

# PSYCH 260

## Neuroanatomy I

Rick O. Gilmore

2021-09-02 09:17:20

# Prelude (2:01)

Human Body for Kids/Brain Song/Human Body Systems



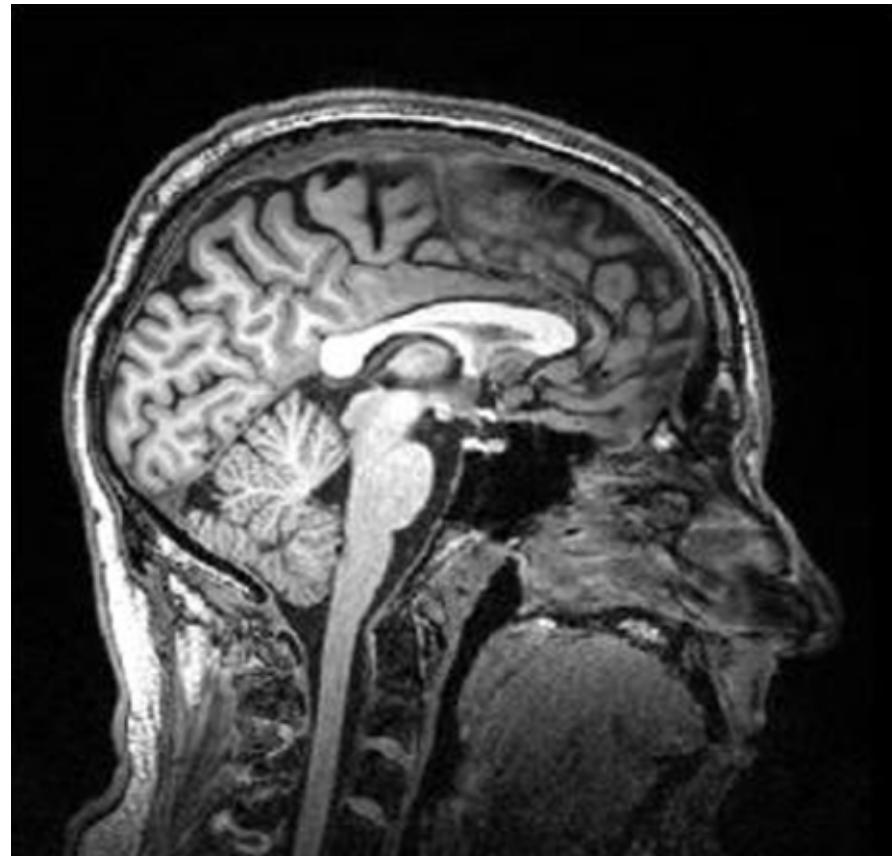
<https://www.youtube.com/embed/Qw8E9WnZTQk>

# Today's topics

- Announcement: Quiz 1 next Thursday (online via Canvas)
- Warm-up
- Wrap up on functional methods
- Neuroanatomy
  - Through song and dance

# Warm-up

What kind of brain imaging technique does this image represent?



# What kind of structural brain imaging technique does this image represent?

- A. Magnetic Resonance Imaging (MRI)
- B. Positron Emission Tomography
- C. Event-related potentials (ERP)

# What kind of structural brain imaging technique does this image represent?

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Which of the following methods has *temporal* resolution on the order of seconds?

- A. functional MRI
- B. EEG
- C. MEG
- D. single-unit recording

Which of the following methods has *temporal* resolution on the order of seconds?

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- D. ~~single-unit recording~~

# Which of the following methods has high/fine *spatial* resolution?

- A. functional MRI
- B. PET
- C. EEG
- D. single-unit recording

# Which of the following methods has high/fine *spatial* resolution?

- A. ~~functional~~ MRI
- B. PET
- C. EEG
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# Which measure(s) would you use to map connections between brain areas?

- A. retrograde/anterograde cell tracers
- B. diffusion tensor imaging (DTI)
- C. PET neuroimaging
- E. both A & B.

# Which measure(s) would you use to measure connections between brain areas?

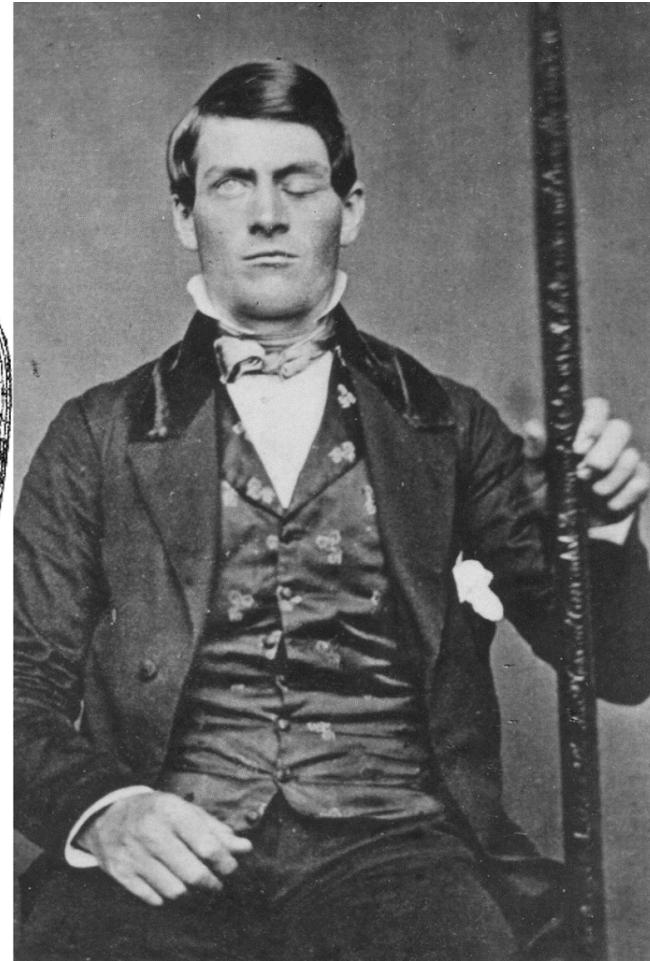
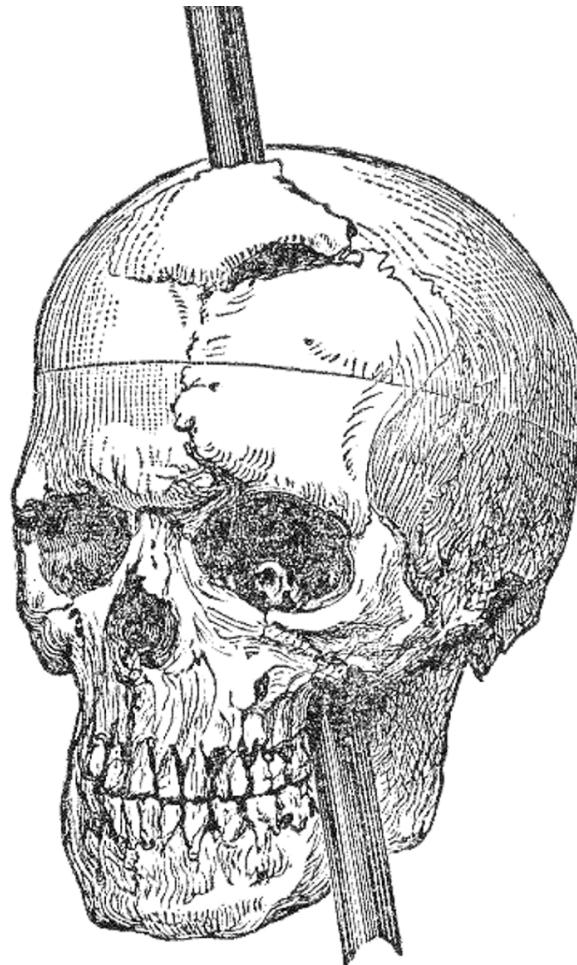
- A. retrograde/anterograde cell tracers
- B. diffusion tensor imaging (DTI)
- C. PET neuroimaging
- E. both A & B.

# Wrap-up on functional methods

# Manipulating the brain

- Nature's "experiments"
  - Stroke, head injury, tumor
  - Neuropsychology
- If damage to X impairs performance on Y -> X critical for/controls Y
- Poor spatial/temporal resolution, limited experimental control

# Phineas Gage



<http://www.doctorsimpossible.com/the-curious-case-of-phineas-gage/>

Bestselling author of *Awakenings* and *A Leg to Stand On*

**OLIVER SACKS**  
The  
**MAN**  
Who  
**MISTOOK**  
**HIS WIFE**  
for a  
**HAT**

*and Other Clinical Tales*

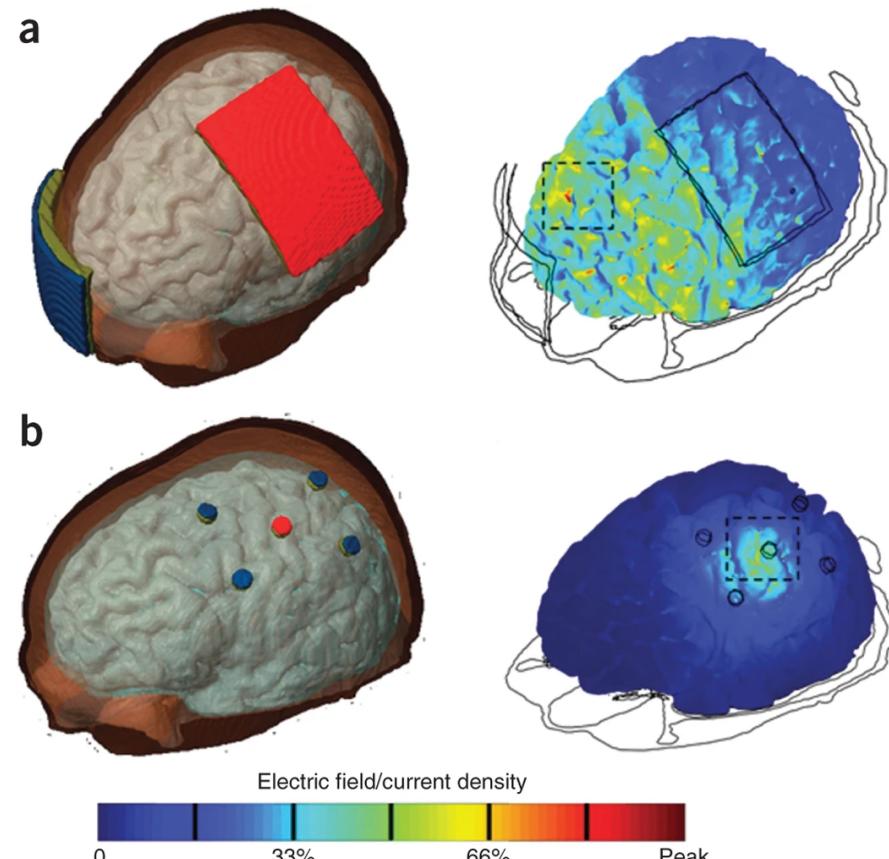
"Beguiling, compassionate, moving....the lucidity and power of a gifted writer."

—John C. Marshall, *The New York Times Book Review*

# Stimulating the brain

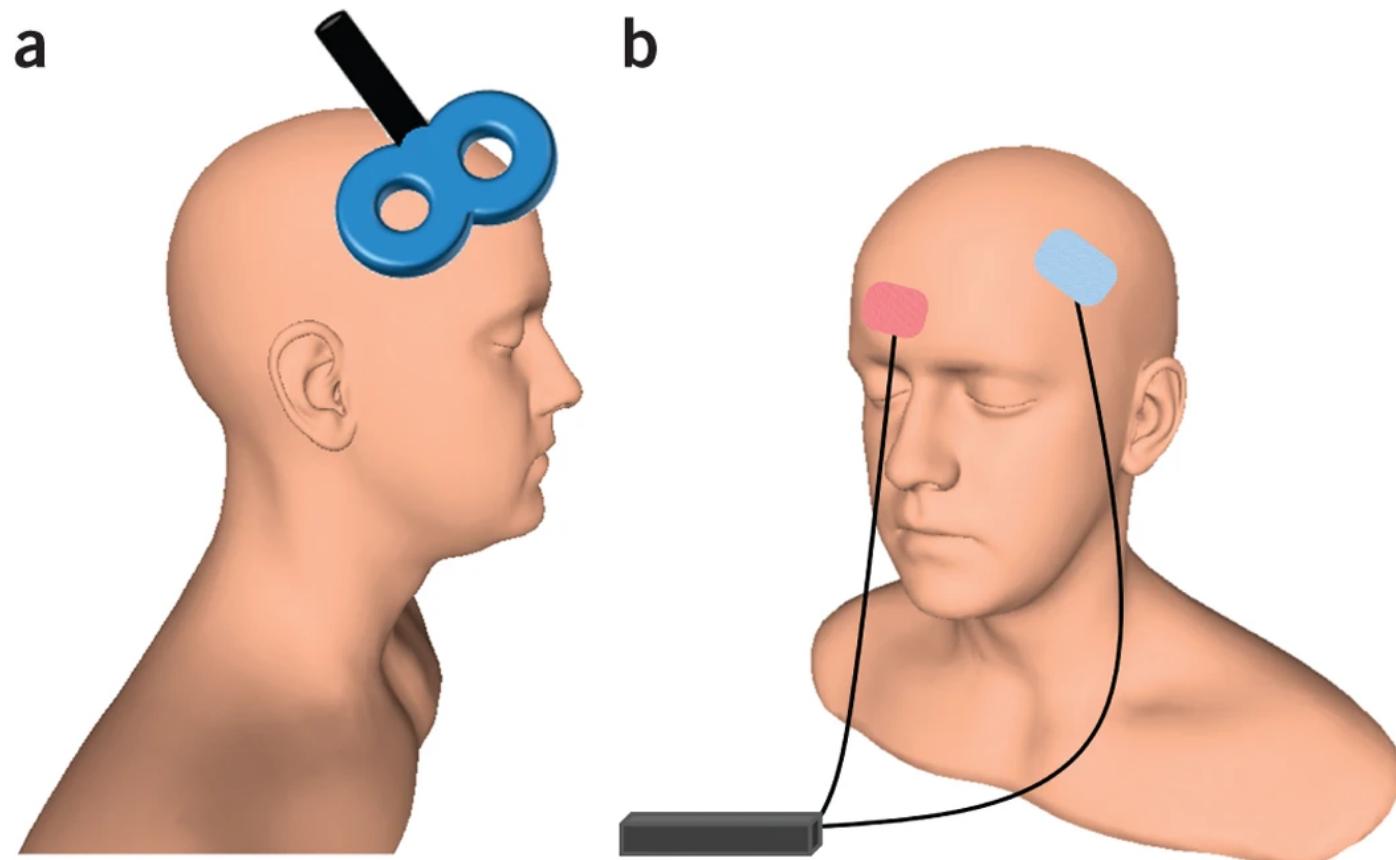
- Pharmacological
- Electrical ([transcranial Direct Current Stimulation - tDCS](#))
  - Inject low levels of electric current
- Magnetic (Transcranial magnetic stimulation - *TMS*)
  - Inject directed pulses of magnetic energy
- Optically (optogenetics)
  - Light activates ion channels in neurons, causes current to flow

# tDCS



[\(Dayan, Censor, Buch, Sandrini, & Cohen, 2013\)](#)

# TMS



(Dayan, Censor, Buch, Sandrini, & Cohen, 2013)

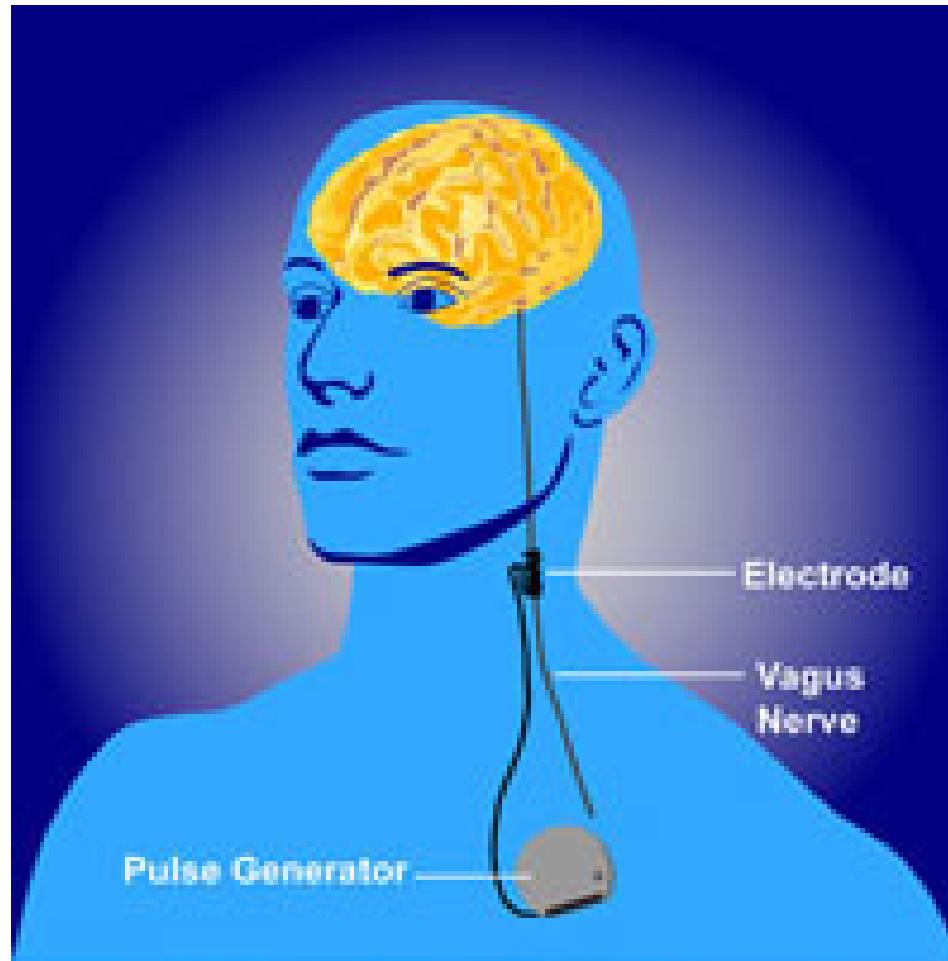
# Optogenetic stimulation

- Insert light-sensitive ion channels into neuronal membrane using genetic engineering
- Open/close channels (activate/inhibit neurons) with light

# Evaluating stimulation methods

- Spatial/temporal resolution?
  - Assume stimulation mimics natural activity. Does it?
  - Optogenetic stimulation similar to natural stimulation, others less so
- Deep (electrical) brain stimulation as therapy
  - Parkinson's Disease
  - Depression
  - Epilepsy

# Deep brain stimulation



<http://www.nimh.nih.gov/health/topics/brain-stimulation-therapies/brain-stimulation-therapies.shtml>

Parkinson's Disease



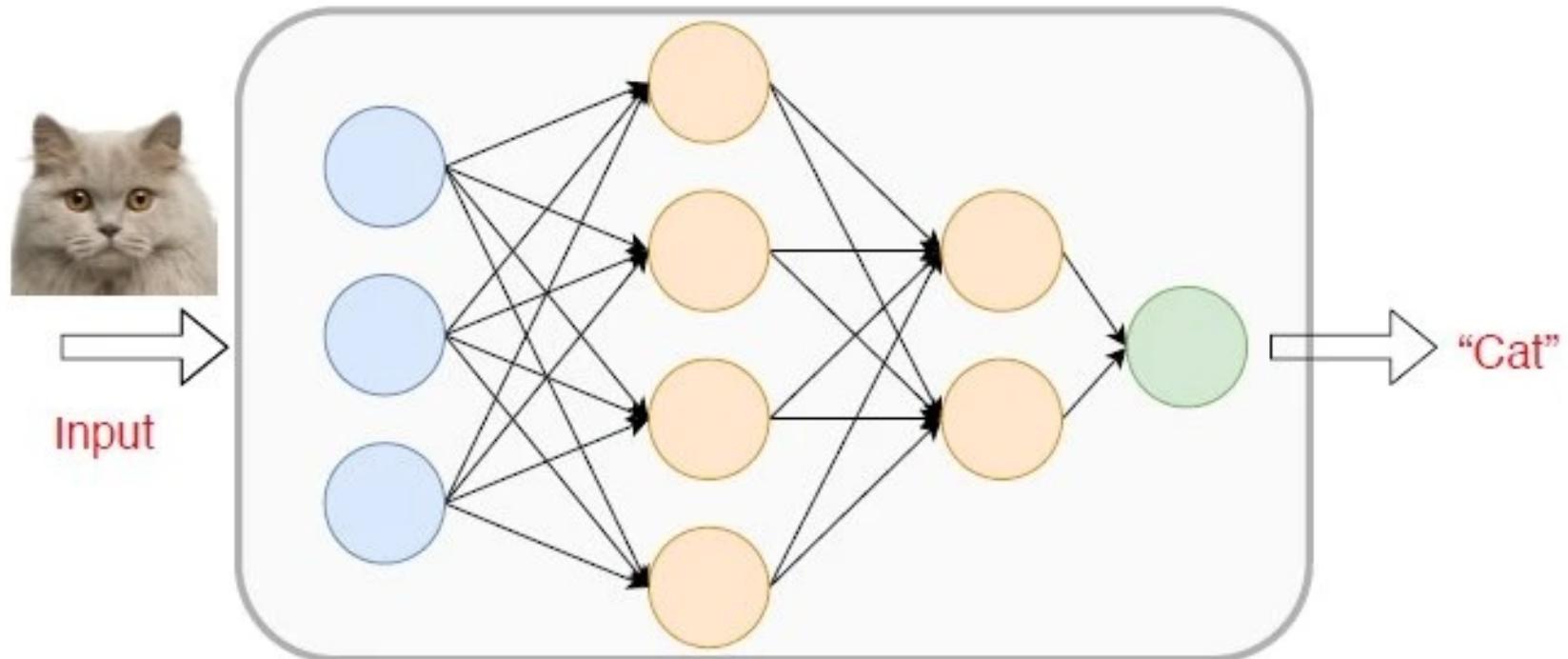
<https://www.youtube.com/embed/KDjWdtDyz5I>

# *Simulating the brain*

- Computer/mathematical models of brain function
- Example: neural networks
- Cheap, noninvasive, can be stimulated or “lesioned”

# Application: AI

## Multilayer Perceptrons

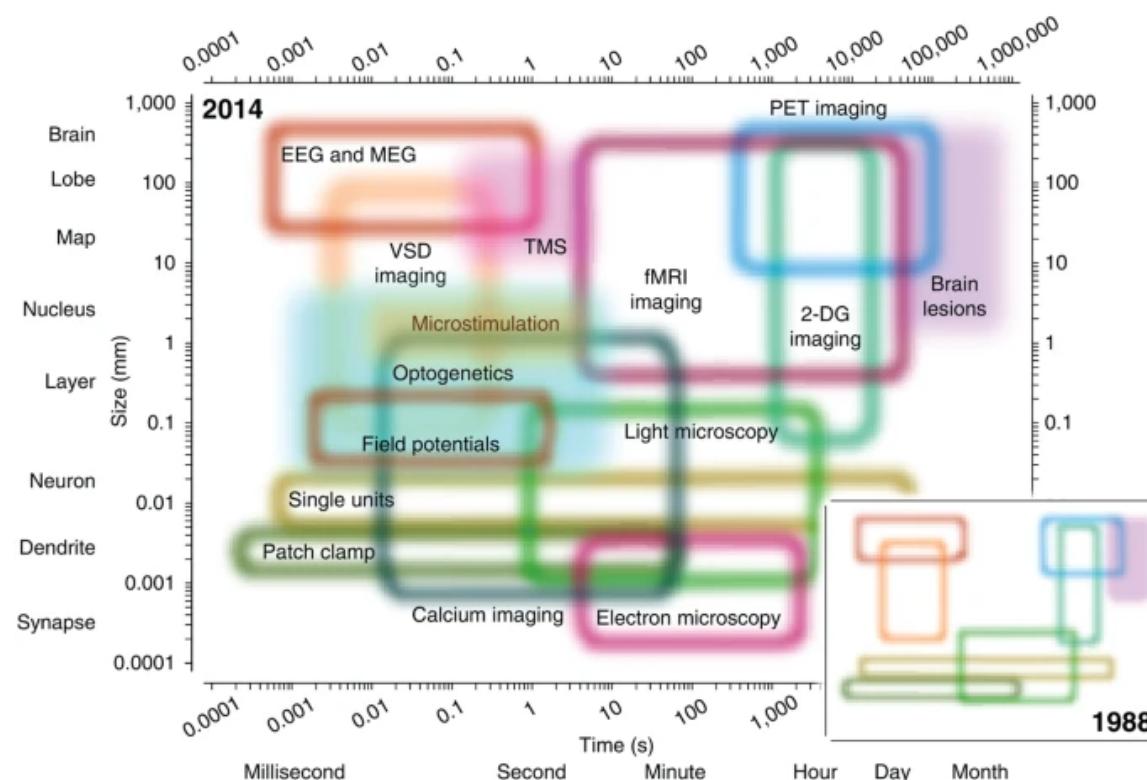


<https://viso.ai/deep-learning/deep-neural-network-three-popular-types/>



<https://www.youtube.com/embed/MPU2HistivI>

# Spatial and Temporal Resolution



(Sejnowski, Churchland, & Movshon, 2014)

# Bottom line...

- Neuroscientists...
  - need to use many tools
  - seek converging evidence

# Neuroanatomy

# Brain anatomy through dance

0:00 / 1:28

# Finding our way around

*Anterior/Posterior*

*Medial/Lateral*

*Superior/Inferior*

*Dorsal/Ventral*

*Rostral/Caudal*

# Finding our way around

*Anterior/Posterior* -> front/back

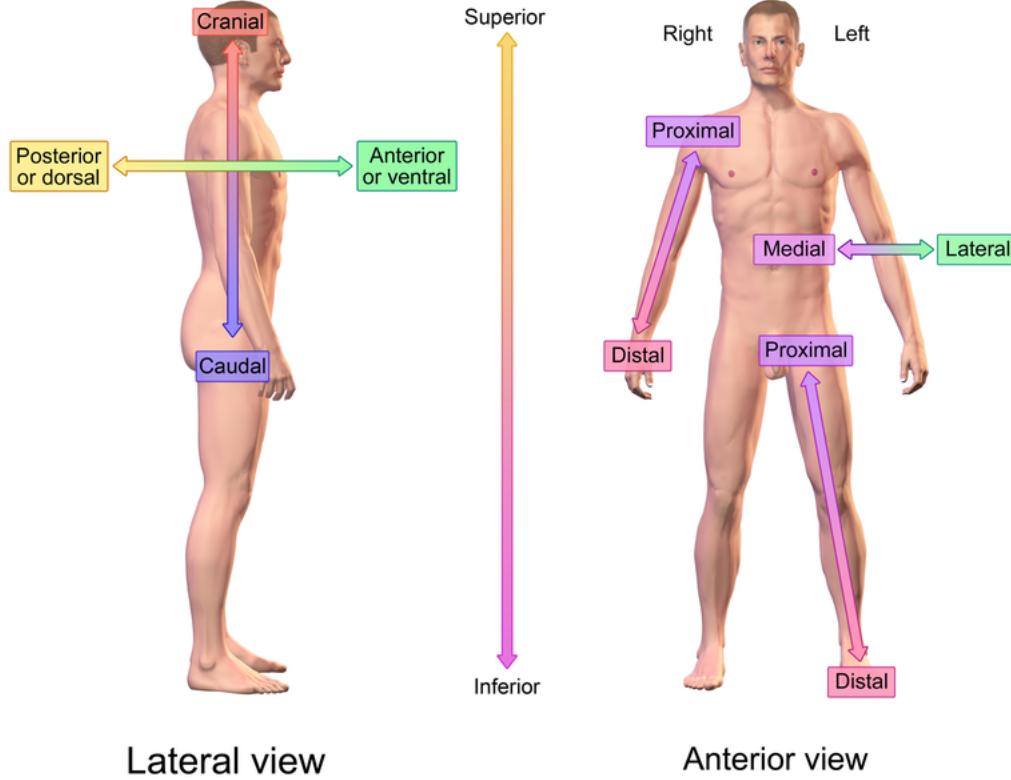
*Medial/Lateral* -> inside/outside

*Superior/Inferior* -> upward/downward

*Dorsal/Ventral* -> back-ward/belly-ward

*Rostral/Caudal* -> head-ward/tail-ward

# Directional image



Lateral view

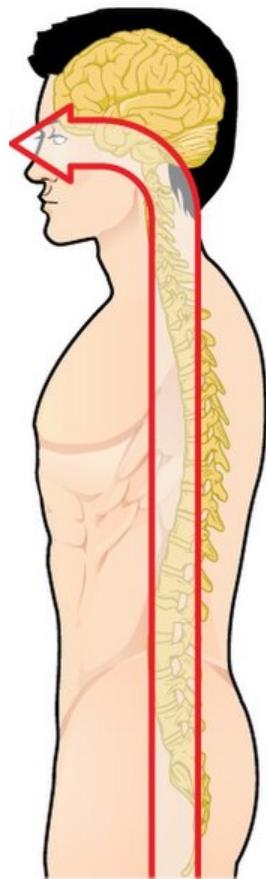
Anterior view

## Directional References

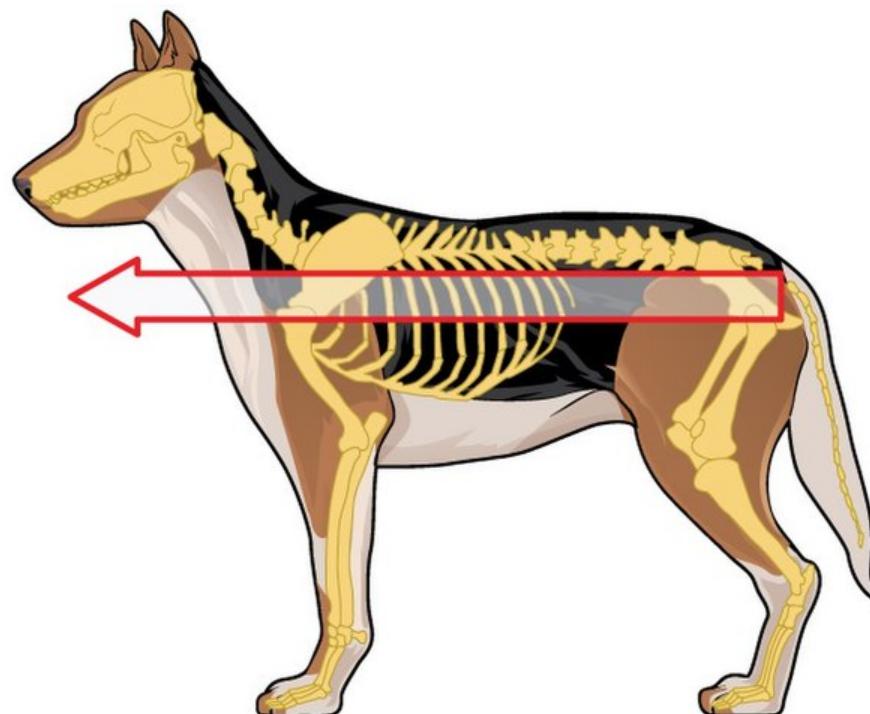
Wikipedia

# Bipeds vs. quadripeds

Human (bipedal)



Dog (quadrupedal)



Wikipedia

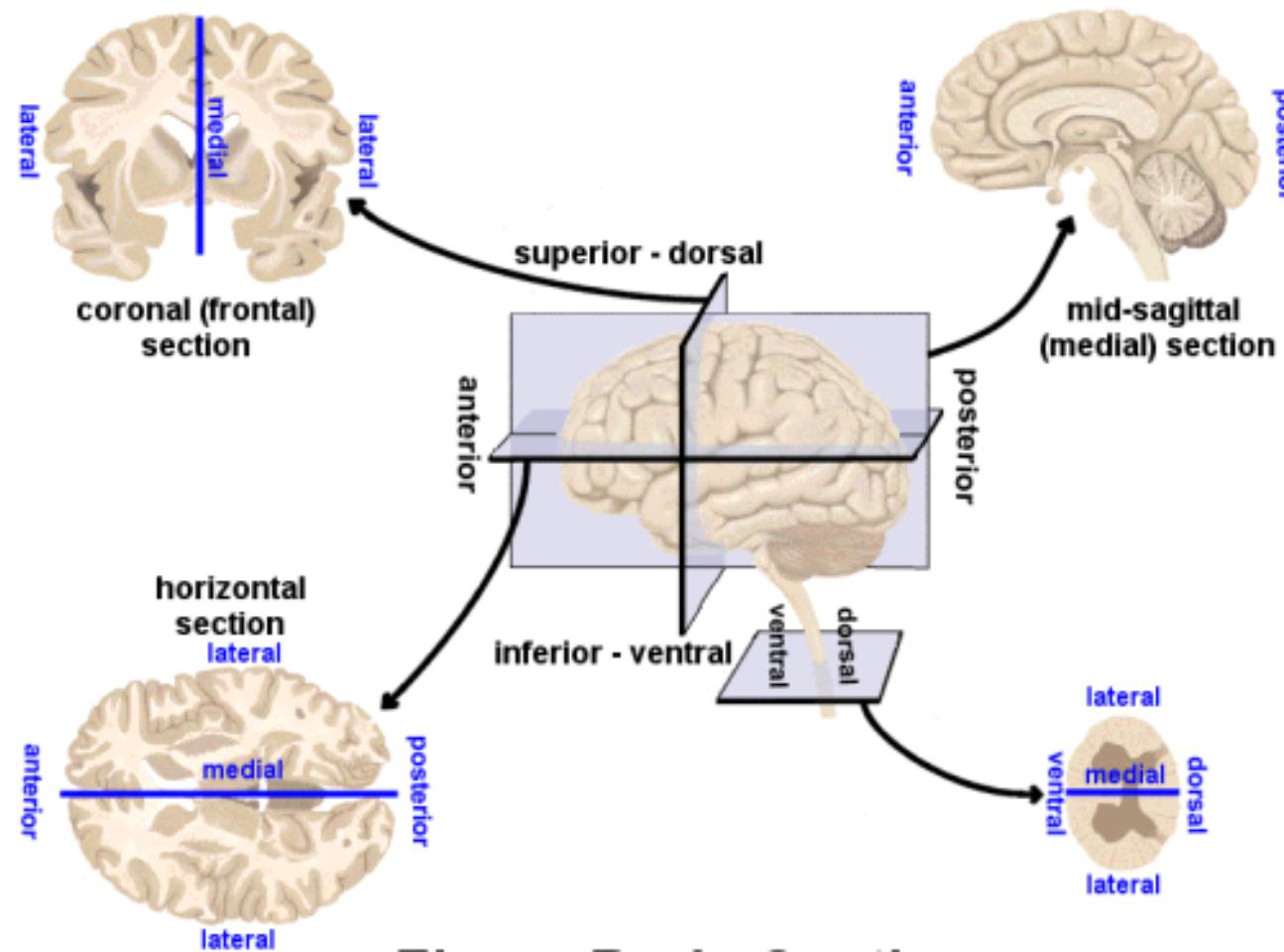
# No matter how you slice it

*Horizontal/Axial*

*Coronal/Transverse/Frontal*

*Sagittal* (from the side)

# Slice diagram



[http://www.scienteteacherprogram.org/biology/chillemistudentguide1-06/brain\\_directions\\_planes\\_sections\\_directions\\_-\\_small.gif](http://www.scienteteacherprogram.org/biology/chillemistudentguide1-06/brain_directions_planes_sections_directions_-_small.gif)

# Supporting structures

*Meninges*

*Ventricular system*

Blood supply

# Meninges

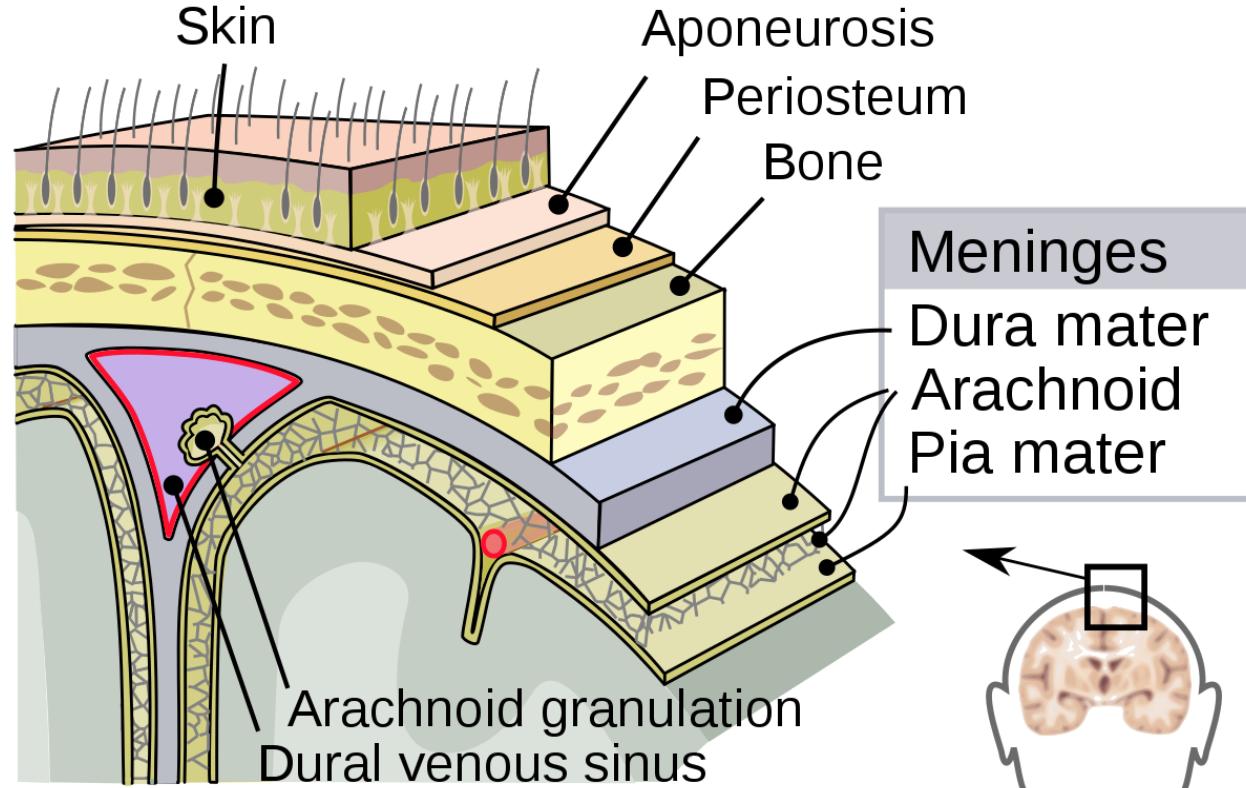
*Dura mater*

*Arachnoid membrane*

*Subarachnoid space*

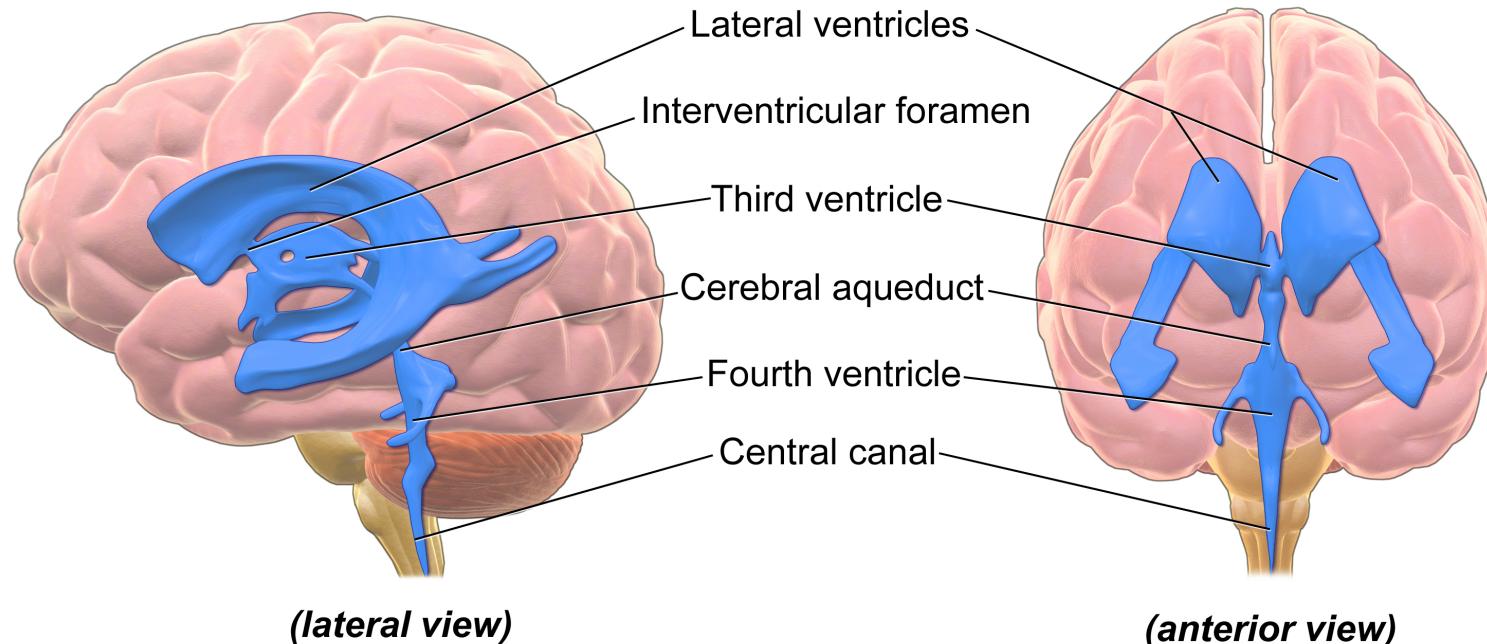
*Pia mater*

# Meninges



<https://upload.wikimedia.org/wikipedia/commons/thumb/8/8e/Meninges-en.svg/1280px-Meninges-en.svg.png>

# Ventricular system



[https://upload.wikimedia.org/wikipedia/commons/d/d4/Blausen\\_0896\\_Ventricles\\_Brain.png](https://upload.wikimedia.org/wikipedia/commons/d/d4/Blausen_0896_Ventricles_Brain.png)

# Ventricles

*Lateral (1st & 2nd)*

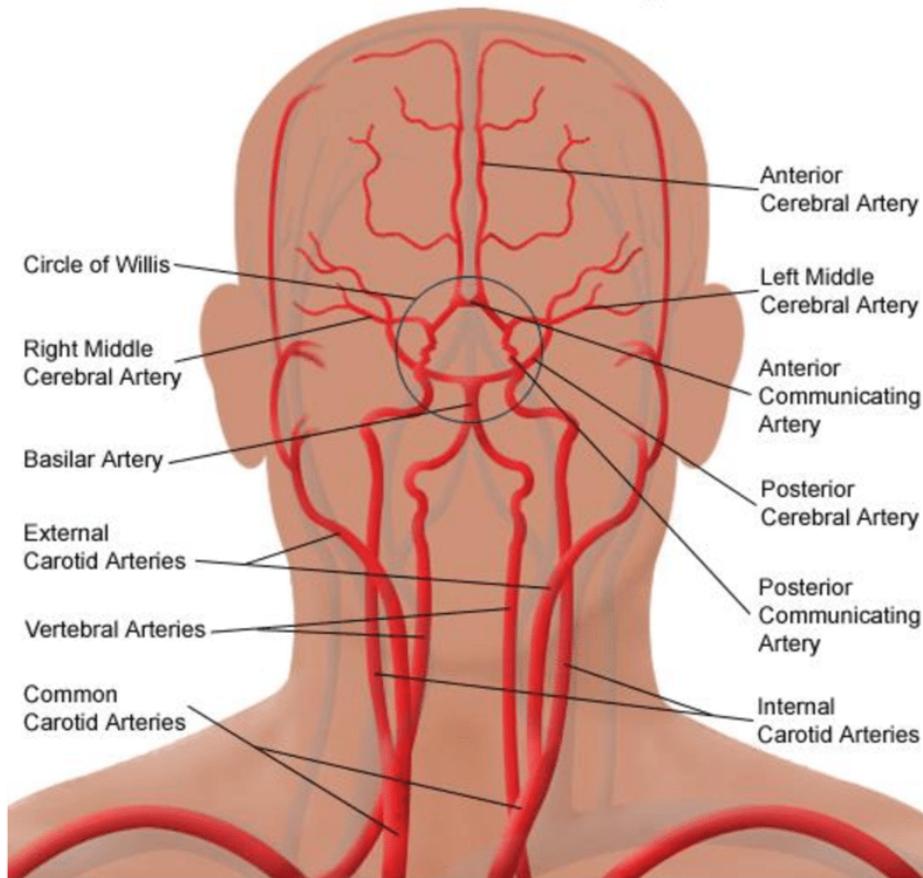
*3rd*

*Cerebral aqueduct*

*4th*

(are filled with) *Cerebrospinal fluid (CSF)*

# Blood Supply



[https://www.researchgate.net/profile/Yohannes\\_Mamo/publication/280830140/figure/fig1/AS:649635857174600/Organization-of-the-human-cerebral-circulation-The-brain-receives-its-blood-supply.png](https://www.researchgate.net/profile/Yohannes_Mamo/publication/280830140/figure/fig1/AS:649635857174600/Organization-of-the-human-cerebral-circulation-The-brain-receives-its-blood-supply.png)

# Blood Supply

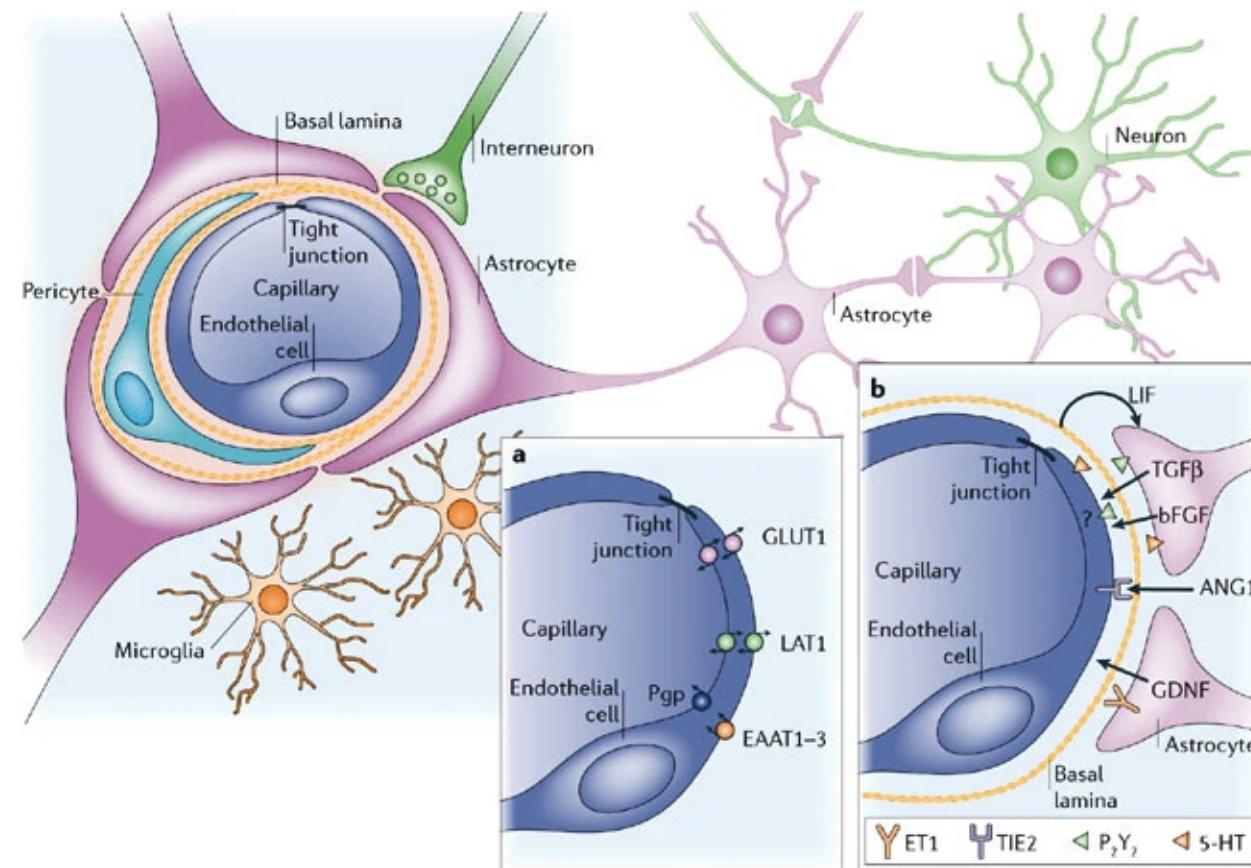
## Arteries

- external & internal carotid; vertebral -> basilar
- *Circle of Willis*
- anterior, middle, & posterior cerebral

# Blood/brain barrier

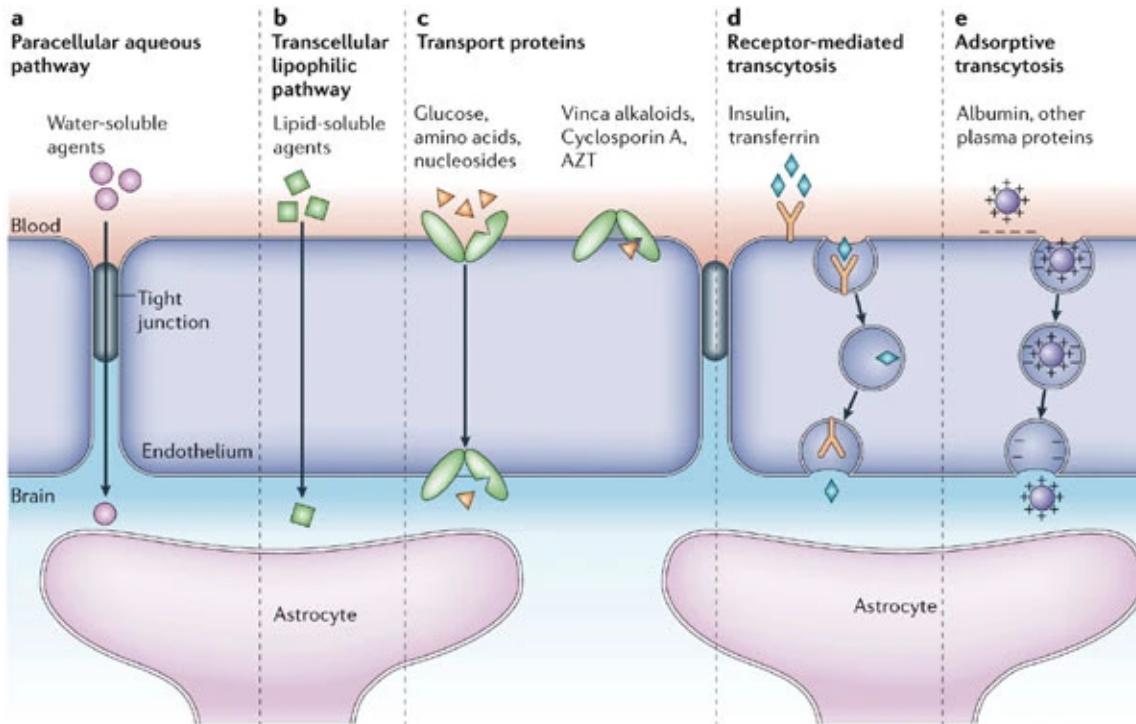
- Isolates CNS from blood stream
- Active transport of molecules typically required
- (endothelial) cells forming blood vessel walls are tightly packed

# Blood/brain barrier



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Nature Reviews | Neuroscience

(Abbott, Rönnbäck, & Hansson, 2006)



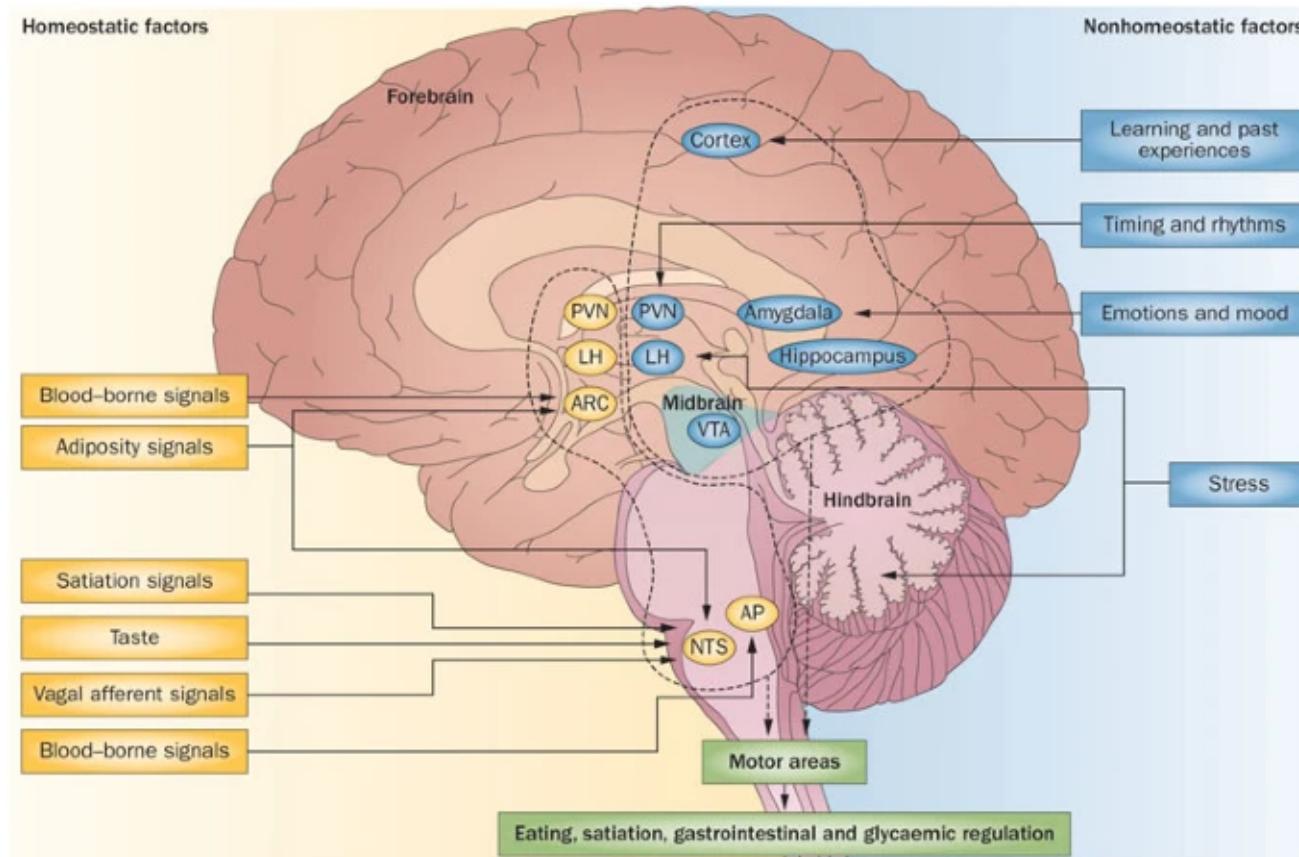
Copyright © 2005 Nature Publishing Group  
*Nature Reviews | Neuroscience*

(Abbott, Rönnbäck, & Hansson, 2006)

# exception is *Area Postrema*

- In brainstem
- Blood-brain barrier thin
- Detects toxins, evokes vomiting

# Area Postrema



(Begg & Woods, 2013)

# Organization of the Nervous System

## Central Nervous System (CNS)

- Brain
- Spinal Cord
- Everything encased in bone

## Peripheral Nervous System (PNS)

# Organization of the brain

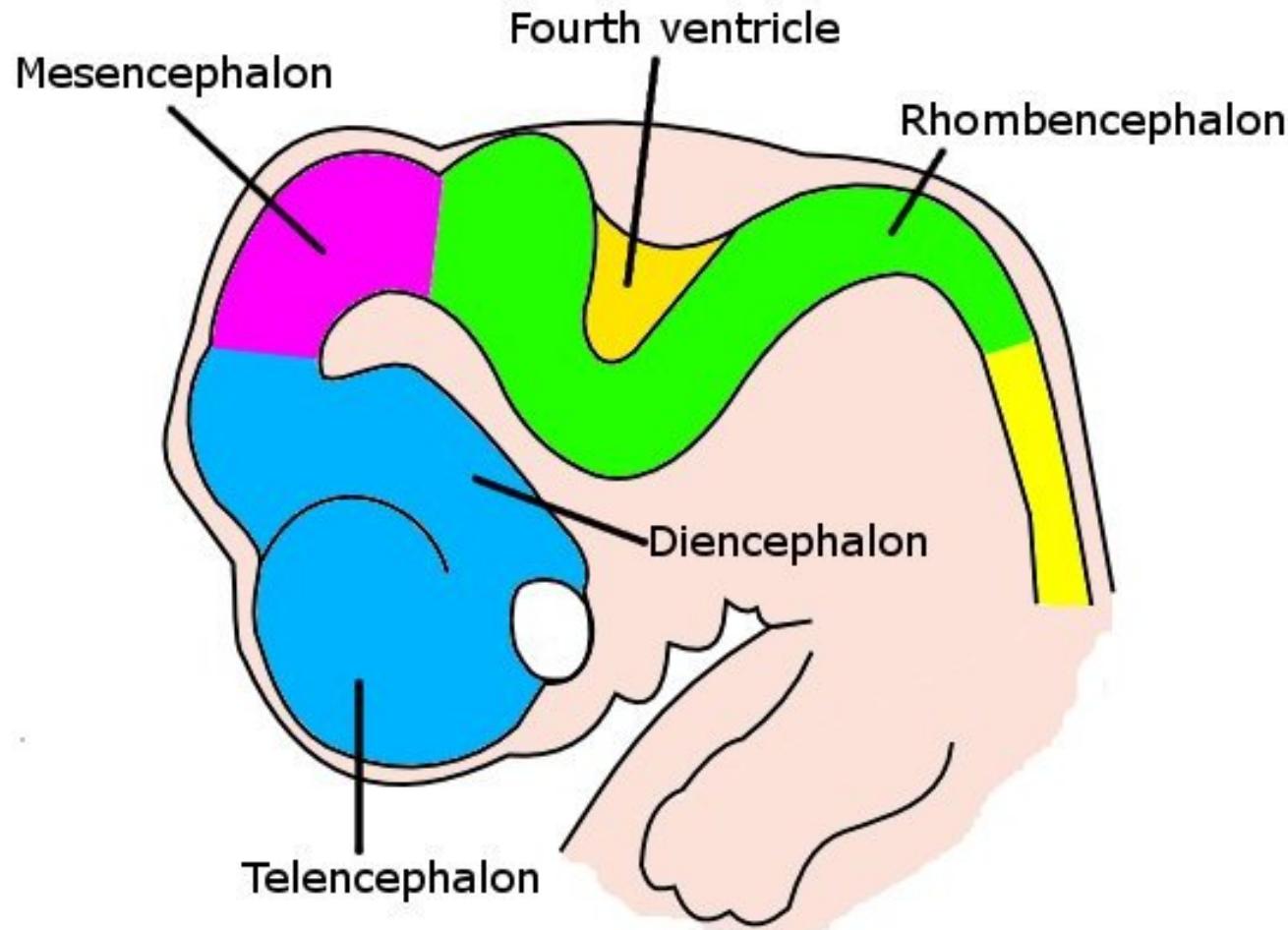
Major division	Ventricular Landmark	Embryonic Division	Structure
<i>Forebrain</i>	Lateral	Telencephalon	<i>Cerebral cortex</i>
			<i>Basal ganglia</i>
			<i>Hippocampus, amygdala</i>
Third		Diencephalon	<i>Thalamus</i>
			<i>Hypothalamus</i>
<i>Midbrain</i>	Cerebral Aqueduct	Mesencephalon	<i>Tectum, Tegmentum</i>

# Organization of the brain

Major division	Ventricular Landmark	Embryonic Division	Structure
<i>Hindbrain</i>	4th	Rhombencephalon	<i>Cerebellum, pons</i>
	-		<i>Medulla oblongata</i>

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# Embryonic brain (~6 weeks gestation)



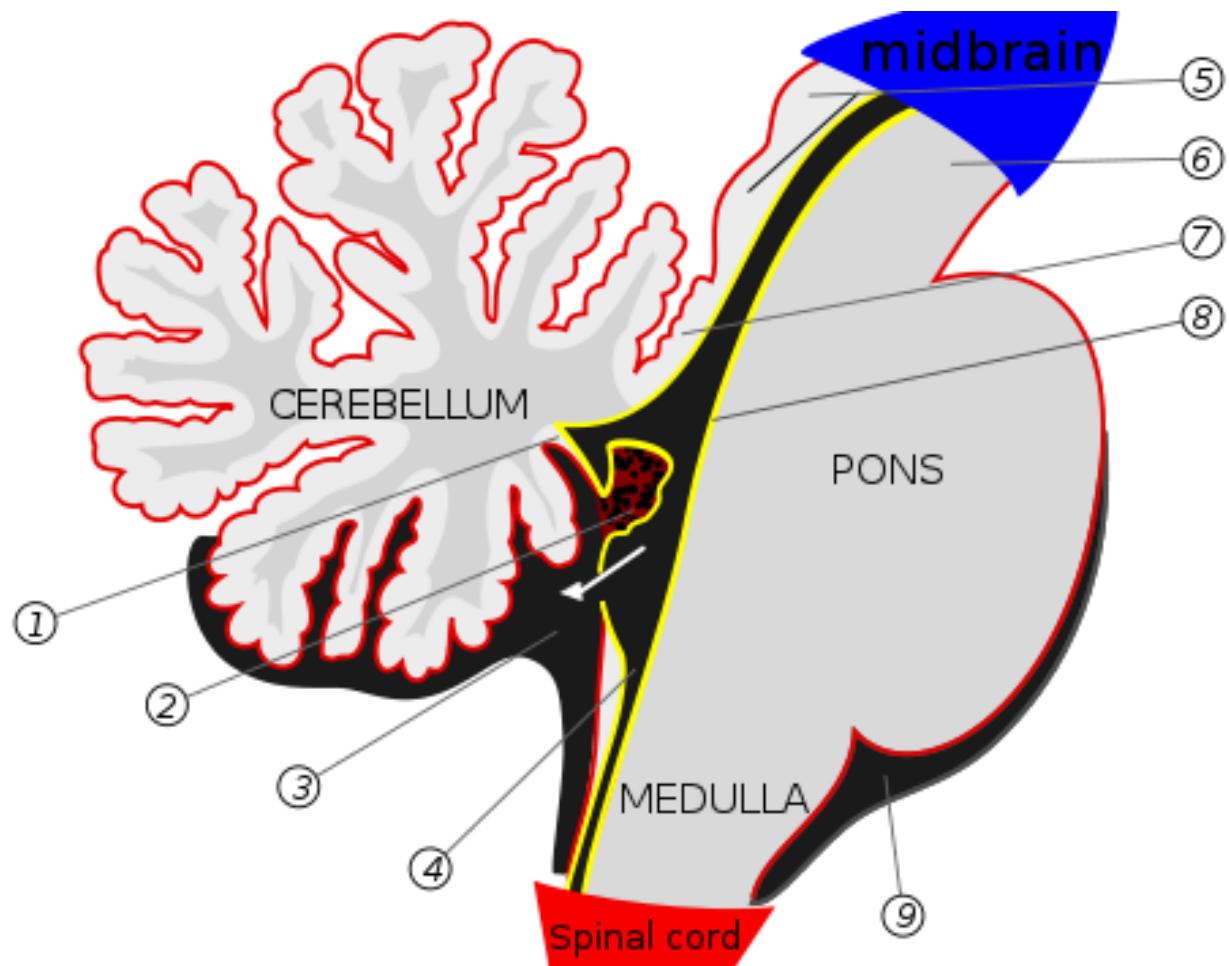
[https://upload.wikimedia.org/wikipedia/commons/c/c8/6\\_week\\_embryo\\_brain.jpg](https://upload.wikimedia.org/wikipedia/commons/c/c8/6_week_embryo_brain.jpg)

# Hindbrain

Structures adjacent to 4th ventricle

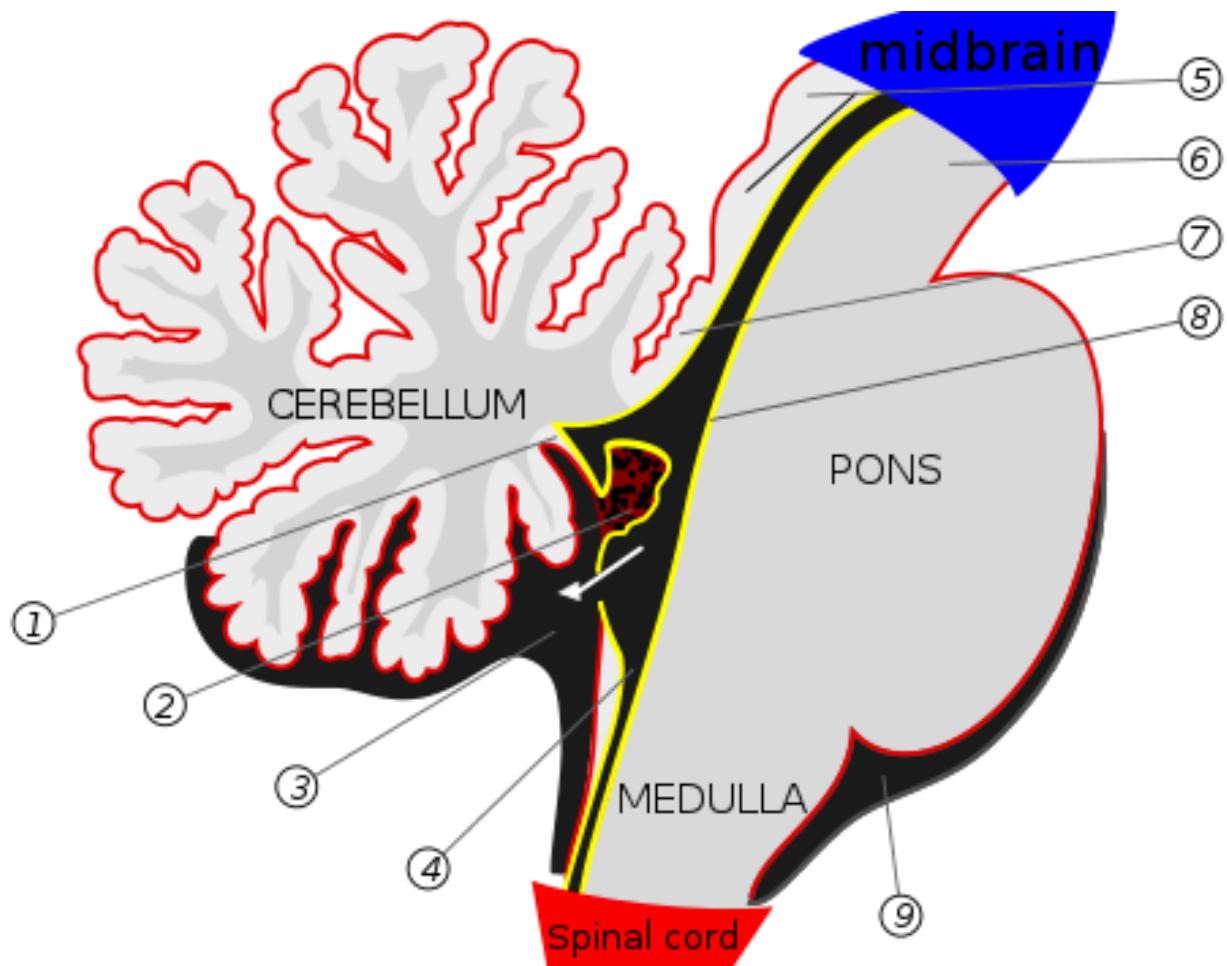
- Medulla oblongata
- Cerebellum
- Pons

# Hindbrain



<https://upload.wikimedia.org/wikipedia/commons/thumb/b/b9/Gray708.svg/500px-Gray708.svg.png>

# Medulla oblongata



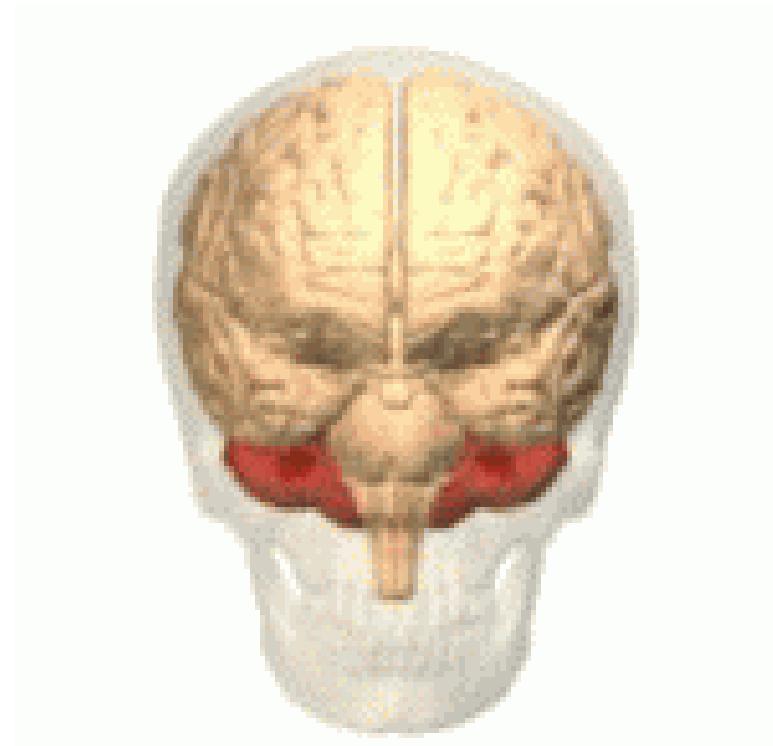
<https://upload.wikimedia.org/wikipedia/commons/thumb/b/b9/Gray708.svg/500px-Gray708.svg.png>

- Fibers of passage (to/from spinal cord)
- Cranial nerves VI-XII
- Cardiovascular regulation
- Muscle tone

# Cerebellum

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- “Little brain”
- Dorsal to pons
- Movement coordination, classical conditioning  
(associative learning), + ???



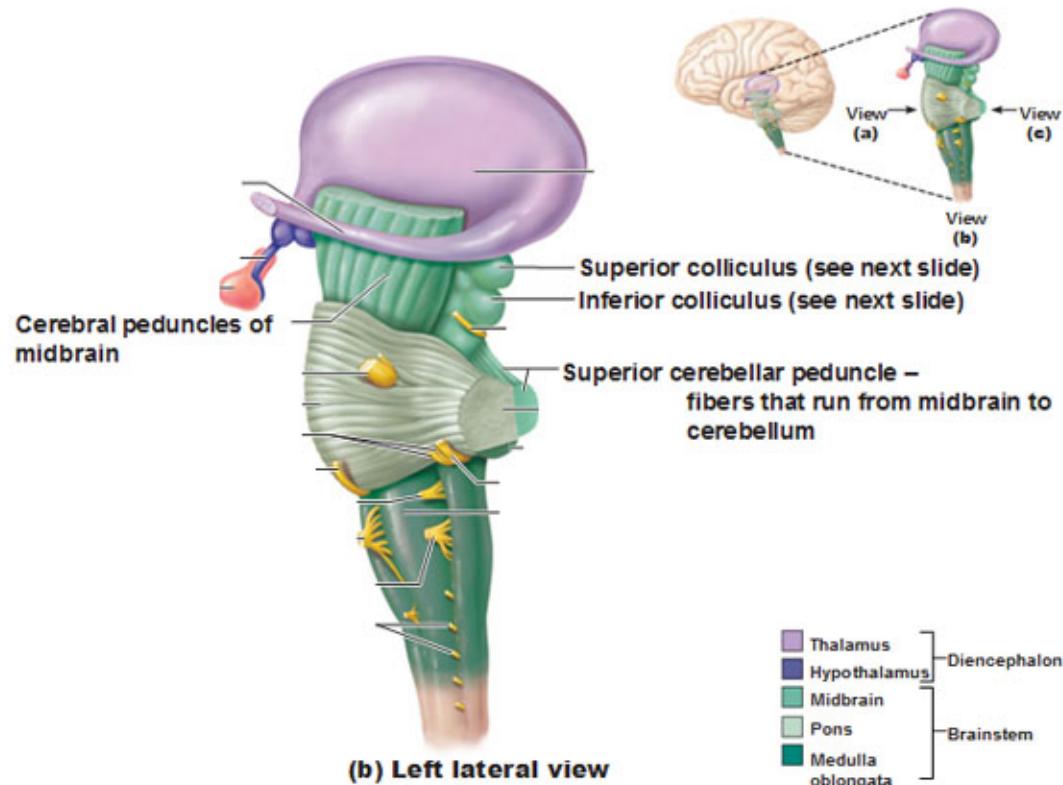
<https://en.wikipedia.org/wiki/Cerebellum>

# Pons

- Bulge on brain stem
- Neuromodulatory nuclei
- Relay to cerebellum
- Cranial nerve V

# Midbrain

## The Brain Stem– The Midbrain

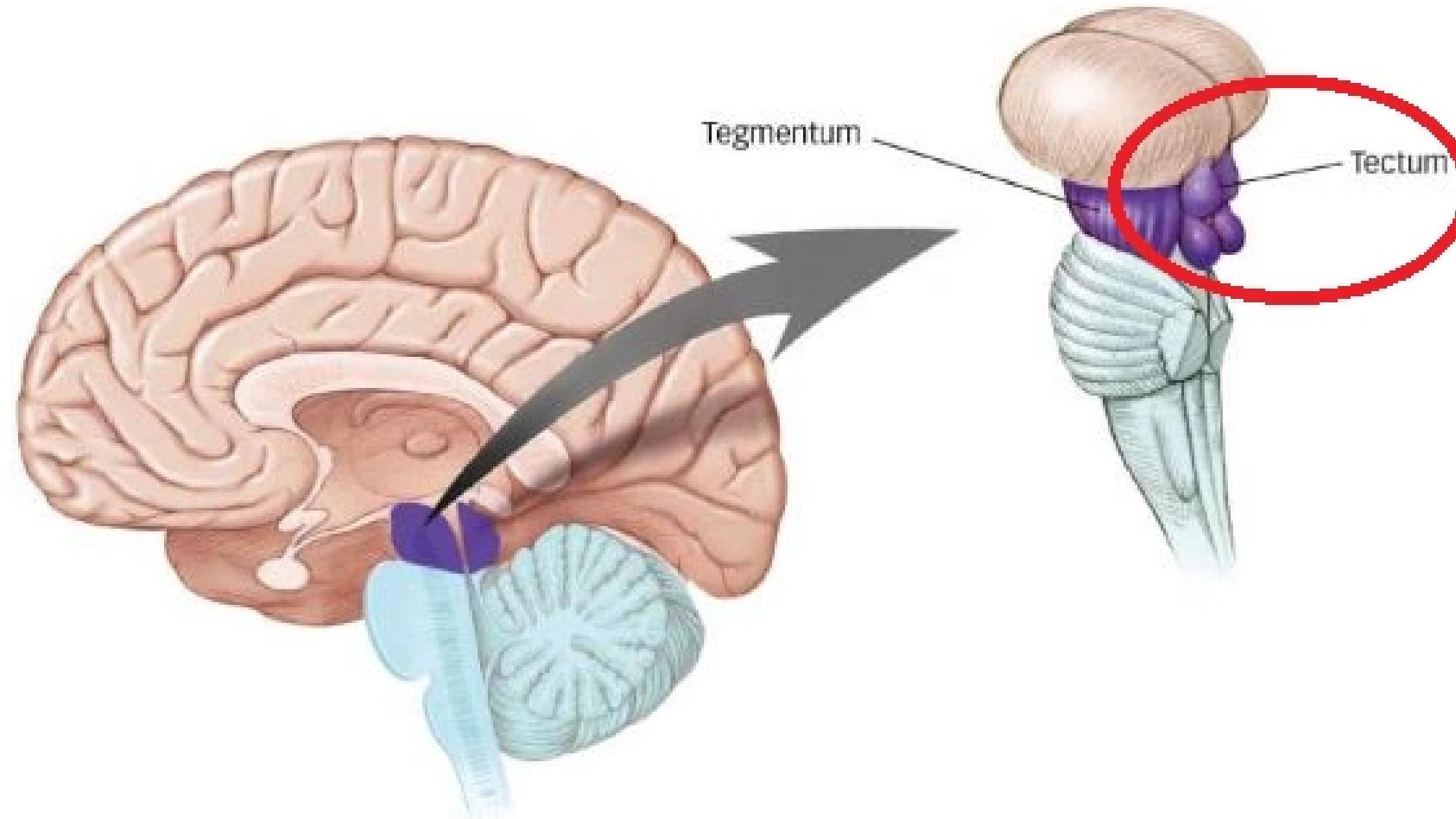


<http://antranik.org/wp-content/uploads/2011/11/the-brain-stem-mid-brain-left-lateral-view-superior-colliculus-inferior-cerebellar-peduncle.jpg>

# Midbrain components

Tectum

Tegmentum



<https://vignette.wikia.nocookie.net/brain-for-ai/images/b/bd/Tectum.png/revision/latest?cb=20170613125935>

# Tectum

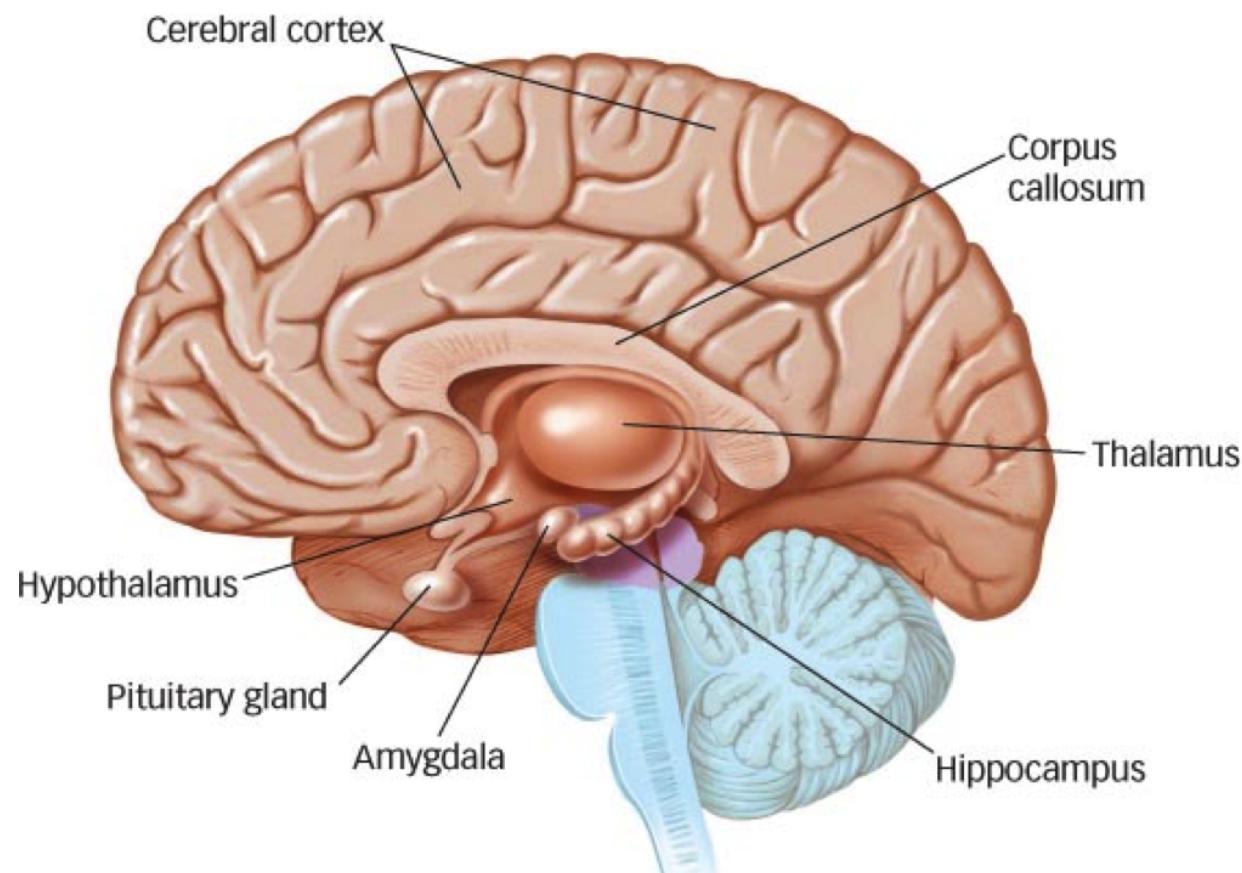
- Tectum -> “roof”
- *Superior colliculus* (reflexive orienting of eyes, head, ears)
- *Inferior colliculus* (sound/auditory processing)

# Tegmentum

- Tegmentum -> “floor”
- Species-typical movement sequences (e.g., cat: hissing, pouncing)
- Cranial nerves III, IV

- *Neuromodulatory nuclei* release neuromodulatory neurotransmitters:
  - *Dopamine (DA)*
  - *Norepinephrine (NE)*
  - *Serotonin (5-HT)*

# Forebrain



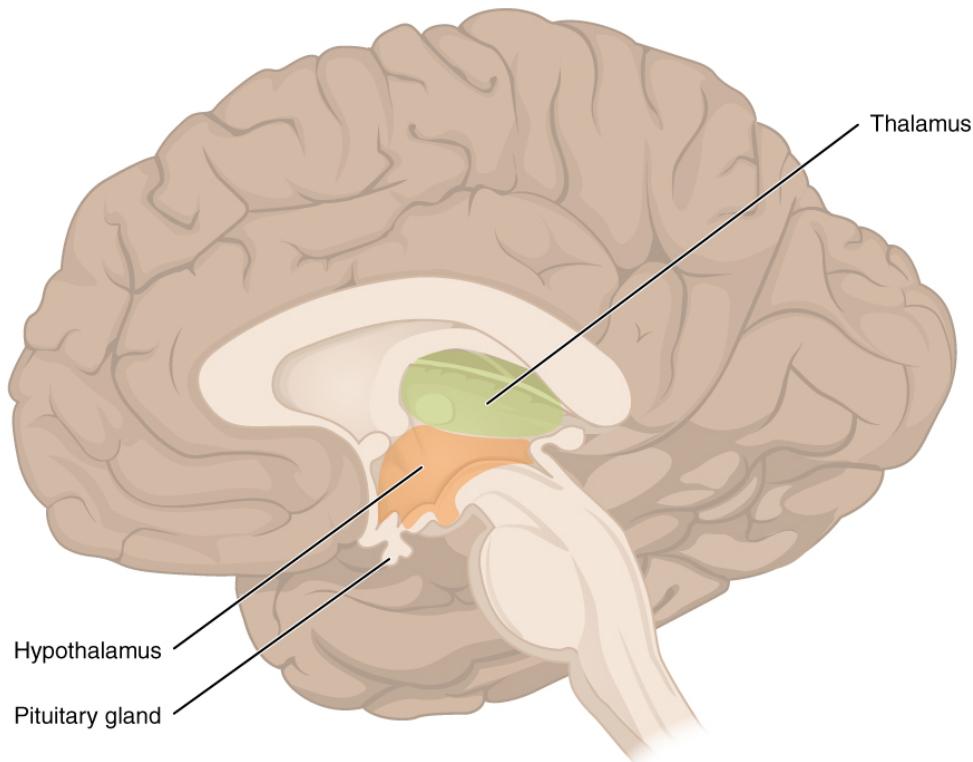
<http://classconnection.s3.amazonaws.com/252/flashcards/1048252/png/forebrain1328987872235.png>

# Forebrain Components

Diencephalon

Telencephalon

# Diencephalon (“between” brain)

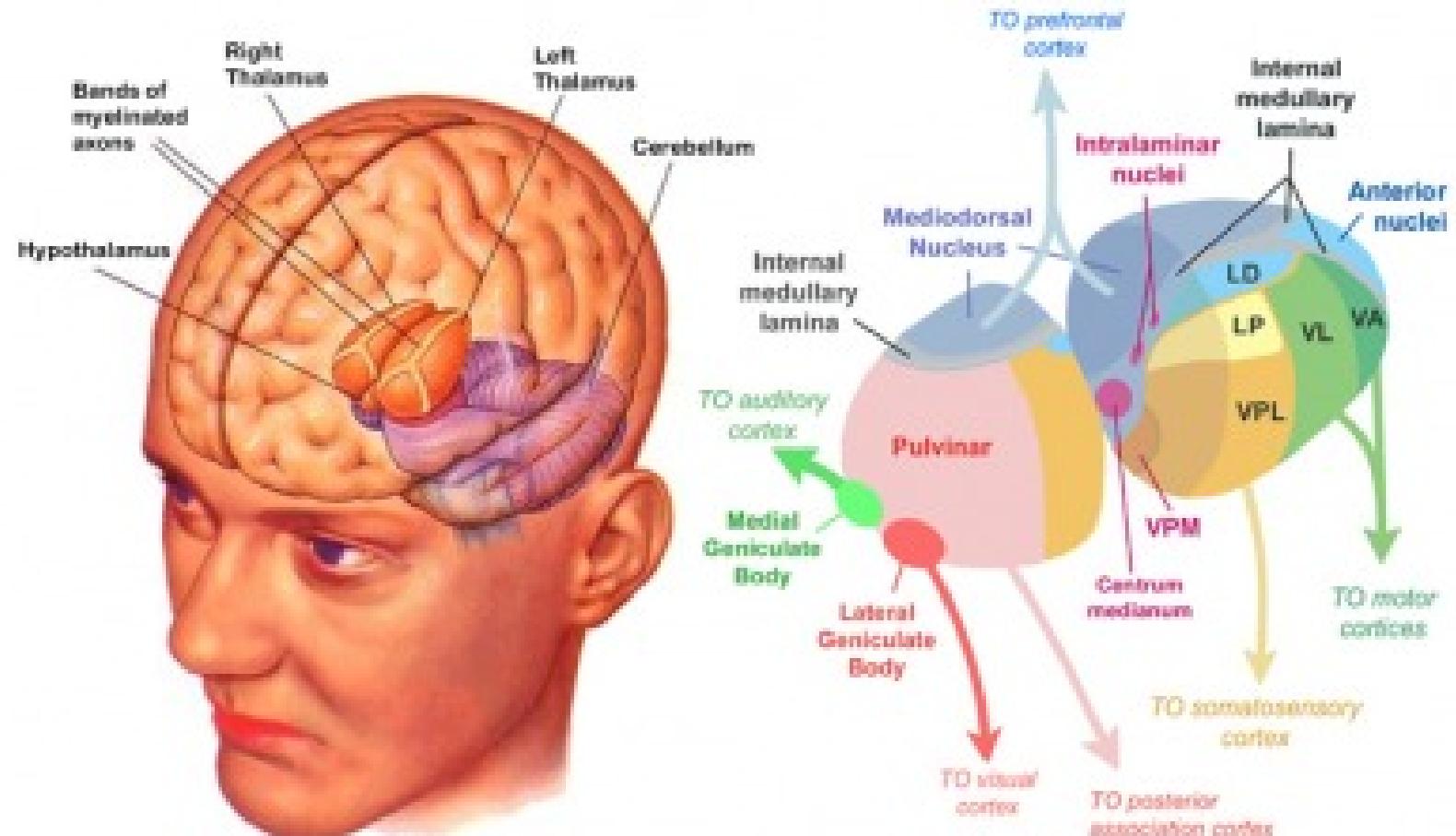


<https://en.wikipedia.org/wiki/Diencephalon>

# Diencephalon components

- Thalamus
- Hypothalamus

# Thalamus



<http://neurobiologychapter3.weebly.com/uploads/1/4/1/8/1418733/5118342.jpg?401x231>

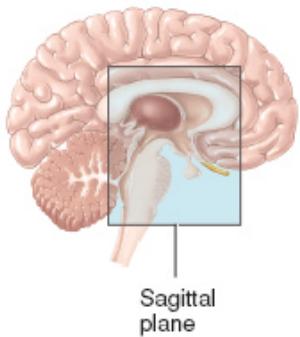
# Thalamus functions

- Input to cortex
- Functionally distinct *nuclei* (collection of neurons)
  - *Lateral geniculate nucleus (LGN)*, vision
  - *Medial geniculate nucleus (MGN)*, audition
  - - others...

# Hypothalamus

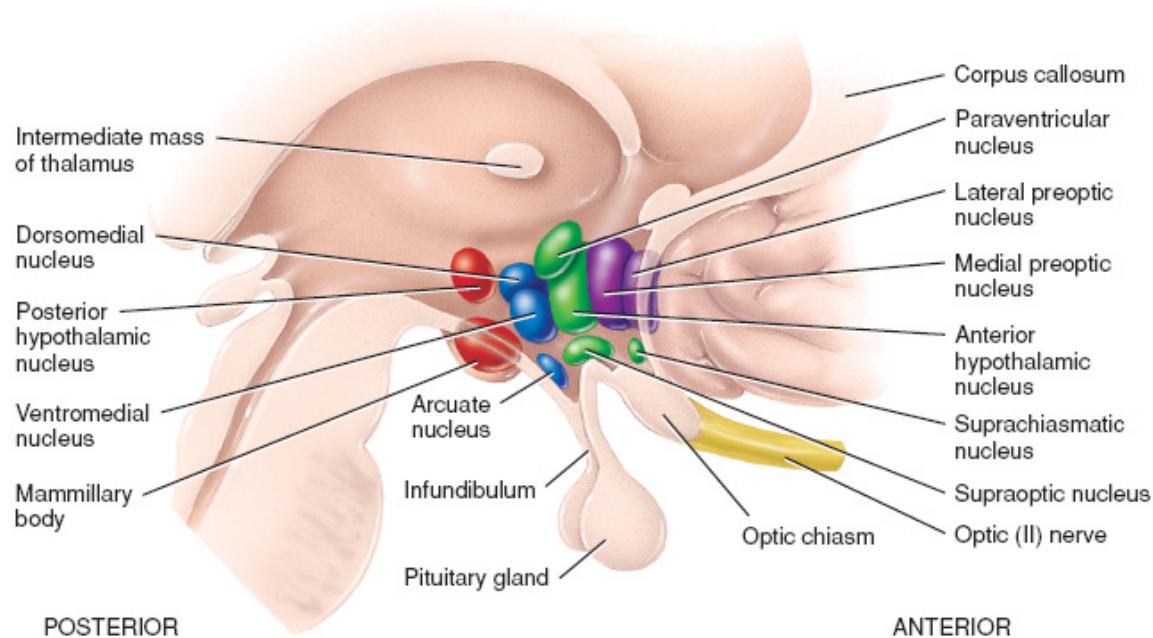
- Five Fs: fighting, fleeing/freezing, feeding, and reproduction
- Controls *autonomic nervous system (ANS)*
- Controls pituitary gland (“master” gland)
  - *Anterior pituitary* (indirect release of hormones)
  - *Posterior* (direct release of hormones)
    - *Oxytocin*
    - *Vasopressin*

# Hypothalamus



Key:

- Mammillary region
- Tuberal region
- Supraoptic region
- Preoptic region



Sagittal section of brain showing hypothalamic nuclei

[http://higheredbcs.wiley.com/legacy/college/tortora/0470565101/hearthis\\_ill/pap13e\\_ch14\\_illustr\\_audio\\_mp3\\_ar](http://higheredbcs.wiley.com/legacy/college/tortora/0470565101/hearthis_ill/pap13e_ch14_illustr_audio_mp3_ar)

# Next time...

- More neuroanatomy...

# References

- Abbott, N. J., Rönnbäck, L., & Hansson, E. (2006). Astrocyte-endothelial interactions at the blood-brain barrier. *Nature Reviews. Neuroscience*, 7(1), 41–53. <https://doi.org/10.1038/nrn1824>
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- Sejnowski, T. J., Churchland, P. S., & Movshon, J. A. (2014). Putting big data to good use in neuroscience. *Nature Neuroscience*, 17(11), 1440–1441. <https://doi.org/10.1038/nn.3839>