

BMD ENG 301

# Quantitative Systems Physiology (Nervous System)

Lecture 2: Neuroanatomy

Professor Malcolm MacIver

# If you want to study the brain ...

- Classical Neuroanatomy
- Functional Neuroanatomy
- *In vivo* Modern Brain Imaging

# Classical Neuroanatomy

## TEST CASE MOUSE BRAIN SECTIONS

animal 1

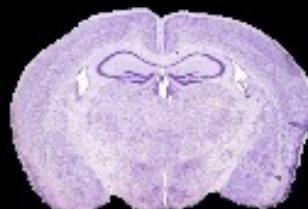


Bregma 1.42mm  
3 serial sections

animal 2



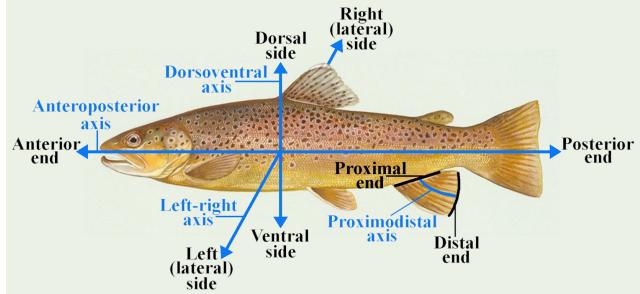
Bregma -1.46mm  
1 section



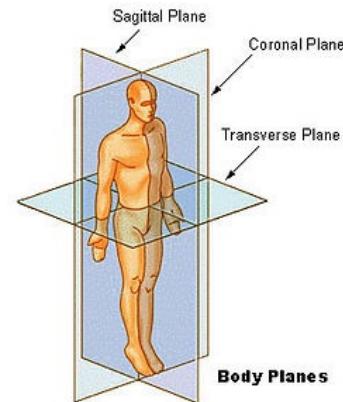
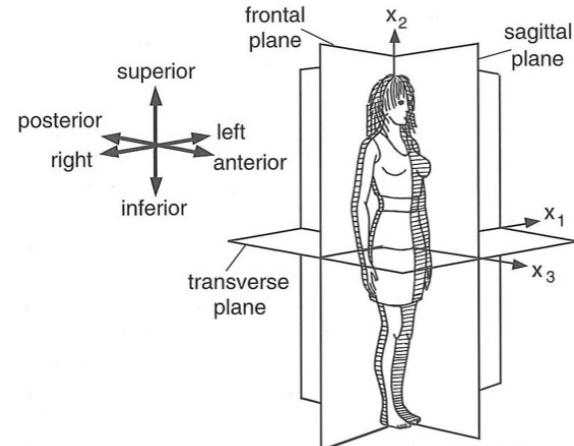
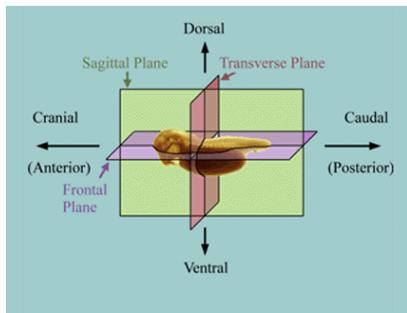
Bregma -3.88mm  
1 section



# Note: Not in textbook



terms of location  
Vertebrates  
(all non-human animals)



terms of location  
humans

# Neuroanatomical Nomenclature – Orientation terms

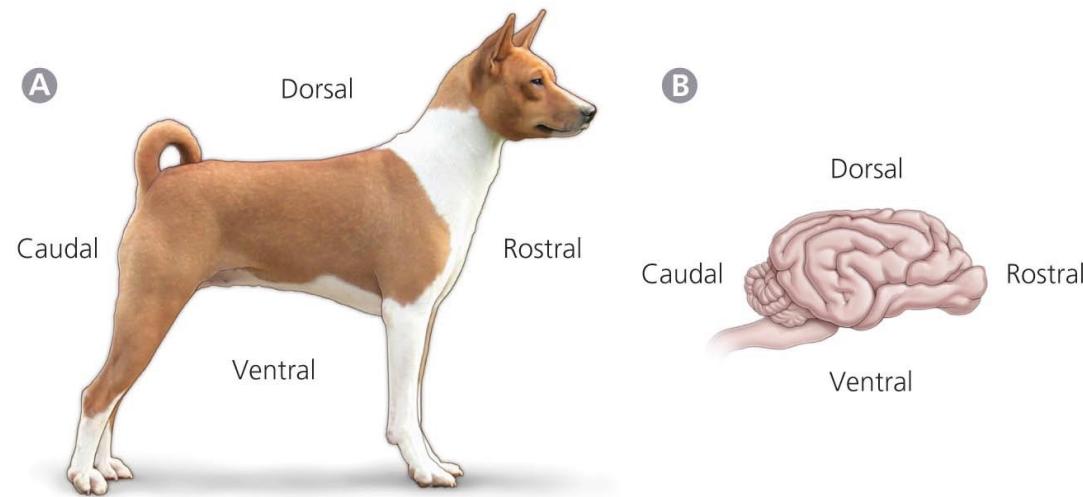


Fig. 1.2

## Human bodies & brains require different orientation terms

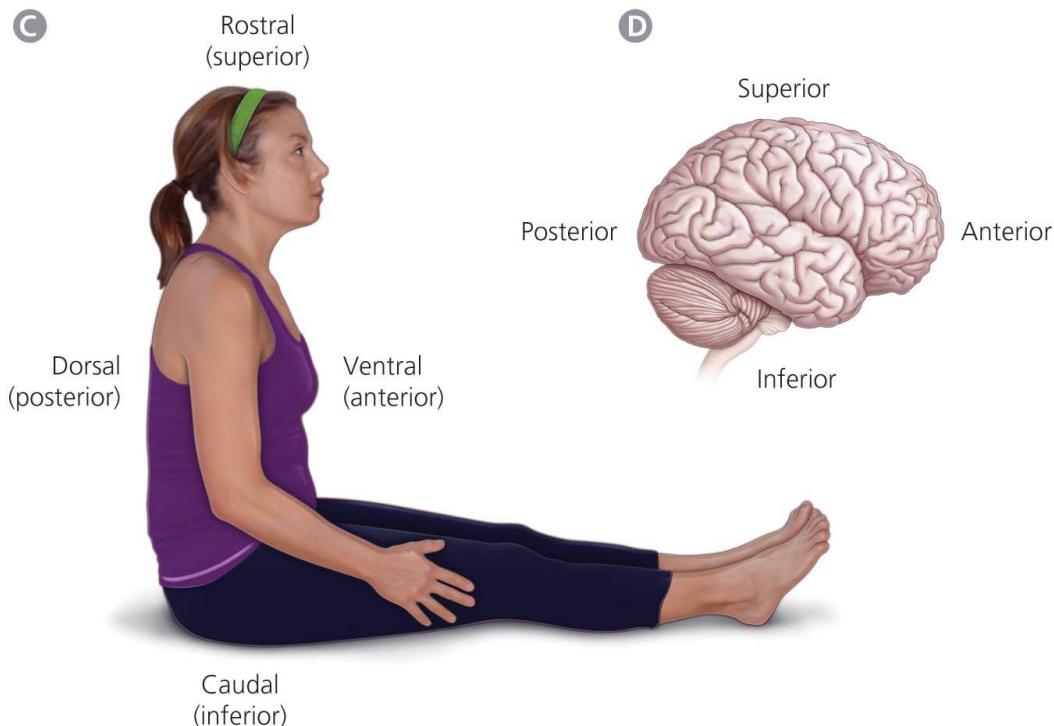
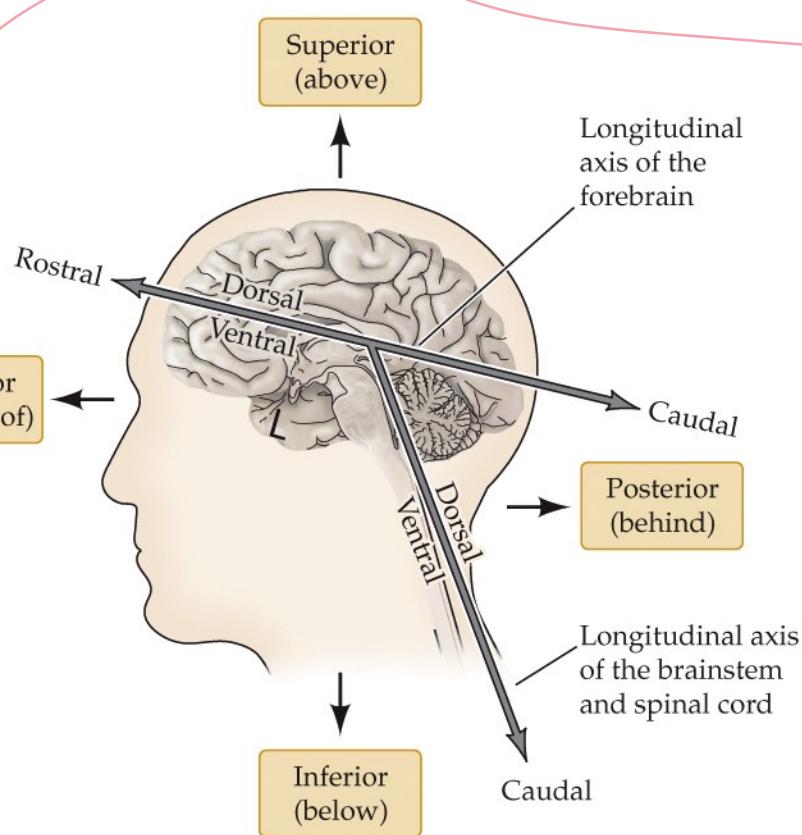
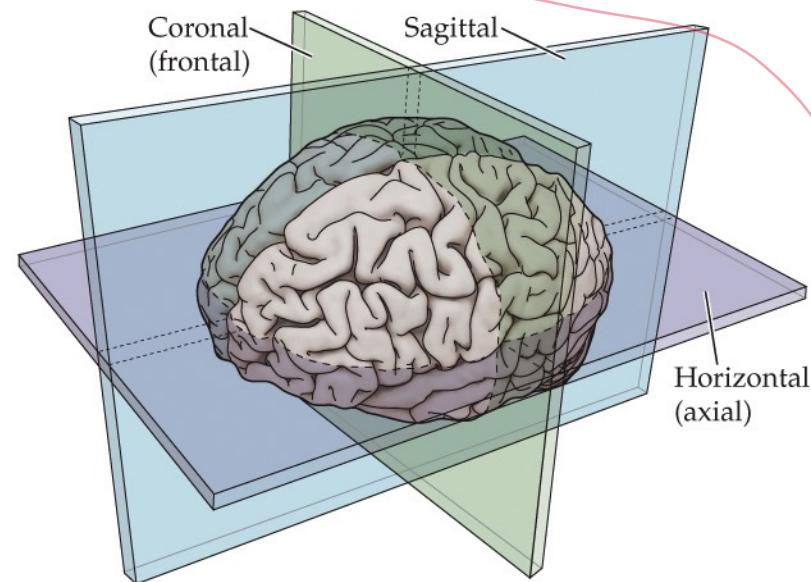


Fig. 1.2

(A)



(B)

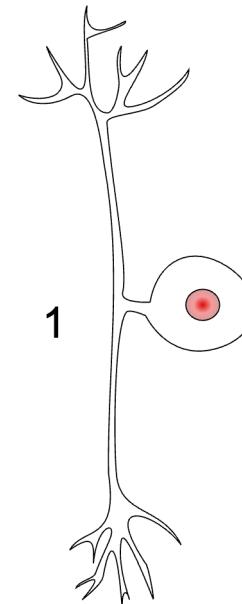


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# The pseudounipolar neuron

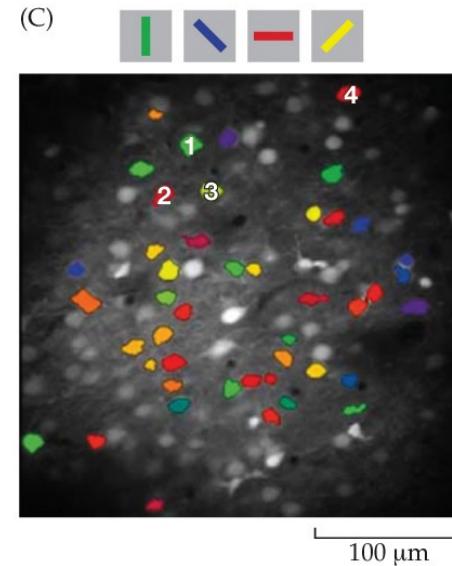
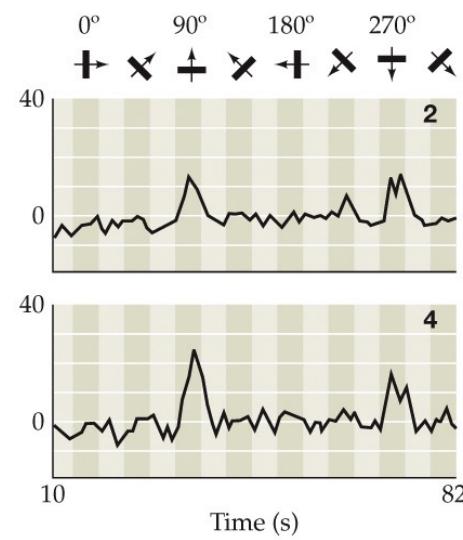
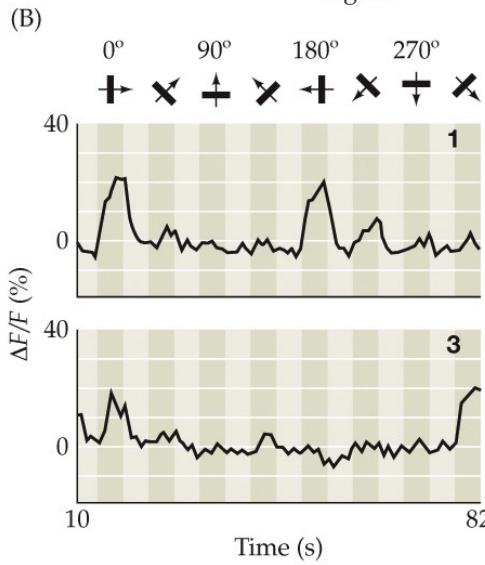
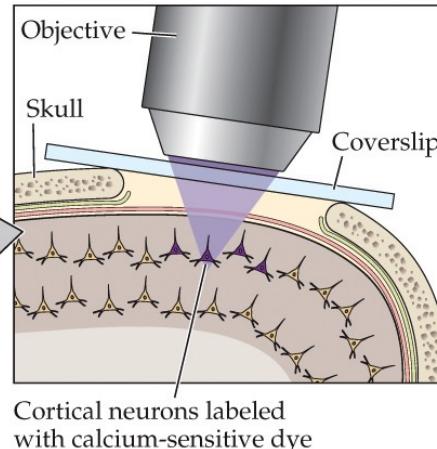
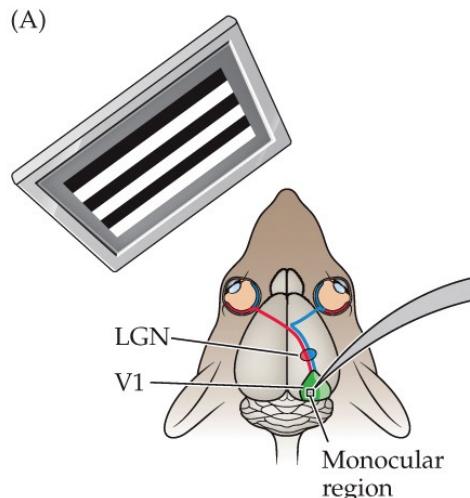
Most sensory afferent neurons are pseudounipolar.... Pseudounipolar neurons have one projection from the cell body, which splits into two axons: one that extends into the periphery and one that extends into the central nervous system.

Afferents that project into the spinal cord from skin and muscle are typically pseudounipolar. The cell bodies of these afferents are located in the dorsal root ganglia near the spinal cord.... The peripheral branch extends through a peripheral nerve, and is part of the sensory receptor in skin or muscle. The central branch projects through the dorsal (posterior) root into the spinal cord, and terminates on interneurons or motoneurons in the spinal cord, and may even project to the brainstem.



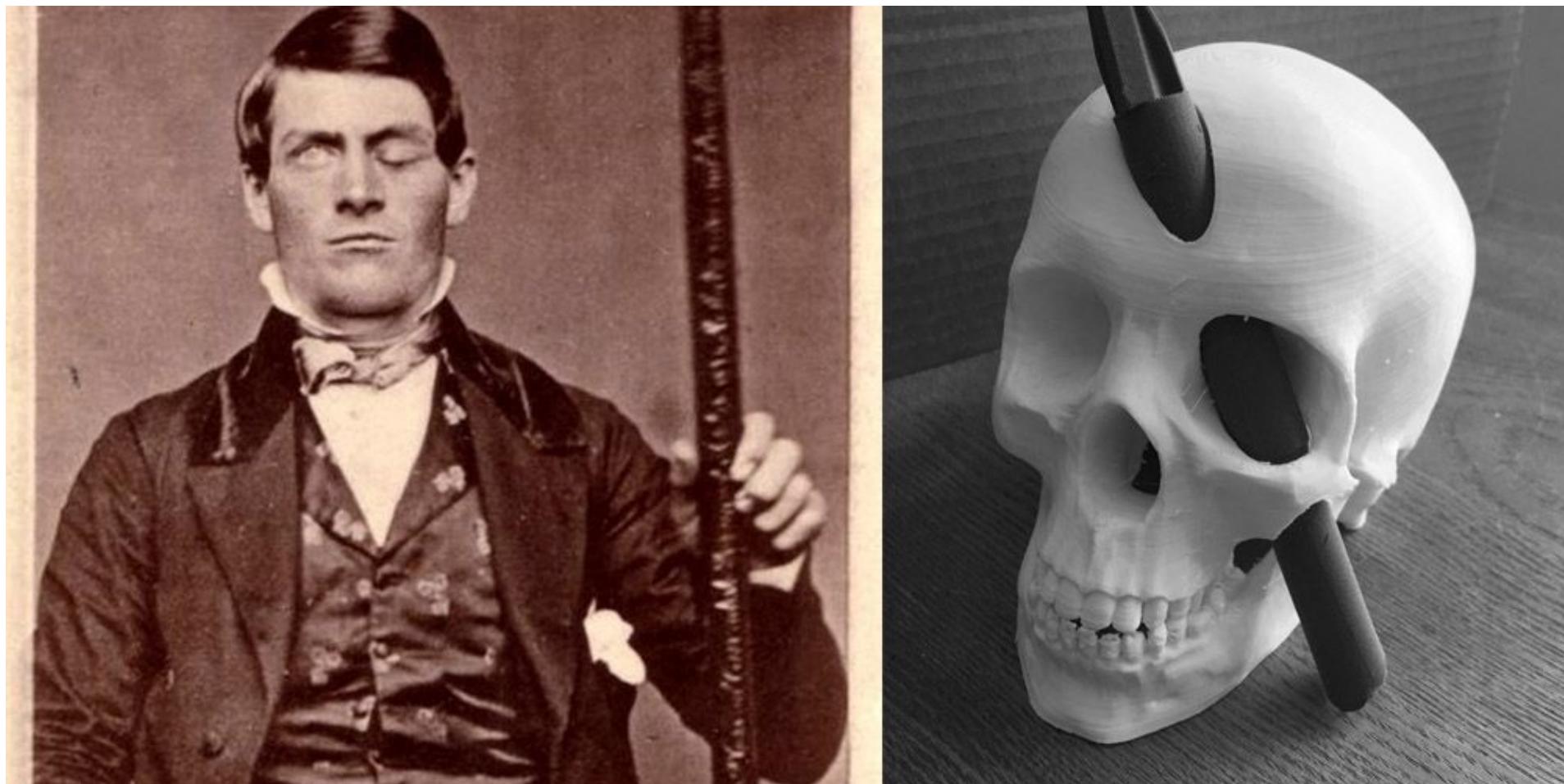
From: <http://pittmedneuro.com/neuron.html>

# Functional Neuroanatomy



[from Mank et al. (2008) *Nat Meth* 5: 805–811; (from Ohkii et al. (2005) *Nature* 433: 597–603]

# Functional Neuroanatomy



Phineas Gage

# *In vivo* Structural Brain Imaging

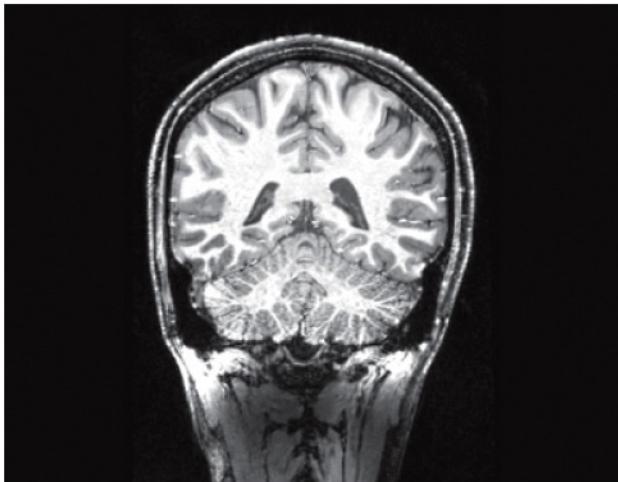
(A)



© iStock.com/kot63.

**NEUROSCIENCE 6e, Figure 1.20**  
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(B)

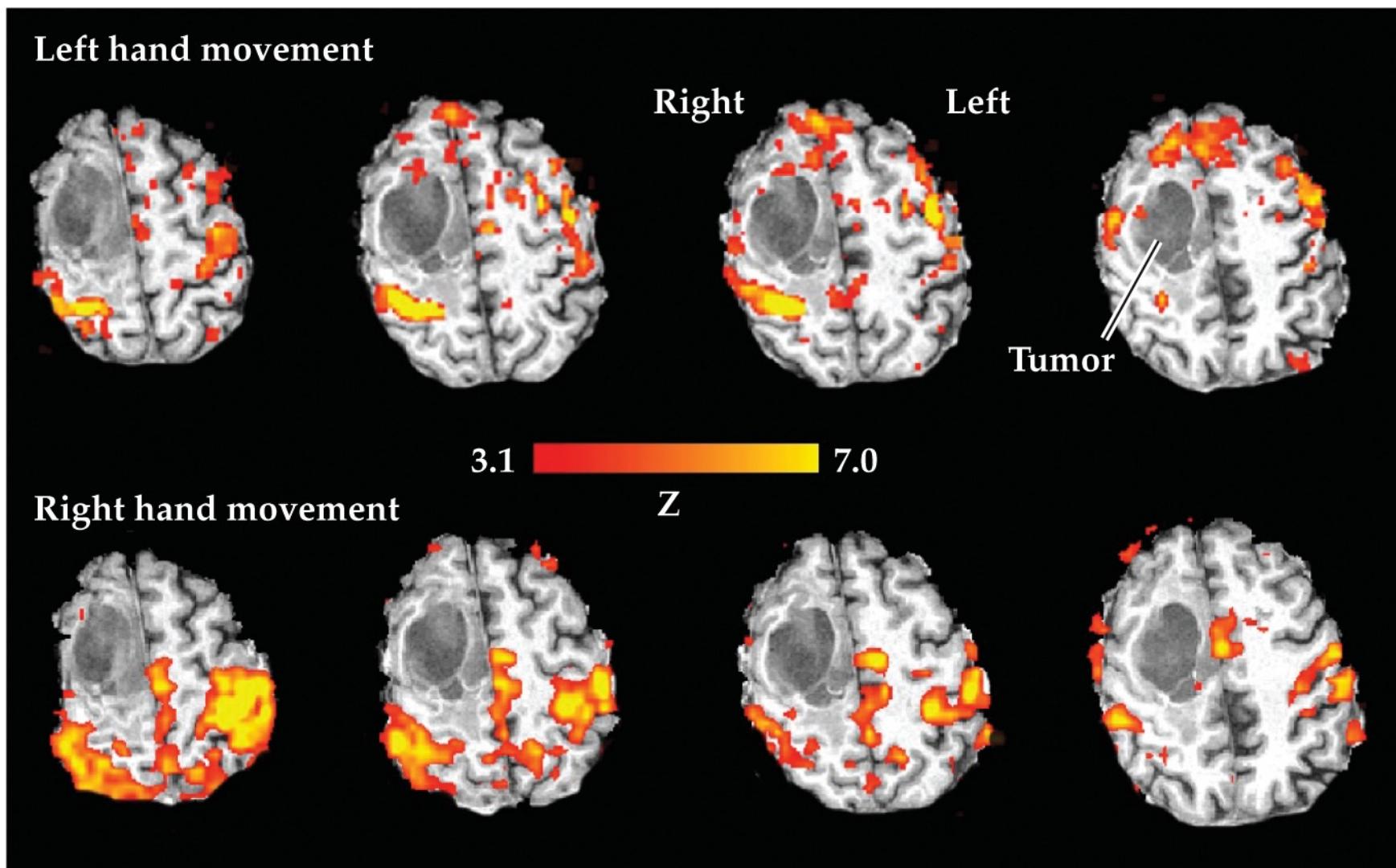


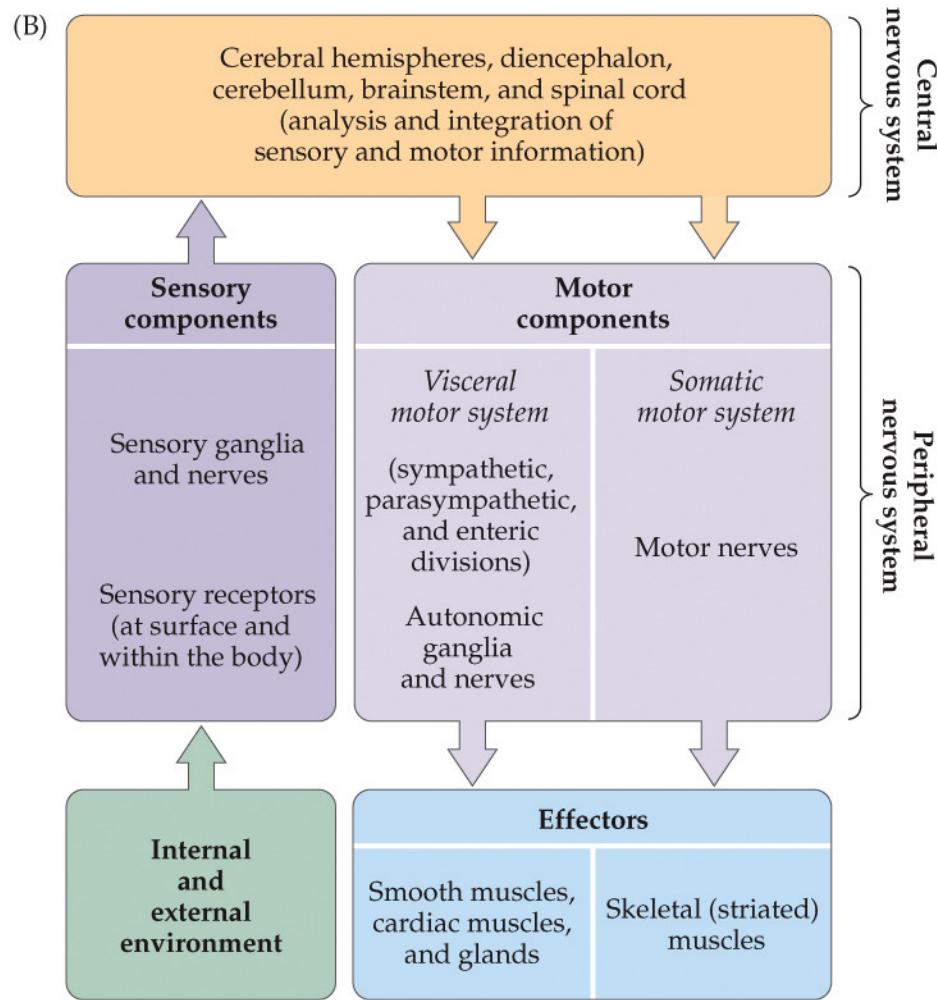
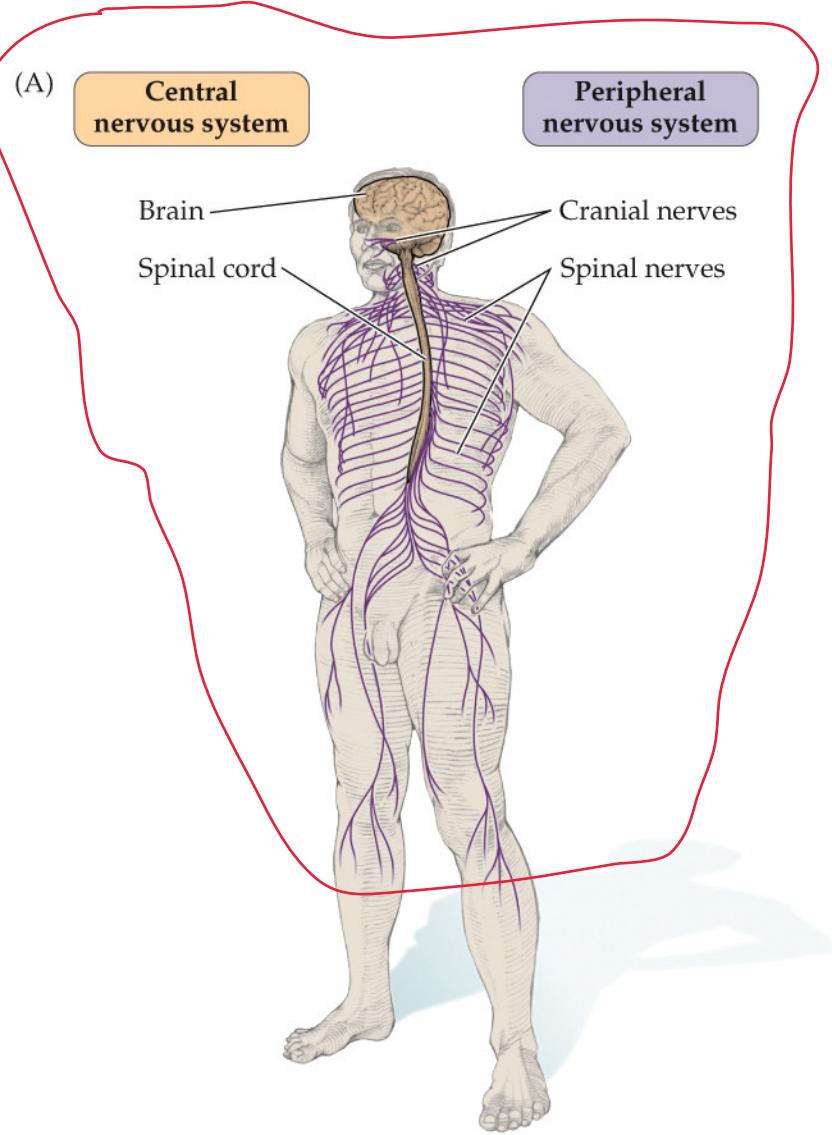
B, C from Seiger et al. (2015) *Neuroimage* 113: 207–216.

(C)

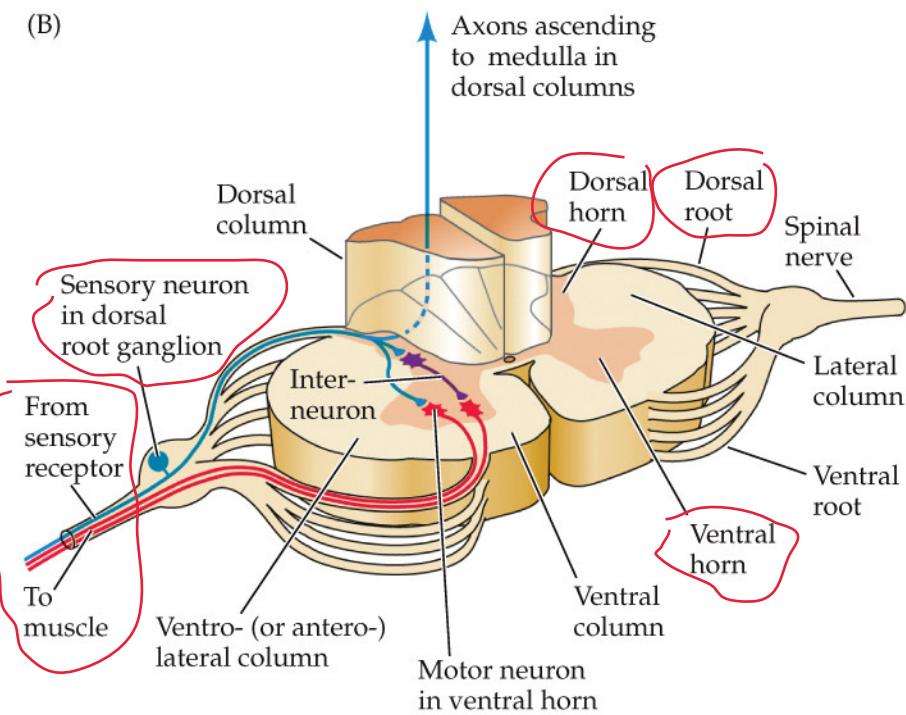
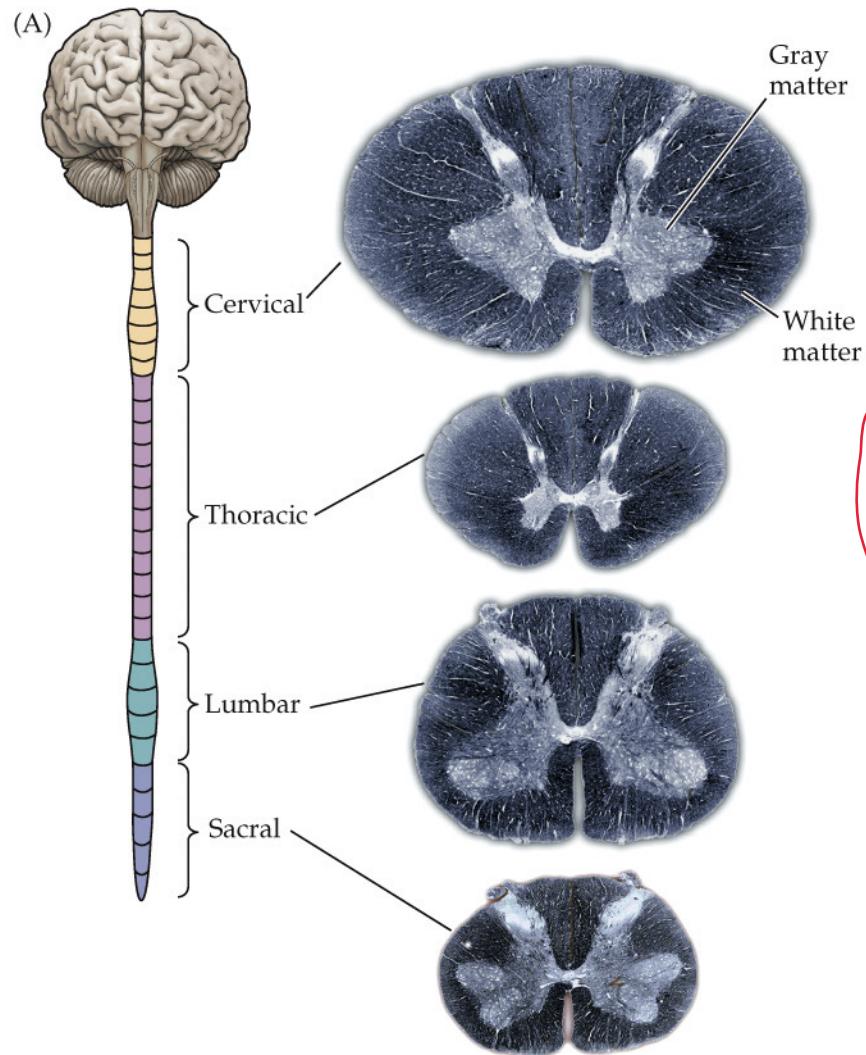


# *In vivo* Functional Brain Imaging

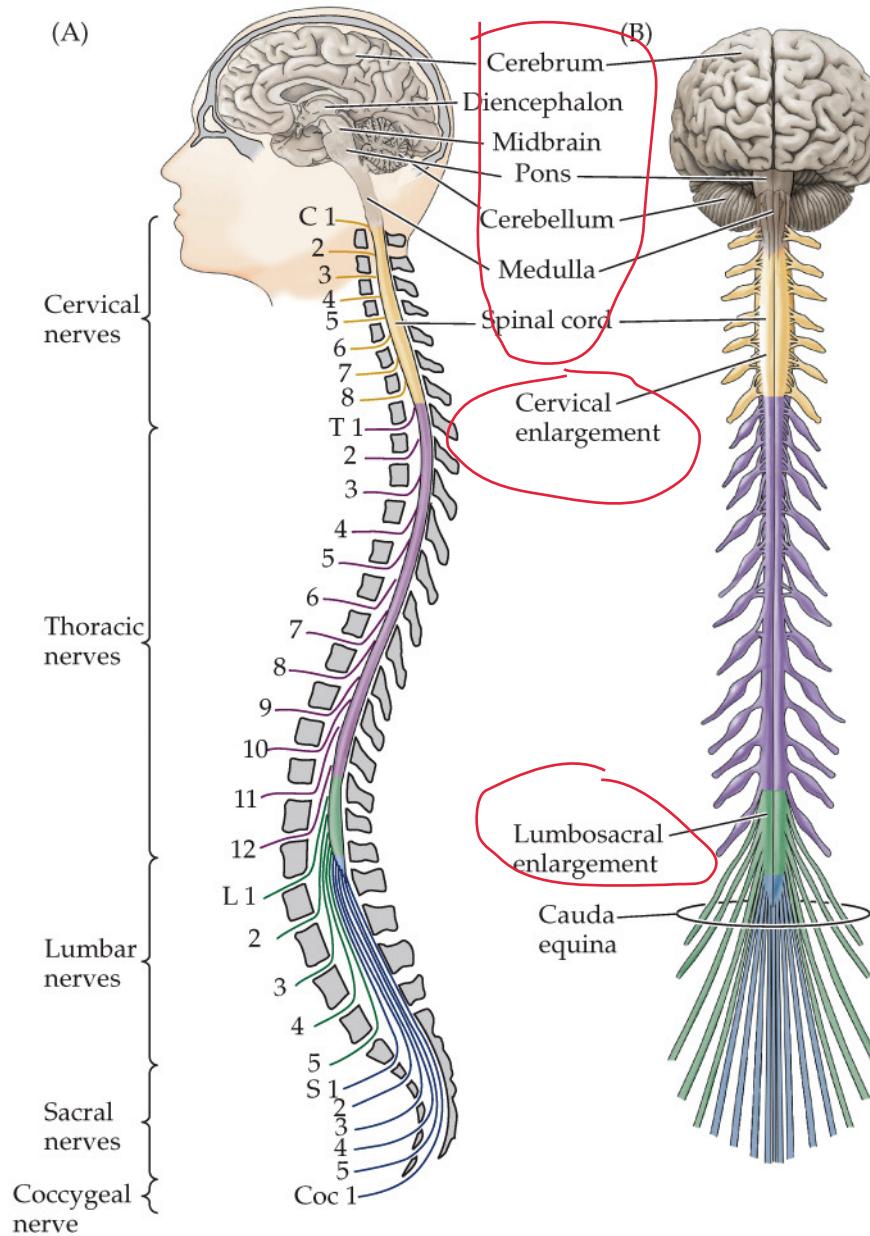




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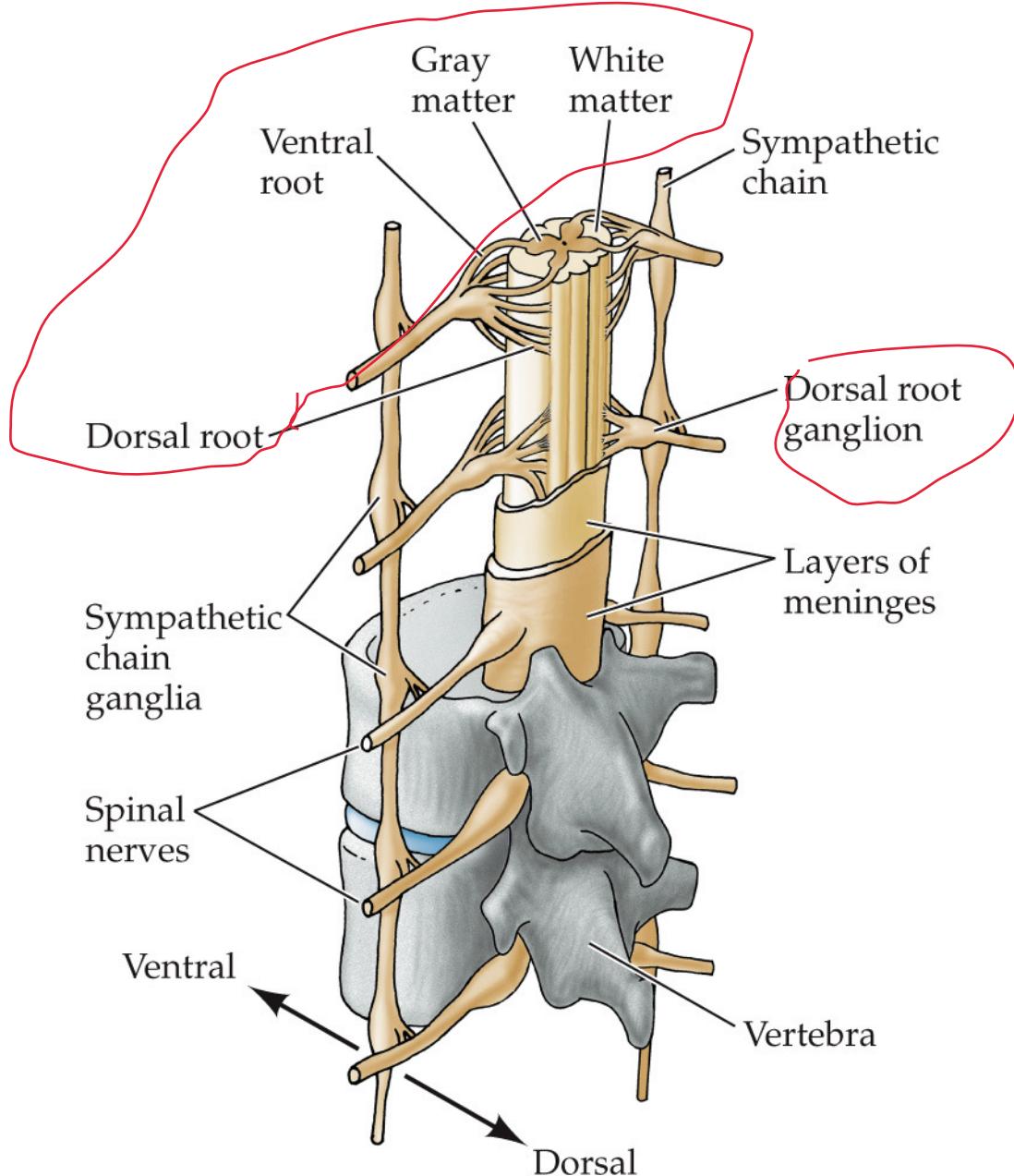


**NEUROSCIENCE 6e, Figure A6**  
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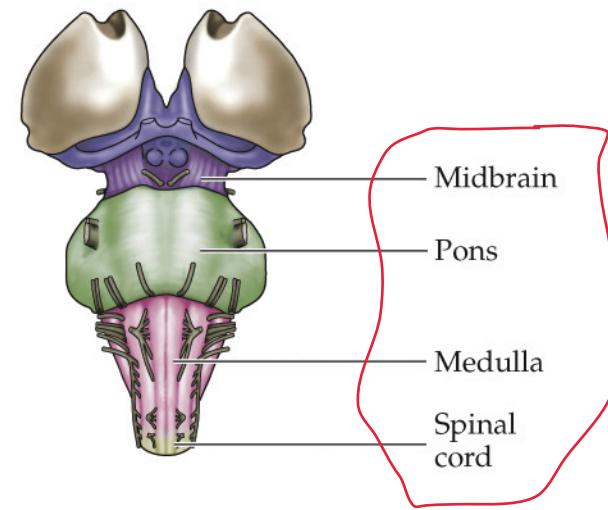
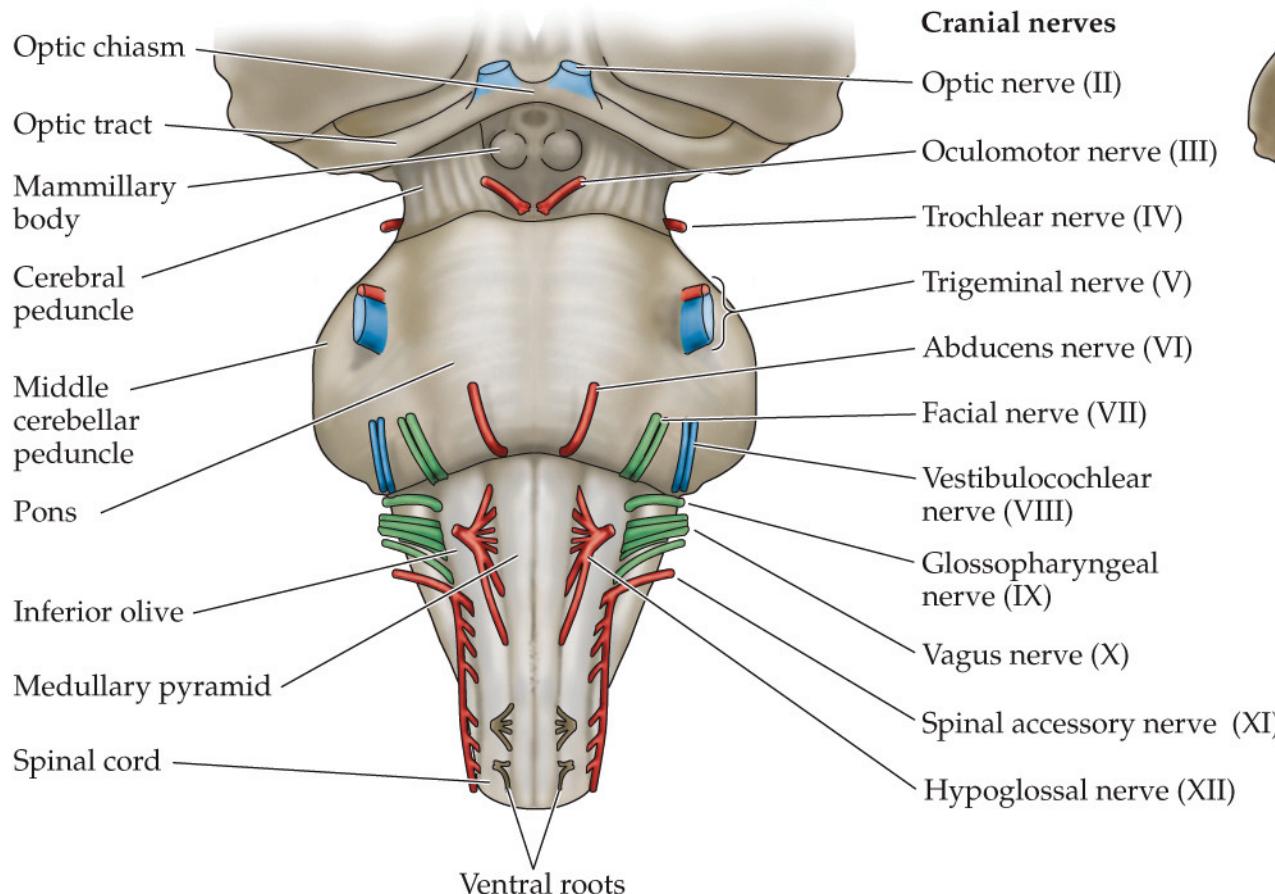
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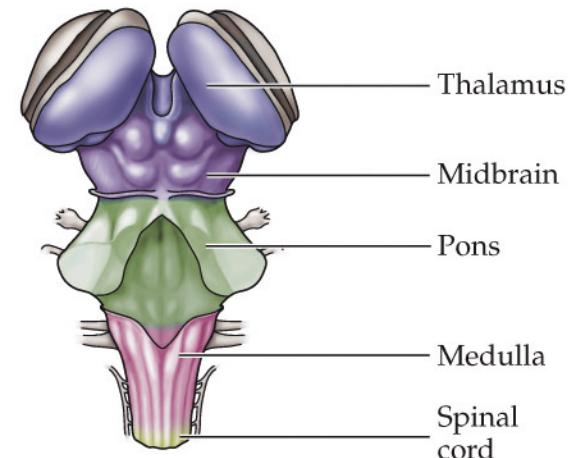
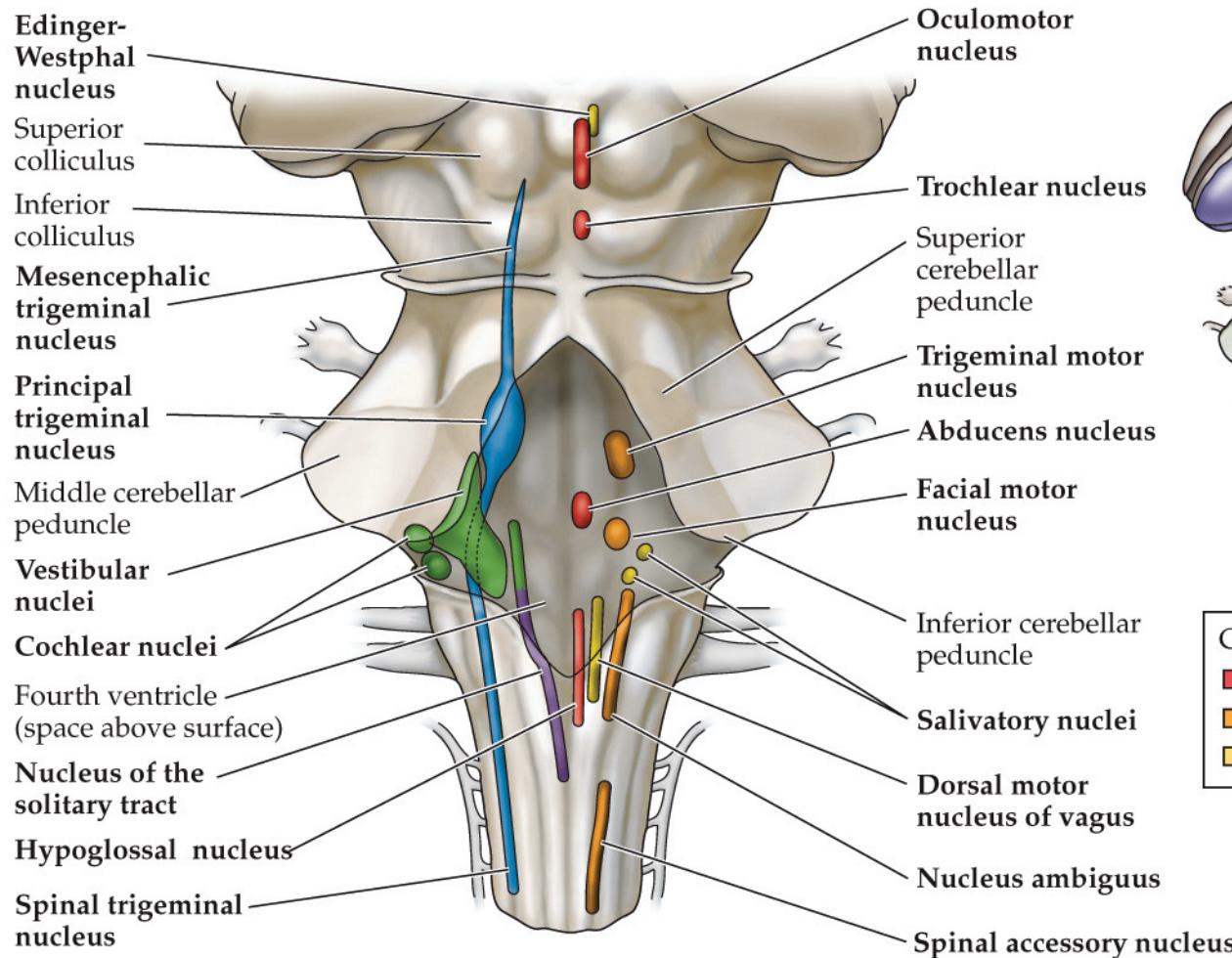
# Cranial nerves of the brainstem



Color key for drawing at left:

- Sensory cranial nerves
- Motor cranial nerves
- Mixed (sensory and motor) cranial nerves

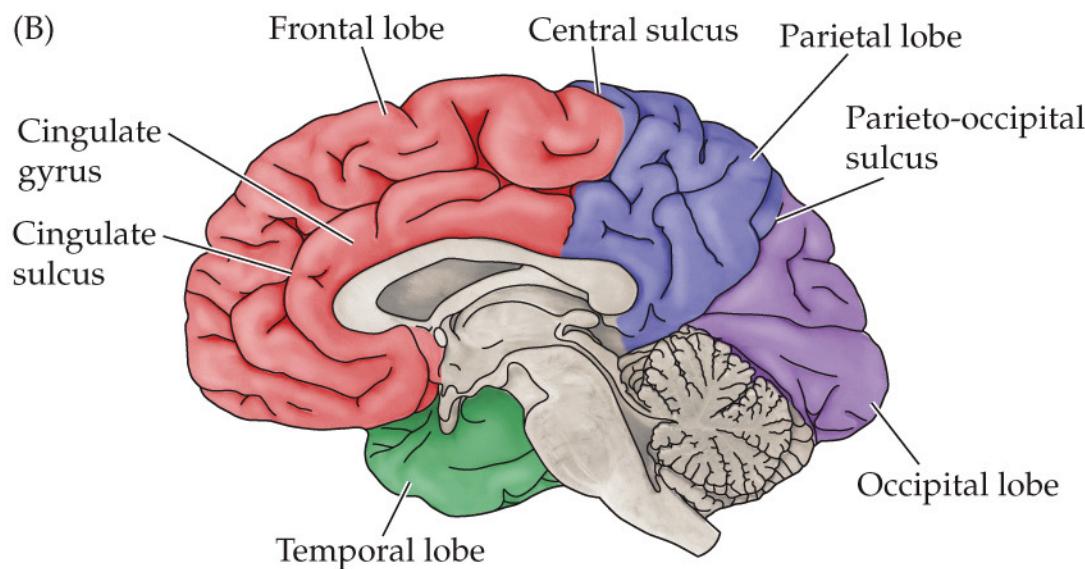
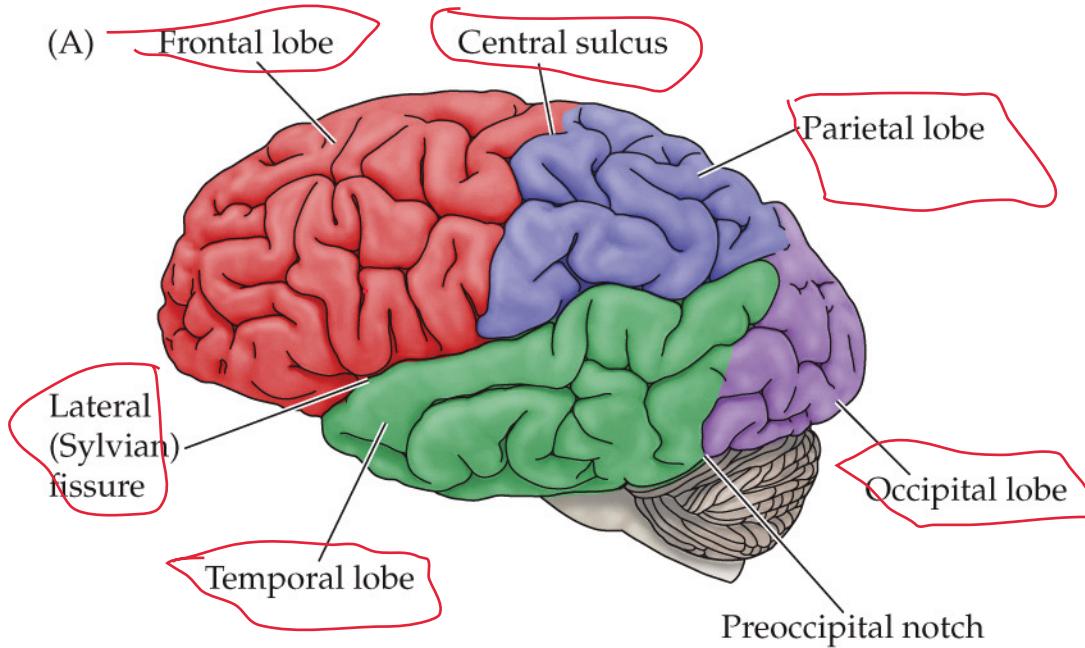
# Cranial nerve nuclei of the brainstem



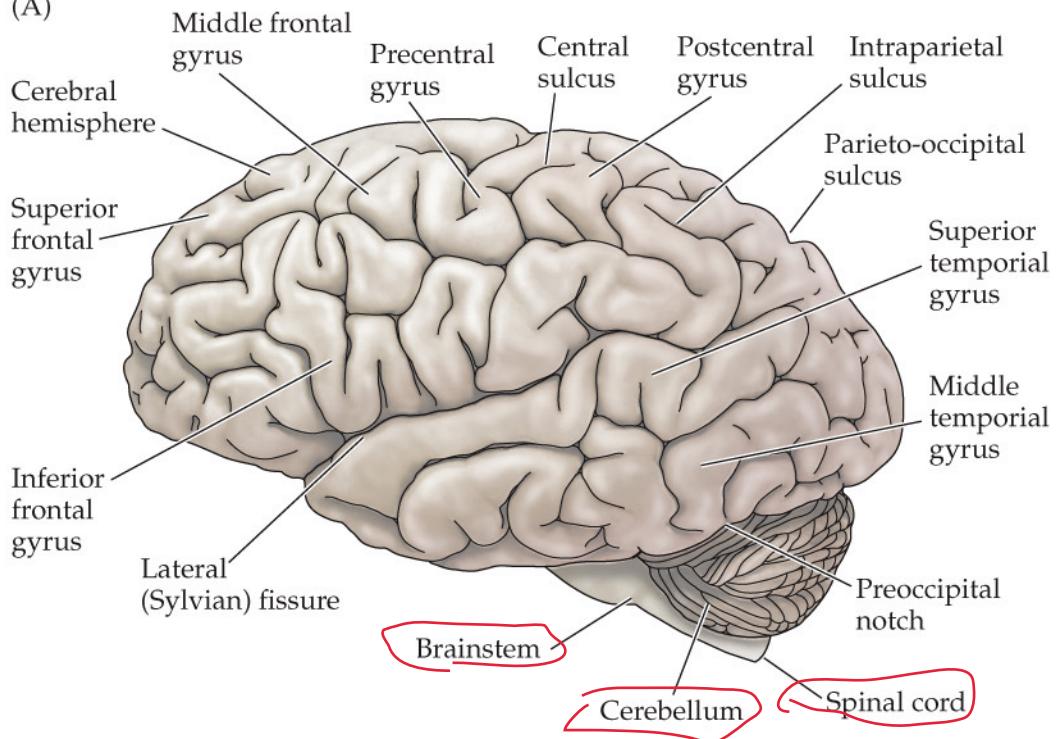
Color key for drawing at left:	
Somatic motor	General sensory
Branchial motor	Special sensory
Visceral motor	Visceral sensory

# Terminology

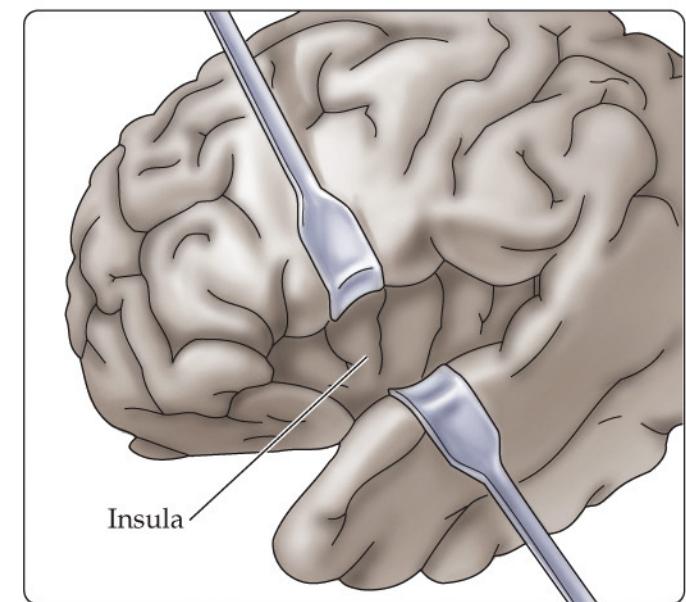
- **Ganglion:** Collections of hundreds to thousands of neuronal cell bodies found **outside the CNS** along the course of peripheral nerves
- **Nucleus:** Collections of hundreds to thousands of neuronal cell bodies found **inside the CNS**



(A)



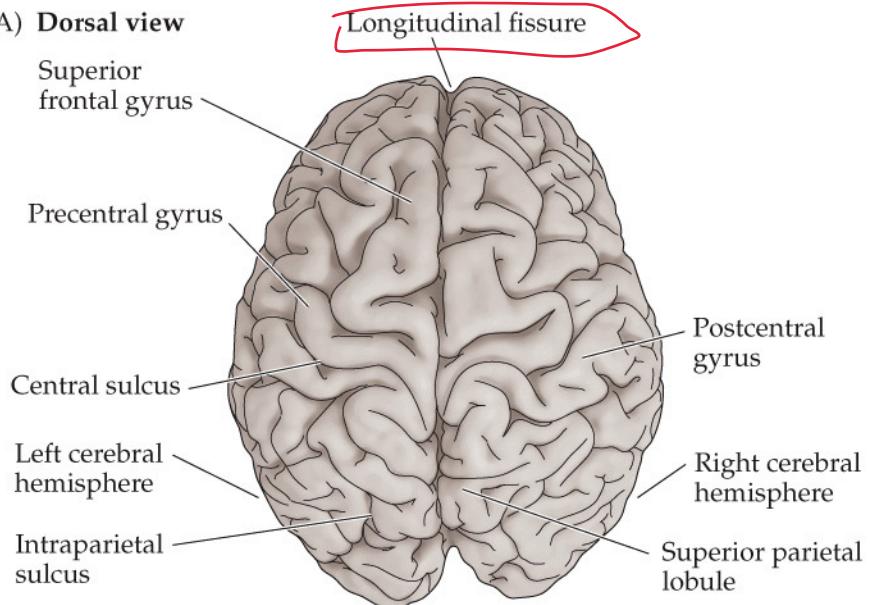
(B)



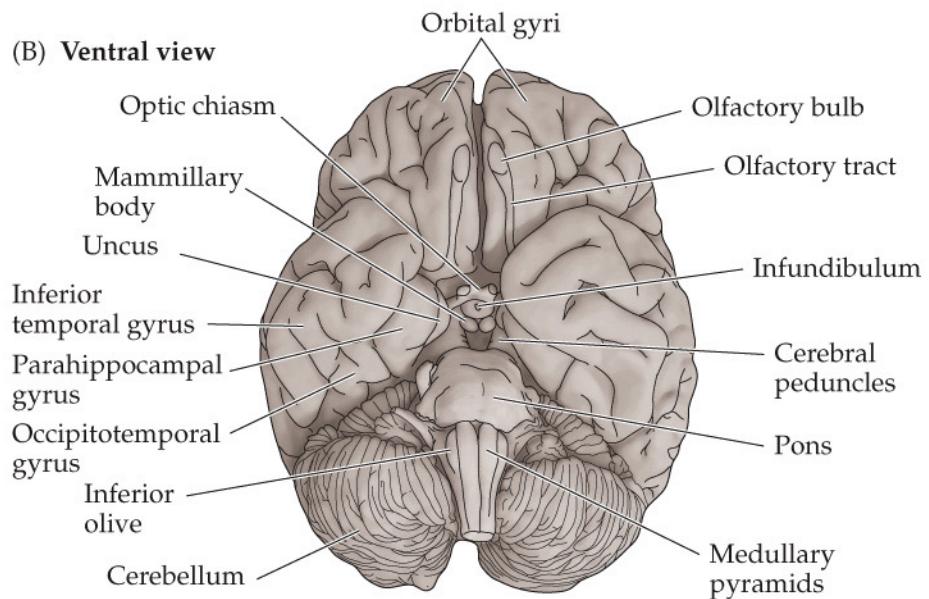
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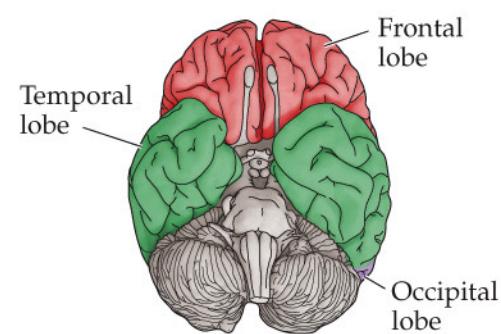
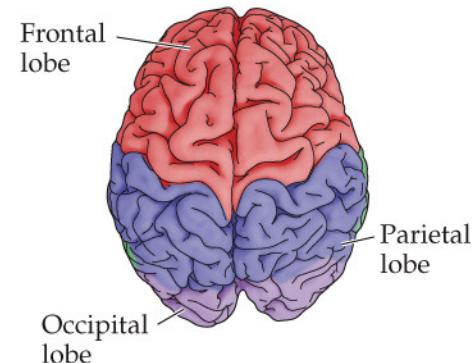
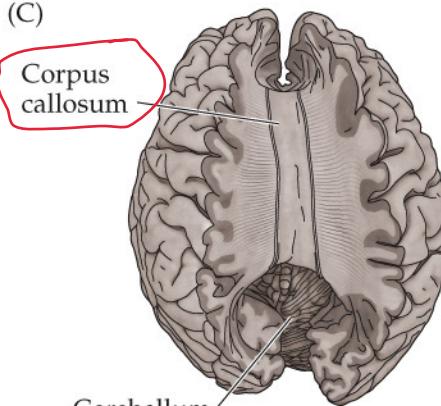
(A) Dorsal view

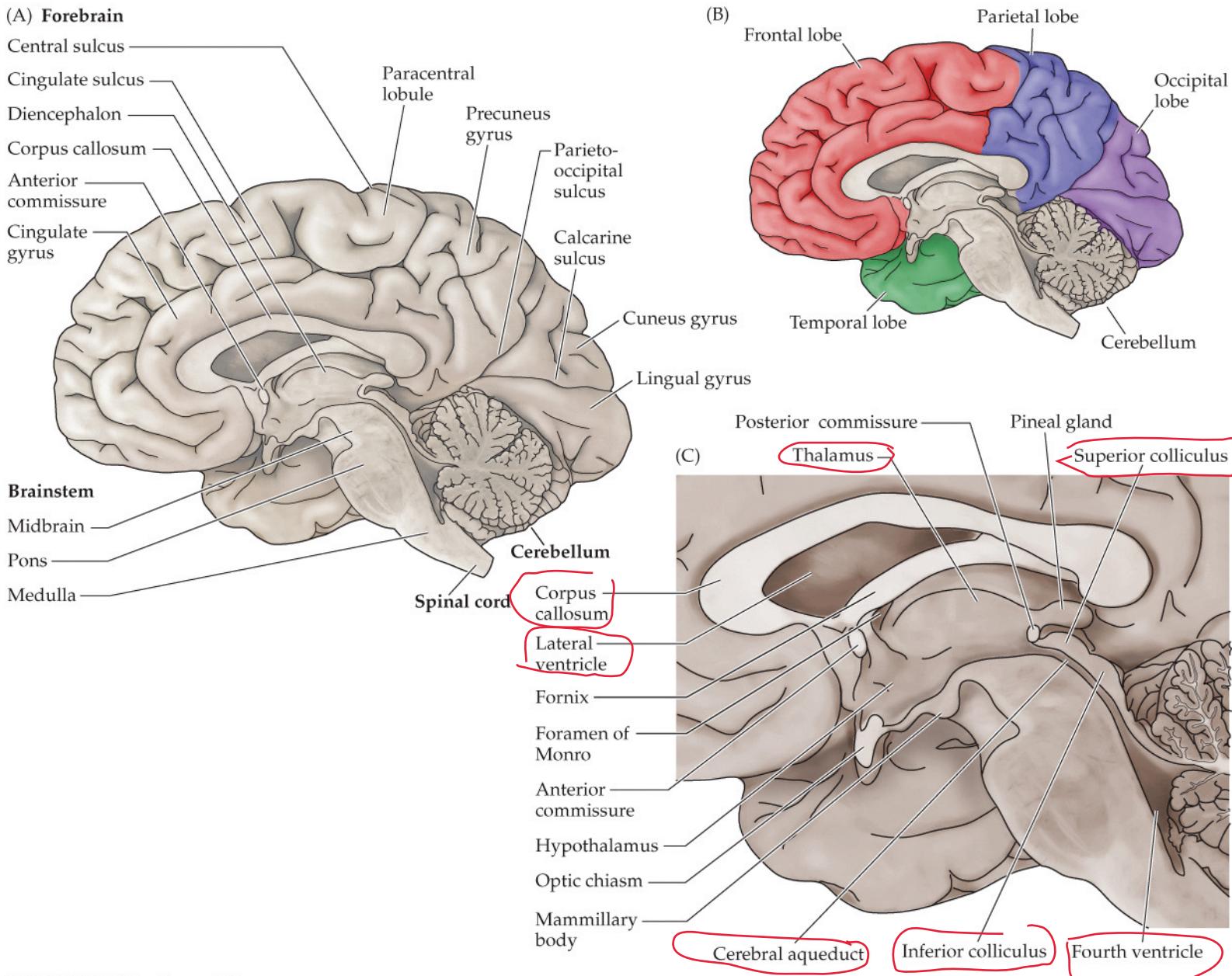


(B) Ventral view



(C)





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# Divisions of the CNS

- Cerebrum
  - cerebral hemispheres, basal ganglia, etc.
- Diencephalon
  - Thalamus, hypothalamus, retina, etc.
- Midbrain
  - Inferior and superior colliculi, etc.
- Pons
- Cerebellum
- Medulla
- Spinal cord

Embryonic brain	Adult brain derivatives	Associated ventricular space
Prosencephalon (forebrain)	Telencephalon Cerebral cortex Cerebral nuclei (basal ganglia, amygdala, basal forebrain)	Lateral ventricles
Diencephalon	Thalamus Hypothalamus Retina	Third ventricle
Mesencephalon (midbrain)	Superior and inferior colliculi Red nucleus Substantia nigra	Cerebral aqueduct
Rhombencephalon (hindbrain)	Metencephalon Cerebellum Pons Myelencephalon Medulla oblongata	Fourth ventricle Fourth ventricle
Spinal cord	Spinal cord	Central canal

# Recap

- CNS, PNS, Cranial nerves, Spinal nerves
- Cerebrum (Cerebral hemispheres), Diencephalon, Cerebellum, Brainstem (Midbrain, Pons, Medulla), Spinal Cord
- Cervical nerves, Thoracic Nerves, Lumbar Nerves, Sacral Nerves, Coccygeal Nerves
- Gray Matter, White Matter
- Dorsal, Ventral, Anterior, Posterior, Caudal, Rostral, Inferior, Superior, Coronal, Horizontal, Sagittal, Transverse