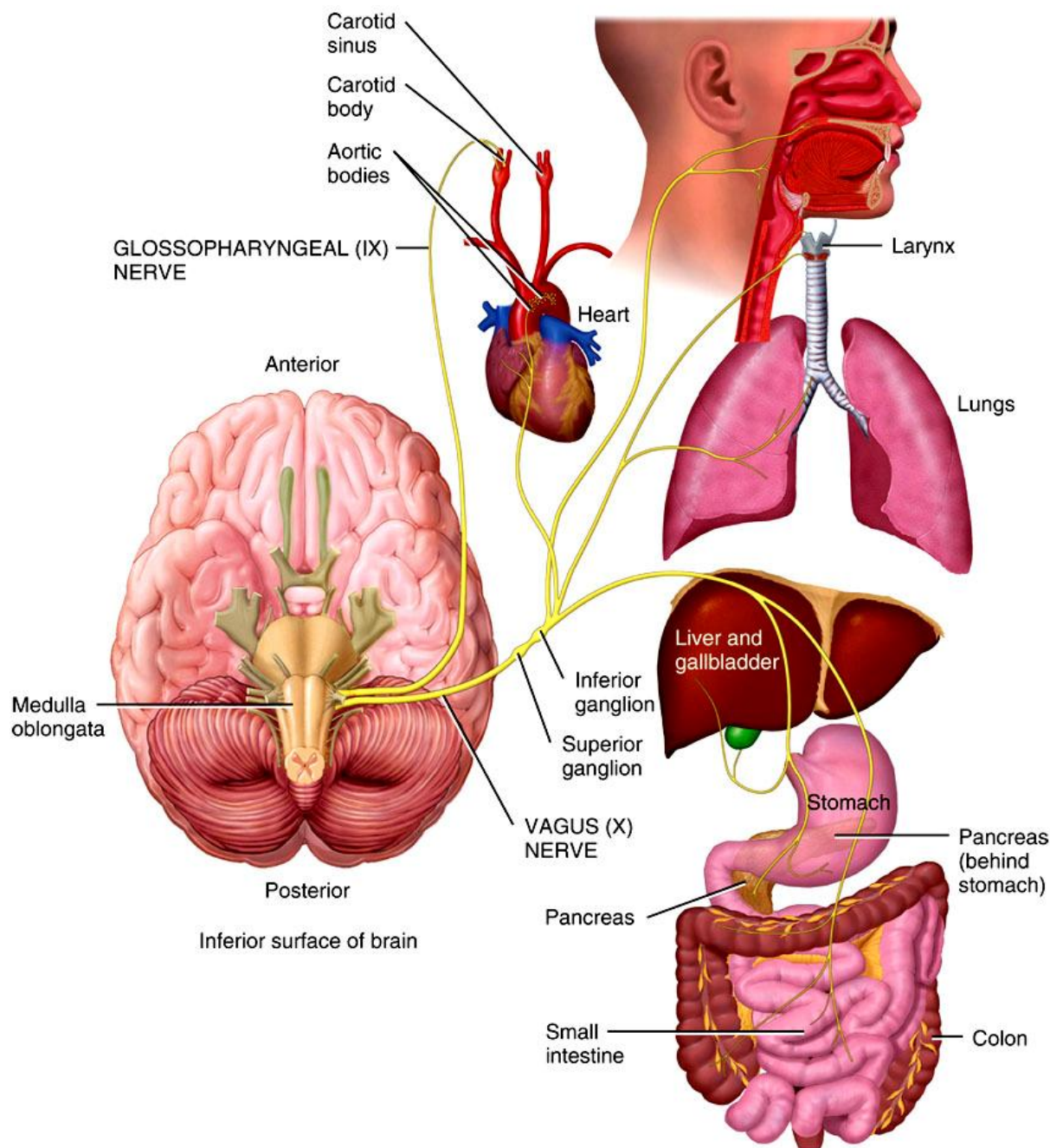
--感覺神經纖維：分佈於咽部、**舌後三分之一的味蕾**

--運動神經纖維：控制咽部的肌肉

--**副交感纖維**：經**耳神經節到耳下腺**

➤ 舌咽神經之作用與味覺、吞嚥運動、唾液分泌及血壓控制有關；頸動脈體 (carotid body) (竇) 亦經舌咽神經將訊息傳導到**呼吸中樞**以控制呼吸作用

迷走神經 (Vagus Nerve): X



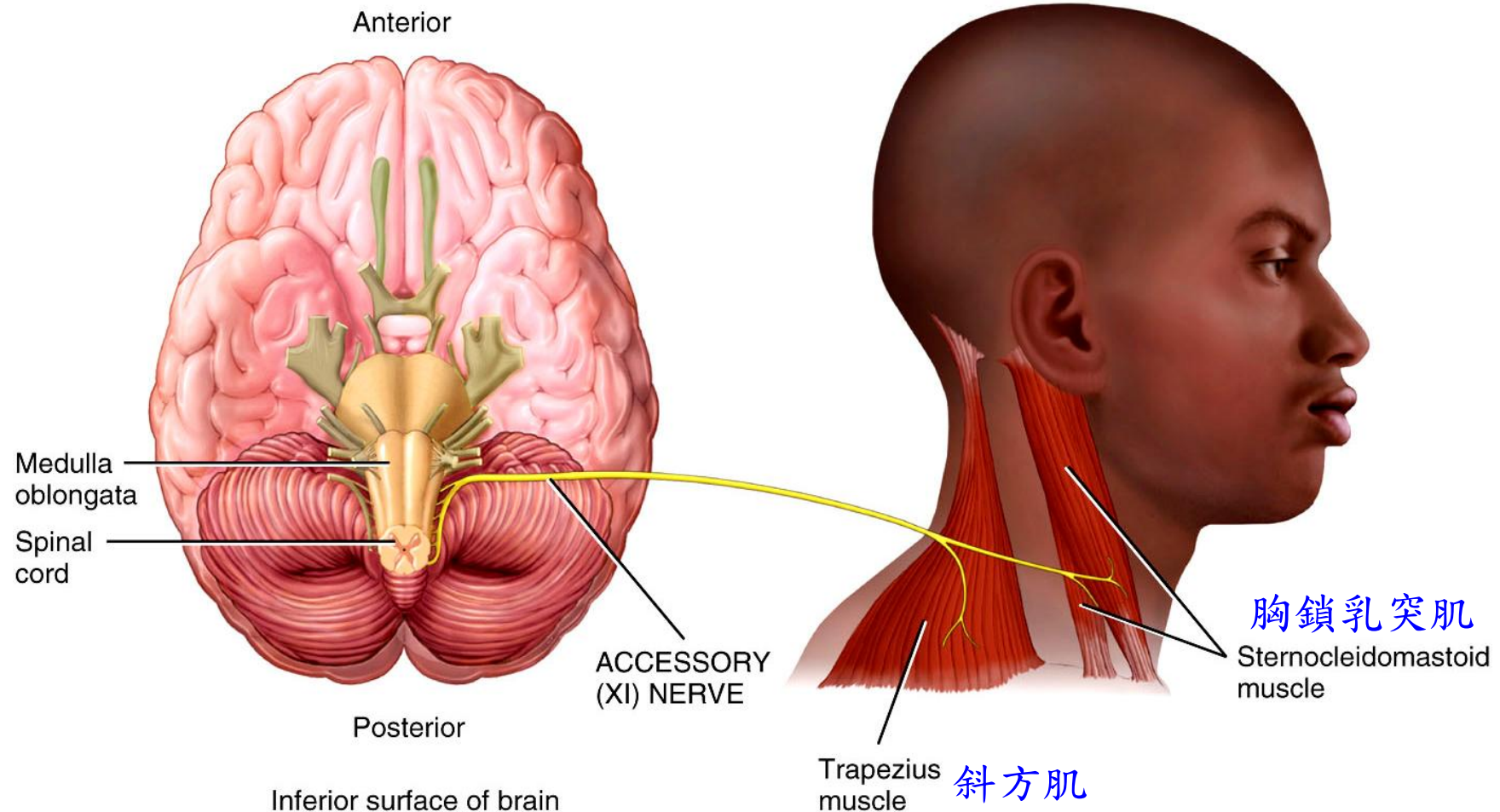
➤ 混合神經，通過頸靜脈孔，它是分佈最廣的腦神經包括頭、頸、胸部及腹部。

--感覺神經纖維：負責會厭味覺、咽、喉頭、主動脈體（竇）及胸腹部內臟感覺。

--運動神經纖維(副交感纖維)：由延腦發出，到達各內臟中之終末神經節後，再換節後纖維而分佈到咽、喉的肌肉，與吞嚥、說話有關。另外一部分則分佈到胸、腹臟器的平滑肌。

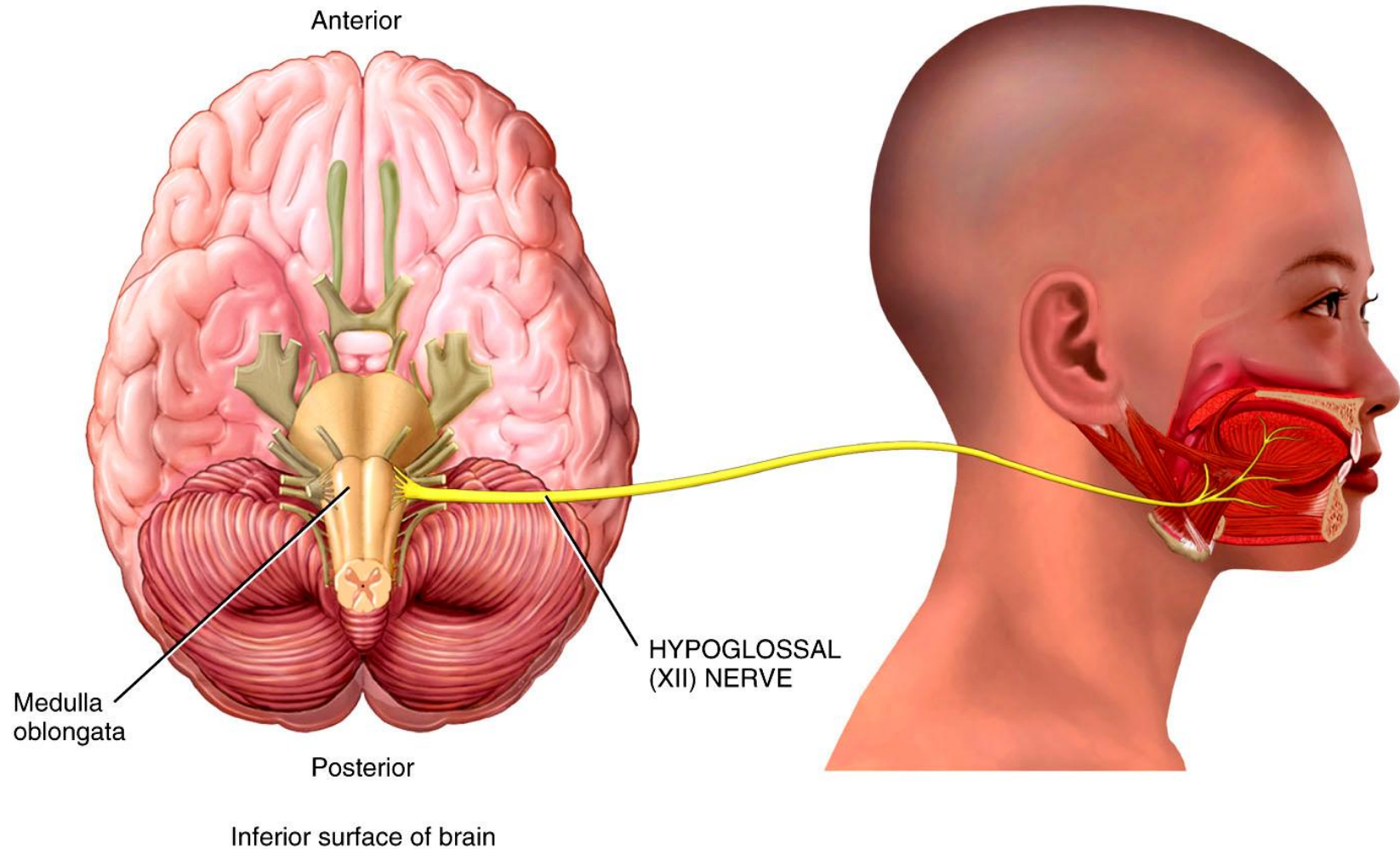
➤ 作用在支配器官的感覺及運動與肌肉收縮，可影響呼吸深淺、腸胃蠕動、胃液分泌及嘔吐作用的傳導。

副神經 (Accessory Nerve): XI



- 混合神經，它有兩個起源：延腦根(cranial roots)和脊髓根(spinal roots)。
 - 延腦根：自延腦發出，通過頸靜脈孔，分佈到咽、喉及軟腭等處的肌肉，與吞嚥及發聲有關。
 - 脊髓根：脊髓根起源自 **脊髓頸部的前五段灰質前角**，分佈到胸鎖乳突肌及斜方肌，它能做頭部轉動和聳肩等動作。

舌下神經 (Hypoglossal Nerve): XII



- 混合神經。
- 運動神經纖維：起源於延腦，通過枕骨大孔外側的舌下神經孔，分佈到舌頭的肌肉，與說話及吞嚥有關；舌下神經受傷，會造成舌頭運動障礙，但不影響味覺。

表 2-6 12 對腦神經之重要概念整理

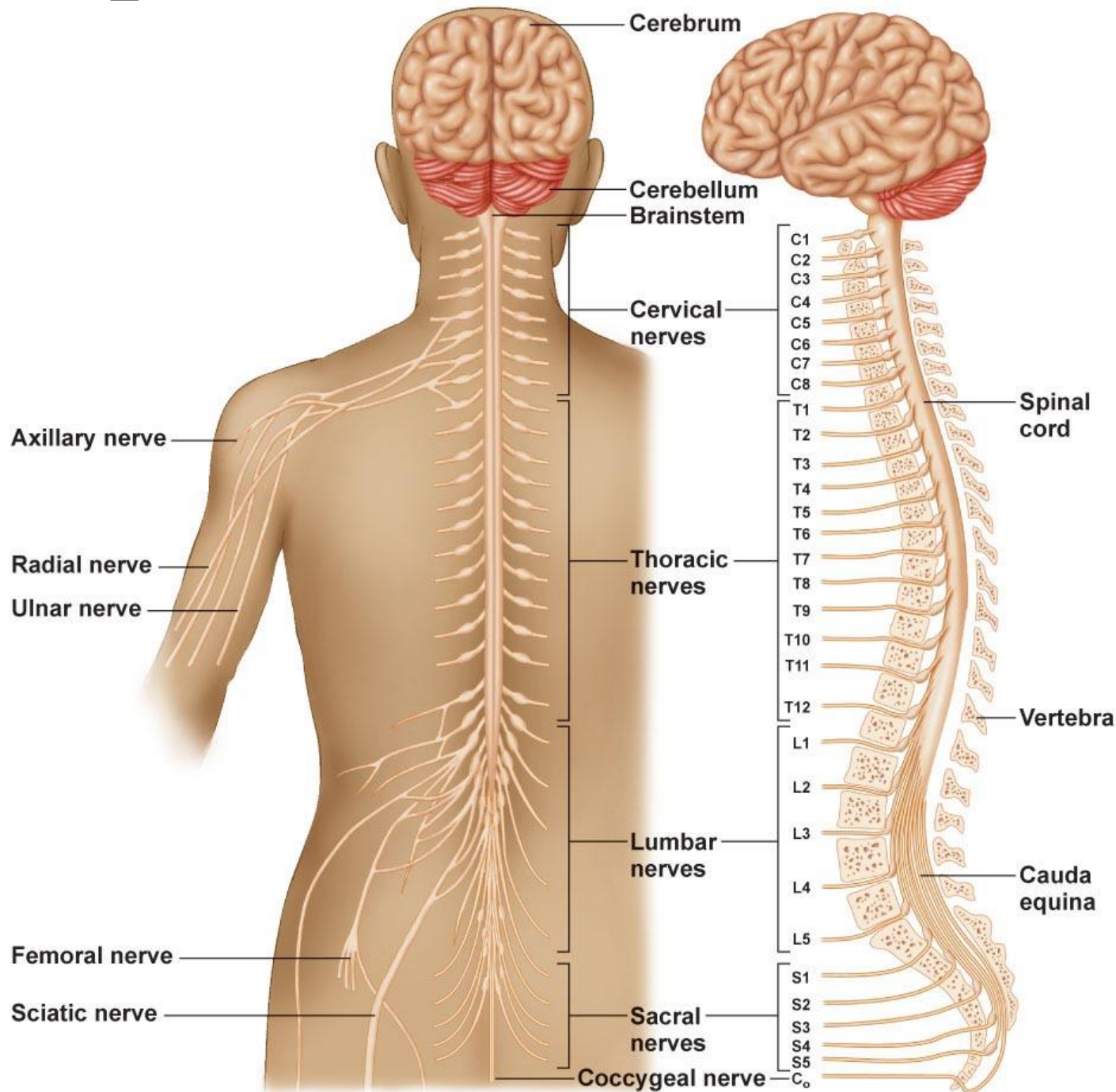
特 性	腦 神 經
最粗大的腦神經	三叉神經(V)
最小的腦神經	滑車神經(IV)
分佈最廣的腦神經	迷走神經(X)
爬行最遠的腦神經	外展神經(VI)
純感覺神經	嗅神經(I)、視神經(II)、前庭耳蝸神經(VIII)
含副交感神經	動眼神經(III)、顏面神經(VII)、舌咽神經(IX)、迷走神經(X)
控制唾液分泌	顏面神經(VII)、舌咽神經(IX)
控制眼球轉動	動眼神經(III)、滑車神經(IV)、外展神經(VI)
控制味覺	顏面神經(VII)、舌咽神經(IX)、迷走神經(X)
控制舌頭一般感覺	三叉神經(V)、舌咽神經(IX)
控制舌頭運動	舌下神經(XII)
控制臉部感覺	三叉神經(V)

➤ 第3、4、6、11、12對腦神經是運動神經，並具有本體感神經纖維；而第5、7、9、10對腦神經則為混合神經

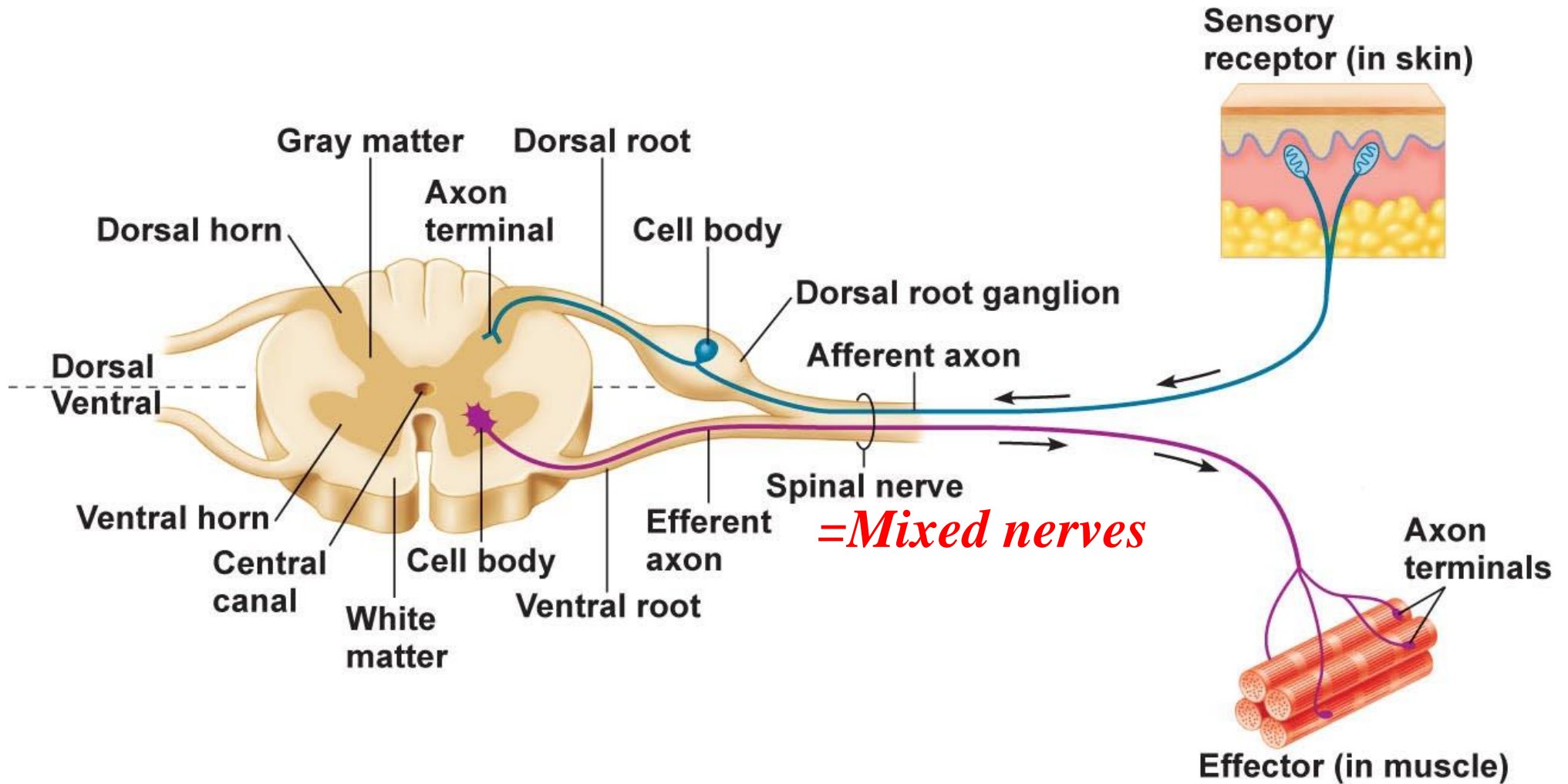
Spinal Nerves

- Part of the **PNS**
- Nerves that arise directly from the spinal cord
- **31 pairs:** 8 cervical, 12 thoracic, 5 lumbar, 5 sacral, 1 coccygeal
- All are mixed nerves that separate near the spinal cord into a dorsal root carrying sensory fibers and a ventral root carrying motor fibers
 - The dorsal root ganglion houses the sensory neuron cell bodies

Spinal Nerves: 31 Pairs

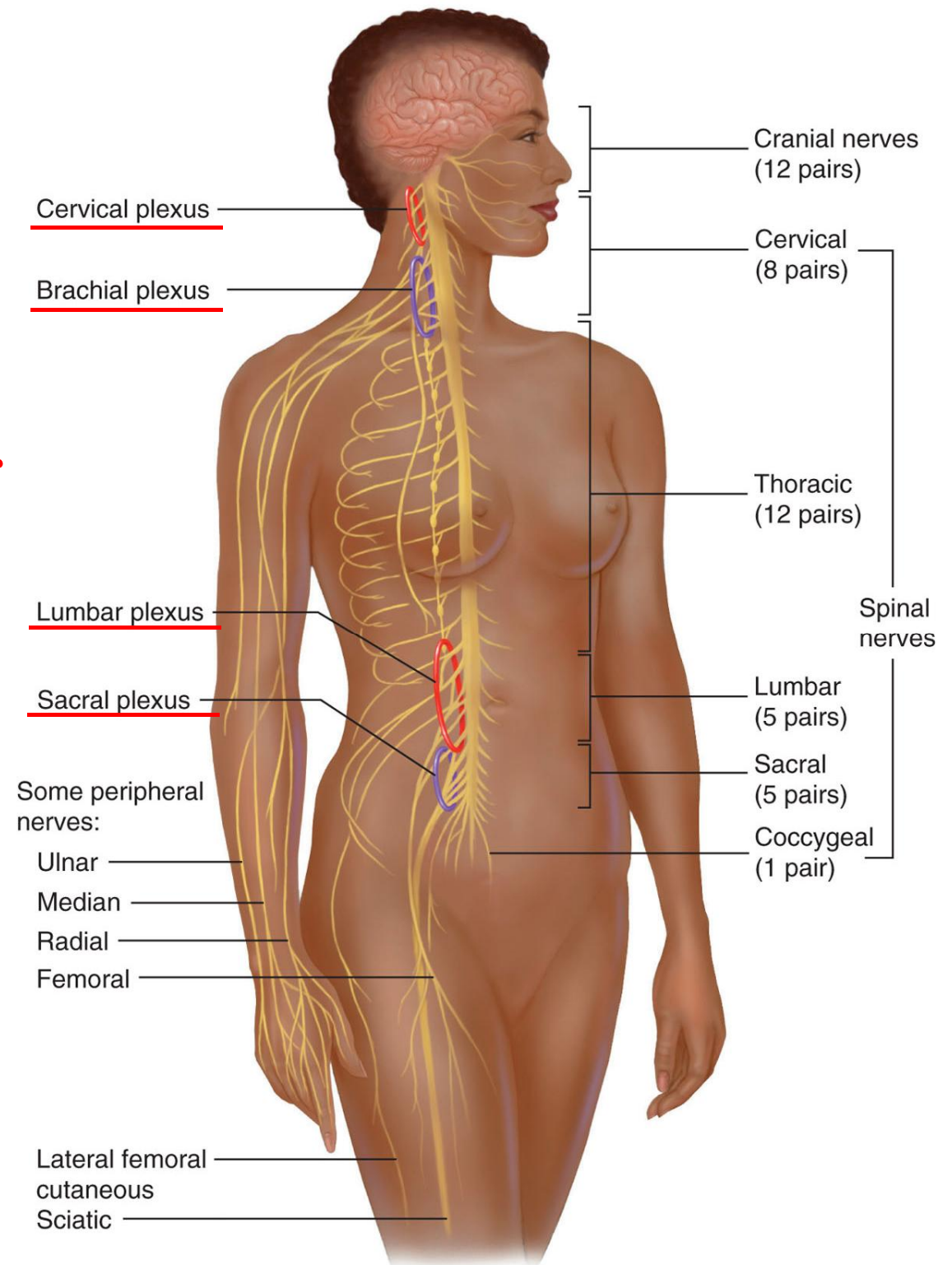


Spinal Nerves



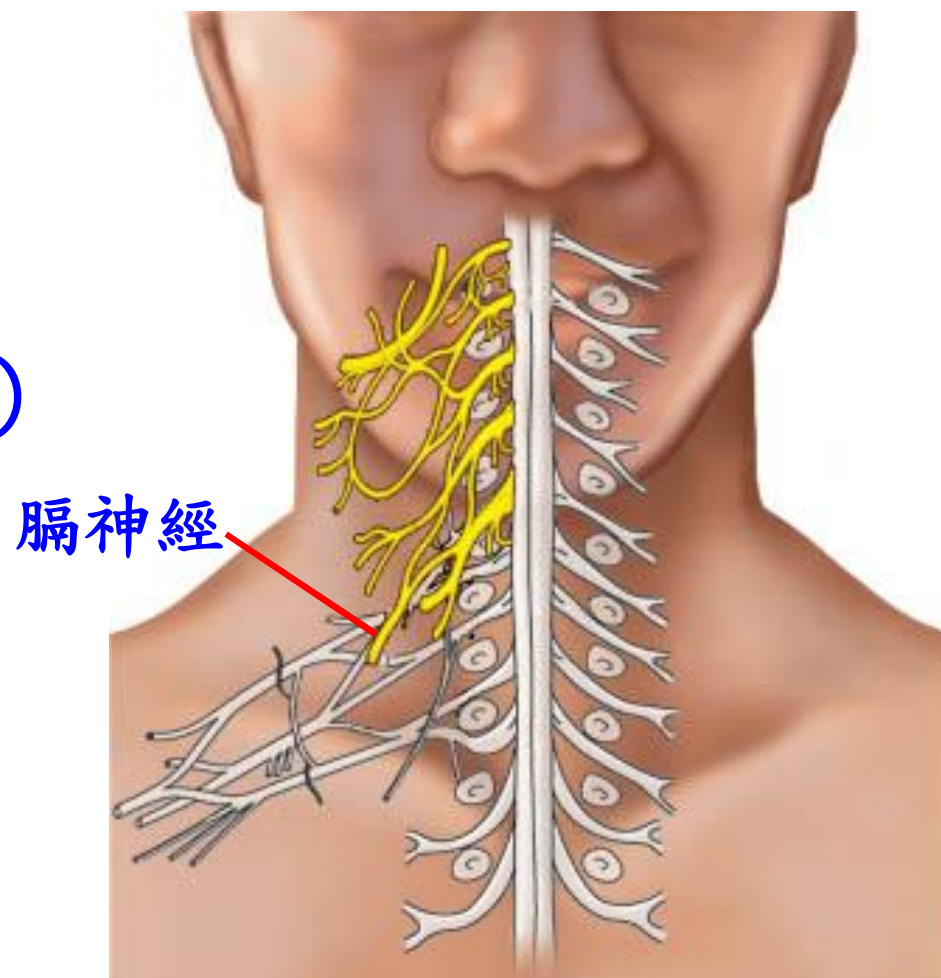
Nerve Plexus

- Joining of ventral rami (branches) of spinal nerves to form **nerve networks or plexuses**
- Found in neck, arm, low back & sacral regions
- No plexus in thoracic region (**T₂-T₁₁, S₅-C₀₁**)
 - T₇ to T₁₂ supply abdominal wall as well



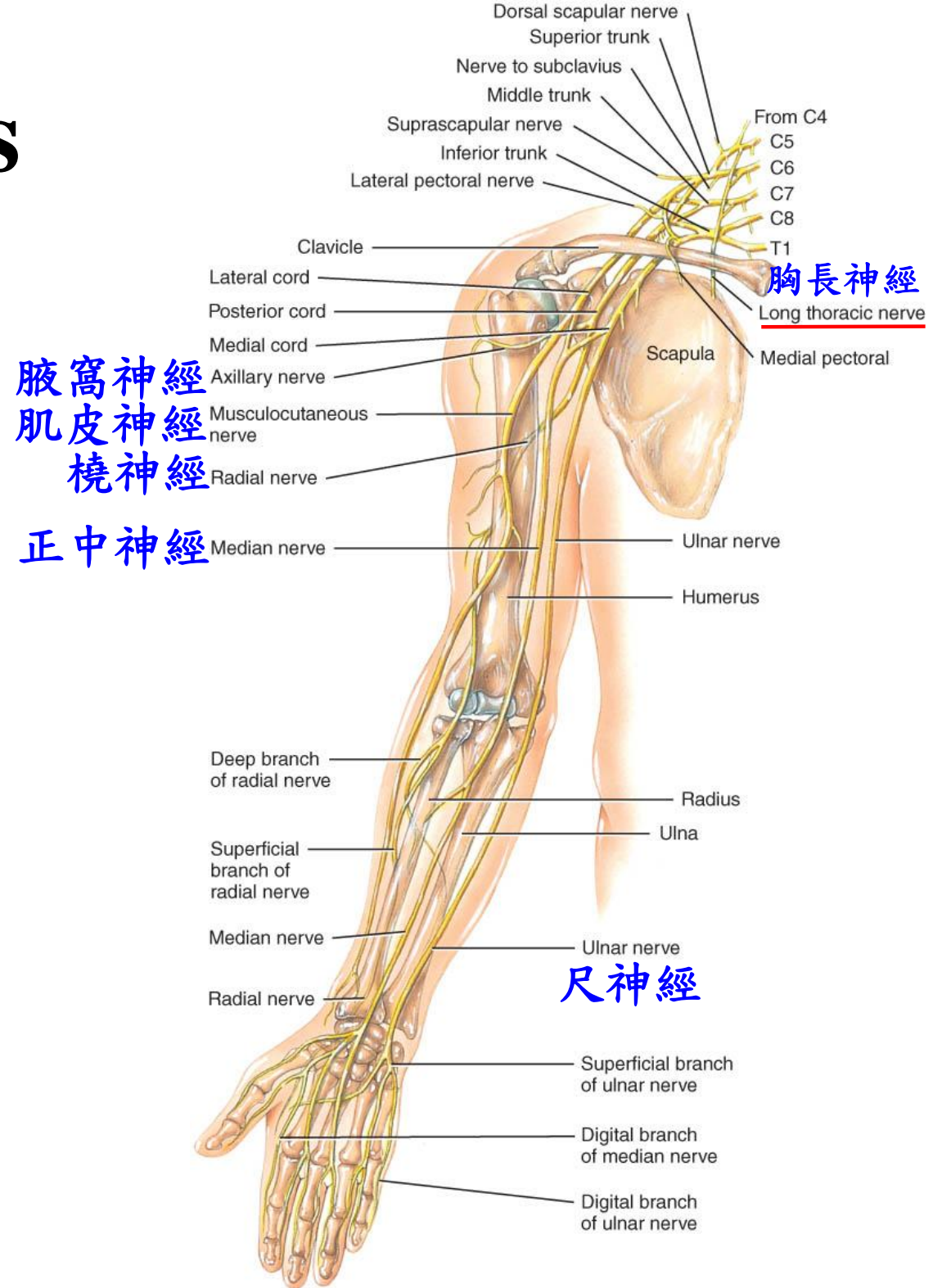
Cervical Plexus

- Ventral rami of spinal nerves (**C1 to C5**)
- Supplies parts of head, neck & shoulders (肩上部)
- **Phrenic nerve (C3-C5)** keeps diaphragm alive
- Damage to cord above C3 causes respiratory arrest

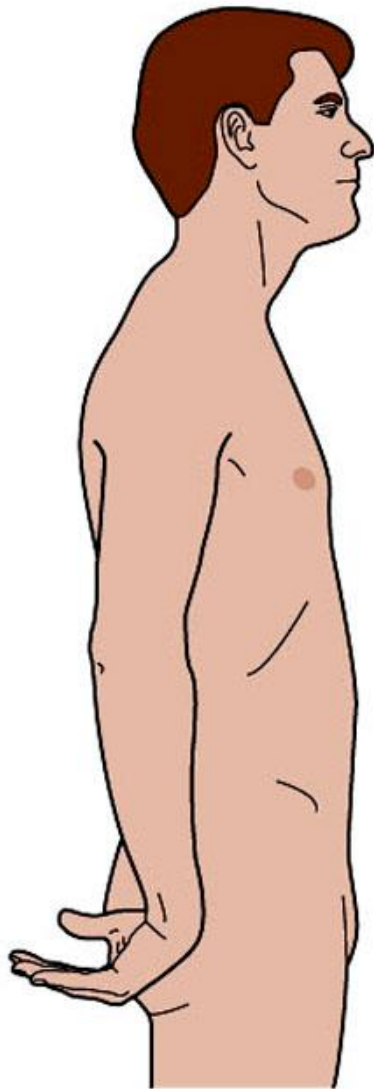


Brachial Plexus

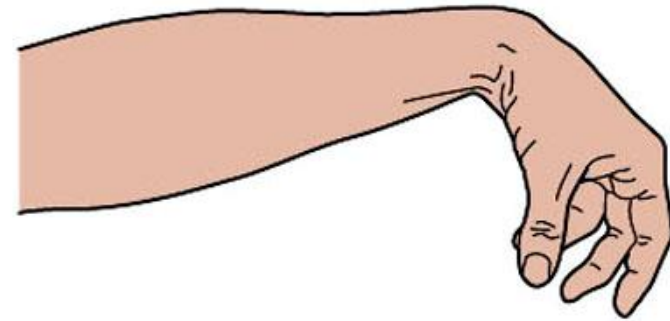
- Ventral rami from **C5-C8** and **T1**
- Supplies shoulder (肩下部) & upper limb
- Passes superior to 1st rib & under clavicle
- **Axillary n.** = deltoid & teres m.
- **Musculocutaneous n.** = elbow flexors (上臂前側)
- **Radial n.** = shoulder & elbow extensors (肘反射)
- **Median & ulnar nn.** = flexors of wrist & hand (前臂前側)



Injuries to the Brachial Plexus



(a) Erb-Duchenne palsy
(waiter's tip)



垂腕

(b) Wrist drop

➤ *Inability to extend the wrist and fingers*

➤ *Loss of sensation along the lateral side of the arm*

Injuries to the Brachial Plexus

猿手



(c) Median nerve palsy

爪型手



(d) Ulnar nerve palsy

翼狀肩

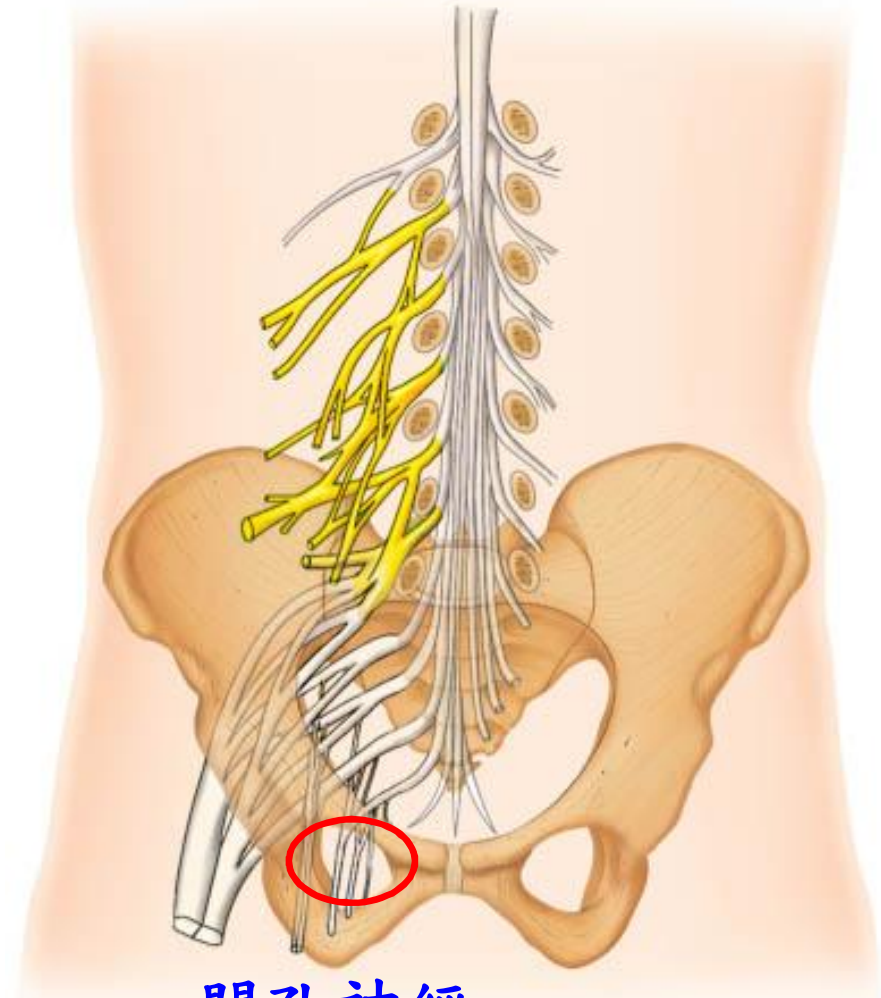


(e) Winging of right scapula

- **Median nerve palsy**- numbness, tingling and pain in the palm and fingers
- **Ulnar nerve palsy**- inability to abduct or adduct fingers
- **Long thoracic nerve injury (Winged scapula)**- the arm cannot be abducted beyond the horizontal position

Lumbar Plexus

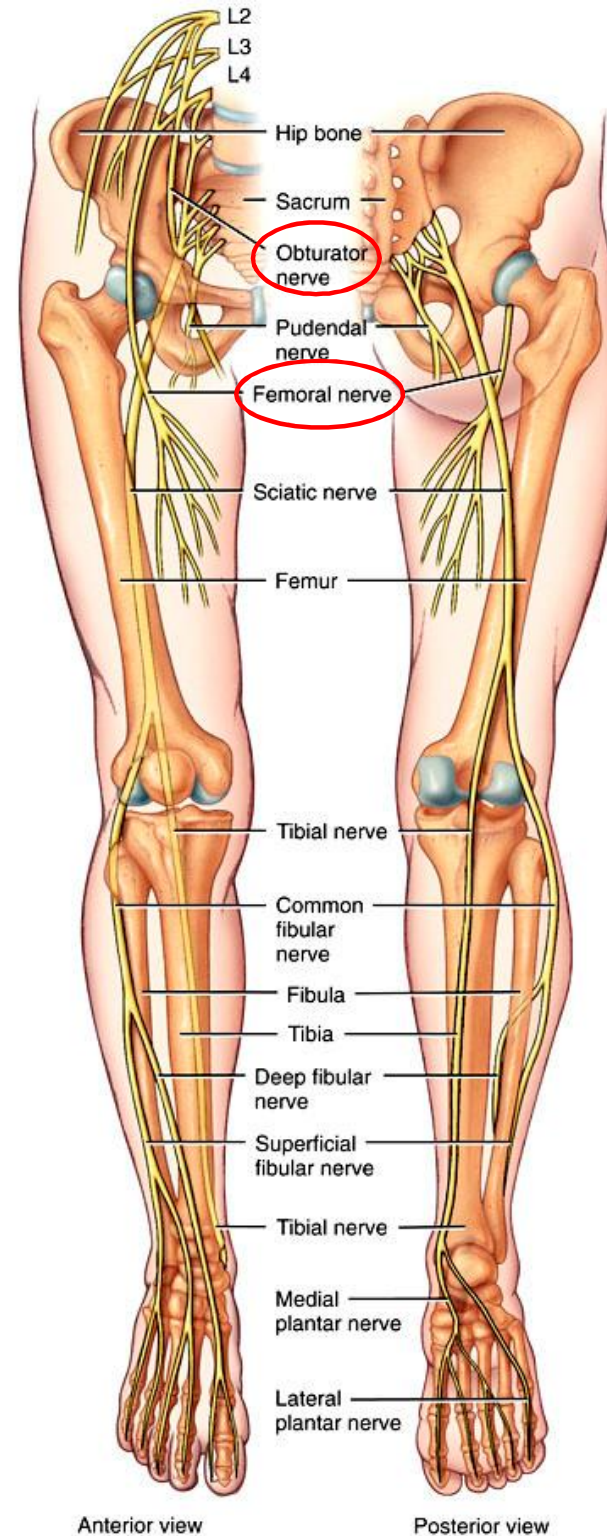
- Ventral rami of **L1 to L4**
- Supplies abdominal wall, external genitals & anterior/medial thigh
- The largest nerve arising from the lumbar plexus is the **femoral nerve** (膝反射的感覺神經纖維)
- Injury to **femoral nerve** causes inability to extend leg & loss of sensation in thigh
- Injury to **obturator nerve** (a common complication of childbirth) causes paralysis of thigh adductors (大腿內側肌)



閉孔神經

Lumbar Plexus

- The *lumbar plexus* supplies the anterolateral abdominal wall, external genitals, and part of the lower extremities

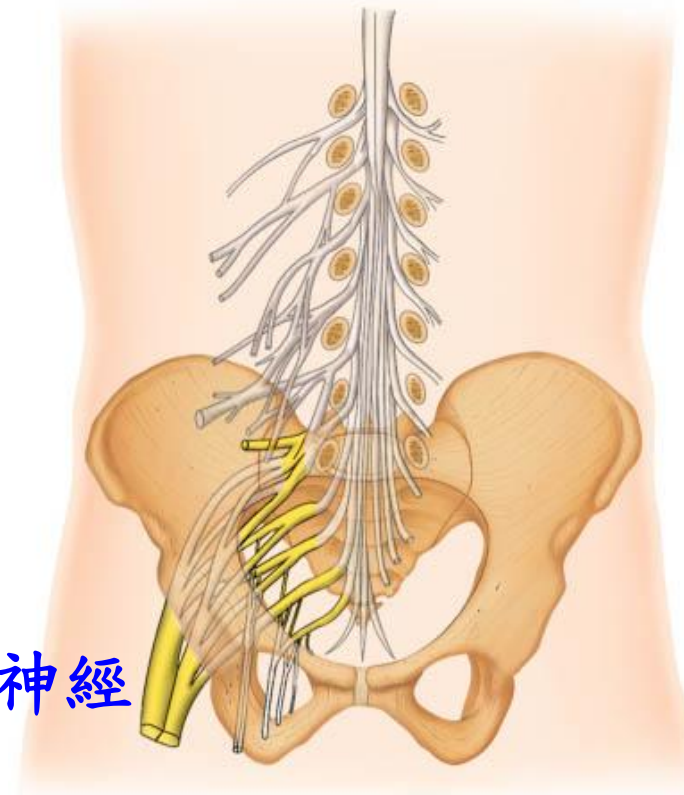


閉孔神經

股神經

Sacral Plexus

- Ventral rami of **L4-L5 & S1-S4**
- Anterior to the sacrum
- Supplies buttocks, perineum & part of lower limb
- **Sciatic nerve = L4 to S3**
supplies post thigh & all below knee
 - Peroneal nerve** (腓神經)
injury produces foot drop or numbness
 - Tibial nerve** (脛神經) injury
produces calcaneovalgus (loss of function on anterior leg & dorsum of foot)



坐骨神經

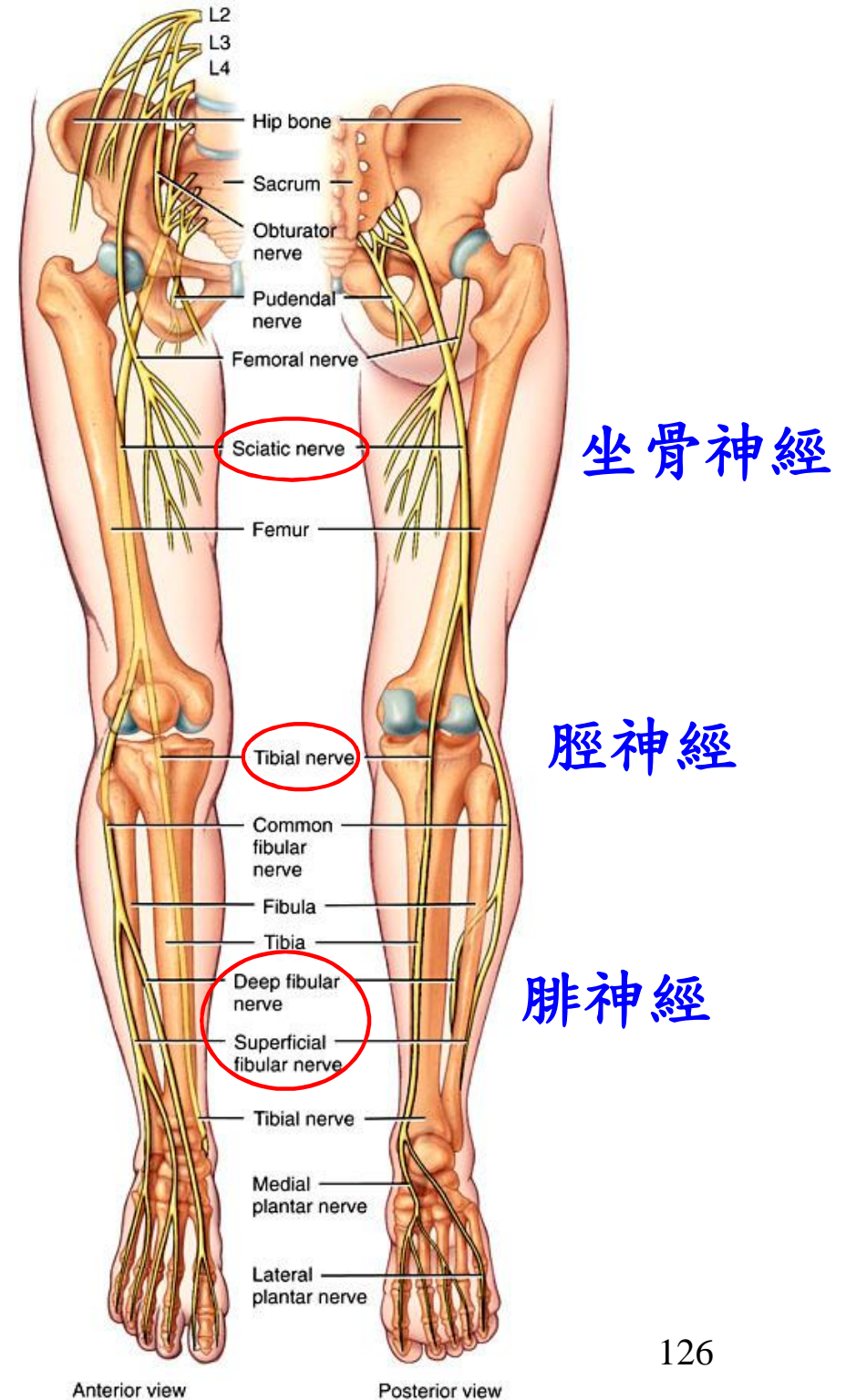
跟骨與脛骨外翻畸形
(仰趾外翻足)

Foot with
calcaneovalgus



Sacral Plexus

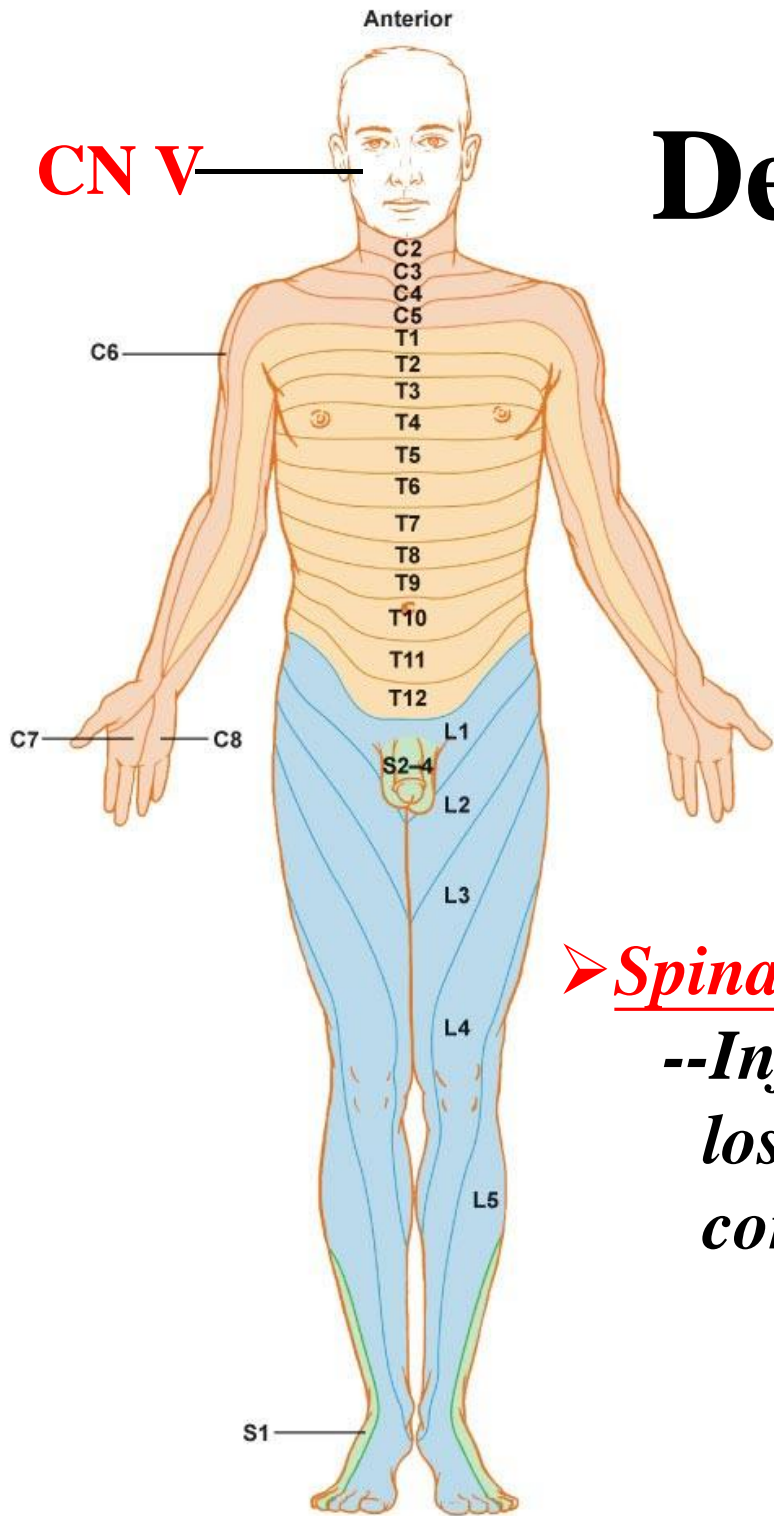
- The largest nerve arising from the sacral plexus (and the largest nerve in the body) is the **sciatic nerve**
- Injury to the sciatic nerve (common peroneal portion) and its branches results in **sciatica**, pain that extends from the buttock down the back of the leg
- Sciatic nerve injury can occur due to a herniated (slipped) disc, dislocated hip, osteoarthritis of the lumbosacral spine, pressure from the uterus during pregnancy, or an improperly administered gluteal injection



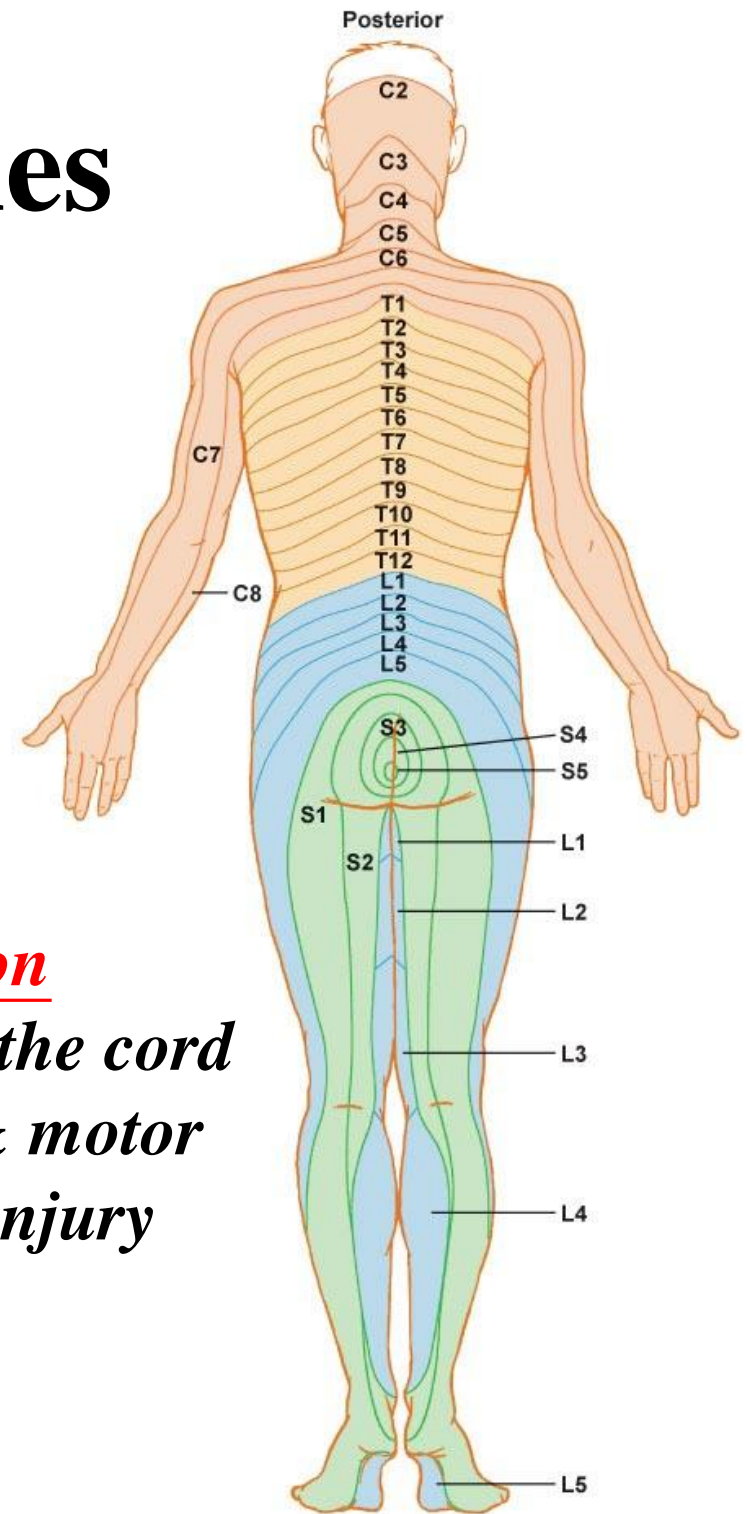
(b) Distribution of nerves from the lumbar and sacral plexuses

Dermatomes

- Area of the skin that provides sensory input to the CNS via one pair of spinal nerves or the trigeminal nerve (CN V)
 - All spinal nerves except **C1** innervate specific, constant segments of the skin; the skin segments are called *dermatomes*
 - Skin on face** supplied by **Cranial Nerve V**
 - Knowledge of dermatomes helps a physician to determine which segment of the spinal cord or which spinal nerve is malfunctioning



Dermatomes



➤ Spinal cord transection

*--Injury that severs the cord
loss of sensation & motor
control below the injury*

Clinical Application:

Neuritis

- **Neuritis** (polyneuritis): inflammation of nerves
- **The main symptoms of neuritis are** tingling, burning, and stabbing pains in the affected nerves
- In severe cases, there may be numbness and loss of sensation and paralysis of the nearby muscles
- Caused by **chronic acidosis**, injury, **vitamin B deficiency** (B₁₂, B₆, B₁, pantothenic acid and B₂), poison (general toxaemia)

