CNS, Neurons, & Methods

Neurolinguistics

Updated: Thu Sep 5 2024

CNS

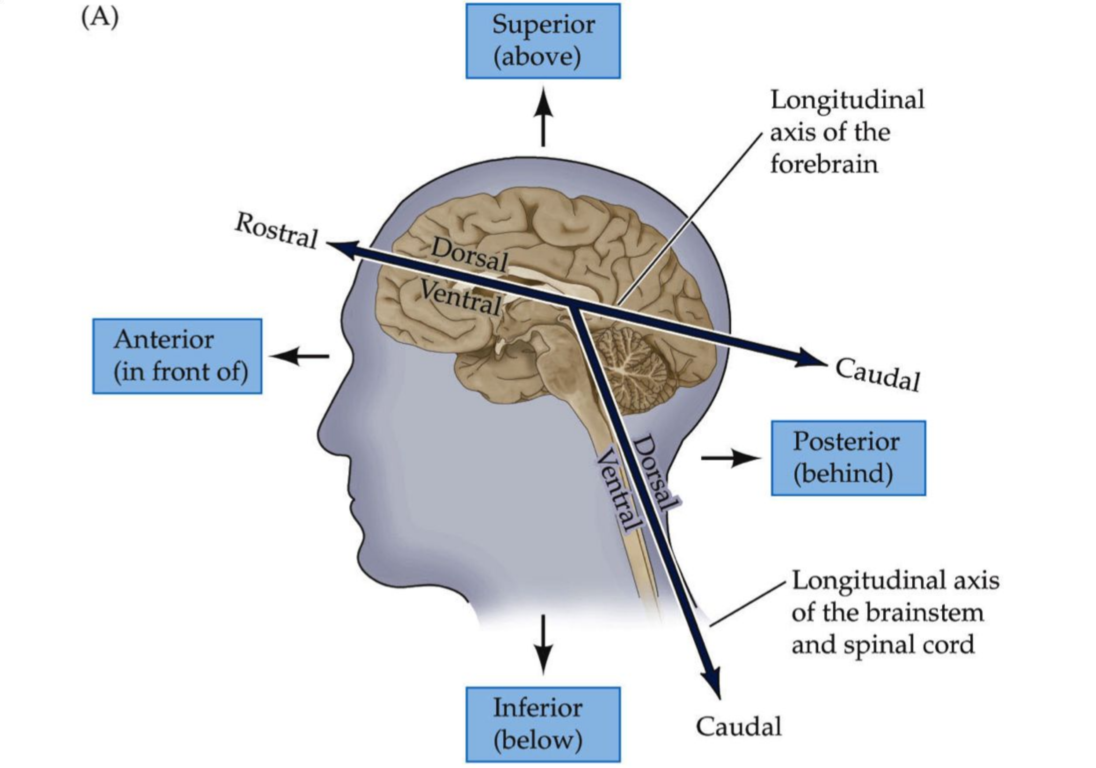
Central Nervous System

How do we refer to different structures?

- **Left** and **right** hemispheres
  - **Contralateral** or **ipsilateral** - opposite or same side
  - **Bilateral** or **unilateral** - both left and right or only one side
  - [3D Brain (www.brainfacts.org)]
- But this is not sufficient
  - So we use standard anatomical terms of location

Anatomical terms of location

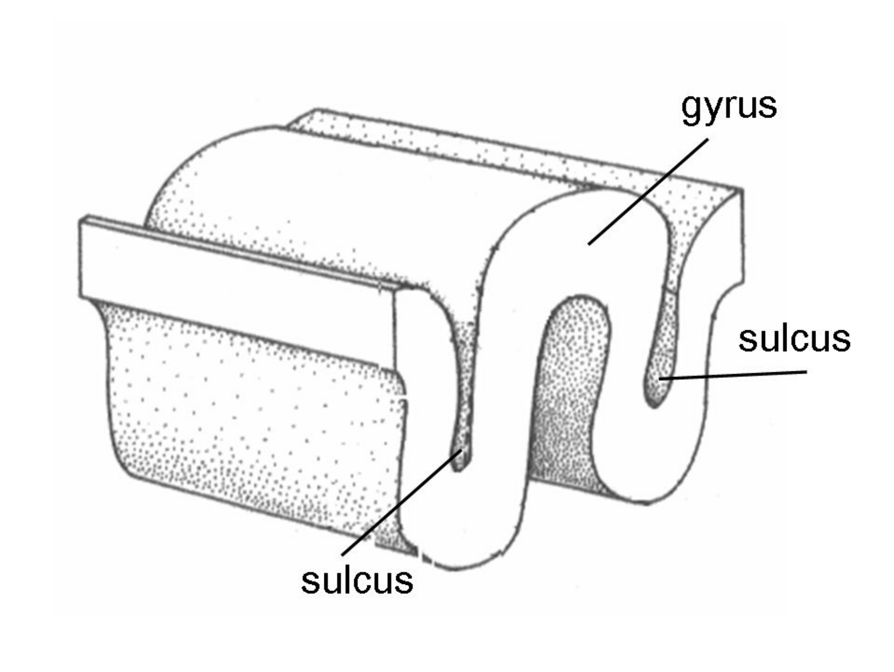
- **Anterior** and **posterior**
  - front and back
- **Superior** and **inferior**
  - above and below
- **Medial** and **lateral**
  - close to and away from the midline
- **Proximal** and **distal**
  - close to and far away from point
- **Rostral** and **caudal**
  - close to face (“beak”) and close to en
- **Dorsal** and **ventral**
  - back and belly



***NEUROSCIENCE, Fourth Edition*, Appendix, Figure A1 (Part 1)**

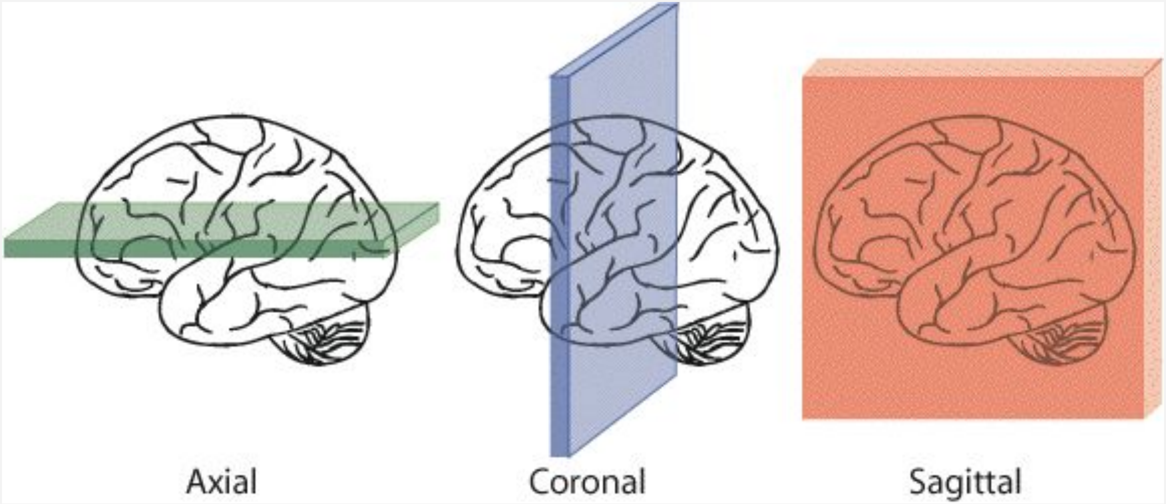
Grooves and ridges

- Sulci are the grooves
- Gyri are the ridges
- If a sulcus is really deep, we call it a fissure



Planes

- **Axial (aka Horizontal or transverse)** - Horizontal axis
- **Coronal -** Vertical plane passing through the ears
- **Sagittal** - Vertical plane passing between the nostrils



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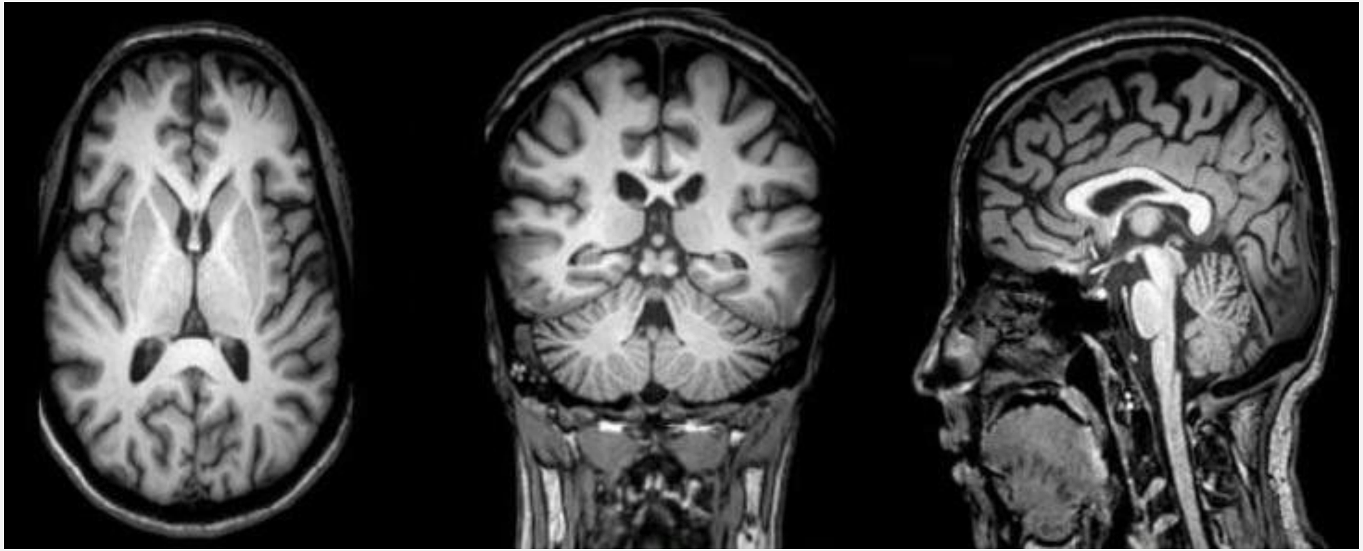
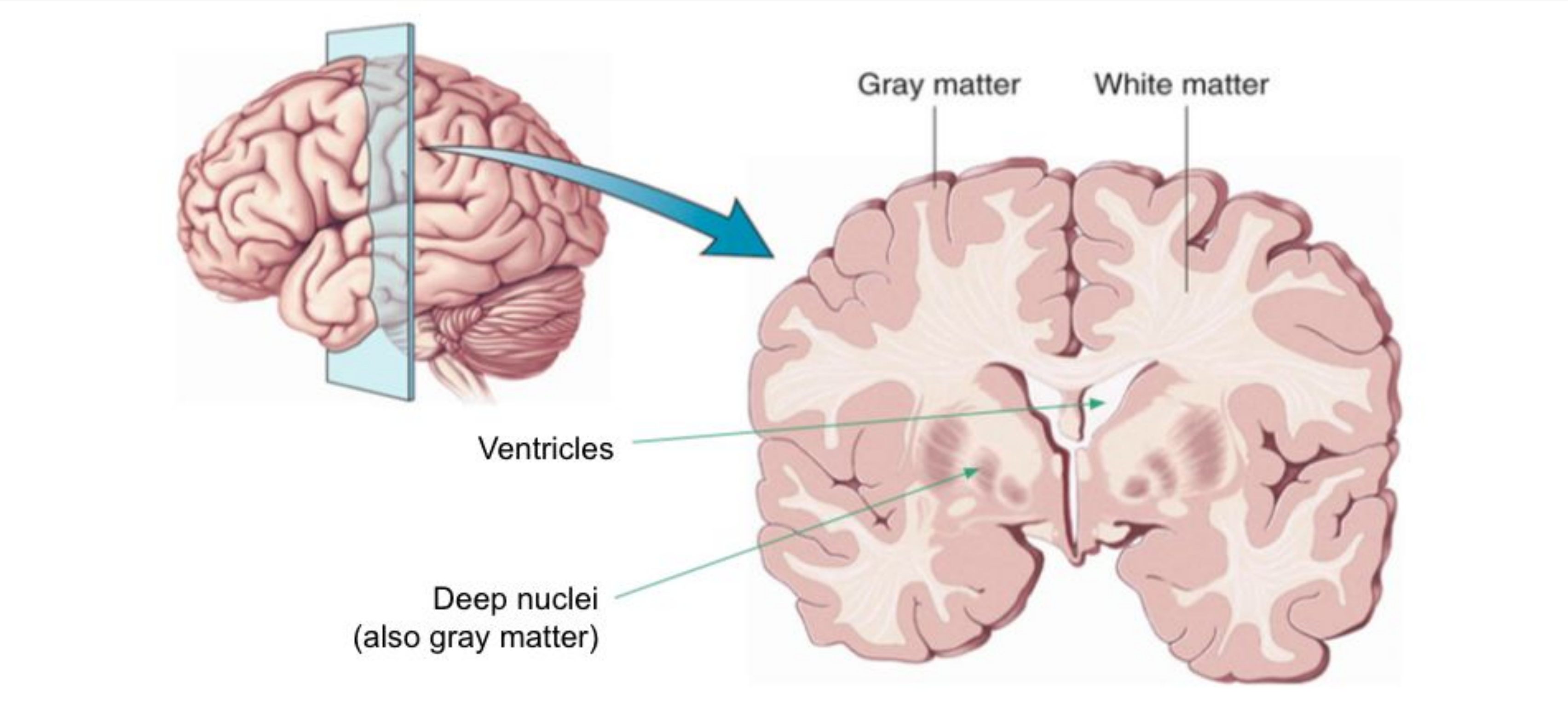


Anatomy Lab

Activity 1

Warning: (pictures of) real brains coming

There are only 4 things (arguably 3)



Intro to the CNS video - UBC Neuroanatomy

Video: Introduction to the Central Nervous System

- A great anatomy resource in general
- In-class activity #1
  - With your group, go through the neuroanatomy lab together
    - Online Neuroanatomy Lab: The Cortex
  - Use it to fill out your group's page on the collaborative whiteboard
    - Collaborative whiteboard

Slide 1 Left
indicate somehow

The Central Sulcus

The Lateral Fissure

Frontal Lobe

Occipital Lobe

Parietal Lobe

Temporal Lobe

Cerebellum

Slide 1 Right
indicate somehow

All of the structures from task 1, plus

The limbic lobe

The parieto-occipital sulcus

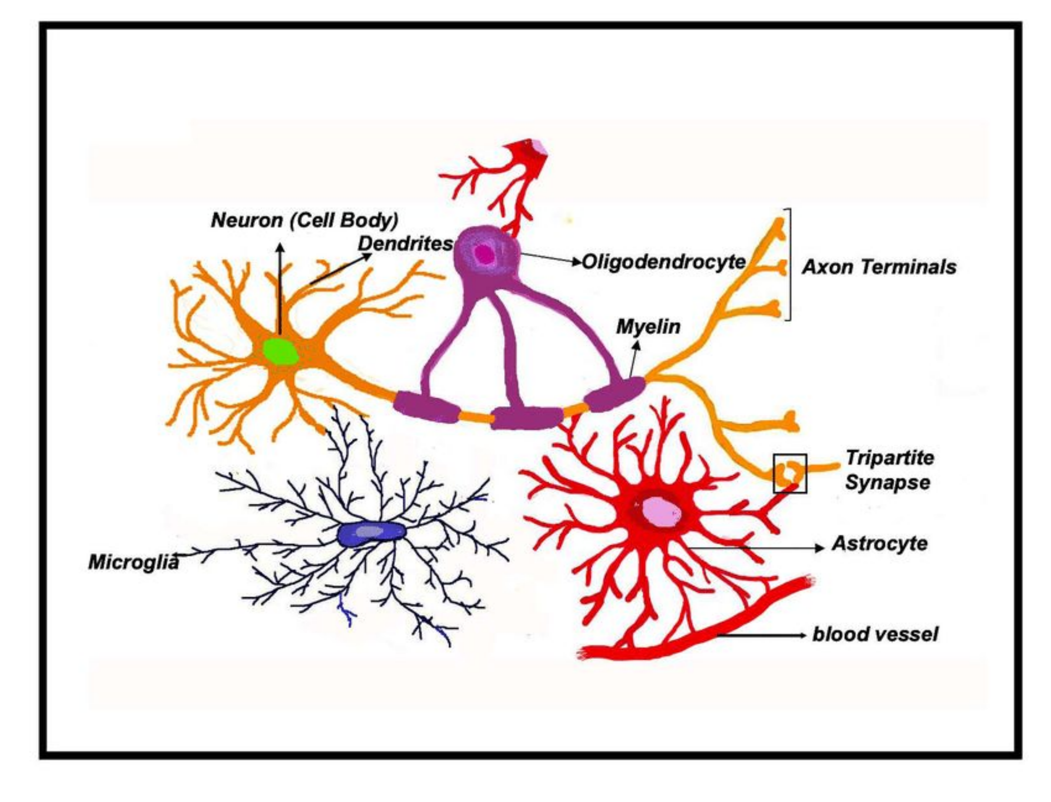
Slide 2 indicate somehow on left and right

The "four things" I mentioned in lecture (gray matter, white matter, ventricles, deep nuclei)

Which plane the figure is (axial, coronal, sagittal).

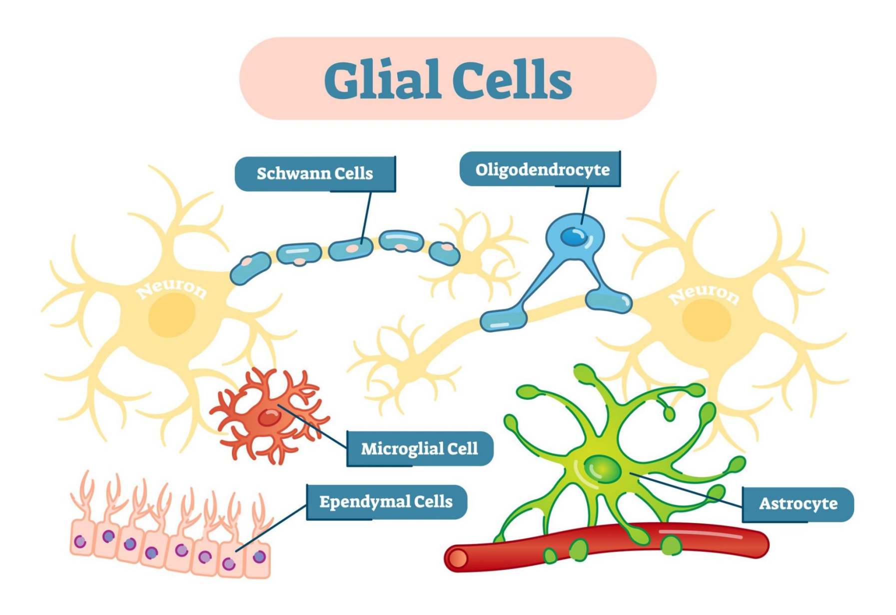
Neurons

Two kinds of cells: neurons and glia



Glia

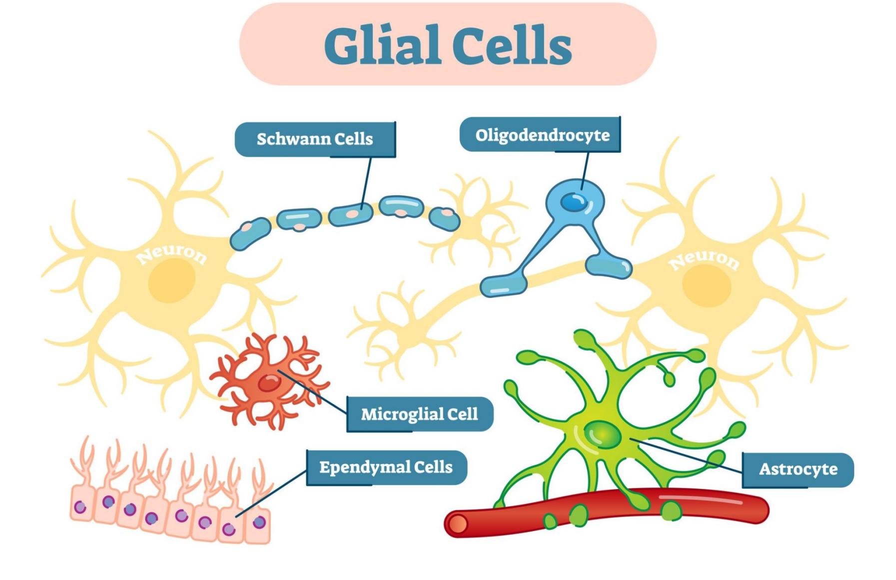
- Glia means “glue”
- Different from neurons:
  - Looks- no axons or dendrites
  - Function - aren’t electrically excitable like neurons
- Two major kinds:
  - **Microglia**: immune cells
  - **Macroglia:** 3 major kinds; ~80% of all brain cells



Macroglia

When a brain area gets damaged, astrocytes come to help!

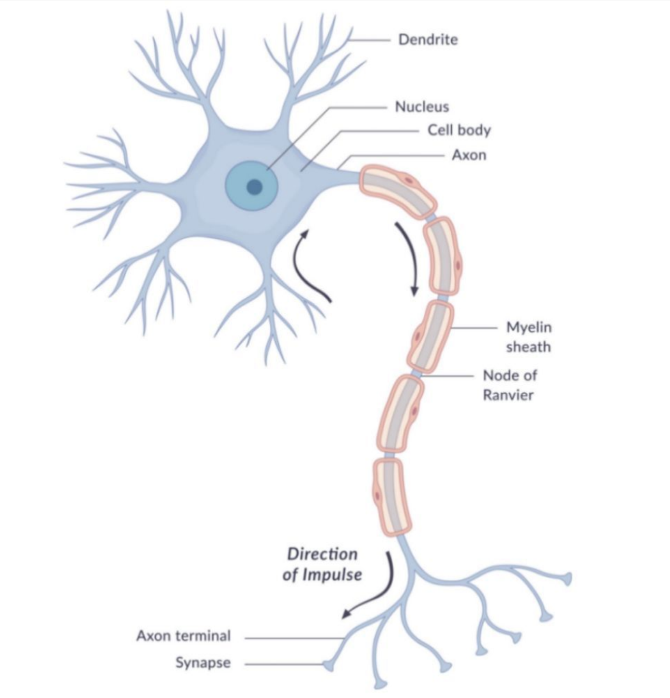
- **Oligodendrocytes** - form the myelin sheath in CNS
- **Schwann cells** - Form myelin sheath in PNS
- **Astrocytes** - housekeepers; support, repair, regulate, maintain BBB



More on GLIA

Neurons

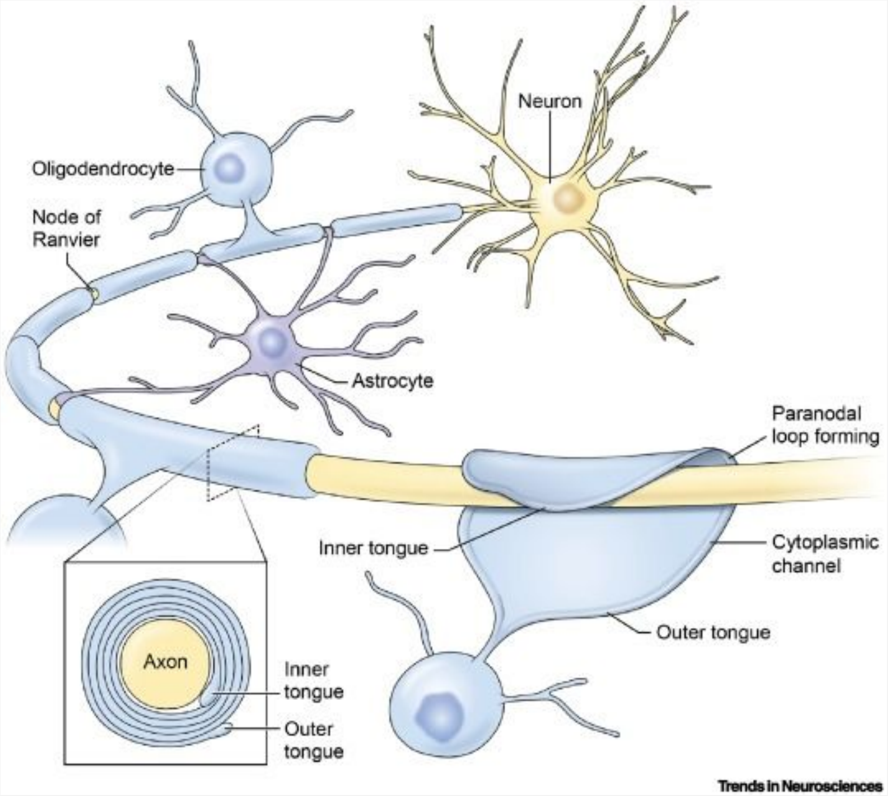
- **Soma** (cell body) - metabolic center containing nucleus and genetic material
- **Dendrites** - several short tree-like branches that receive incoming signals from other neurons
- **Axon** - one long tube-like branch that carries outgoing signals to other neurons
- **Presynaptic terminals** - enlarged regions at the ends of an axon the transmit signals



Link to learn more about neurons

More on Myelin

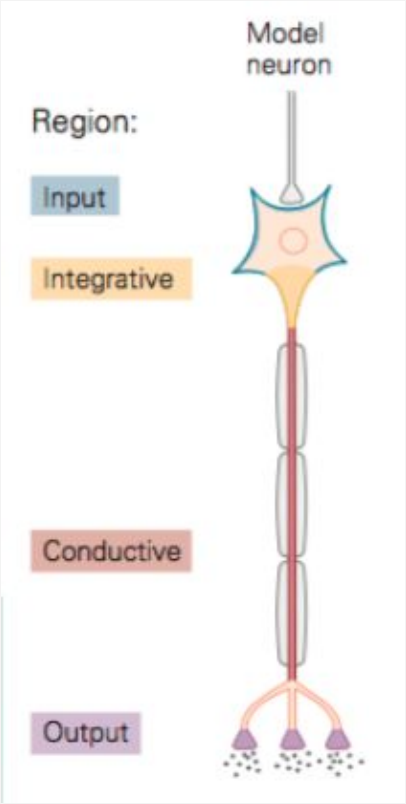
- Myelin is a fatty membrane
- Fun fact: because it is composed of fats, it repels water!



Signaling

Signaling in neurons is highly stereotyped; all neurons generate the same four signals in sequence:

1) **Receptive (input)** - graded local signals (by opening ion channels)
2) **Integrative (trigger)** - determines whether an action potential is generated, if the threshold is reached (-55mV)
3) **Conductive** - propagates all or nothing action potential down the axon (see 5)
4) **Output** - action potential causes the presynaptic terminal to release neurotransmitter



Firing neurons require energy; to get it, they recruit oxygen that is delivered to the cells via our blood

The trigger is also called when the neuron fires (or when the neuron sends the signal). It actually sends a detectable electrical signal

Action potentials

[For those interested](#)

Methods

Language Areas

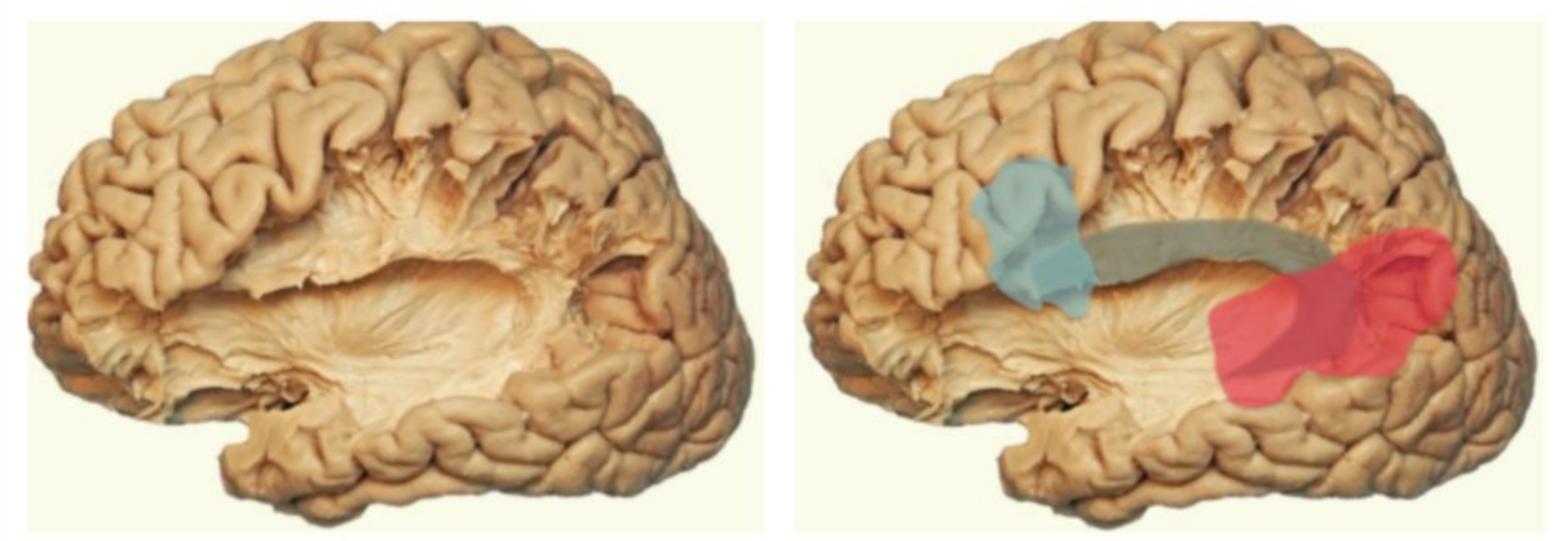
There are two major language areas: **Broca's area** and **Wernicke's area**

- **Broca's area**
  - Located in **frontal lobe**, anterior to premotor association, in **left* inferior frontal gyrus (LIFG)**
  - Once thought to be responsible for simply language **production**
- **Wernicke's area**
  - Located in left* **parietal** and **temporal lobes** around **lateral fissure** and **primary auditory area**
  - Once thought to be responsible for simply language **comprehension**

* In most right-handed people; left-handed people tend to have language areas represented bilaterally.

Language Areas

- Broca’s and Wernicke’s areas are connected by the arcuate fasciculus
    - The arcuate fasciculus is a white matter tract (also called a fiber tract, projections, etc.)



Lesion method

- When brain areas are **damaged by injury or disease** (lesion), we can **observe** how behavior changes and **infer** what those brain areas were responsible for.
- An “oldie but a goodie”
  - **1836**: Marc Dax gives a talk observing lesions in left hemisphere lead to language impairments
  - **1861:** Paul Broca’s patient, who can only say “tan”, is found to have an LIFG lesion.
  - **1874:** Carl Wernicke finds comprehension deficits in patients with left temporal lobe damage.
- But, it has some problems
  - We can’t go around lesioning people’s brains
  - We can’t choose the location (“accidental experiments”)
  - It’s hard to get the timing right
  - We used to have to wait for autopsy, but now we can use imaging techniques

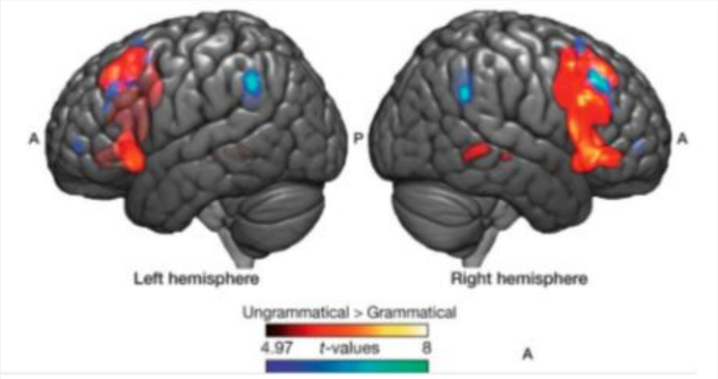
Linguistics & Psycholinguistic Theory

- Created more **fine-grained tests** that resulted in a revision of the classical view of Broca's and Wernicke's areas.
    - Broca's patients found to have trouble with hard sentences like *the boy was pushed by the girl*, suggesting that **Broca's processes grammar during both comprehension and production**
    - Wernicke's patients found to have trouble selecting words during production (in addition to comprehension deficits), suggesting that **Wernicke's supports lexical-semantic processes**.
- First to suggest that subcomponents of language might have different localizations in the brain.

e.g. Zurif, Caramazza, and Myerson, 1972; Caramazza and Zurif, 1976

Functional Magnetic Resonance Imaging (fMRI)

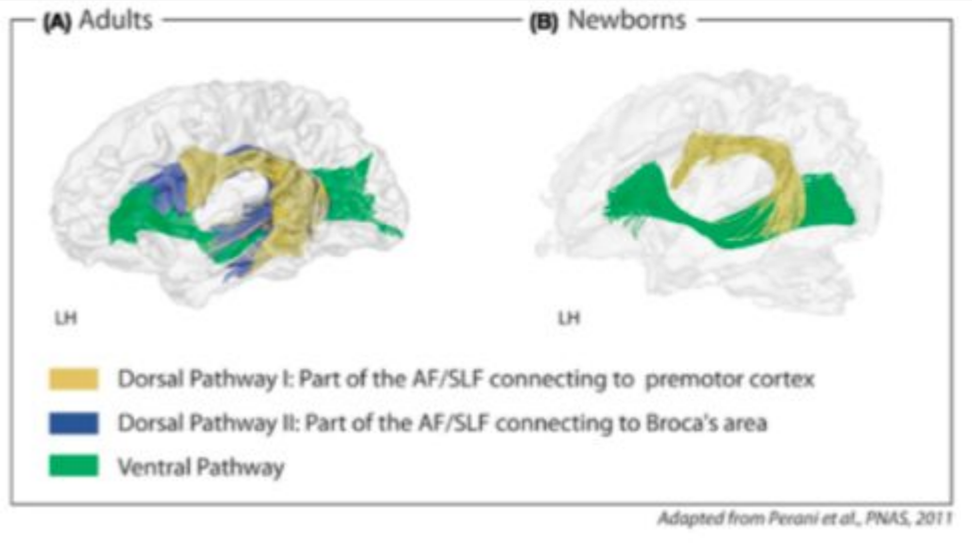
- Measures changes in blood flow in the brain
  - Neurons need more oxygen when they fire
  - Uses a big magnet to measure the ratio of oxygenated to deoxygenated blood during a particular task; determines which brain areas are more active during the task
- Limitations
  - It’s kind of invasive* (and sometimes dangerous)
  - It’s really expensive
  - You can’t move
  - It’s indirect
  - It’s too slow to detect real-time changes



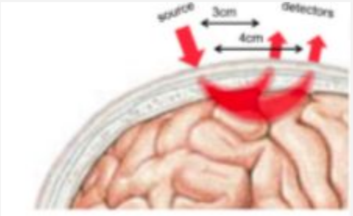
* Though not as invasive as PET (radioactive tracer)

Diffusion Tensor Imaging (DTI)

- Another type of MR imaging used to **visualize white matter tracts** in the brain by measuring the **diffusion of water molecules**
  - Water diffusion through brain tissues is not free, so diffusion can tell us something about the structures that are in the way (and the orientation they are in)
- Limitations
  - It's not very precise
  - It's structural, not functional
  - You can't move
  - It's really expensive



Near-infrared spectroscopy (NIRS)



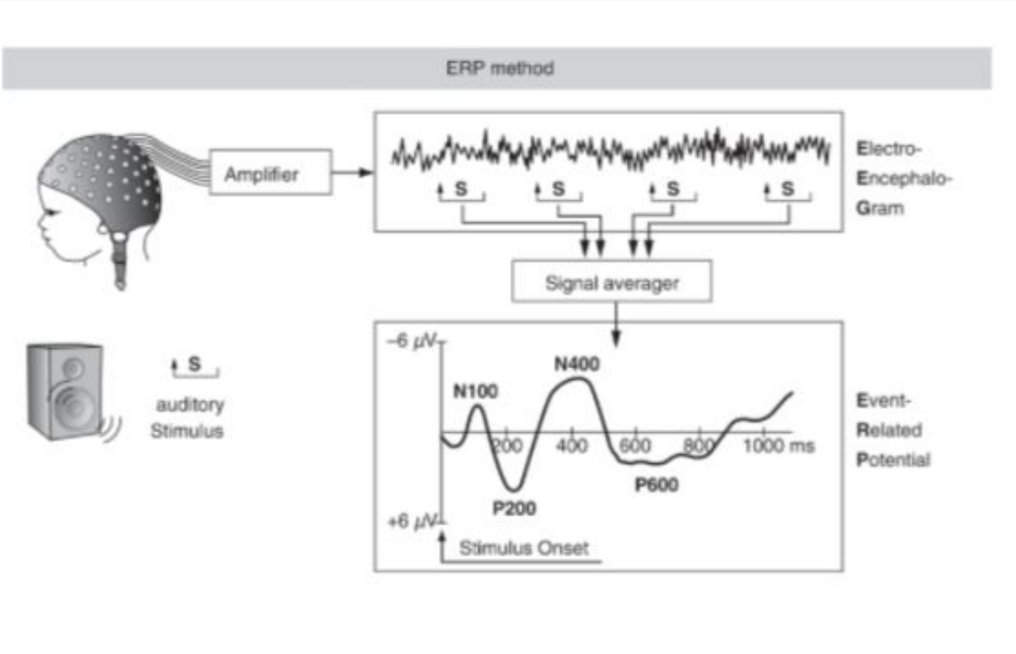
- Also **measures changes in blood flow** (BOLD signal) during a task, but **uses a light** instead of a big magnet
- Nice because
  - It's less expensive
  - It doesn't make any noise
  - You can move around
  - You can use it with babies
- Limitations
  - Spatial resolution is poorer than fMRI
  - Many sources of extra noise (skull, hair, etc)

Event-related potentials (ERPs)

- Measures **electrical potentials of neurons** directly in response to a stimulus
  - Uses a net or cap of sensors placed on the scalp
  - Temporal resolution is very good
- Limitations
  - It’s hard to tell exactly where the signal is coming from
  - Many neurons
  - You can’t talk (reading or listening studies only)

ERP components

- Components identified by
  - Peak latency
  - Peak amplitude
  - Scalp distribution (which electrodes)
  - Polarity (positive or negative)
- Components in speech and language
  - N100
  - ELAN
  - LAN
  - N400
  - P600

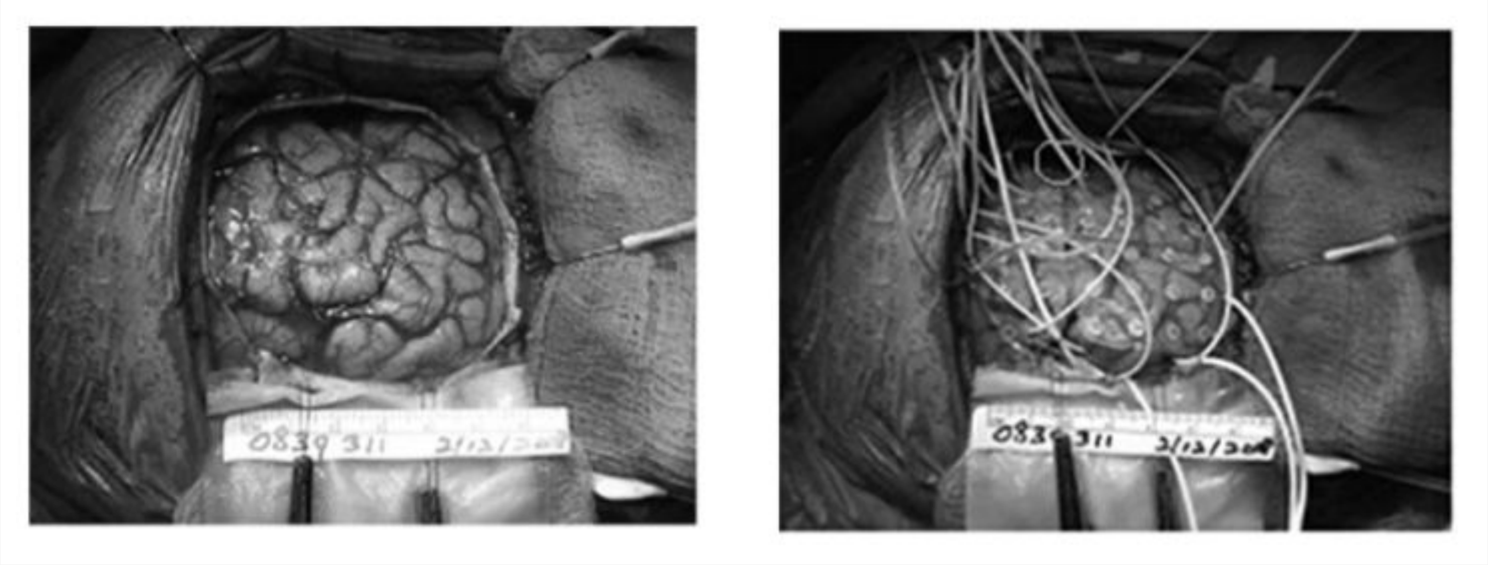


Magnetoencephalography (MEG)

- Measures the **magnetic fields** produced by **electrical current** in neurons
  - Like scalp ERP, except we measure magnetic fields instead of electric
- Limitations
  - Magnetic fields are tiny!
  - It's big and expensive

Direct recording

- **Directly measure from electrodes** in or on the brain
  - Temporal and spatial resolution are both great!
  - But, you can only do it in patients who are already having this done for medical reasons



More resources (optional)

- For more details on some of these methods, here are some great videos from a recent course at MIT:
  - fMRI
  - ERPs
  - MEG
  - Direct stimulation
  - DTI (not from the MIT course, but helpful)
  - TMS

And a wonderful website: nancysbraintalks for learning more, from Neuroscience professor Nancy Kanwisher at MIT

Tips

- Set a timer for 30-60 minutes for each paper (2-3 hours prep per week)
- Spend longer only for papers you are discussion leader for (about 3 per semester)
- Final paper – topic selection coming soon
  - Select 3 papers you might like to read and use for your paper