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
Minor: Spanish / Integrative Approaches to Health & Wellness
Hometown: Warren, OH
Jenna McCloskey

Major: Neuroscience
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

Two Trends as Nervous System Evolves:
- Relative size increases (rat → human)
- Relative complexity increases (rhesus monkey → human)
  - More folds = more surface area for neurons

Gyri: hills
Sulci: valleys
Fissures: large valleys
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

- Development unfinished until early 20’s
  - Why kids/teens show limited impulse control
- Phineas Gage case study
Divisions of the Nervous System

Nervous System (NS)

Peripheral NS
- Autonomic NS
  - Sympathetic NS
  - Parasympathetic NS
- Somatic NS

Central NS
- Brain
  - Forebrain
  - Midbrain
  - Hindbrain
  - Telencephalon
  - Diencephalon
  - Mesencephalon
  - Metencephalon
  - Myelencephalon
- Spinal Cord
  - Pons
  - Cerebellum
  - Medulla

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

Loss of ability to understand or express speech.
Broca’s Aphasia

Wernicke’s Aphasia

I want an apple

I want an apple

Marble yel leen I him gophobic
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

<table>
<thead>
<tr>
<th>Pons</th>
<th>Cerebellum</th>
<th>Medulla</th>
</tr>
</thead>
<tbody>
<tr>
<td>Receiving info from inner ear</td>
<td>Motor coordination</td>
<td>Heartbeat</td>
</tr>
<tr>
<td>States of arousal</td>
<td>Sensori-motor integration</td>
<td>Breathing</td>
</tr>
<tr>
<td>Serotonin neurotransmitter system</td>
<td>Motor learning</td>
<td>Alertness</td>
</tr>
</tbody>
</table>

![Diagram of brain parts](image)
Structure of a Typical Neuron

- Dendrites
- Nucleus
- Cell Body
- Axon
- Schwann’s Cells
- Myelin Sheath
- Node of Ranvier
- Axon Terminals
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)
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
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 from the 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
1. Dendrites receive a signal from other neurons (sensory)

2. Cell body uses impulse to create a new signal

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

a Chemical synapse
- Action potential
- Ca^{2+}
- Presynaptic terminal
- Synaptic vesicle
- Neurotransmitter
- Ionotropic receptor
- Metabotropic receptor
- Membrane potential
- Gene expression
- Biochemical cascades
- Postsynaptic terminal

b Electrical synapse
- Action potential
- Gap junction channel
- Coupling potential
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
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!