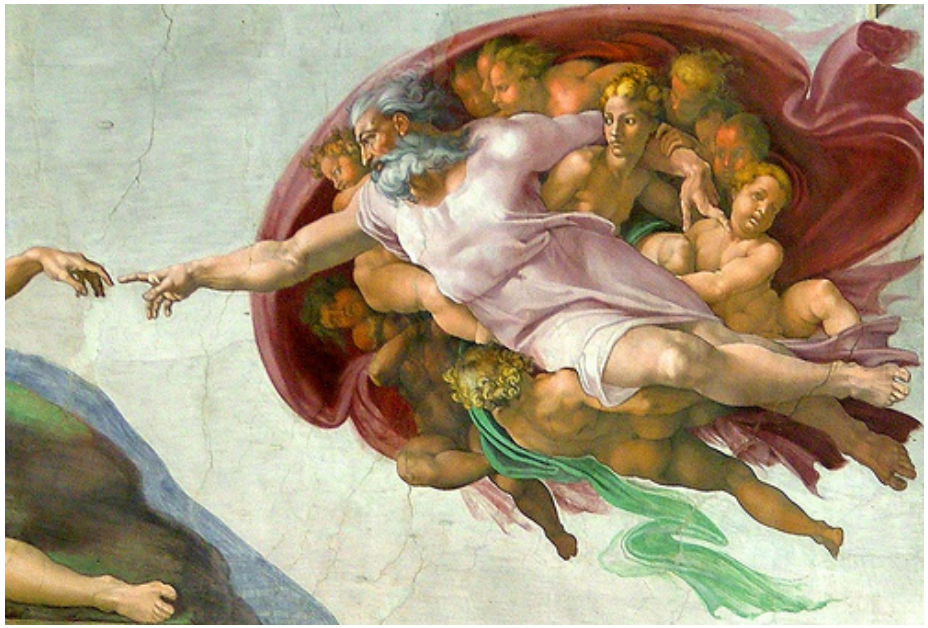
成功大學心智影像研究中心
"功能性磁振造影工作坊"

神經系統簡介

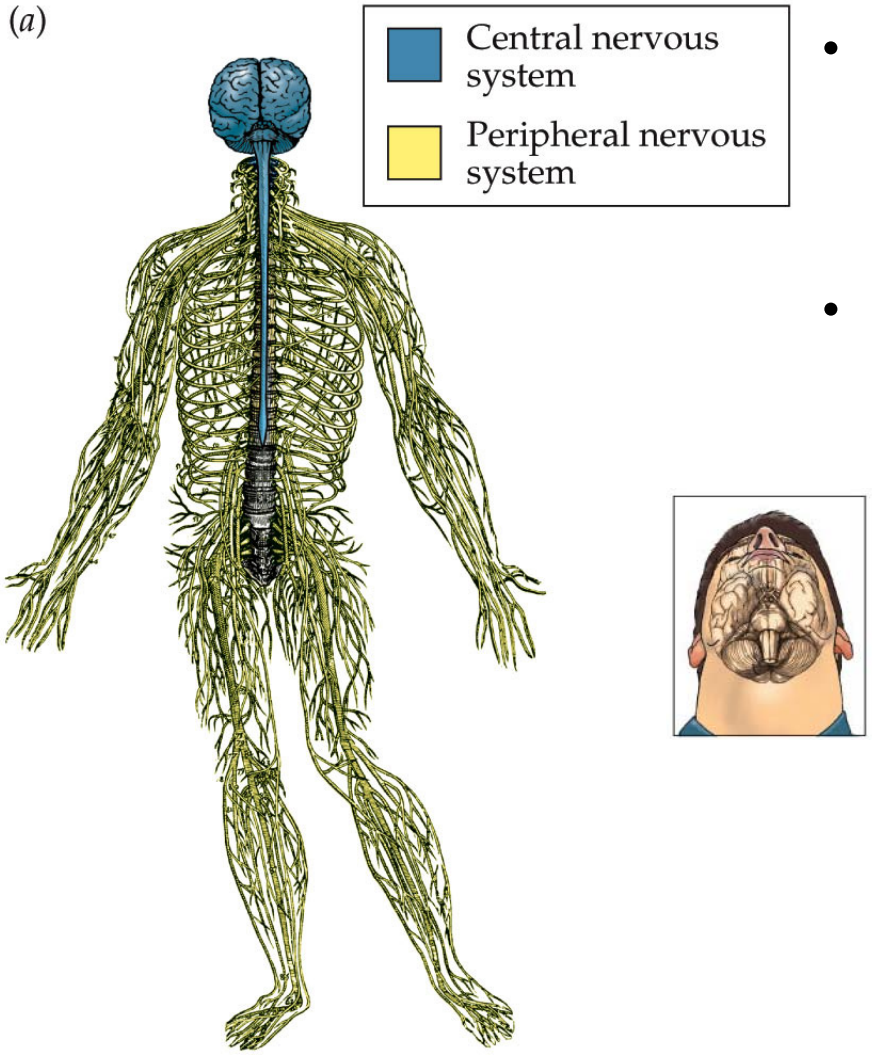
國立台灣大學心理學系　　助理教授 葉俊毅

Outline

- 神經元 Neuron
  - 神經結構
  - 神經電生理
  - 神經突觸
- 大腦 Brain
  - 大腦結構
  - 大腦皮質
  - 大腦皮質區功能
- 心智與腦 Mind and Brain

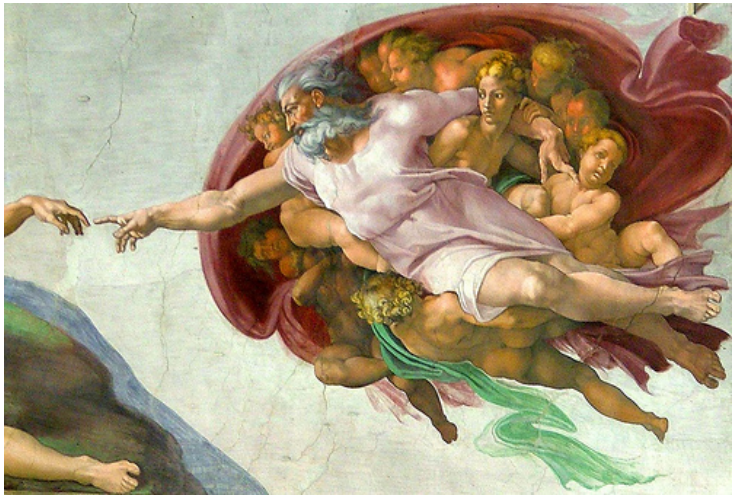


神經系統

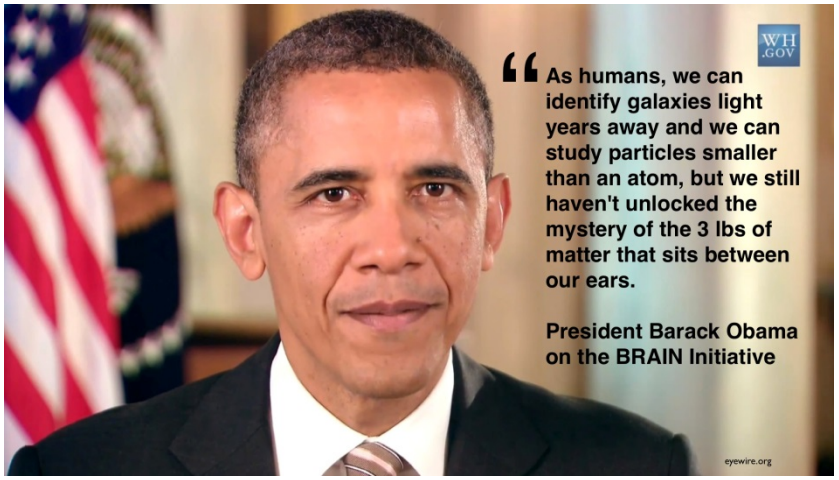


- **中樞神經系統** (Central Nervous System)
  - **腦(brain)**
  - 脊髓(spinal cord)
- **周圍神經系統** (Peripheral Nervous System)
  - 體神經 (somatic nerves):
    - 負責感知與運動
    - 腦神經(cranial nerves)：12對
    - 脊神經(spinal nerves)：31對
  - 自主神經(autonomic nerves):
    - 負責生理平衡的調節
    - 交感神經(sympathetic nerves)
    - 副交感神經(parasymapthetic nerves)
    - 腹內神經(enteric nerves)

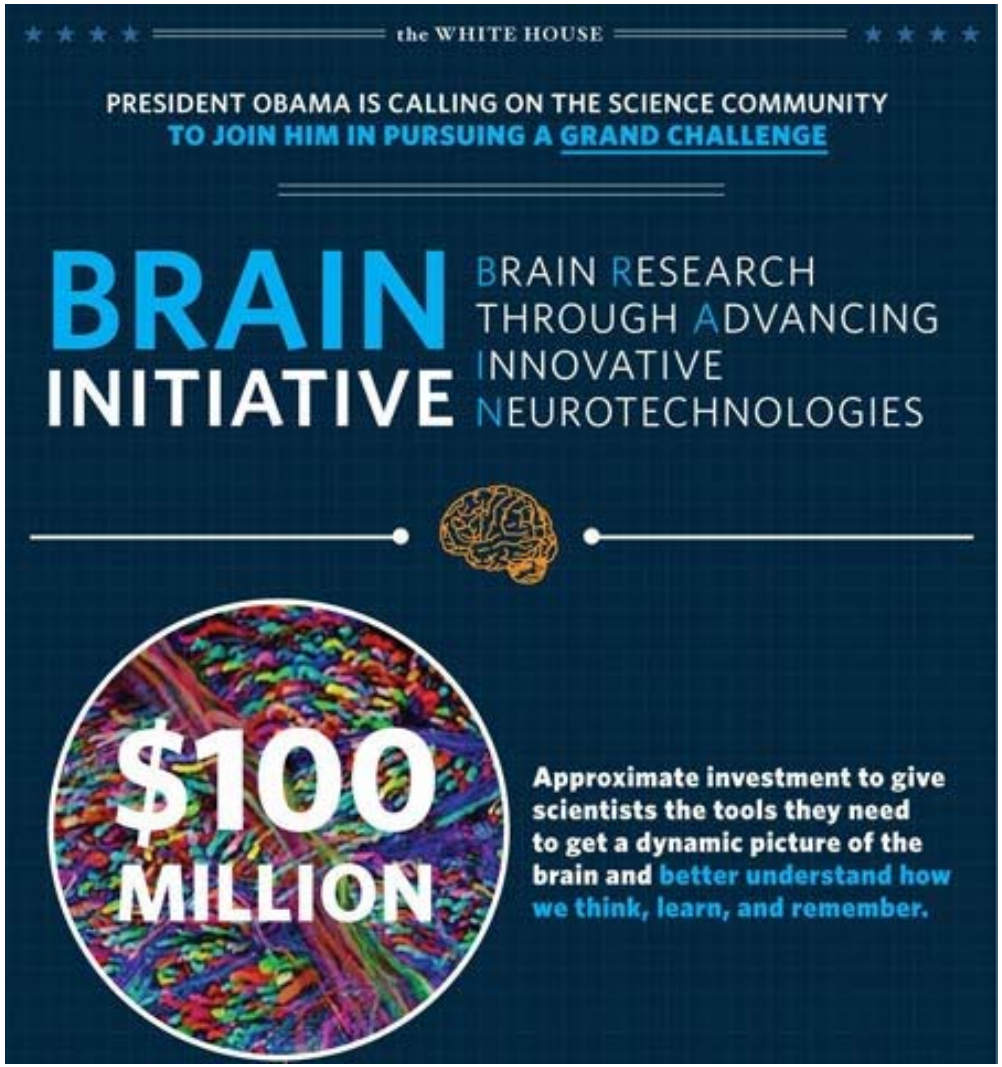
大腦負責...



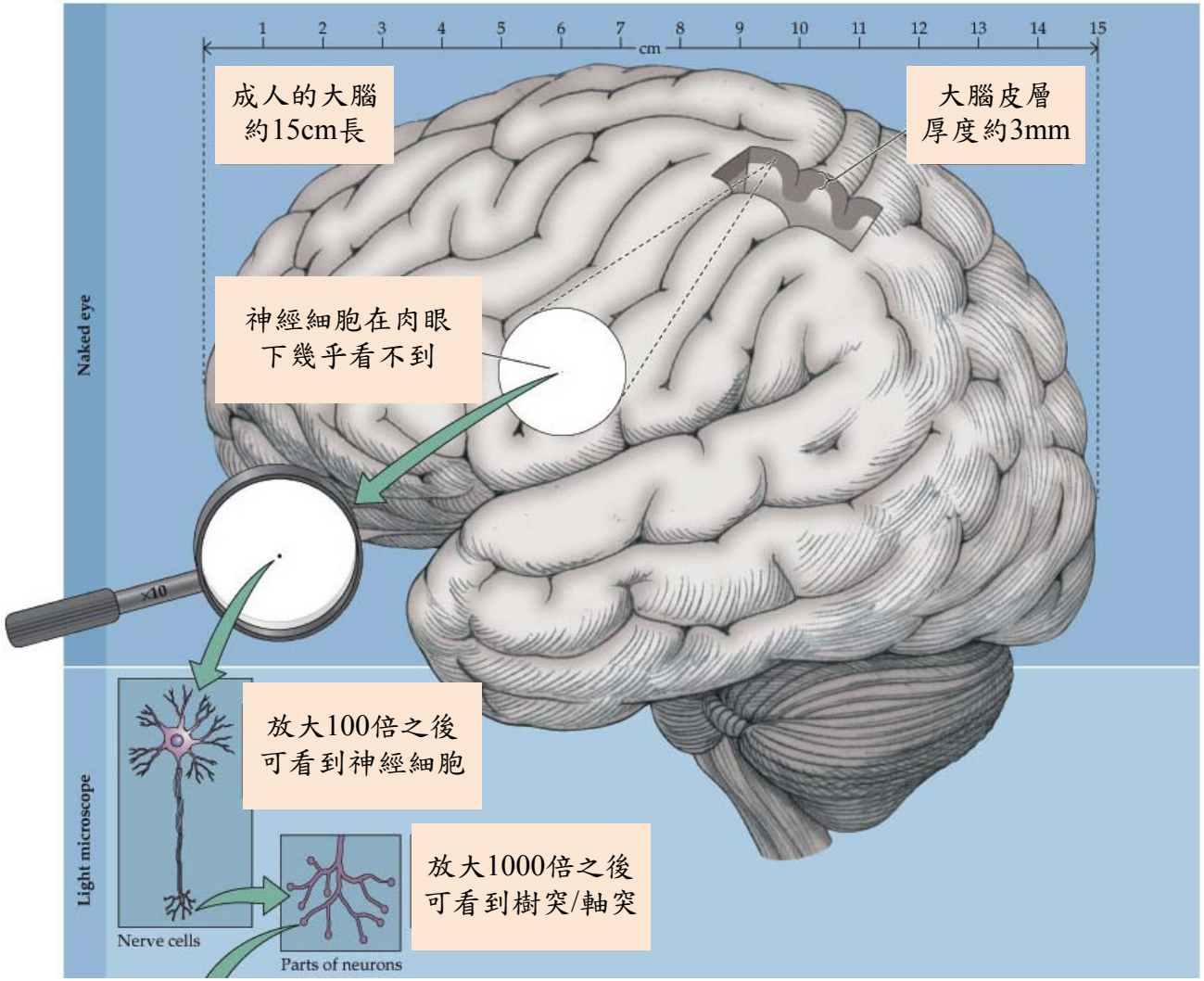
大腦負責…



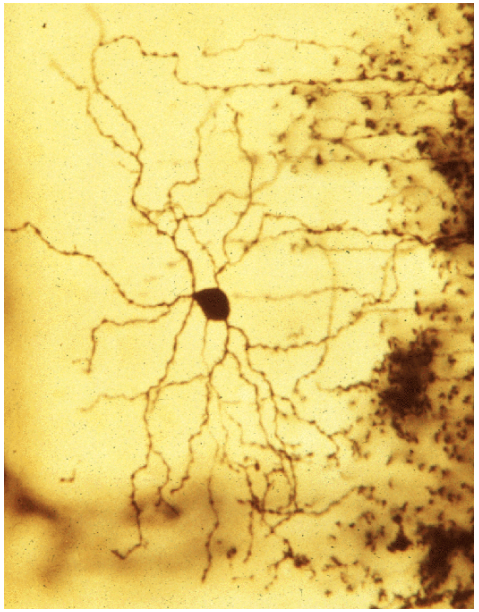
“As Humans, we can identify galaxies light years away and we can study particles smaller than an atom, but we still haven’t unlocked the mystery of the 3 lbs of matter that sits between our ears.”

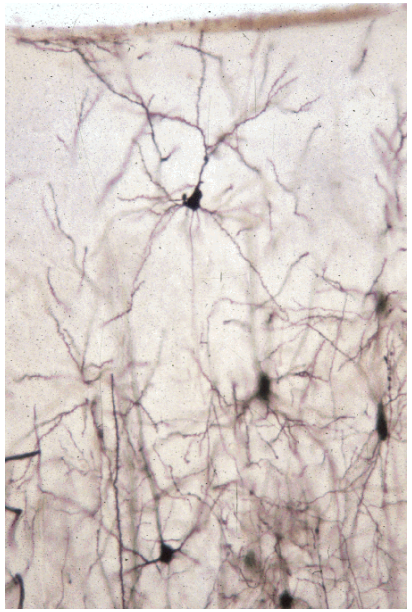


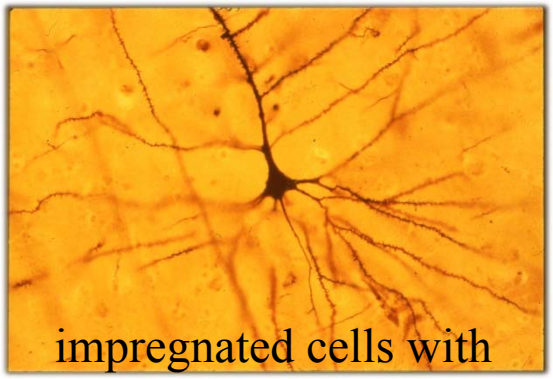
大腦: 由神經細胞與神經膠細胞所組成的



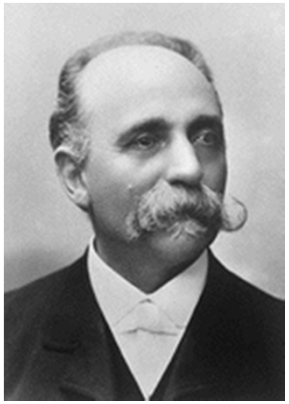
- 神經元 (Neurons): 具有接收、整合與輸出訊息功能。人腦有$10^{11\sim12}$個神經元。
- 神經膠細胞 (Glial cells): 負責清理、營養、修補等支援神經細胞的運作。
- Glial cells outnumber Neurons 10:1



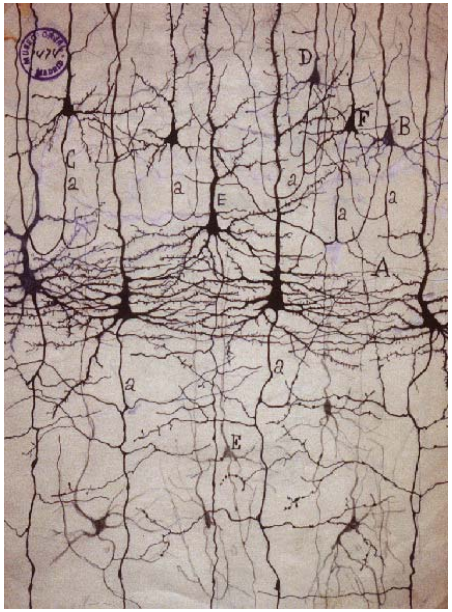




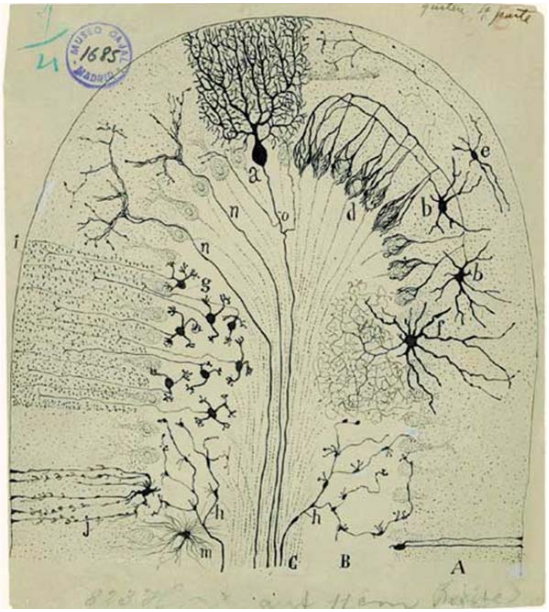
impregnated cells with silver nitrate and then reacted to turn black



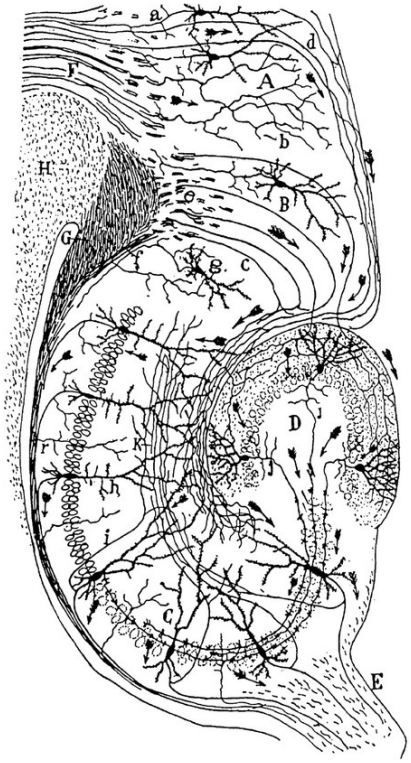
Camillo Golgi



- Pyramidal Cells



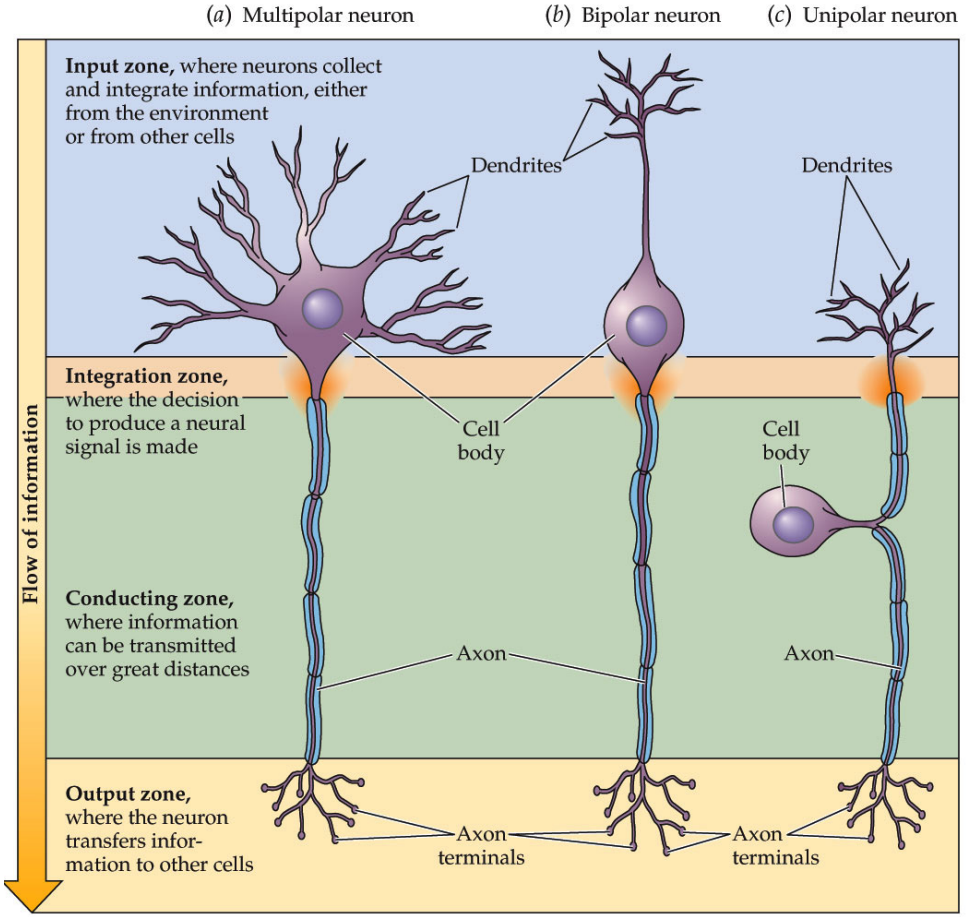
Cerebellum



Rodent hippocampus

Santiago Ramon Y Cajal

神經細胞的分類



大腦皮質
椎狀細胞

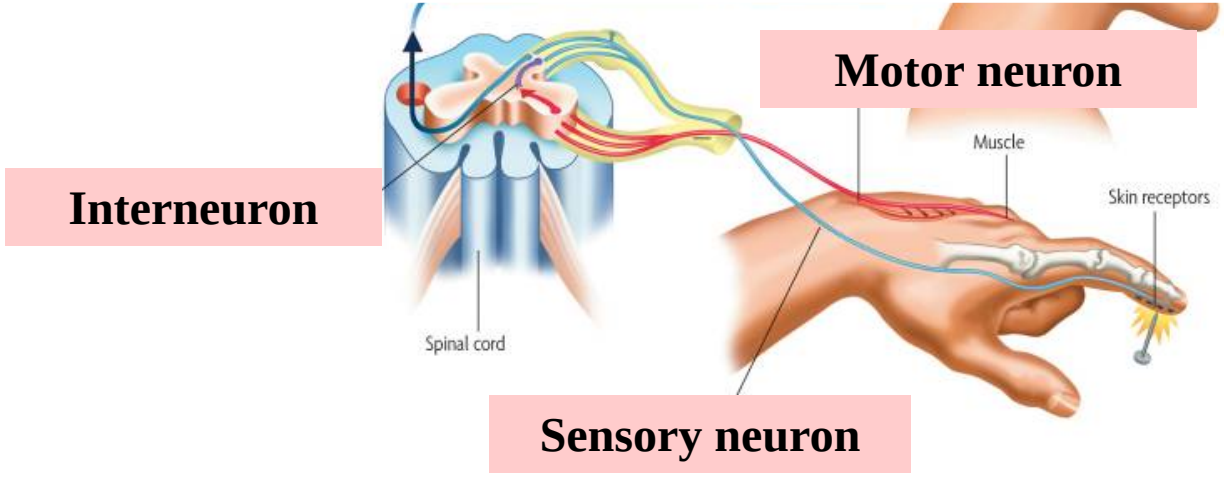
視網膜
雙極細胞

脊隨
體感細胞

- 神經元有兩百種以上的型態，可根據其結構(structure)、功能(function)及大小(size)做分類。
- Structures: **unipolar, bipolar, multipolar**…
- Functions: **sensory, motor or inter-neurons**; can be **excitatory or inhibitory**.
- Each neuron makes 100 – 10,000 connections.

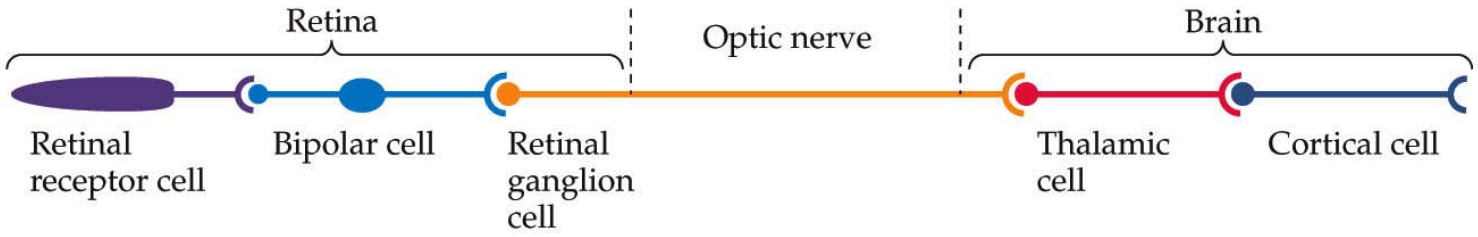
神經細胞的分類

- 感覺神經元 (Sensory neuron): 將周邊感覺接受器所接收到的訊息網中樞神經系統(CNS)傳遞。
- 運動神經元 (Motor neuron): 將中樞神經系統訊息從肌肉及內分泌腺體傳遞。
- 中介神經元 (Interneuron): 將感覺神經元訊息傳遞至運動神經元或其他中介神經元。
- 神經網絡 (Neural circuit): A set of neurons that affect one another.

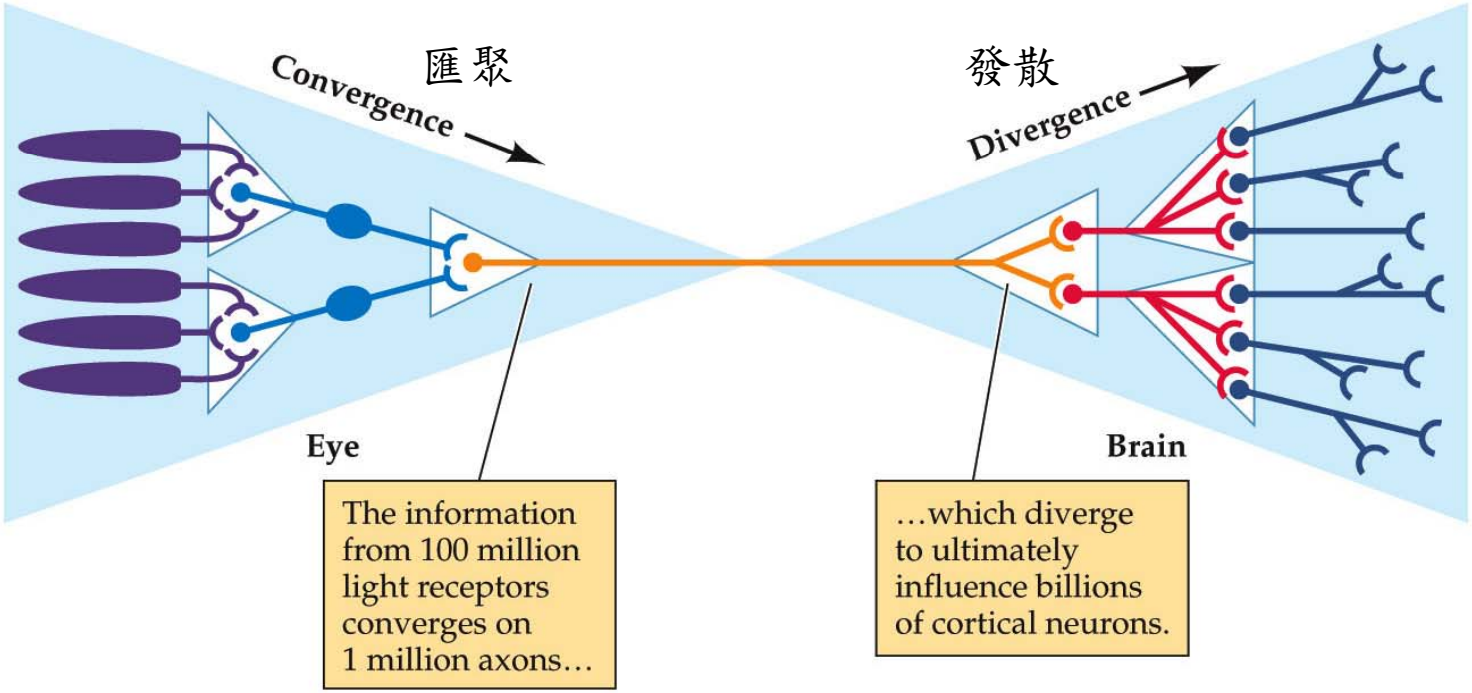


神經迴路 (neural circuit) – 視覺系統

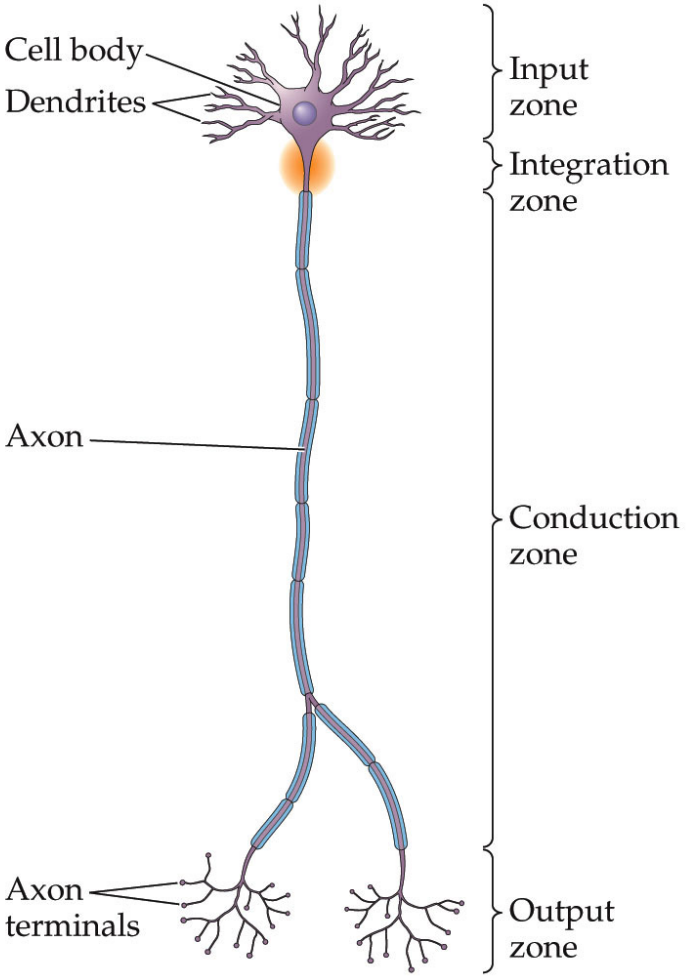
(*a*) The visual system represented as a neural chain



(*b*) A more realistic representation, showing convergence and divergence



神經細胞的主要結構



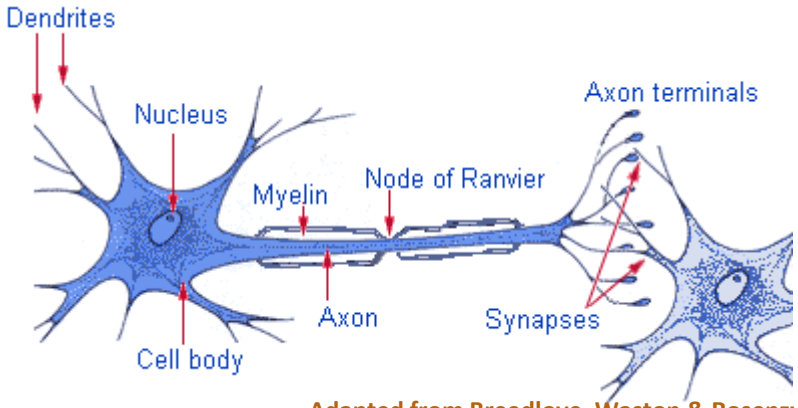
- 樹突(dendrites)：receiving information from other neurons.
- 細胞體(soma): receiving and combining inputs from other neurons.
  - 粒線體 (mitochondria): produce energy.
  - 細胞核 (nucleus): contains genetic instructions.
  - 核醣體 (ribosomes): translate genetic instructions into proteins.
- 軸突(axon)：transmitting the cell's electrical impulse away from the soma.
- 軸突末端(axon terminals)：communicating the cell's activity to other cells at **synapses**.

神經細胞的主要結構: dendrites and axon

- Distinctions between dendrites (樹突) and axon (軸突)

TABLE 2.1 Distinctions between Axons and Dendrites

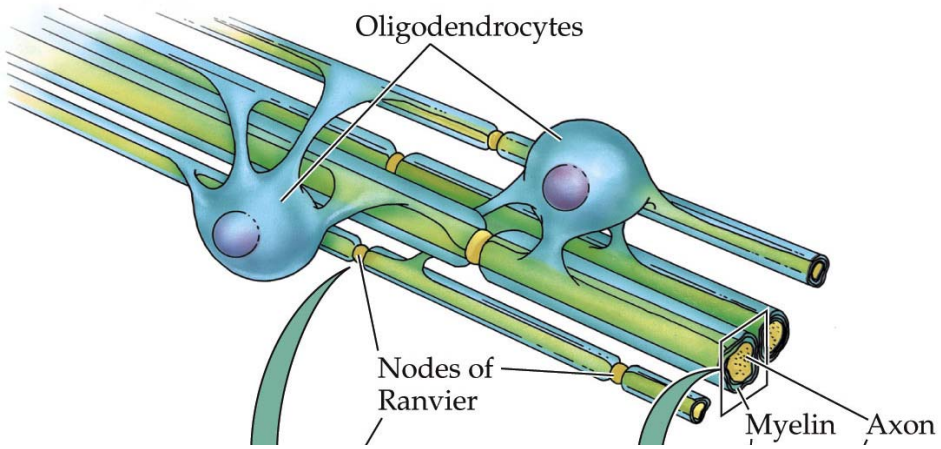
Property	Axons	Dendrites
Number	Usually one per neuron, with many terminal branches	Usually many per neuron
Diameter	Uniform until start of terminal branching	Tapering progressively toward ending
Axon hillock	Present	No hillock-like region
Sheathing	Usually covered with myelin	No myelin sheath
Length	Ranging from practically non-existent to several meters long	Usually much shorter than axons



Adapted from Breedlove, Waston & Rosenzweig (2010) Biological Psychology

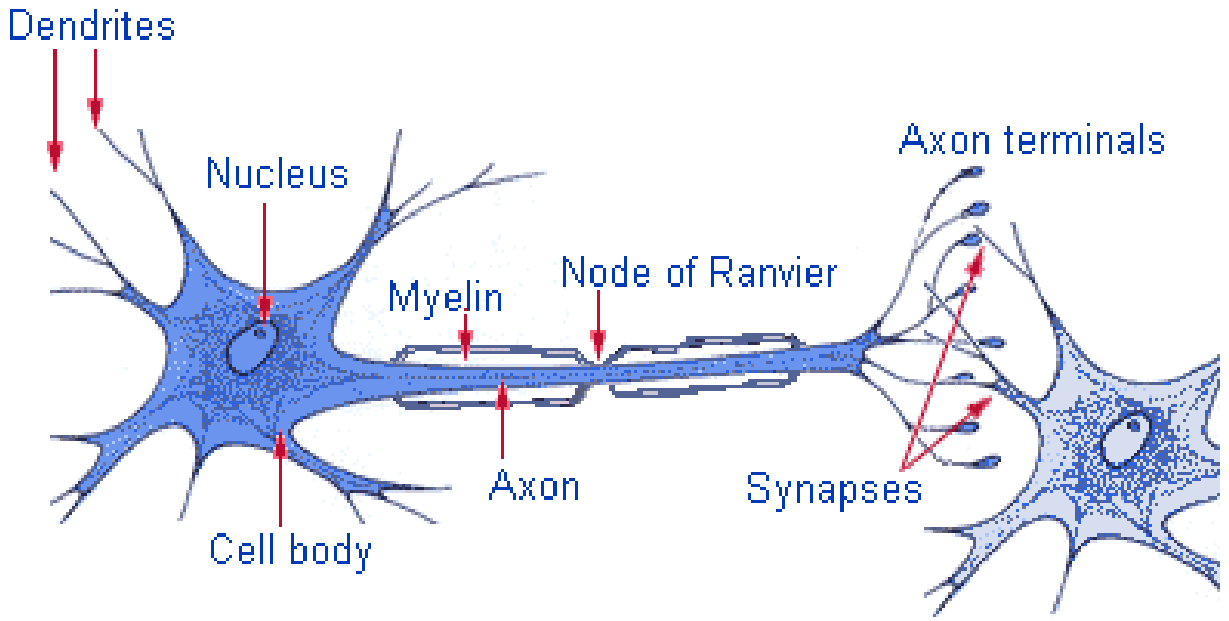
神經細胞的主要結構: axon

- Axon (Cont.)
  - 髓鞘 (Myelin sheath): the fatty insulation around the axons that improves the speed of conduction of nerve impulses.
  - 欒非爾氏節 (Node of Ranvier): gaps between segments of myelin.
  - 多發性硬化症 (Multiple sclerosis): a demyelinating disease (自體免疫系統攻擊髓鞘，造成中樞神經系統同時有多處的神經出現髓鞘脫失受損的情形).



神經細胞彼此間如何傳遞訊息？

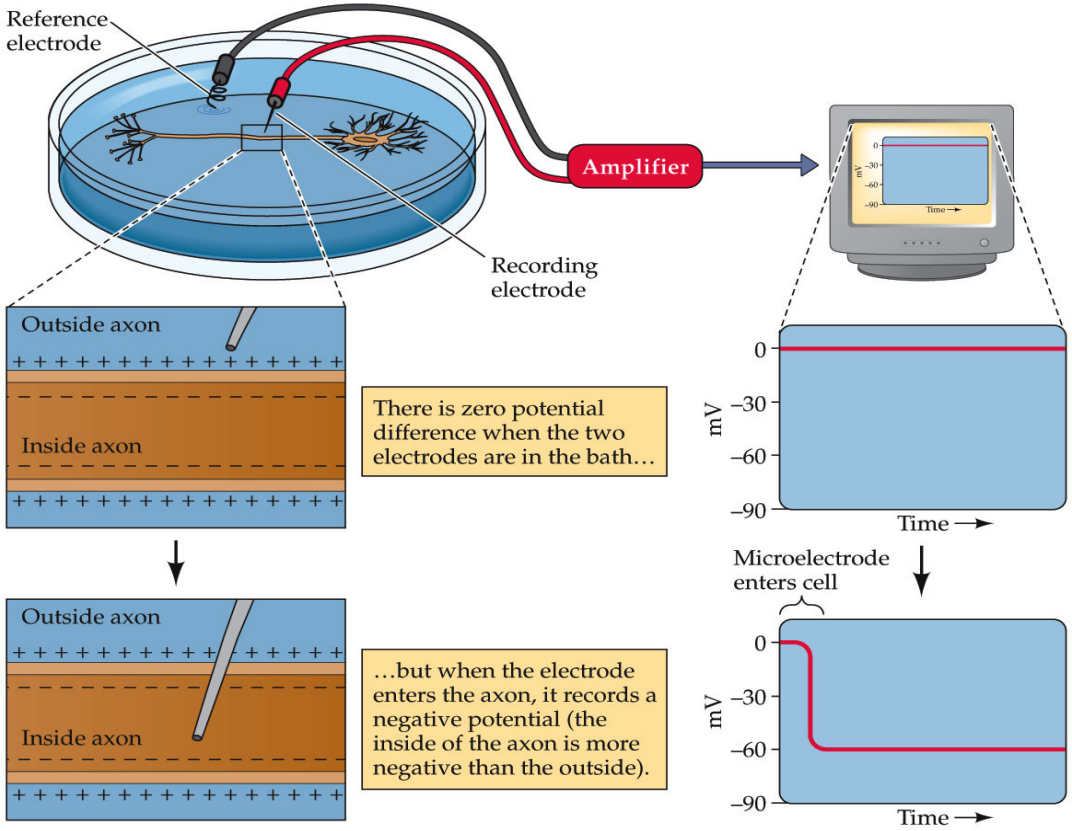
- Electrical signals (電訊號) – either within the neuron (membrane potentials) or between neurons (gap junctions)
- Chemical signals (化學訊號) – between neurons (neurotransmitters and receptors)



神經膜電位(membrane potential)

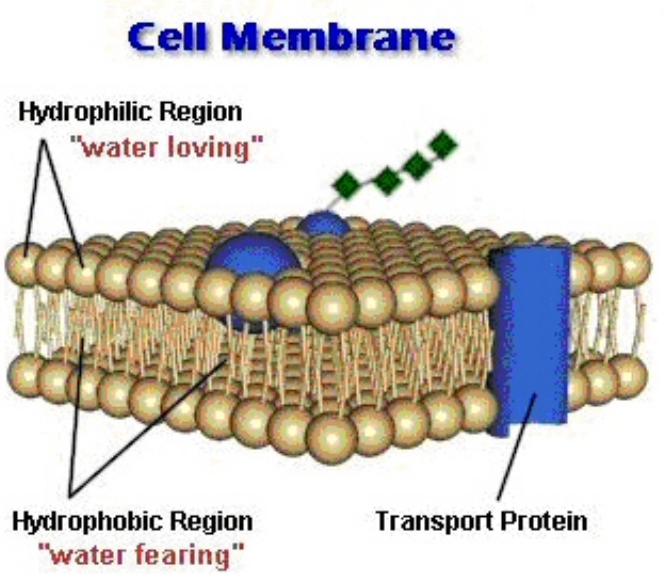
- **神經細胞膜電位(membrane potential)**：細胞膜內外的電位差，通常細胞內的電位是低於細胞外的電位(cells contain many proteins which are negatively charged)。

- 神經細胞膜在靜止時的電位差稱之為**靜止膜電位(resting membrane potential)**，其大小通常為 -60 mV (-50 ~ -80 mV)。

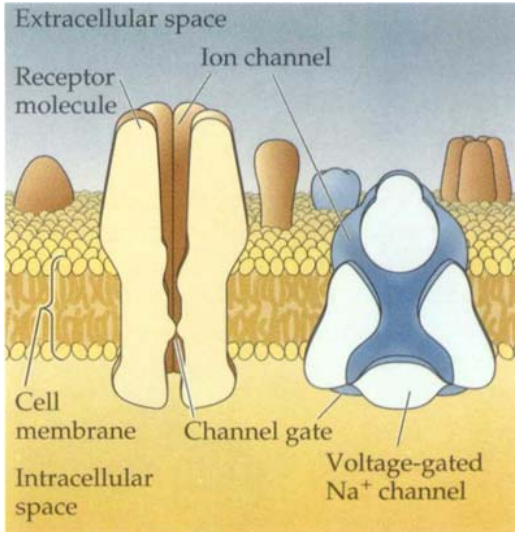


神經膜電位

- 細胞膜的構造 ：神經細胞膜由兩層磷脂質(phospholipid bilayer)所構成，含有兩端：
  - 極性端(polar head) ：磷酸根(phosphate group) ，是親水性的(hydrophilic)
  - 非極性端(nonpolar head) ：脂肪酸(lipid acid) ，由碳鍊的非極性共價鍵形成，為疏水性的(hydrophobic)。



- 細胞膜上的蛋白質結構：
  - 受體(receptors)
  - 離子管道(ion channels)
  - 轉運子(transporter)或幫浦(pump)

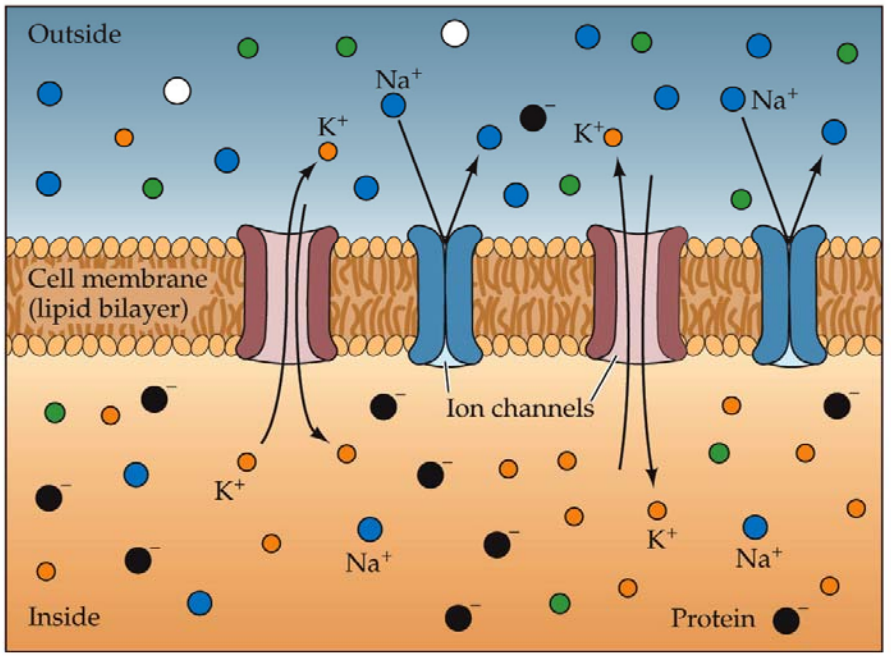


神經膜電位

- 靜止膜電位 (resting membrane potential) ：因為細胞膜內(intracellular) 與細胞膜外(extracellular)的正離子(cations)與負離子(anions) 種類分佈不均。

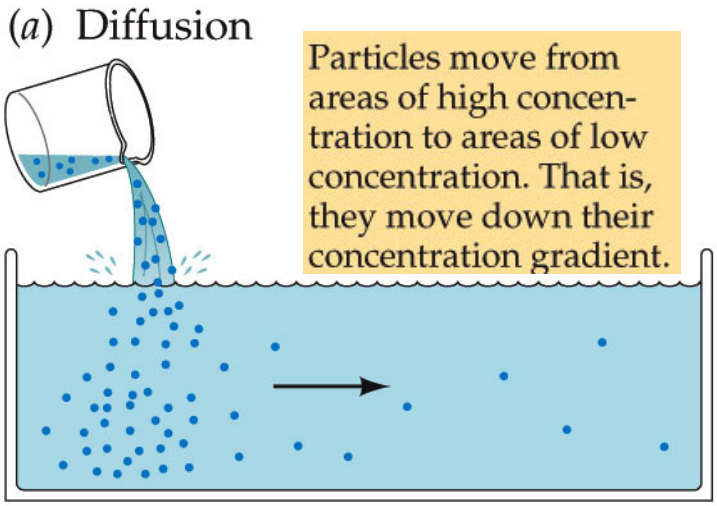
- Extra > Intra : Na^+ and Cl^- (鈉離子sodium 跟氯離子chloride)
- Intra > Extra : K^+ and anion$^-$ (鉀離子potassium 跟蛋白質負離子)

	Na^+	K^+	Cl^-	Ca^{2+}	$^-$ Proteins
Outside cell	many	few	many	many	few
Inside cell	few	many	few	few	many

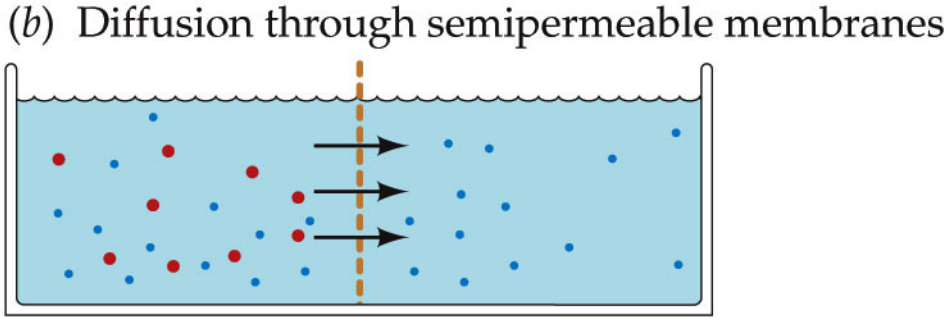


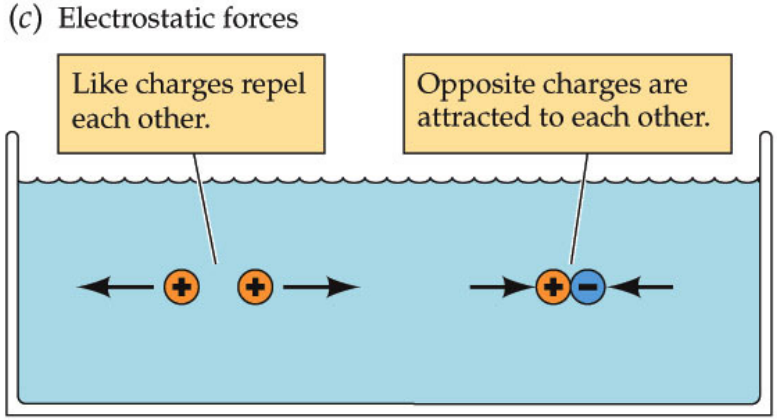
神經膜電位

- 靜止膜電位 (resting membrane potential)的維持主要反映細胞膜內外平衡的兩股的力量(以鉀離子為例)。



- Diffusion force (擴散壓力): drive K^+ out
- Electrostatic forces (靜電力): keep K^+ in





● *Biological Psychology 6e*, Figure 3.2

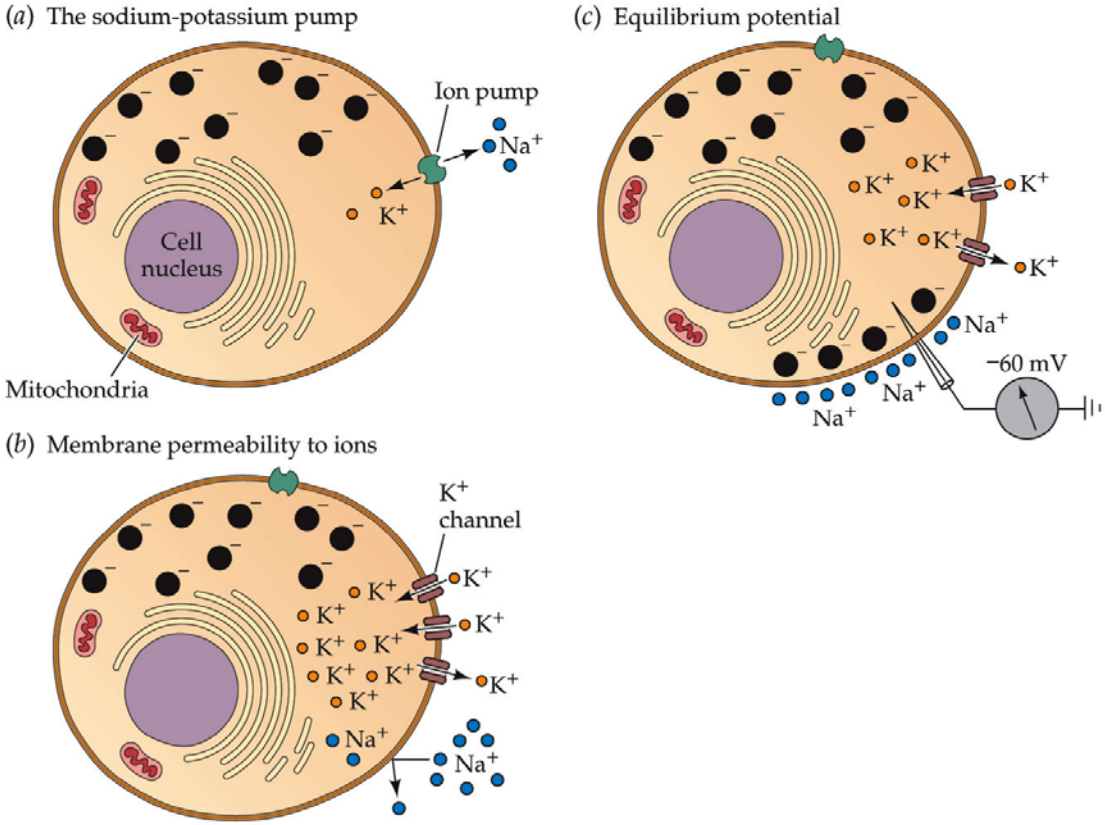
神經膜電位

- 擴散壓力與靜電力的平衡主要依賴**鈉鉀幫浦 (The sodium-potassium pump).**

- **鈉鉀幫浦 (The sodium-potassium pump):** 3 sodium out for every 2 potassium in, need energy.

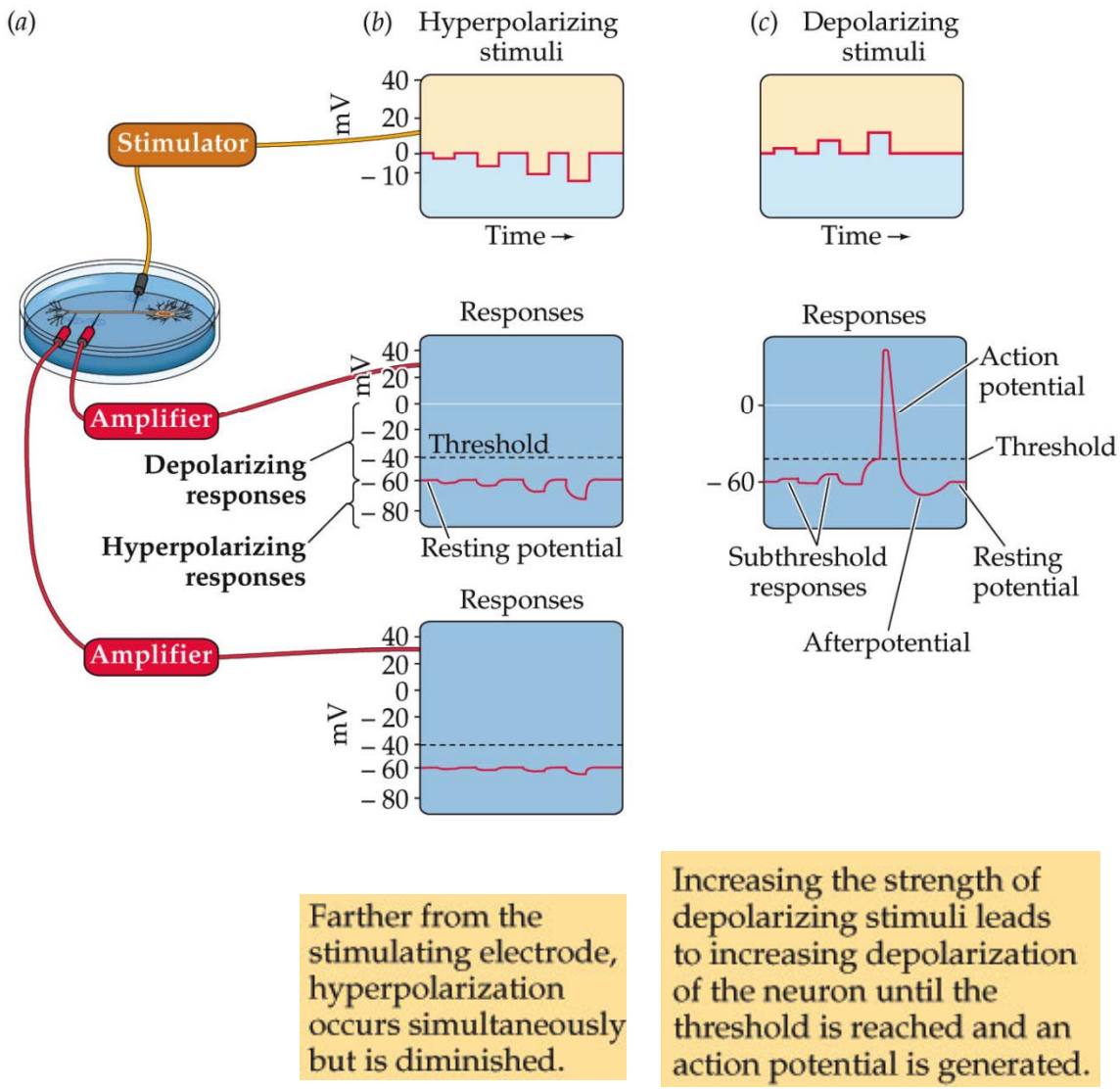
- **膜電位動態平衡 (Equilibrium)**: 鉀離子與鈉離子進出細胞膜的數目是平等的時候

[forces exerted by ions' concentration gradient (OUT) and by electrostatic pressure (IN) are balanced.]



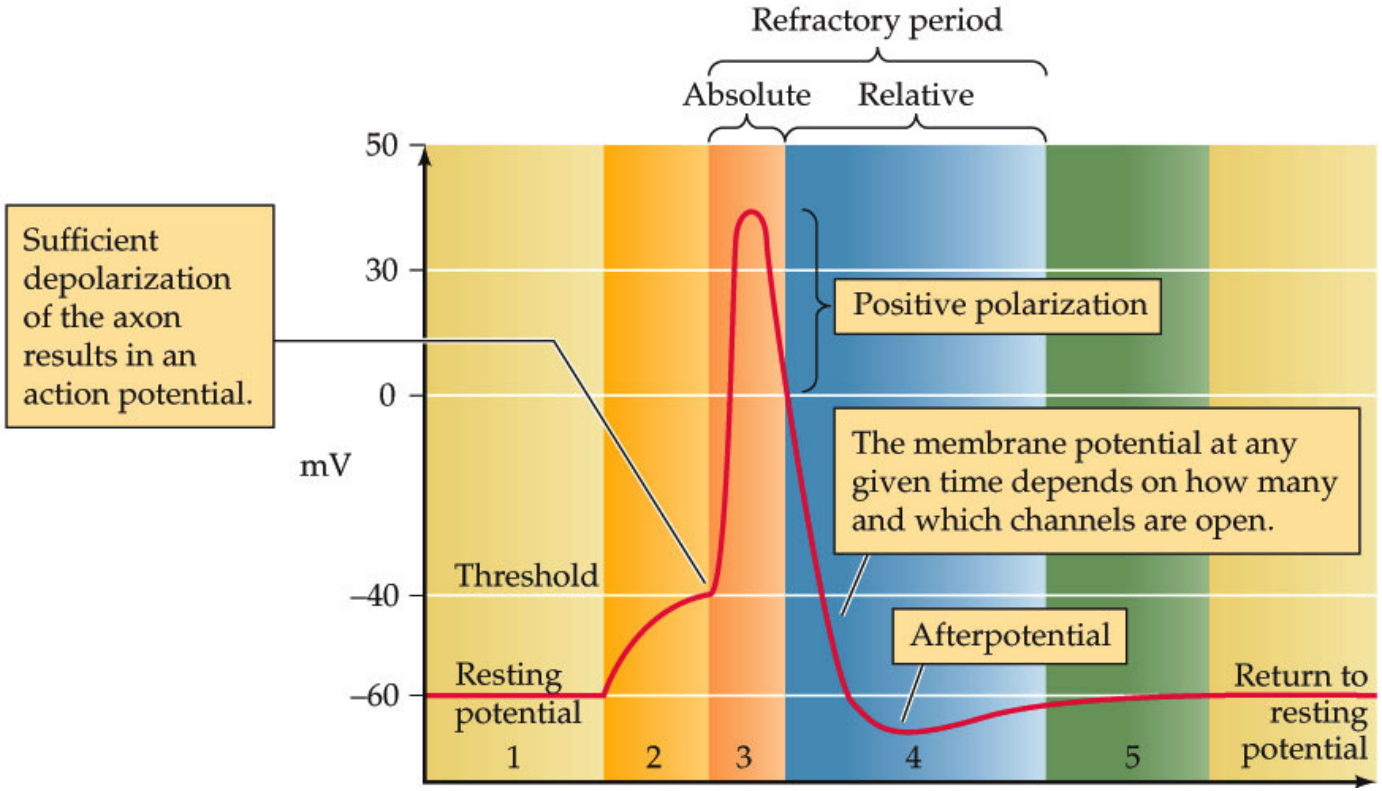
活動電位(action potential)

- **在地電位** (local potential): 因電刺激在細胞膜上所產生的微小電位變化(可正可負)，會隨著時間跟傳送距離增加而慢慢減小。
- **去極化** (depolarization): 在神經內部施予正電流，使其電位高於靜止膜電位。
- **再極化** (repolarization): 膜電位再回到正常的靜止電位。
- **過極化** (hyperpolarization): 在神經內部施予負電流，使其電位低於靜止膜電位。



活動電位

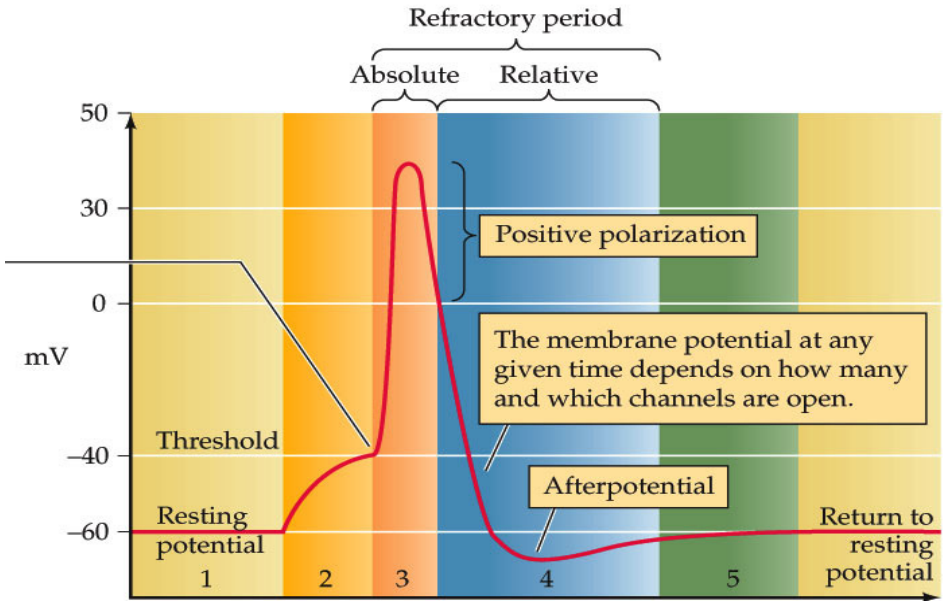
- 活動電位 (**Action potential**): 當去極化電流(depolarization) 逾越某一閾值(threshold)，膜電位便一連串制式的電位變化，稱之為活動電位 (initiated in the **axon hillock,** between soma and axon)。活動電位的大小通常是一定的，獨立於刺激的強度。



Biological Psychology 6e, Figure 3.6

Adapted from Breedlove, Waston & Rosenzweig (2010) Biological Psychology

活動電位



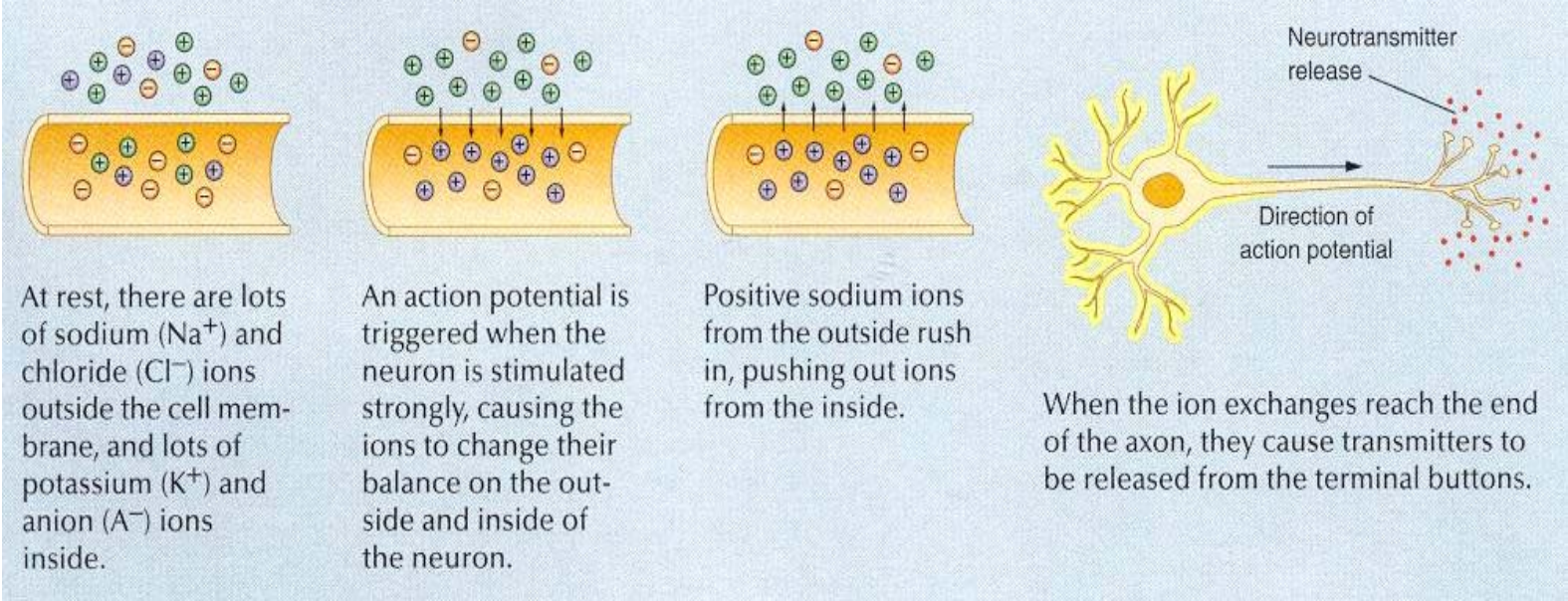
- Absolute refractory period (絕對反挫期): no amount of stimulation can induce another action potential (period 3).
- Relative refractory period (相對反挫期): only a very strong stimulation can produce another action potential (period 4).

- 活動電位的階段:

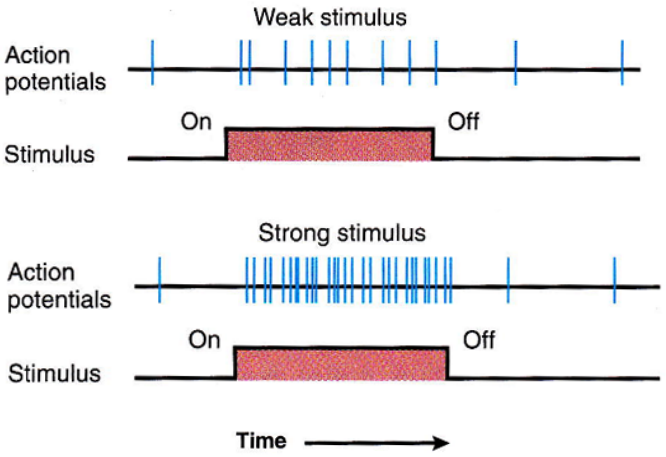
1) Resting period.
2) resting potential reaches threshold (-60 mV → -40 mV).
3) 去極化: the membrane potential reaches +40 mV (influx of sodium ions, **voltage-gated Na^+ channels**).
4) 再極化: The membrane potential reaches -70 mV (outflow of potassium ions, **voltage-gated K+ channels,** afterpotential – the undershoot phase).
5) The membrane potential reaches the resting level (-60 mV).

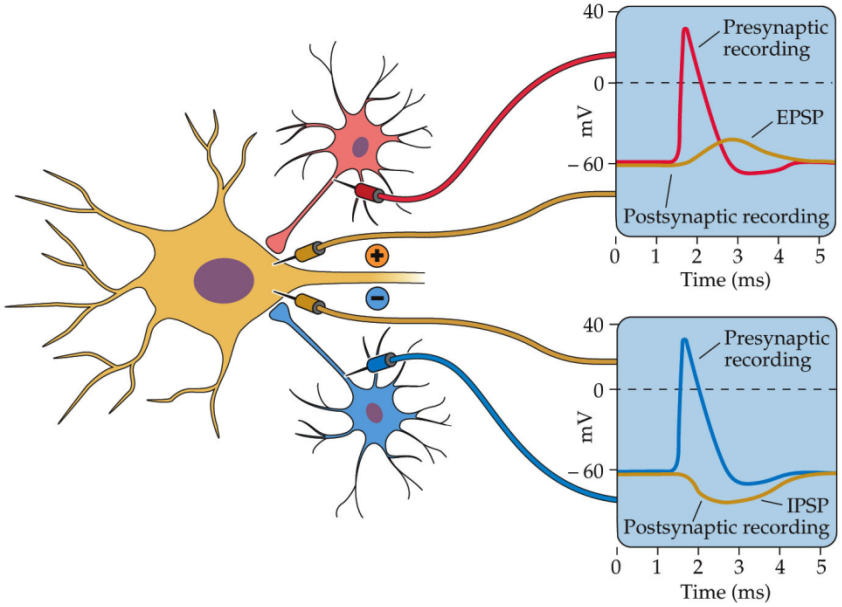
活動電位的特性

- Action potential: neural impulse (神經衝動) or spikes.
  - 離子(ions)進出離子管道(ion channels) 產生電位的改變。
  - 全有全無性質(All-or-None law):行動電位的大小是固定的，並不會因為刺激的大小而有所改變。一旦行動電位在細胞體跟軸突的交界生成，訊號就會隨著軸突傳到突觸，並不會中途停止或消失。.
  - 自行前進(self-propogated) and 不衰減(non-decremental)



活動電位的特性

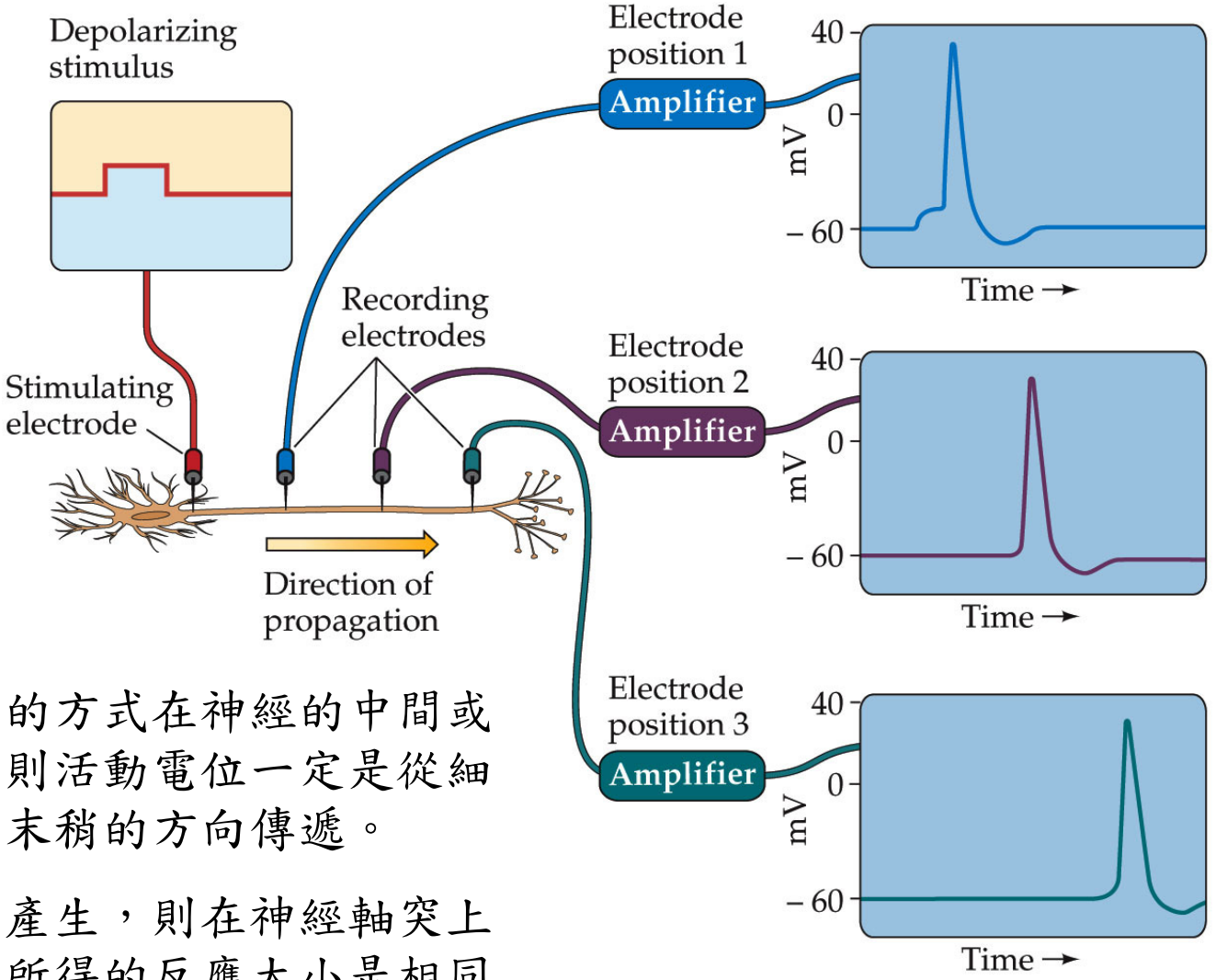




- **活動電位特性 (action potential):**
  - -- **All-or-None**
  - -- **Fixed amplitude**: ~80-100 mV
  - -- Duration: ~2 ms
  - -- Refractory Period: ~1-3 ms
  - -- Limited rate: 100~500 per second
  - -- Communication over distances
  - -- **Rate code**

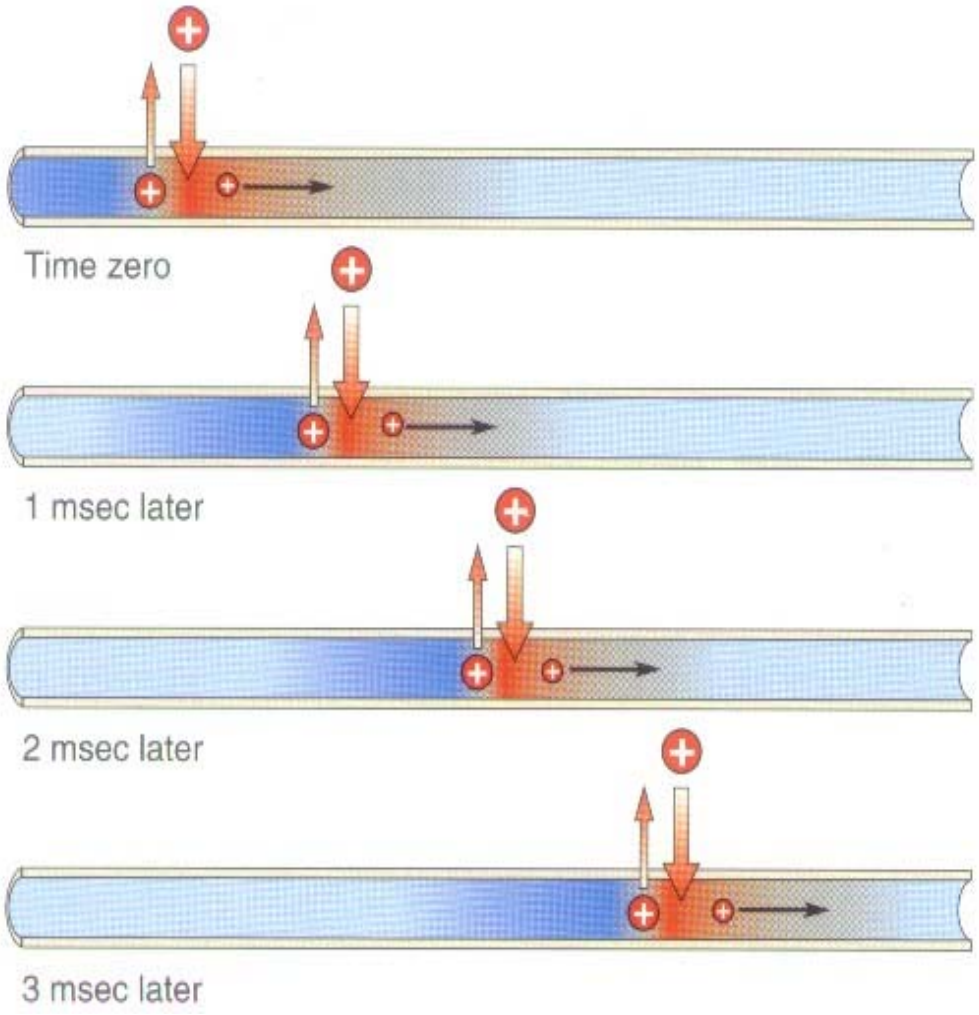
- **在地電位特性 (local potential)**:
  - -- **Graded - with intensity**
  - -- **Passive decay** - in space and time
  - -- Summation - in space and time
  - -- EPSP (excitatory postsynaptic potential)
  - -- IPSP (inhibitory postsynaptic potential)
  - -- adding/subtracting signals locally
  - -- **Amplitude code**

活動電位的傳輸



- 除非是用人為的方式在神經的中間或末稍刺激，否則活動電位一定是從細胞本體往軸突末稍的方向傳遞。
- 活動電位一旦產生，則在神經軸突上任何一點測量所得的反應大小是相同的，不因距離衰減。

活動電位的傳輸



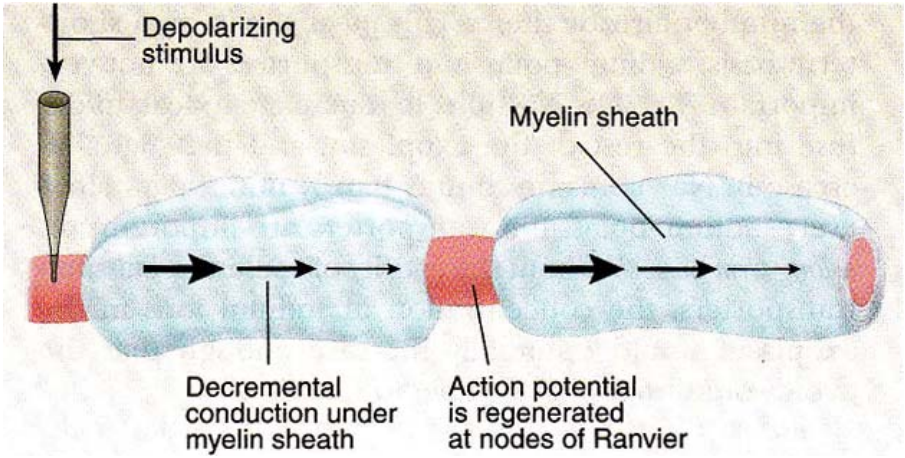
- 鈉離子進入後，會往兩方擴散，使得鄰近地區的正電升高，產生去極化，引發鄰近區域的活動電位。
- 剛產生過活動電位的區域，正在反挫期，於是無法產生活動電位，造成神經訊號只會往前傳，不會往後傳。
- 由於訊號的傳導依賴鈉離子一點點的擴散，所以速率較電流傳導速度慢。

活動電位的傳輸

- 影響神經傳導速率的因素:
  - 傳導速率 (conduction velocity): varies with the diameter of axon, example: 2 um - 5 m/s; 20 um - 120 m/s; up to 1/3 the speed of sound in air.
  - 神經軸突的粗細，**越粗越快**，因為粗的軸突內阻較低，所以可以用passive conduction的方式走較遠而不致耗損太多。
  - 神經細胞膜的電阻(membrane resistance)越低則電流越易流到細胞之外。
  - 神經細胞膜的電容(membrane capacitance)越高則電流越易充滿電容而不往前進。
  - 粗的神經除了傳導速率較快外，也較容易達到興奮的閾值，原因是有較大的表面積，較多的voltage-dependent ion channels。細的神經需要較多的去極化，也較容易被藥物所阻斷。
  - 烏賊的巨大神經直徑約1 mm是加粗神經以增進傳導速率的致極表現。但是更粗就會妨礙整個個體的容納平衡。所以必須設計其他的方法。
  - **可能有又細又快的傳導方式嗎？**

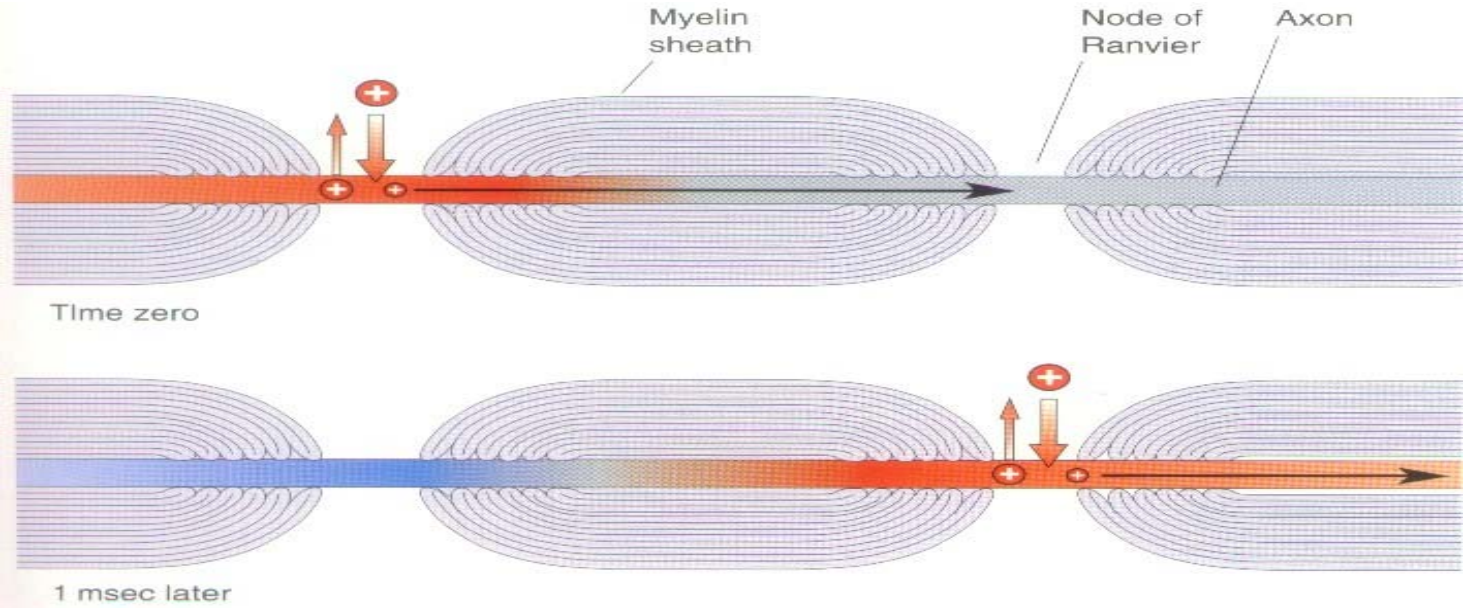
活動電位的傳輸

- 髓鞘(myelin sheath)的功能:
  - 髓鞘發展是一個加速神經傳導又不加粗神經的方法。[脊椎動物]
  - 減少膜電容。降低停駐於膜上的電量。
  - 增加膜電阻，增加在神經軸突內傳導的電流。
  - 禁止離子的交換，所以鈉鉀幫浦不必運作耗費能量。
  - 髓鞘不會全程包裹著軸突，而是每隔0.2到2.0 mm停下來一段，在這所謂的**欒非爾氏節(node of Ranvier)**中，離子可以自由的交換。這便造成所謂的**跳躍式傳導(saltatory conduction)**。



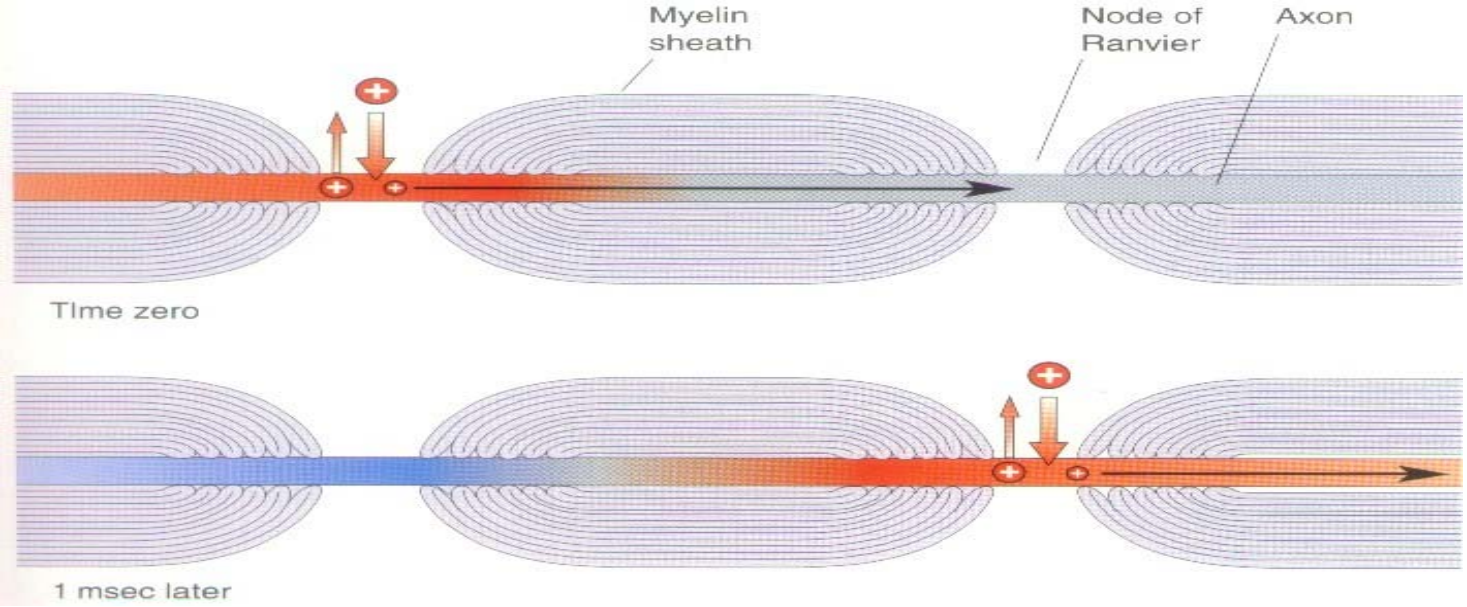
活動電位的傳輸

- 跳躍式傳導 (Saltatory Conduction):
  - active + passive :主動與被動傳輸合併使用
  - 快速:100 m/sec。
  - 節省能量:避免sodium potassium pump過於勞累消耗ATP。
  - 節省體積：很細的神經也達到烏賊巨大神經的功能。
  - 與**多發性硬化症(multiple sclerosis)**有關。

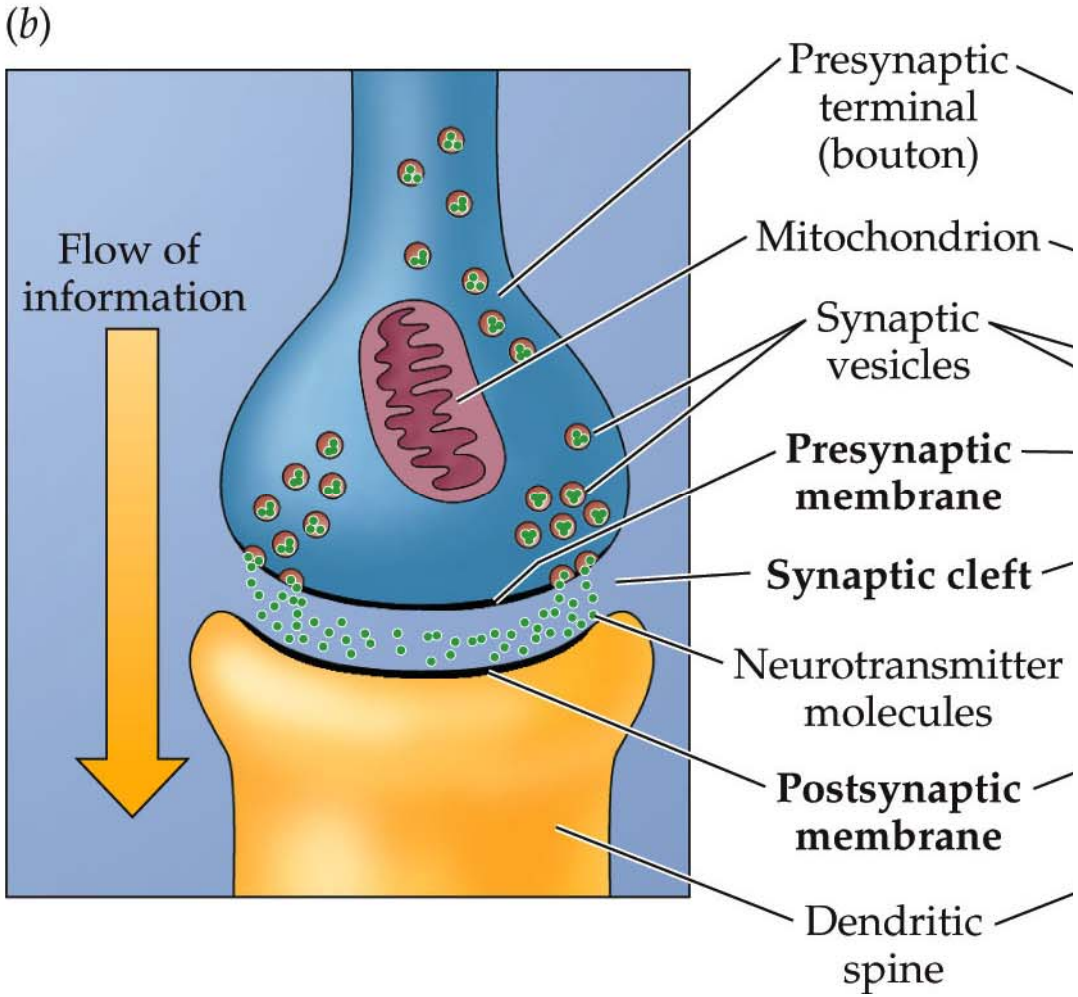


活動電位的傳輸

- 主動與被動傳輸都需要能量，這些能量來自於粒線體的ATP。當神經活動後，血液會迅速帶來氧氣及葡萄糖，補充啟動鈉鉀幫浦所需能量，讓細胞膜內外離子分佈恢復靜止電位狀態。
- 功能性磁振造影技術(*f*MRI)，主要在偵測大腦區域性的血氧濃度變化，這些變化跟該區域的神經活動有密切的關聯(特別是突觸後電位變化)。



神經突觸(synapse)



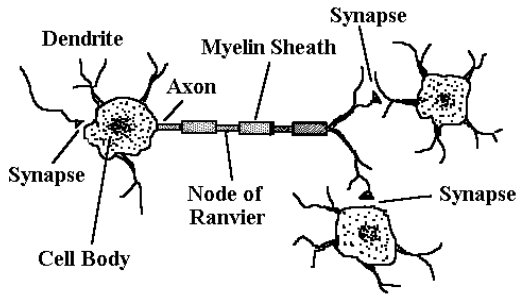
- 突觸前細胞膜 (**presynaptic membrane**)
  - ➢突觸胞囊(synaptic vesicle) :30-140 nm
  - ➢神經傳導素(neurotransmitter)
  - ➢神經調節素(neuromodulators)
- 突觸溝 (**synaptic cleft**)：20-40 nm, 透過化學物質傳遞神經訊息
- 突觸後細胞膜 (**postsynaptic membrane**)
  - ➢ 受體分子(receptor molecule)
  - ➢ **興奮性**或**抑制性**訊號
  - ➢ 樹突脊(dendritic spines)
  - ➢ 神經可塑性(neural plasticity)

神經突觸

- Table 3.1 神經元中不同電位信號的比較

TABLE 3.1 Characteristics of Electrical Signals of Nerve Cells

Type of signal	Signaling role	Typical duration (ms)	Amplitude	Character	Mode of propagation	Ion channel opening	Channel sensitive to:
Action potential	Conduction along a neuron	1–2	Overshooting, 100 mV	All-or-none, digital	Actively propagated, regenerative	First Na^+, then K^+, in different channels	Voltage (depolarization)
Excitatory postsynaptic potential (EPSP)	Transmission between neurons	10–100	Depolarizing, from less than 1 to more than 20 mV	Graded, analog	Local, passive spread	Na^+–K^+	Chemical (neurotransmitter)
Inhibitory postsynaptic potential (IPSP)	Transmission between neurons	10–100	Hyperpolarizing, from less than 1 to about 15 mV	Graded, analog	Local, passive spread	Cl^-–K^+	Chemical (neurotransmitter)



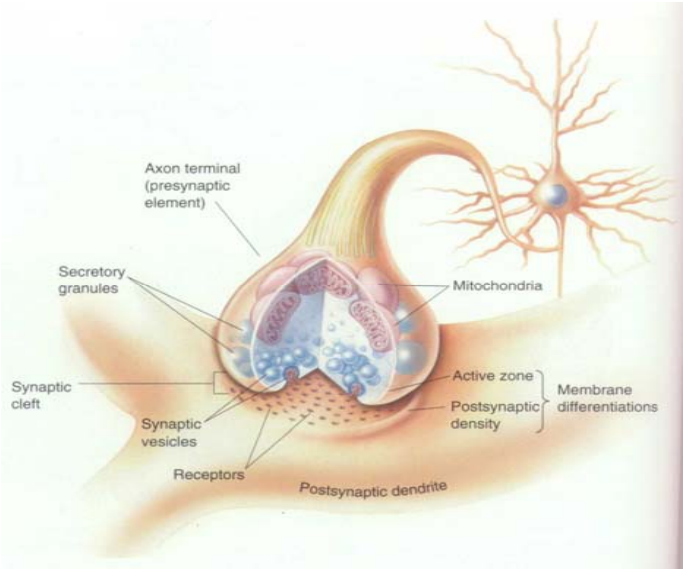
神經突觸

- 突觸的種類

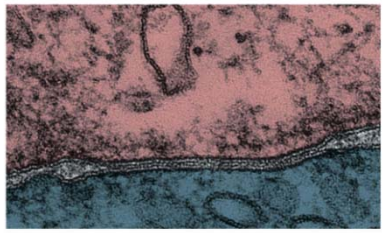
➢ **化學突觸**：單向傳導, 訊號放大, 訊號可逆轉(由興奮變抑制)。

➢ **導電突觸** (electrical synapses)：

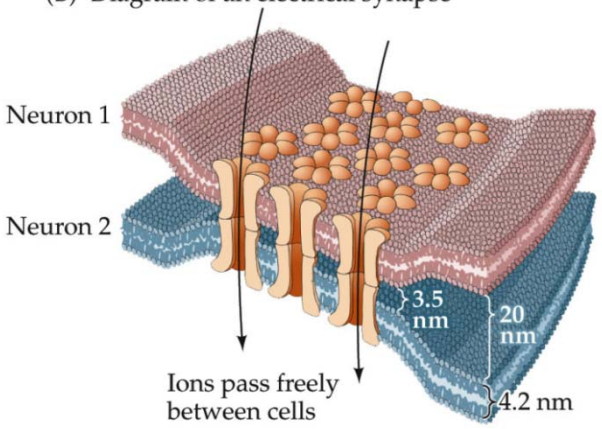
- 兩個神經元之間相距只有3 nm，可以透過所謂的**Gap Junction**將電流直接由突觸前的神經元傳到突觸後的神經元。
- 導電突觸在神經細胞中不常見，但在神經膠細胞、表皮細胞、平滑肌、心肌與肝臟細胞常存在。
- 在發展中的神經系統常出現，他使得發育中彼此相鄰近的細胞可以共享相似的電流與化學環境訊號，協調彼此的生長與成熟過程。
- 多半用在無脊椎動物或脊椎動物的逃避反射中感覺神經到運動神經的突觸中。



(A) Electron micrograph of an electrical synapse

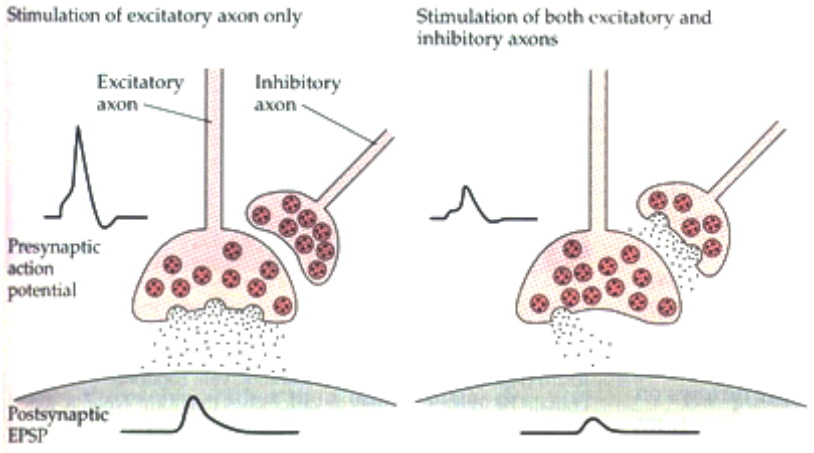


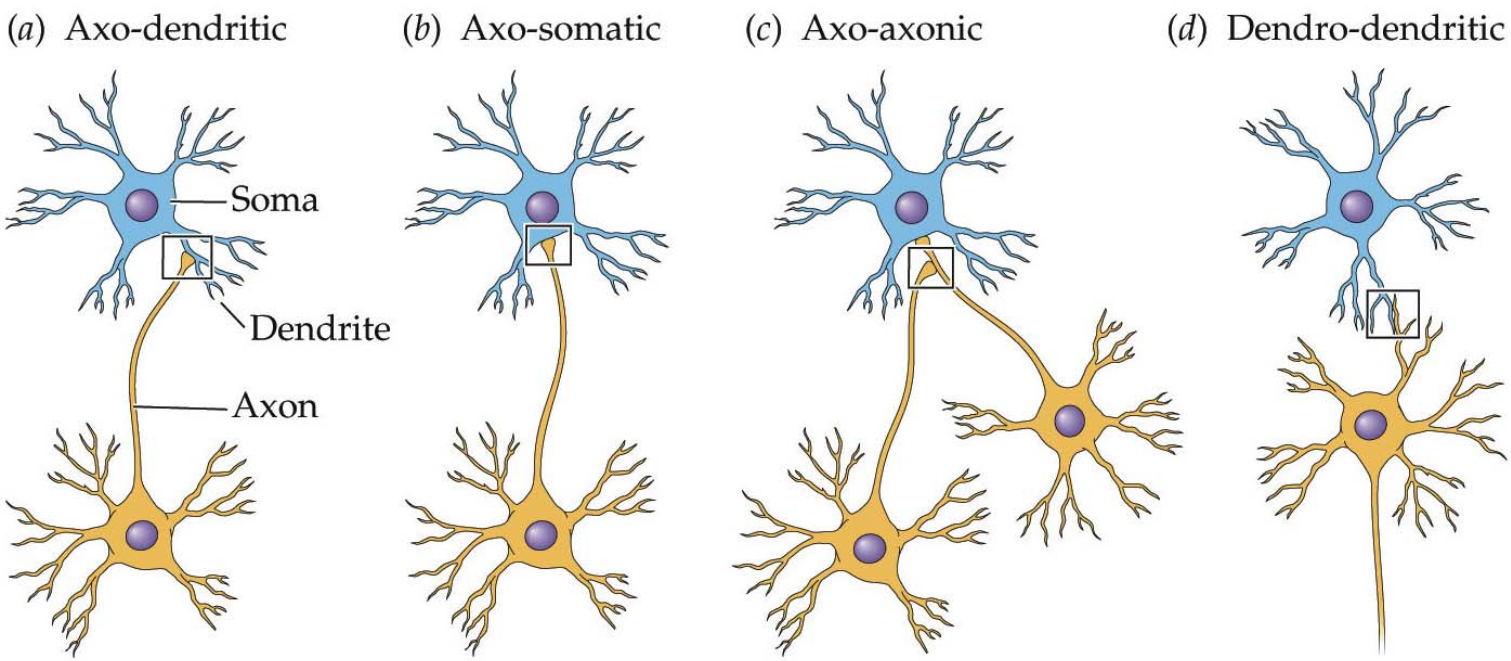
(B) Diagram of an electrical synapse



神經突觸

- 突觸的形式: 從突觸前與突觸後所在的elements來區分
  - **Axo-dendritic (dendritic spines)**
  - **Axo-somatic**
  - **Axo-axonic (減少神經傳導素釋放)**
  - **Dendro-dendritic**





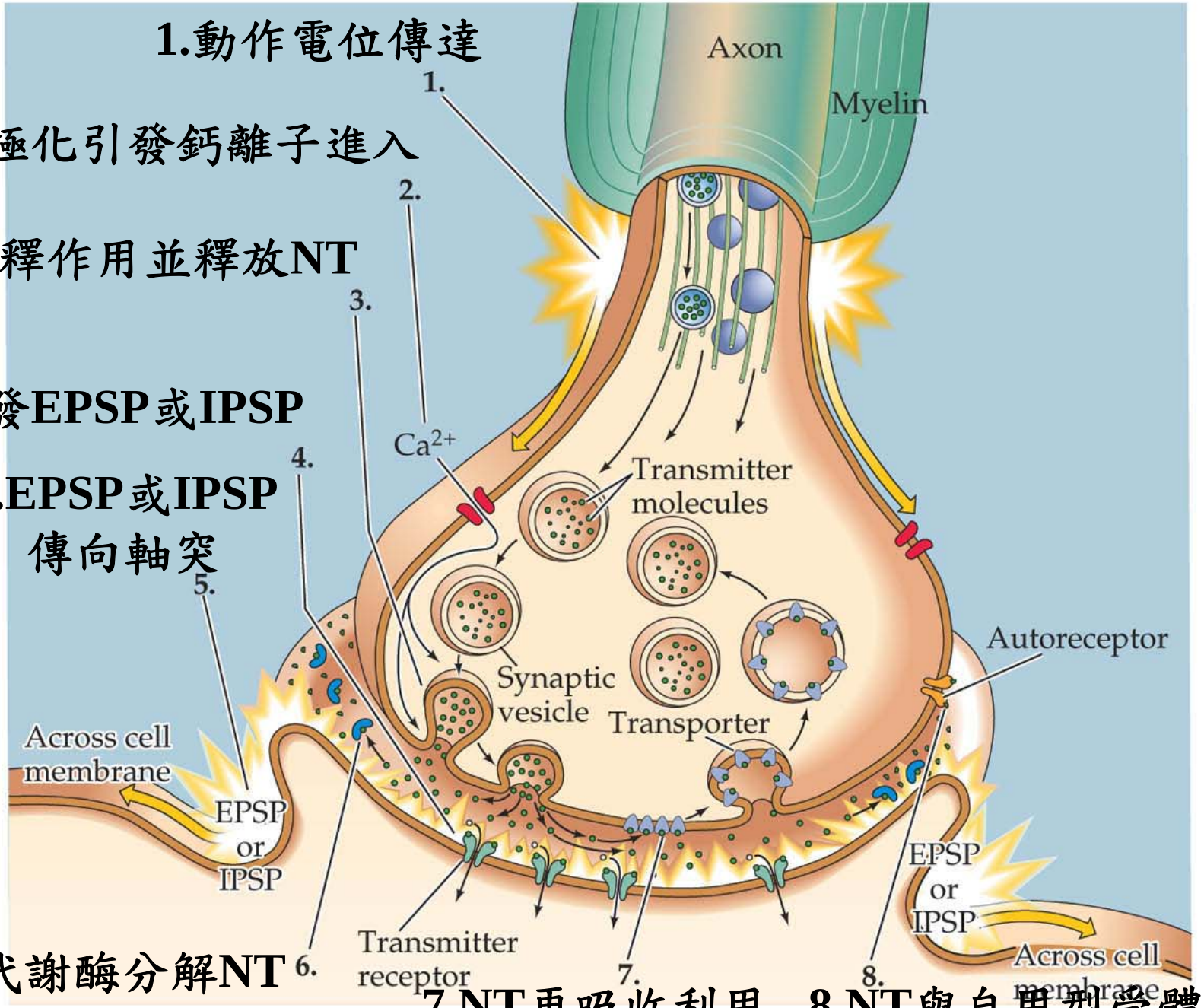
1.動作電位傳達

2.去極化引發鈣離子進入

3.外釋作用並釋放NT

4.引發EPSP或IPSP

5.EPSP或IPSP傳向軸突



6.代謝酶分解NT

7.NT再吸收利用　8.NT與自用型受體結合

BIOLOGICAL PSYCHOLOGY, Fourth Edition, Figure 3.13 © 2004 Sinauer Associates, Inc.

神經受體 (receptor)

- **Receptor Activation (受體啟動)**

➢ 神經傳導素與突觸後樹突或細胞體細胞膜上的受體 (receptors) 結合。

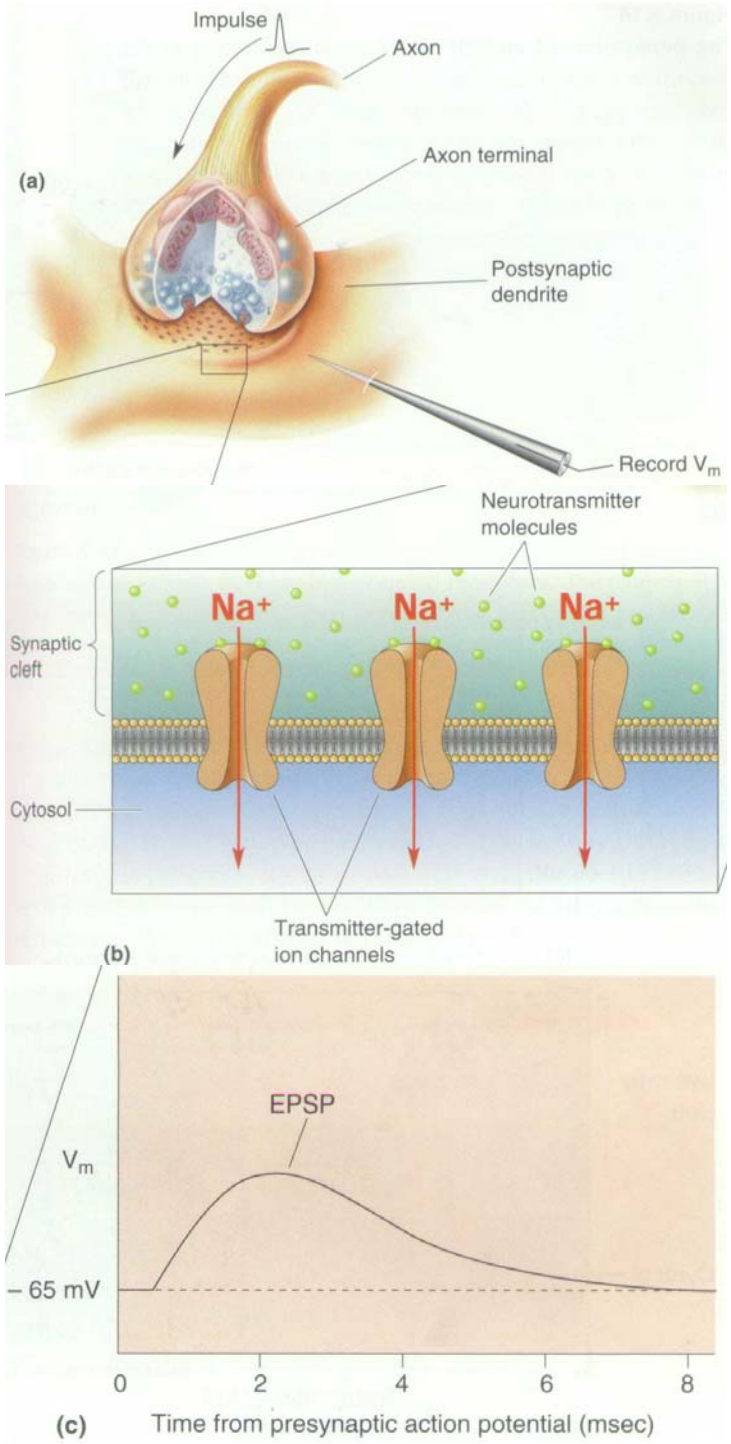
➢ 導致突觸後細胞膜上的某些離子管道打開，此為化學控制管道(chemical gated channel) 。

➢ 導致突觸後細胞膜快速的電位變化，形成突觸後電位 (postsynaptic potential, PSP)。

➢ 化學控制管道和電位控制管道不同，不會擴及開放附近的管道。

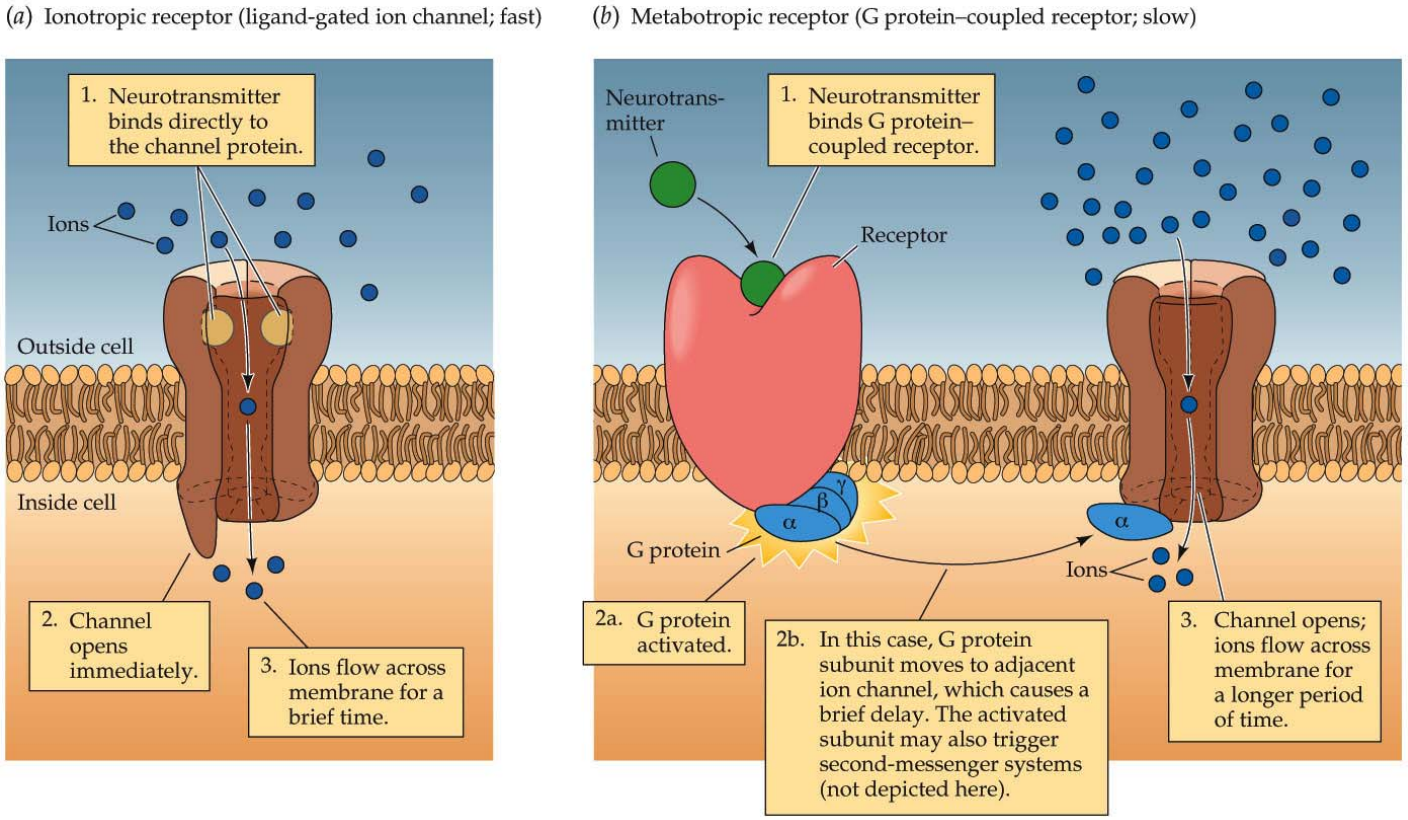
➢ 突觸後電位 (i.e. local potential)以電流方式在細胞膜上流動，隨距離而逐漸衰退。

- 對照action potential (行動電位)不隨距離而衰退。



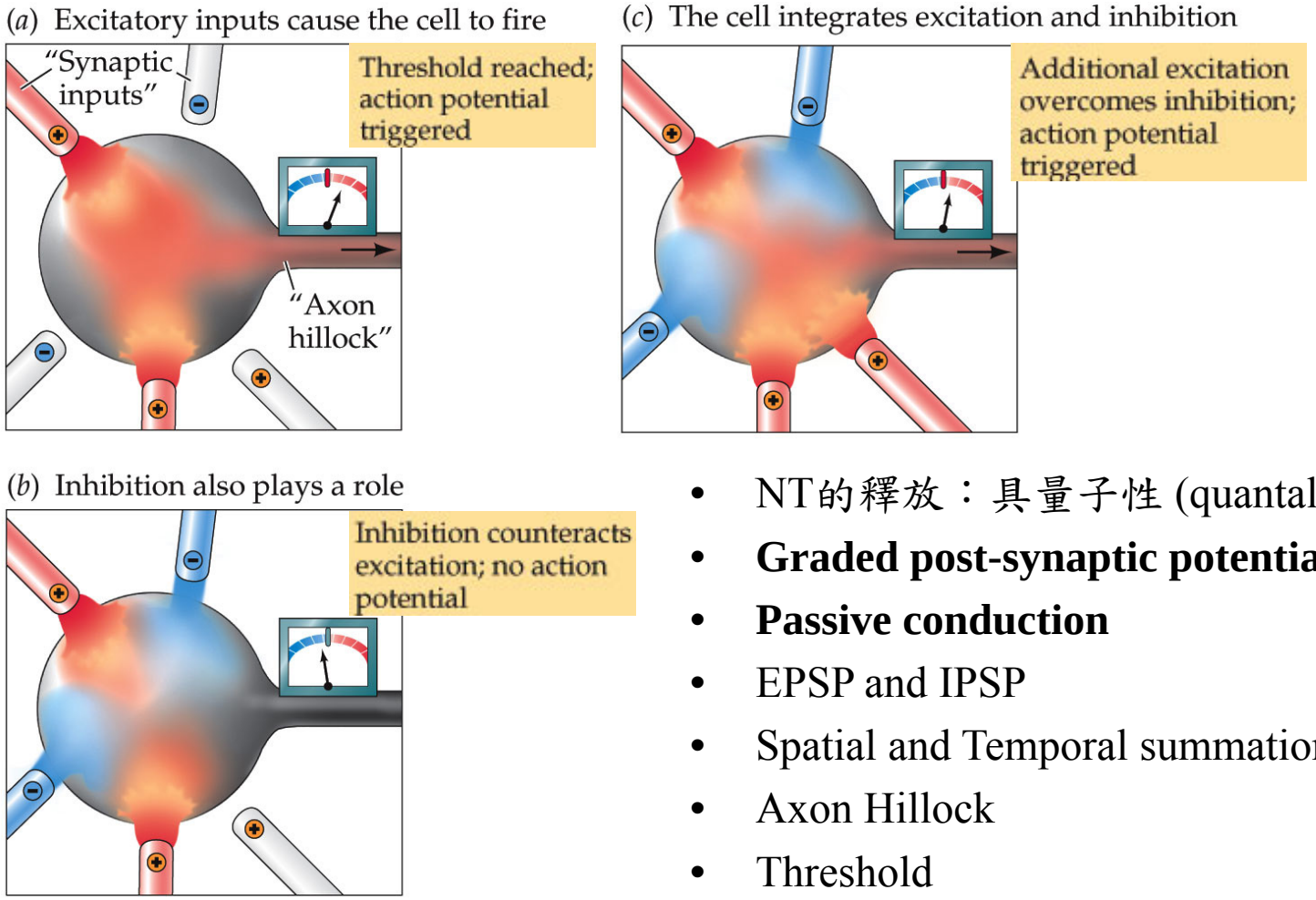
神經受體

- **Types of Receptor**
  - Ionotropic receptors (離子型受體)：直接
    - 興奮型離子受體 (excitatory)
    - 抑制型離子受體 (inhibitory)
  - Metabotropic receptors (代謝型受體)：間接



神經受體

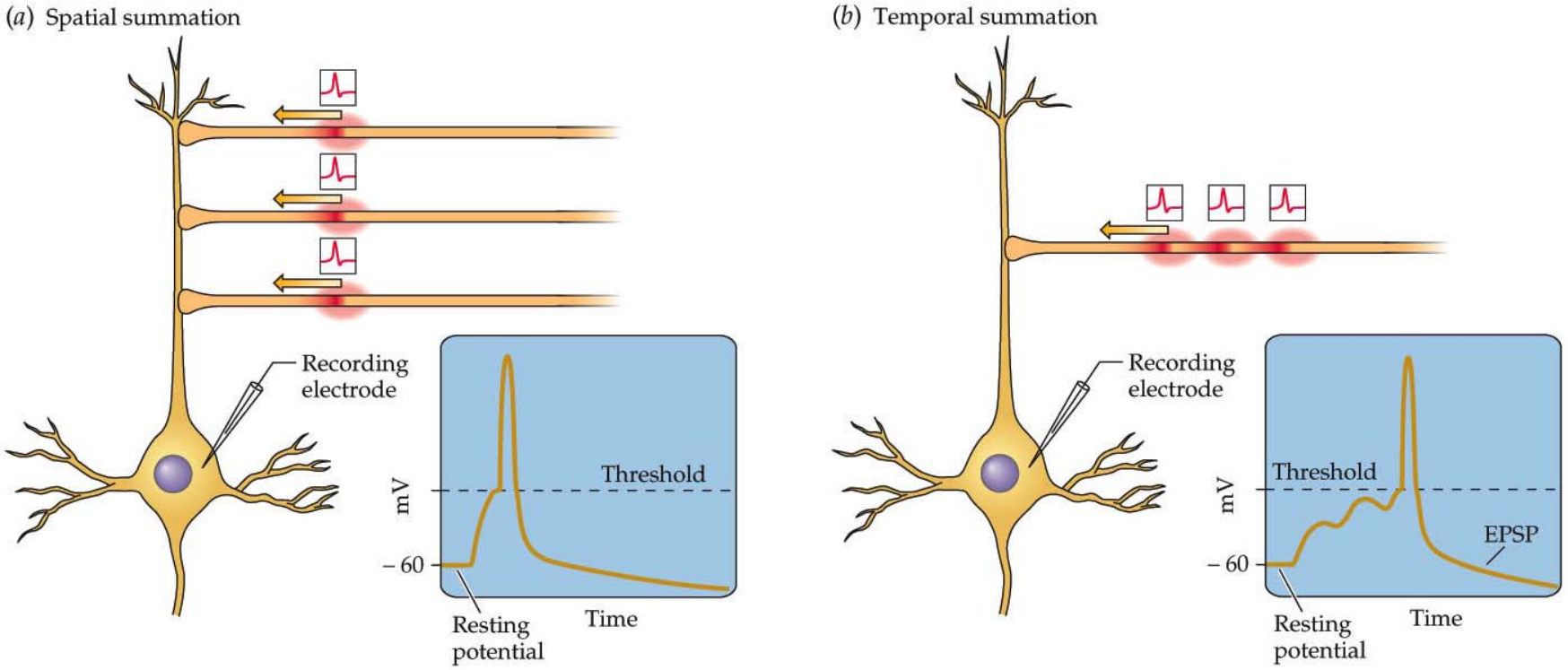
- Postsynaptic summation (突觸後加成作用)：興奮與抑制



- NT的釋放：具量子性 (quantal release)
- **Graded post-synaptic potential**
- **Passive conduction**
- EPSP and IPSP
- Spatial and Temporal summation
- Axon Hillock
- Threshold

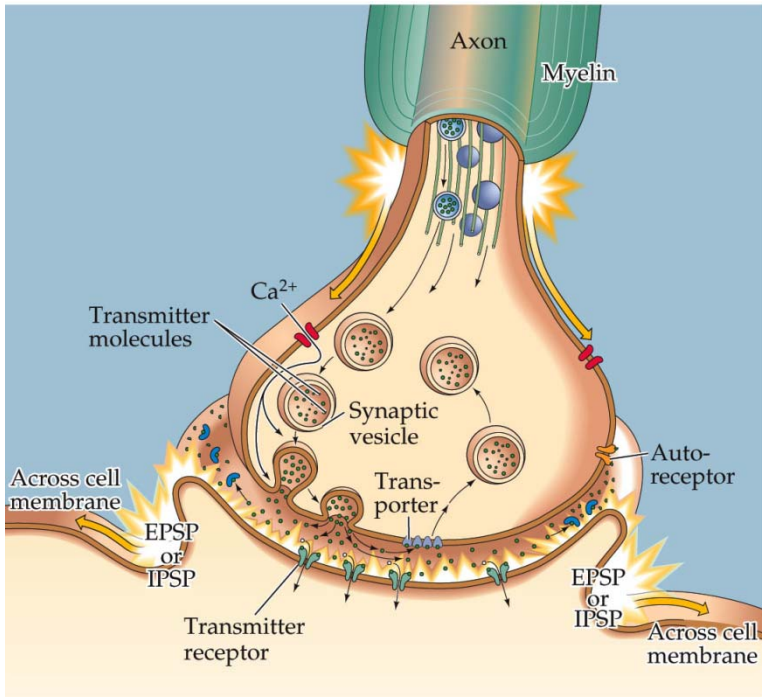
神經受體

- Psotsynaptic summation (突觸後加成作用)：space vs. time
- 一個神經細胞本體或樹突上有成千上萬個突觸，不同來源與不同性質的突觸後電位，會透過細胞膜作時間與空間加成。



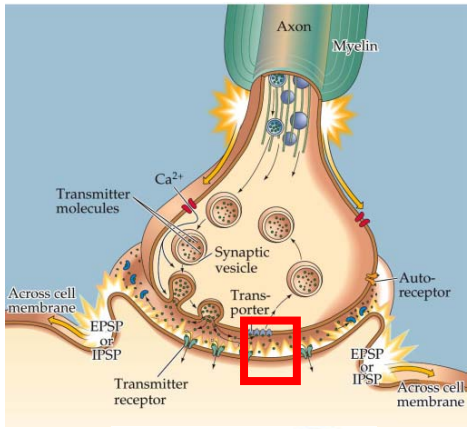
神經傳導物質 (Neurotransmitters)

- Criteria for Neurotransmitters
  - Substance exists in presynaptic axon terminals
  - Is synthesized in presynaptic cells
  - Is released when action potentials reach axon terminals
  - Receptors for the substance exist on postsynaptic membrane.
  - When applied, substance produces changes in postsynaptic potentials.
  - Blocking substance release prevents changes in postsynaptic cell.



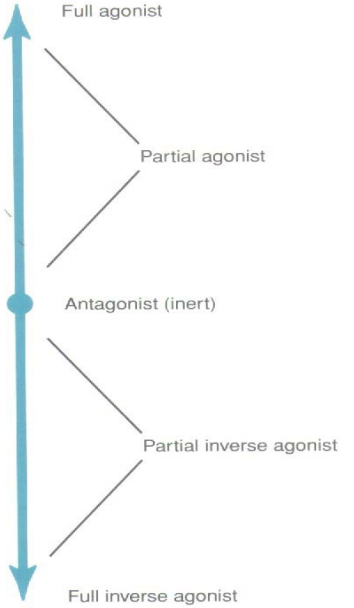
***Biological Psychology 6e*, Figure 3.12**

神經傳導物質 (Neurotransmitters)



- **Ligand (配體) and Receptor (受體) : key-lock**
  - Endogenous ligands (內生型): occurring naturally within the body. Ex: **neurotransmitters**, hormones
  - Exogenous ligands (外源型): introduced from outside of the body. Ex: drugs, toxin, venom

- A **Ligand** is a substance that binds to a receptor has one of three effects:
  - **Agonist (致效劑)** : initiates the normal effects of the transmitter on that receptor.
  - **Antagonist (拮抗劑)** : binds to the receptor and does NOT activate it, and therefore blocking it from being activated by other ligands.
  - **Inverse Agonist (反向致效劑)** : binds to the receptor and initiates an effect that is the reverse of the normal function of the receptor.



神經傳導物質 (Neurotransmitters)

TABLE 4.1 Some Synaptic Transmitters and Families of Transmitters

Family and subfamily	Transmitter(s)
AMINES 胺類	
Quaternary amines	Acetylcholine (ACh)
Monoamines	*Catecholamines*: norepinephrine (NE), epinephrine (adrenaline), dopamine (DA)
	Indoleamines: serotonin (5-hydroxytryptamine; 5-HT), melatonin
AMINO ACIDS 氨基酸	Gamma-aminobutyric acid (GABA), glutamate, glycine, histamine
NEUROPEPTIDES 神經類胜肽: **short trains of amino acids**	
Opioid peptides	*Enkephalins*: met-enkephalin, leu-enkephalin
鴉片類胜肽	*Endorphins*: β-endorphin
	Dynorphins: dynorphin A
Other neuropeptides	Oxytocin, substance P, cholecystokinin (CCK), vasopressin, neuropeptide Y (NPY), hypothalamic releasing hormones
GASES 氣體	Nitric oxide, carbon monoxide

神經傳導物質 (Neurotransmitters)

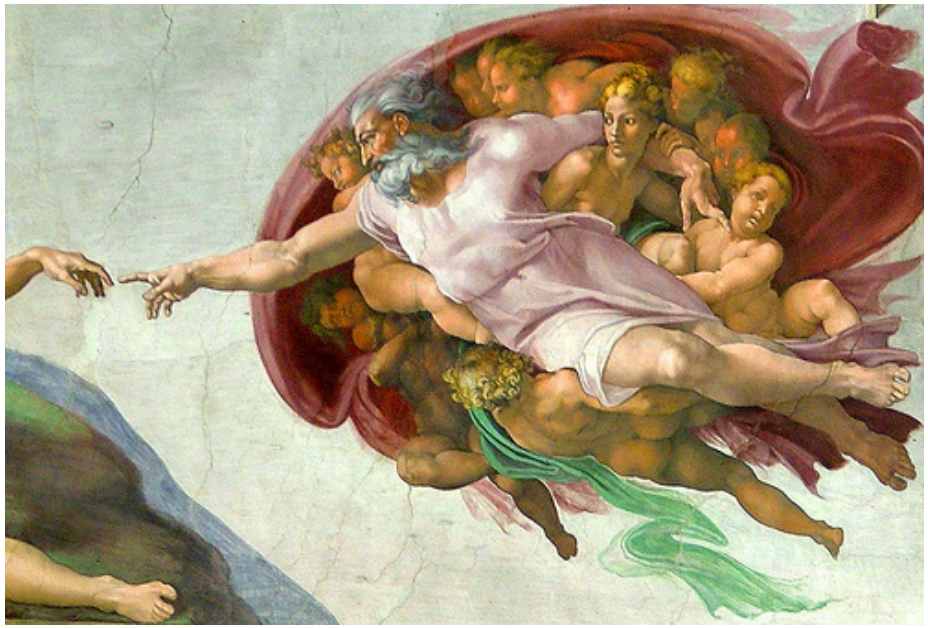
Name	Distinguishing Features	Related Disorders and Symptoms	Drugs That Alter
Acetylcholine 乙醯膽鹼	Causes muscles to contract; memory; arousal	Alzheimer's disease, delusions (shortage); convulsions, spasms, tremors (excess)	Physostigmine (increases, used to treat Alzheimer's disease); scopolamine (blocks)
Dopamine 多巴胺	Motivation, reward, movement, thought, learning	Parkinson's disease, depression, attention-deficit/hyperactivity disorder (ADHD) (shortage); aggression, schizophrenia (excess)	Amphetamine, cocaine (causes release); chlorpromazine (blocks at receptors); methylphenidate (Ritalin, blocks reuptake)
Noradrenaline (norepinephrine) 副腎上腺素	Dreaming, attention	Depression, fatigue, distractability (shortage); anxiety, headache, schizophrenia (excess)	Tricyclic antidepressants such as amitriptyline (keeps more available at the synapse)
Serotonin 血清素	Primary inhibitory neurotransmitter regulating mood, sleep	Obsessive-compulsive disorder, insomnia, depression (shortage); sleepiness, lack of motivation (excess)	Fluoxetine (Prozac), tricyclic antidepressants (keeps more present at the synapse)
GABA (gamma-aminobutyric acid) 胺基丁酸	Inhibits sending neuron	Anxiety, panic (?), epilepsy, Huntington's disease (shortage); sluggishness, lack of motivation (excess)	Sedatives (such as phenobarbital), alcohol, benzodiazepines (such as Valium, Halcion) (mimics effects)
Endogenous cannabinoids 內源型大麻素	Memory, attention, emotion, movement control, appetite	Chronic pain (shortage); memory and attention problems, eating disorders, schizophrenia (?) (excess)	R141716A (blocks effects of); Tetrahydrocannabinol (THC) (mimics effects of)

Outline

- 神經元 Neuron
  - 神經結構
  - 神經電生理
  - 神經突觸

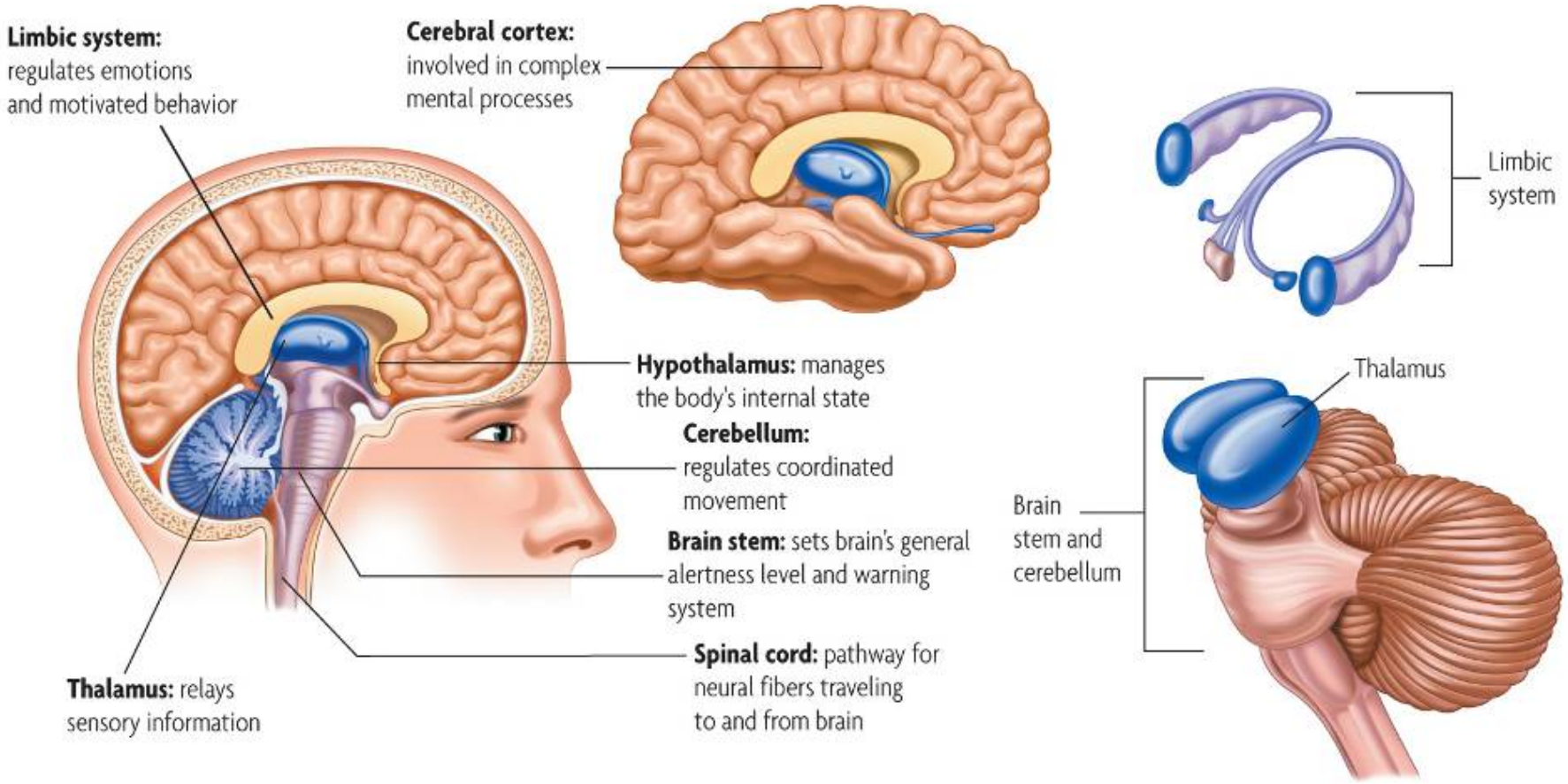
- 大腦 Brain
  - 大腦結構
  - 大腦皮質
  - 大腦皮質區功能

- 心智與腦 Mind and Brain

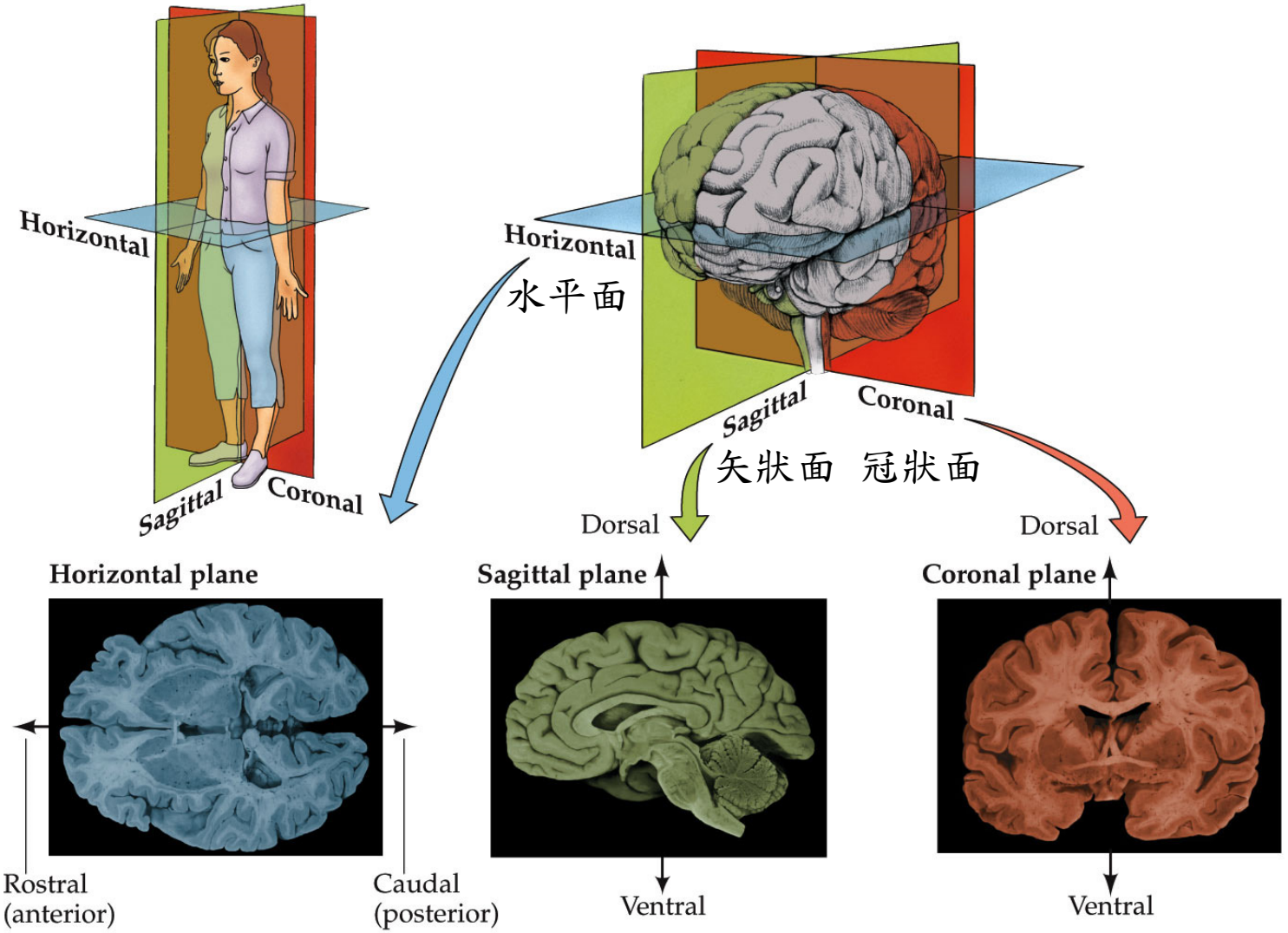


大腦結構

- The brain can be divided into three main parts: brain stem (腦幹), limbic system (邊緣系統), and cerebral cortex (大腦皮質).



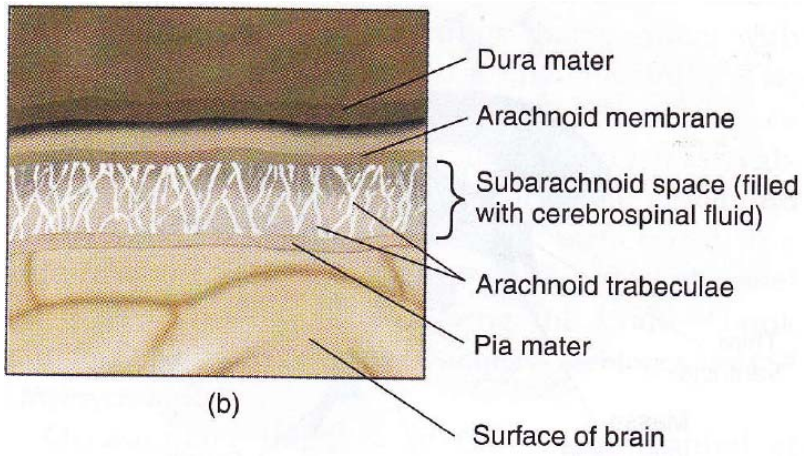
大腦方位名稱



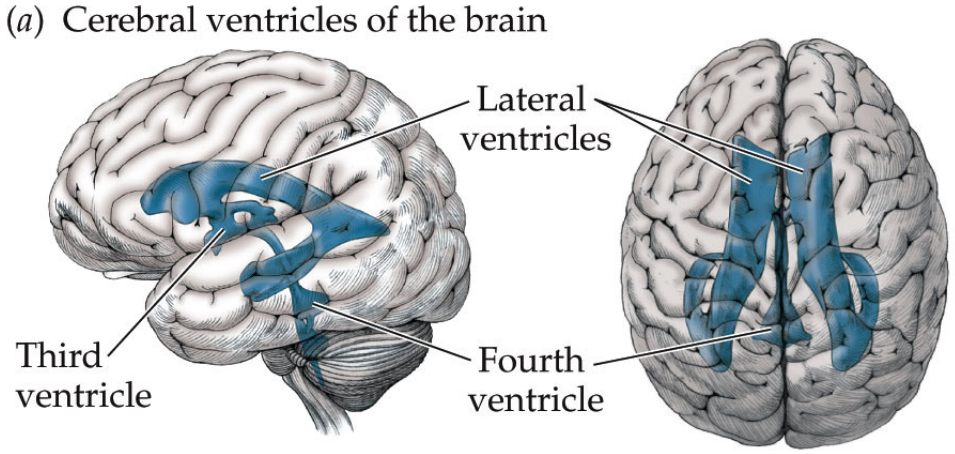
***Biological Psychology 6e*, Box 2.2**

大腦結構：腦室 ventricles

- Meninges (腦膜)：protective membranes
  - dura mater (硬腦膜): tough outermost sheet
  - arachnoid mater (蜘蛛膜)：含有腦脊液[cerebrospinal fluid, CSF，由I&II ventricles的脈絡叢(choroid plexus)製造]，負責保護腦組織與營養及廢物交換。頭部受傷常造成蜘蛛膜下腔（與軟腦膜間）出血。
  - pia mater (軟腦膜): adheres tightly to the surface of the brain.
- Ventricles (腦室)：側腦室(I and II)→第三腦室→第四腦室→3 openings below the cerevellum→蜘蛛膜下結構(absorbed back through large veins beneath the top of the skull)



Adapted from Carlson (2013) Physiology of Behavior, Figure 3.4

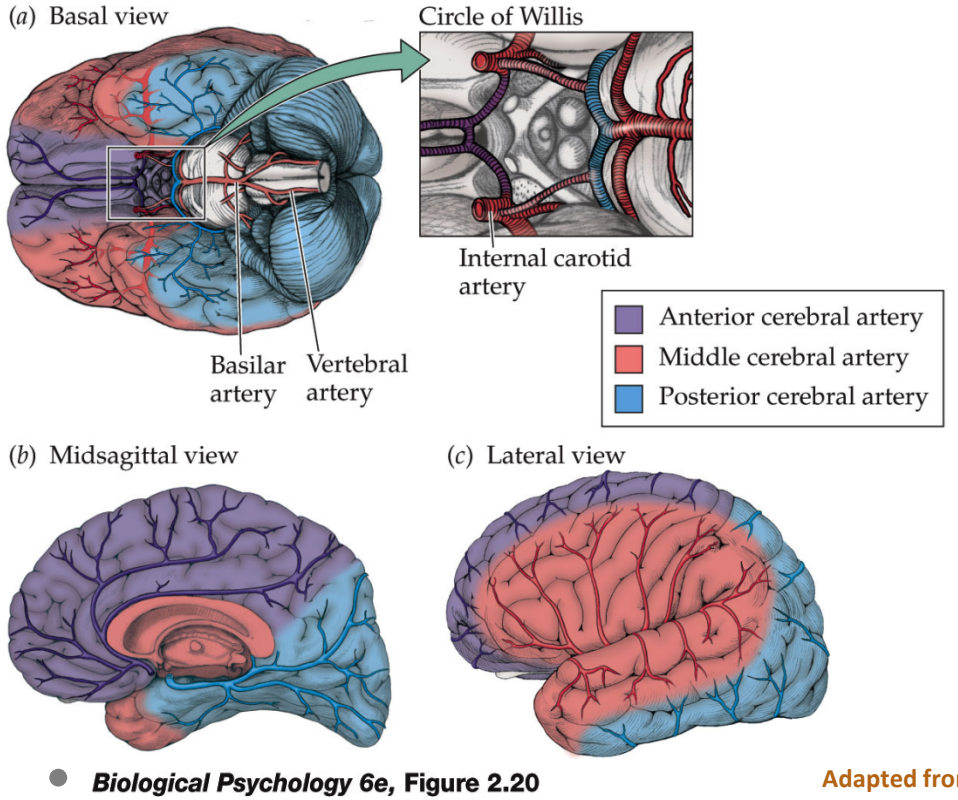


***Biological Psychology 6e*, Figure 2.19**

Adapted from Breedlove, Waston & Rosenzweig (2010) Biological Psychology

大腦結構: 血液循環系統 vascular system

- ~2%重量，消耗20%能量。依賴持續的血液供應。
- Carotid artery（頸動脈）→ external branch and internal branch → anterior and middle cerebral artery：供血給大腦半球的前半與中間(purple and pink)。
- Vertebral arteries（椎動脈）→ basilar artery→ posterior cerebral artery：供血給腦幹及半球後方。

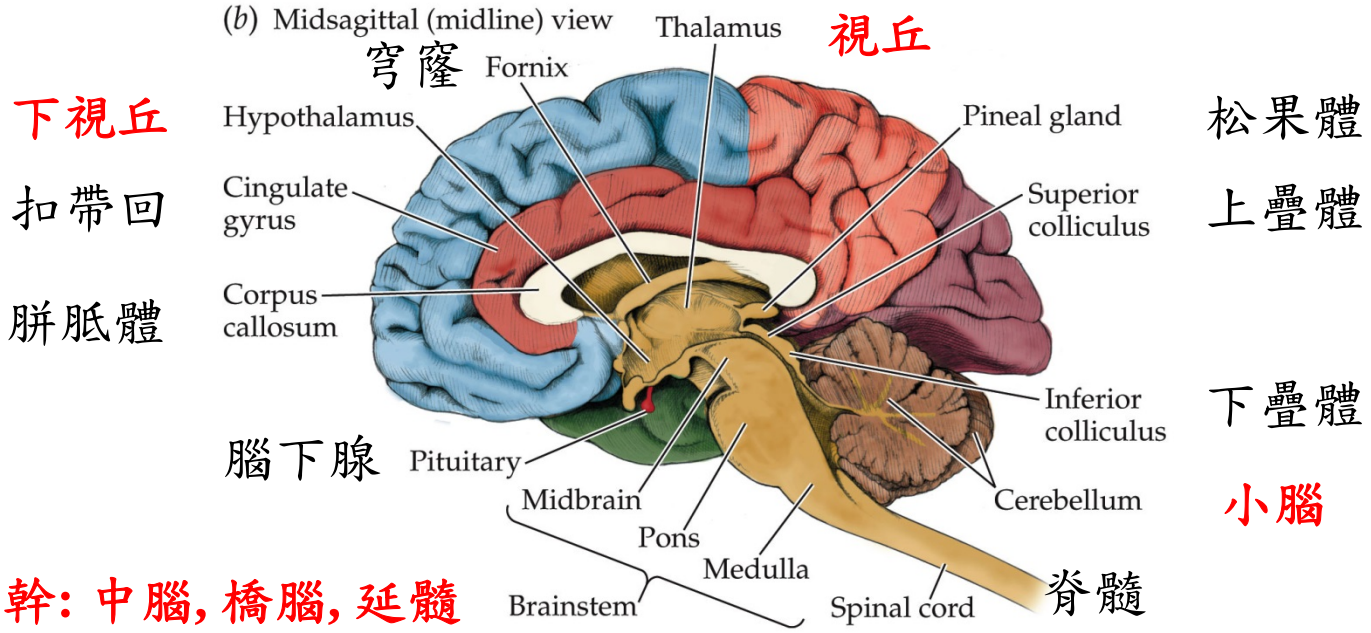


- Stroke (中風): brain lesions caused by a reduction/blockage of blood flow to the brain.
- Circle of Willis：三個血管交會使得彼此可以相互支援。從而減少中風的不利後果
- Blood-brain-barrier (BBB,血腦障蔽)：源於微血管的結構，緊密到使物質不易通過，使腦得到保護。

***Biological Psychology 6e*, Figure 2.20**

大腦結構： 腦幹 brain stem

- 視丘 (thalamus): 感覺訊息進入大腦皮層門檻。跟注意力/睡眠功能相關。
- 下視丘 (hypothalamus): 飢、渴、生殖、溫度、體內平衡。
- 橋腦(pons): 含重要之運動控制及感覺神經核(cranial nerve nucleus)。
- 延髓(medulla): 控制心跳、血壓、睡眠、清醒、及諸多腦神經核。所有連接脊椎跟腦的軸突都會經過此結構。
- 小腦(cerebellum): 運動與認知功能的控制。



Biological Psychology 6e, Figure 2.12 (Part 2)

大腦結構: 基底核 basal ganglia

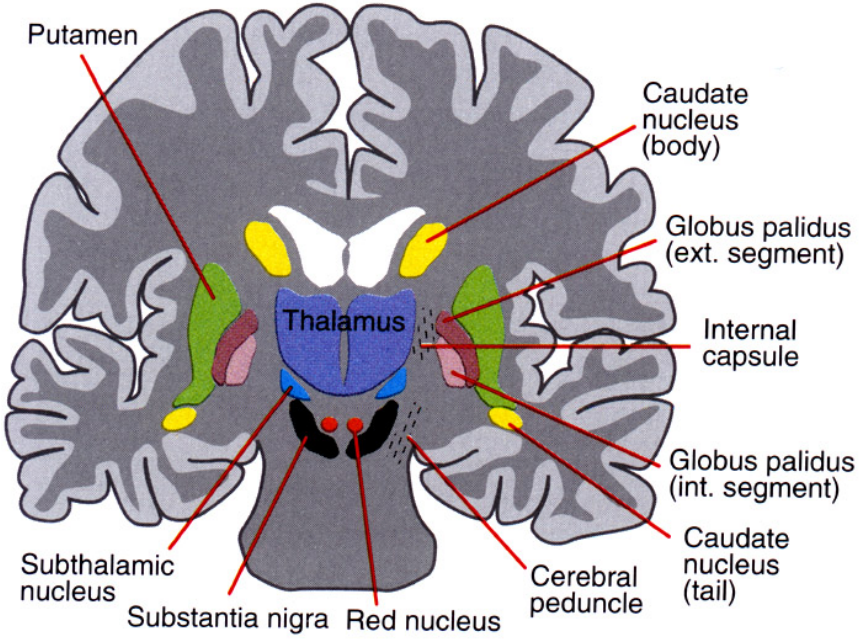
- Basal ganglia (基底核)：
  與運動控制有關。

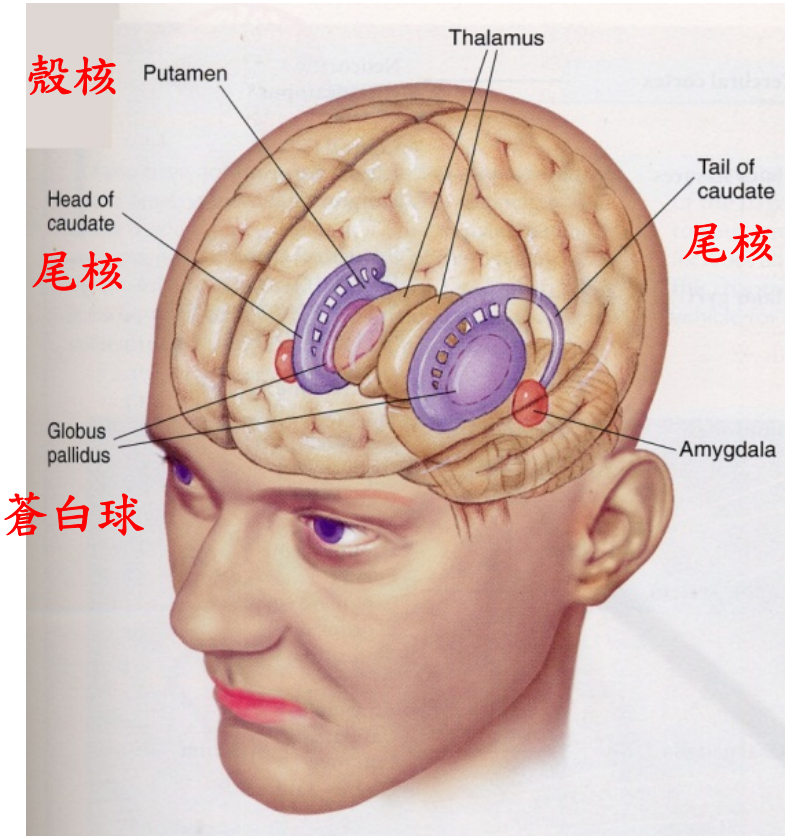
➢ caudate nucleus (尾核)

➢ putamen (殼核)

➢ globus pallidus (蒼白球)

➢ **substantia nigra (黑質體): Parkinson's**

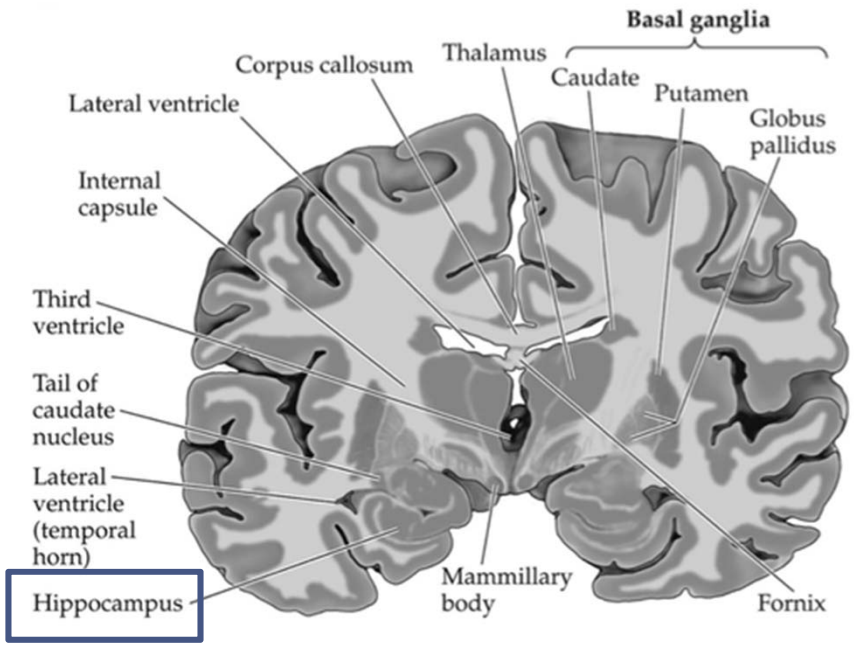


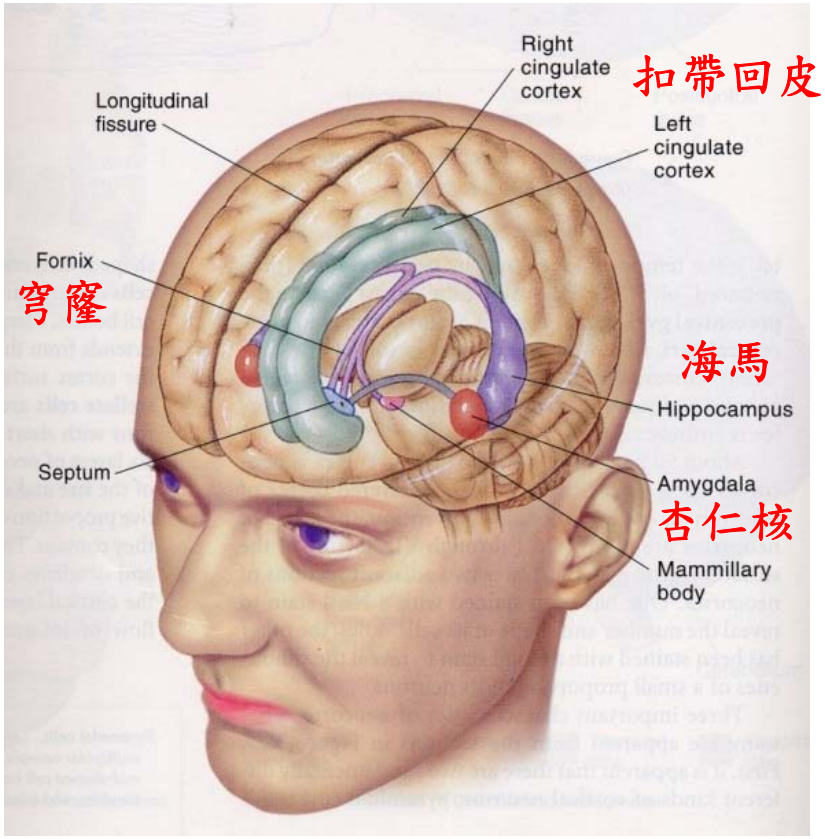


http://www.intechopen.com/books/basal-ganglia-an-integrative-view/clinical-motor-and-cognitive-neurobehavioral-relationships-in-the-basal-ganglia

大腦結構: 邊緣系統 limbic system

- Limbic system (邊緣系統)：
  - amygdala (杏仁核)：嗅覺與情緒。
  - hippocampus (海馬)：學習與記憶。
  - fornix (穹窿)為其輸出通道。
  - cingulate gyrus (扣帶回皮層)：情緒與注意力。
  - olfactory bulb and mammillary body.

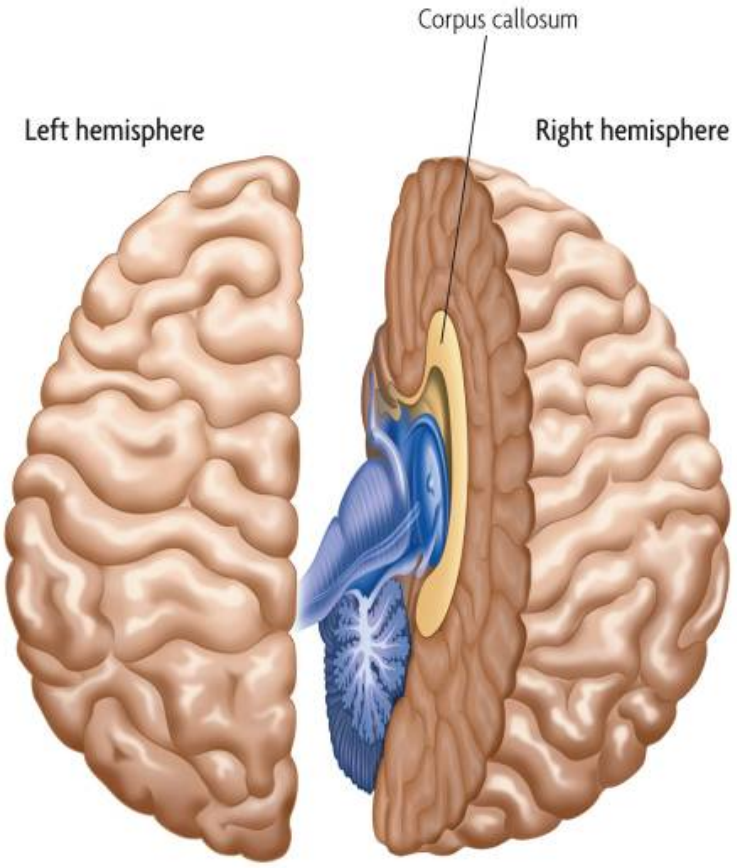




http://quizlet.com/12213357/neuro-block1-brain-int-feat-flash-cards/

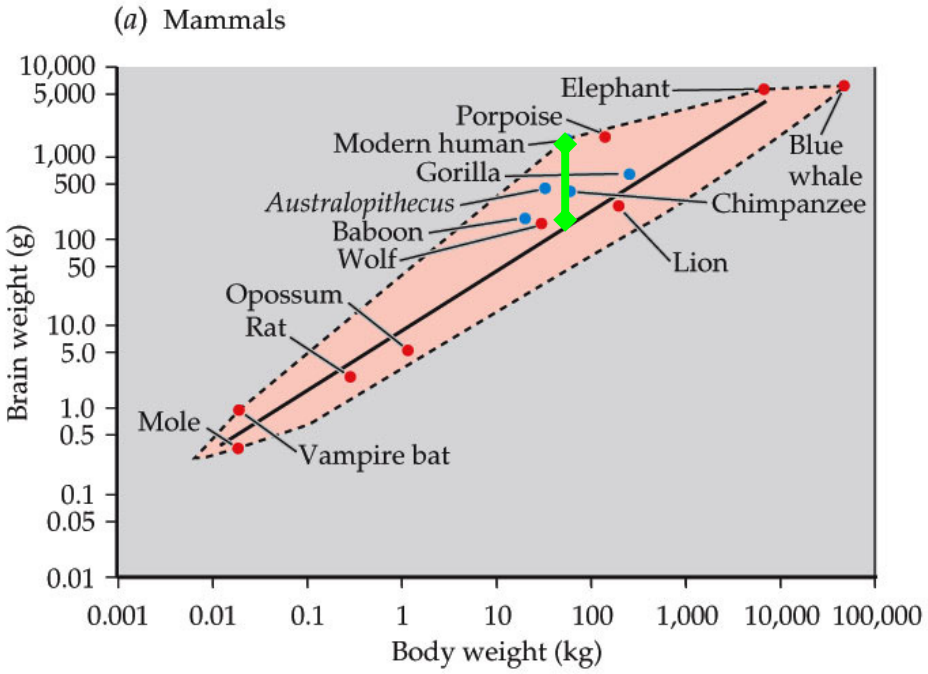
大腦結構: 大腦皮質 cerebral cortex

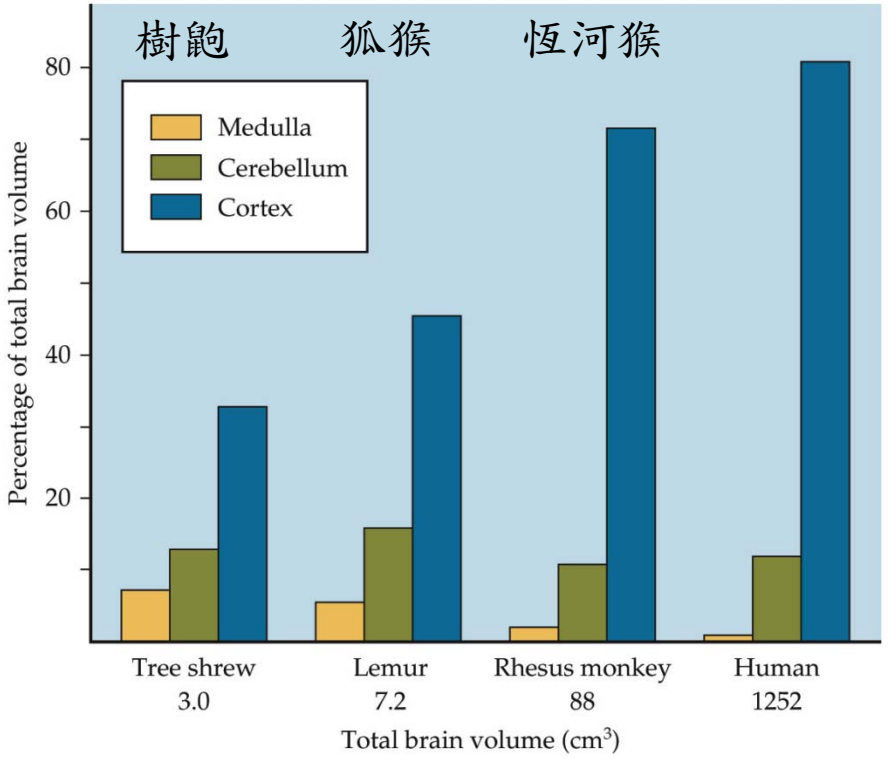
- The Brain (大腦)
  - ~1400 g, 2% of the human body weight
  - 腦迴(gyri, gyrus) : 突起部分
  - 腦溝(sulci, sulcus) : 凹陷部分
- Cerebral Cortex (大腦皮質):
  - 大腦的最外層
  - 由高達數十億個細胞所組成
  - 大腦皮層厚度約是 0.25 cm
- Cerebral Hemispheres (大腦半球):
  - 由左右兩個半球組成。左半球控制右邊身體，右半球控制左邊身體。
  - 兩半球間由胼胝體 (corpus callosum) 連接



大腦皮質(Cerebral Cortex)



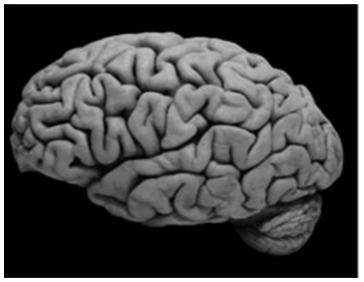





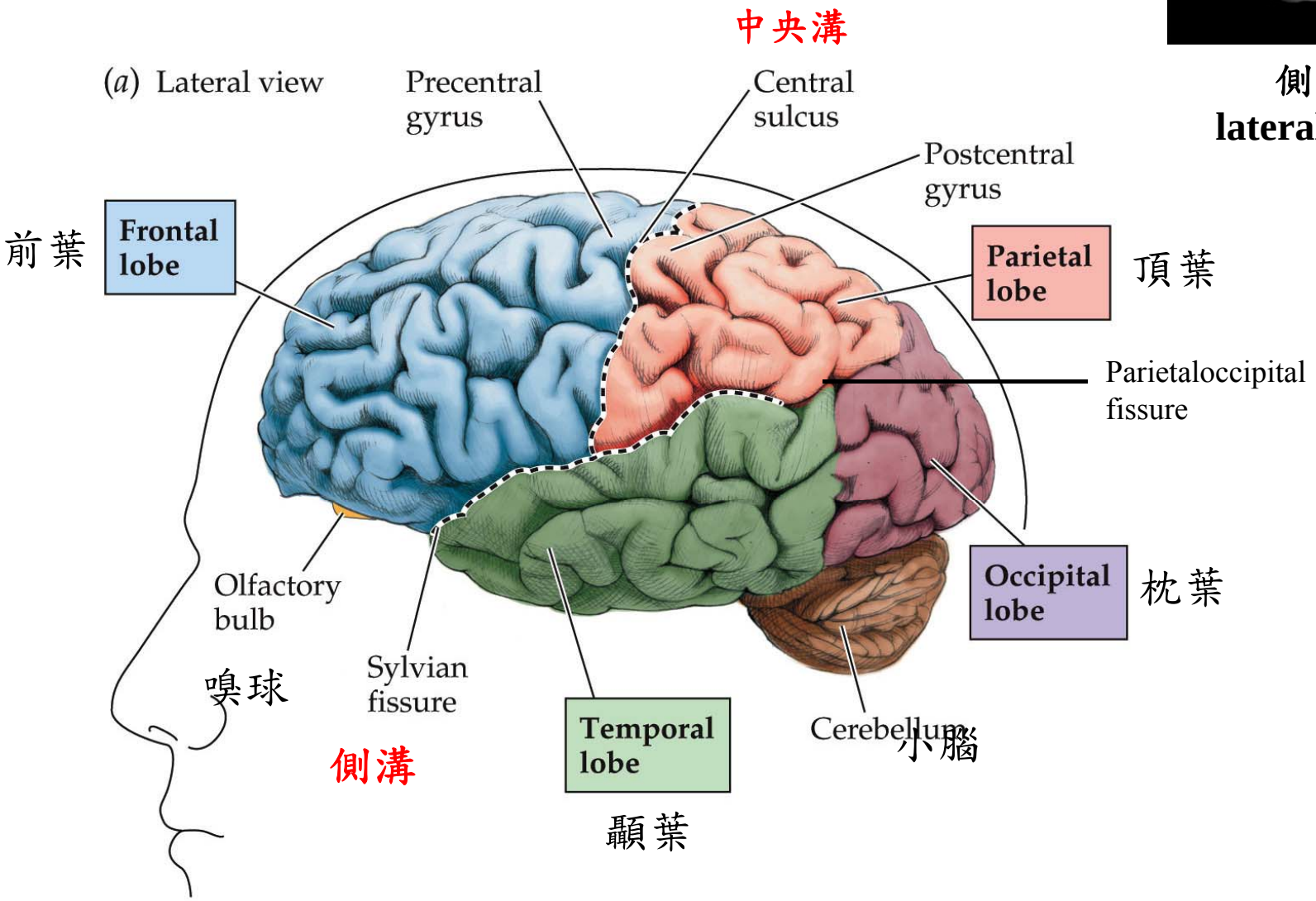
***Biological Psychology 6e*, Figure 6.12**

***Biological Psychology 6e*, Figure 6.15**

大腦皮質



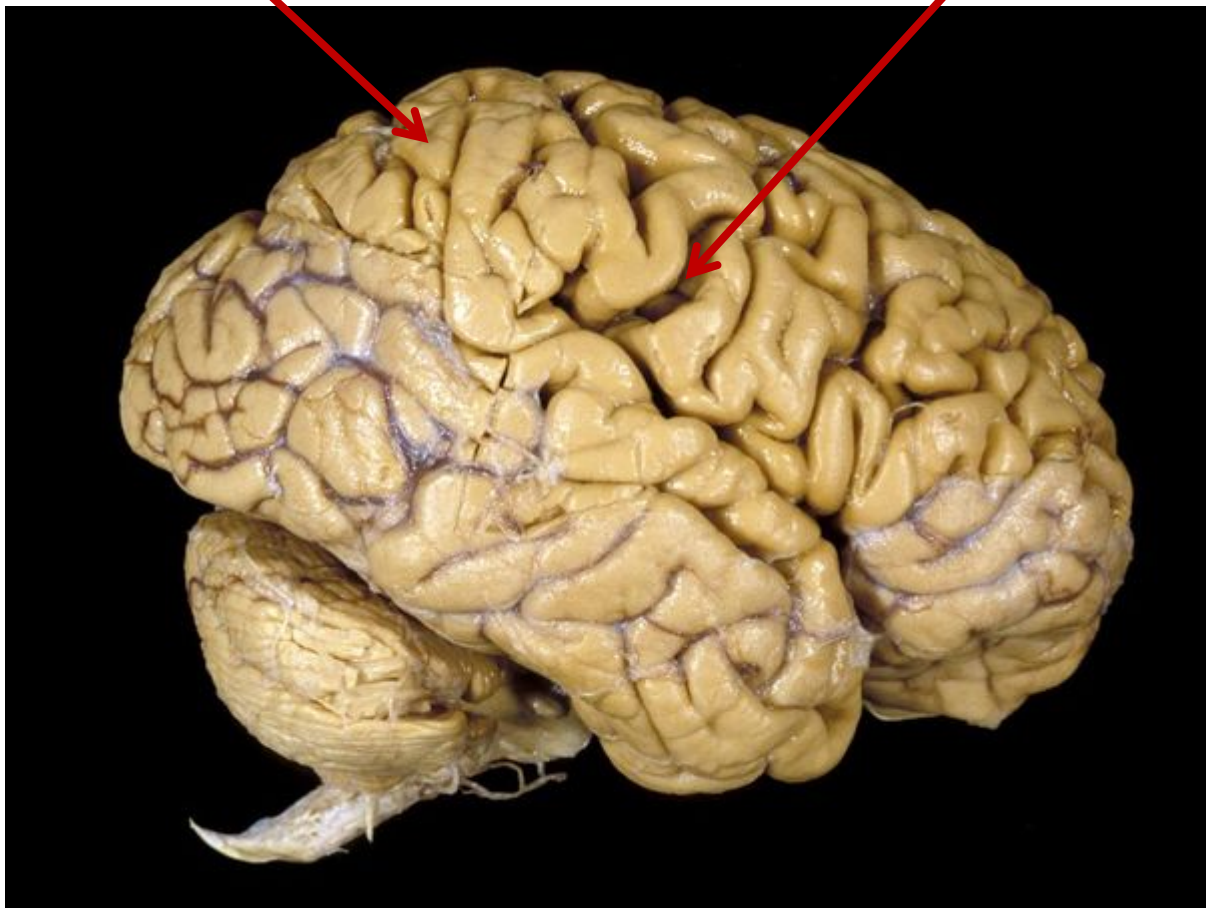
側面
lateral view



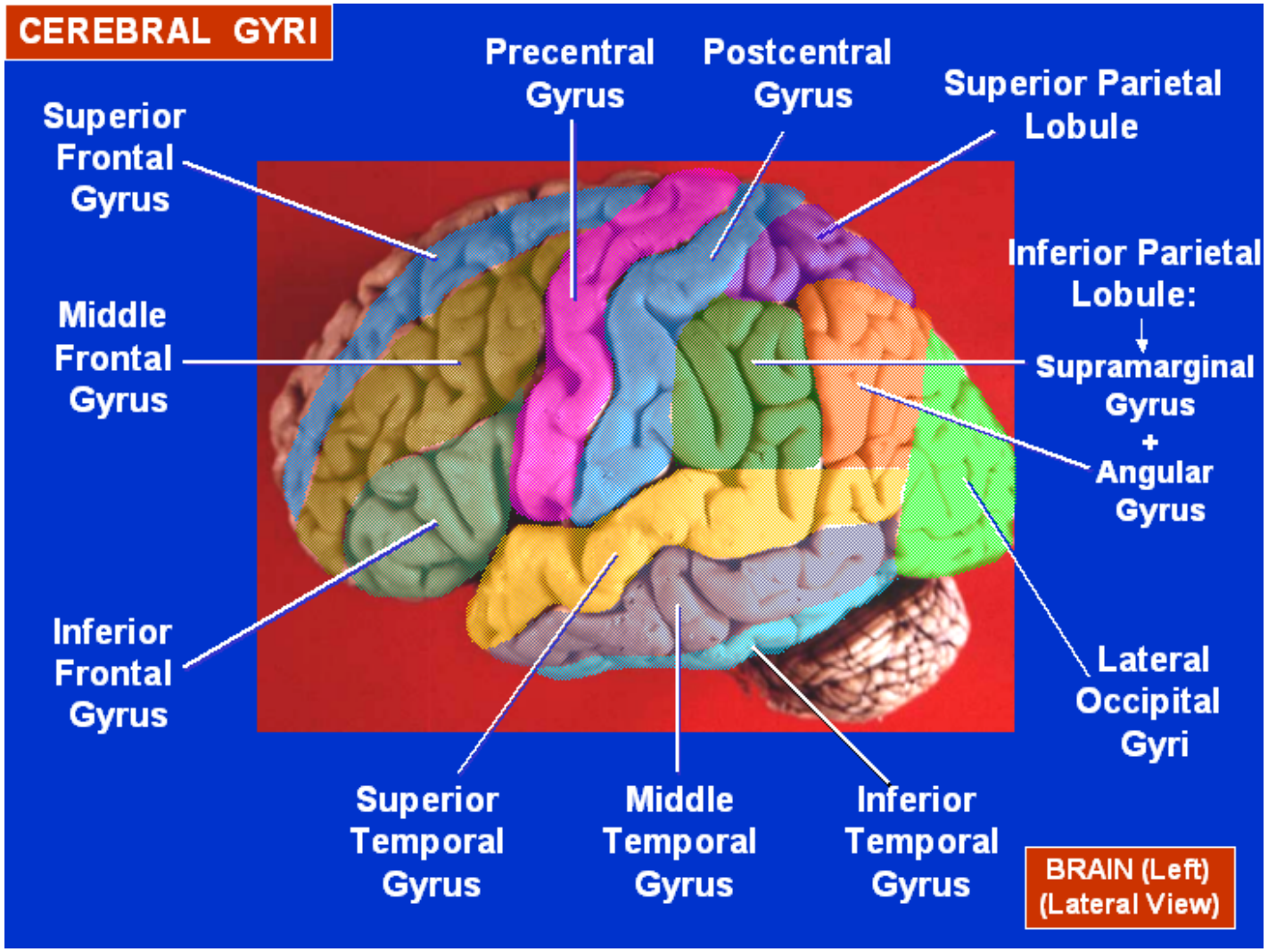
Biological Psychology 6e, Figure 2.12 (Part 1)

大腦皮質

腦迴(gyri, gyrus)：突起部分　　腦溝(sulci, sulcus)：凹陷部分

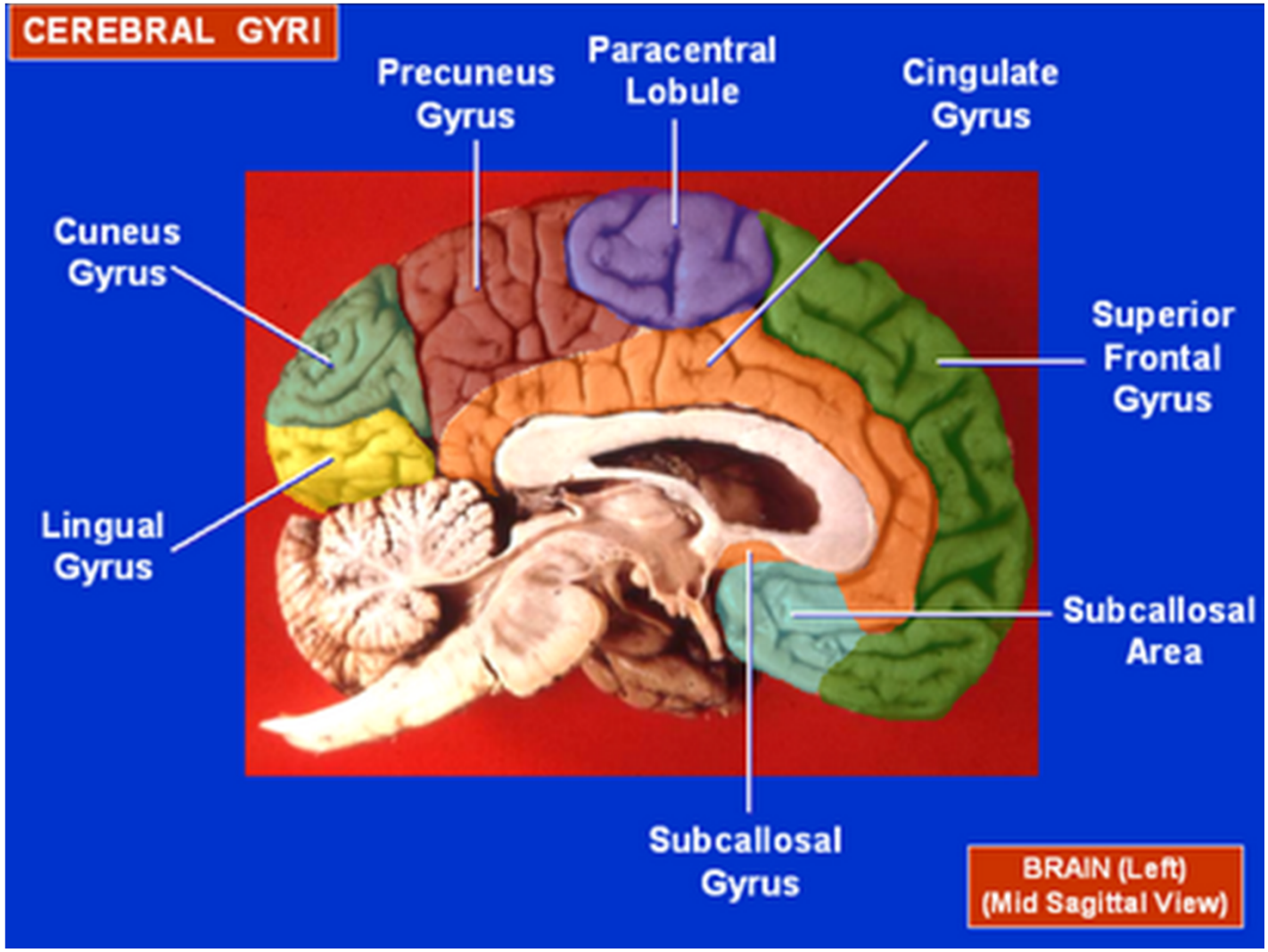


大腦皮質: 腦迴



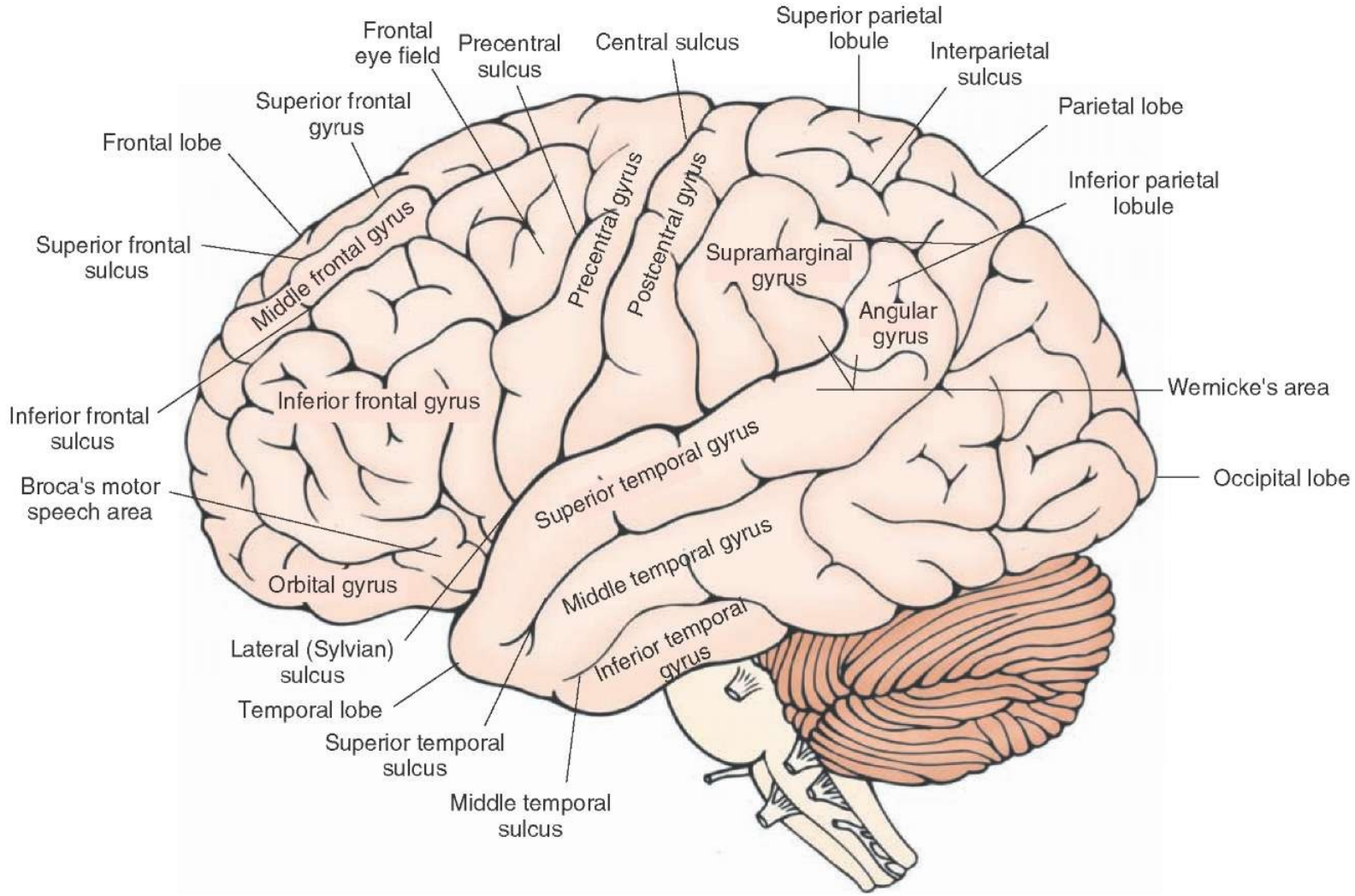
http://commons.wikimedia.org/wiki/File:Cerebral_Gyri_-_Lateral_Surface.png

大腦皮質: 腦迴



http://commons.wikimedia.org/wiki/File:Cerebral_Gyri_-_Lateral_Surface.png

大腦皮質: 腦迴與腦溝

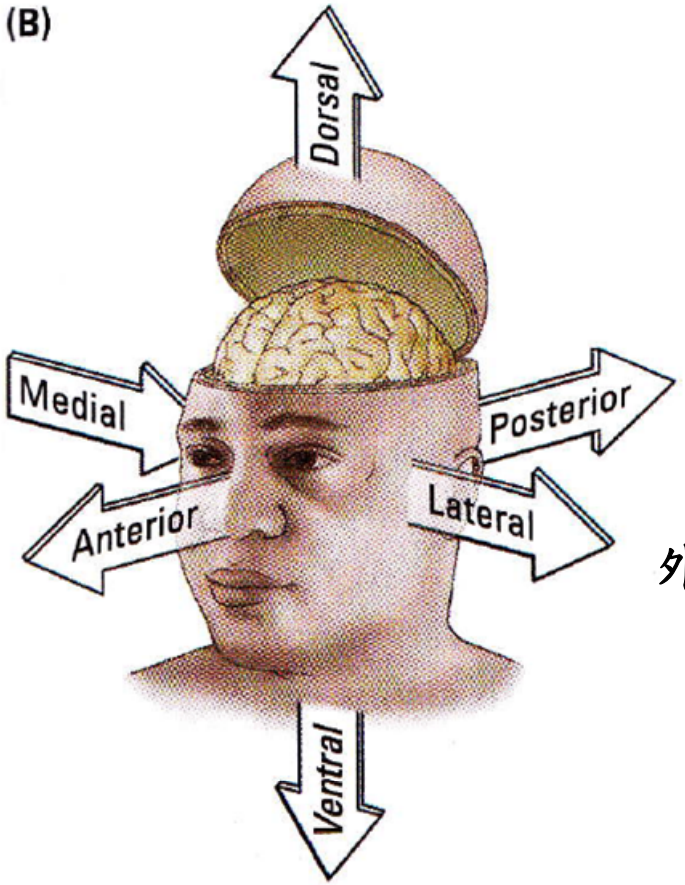


http://what-when-how.com/neuroscience/overview-of-the-central-nervous-system-gross-anatomy-of-the-brain-part-1/

大腦方位名稱

背側 Dorsal

內側 Medial



後端 Posterior

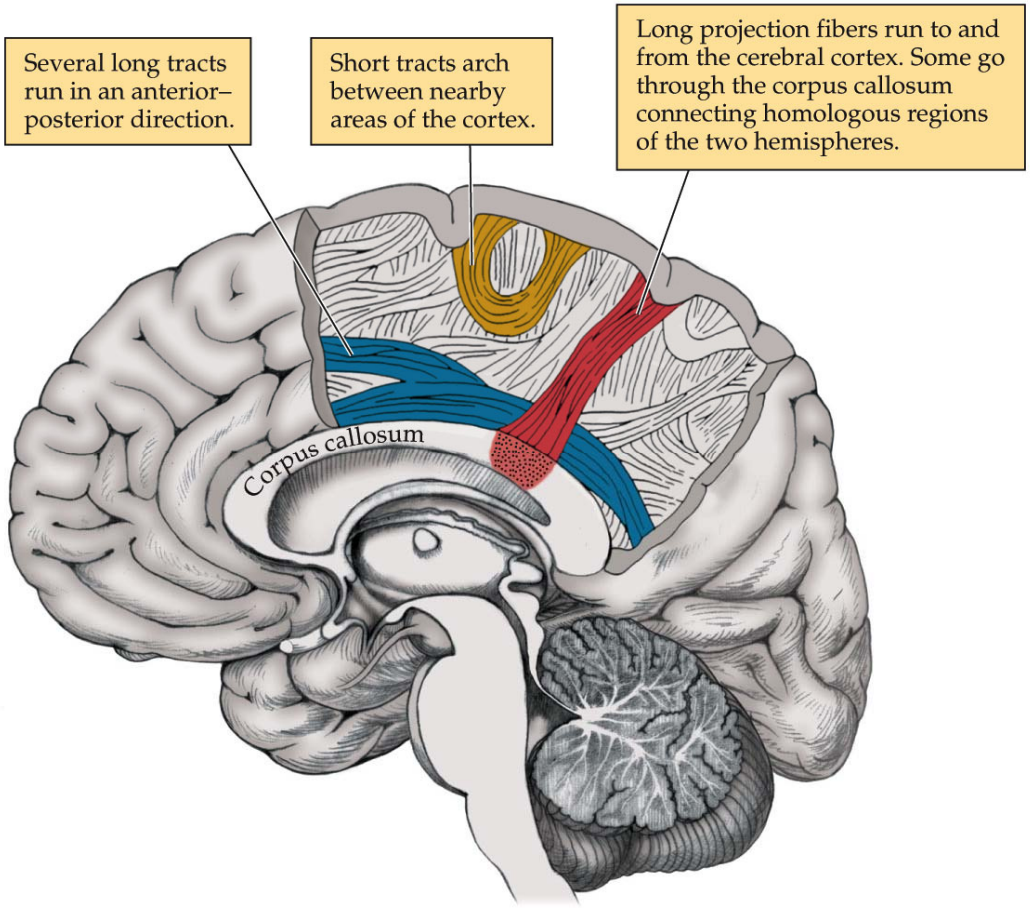
前端 Anterior

外側 Lateral

腹側 Ventral

大腦皮質

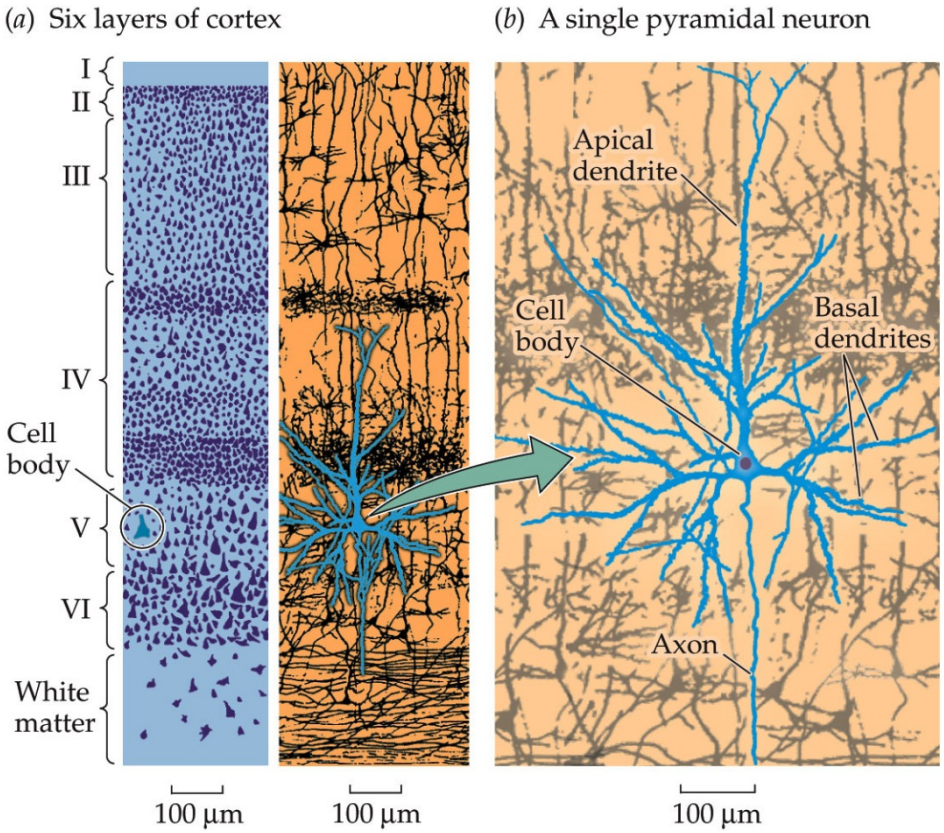
- white matter (白質):由神經纖維組成，藏在皮層底下或內部。



- 短聯結(short tracts)：連絡鄰近的大腦區域。Ex: 箭形束(arcuate fasciculus)。
- 長聯結(long tracts)：連絡遠距/左右半球的大腦區域。Ex: 胼胝體(corpus callosum)、前後交叉束(anterior or posterior commissure)

大腦皮質

- gray matter (灰質): 由神經細胞組成，在大腦皮質表面。
  - **Neocortex** (isocortex): neurons arranged in 5-6 distinct layers.
  - Some structures are made up allocortex: with 3 layers or unlayered.



- L-1: neural fibers
- L-2/3 (super-granular): small pyramidal cells (錐狀細胞), sending information to other cortical areas and to L-5/6.
- L4: granular cells (粒狀細胞), the input layer.
- L-5/6 (infra-granular): larger pyramidal cells, sending information to subcortical structures.

Biological Psychology 6e, Figure 2.17

Adapted from Breedlove, Waston & Rosenzweig (2010) Biological Psychology

大腦皮質

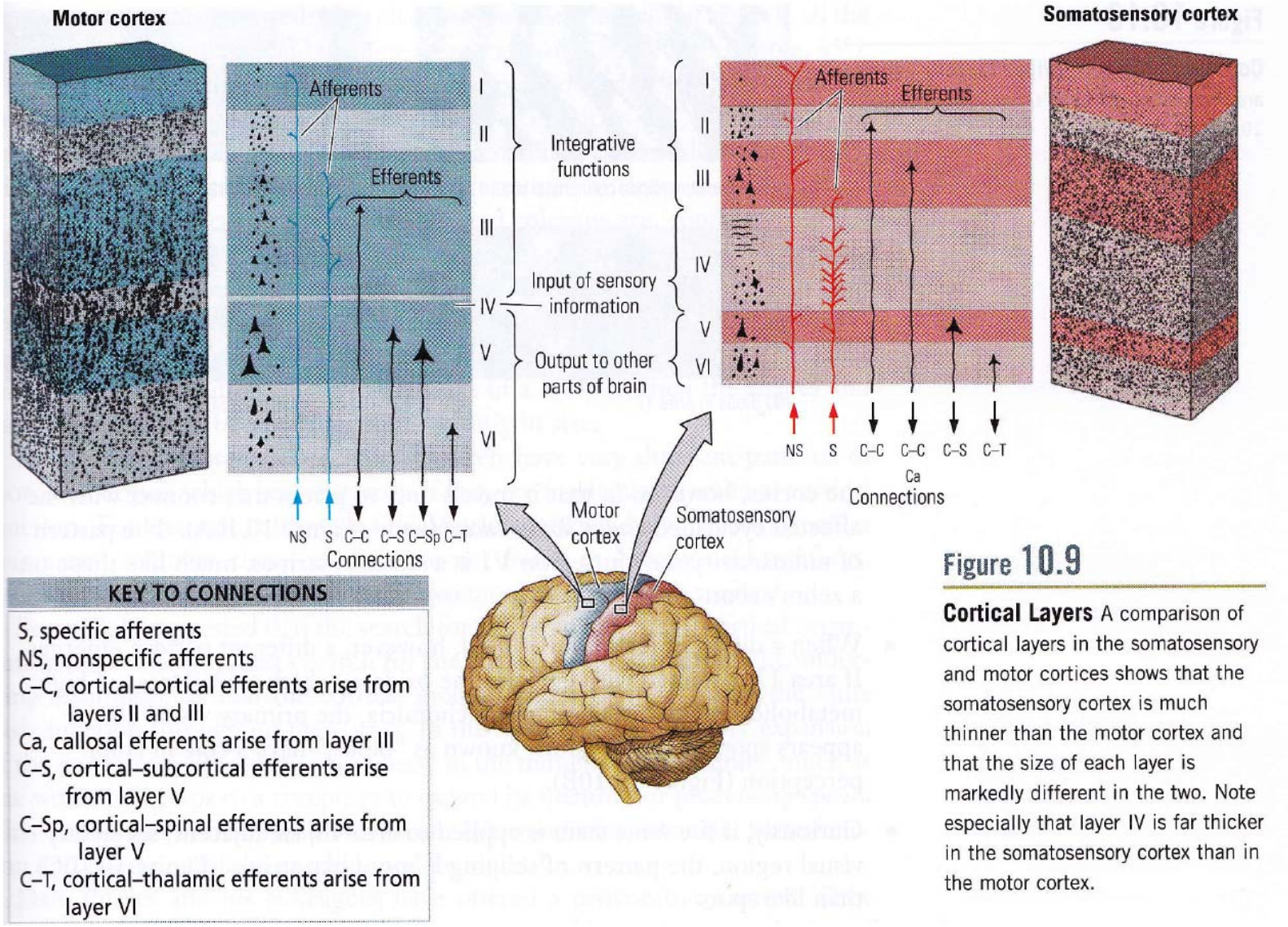
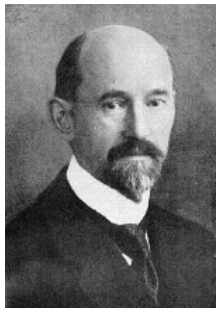


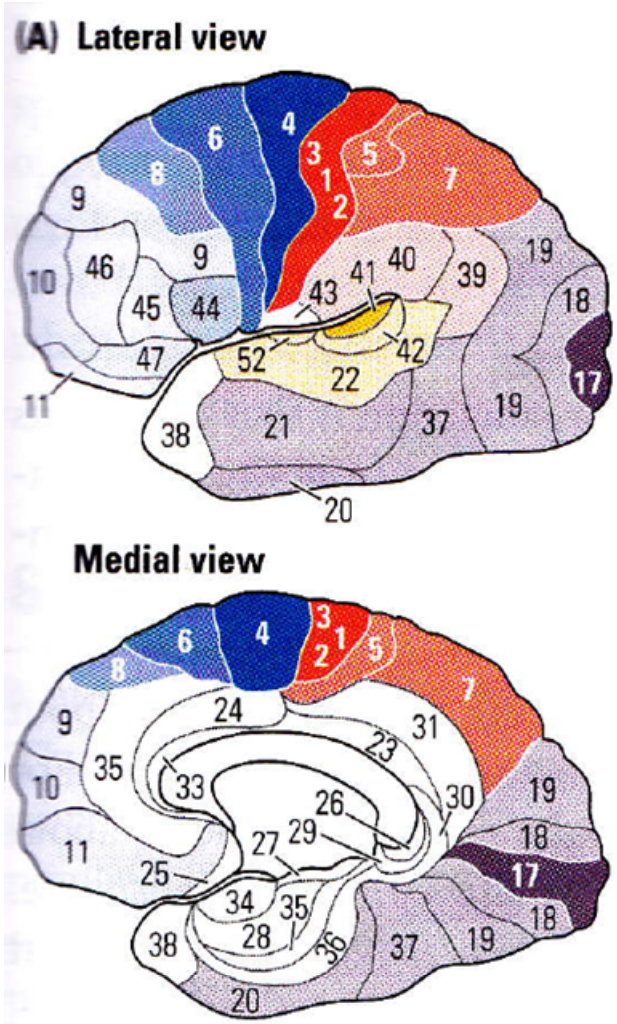
Figure 10.9

Cortical Layers A comparison of cortical layers in the somatosensory and motor cortices shows that the somatosensory cortex is much thinner than the motor cortex and that the size of each layer is markedly different in the two. Note especially that layer IV is far thicker in the somatosensory cortex than in the motor cortex.

大腦皮質功能



Korbinian Brodmann

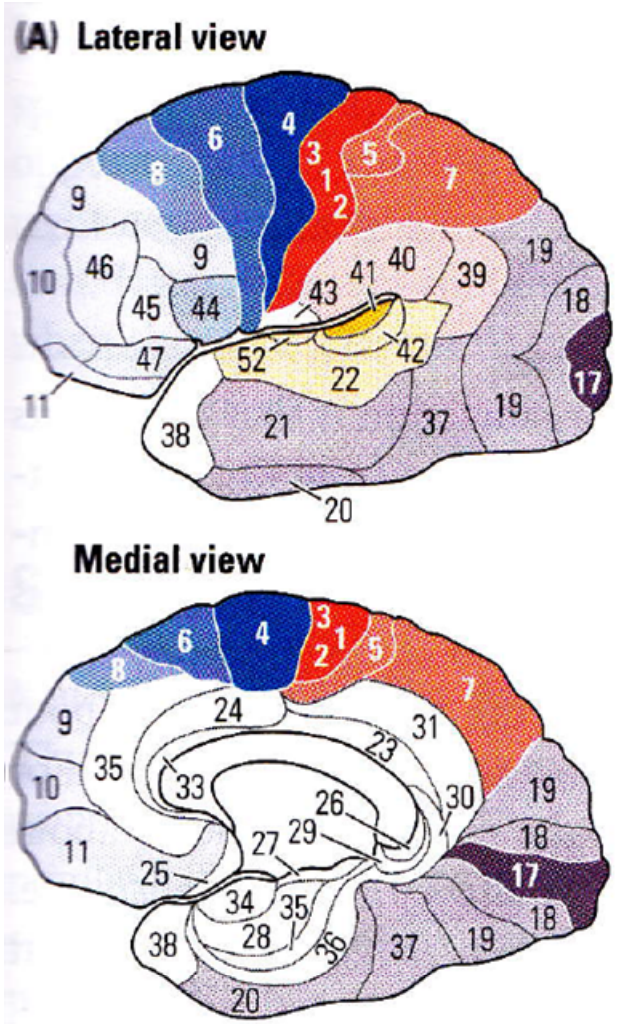


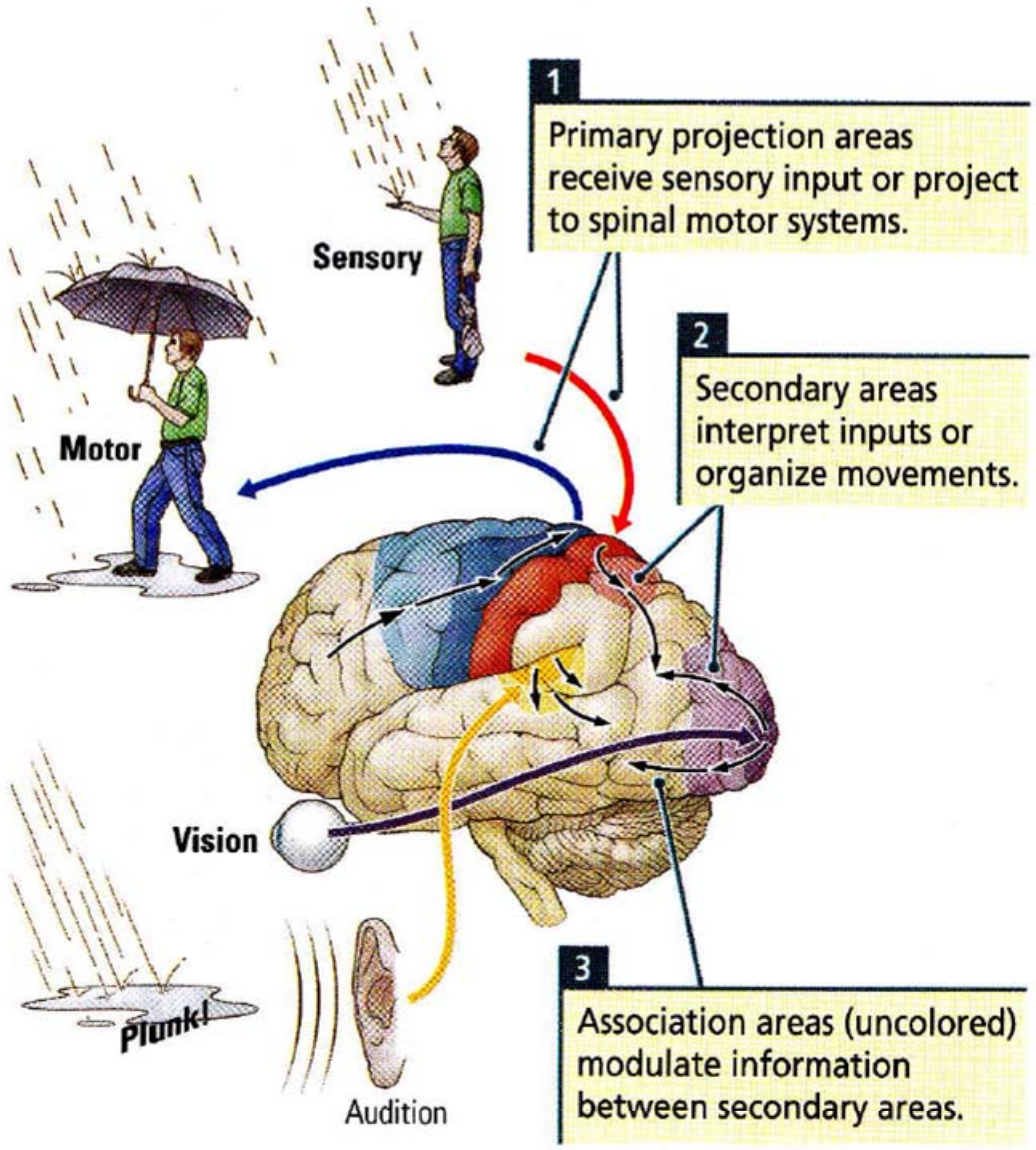
(B)

Function	Map code	Brodmann area
Vision		
primary		17
secondary		18, 19, 20, 21, 37
Auditory		
primary		41
secondary		22, 42
Body senses		
primary		1, 2, 3
secondary		5, 7
Sensory, tertiary		7, 22, 37, 39, 40
Motor		
primary		4
secondary		6
eye movement		8
speech		44
Motor, tertiary		9, 10, 11, 45, 46, 47

依照細胞的大小排列及形態，Brodmann曾經把皮層分成40幾個區域。

大腦皮質功能





Adapted from Kolb & Whishaw (2009) Fundamentals of Human Neuropsychology, Figure 3.23

www.thehumanbrain.info

Brain – The Atlas of the Human Brain in Stereotaxic Space

A short introduction in to the Atlas of the Human Brain and the Brain used throughout for the research on this site. To take a more systematical approach to the use of the provided material both on the DVD from the "Atlas of the Human Brain" and the applications you can find on this website the following explanatory steps might help.

Figure 1:
The Brain used for research in the "Atlas of the Human Brain" and which are used for the main applications is from a 24-year-old male from the Vogt collection in Düsseldorf. Further details about The Brain .
The overall layout of the Atlas and the website is based on the diffentiation of the macroscopic area which is mainly represented in the Head & Brain area.

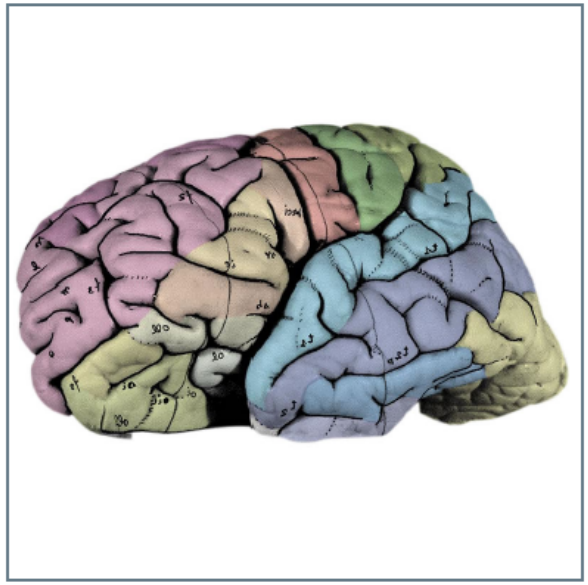
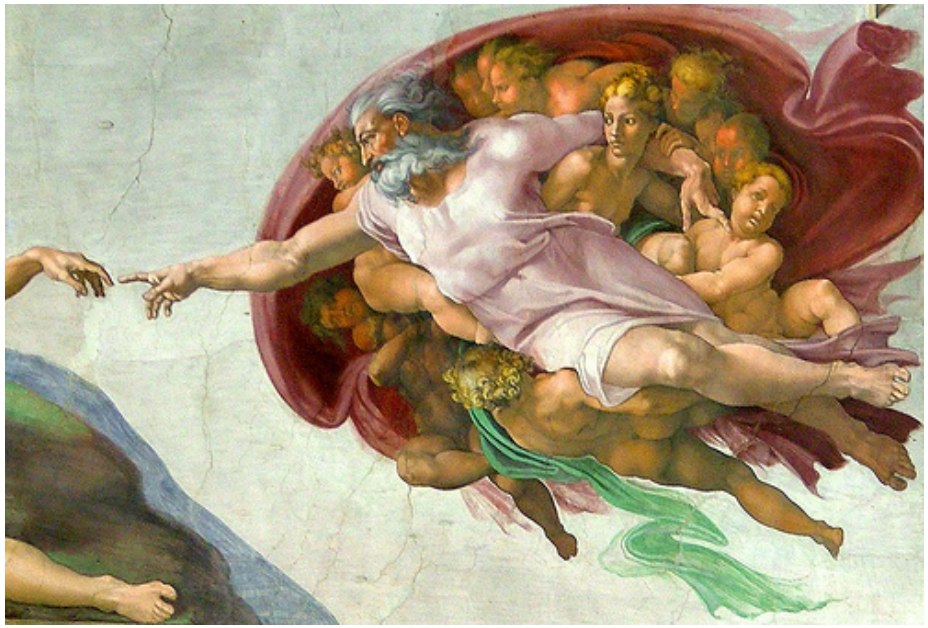


Figure 2:
After determining the surface of the brain the brain is cut in 5 blocks prior to the sectioning process according to the sterotaxic space. Photographs and diagrams are available in the "Atlas of the Human Brain" and in the sections area whereas you can also find the very brain in the corresponding virtual microscopy (nissl staining).

Figure 3:
Following the delineation process based on analysis of the cyto- and myelostructure of each slice, there are several reconstructions in three dimensions. The 3D Models of the thalamic and subthalamic structures, distinguished nuclei and their subdivisions are visually represented in the 3D Reconstruction area.

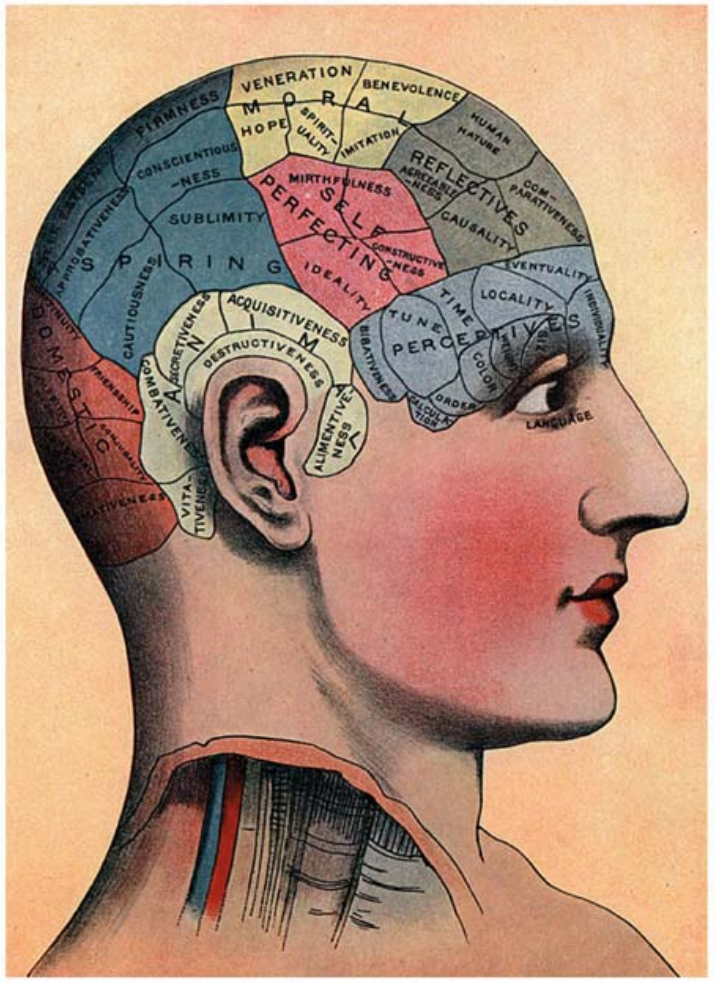
Outline

- 神經元 Neuron
  - 神經結構
  - 神經電生理
  - 神經突觸
- 大腦 Brain
  - 大腦結構
  - 大腦皮質
  - 大腦皮質區功能
- 心智與腦 Mind and Brain

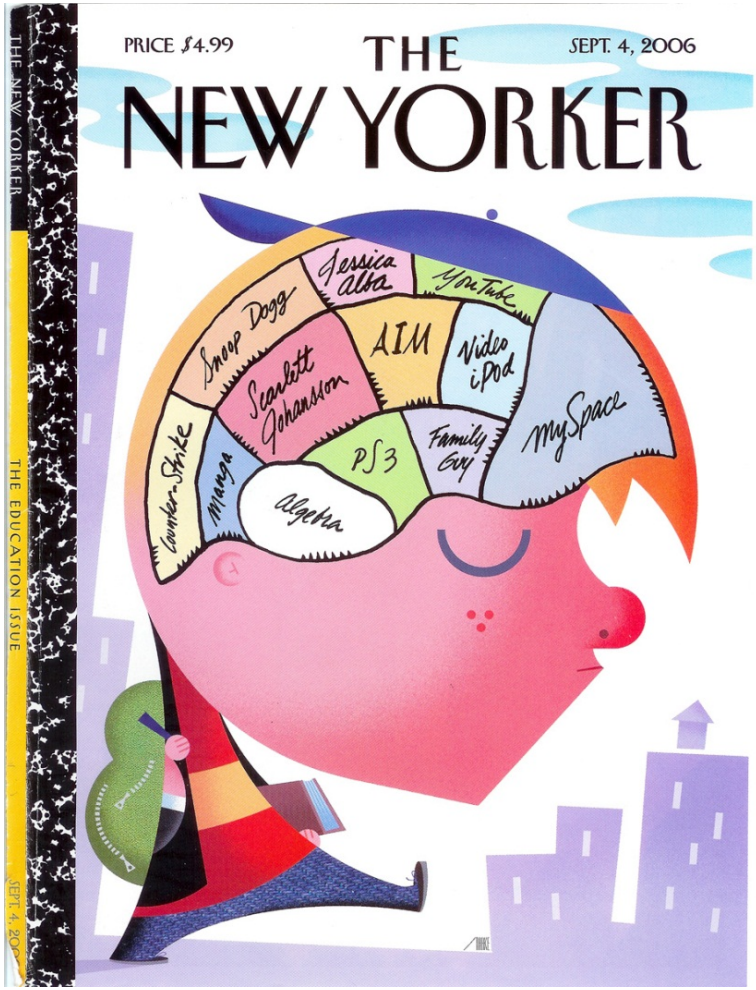


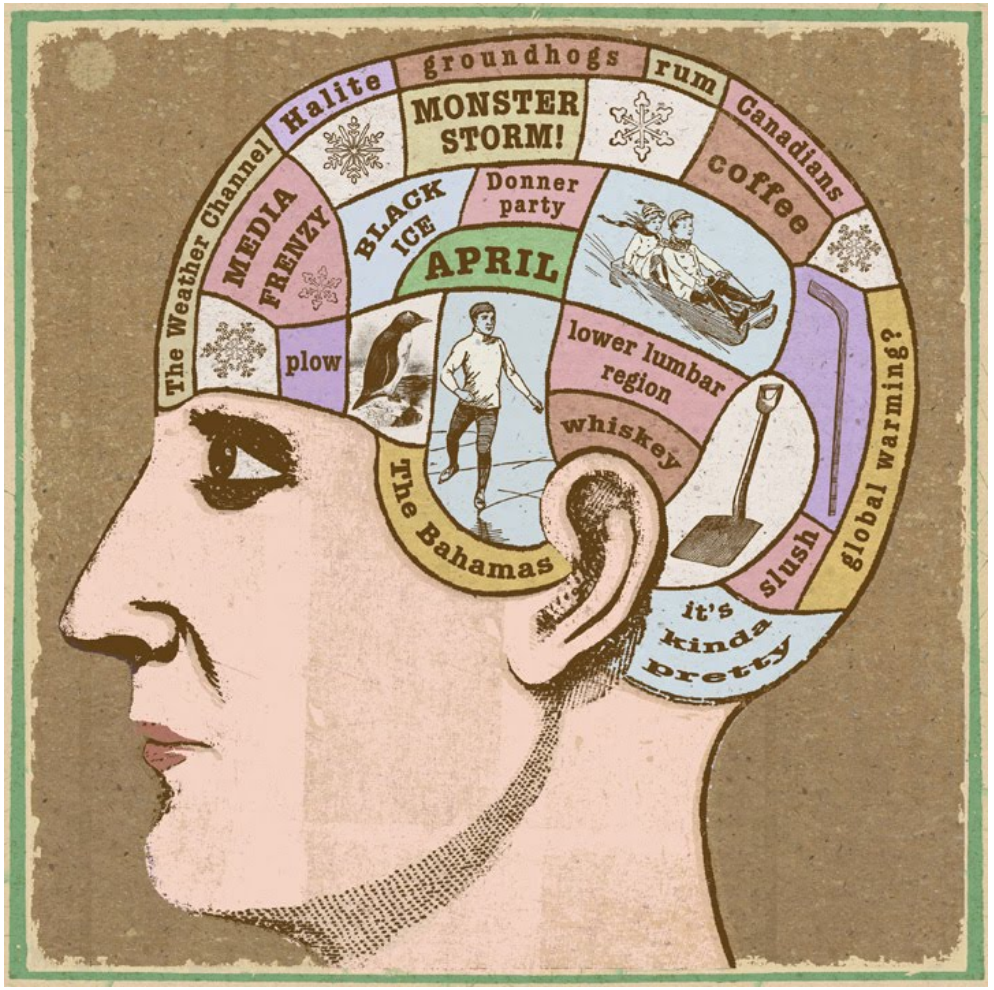
大腦功能: Phrenology

- **Gall** (1758-1828): 創立了「**顱相學**」(phrenology)，認為腦可以區分成不同的部位，各自掌管某種心理的特徵，並且使頭顱相應的骨頭稍稍隆起，因此從顱骨外型的凹凸與面積大小，可以判斷一個人的心理特徵及不同的心理機能。
  - 在**19世紀**一度風靡歐美各國，許多追隨者不斷宣稱自己又發現了頭顱的某某“新區” 及代表某種精神特質。
  - 這個學說未有確切的證據證實頭顱外形與人的聰明智慧和個性品質有關，僅僅是一種主觀的推斷，因此逐漸為時代所淘汰。
  - **The whole brain is active when we are doing almost any task.**

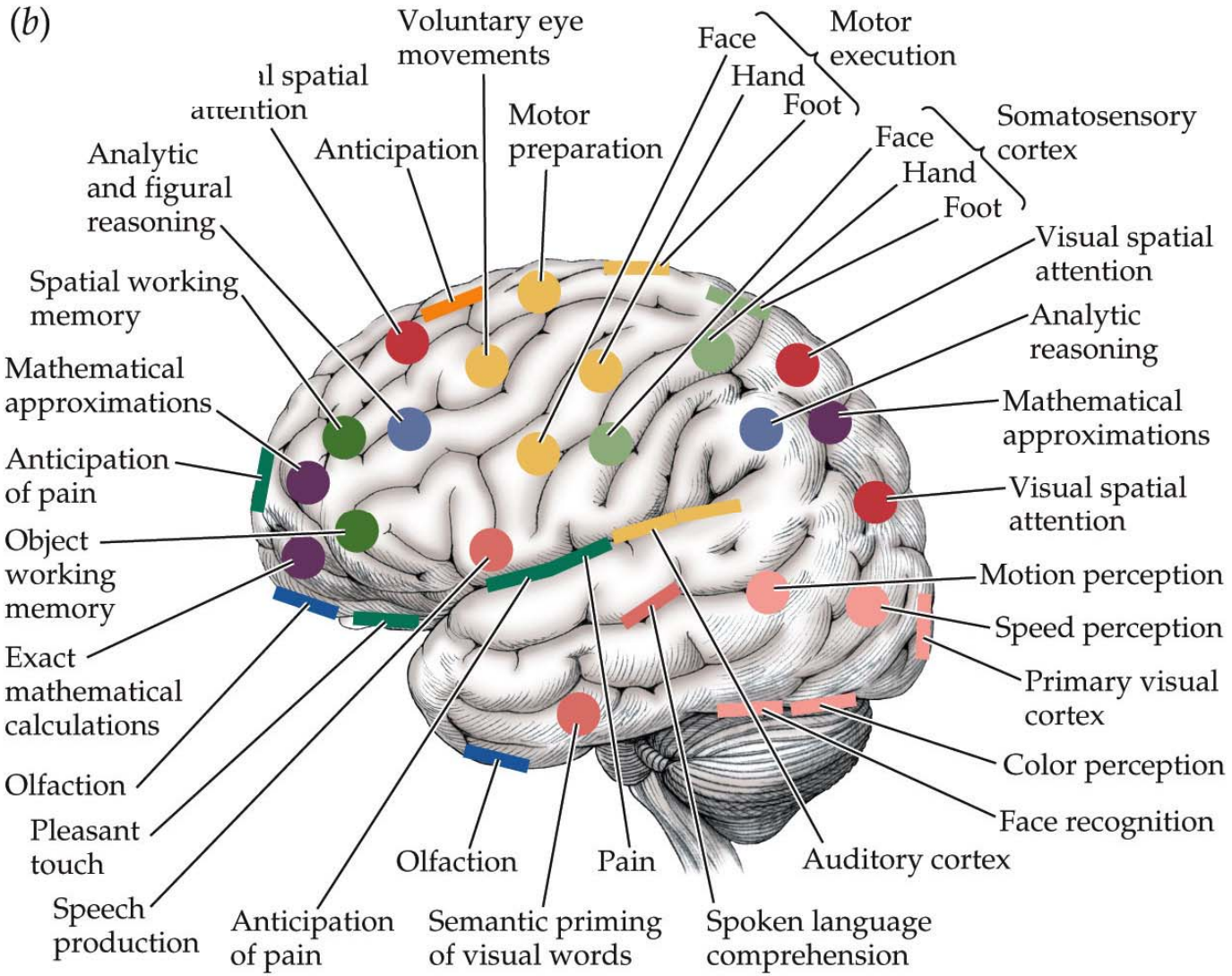


大腦功能: New phrenology?





大腦功能: New phrenology

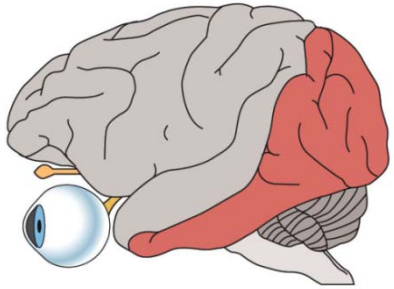


***Biological Psychology 6e*, Figure 1.11 (Part 2)**

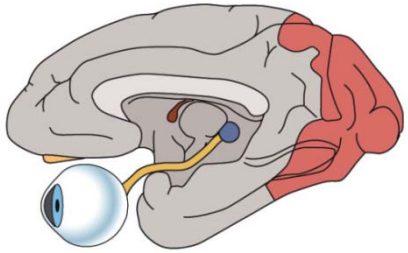
Adapted from Breedlove, Waston & Rosenzweig (2010) Biological Psychology

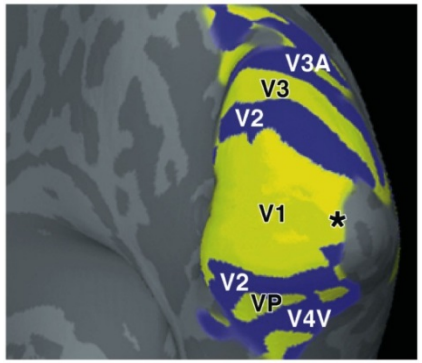
大腦神經網絡: Visual Functions

(*a*) Macaque brain, lateral view



(*b*) Macaque brain, medial view





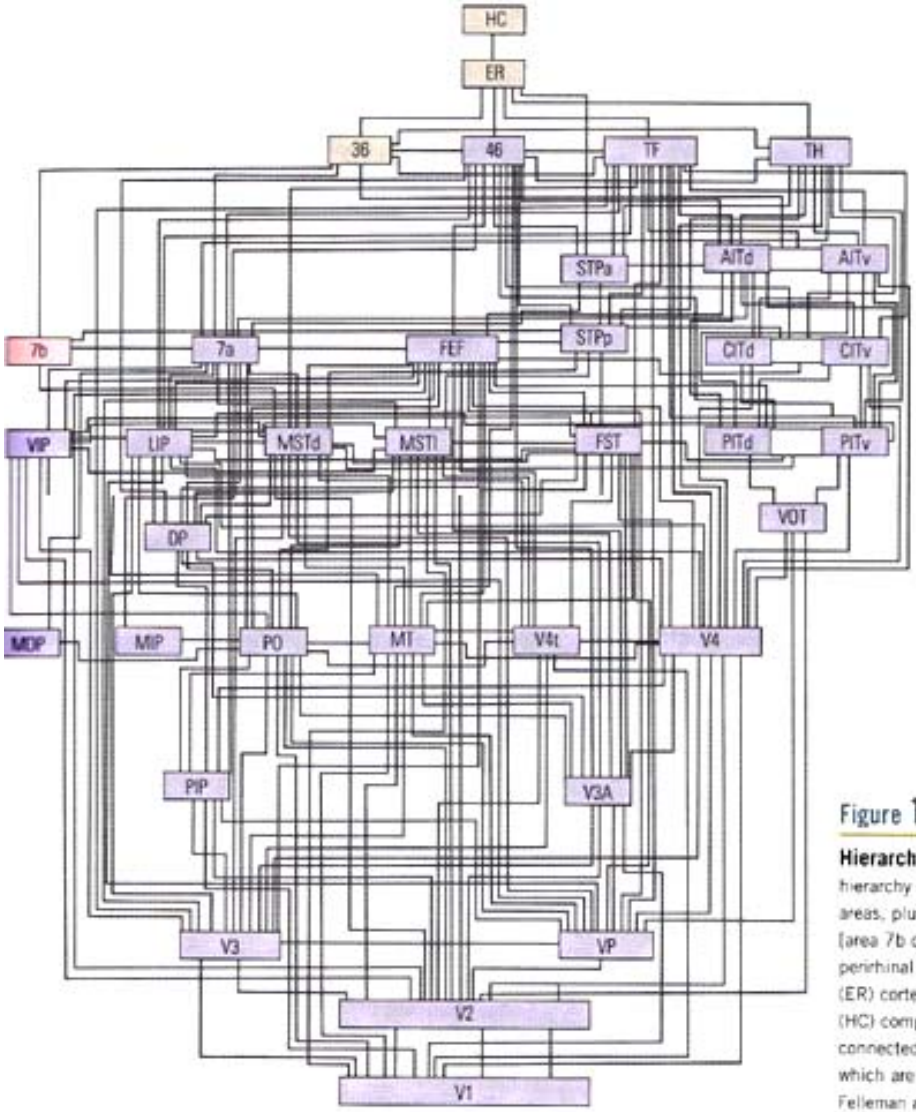
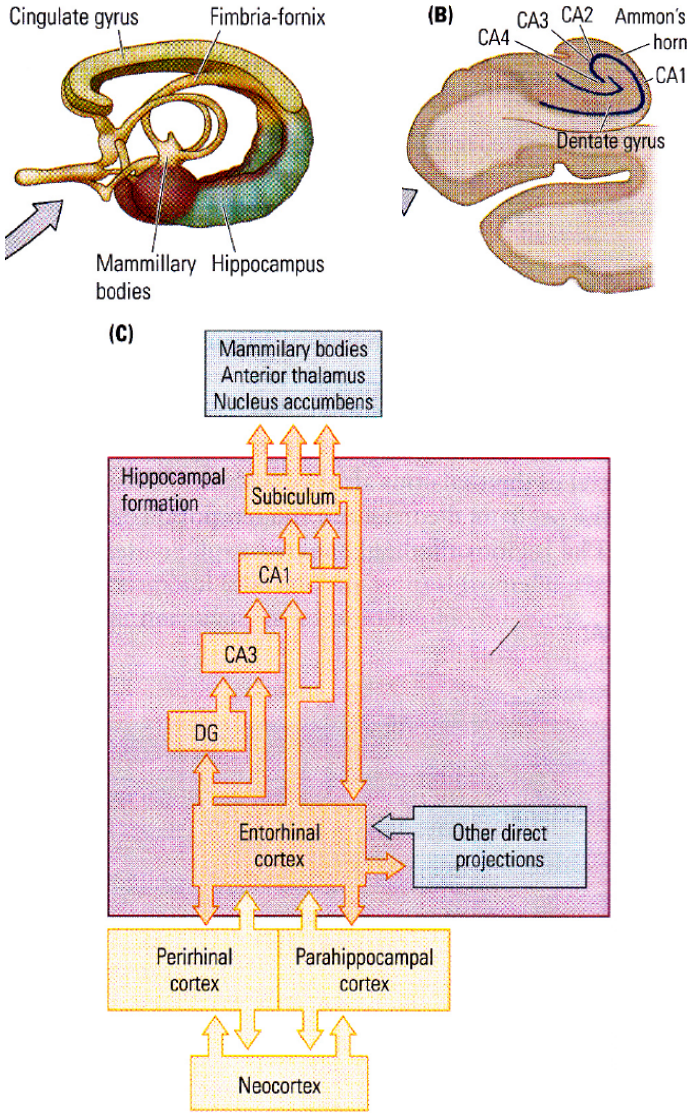
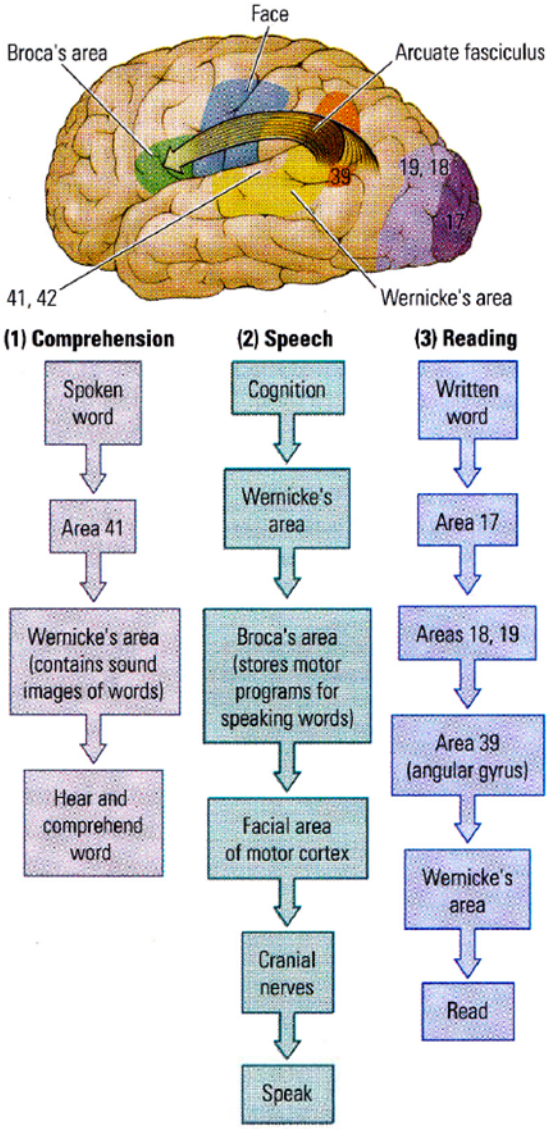


Figure 10.20

Hierarchy of Visual Areas This hierarchy shows 32 visual cortical areas, plus several nonvisual areas (area 7b of somatosensory cortex, perirhinal area 36, the entorhinal (ER) cortex, and the hippocampal (HC) complex). These areas are connected by 187 linkages, most of which are reciprocal pathways. (After Felleman and van Essen, 1991.)

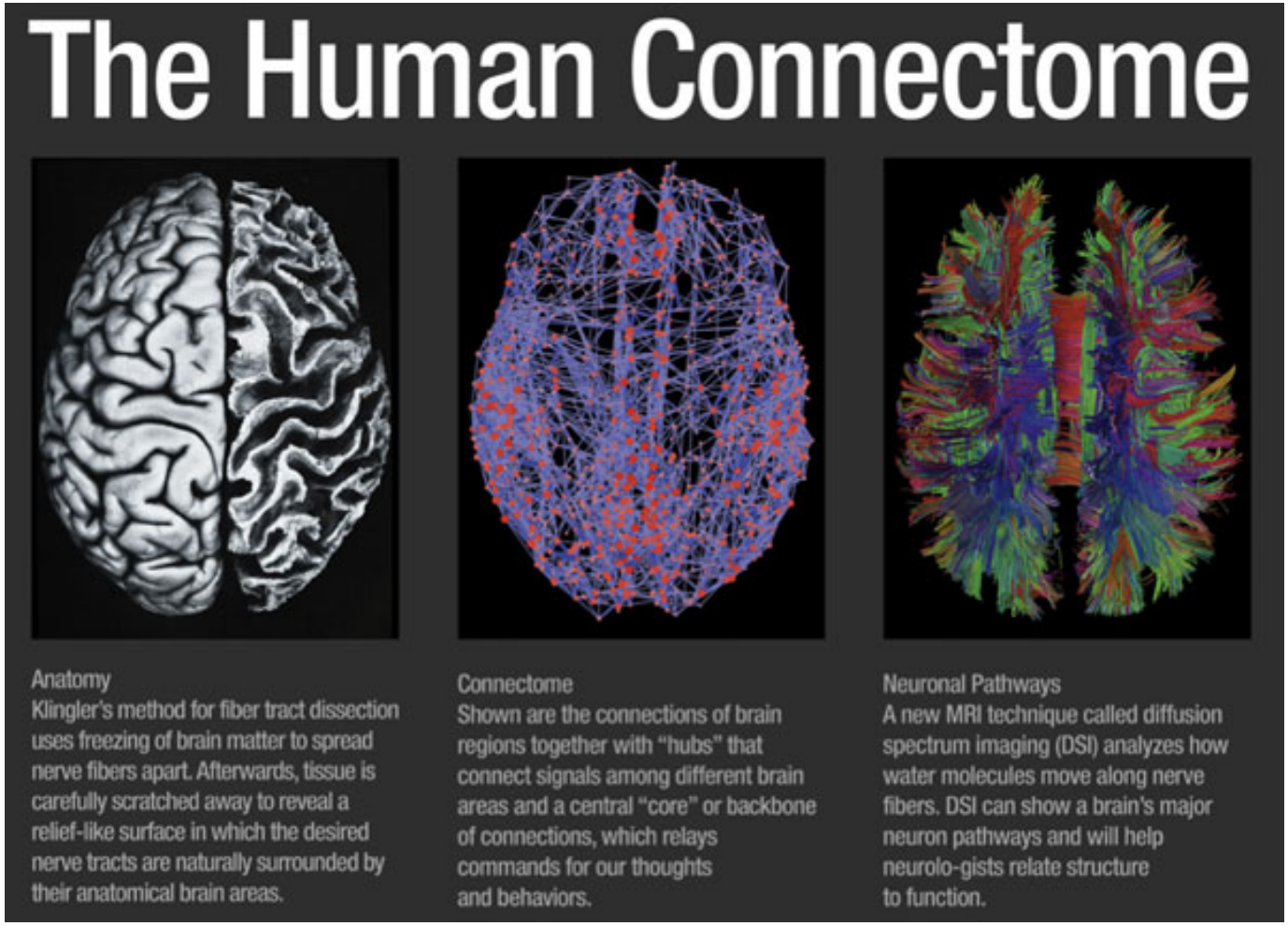
大腦神經網絡: Cognitive Functions





Adapted from Kolb & Whishaw (2009) Fundamentals of Human Neuropsychology, Figures 18.8, 19.7

大腦神經網絡



http://scimaps.org/maps/map/the_human_connectome_115/

心智與腦

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Mental
Process
心智歷程

Environment
環境/文化

Behavior 行為

SNAPSHOT

The Dilemma in Relating Behavior and Consciousness

In his paper titled "Consciousness Without a Cerebral Cortex: A Challenge for Neuroscience and Medicine," Bjorn Merker reviewed the difficulty in determining what is unconscious and what is conscious behavior. Our understanding of this dilemma dates to Hughlings-Jackson's idea that similar-appearing behaviors have vastly different implications, depending on how they are hierarchically represented in the brain.

The difficulty in relating brain injury to behavior is illustrated by Theresa Marie "Terri" Schiavo, a 26-year-old woman from St. Petersburg, Florida, who collapsed in her home in 1990 and experienced respiratory and cardiac arrest.

Although Terri was completely unresponsive and in a coma for 3 weeks, as she did become more responsive, her normal conscious behavior did not return. Terri was diagnosed as being in a **persistent vegetative state** (PVS): she was alive but unable to communicate or to function independently at even the most basic level. In 1998, Terri's husband and guardian, Michael Schiavo, petitioned the courts to remove her gastric feeding tube, maintaining that she would not wish to live under such severe impairment. Terri's parents, Robert and Mary Schindler, were opposed, citing their belief that Terri's behavior signaled that she was consciously aware and fighting to recover. The battle lines were drawn.

By March 2005, the legal history concerning the Schiavo case included 14 appeals, numerous motions, petitions, and hearings in the Florida courts, and 5 suits in Federal District Court. Florida legislation favorable to the Schindlers was struck down by the Supreme Court of Florida; a subpoena by a U.S. Congressional committee in an attempt to qualify Schiavo for witness protection resulted in federal legislation (Palm Sunday Compromise); and the Supreme Court of the United States refused to review the case four times.

A CT scan of a normal adult brain (left) and Terri Schiavo's brain (right). (Michael Schiavo.)

Judges, legislators, and the viewing public were presented with videos of Terri glancing around her room, looking at people in the room and smiling. Her parents and the physicians who supported them interpreted these actions as evidence that Terri was conscious and that she would eventually recover normal brain function. Her husband and the physicians who supported him argued that Terri's behaviors were not conscious but rather were reflexive actions.

Amid a storm of national controversy, Michael Schiavo prevailed. Terri's feeding tube was removed, and she died 13 days later at a Pinellas Park, Florida, hospice on March 31, 2005, at the age of 41.

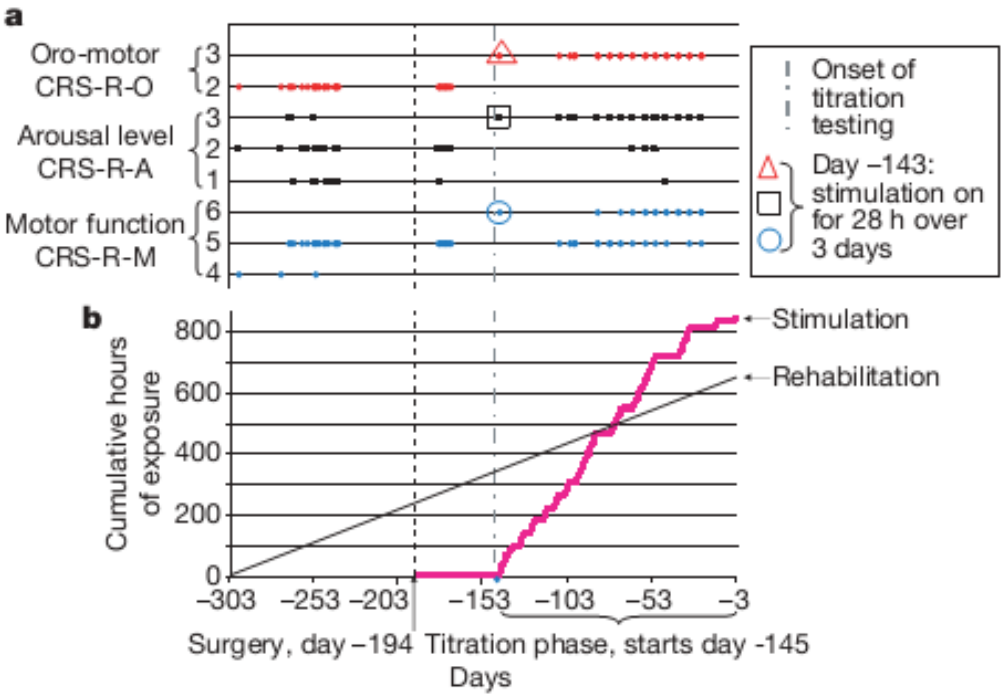
Merker, B. Consciousness without a cerebral cortex: A challenge for neuroscience and medicine. *Behavioural and Brain Sciences* 30:63–134, 2007.

心智與腦

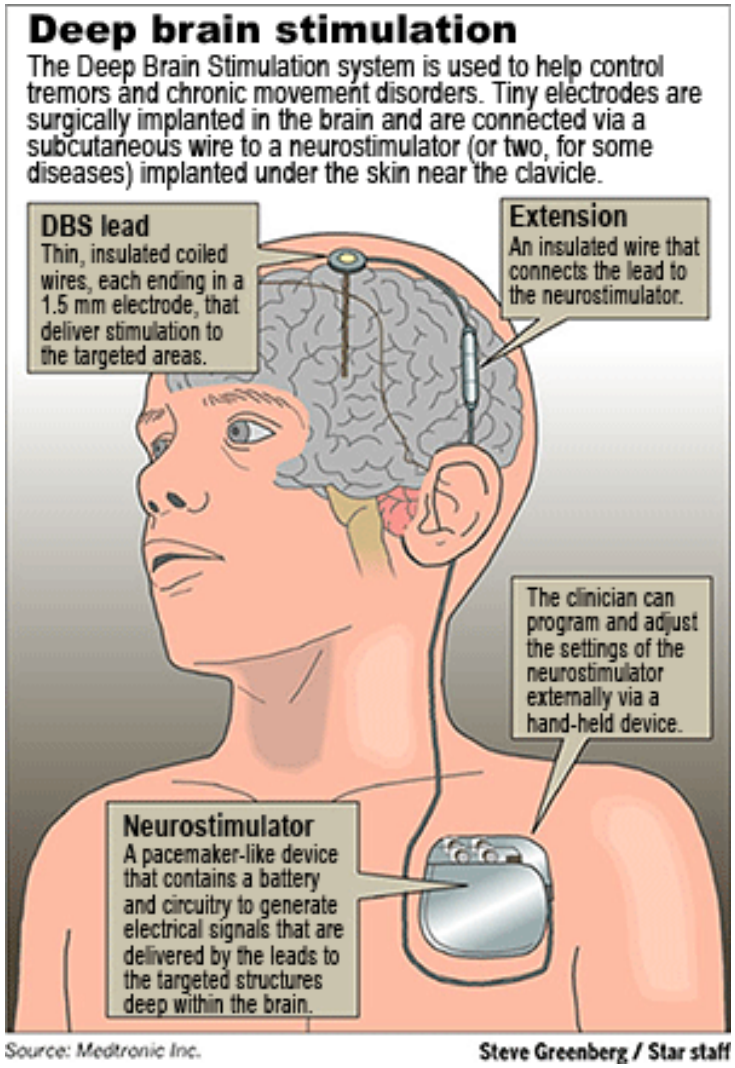
http://www.youtube.com/watch?v=9wBzOmg-c0g

心智與腦

Behavioral improvements with thalamic stimulation after severe traumatic brain injure (Schiff et al 2007 Nature 600-603)

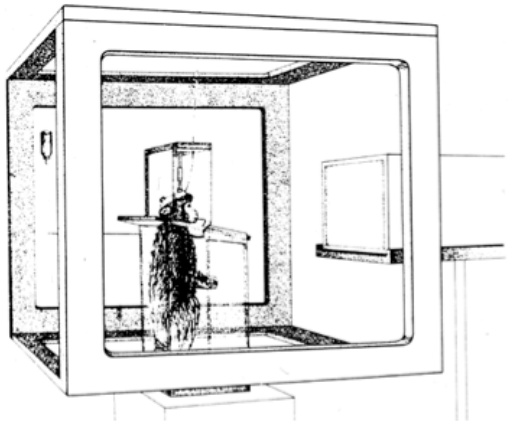


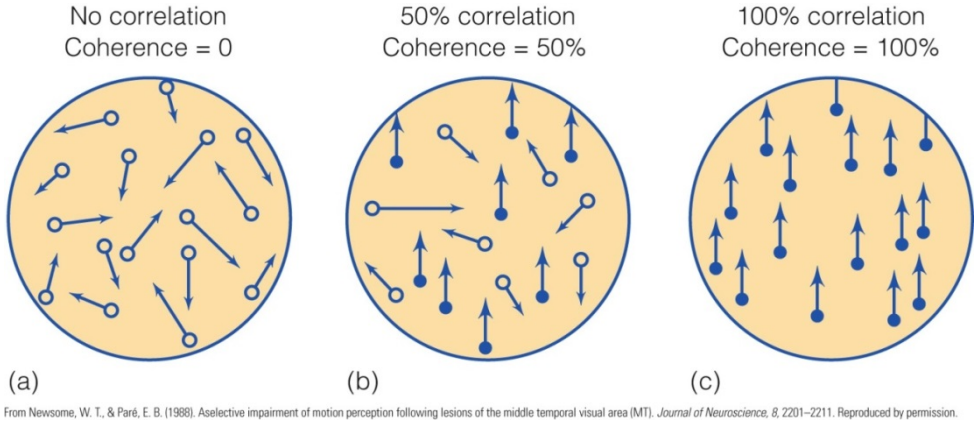
CRS: coma recovery scale



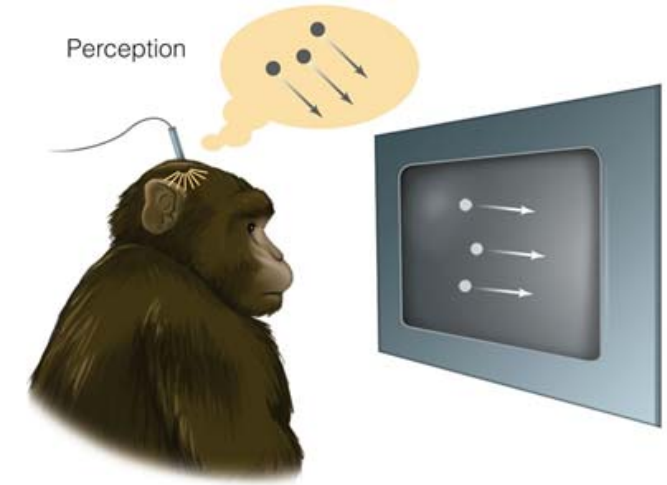
心智與腦

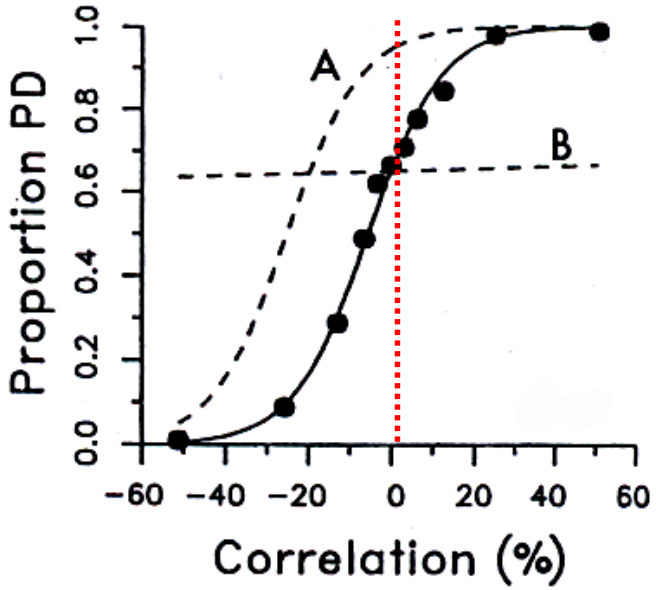
Williams Newsome





From Newsome, W. T., & Paré, E. B. (1988). Aselective impairment of motion perception following lesions of the middle temporal visual area (MT). *Journal of Neuroscience, 8,* 2201–2211. Reproduced by permission.





Salzman et al. (1992). Journal of Neuroscience, 12, 2331-2355

The New York Times

September 14, 2012

Brain Implant Improves Thinking in Monkeys, First Such Demonstration in Primates

By BENEDICT CAREY

Scientists have designed a brain implant that sharpened decision making and restored lost mental capacity in monkeys, providing the first demonstration in primates of the sort of brain prosthesis that could eventually help people with damage from dementia, strokes or other brain injuries.

The device, though years away from commercial development, gives researchers a model for how to support and enhance fairly advanced mental skills in the frontal cortex of the brain, the seat of thinking and planning.

The new report appeared Thursday in The Journal of Neural Engineering.

In just the past decade, scientists have developed brain implants that improve vision or allow disabled people to use their thoughts to control prosthetic limbs or move computer cursors. The new paper, led by researchers at Wake Forest Baptist Medical Center and the University of Southern California, describes a device that improves brain function internally, by fine-tuning communication among neurons.

Previous studies have shown that a neural implant can do this for memory in rodents, but the new report extends that work significantly, experts said — into brains that are much closer to those of humans.

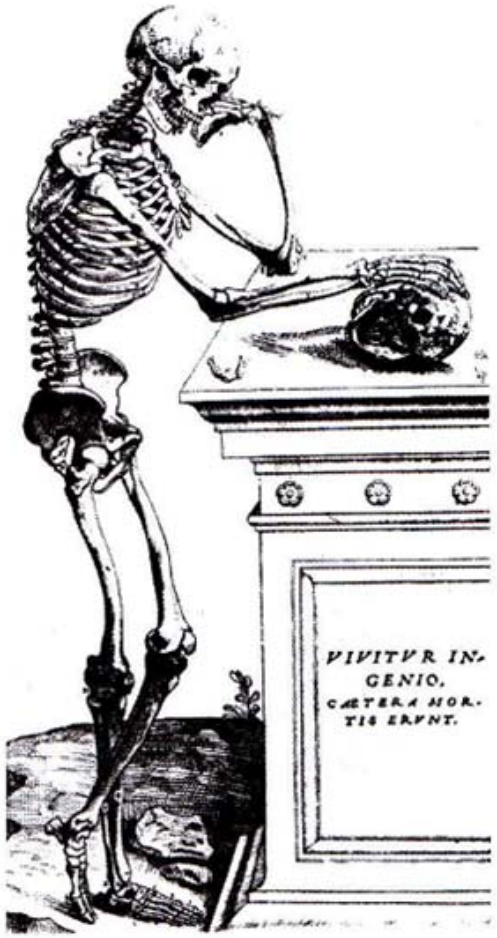


FIGURE 1.1 Studying the Brain

Will the human brain ever completely understand its own workings? A sixteenth-century woodcut from the first edition of *De humani corporis fabrica (On the Workings of the Human Body)* by Andreas Vesalius.

(Courtesy of National Library of Medicine.)