

Functions of the Central Nervous System

6.2.2024

Learning outcomes

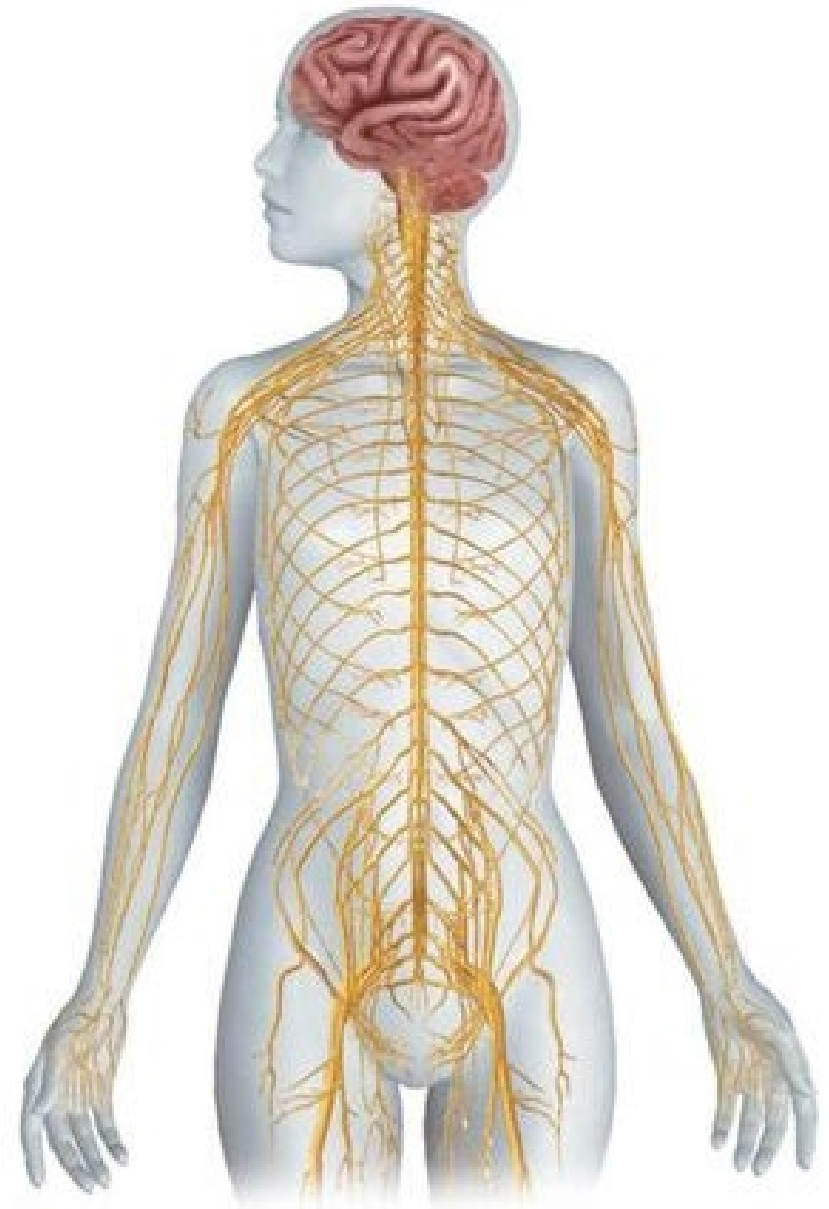
Recognize the essential anatomical structures and functions of central nervous system

Understand the brain functions related to different cortical lobes

Recognize the general vascular anatomy of the brain

Central and peripheral nervous system

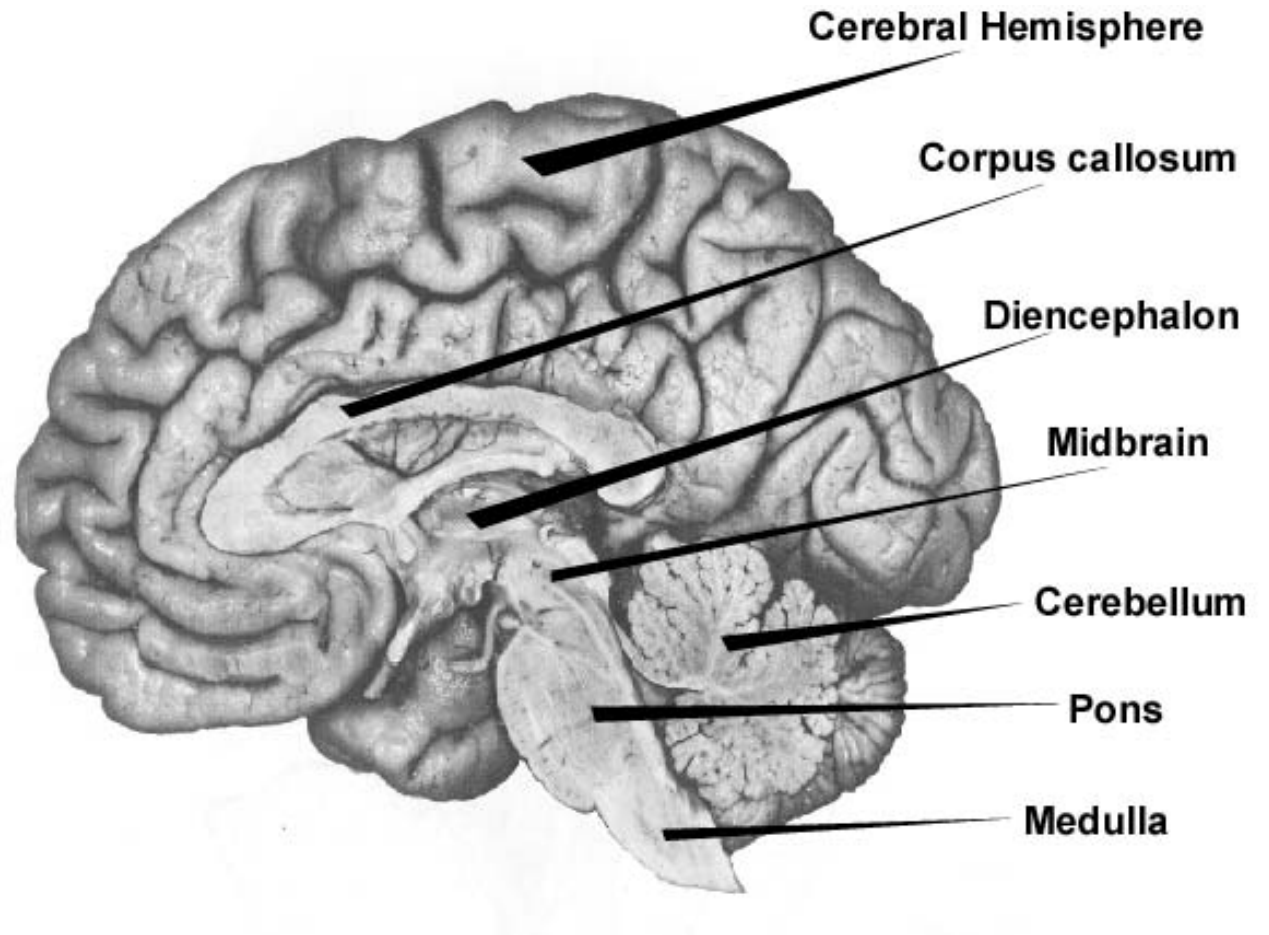
- Central nervous system = brain + spinal cord
- Peripheral nervous system = efferent + afferent nerves
- Nervous tissue (Lecture 2)



Central nervous system (CNS)

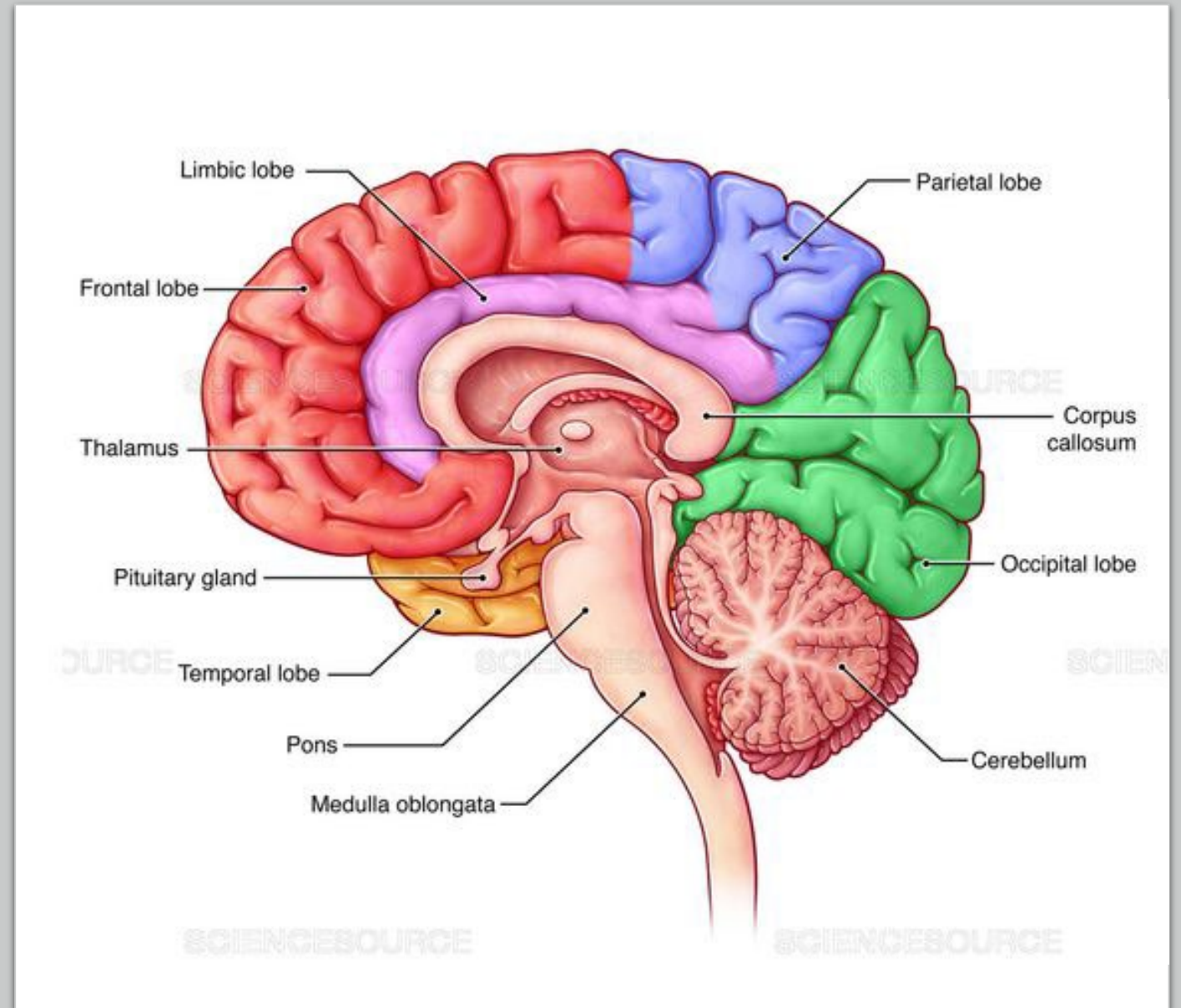
= Cerebrum + cerebellum
+ brainstem + spinal cord

- Brainstem =
(diencephalon,
interbrain) + midbrain +
pons + medulla
oblongata

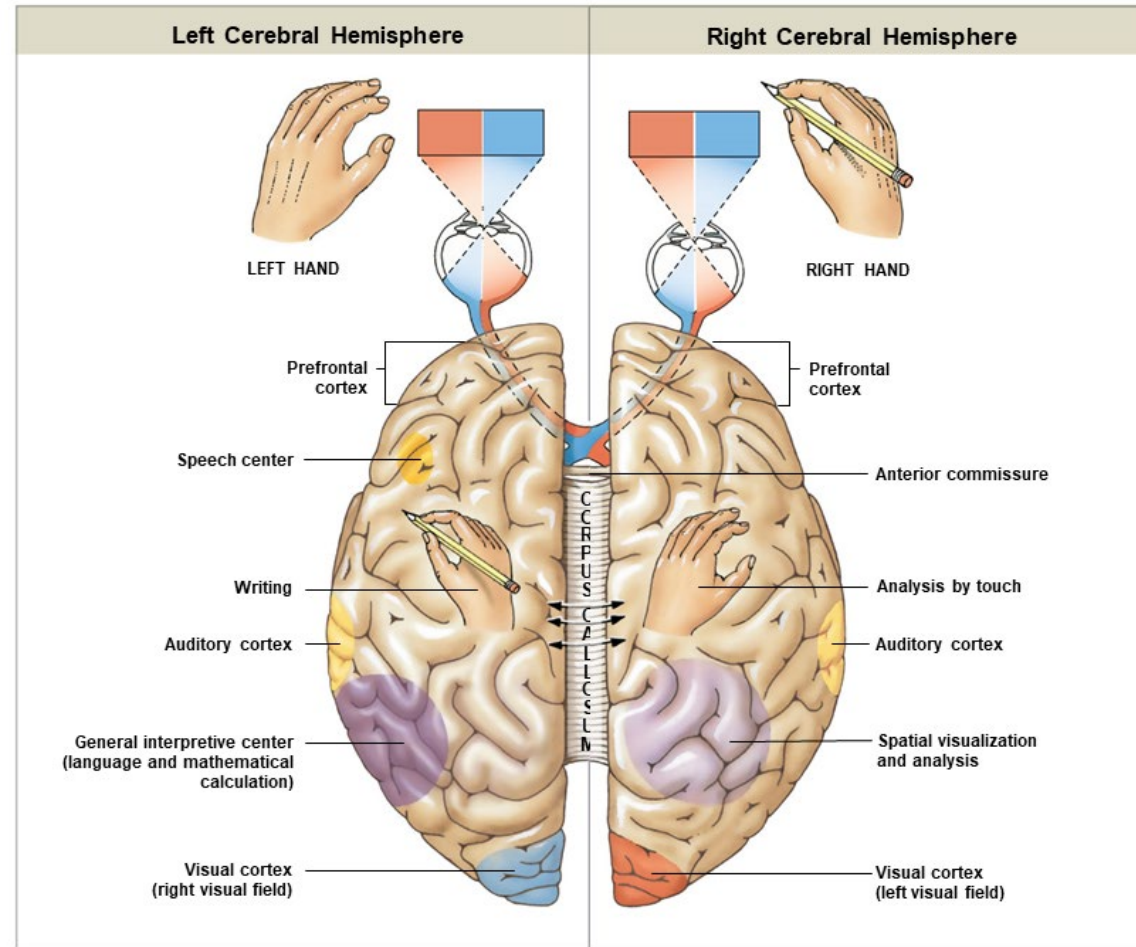


Cerebrum

- Two hemispheres, connected via corpus callosum
- 4 lobes/hemisphere
 - Frontal lobe
 - Parietal lobe
 - Temporal lobe
 - Occipital lobe
- Composed of gyri and sulci



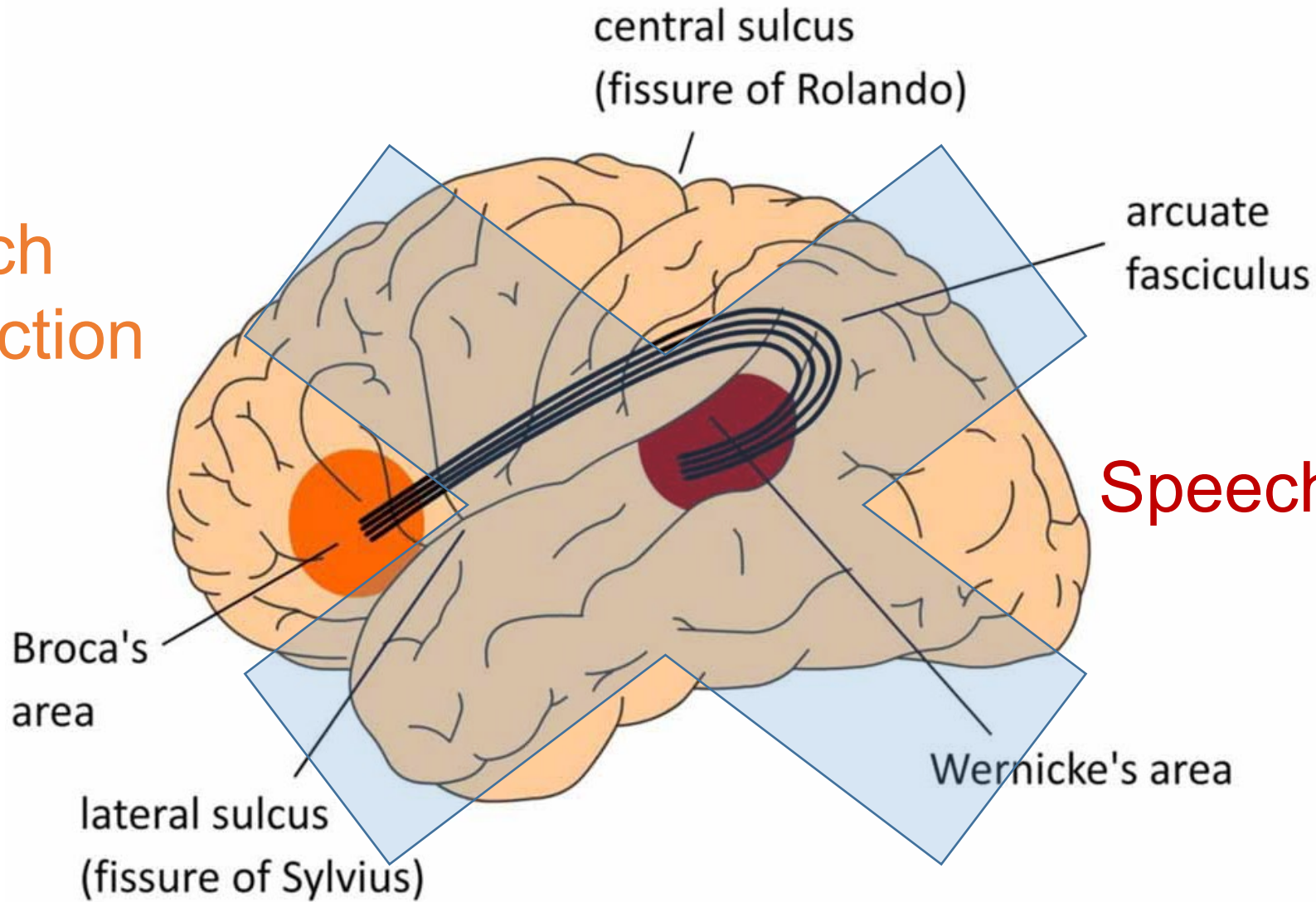
Cerebrum is structurally and functionally asymmetric



Considerable individual differences!

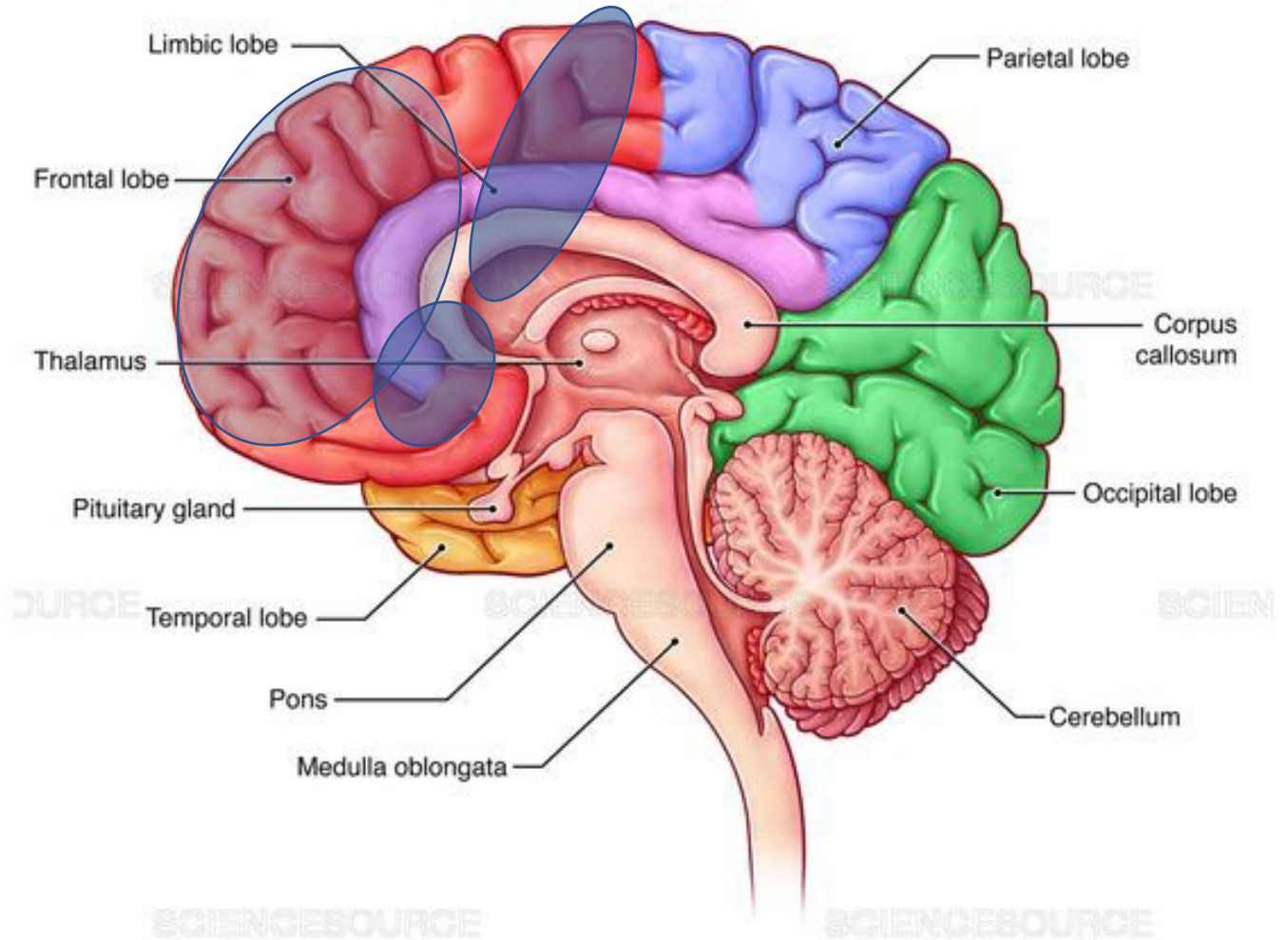
Speech production

Speech perception



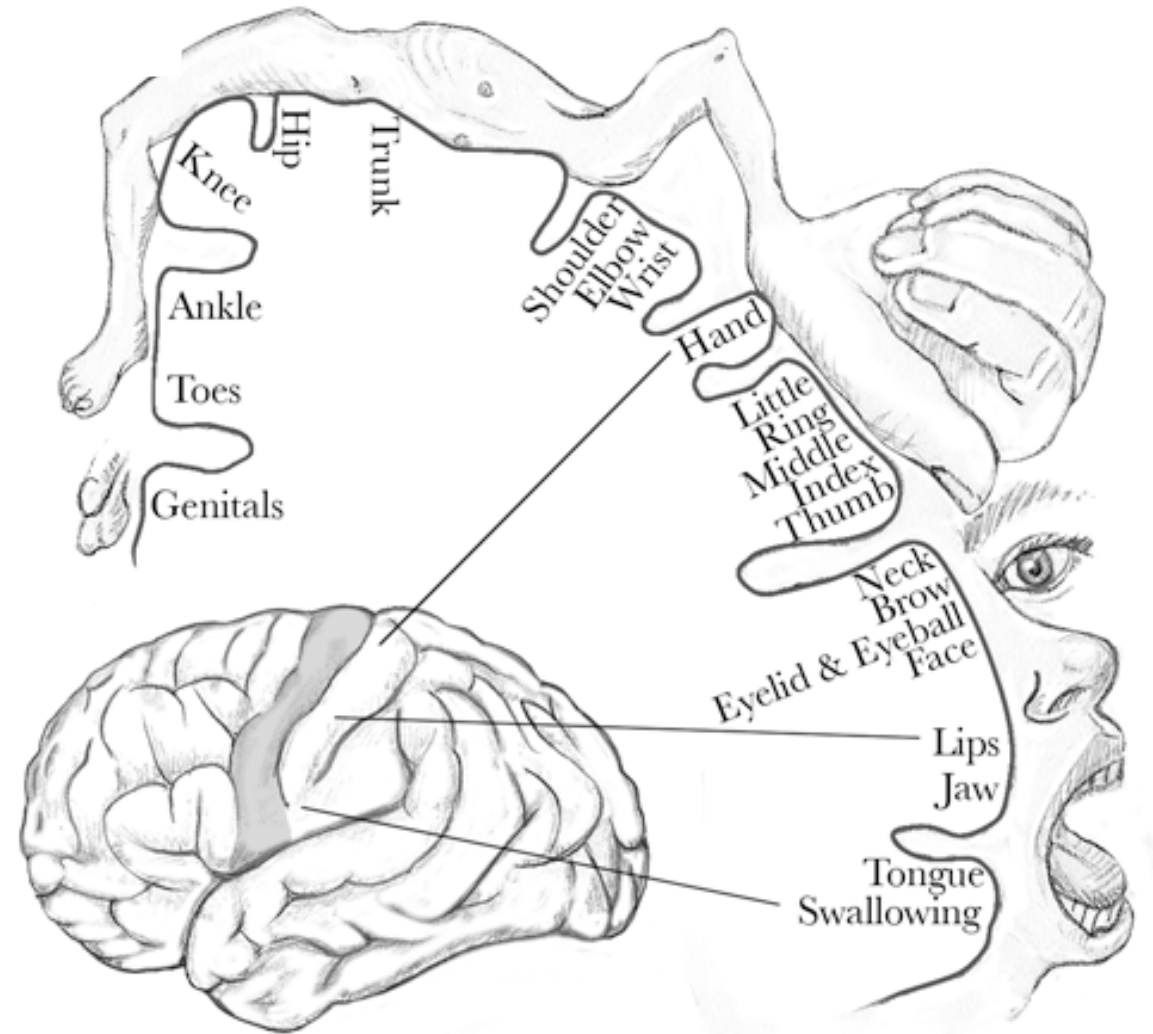
Frontal cortex

- Motor cortex
- Decision making, executive functions, impulse control, attention
- Broca's area in speech production



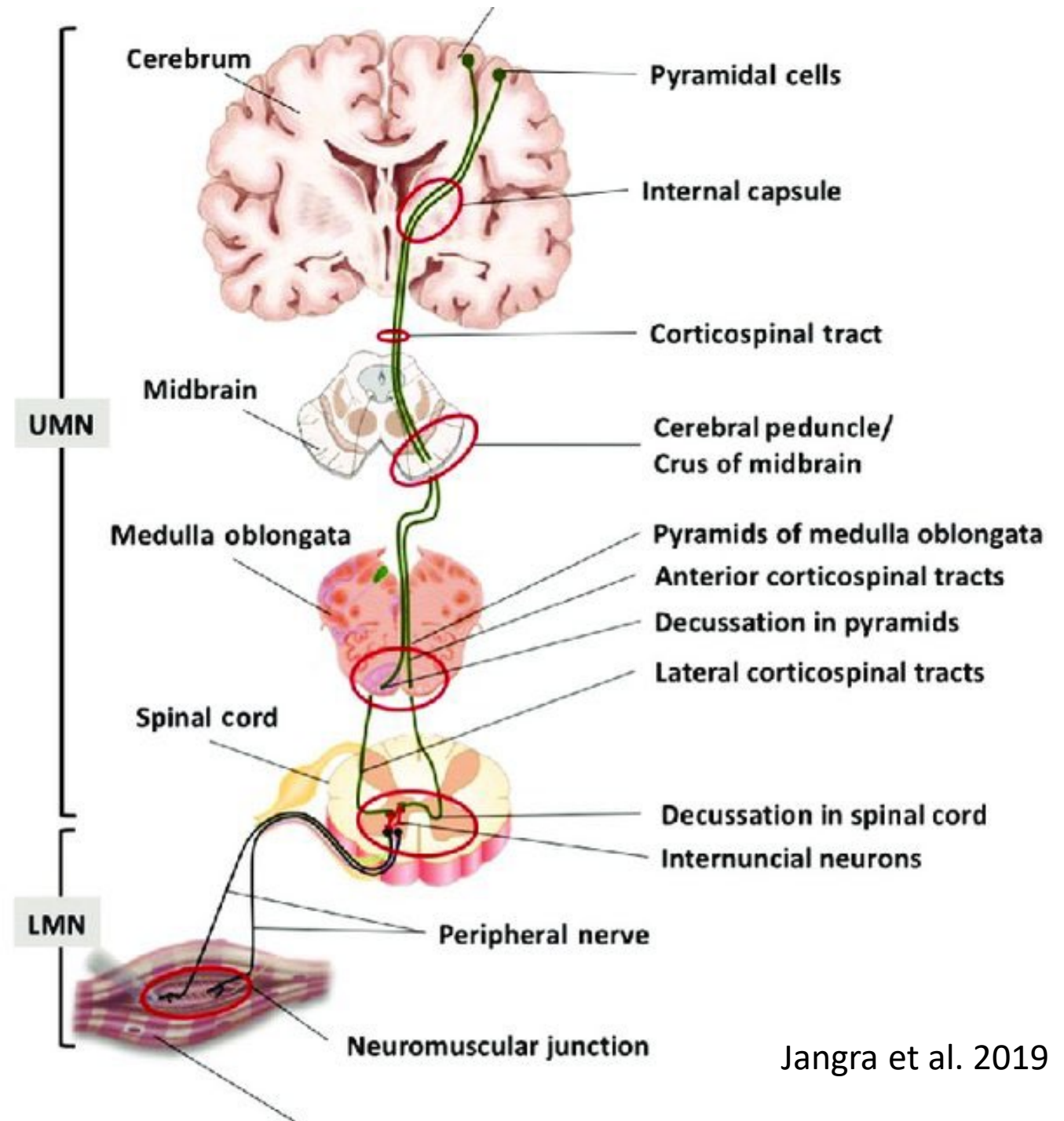
Motor homonculus

The cortical area reserved reflects the preciseness of the corresponding motor movements

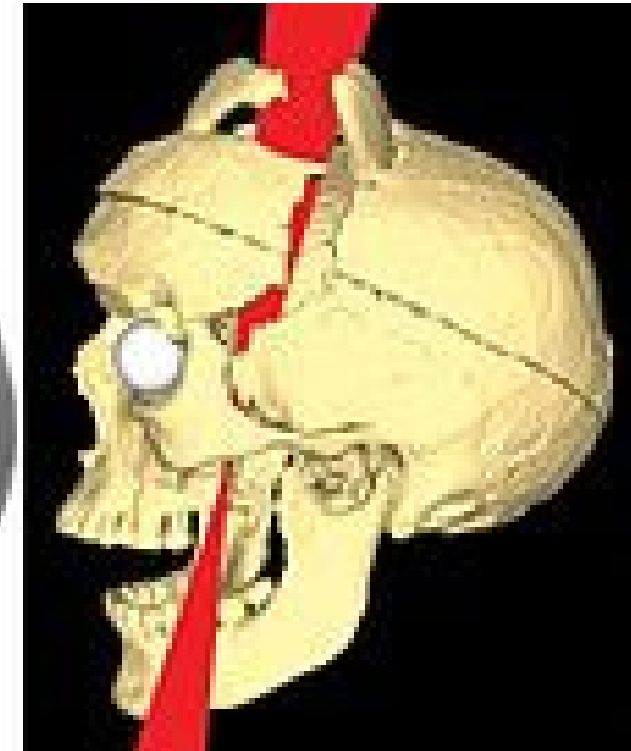
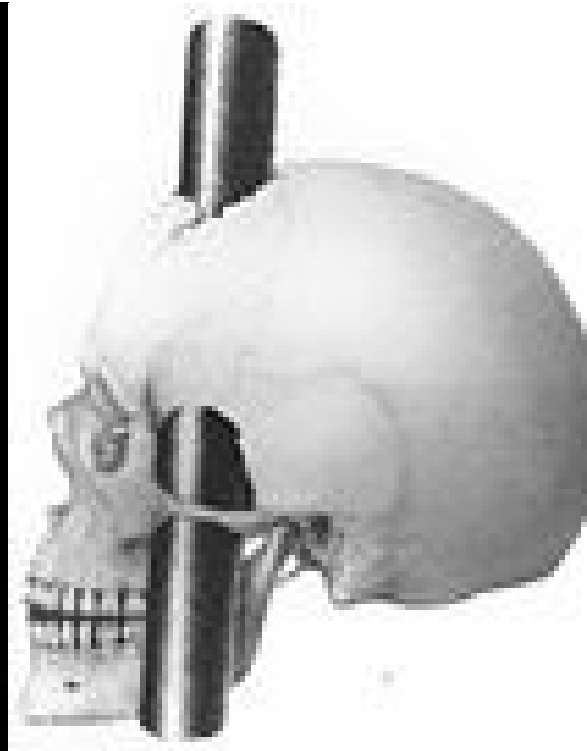


Motor

- Left hemisphere controls the right-sided movements and vice versa
- UMN, upper motor neuron; LMN, lower motor neuron
- Axons of the upper motoneuron travel to spinal cord and cross



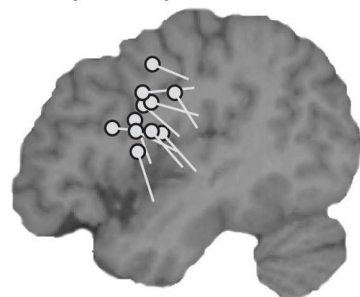
Frontal lobe in impulse control and executive functions: case of Phineas Gage by 1848



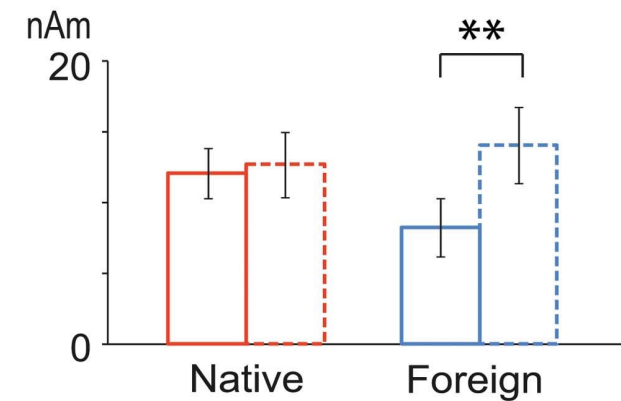
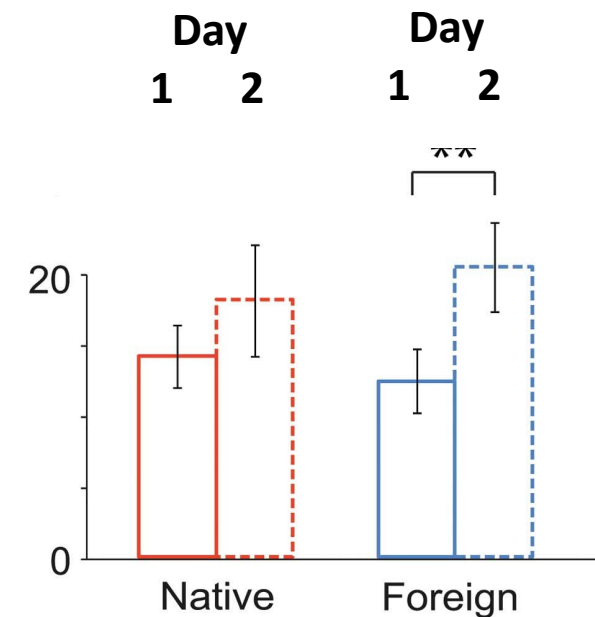
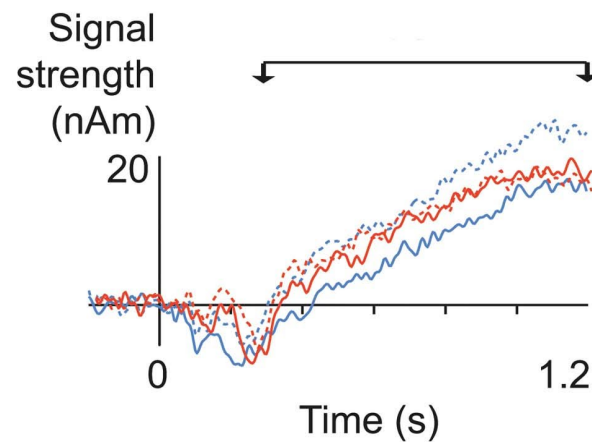
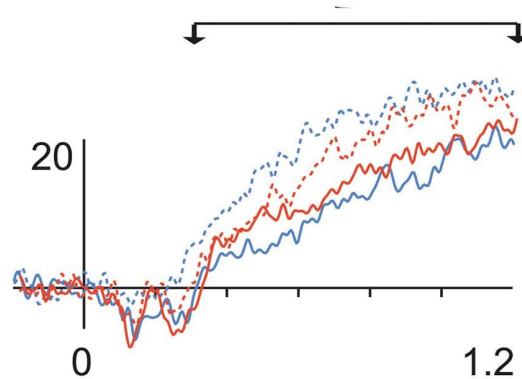
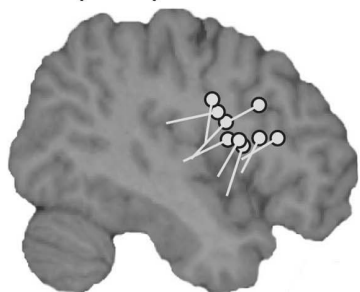
Wikipedia

Learning of foreign language activates frontal cortex

LF (n=11)

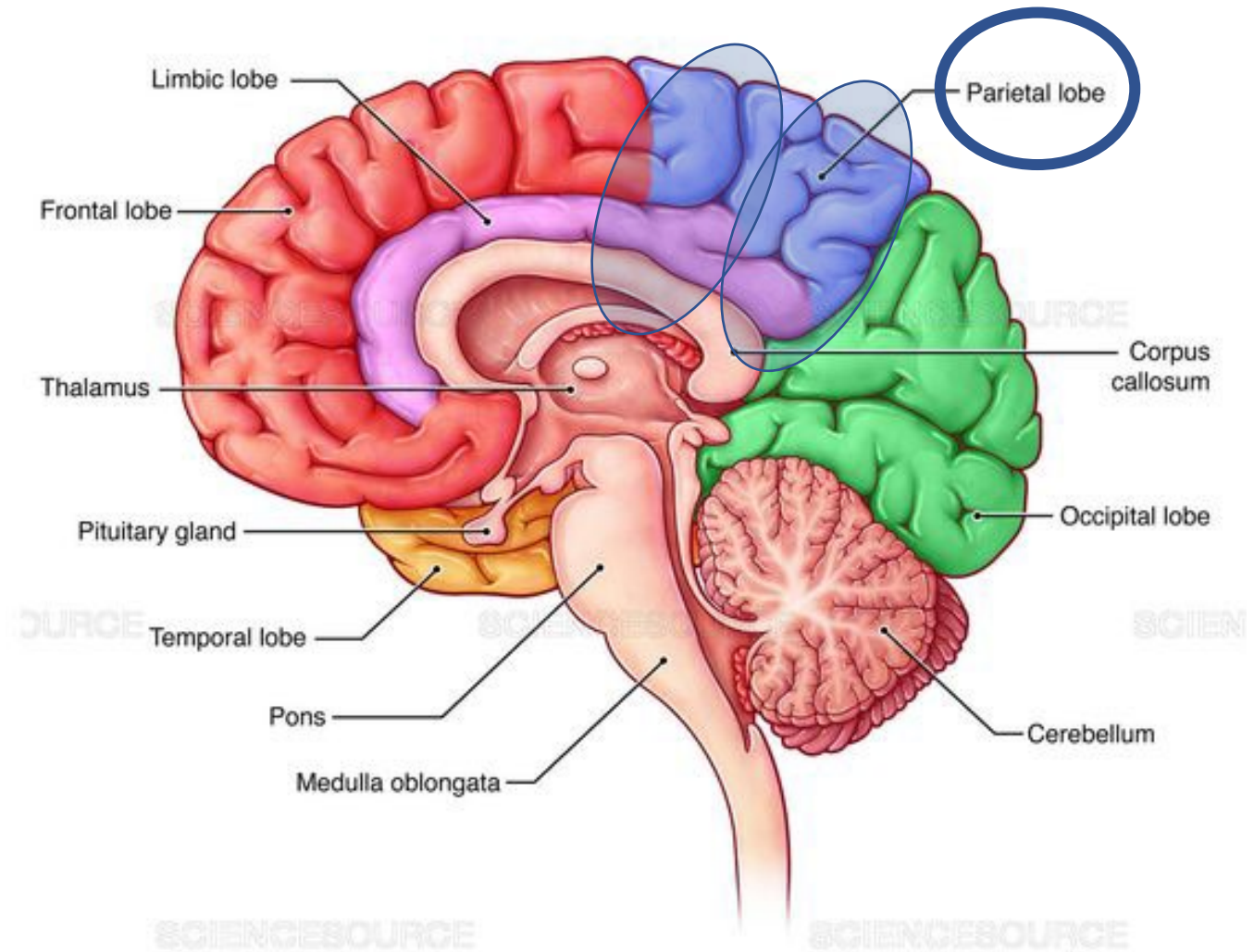


RF (n=9)

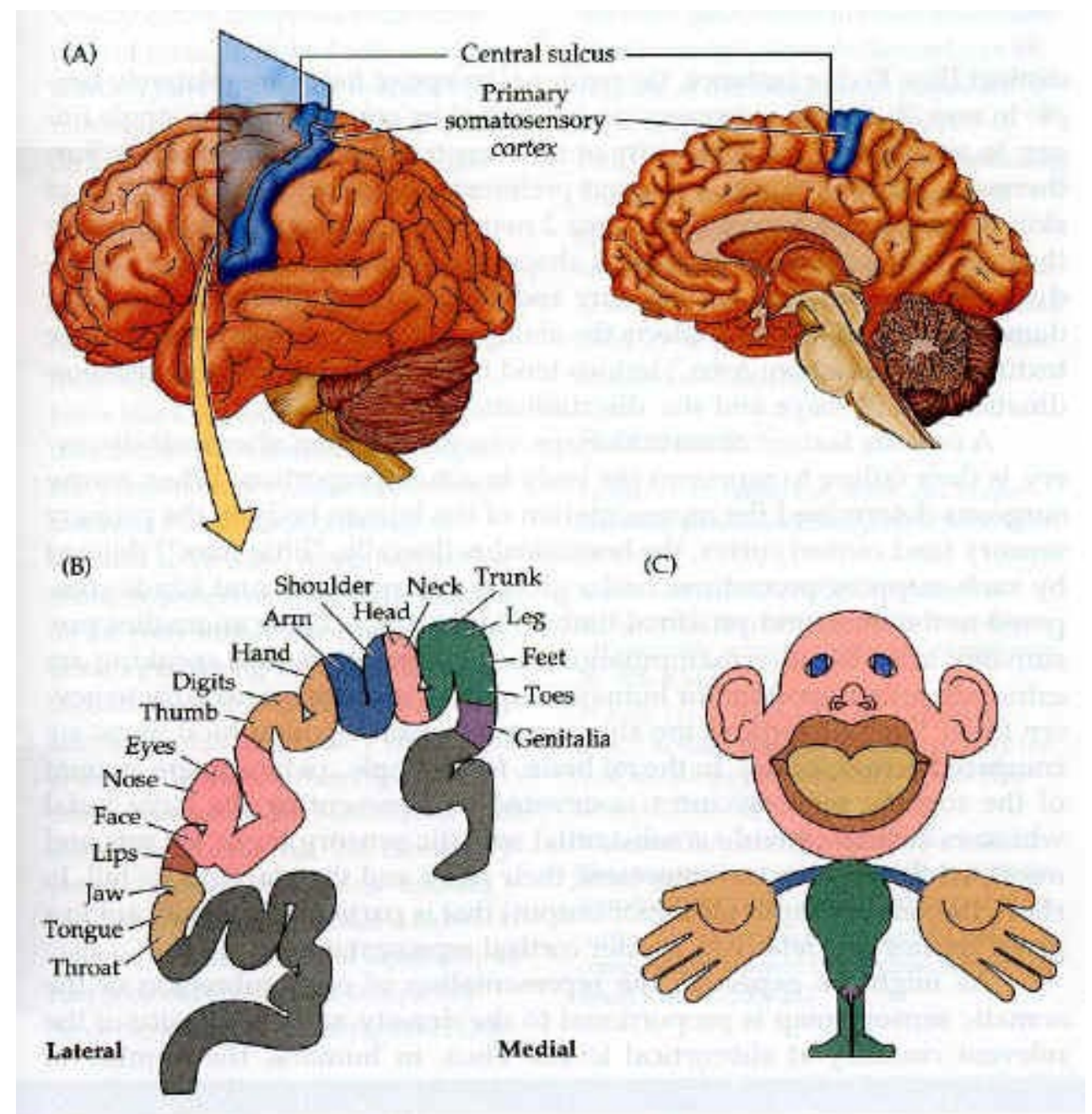


Parietal lobe

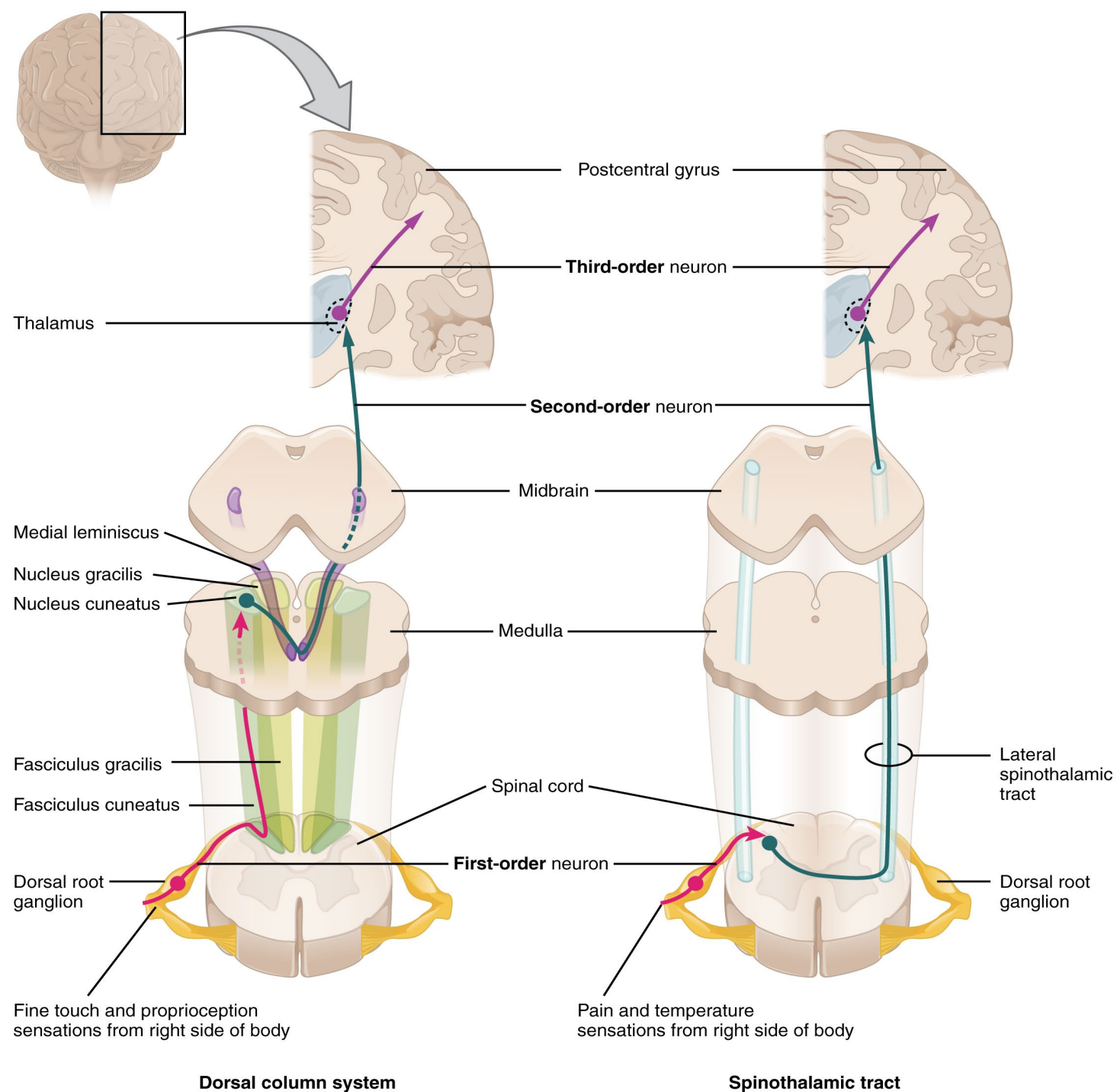
- Somatosensory cortex
- Association areas:
Spatial awareness,
motor control
- Attention and orientation



- Somatosensory homonculus: the resolution of sensation is reflected in the size of the corresponding cortical area
- Back vs. fingertips



- Left hemisphere processes most of the sensory information collected from the right side of the body, and vice versa



open.oregonstate.edu/aandp/chapter/14-5-sensory-and-motor-pathways/

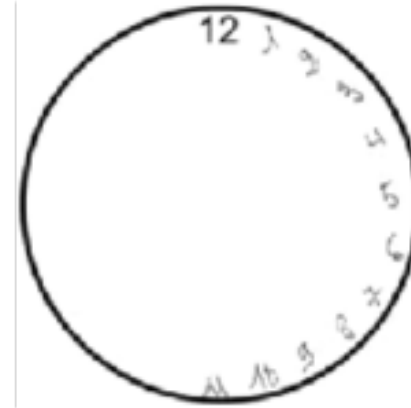
A



'copy this drawing'

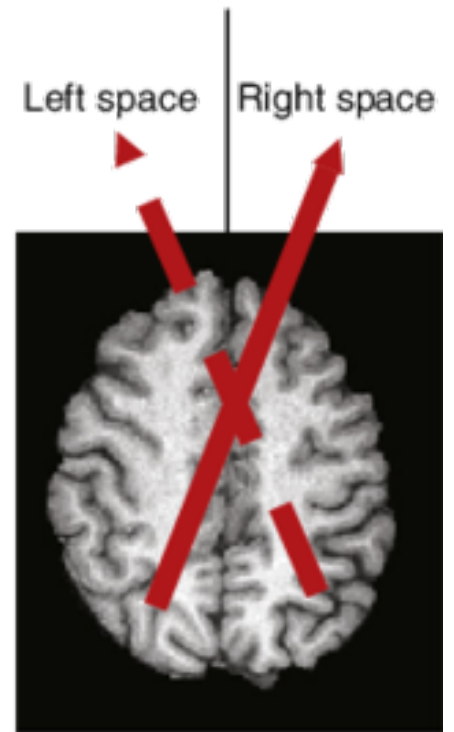


'cancel all the lines'



'fill in the numbers
on the clock'

B



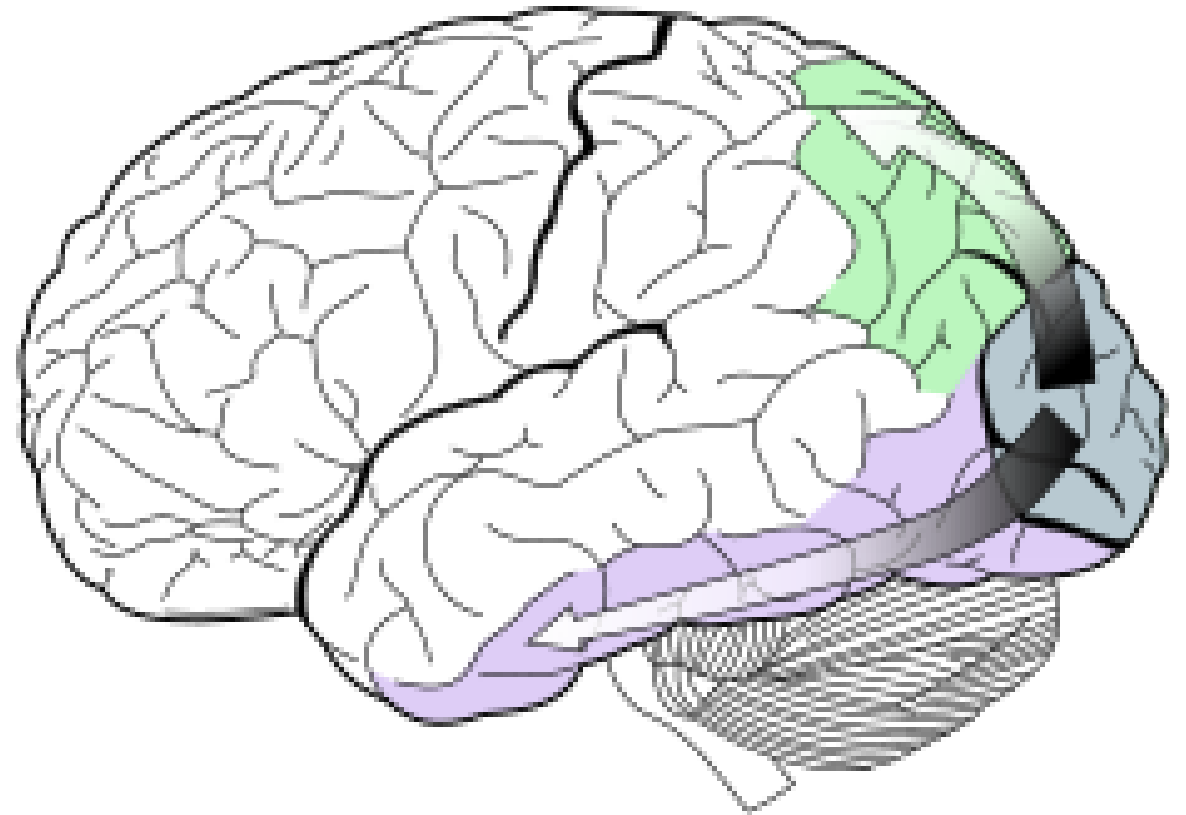
Current Biology

O'shea 2009

Neglect, i.e., inattention
is common after lesion
of parietal lobe

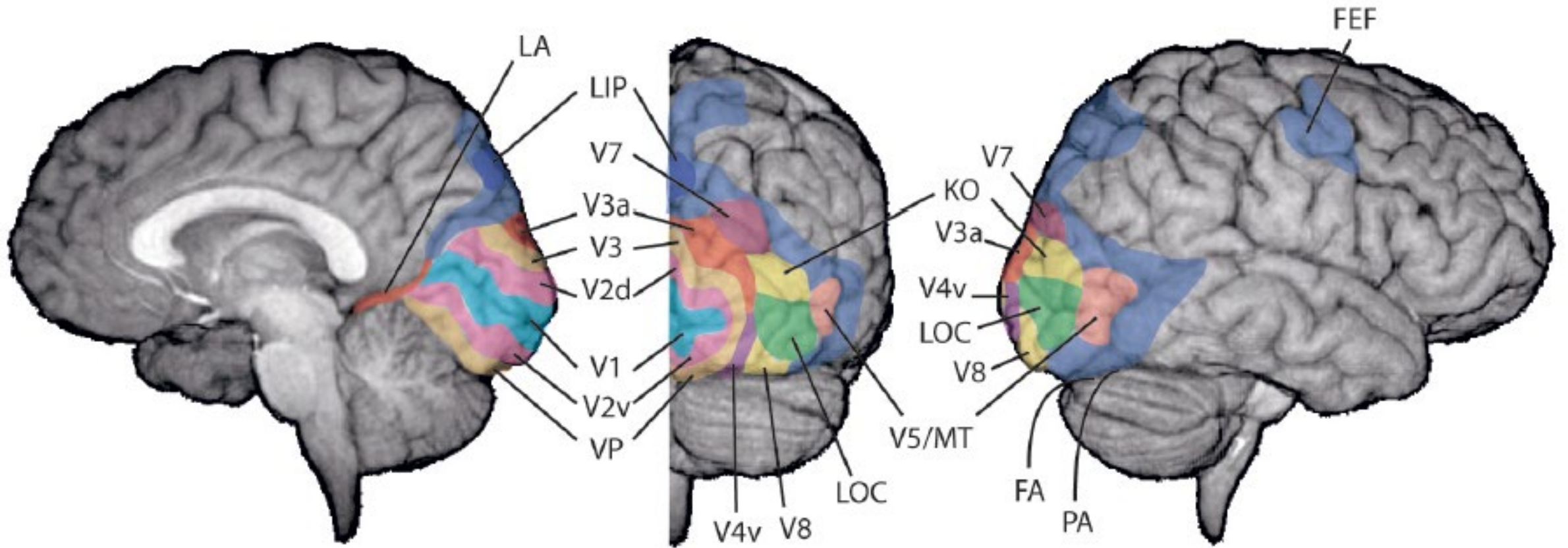
Occipital lobe

- Visual cortex
- Two main streams
 - Ventral: object recognition
 - Dorsal: spatial awareness, guidance of actions



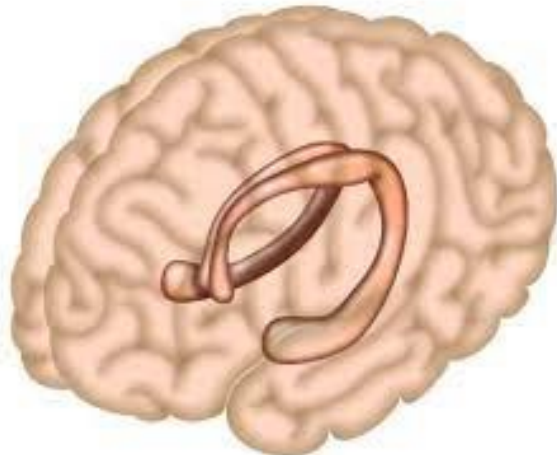
Wikipedia

Visual cortex occupies 1/3 cerebral cortex

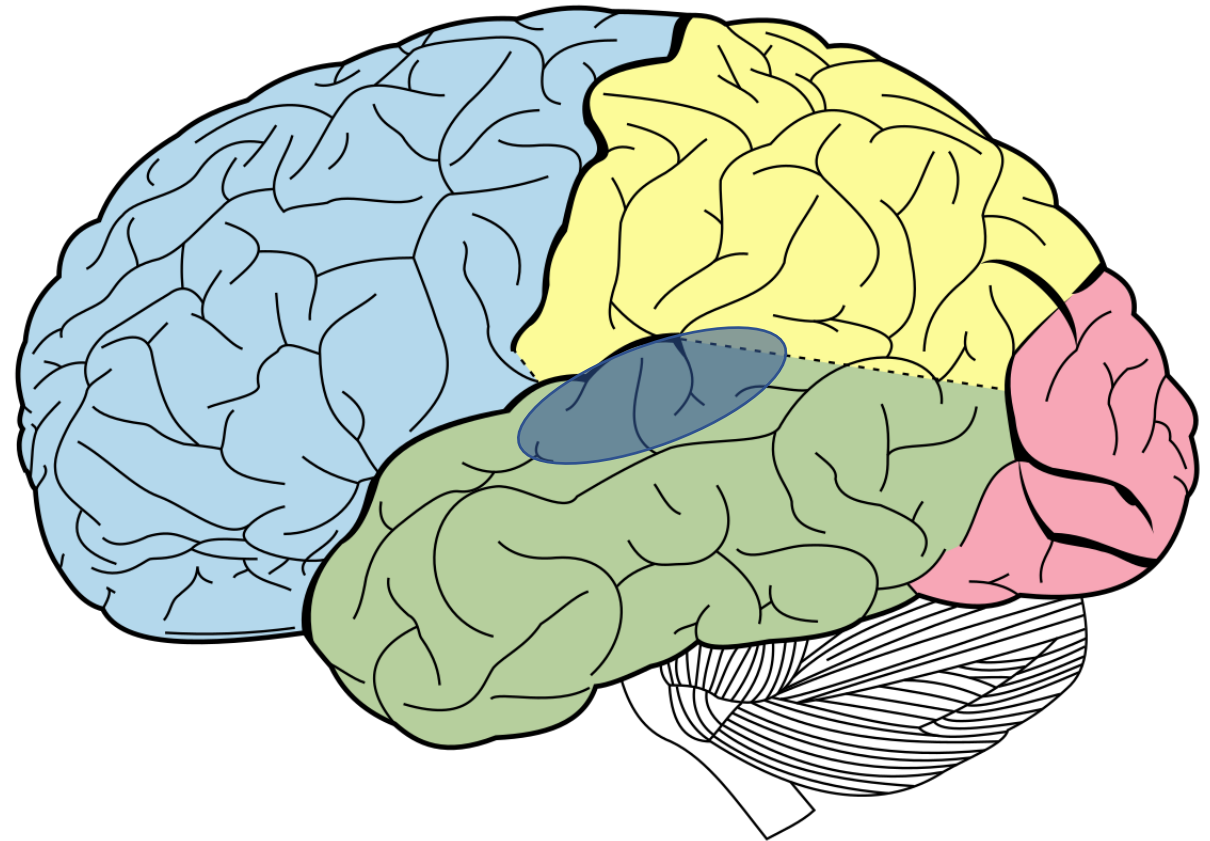


Temporal lobe

- Auditory cortex
- Language: *e.g.*, speech and reading comprehension
- Memory (hippocampus)

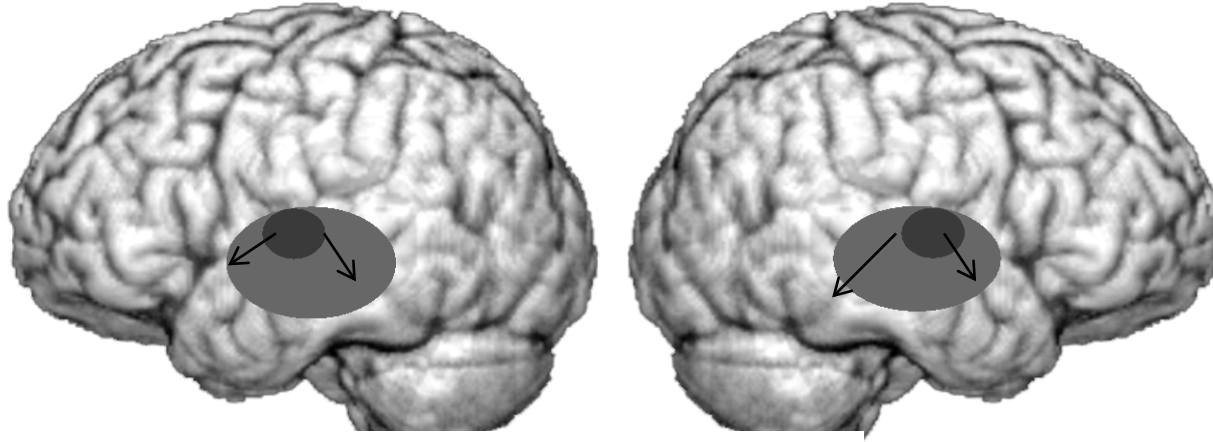


Medicalxpress.com



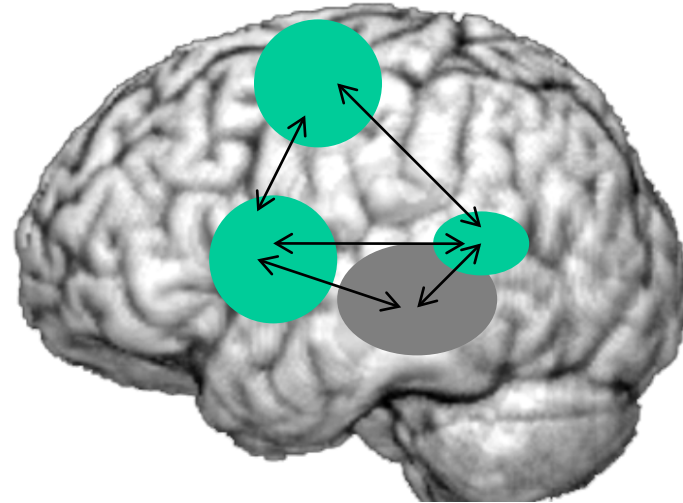
Wikipedia

Ventral stream: Recognition of sounds



- “Which sound?”
- Different roles for the left and right auditory cortex

Dorsal stream: Sound localization and connection to speech production



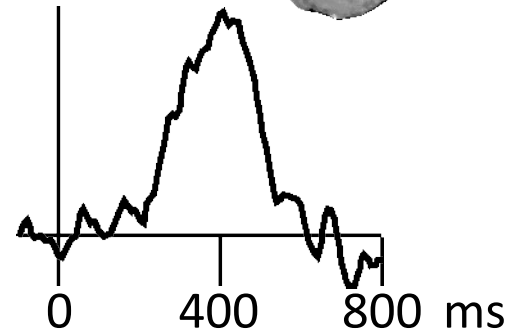
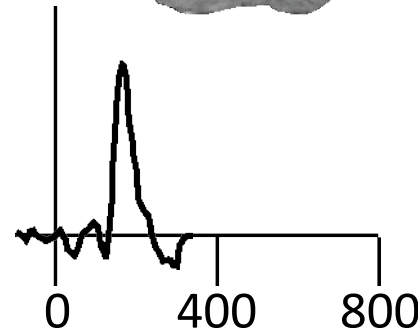
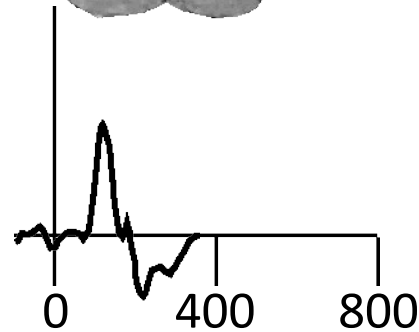
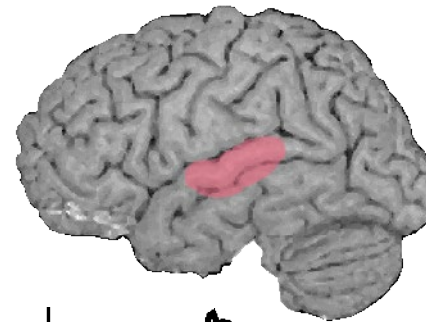
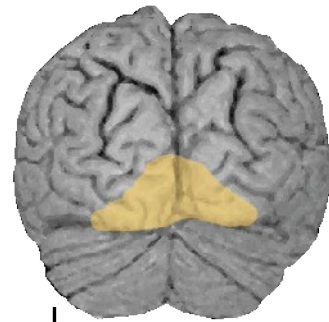
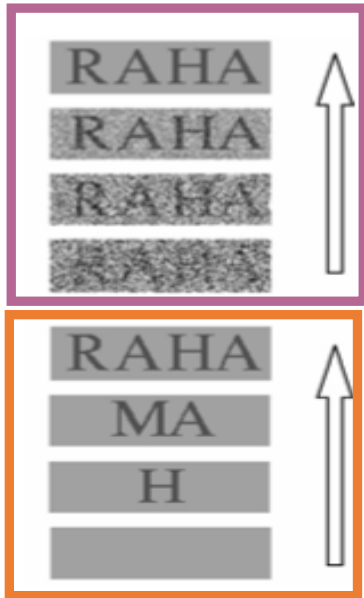
- "Where?"
- Connecting heard (speech) sounds to articulation and speech production

Example: Reading activates occipital and temporal areas

Visual features

Letter strings

Meaning, text structure



*Salmelin 2007,
Pykkänen &
Marantz 2003*

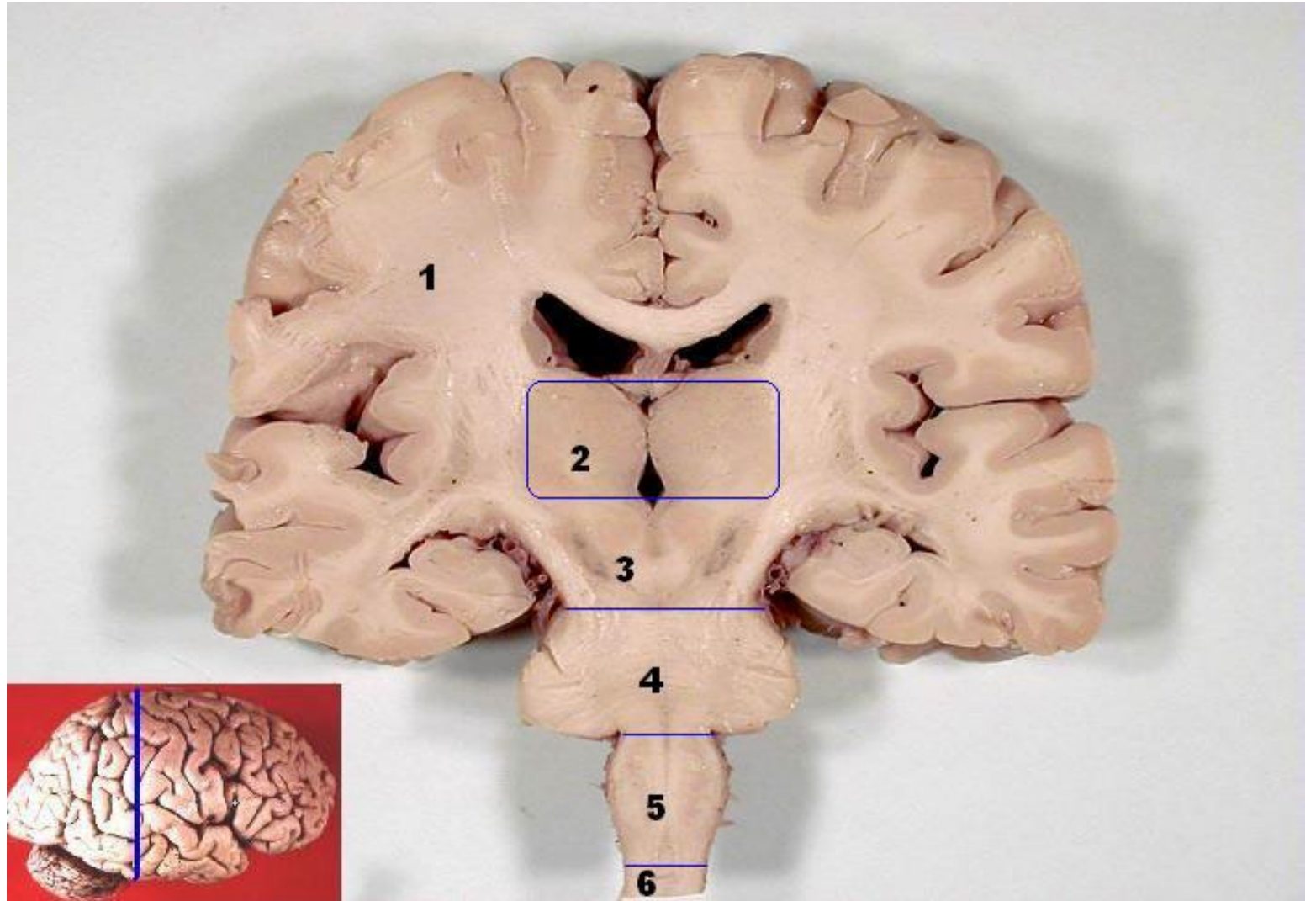
*Words =
nonwords*

*Words ≠
nonwords*

Courtesy of Riitta Salmelin

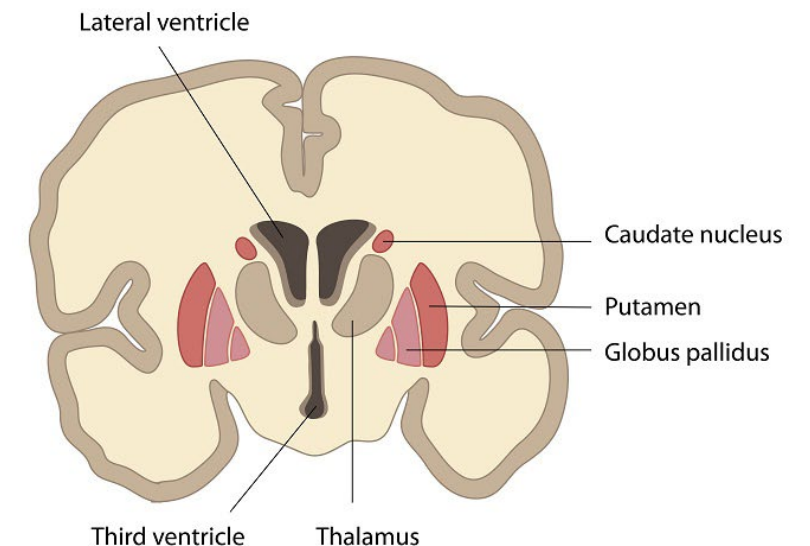
Brainstem

- 2 = diencephalon,
interbrain
- 3 = midbrain
- 4 = pons
- 5 = medulla oblongata



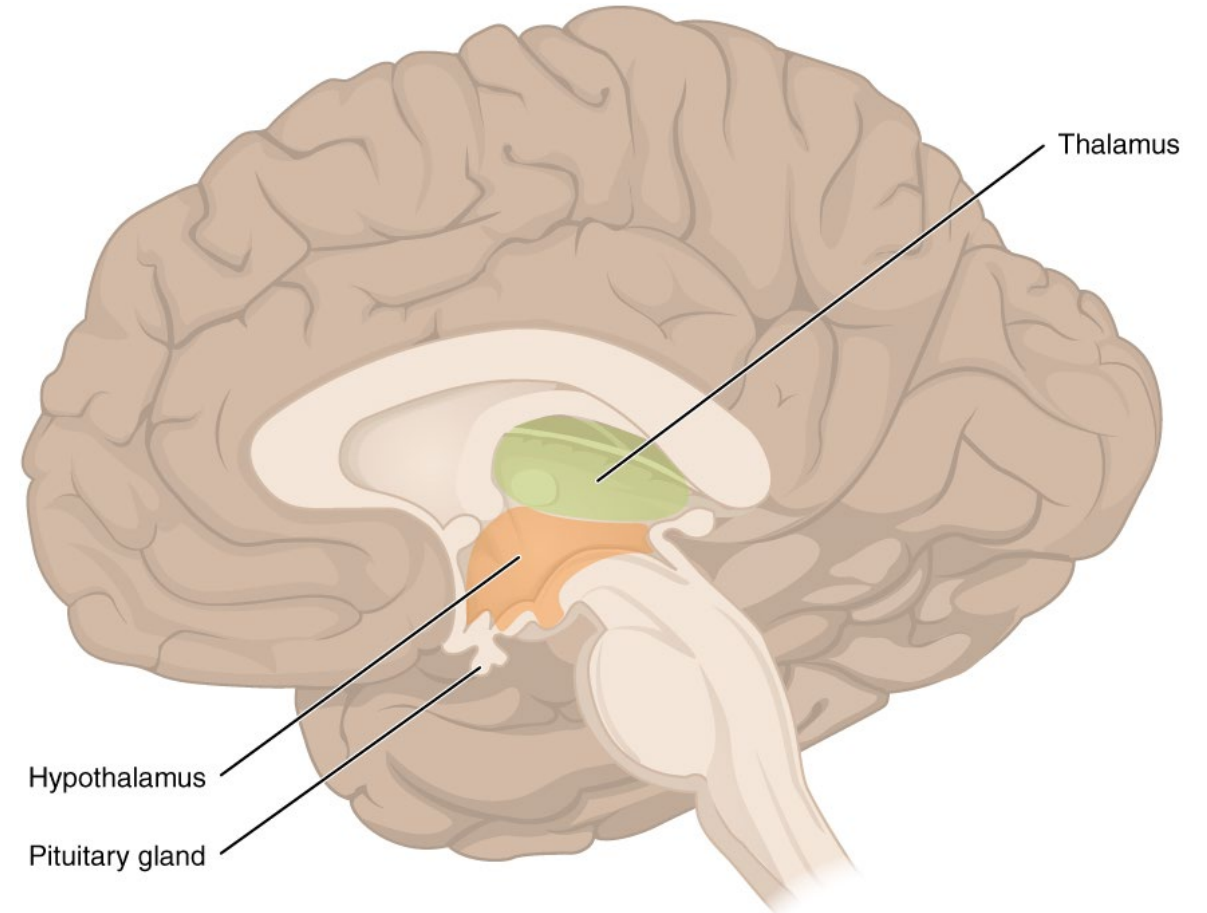
Diencephalon: Thalamus

- 80% of the diencephalon
Apart from the sense of smell, all sensory information is passed to the cerebral cortex via thalamus
- Movement control, in collaboration with *basal ganglia*



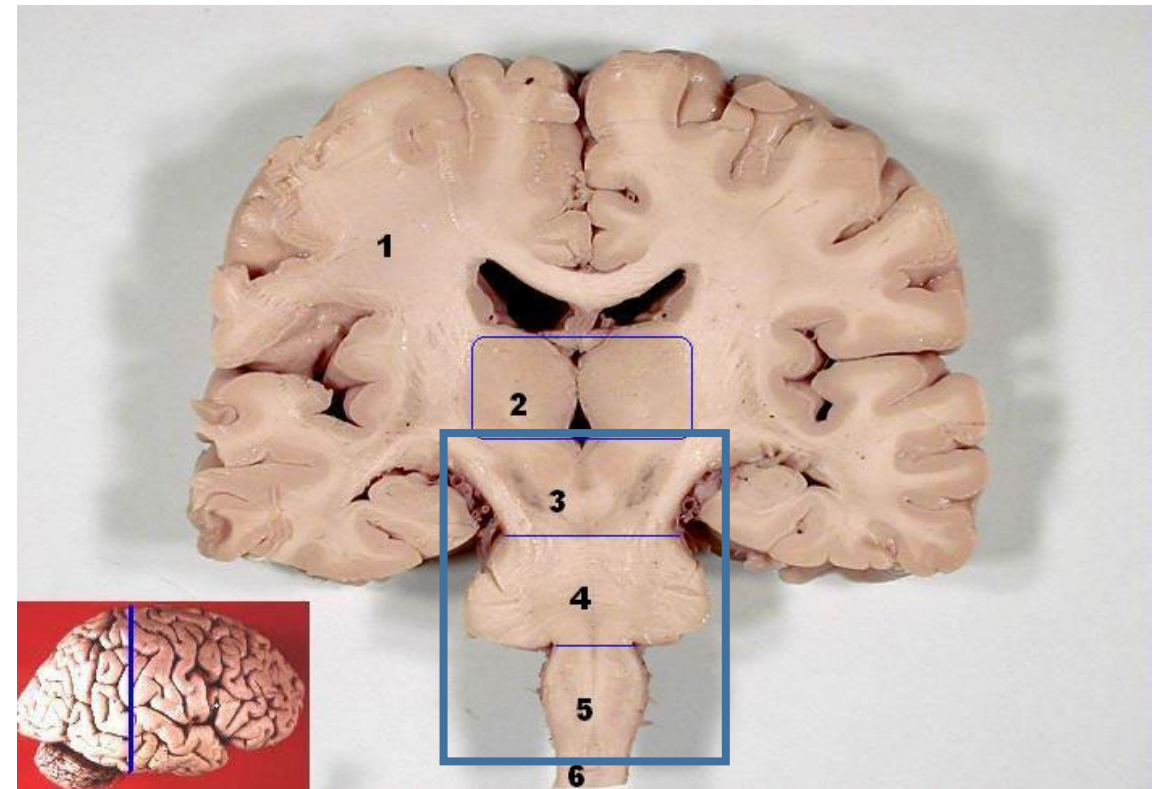
Diencephalon: Hypothalamus

- Synthesizes hormones to control the secretory activity of pituitary gland
 - Control of autonomic nervous system
- Regulation of homeostasis



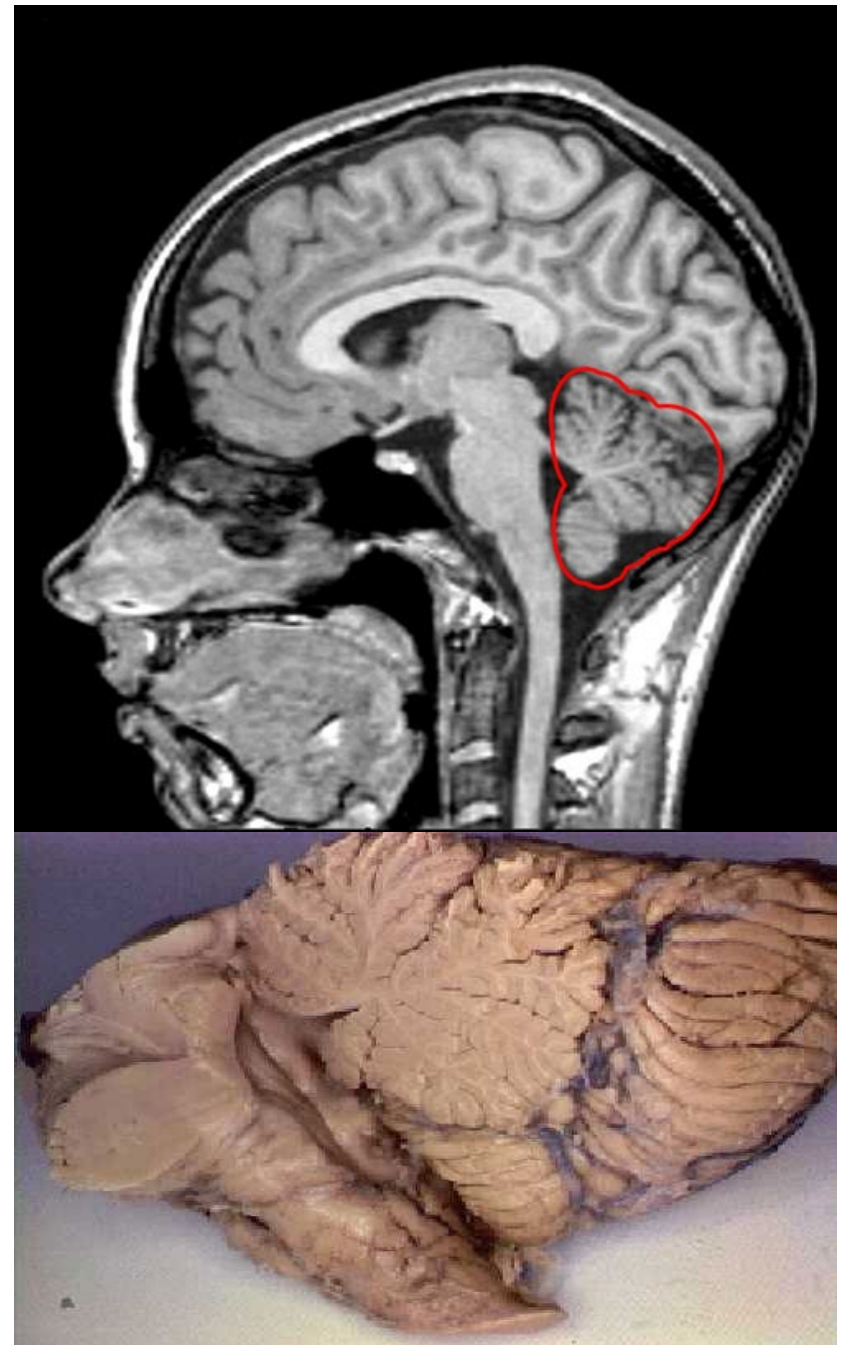
Midbrain, pons, medulla

- Efferent and afferent nerve tracts, cranial nerve nuclei
- Control of sleep-wake cycle and arousal
- Control of autonomic nervous system: breathing, cardio-vascular functions (blood pressure, pulse rate)



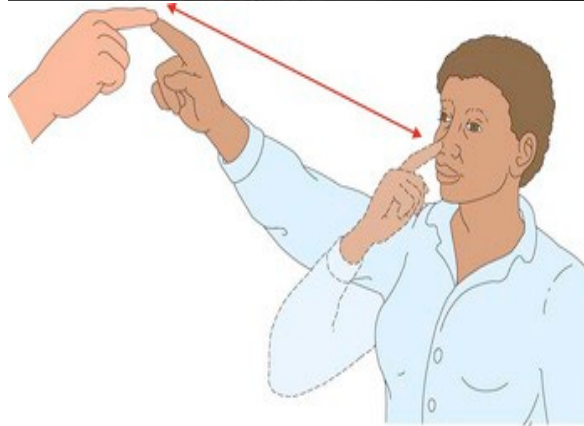
Cerebellum

- 1-2 mm thick gray matter
- n. 30 million neurons
- Control of fine-grained movements:
Cannot initiate movements alone, but it has a central role in movement timing, transition from movement to another, and in controlling the strength of muscle contraction

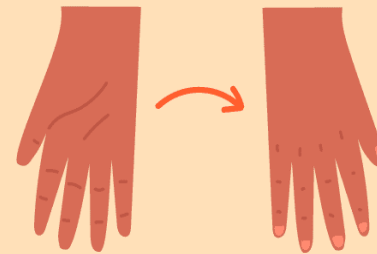


How can cerebellum be so important in movement control if it cannot initiate movements by itself?

- So-called cerebellar tests: eye movements, line walking, finger-to-nose test, heel-to-knee test, diadochokinesis
- Attenuation of tremor



How Dysdiadochokinesia is Diagnosed



Having patient flip hand quickly on surface of table



Asking patient to demonstrate movement of turning a doorknob



Having patient tap foot quickly

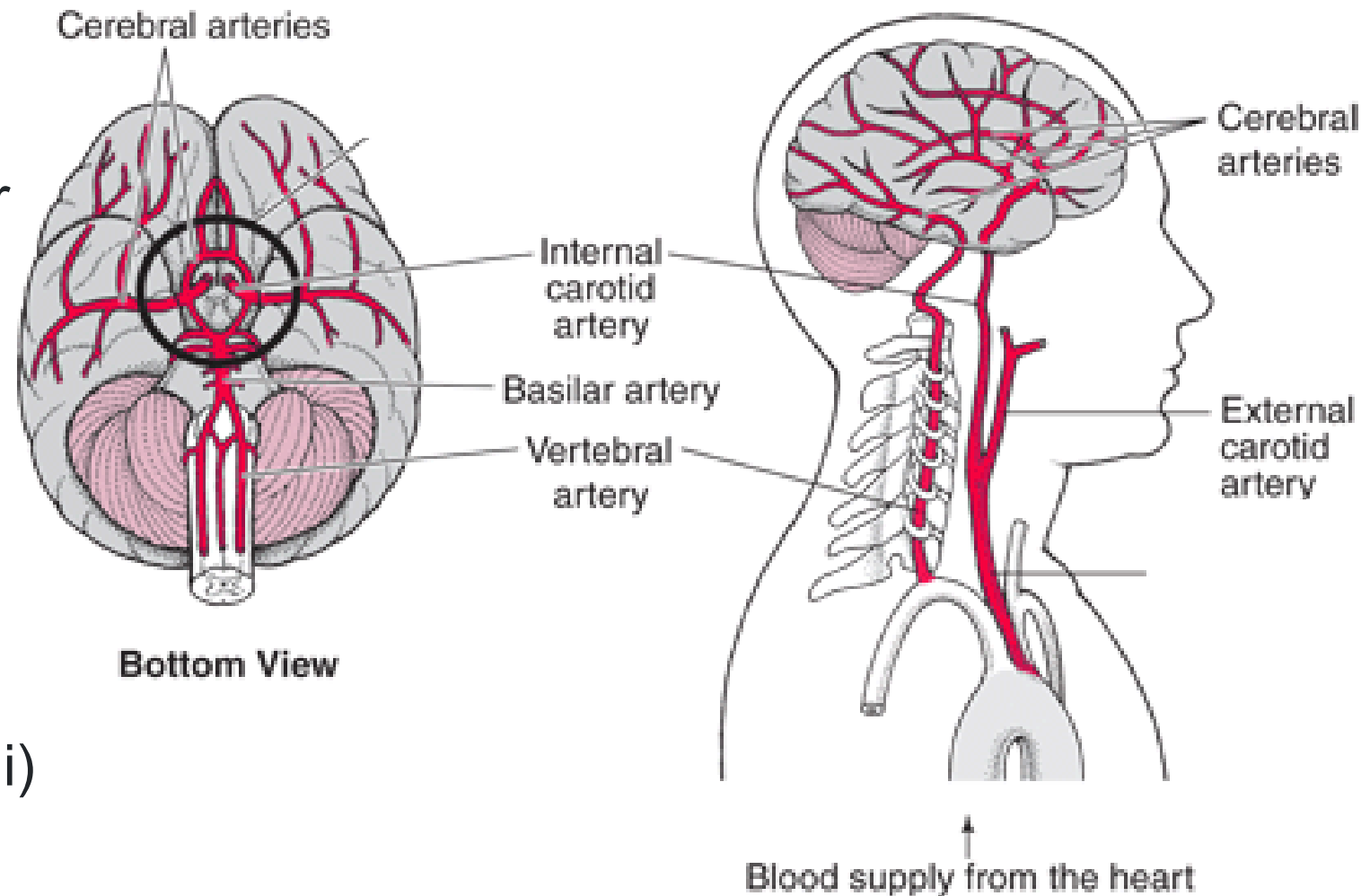
DA. DA. DA. DA.



Asking patient to repeat syllables

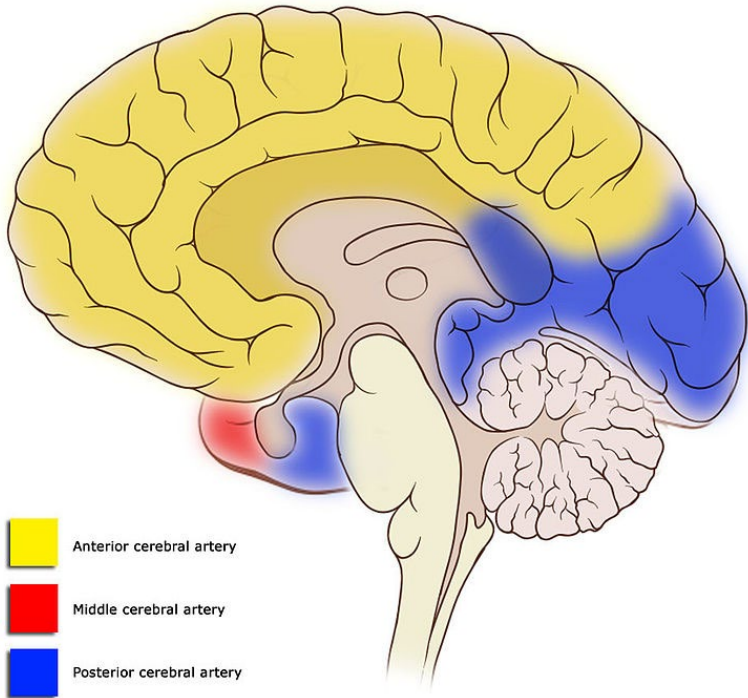
Brain vascular anatomy

- 20% oxygen consumption
- 1 liter of oxygenated blood per minute
- Carefully regulated: self-regulation with only a little neural control, direct effect of O₂ and CO₂ levels
- Circle of Willis (Circulus Willisii) assures the blood circulation

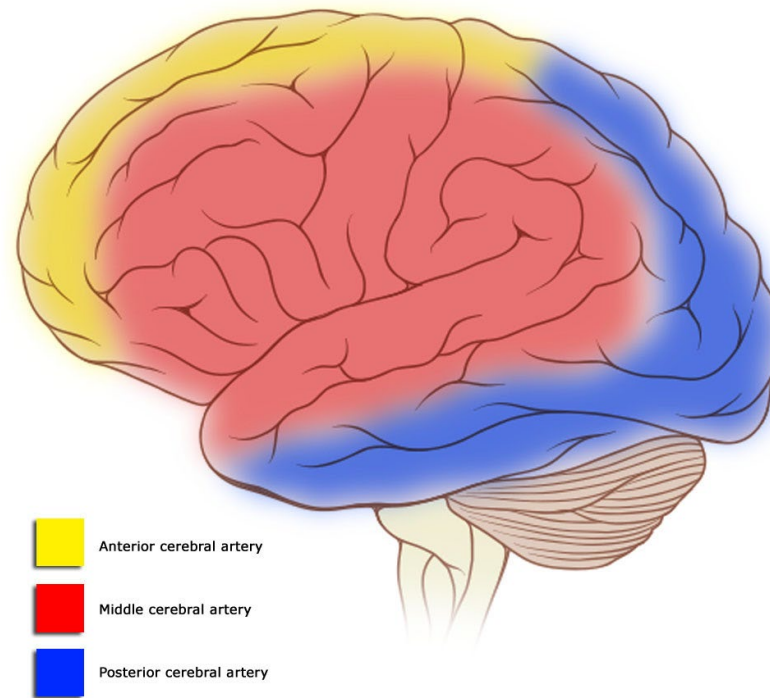


Blockage in carotid vs. vertebral/basilar vs. cerebral aretery

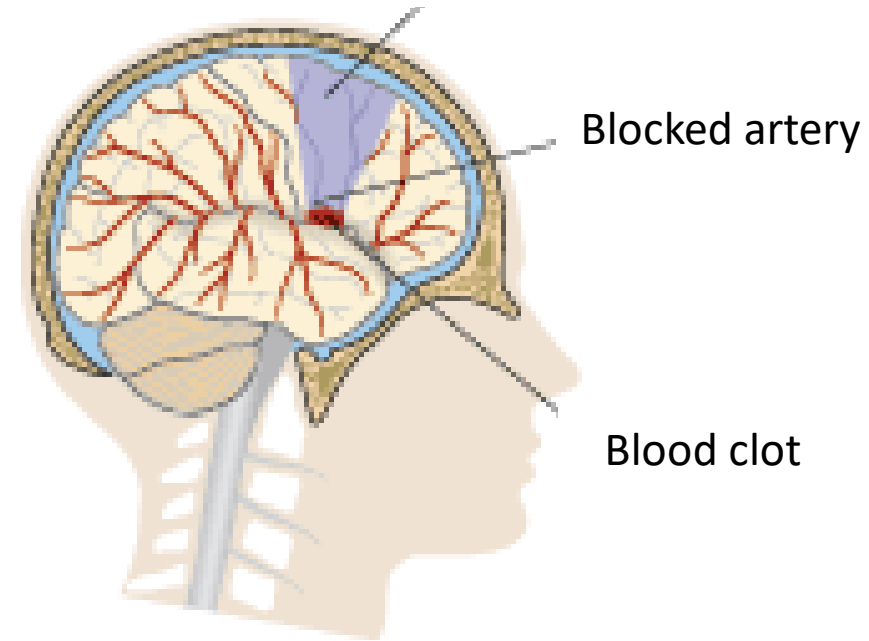
Cortical vascular territories



Cortical vascular territories

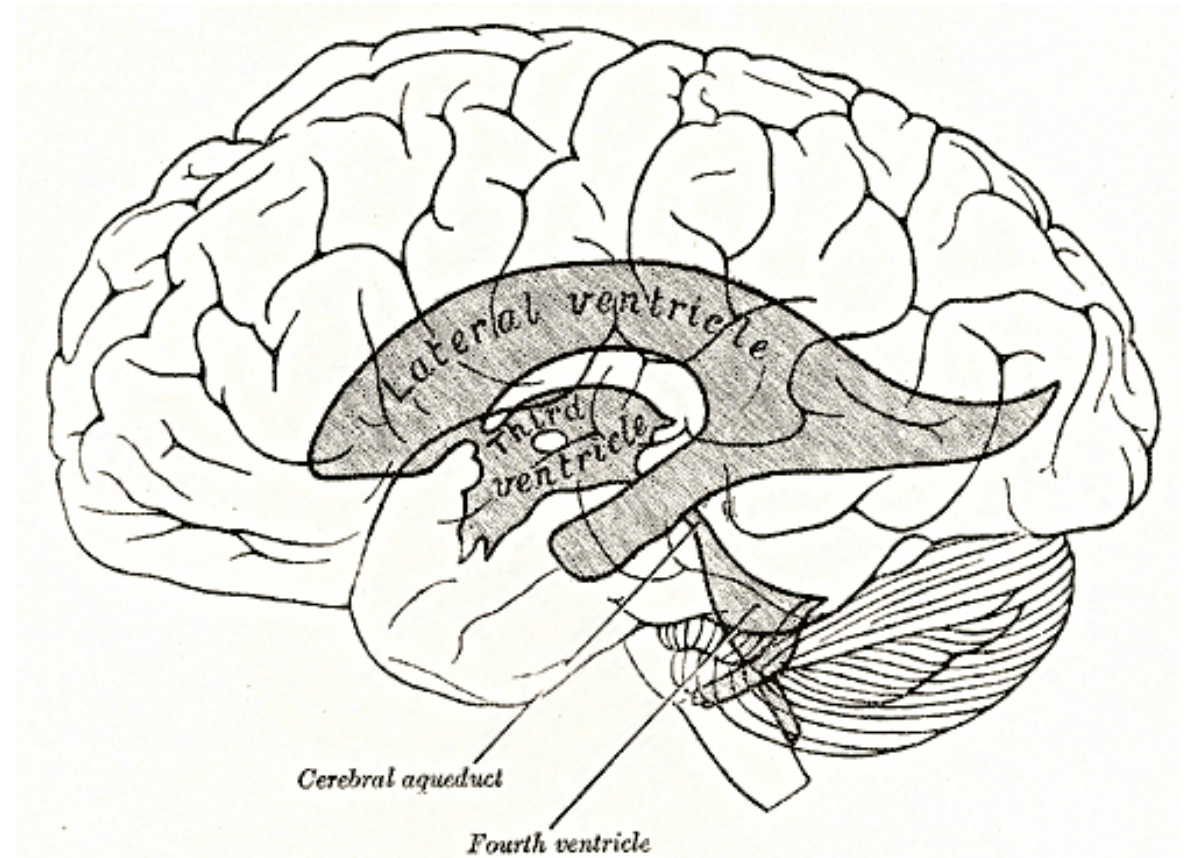


Ischemic area



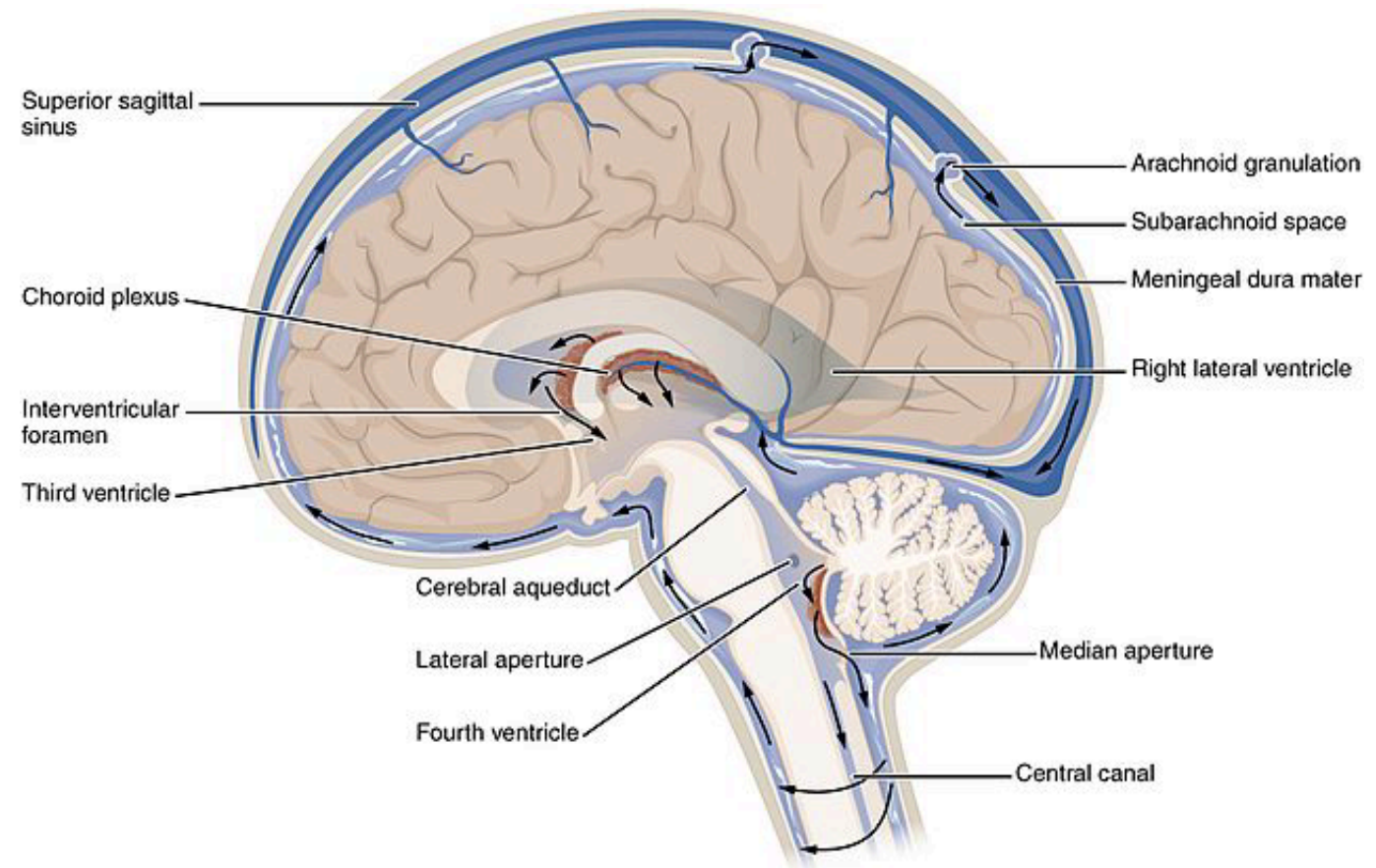
Brain is surrounded and protected by cerebrospinal fluid and meninges

- Cerebrospinal fluid (CSF), derived from plasma, is produced in the *choroid plexus* of ventricles
- Volume 100-150 ml, generated ~400-500 ml/day
- Mechanical and immunological protection of the brain, removal of cellular waste to blood circulation
- CSF important in diagnostics of, e.g., CNS infections



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- *Dura mater*, the outermost layer of meninges
- CSF flows in-between the other meninges, *i.e.*, *arachnoidea mater* and *pia mater*
- In spinal cord, dura matter is separated from periosteum by *epidural space*

