Neuroplasticity Series: Part 1

Hosted by **BRAIN OSU** (Buckeyes Raising Awareness in Neuroscience)

Agenda

- Introductions
- How neuroplasticity works
- Neuroplasticity in learning
- Why neuroplasticity is important

What is B.R.A.I.N?

- A 501(c) nonprofit undergraduate Ohio State organization focused on raising awareness in all things neuroscience!
- We hope to provide support to those affected by neurological injuries and illnesses while increasing awareness and education within the Ohio State and Central Ohio community.
- We helped create and continue to fund “NeuroNights” (go.osu.edu/neuronights)
- Brain Injury Awareness 5K (go.osu.edu/BIA5K)
    - Since 2018, we have raised $4,097 in donations and over $10,000 in sign-ups to help brain injury survivors at the Ohio State Wexner Medical Center!
    - Join us! Prices increase after March 8th.

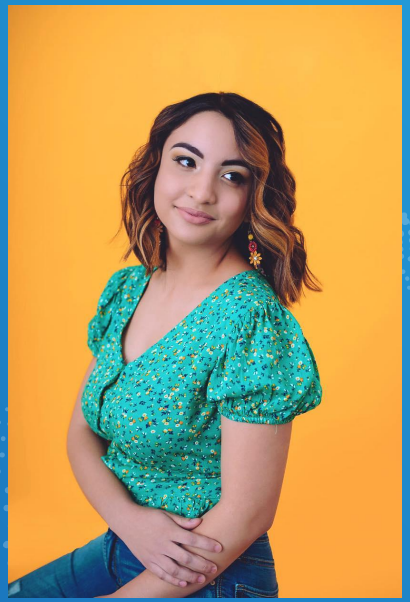
Sanjana Ranade

Major: Neuroscience

Minor: Spanish

Hometown: Gahanna, Ohio

Chelsea Glaspell



Major: Neuroscience

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Minors: Child Abuse & Neglect Studies + Diversity, Equity & Inclusion Studies

Hometown: Cleveland, Ohio

Kavya Pamulapati

Major: Neuroscience

Minor: Spanish

Hometown: Upper Arlington, Ohio

“

What are our brains made of?

Relative Size & Complexity

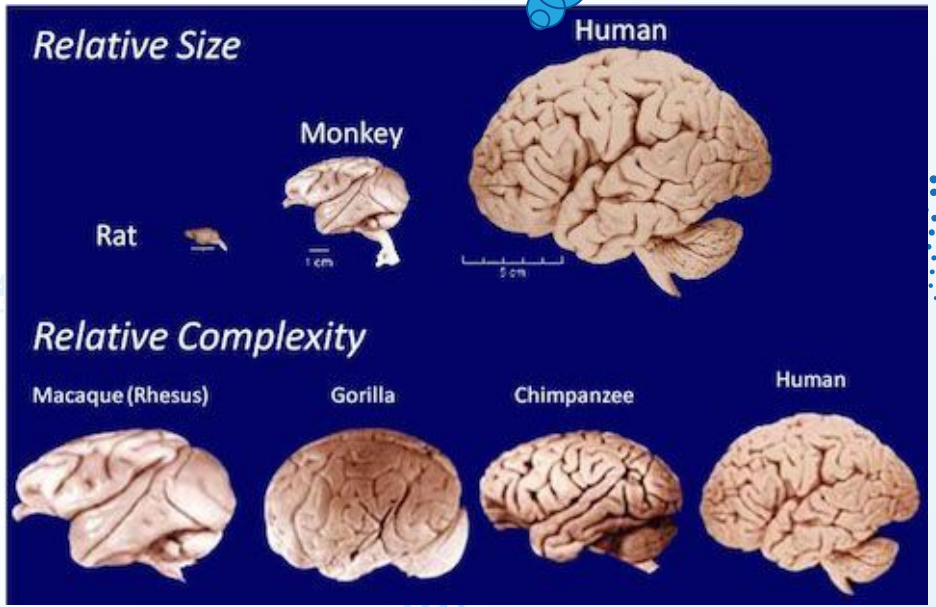
Gyri: hills

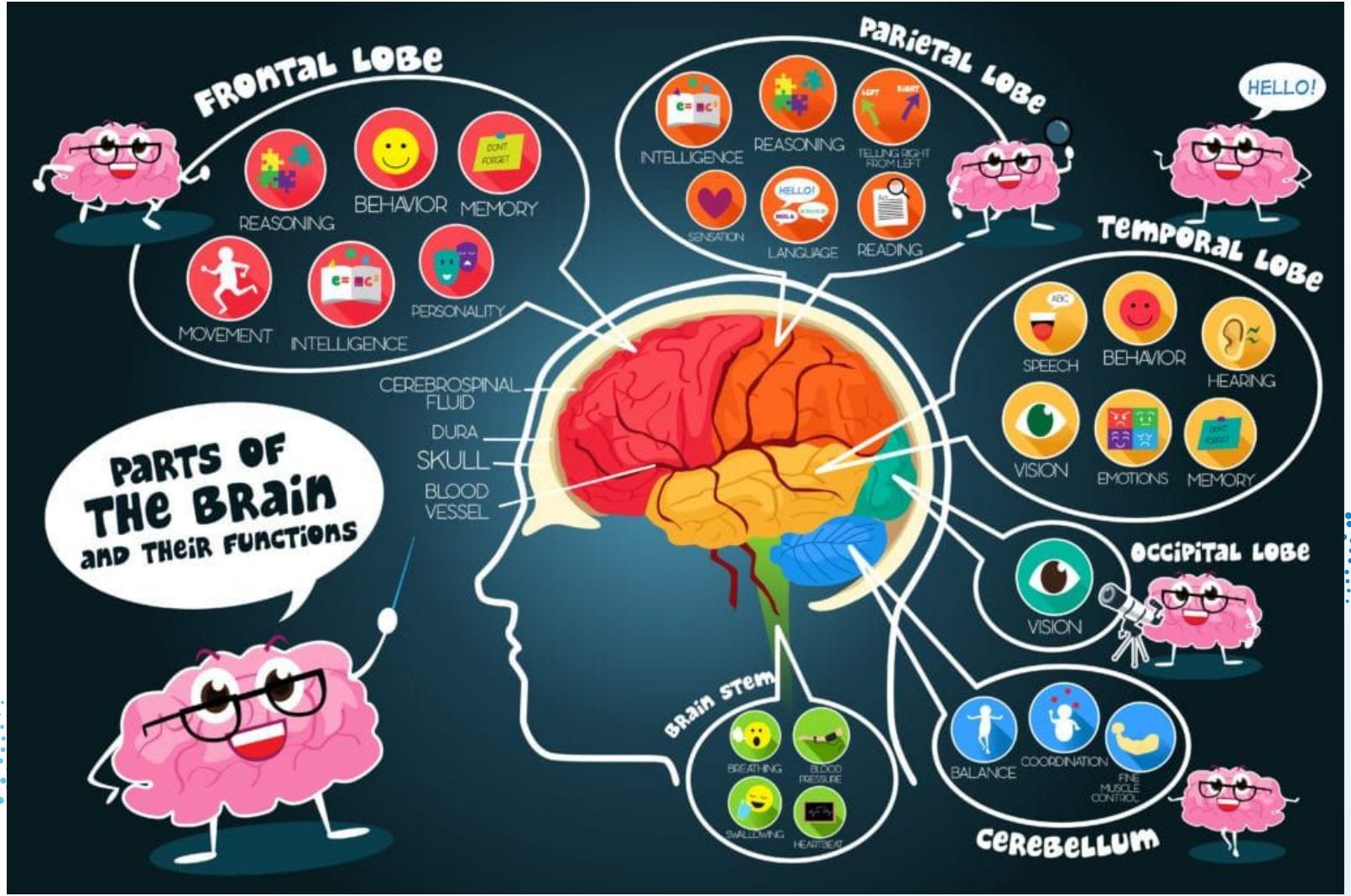
Sulci: valleys

Fissures: large valleys

Two Trends as Nervous System Evolves:

- Relative size increases (rat → human)
- Relative complexity increases (rhesus monkey → human)
  - More folds = more surface area for neurons



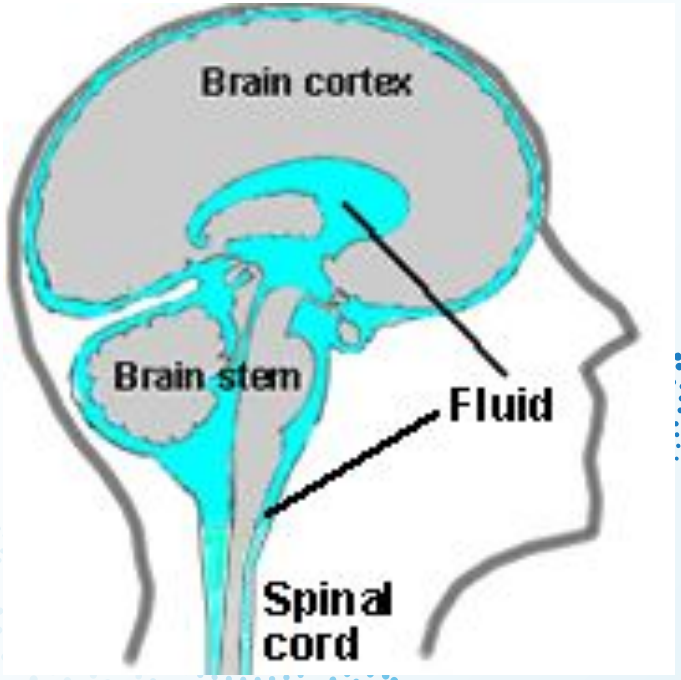

Parts of the Brain and their functions
Frontal Lobe
REASONING
BEHAVIOR
MEMORY
MOVEMENT
INTELLIGENCE
PERSONALITY
Parietal Lobe
INTELLIGENCE
REASONING
TELLING RIGHT FROM LEFT
SENSATION
LANGUAGE
READING
HELLO!
Temporal Lobe
SPEECH
BEHAVIOR
HEARING
VISION
EMOTIONS
MEMORY
Occipital Lobe
VISION
Cerebellum
BALANCE
COORDINATION
FINE MUSCLE CONTROL
Brain Stem
BREATHING
BLOOD PRESSURE
SWALLOWING
HEARTBEAT
CEREBROSPINAL FLUID
DURA
SKULL
BLOOD VESSEL

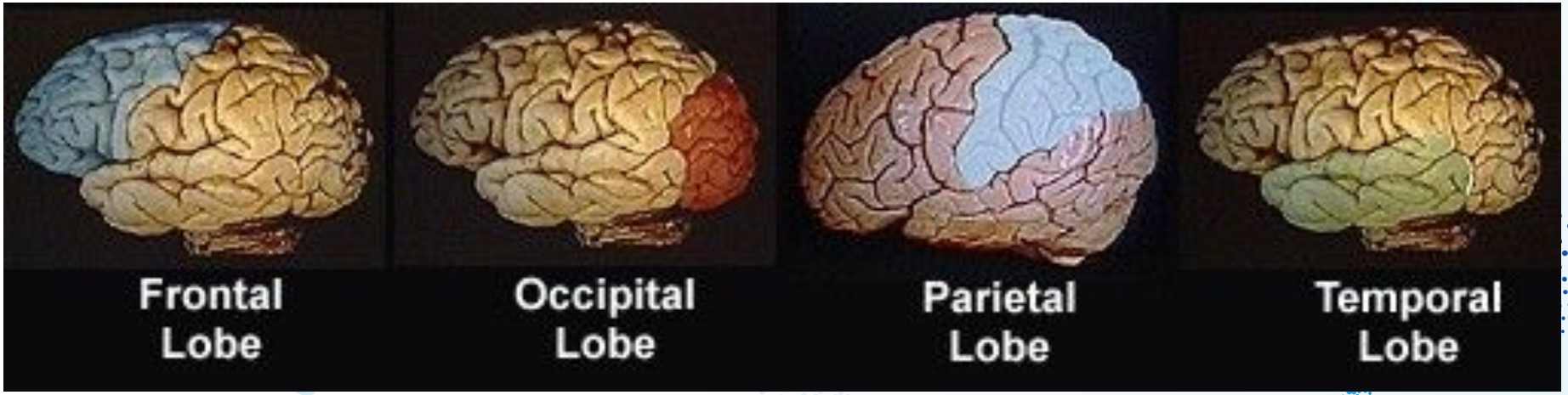
Cerebrospinal Fluid

- Clear, colorless fluid found in ventricles of brain
- Produced in the choroid plexus

Functions:

- Cushion
- Mechanical protection
- Chemical stability
- Clear waste
- Maintain pressure

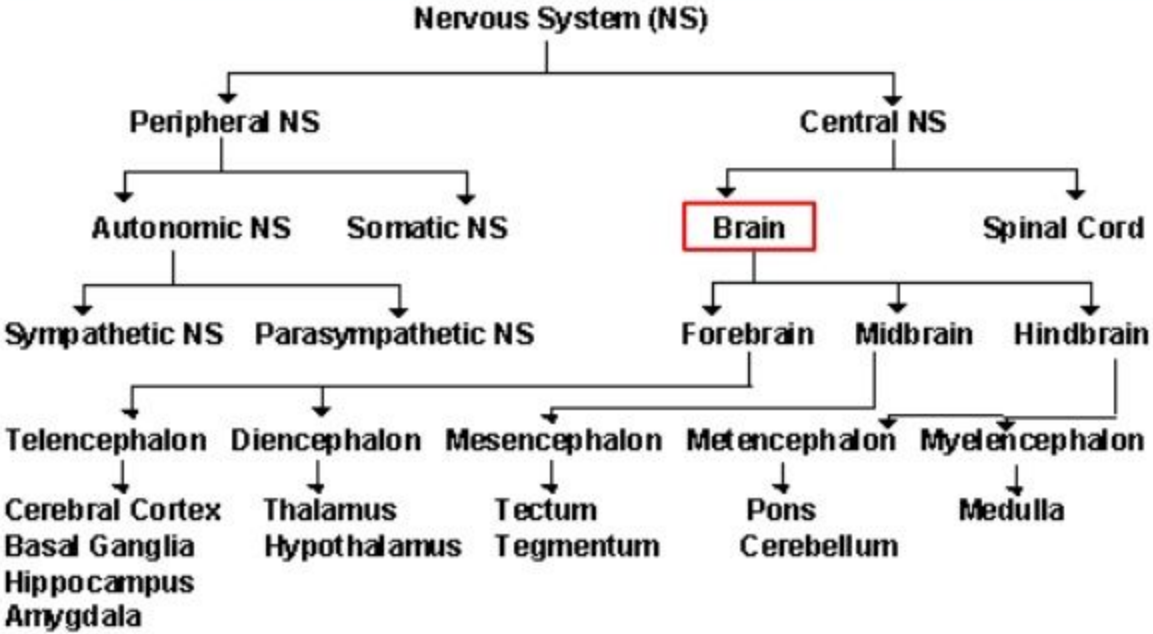



Frontal Lobe
Occipital Lobe
Parietal Lobe
Temporal Lobe

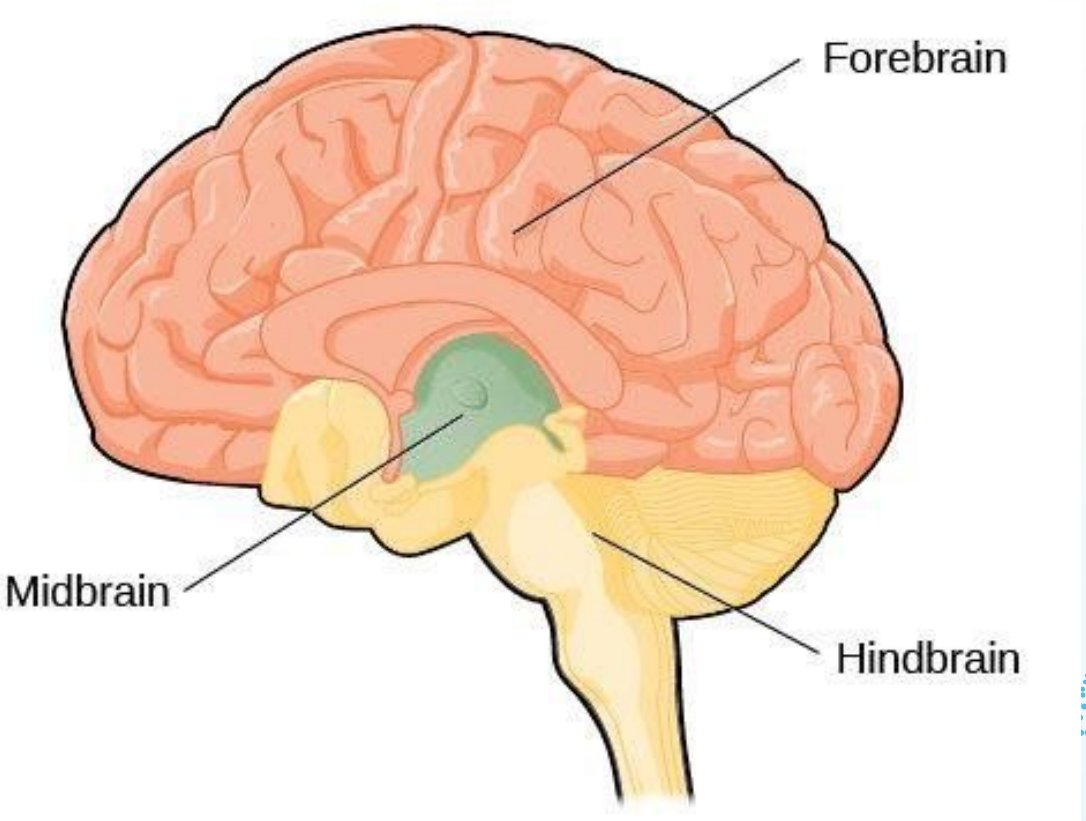
Frontal Lobe

- Development unfinished until early 20's
  - Why kids/teens show limited impulse control
- Phineas Gage case study

Divisions of the Nervous System



http://faculty.washington.edu/chudler/nsdivide.html


Forebrain
Midbrain
Hindbrain

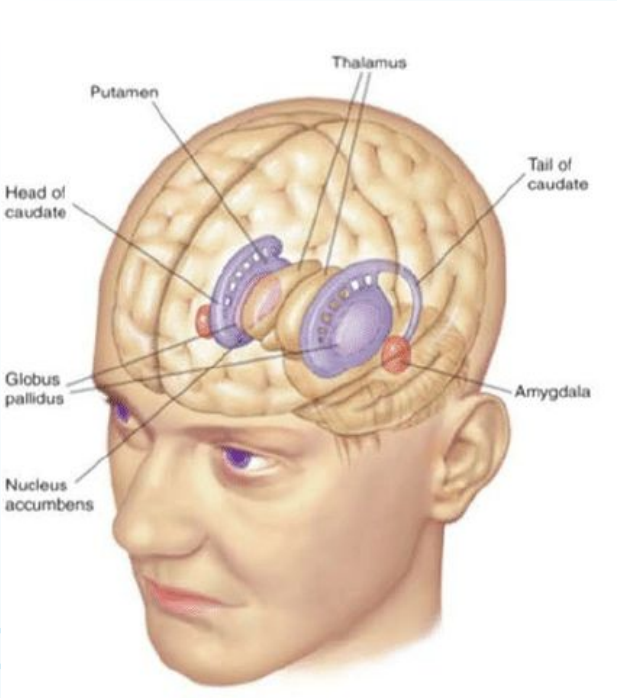
Forebrain: Cerebral Cortex & Basal Ganglia

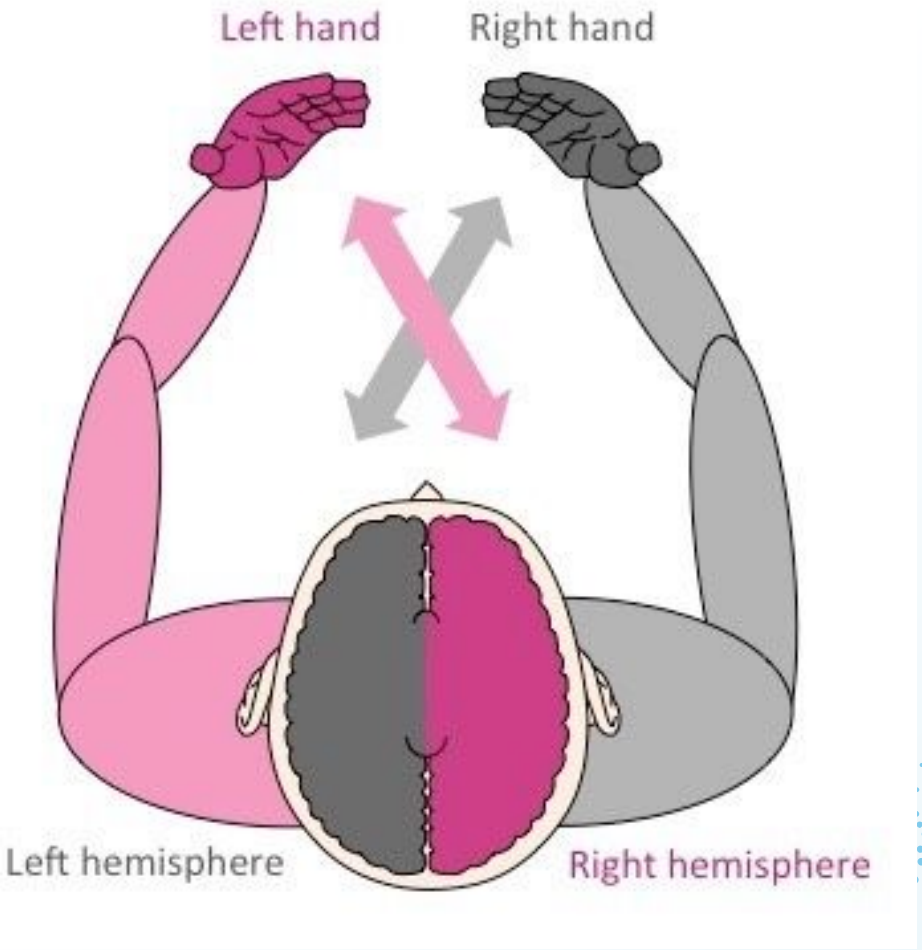
Cerebral Cortex

- Lots of sulci & gyri
- Organized into layers / columns
- Contralateral connections (eg. control of limbs is controlled by opposite hemispheres)

Basal Ganglia

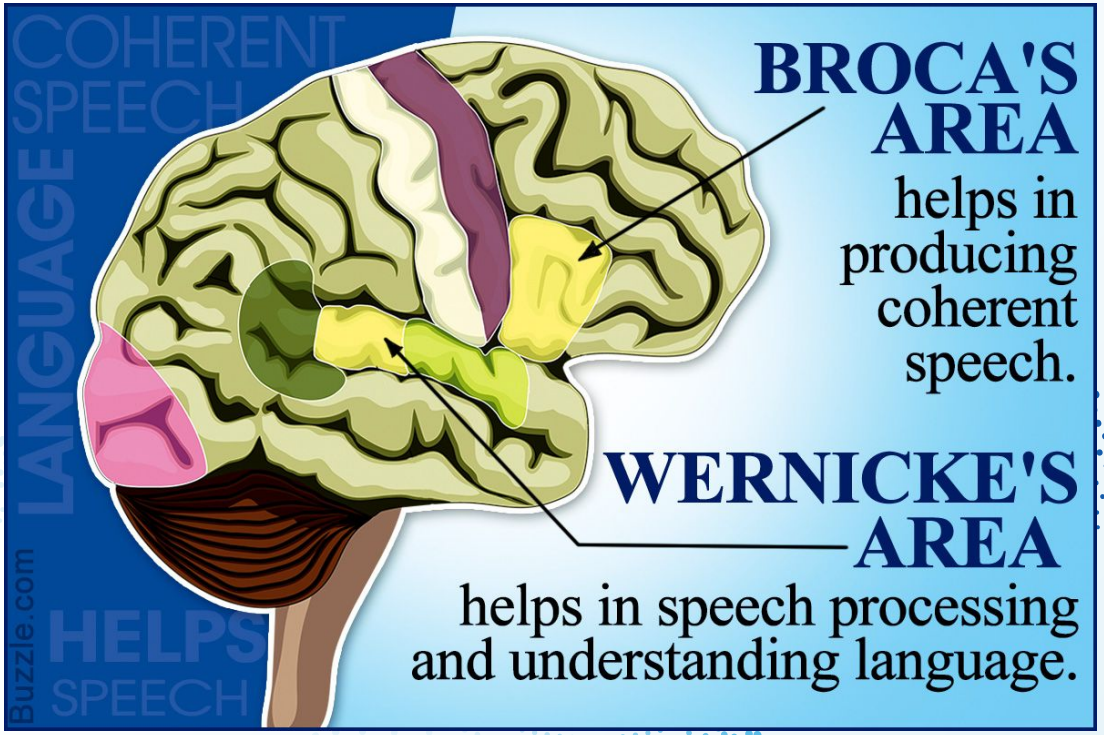
- Motor memory
- Planning of movement
- Pleasure, fear, aggression, addiction

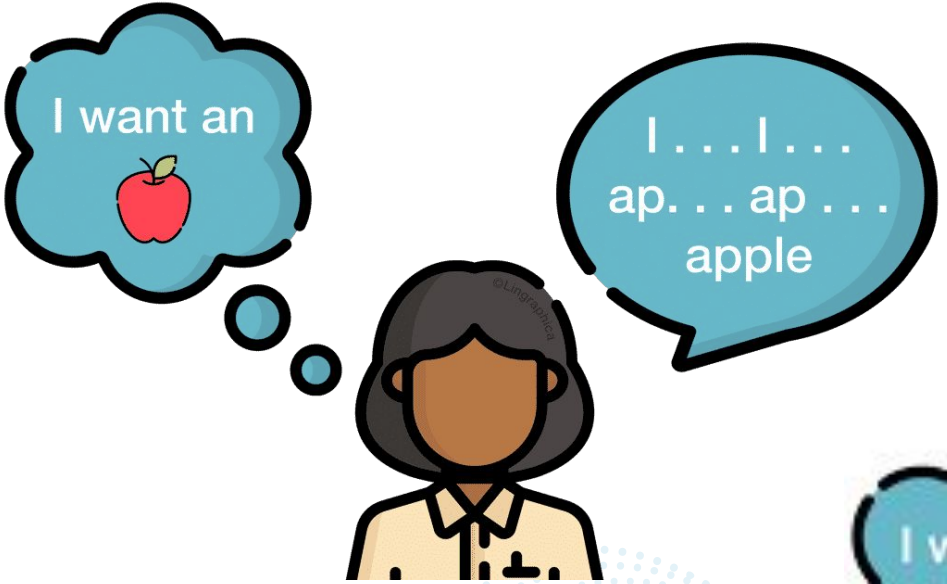



Left hand
Right hand
Left hemisphere
Right hemisphere

Aphasia

Loss of ability to understand or express speech





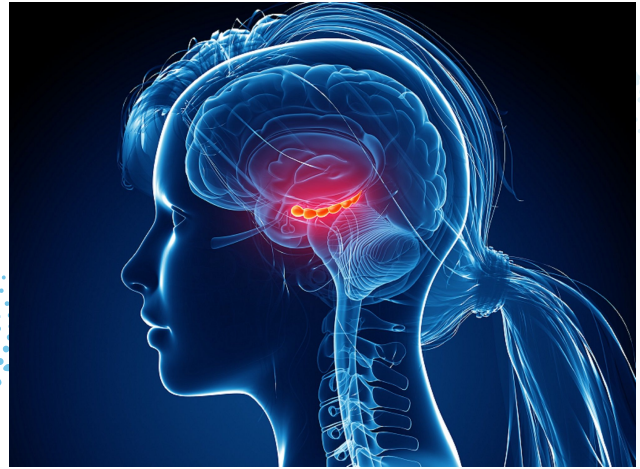
Broca's Aphasia

Wernicke's Aphasia

Forebrain: Hippocampus & Amygdala

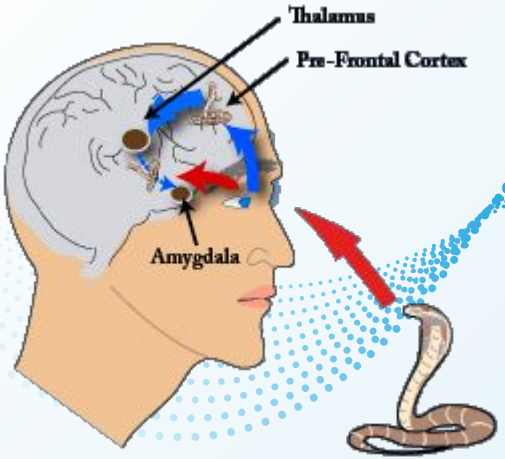
Hippocampus

- Memory
- Spatial navigation

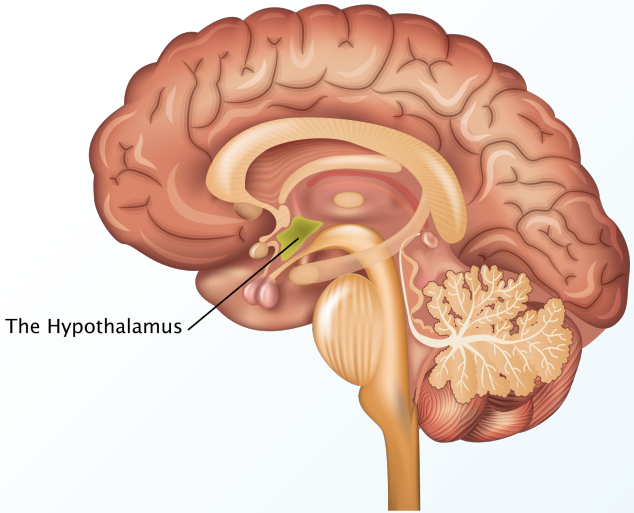


Amygdala

- Aggression, fear
- Fight or flight

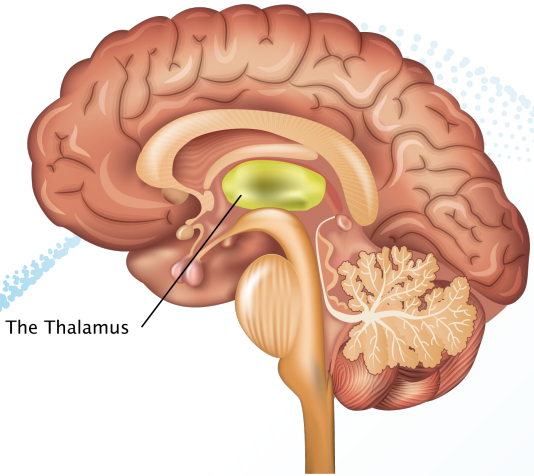


Forebrain: Thalamus & Hypothalamus



Thalamus

- Sensory relay (touch, vision, smell)



Hypothalamus

- Homeostasis (body temp., thirst, hunger)
- Controls endocrine system (hormones)
- Role in fight or flight

Hindbrain: Pons, Cerebellum, & Medulla

Pons

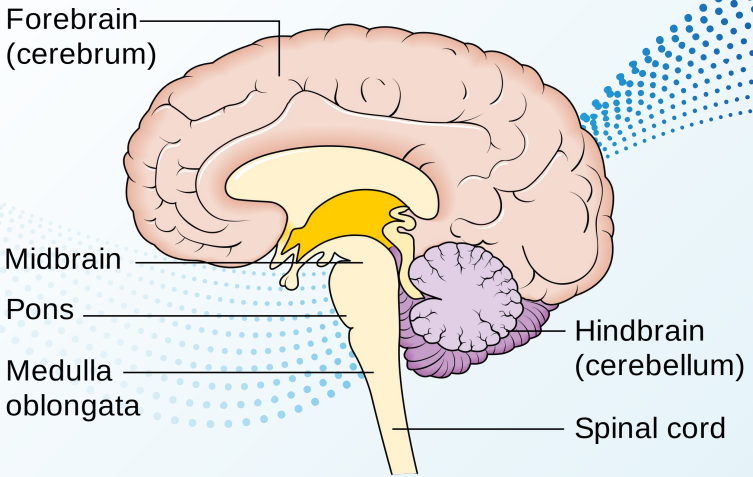
- Receives info from inner ear
- States of arousal
- Serotonin neuro-transmitter system

Cerebellum

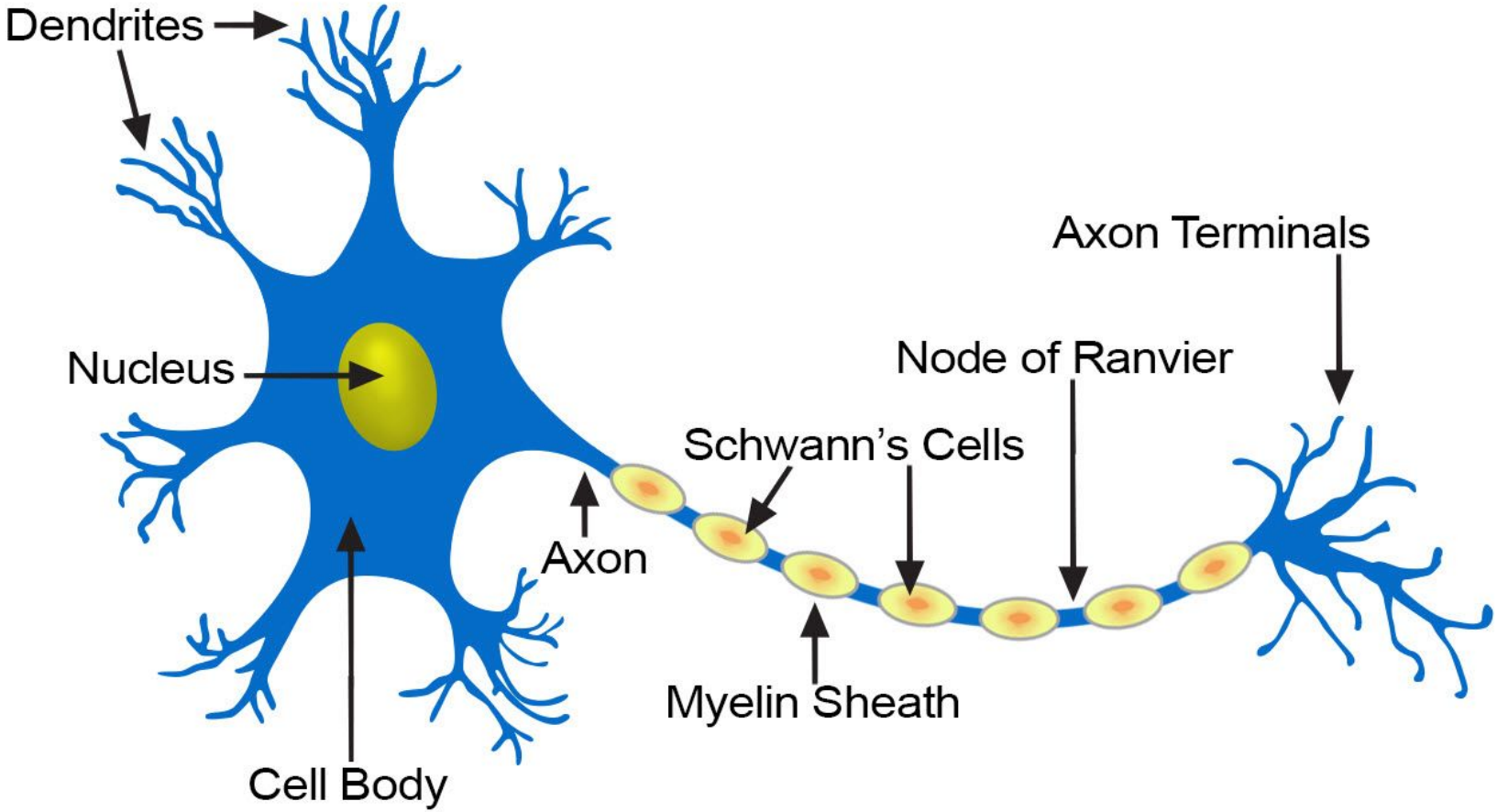
- Motor coordination
- Sensori-motor integration
- Motor learning

Medulla

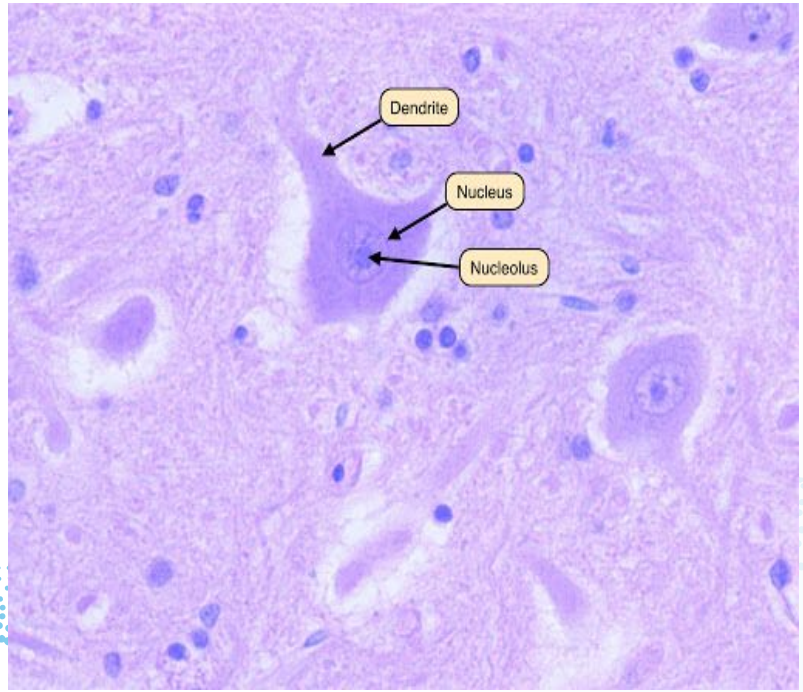
- Heartbeat
- Breathing
- Alertness



Structure of a Typical Neuron



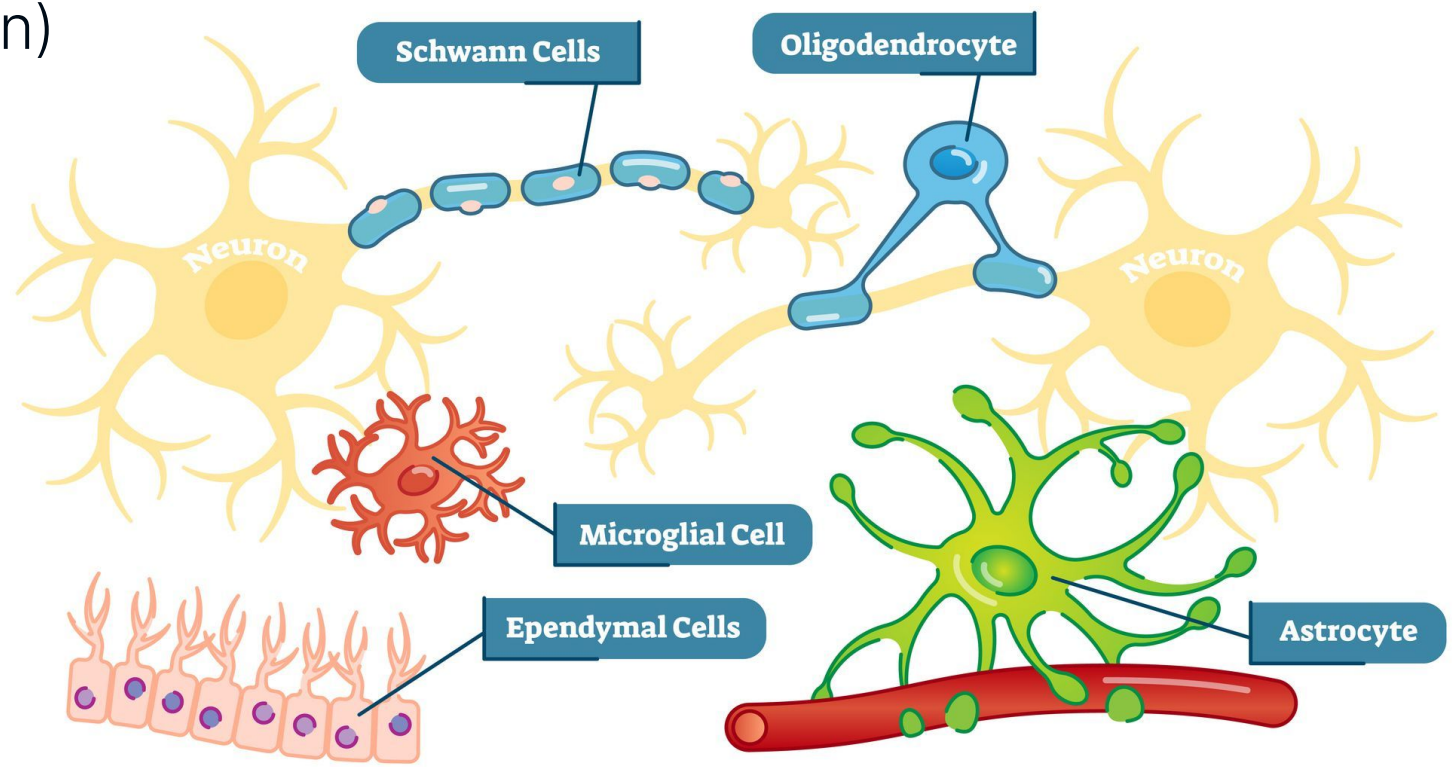
Neuron Fun Facts



- Nervous system contains 100 billion neurons
- Neurons in the brain are not replaced
- Can change shape

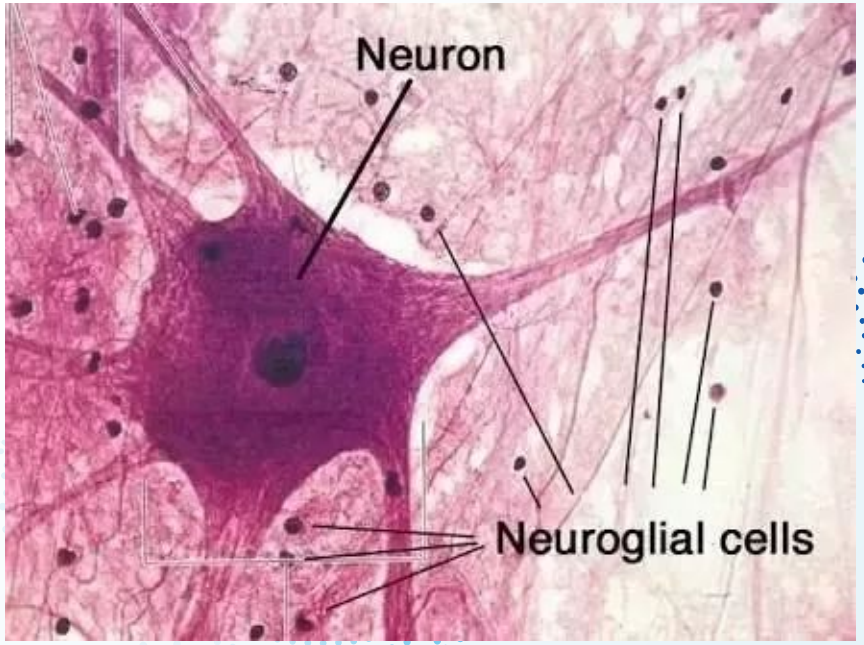
AKA Support Cells (support neuronal function)

Glial Cells

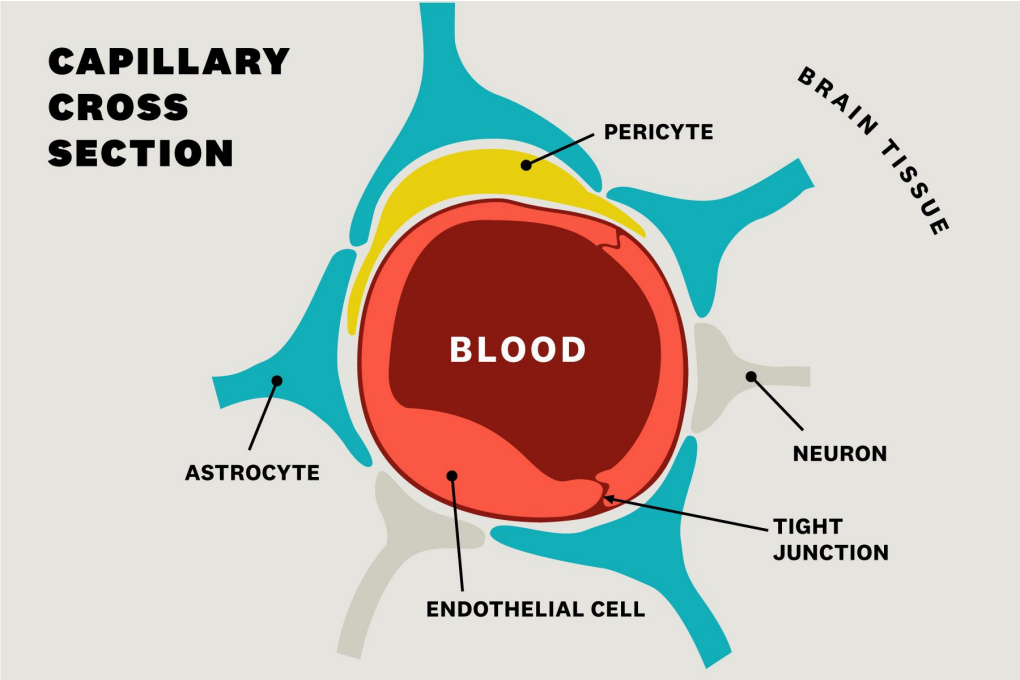


Functions of Glial Cells

- **Astrocytes:** chemical signaling, structural support, form blood-brain barrier, scar tissue formation
- **Oligodendrocytes:** myelinate axons
- **Microglia:** clean-up, repair, defense against infection



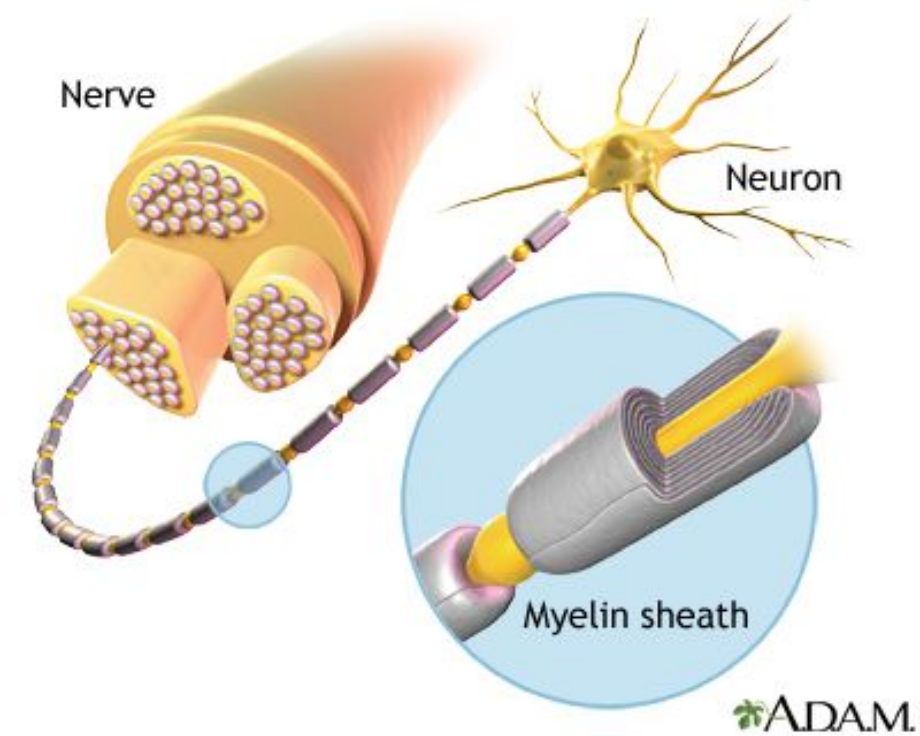
Astrocytes & The Blood-Brain Barrier



- Barrier between brain/blood supply (blood = poison to neurons)
- Protects brain from pathogens
- Formed by astrocyte “feet” (in blue)

Myelinating Glia

- Oligodendrocytes
- Myelinate (add myelin to) axons
- Myelin = insulation to help neurons communicate faster



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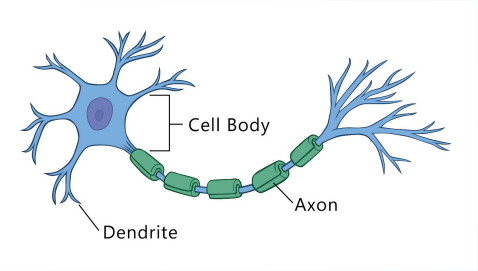
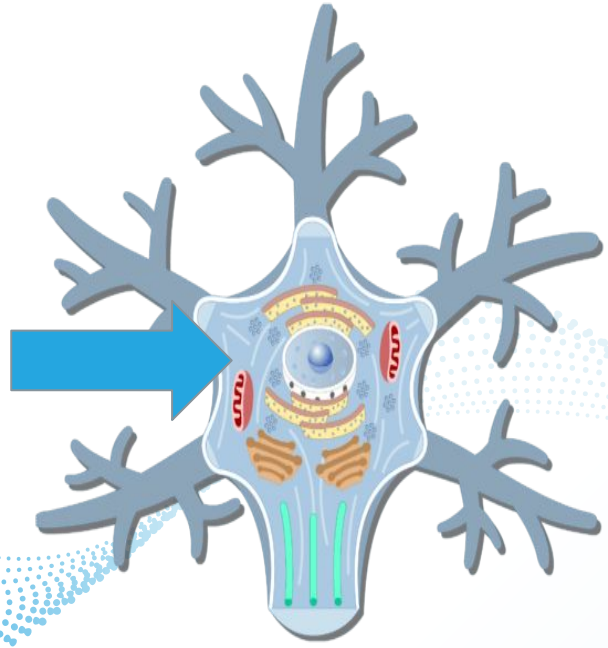
How do our brains communicate?

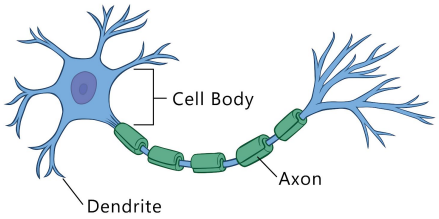
Basics of Neurons: Cell Body



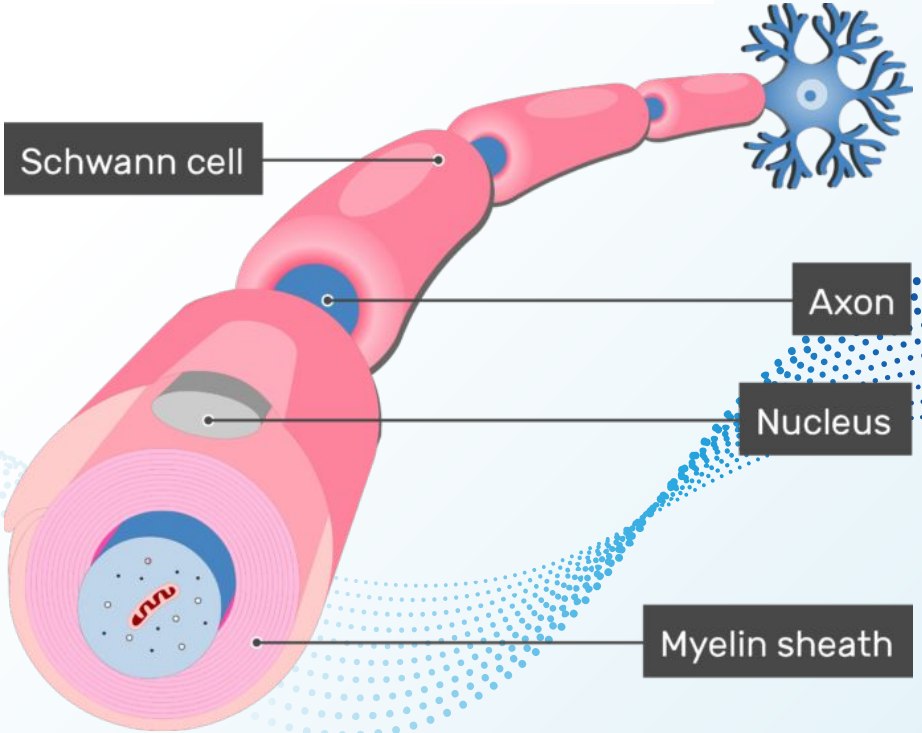


- Contains:
  - Nucleus
  - Carries genetic information
- Function:
  - Structural support
  - Controls cell function
  - Takes in information from other neurons to send down axon

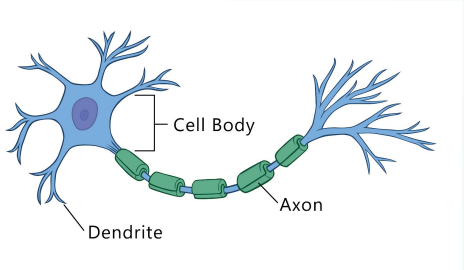
Basics of Neurons: Axons & Myelin Sheath



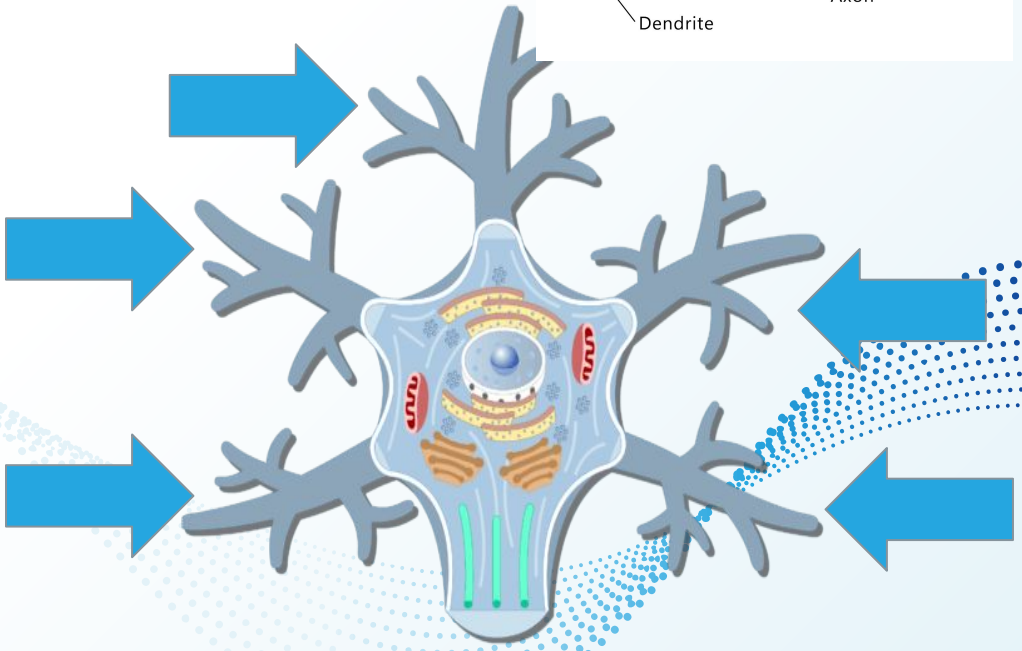
- **Axon** - nerve fiber stemming cell body allow impulses to move downwards and be sent to other neurons
- **Myelin Sheath** - fatty covering around nerve fibers made from:
  - Oligodendrocytes (CNS)
  - Schwann Cells (PNS)

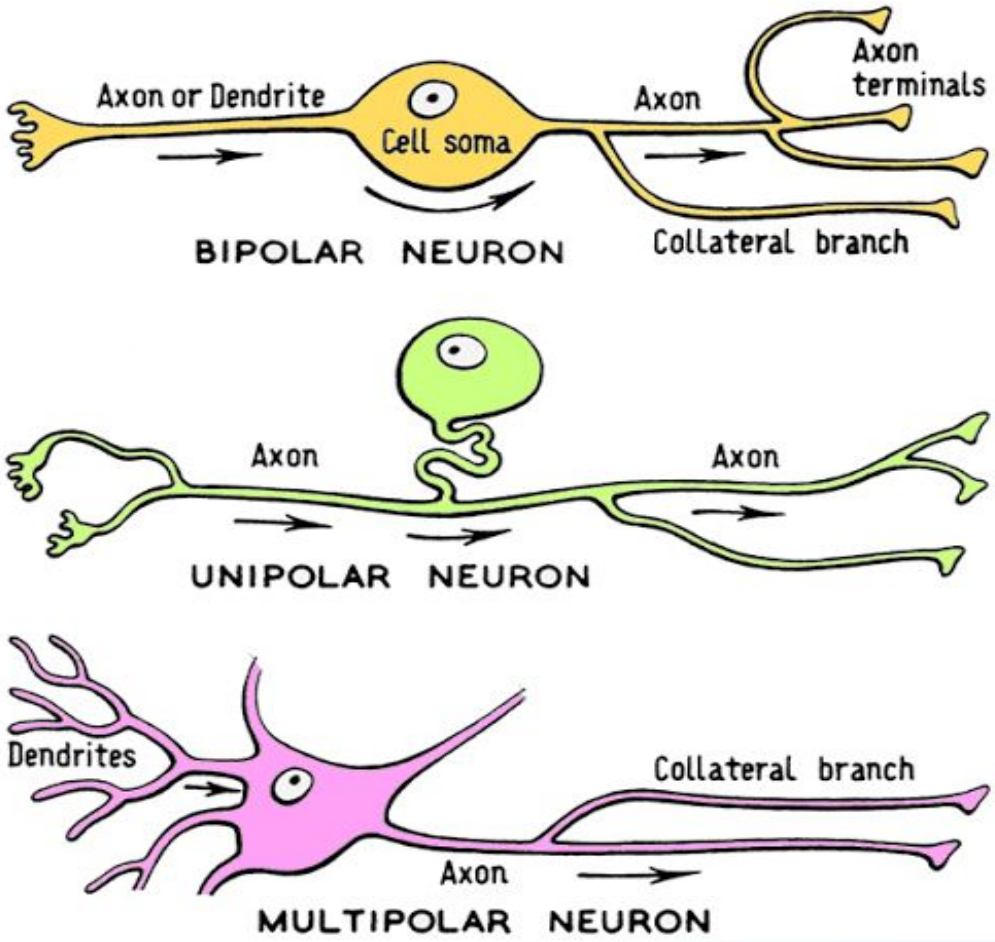


Basics of Neurons: Dendrites



- **Dendrites** - branching extensions from cell body
  - Receive signals from other neurons
  - Converts signal to electrical impulses that move towards the cell body



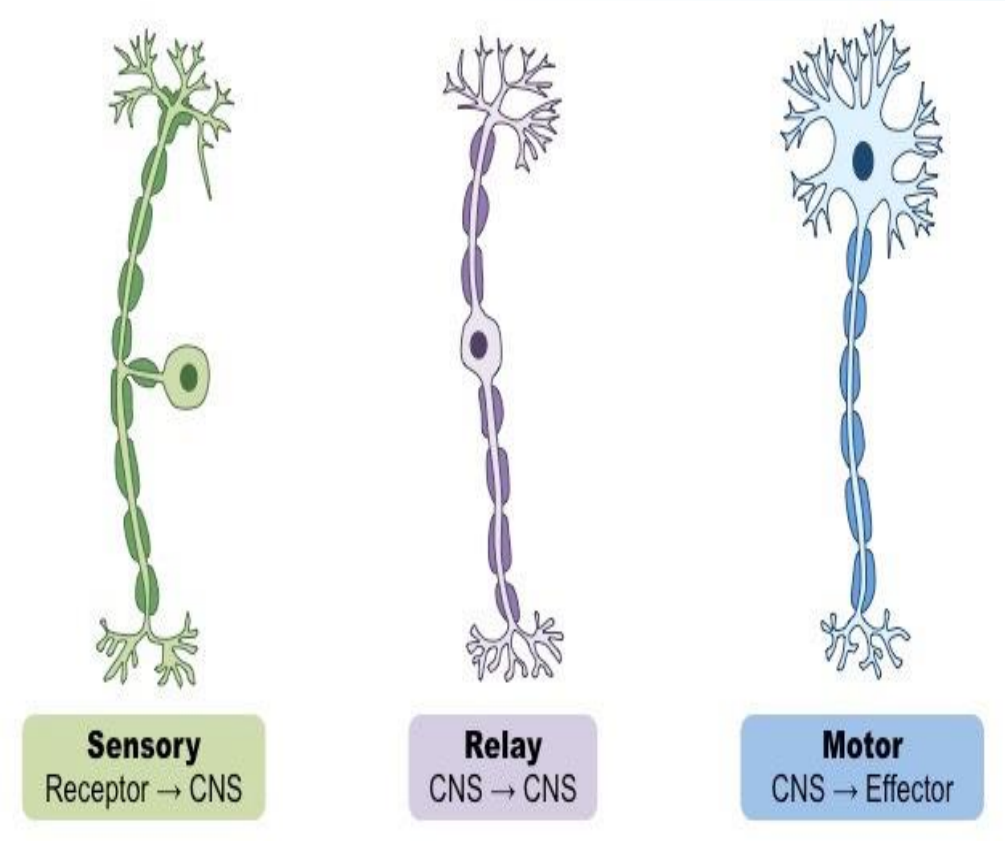


Types of Neurons: Structure

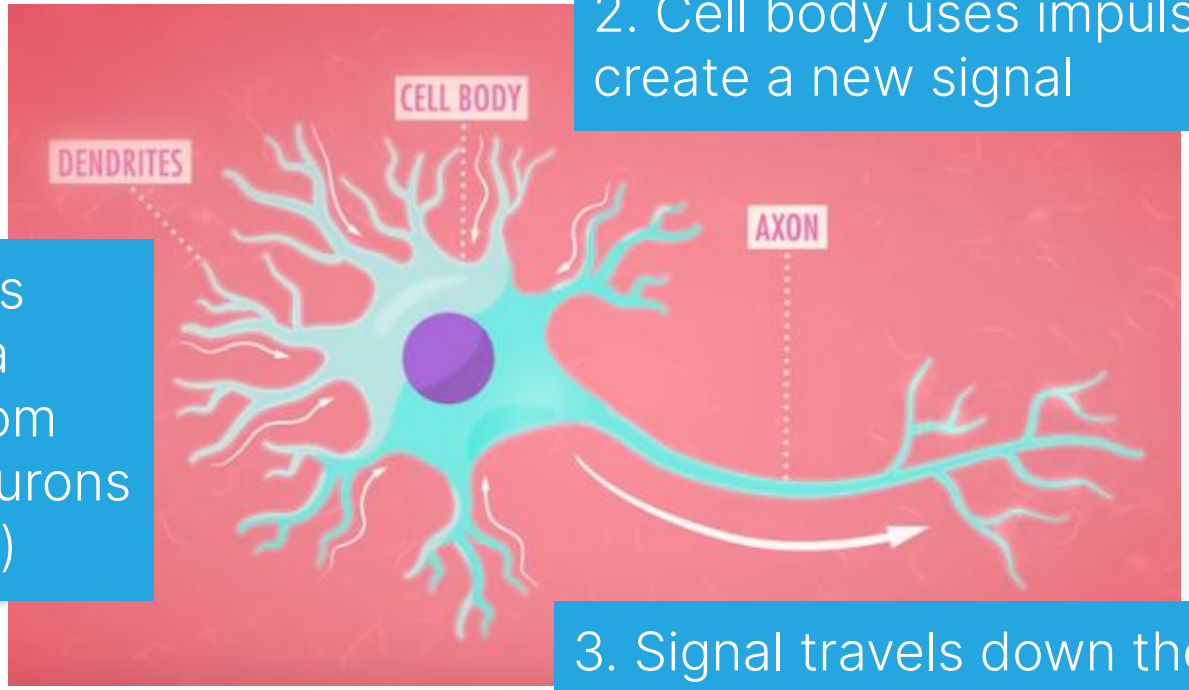
- Neurons can vary in size and shape
  - **Bipolar** - one axon, one dendrite
  - **Unipolar** - structure away from cell body
  - **Multipolar** - one axon, many dendrites

Types of Neurons: Function

- Can also be classified by function
  - **Sensory** - any structure, signals going to CNS
  - **Motor** - multipolar, signals out of CNS
  - **Interneurons** - connect motor and sensory neurons



2. Cell body uses impulse to create a new signal

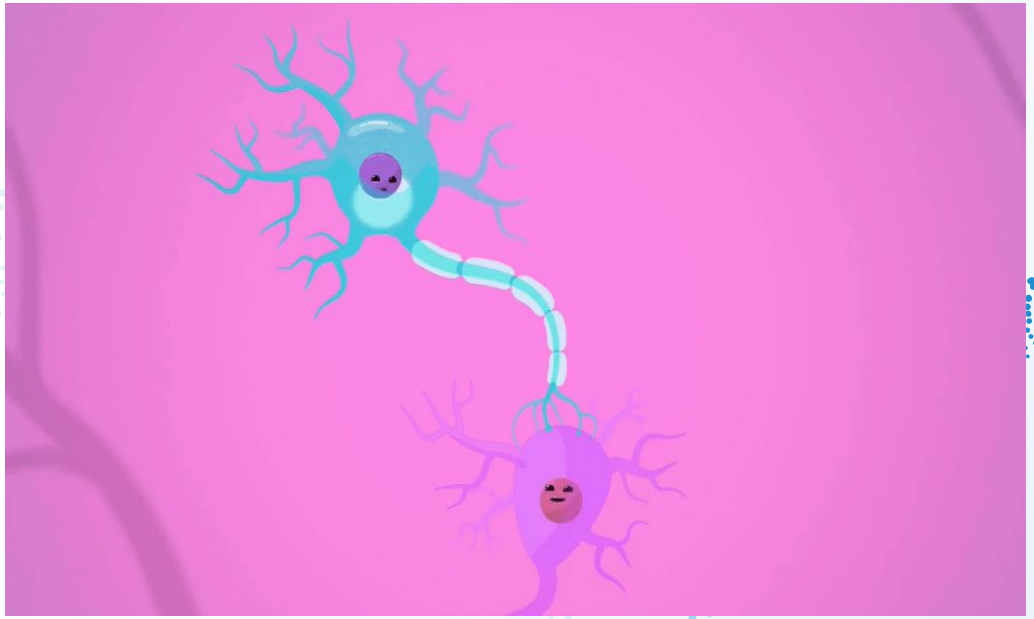


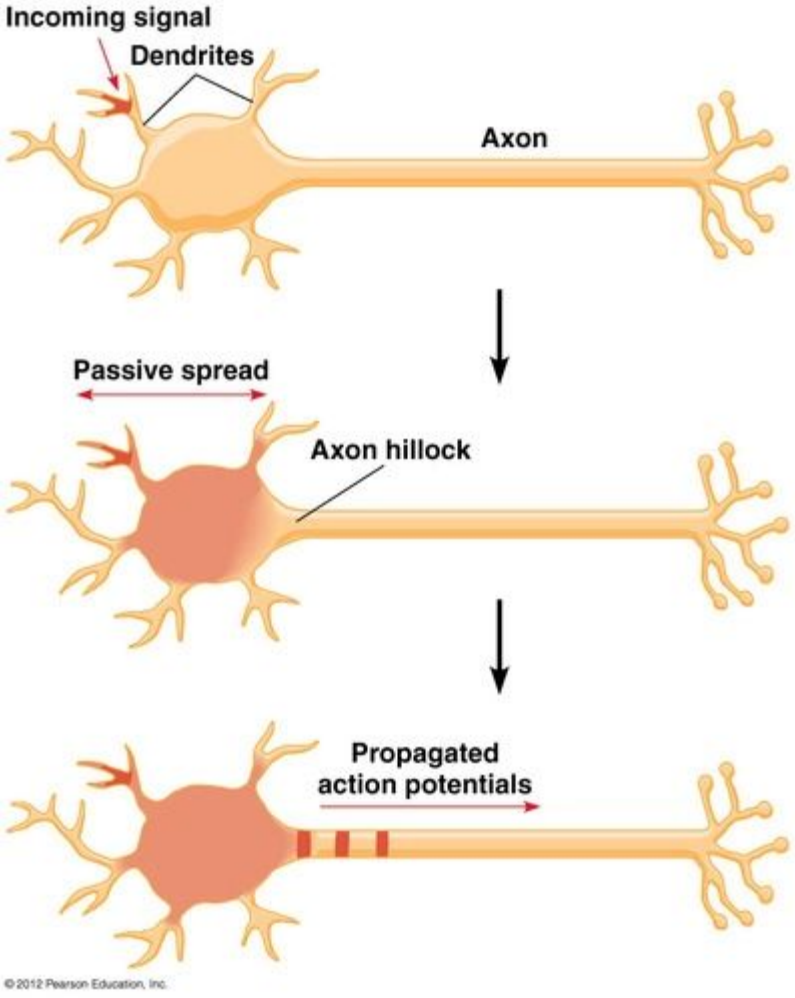
1. Dendrites receive a signal from other neurons (sensory)

3. Signal travels down the axon to the axon terminal to connect to other neurons

The “Talking Point”

- **Synapse** - Where two neurons communicate or send signals
- Presynaptic →→→→→ Postsynaptic
- Can be chemical or electrical signalling





Action Potentials

- **Action Potential** - signal that occurs during rapid electrical activity
  - Due to depolarization or lessening of the cell's polarity

Chemical Synapse

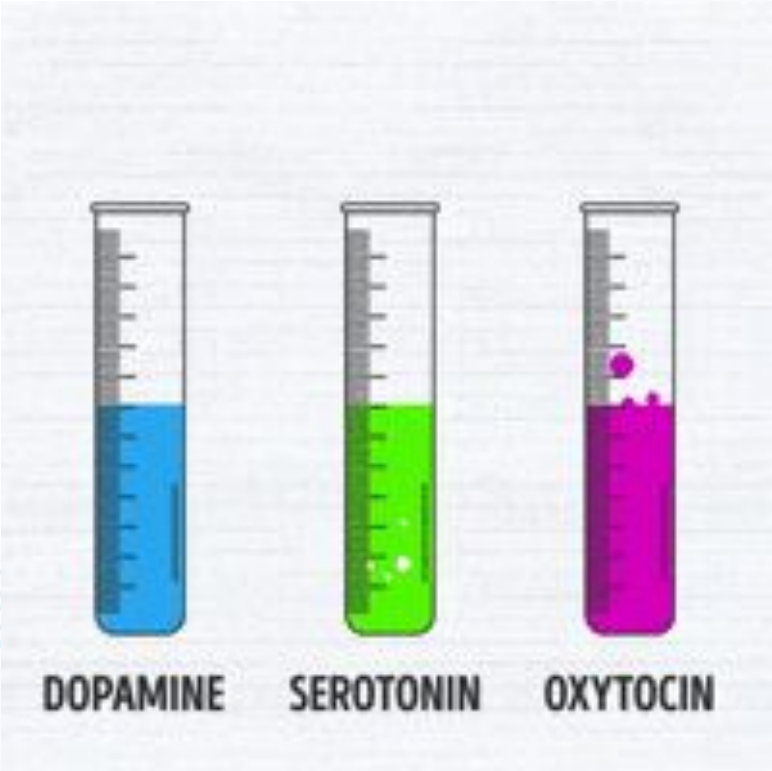
- Nerve impulses transmitted by neurotransmitters
- Can travel downwards
- Has synaptic vesicles with neurotransmitters
- Slow movement
- Found in both the CNS & PNS

Electrical Synapse

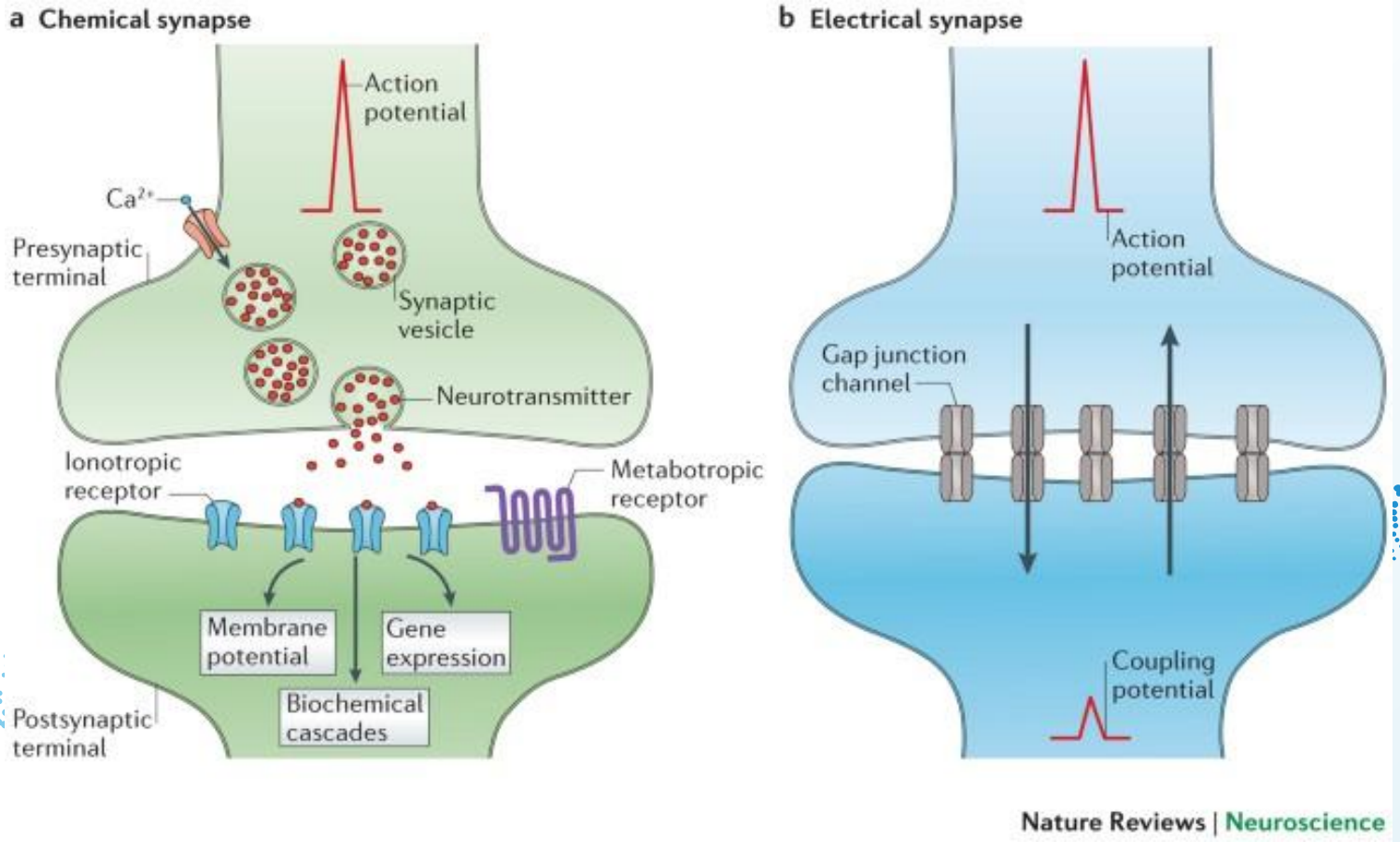
- Nerve impulses transmitted through gap junctions
- Can travel downwards and upwards
- No synaptic vesicles
- Rapid movement
- Found in the CNS

Neurotransmitters

- **Neurotransmitters** - chemical messengers released by neurons
  - Examples include, dopamine, serotonin & adrenaline



At the Synapse



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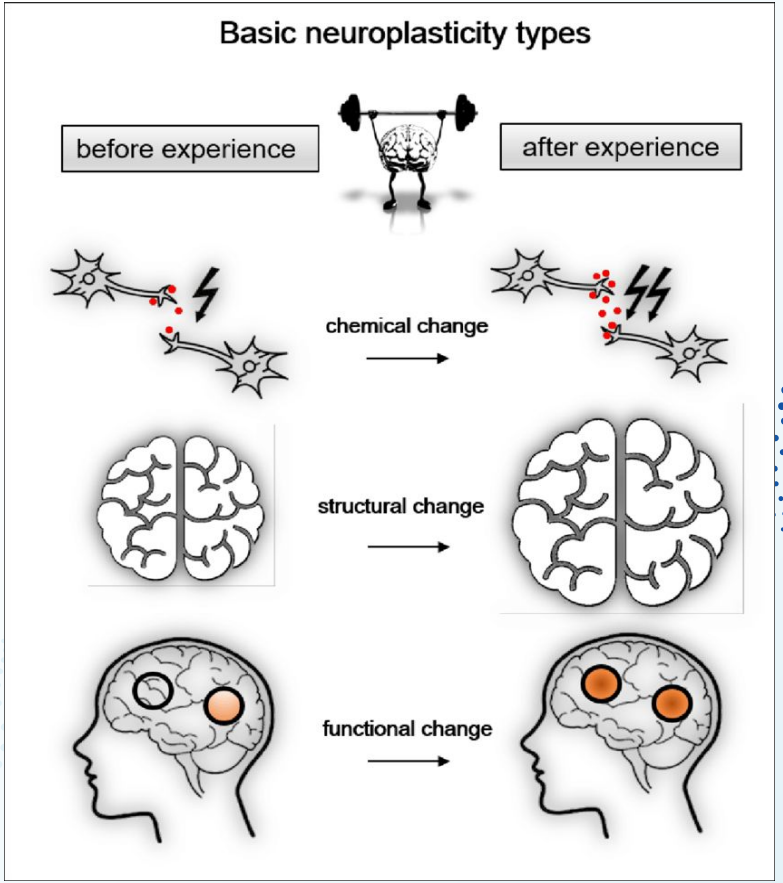
What is neuroplasticity?

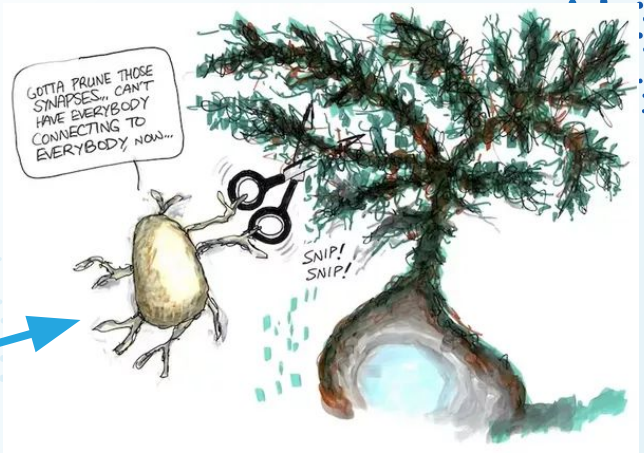
What do we mean by plasticity?

- Plastic = flexible, changeable
- Our brains are not "hardwired," connections are formed and lost throughout our lives
- Change in response to experience and environment



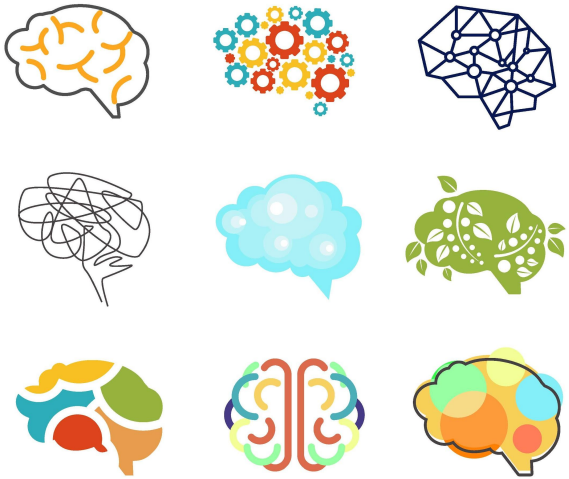
How our brains develop

- We are born with more neurons than we will ever need
- Highly connected--too many connections!
- Solution: synaptic pruning



Microglia

How our brains change with (different) experience



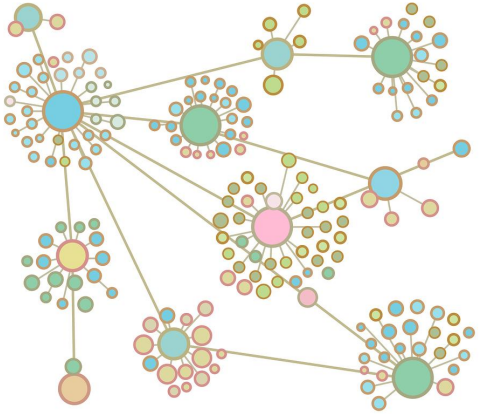
- No one's brain is exactly the same
- Which synapses are "pruned" depends on which ones we actually use
- What we learn and do as kids shapes our brains and helps make us who we are

CAUTION:

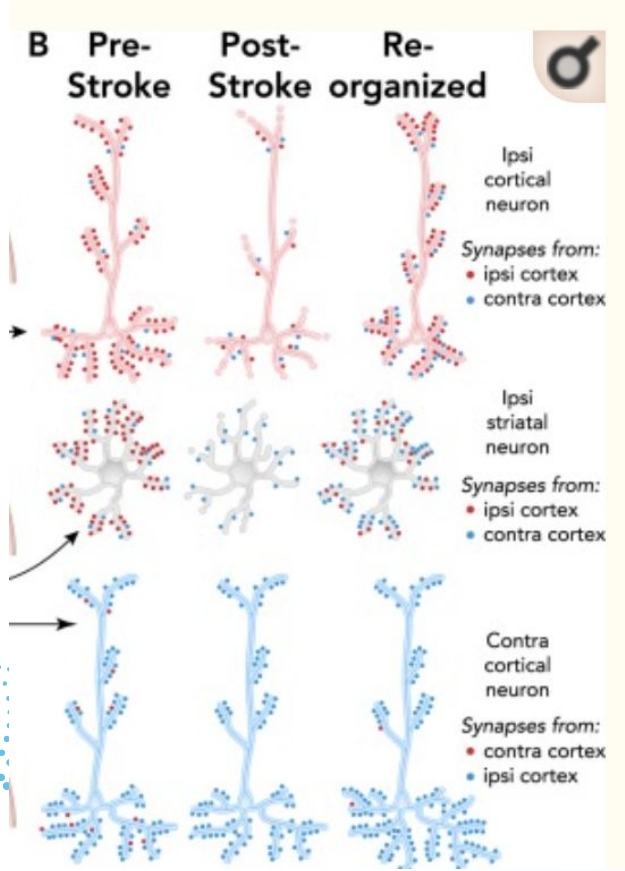
Our brains are **NOT** "hardwired" as adults

Learning

- When we learn, we are capable of forming new connections between neurons
- Strengthening connections - long term potentiation
- Loss of connections - long term depression



Problem: no new neurons



- Individual neurons can change, but once they die, they can't be replaced
- Solution? remaining neurons compensate for damage or loss

Mythbusting

- We only use 10% of our brains
- An old dog can’t learn new tricks
- Our left brain is logical, our right brain is creative, and people are either more “left-brained” or “right-brained”

Questions?

Register for March 9th session!

https://osu.zoom.us/meeting/register/tJEqdemvqj0jHteN8XjPgJWodLpQRKHBbtFw

See you then!