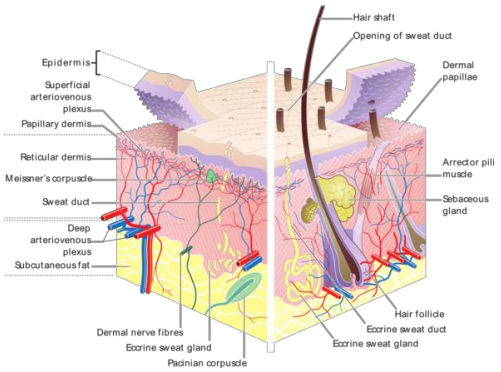
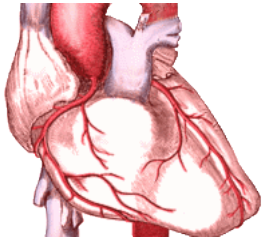
Organization and Function of the Nervous System

말초신경계통 末稍/周围神经系统
Peripheral Nervous System (PNS)

Somatic
체성신경계 SNS
躯体神经系统

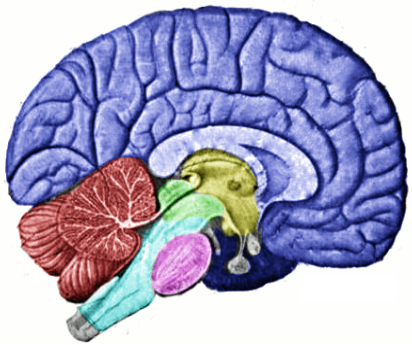


Autonomic
자율신경계 ANS
自主/植物/内脏神经系统



중추신경계통 中樞神經系統
Central Nervous System (CNS)

Brain
뇌



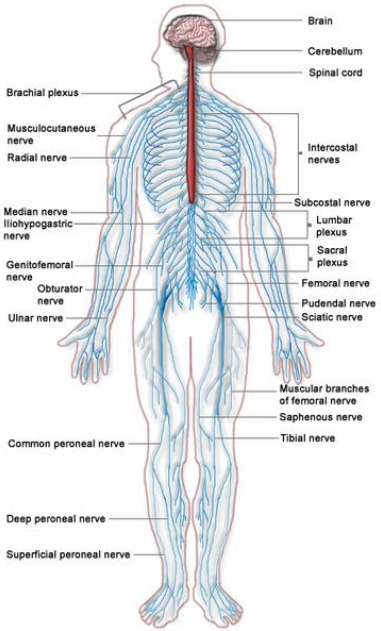
Spinal Cord
척수

Image Source: Wikimedia Commons

Peripheral Nervous System (PNS)

Somatic: Nerves connecting to voluntary skeletal muscles and sensory receptors

- ***Afferent* Nerve Fibers (incoming)**: Axons that carry info away from the periphery to the CNS 들신경섬유-神經纖維,구심(求心)신경섬유
- ***Efferent* Nerve Fibers (outgoing)**: Axons that carry info from the CNS outward to the periphery 날신경섬유, 원심(遠心)신경섬유



Autonomic: Nerves that connect to the heart, blood vessels, smooth muscles, and glands

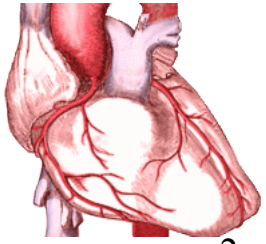
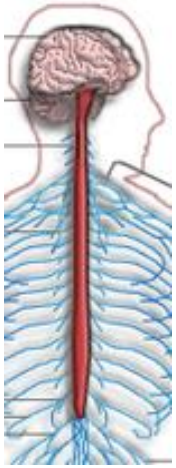


Image Source: Wikimedia Commons

Central Nervous System (CNS)

CNS = Spinal Cord + Brain



Spinal Cord

- Local feedback loops control reflexes ("reflex arcs")
- Descending motor control signals from the brain activate spinal motor neurons
- Ascending sensory axons convey sensory information from muscles and skin back to the brain

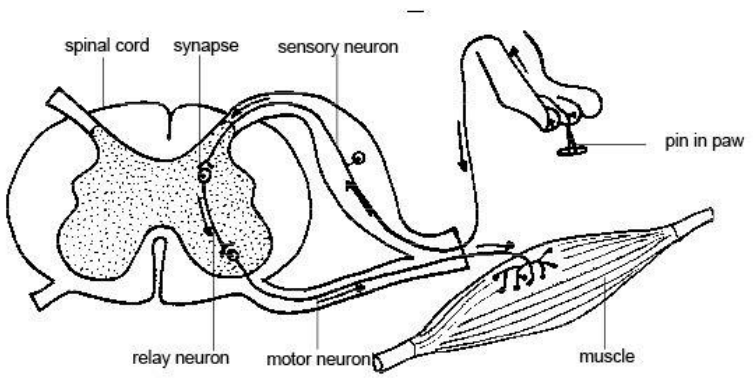


Image Source: Wikimedia Commons

CNS = Spinal Cord + **Brain**

〔의학〕 능뇌(菱腦); 후뇌; 수뇌(獸腦);
〔동물〕 (곤충 등의) 후대뇌

Major Brain Regions: The Hindbrain

Medulla Oblongata 수(髓) + elongated = 연수(延髓)

Controls breathing, muscle tone 근(육)긴장
and blood pressure

bridge(latin)다리뇌 또는 교뇌(橋腦)
脳桥

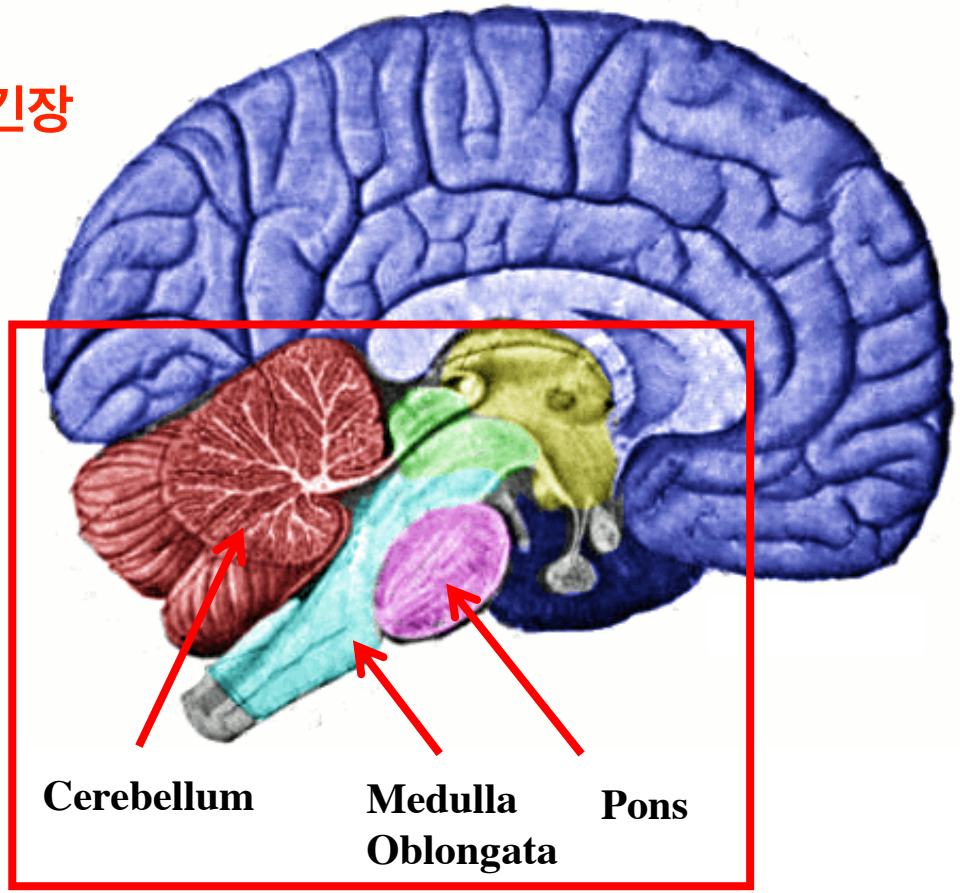
Pons

Connected to the cerebellum & involved in sleep and arousal

小脑

Cerebellum

Coordination and timing of voluntary movements, sense of equilibrium, language, attention,…



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Major Brain Regions: Midbrain & Retic. Formation

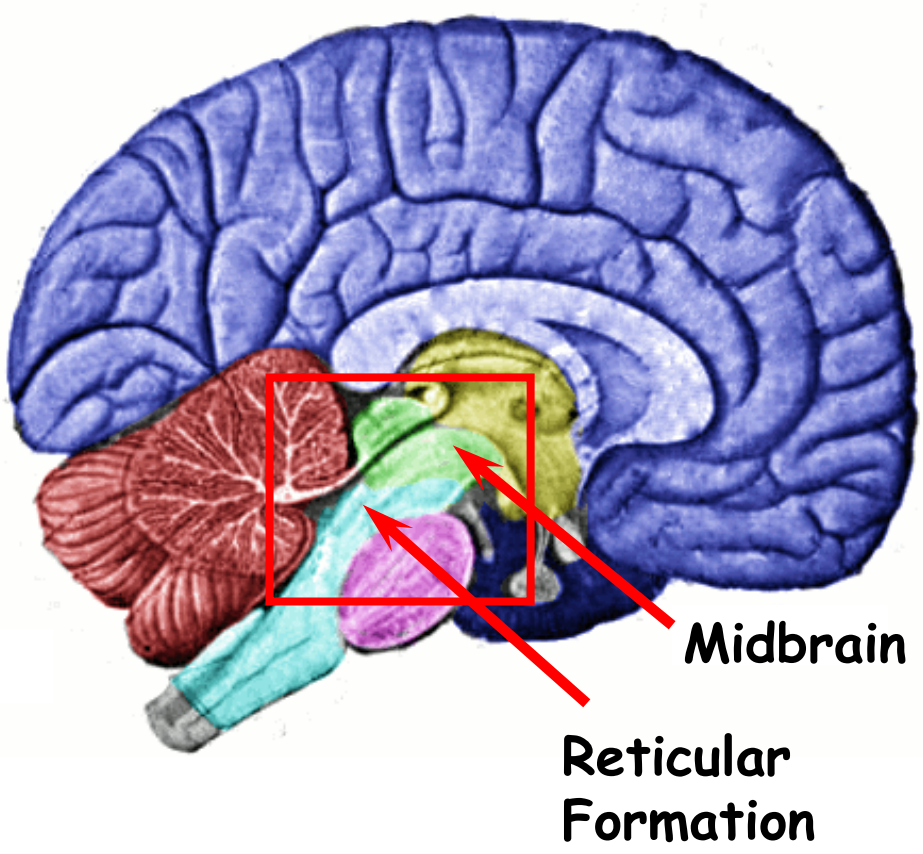
Midbrain

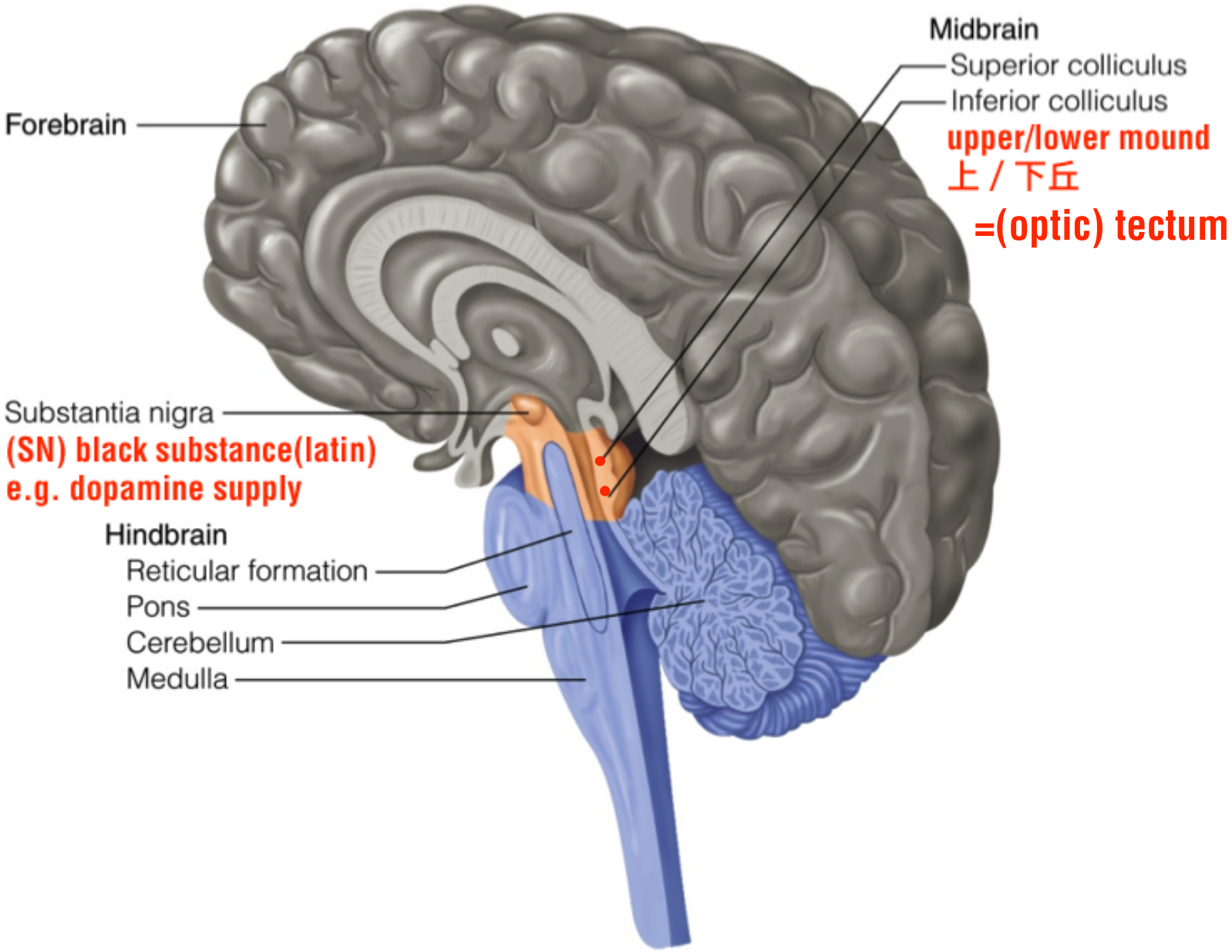
Eye movements, visual and auditory reflexes

rete = net(latin)그물체/망상체

网状结构Reticular Formation

Modulates muscle reflexes, breathing & pain perception. Also regulates sleep, wakefulness & arousal




Midbrain
Superior colliculus
Inferior colliculus
upper/lower mound
上 / 下丘
=(optic) tectum
Forebrain
Substantia nigra
(SN) black substance(latin)
e.g. dopamine supply
Hindbrain
Reticular formation
Pons
Cerebellum
Medulla

Major Brain Regions: Thalamus & Hypothalamus

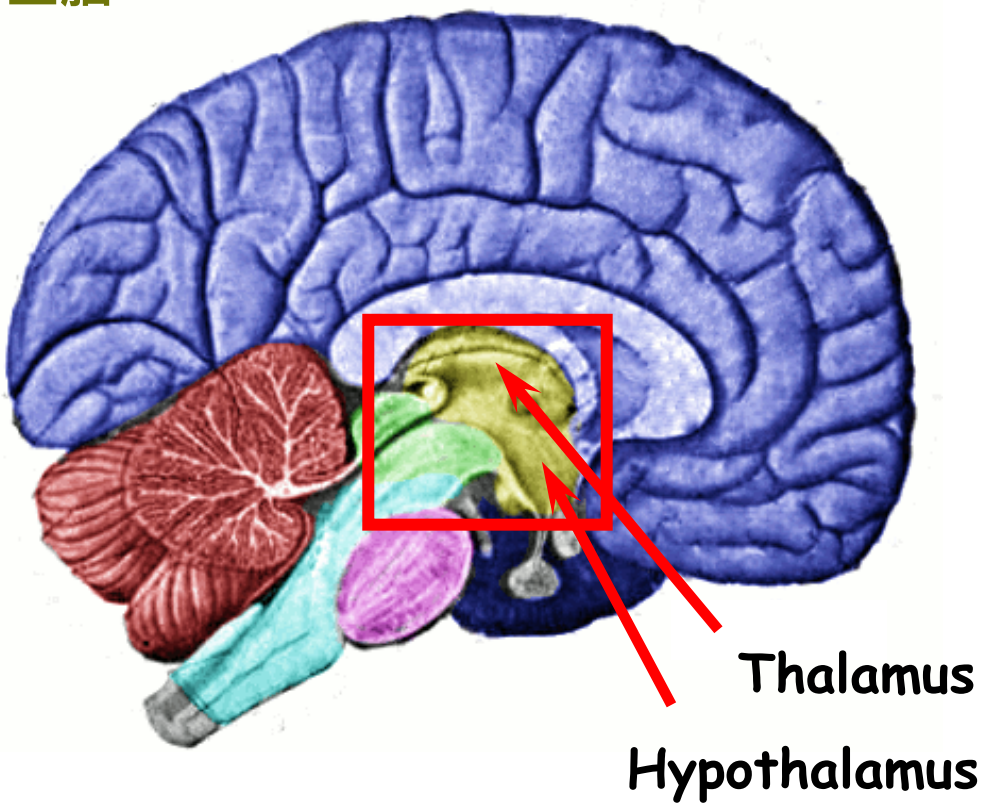
Thalamus 시상(視床) 丘脑

"Relay station" for all sensory info (except smell) to the cortex, regulates sleep/wakefulness

시상하부 下丘脑

Hypothalamus

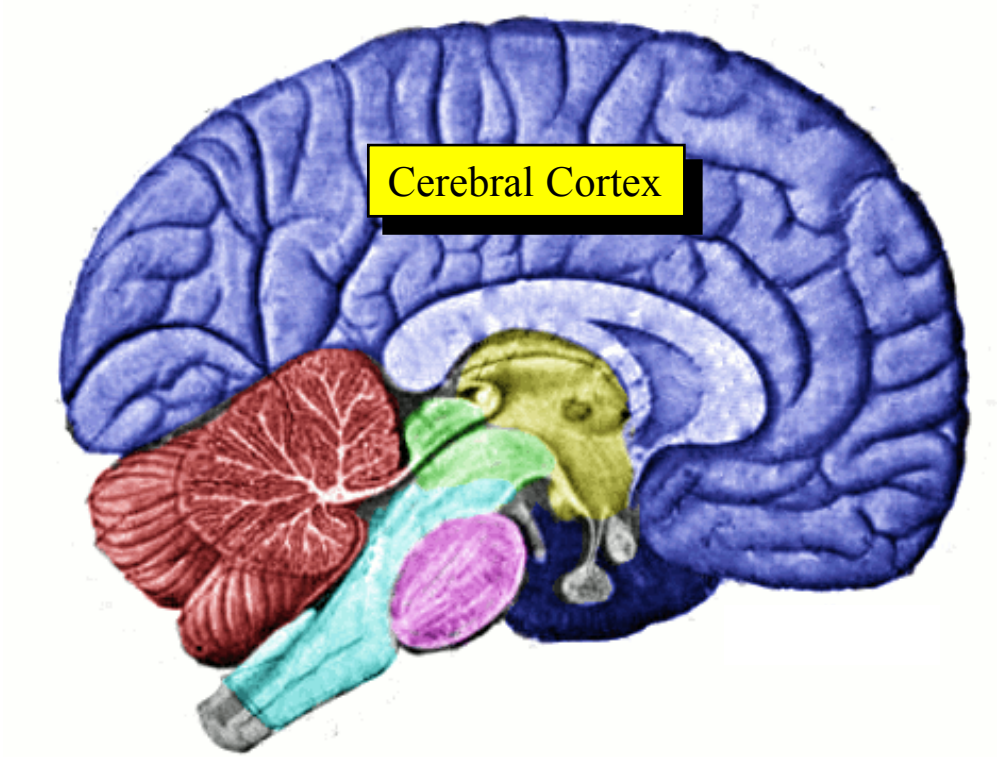
Regulates basic needs Fighting, Fleeing, Feeding, and Mating

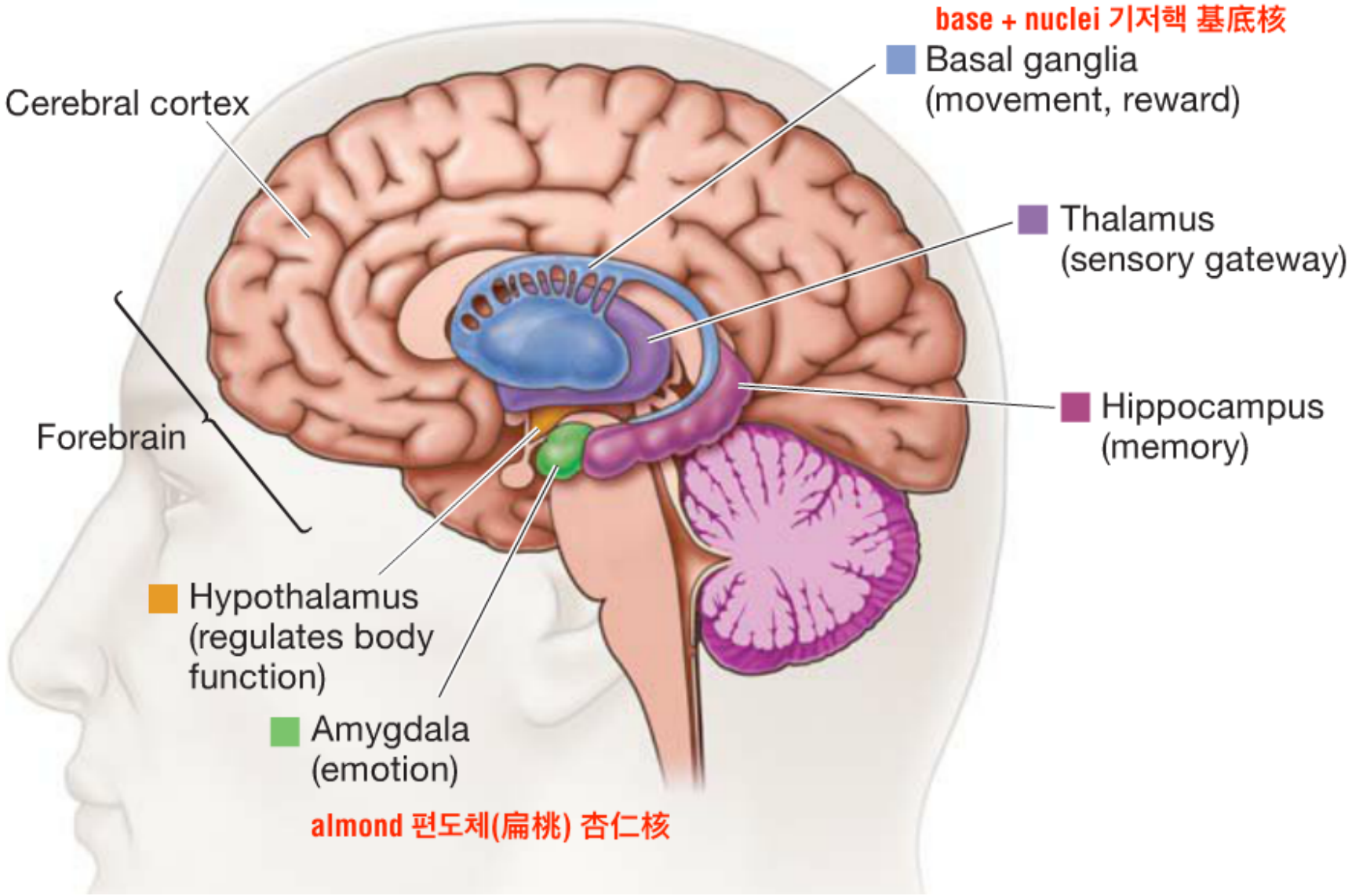


Major Brain Regions: The Cerebrum

- Consists of: Cerebral cortex, basal ganglia, hippocampus, and amygdala

- Involved in perception and motor control, cognitive functions, emotion, memory, and learning

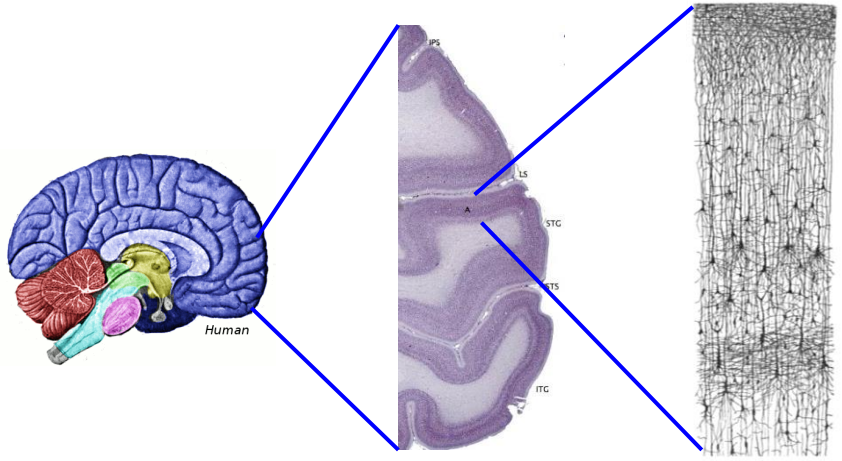



base + nuclei 기저핵 基底核
Basal ganglia
(movement, reward)
Cerebral cortex
Thalamus
(sensory gateway)
Hippocampus
(memory)
Forebrain
Hypothalamus
(regulates body
function)
Amygdala
(emotion)
almond 편도체(扁桃) 杏仁核

Cerebral Cortex: A Layered Sheet of Neurons

✦ Cerebral Cortex: Convoluted surface of cerebrum, about 1/8th of an inch thick **(a 14-inch thin pizza…**

- Approximately 30 billion neurons
- Each neuron makes about 10,000 synapses, approximately 300 trillion connections in total



✦ Six layers of neurons

- Relatively uniform in structure
- Is there a common computational principle operating across cortex?

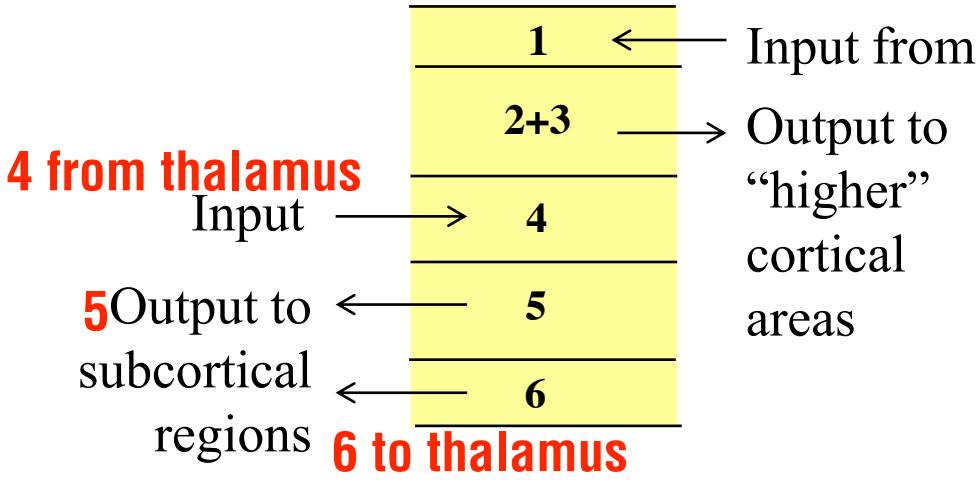


Image Source: Wikimedia Commons

How do all of these brain regions interact to produce cognition and behavior?

Don’t know fully yet!

But inching closer based on:

- electrophysiological,
- optical,
- molecular,
- functional imaging,
- psychophysical,
- anatomical
- connectomic*
- lesion (brain damage) studies…
  손상

*the production and study of connectomes: comprehensive maps of connections within an organism's nervous system, typically its brain or eye.

Neural versus Digital Computing

- Device count:
  - Human Brain: 10^{11} neurons (each neuron ~ 10^4 connections)
  - Silicon Chip: 10^{10} transistors with sparse connectivity
- Device speed:
  - Biology has 100μs temporal resolution
  - Digital circuits are approaching a 100ps clock (10 GHz)
- Computing paradigm:
  - Brain: Massively parallel computation & adaptive connectivity
  - Digital Computers: sequential information processing via CPUs with fixed connectivity
- Capabilities:
  - Digital computers excel in math & symbol processing…
  - Brains: Better at solving ill-posed problems (speech, vision)

Conclusions and Summary

- Structure and organization of the brain suggests computational analogies
  - Information storage: Physical/chemical structure of neurons and synapses
  - Information transmission: Electrical and chemical signaling
  - Primary computing elements: Neurons
  - Computational basis: Currently unknown
- In this course, we will try to understand computation in the brain through:
  - Descriptive models
  - Mechanistic models
  - Interpretive models

Computational Neuroscience

Next Week:
Descriptive Models of Neural Encoding and Decoding by Adrienne Fairhall