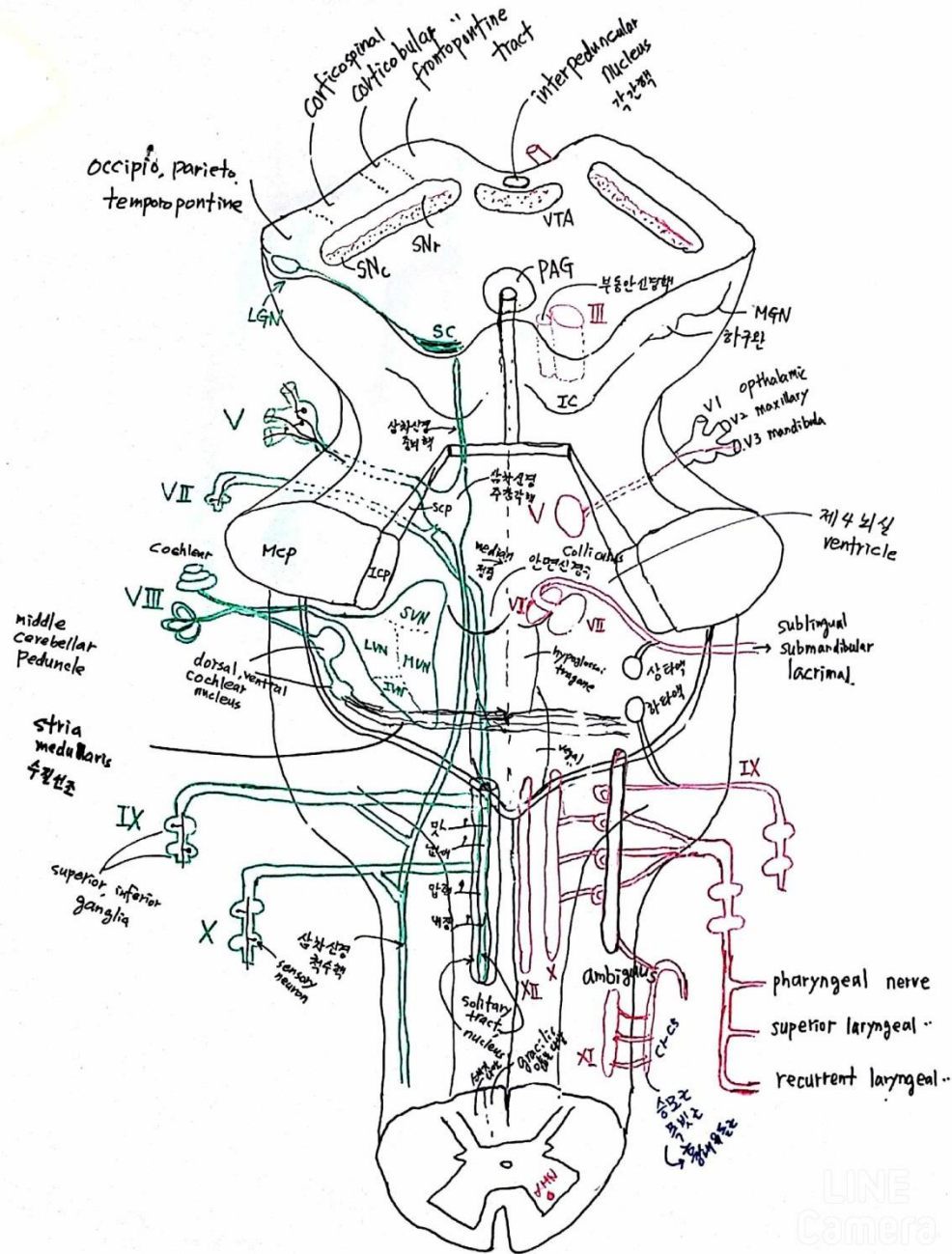
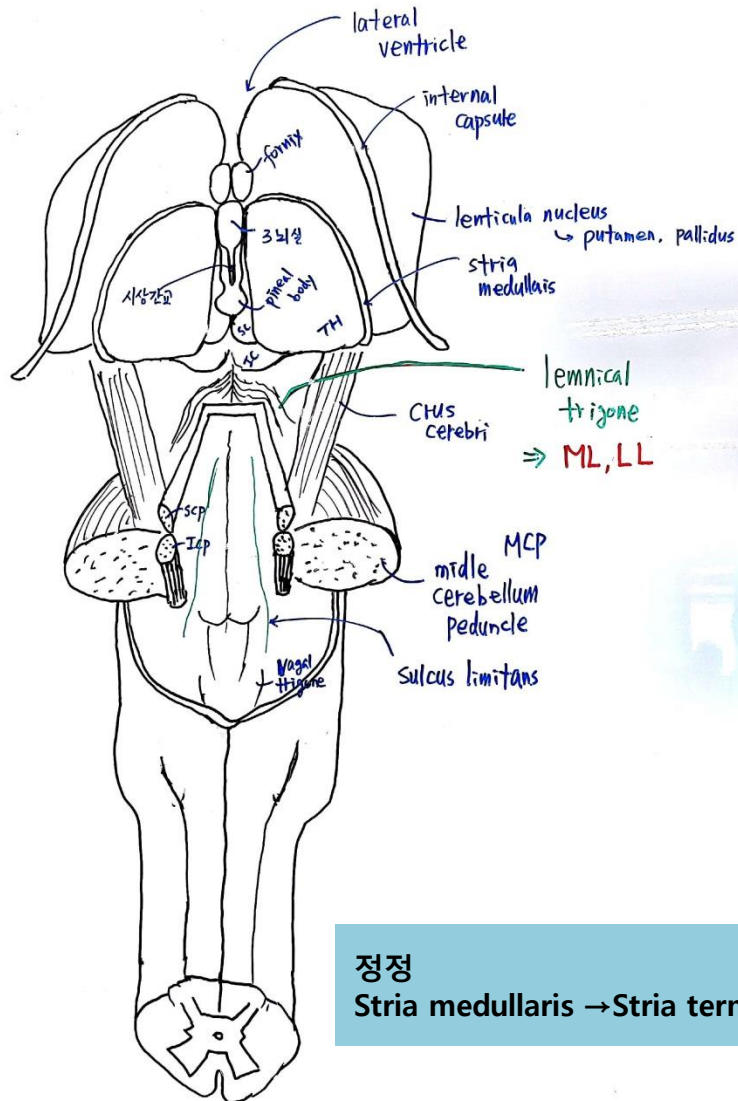


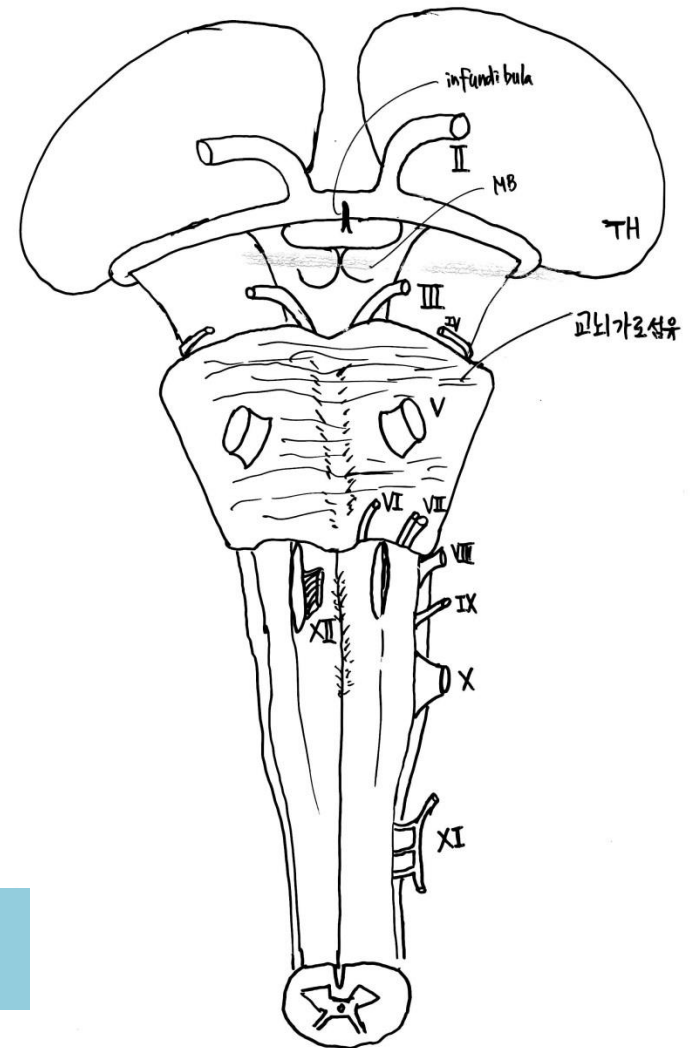
#1 - 뇌간의 뇌신경



#2 - 뇌간 앞면, 뒤면

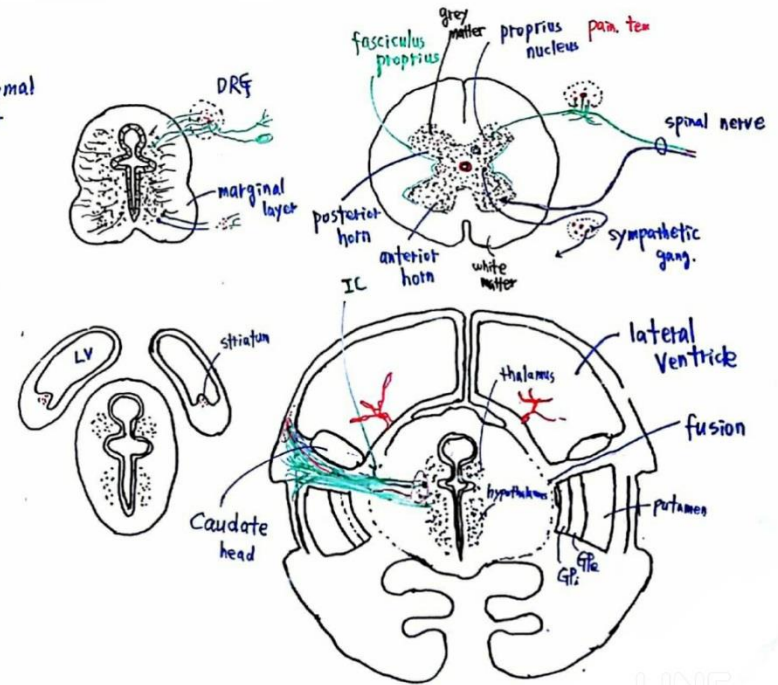
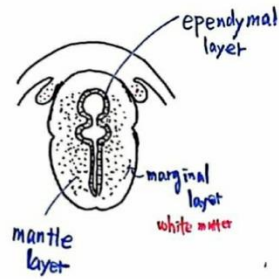
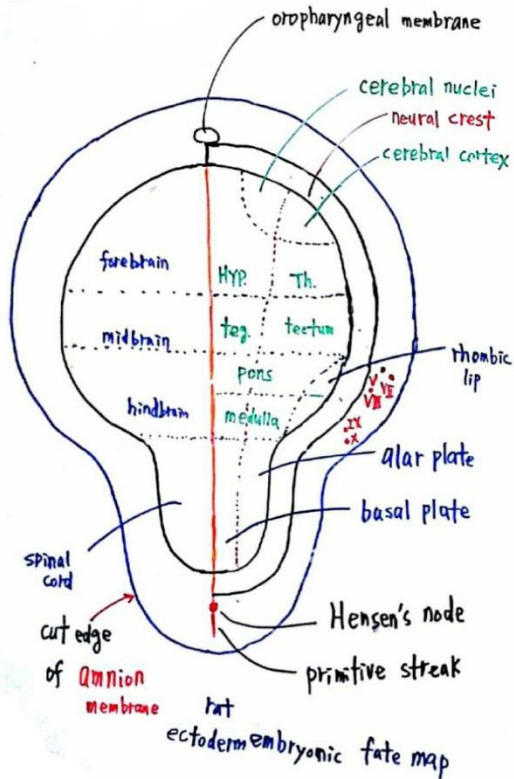


정정
Stria medullaris → Stria terminalis



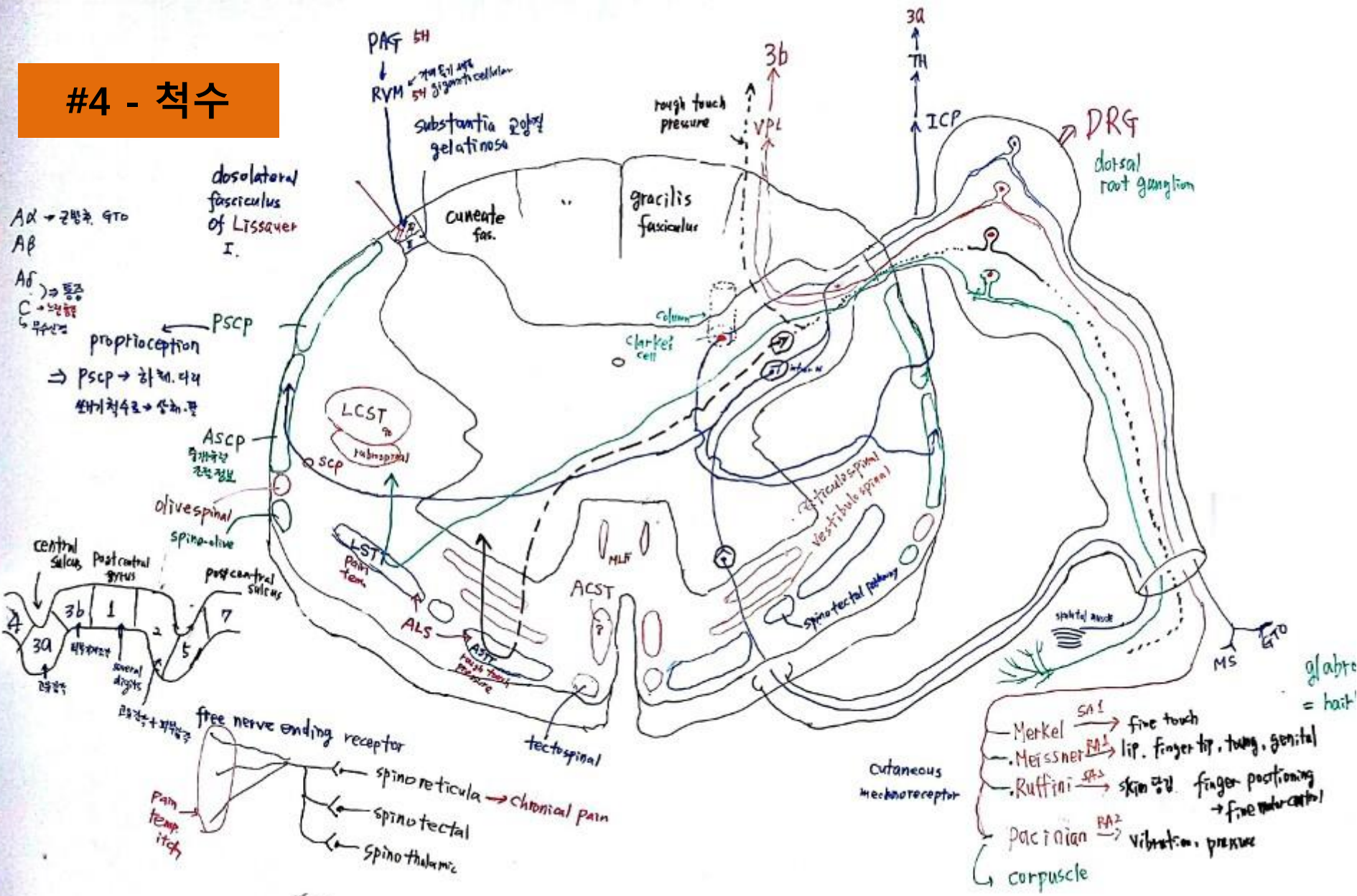
#3 - 발생

#3

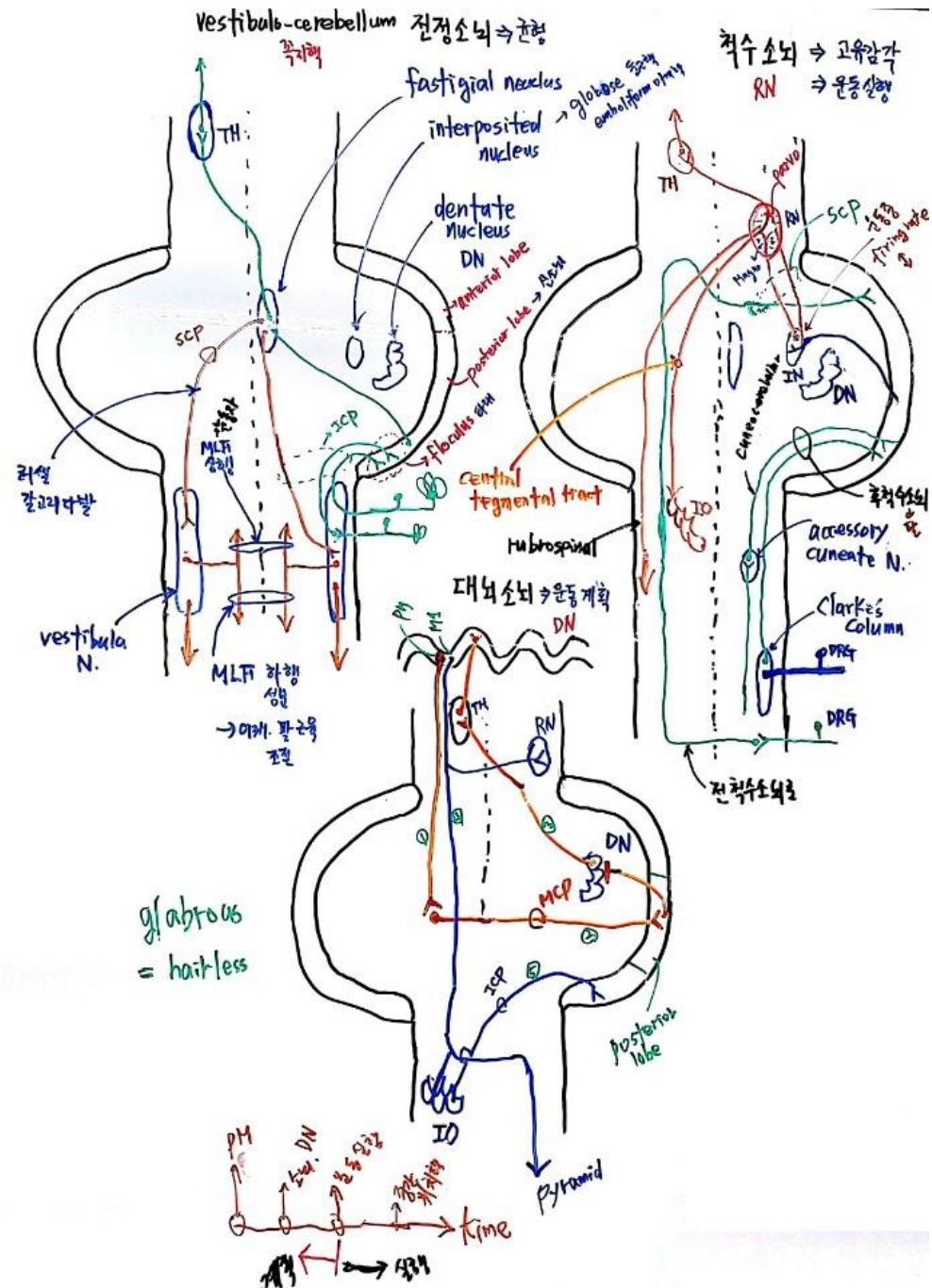


추가 - 가운데 빨간 선 Notochord

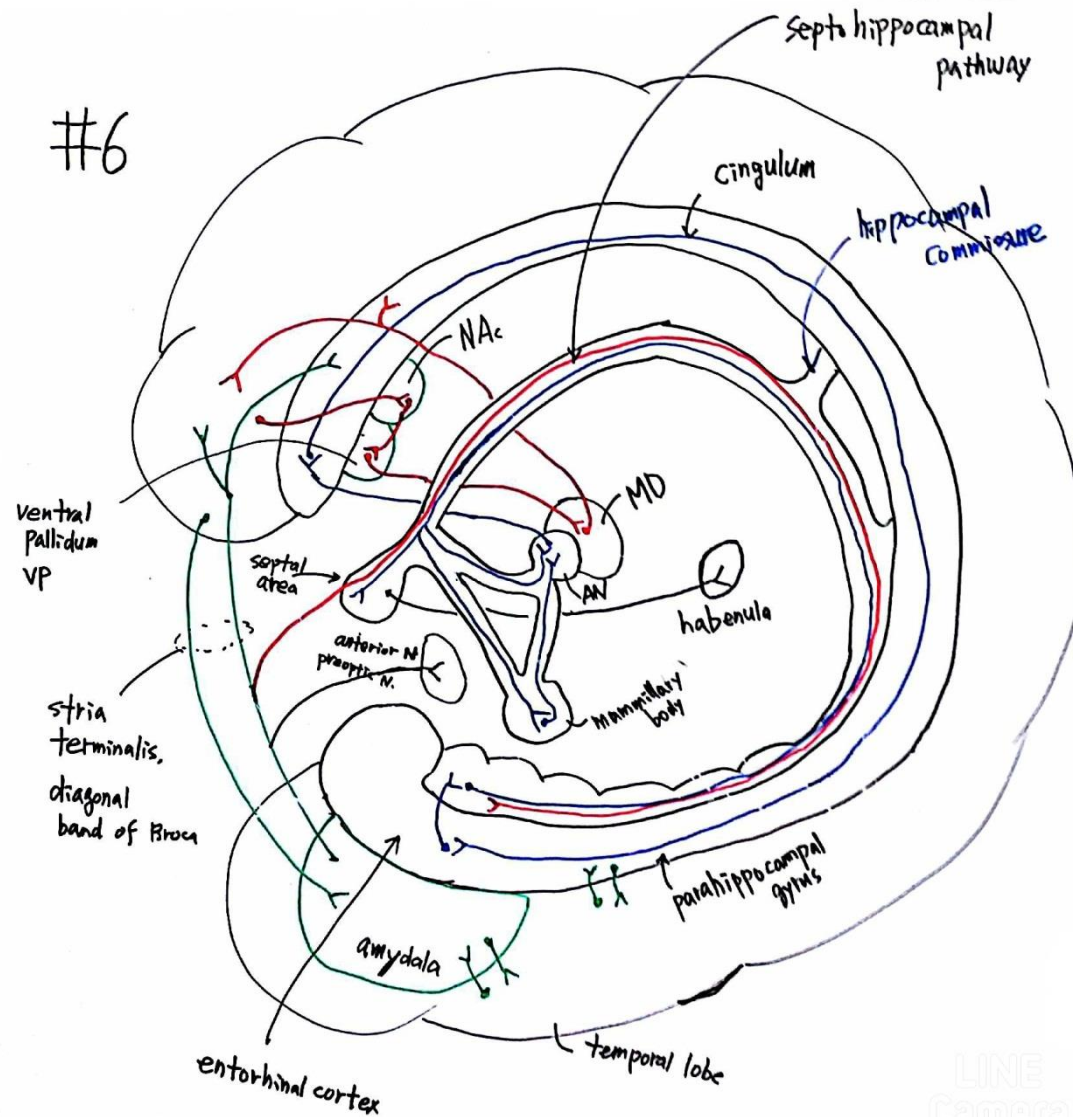
#4 - 척수



#5 - 소노



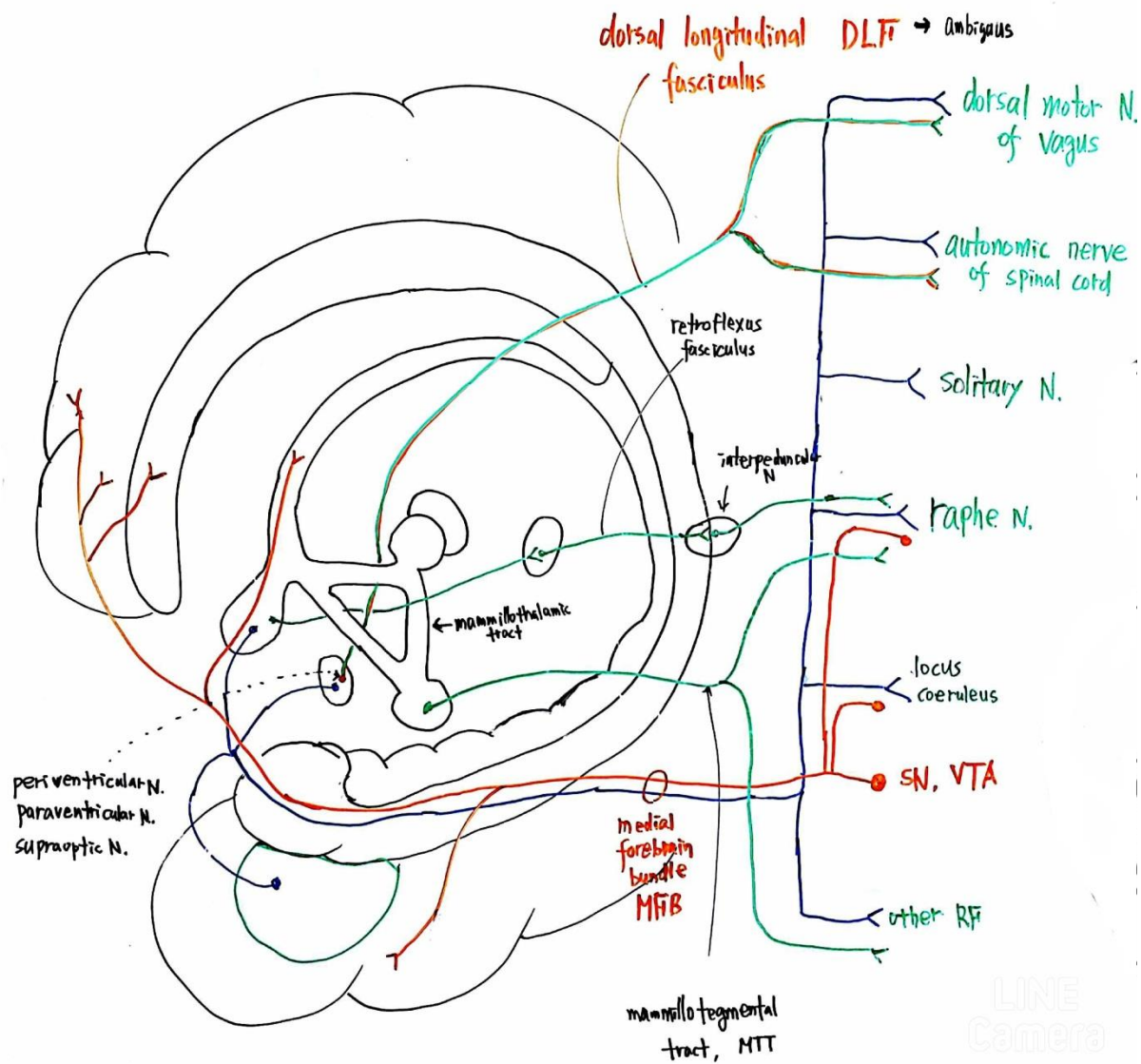
#6 - 변연계1



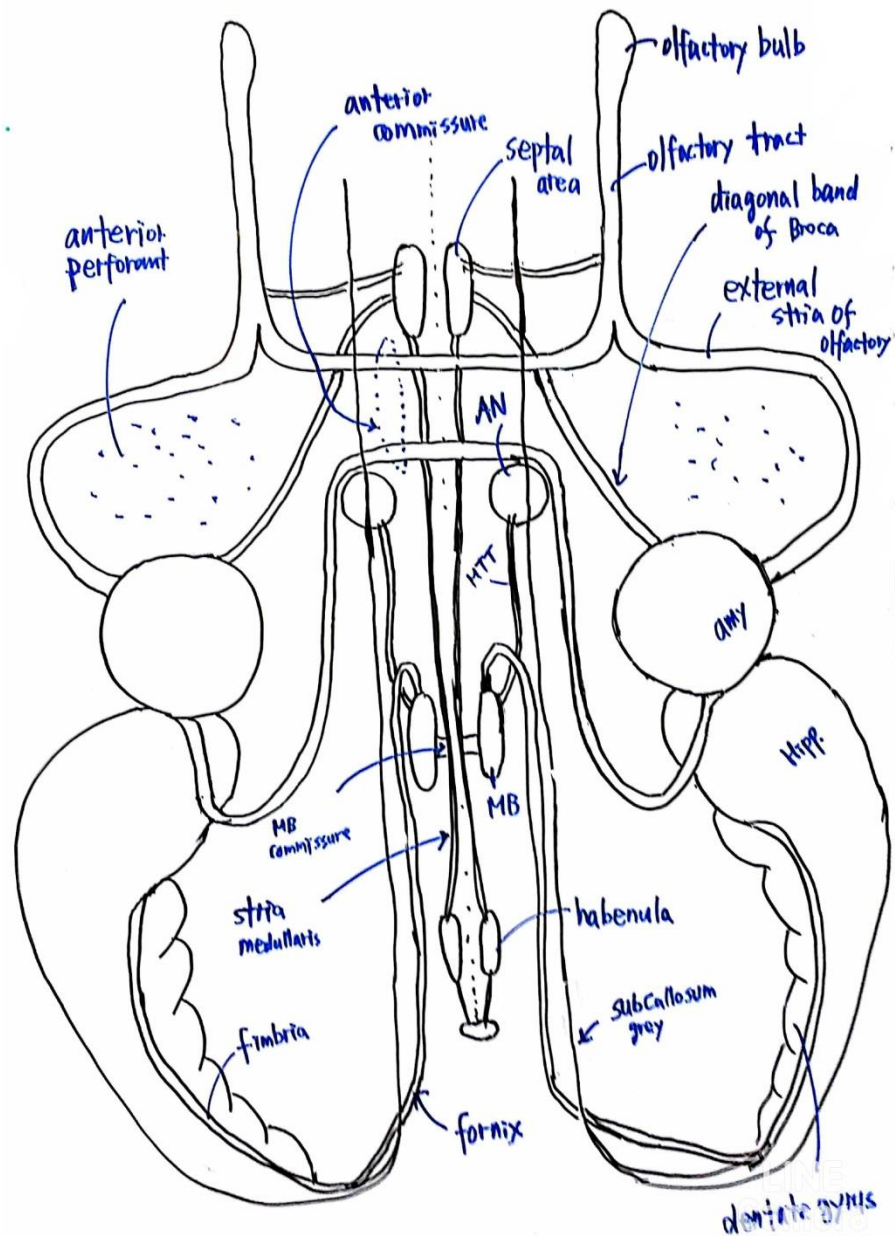
#6 - 변연계2

정정

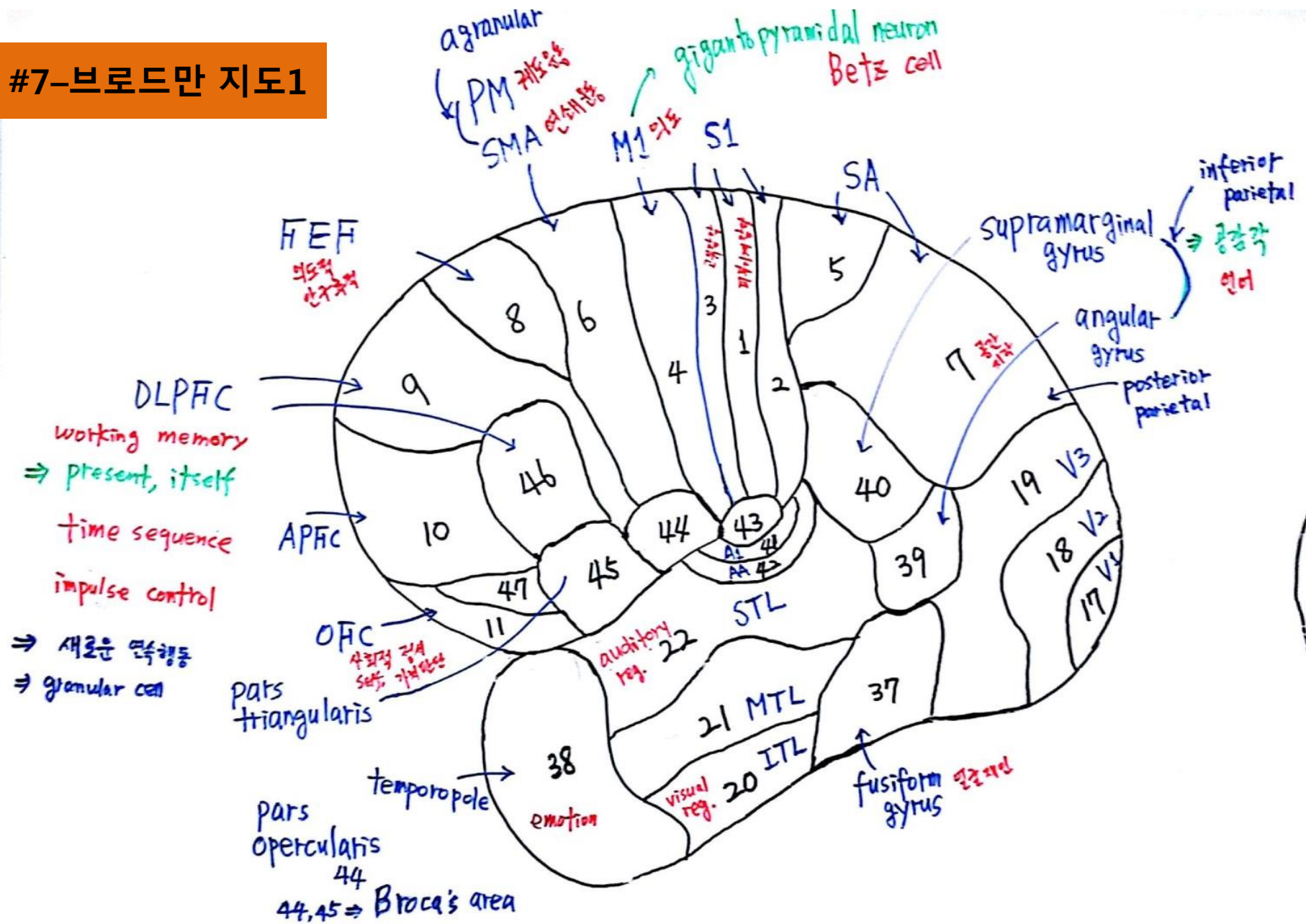
autonomic nerve → autonomic nuclei



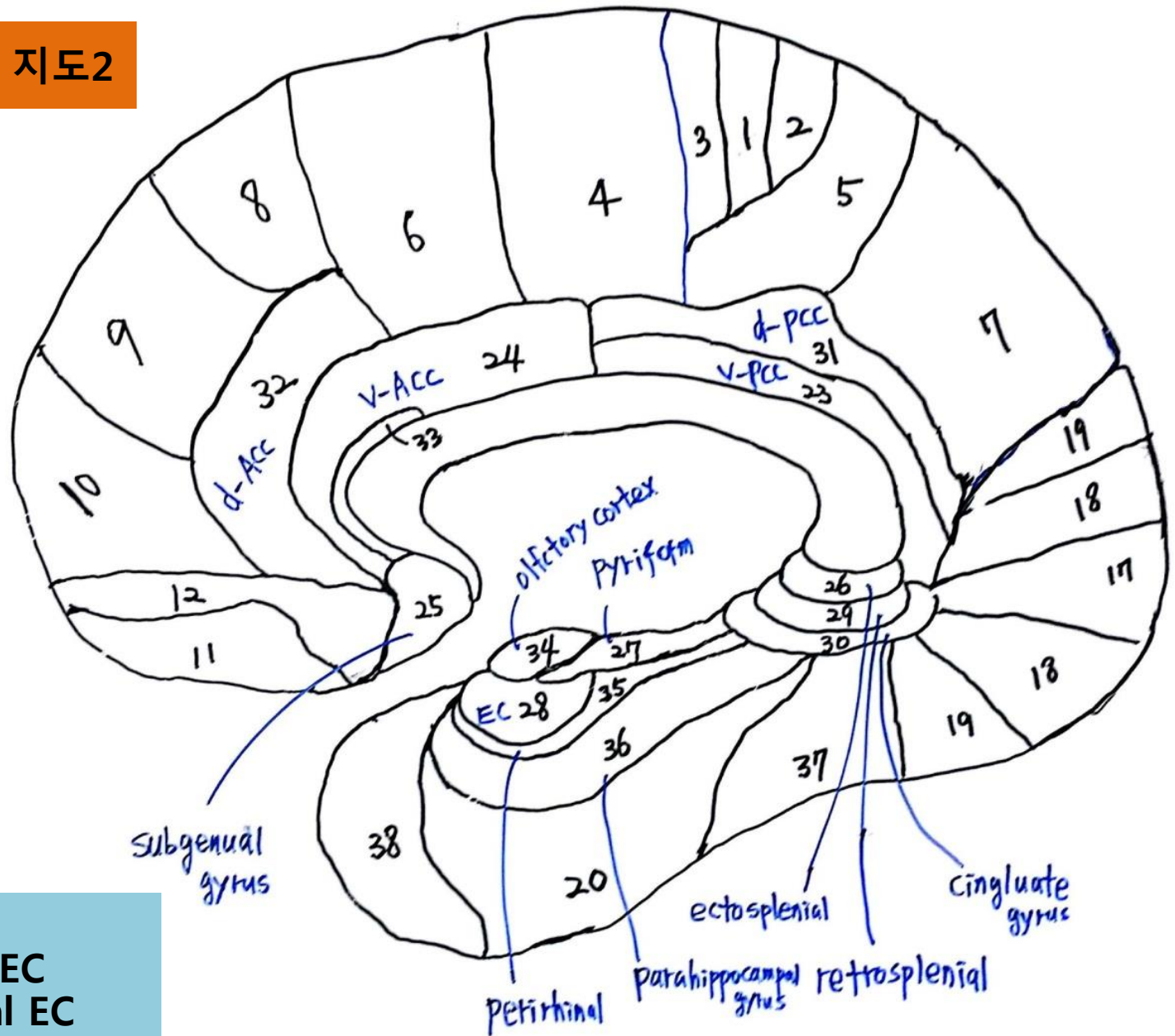
#6 - 변연계3



#7-브로드만 지도1



#7-브로드만 지도2

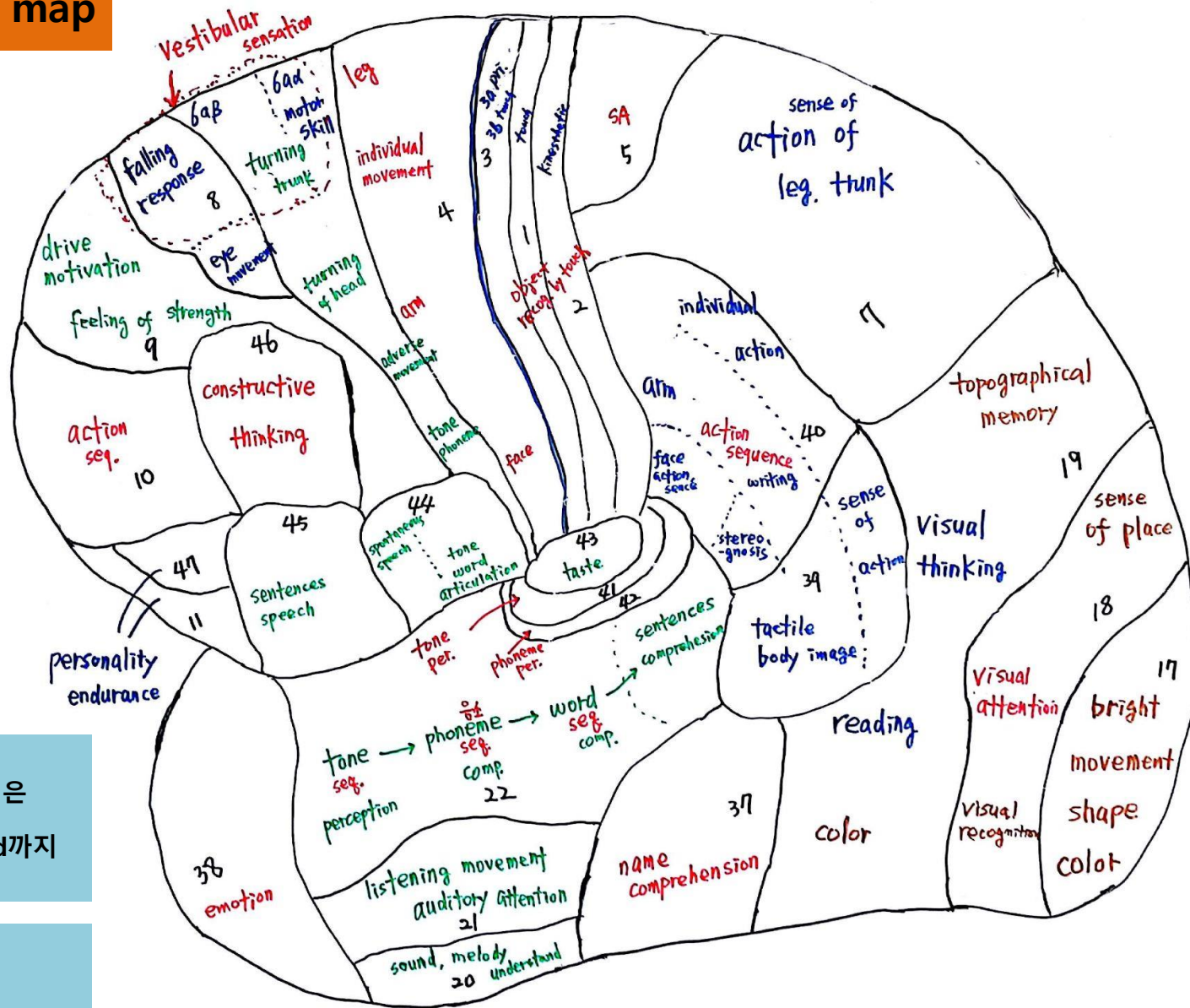


수정

34 - dorsal EC

28 - ventral EC

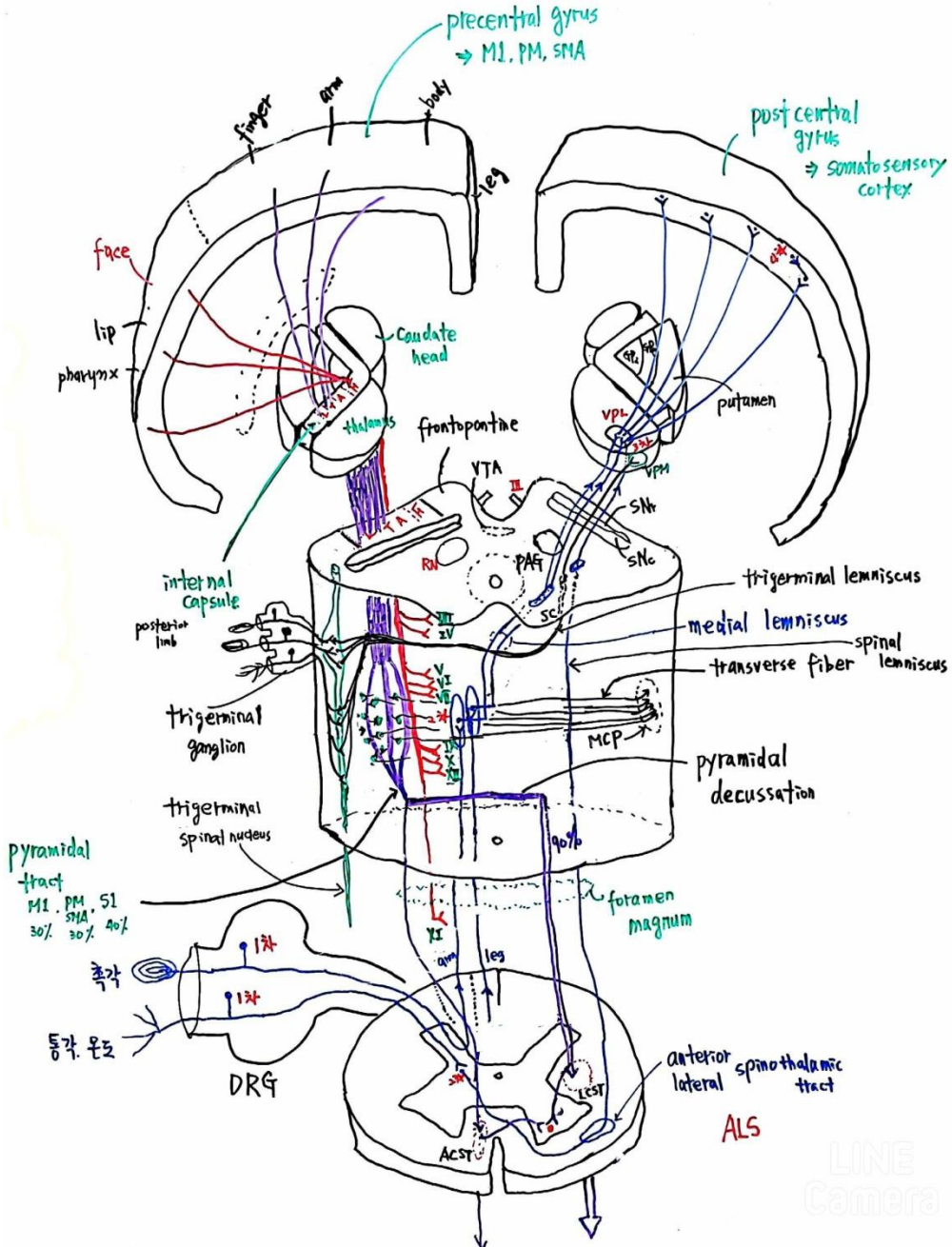
#7-Karl Kleist map



수정
Vestibula sensation 영역은
-8번
-6aβ turning trunk, head까지
* 6aα 영역은 제외

내용 확인
-6aα 영역에 feeling of
strength 추가

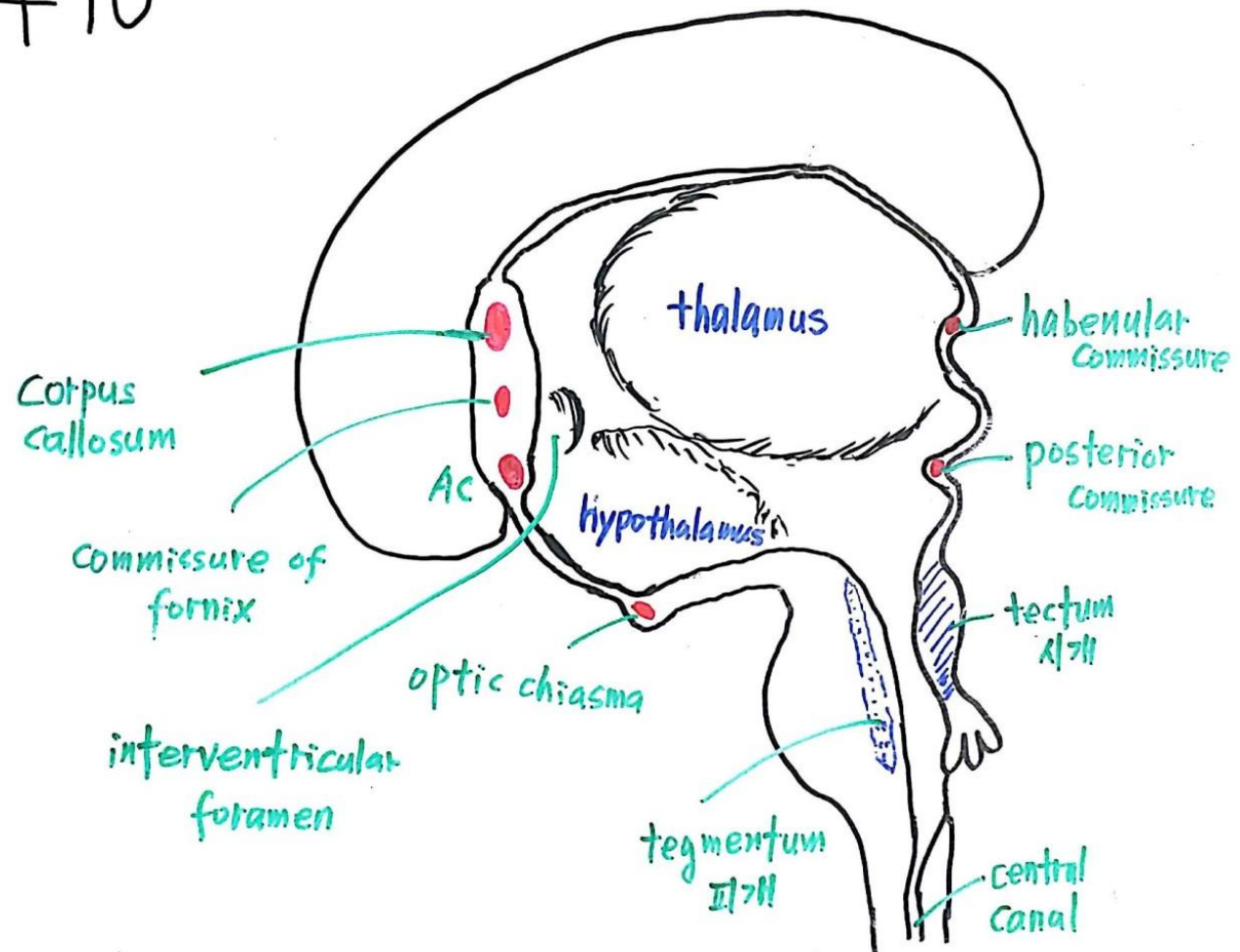
#9 – 신경로



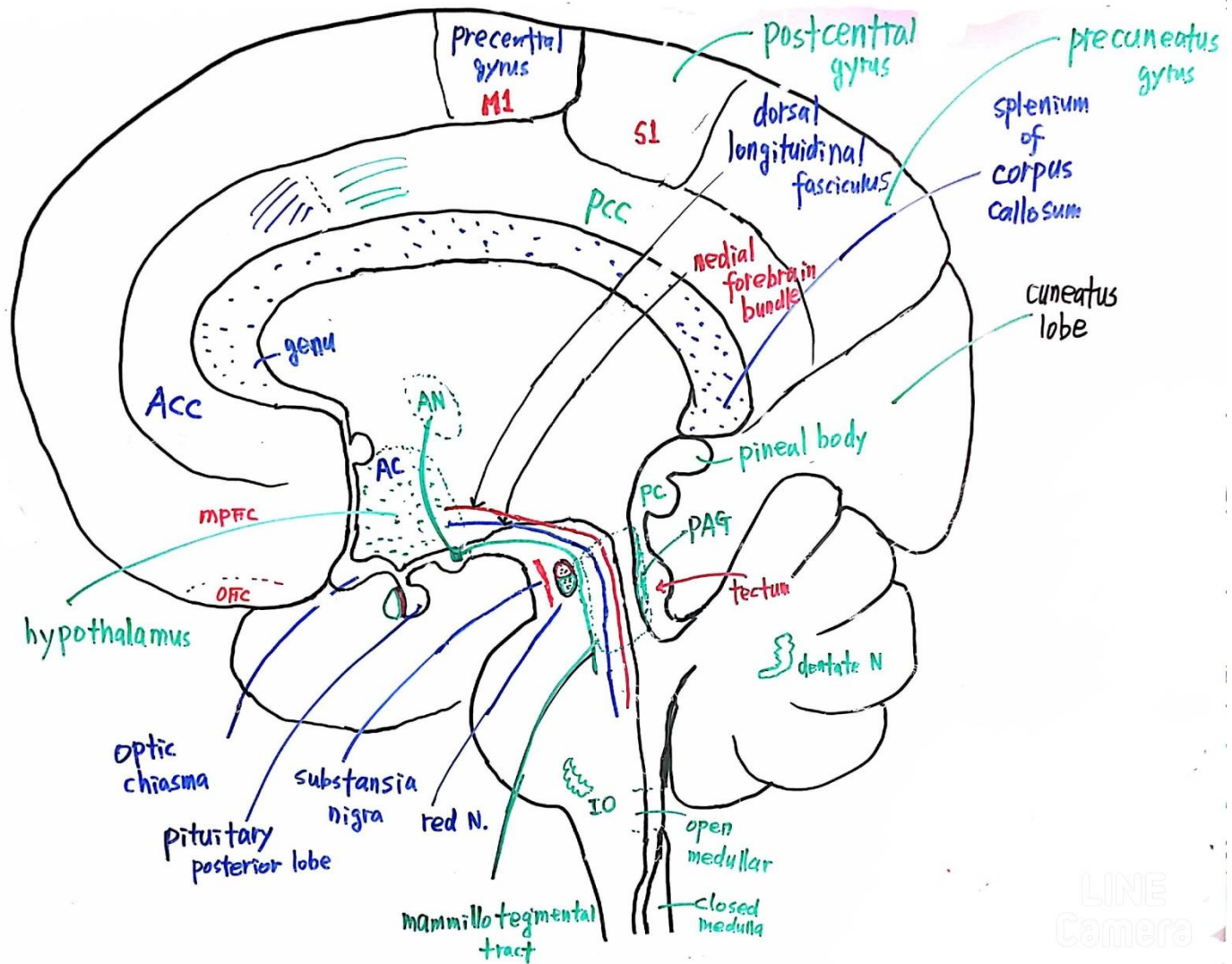
* 주의
편의상 척수단면은 앞뒤가 바뀜

#10 - 대뇌의 주요 단면1 태아

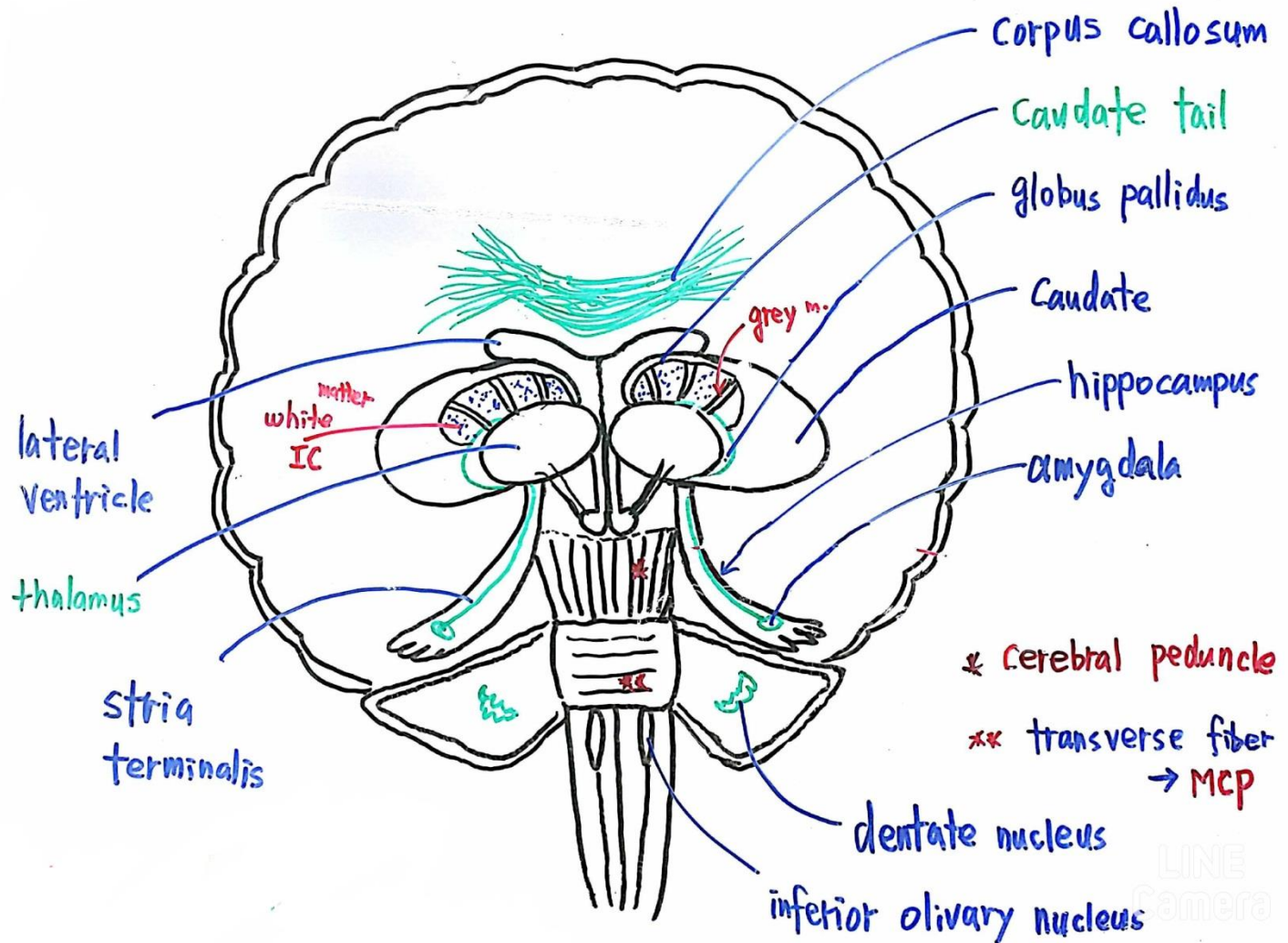
#10



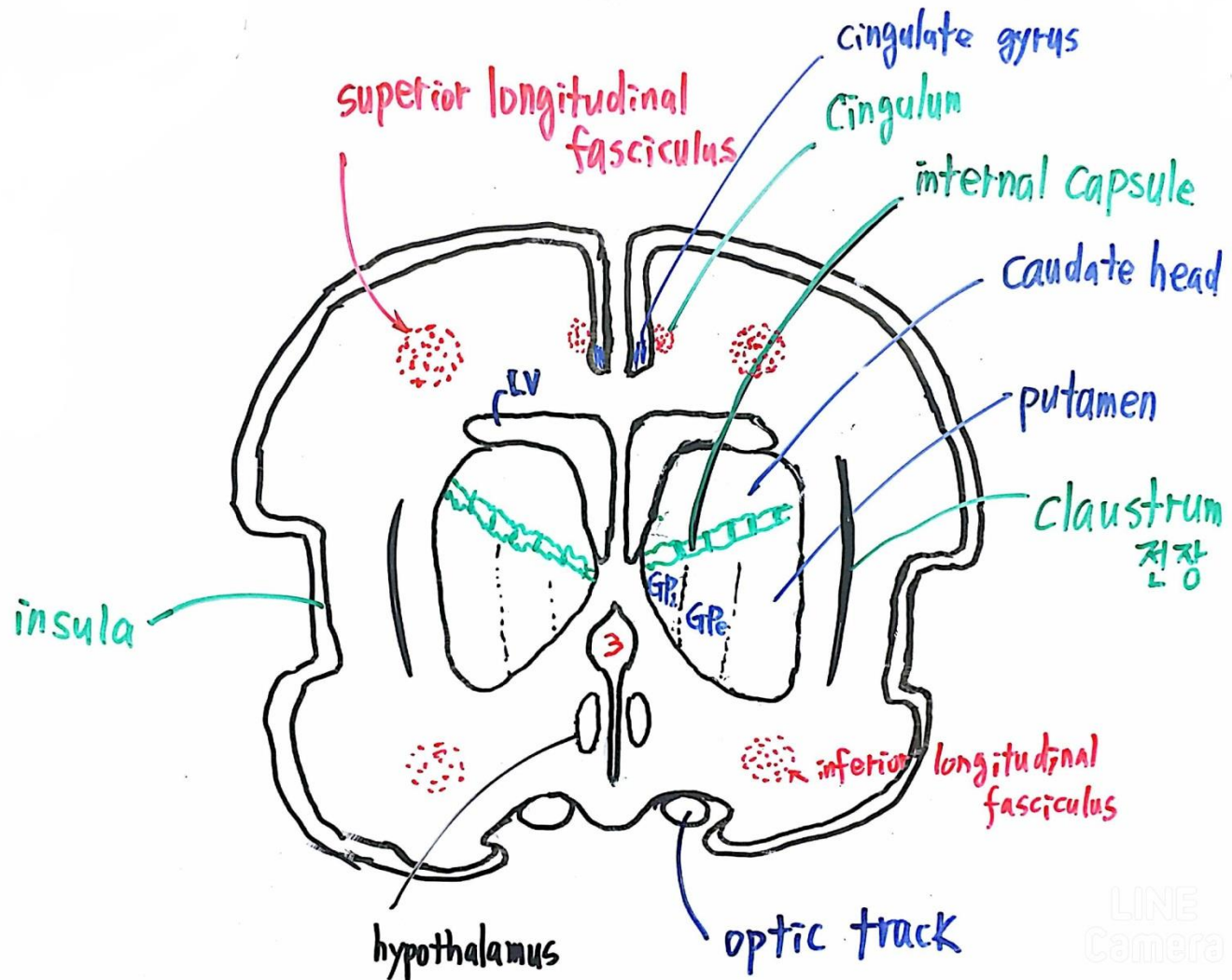
#10 - 대뇌의 주요 단면2



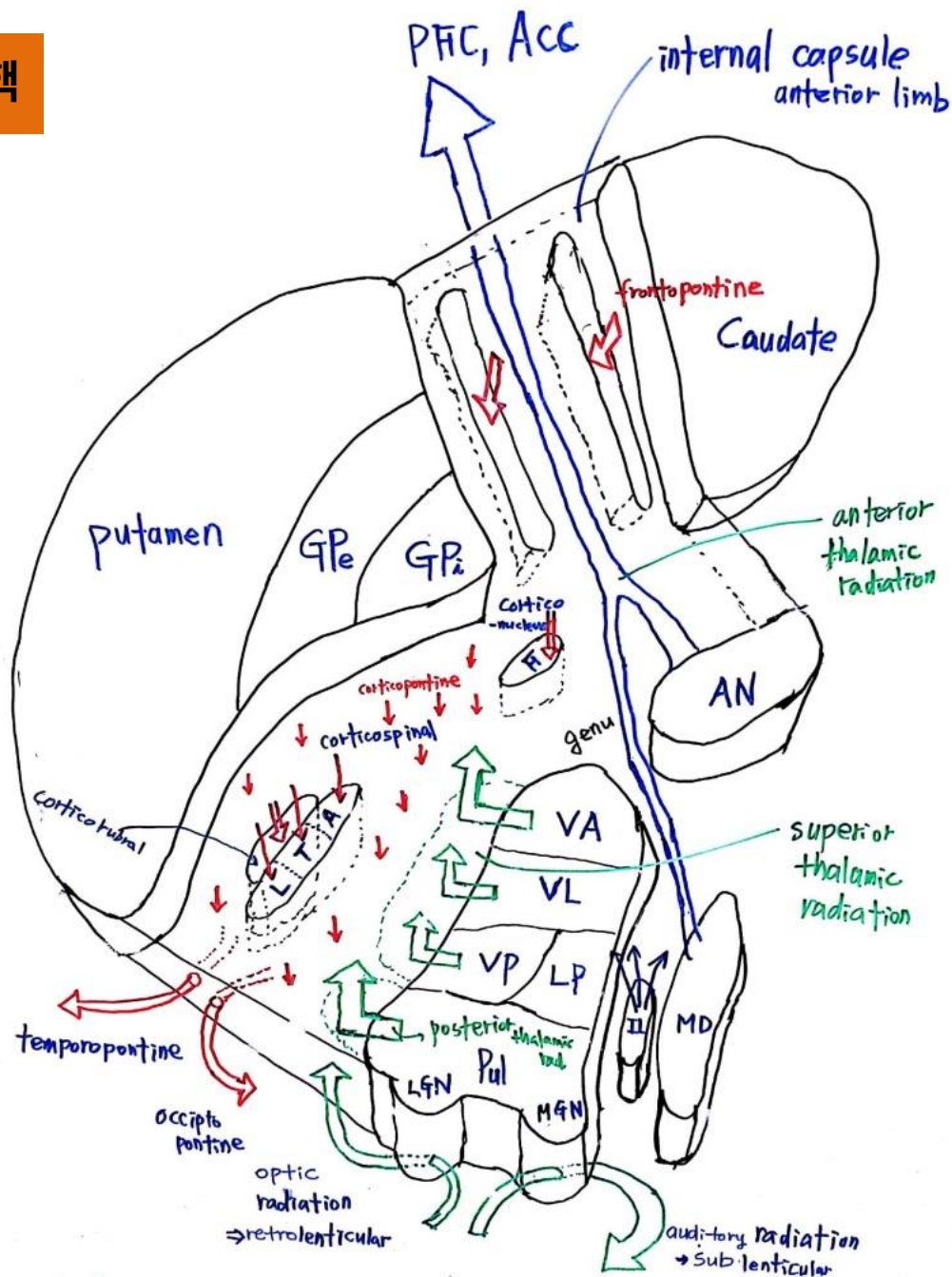
#10 - 대뇌의 주요 단면3



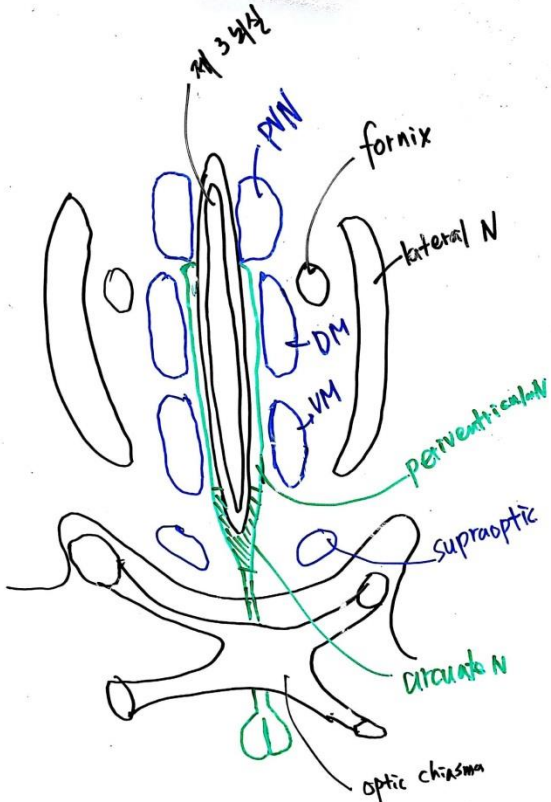
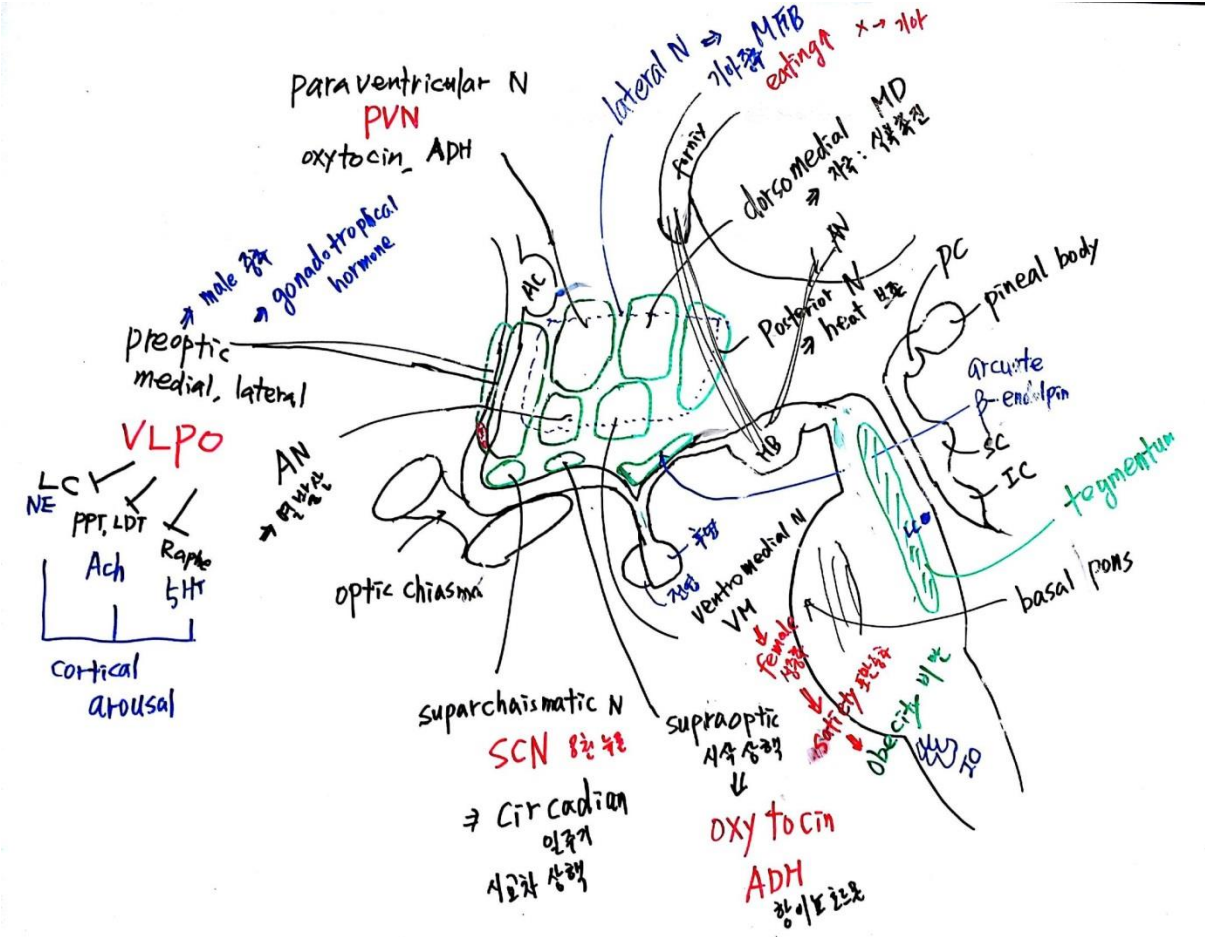
#10 - 대뇌의 주요 단면4



#8-시상, 내낭, 기저핵

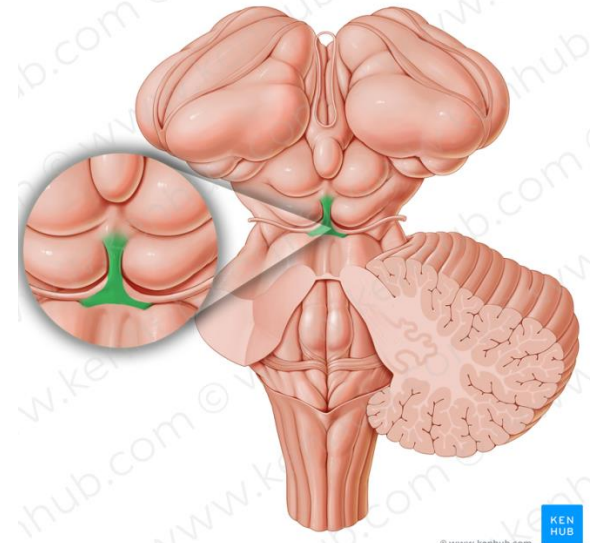
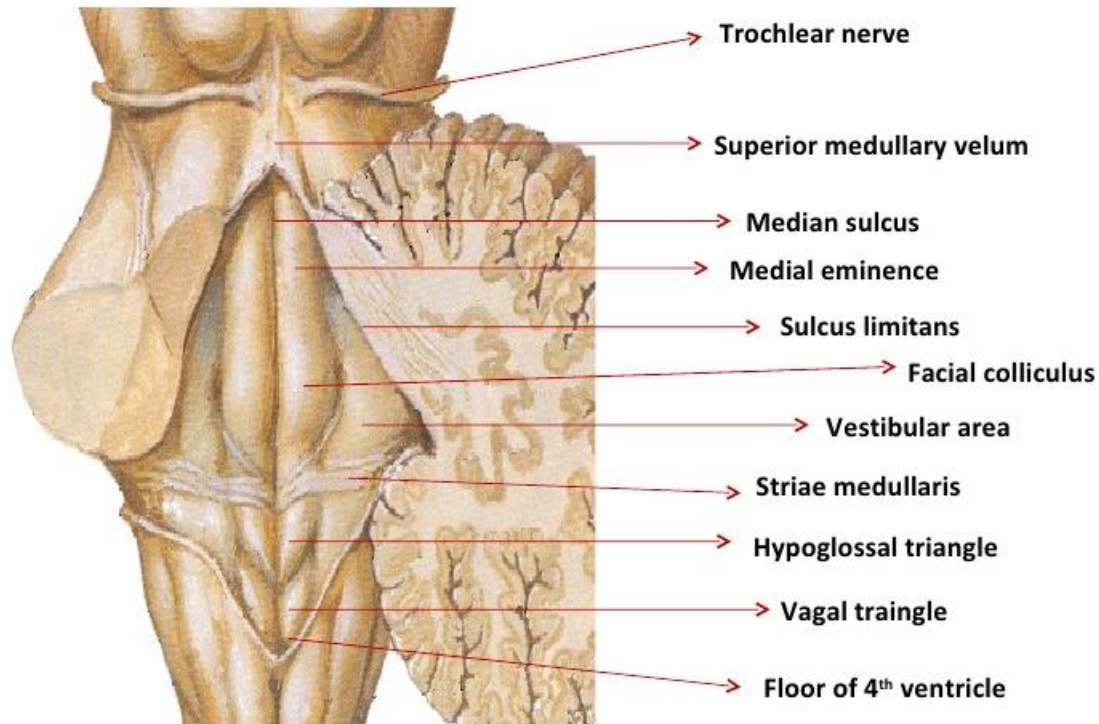


보조 - 시상하부



#2보조 – superior medullary velum

PONS (dorsal view)



Roof or posterior wall of fourth ventricle :

Superior part of the roof ;

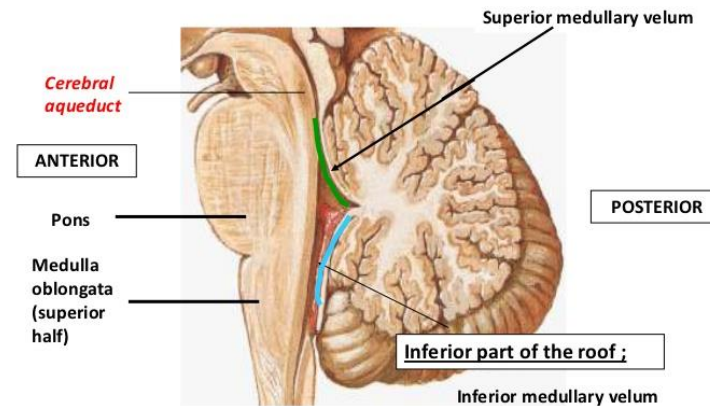
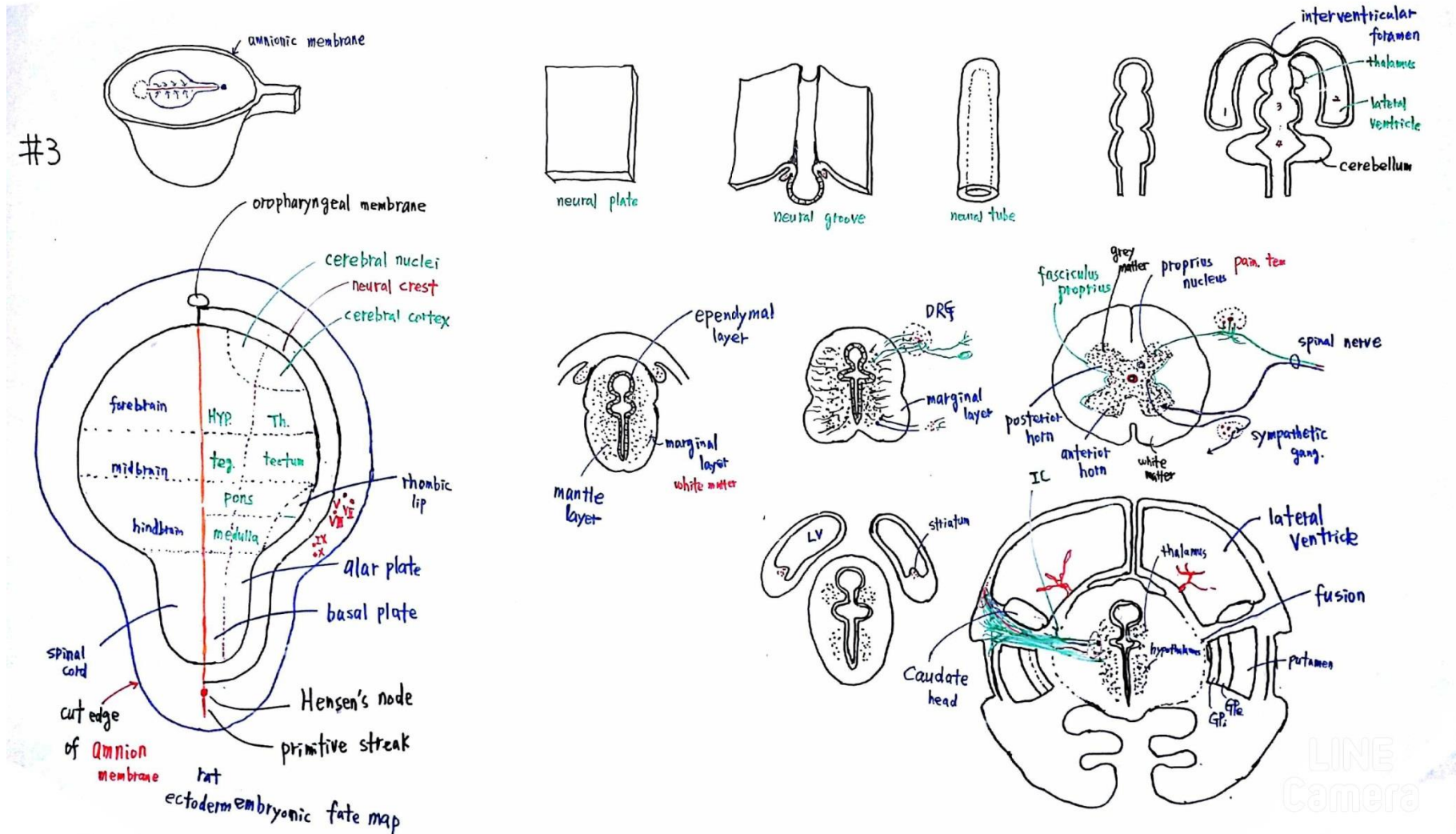


Fig. : Sagittal section of the 4th ventricle

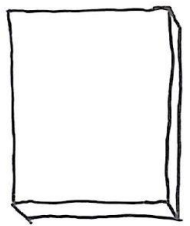
#3보조 - 발생 이해 자료

#3

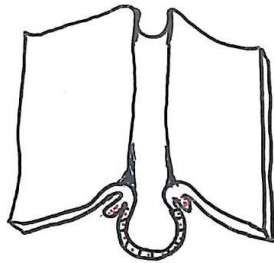


Swanson

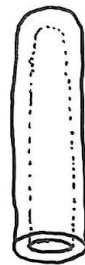
#3보조 - 발생 과정



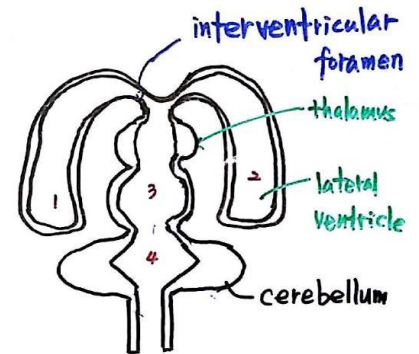
neural plate



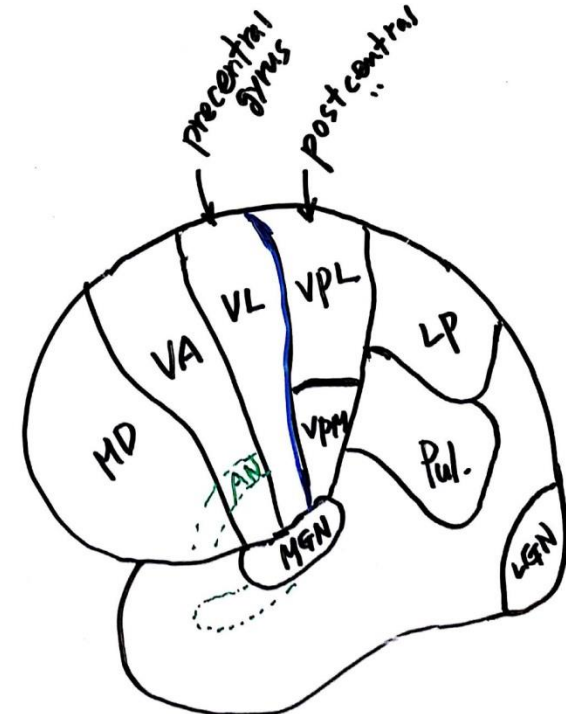
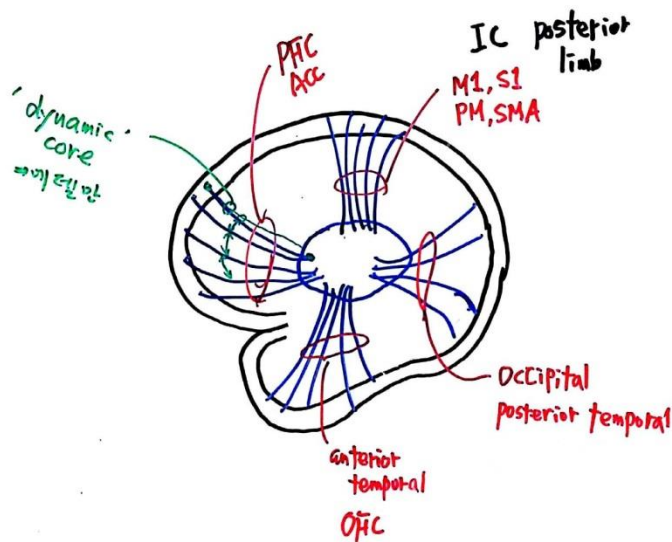
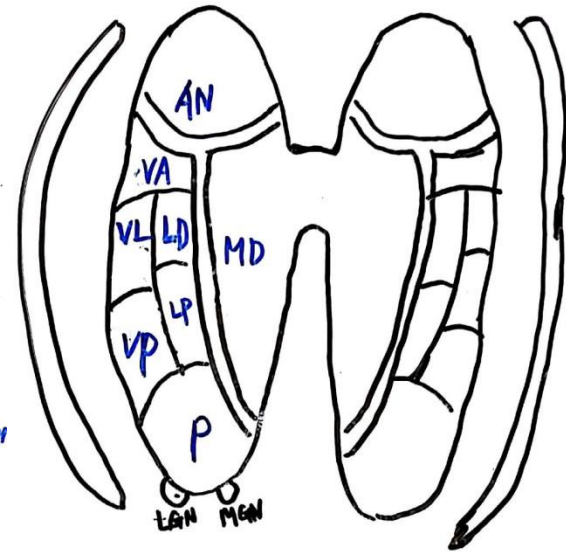
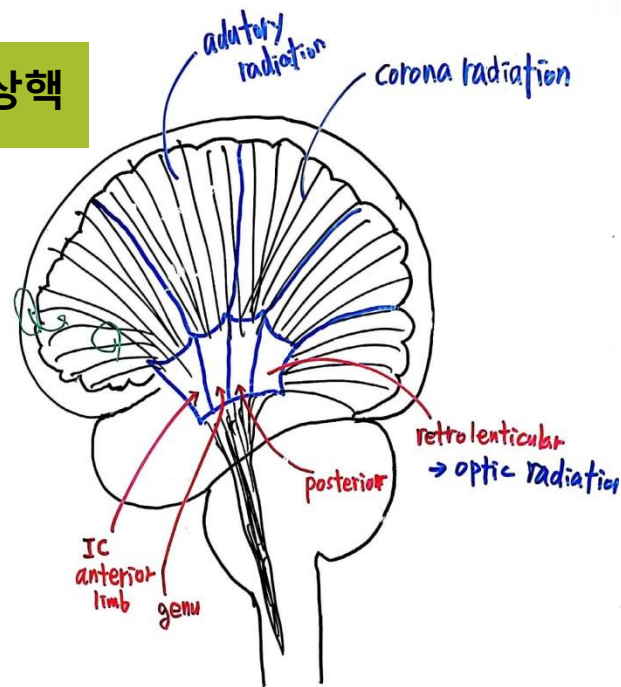
neural groove



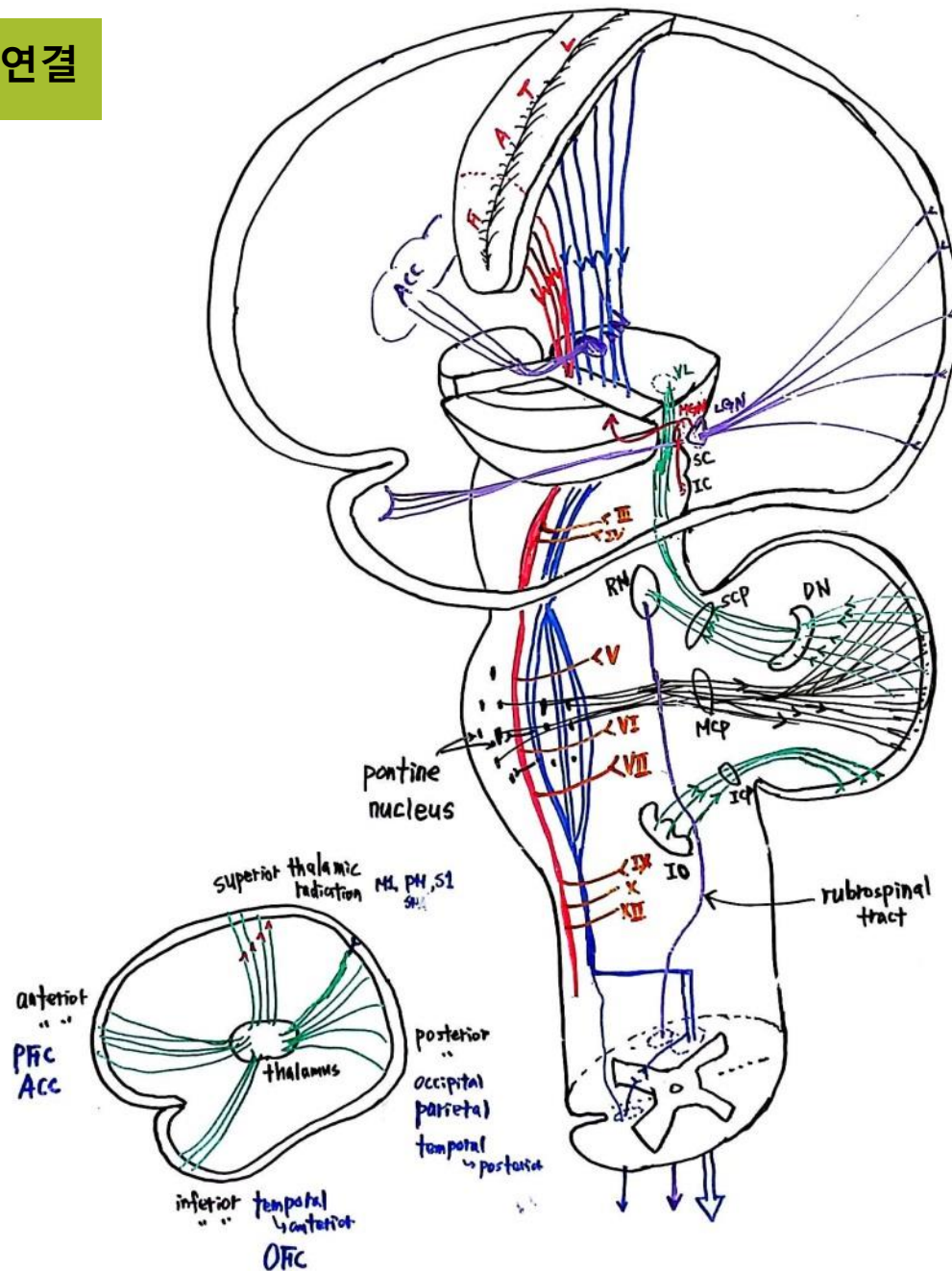
neural tube



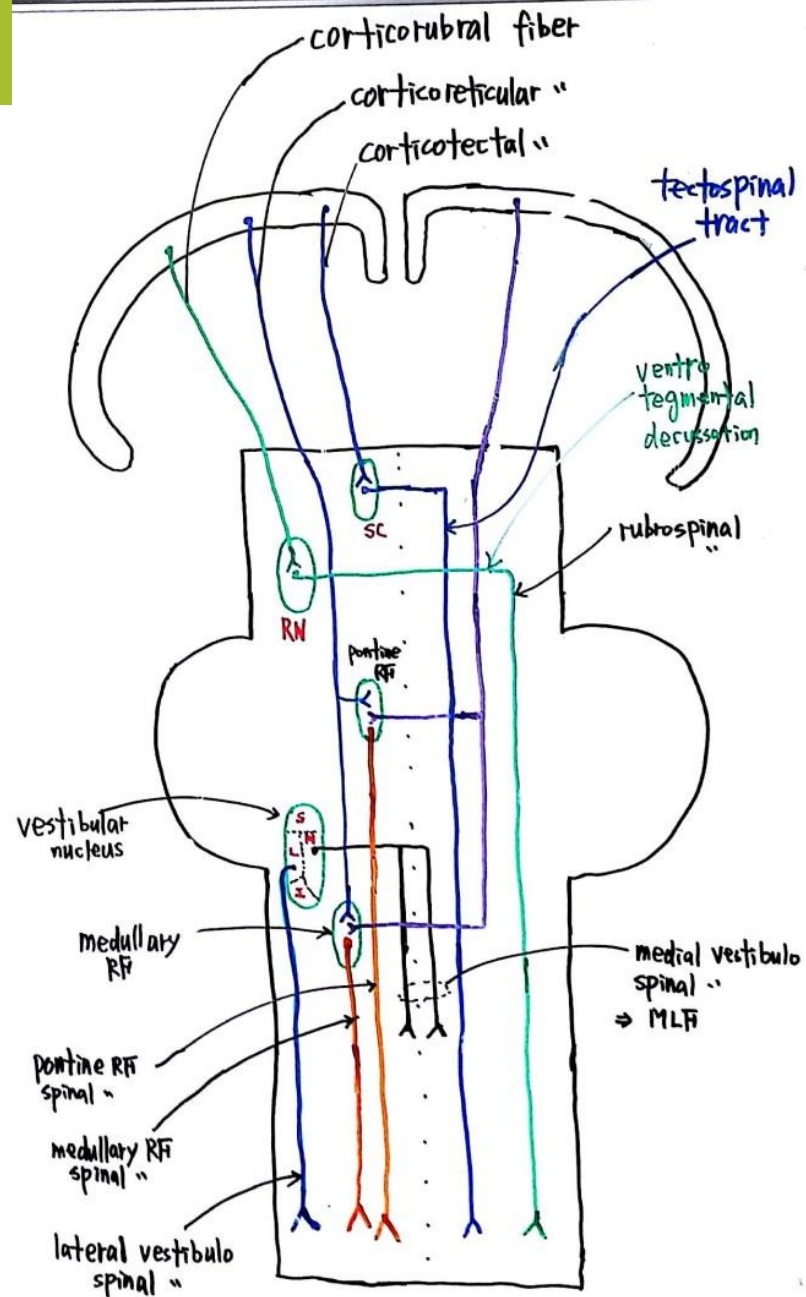
#7보조 - 시상방사, 시상핵



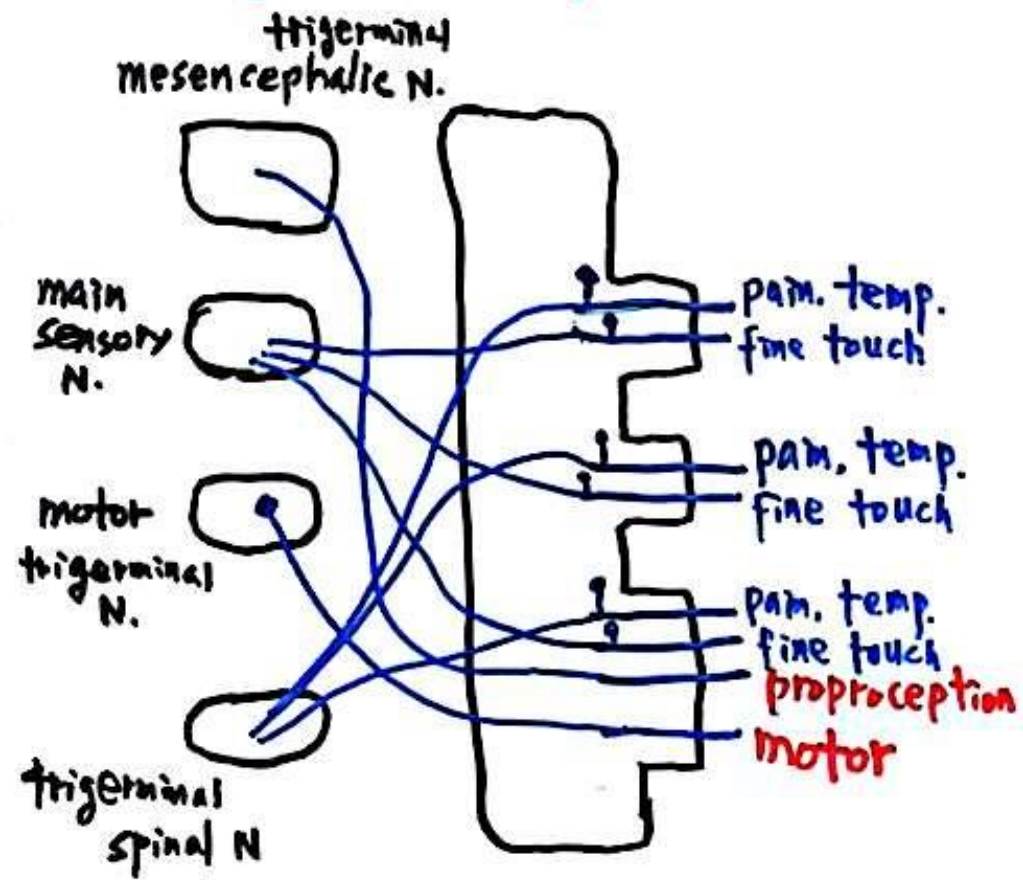
#9보조 - 신경로, 소뇌연결



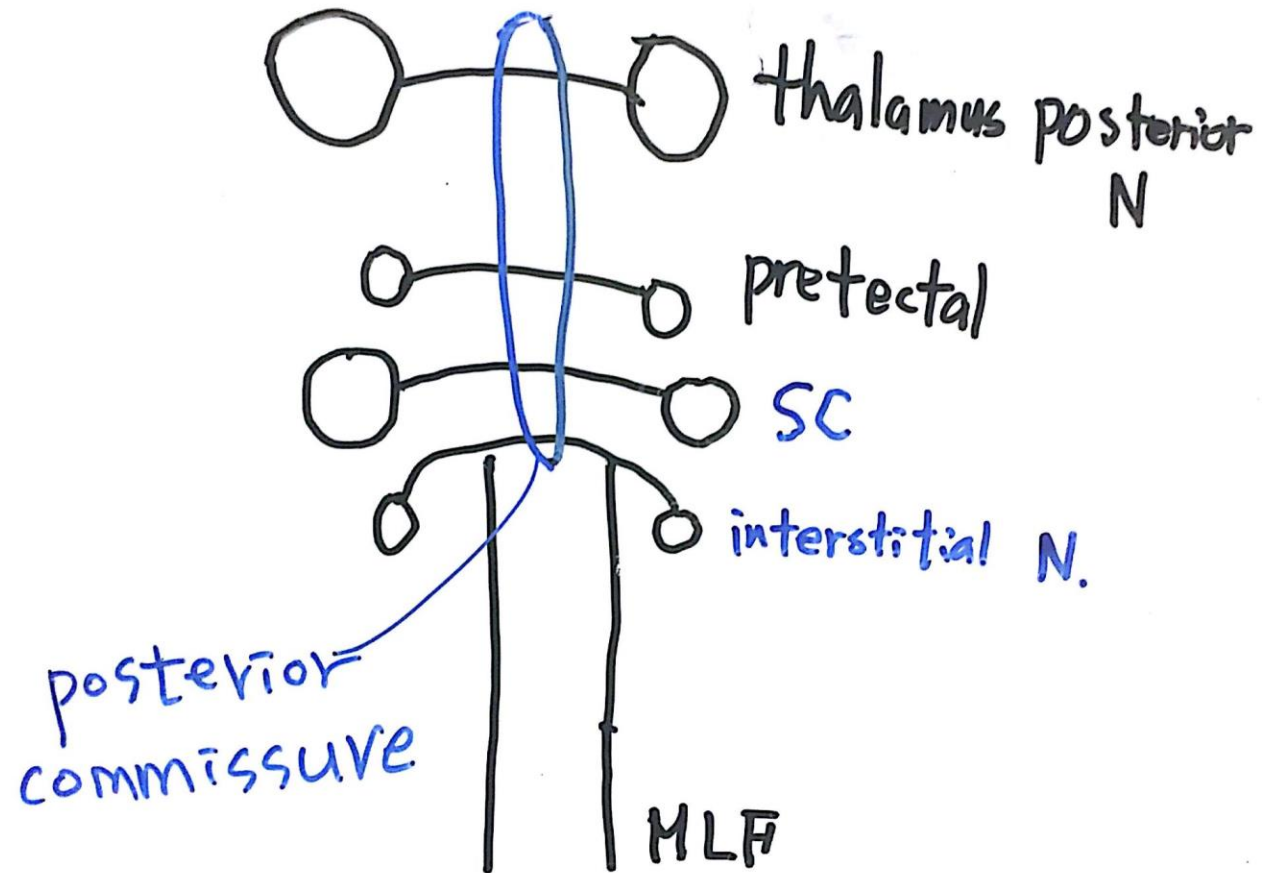
#9보조 - 신경로(하행운동)

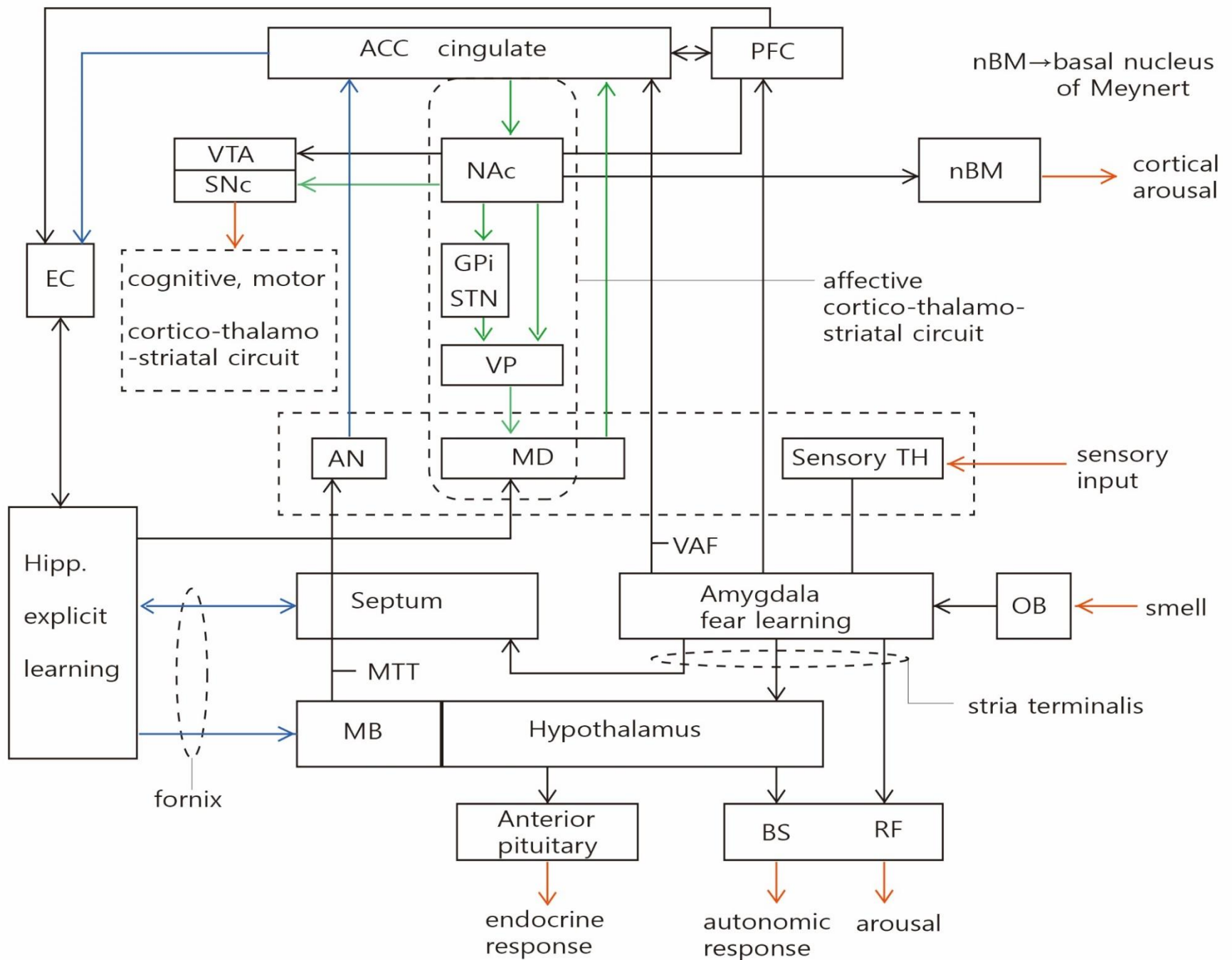


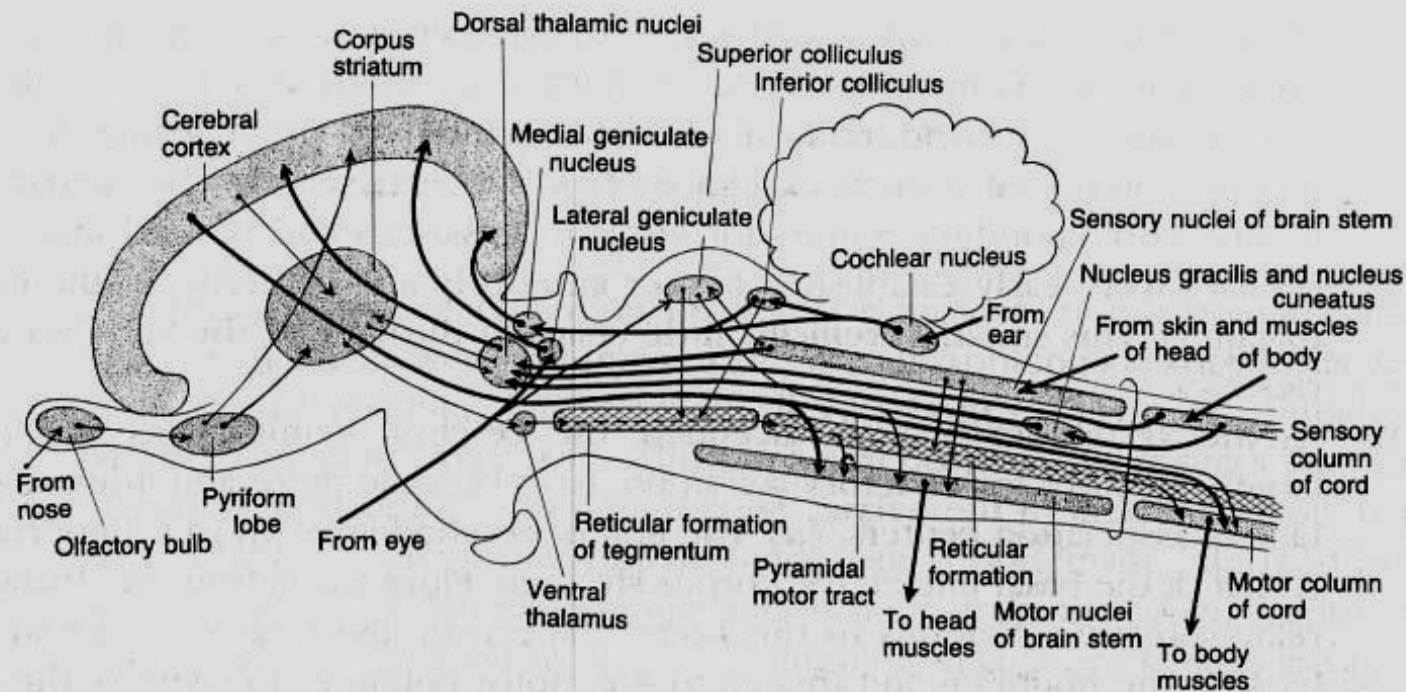
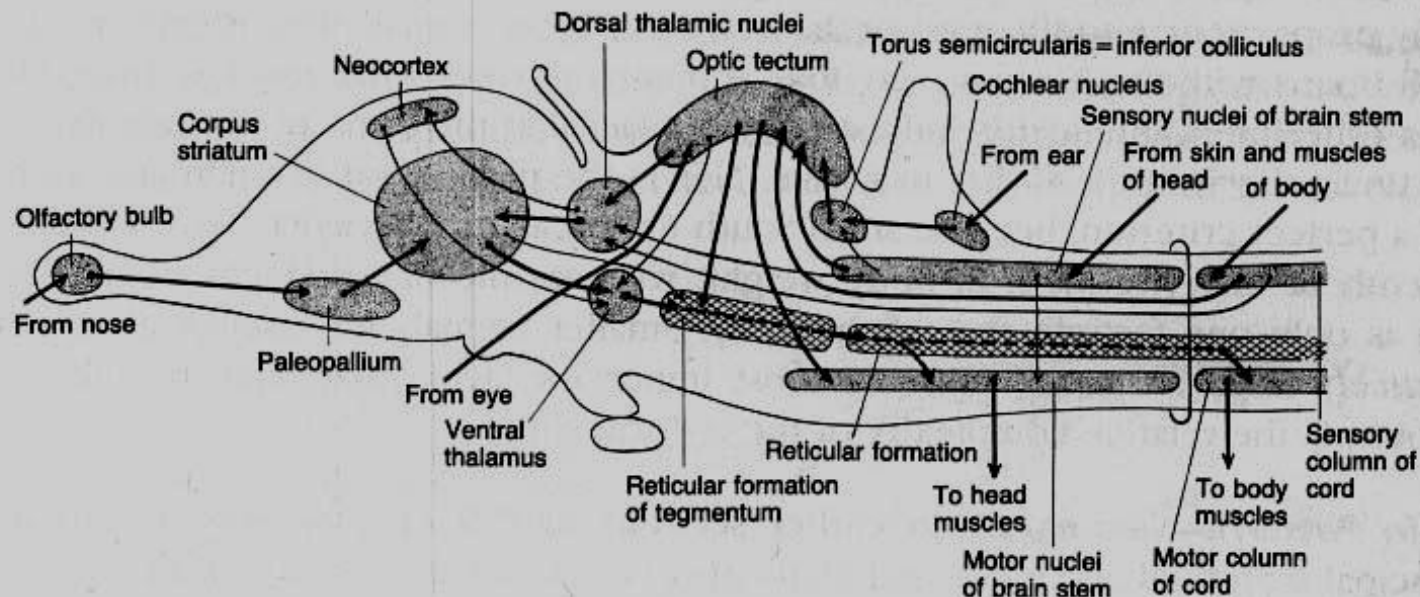
#9보조 - 삼차신경



#10보조 - 후교련







Association areas

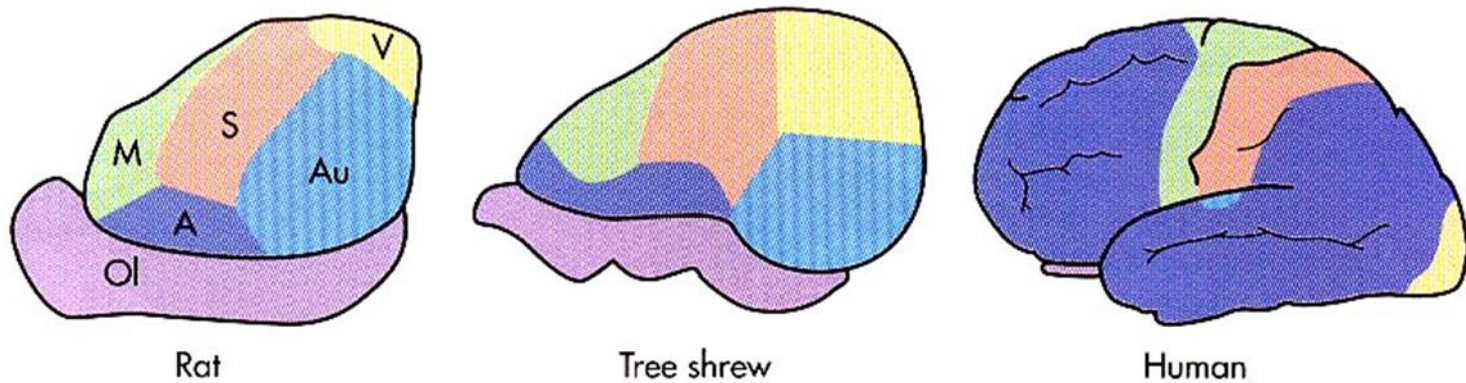
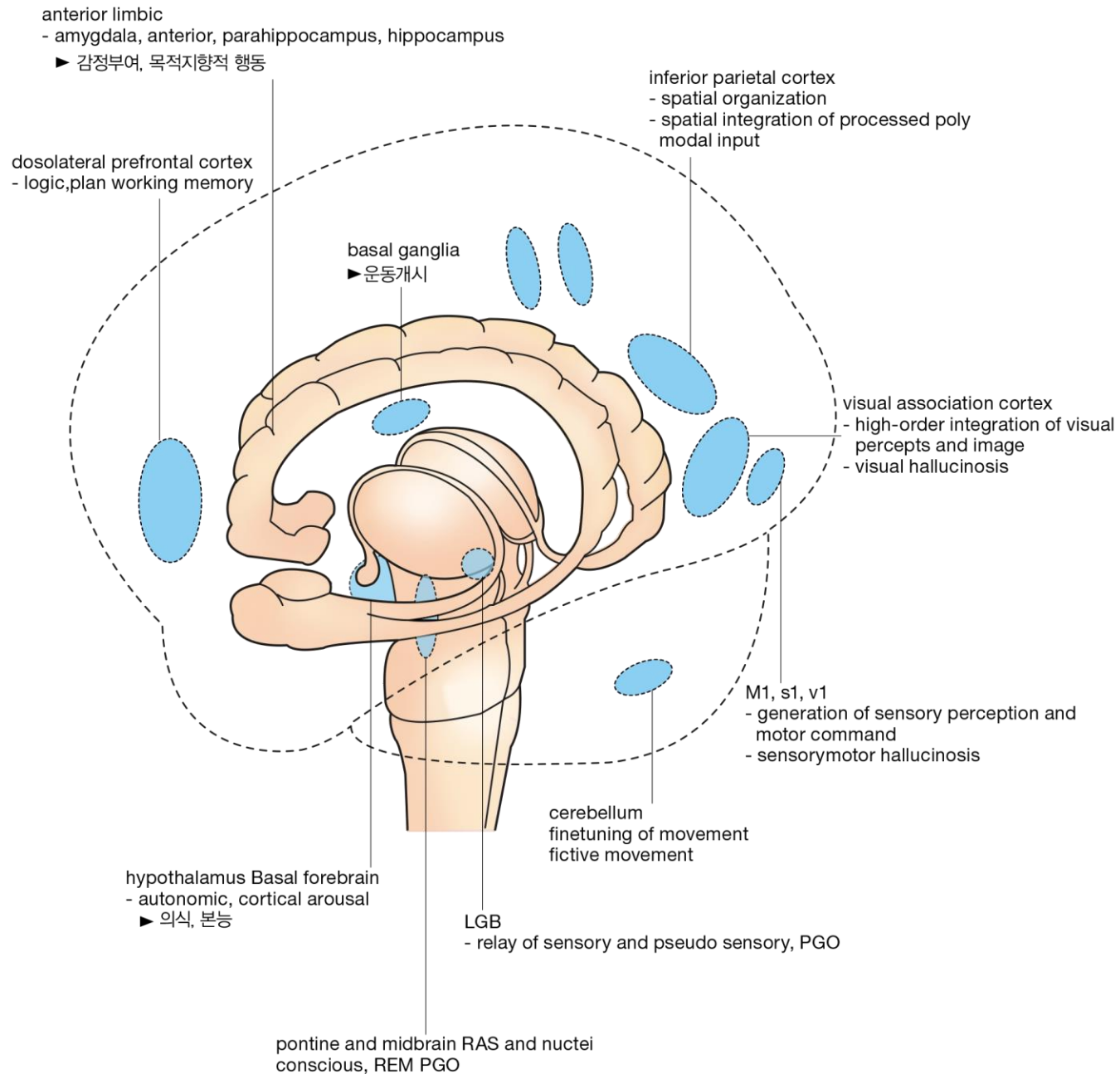
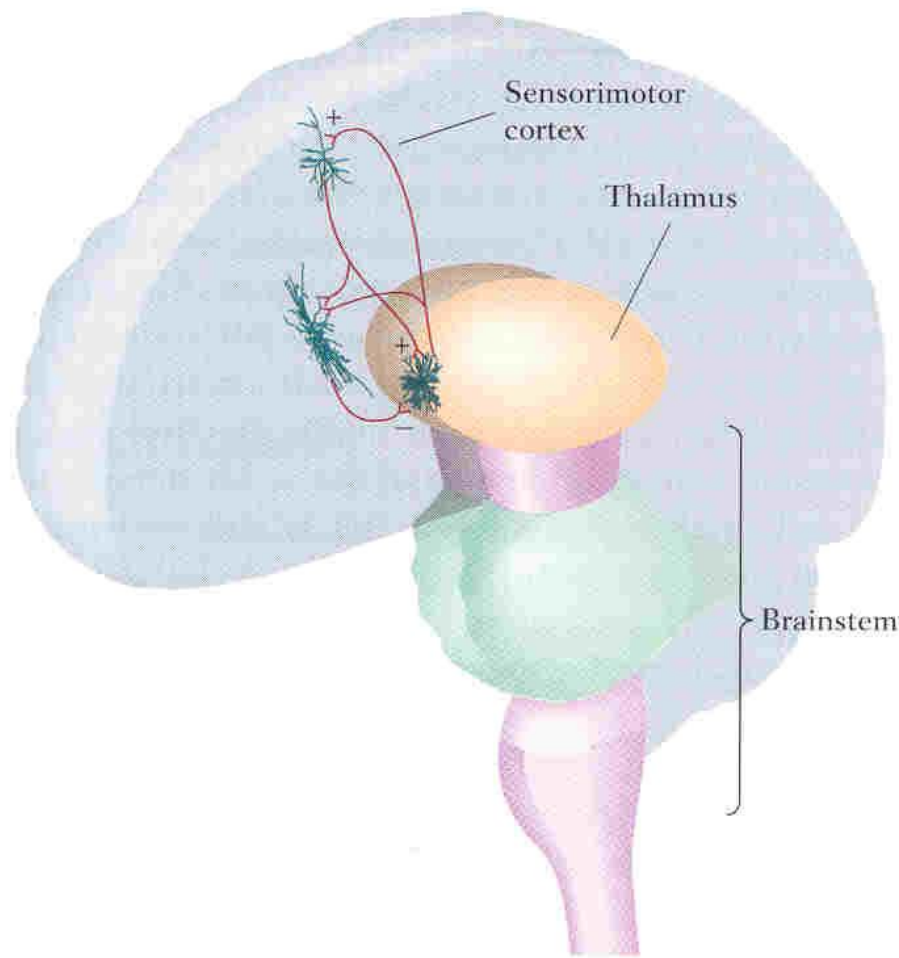


FIGURE 22-14

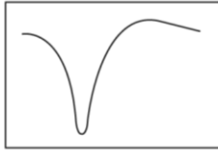
Motor (M), auditory (Au), somatosensory (S), visual (V), olfactory (Ol), and association (A) areas of the cerebral hemispheres of three different mammalian species. All three brains are drawn the same size, even though the human brain is far larger than the other two; the relative and absolute increase in the amount of association cortex is apparent. [Modified from Penfield W: Speech, perception and the cortex. In Eccles JC, editor: *Brain and conscious experience*, New York, 1966, Springer-Verlag.]





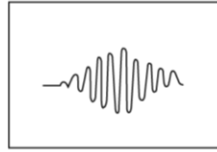
The Thalamocortical System The thalamus has such specific reciprocal interconnections between its nuclei and the cortical regions that are involved in processing each domain of sensation that it can function not only as a gateway for the simultaneous processing of many channels of perceptual data in parallel but also as a selector of individual channels when attention to detail is called for. Thus the pathway to the lateral geniculate body (the visual thalamus) may be opened and other gates closed when close visual inspection is needed. The visual thalamus may also be triggered automatically in REM sleep, accounting in part for the visual detail of dream consciousness.

Slow oscillation
(0.5-1.0Hz,
neocortex)



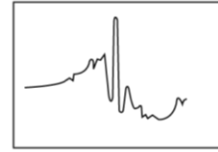
← 1.0s →

Spindle
(11-15Hz,
thalamus)

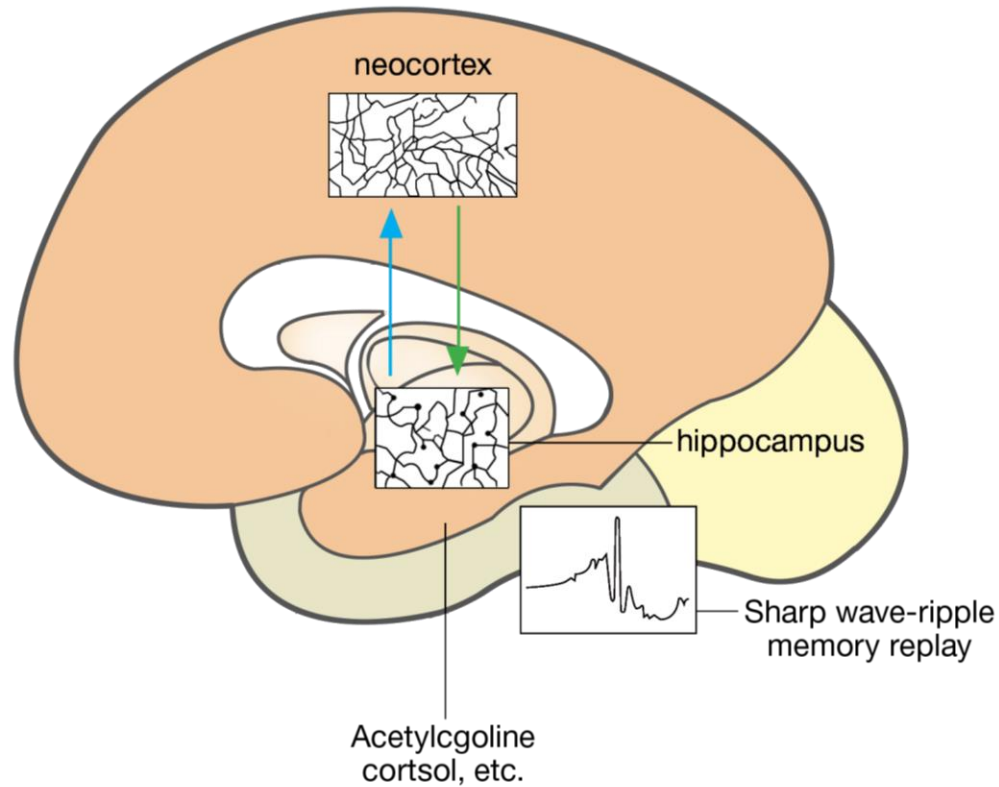


← 0.5s →

Sharp wave ripple
(11-15Hz,
hippocampus)



← 0.2s →



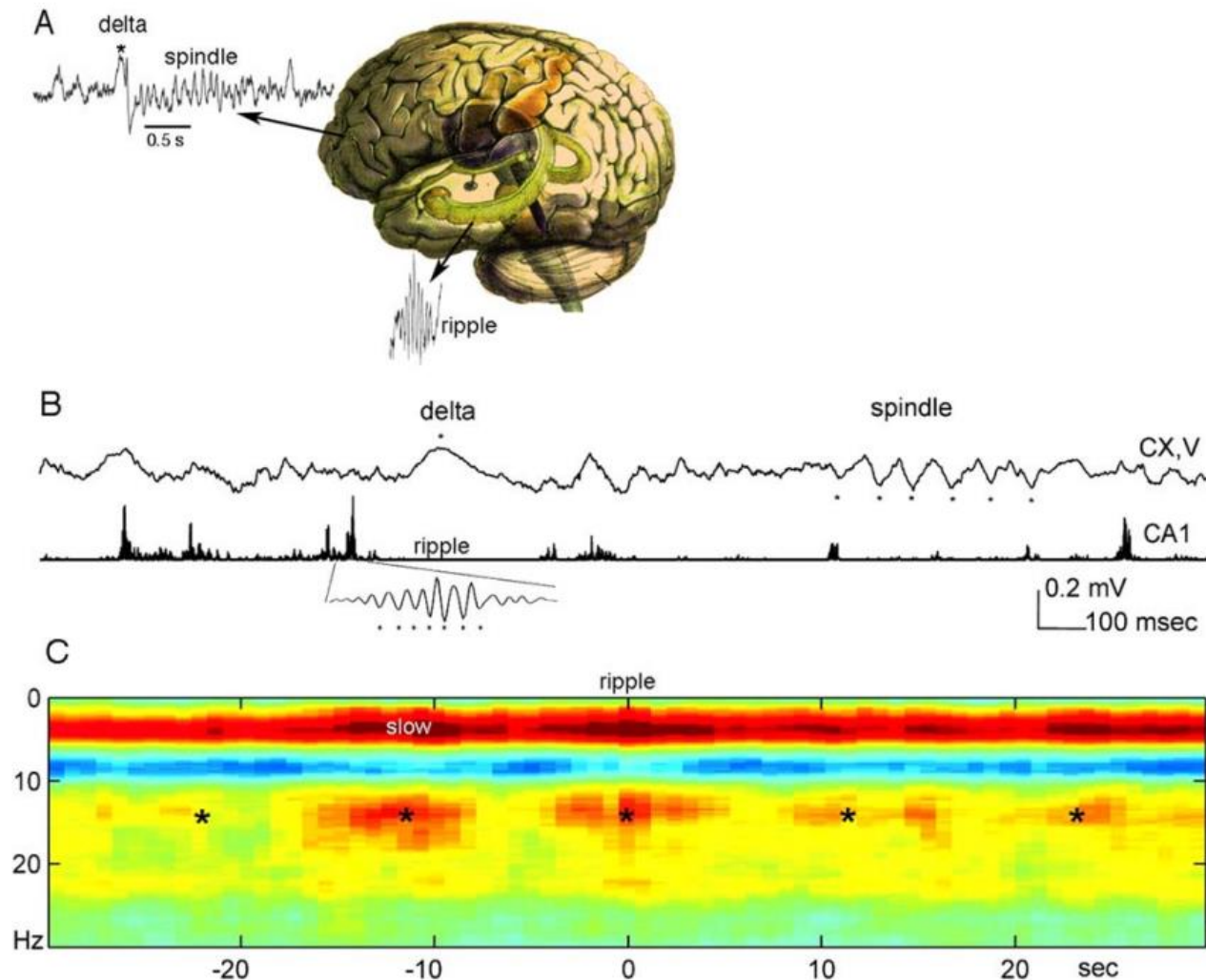
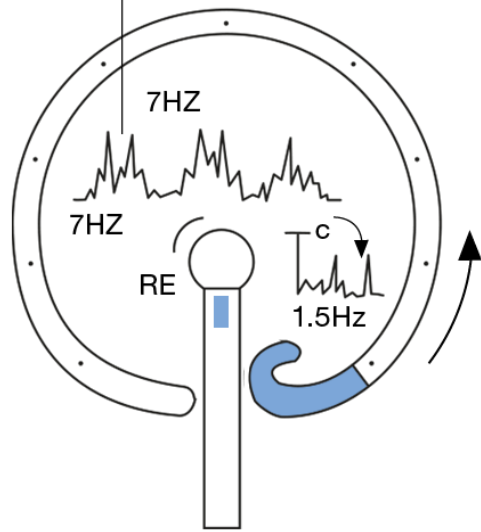


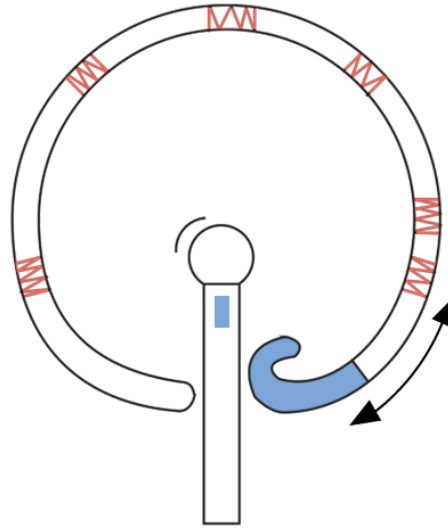
FIGURE 18. Hippocampal-neocortical cross-frequency interactions during sleep. (A) Hippocampal SPW-Rs can induce prefrontal delta wave and sleep spindle. Both spindles and ripples then travel from their source location. (B) Traces of neocortical layer V and hippocampal CA1 (filtered between 140 and 240 Hz and rectified) LFP in the rat. (Inset) Filtered ripple at a faster time scale. Dots: peak of delta wave, troughs of sleep spindle and hippocampal ripple waves. (C) Hippocampal ripple peak-triggered neocortical

spectrogram. Power spectrograms, centered on ripples (time 0 s), were averaged and normalized by the mean power over the entire recording session and log transformed. Note increased correlation of power in the slow oscillation (delta; 0.5–4 Hz) and sleep spindle (10–18 Hz) bands with hippocampal ripples. *Slow (~0.1 Hz) comodulation of neocortical and hippocampal activity. Reproduced from Sirota et al. (2003).

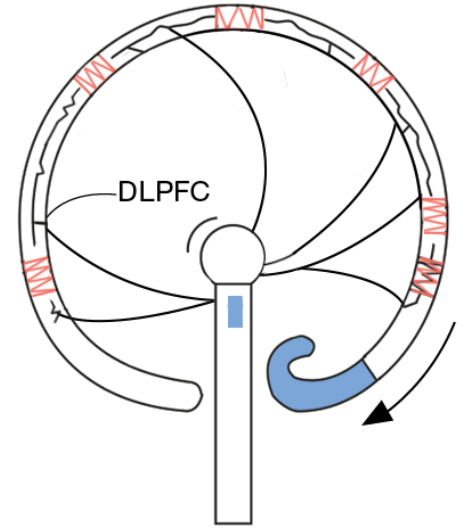
Sleep spindle



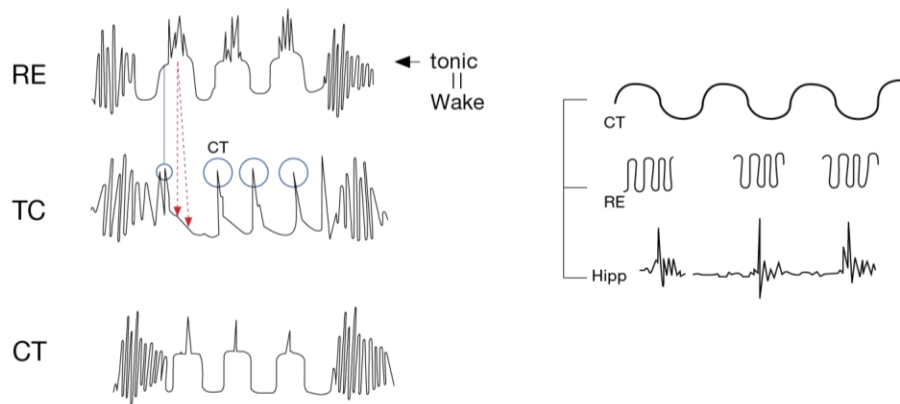
NREM



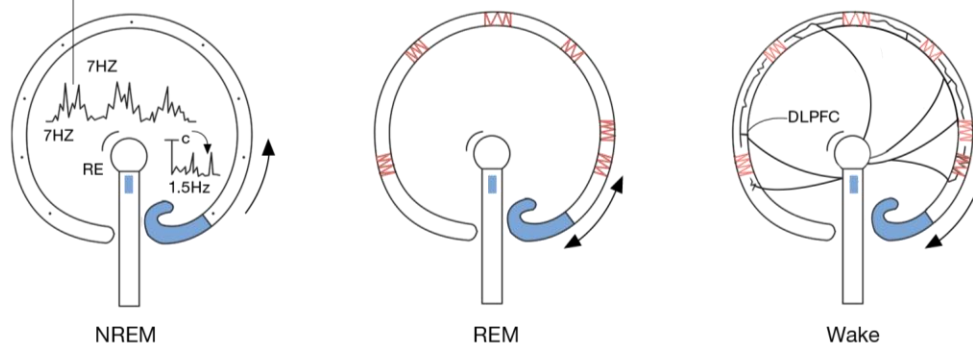
REM



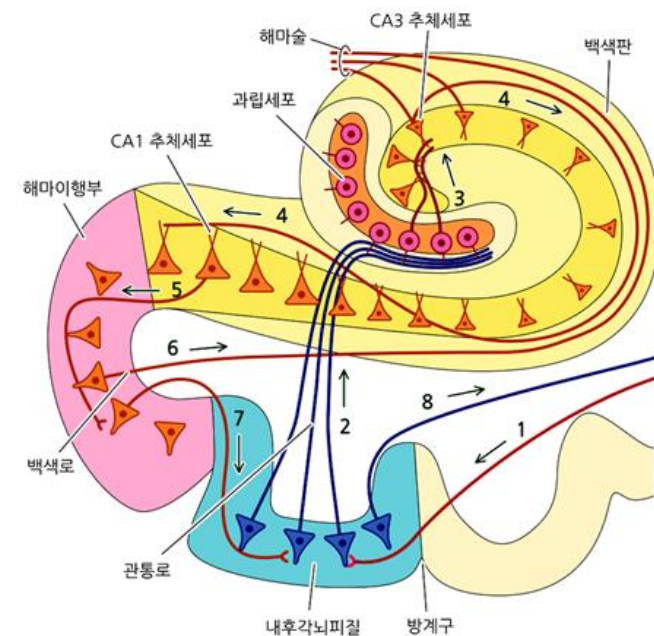
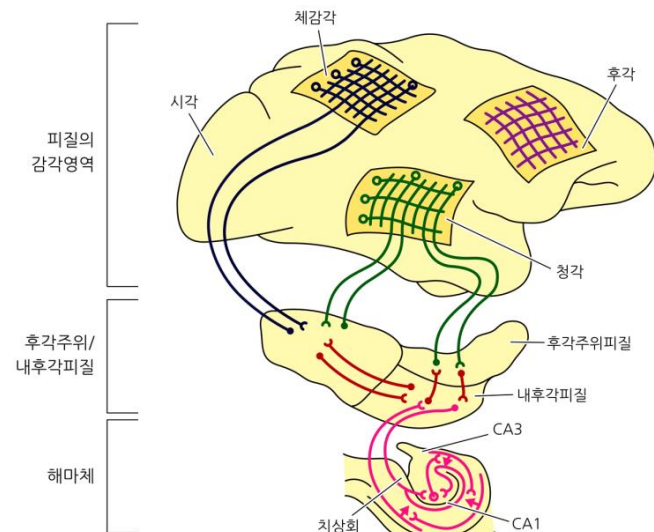
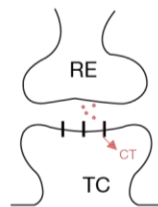
Wake

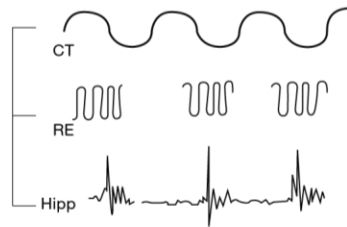
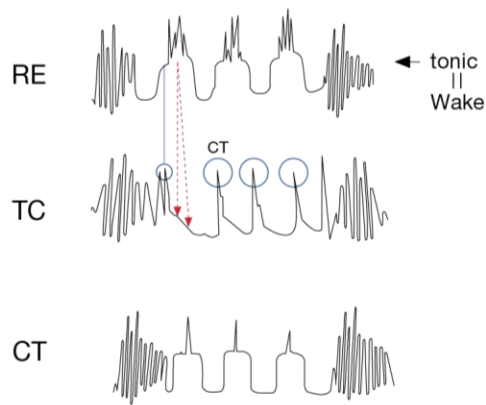


Sleep spindle

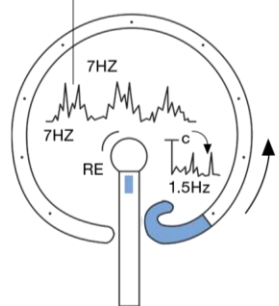


	NREM	REM	Wake
Ach	↑	↑↑↑↑	↑↑
NE	↑		↑
5HT	↑		↑
DA		↑	↑
cortical connectivity	•	* *	↔
DLPFC	△	X	○

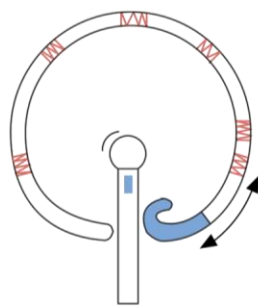




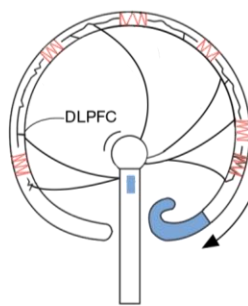
Sleep spindle



NREM

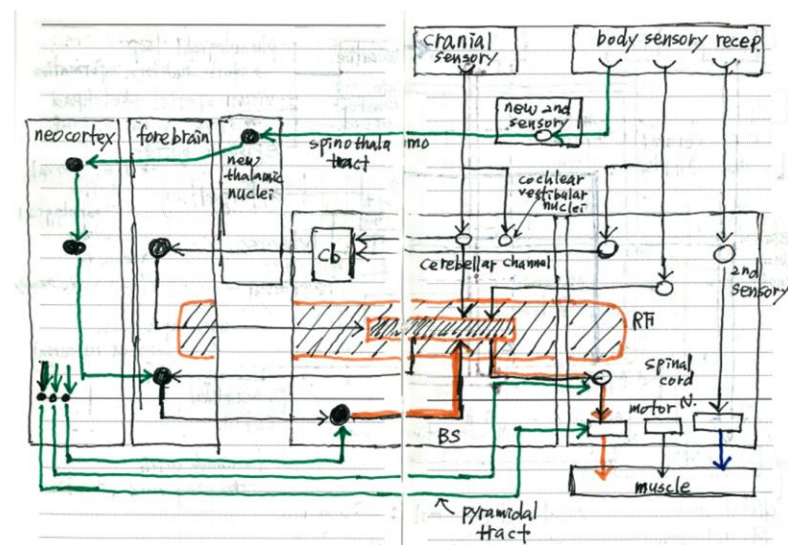
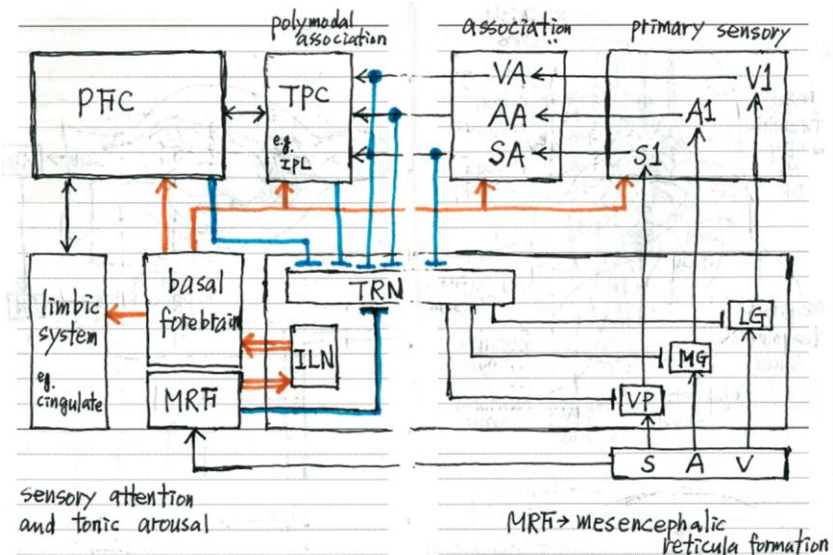
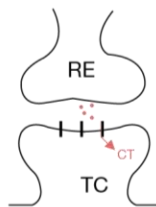


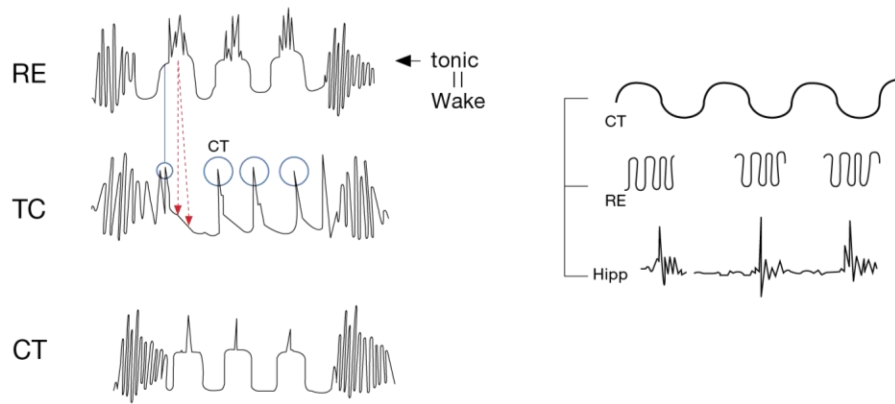
REM



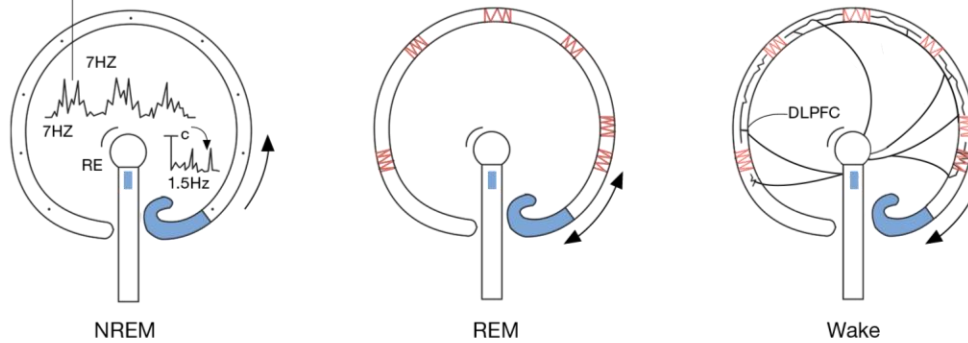
Wake

	NREM	REM	Wake
Ach	↑	↑↑↑↑	↑↑
NE	↑		↑
5HT	↑		↑
DA		↑	↑
cortical connectivity	••••	*•••*	••••
DLPFC	△	X	○

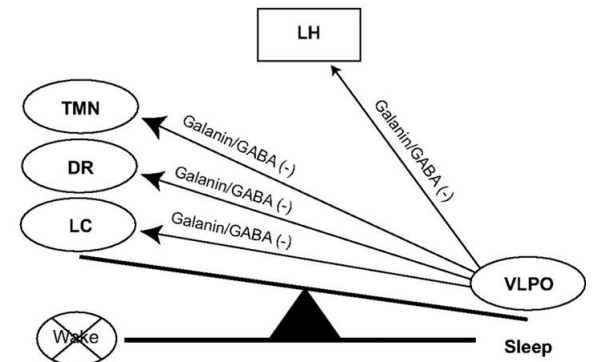
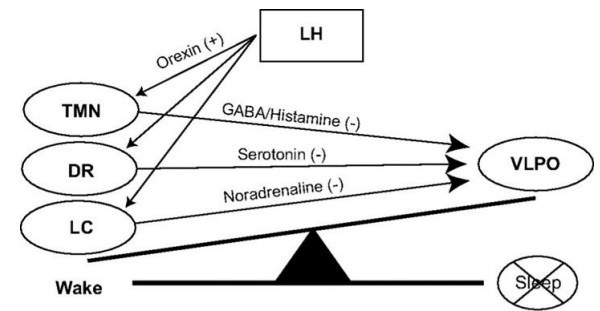
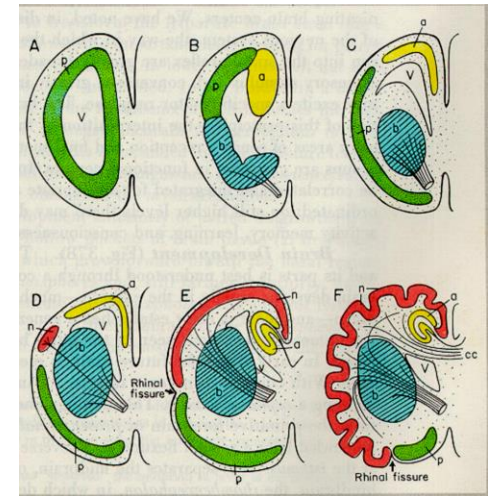
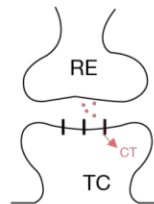


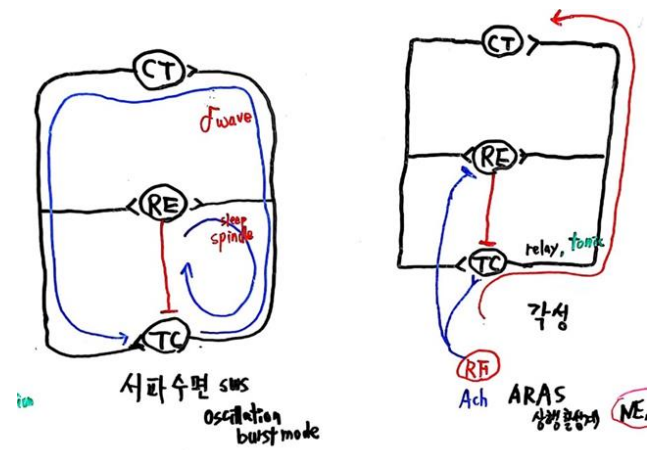
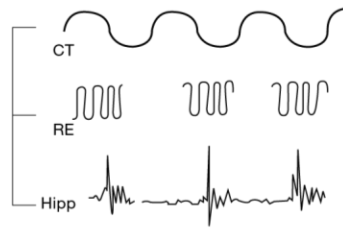
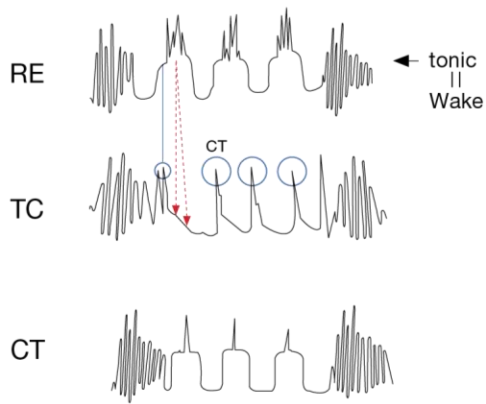


Sleep spindle

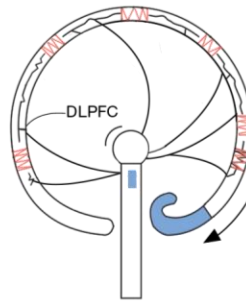
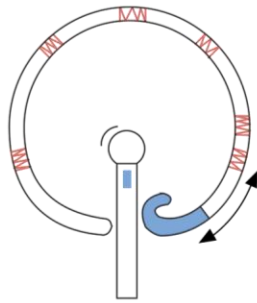
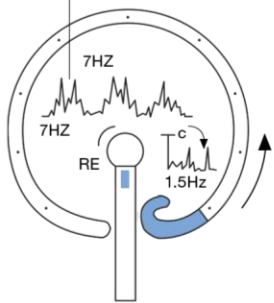


	NREM	REM	Wake
Ach	↑	↑↑↑↑	↑↑
NE	↑		↑
5HT	↑		↑
DA		↑	↑
cortical connectivity			
DLPFC	△	X	○





Sleep spindle

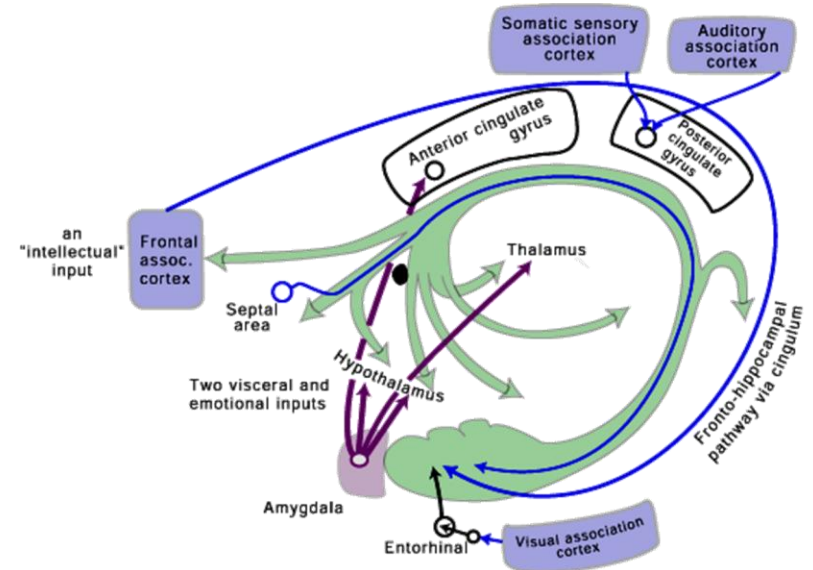
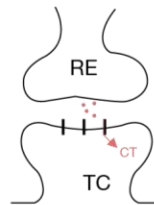


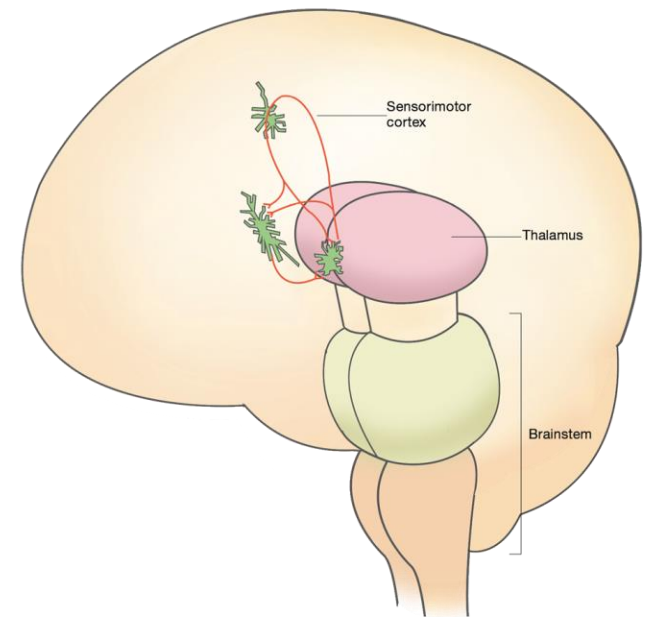
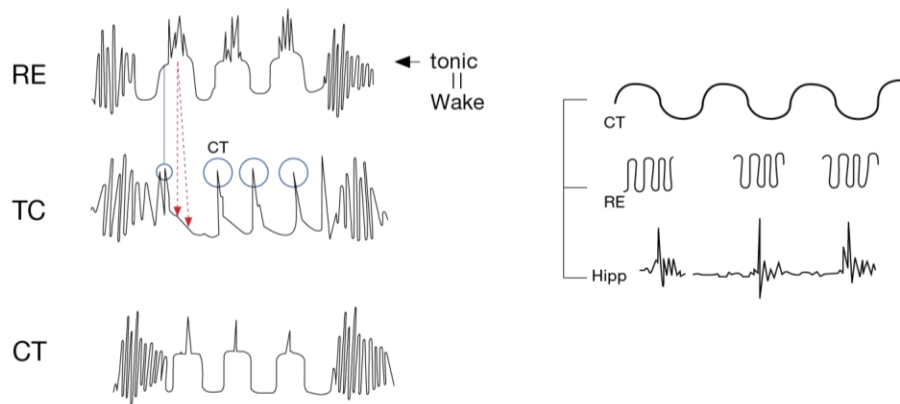
NREM

REM

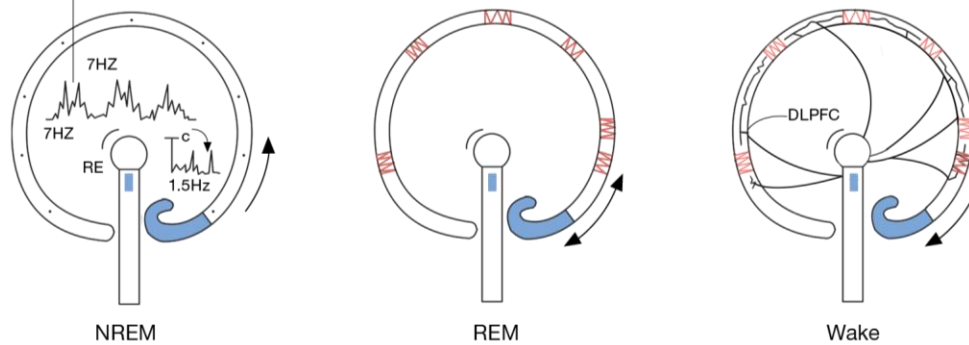
Wake

	NREM	REM	Wake
Ach	↑	↑↑↑↑	↑↑
NE	↑		↑
5HT	↑		↑
DA		↑	↑
cortical connectivity			
DLPFC	△	X	○

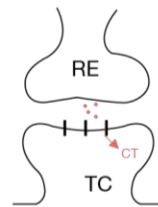




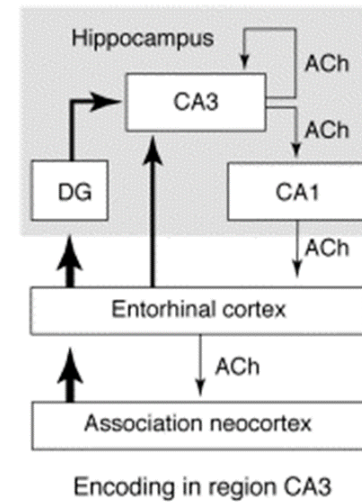
Sleep spindle



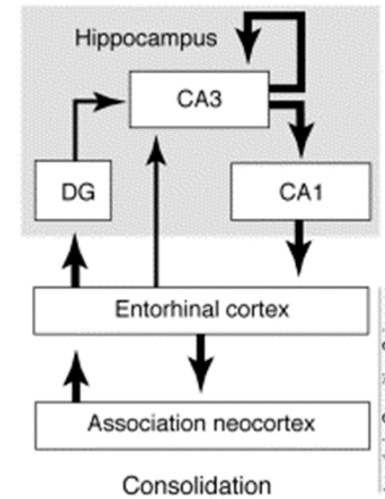
	NREM	REM	Wake
Ach	↑	↑↑↑↑	↑↑
NE	↑		↑
5HT	↑		↑
DA		↑	↑
cortical connectivity			
DLPFC	△	X	○

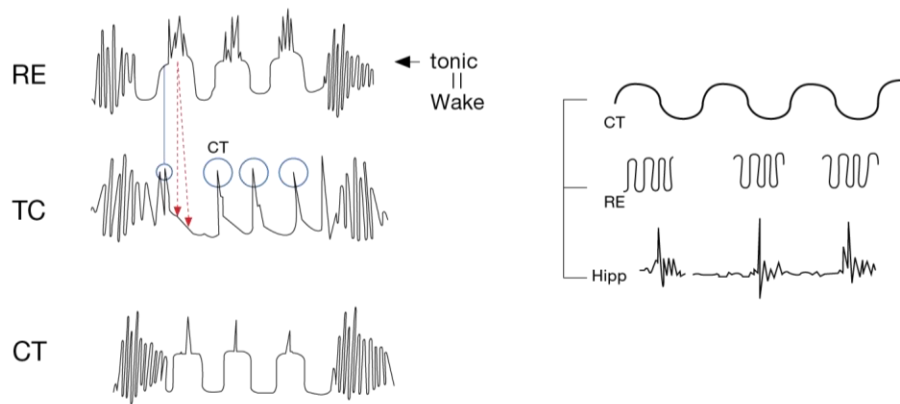


A Waking (high ACh)

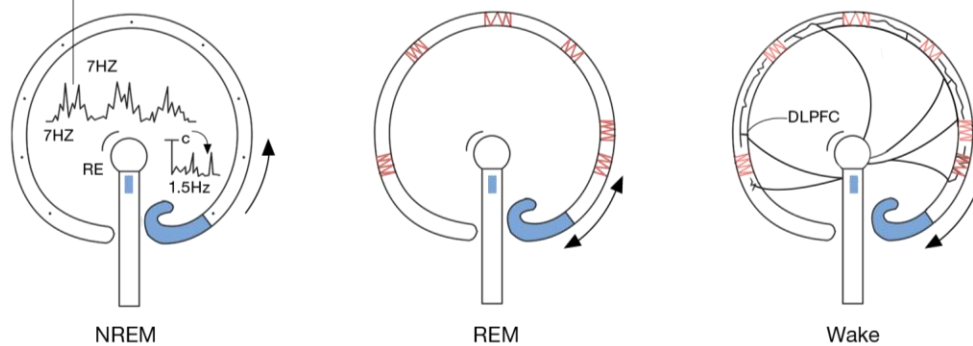


B Slow-wave sleep (low ACh)

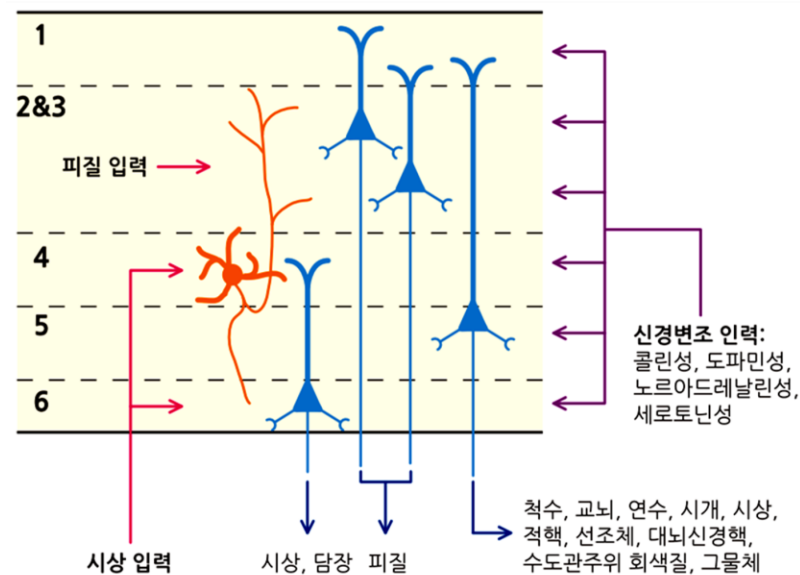
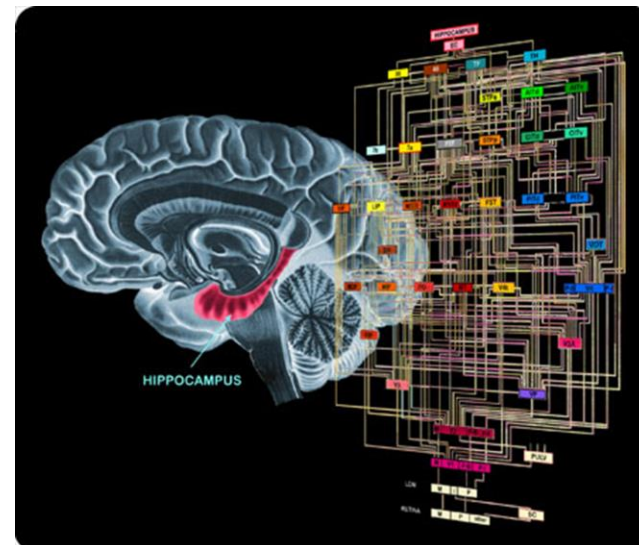
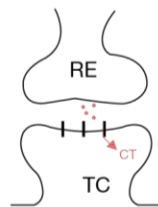


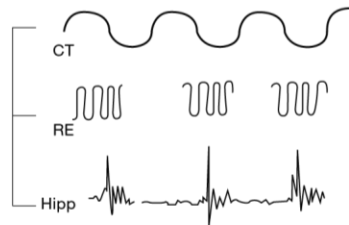
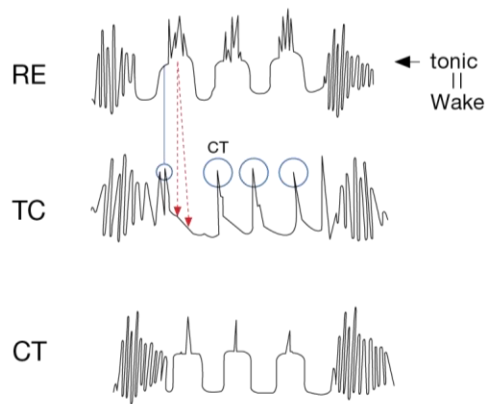


Sleep spindle

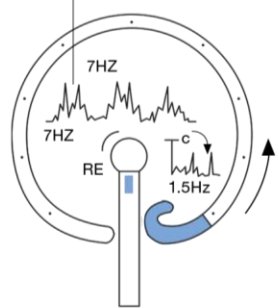


	NREM	REM	Wake
Ach	↑	↑↑↑↑	↑↑
NE	↑		↑
5HT	↑		↑
DA		↑	↑
cortical connectivity	• • • •	* * *	↕ ↕ ↕ ↕
DLPFC	△	X	○

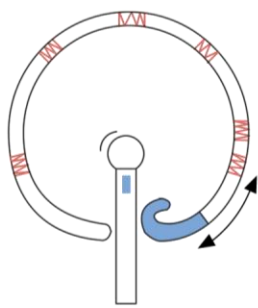




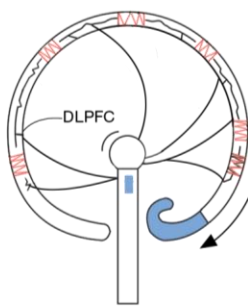
Sleep spindle



NREM

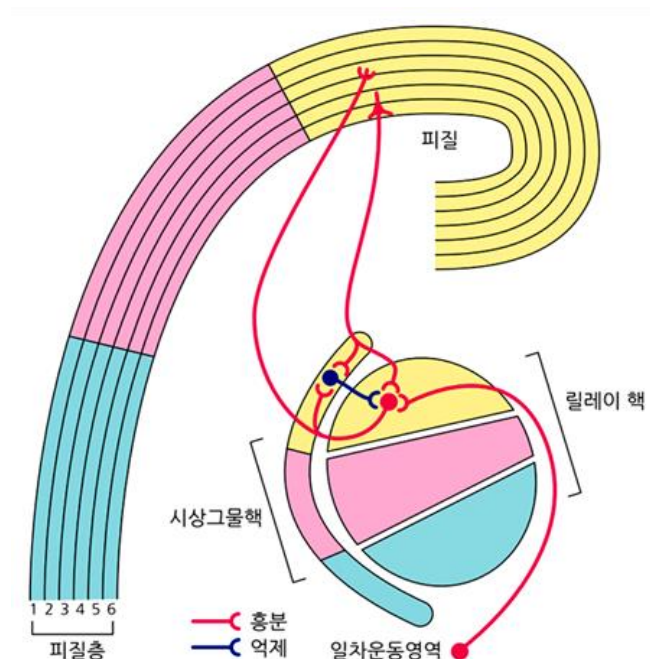
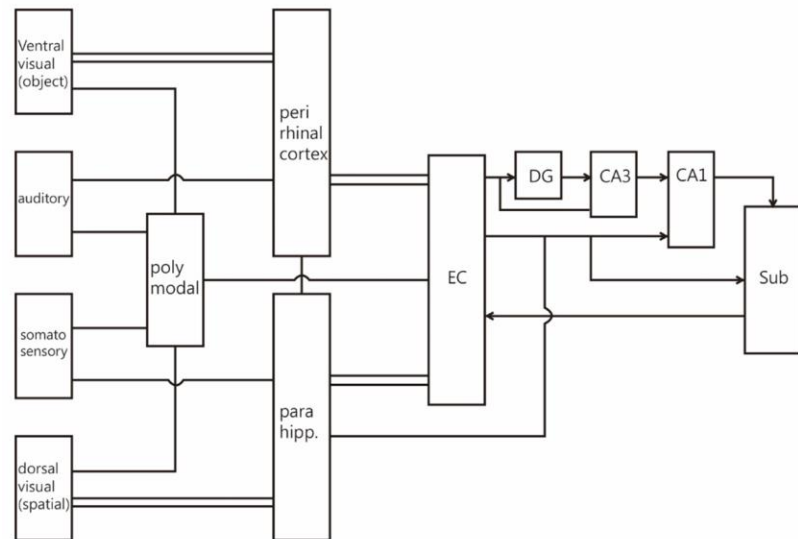
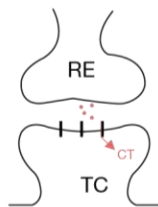


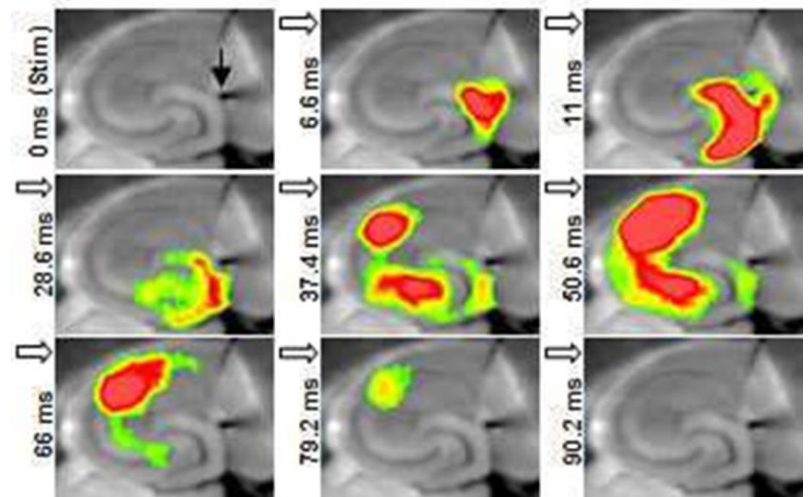
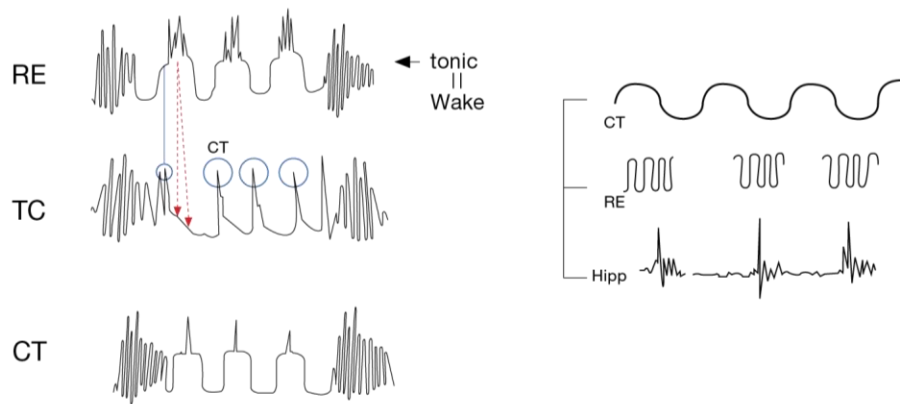
REM



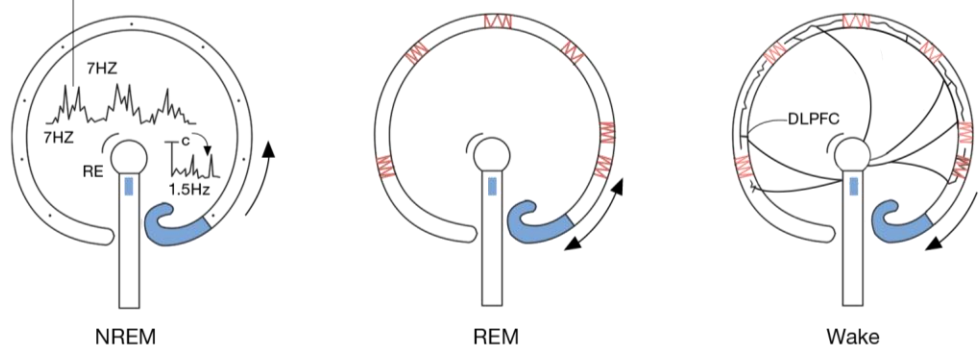
Wake

	NREM	REM	Wake
Ach	↑	↑↑↑↑	↑↑
NE	↑		↑
5HT	↑		↑
DA		↑	↑
cortical connectivity			
DLPFC	△	X	○

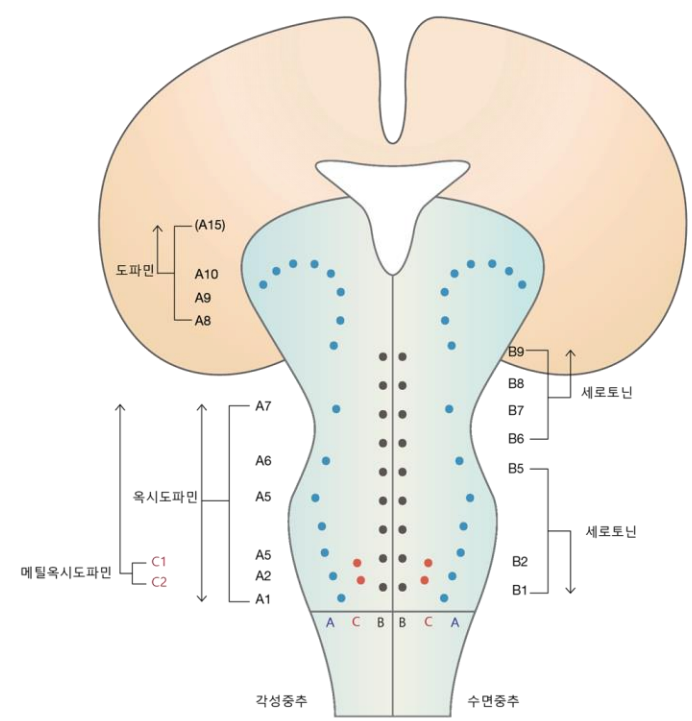
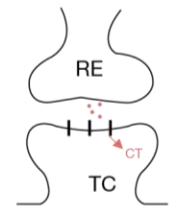


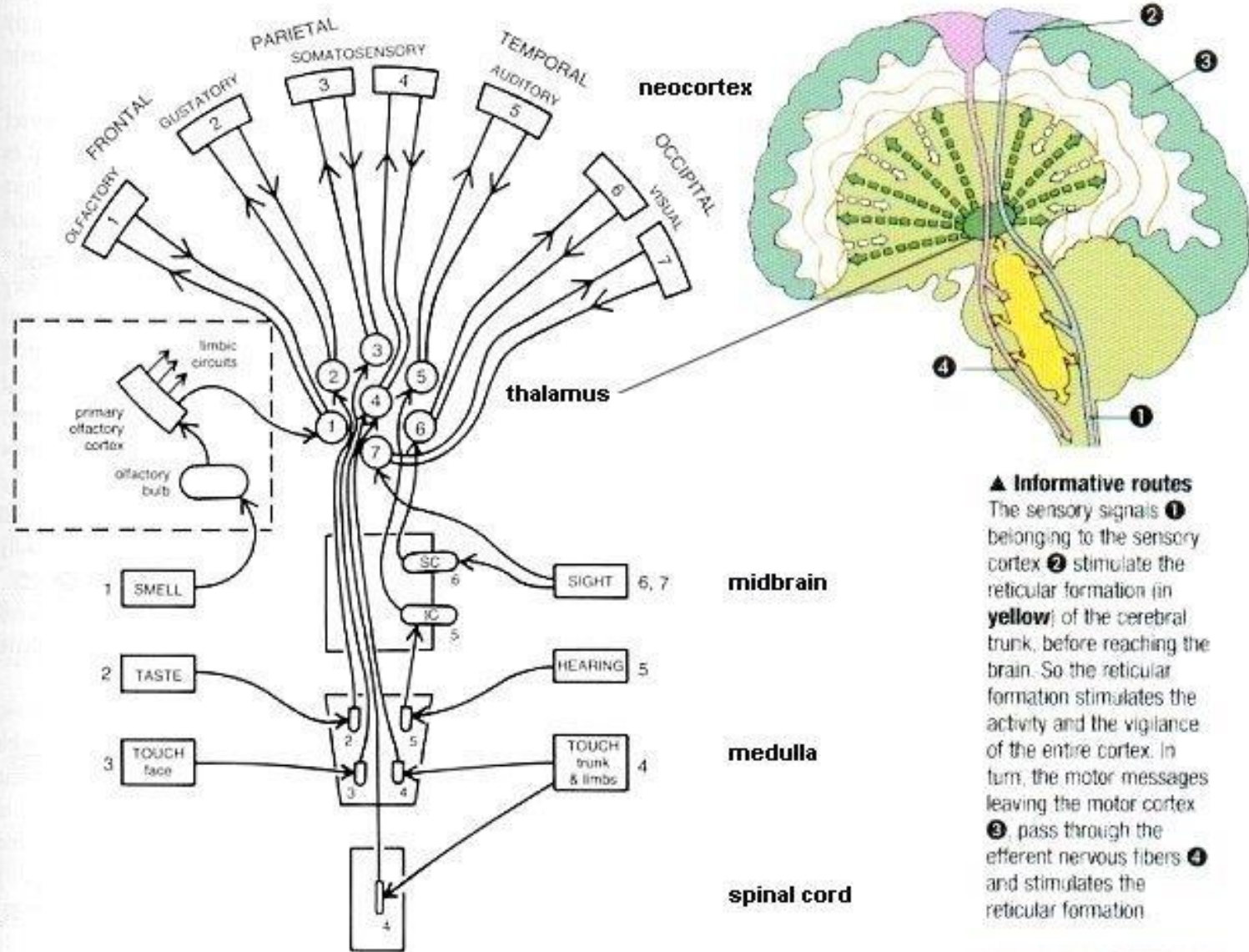


Sleep spindle



	NREM	REM	Wake
Ach	↑	↑↑↑↑	↑↑
NE	↑		↑
5HT	↑		↑
DA		↑	↑
cortical connectivity	• • • • •	* * *	↔ ↔ ↔
DLPFC	△	X	○



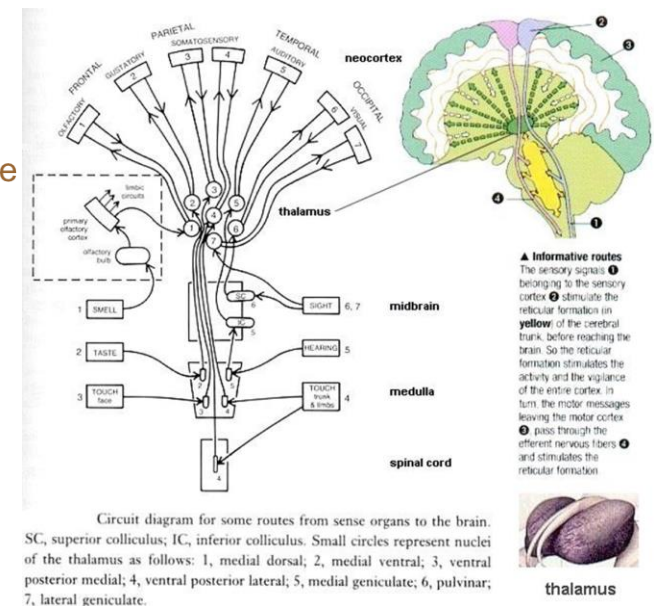
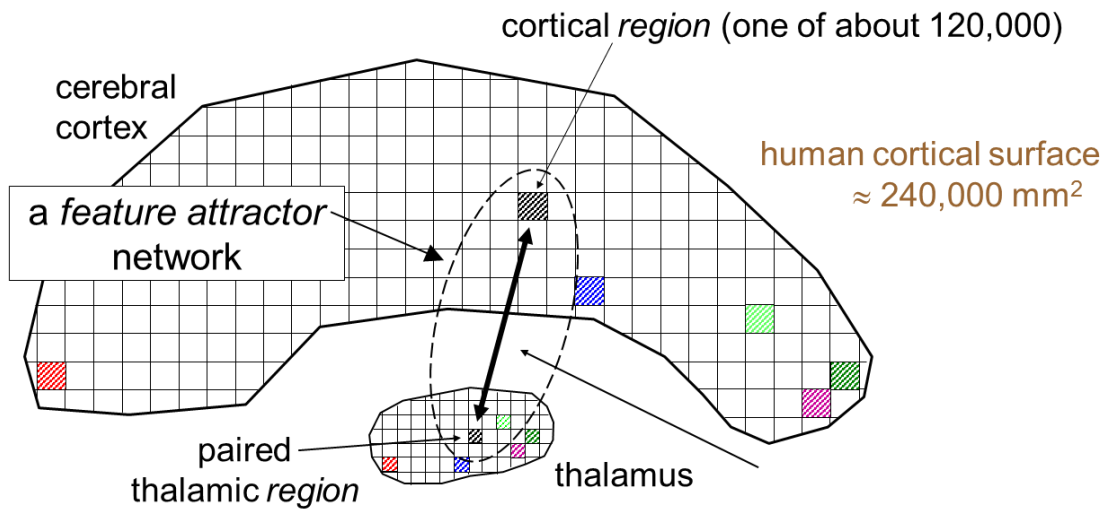
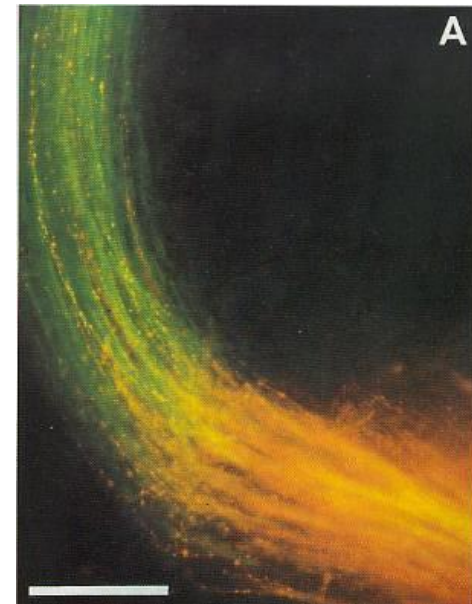
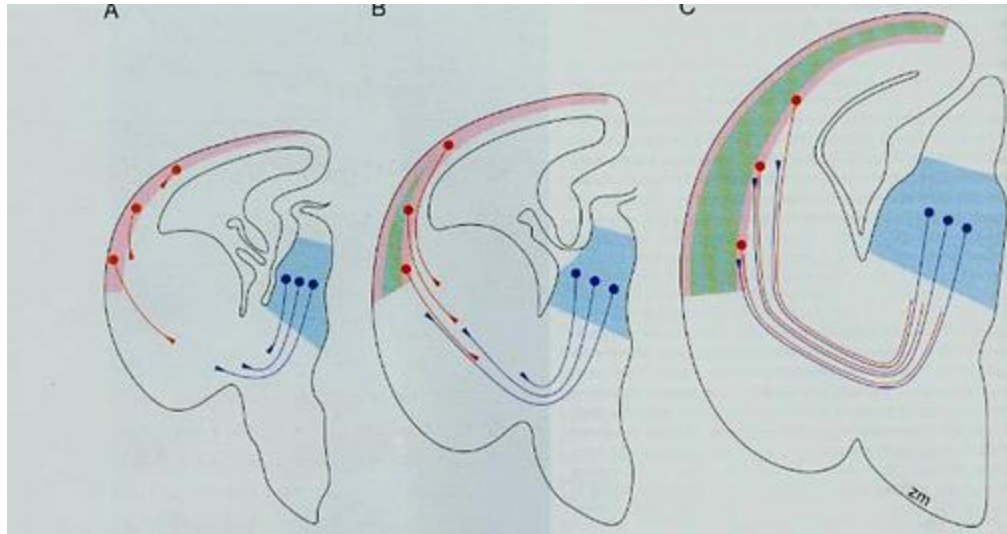


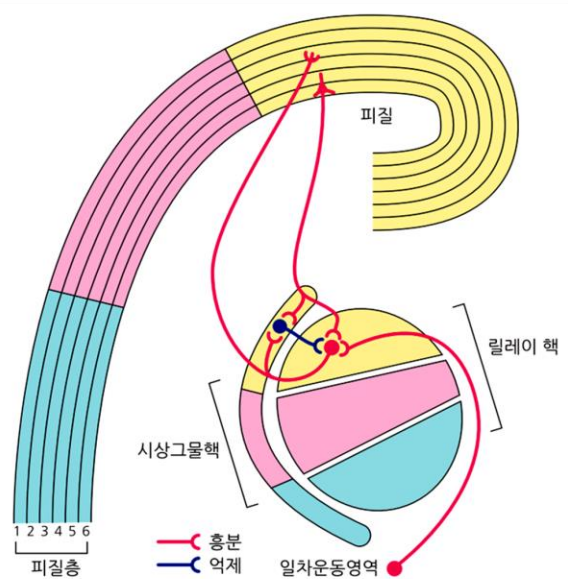
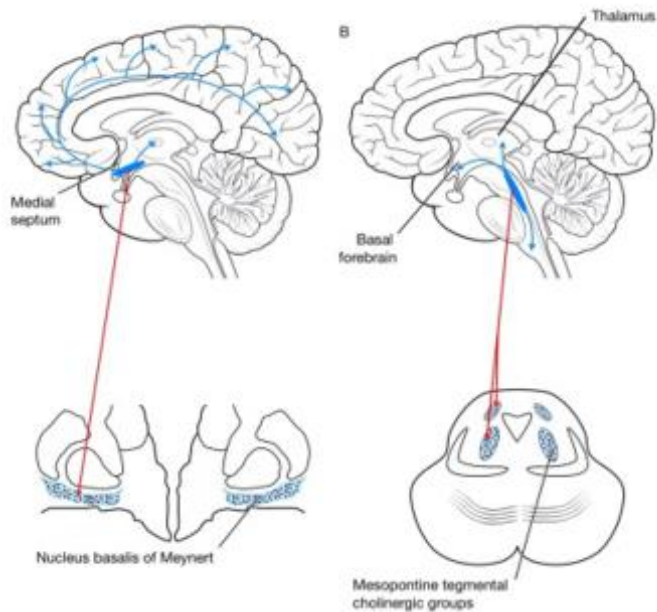
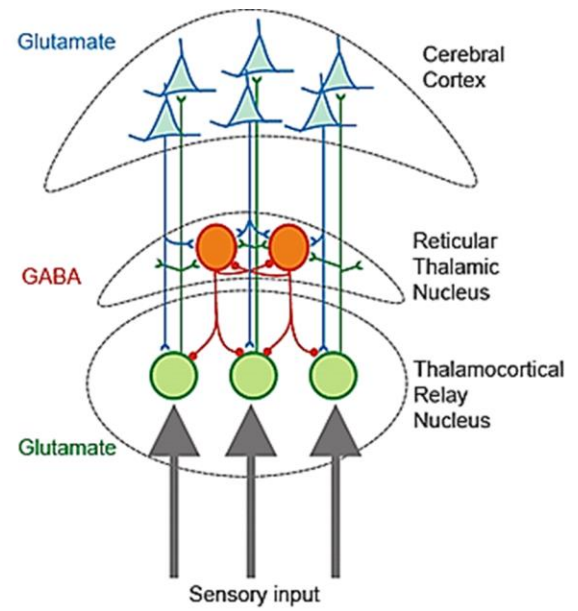
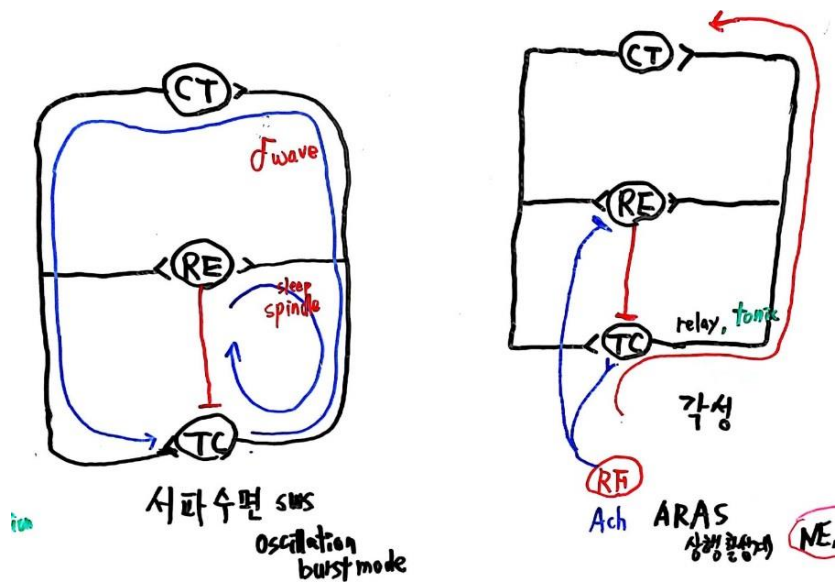
Circuit diagram for some routes from sense organs to the brain. SC, superior colliculus; IC, inferior colliculus. Small circles represent nuclei of the thalamus as follows: 1, medial dorsal; 2, medial ventral; 3, ventral posterior medial; 4, ventral posterior lateral; 5, medial geniculate; 6, pulvinar; 7, lateral geniculate.



thalamus

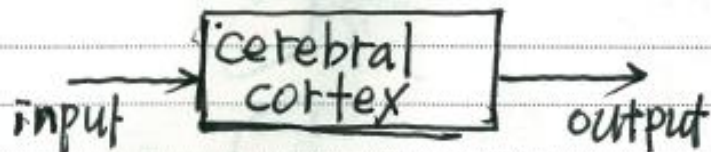
Projections from preplate guide thalamocortical fibers



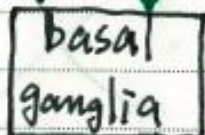


and neuromodulatory input
guided by statistical properties
of input and neuromod

unsupervised learning



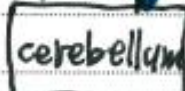
input reward



reinforcement learning



input

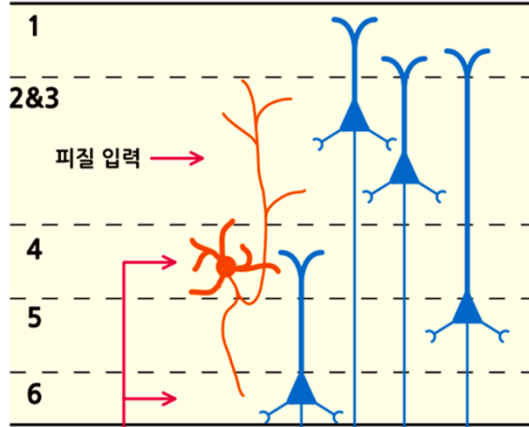


output target

supervised learning

guided by SNc
DA input

guided by error signal
from IO



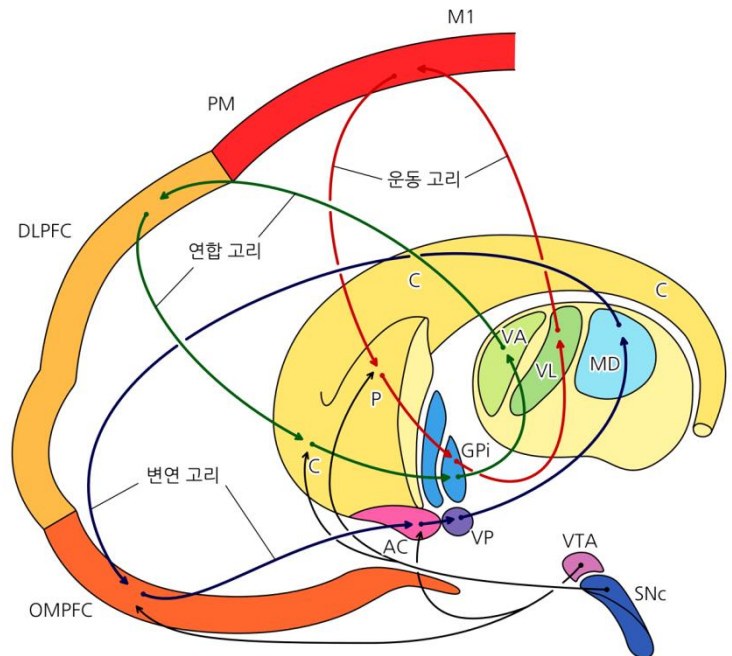
피질 입력

시상 입력

시상, 담장, 피질

신경변조 인력:
콜린성, 도파민성,
노르아드레날린성,
세로토닌성

척수, 교뇌, 연수, 시개, 시상,
적핵, 선조체, 대뇌신경핵,
수도관주위 회색질, 그물체



지각

연합 조합 세계는 우리의 상태이다

지각의 단계: 지각 → 재인 → 행동

행동은 지각의 결과이다. recognition

시각: 초급단계 → 선분, 방향, 색채, 깊이
중급 → 색, 형태, 향등성, 윤곽선 연결, 간경배경구별
고급 → 사물 지각, 식별, 의미, 행동 필요 정보 만든다.

우리가 참여하는 현실세계는 신경시스템이 만들어내는
아름다운 속임수이다. 의미 부여

의미는 같은 것을 식별하는 능력

운동을 정확한 순서로 엮으면

고도의 적응력 있는 행동: 집짓기, 베짜기

혀와 입술 움직임을 순서화 된 운동 → 언어

감각의 단서가 '무엇'이며

'무슨 의미' 인가를 추론 → 지각

주의, 기대, 지각은 세계를 분류한다
의미

시각 기억 연합 → 맥락 기억

지각

연합 조합 **세계는 우리의 상태이다**

지각의 단계: 지각 → 재인 → 행동

행동은 지각의 결과이다. recognition

시각: 초급단계 → 선분, 방향, 색채, 깊이

중급 → 색 형태 항등성, 윤곽선 연결, 간경배정구별

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운동을 정확한 순서로 엮으면

고도의 적응력 있는 행동: 집짓기, 배짜기

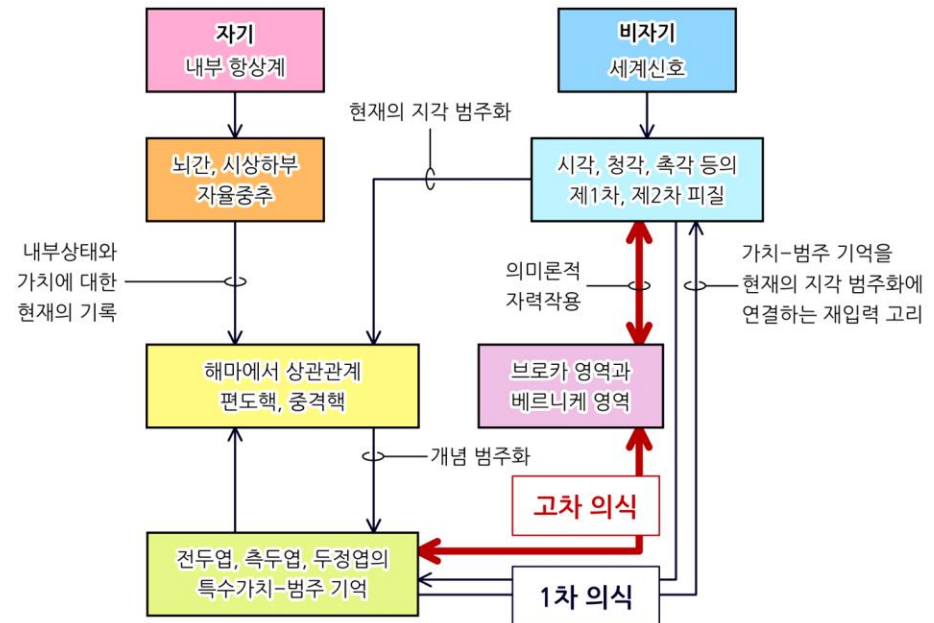
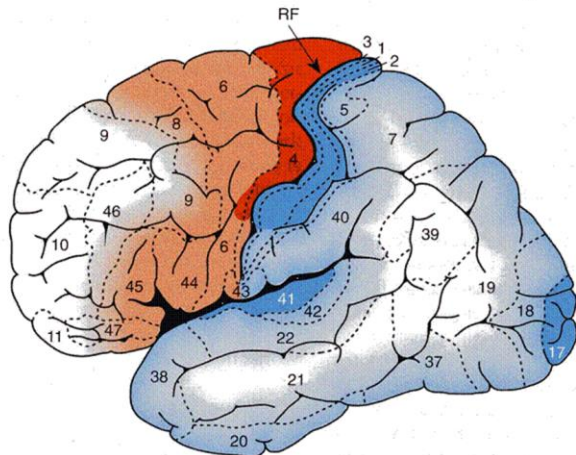
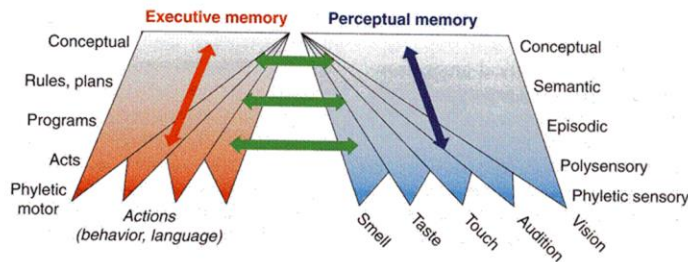
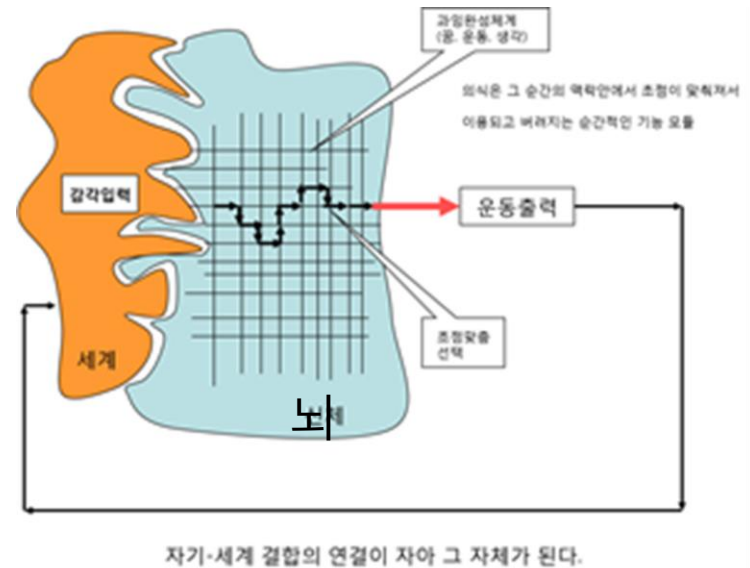
혀와 입을 움직일 순서 확 된 운동 → 언어

감각의 단서가 '무엇'이며

'무슨 의미' 인가를 추론 → 지각

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시각 기억 연합 → 맥락 기억



의미 기억 : general → 경험중첩 → 서서히, 작업의 목적

기억 \Rightarrow 생각, 행동에 지속적으로 반영 표상

기억의 연합 ⇒ 반복, 근접, 동기
↳ 시간, 공간

기억 인출 ⇒ 감각, 기억, 감정
 ↓ ↓
 재인 회상
 친숙함

대상 ⇒ 속성을 분류하는
 한 묶음의 관계

새로운 기억의 획득은 옛 기억의 인출 필연적으로
encoding retrieval 수반한다.

반도체 : 주소지정방식

인간 기억: **내뽕 주소 방식**

요점 기억 \Rightarrow 일반화, 조직화, 범주화
 \Rightarrow 이해가 빠르다

① 상태의존적: Ach ↑ NE, 5HT ↓

REM-ON: PPT, LDT Ach ↑ ⇒ 연상 → 과잉연상
cell

REM-OFF: LC NE ↓ → 주의력 소멸 → 무제한 연결
cell

낮: 주의력 느슨 → 몽상, 상상
NE ↓

② 감각입력, 목적지향성 → 뇌작동 ⇒ 생각

Sensory input, PFC off → 뇌작동 ⇒ 꿈

③ 시각 이미지의 정서적 상영

정서 선택 → 정서 내용 호응

공포, 분노

④ 놀람 반응을 통한 off-line 학습

서파수면 - 사건기억

REM - 절차기억 학습 replay

⑤ 불면속: 시간, 장소, 사람, 행동

일화기억 인출
불가

기절 정신증후군: 착각, 작화, 기억상실
방향상실

⑥ NE ↓ → 기억 공고화 단됨

인접는 꿈의 환각과 현실을 구분

⑦ right inferior parietal → metaphor, self

left - " → REM inactive

Two-stage model of long-term memory formation

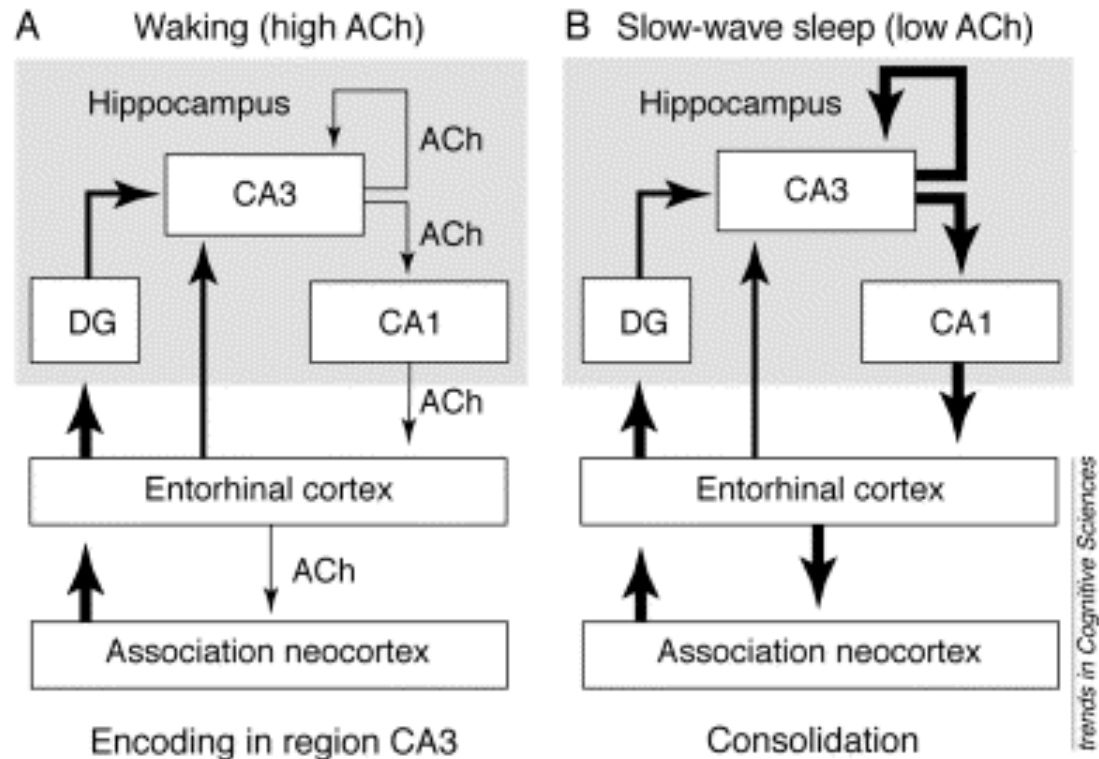
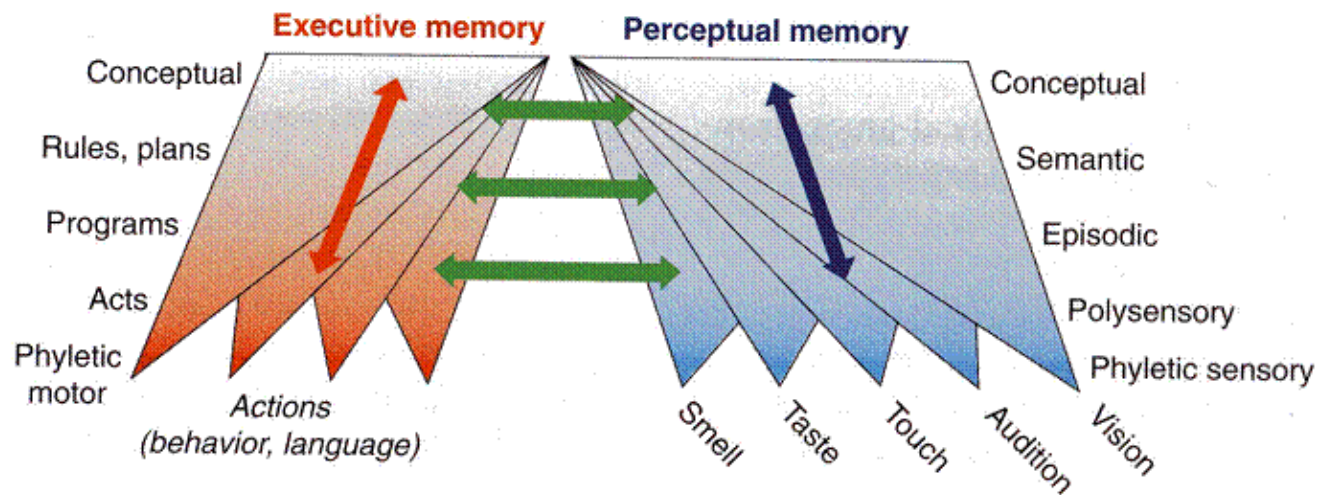


Fig. 1.. (A) During active waking, information coded by neocortical structures flows through the entorhinal cortex and dentate gyrus (DG) into hippocampal region CA3 (connections less sensitive to modulation by ACh; thick arrows). Here, synaptic modification forms an intermediate-term representation, binding together different elements of an episodic memory. Connections suppressed by ACh modulation (thin arrows) to region CA1, entorhinal cortex and association cortex are strong enough to mediate immediate retrieval, but do not overwhelm the feedforward connectivity.

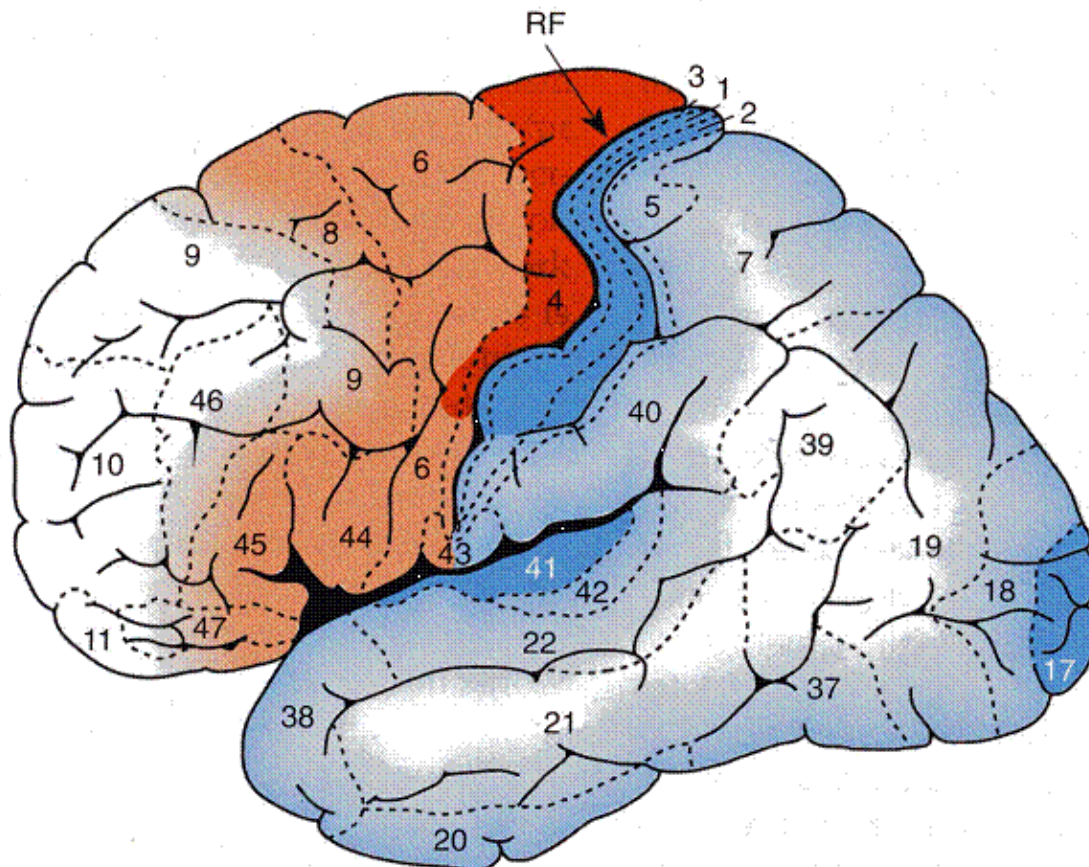
(B) During quiet waking or slow-wave sleep, memories are reactivated in region CA3 during EEG phenomena termed sharp waves. These waves of activity flow back through region CA1 to entorhinal cortex[5] and neocortex [26]. This will enable the slow consolidation (formation of separate traces) of long-term episodic memory in hippocampal region CA1, entorhinal cortex and association neocortex, and might underlie modification of semantic memory within circuits of association neocortex.



Schematic diagram of the hierarchical organization of memory networks (cognits) in the human cortex, lateral view of left hemisphere.

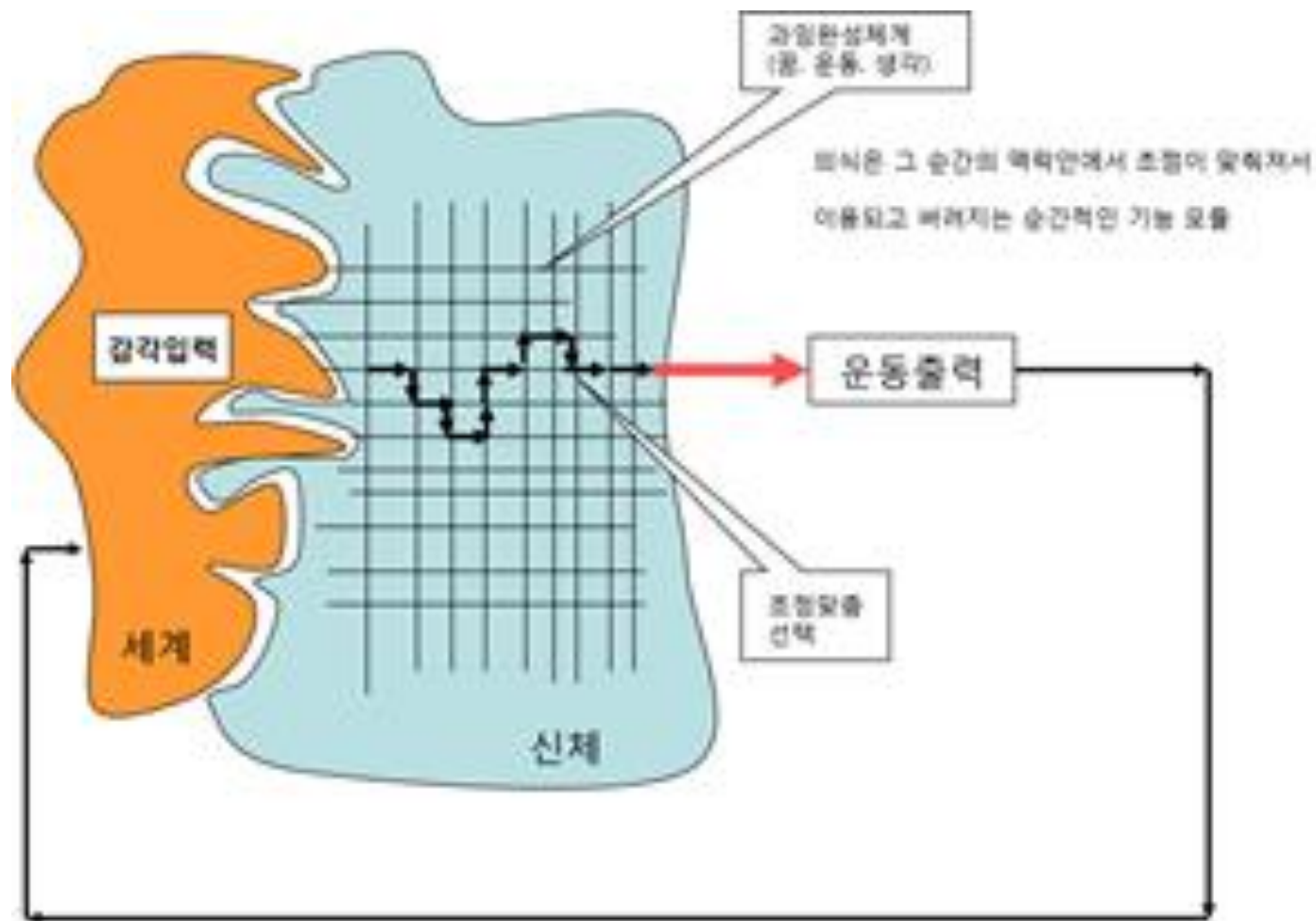
Upper: Gradients of development and of organization of cortical cognits, with the same color code as in the map below. Bidirectional arrows symbolize: blue, perceptual cortico-cortical connectivity;

red, executive cortico-cortical connectivity; green, reciprocal connectivity between posterior and frontal cortices.

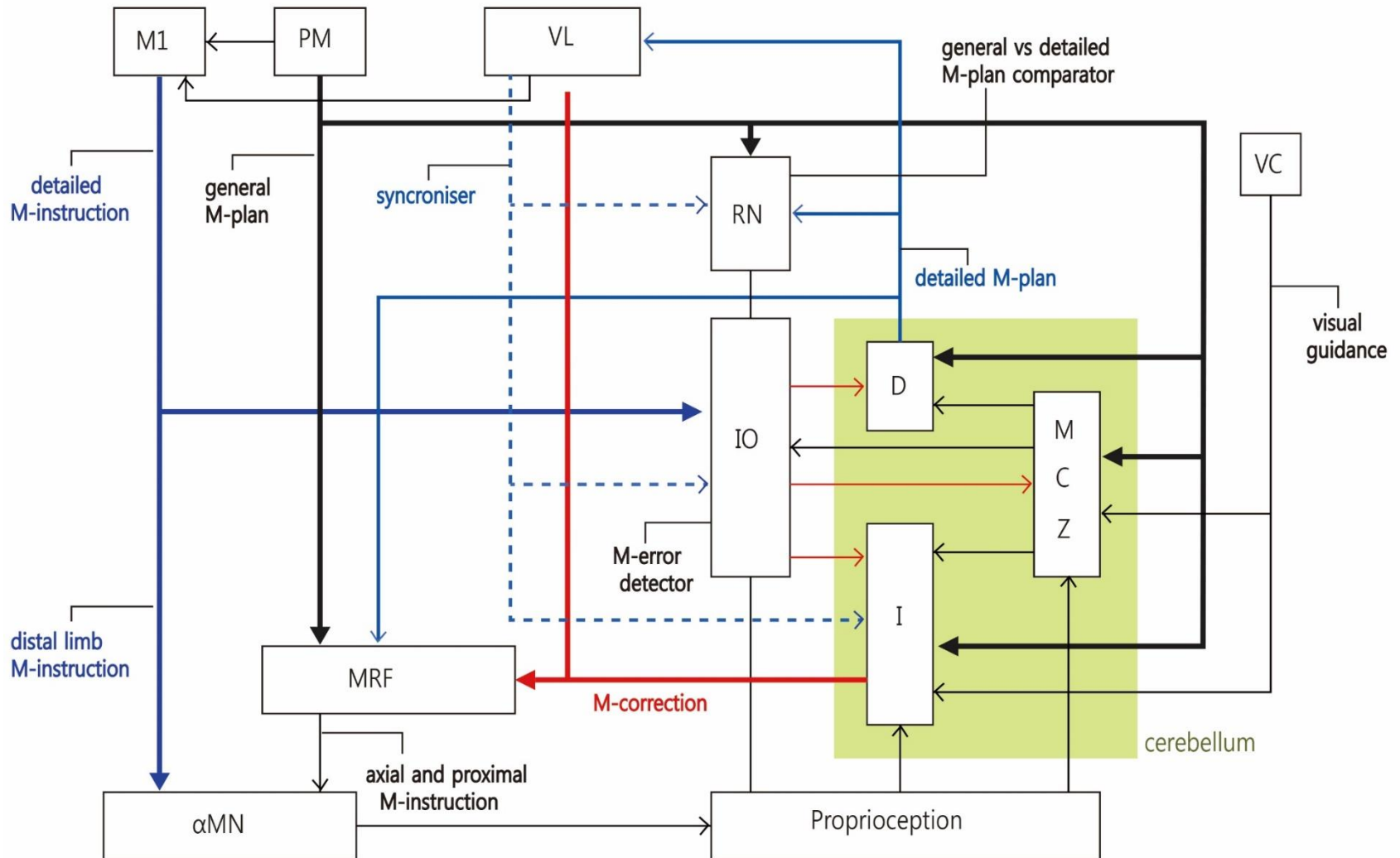


Note increasing span and overlap of networks as they develop from the bottom up. As they grow upwards in the hierarchy, nets become more widespread and represent progressively more abstract memory and knowledge.

Lower: Brodmann's cytoarchitectonic map. RF, Rolandic fissure. The posterior cortex is shaded blue to white from primary sensory to association areas, the frontal cortex red to white from primary motor to prefrontal cortex.

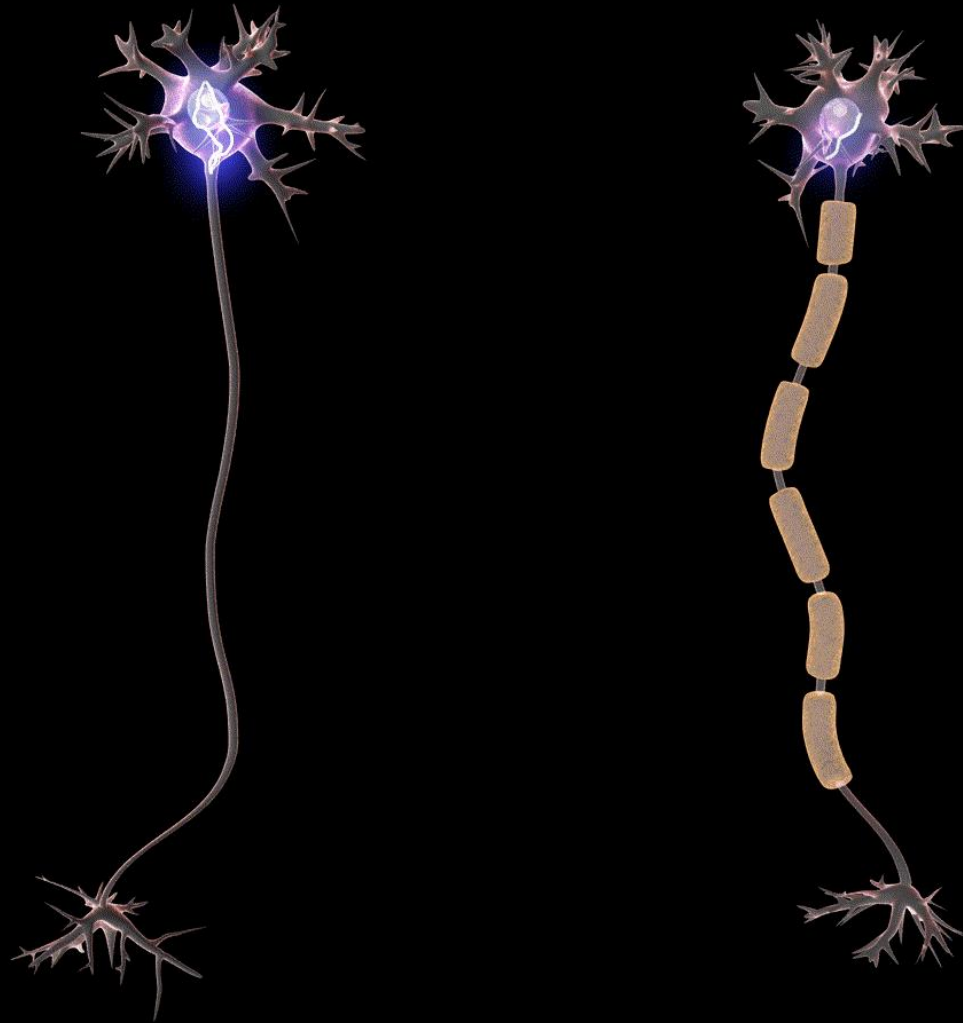


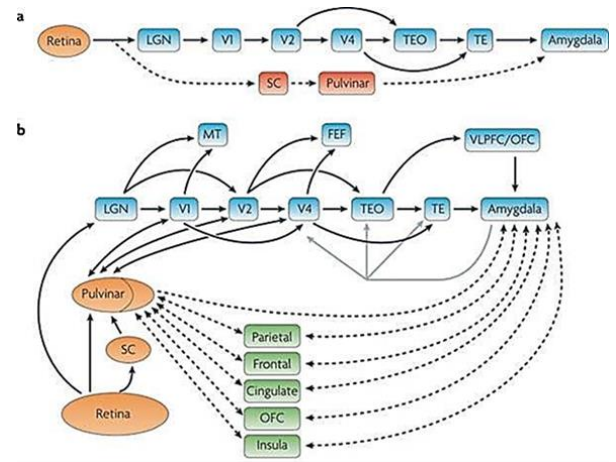
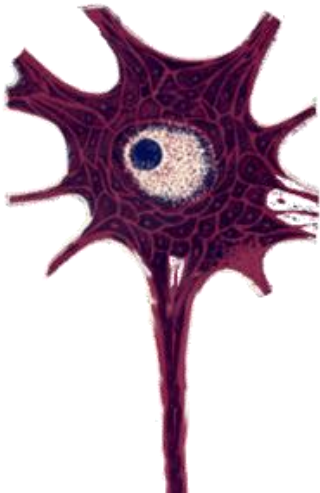
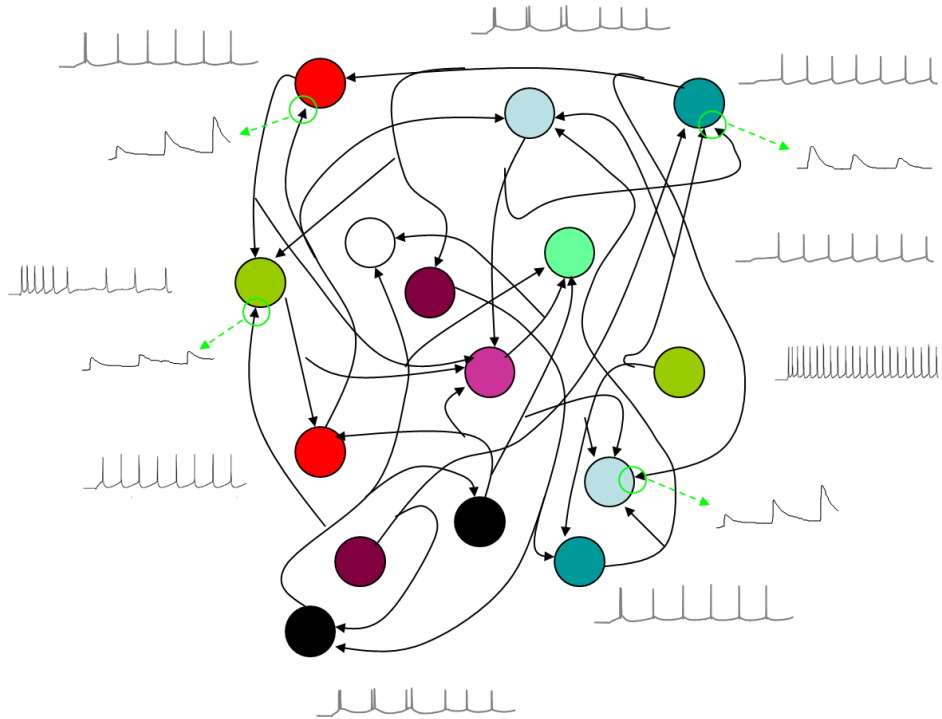
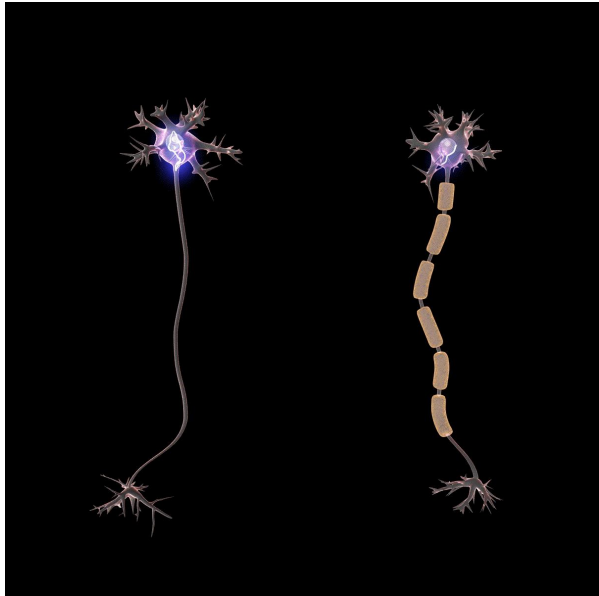
자기-세계 결합의 연결이 자아 그 자체가 된다.



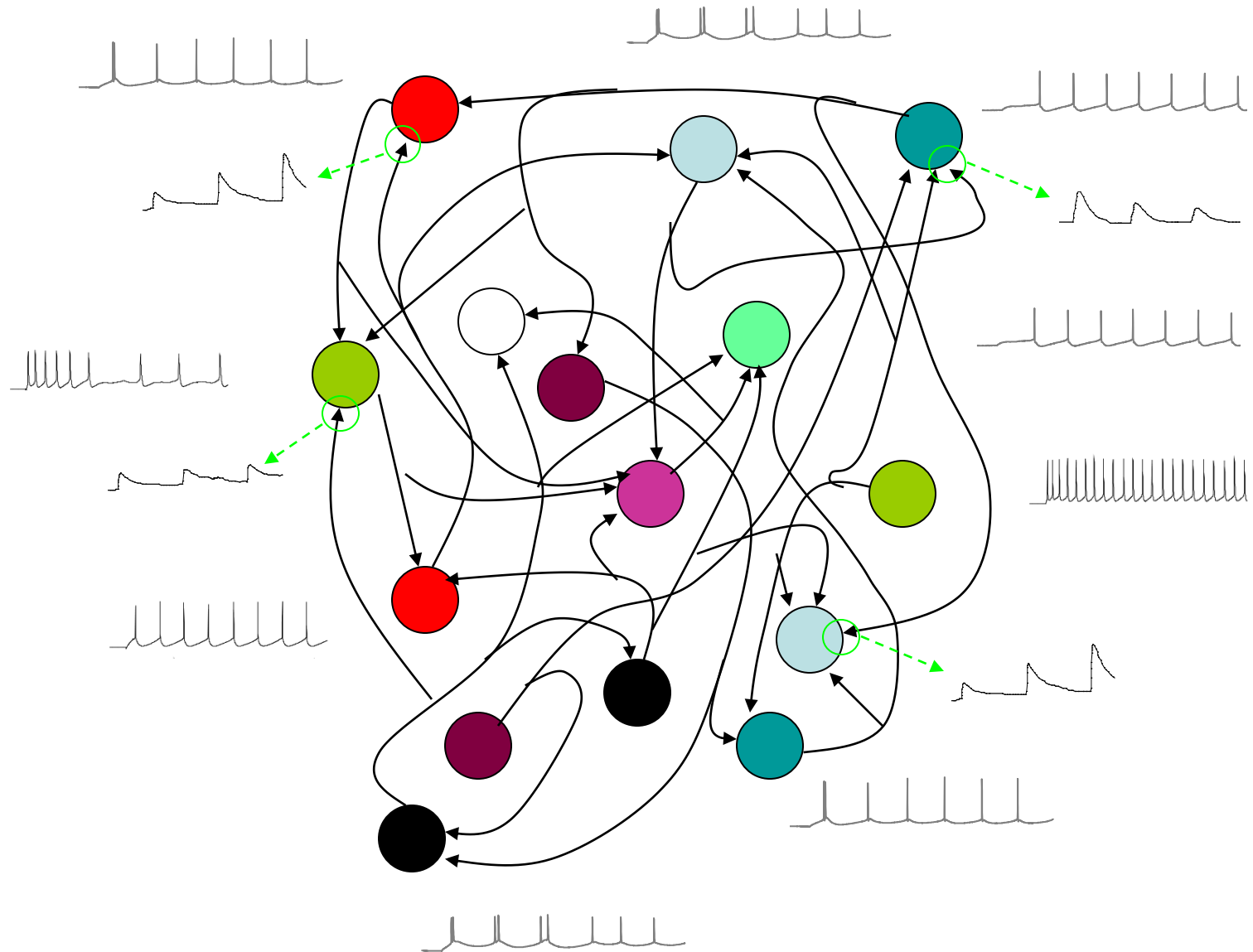
D-dentate N.
I -interposed N.
M-movement

**More details
Myelin and Saltatory
Conduction**

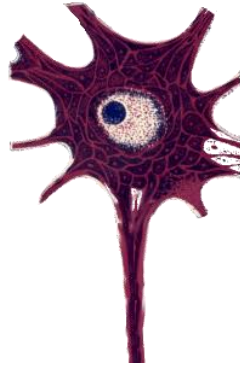




Complex Network

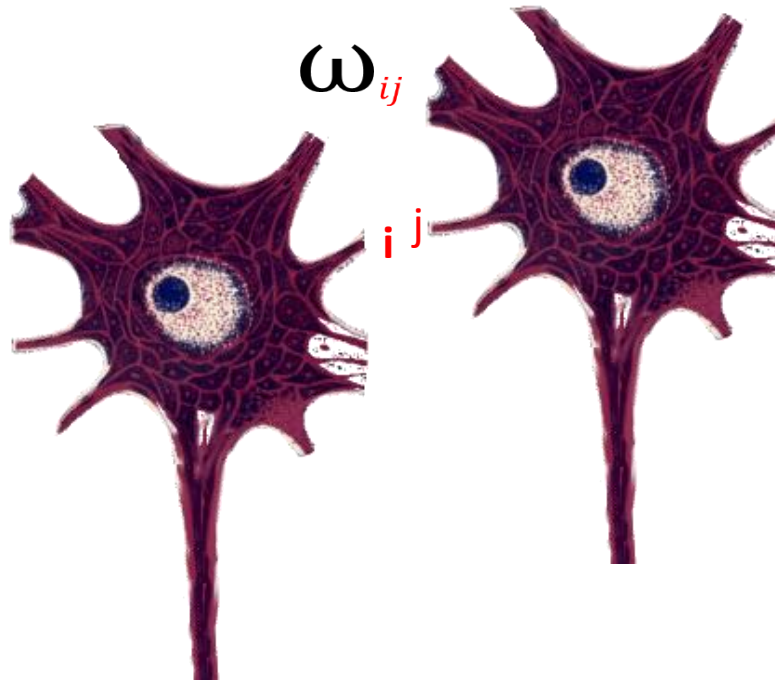


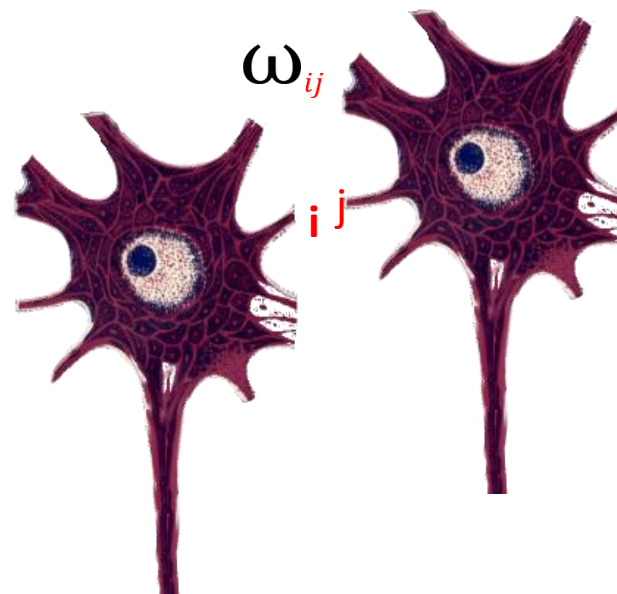
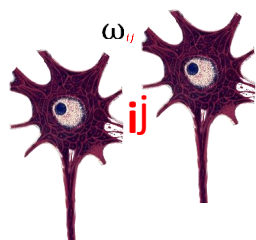
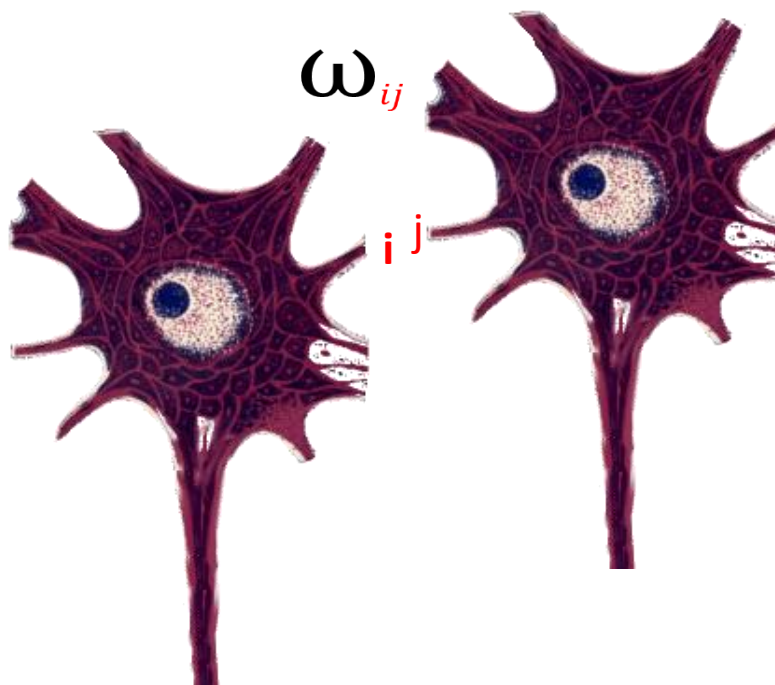
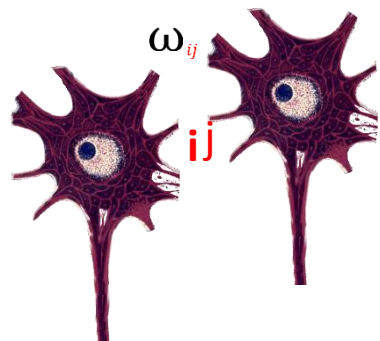
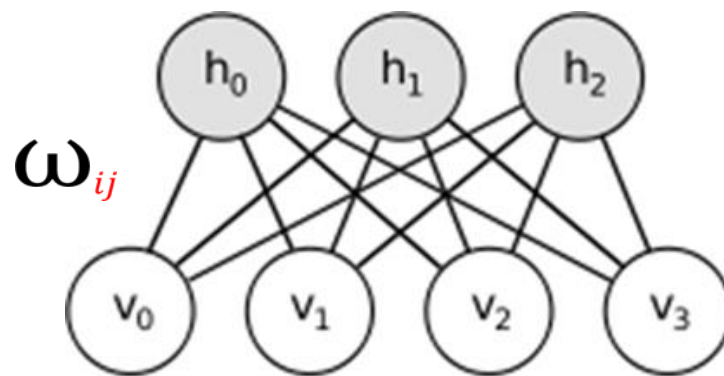
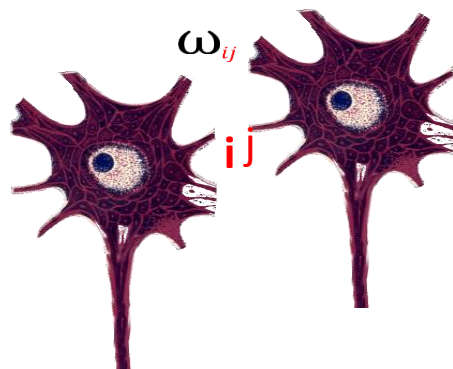
Action potential computation



For much of neurobiology,
information is represented by the paradigm of “*firing rates*”,
i.e. information is represented
by the rate of generation of action potential spikes,
and the exact timing of these spikes is unimportant.

$$\omega_{ij} \begin{bmatrix} 0.3 & 0.4 & 0.3 & 0 \\ 0.3 & 0.1 & 0.4 & 0.2 \\ 0 & 0 & 0.5 & 0.5 \\ 0.3 & 0.5 & 0.2 & 0 \end{bmatrix}$$

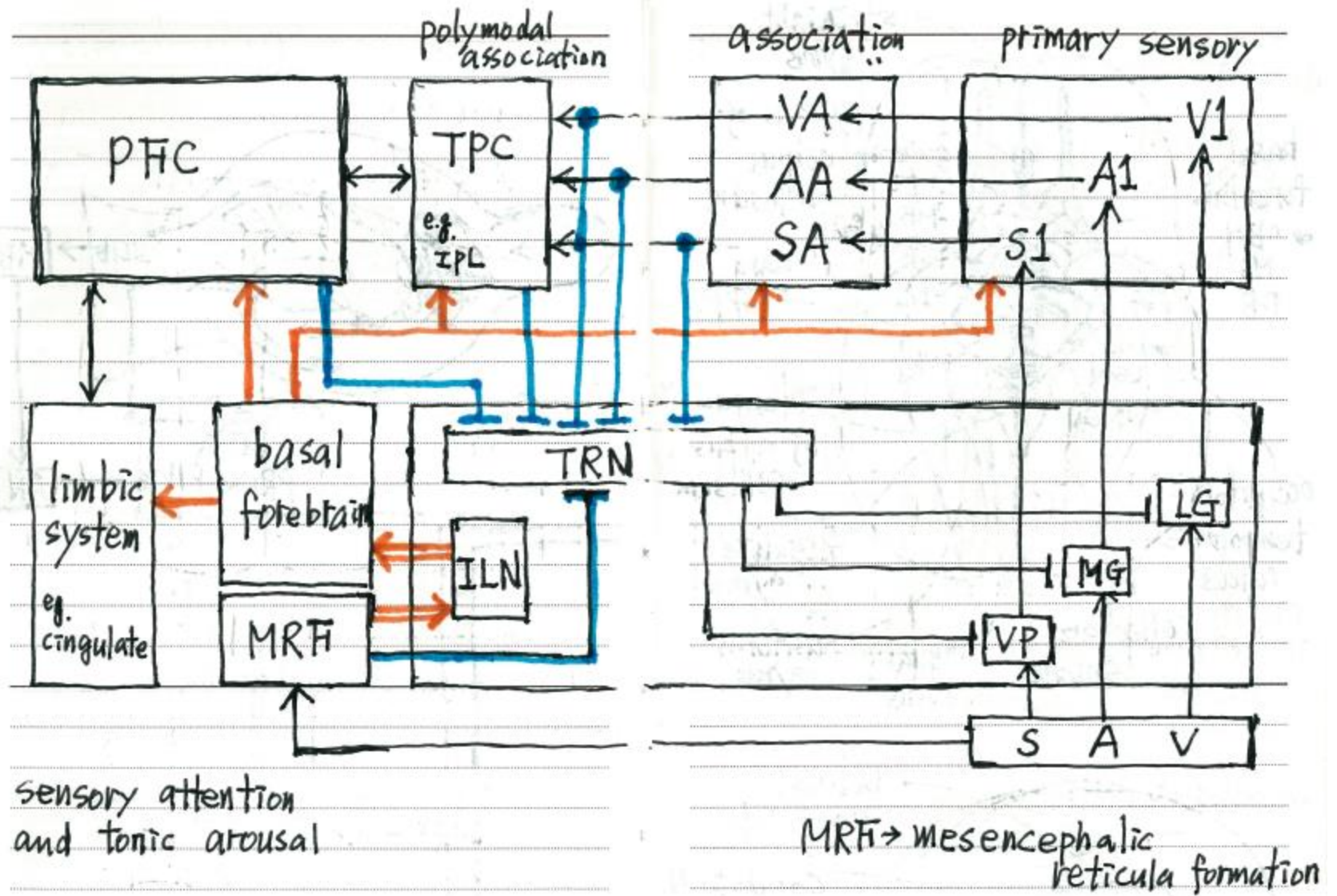


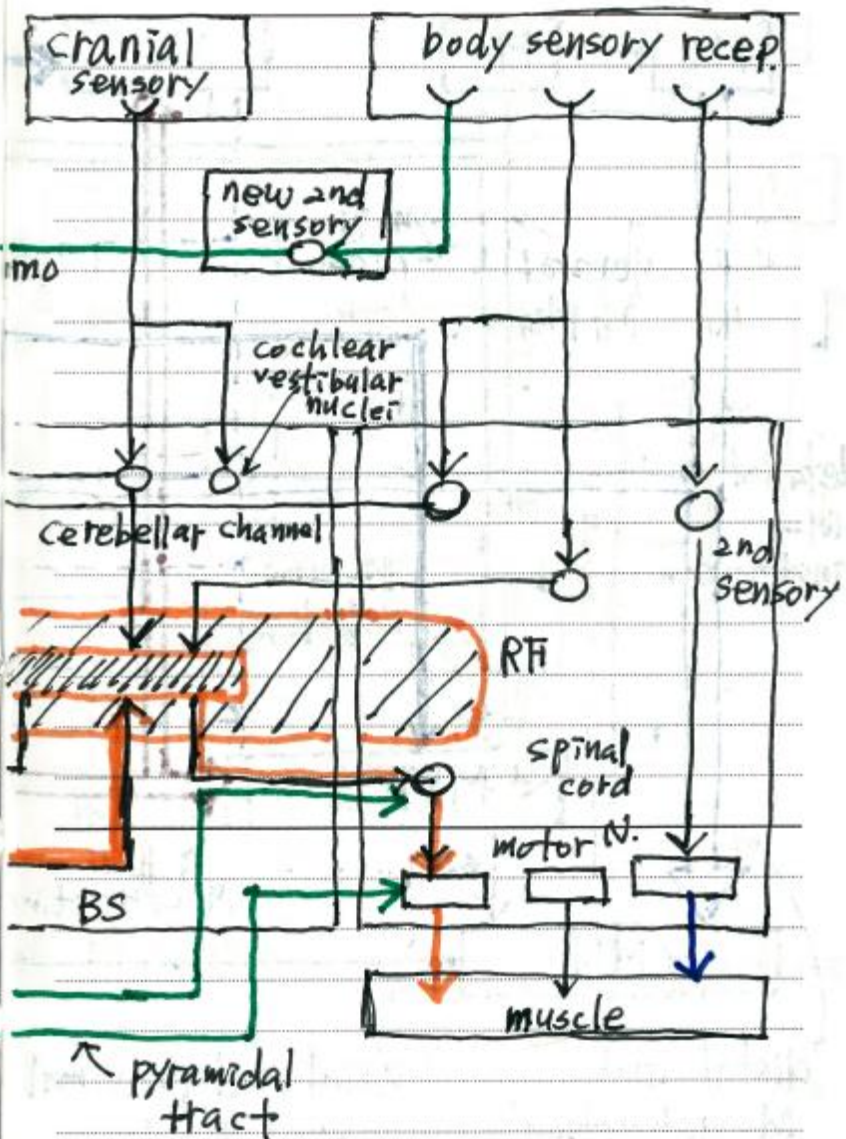
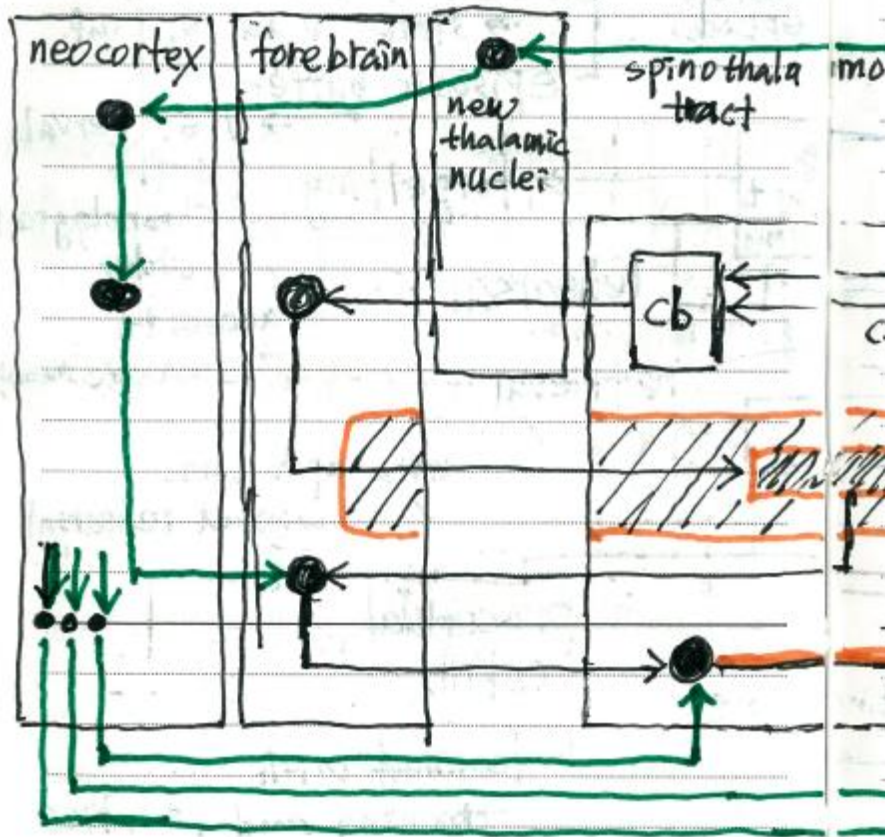






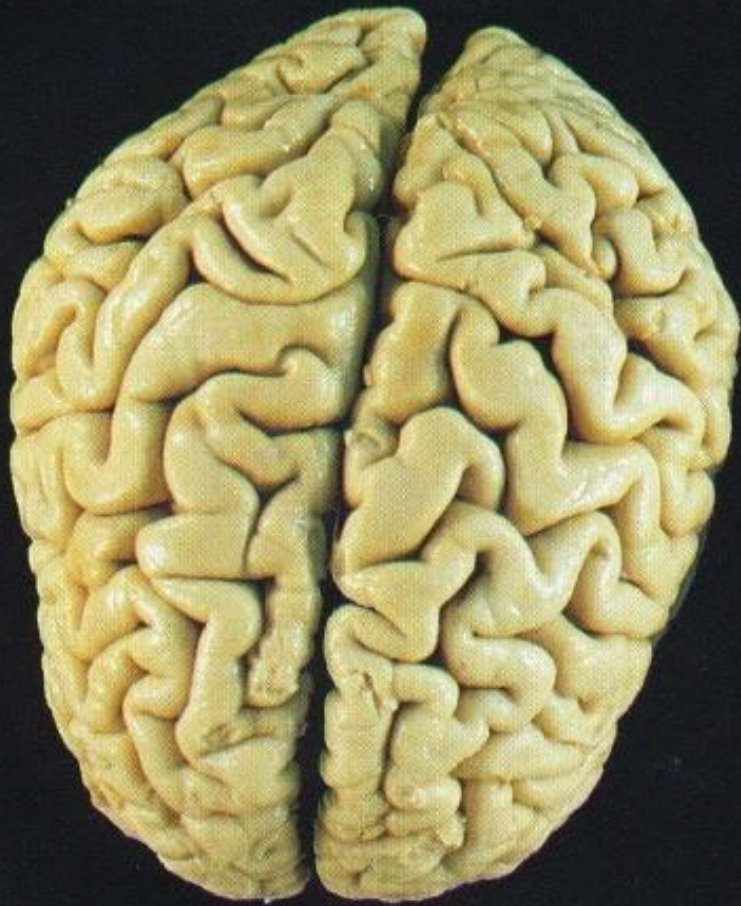




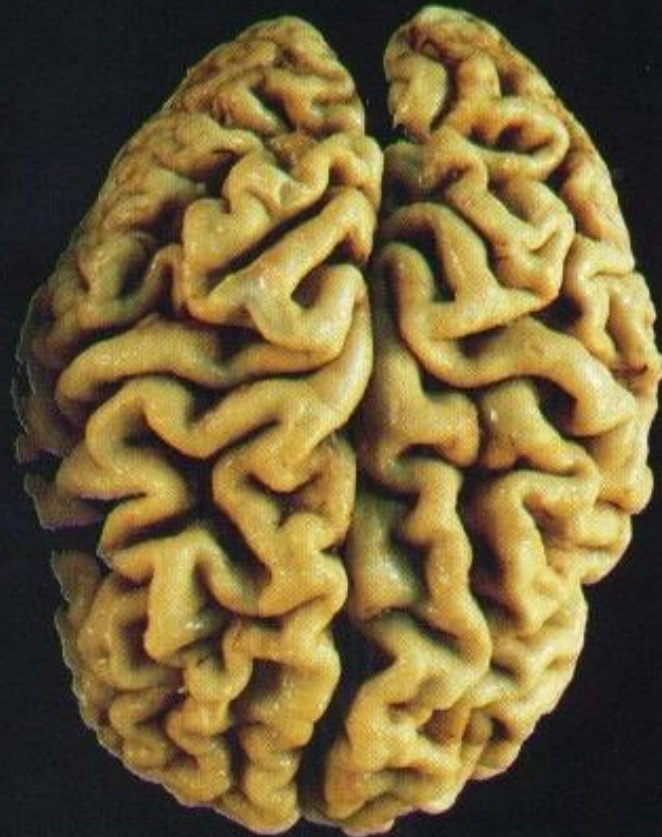




NORMAL

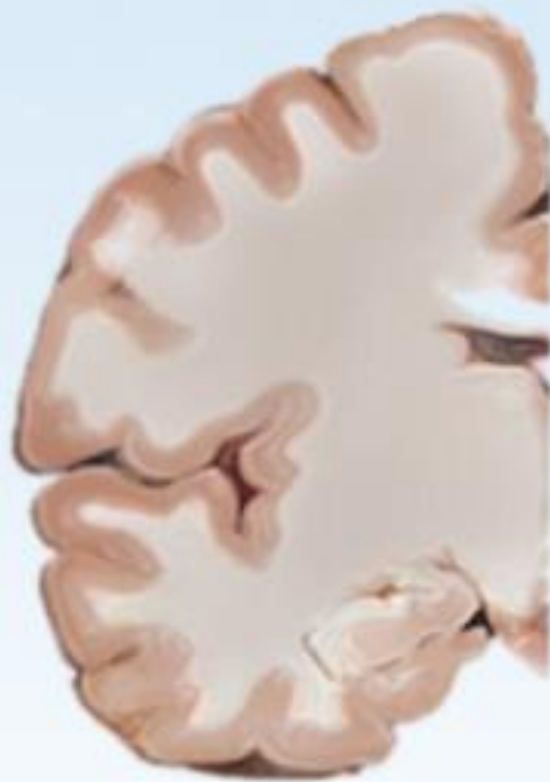


Normal Brain

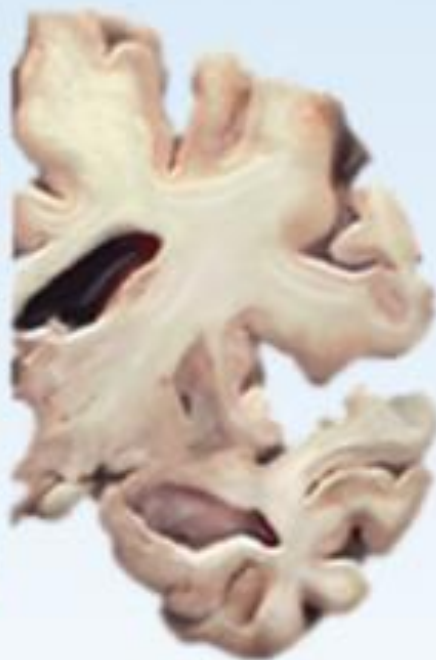


Alzheimers Brain

정상 뇌



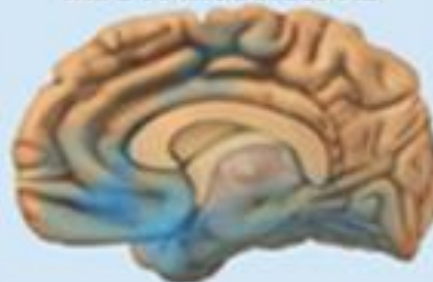
알츠하이머병 뇌



Preclinical AD



Mild to Moderate AD



Severe AD





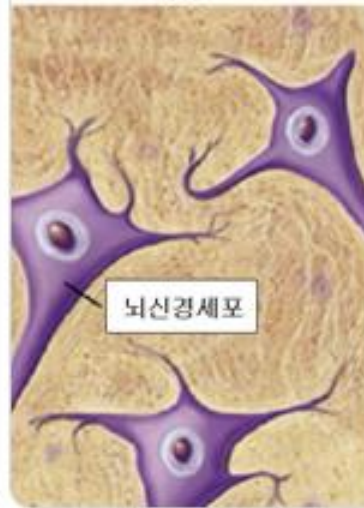
정상인의 뇌



치매 환자의 뇌

정상인의 뇌와 치매 환자의 뇌

정상



뇌신경세포

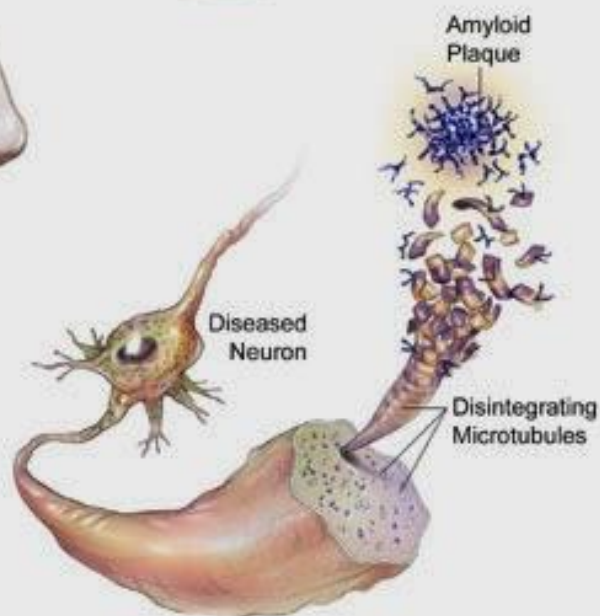
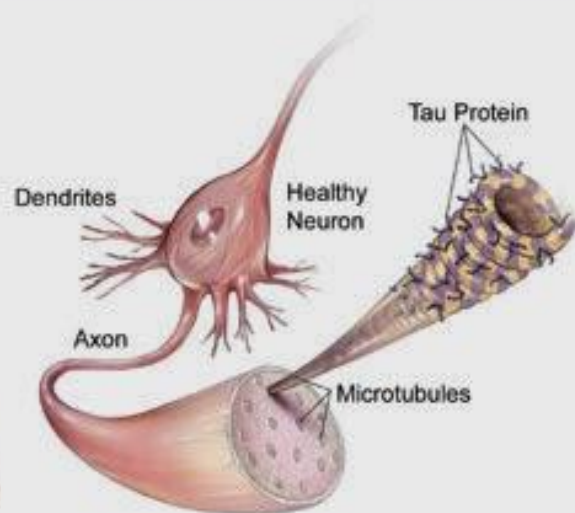
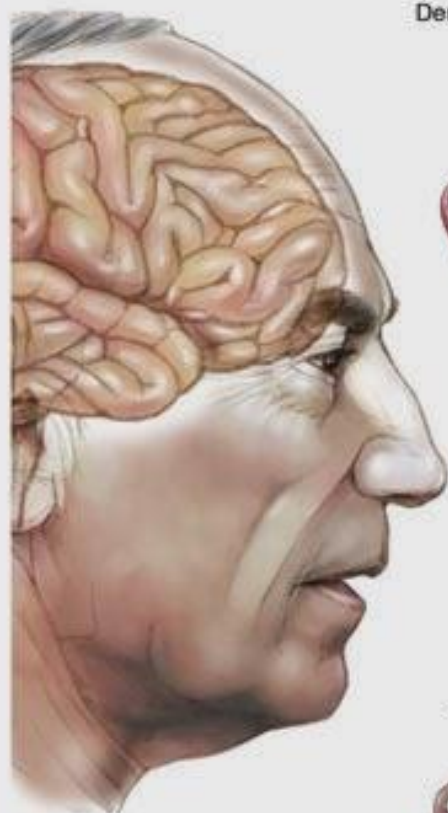
알츠하이머병



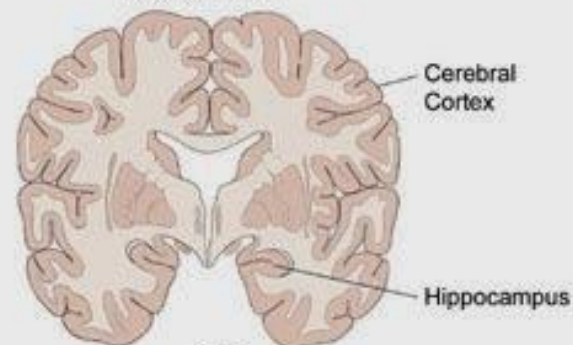
신경섬유매듭

아밀로이드 단백질

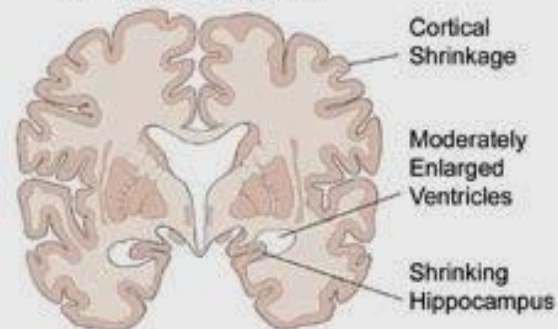
정상인과 알츠하이머병 환자의 뇌 신경세포



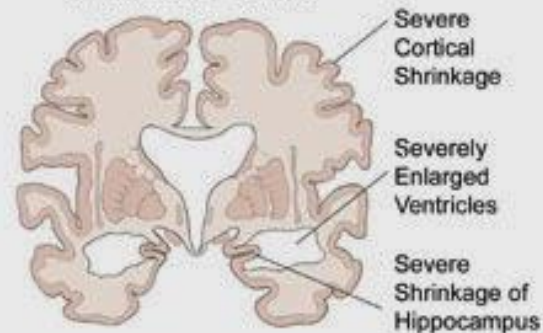
Healthy Brain



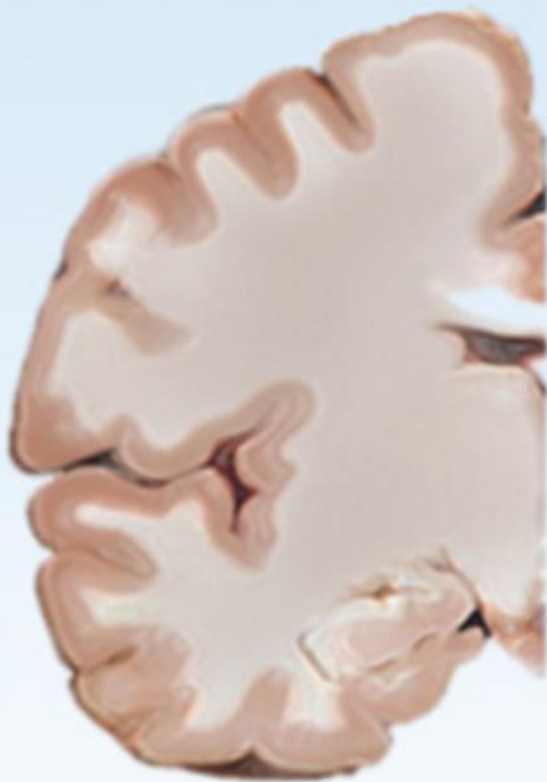
Mild Alzheimer's Disease



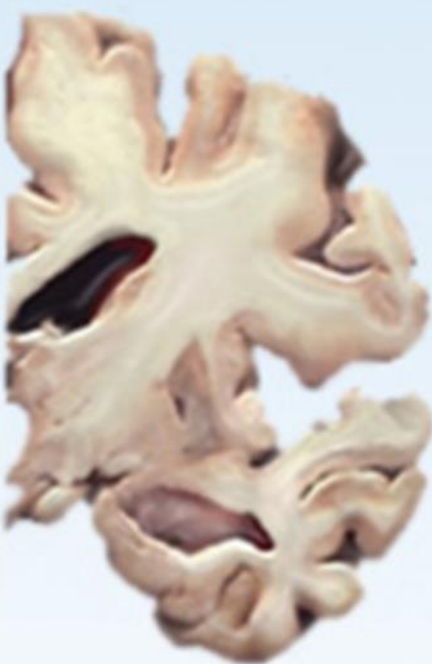
Severe Alzheimer's Disease



정상 뇌



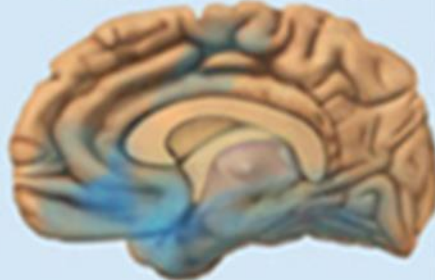
알츠하이머병 뇌



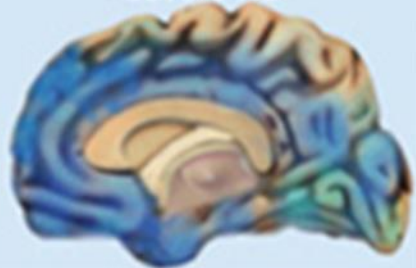
Preclinical AD

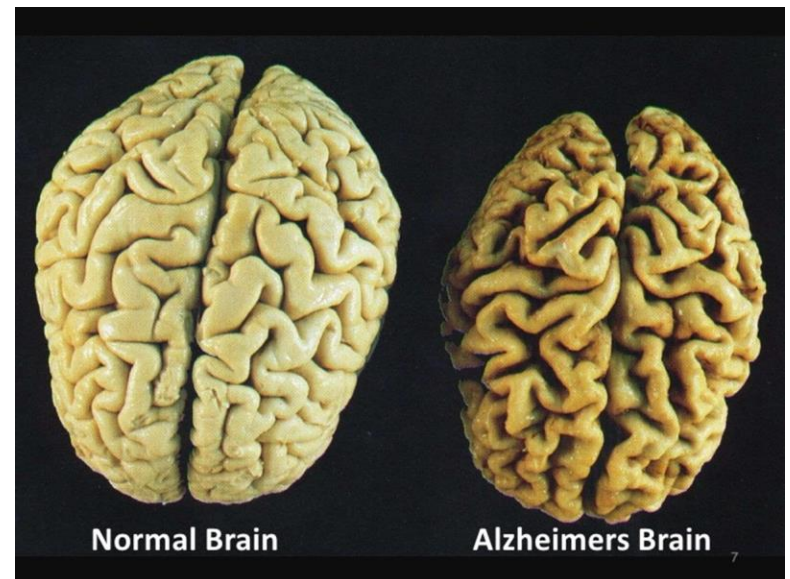
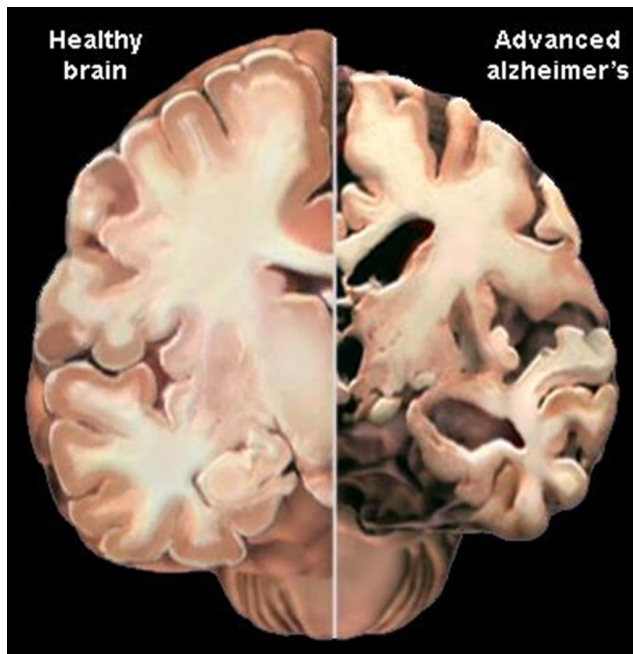
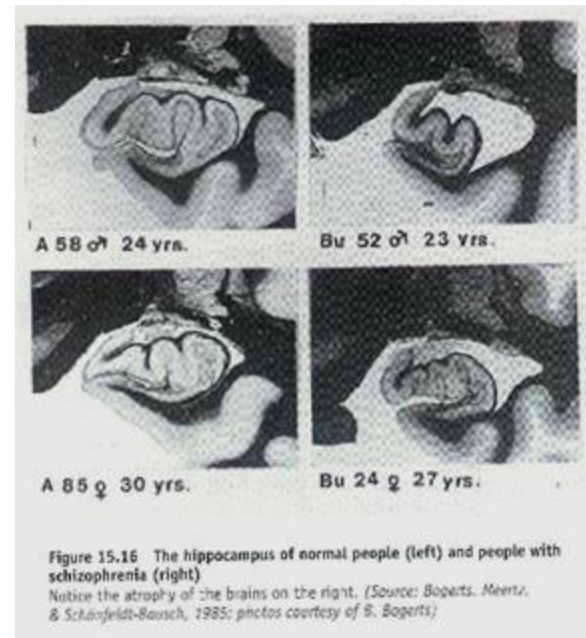
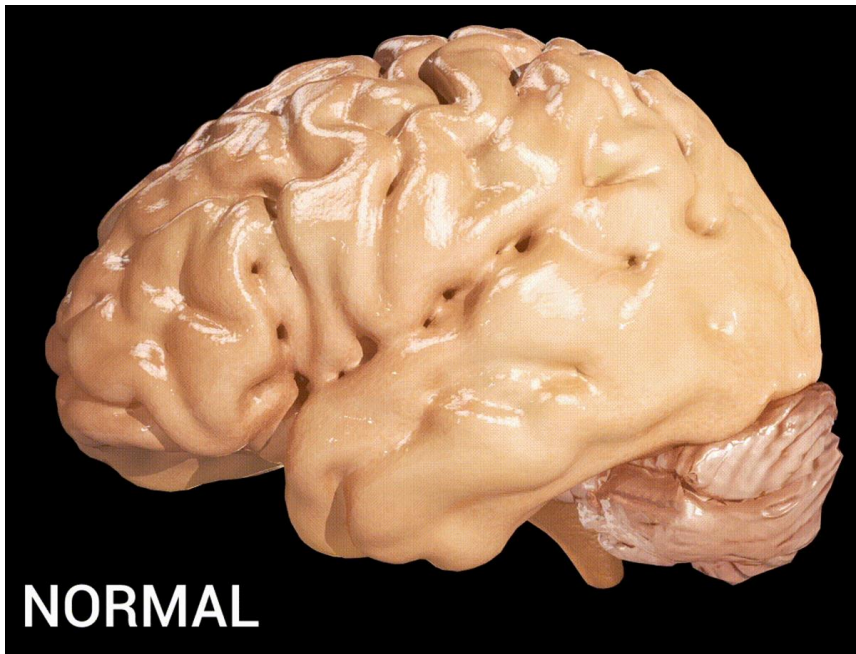


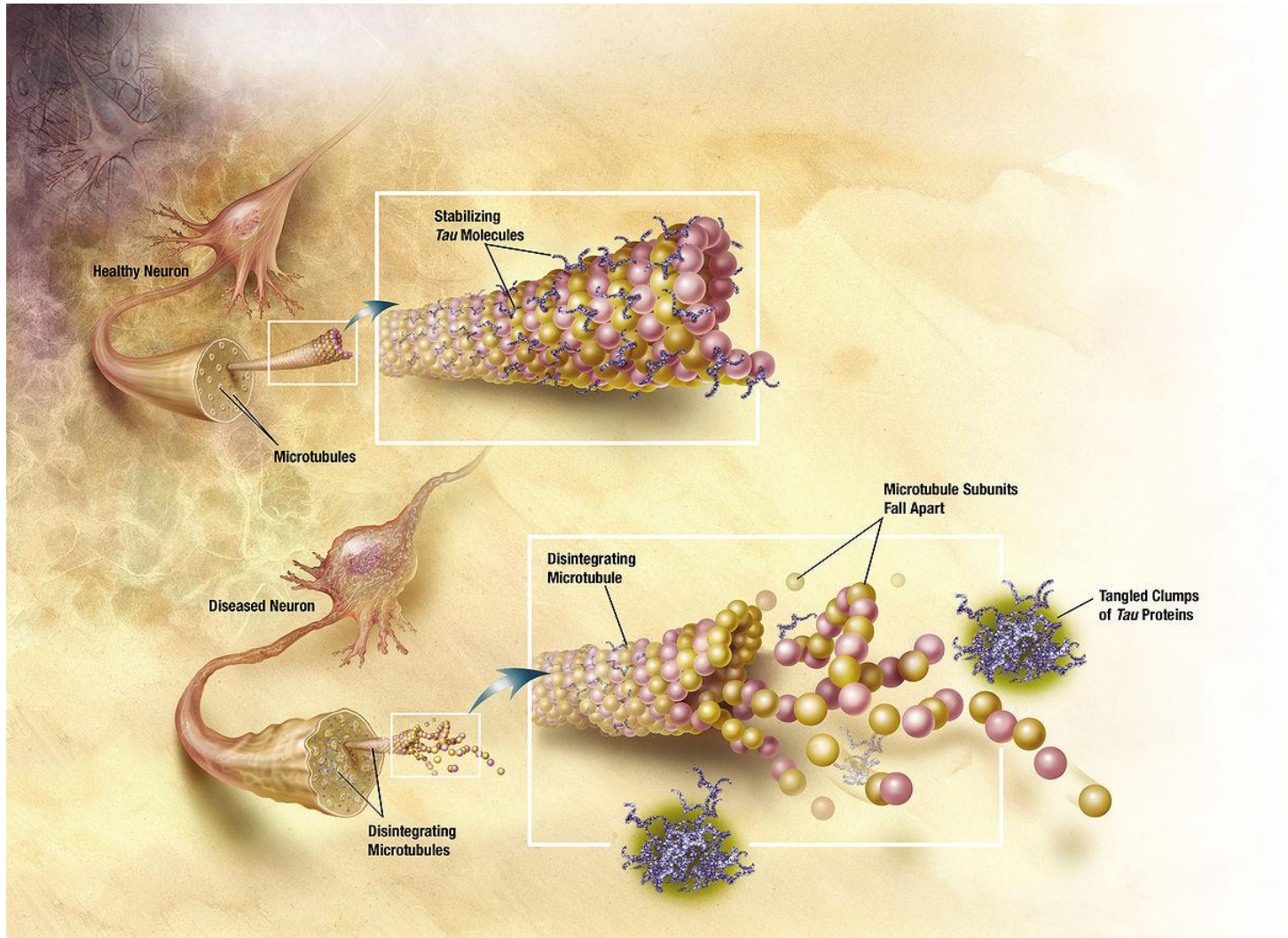
Mild to Moderate AD



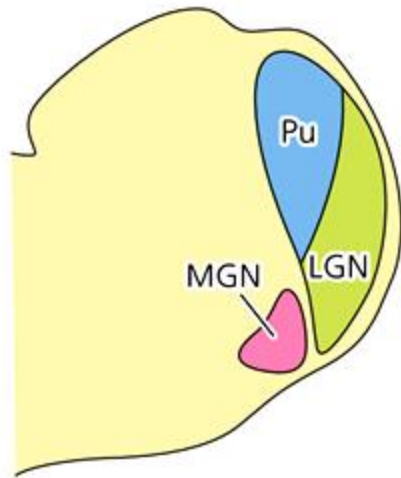
Severe AD



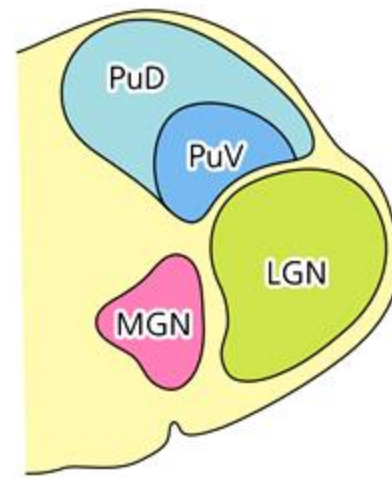




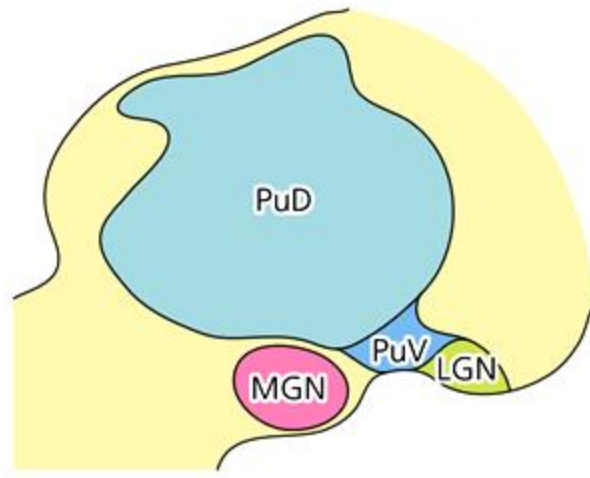
나무두더지



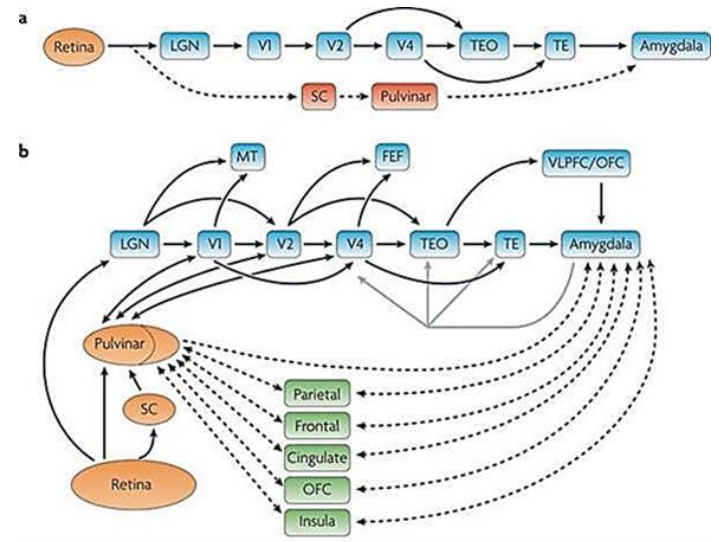
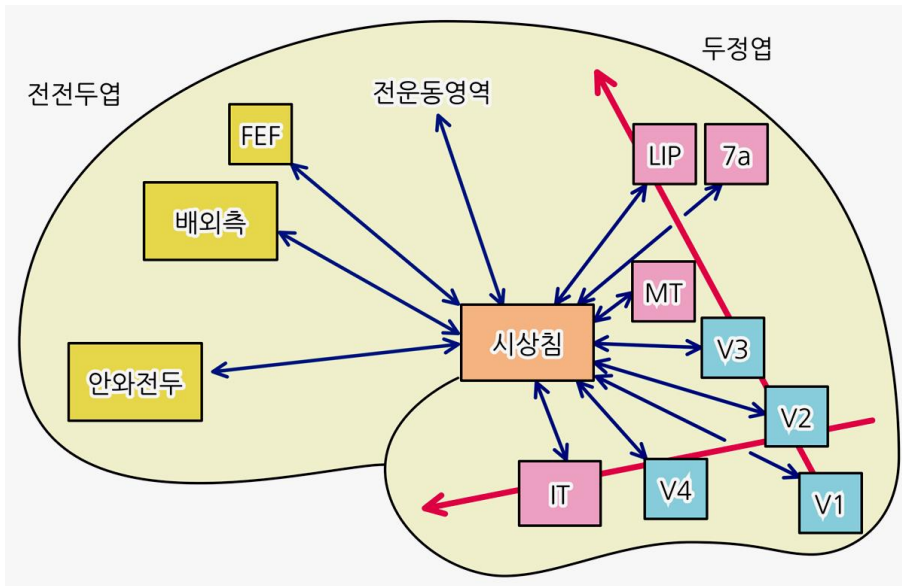
갈라고

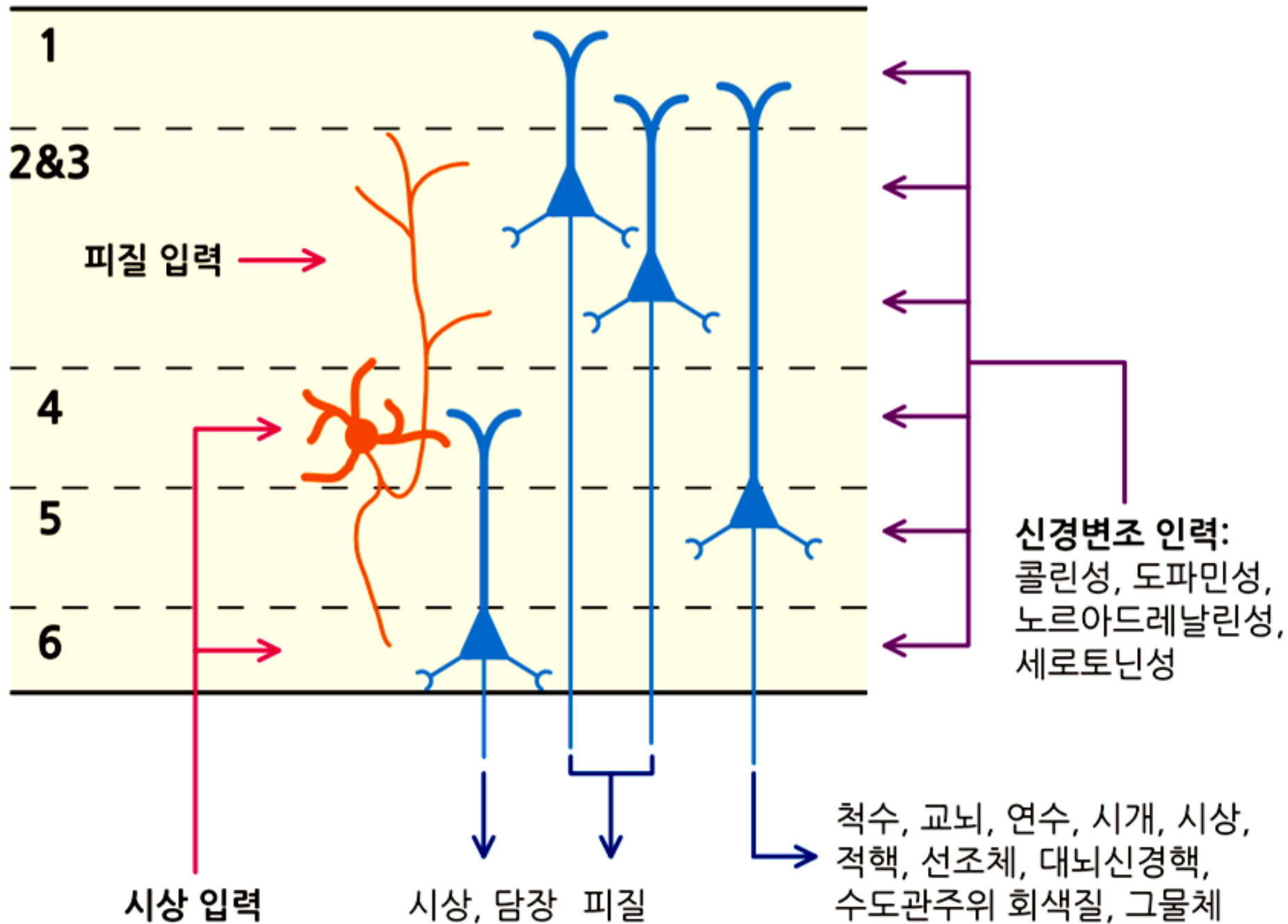


사람



MGN : 내측슬상핵, LGN : 외측슬상핵, Pu : 시상침, PuD : 배측시상침, PuV : 복측시상침



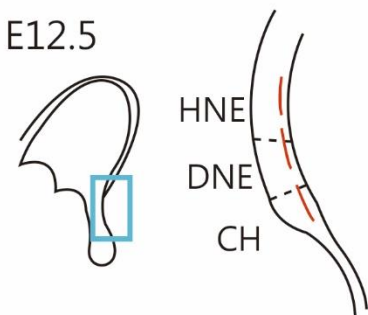


A

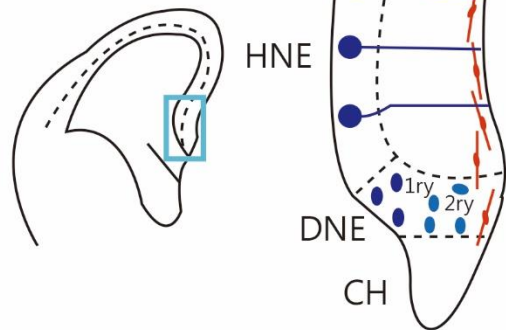
B

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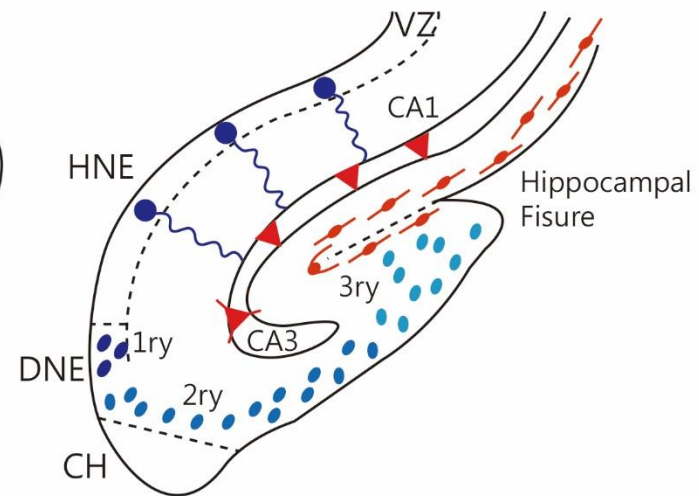
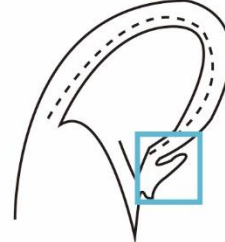
E12.5



E14.5

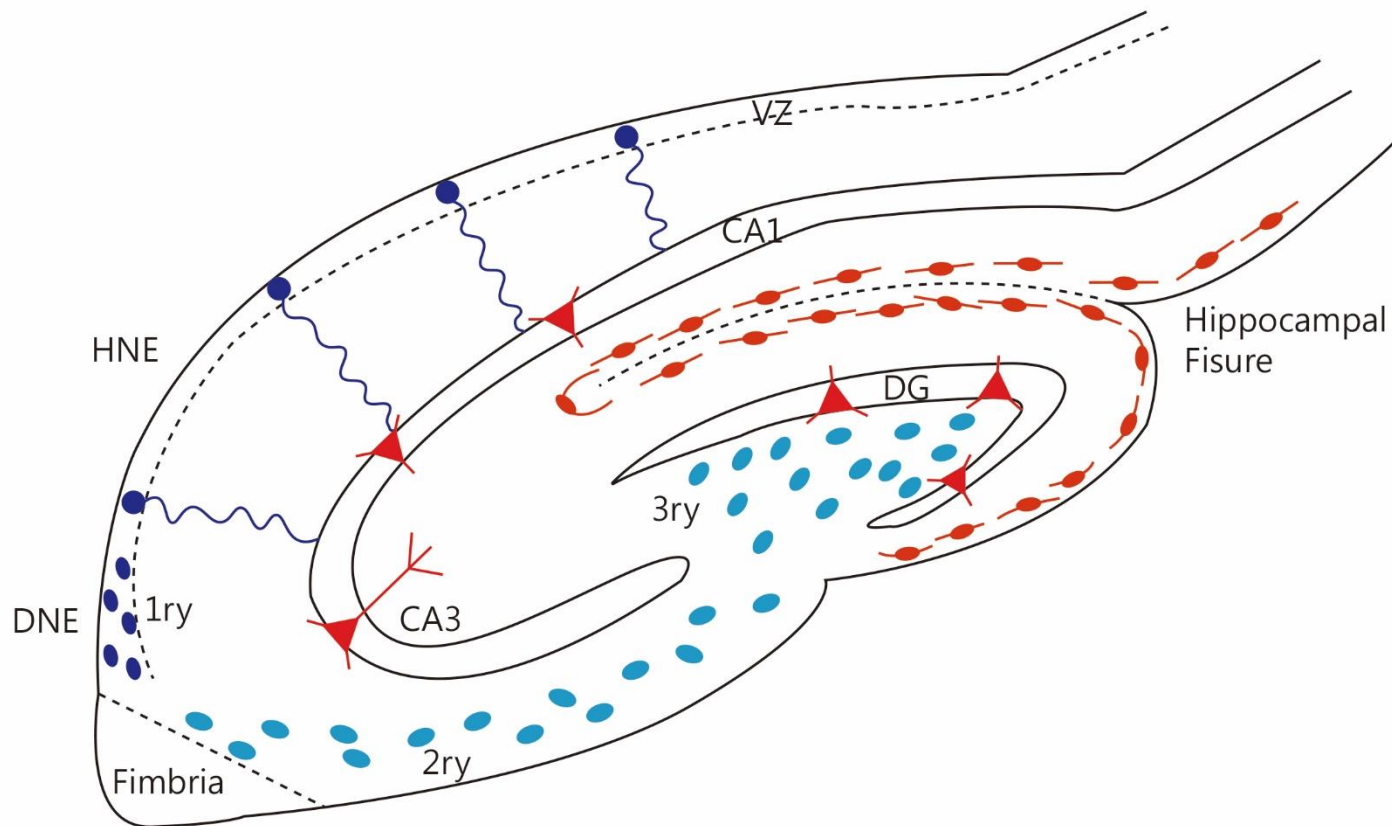
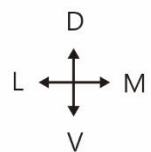
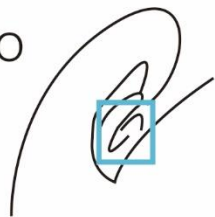


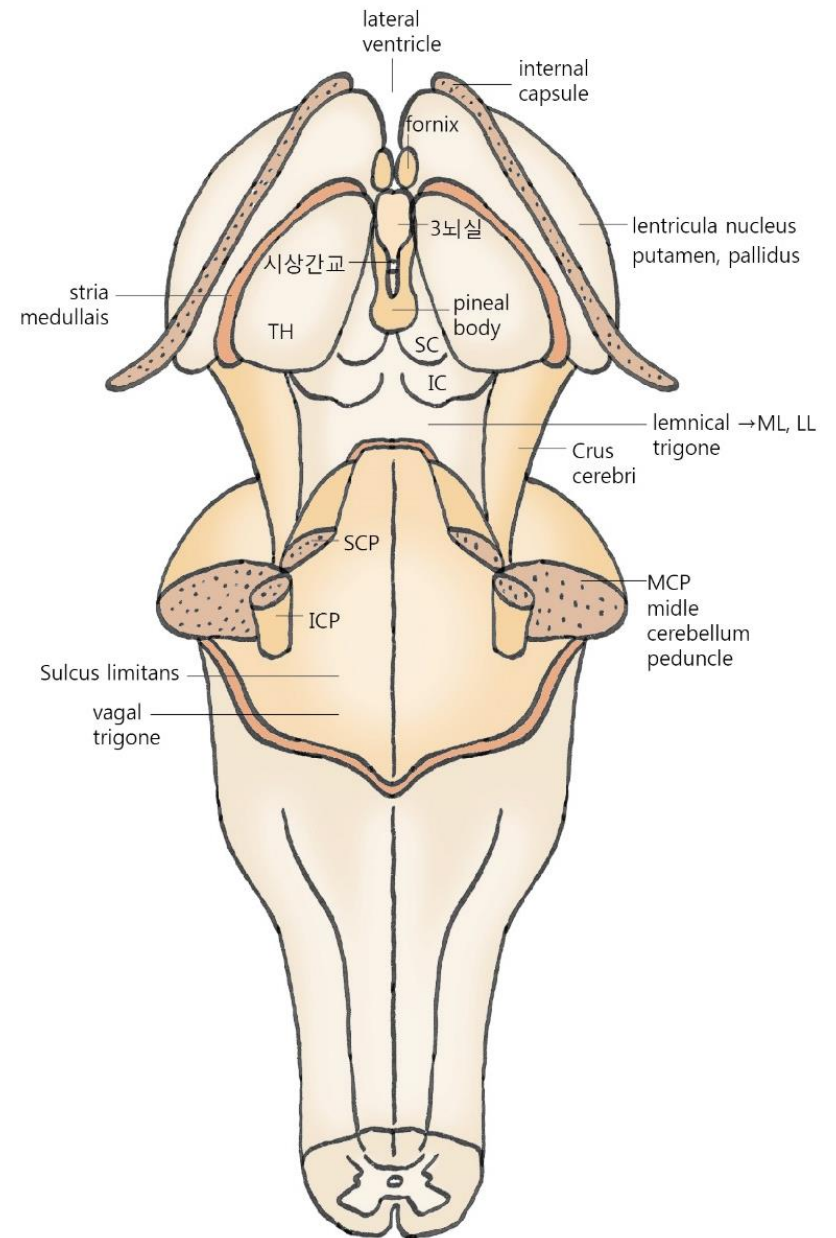
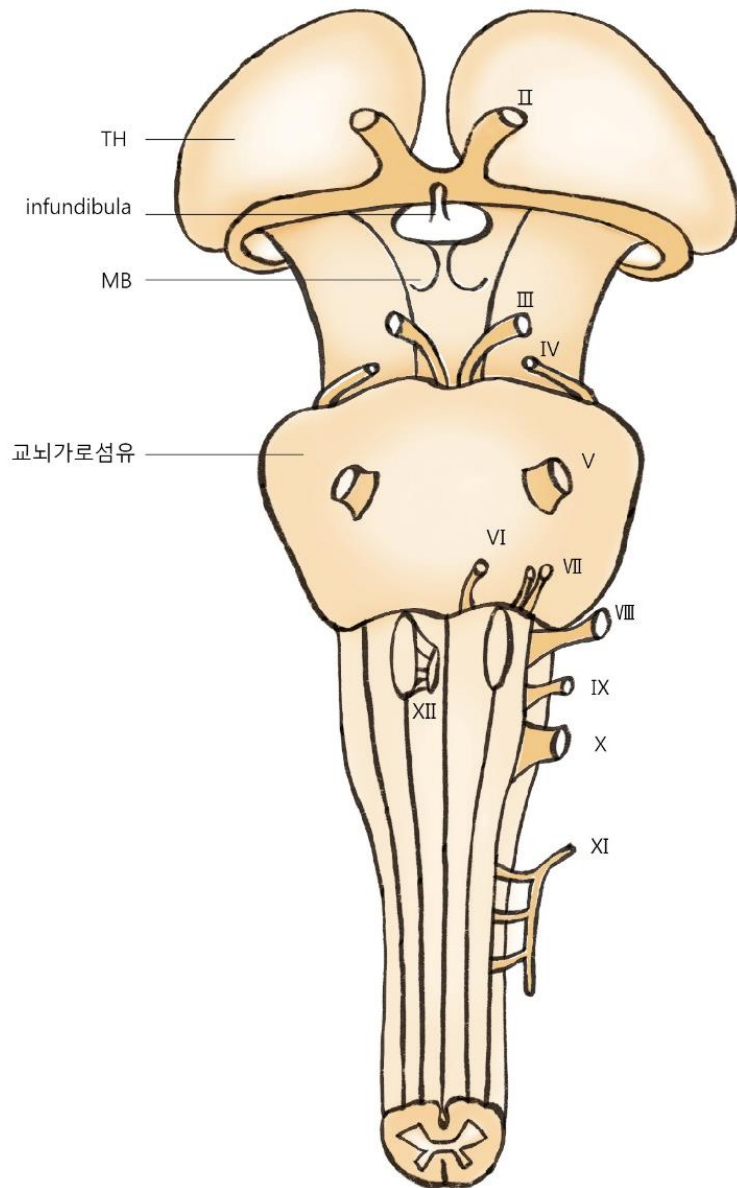
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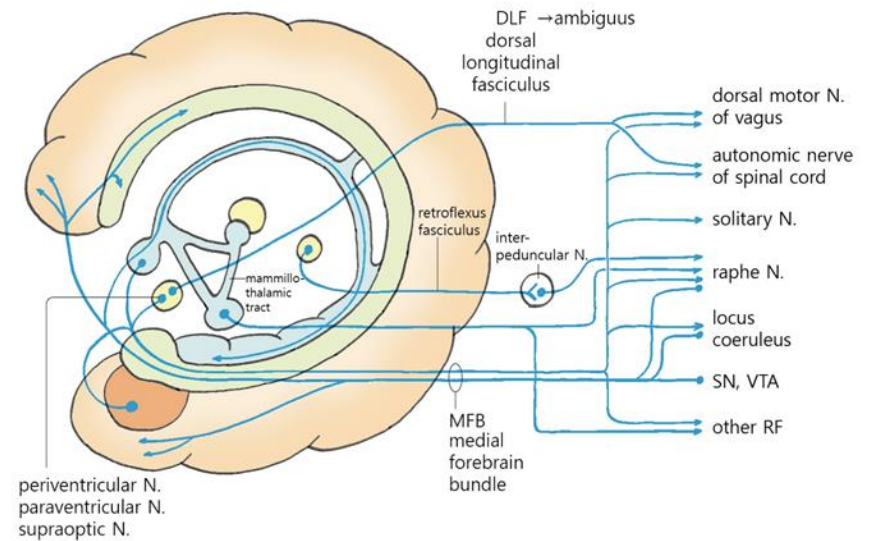
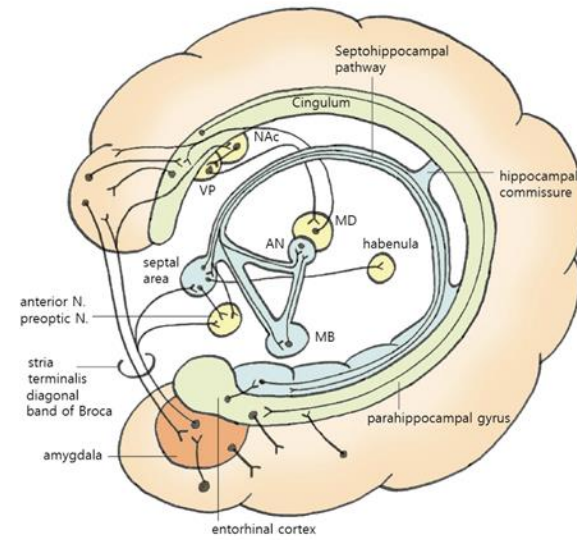
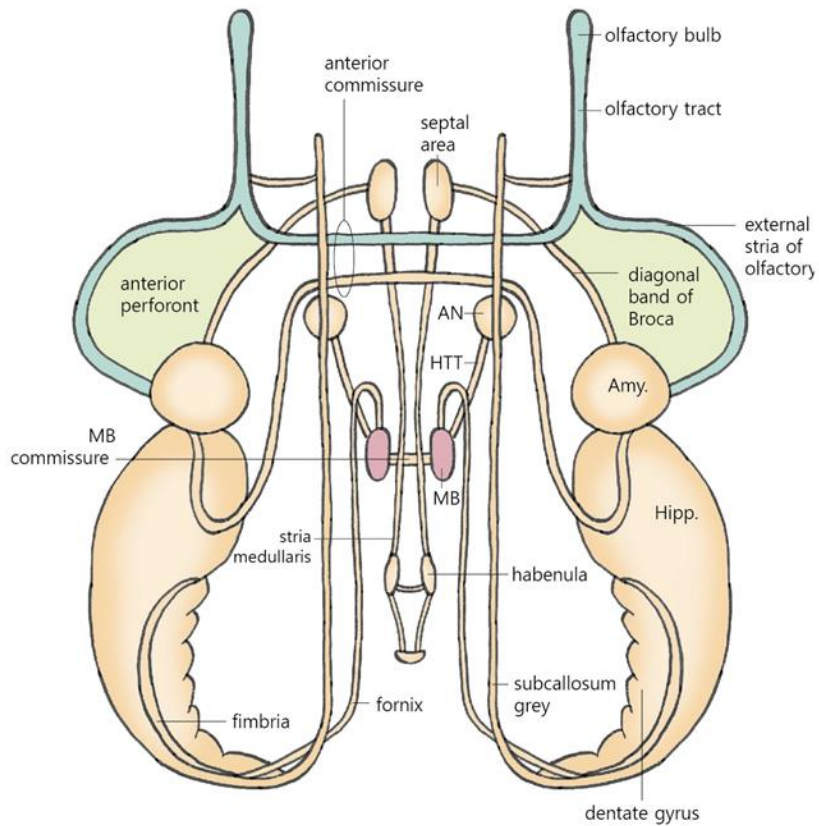


D

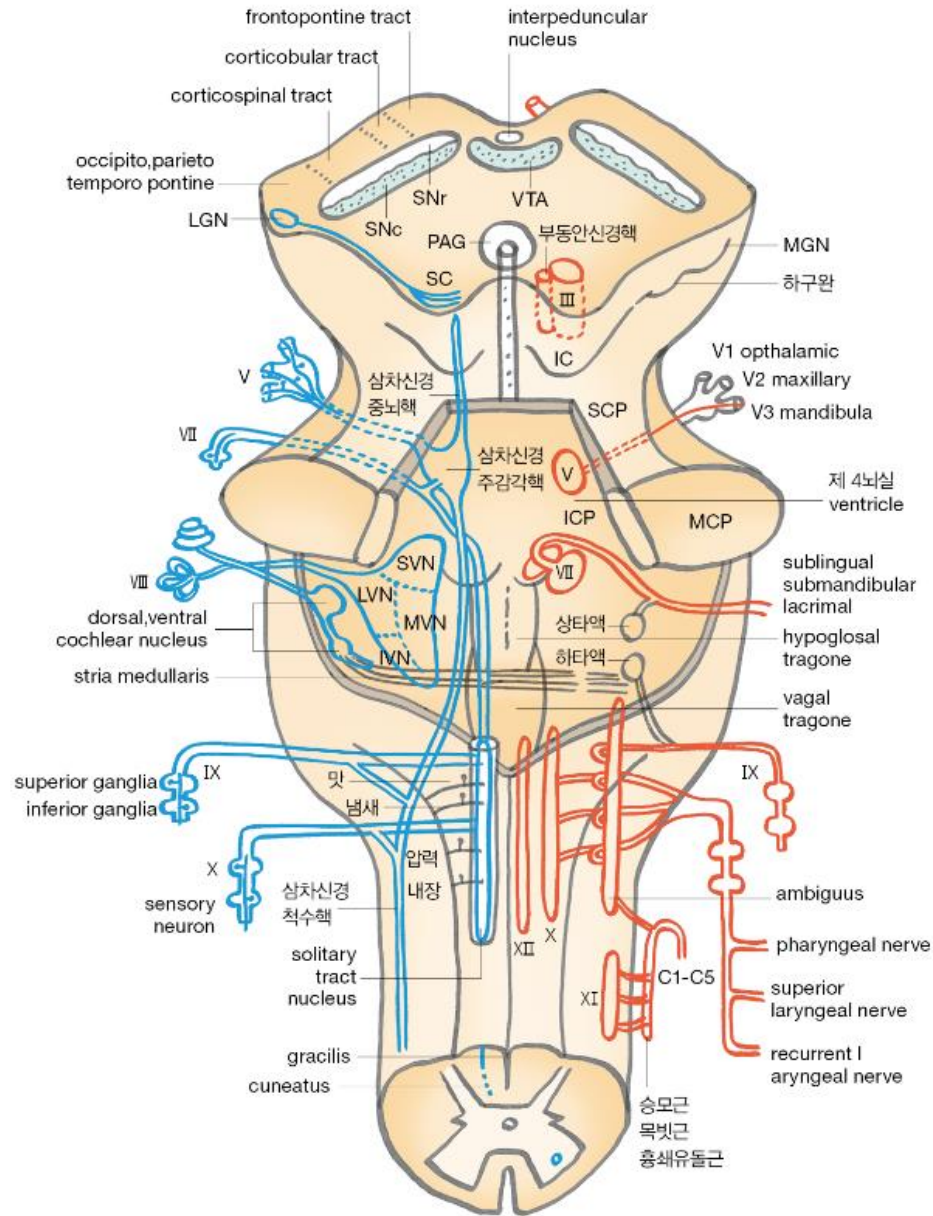
PO

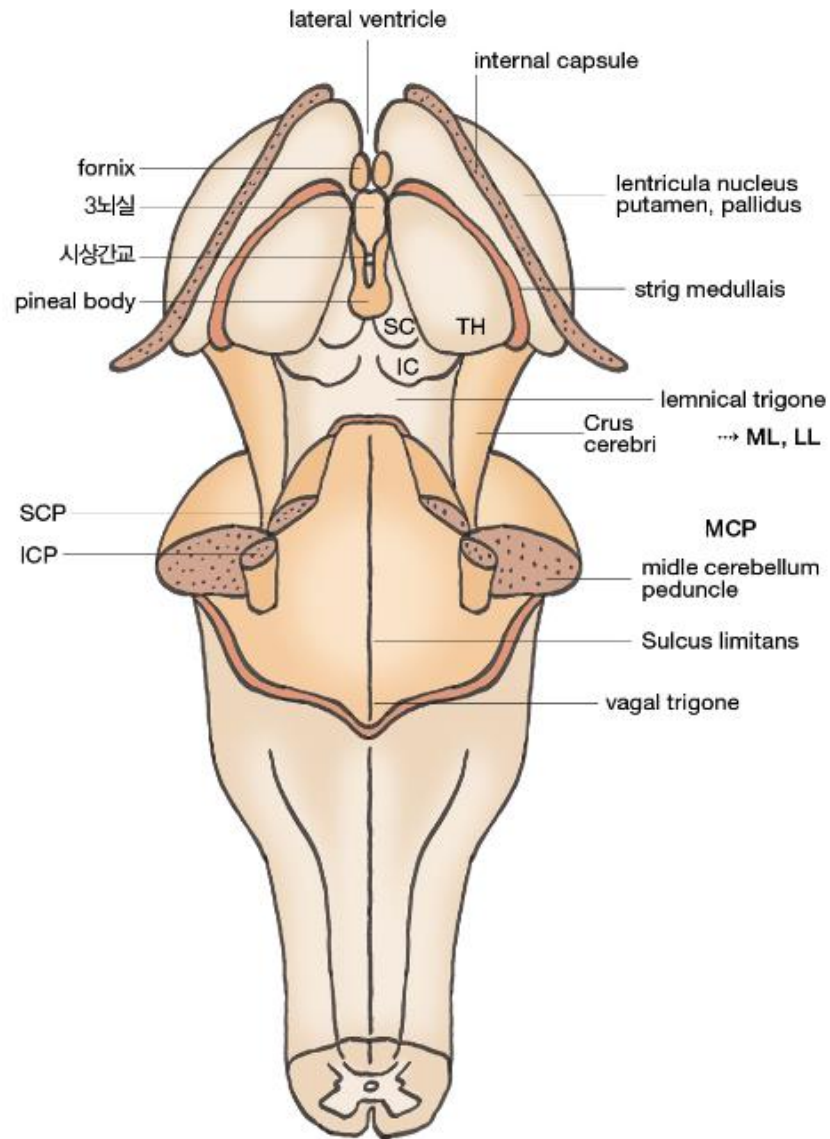


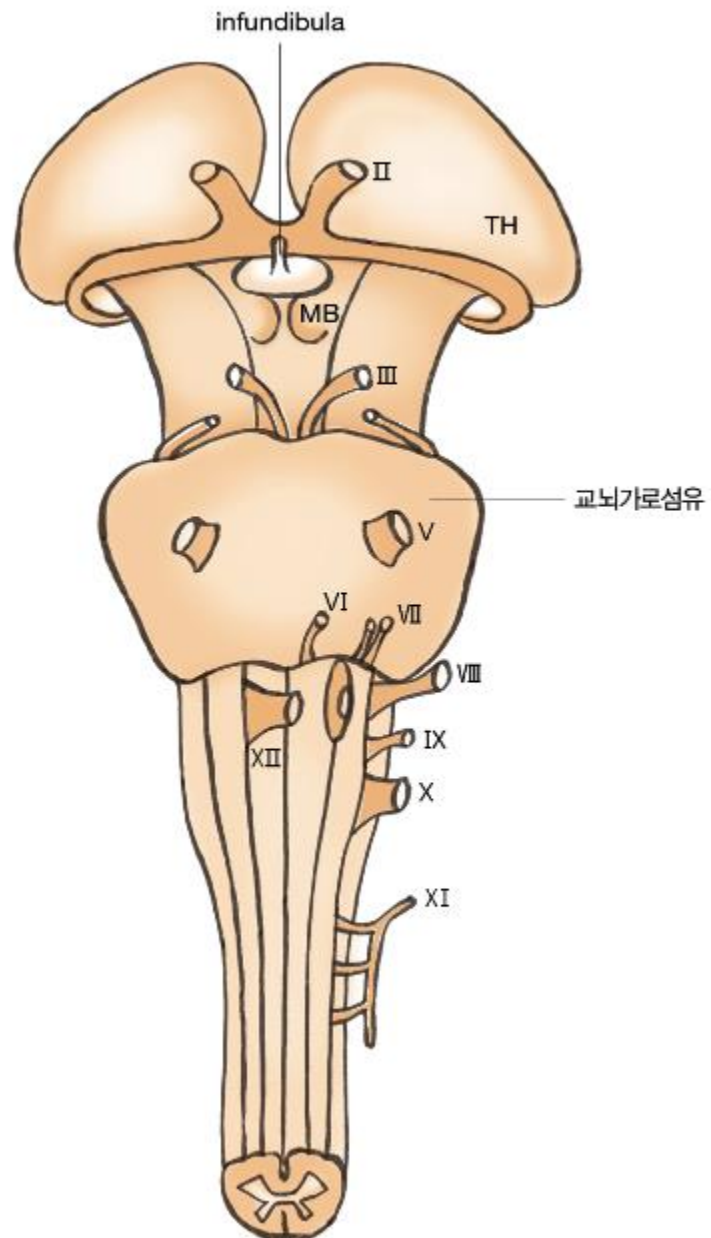


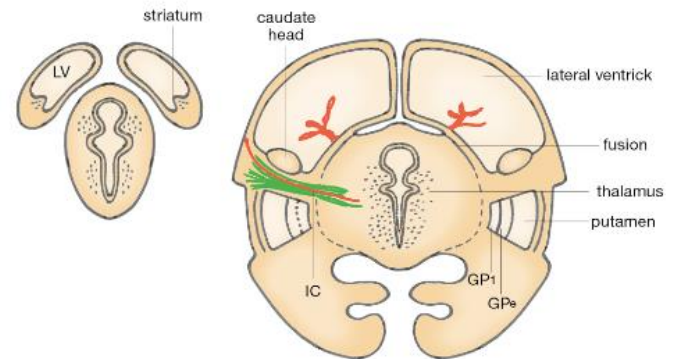
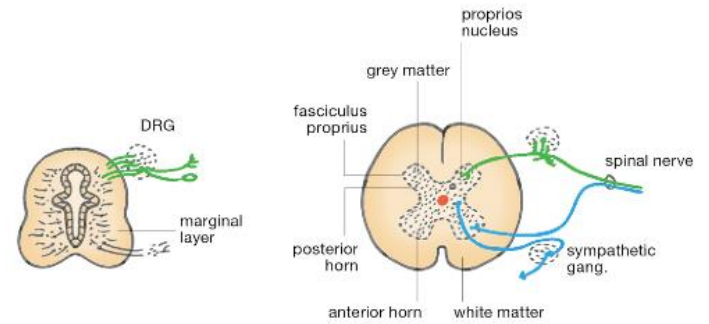
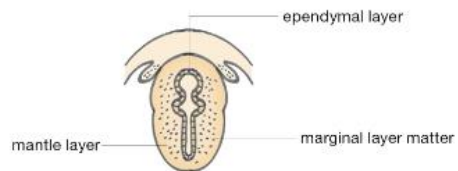
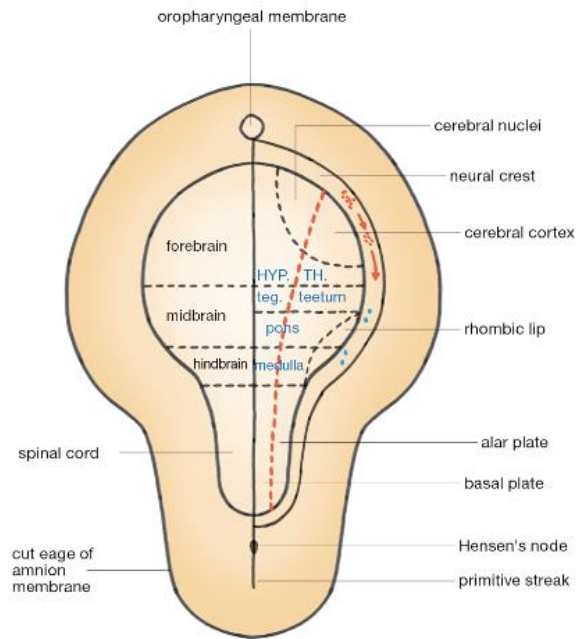


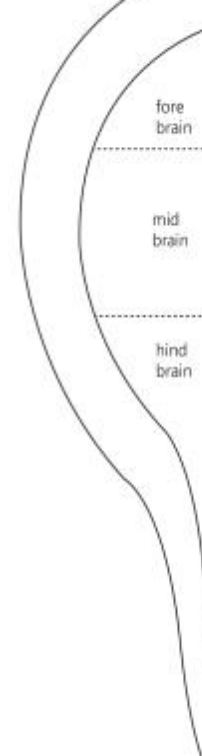
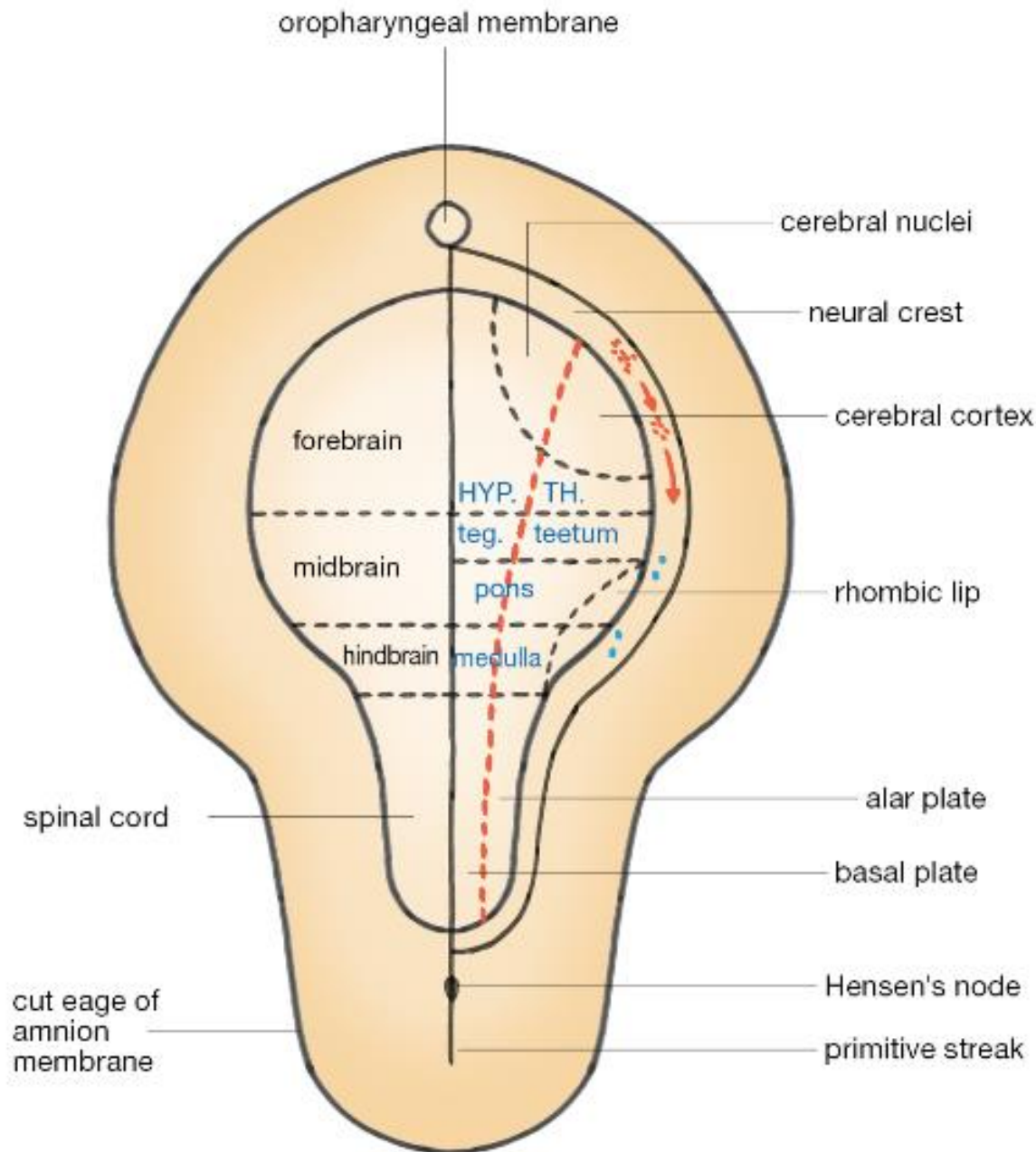
#1 뇌간의 뇌신경

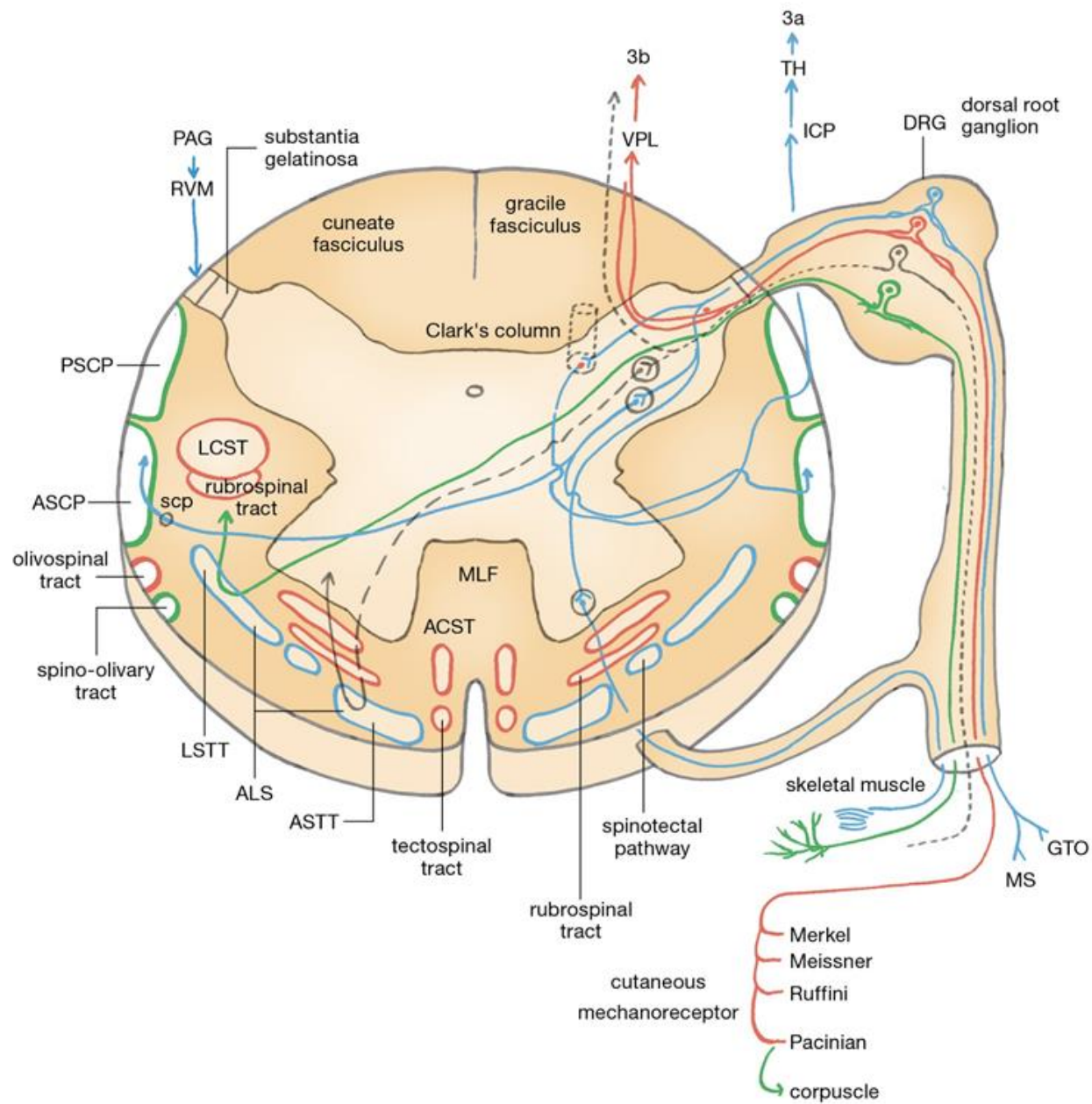


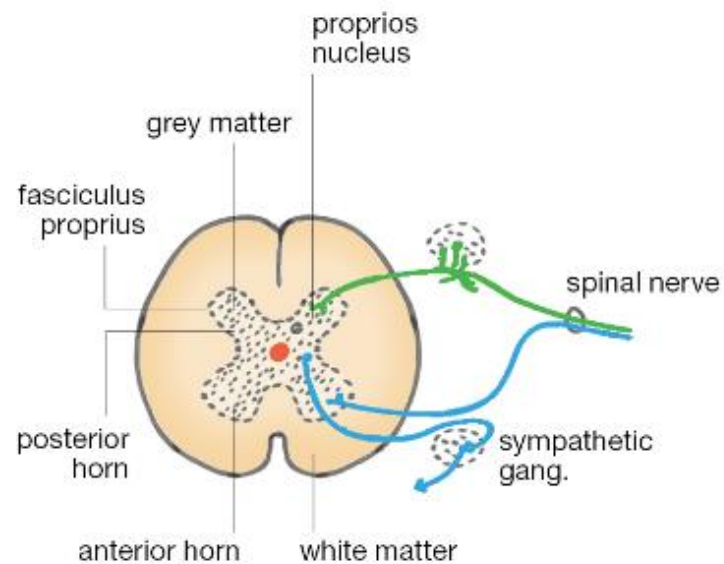
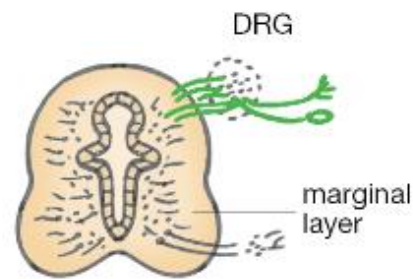
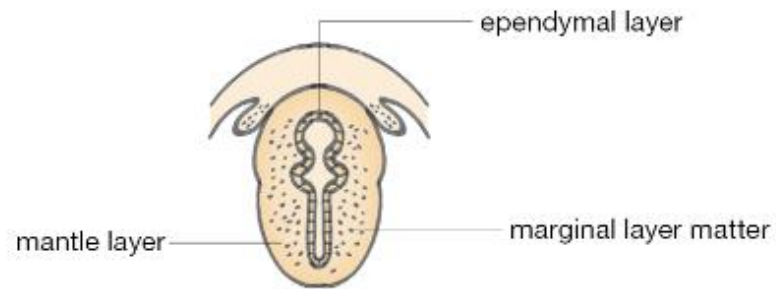


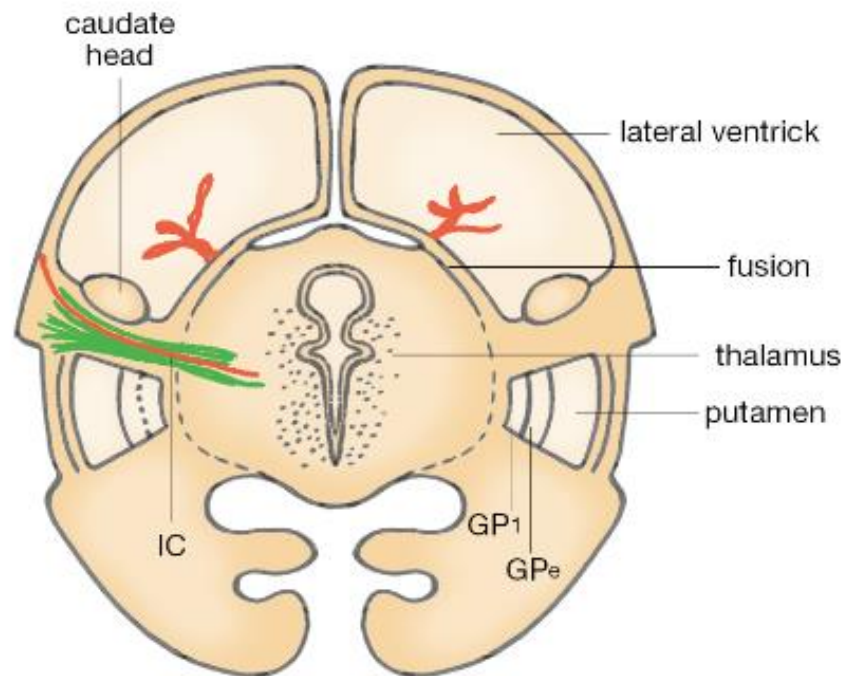
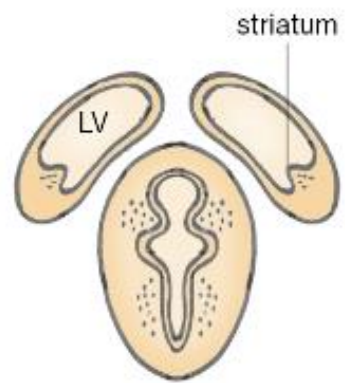


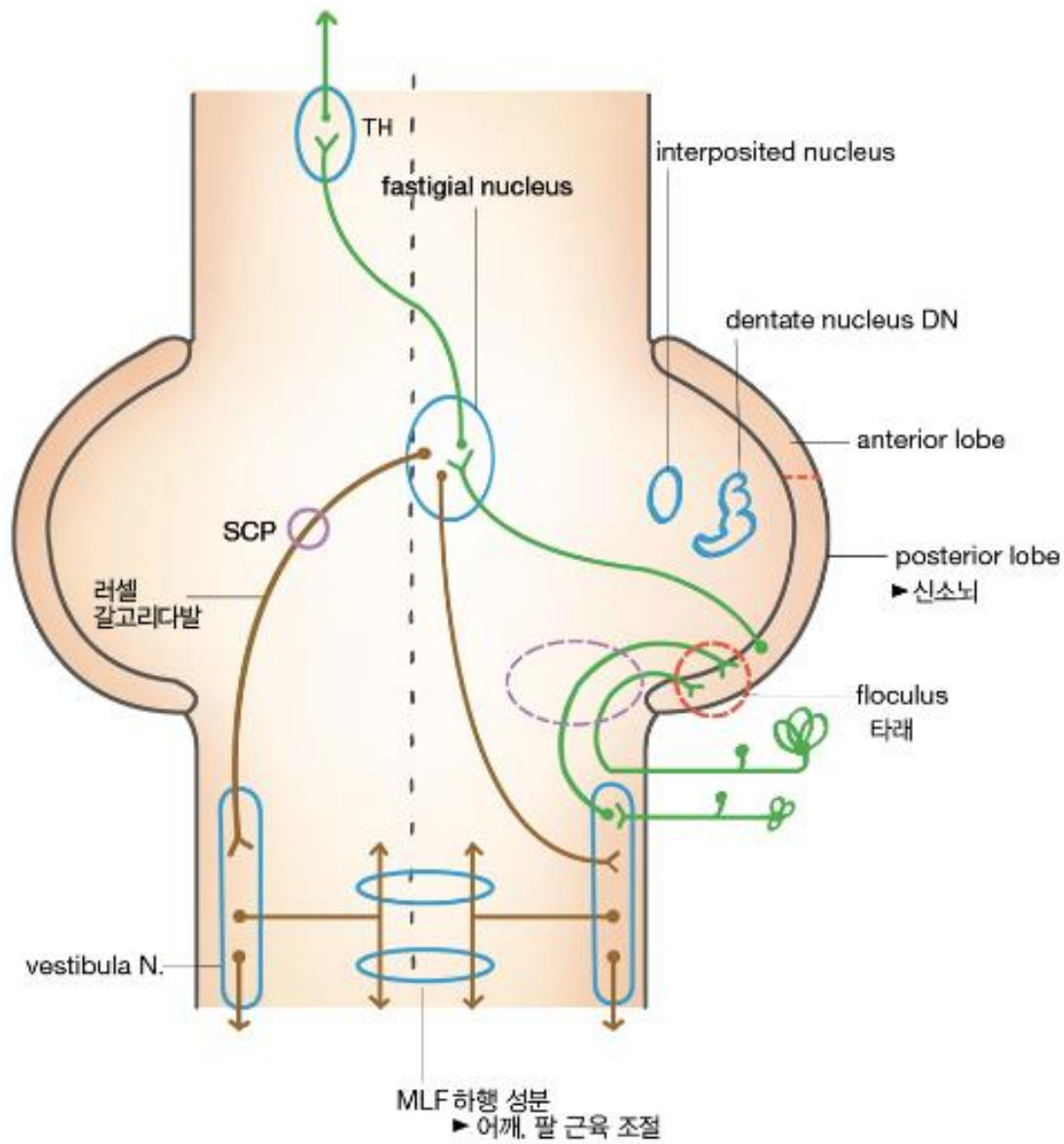






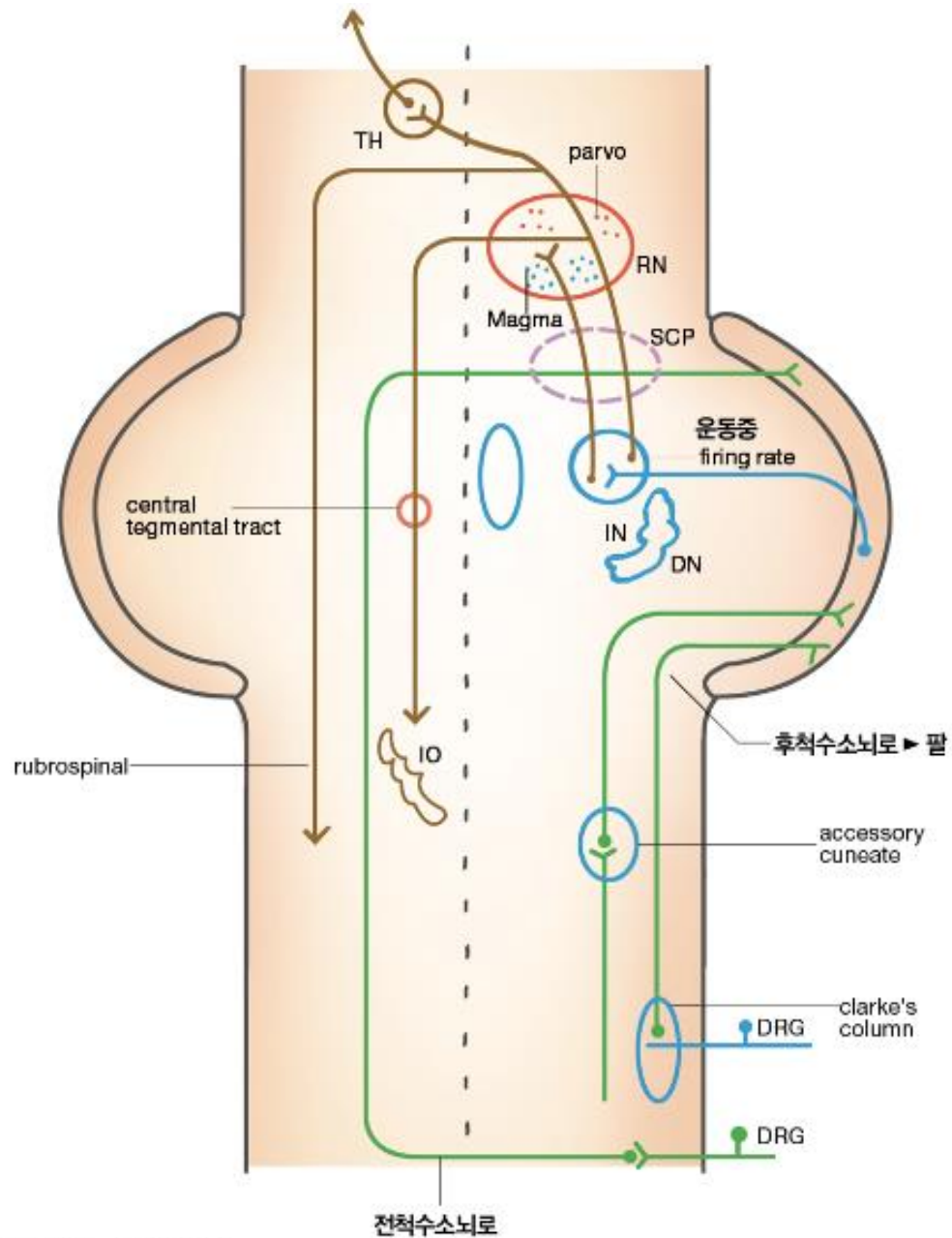






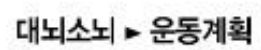
vestibule-cerebellum 전정소뇌 ▶ 균형

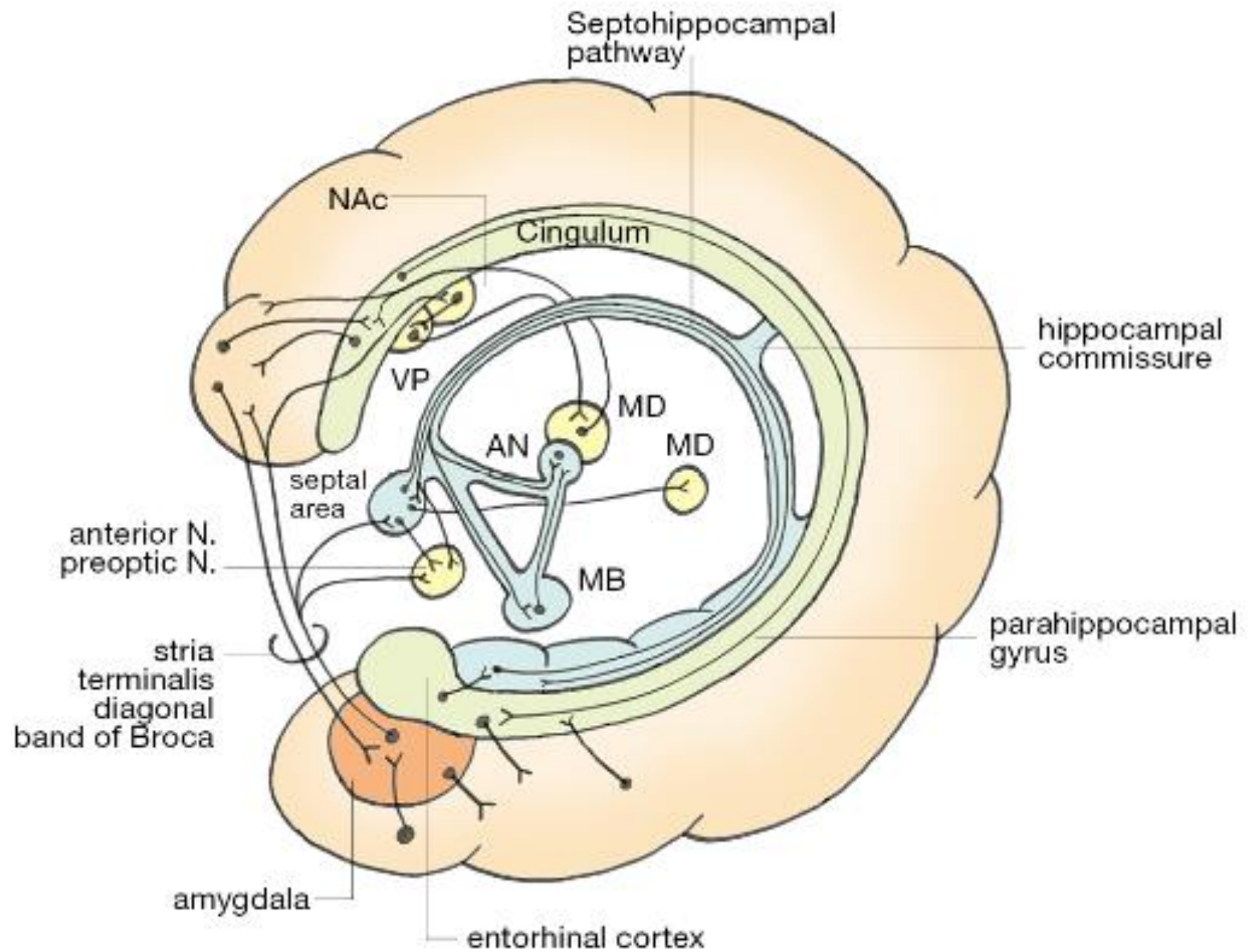
꼭지핵

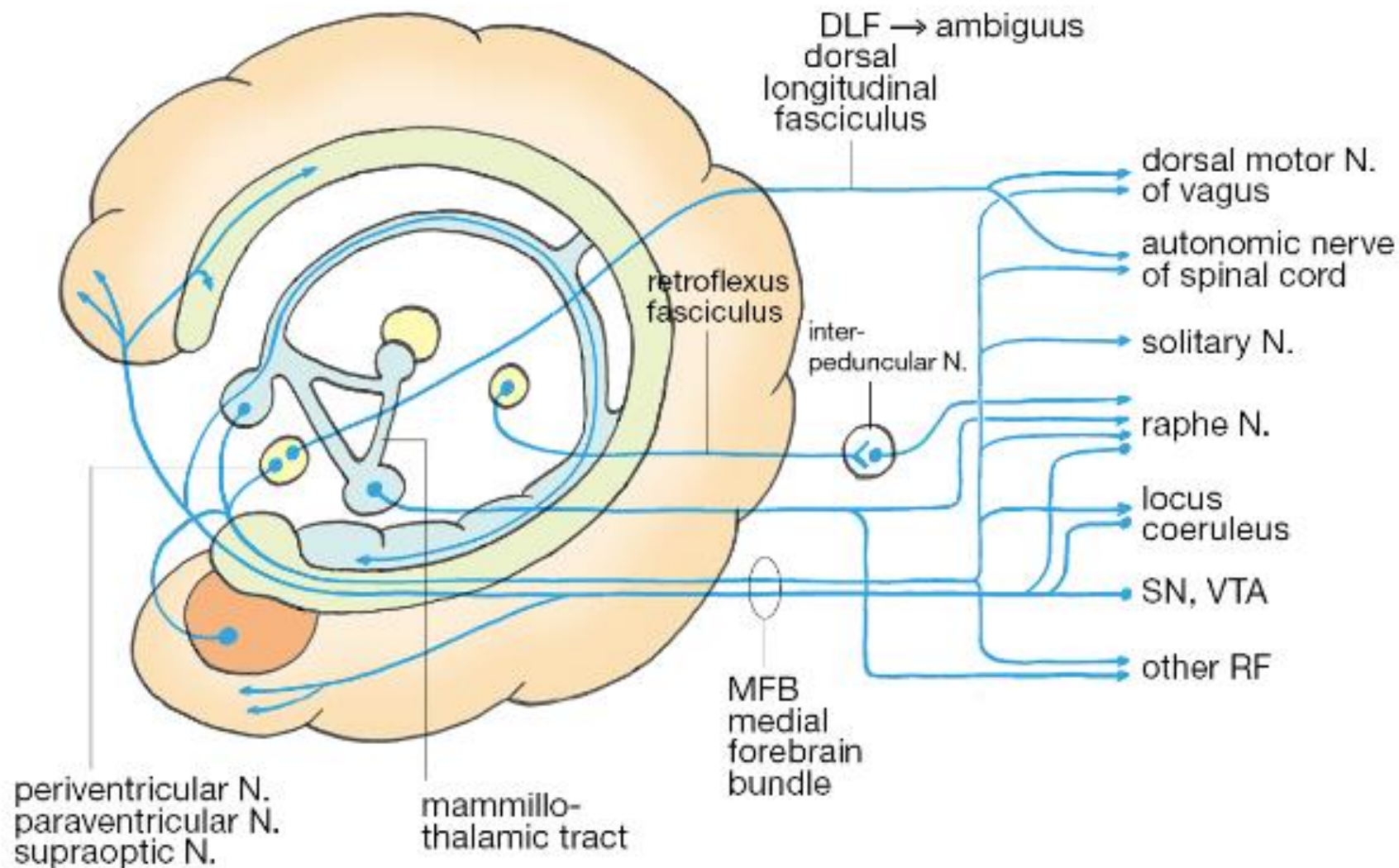


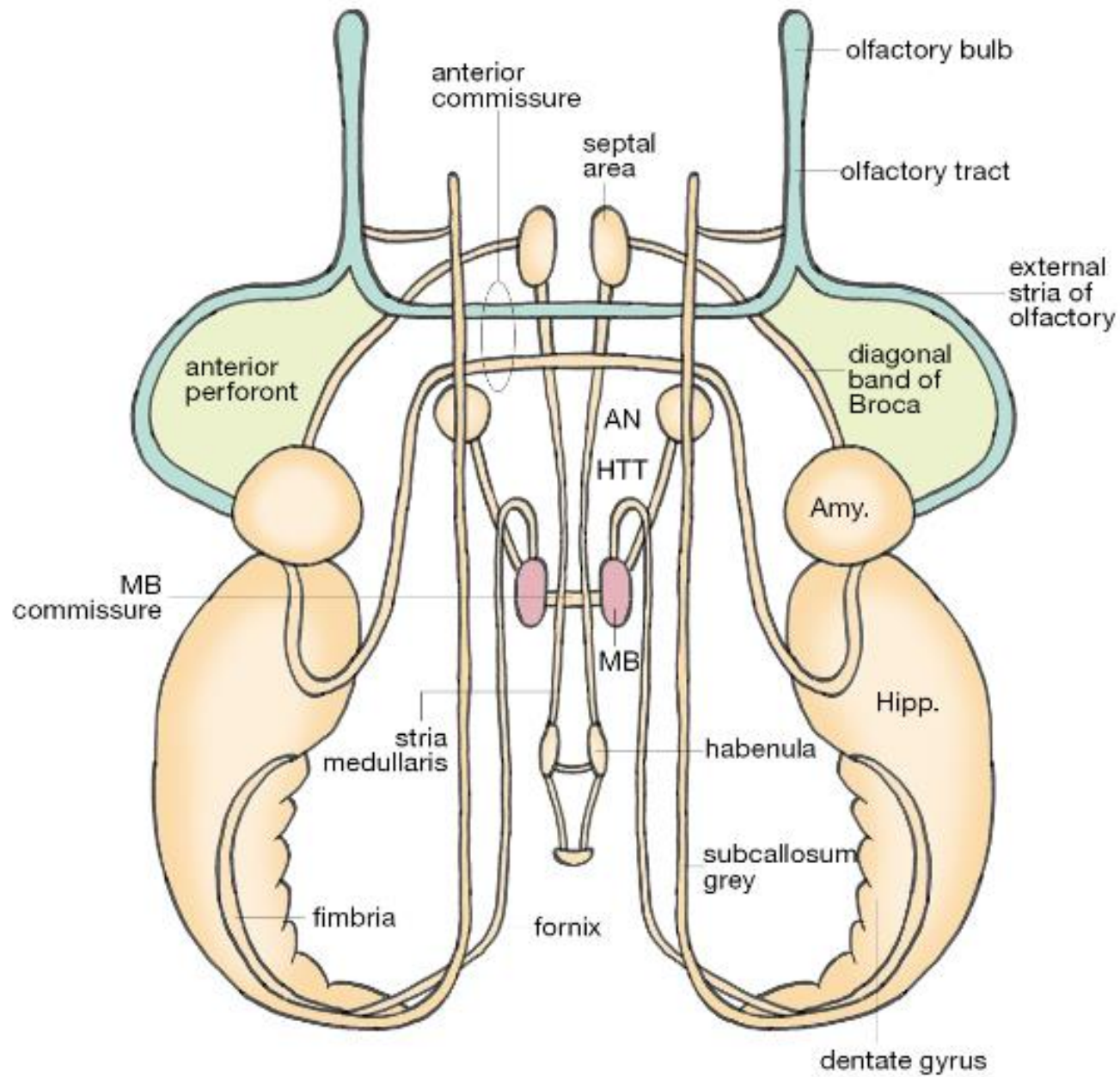
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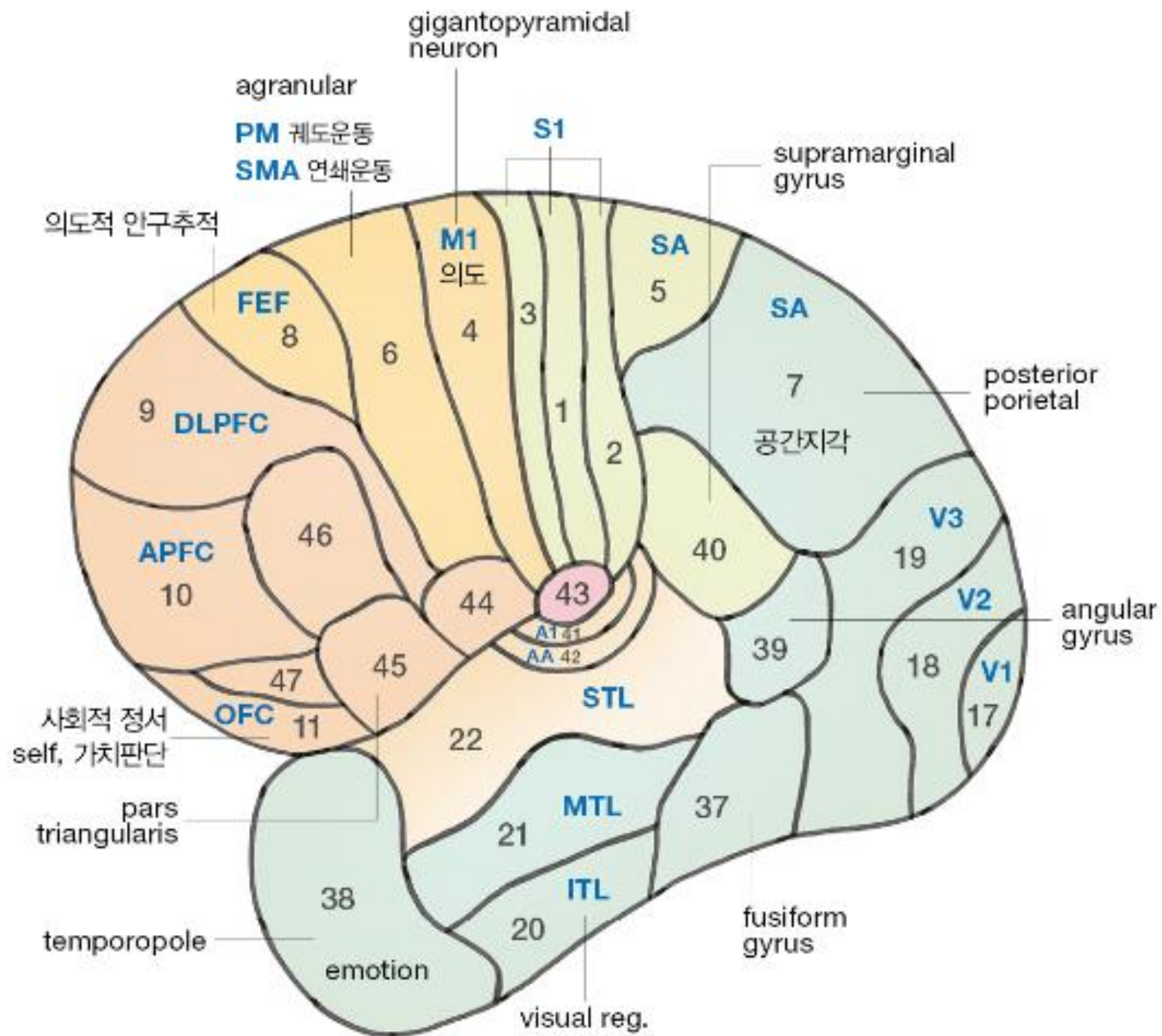
RN > 운동 실행

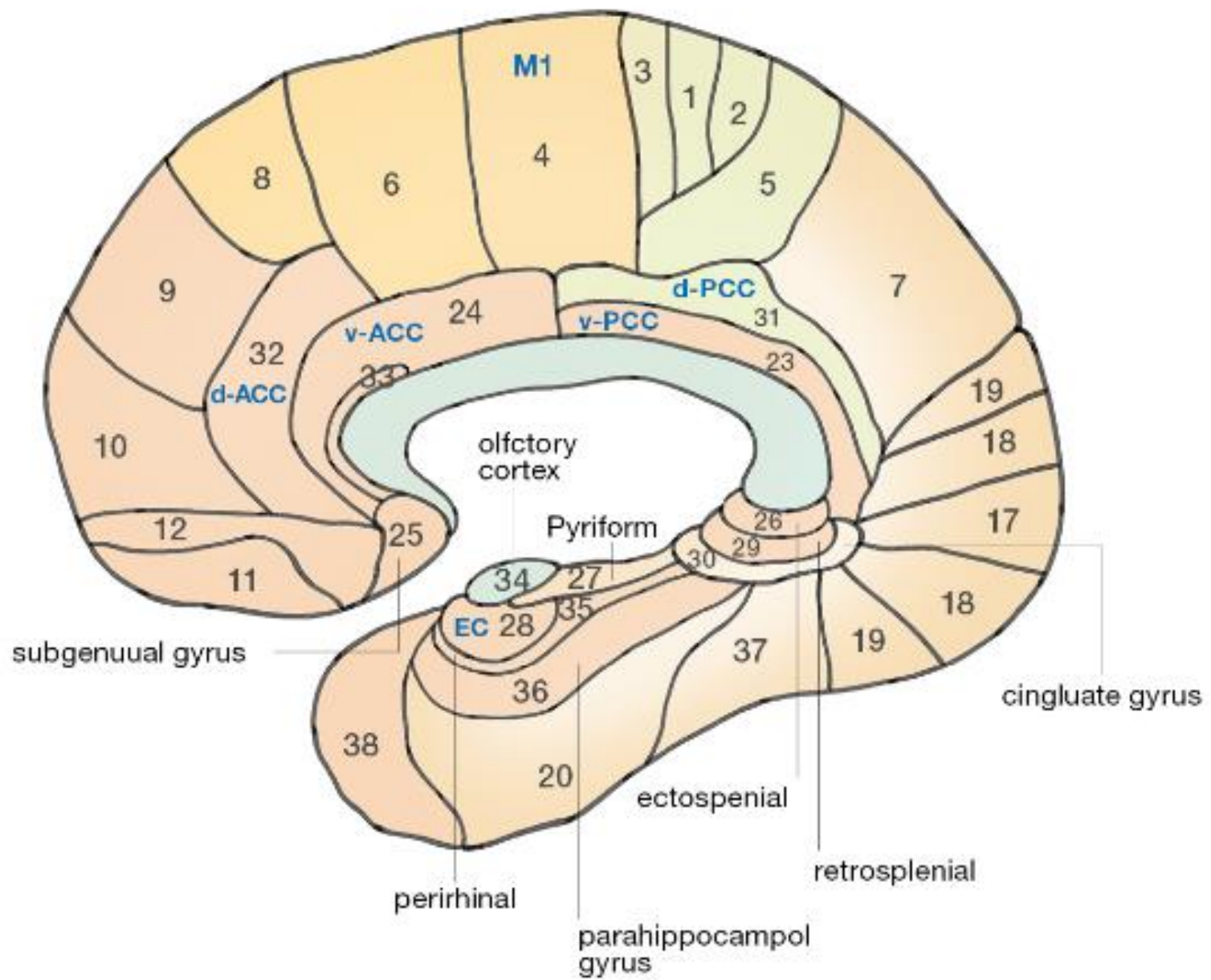


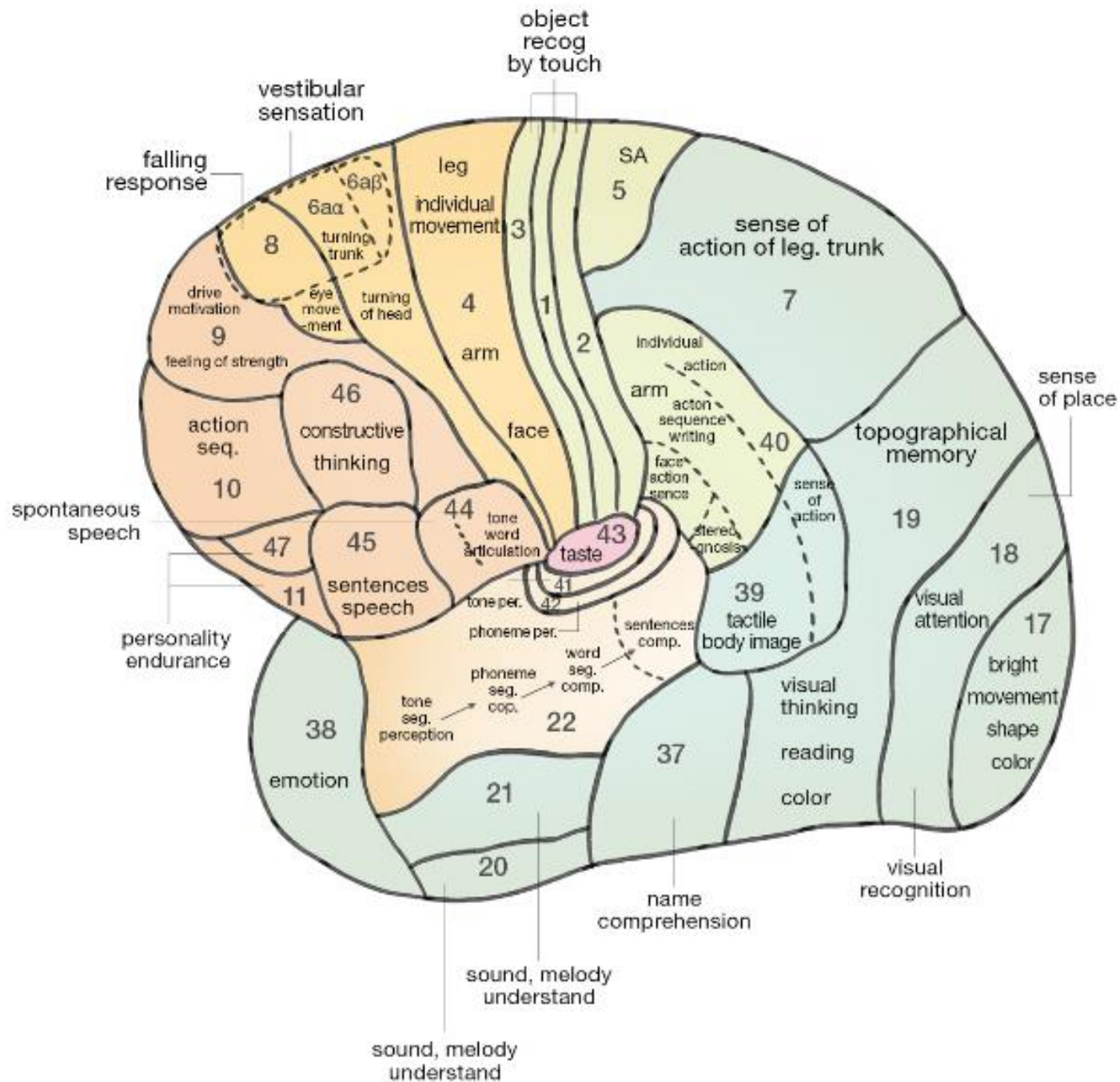


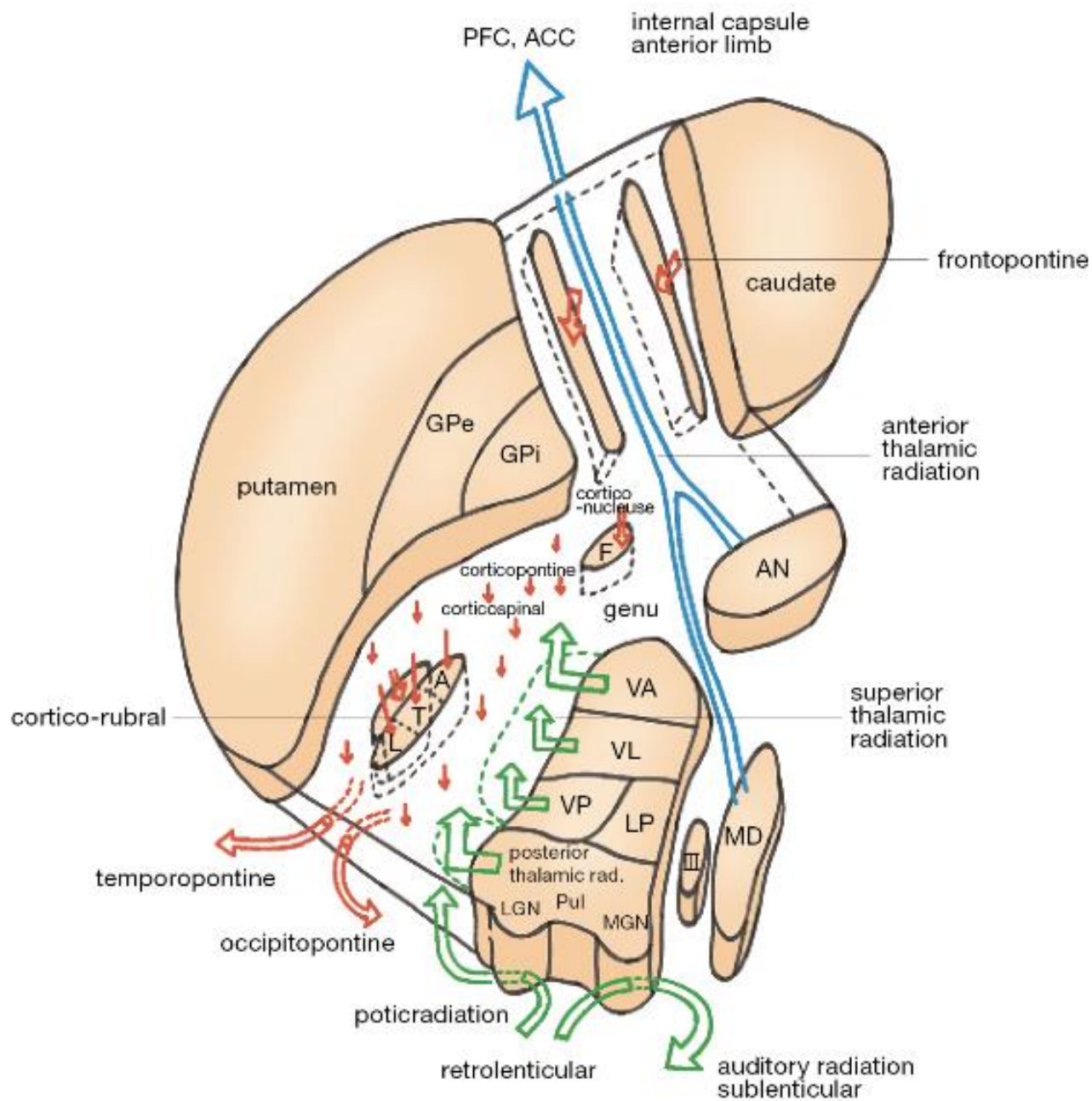


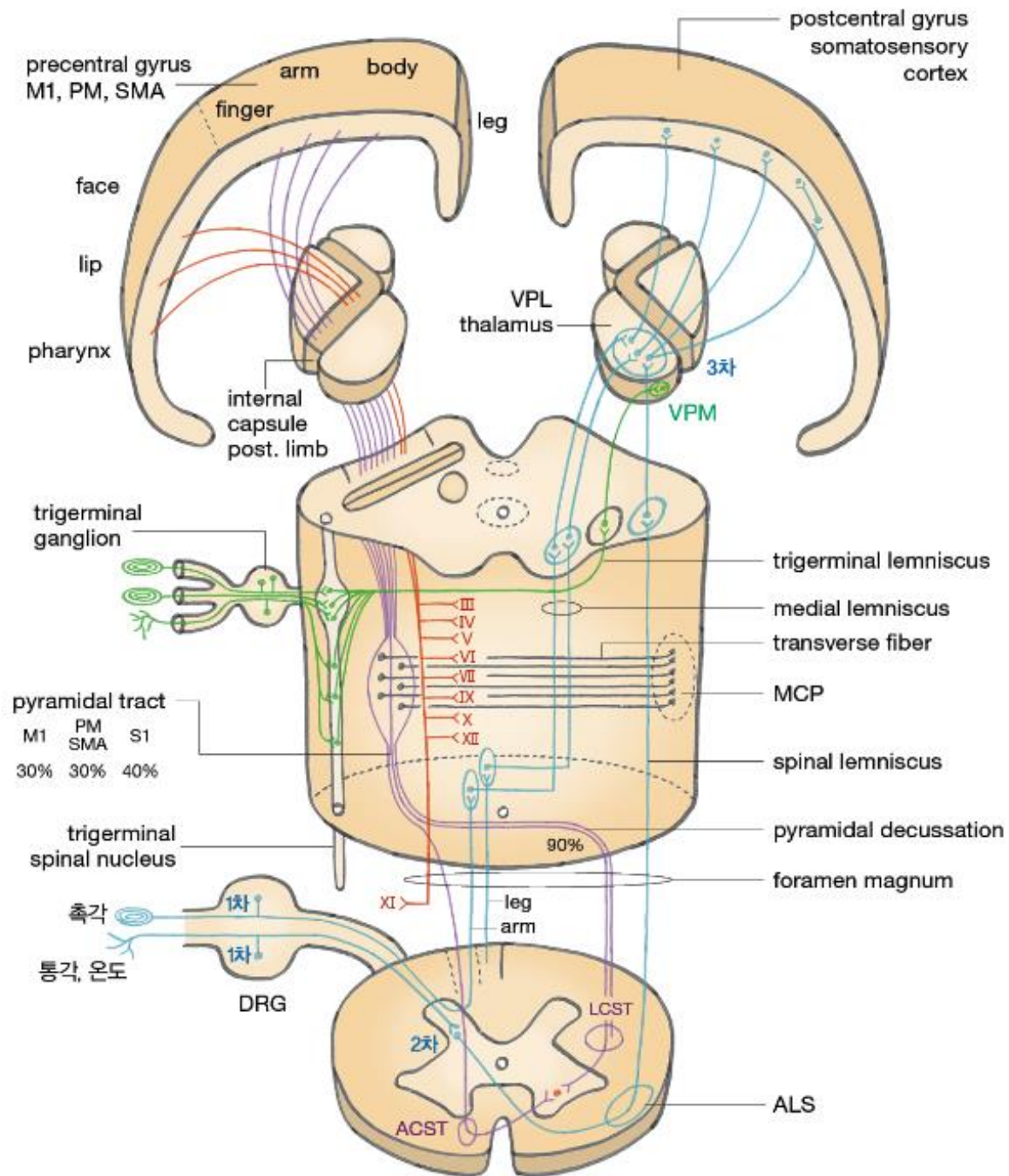


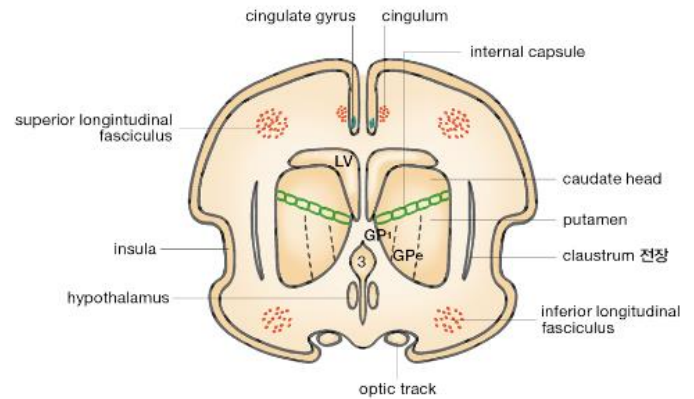
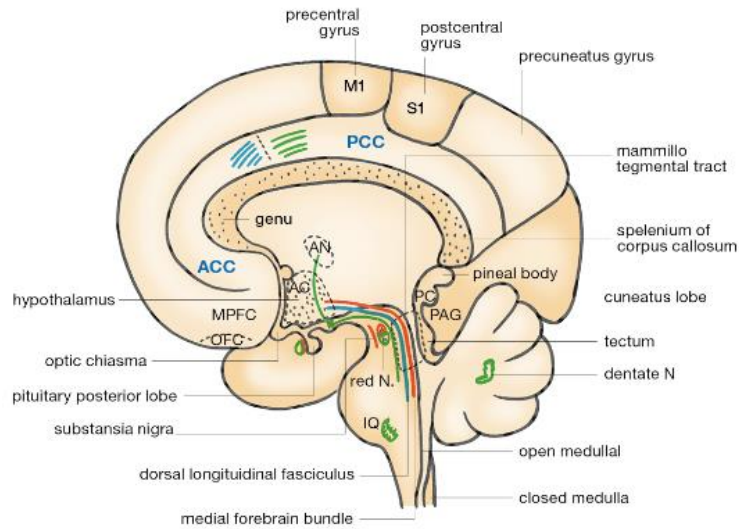
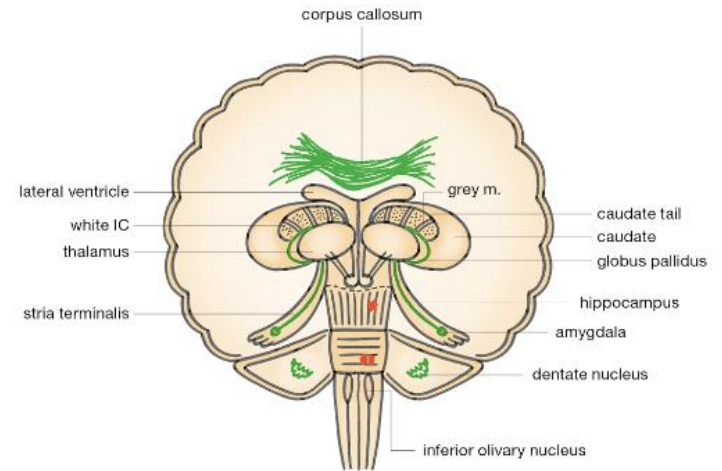
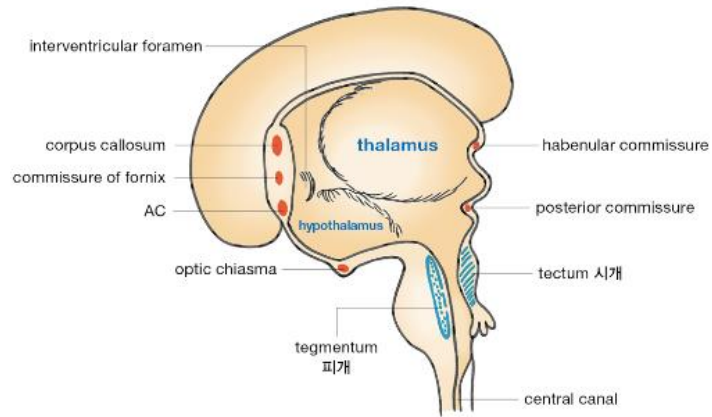


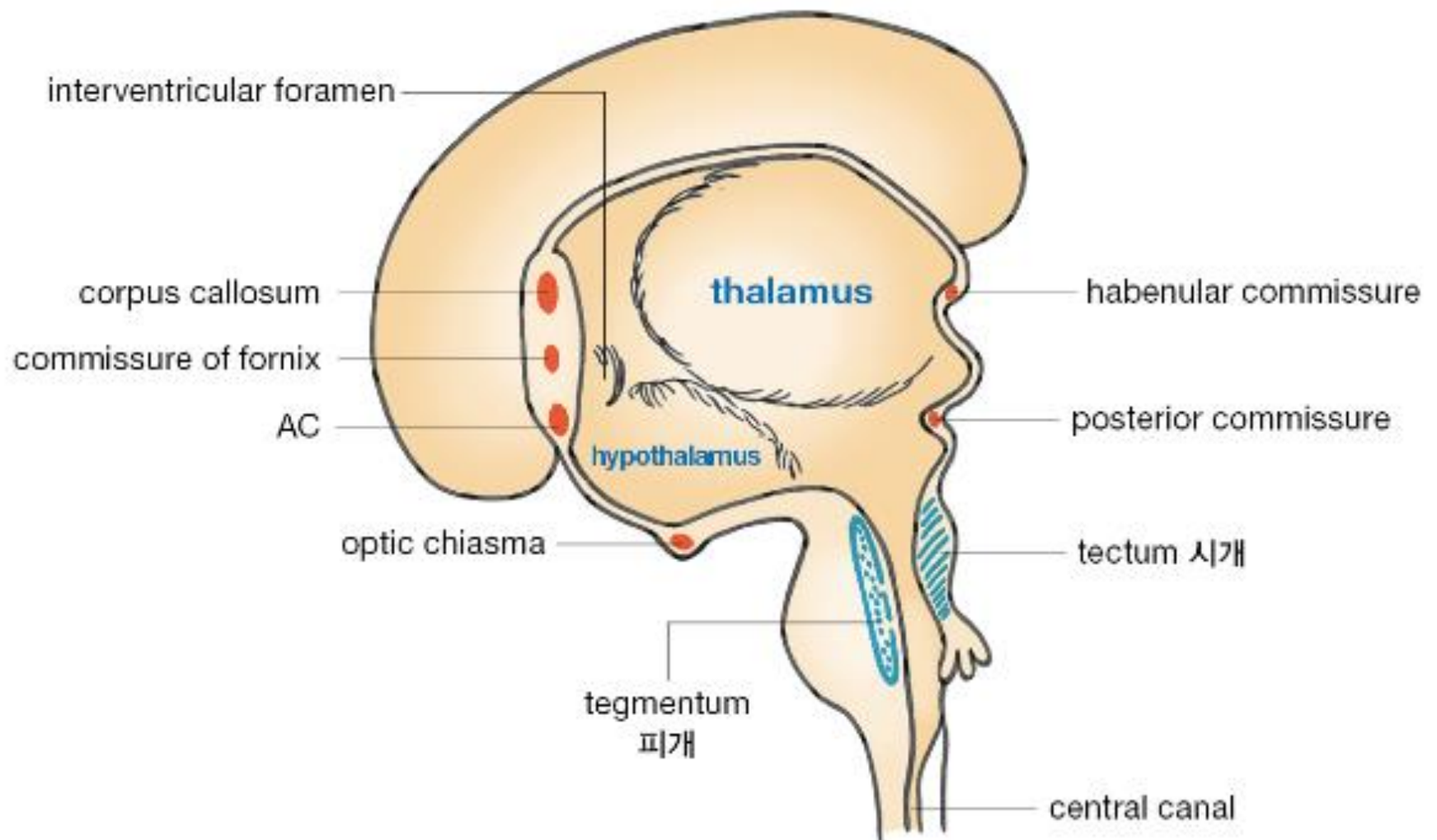


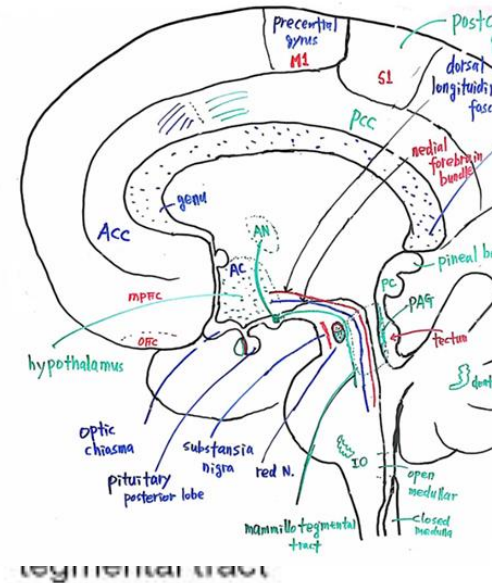
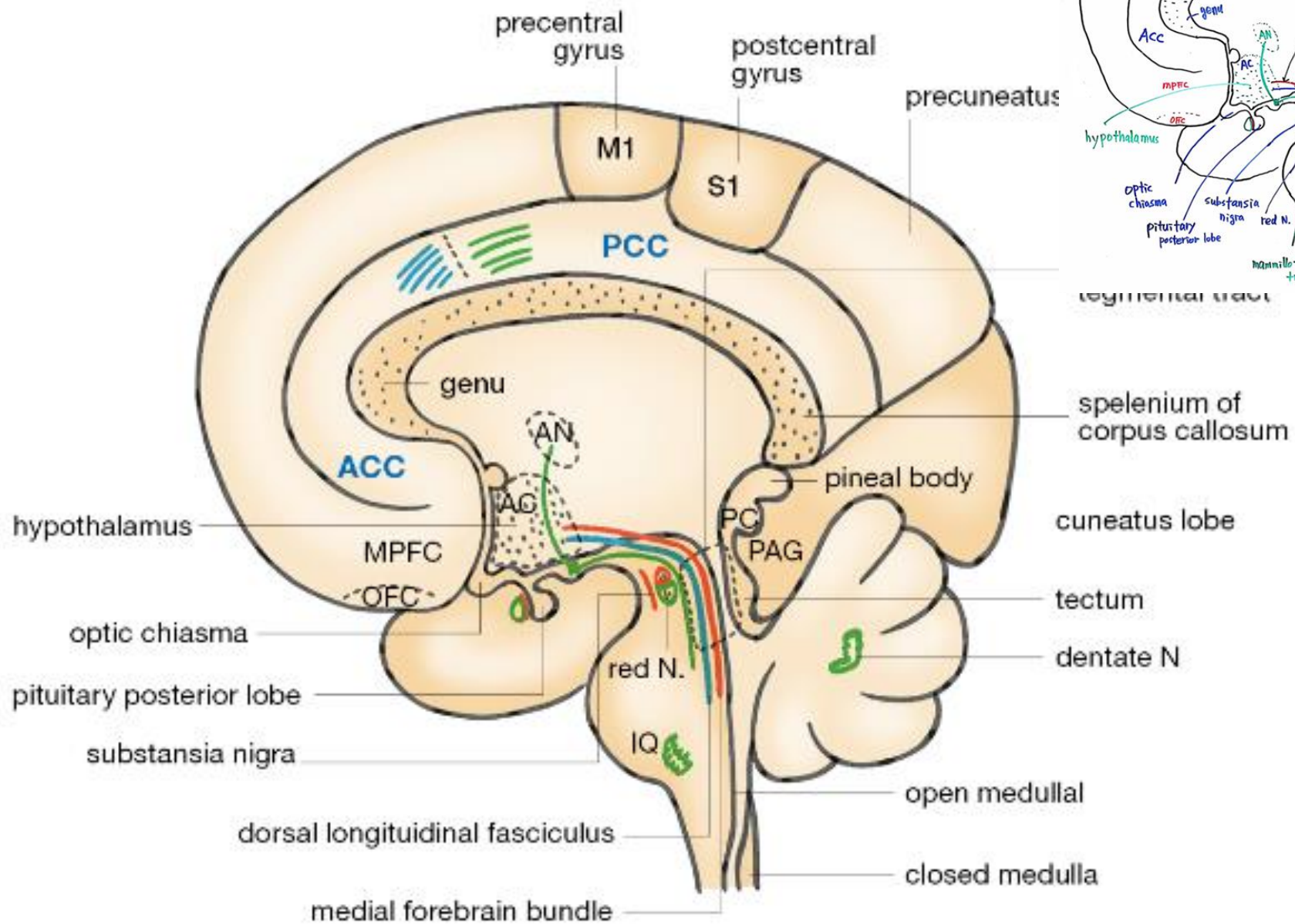


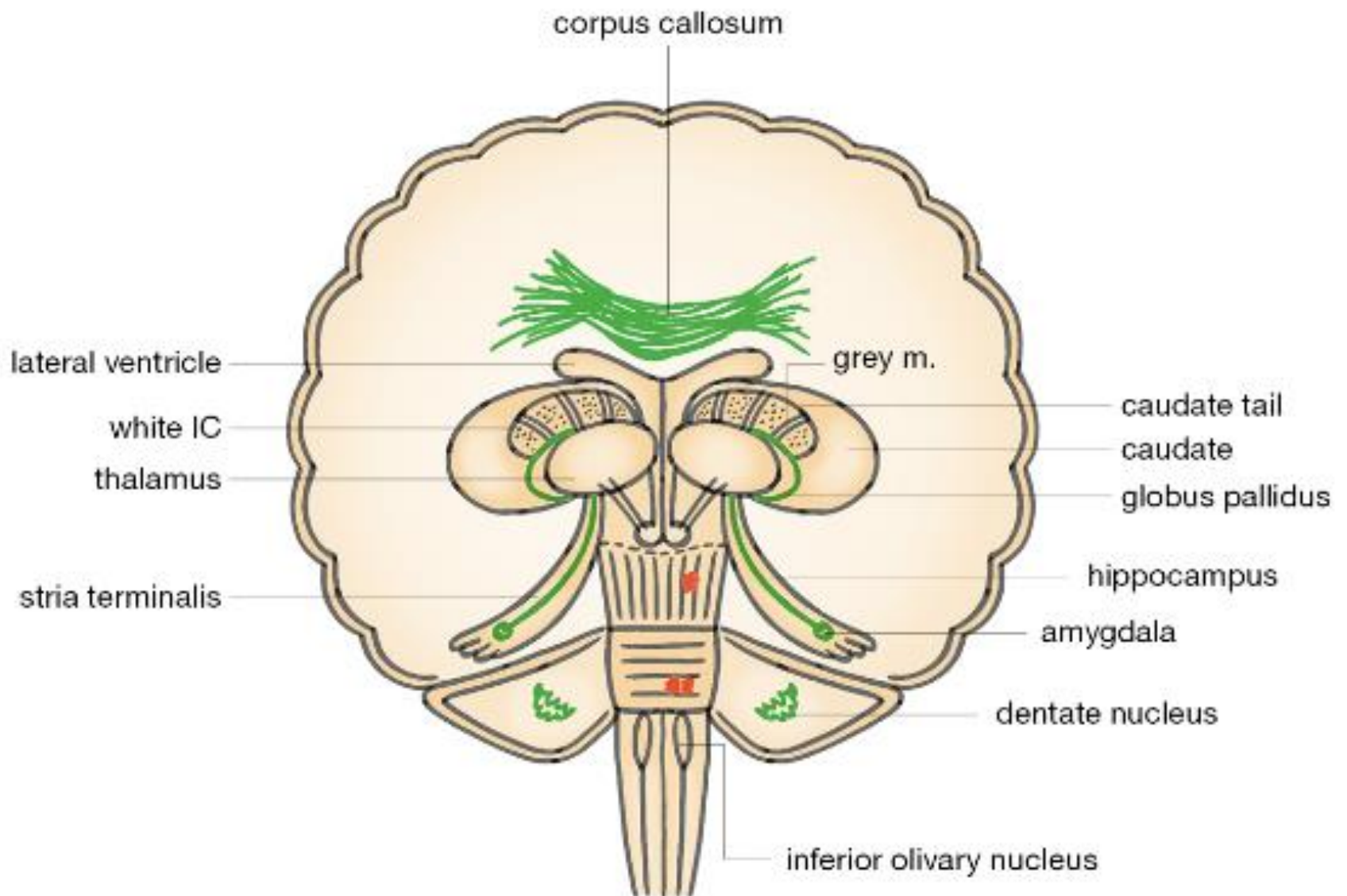


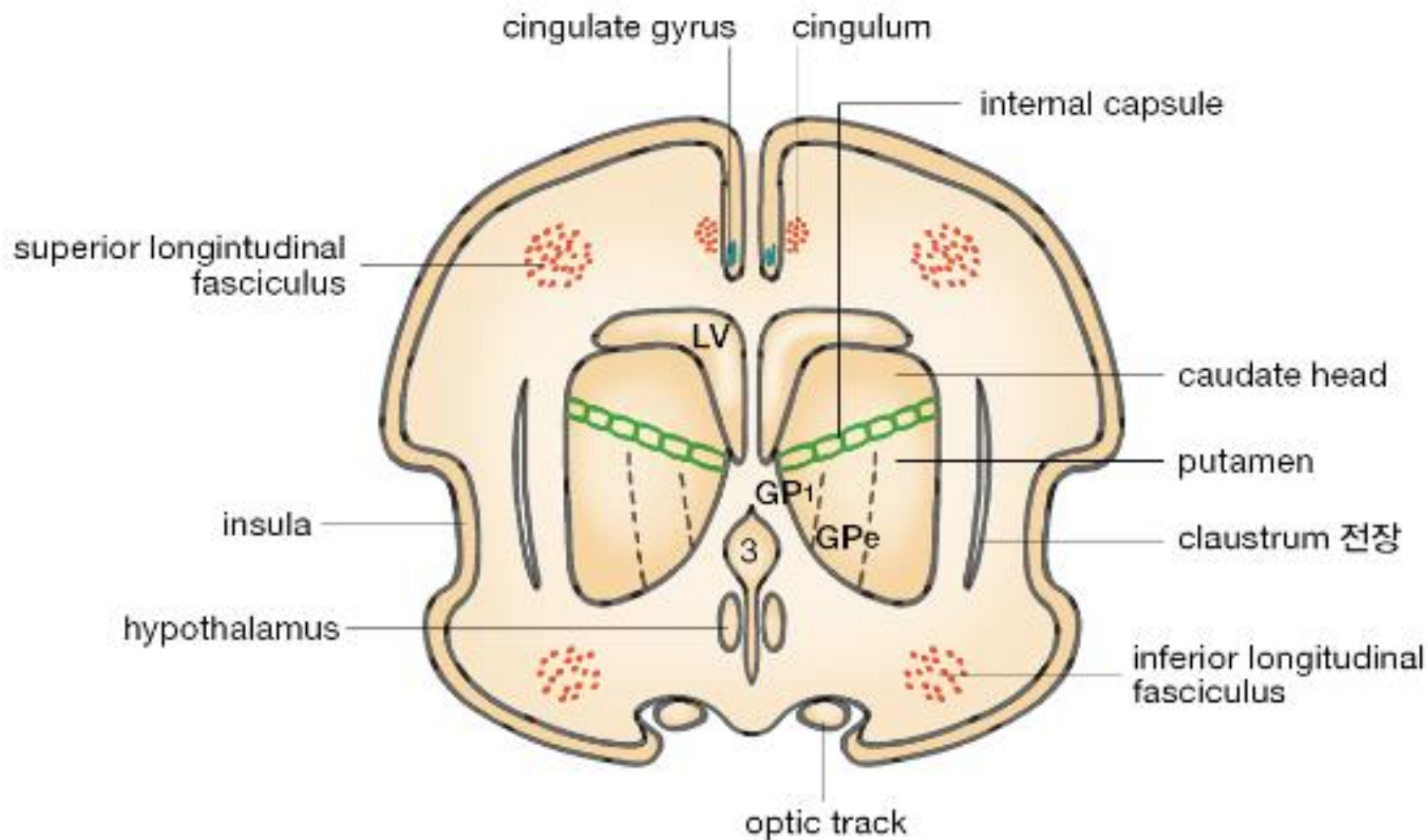


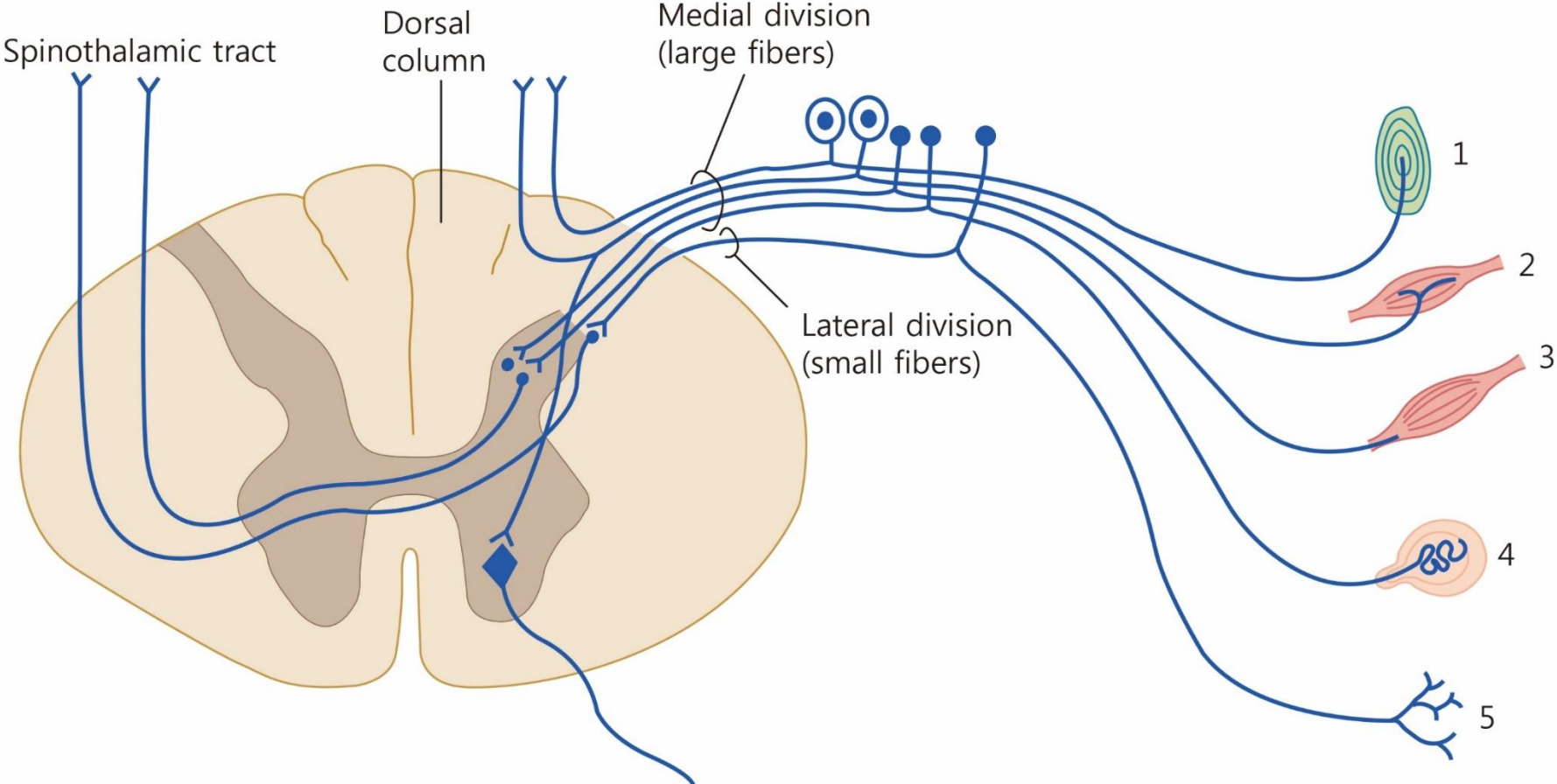


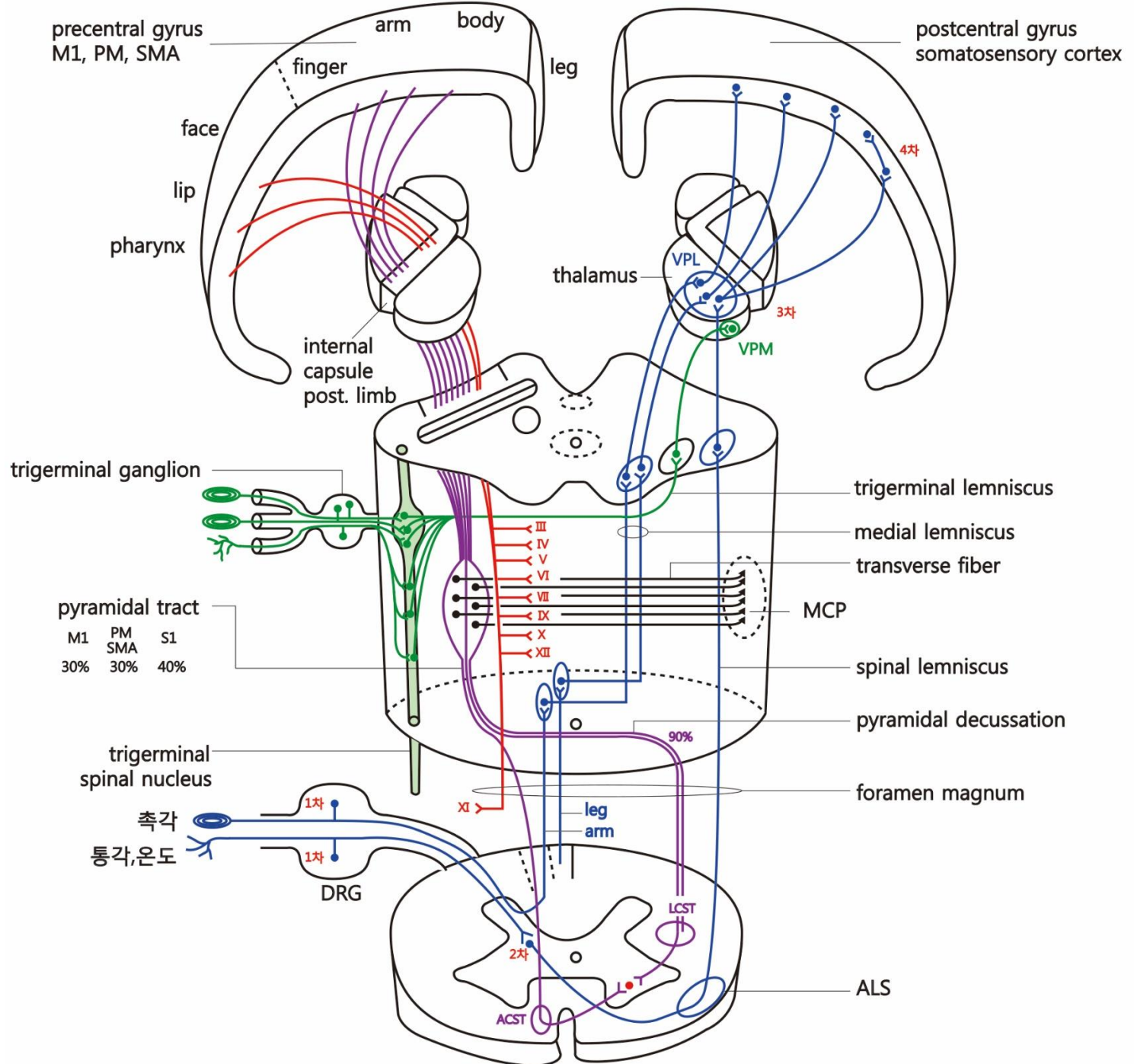


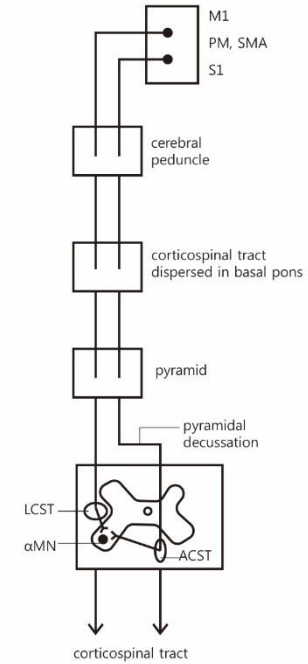
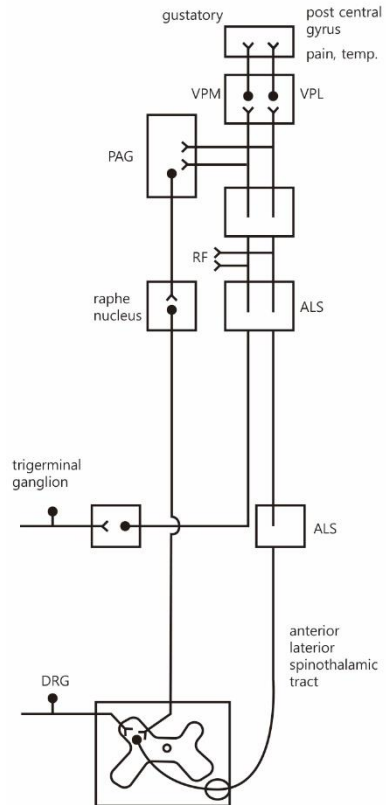
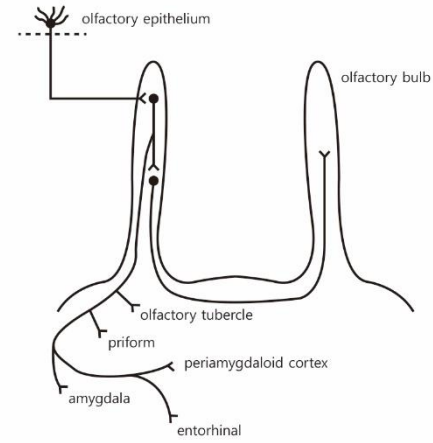
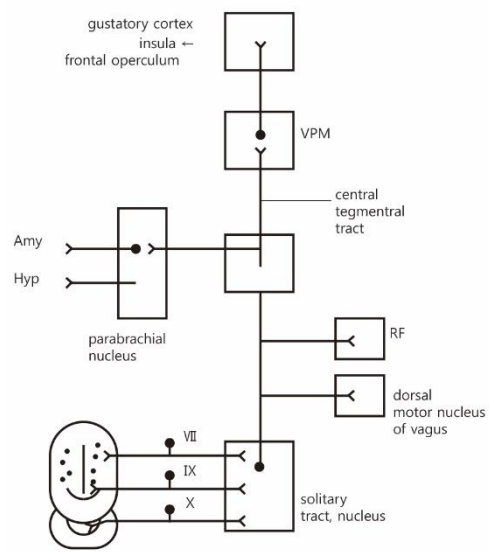


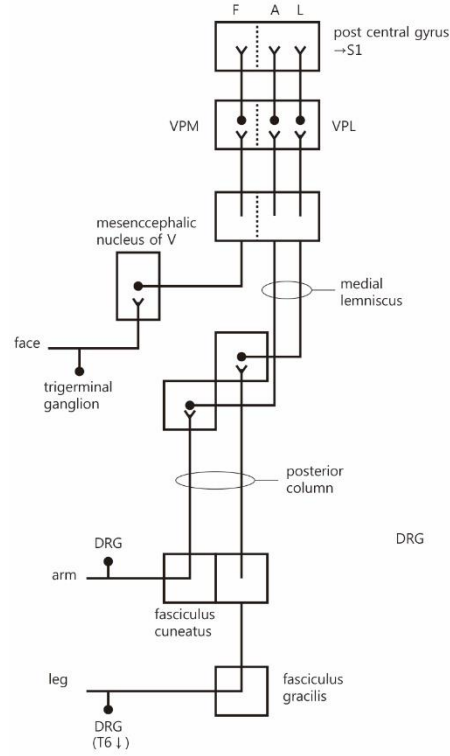




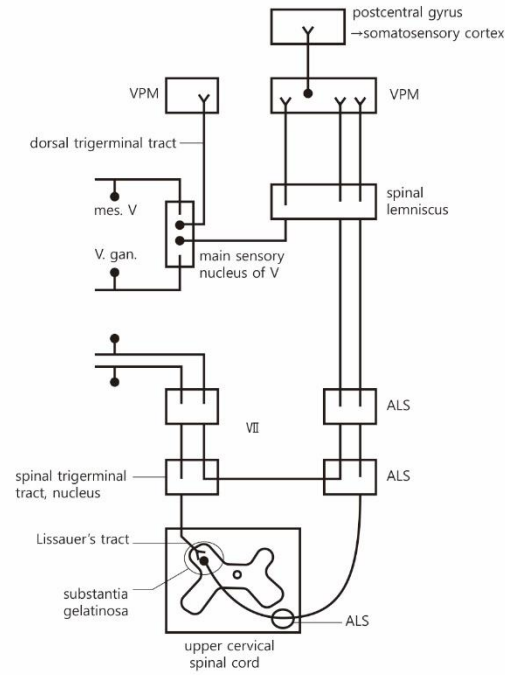




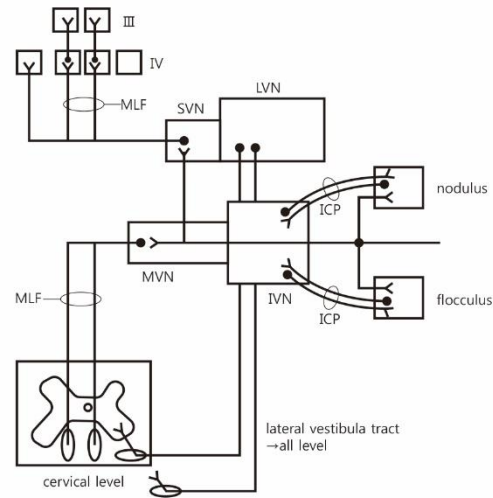




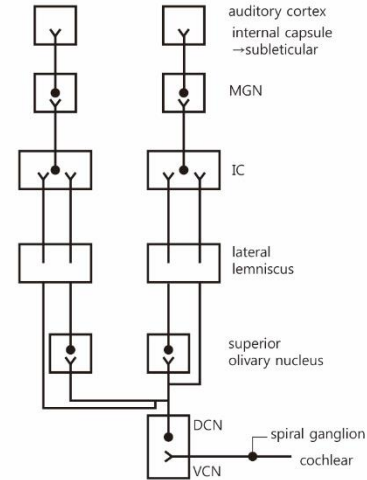
PC-ML



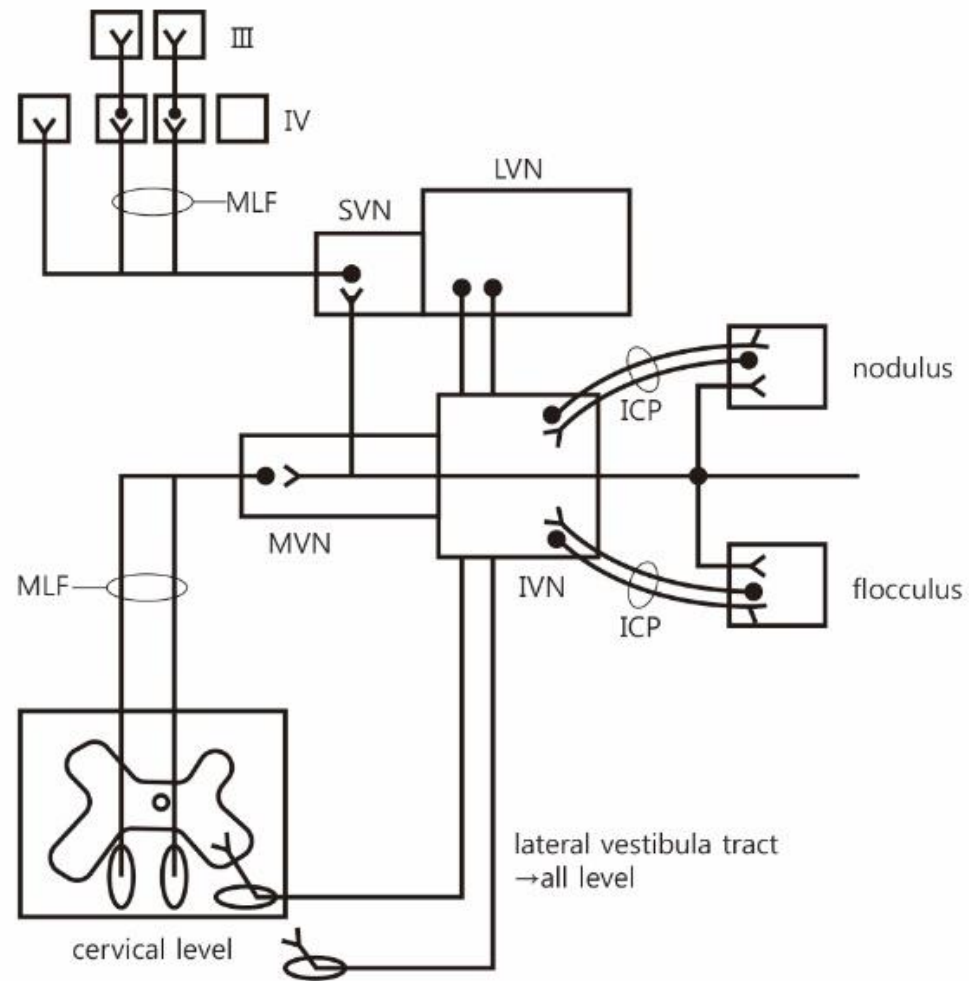
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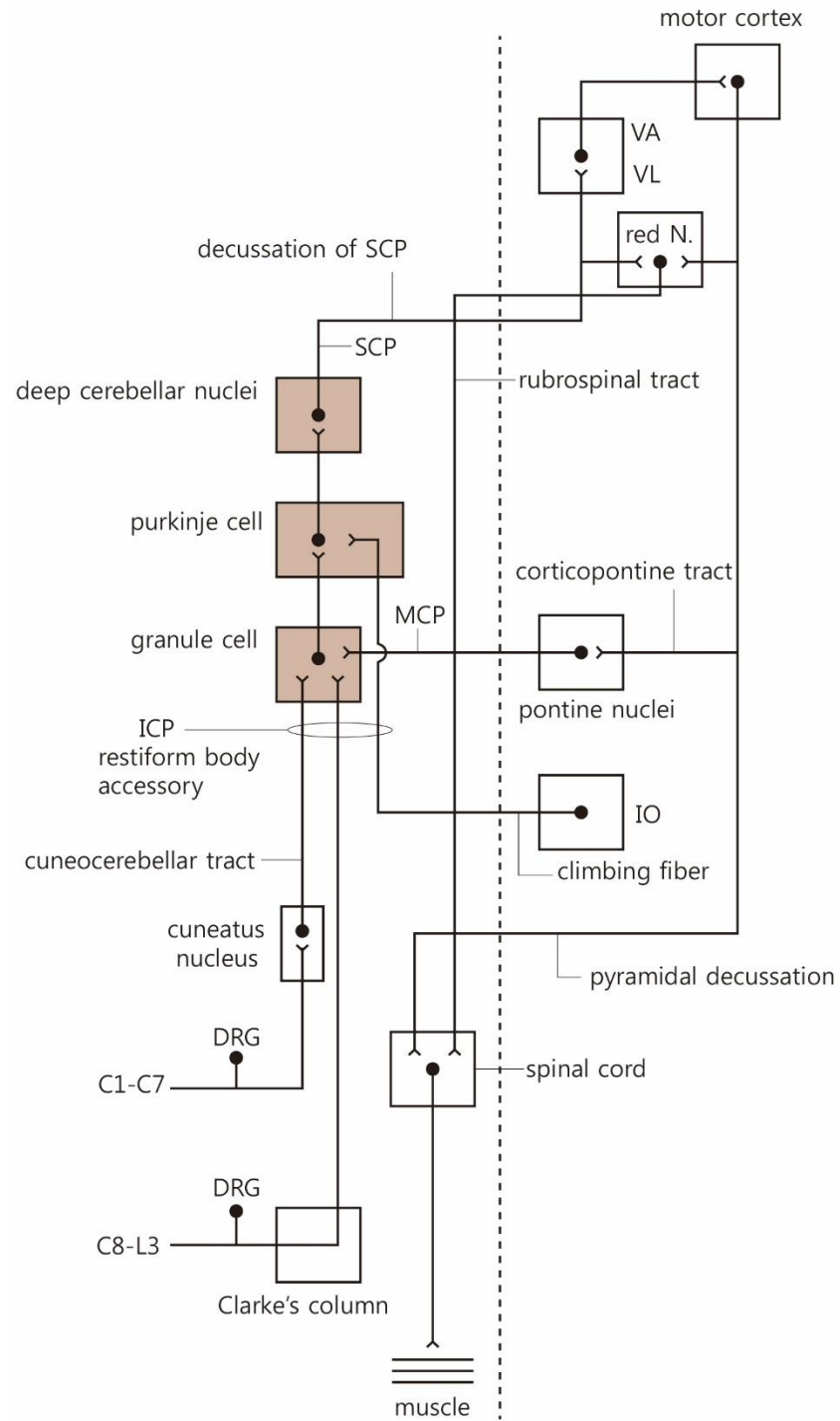
vestibular tract

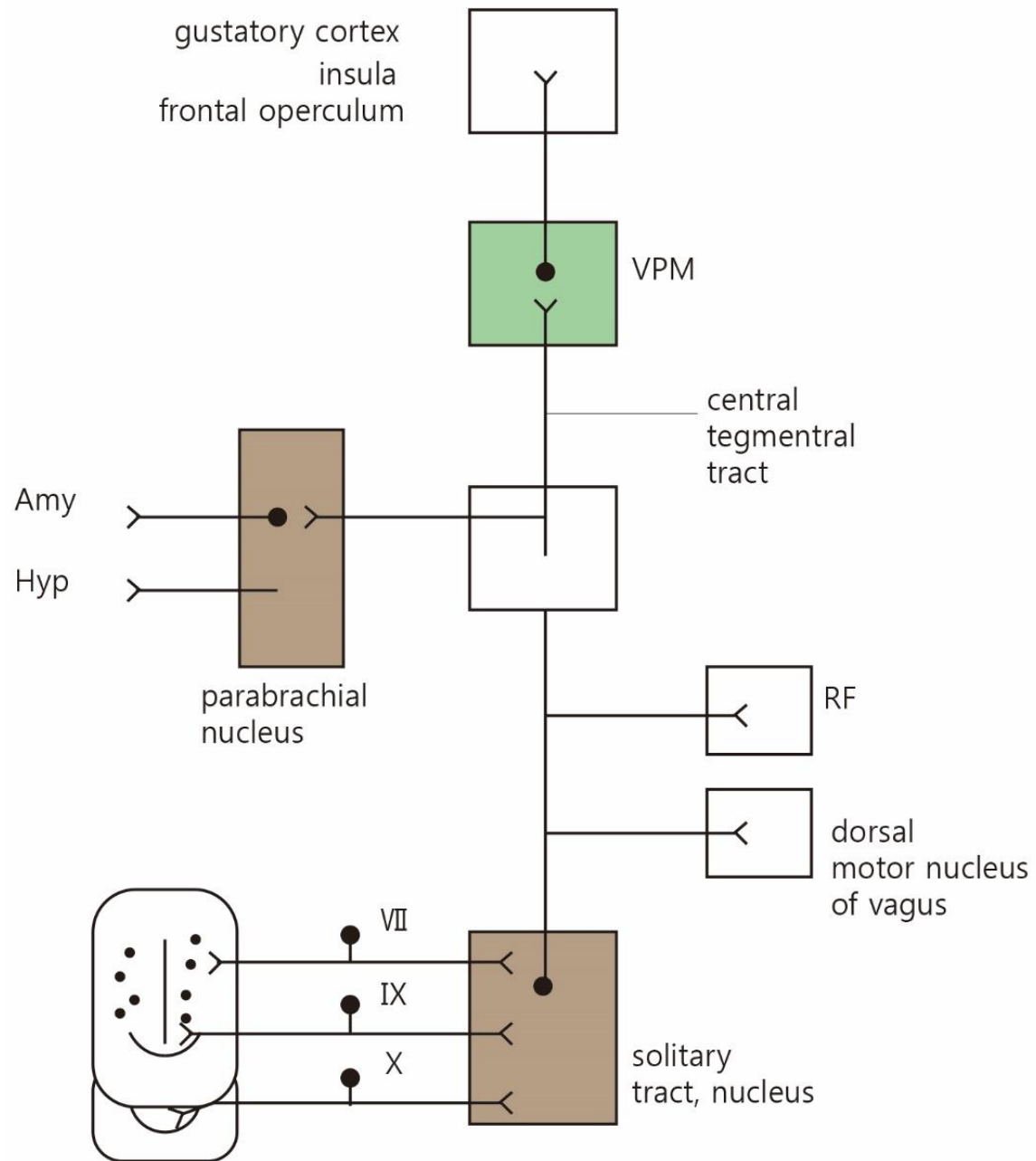


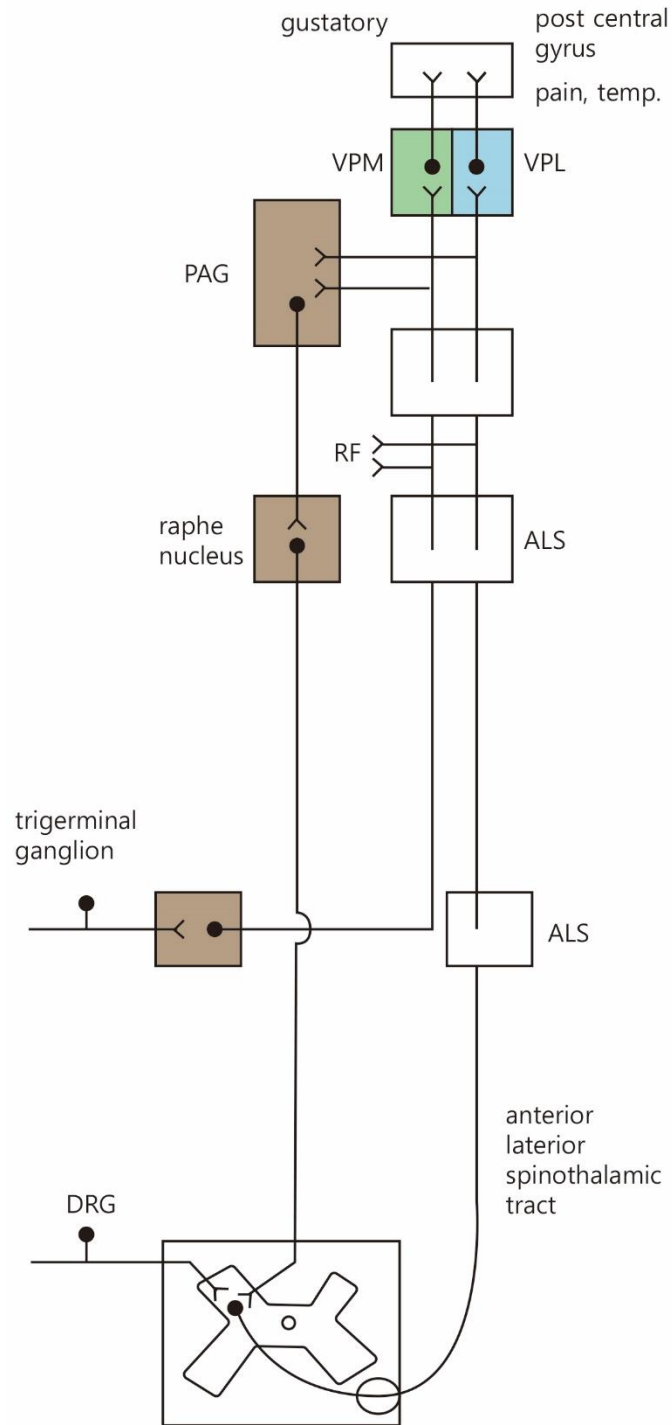
auditory pathway

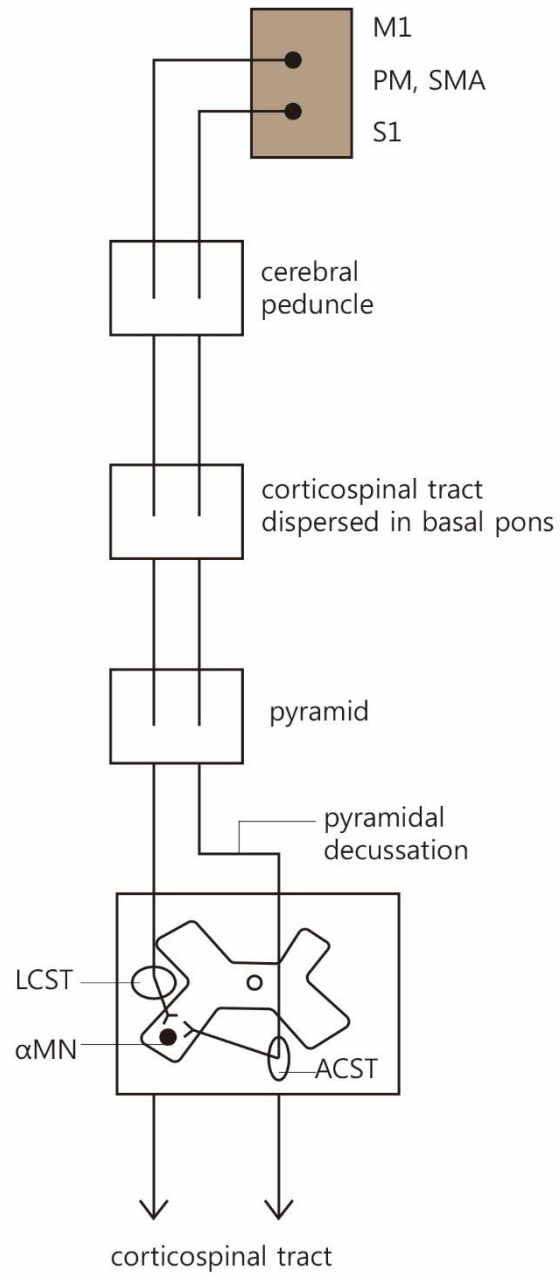


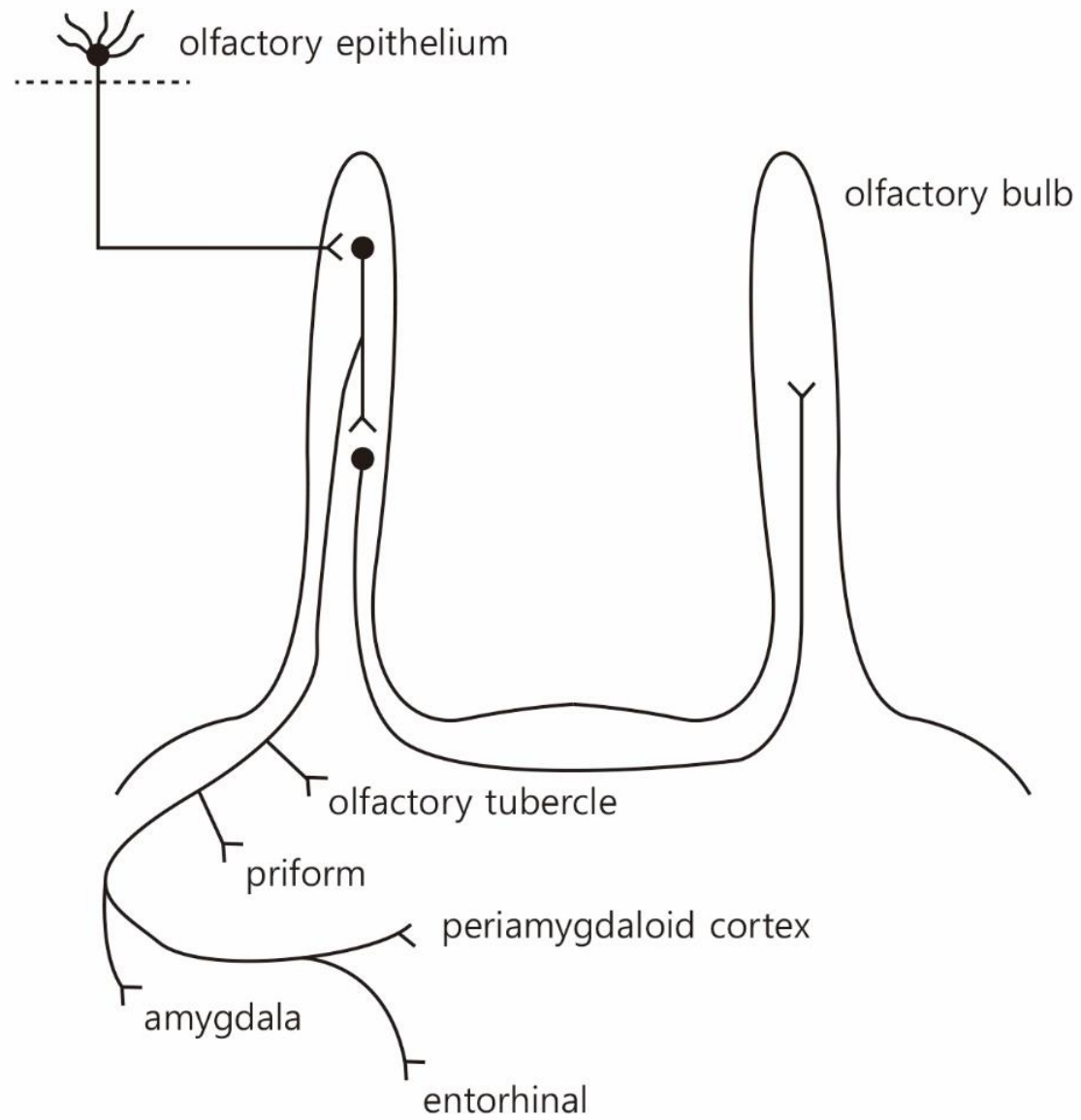
vestibular tract

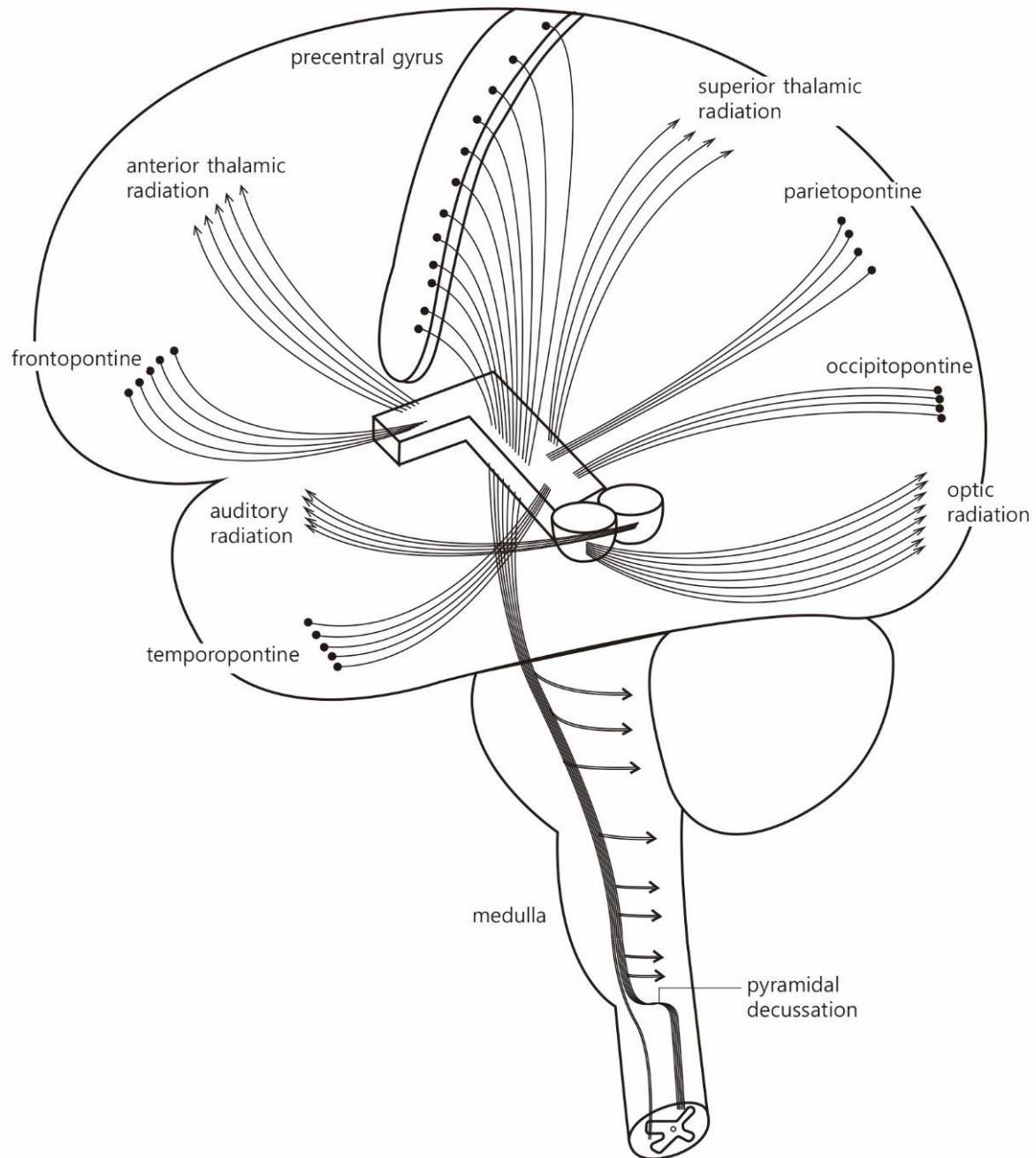












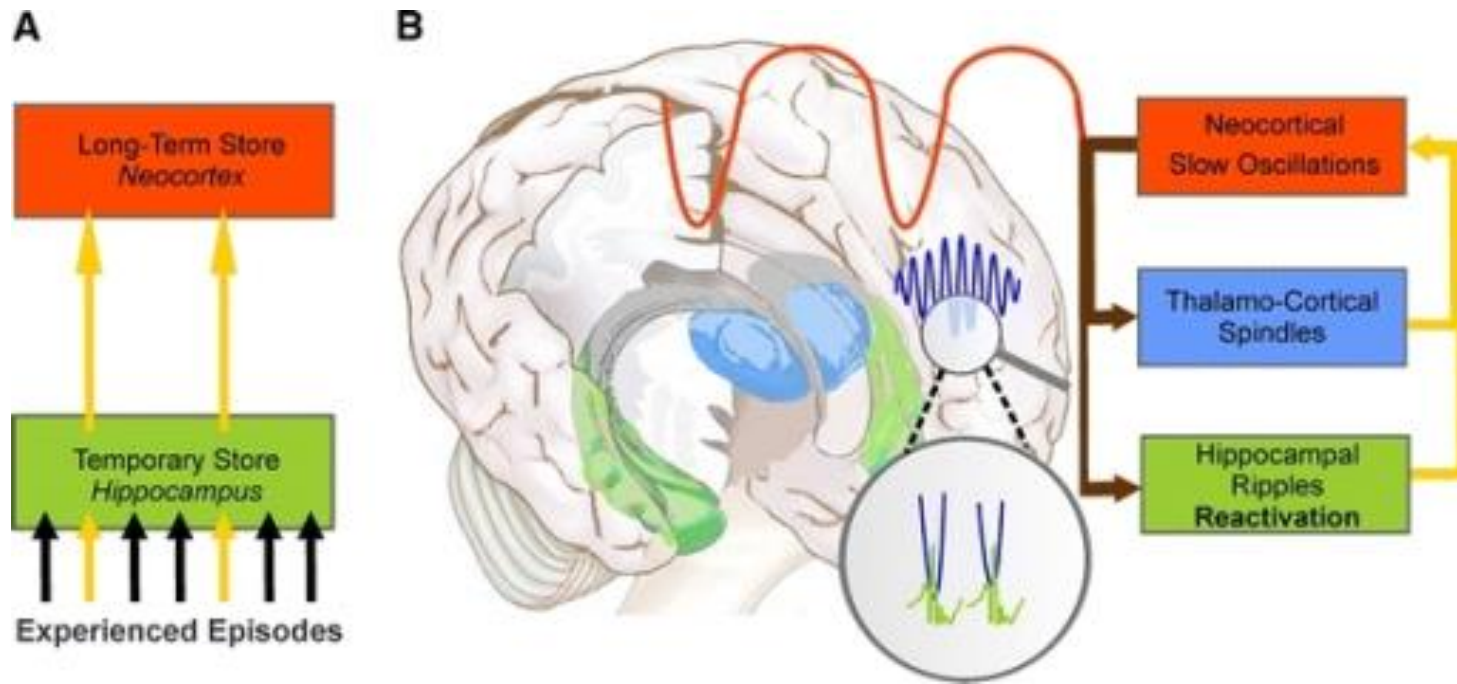


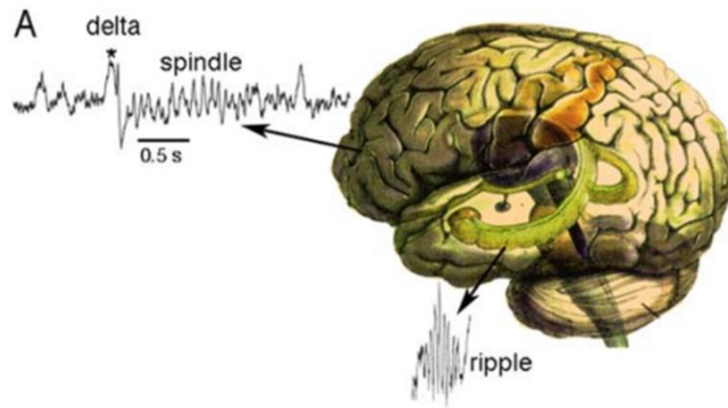
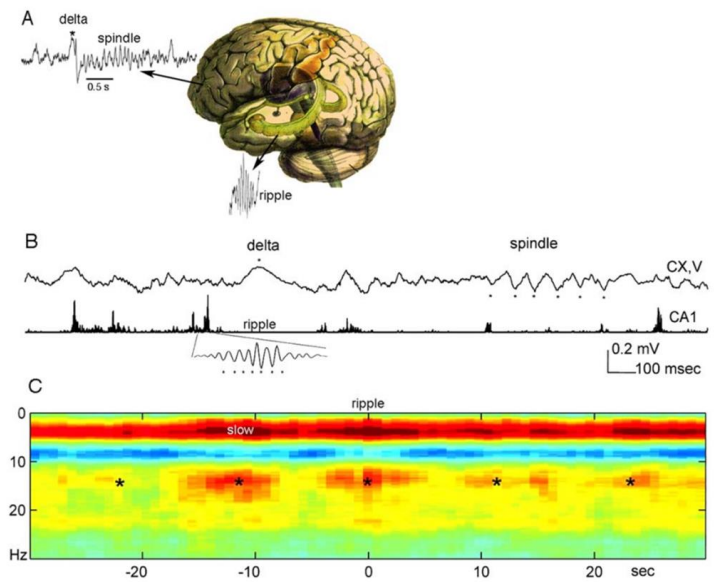
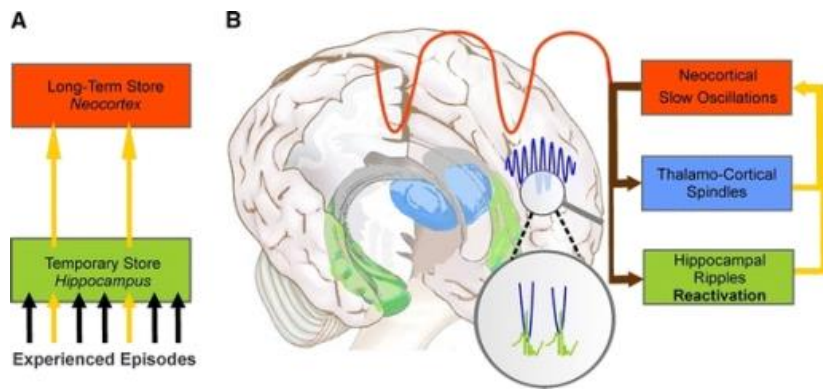
Fig1: Active system consolidation during sleep.

a During slow-wave sleep (SWS) memories newly encoded into a temporary store (i.e. the hippocampus in the declarative memory system) are reactivated to be redistributed to the long-term store (i.e. the neocortex).

b System consolidation during SWS relies on a dialogue between neocortex and hippocampus under top-down control by the neocortical slow oscillations (red).

The depolarizing up phases of the slow oscillations drive the repeated reactivation of hippocampal memory representations together with sharp-wave ripples (green) in the hippocampus and thalamo-cortical spindles (blue).

This synchronous drive allows for the formation of spindle-ripple events where sharp-wave ripples and associated reactivated memory information becomes nested into single troughs of a spindle (shown at larger scale); in the black-and-white version of the figure red, green and blue correspond to dark, middle and light grey



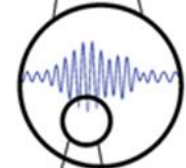
A

SWS

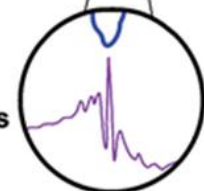
**Neocortical
slow oscillations**

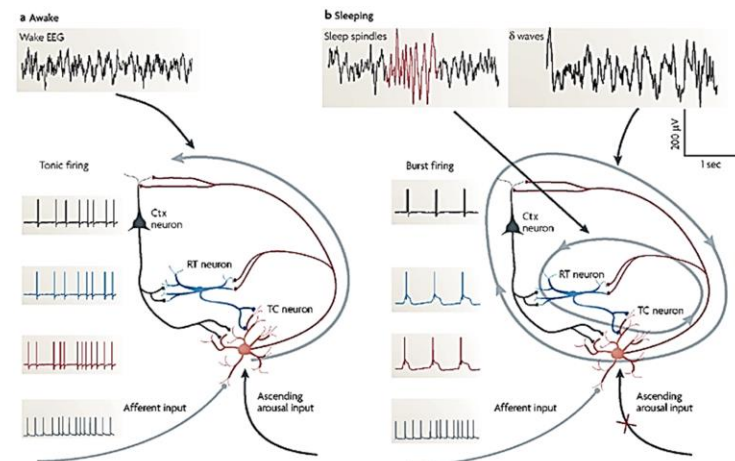
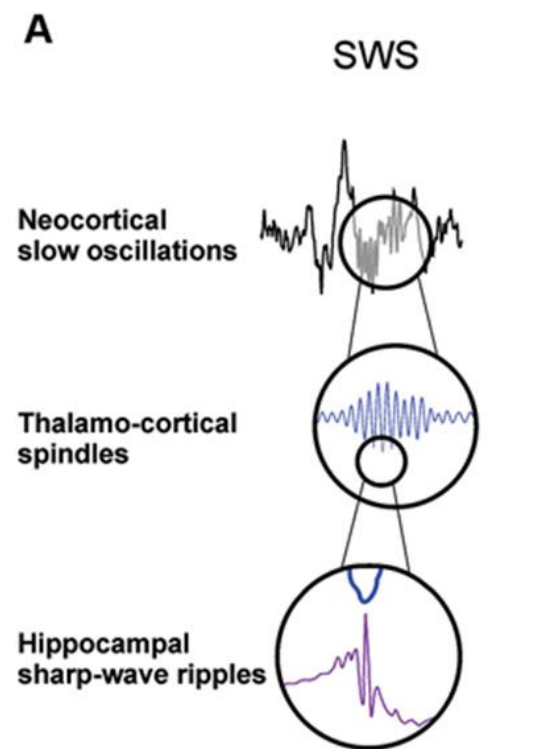
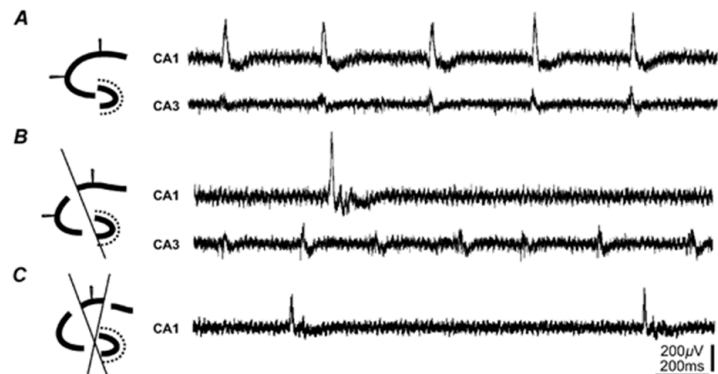
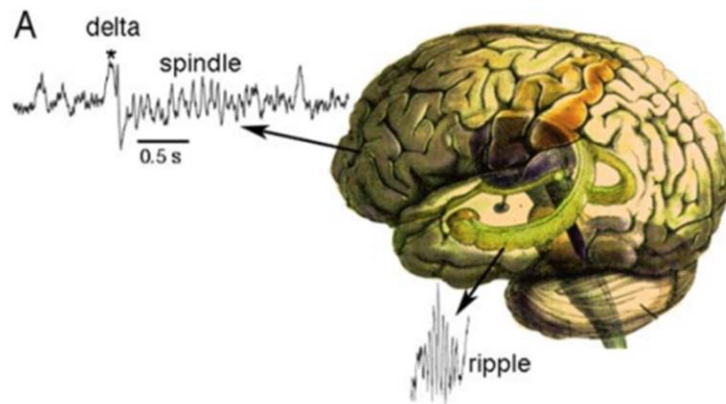
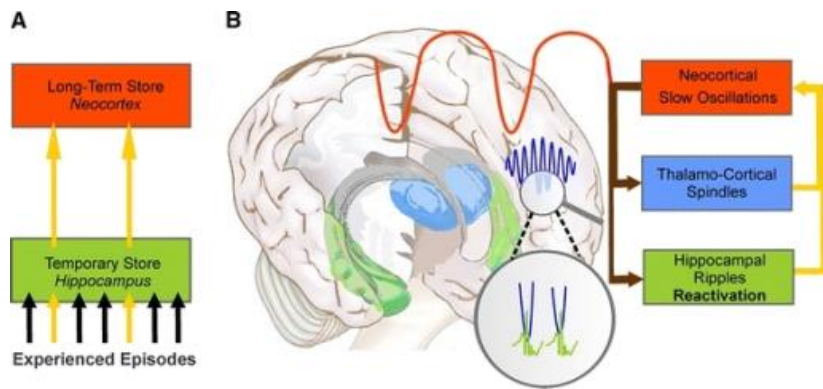


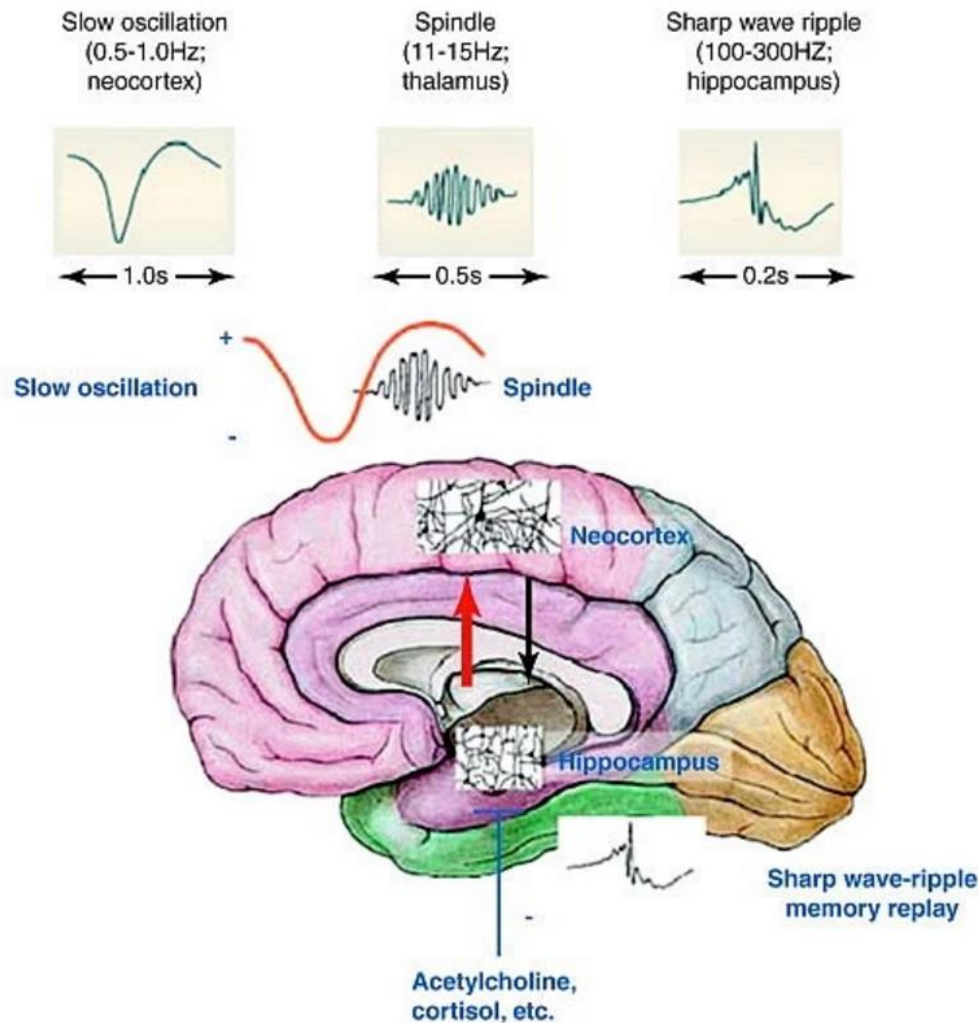
**Thalamo-cortical
spindles**



**Hippocampal
sharp-wave ripples**

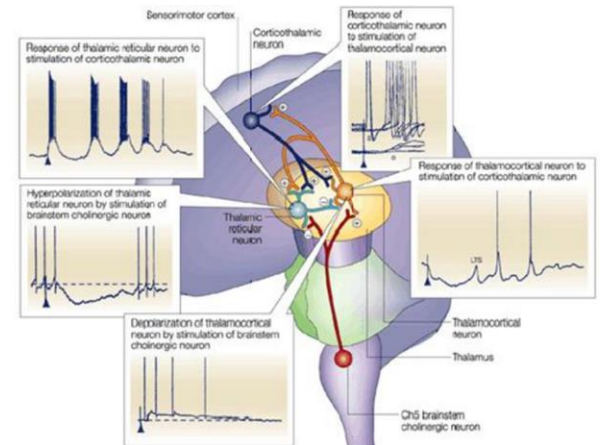






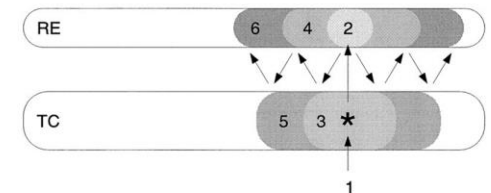
TRENDS in Cognitive Sciences

Fig. 57. Thalamo-cortical loops implicated in coherent NREM sleep oscillations

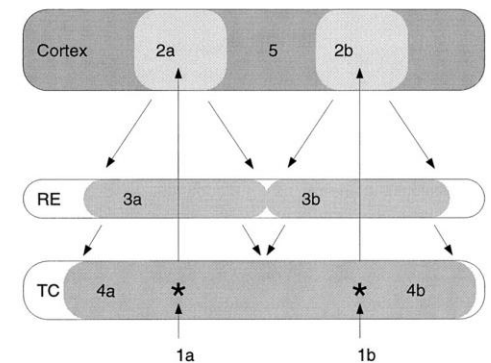


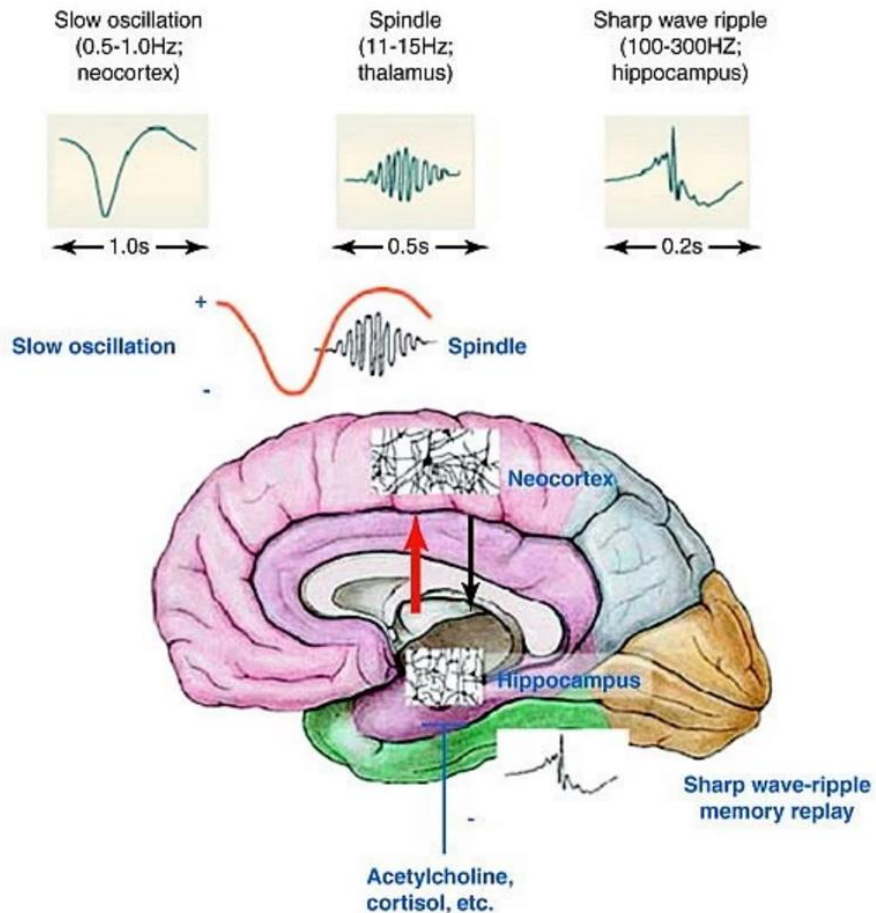
The thalamocortical machinery implicated in NREM oscillations and their control by brainstem cholinergic neurons. Note peribrachial stimulation hyperpolarizes thalamic reticular neurons and depolarizes thalamic relay neurons (Steriade, cartoon: Hobson and Pace-Schott, 2002).

A Isolated thalamus

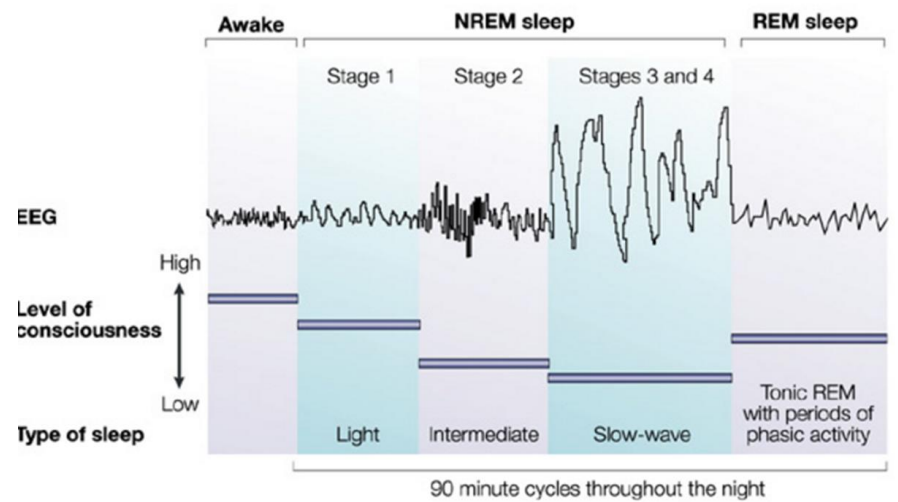


B Thalamocortical system

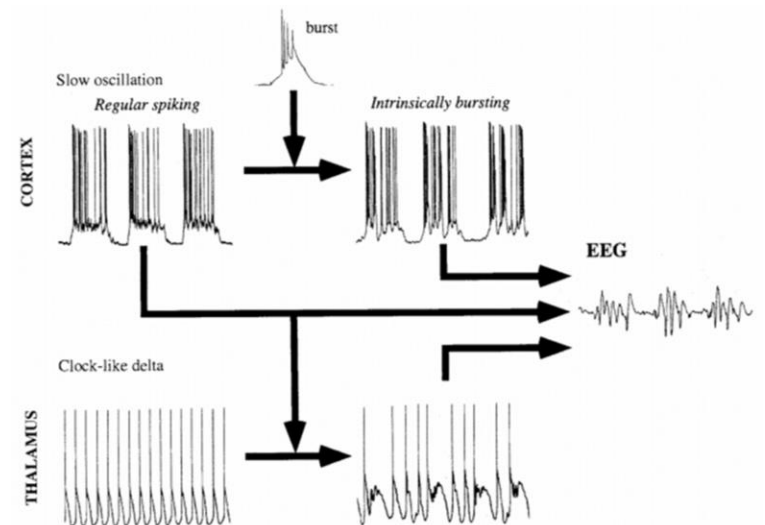


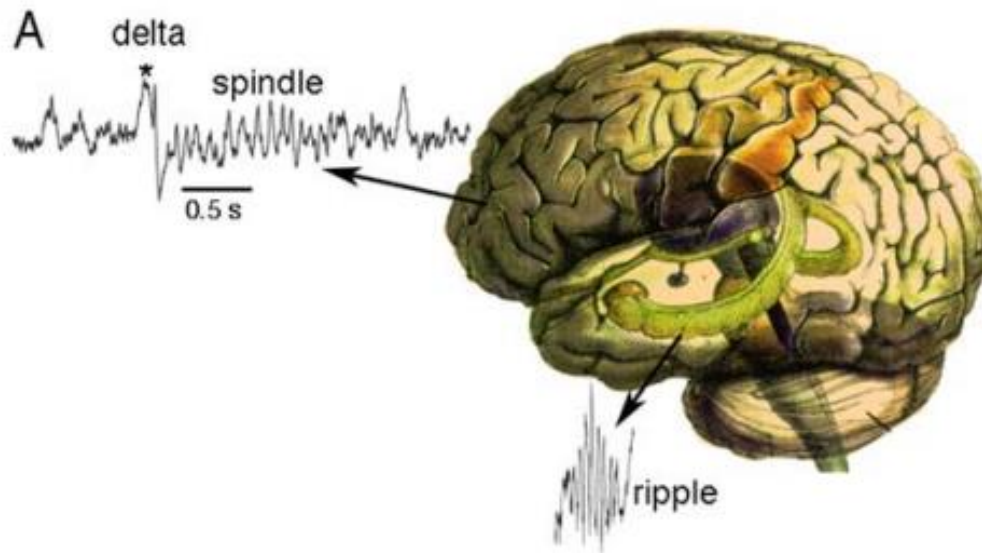


TRENDS in Cognitive Sciences



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Slow oscillation
(0.5-1.0Hz;
neocortex)



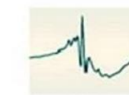
1.0s

Spindle
(11-15Hz;
thalamus)

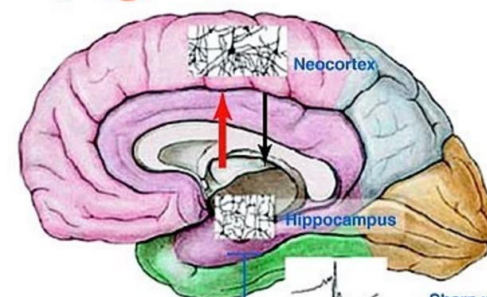


0.5s

Sharp wave ripple
(100-300Hz;
hippocampus)



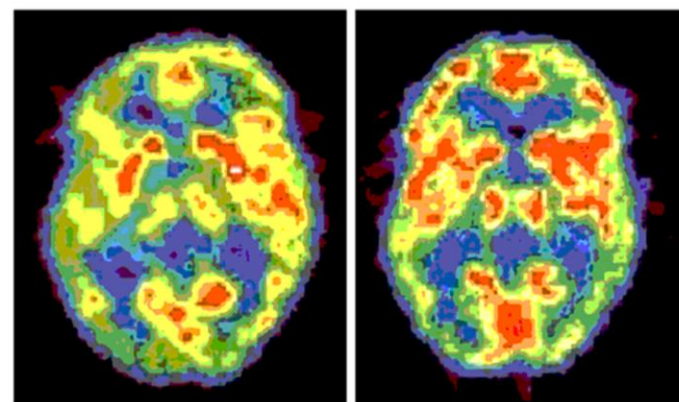
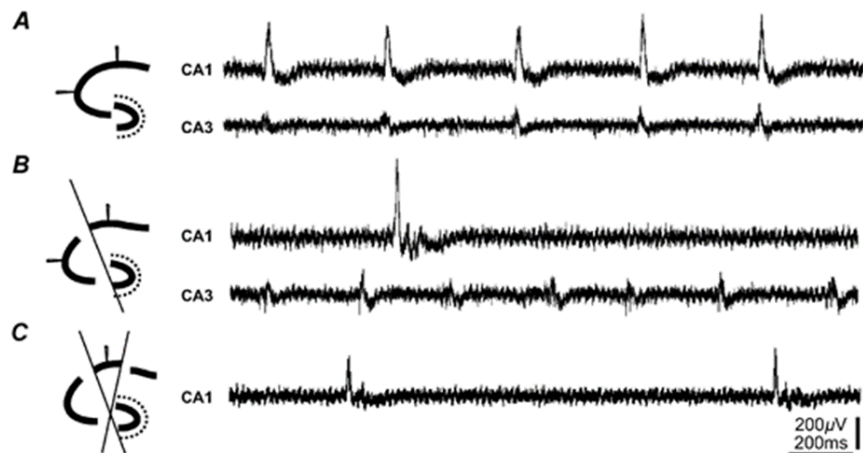
0.2s



Sharp wave-ripple
memory replay

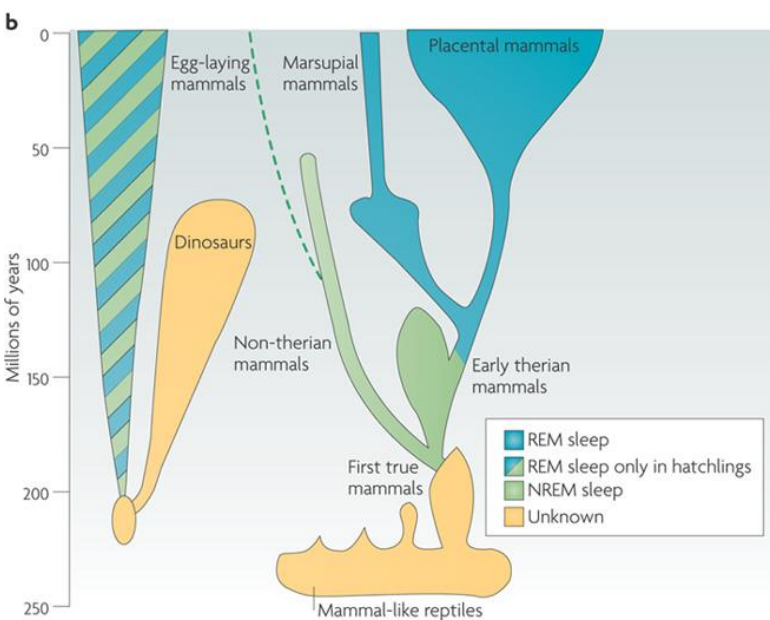
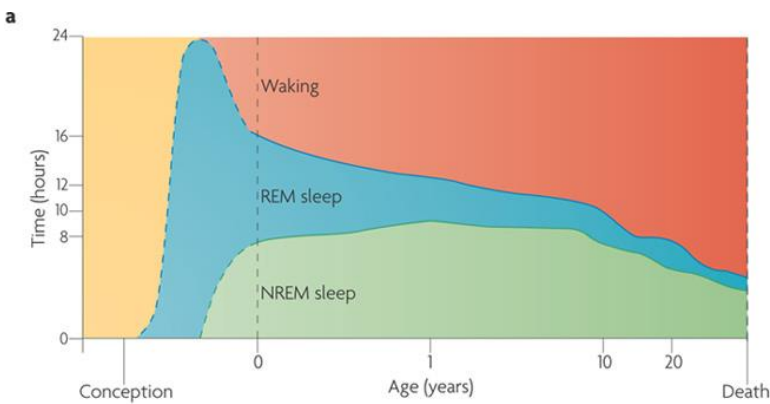
Acetylcholine,
cortisol, etc.

TRENDS in Cognitive Sciences

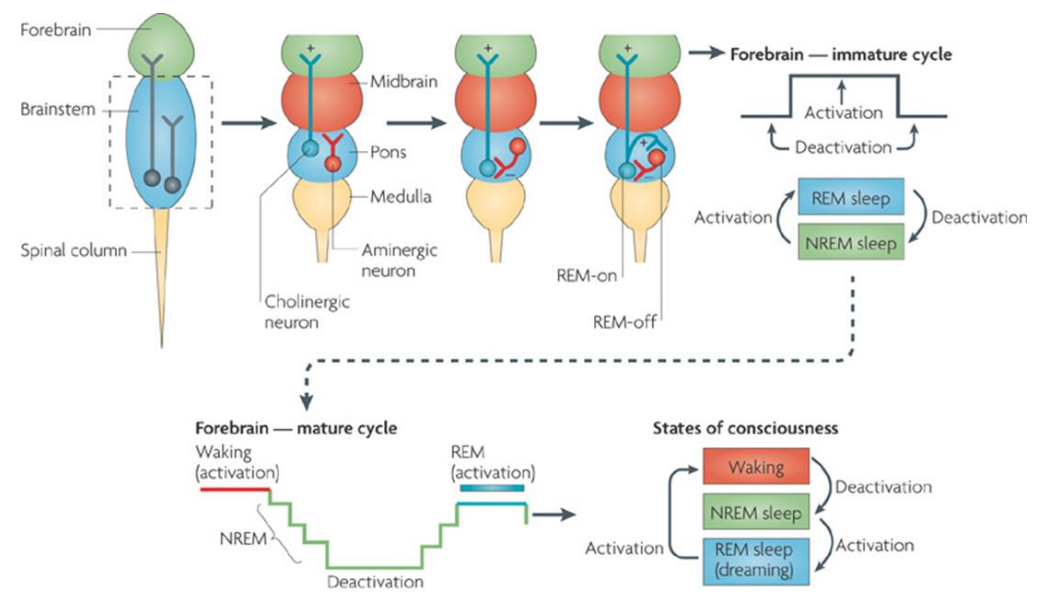


NREM

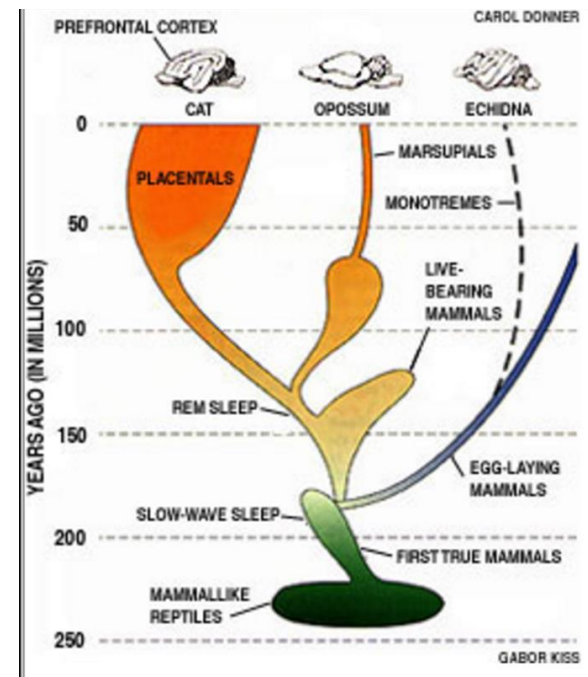
REM



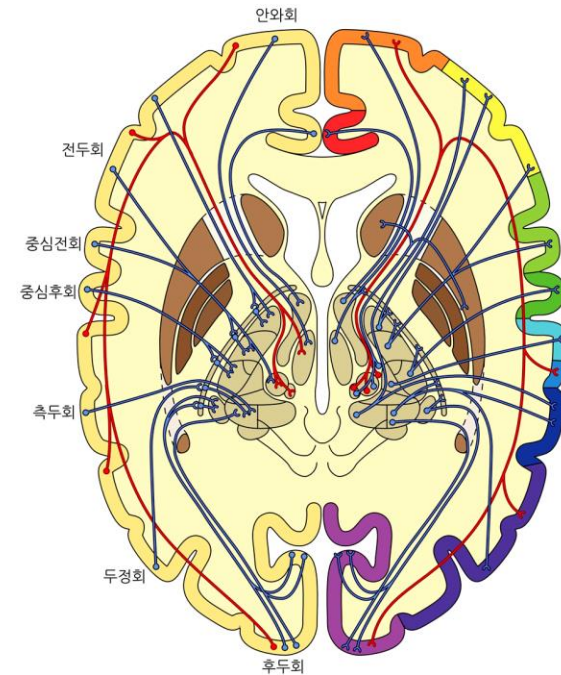
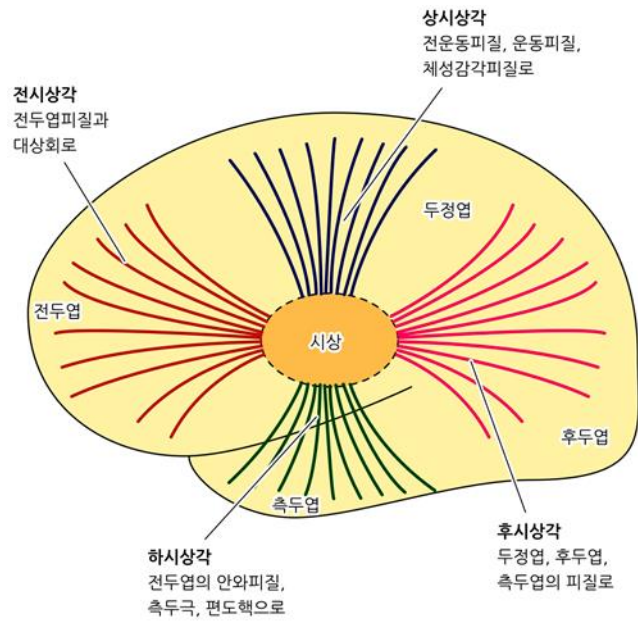
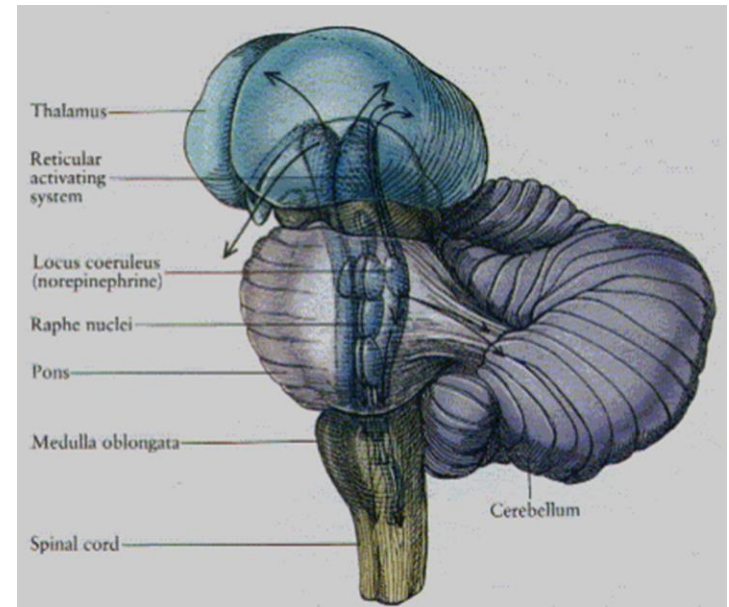
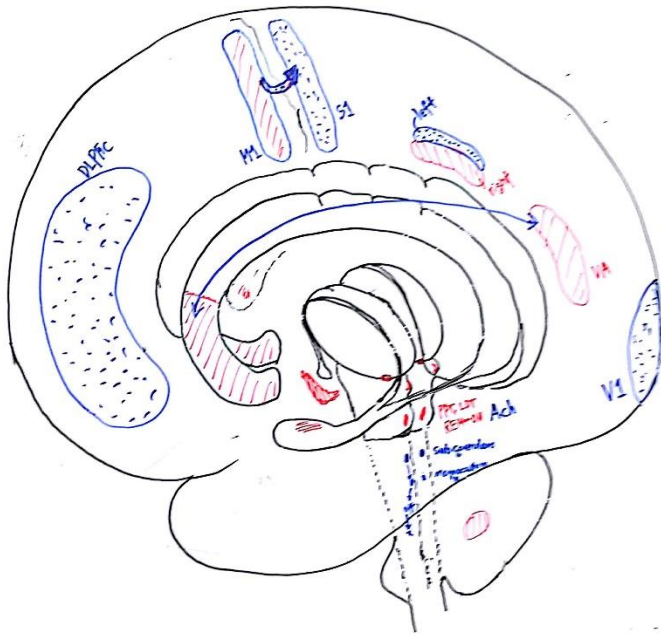
Nature Reviews | Neuroscience



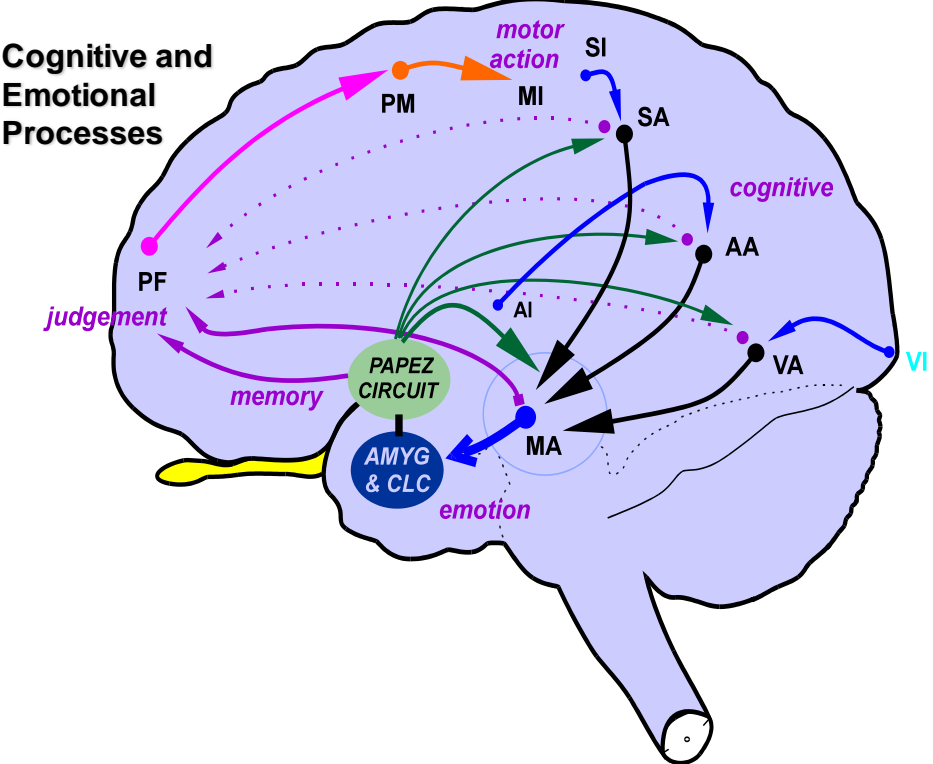
Nature Reviews | Neuroscience



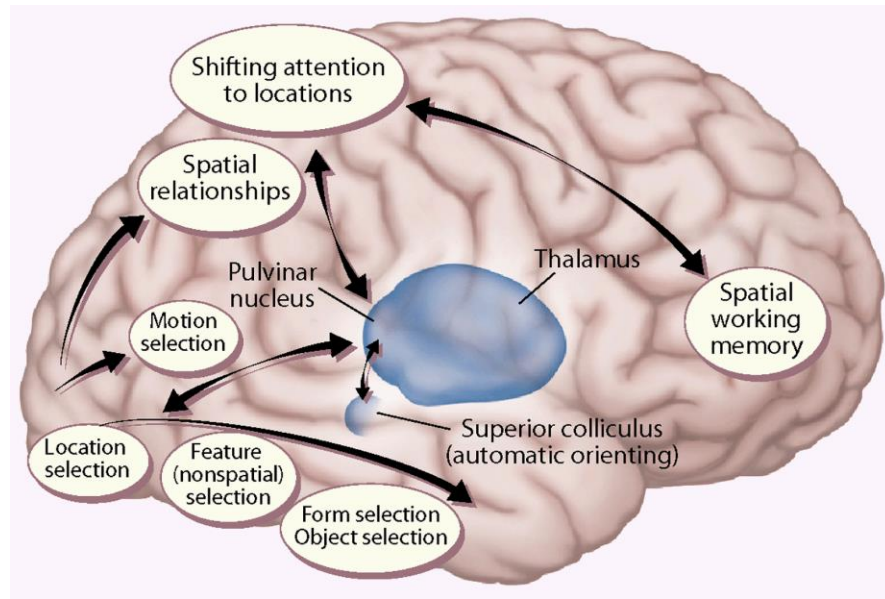
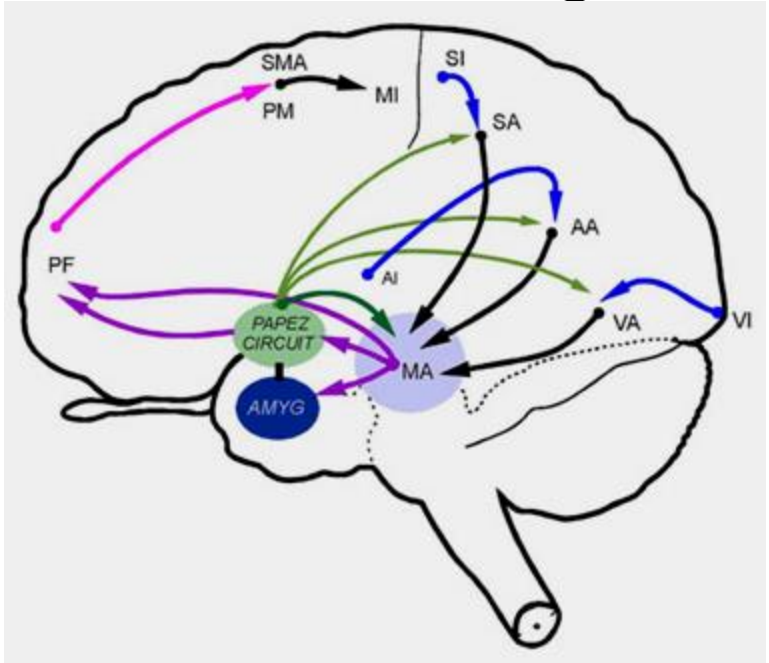
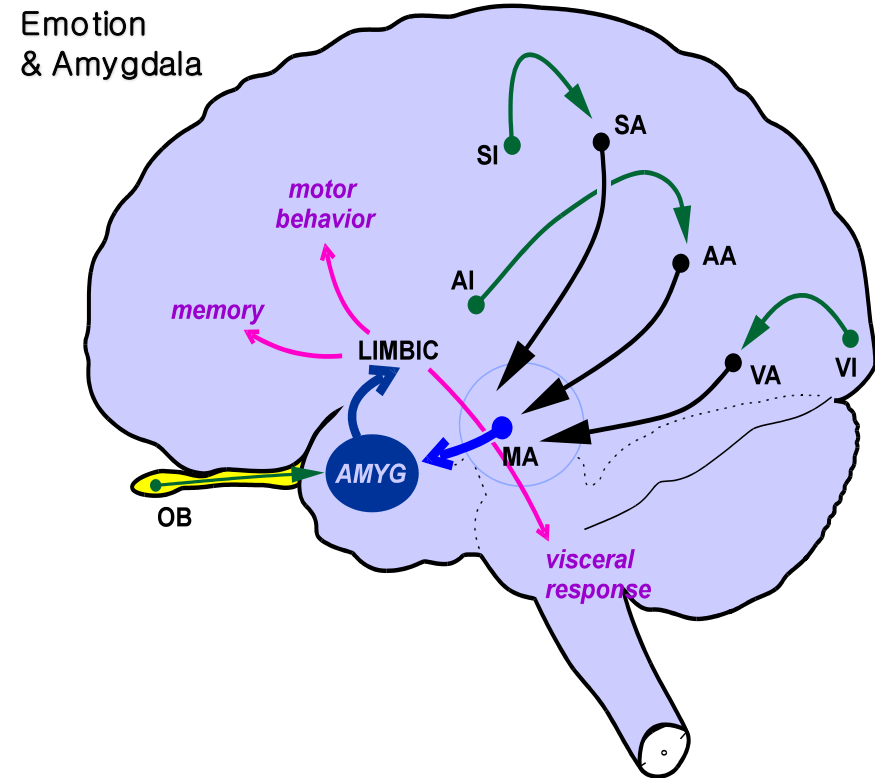
GABOR KISS

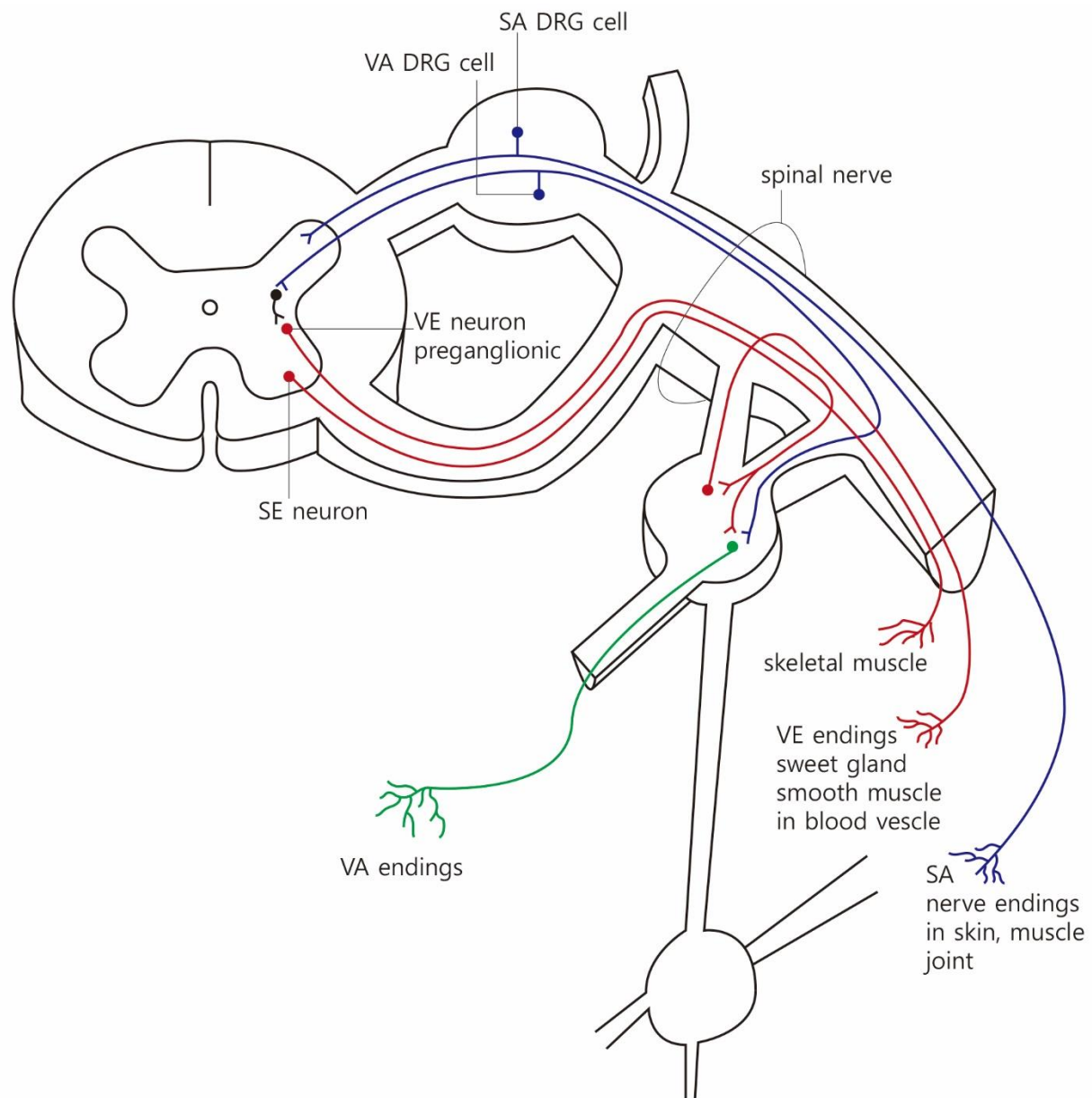


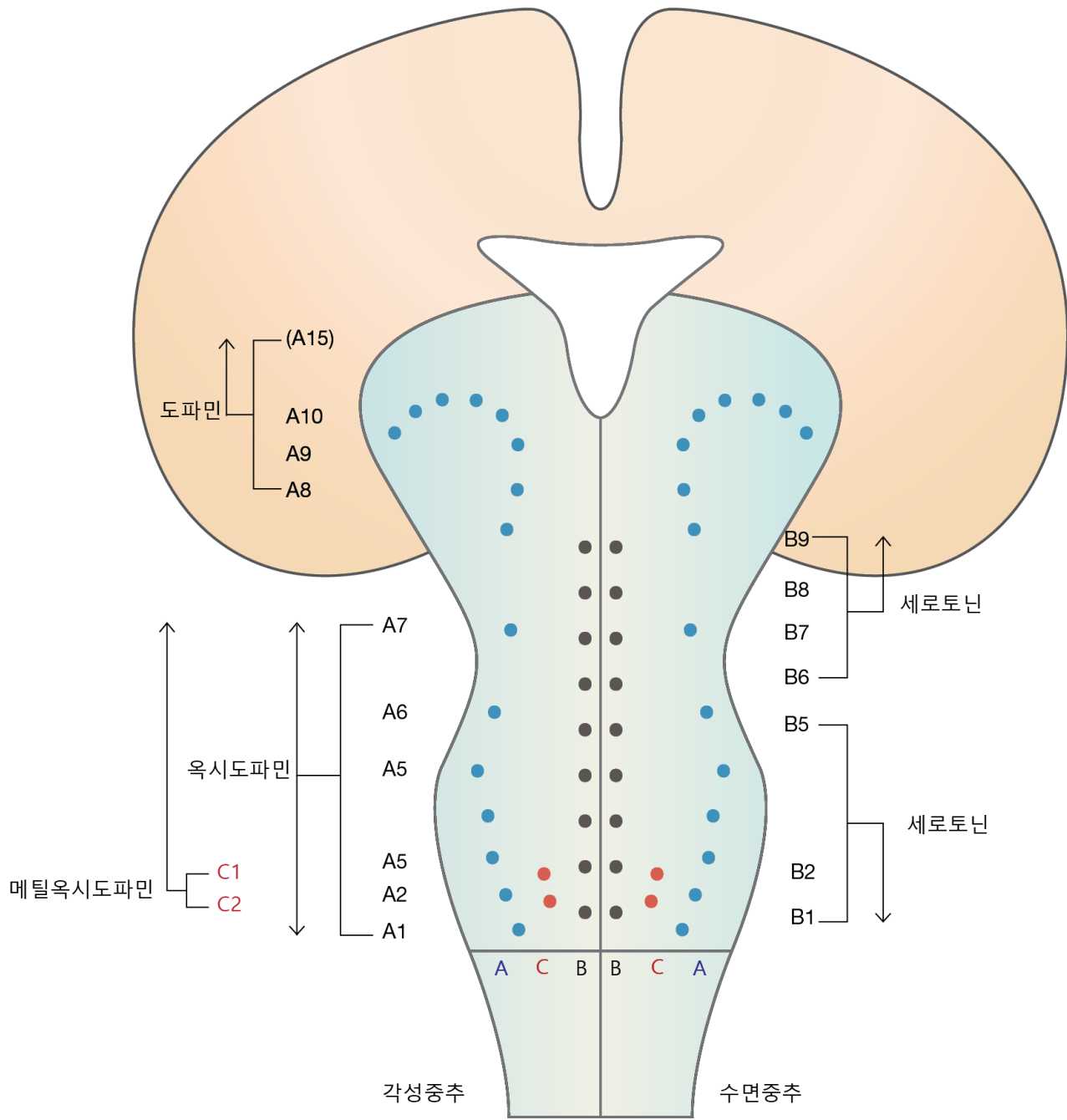
Cognitive and Emotional Processes

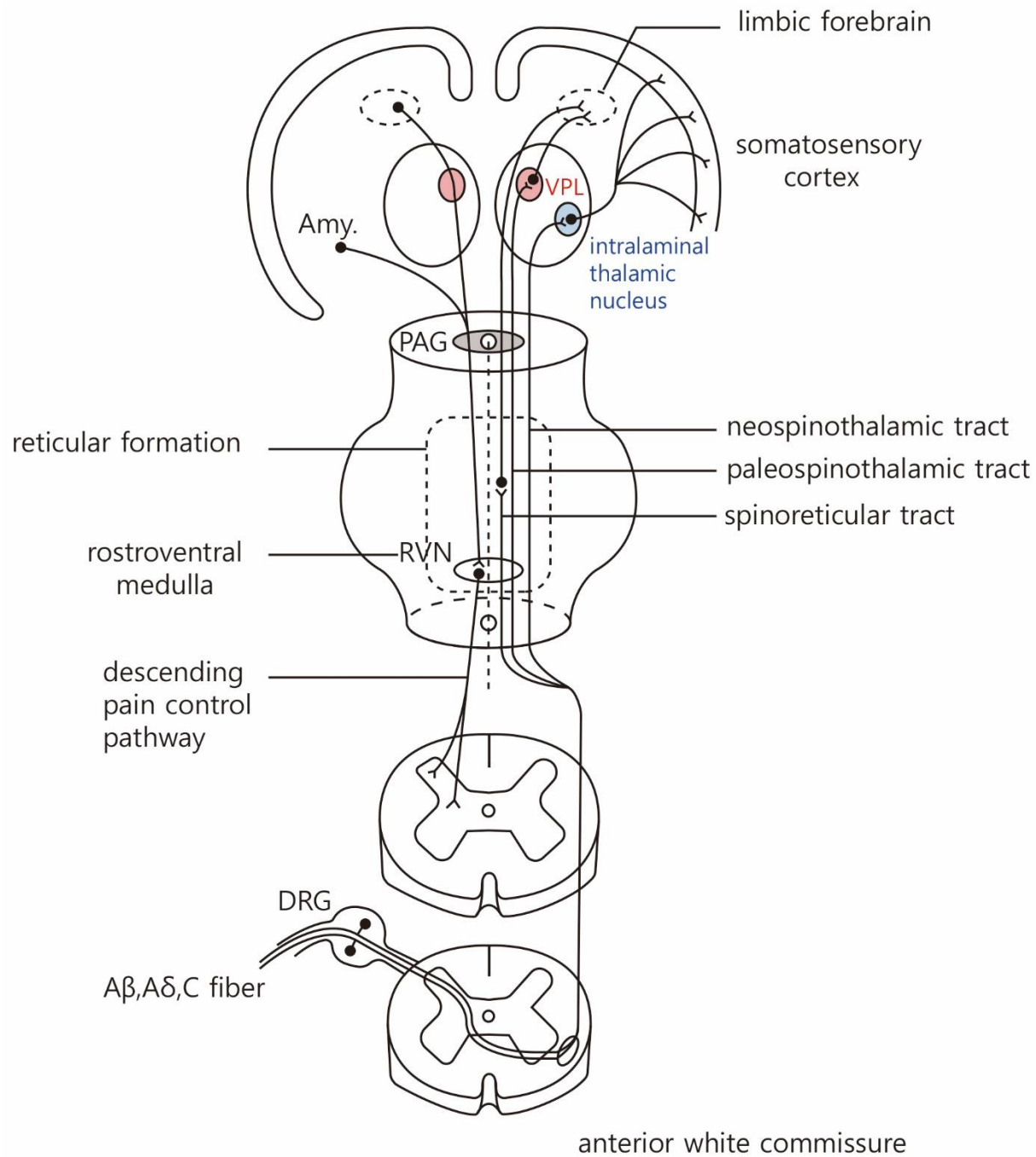


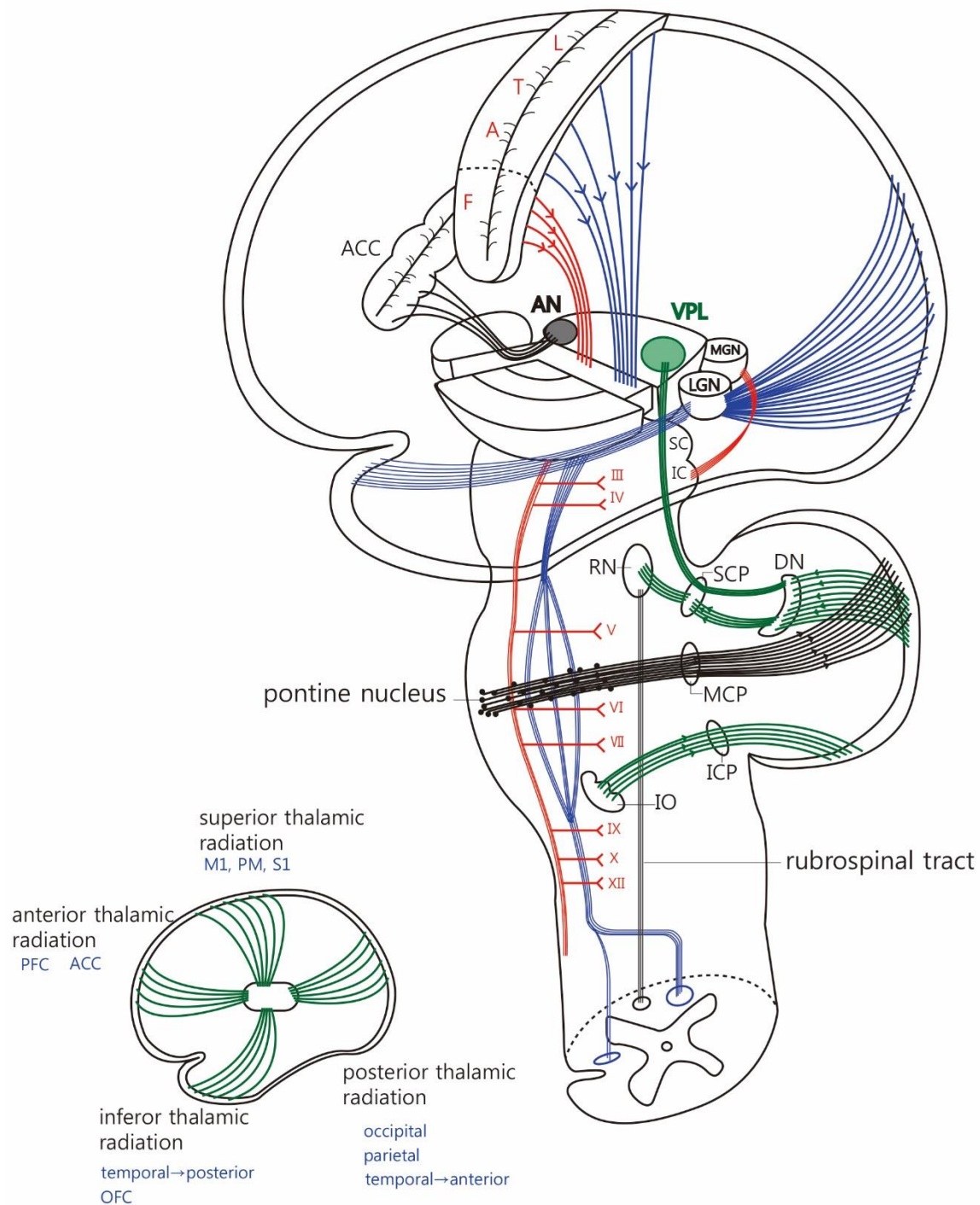
Emotion & Amygdala

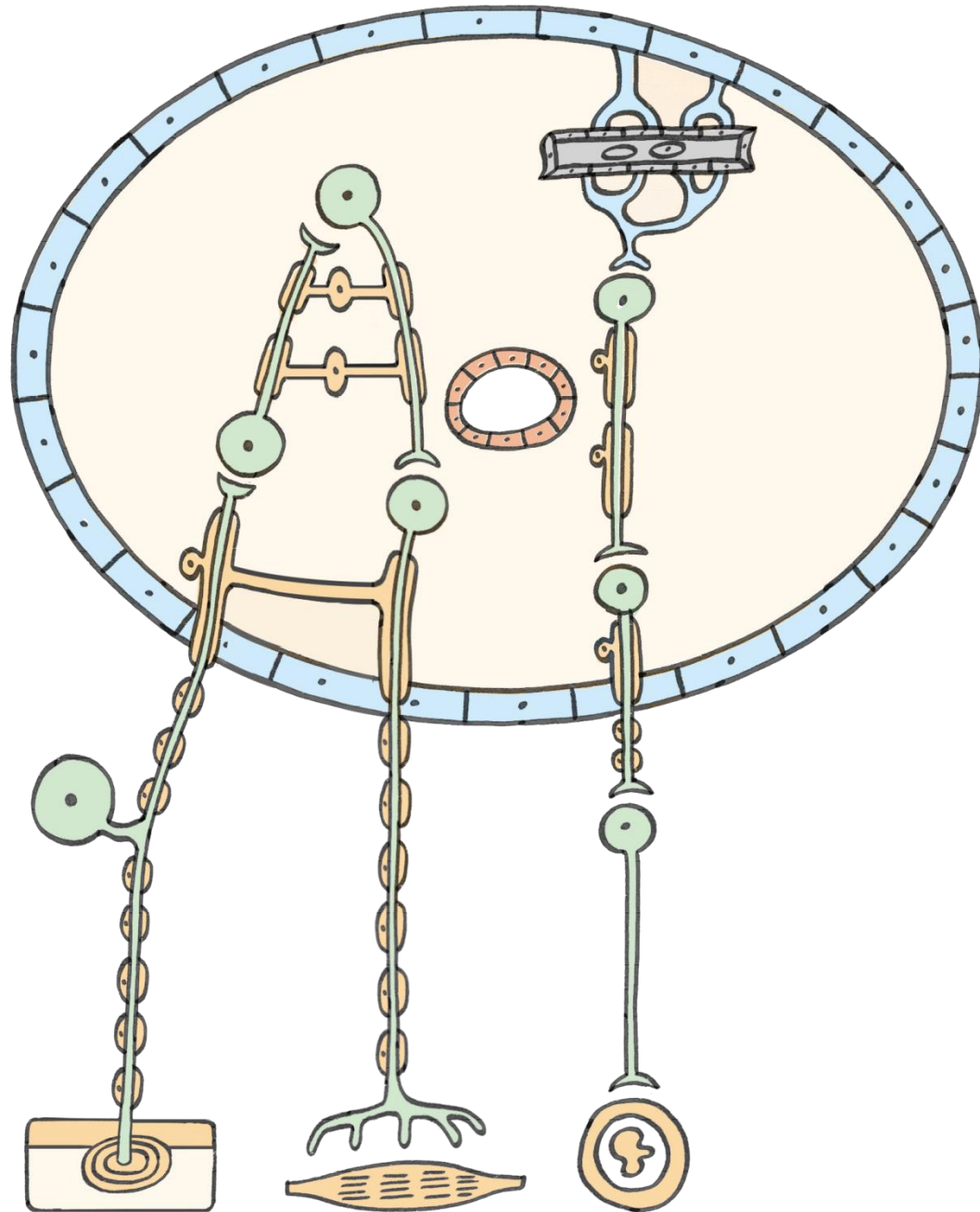


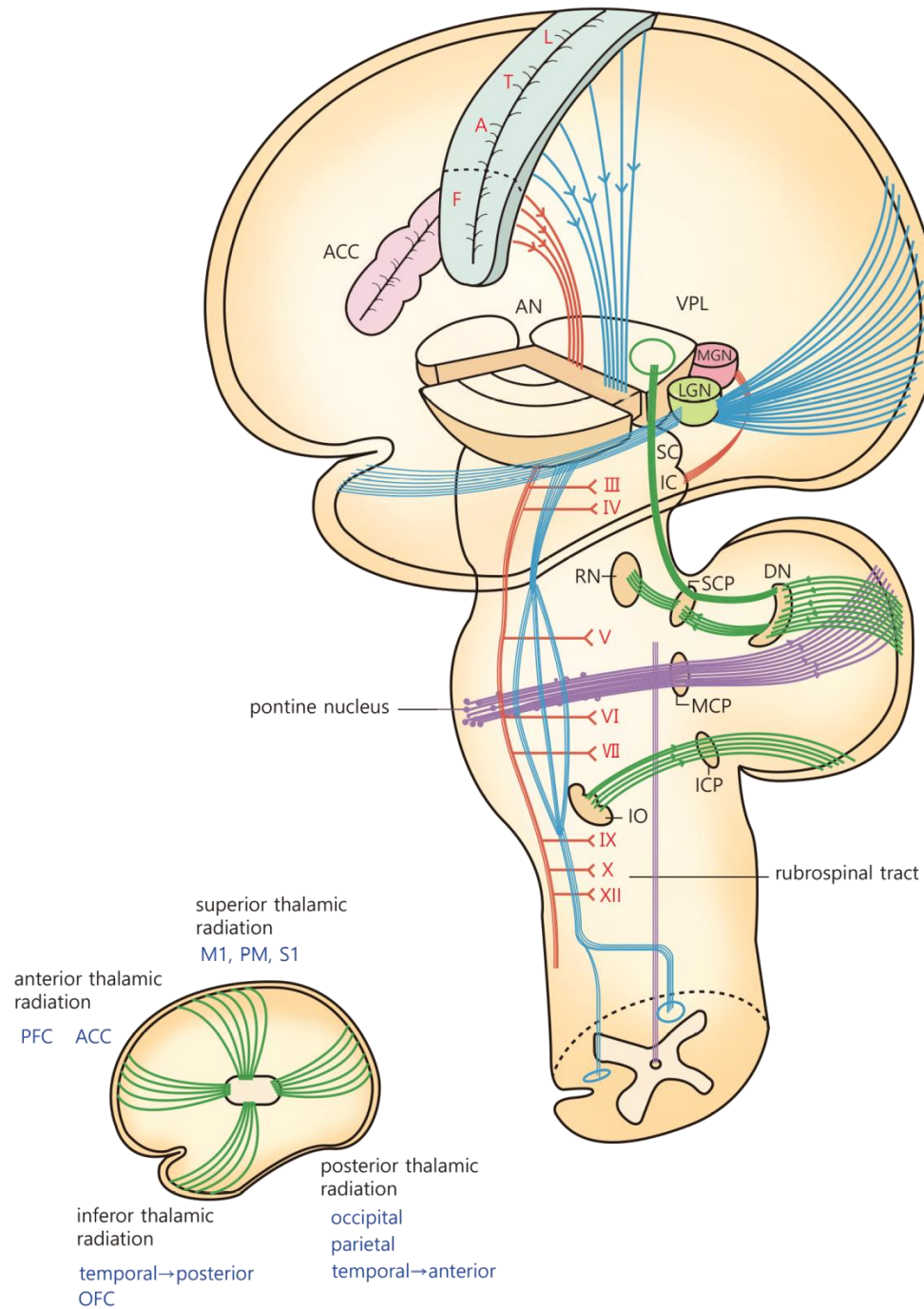


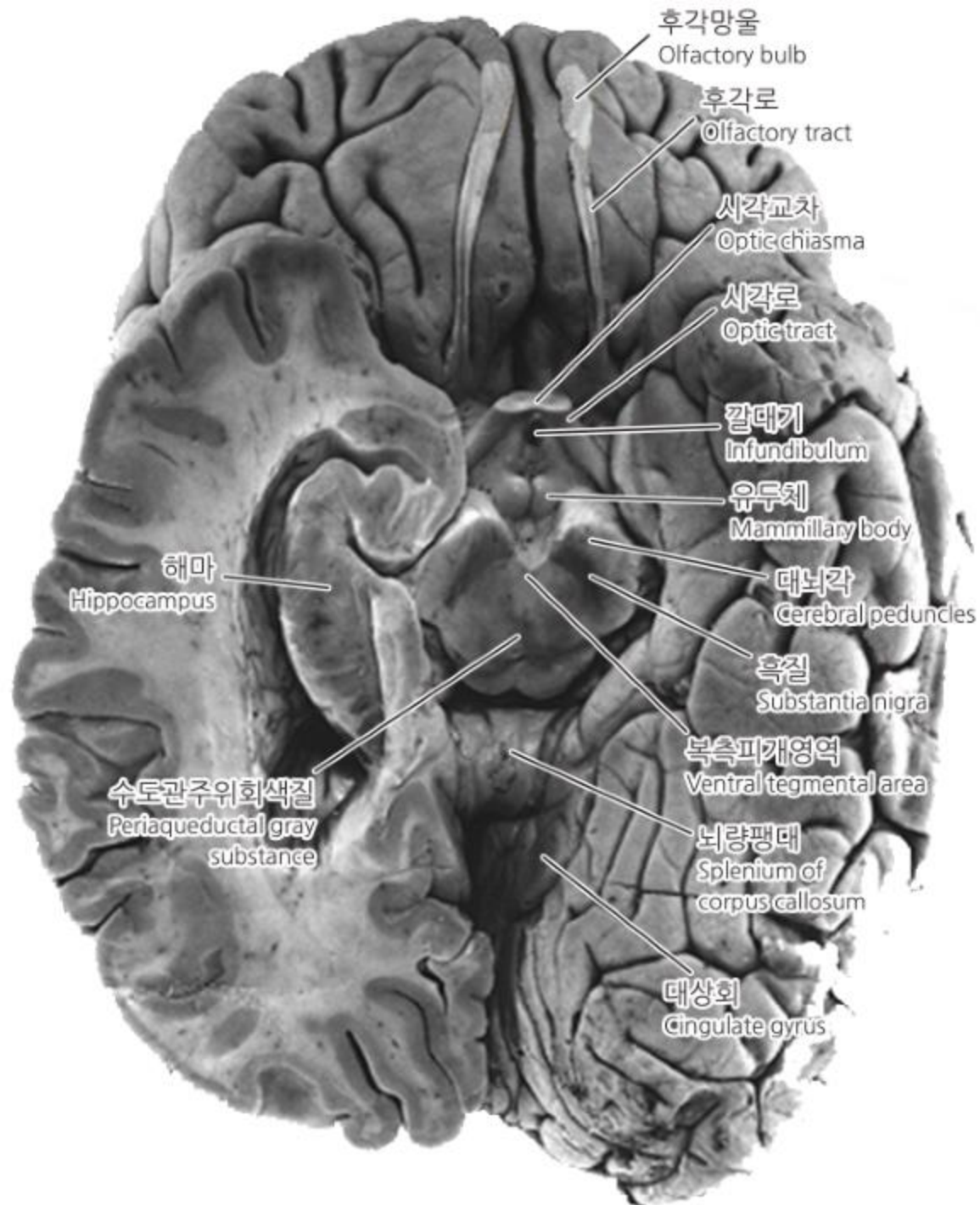




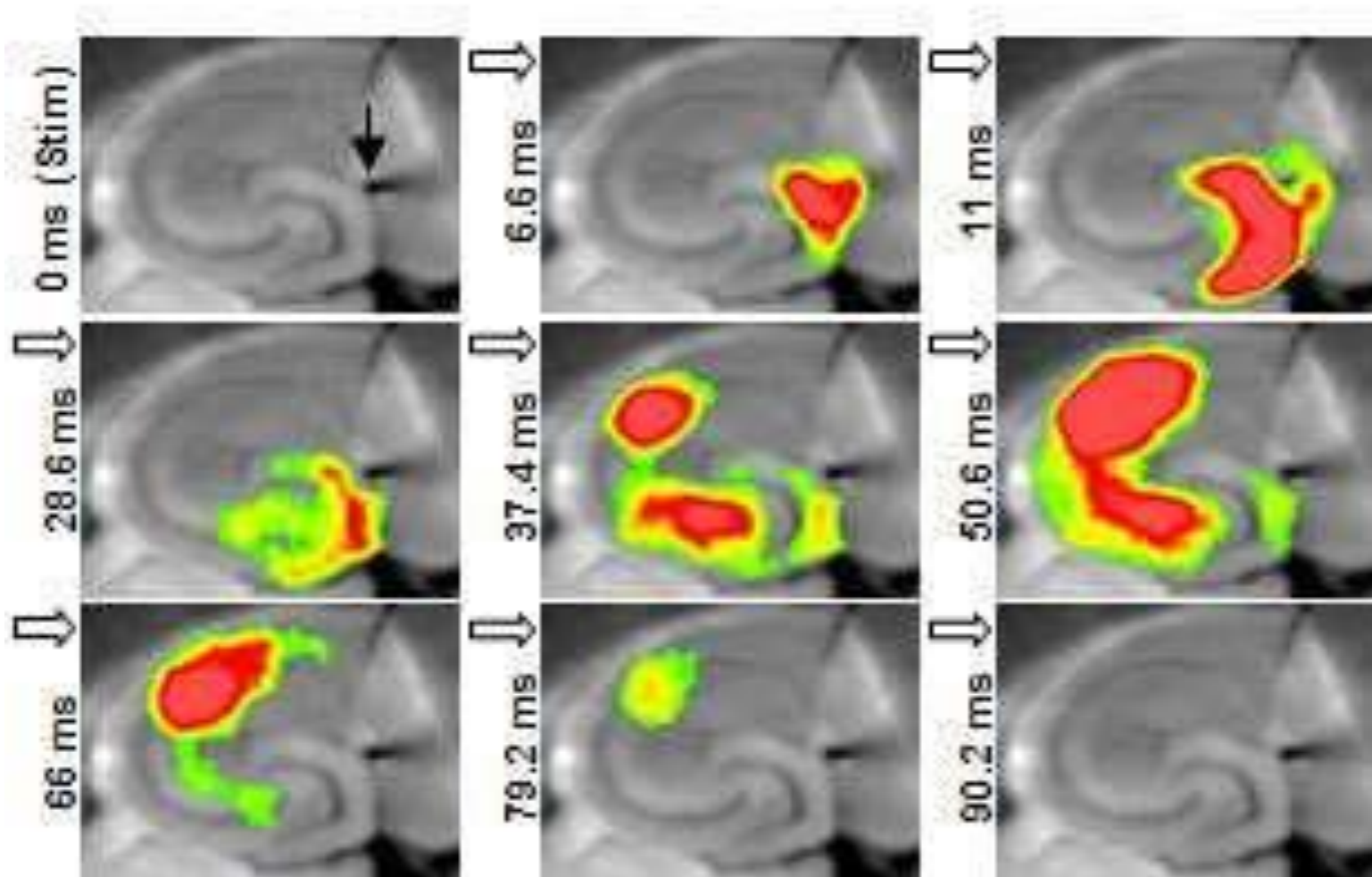






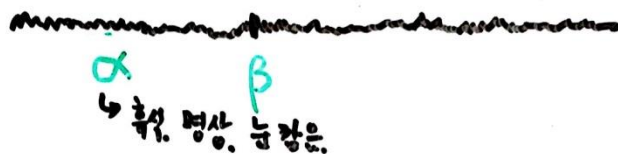






Filmstrip of an activity wave through the hippocampus. The activity wave is triggered by stimulating the input region with a microelectrode (black arrow) and recorded using voltage-sensitive dyes. Warmer colors represent stronger neuronal activity. Credit: MPI of Psychiatry

각성



SWS ①



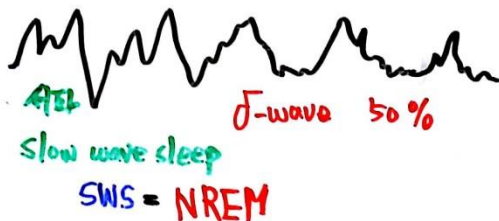
②



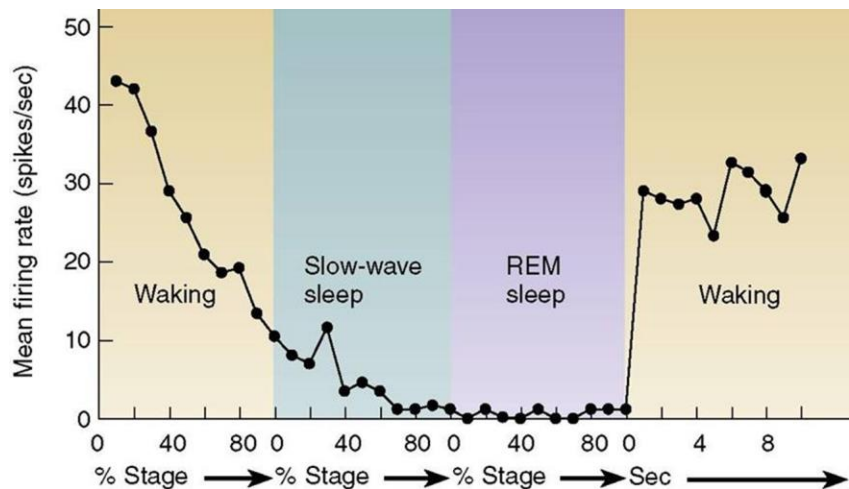
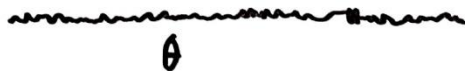
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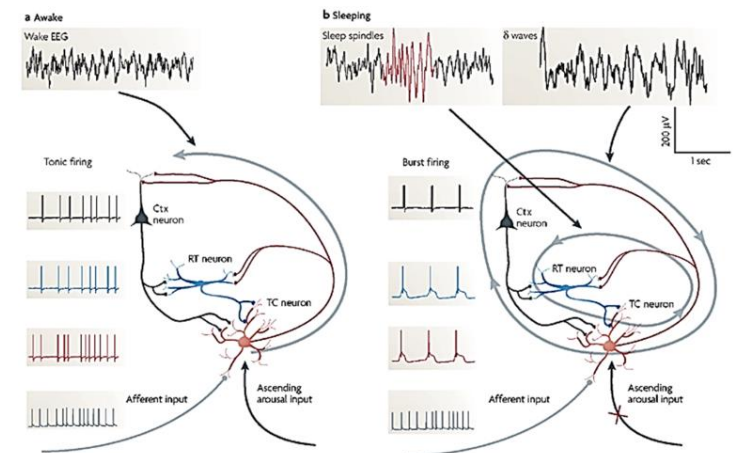
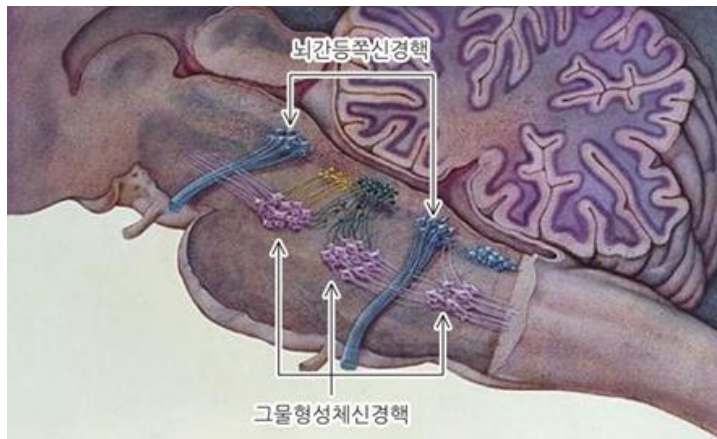
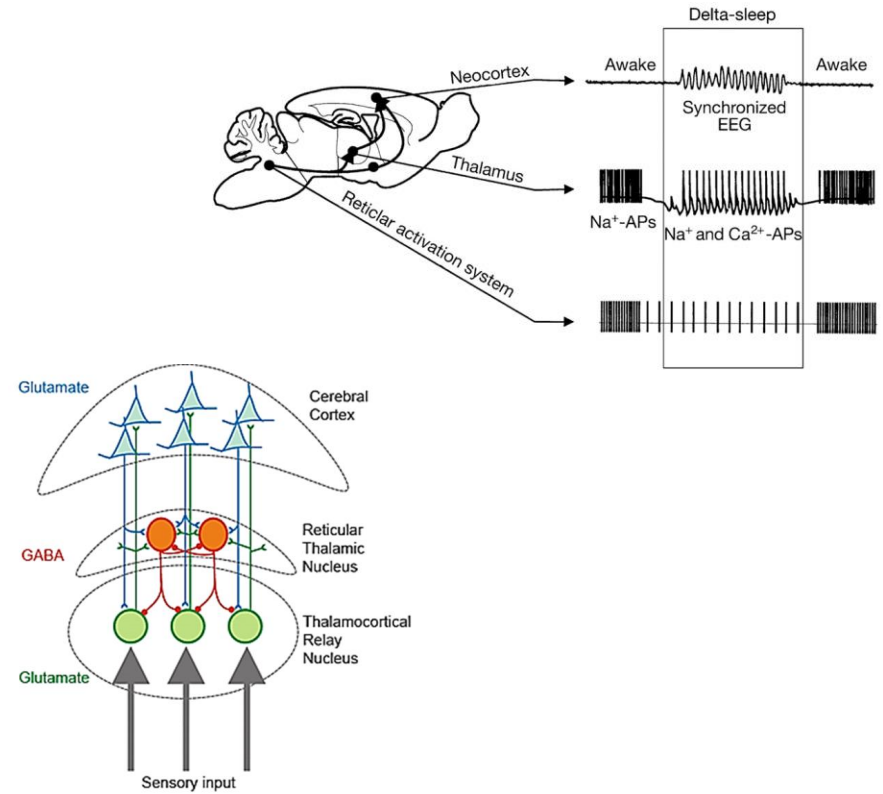
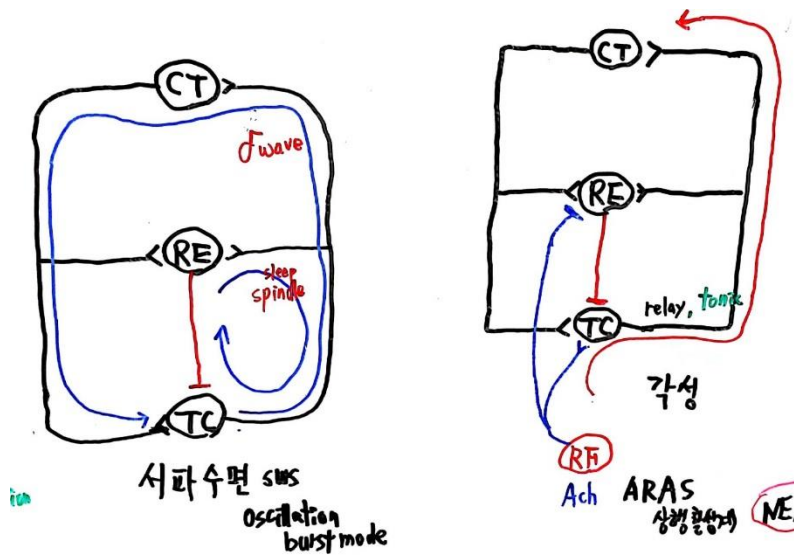


④



REM





Slow oscillation
(0.5-1.0Hz;
neocortex)



1.0s

Spindle
(11-15Hz;
thalamus)



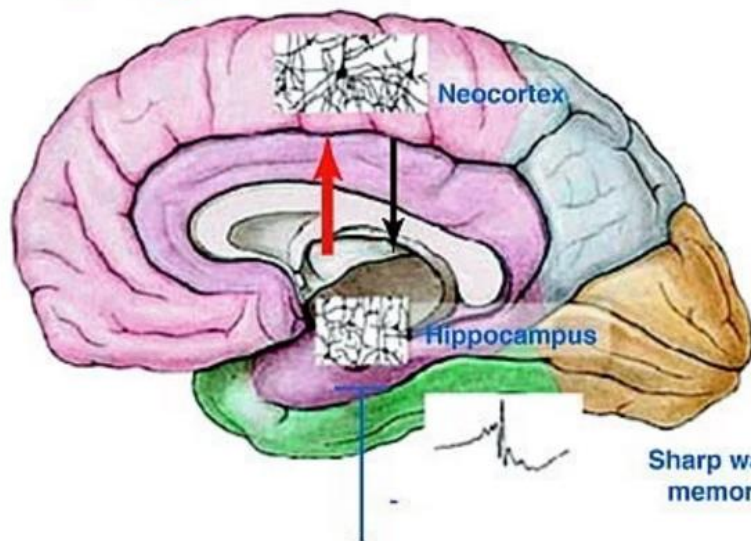
0.5s

Sharp wave ripple
(100-300Hz;
hippocampus)



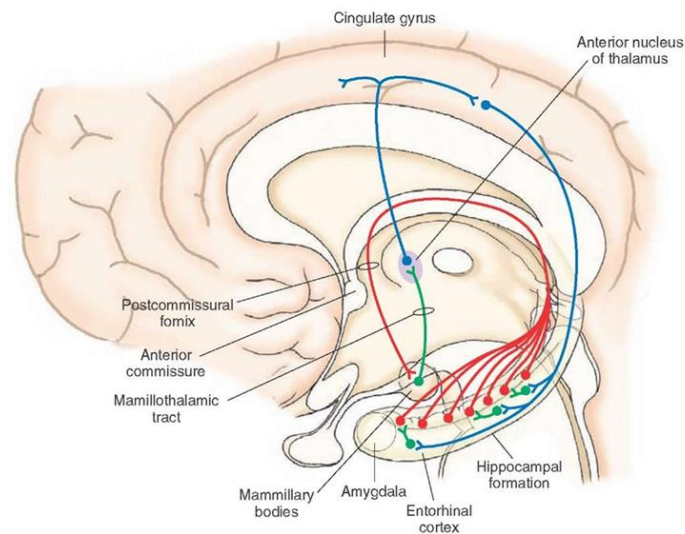
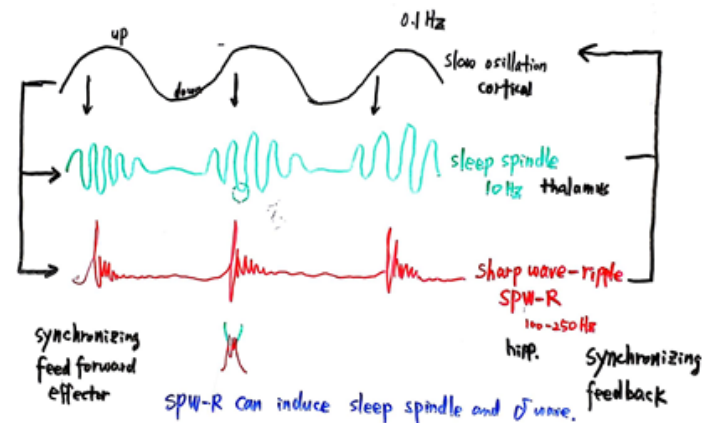
0.2s

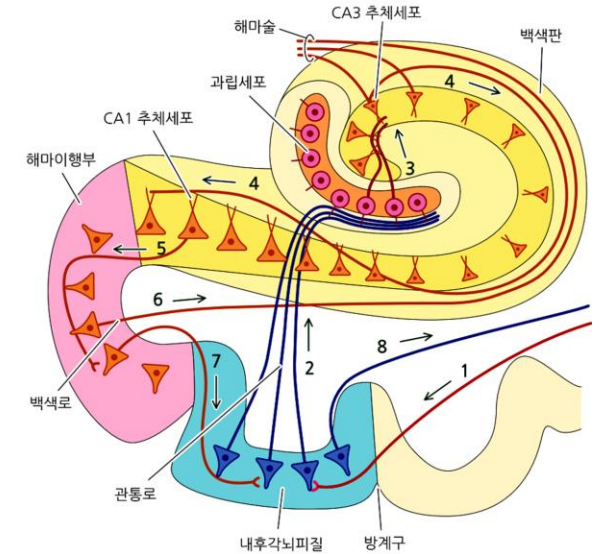
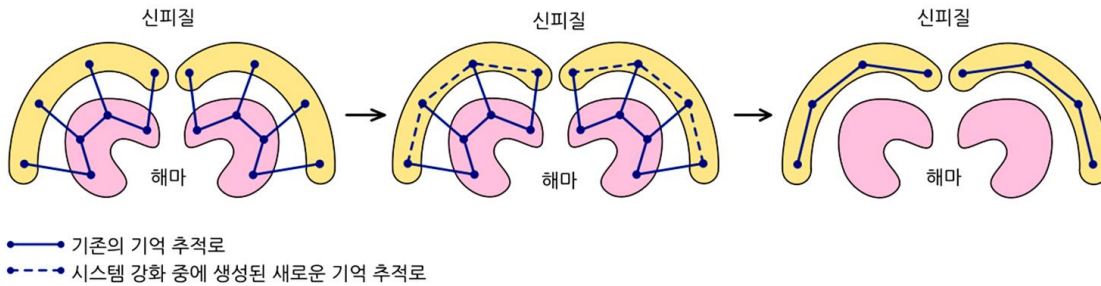
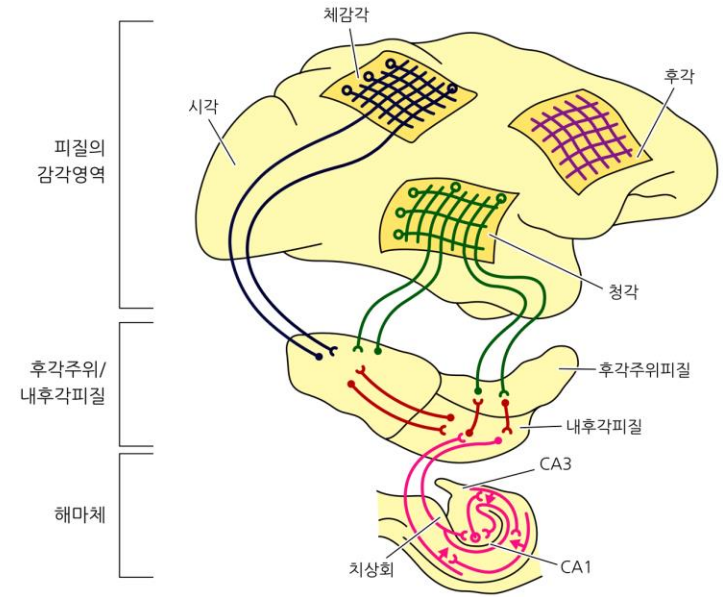
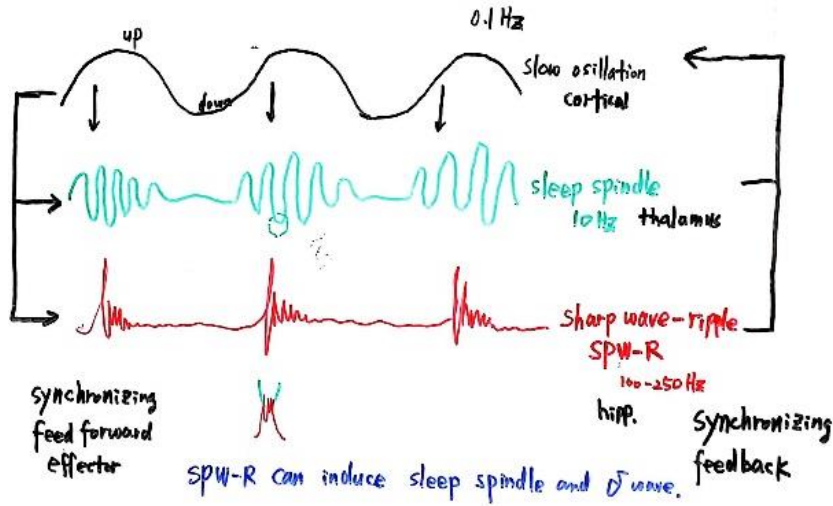
Slow oscillation

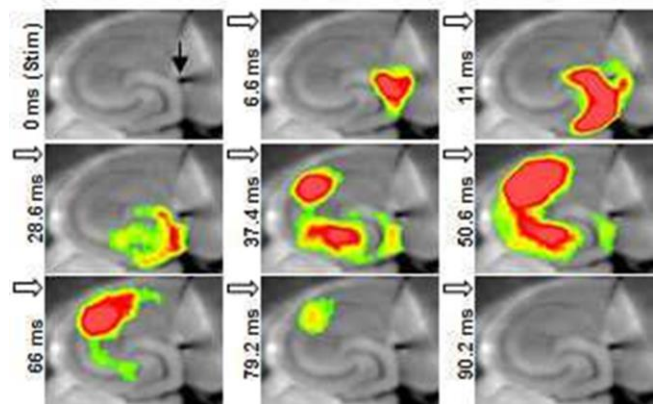
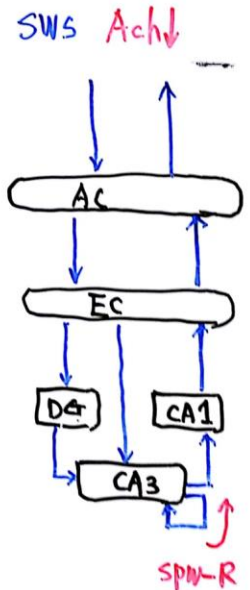
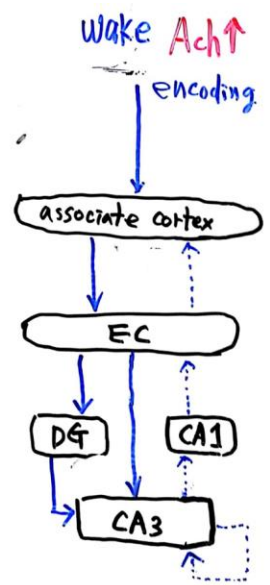
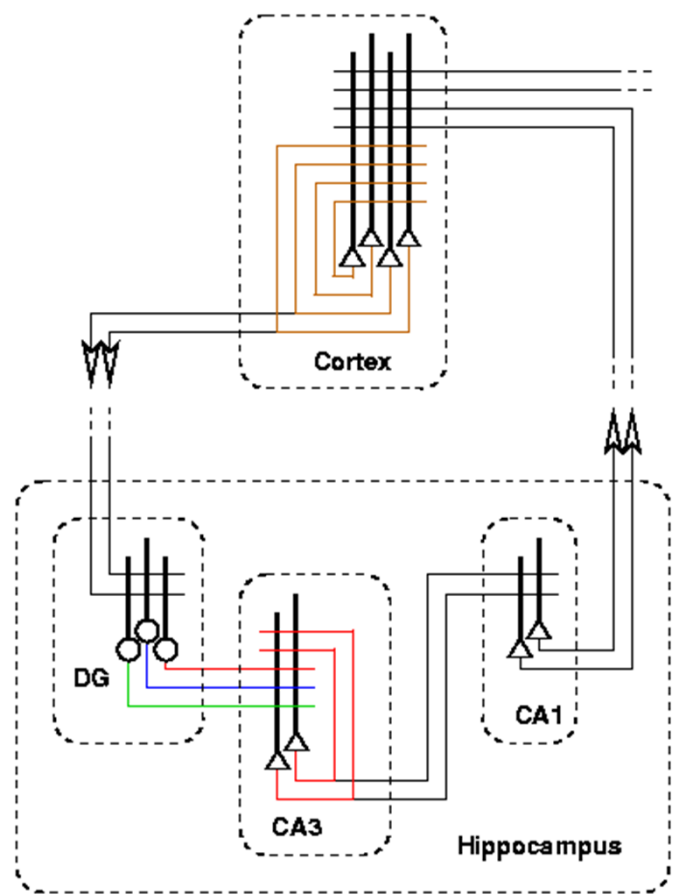
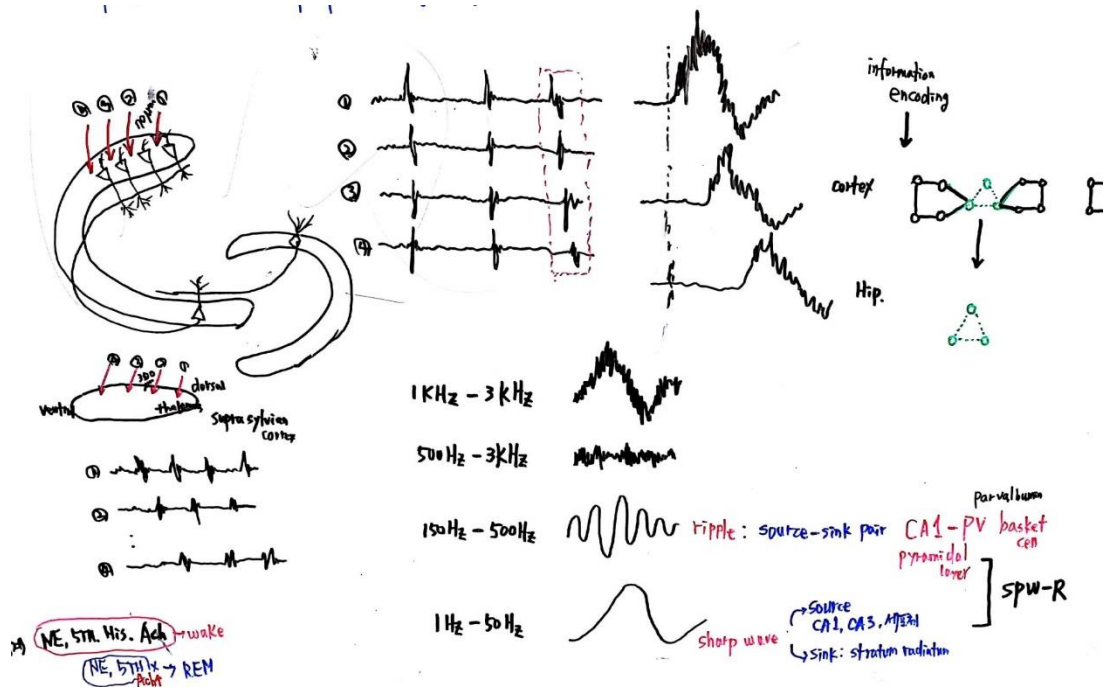


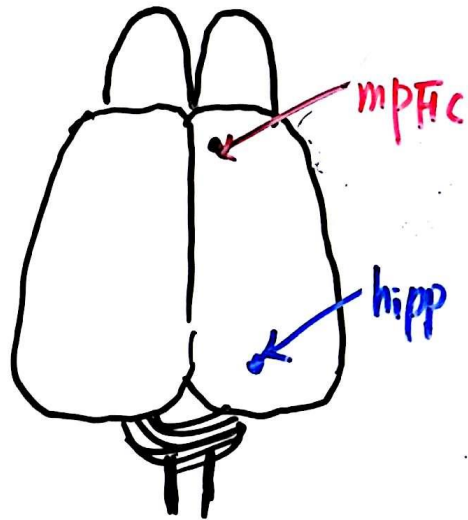
Acetylcholine,
cortisol, etc.

Sharp wave-ripple
memory replay









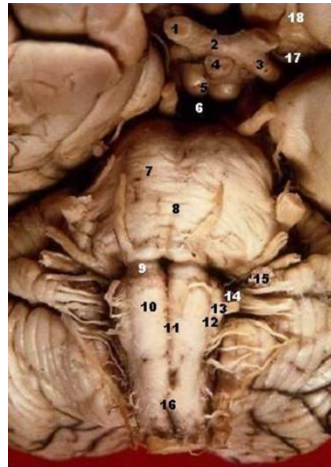
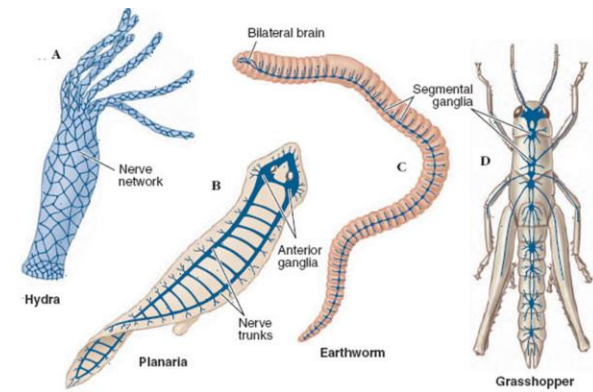
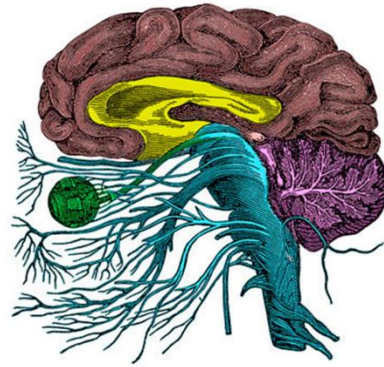
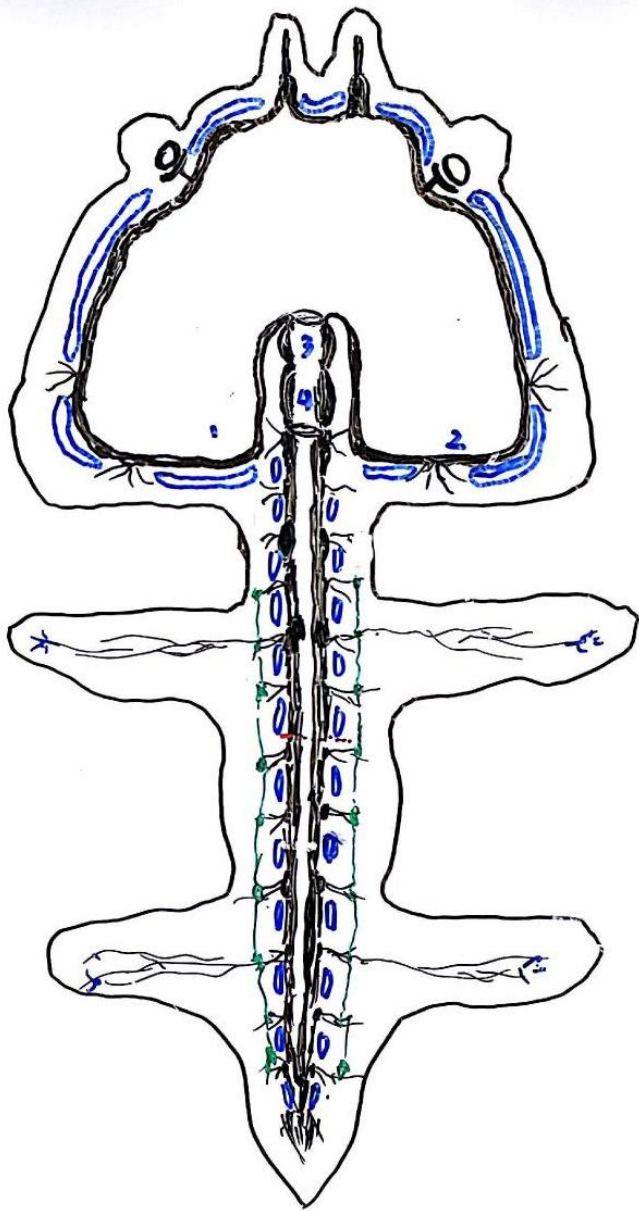
sleep spindle



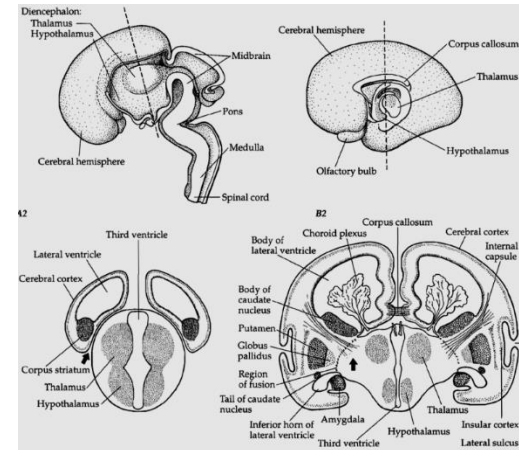
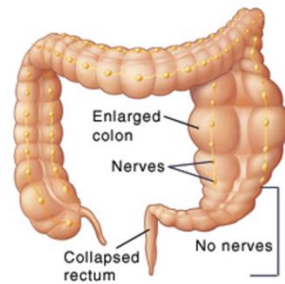
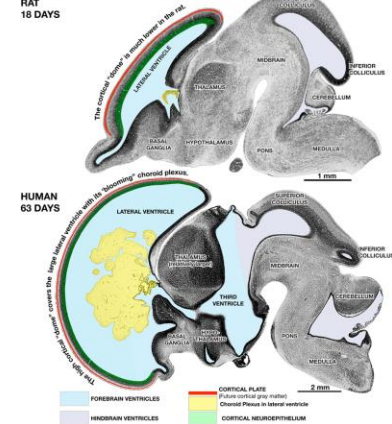
SPW-R



spindle-ripple cooccurrence



THE BRAINS OF RAT AND HUMAN EMBRYOS AT THE SAME STAGE OF DEVELOPMENT



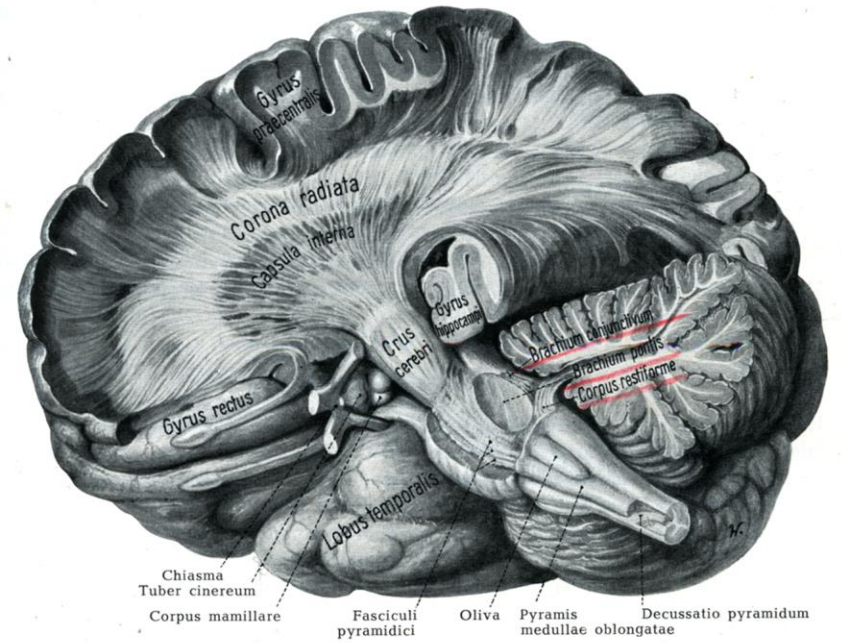
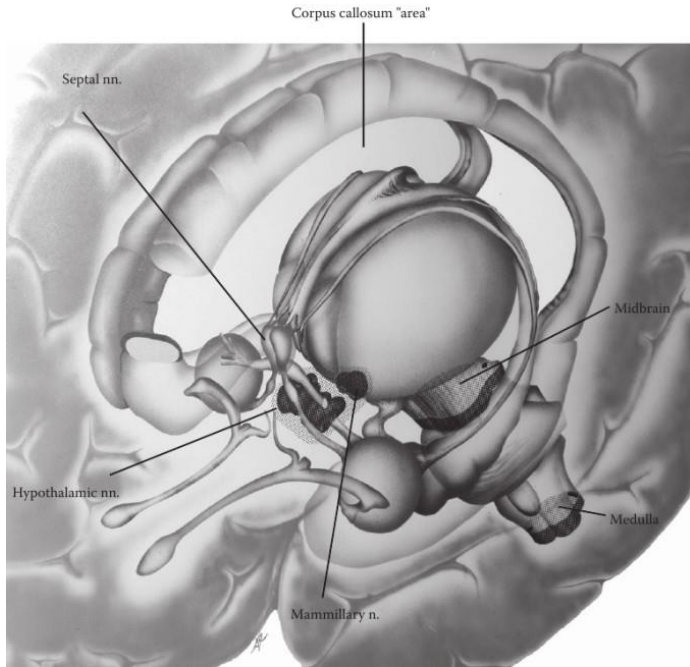
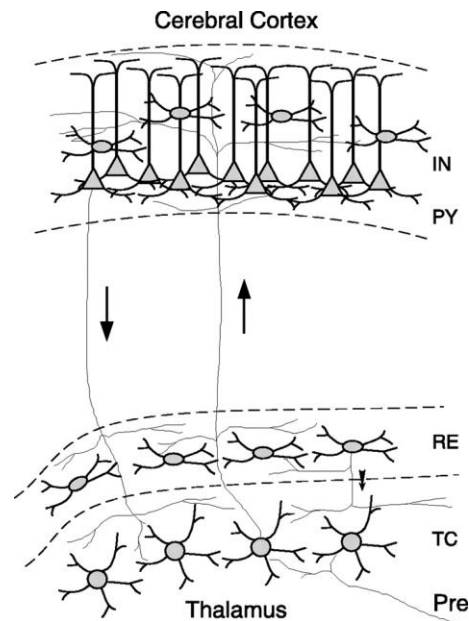
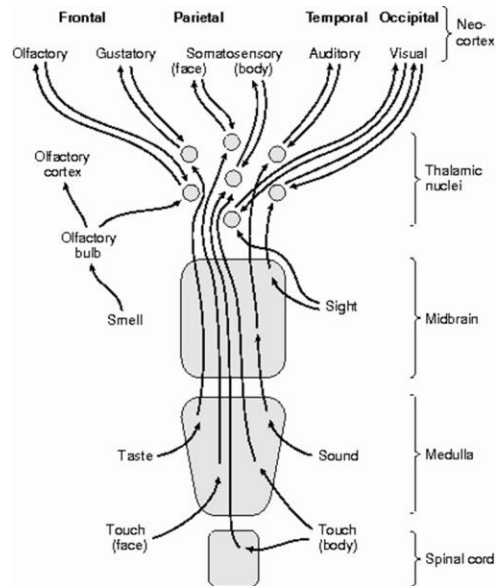
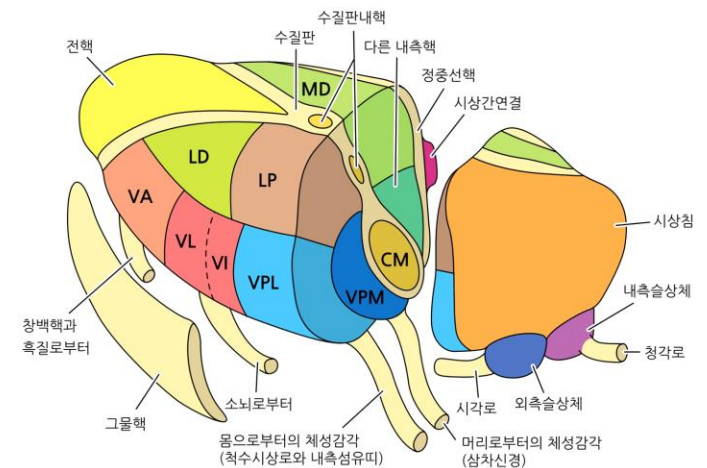
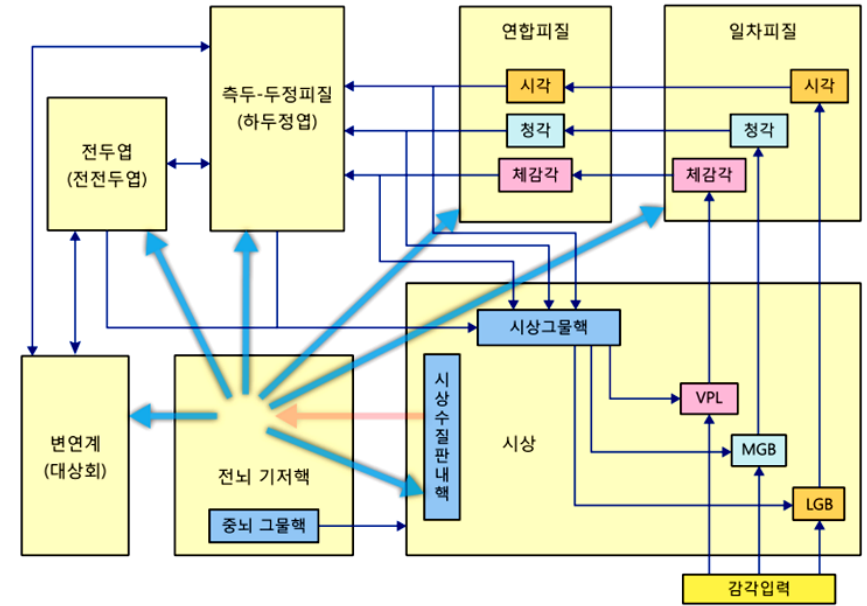
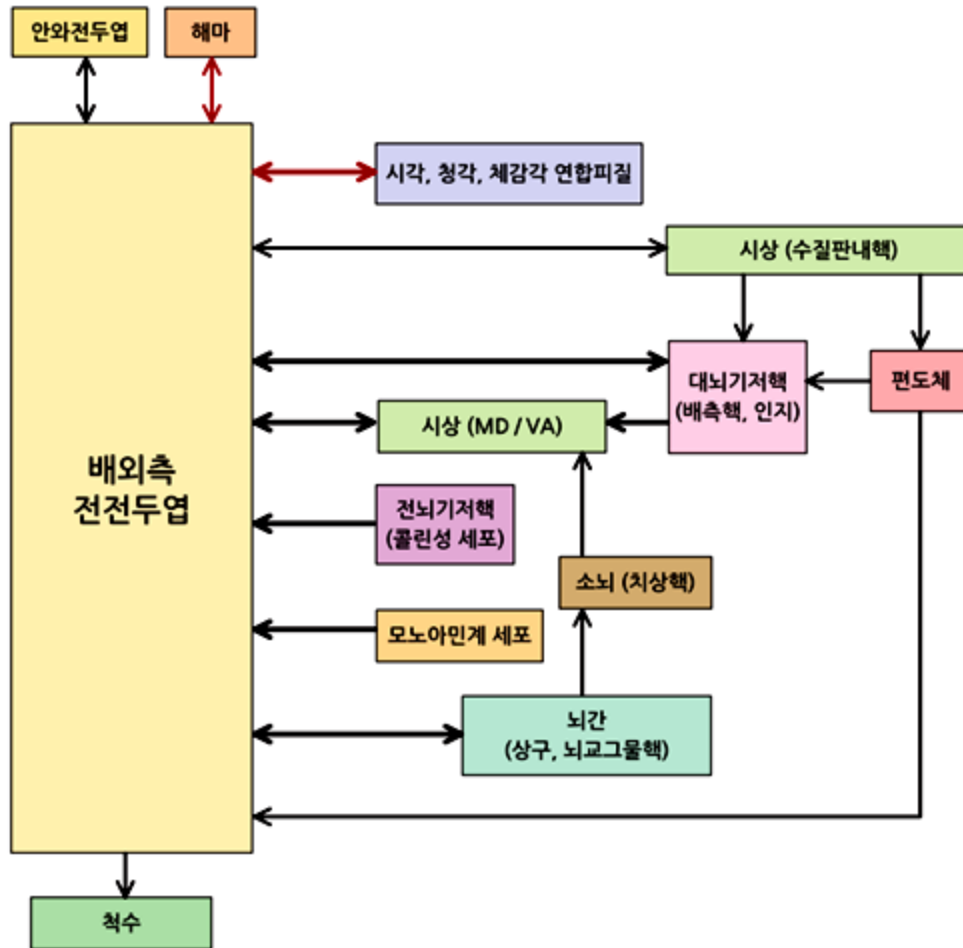
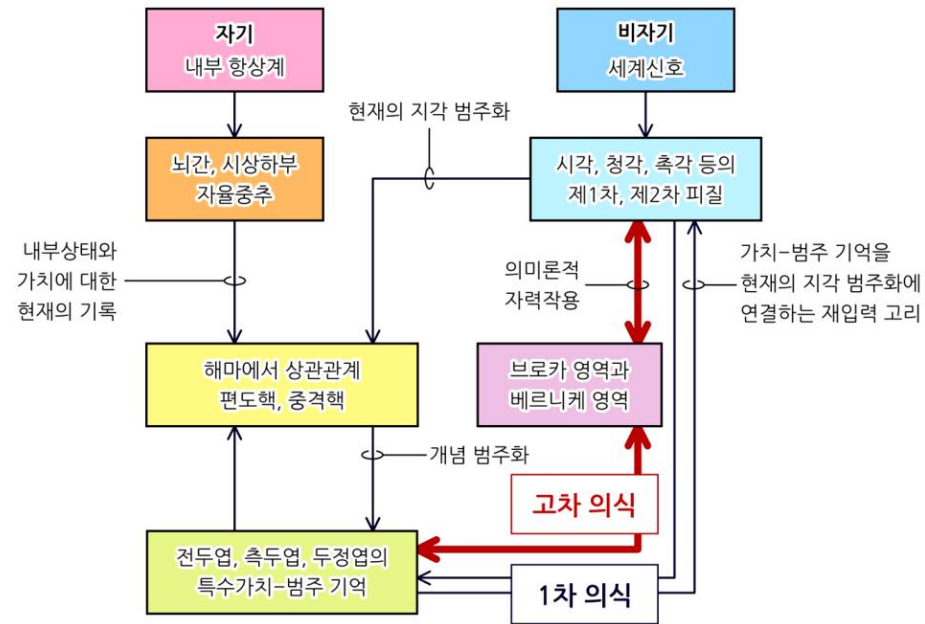


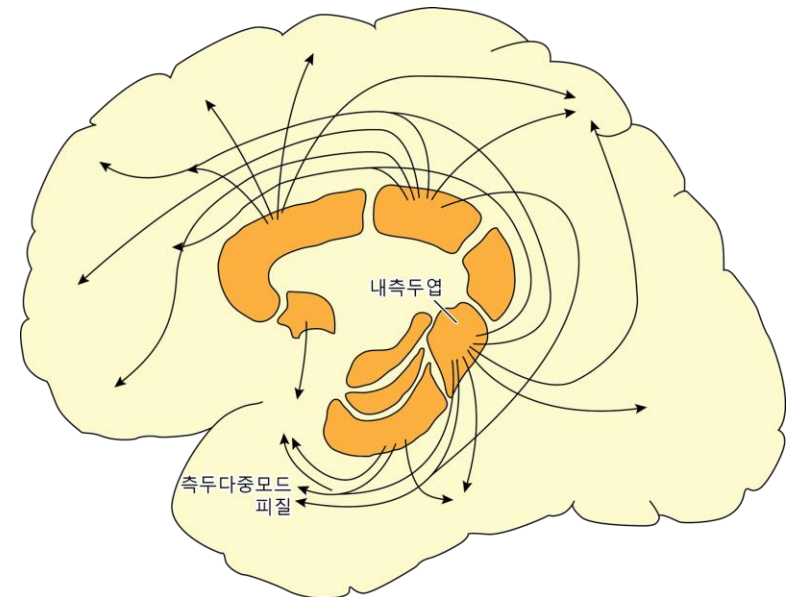
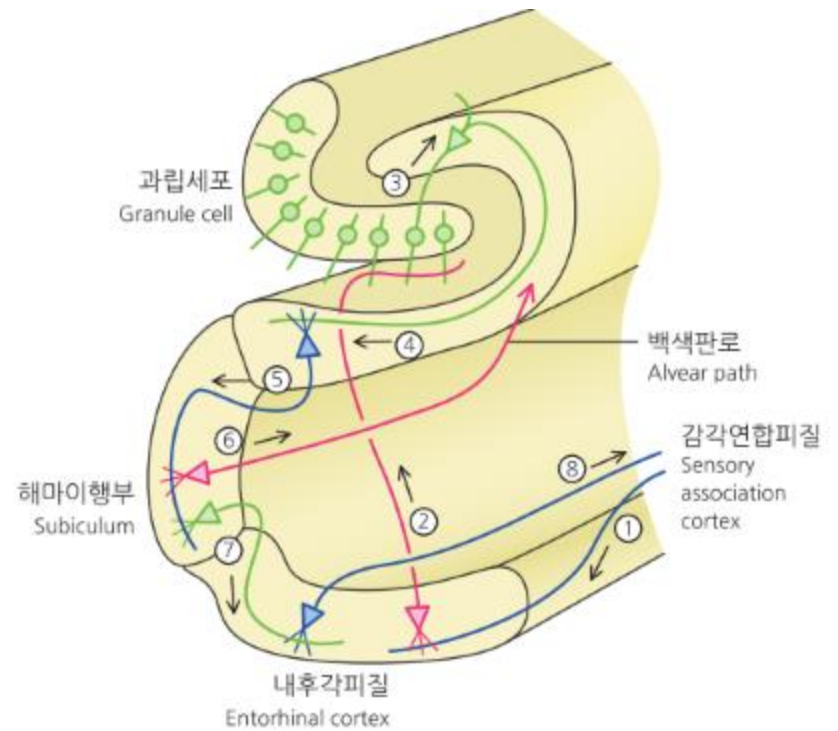
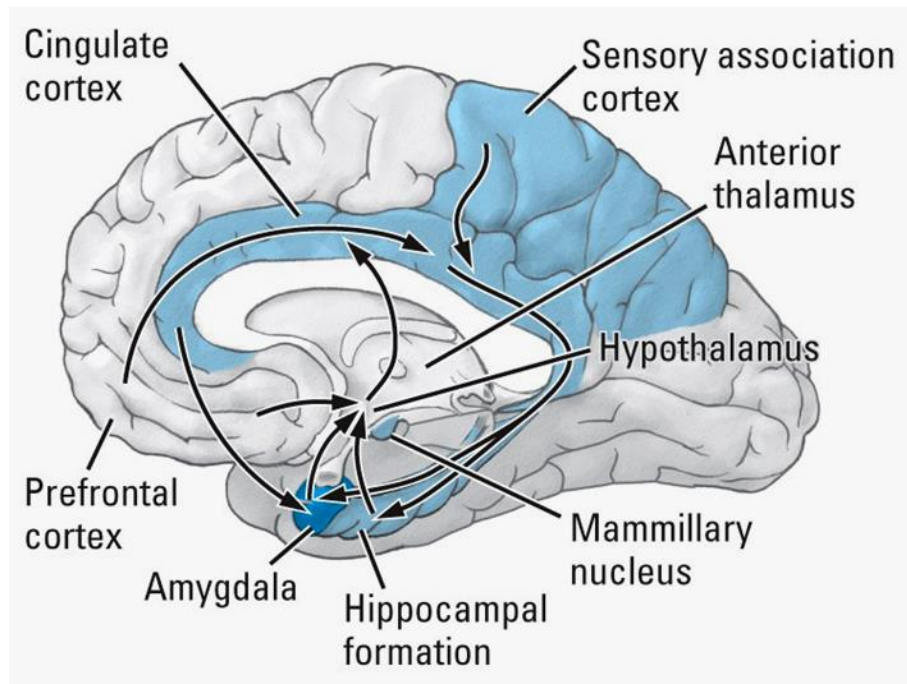
Abb. 443.

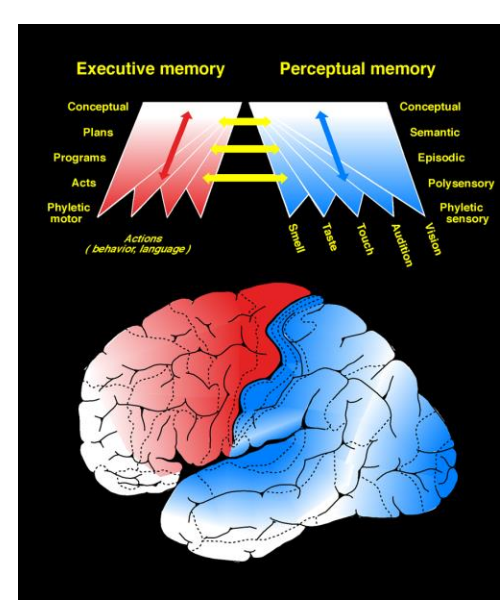
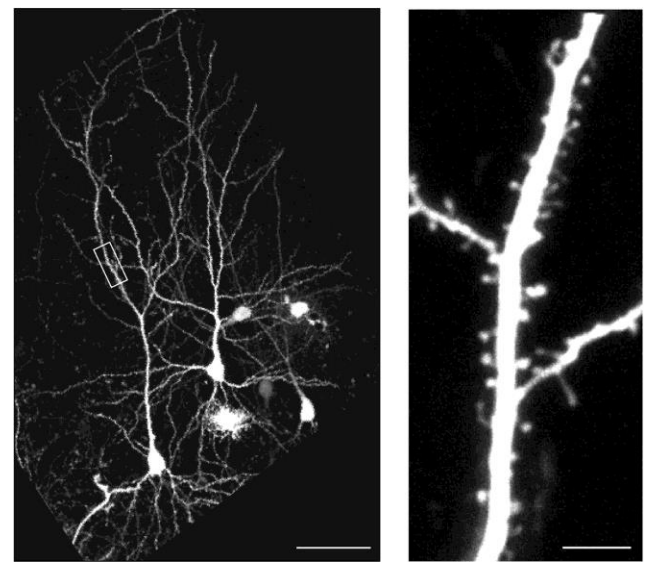
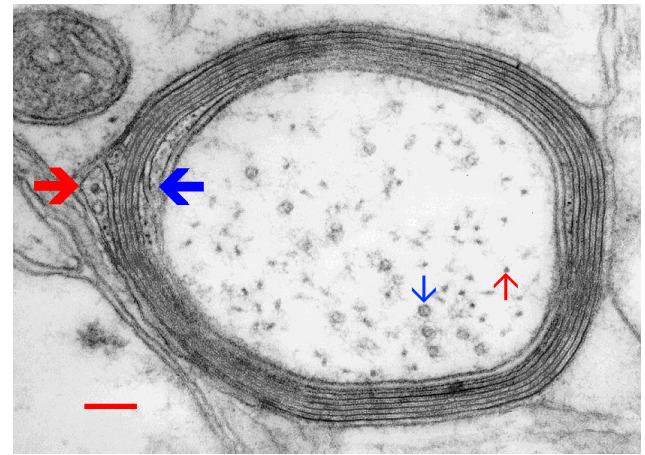
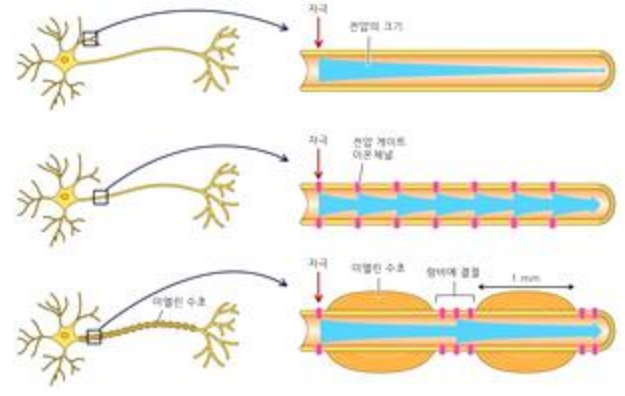
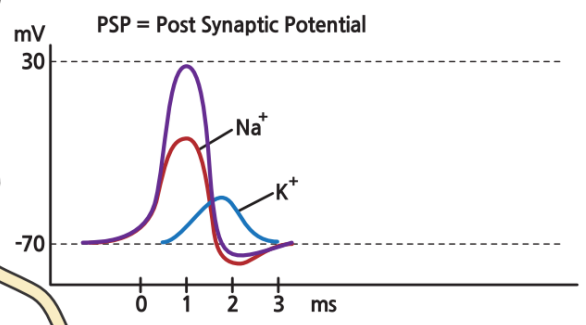
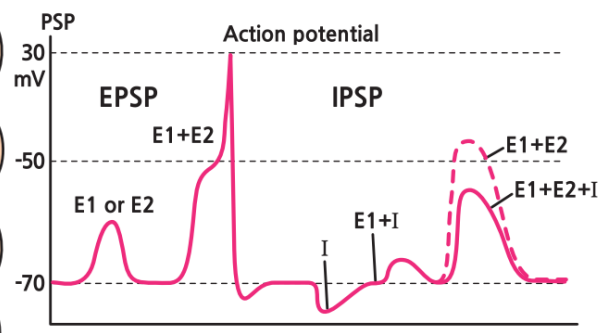
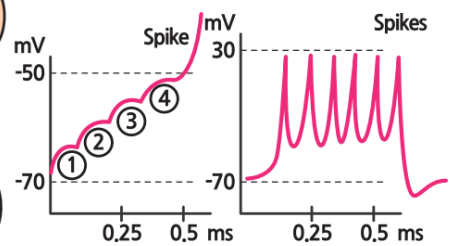
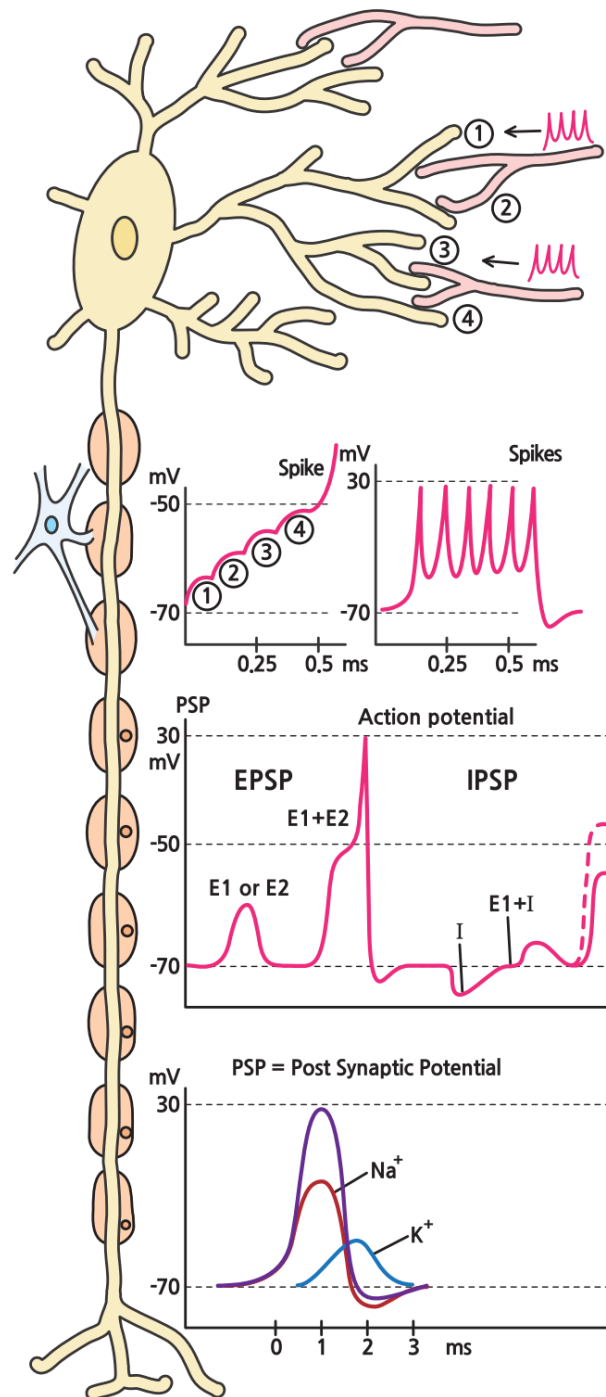
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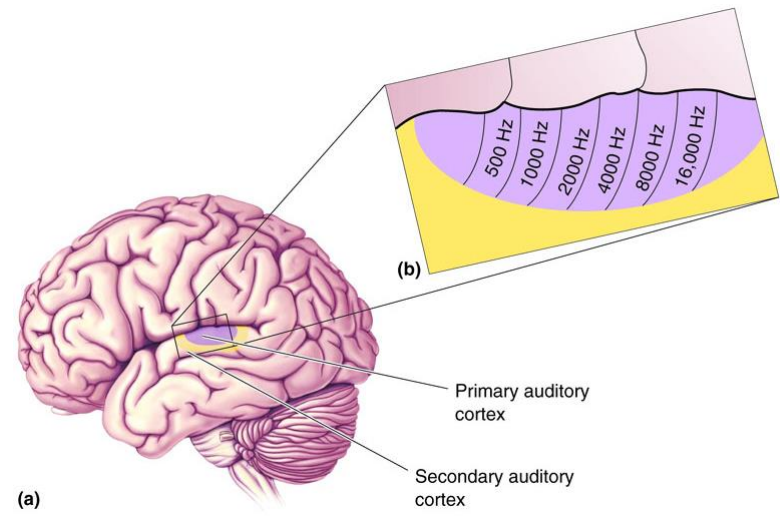
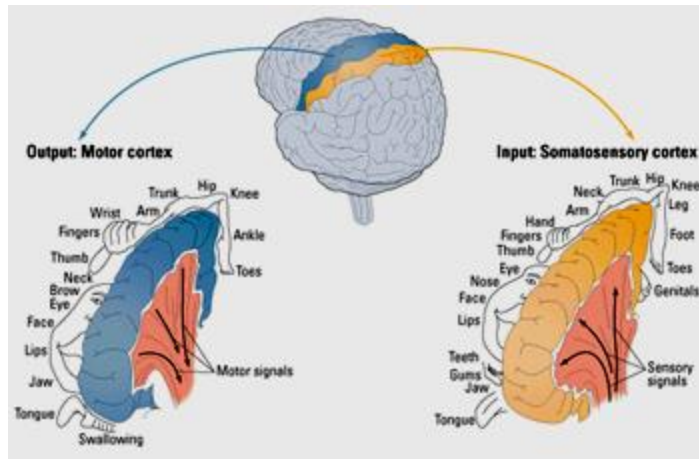












감각

일반 감각 : 내장감각, 통증, 가려움, 고유감각

특수 감각 : 시각, 청각, 미각, 후각, 균형감각

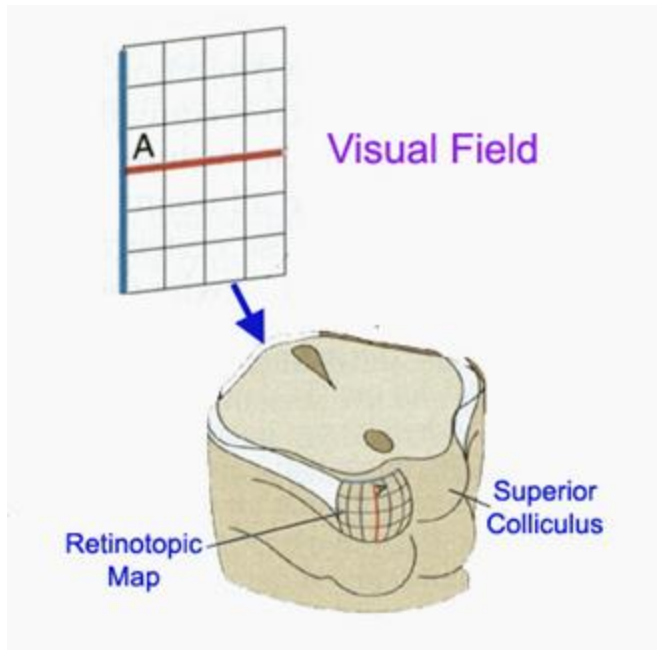
척수신경 31개, 뇌신경 12

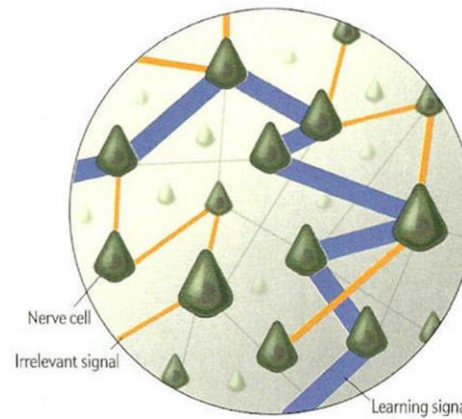
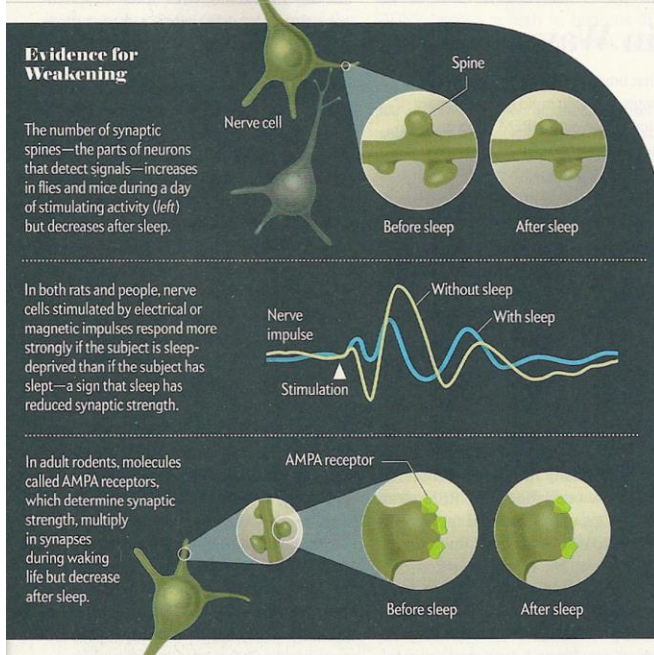
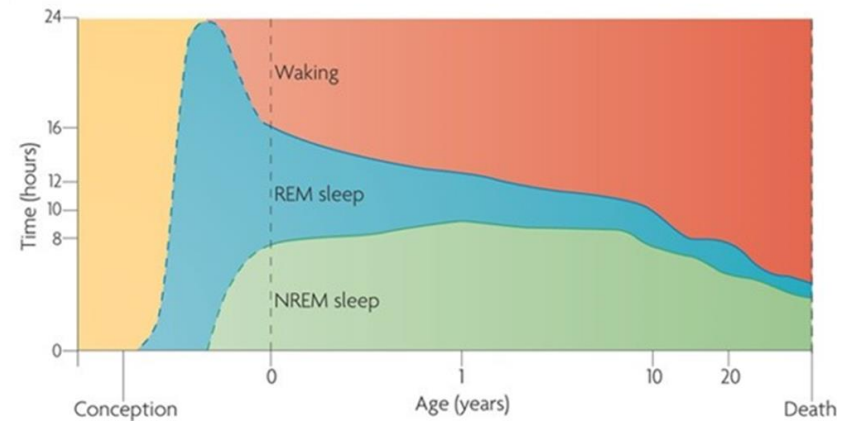
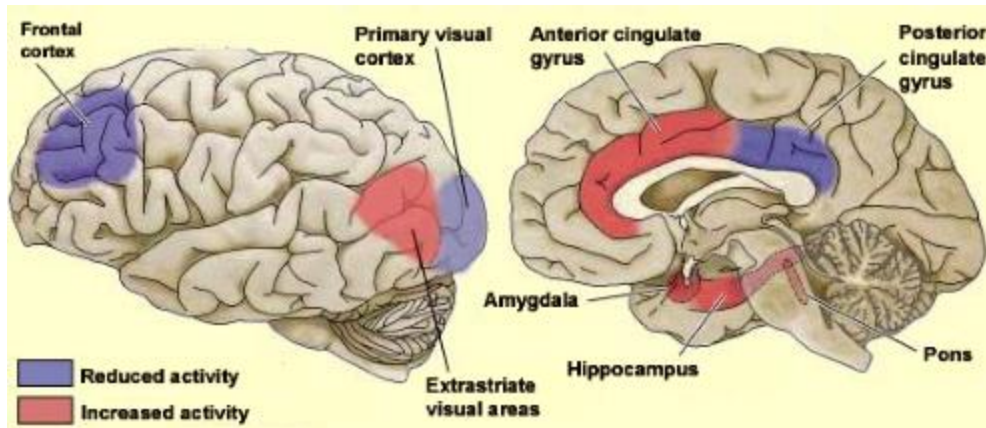
감각 4 요소 : modality, 위치, 강도, 지속시간

Channel → Map : somatotopic
retinotopic
tonotopic

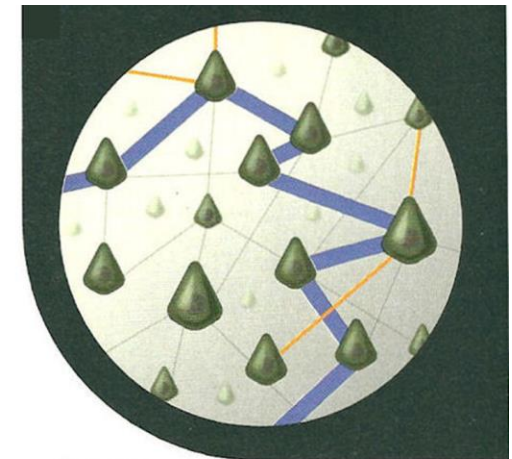
뇌는 운동과 지각 먹고 싶은 열정

소리 → 단어 → 음악





Awake - Nerve cells fire in response to both important (worthy of remembering) (purple) and unimportant (incidental) (orange) stimulation from the environment, strengthening the synapses in the neuronal circuits that have been activated.



Asleep - Spontaneous firing selectively removes or weakens (represented by thinned lines) neuronal links. Somehow unimportant links get weakened more than significant ones do, allowing important memories to remain intact.

마스터 텍스트 스타일을 편집합니다

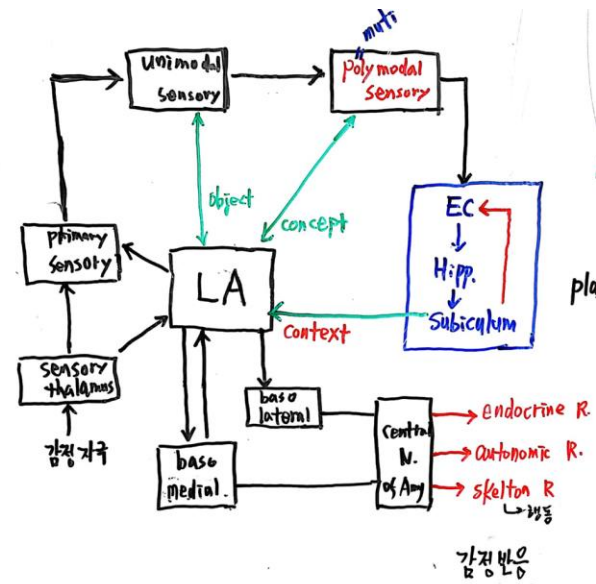
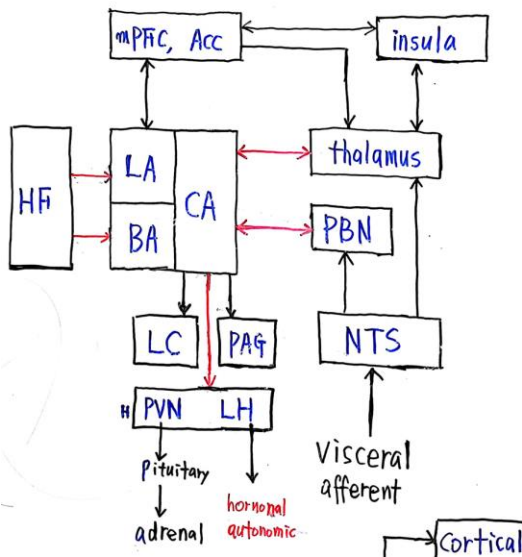
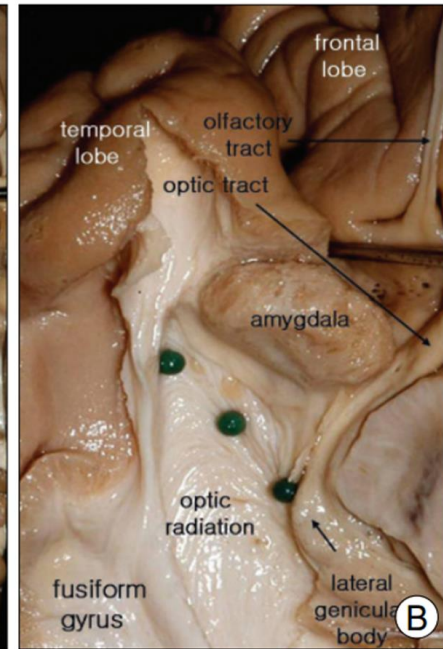
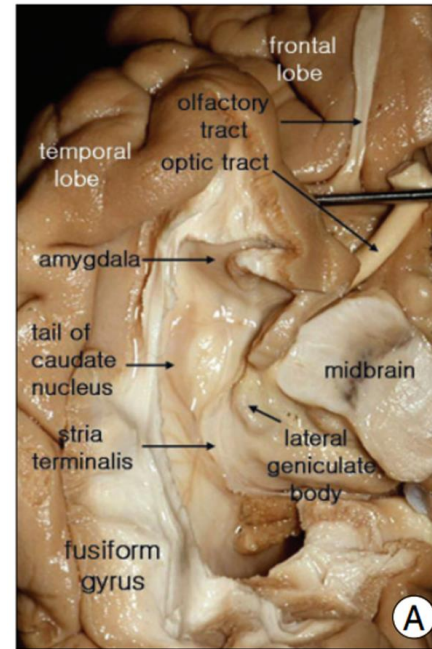
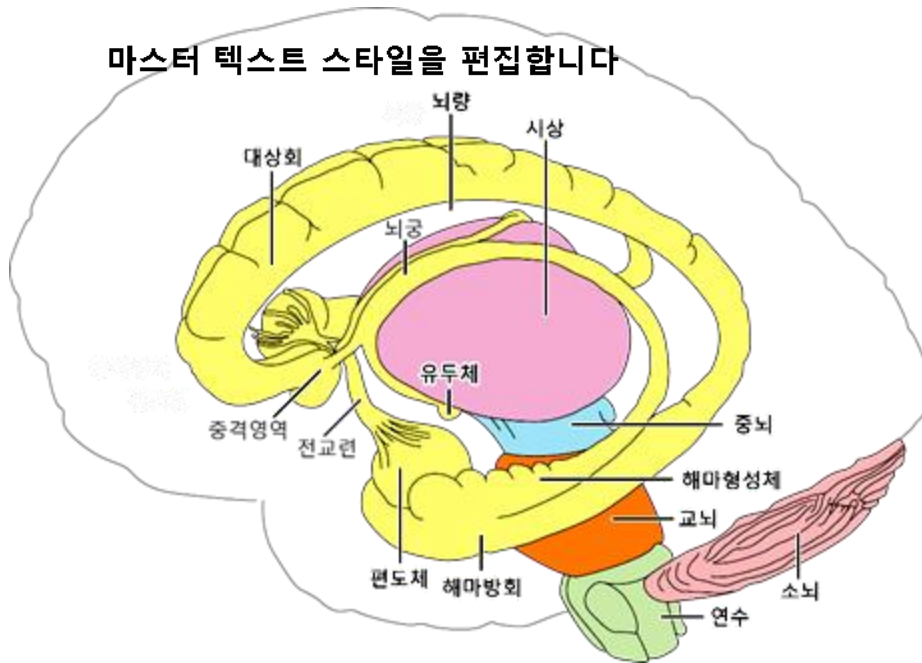


Figure 1
Examples of Prefrontal Spindles and Hippocampal Ripples

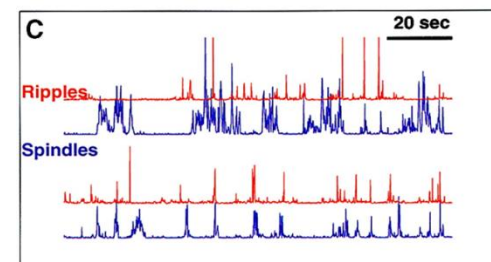
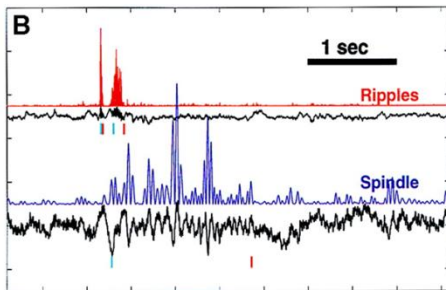
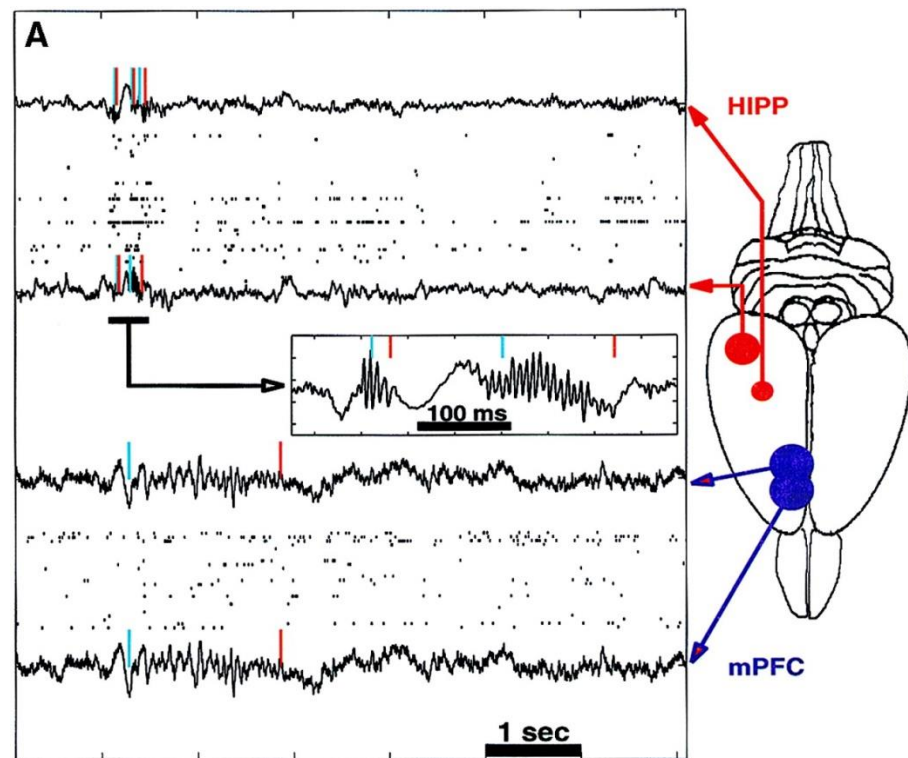
(A) Recording locations, LFP traces, and neuronal activity. An example of local field potential (LFP) recordings from the hippocampus (HIPP) and the medial prefrontal cortex (mPFC), together with rasters of single neuron activity in these areas. Pairs of successive bars indicate the beginnings (cyan) and ends (red) of the identified events (ripples for the HIPP traces and spindles for the mPFC traces).

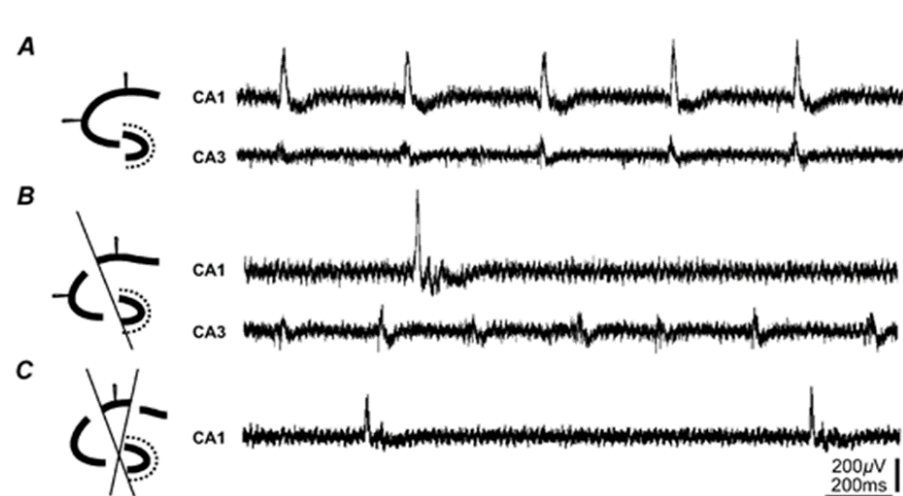
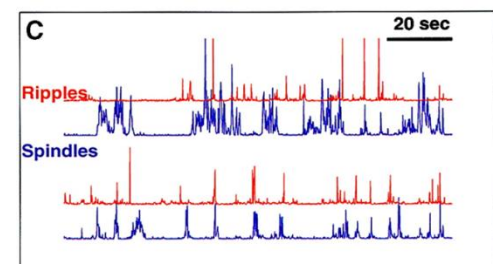
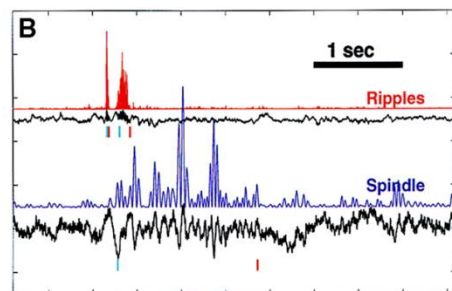
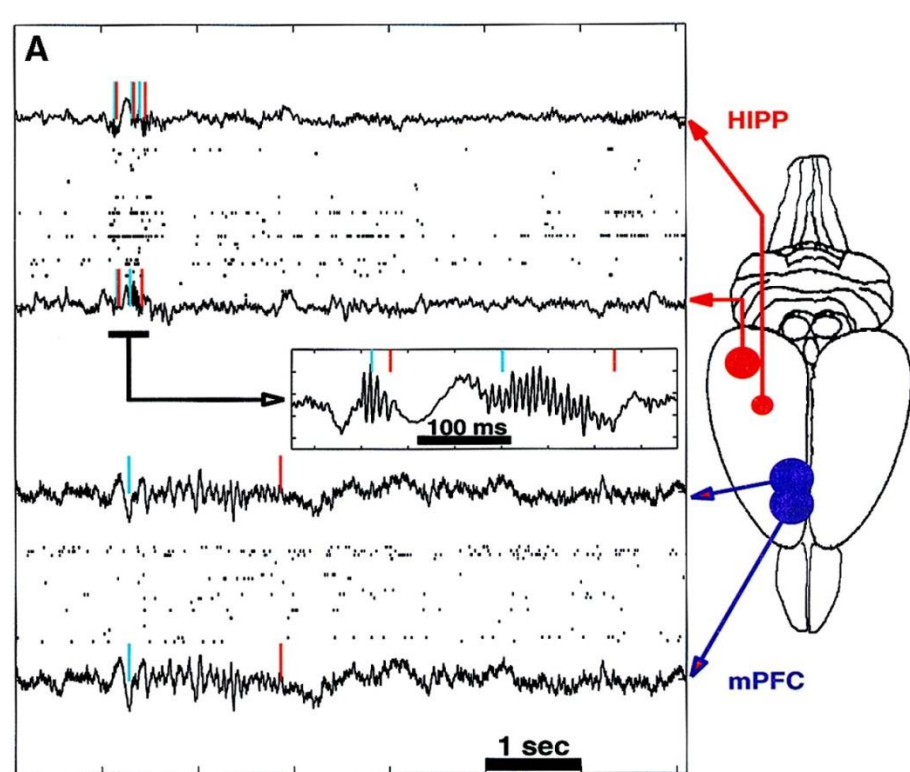
A magnification of an LFP trace segment containing two ripple events is displayed in the inset. A diagram of the rat brain indicating the recording sites is also shown.

(B) Raw and filtered LFP waveforms. Magnification of a time interval containing the ripples and spindle events from the middle two traces of Figure 1a, together with the squared-amplitude filtered traces (red and blue curves) computed as described in the Experimental Procedures.

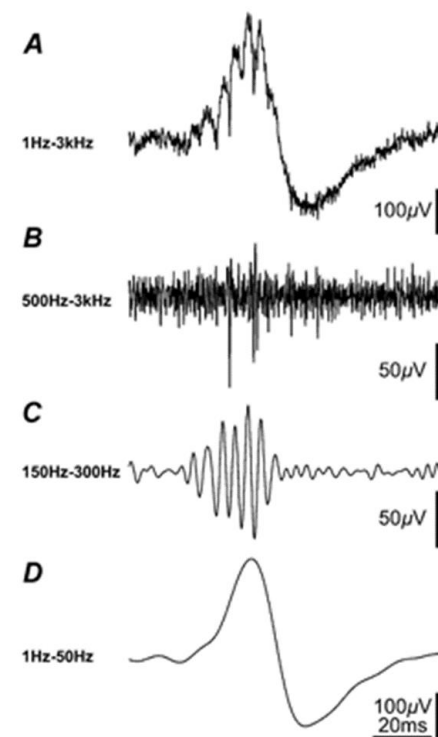
A large value of the red trace indicates the presence of a ripple in the hippocampal recording trace, while large values of the blue trace indicate the presence of spindle oscillations.

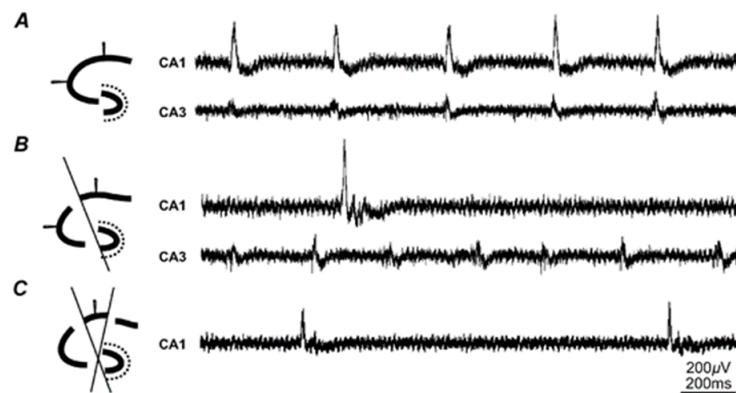
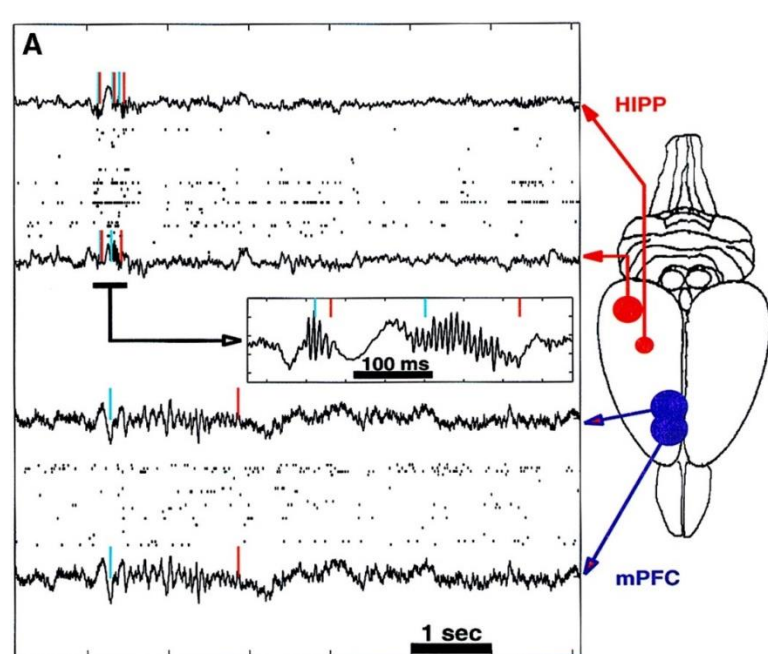
(C) **Illustration of spindle–ripple cooccurrence.** The red and blue curves indicate squared-amplitude filtered hippocampal and prefrontal traces, respectively.



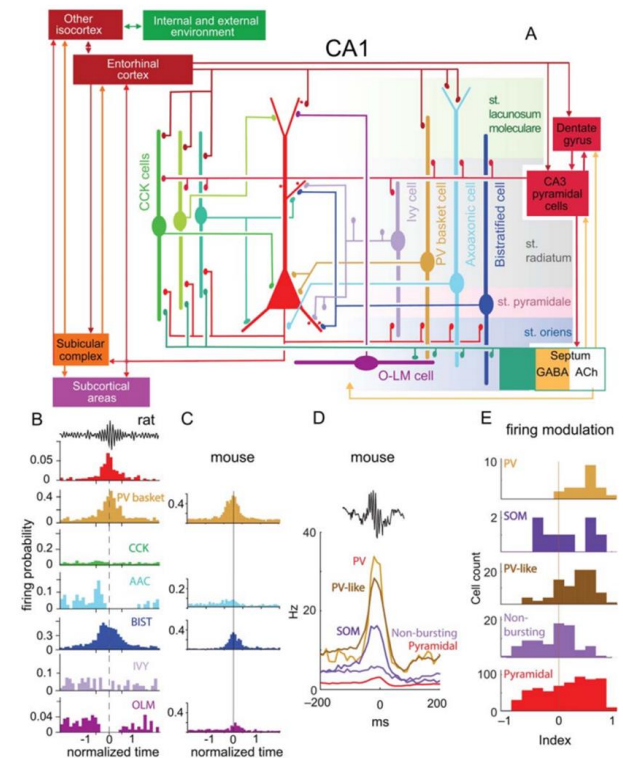
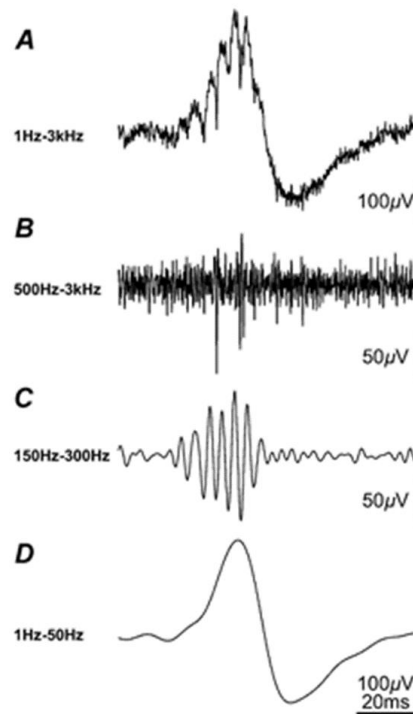
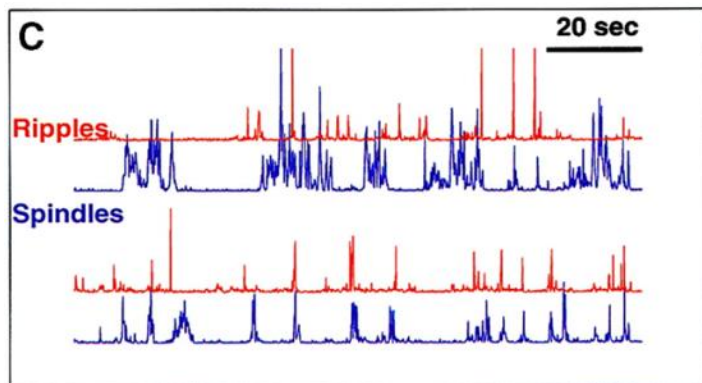


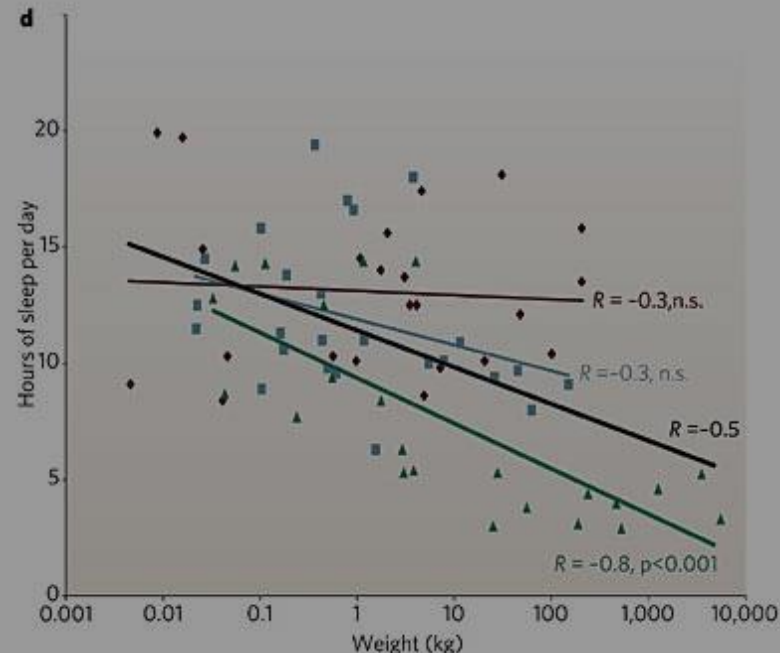
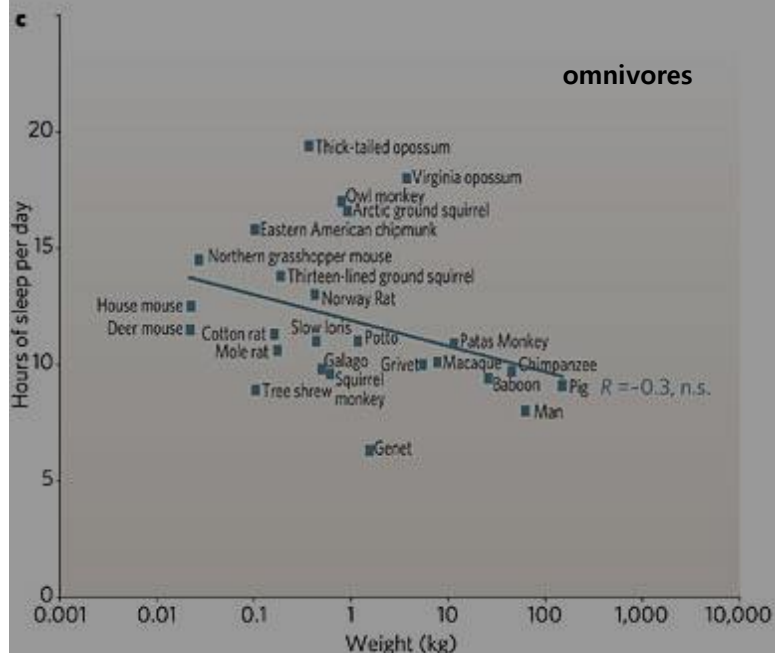
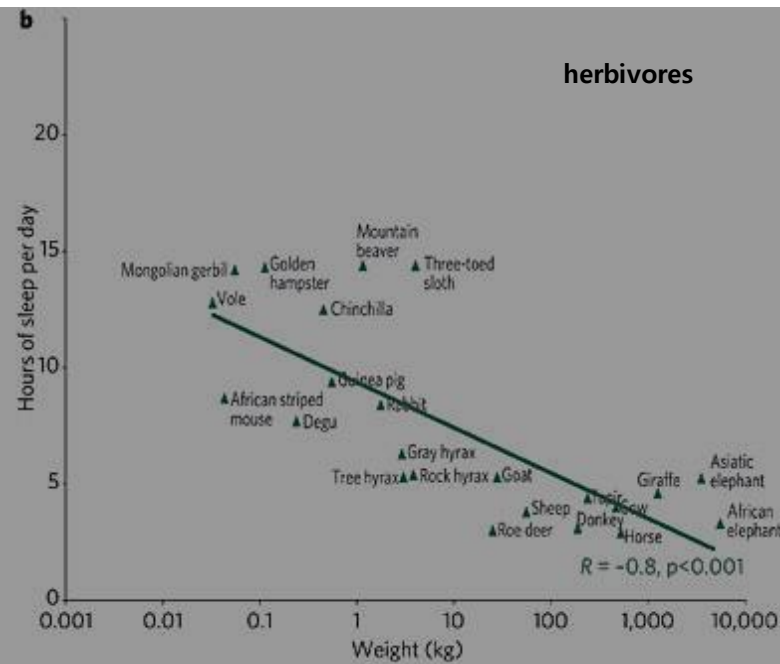
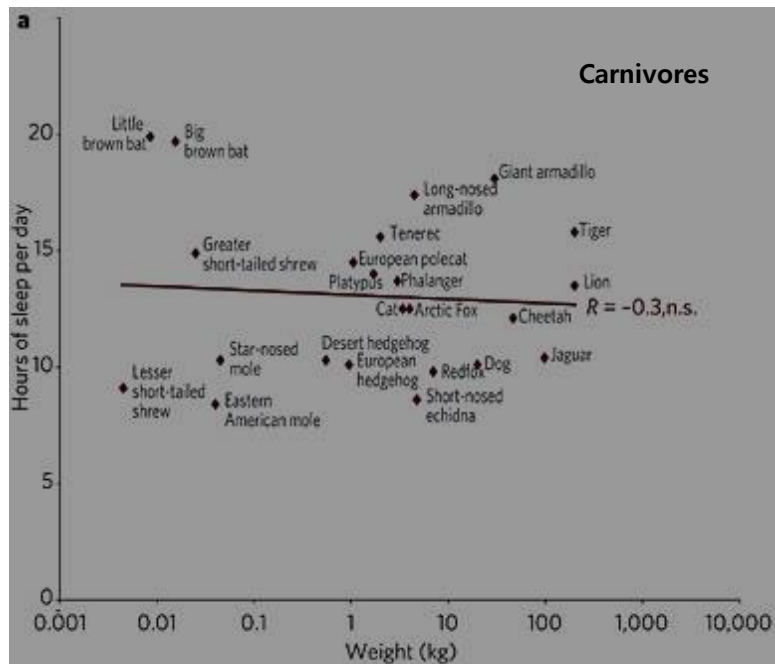
spindle-ripple cooccurrence





spindle-ripple cooccurrence





a, Carnivores are shown in dark red; b, herbivores are in green and c, omnivores in grey. Sleep times in carnivores, omnivores and herbivores differ significantly ($P < 0.0002$, F test, d.f. 2,68), with carnivore sleep amounts significantly greater than those of herbivores ($P < 0.001$, t-test, d.f. 24, 22). Sleep amount is an inverse function of body mass over all terrestrial mammals (black line).



FIGURE 3. Unihemispheric slow waves in cetaceans.

From the following article:

Clues to the functions of
mammalian sleep

Jerome M. Siegel

Nature 437, 1264-1271(27 October
2005)

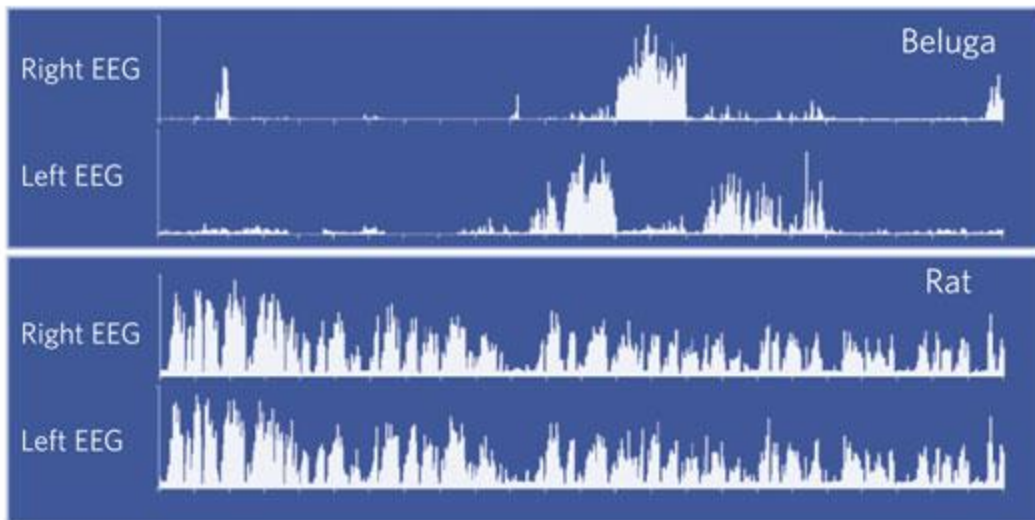
Top, photos of immature beluga,
adult dolphin and section of adult
dolphin brain.



Electroencephalogram (EEG) of adult
cetaceans, represented here by the
beluga, during sleep are shown.

All species of cetacean so far
recorded have unihemispheric slow
waves^{30, 31, 98, 99, 100.}

Top traces show left and right EEG
activity. The spectral plots show 1–
3-Hz power in the two hemispheres
over a 12-hour period.



The pattern in the cetaceans
contrasts with the bilateral pattern
of slow waves seen under normal
conditions in all terrestrial mammals,
represented here by the rat (bottom
traces).

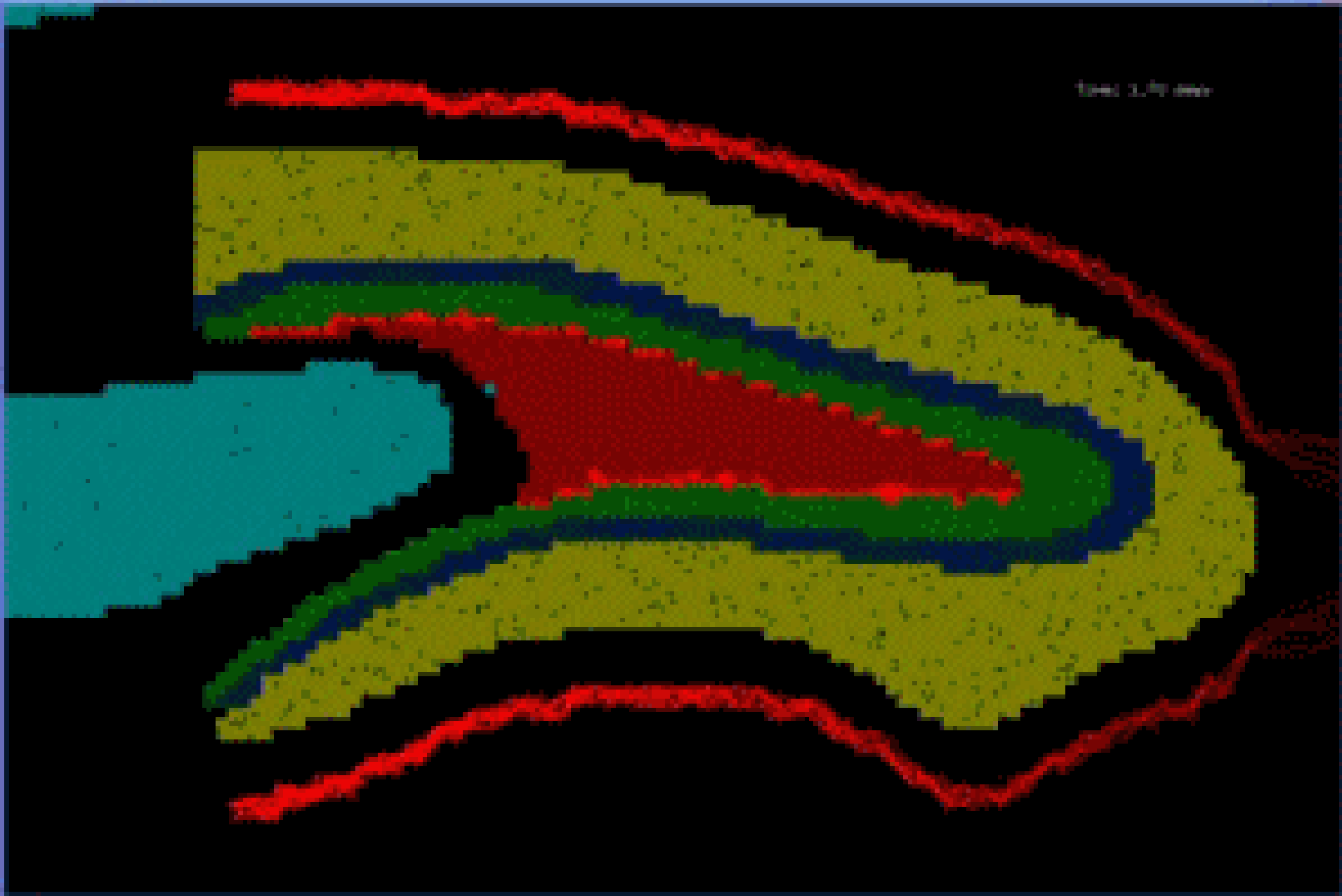
The brain photograph is from the
University of Wisconsin, Michigan
State, and the National Museum of
Health Comparative Mammalian
Brain Collections.

Human

Fly Mouse



5cm



Animated neurogenesis

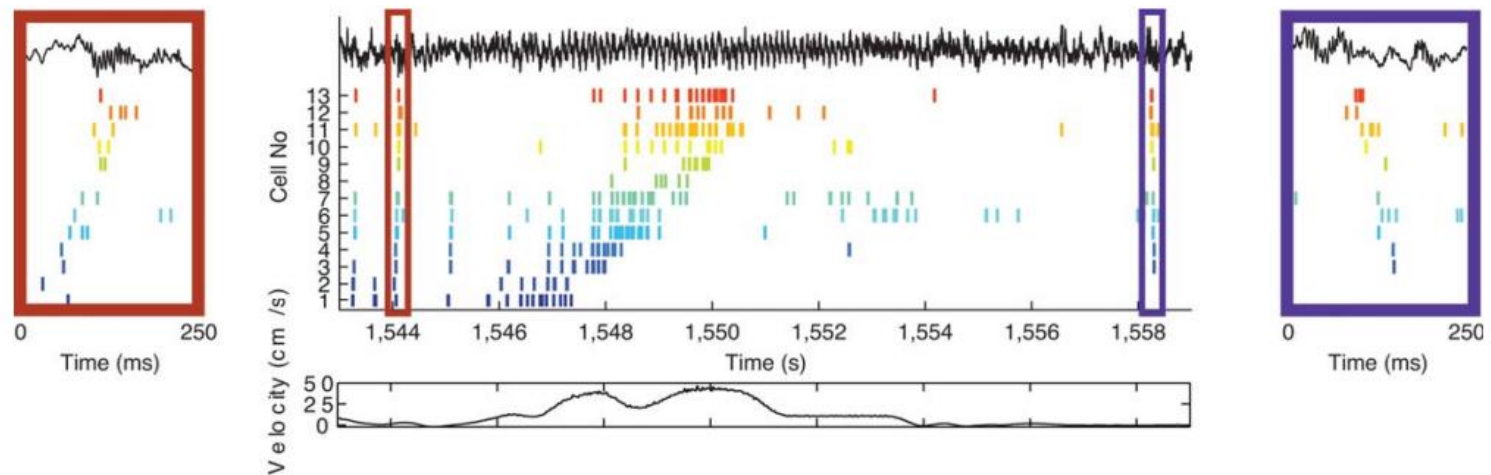
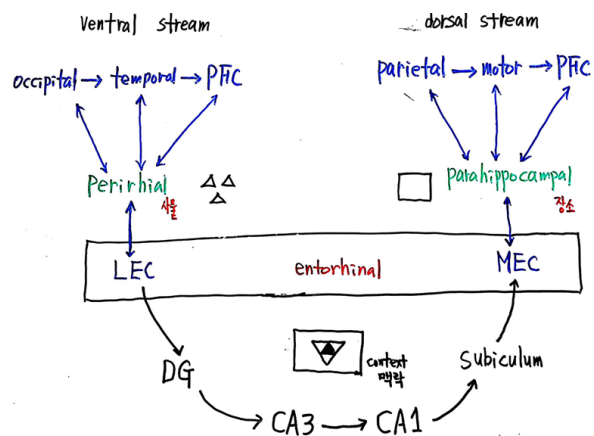
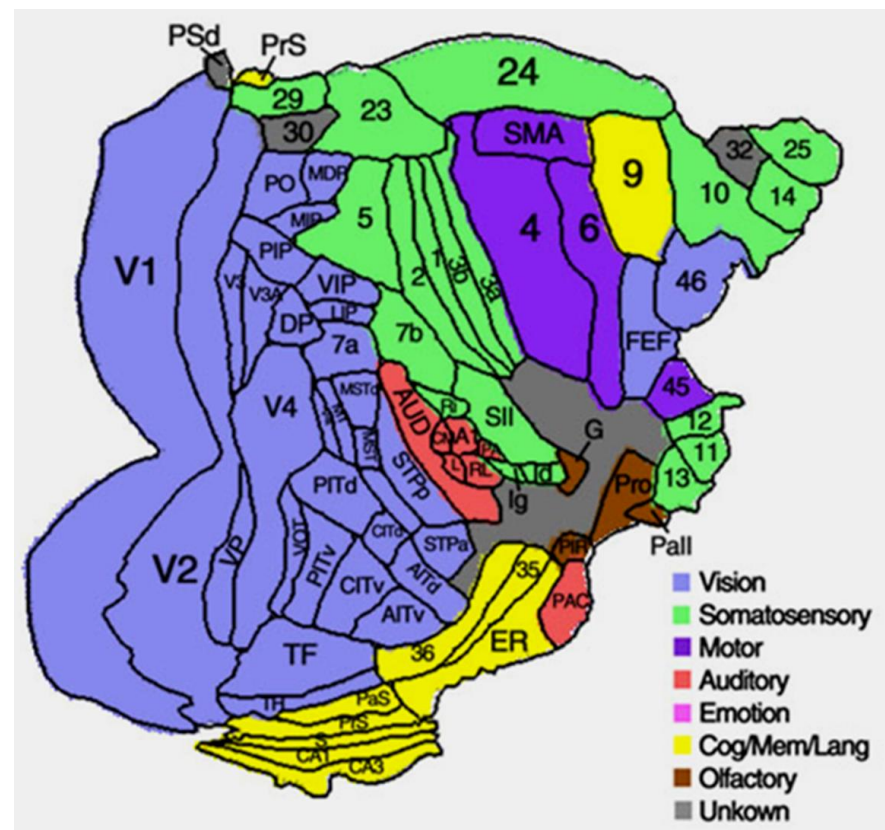
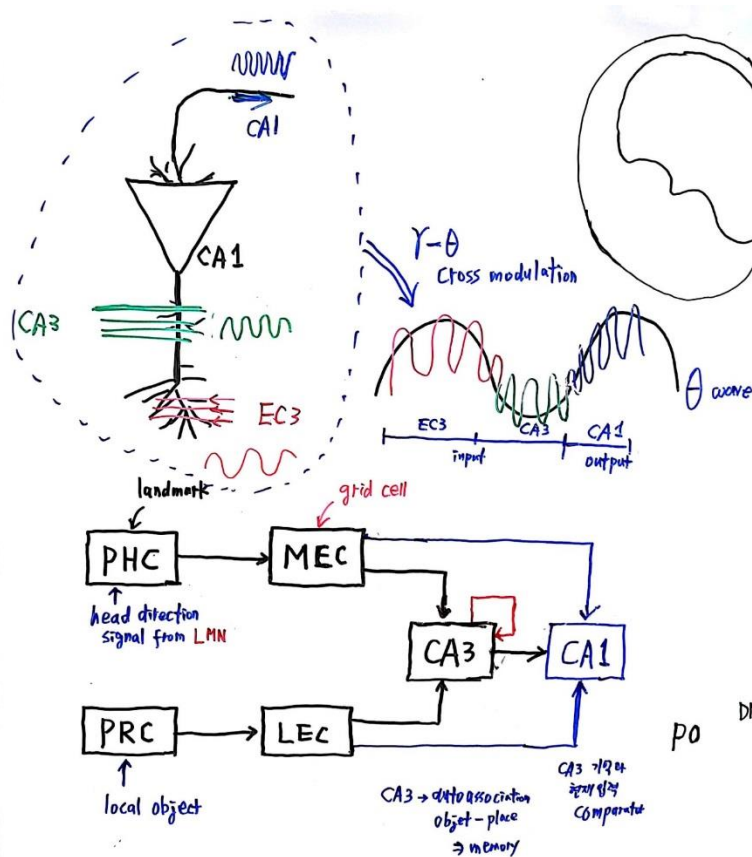
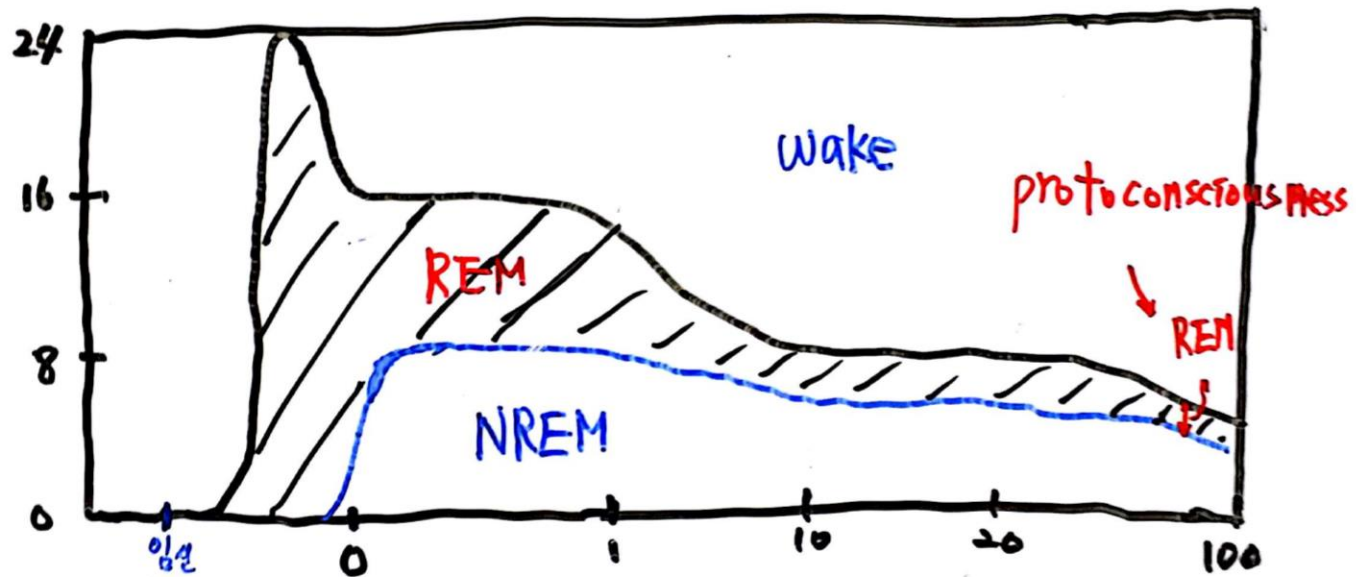


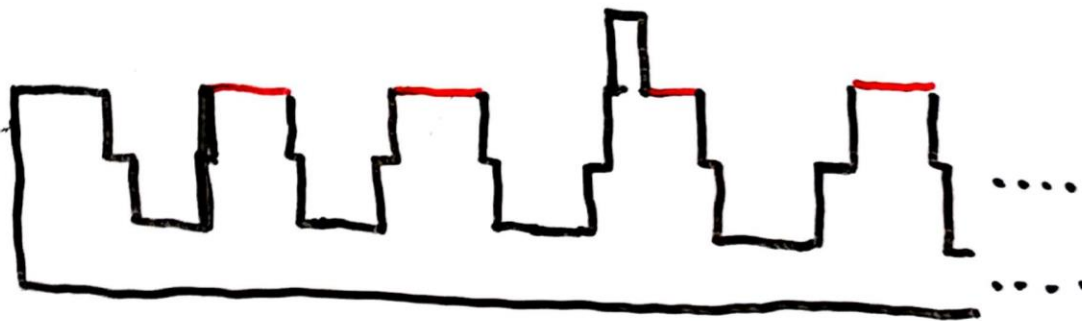
FIGURE 43. Place cell sequences experienced during behavior are replayed in both the forward and reverse direction during awake SPW-Rs. Spike trains for place fields of 13 CA3 pyramidal cells on the track are shown before, during and after a single traversal. Sequences that occur during track running are reactivated during SPW-Rs both before and after the run, when the rat stays

immobile. Forward replay (left inset, red box) occurs before traversal of the environment and reverse replay (right inset, blue box) after. The CA1 local field potential is shown on top and the animal's velocity is shown below. Reprinted from Diba and Buzsáki (2007).

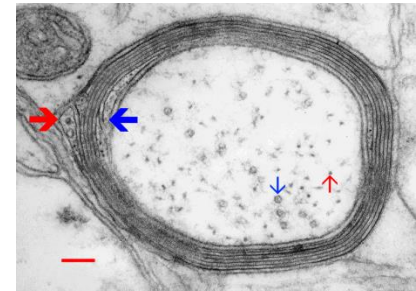
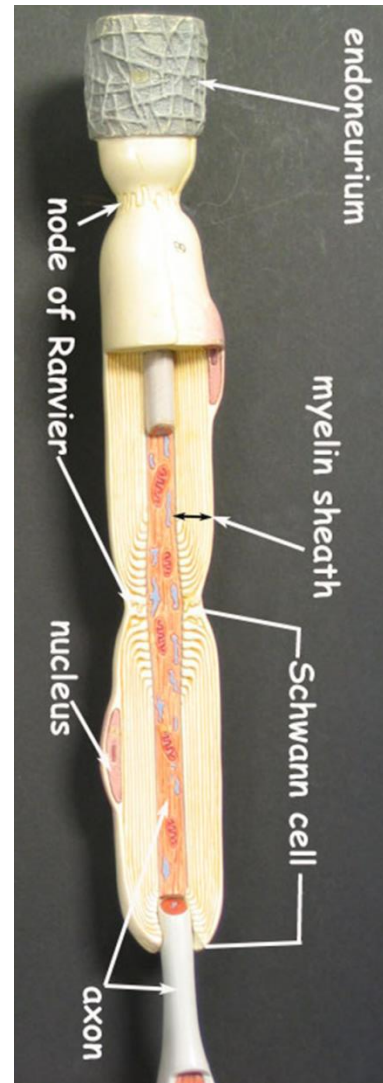
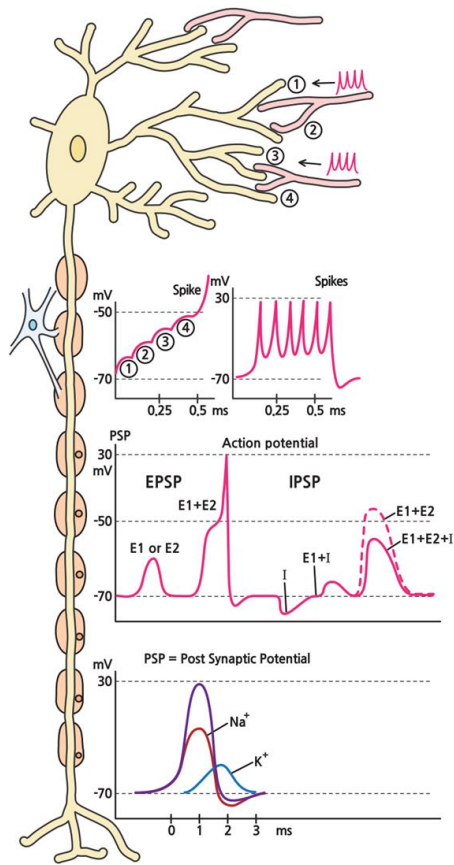
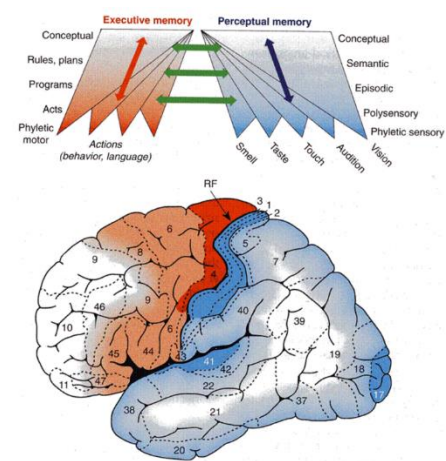
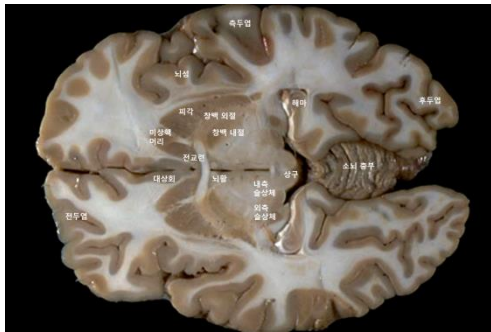
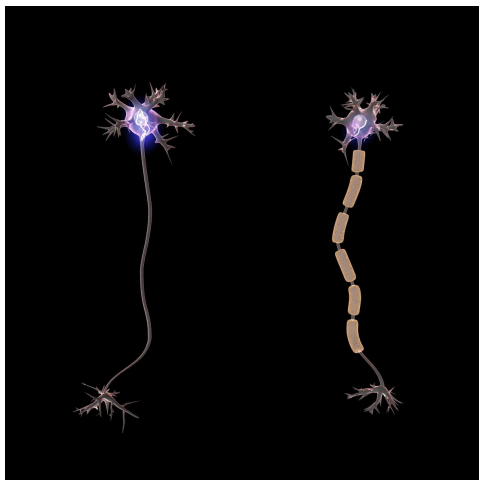


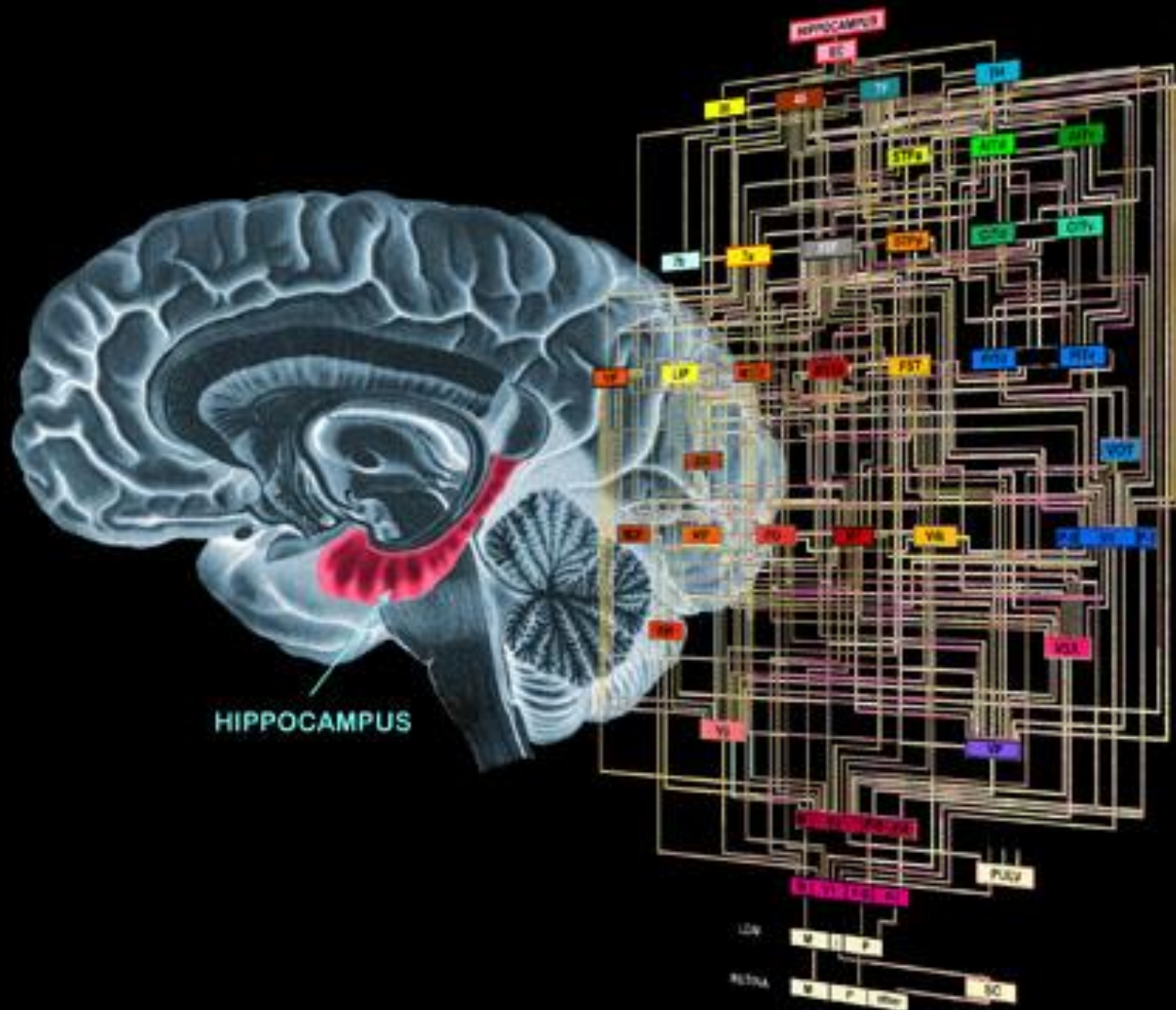


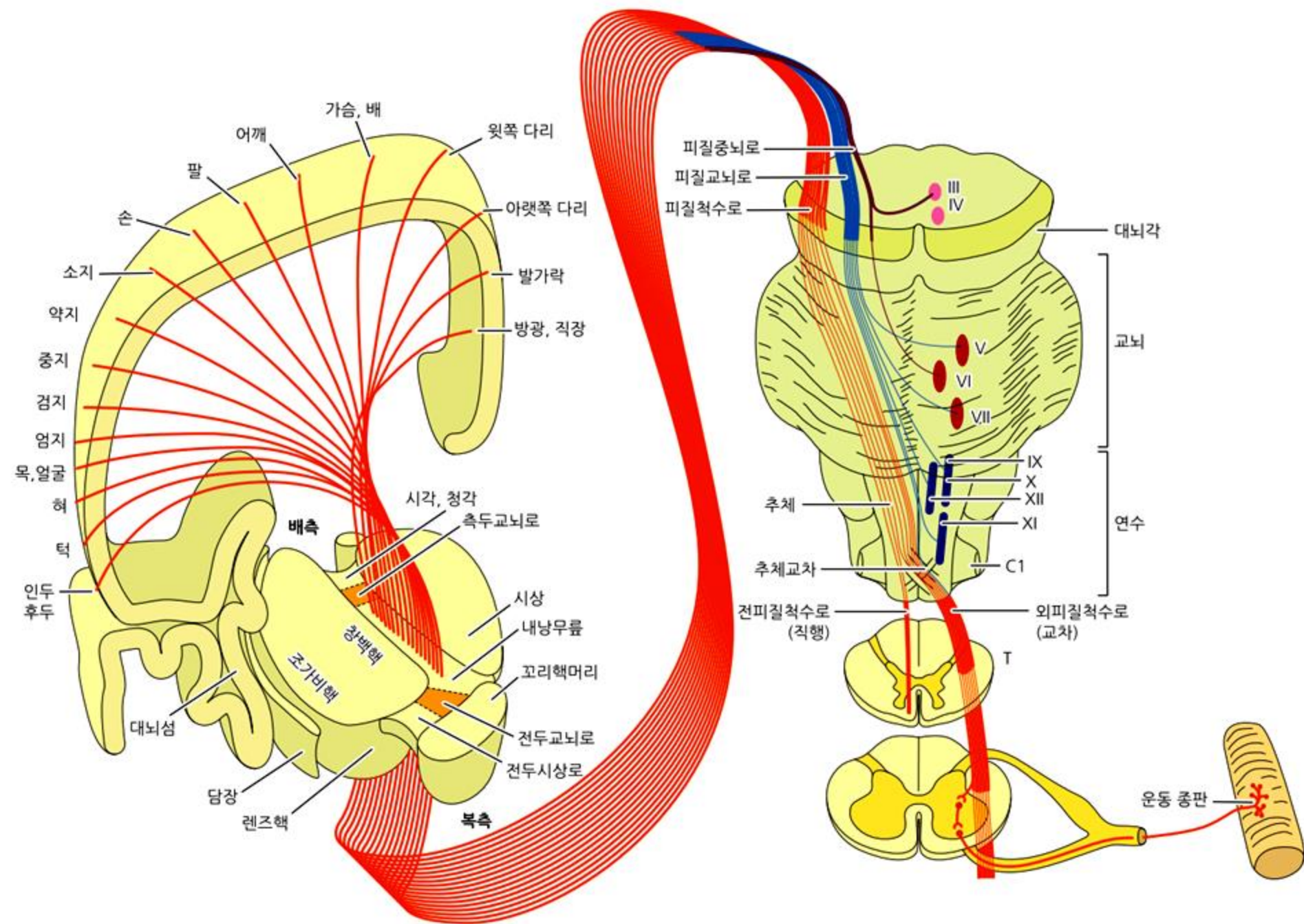
10 주 비숙아 → 87% REM



1 week baby







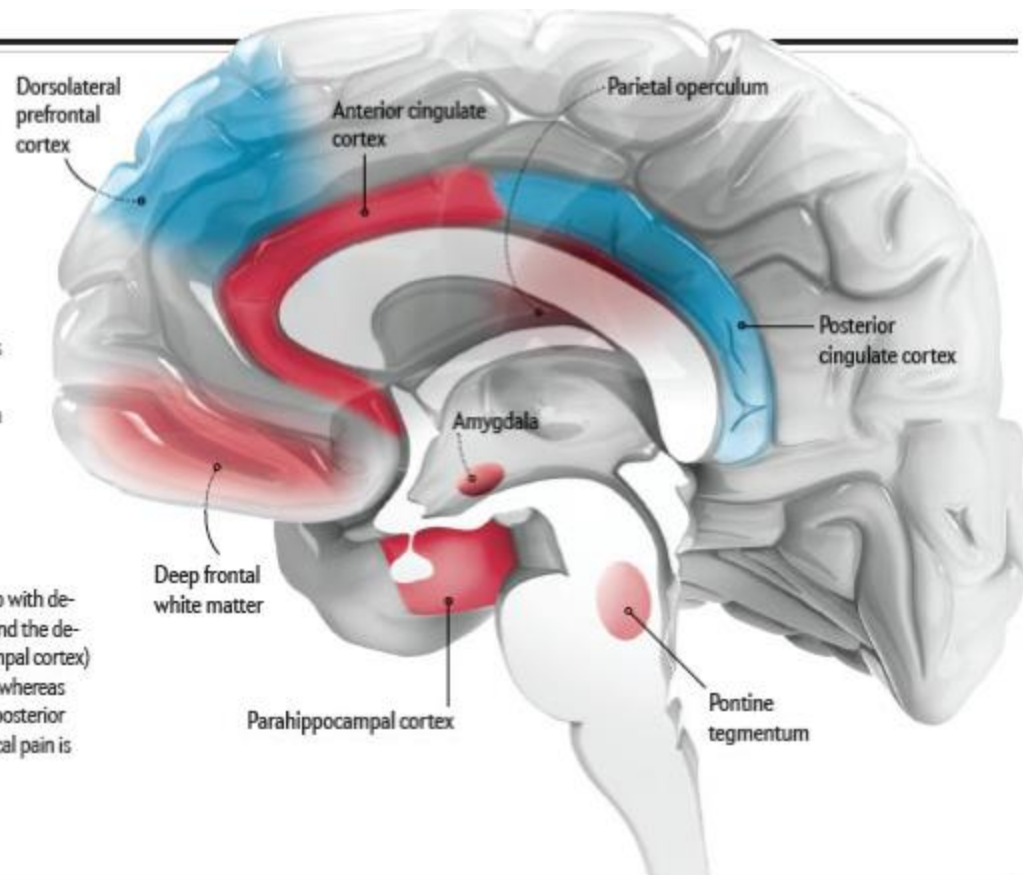
How Sleeping Brains Lie

Investigators have long believed that the human brain progresses through the admittedly complex stages of awareness in a well-coordinated manner (*right*). But recent studies (*below*) suggest that the patterns of neuronal activity during sleep are more haphazard than researchers once thought.

Regular Cycles

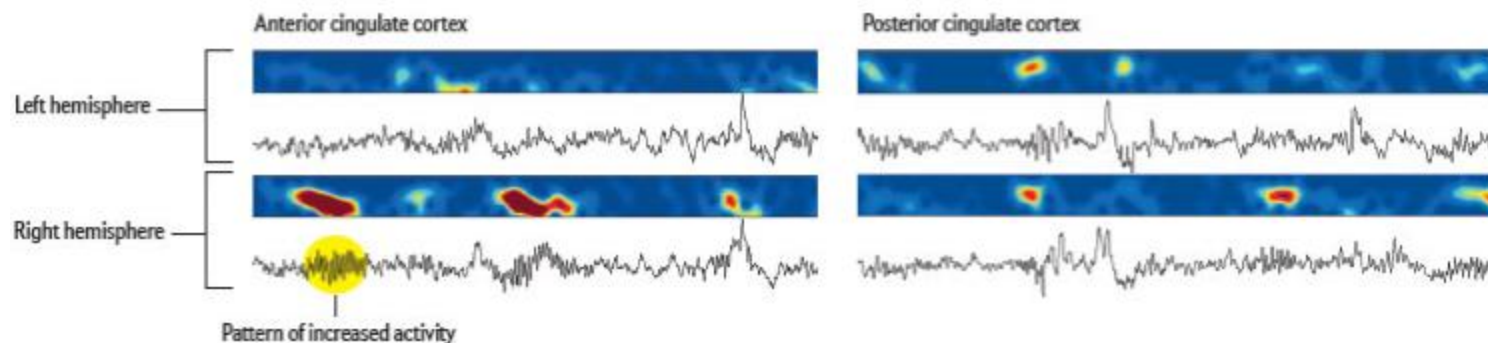
For unknown reasons, parts of the brain that help with detecting errors and conflicts (anterior cingulate) and the development of long-term memory (parahippocampal cortex) typically become more active during REM sleep, whereas the region that mediates the awareness of pain (posterior cingulate) becomes less active. As a result, physical pain is unusual in dreams experienced during REM.

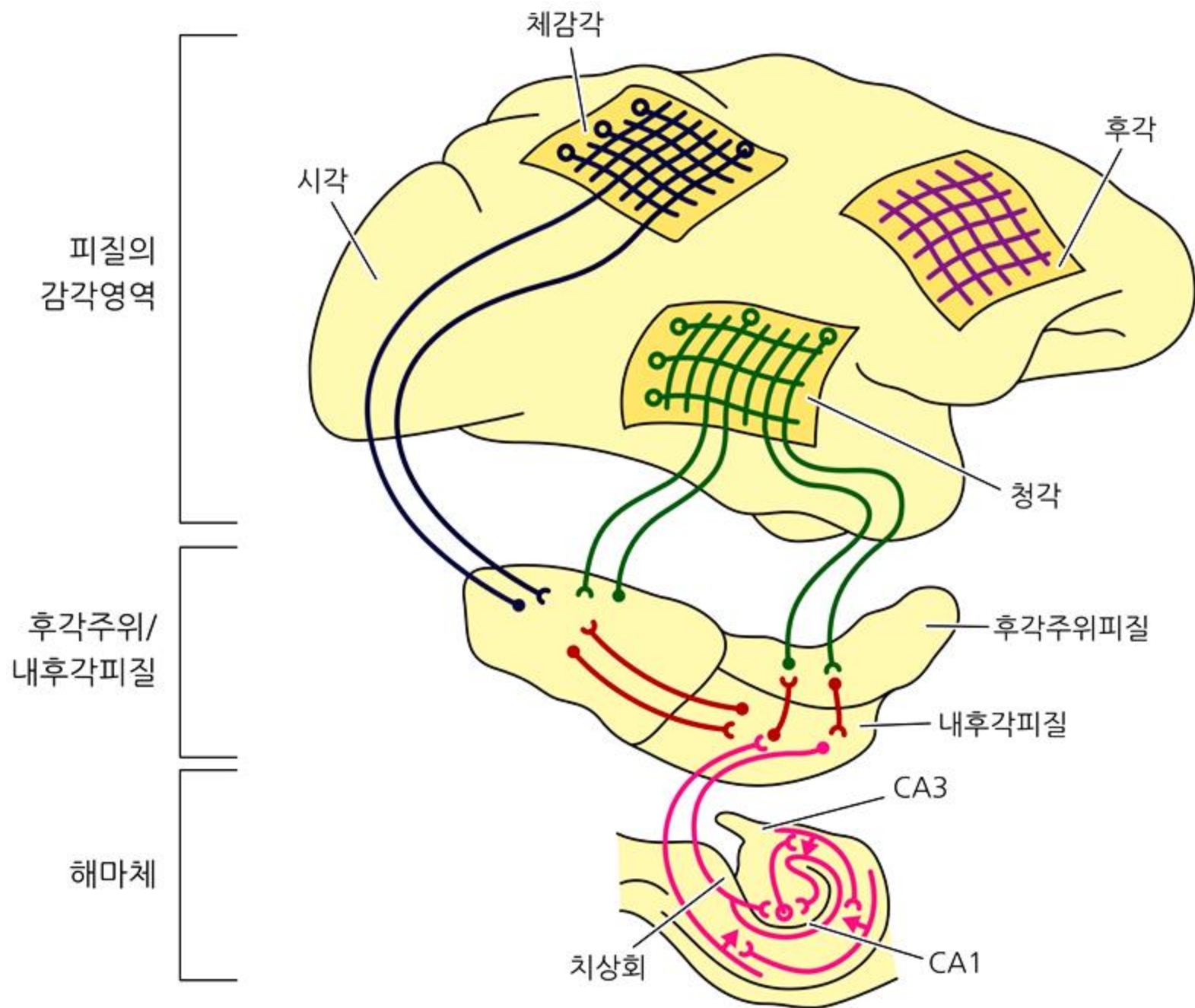
More active Less active

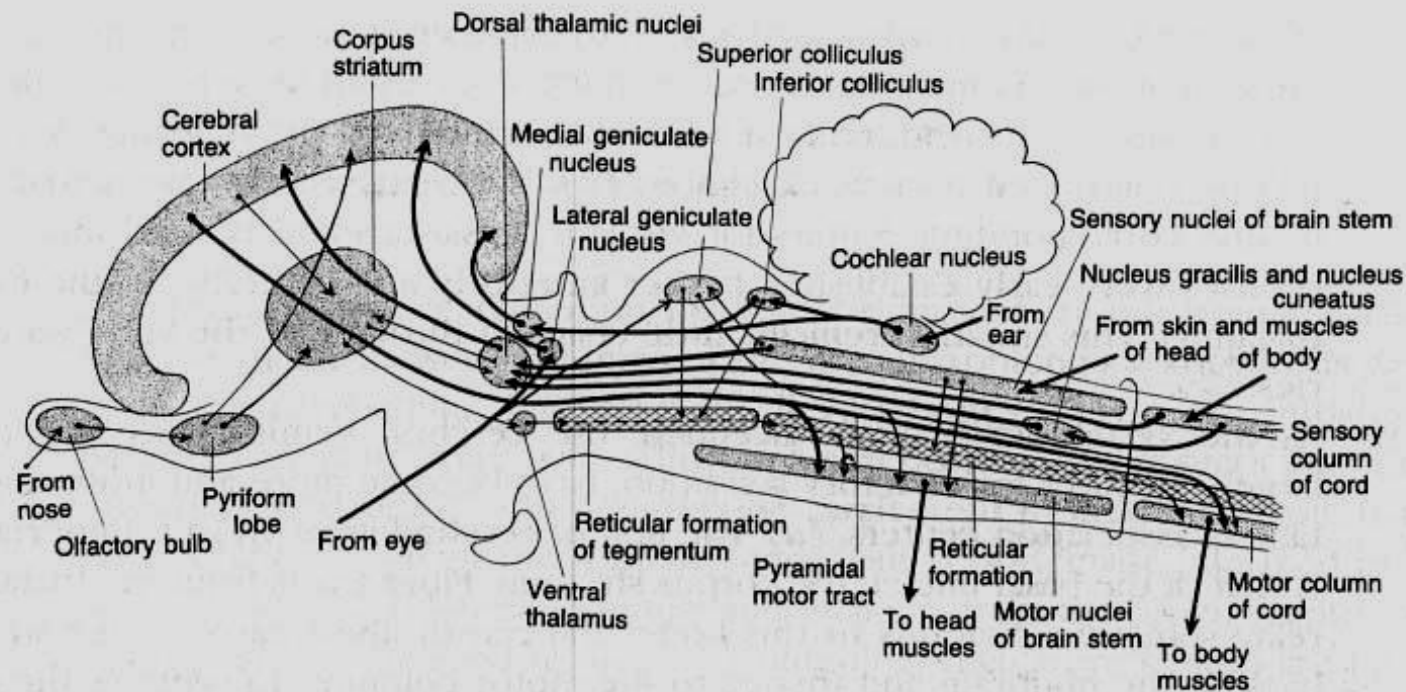
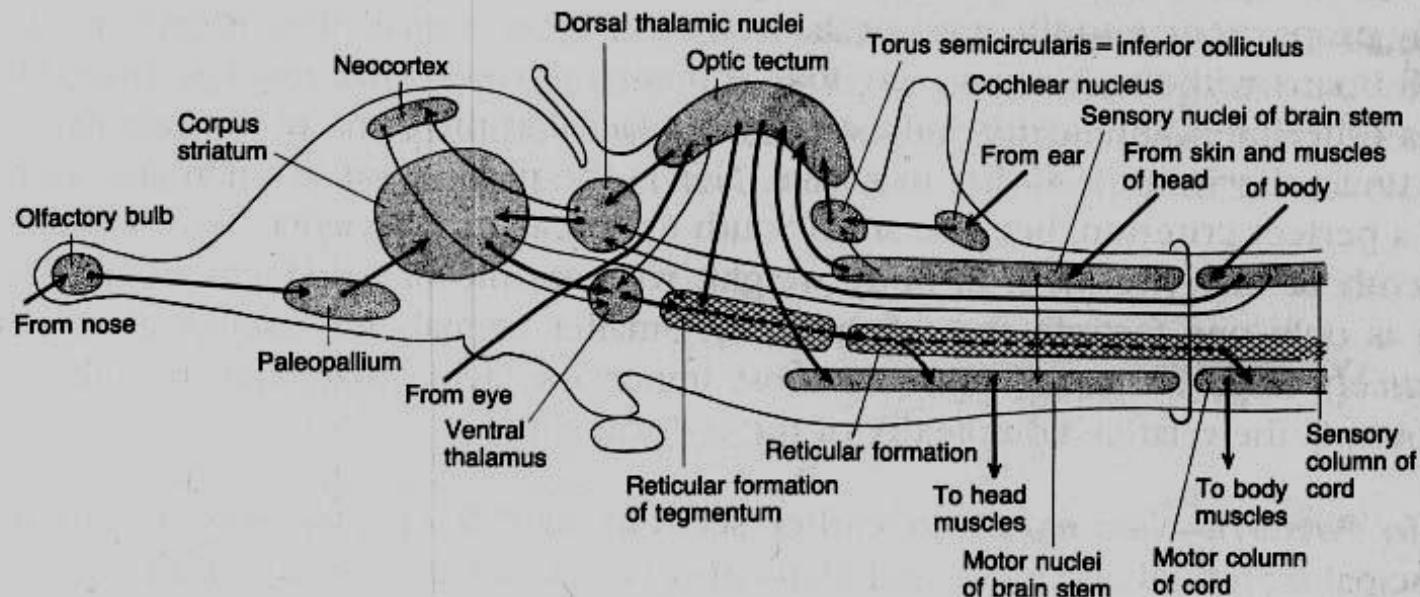


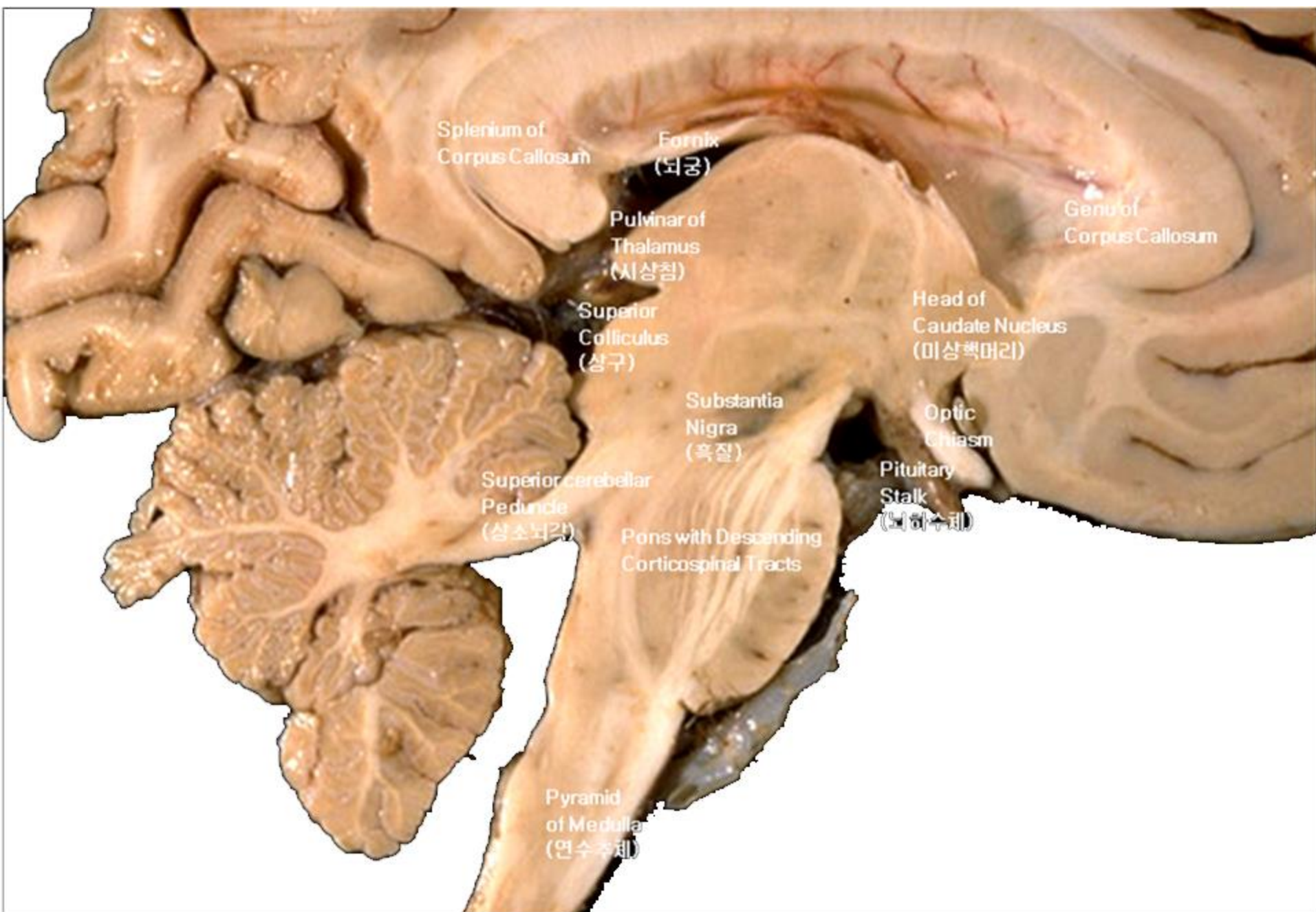
Irregular Activity

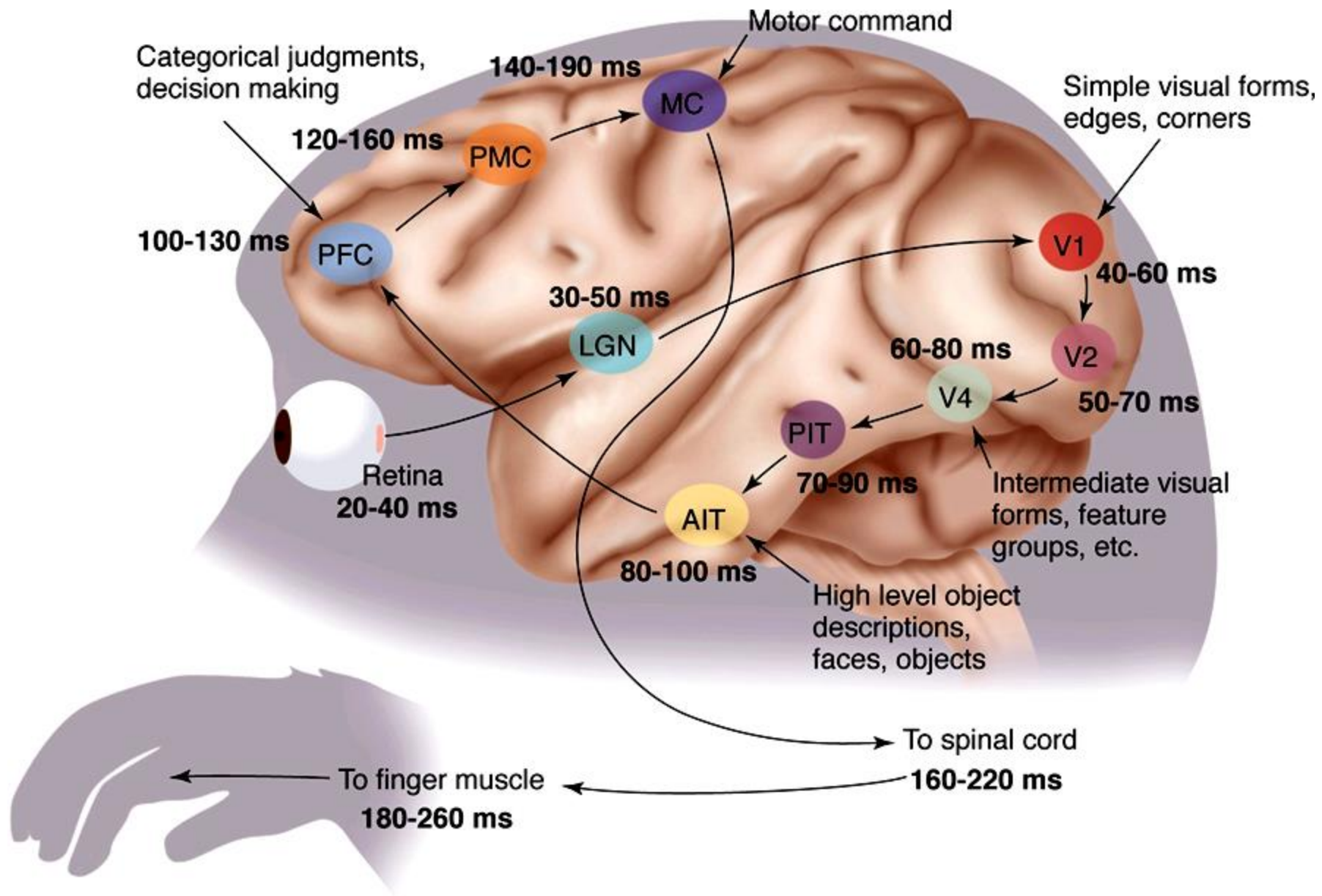
These EEG readings show that the left and right halves of the same parts of the cerebrum experience spurts of activity at different times during NREM sleep. Such evidence supports the hypothesis that the various regions of the brain do not fall asleep all at once or progress through the various stages of sleep in lockstep.

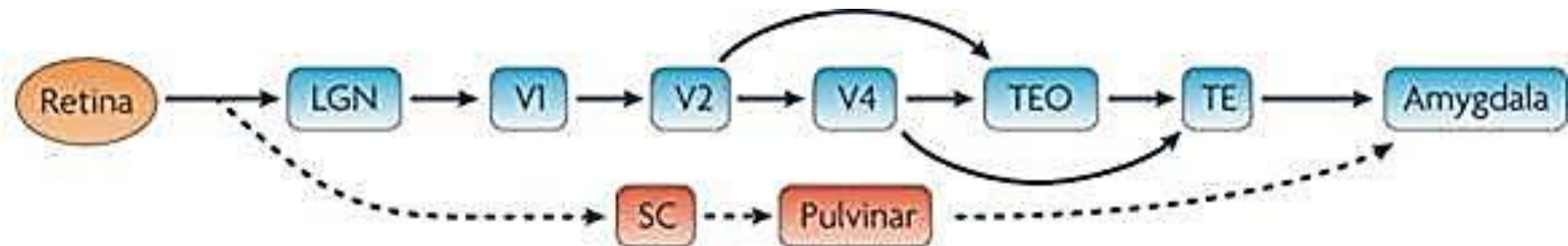
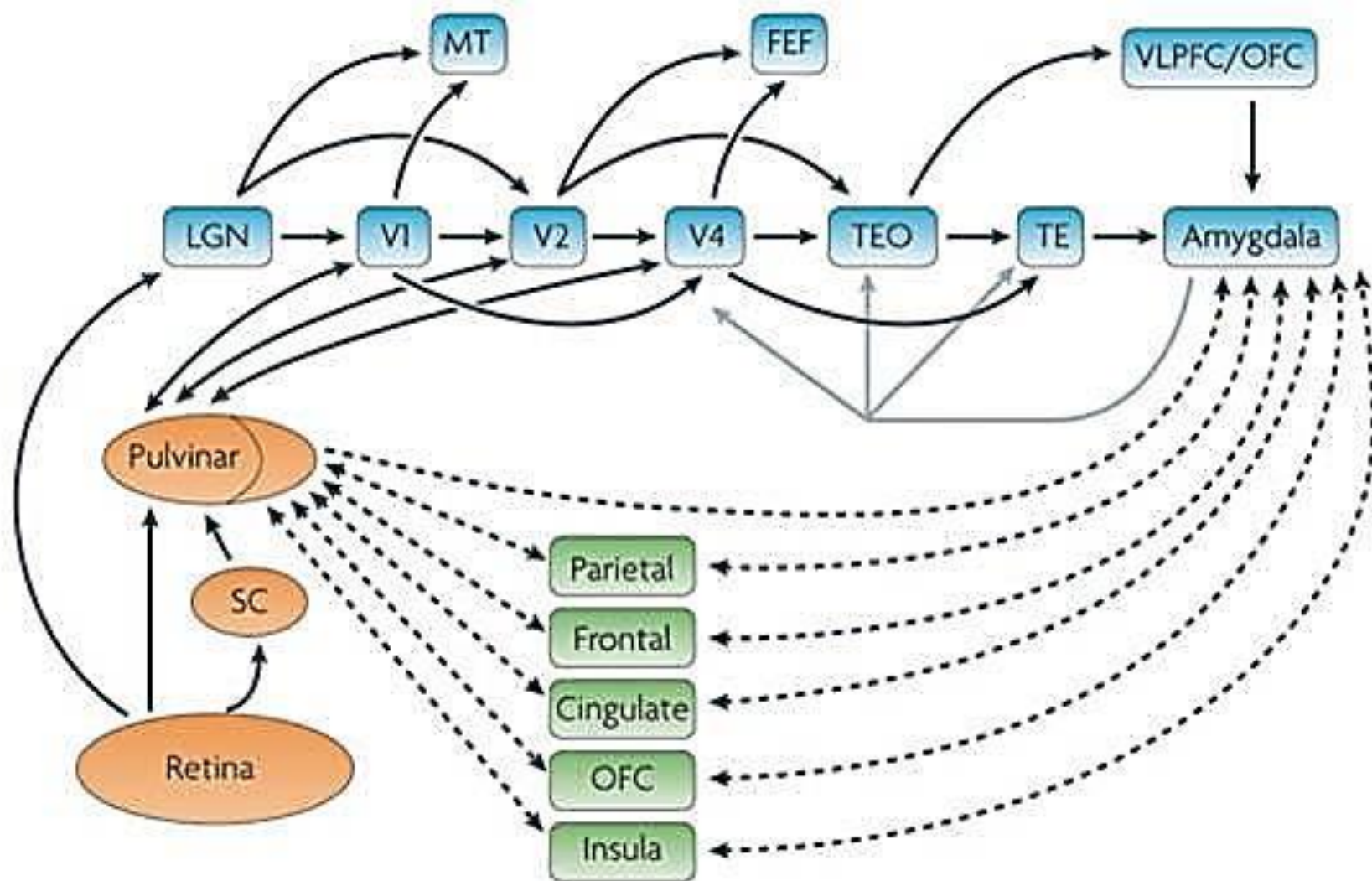


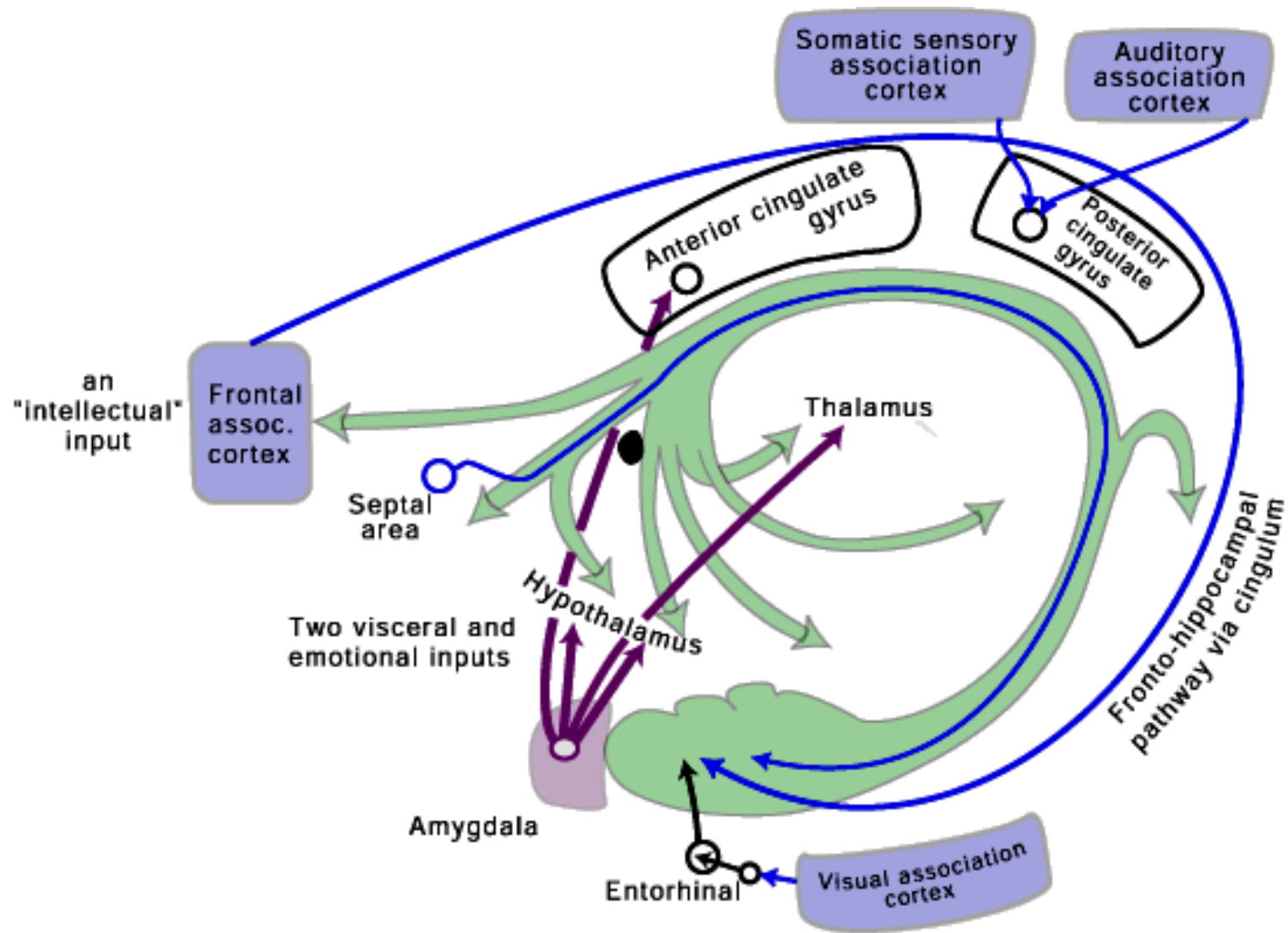


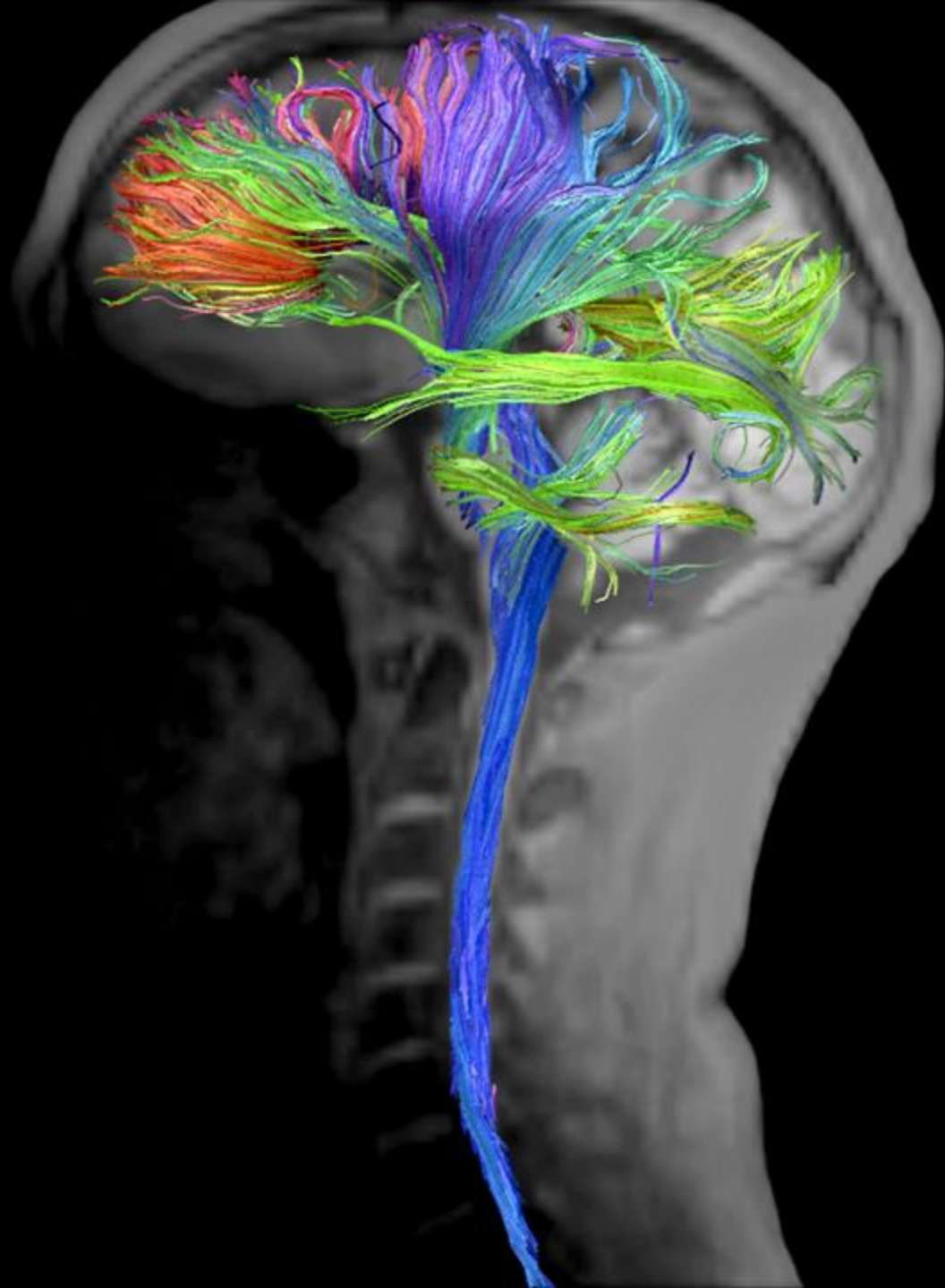


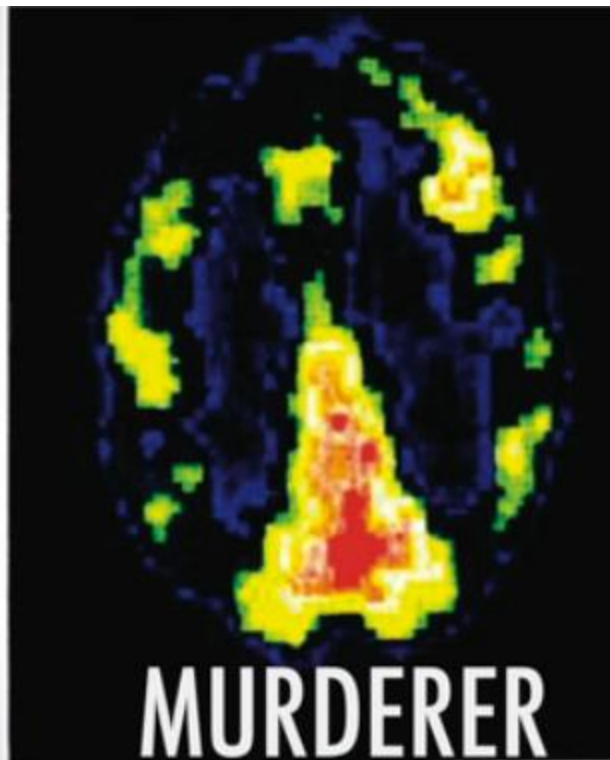
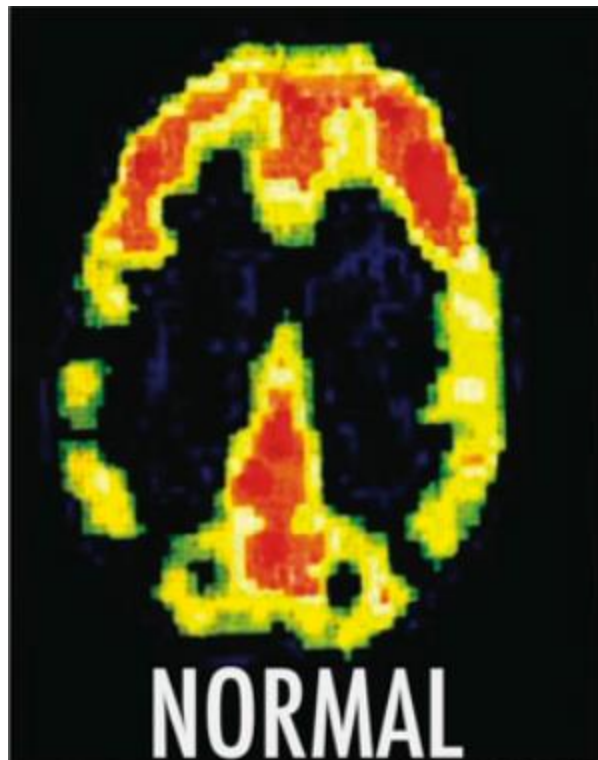




a**b**







Admissibility of brain scans in criminal trials

Wednesday, October 1, 2014

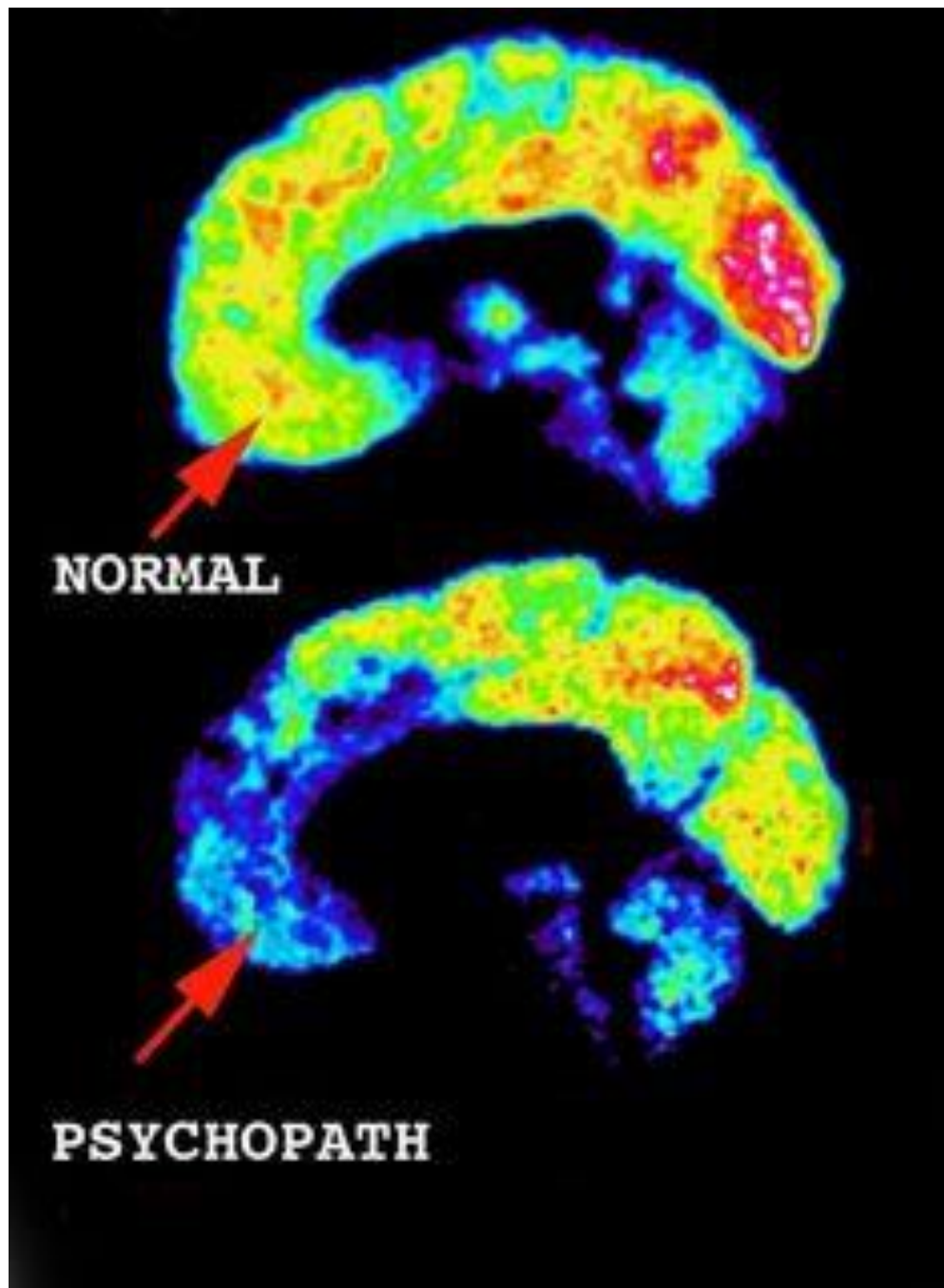
posted by Rita Handrich

brain normal or murdererIt's been a while since we've done an update on neurolaw issues and we think you'll want to read the entire article upon which this post is based.

The article is published in Court Review: Journal of the American Judges Association (which is probably a journal you would benefit from perusing regularly).

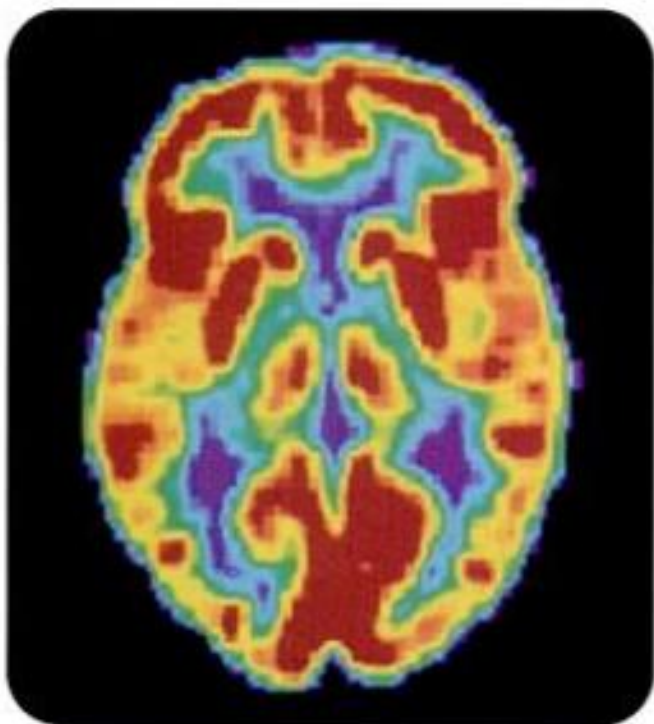
The article (authored by a psychiatry professor with both MD and JD degrees) offers a review of past courtroom use of the Positive Emission Tomography (commonly referred to as a PET scan) and their potential admissibility for criminal trials.

This is obviously a very contentious topic but one that is essential for trial advocates to monitor. Here are just a few of the thoughts on (past and future) admissibility of the PET Scan that Dr. Rushing offers to the judges for whom the journal is written.

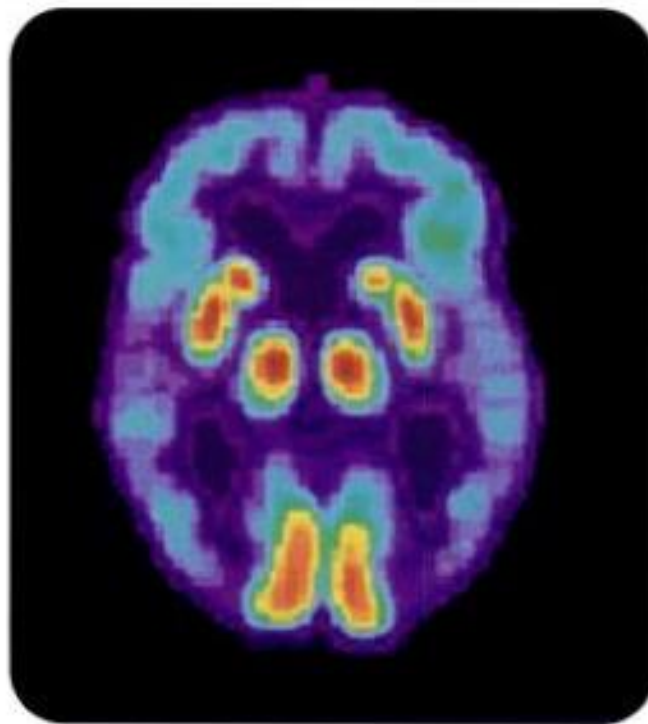


Life as a Nonviolent
Psychopath
Neuroscientist James Fallon
discovered through his work
that he has the brain of a
psychopath, and
subsequently learned a lot
about the role of genes in
personality and how his
brain affects his life.

Life as a Nonviolent
Psychopath
theatlantic.com

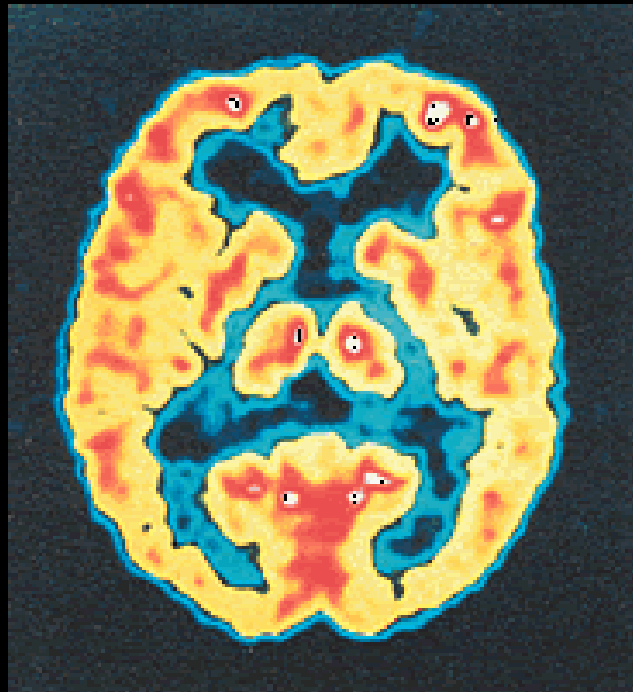


PET Scan of Normal Brain

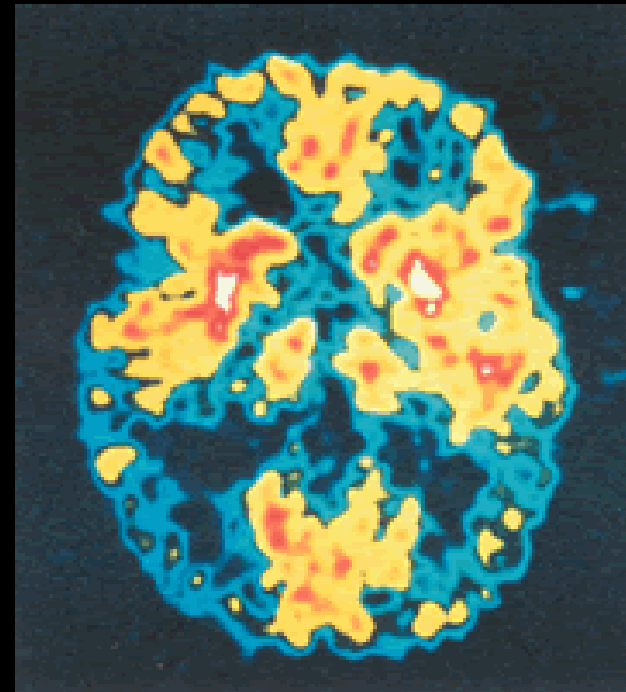


PET Scan of Alzheimer's Disease Brain

BRAIN SCANS HELP IDENTIFY ALZHEIMER'S



NORMAL

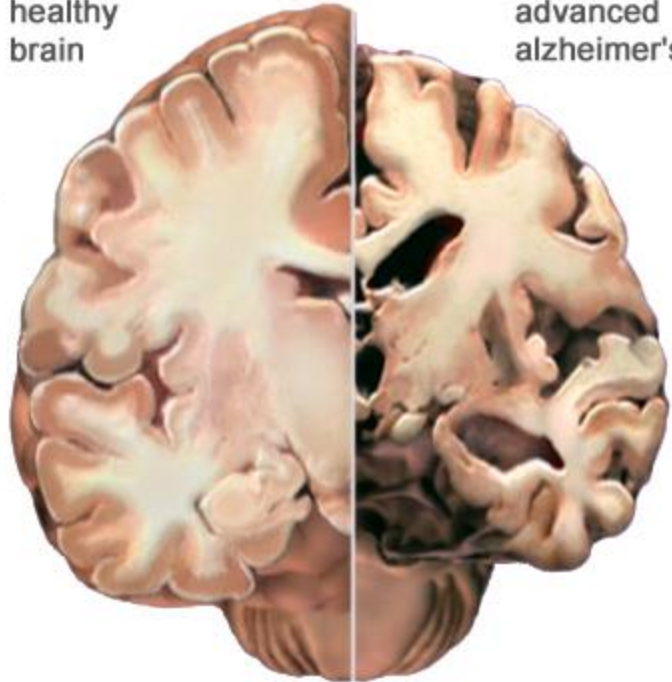


ALZHEIMER'S

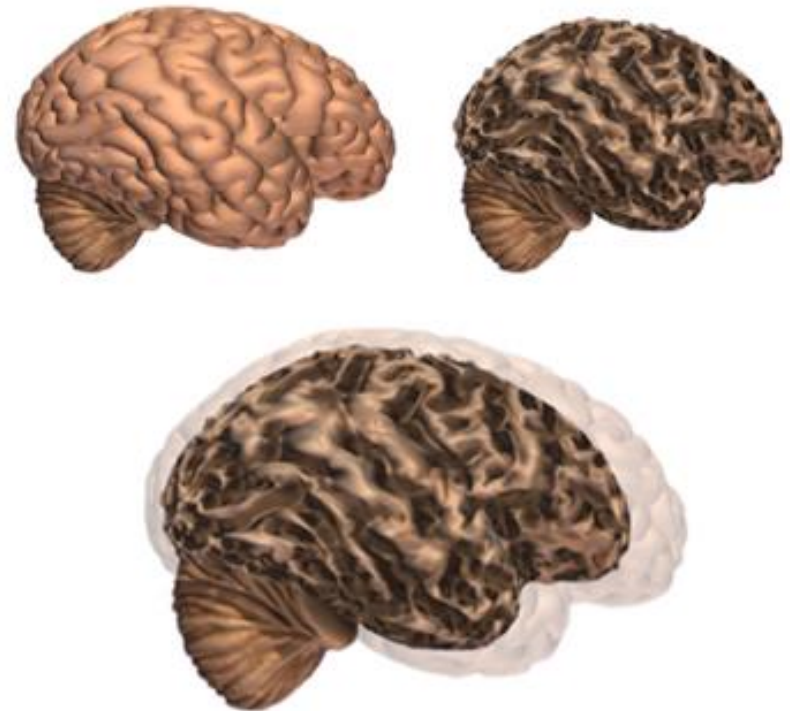
Brain scans done with Positron Emission Tomography (PET) show how Alzheimer's affects brain activity. The left image shows a normal brain, while the right is from a person with Alzheimer's. The blue and black areas in the right image indicate reduced brain activity resulting from the disease.

Images courtesy of Alzheimer's Disease Education and Referral Center, National Institute on Aging

healthy
brain

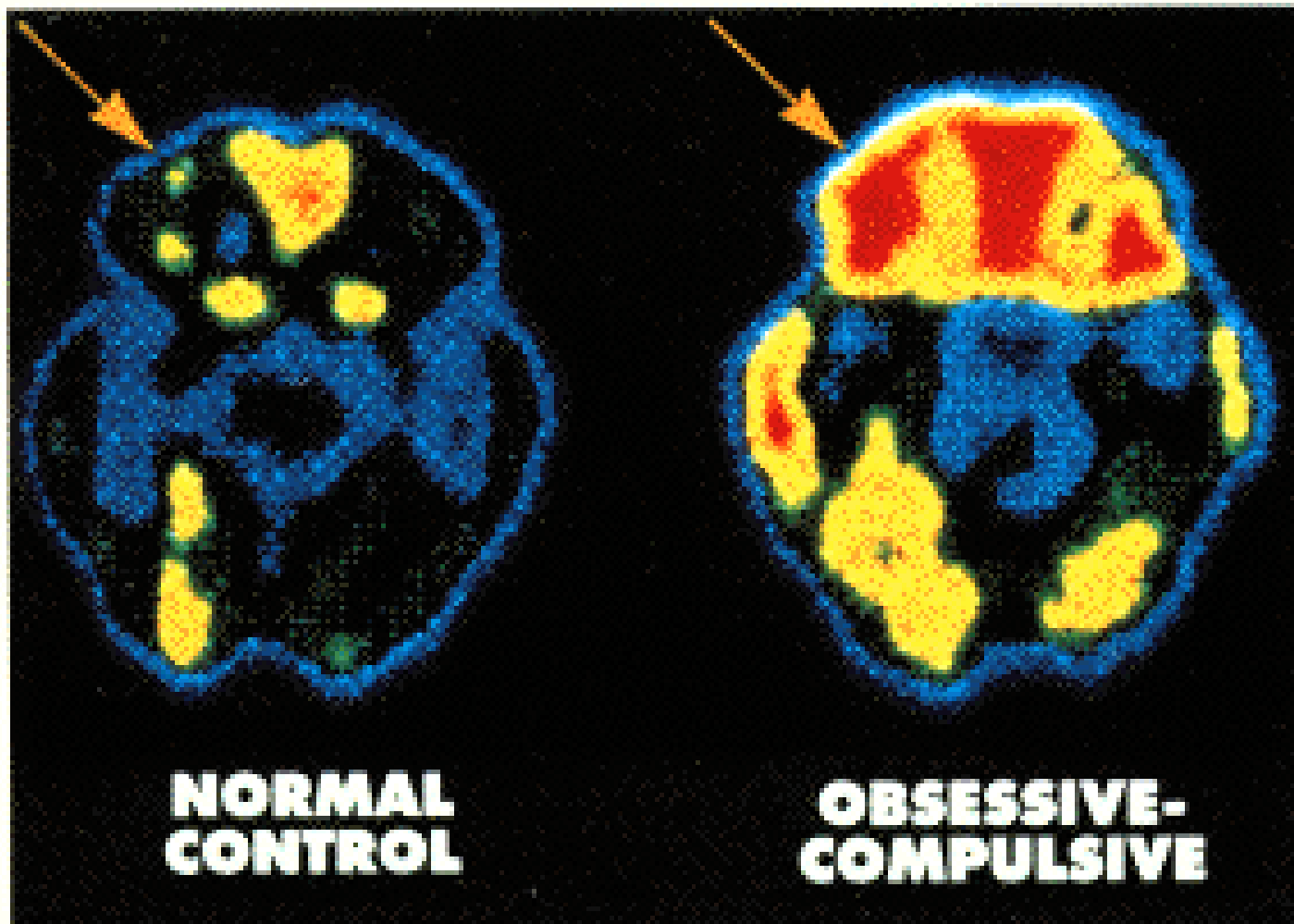


advanced
alzheimer's



Alzheimer's changes the whole brain
[PREVIOUS](#)[NEXT](#)

Comparative illustration of a brain with Alzheimer's versus a healthy brain. Alzheimer's disease leads to nerve cell death and tissue loss throughout the brain. Over time, the brain shrinks dramatically, affecting nearly all its functions.



**HIGH ENERGY USE IN THE BRAIN
OF A TYPICAL PERSON WITH OCD**

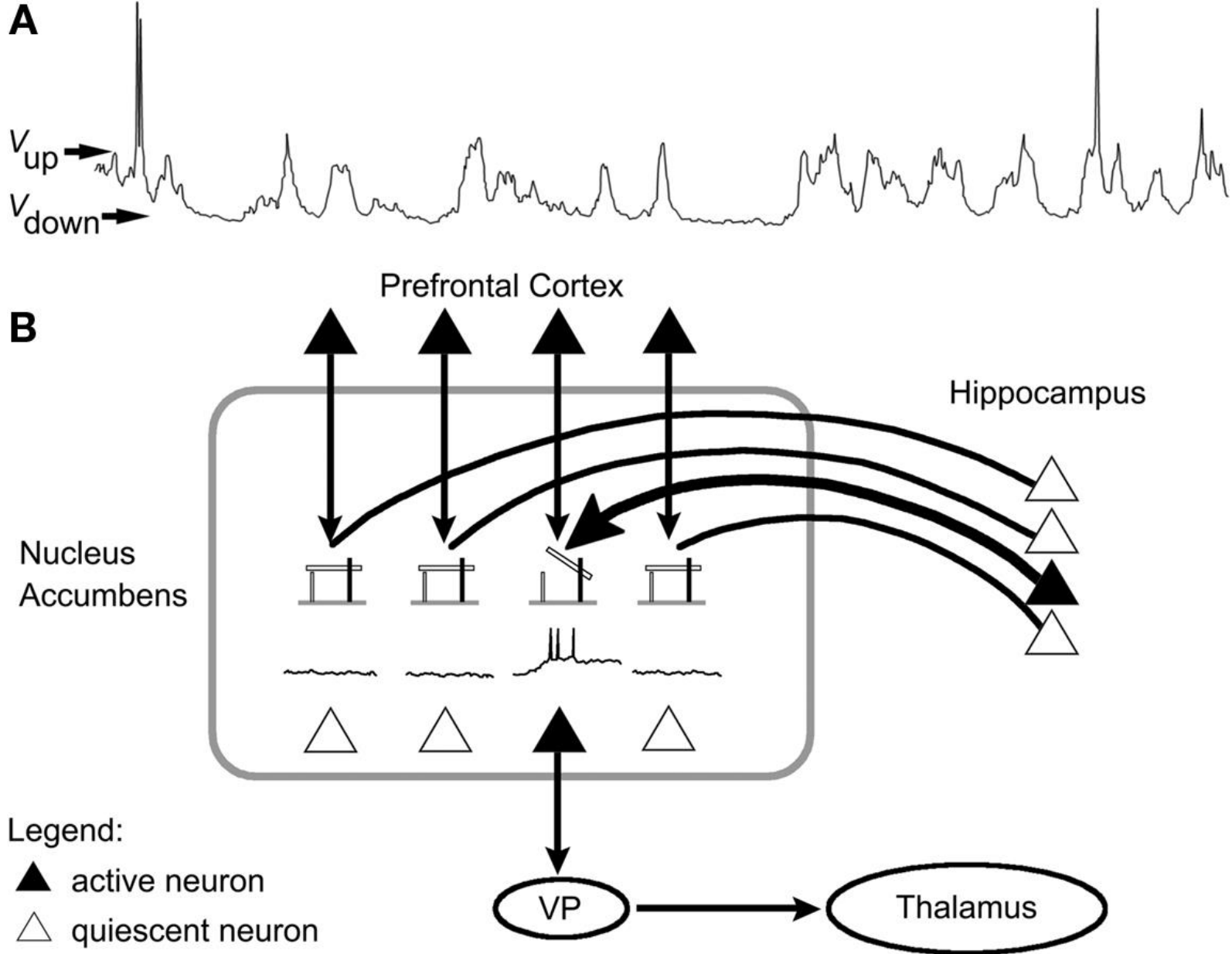
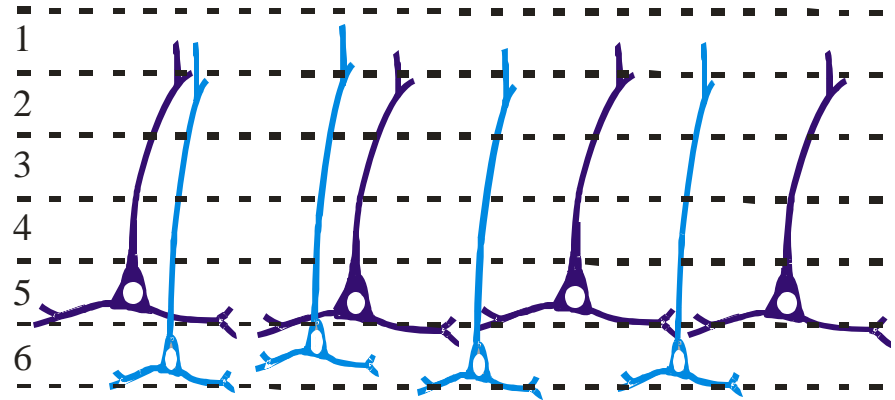
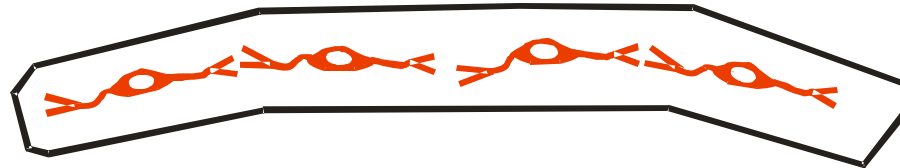


Figure 1. Hippocampus gating of information flow from the prefrontal cortex via modulation of nucleus accumbens neuronal activity. (A) Recording of the membrane potential of a Nacc neuron showing oscillations between a quiescent “down” state (V_{down} membrane potential) and a firing “up” state (V_{up} membrane potential). (B) Projections from the hippocampus and the prefrontal cortex converge onto Nacc neurons, which in turn project on the ventral pallidum, which itself sends projections onto the thalamus. Hippocampus input appears to shift Nacc neurons from their down to their up state, thus efficiently gating prefrontal input to the Nacc (modified with permission from [Grace, 2000](#)). VP: ventral pallidum.

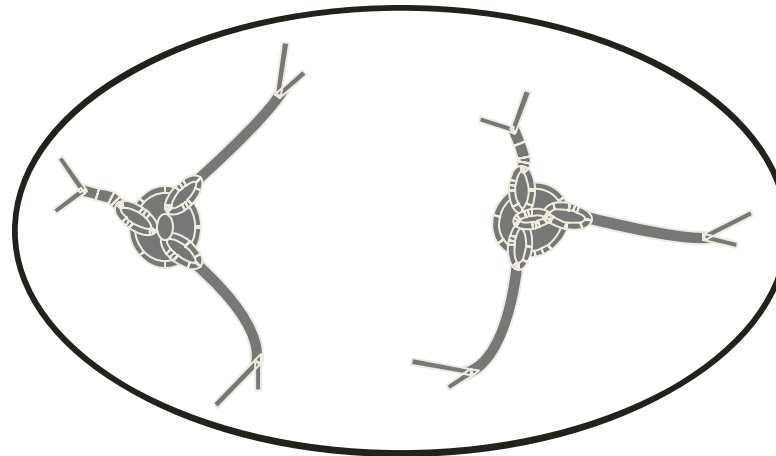
Cortex



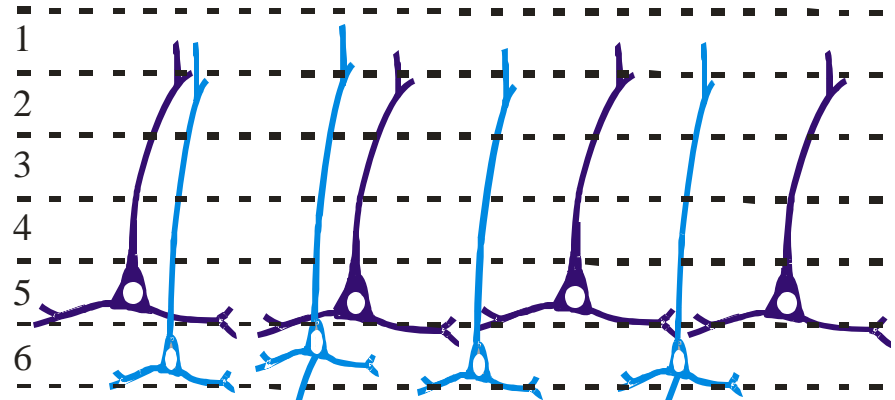
TRN



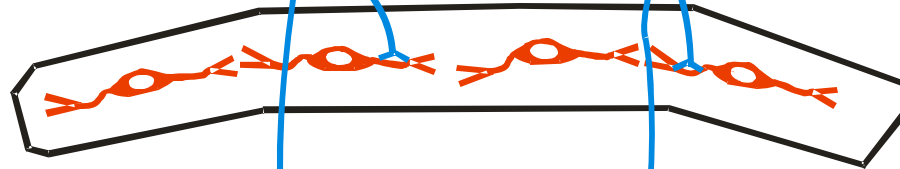
Thalamus



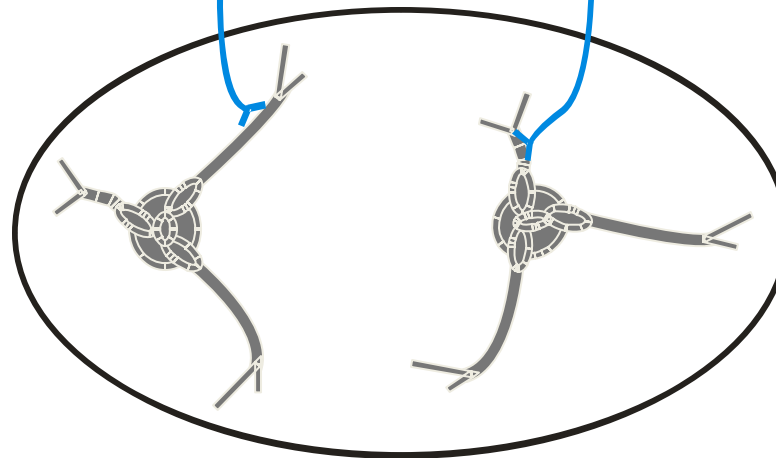
Cortex



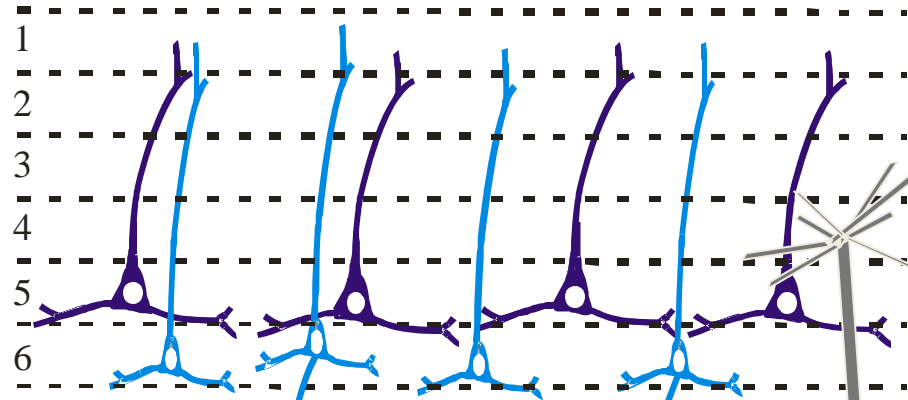
TRN



Thalamus

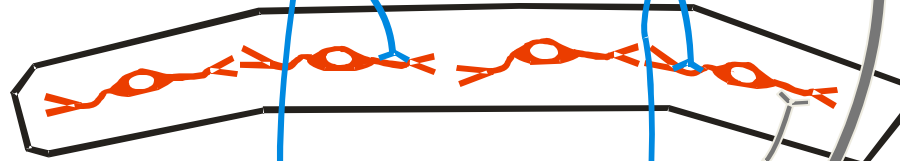


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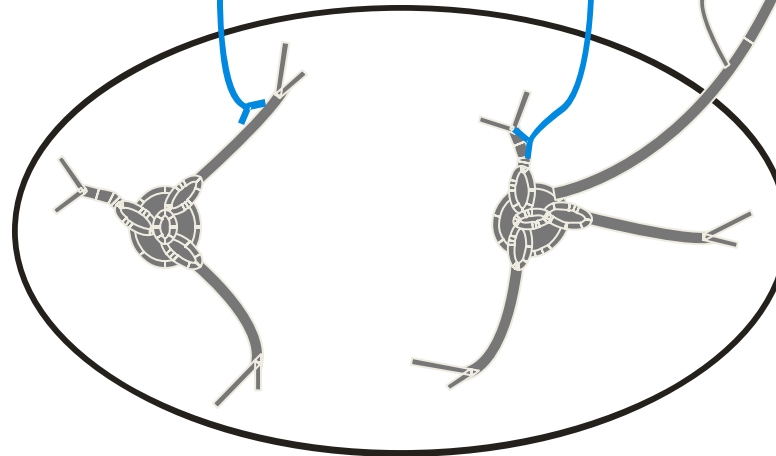


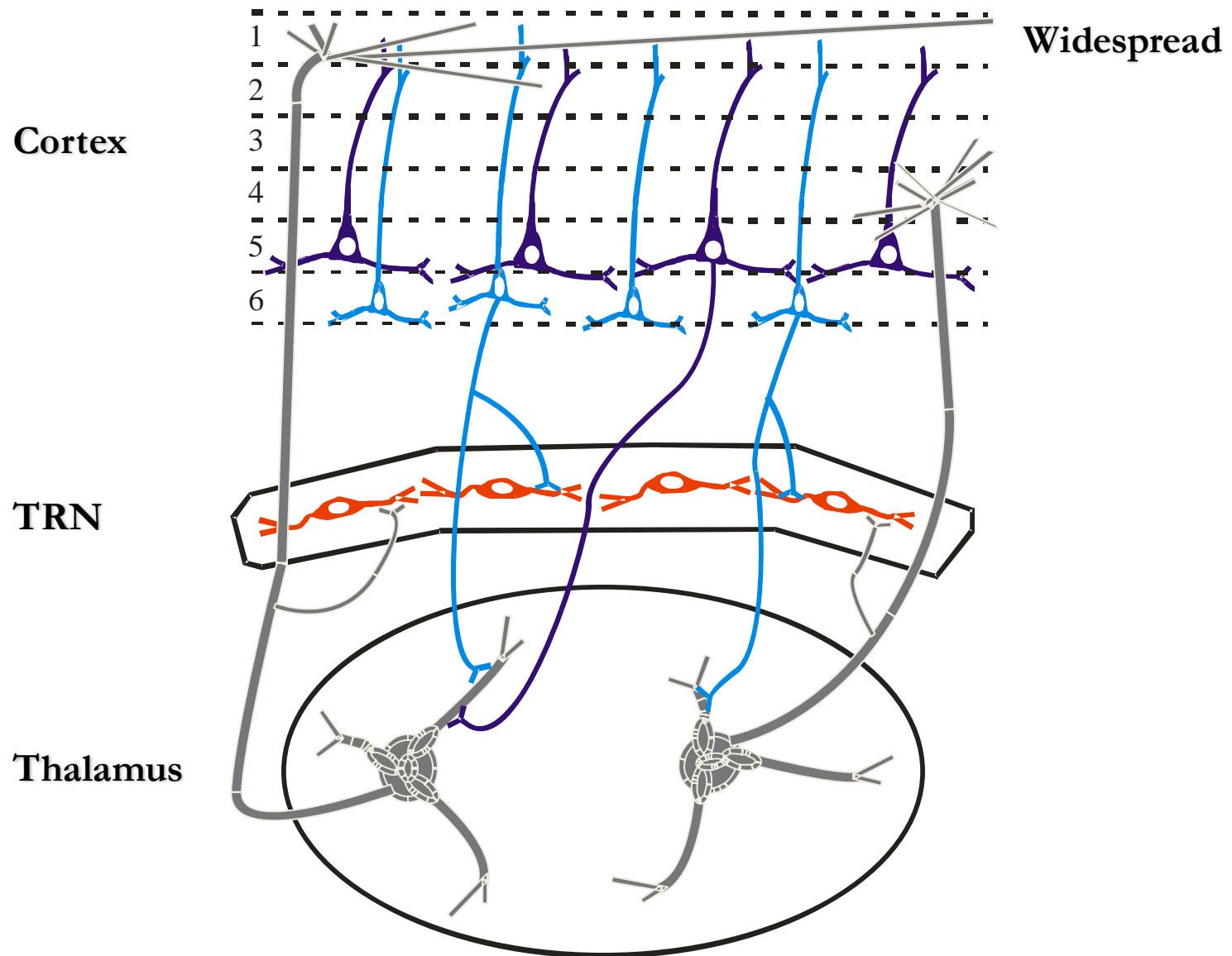
Focal

TRN

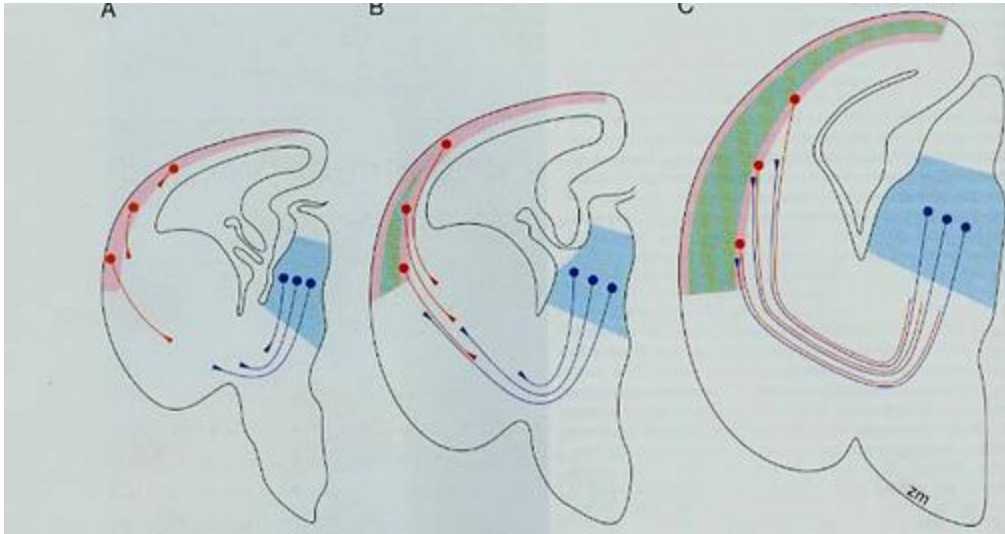


Thalamus





Projections from preplate guide thalamocortical fibers

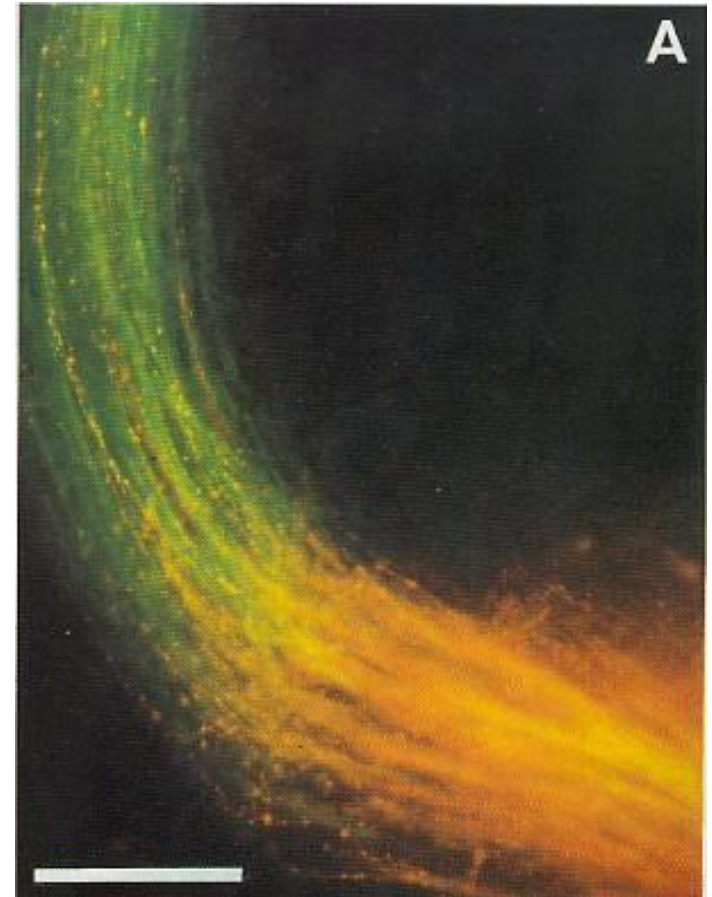


Top: Preplate cells send out their axons towards the internal capsule (red). Thalamic axons project through the IC and meet cortical axons.

Right: Handshake between thalamic and preplate axons and precise topography of early thalamocortical projections

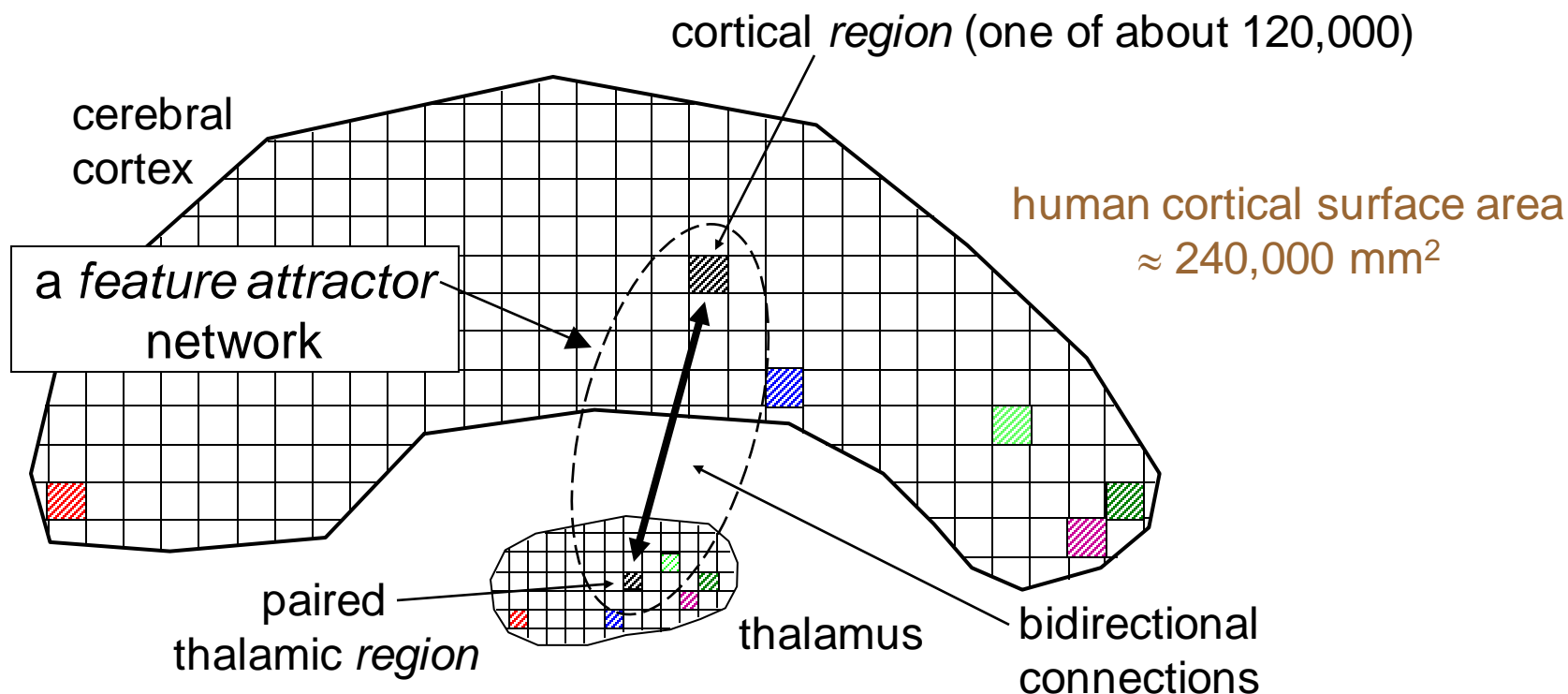
Note:

Axons travel together (fasciculation)
Axons use preexisting projections
Guidepost cells show the way



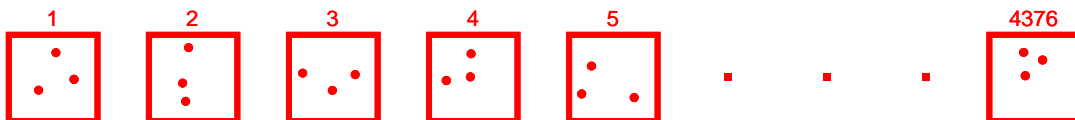
Feature Attractor Neuronal Networks

Each Feature Attractor Network Implements one 'Column' of Tokens



Each region encompasses a cortical surface area of roughly 2 mm^2 and possesses a total of about 200,000 neurons.

An *object* (sensory, abstract, etc.) or *action* (movement process, thought process, etc.) is represented by a collection of feature attractor tokens, each expressing a single *token* (node) from its *lexicon*.



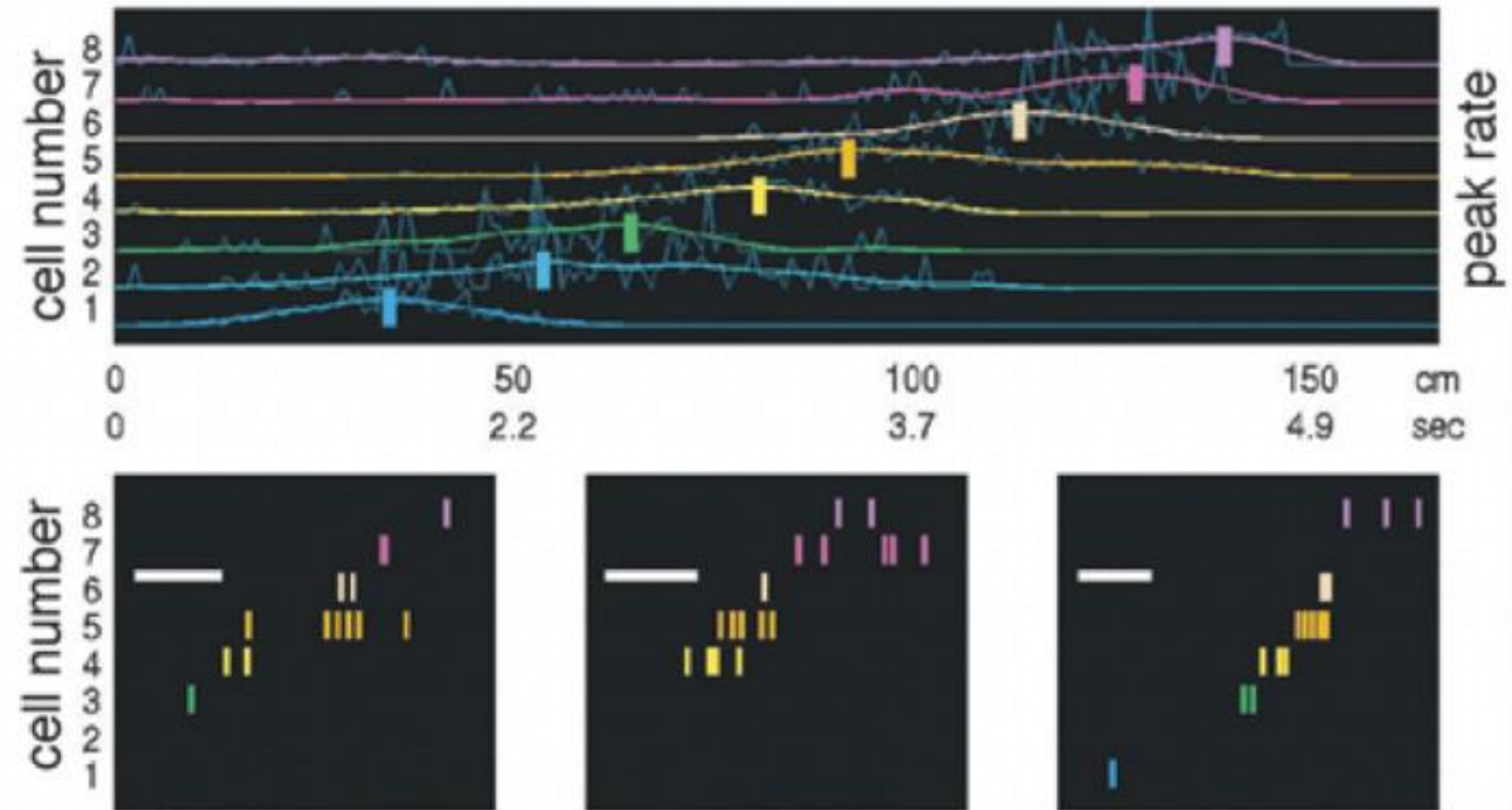
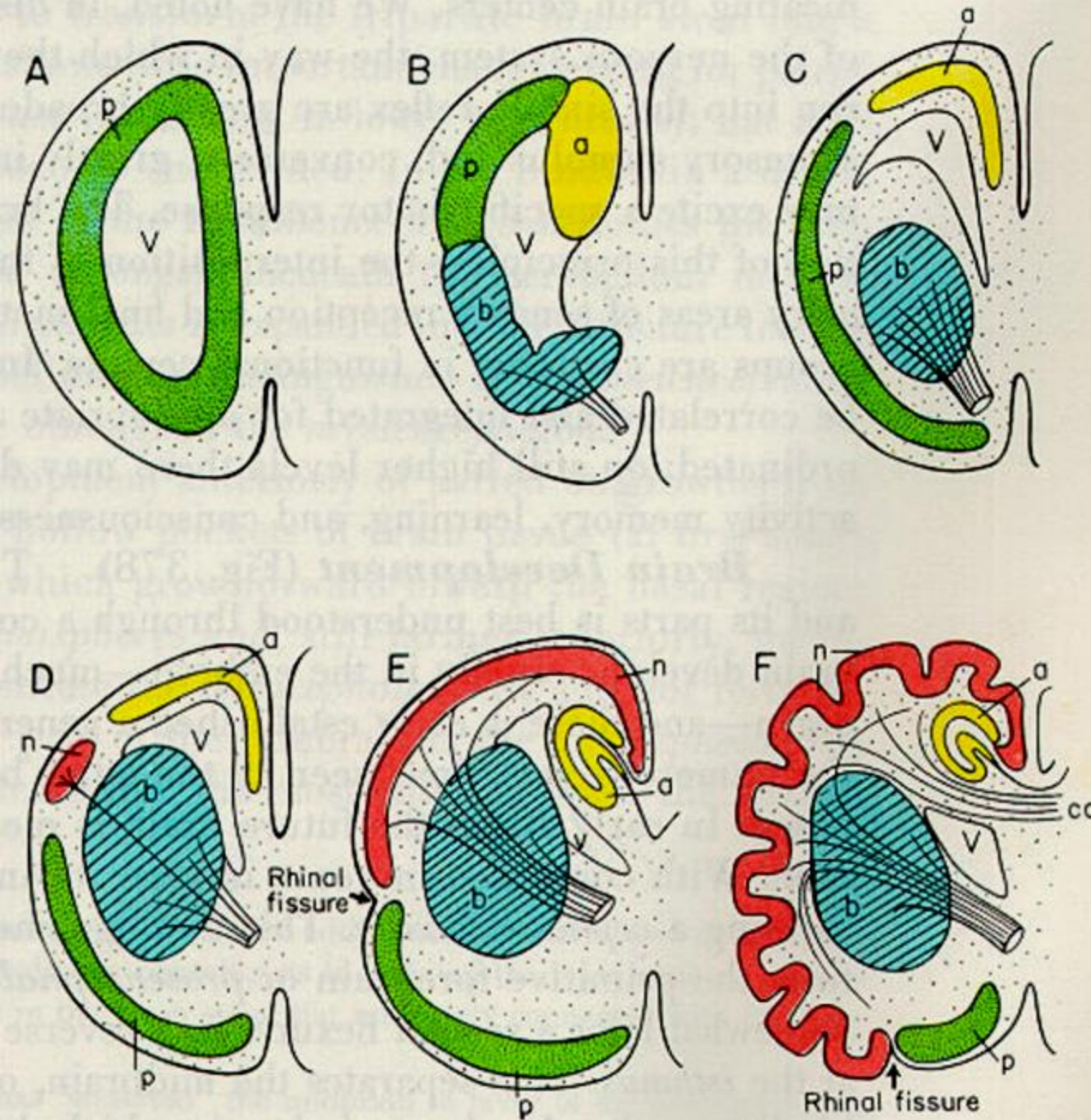


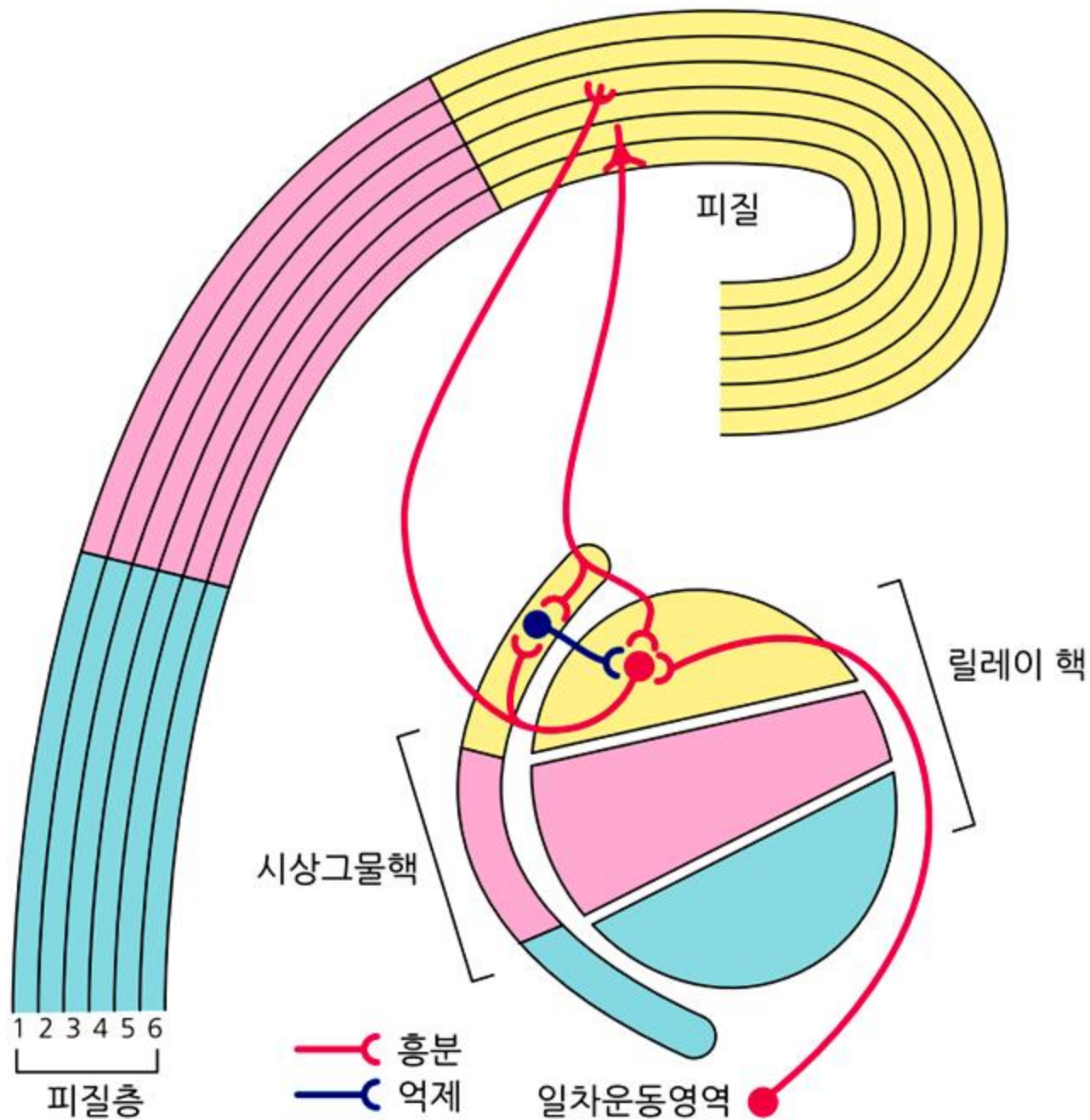
Figure 7: Time-compressed *off-line* replay of learned neural patterns. Replay of waking assembly sequences during sleep. Smoothed place fields (colored lines) of 8 place cells during runs from left to right on a track (average of 30 trials). Vertical bars mark the positions of the normalized peaks of the smoothed fields. Non-uniform time axis below shows time within average lap when above positions were passed. Bottom panels, three SPW-R-related sequences from slow wave sleep after the waking session. Note similar sequences during SPW-Rs and run. Note also difference in timescale. Bar = 50 ms. Modified after Lee and Wilson (2002).

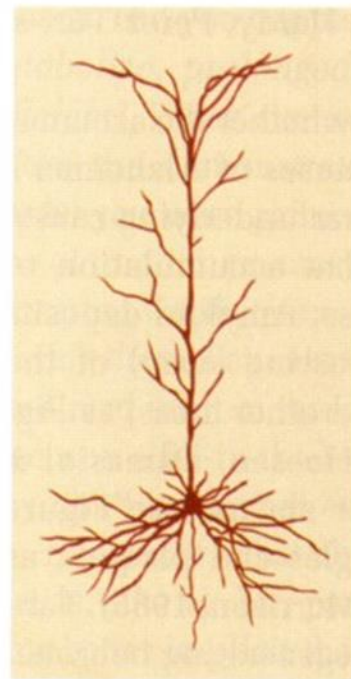


hemispheres, and the archicortex towards the midline.

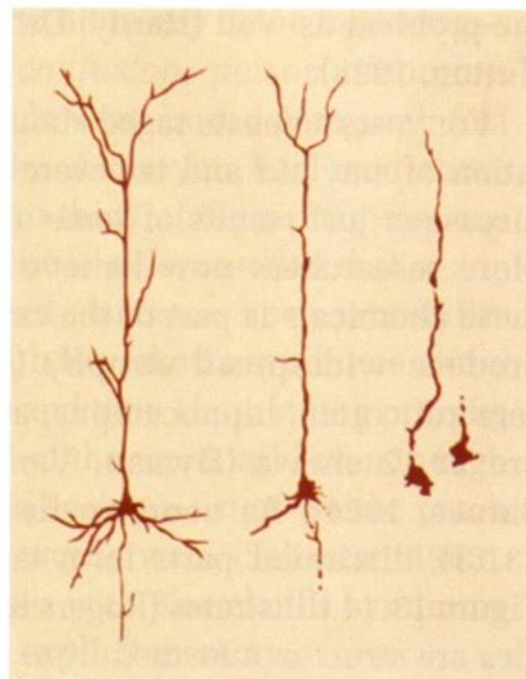
As these cortices expand, they move from the primitive position near to the ventricle, to a more superficial position, overgrowing the ventral **basal ganglia** (b), which are motor control areas. Axon tracts growing to and from the neocortex traverse the basal ganglia giving them a striated appearance (and hence the name *corpora striata*) (ganglion = a definable cluster of nerve cells).

Further expansion in advanced mammals, throws the neocortex into folds (*gyri*) and grooves (*sulci*). Right & left neocortices are linked by fibres (axons) crossing between corresponding points, to form the *corpus callosum* (cc). (v = ventricle).





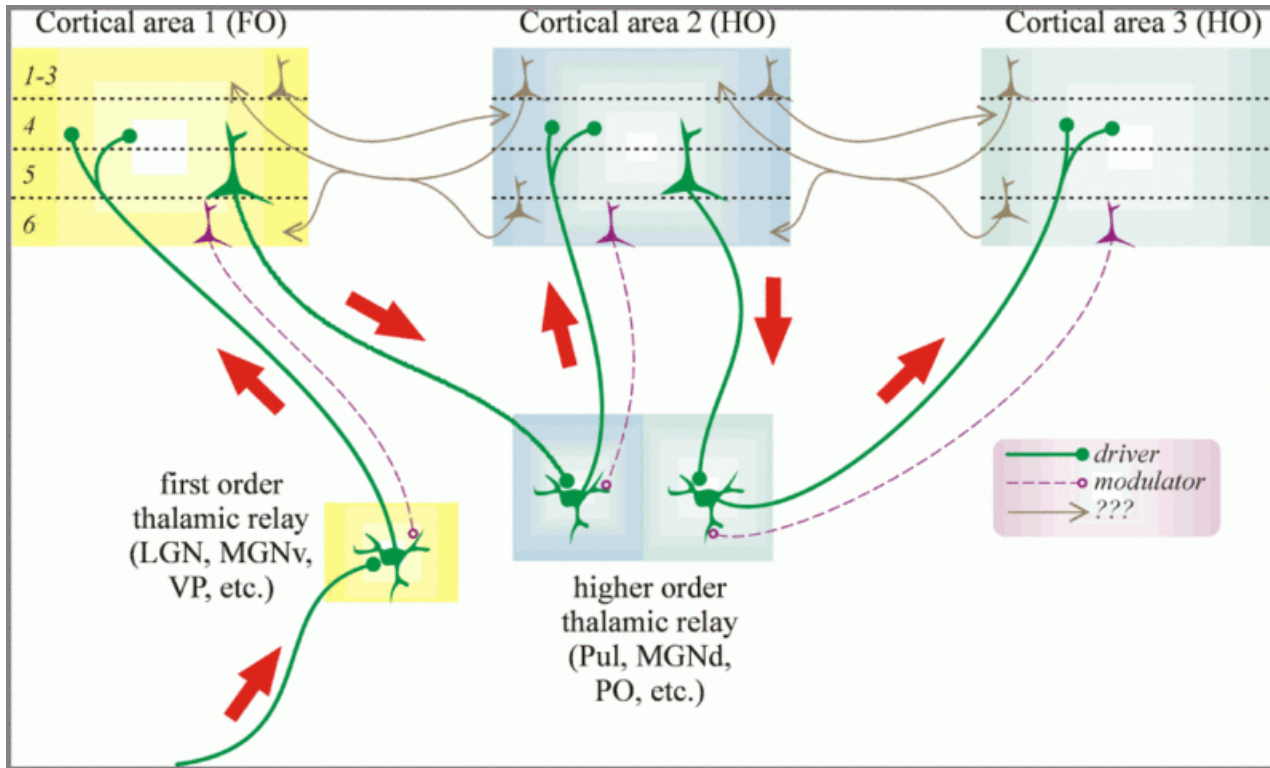
(a)



(b)



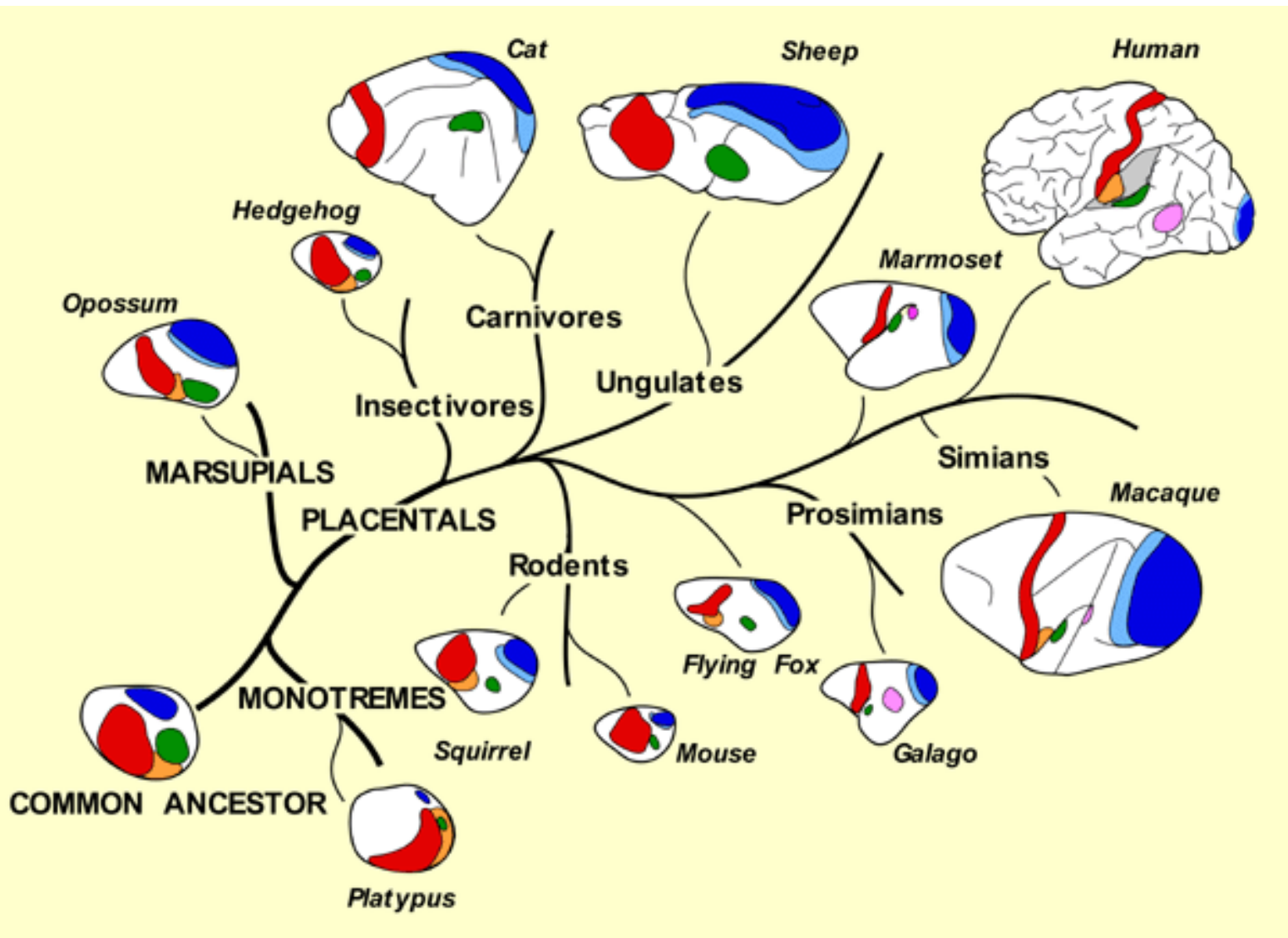
Thalamocortical Oscillations



See RotB p.178, or: Figure 5: Schematic diagram showing first order and higher order relays. A first order thalamic relay represents the first relay of peripheral or subcortical information of a particular type to a first order or primary cortical area.

A higher order relay relays information from layer 5 of one cortical area to another cortical area; this can be between first order and higher order cortical area or between two higher order cortical areas. The difference is the driver input, which is subcortical for a first order relay and from layer 5 of cortex for a higher order relay.

Abbreviations: FO, first order; HO, higher order; LGN, lateral geniculate nucleus; MGNd and MGNv, dorsal and ventral portions of the medial geniculate nucleus; PO, posterior nucleus; Pul, pulvinar; TRN, thalamic reticular nucleus; VP, ventral posterior nucleus



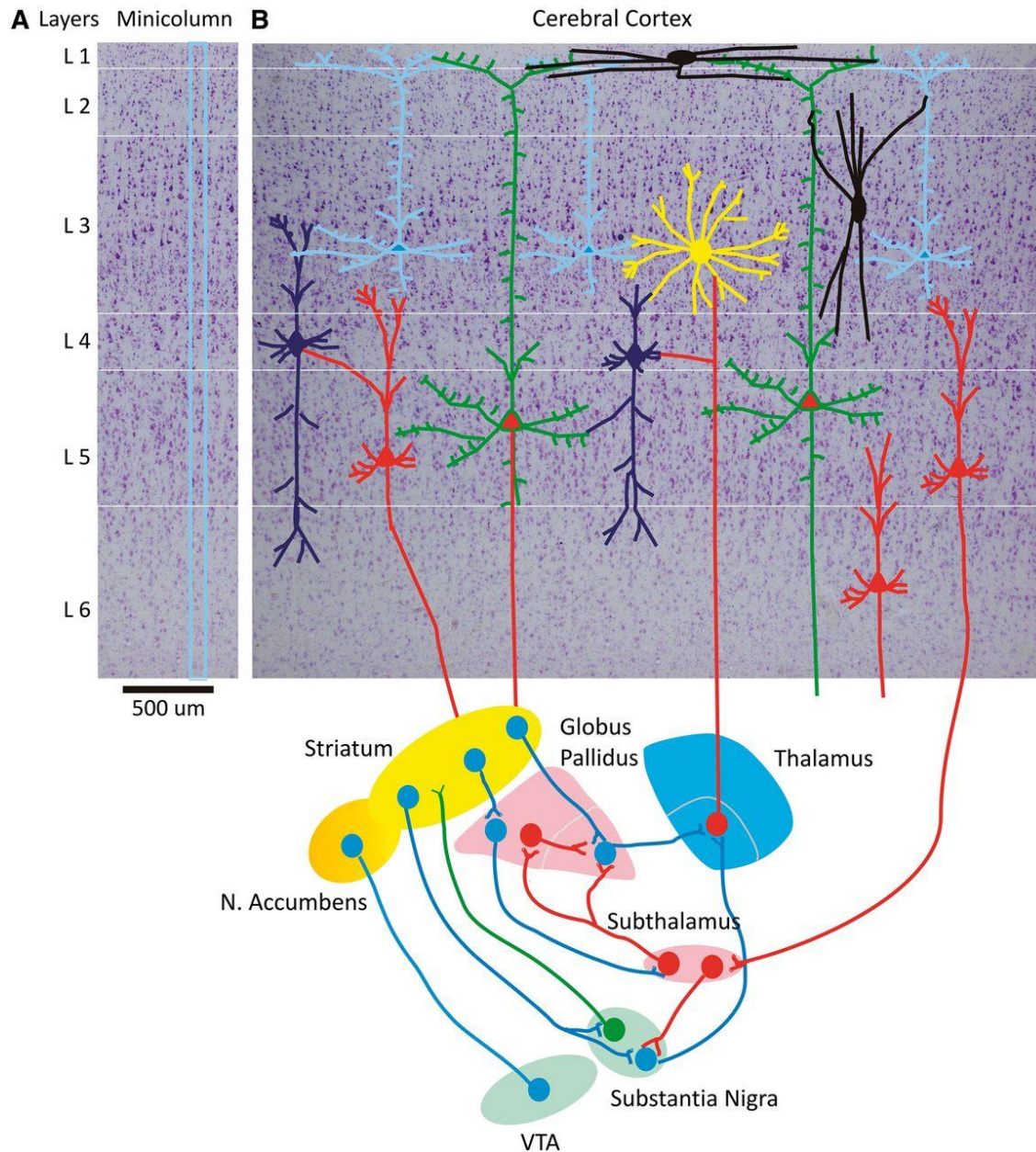
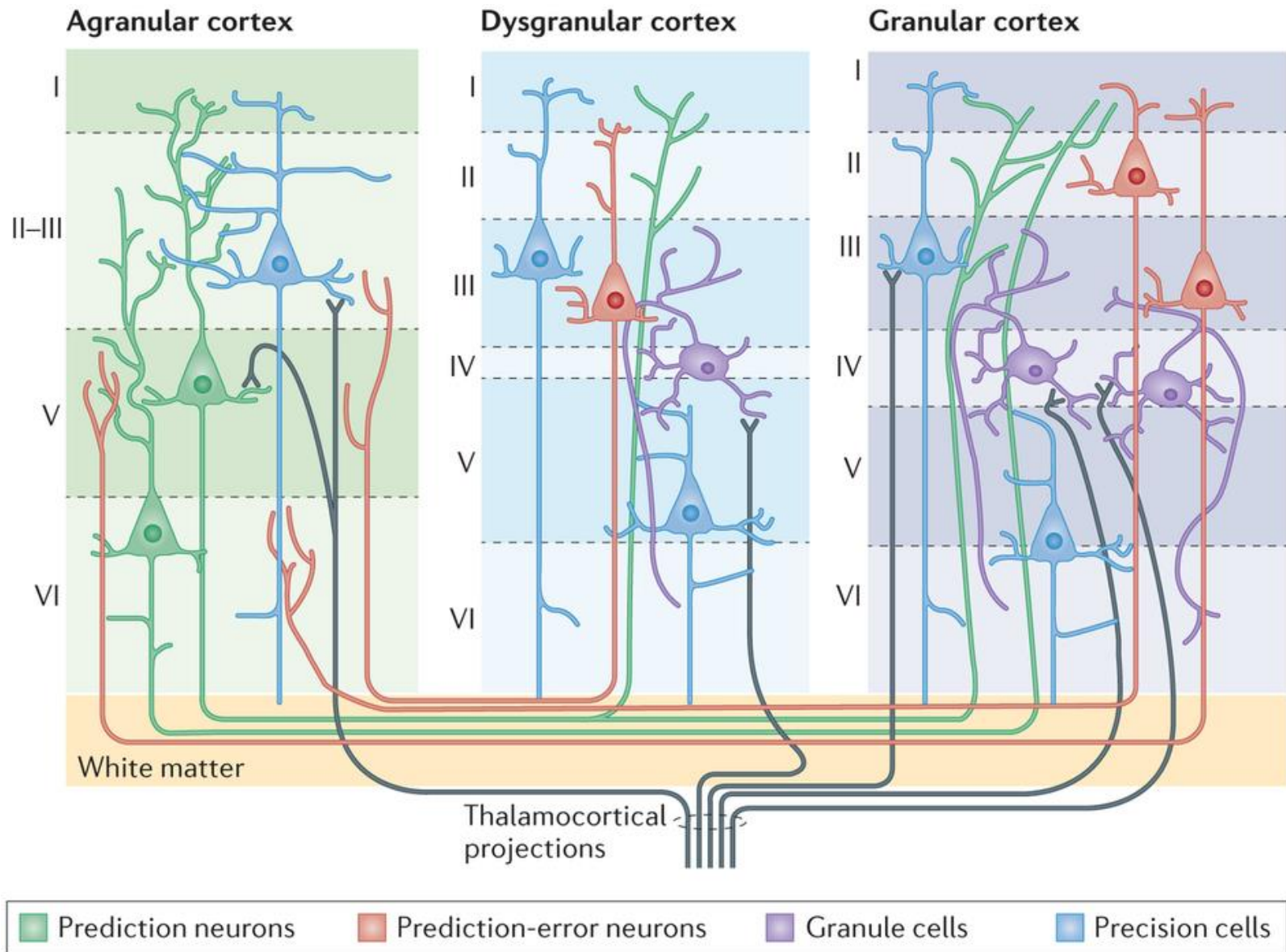


Figure 1
Prefrontal cortical minicolumn with cortico-striatal-thalamo-cortical circuits. (A) A prefrontal cortical minicolumn in human brain.

(B) Laminar and columnar display of prefrontal cortex and its major cell types and connections to basal ganglia and thalamus.

The six-layered cerebral cortex with pyramidal neurons and cortical interneurons is presented at the top with a Nissl background.

These neurons are connected to the thalamus and the basal ganglia as shown at the bottom of the figure. VTA = ventral tegmental area; N. Accumbens = nucleus accumbens



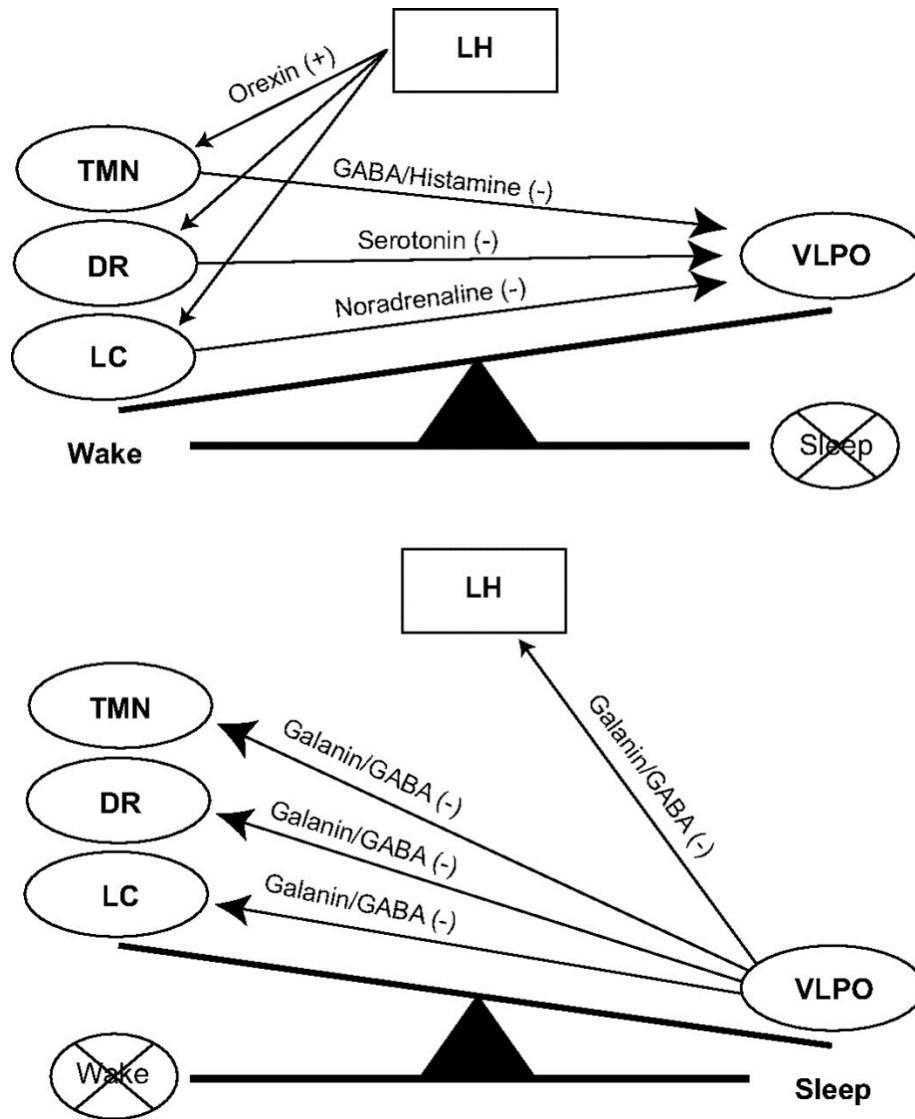


Figure 7.
The "flip-flop" switch model of transitions between sleep and wakefulness (1117).

The wake state is stabilized by lateral hypothalamic (LH) excitatory orexinergic input to wake-related nuclei, including GABAergic/histaminergic neurons of the tuberomammillary nucleus (TMN), serotonergic neurons of the dorsal raphe nucleus (DR), and noradrenergic neurons of the locus coeruleus (LC).

During sleep, GABAergic/galaninergic ventrolateral preoptic (VLPO) neurons inhibit wake-promoting nuclei, including LH.

Transitions between wake and sleep are due to mutual inhibition between these sleep- and wake-related nuclei. (Adapted from Saper et al. Nature 437: 1257–1263, 2005, with permission from MacMillan Publishers Ltd.)

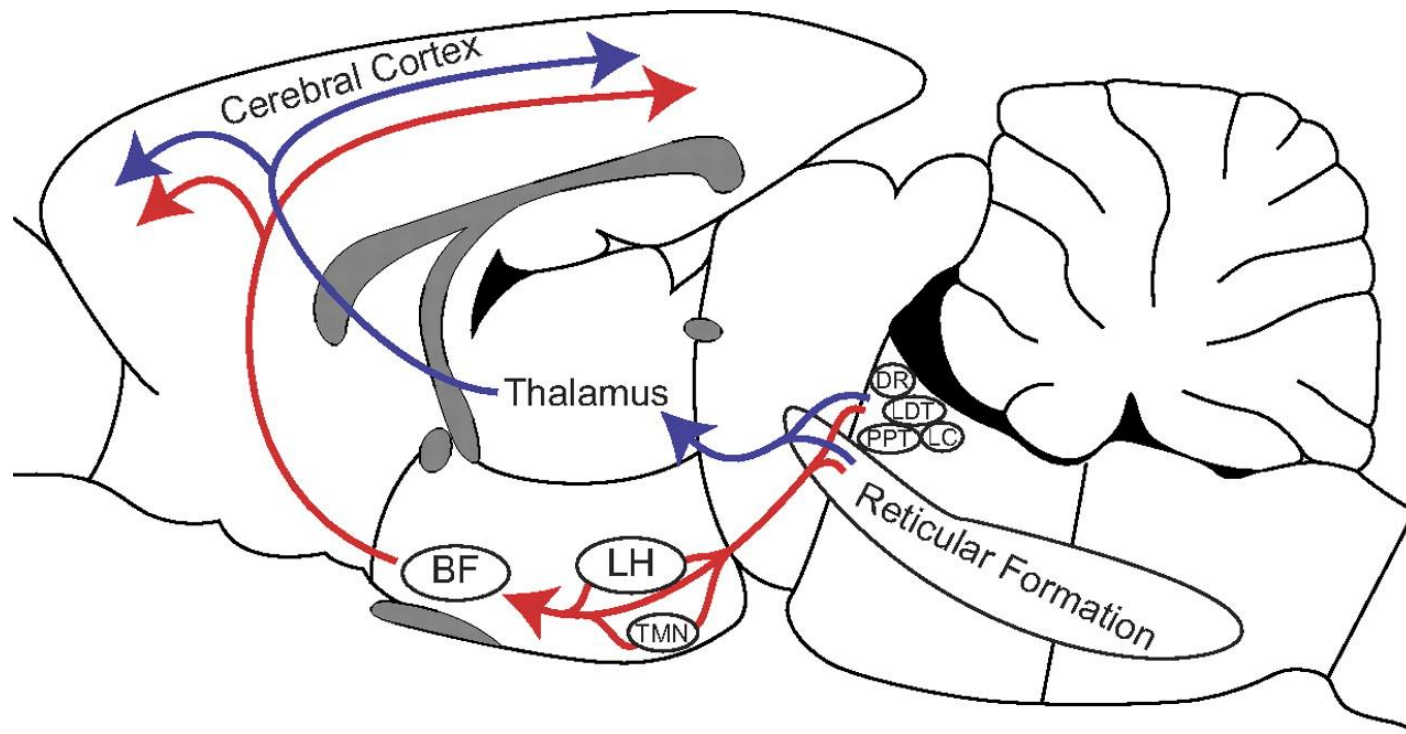


Figure 5.
Dorsal and ventral pathways of the ascending reticular activating system (ARAS).

The dorsal pathway (blue) originates in pontine and midbrain reticular formation, most prominently cholinergic (LDT/PPT) and glutamatergic neurons which project to the "nonspecific" intralaminar and midline thalamic nuclei which diffusely innervate many areas of the cerebral cortex as well as thalamic relay neurons with more selective projections patterns.

The ventral pathway also originates in pontine/midbrain regions and projects to the lateral hypothalamic (LH) and tuberomammillary (TMN) nuclei of the hypothalamus, as well as the basal forebrain (BF).

Output of LH and TMN also ascend to BF, which in turn projects to the cortex.

Noradrenergic neurons of the locus coeruleus (LC) and serotonergic neurons in the dorsal raphe (DR) contribute to both pathways and send direct projections to the cortex as do histamine neurons of the TMN and orexinergic neurons in the LH. LDT, laterodorsal tegmental nucleus; PPT, pedunculopontine nucleus. [Adapted from Paxinos and Watson (1989), with permission from Elsevier.]

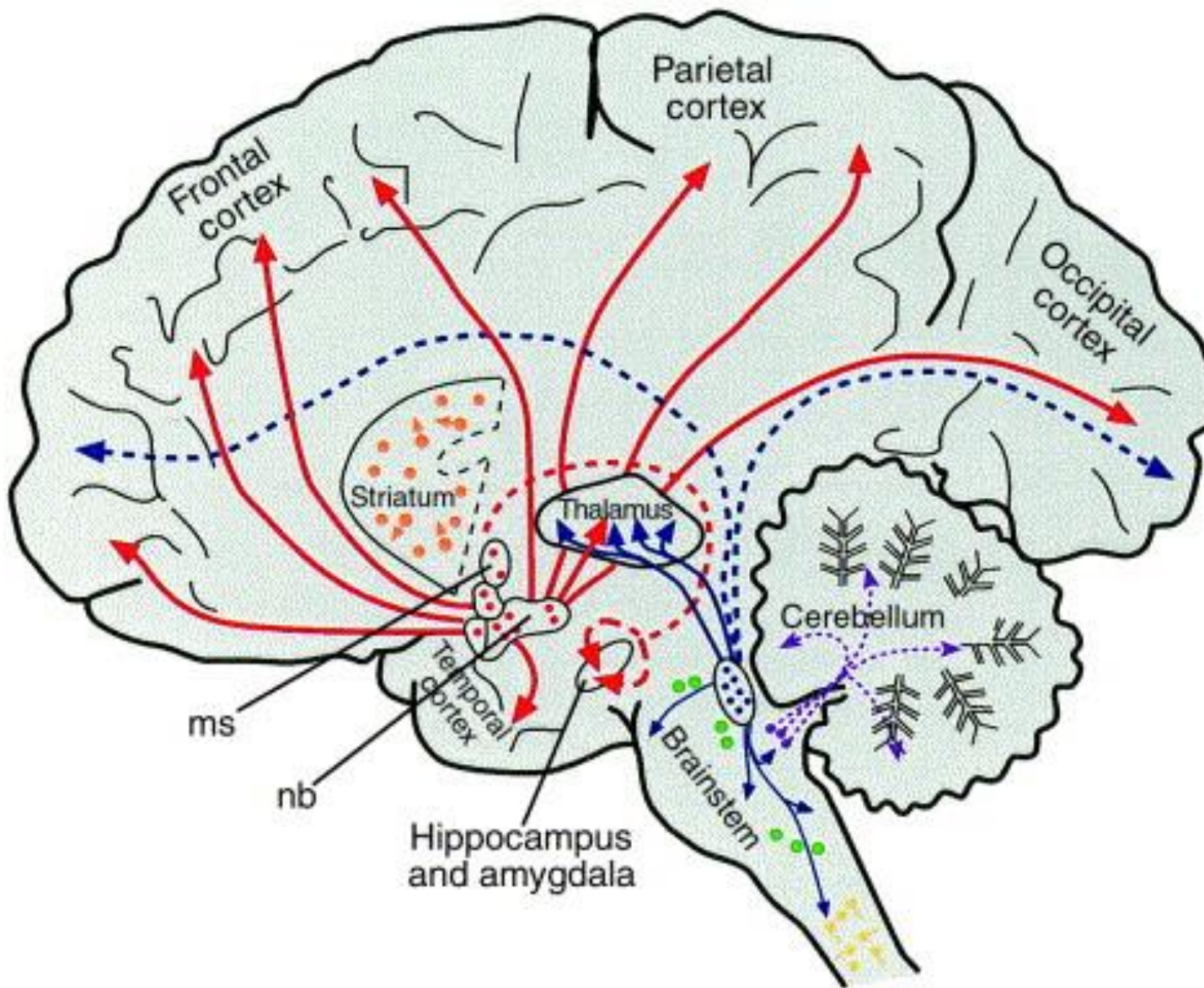
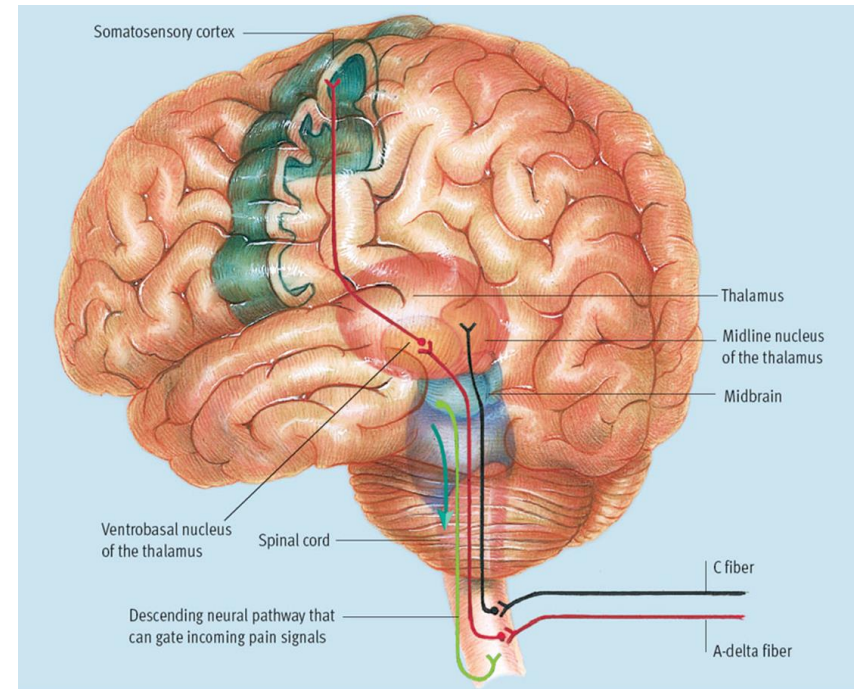
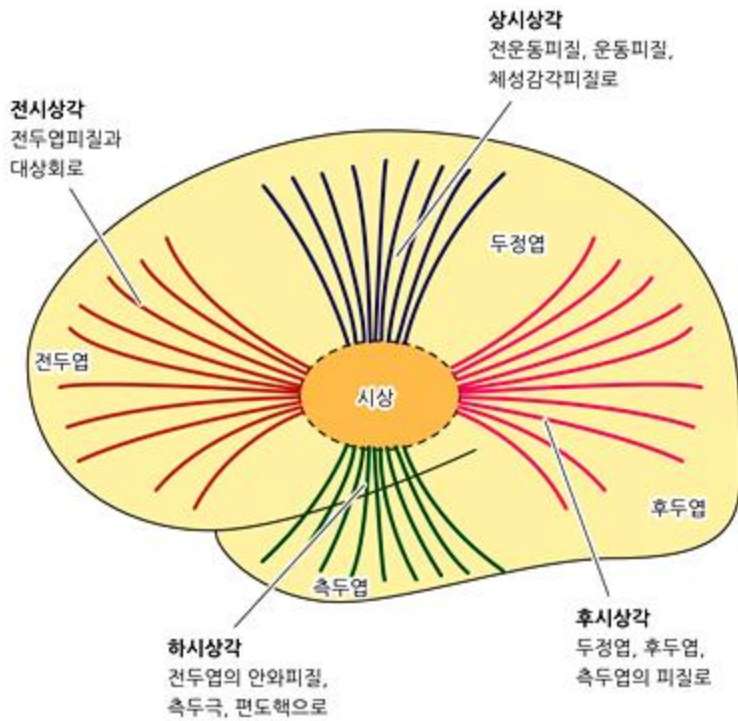


Fig. 1. Cholinergic systems in the human brain.

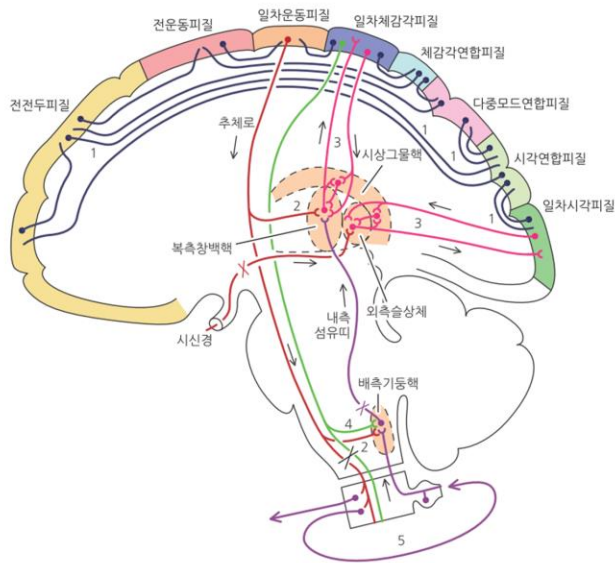
Two major pathways project widely to different brain areas: basal-forebrain cholinergic neurons [red, including the nucleus basalis (nb) and medial septal nucleus (ms)] and pedunculo-pontine-lateral dorsal tegmental neurons (blue).

Other cholinergic neurons include striatal interneurons (orange), cranial-nerve nuclei (green circles), vestibular nuclei (purple); and spinal-cord preganglionic and motoneurons (yellow).

A group of cholinergic neurons in the thalamic paracentral nucleus (not shown), thought to project to striatum and visual cortex, has recently been identified in macaque brain¹⁰¹. The habenula-interpeduncular pathway is also not shown.



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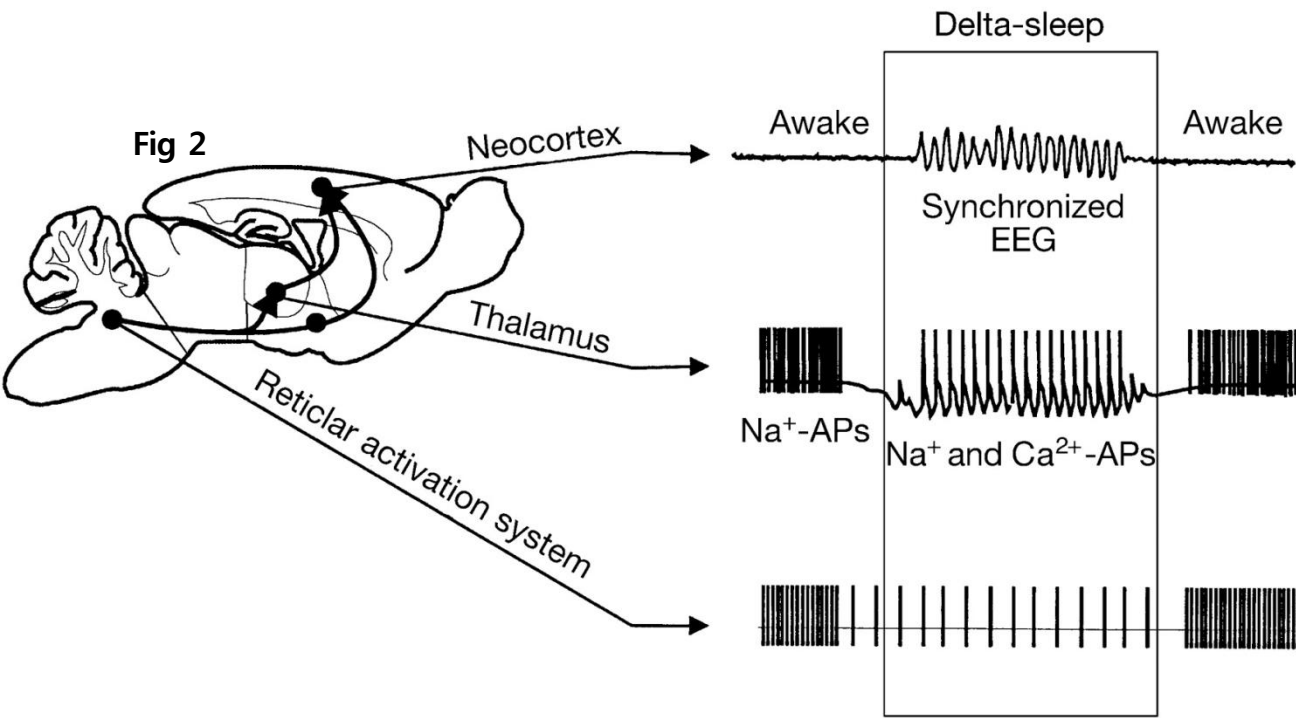


Fig 2 Thalamic relay neurones induce cortical delta activity during natural sleep.

The occurrence of delta activity in the EEG during natural sleep is intimately linked to a change in the firing mode of thalamic relay cells.

During wakefulness, these neurones fire fast sodium action potentials. As in this mode incoming sensory input is relayed to the cortex, it is called the relay mode.

During delta sleep the thalamic relay cells display slow Ca²⁺-dependent action potentials triggering fast Na⁺-dependent spikes in a highly regular fashion. The firing mode of thalamic relay cells is controlled by cholinergic, noradrenergic, and serotonergic brain stem nuclei.

Cholinergic and adrenergic neurones in the brain stem and basal forebrain play a major role in activating the thalamus and neocortex. They are silent during delta sleep.

Thus, anaesthetic-induced depression of neurones in the brain stem may contribute to EEG-synchronization seen during anaesthetic-induced hypnosis.

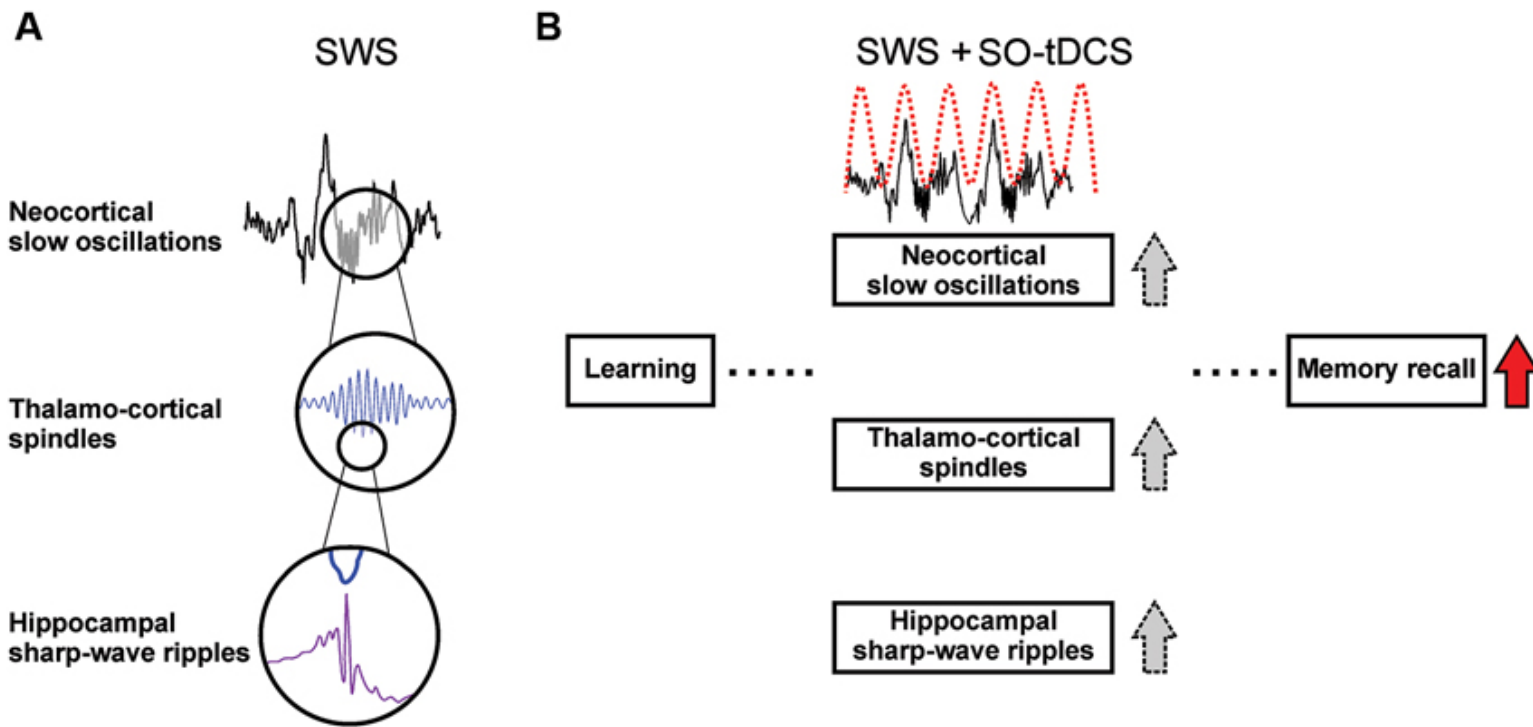


Figure 1. Sleep-associated brain oscillations relevant for memory consolidation and supposed effects of SO-tDCS (slow oscillatory transcranial direct current stimulation).

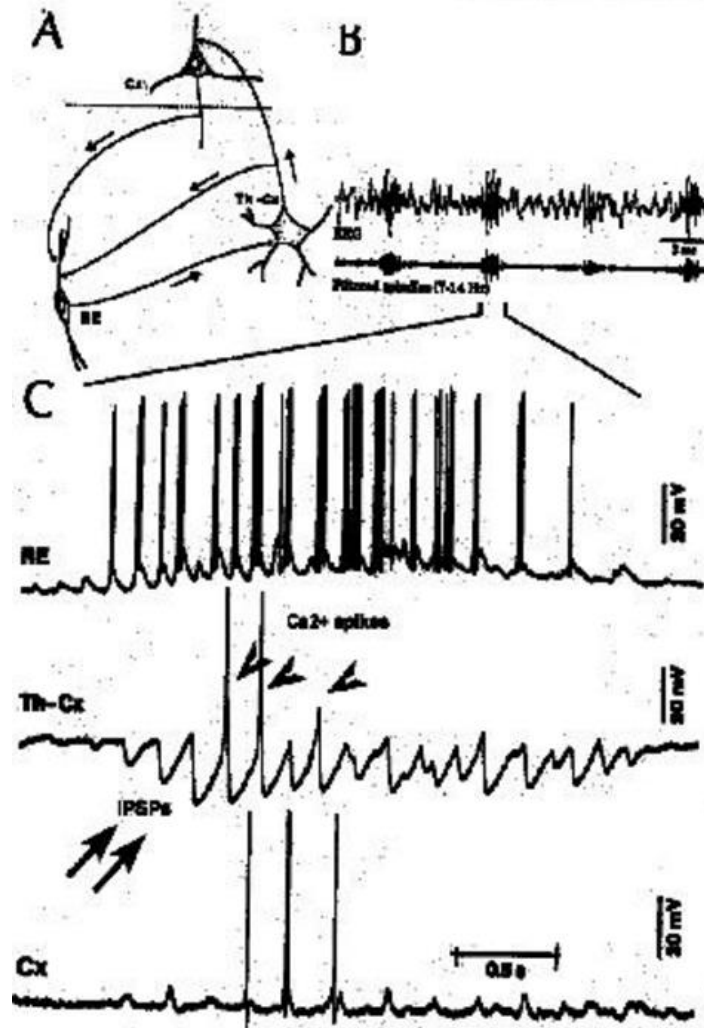
(A) Temporal relation of SO, sleep spindles and hippocampal SWRs.

Sleep spindles and hippocampal SWRs occur preferentially within the Up-state of the SO ([Isomura et al., 2006](#); [Mölle et al., 2009](#)). SWRs are temporally coupled to spindles, with individual SWRs nesting into the troughs of spindles ([Siapas and Wilson, 1998](#); [Wierzynski et al., 2009](#); [Clemens et al., 2011](#)).

Pre-sleep learning enhances activity of and coherence between these oscillations ([Mölle et al., 2009](#)), and it is assumed that the interplay of these oscillations subserve the communication between hippocampus and neocortex ([Sirota et al., 2003](#)) and therefore the transfer of hippocampus-dependent memory traces from the hippocampal short-term-store to the neocortical long-term store (for review see [Marshall and Born, 2007](#)).

(B) SO-tDCS is assumed to enhance endogenous SO activity, and thus improve the consolidation of memory. It was shown that SO-tDCS enhances post-stimulation power of EEG SO and spindle activity as well as memory consolidation in a hippocampus-dependent task ([Marshall et al., 2006](#)). A simultaneous enhancement of these rhythms and SWRs during SO-tDCS yet needs to be shown.

Fig. 54. Intracellular aspects of spindling in the thalamocortical system



Spindle oscillations in reticular (RE), thalamocortical (Th-Cx, VL) and cortical (Cx, motor) neurons. A: Circuit of 3 neurons. B: Two rhythms (7-14 Hz and 0.1-0.2 Hz) of spindle oscillations in cortical EEG. C: Intracellular recording in cats under barbiturate anesthesia. Note rhythmic spike-bursts of RE neuron during a spindle sequence and concomitant IPSPs leading to post-inhibitory rebound bursts in Th-Cx and Cx neurons. (Steriade, 2002)

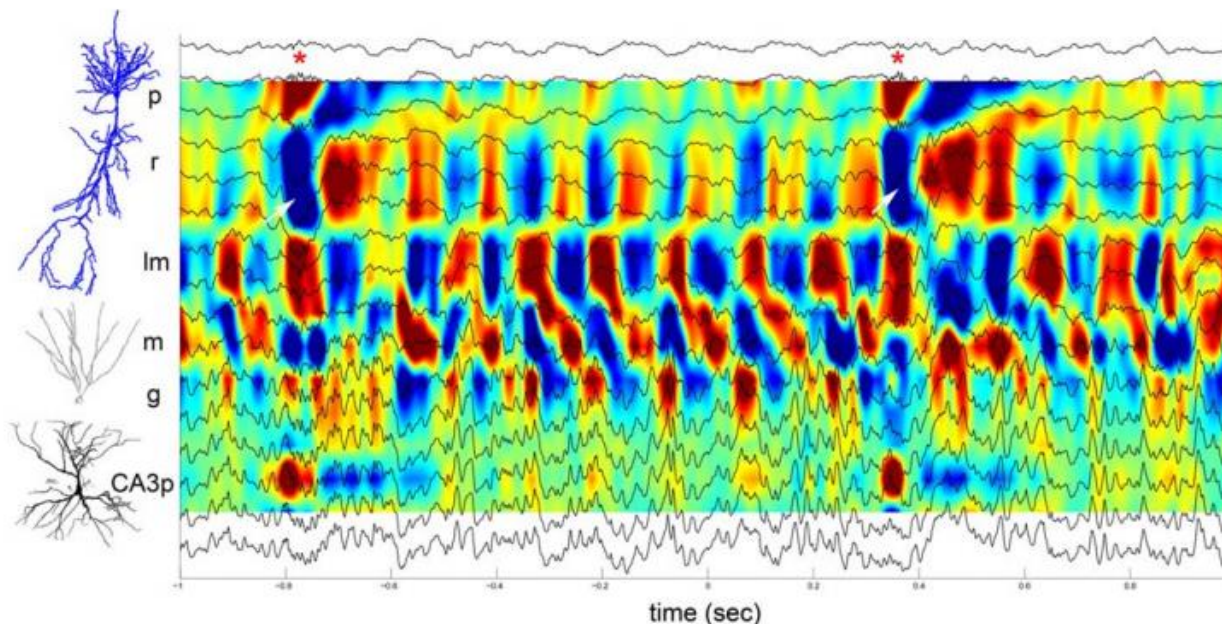


FIGURE 5. SPW-Rs embedded in a stream of theta waves. Two-second epoch of activity during REM sleep recorded with a linear silicon probe, covering the CA1-CA3-axis. LFP traces (16 sites) are superimposed on the CSD map. Two SPW-Rs were detected (asterisks). Note that in both cases, ripples in the CA1 pyramidal layer are coupled with a large SPW in str. radiatum

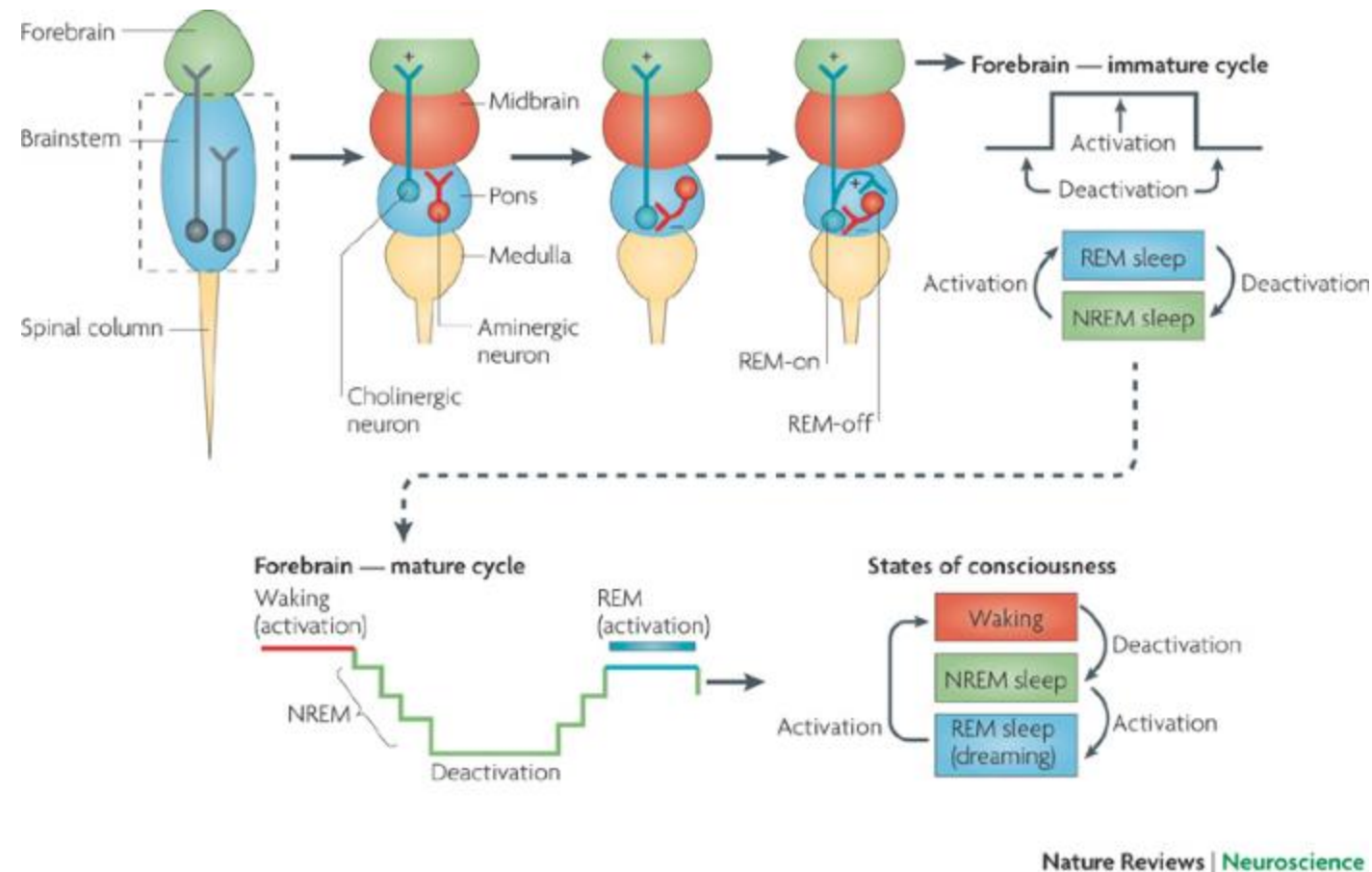
(white arrows) and a large source in the CA3 pyramidal layer. P, CA1 pyramidal layer; r, str. radiatum; lm, str. lacunosum-moleculare; m, dentate molecular layer; g, granule cell layer; CA3p, hilus, pyramidal layer of CA3c subregion (Sullivan and Buzsáki, unpublished data).

FIGURE 3 | Proposed steps in brain development leading to the emergence of the NREM–REM sleep cycle and its alternation with waking.

Following fertilization, blastulation, gastrulation and neural crest formation (not shown) the developing brain takes on a recognizable form in a tripartite structure (forebrain, brainstem and spinal cord) and then through a second tripartite division of the brainstem (to form the midbrain, pons and medulla).

The processes described in this Review develop in these parts. Based on inferences derived from adult neurobiology, the figure schematizes how the establishment of neuronal location (in the brainstem) and chemical signature (aminergic or cholinergic) might parallel the development of, first, activation and inactivation and, later, of rapid eye movement (REM) sleep, non-rapid eye movement (NREM) sleep and waking.

For example, initial activity of cholinergic brainstem neurons probably leads to forebrain activation; subsequent activity of aminergic brainstem neurons and their interaction with cholinergic neurons result in a primitive cycle of brain activation and deactivation.



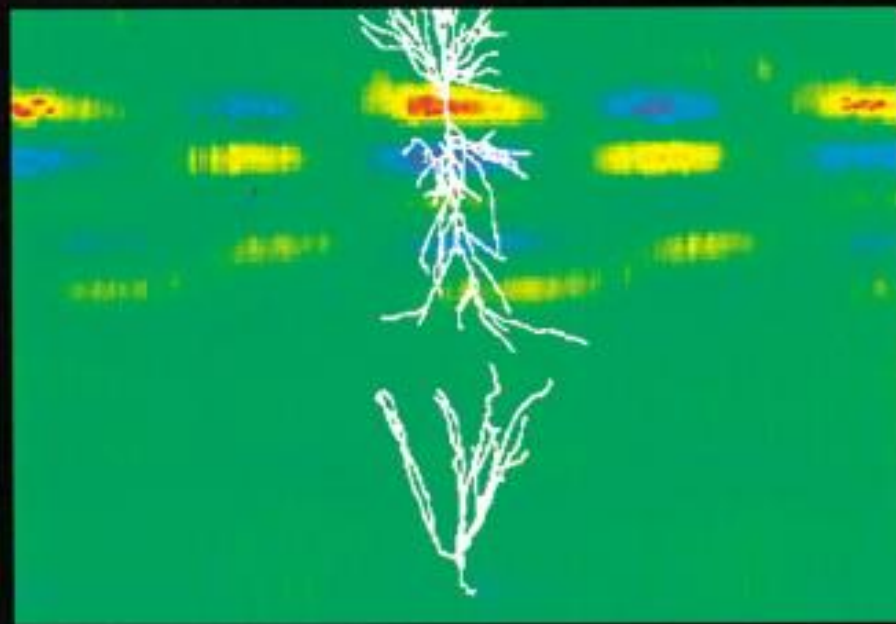
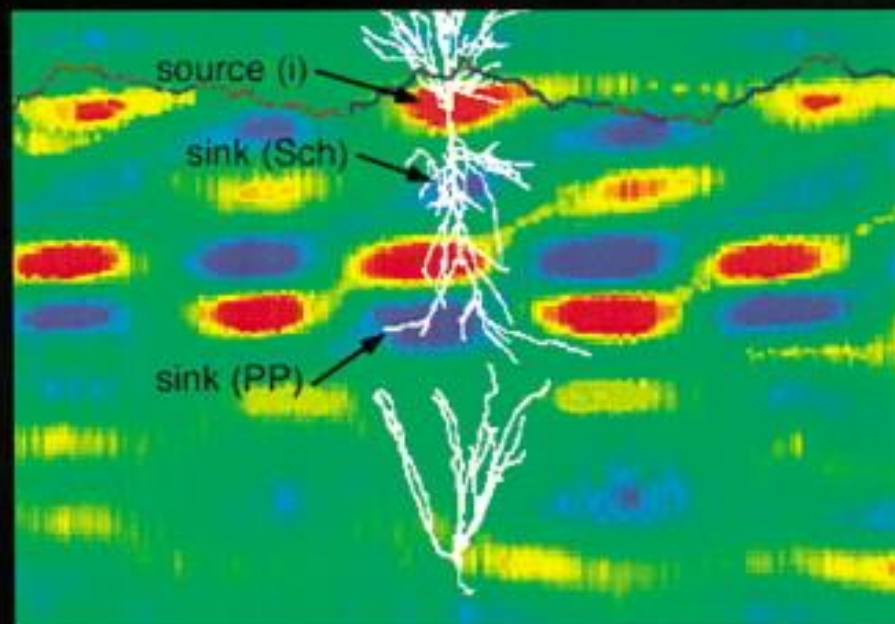
These are the building blocks of adult conscious states, although many of the details of the transition to adult states of consciousness remain to be established.

As a differentiated neuronal circuitry is formed in the forebrain, a complex set of features comes to characterize the REM–NREM sleep cycle. The protoconsciousness that I intuit in this Review would begin here and continue as REM sleep dreaming throughout life.

During the third trimester of pregnancy in humans REM-like brain activation predominates, but in the first years of life the time that the brain is in the REM sleep state declines, whereas the time it is in the NREM sleep state and the waking state increases (see also Fig. 2).

intact brain

bilateral EC lesion



source

sink

100 ms

Figure 4.
Entorhinal Cortex-Mediated Theta
Dipole in the Hippocampus

The simultaneously obtained field potentials (see Figure 1) were converted to one-dimensional current-source density (CSD) maps.

Left: intact rat.

Voltage trace of theta recorded in the CA1 pyramidal layer is superimposed for reference (gray trace).

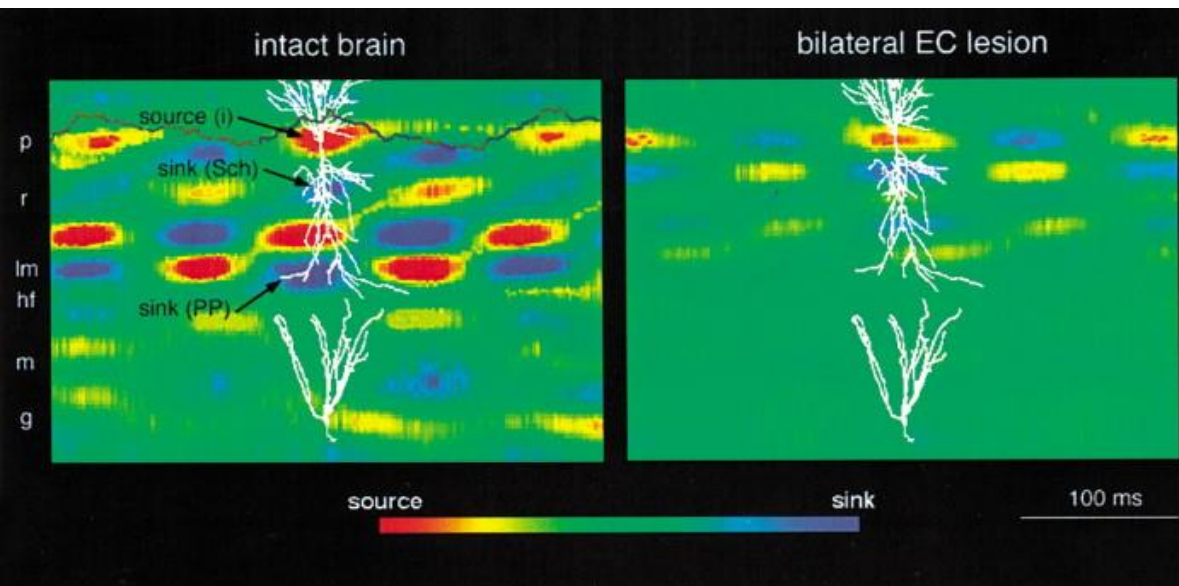
Rhythmic sources (red) in the pyramidal layer (p) are coupled to rhythmic sinks (blue) in the stratum lacunosum-moleculare (lm) representing a putative inhibitory source (I) and excitation by the perforant path input (PP).

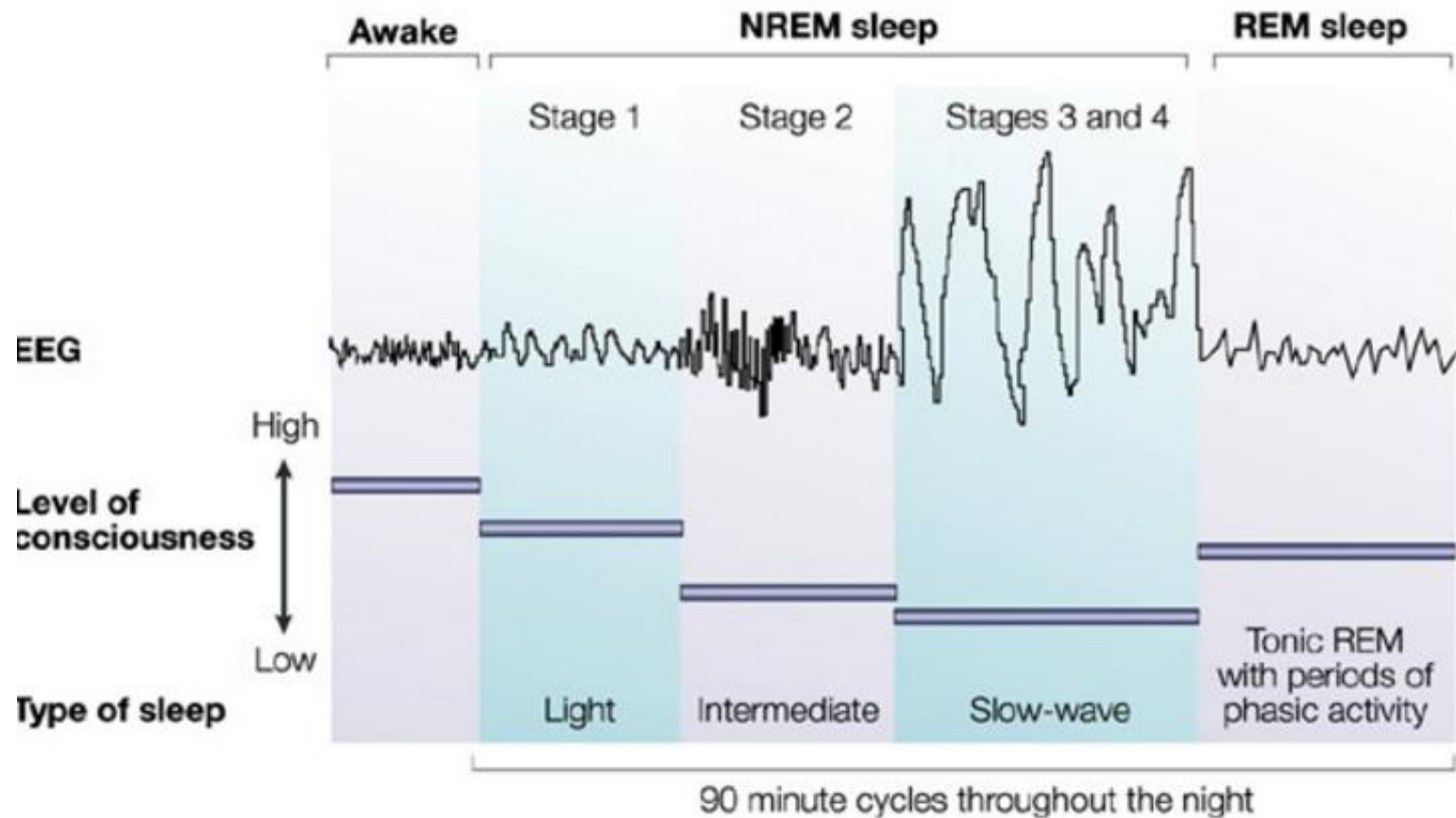
An additional sink, mediated by the Schaffer collaterals of CA3 pyramidal cells (Sch), is present in str. radiatum (r).

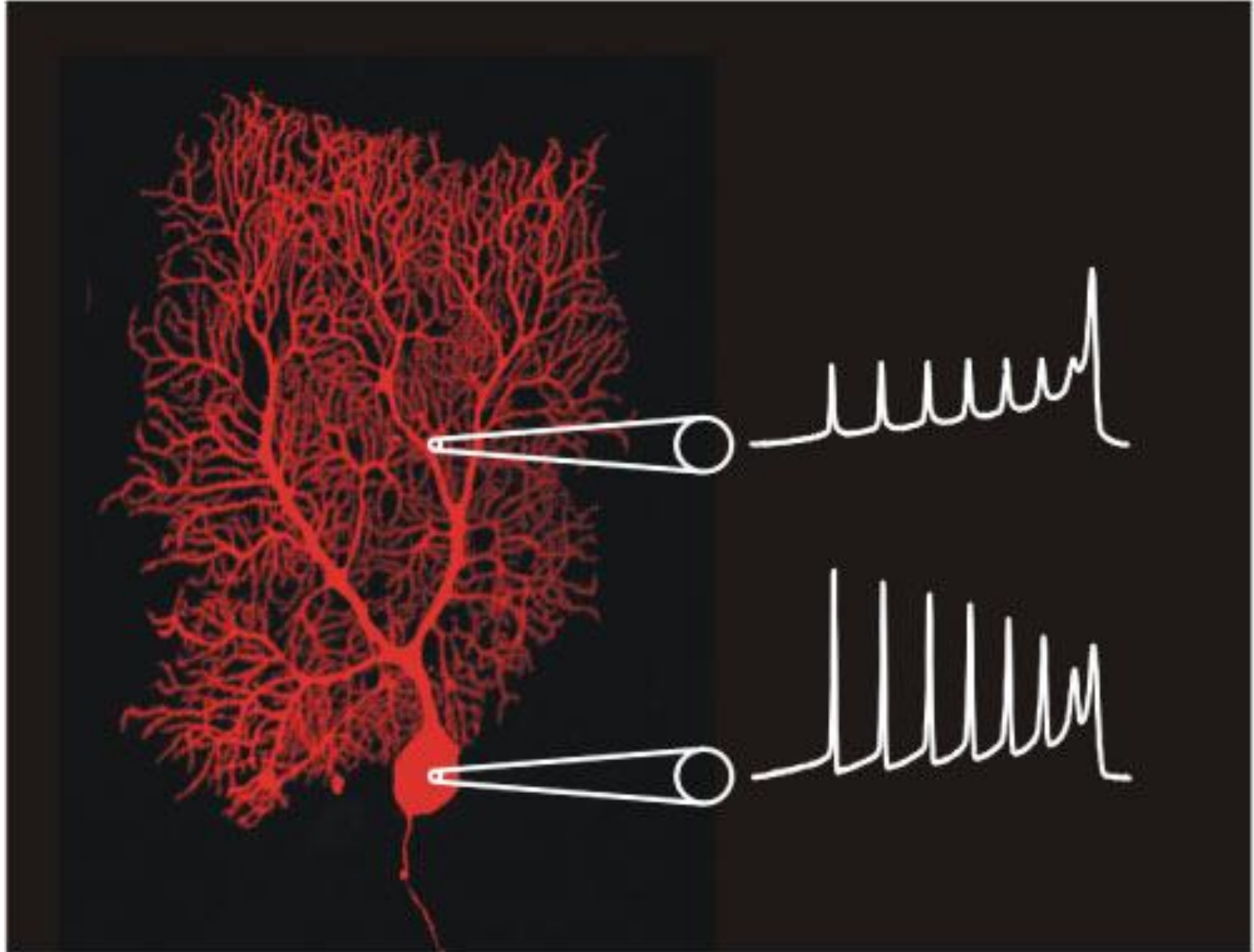
Right: same animal 2 days after bilateral removal of the entorhinal cortex (EC).

Note the absence of sink at the distal dendrites and the survival of the more proximal source-sink pair.

The same time and color scales apply to both CSD maps. m, molecular layer; g, granule cell layer (Kamondi et al., 1998a).







Dual soma-dendritic patch recordings from rat cerebellar Purkinje cells are used in conjunction with focal drug ejections to determine the ionic basis of Purkinje cell output.

Serum Free

BDNF

CA1 Apical Dendrite Spine Density

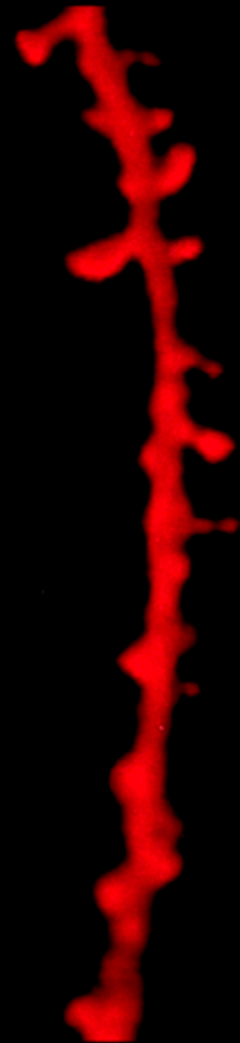
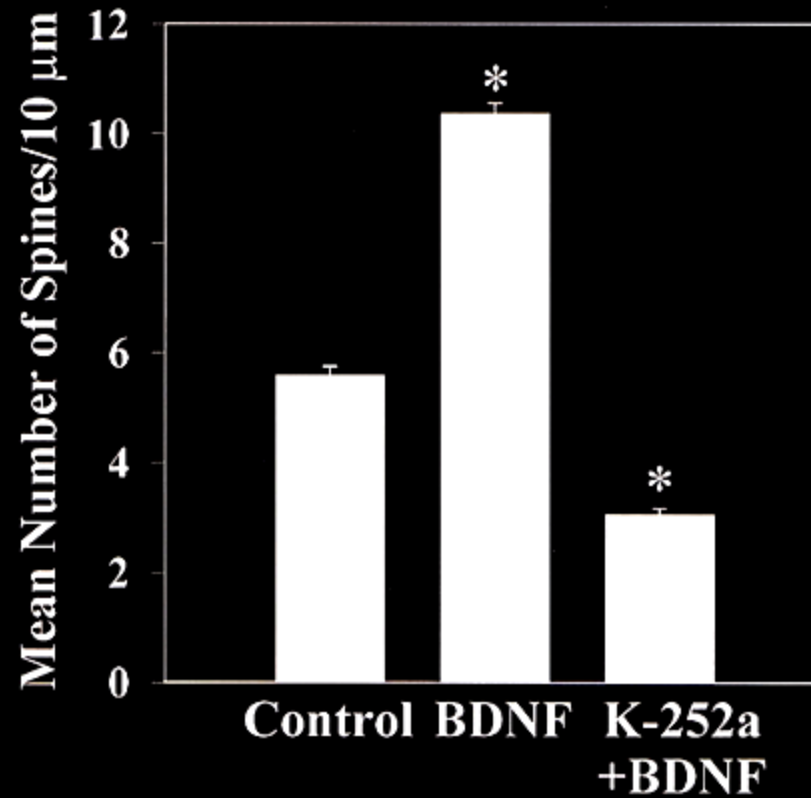
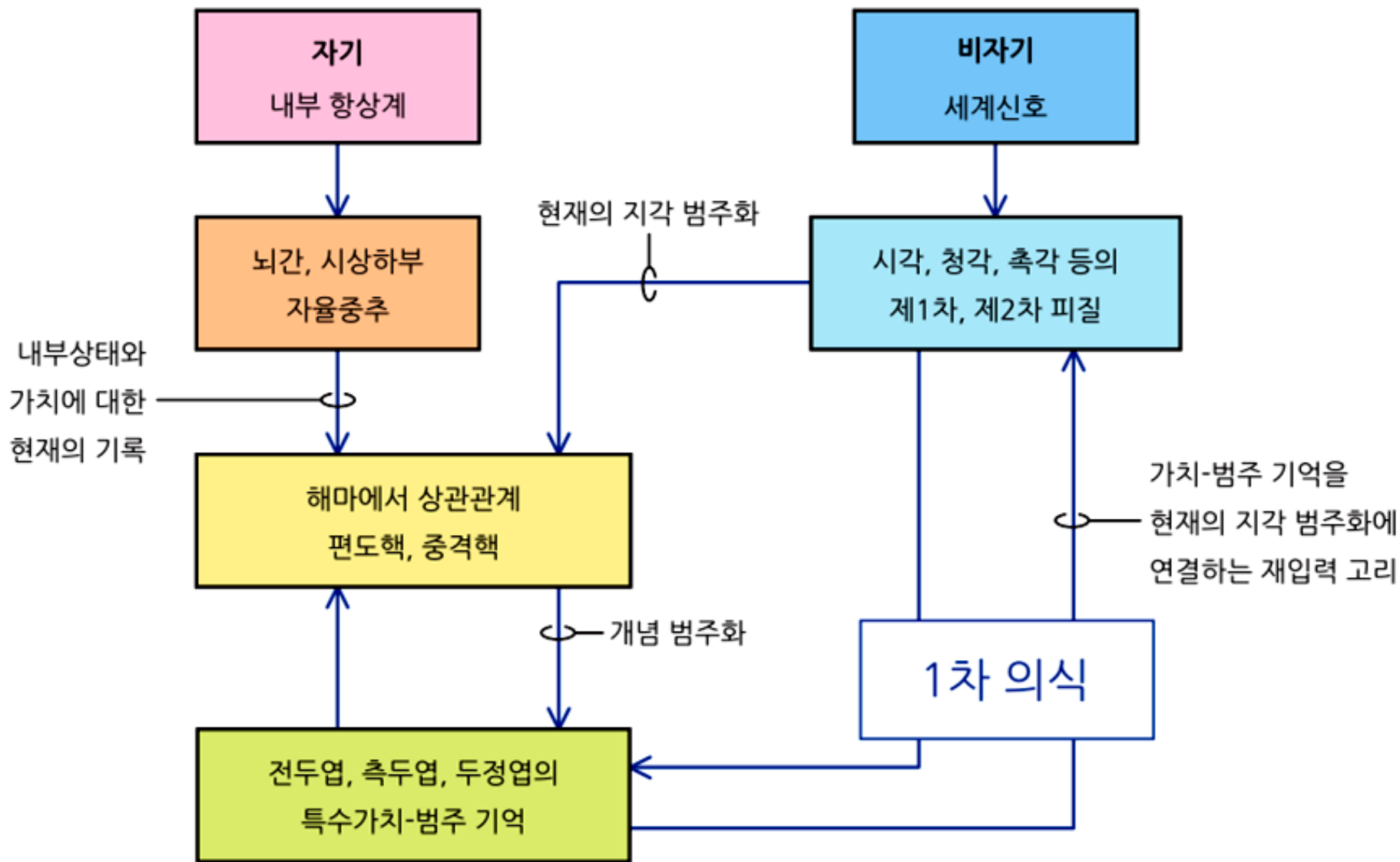
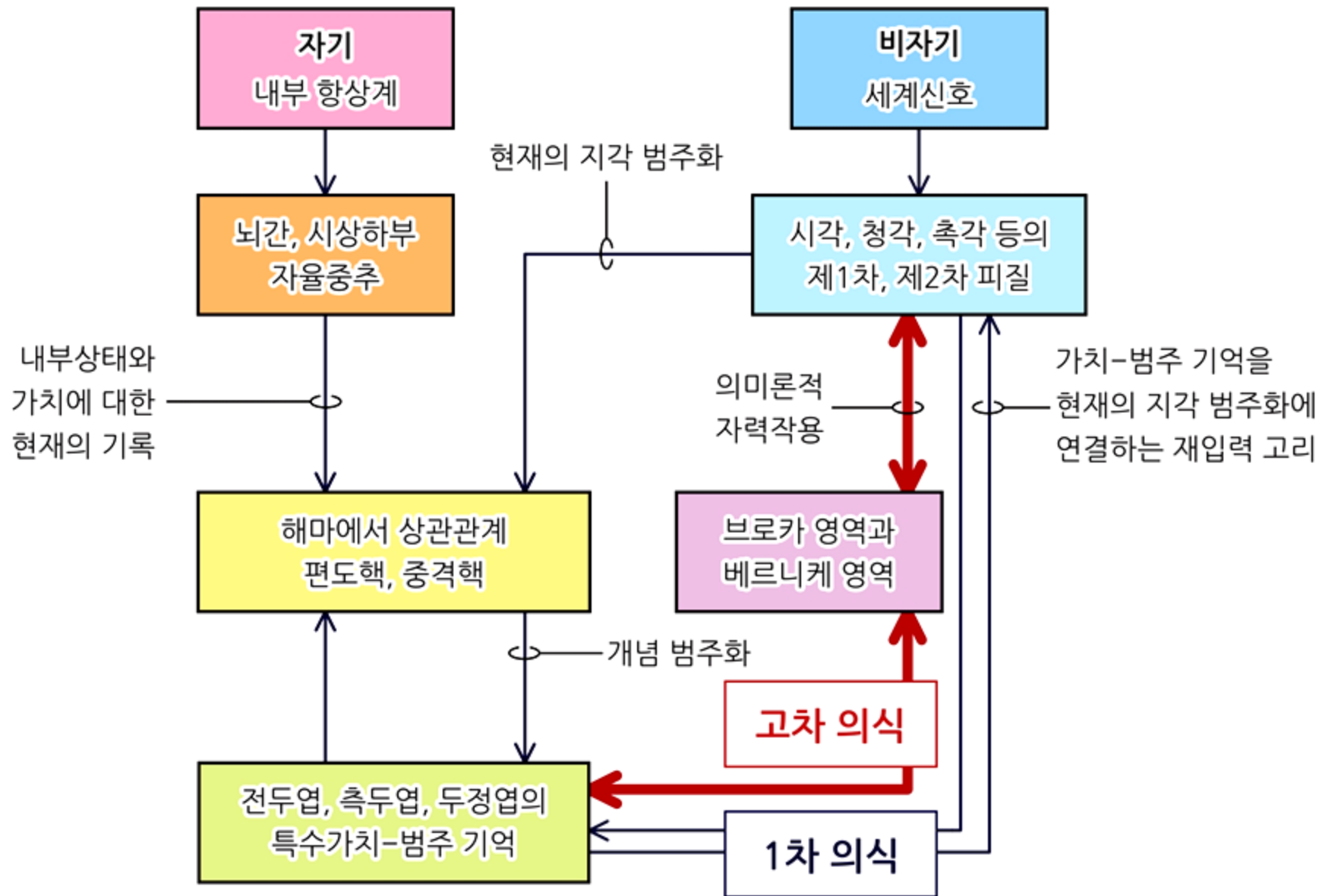


Figure 1. BDNF increases dendritic spine density in CA1 pyramidal neurons of hippocampal slices. Representative apical dendritic segments from CA1 pyramidal neurons from a serum-free (control; *left*) and a BDNF-treated hippocampal slice culture (250 ng/mL, 5–7 div; *right*). CA1 pyramidal neurons were filled with Alexa-594 during whole-cell recording, and later imaged by laser-scanning confocal microscopy. (*Middle*) Histograms of the number of dendritic spines per 10 μm of apical dendrite. The tyrosine kinase inhibitor K-252a blocked the BDNF-induced increase in dendritic spine density. Adapted from Tyler and Pozzo-Miller (2001).









Leersia oryzoides, spikelets, photo Russ Kleinman, Burro Mtns., Mangas Springs, Sept. 22, 2008



Leersia oryzoides, edge of blade, photo Russ Kleinman, Burro Mtns., Mangas Springs, Oct. 16, 2007

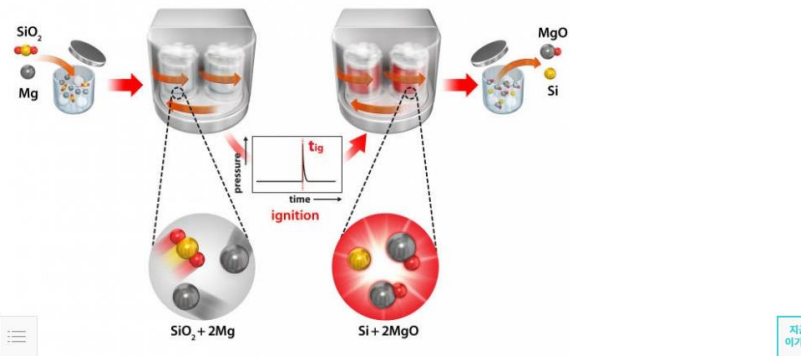
**Vascular Plants of the Gila Wilderness
Presented in Association with the
Western New Mexico University Department of Natural Sciences
Leersia oryzoides (Linnaeus) Swartz
(Rice Cutgrass)**

농사 짓고 남은 벼 껍질로 실리콘 만든다

2017년 01월 12일 18:00

● 1분 요약

우리나라에선 왕겨가 연간 70만톤 나온다. 왕겨에 들어있는 실리카를 이차전지 음극재의 소재로 쓸 수 있는 실리콘으로 쉽게 바꾸는 기술이 개발됐다. 음극재는 대부분 해외 기업에 의존하는 형편이다.



한국에너지기술연구원이 개발한 벼 껍질(왕겨)로 실리콘을 대량 생산하는 기술. - 한국에너지기술연구원 제공

연간 70만 톤씩 나오는 왕겨를 이용해 실리콘을 생산하는 기술이 나왔다. 이렇게 만든 실리콘은 이차전지 음극재 소재로 적합하다.

서명원 한국에너지기술연구원 청정연료연구실 선임연구원 연구팀은 벼 껍질(왕겨)에서 추출한 실리카를 이용해 실리콘을 생산하는 새로운 공정 기술을 개발했다고 12일 밝혔다. 실리카에서 실리콘을 얻는 환원율이 91.7%로, 기존 캐나다 토론토대학 연구팀이 보유한 세계 최고치 83.2%보다도 높다.

왕겨에는 실리콘(규소)의 원료인 나노 구조의 실리카(이산화규소)가 20% 가량 함유돼 있다. 이를 실리콘으로 환원시키면 실리콘의 부피 팽창을 효율적으로 제어할 수 있다. 음극재로 사용하면 용량이 높고 출력이 좋아진다. 왕겨의 실리카를 실리콘으로 환원하는 기존 '마그네슘 열환원법' 공정은 600~900도의 고온에서 작업하고, 작업 시간도 5시간 이상 걸리는 단점이 있었다.

반면 연구진이 개발한 '마그네슘 밀링 공정'은 상온(25도)과 상압(1기압)에서 50분 이내에 실리콘 환원이 가능하다. 또 5L 단위의 대용량을 구현해 공정을 대량 생산 규모로 확대할 수 있는 가능성도 높였다.

연구진은 현재 연간 3t의 왕겨로 실리콘을 생산할 수 있는 대량 생산 공정의 기본 설계를 마친 상태다. 서 연구원은 “기업으로의 기술 이전과 후속 연구를 통해 기술을 실증할 계획”이라며 “음극재 시장의 판도를 뒤집을 수 있는 원천 기술을 국내에서 확보했다는 데 의의가 크다”고 말했다.

연구 결과는 국제학술지 ‘나노 레터스’에 게재됐다.

자
이
기

000-000

“왕겨, 고부가가치 될 줄 몰랐죠”
[인터뷰] 최장욱 카이스트 EEWS 교수

벼는 전 세계적으로 연간 약 4억 7천만 톤의 규모로 생산되고 있다. 국내만 해도 연간 4백만 톤 이상의 규모가 생산된다. 벼는 도정을 거치는 과정 중에 부산물로 왕겨가 생긴다. 왕겨(Rice husk, 일부는 쌀겨라고도 함)는 현미를 도정해 정백미를 만들 때 발생하는 과피와 종피, 호분층 등의 분쇄혼합물이다.

벼의 외피를 감싸고 있는 것으로 벼 곡식 낱알의 겉부분에 위치함으로써 곡식을 비와 바람 등 외부 환경으로부터 보호하며, 해충으로부터도 지켜줘 여러모로 유익한 역할을 담당하고 있다.

왕겨는 어느새 우리 생활에 매우 밀접한 자원으로 다가와 있다. 유기물과 무기물의 복합체로 구성돼 있는 만큼 다양한 에너지원으로 사용될 수 있는 가능성이 있어 많은 연구자들에게 매력적인 대상으로 떠오른 것이다.

▲ 최장욱 카이스트 EEWS 교수 ©황정은

왕겨를 이용한 이차전지

최근 과학기술분야에서 떠오르는 내용 중 하나를 꼽으라면, 단연 지속가능한 기술을 언급할 수 있다. 이는 기술발전의 구호에 묻혀 있던 자연환경에 대한 입체적인 접근으로, 자연과 함께 성장하는 기술의 발전을 의미한다.

때문에 청정에너지에 대한 연구도 계속 심화되고 있으며, 이러한 내용의 일환으로 이차전지에 대한 연구 역시 활발하게 이뤄지고 있다. 이런 가운데 왕겨를 사용한 고용량 이차전지 기술이 국내 연구진에 의해 개발돼 주목을 받고 있다.

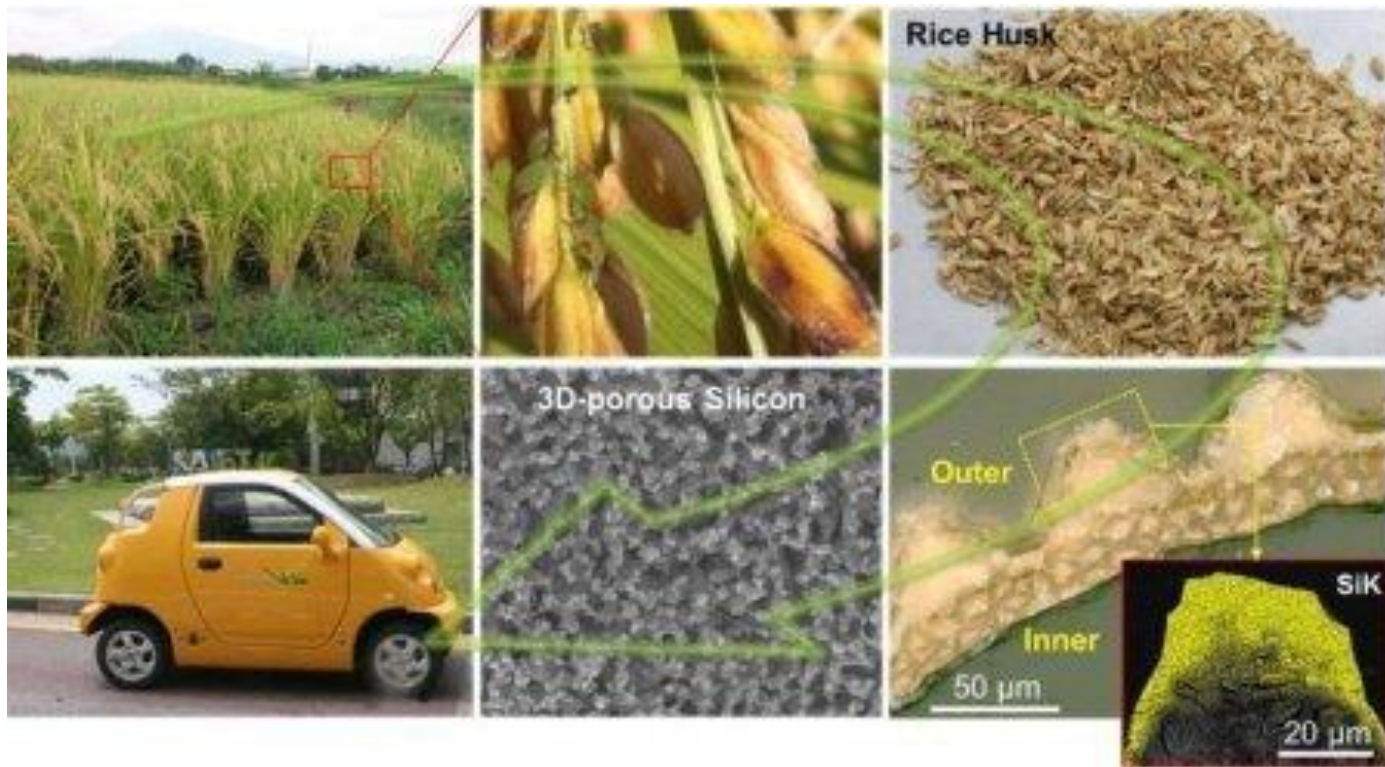
최장욱 카이스트 EEWS 교수팀과 생명화학공학과 박승빈 교수팀이 공동연구를 진행해 왕겨를 이용한 고용량 이차전지를 개발한 것이다.

연구팀은 왕겨 내부에 존재하는 다공성 천연 실리카 물질을 분리·정제해 고용량 리튬이온 이차전지 음극소재인 3차원 다공성 실리콘 물질을 개발했다. 해당 연구 결과는 그 성과를 인정받아 자연과학분야의 세계적 권위지 ‘미국국립과학원회보(PNAS)’ 온라인 판에 게재됐다.

“전 세계적으로 벼는 많은 양이 생산되는 상태고, 벼의 도정 부산물인 왕겨 역시 지역에 따라 차이가 있지만 그 양이 매우 많은 편입니다. 보통 무게비로 벼의 약 20%를 차지하고 있으며, 2012년 기준으로 국내에서만 약 80만 톤의 왕겨가 도정과정에서 부산물로 생산됐죠.

국내의 경우 벼 저장과 활용성을 위해 전국적으로 미곡종합처리장에서 지속적인 도정작업이 진행되기 때문에 부산물로 발생하는 왕겨는 연간 일정하게 발생하고 있습니다. 처리과정에서의 오염이 적어 상업적으로 가치가 높은 바이오매스라고 할 수 있죠.”

왕겨의 활용은 다양한 분야에서 일어났지만, 외피가 규소로 치밀하게 피복돼 있어 부식이 어렵고 마모성이 높으며, 부피가 크다는 점 때문에 이송과 가공이 어려워지면서 고부가 가치 용도로 사용하는 데 여러 어려움이 있었다. 가능성은 있으나 실질적인 가공 기술이 한계로 작용해 산업화와 상용화에 걸림돌로 작용했던 것이다. 때문에 대부분 부가가치가 낮은 축산시설 깔개와 퇴비, 혹은 상토와 보온재 등의 활용이 그간 왕겨 활용의 전부였다.



벼의 도정 부산물로 발생된 왕겨로 부터 고용량 리튬 이차전지
용 3차원 다공성 실리콘 음극소재 개발. (오른쪽 아래 이미지는
왕겨의 외피에 존재하는 실리카의 존재를 나타낸다.) ©카이스트

하지만 최 교수는 연구 활동을 진행하며 만난 파트너 박승빈 교수와 여러 이야기를 나누던 차에, 왕겨가 훌륭한 고부가가치 재료가 될 수 있다는 힌트를 얻었다.

“왕겨에는 실리카라는 물질이 포함되어 있습니다. 벼의 뿌리에서 생물학적으로 실리카를 선택적 흡수하거나 정착하는 과정을 통해 20wt%의 높은 순도의 실리카를 포함하고 있죠. 또한 왕겨 내부에 존재하는 쌀을 외부 바이러스나 해충으로부터 보호하고, 저장에 용이하도록 다공성 형태의 구조로 이뤄져 있어요. 우리 팀은 왕겨 표피에 존재하는 다공성 실리카로부터 3차원 구조의 다공성 실리콘 입자를 추출·합성했습니다.”

최근 이슈가 되고 있는 친환경 전기자동차의 경우 이차전지가 중요한 역할을 한다. 전지이기 때문에 음극과 양극이 존재하는데, 음극의 재료로는 주로 흑연이 사용된다. 그동안은 흑연에서 무게당 용량이 높은, 즉 한 번 충전하면 사용량이 높은 실리콘을 사용하려고 했는데 실리콘의 사용은 용량적 측면에서는 장점을 지니고 있으나 수명의 측면에서는 단점을 안고 있었다.

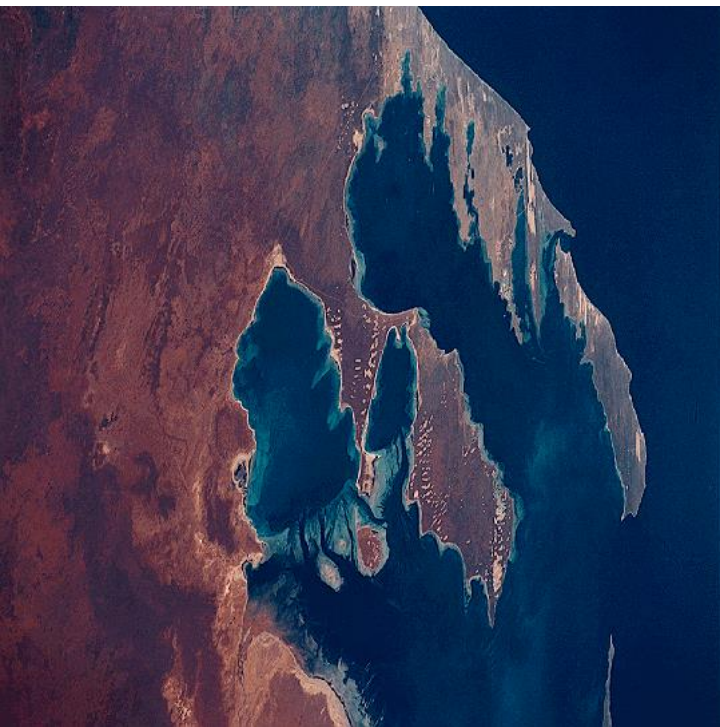
“전지의 수명은 충·방전의 주기를 얼마나 반복할 수 있느냐의 문제를 안고 있습니다. 기존 흑연계통의 재료를 사용할 경우 수백 주기 정도를 사용할 수 있는 것으로 알려져 있어요. 일반적으로 2년 정도 사용한다고나 할까요. 하지만 실리콘은 그만큼의 수명이 나오지 않아요. 이것은 실리콘이 갖고 있는 여러 가지 재료상 문제 때문입니다.”

간단히 이야기하자면 충·방전 과정에서 부피가 커지기 때문이다. 많은 연구자들이 연구를 진행한 결과, 부피가 팽창함으로써 다양한 문제를 도출하고 있으며 이러한 문제는 아주 작은 실리콘을 만듦으로써 해결할 수 있다. 나노미터 규모의 작은 실리콘 기술이 필요한 이유다.

“그렇다면 실리콘 나노기술을 어떻게 만들 것인가가 다음 이슈가 되겠죠. 여러 가지 합성방법이 있겠지만 저와 박승빈 교수는 왕겨의 껍질에서 해답을 찾았습니다. 벼에는 실리콘 옥사이드라는 물질이 있어요. 나노미터 수준의 기공을 이미 만들고 있는 거죠. 아마 자연 상태의 물질이기 때문에 왕겨 안에 있는 내용물을 박테리아나 벌레로부터 보호하기 위해 만들어진 구조가 아닌가 싶어요.

이러한 왕겨의 구조가 2차전지의 전극재료로 사용될 수 있을 것이라는 생각이 들었고, 실제로 연구실에서 실험을 진행한 결과 다른 실리콘 구조보다 수명특성이 좋은 것을 확인할 수 있었죠.”

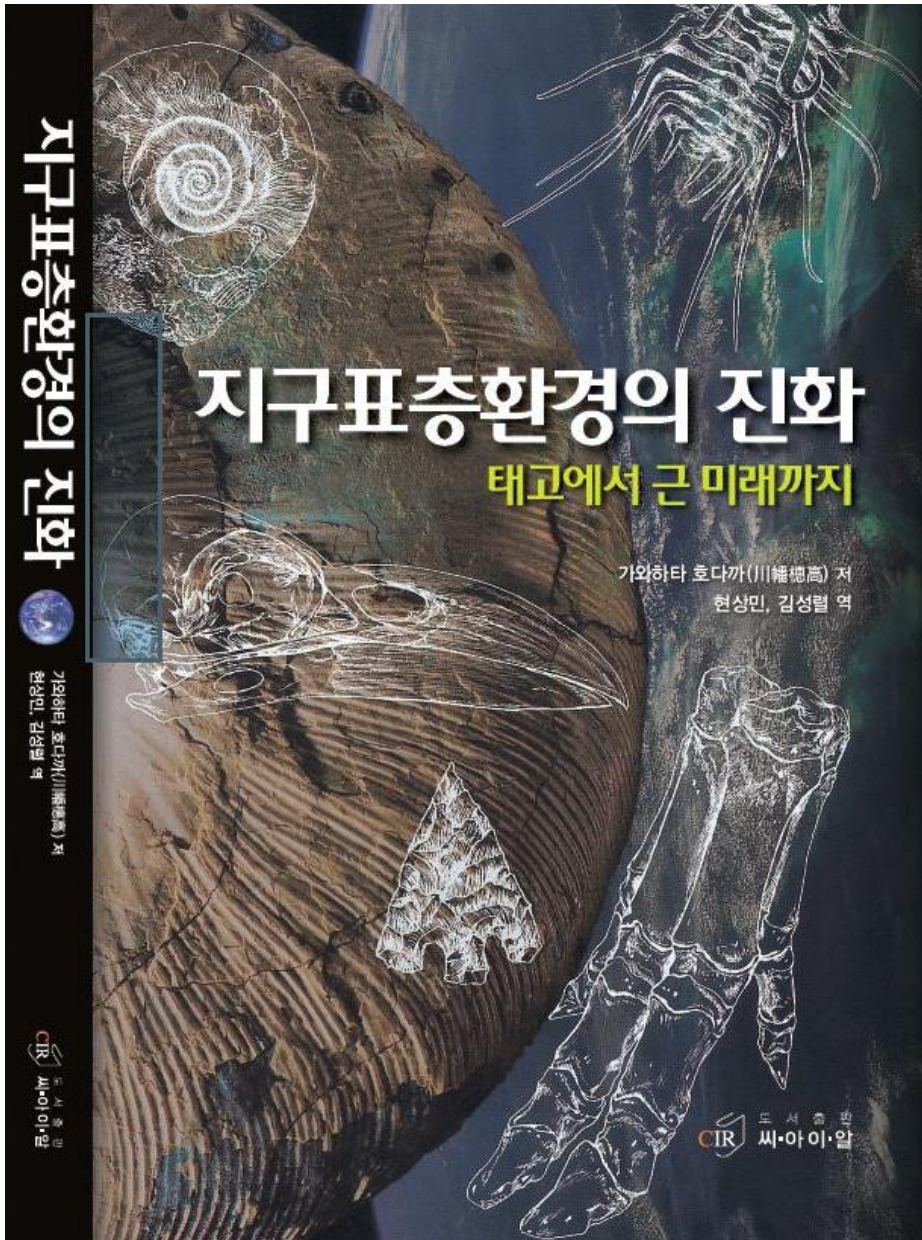
▲ 벼의 도정 부산물로 발생된 왕겨로 부터 고용량 리튬 이차전지용 3차원 다공성 실리콘 음극소재 개발. (오른쪽 아래 이미지는 왕겨의 외피에 존재하는 실리카의 존재를 나타낸다.) ©카이스트



서호주

'박문호의 자연과학 세상'
해외학습탐사

제13회 여름방학 탐사대



한국해양과학기술원 번역서, 2013년 우수학술도서 선정

『지구표층환경의 진화, 태고에서 근 미래까지』는 지구 표층(지각)의 지질시대적 변화환경의 분석을 통하여 45억 년 지구의 역사를 체계적으로 설명하고, 지구환경의 가까운 미래변화상에 대한 이해를 돕는 내용으로 구성된 학술서적이다

일본 도쿄대학 대기해양연구소 교수 가와하타 호다까(川幡徳高)가 저술하였고, 서울대학교 이용일 교수가 감수했으며, 해양과기원 현상민·김성렬 박사의 번역을 거쳐 지난해 12월 출간된 바 있다.

이 책은 지구의 탄생부터 가까운 미래까지 지구표층의 변화를 주도해온 다양한 요소들을, 현재까지 연구된 지구사적인 결과들과 대비시키고 있다. 특히 지질과학을 전공하는 분야의 관계자들에게 유용하게 활용되고 있는 것으로 알려진다.

목차

1. 지구표층환경 시스템과 연대
2. 선캄브리아시대의 지구표층환경
3. 고생대의 지구표층환경
4. 중생대의 지구표층환경
5. 신생대의 지구표층환경
6. 제4기의 지구표층환경
7. 초장기 환경변화
8. 인간권의 성립과 현대 및 근 미래 환경의 행방

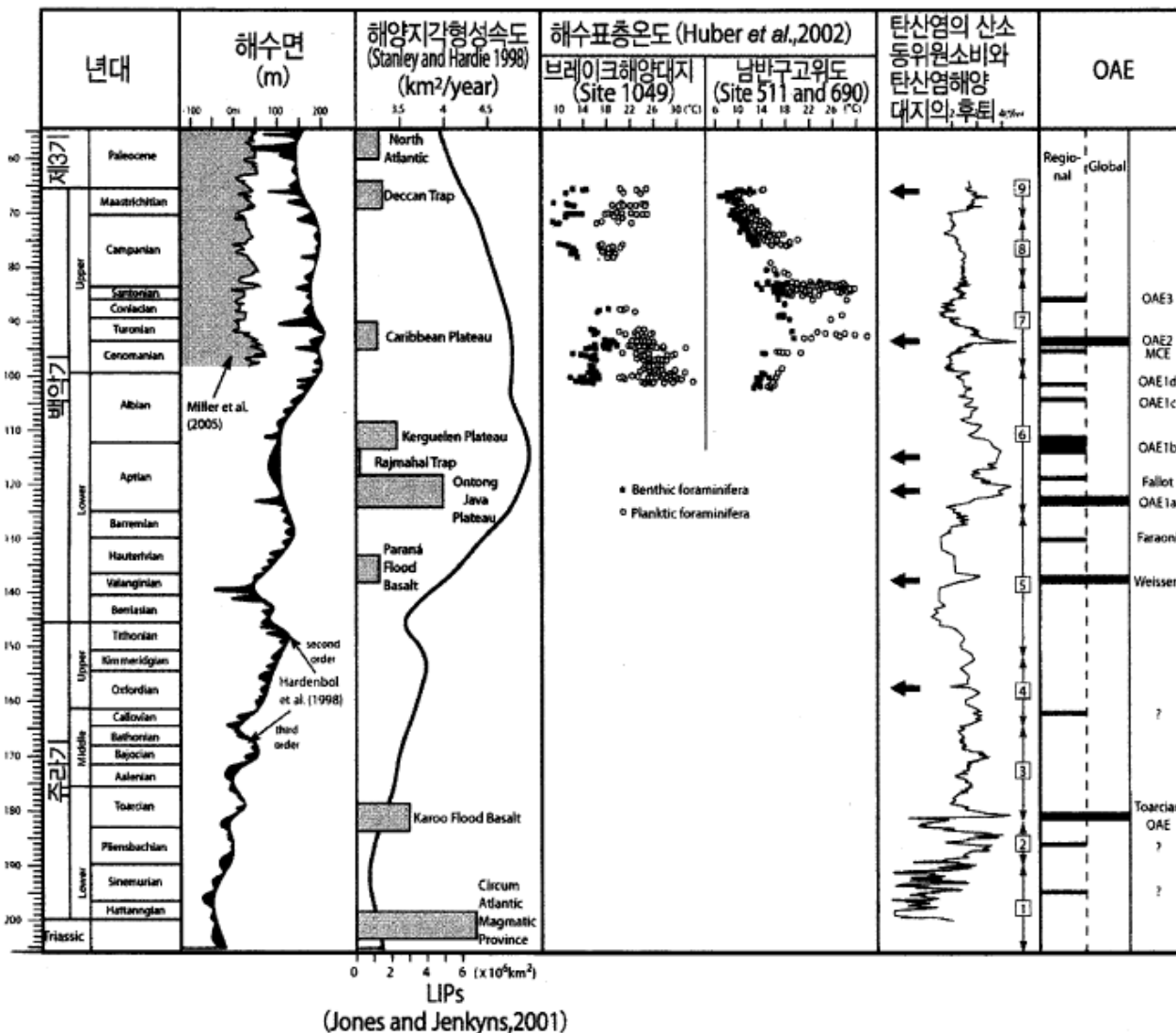


그림 4-8. 쥐라기부터 백악기에 걸친 해수면, 해양지각 생산, 고(古)수온, 탄산염의 $\delta^{13}\text{C}$ 값, 탄산염대지의 침수, OAE(해양 무산소 이벤트) 등을 종합한 그림(Takashima 등, 2006). 과거 수온에 대해서는 브레이크해양대지 및 남반구 고위도지역을 나타낸다. 투로니안기부터 캄바니안기에 걸친 수온저하는 고위도지역에서 크다는 것을 알 수 있다.

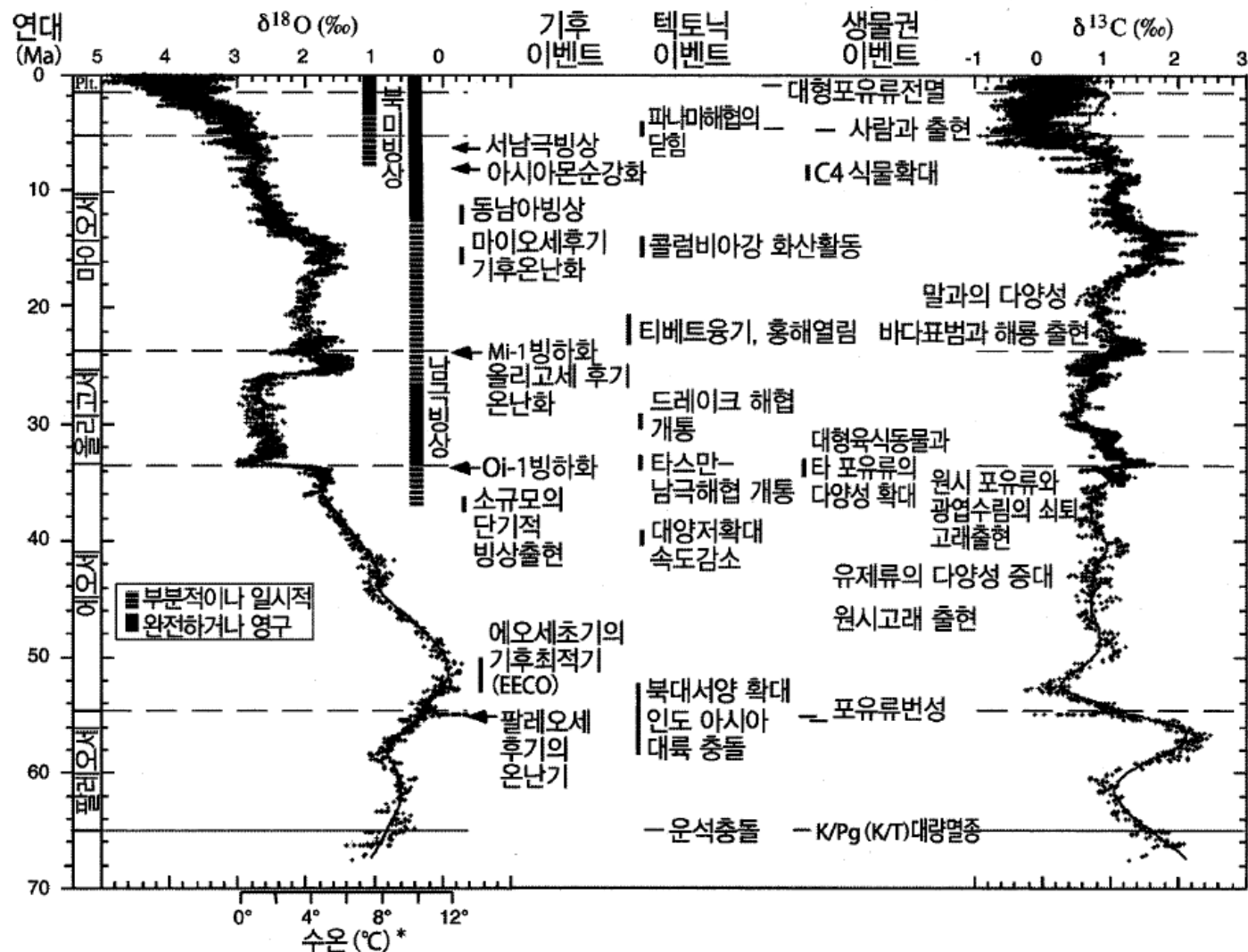


그림 5-1. DSDP/ODP 프로그램을 통해서 40개 지점을 굴삭하여 얻은 시추퇴적물에 포함된 유공충에 대한 동위원소 분석결과를 통합한 그림. 신생대의 저서성 유공충의 $\delta^{18}\text{O}$ 값, $\delta^{13}\text{C}$ 값과 다양한 환경변화(Zachos 등, 2001).

왕겨의 표피에 존재하는 다공성 실리카에서 3차원 구조의 다공성 실리콘 입자를 추출·합성한 연구팀은 기존 실리콘 기반의 음극소재가 갖고 있는 고질적 문제점이 효과적으로 개선되는 것을 확인할 수 있었다. 충·방전 시 부피가 팽창하거나 수축하면서 발생하는 박리화 및 계면 불안정성 문제가 개선된 것이다.

“우리가 개발한 연구가 성능측면에서 기존 실리콘 재료보다 우수한 것을 확인했어요. 그리고 무엇보다 가장 큰 이점은 사용할 수 있는 재료의 양이 매우 많다는 것입니다. 아무리 좋은 물질이라 해도 재료가 고갈된다면 무용지물이죠.

하지만 왕겨는 2차전지가 폭발적으로 증가하는 것을 감안하더라도 최고 100~1000배는 양이 많습니다. 게다가 왕겨의 고부가가치 이용사례는 거의 없기 때문에 앞으로 해당 기술은 더욱 큰 이점을 갖게 될 것이라고 생각합니다.”

최 교수는 “개발한 연구결과를 현재 사용하고 있는 전지와 비교하자면, 흑연대비 왕겨에서 유래된 실리콘은 한 번 충전했을 때 그 밀도가 세 배에서 다섯 배까지 용량이 많다”며 “이것을 사용시간으로 계산하면 약 1.5~2배 정도 효능이 증가했다고 볼 수 있다”고 덧붙였다.

약 2년에 걸쳐 진행된 이번 연구는 재료의 이점과 연구결과의 성능으로 인해 많은 국가로부터 관심을 받고 있다. 특히 쌀을 주식으로 삼는 국가의 관심이 더욱 높은 상태다.

“인도나 중국, 태국 등의 국가에서 많은 관심을 보이고 있어요. 무엇보다 이번 연구는 자연에서 존재하는 유용한 자원을 실제 과학기술분야에 사용할 수 있다는 가능성을 보여준 사례여서 더욱 관심이 많은 것 같습니다. 보통의 경우에는 자연 속 자원들을 놓치는 경우가 많잖아요. 더불어 앞서 언급했듯, 융합 연구의 시너지를 보여준 사례라고나 할까요.”

최 교수는 “왕겨 표피로부터 만들어진 상호 연결된 다공 구조에 의해 실리콘의 부피 팽창을 효과적으로 제어해 우수한 용량을 유지하고 출력특성을 갖는 전지로 개선했을 수 있었다”며 “이에 따라 기존 실리콘 기반의 리튬 이차전지가 갖고 있던 한계와 용량·사이클 불안정성 등의 문제를 효과적으로 극복할 수 있었다”며 연구의 의미를 밝혔다.

앞으로 농가 혹은 농업관련 정부부처와 협업을 통해 연구를 진행하겠다는 최장욱 교수. 실생활에 도움이 되는 연구로 대중과 현직 종사자들에게 다가가겠다는 포부를 밝히며 심도 있는 연구로 기술발전을 이끌어 갈 것이라고 이야기했다.

(2) 타스만해협(Tasman Gateway)의 열림

에오세와 올리고세 경계에 두드러졌던 한랭화의 원인은 아직 확실하게 규명되지 못한 상태이지만 다음과 같은 두 가지 가설이 있다. 즉, 1) 남극대륙의 열적고립화를 초래했을 것으로 추측되는 타스만해협의 개통(열림)(Kennett, 1977)과 2) p_{CO_2} 의 대기 값이 임계한계 이하로 감소되었다는 것이다.

남극대륙과 오스트레일리아대륙과의 분리는 백악기 후기에 시작되었지만 최종적으로 분리되어 타스만해협이 열리게 된 것은 에오세가 끝날 즈음이었다(그림 5-7)(Exon 등, 2003). 타스만해협이 열렸다고 해도 34Ma 경에는 수심이 50m 정도였으며, 약 32Ma에 2,000m 이상 깊어져 부유성과 천해성 생물이 남인도양과 태평양 사이를 직접 왕래할 수 있게 되었다(Kennett, 1977; Stickly 등, 2004). 이러한 현상에 따라 남극대륙은 열적고립화가 촉진되고 남극대륙이나 그 주변 해역에는 눈과 얼음이 증가하게 되었으며 그 결과 알베도 값이 높아지고 강한 플러스 피드백이 작용했을 것으로 추측되고 있다.

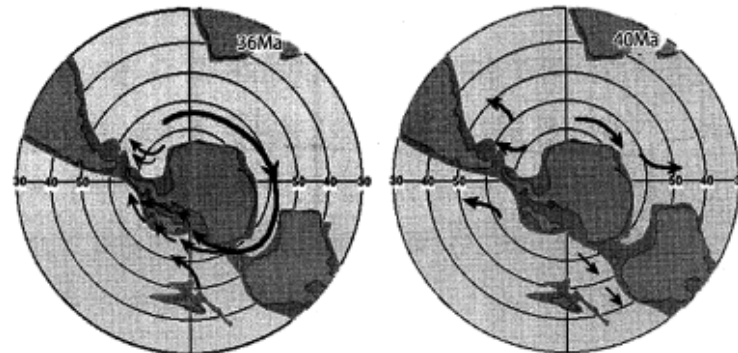


그림 5-7. 남극 주변해역에 있는 두 개의 해협(타스만해협과 드레이크해협)이 형성되는 과정(Kennett, 1977; Stickly 등, 2004; Scher and Martin, 2006).

신생대의 한랭화는 p_{CO_2} 와 관련되는 것으로 자주 설명되고 있다. 실제로 신생대에 p_{CO_2} 가 감소되었다고 보고된 바 있는데 p_{CO_2} 의 미묘한 변화가 빙상의 양을 변화시키는 방아쇠(트리거) 역할을 해서 열방사에 영향을 주었을 뿐만 아니라 대기순환의 형태나 습도 변화에도 영향을 미쳤을 가능성이 높다(그림 7-6). 그러나 빙상을 형성하기 위해서는 p_{CO_2} 변화에 동반되는 한랭화 이외에도 수분공급 또한 결정적인 요소가 된다(Bartek 등, 1996).

(3) 드레이크해협(Drake Passage)의 열림

기본적으로 타스만해협과 드레이크해협이 완전하게 열리고 나서야 비로소 남극주변의 해류가 완벽하게 되었다. 현재 드레이크해협의 개방 시기를 놓고 1) 32~33Ma인 올리고세 초기, 2) 마이오세 초기(22~17Ma)라는 두 가지 학설이 있다. 이와 같이 견해가 크게 엇갈리는 것은 스코티아(Scotia) 도호(island arc)나 스코티아 마이크로플레이트(micro plate)의 발달에 대한 추정이 어렵기 때문이다. 태평양과 대서양 통로가 개통되었다고는 해도 드문드문 산재해 있는 대륙의 존재나 해저지형이 다양하게 영향을 주었다고 추측된다(Livermore 등, 2005; Scher and Martin, 2006).

5.2.5 한랭화기후가 생명권에 미치는 영향

신생대의 한랭화는 생물화학 순환시스템에도 중요한 영향을 가져왔다.

(1) 규조의 진화와 초본식물 지대의 확대

규조는 현재 1차 생산의 약 40%, 엑스포트(export) 생산의 약 50%를



담당하고 있다. 또한 탄소순환을 다루는 데 있어 중요한 독립영양 플랑크톤으로 해양뿐만 아니라 담수지역에서도 서식하고 있으며 생태학적으로도 가장 발달된 진핵생물로 알려져 있다(Smetacek, 1999). 세포는 생물기원 오팔의 피각(frustule)으로 감싸여져 있다. 규조의 대증식(bloom)으로 나타나는 적조³⁾는 일반적으로 해안지역에서 일어난다. 외해에서 일어나는 대증식, 특히 봄철에 북태평양 중·고위도역에서 일어나는 대증식은 용승과정과 관계되어 있는 것으로 생각된다.

신생대 동안 규조의 다양성은 K/Pg경계에 멸종된 후 서서히 번성하기 시작하여 수온이 비교적 높았던 팔레오세나 에오세에는 거의 변화가 없었다. 그 후 에오세와 올리고세 경계(E/O), 그리고 마이오세 중·후기 이후에 급격히 증가하여 현재에 이르고 있다(Spencer-Carvato, 1999). 규조가 번식하는 데에는 원료가 되는 규산 등 주요 영양염이 필요하다.⁴⁾



이러한 현상은 E/O경계 이후에 남극대륙에 빙상이 발달된 것과 연관되어 있다. 빙상의 발달은 극지역의 수온이 낮은 상태로 유지되었다는 것이며 밀도가 높은 심층수 또는 저층수의 형성도 촉진되어 해양 대순환이 활발해진다는 것을 의미한다. 극지역에서 표층수의 침강은 수직혼합을 촉진시키고 결과적으로 표층수에 영양염을 다량으로 공급하게 된다. 또한 해양 전체에서 육지에서 해양으로 영양염이 공급되는 것은 기본적으로 육지에서의 풍화작용이 중요한 영향을 미친다. 풍화의 정도는 육지의 상승속도와 강수량에 큰 영향을 받는다. 대륙의 충돌 등에 의한 대륙의 상승속도와 하천에 있는 현탁물질의 총 공급량과는 플러스의 상

3) 적조를 초래하는 생물로는 규조 외에 와편모조 등도 있다.

4) 해양의 1차생산을 지탱하는 주요 영양염으로는 질산, 인산, 규산이 있다.

관관계(positive relationship)가 있으며(Holland, 1981) 육지의 생태계 변화 또한 하천에서 해양으로 공급되는 실리카 공급이 영향을 주었을 것으로 추측된다.

초본식물은 E/O경계 부근까지는 드물게 존재했지만 고위도지역의 빙하화 등으로 건조화 되면서 영역을 확대해 나갔는데 그러한 변화와 함께 유제류(有蹄類)(소 등과 같이 발끝에 발굽이 있는 동물)도 증가해 갔다(Janis 등, 2002). 초본식물은 최대 15%(중량)의 실리카를 포함할 수 있으며 플랜트 오팔⁵⁾을 남긴다. 초본식물인 C3식물의 화분은 에오세 초기인 약 55Ma까지 거슬러 올라갈 수 있는데(Jacobs 등, 1999) 플랜트 오팔은 에오세 후기 이후에 증가했다고 보고된 바 있다(Retallack, 2001).



초본식물은 뿌리를 통해 땅 속 깊은 곳에서 실리카를 흡수하고 마른 풀이나 초목을 섭취한 동물의 잔해가 풍화되면 하천이나 지하수를 통해 더욱 많은 실리카가 해양으로 공급되게 된다. 주로 초본식물로 이루어지는 초지는 약 17Ma까지 C3식물이 대부분을 차지하면서 확대되어 간 것으로 추정되고(Retallack, 2001), 그 후 약 7Ma에는 C4식물이 진출했다(그림 5-12). 이러한 육지의 환경변화는 해양으로 실리카 공급을 증가시키고 네오진기에 구조의 다양성 확대에 영향을 주었다고 설명된다(Falkowski 등, 2004). 일반적으로 C3식물은 나무나 관엽식물, 그리고 향초 외에도 여러 종류의 초본식물에 많으며, C4식물은 열대 및 아열대



5) 플랜트 오팔(plant opal or phytolith)은 토양에 남겨진 식물 규산체를 일컫는 총칭. 벼과(벼·대나무·갈대·참억새 등)나 금방동사니 등인 초본식물부터 떡갈나무 등과 같은 수목에는 규질화된 세포가 존재하는데 식물이 고사된 후에도 식물 규산체는 토양에 화석으로 남는다. 이것이 풍화되어 하천을 통해 바다로 공급되면 해양에서 규산이 증가하게 된다. 또한 플랜트오팔과 관계된 것으로 피자식물 단자엽류가 쌍자엽식물에 비해 SiO₂ 함유량이 높다.



의 사반나 초본식물과 온대의 넓은 초원에 있는 초본식물, 그리고 건조 지역의 초본식물에 많다.

(2) 코코리스, 와편모조류

와편모조류는 입자형태인 유기물뿐만 아니라 용존 유기물을 영양염으로 이용하여 동화시킬 수 있다. 주라기 및 백악기에 해양에서는 해침에 의해 증가된 연안역환경과 외해의 빈영양 상태인 두 가지 환경 조건에서 이러한 영양염 이용방법은 성공적으로 이루어졌을 것이다(그림 4-3). 광합성 능력을 지닌 와편모조는 1차생산자로서 먹이사슬에서 중요한 위치를 차지한다. 특히 갈충조는 와편모조류에서 단세포조류를 일컫는 총칭으로 산호와 공생하는 것으로 유명하다.

코코리스는 현재 영양염이 중간 또는 빈영양 환경에서 서식하는 그룹에 속한다. 유기화합물의 일종인 알케논(alkenone)을 생산하는 *Emiliania huxleyi*나 표준화석인 *Coccolithus pelagicus*가 잘 알려져 있다. 코코리스는 외양에서 중요한 1차생산자이며 작은 탄산염 생물각으로 덮여져 있다. 주라기와 백악기에 다양성이 증가되었다(그림 4-3). 와편모조와 코코리스의 다양성은 에오세 이후 줄어들기 시작했으며 기본적으로 신생대 중·후기로 가면서 해수면이 하강한 시기와 일치한다(그림 4-3).

(3) 고래류의 진화

규조의 번성과 관련되어 있다고 생각할 수 있는 것 중 하나는 해양의 먹이사슬에서 상위에 존재하는 고래류다. 고래목에 속하는 수생 포유류로, 현존하는 고래의 크기는 약 2m에서 25m를 넘으며 서식지도 적도지

Supernova do it all !

And what produces cosmic rays? The answer appears to be supernova explosions, although some particles may be accelerated to near-light velocities in interstellar space. The outermost layers of a supernova, blown into space at the highest velocities, may become cosmic-ray particles, traveling through interstellar space at nearly the speed of light. The bulk of the supernova explosion emerges at far more modest velocities, and eventually merges with other interstellar gas, enriching it in elements heavier than helium. But the fastest-moving particles speed on their random ways until they encounter something to stop them, perhaps an interstellar atom, perhaps a star, perhaps one of us. Thus the relationship of supernovae to the evolution of life on Earth appears to be straightforward. Supernovae make cosmic-ray particles; cosmic-ray particle impacts produce mutations; mutations drive evolution.

If this is so, supernovae do it all: They made our planet, they made our bodies, and they made the evolution that brought us here. We are living on the product, as the product, and by the product of stars that collapsed and then exploded, seeding the universe with their heavy elements and their fast-moving cosmic-ray particles. Far from being an isolated event, far distant from Earth and incapable of having any effect on us, Supernova 1987A can be seen as the latest in the chain of events that shaped our solar system, our Earth, ourselves.

