COGS 17 Week 3

Spring 2024, A03

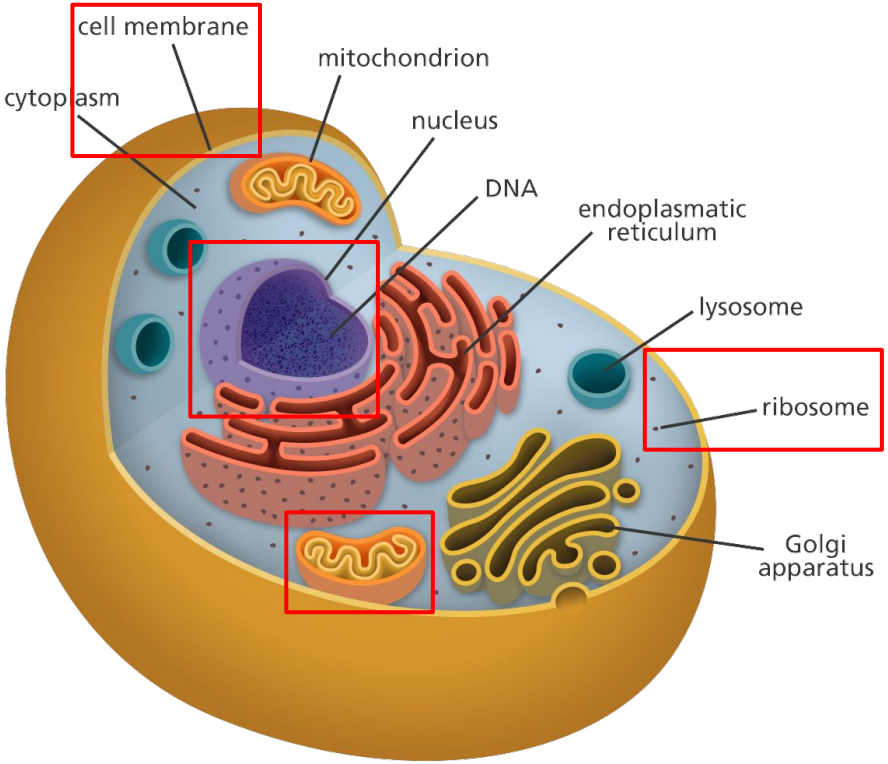
Slides Adapted From Previous Quarter

By: Jason Chen

Problem Set for Today

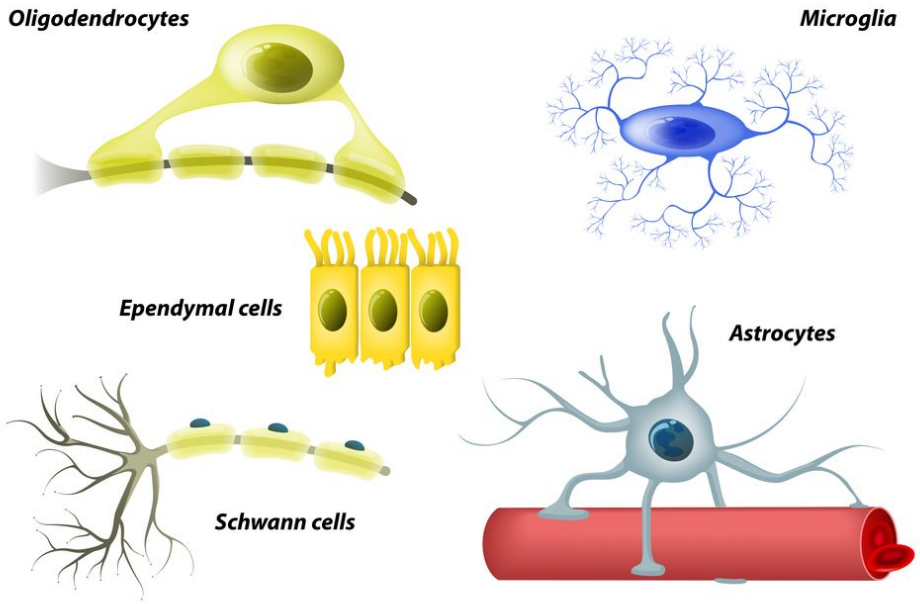
- Link: https://docs.google.com/document/d/1HYoP3TxzcKxuYK0lqclrwgEDAaeffJb91cn3GmwXvQ4/edit?usp=sharing

Cells



- Nucleus -- where DNA stored
- Ribosome -- where protein synthesis occurs
- Mitochondria -- Produce ATP, the “powerhouse” of the cell
- Cell membrane -- lipid, **BILAYER**, semi permeable membrane

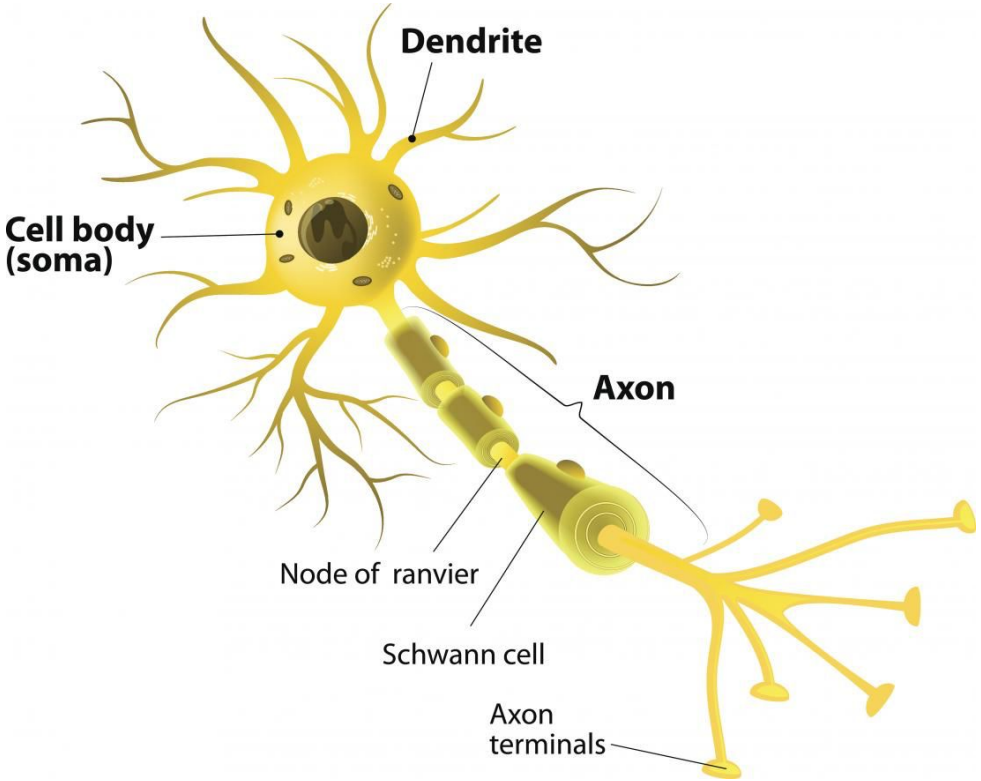
Glial Cells



- Non-neural cells of the nervous system with multiple functions
- Do **NOT** participate in information transfer
- Much smaller than neurons, but much more numerous
- ~50% of brain by weight

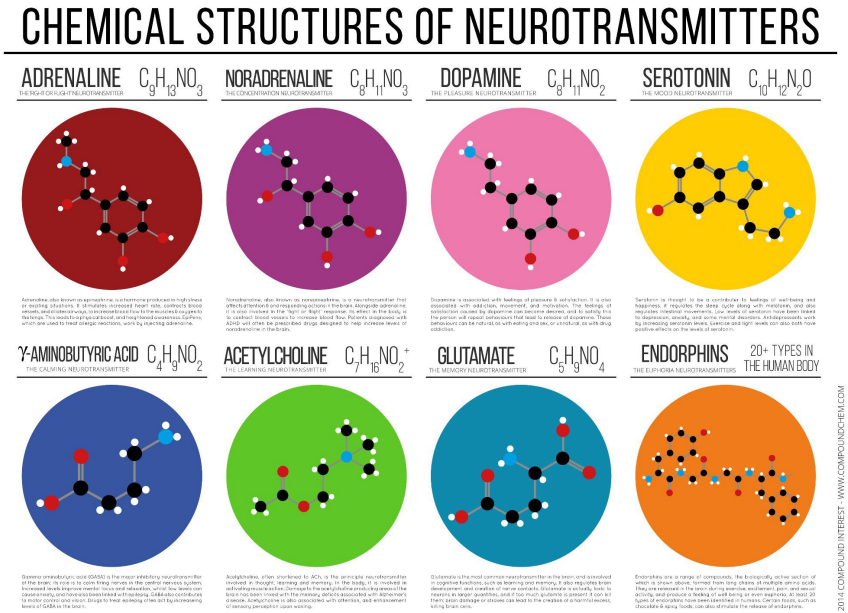
Neurons

- Cells that are specialized for **INFORMATION TRANSFER**
- Modified processes (i.e. dendrites & axon)
- Dendrites -- reception of **INCOMING** message via receptors
- Axon -- Site of release of **OUTGOING** message
- Modified membrane -- ion channels

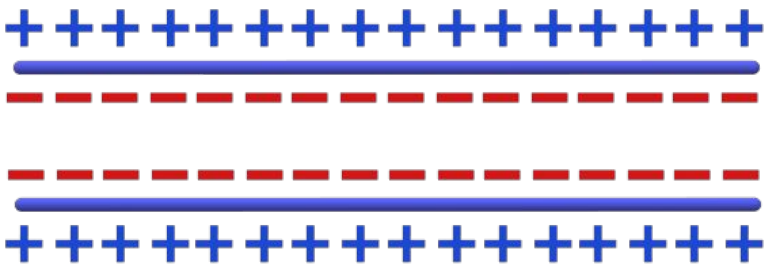


Neurotransmitters (NT)

- Endogenous chemicals that allow neurons to **communicate** with each other throughout the body
- E.g. Acetylcholine (ACh), GABA, Glutamate, Serotonin (5-HT), Norepinephrine, etc.
- May have different effects in different parts of body

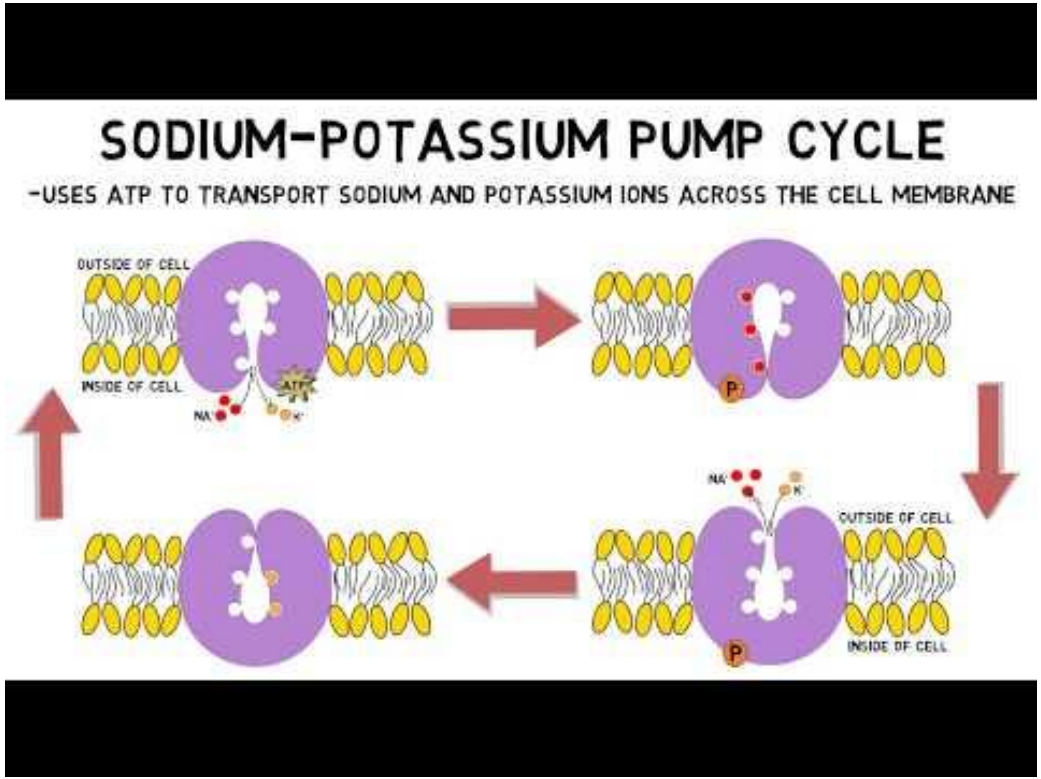


Resting Potential

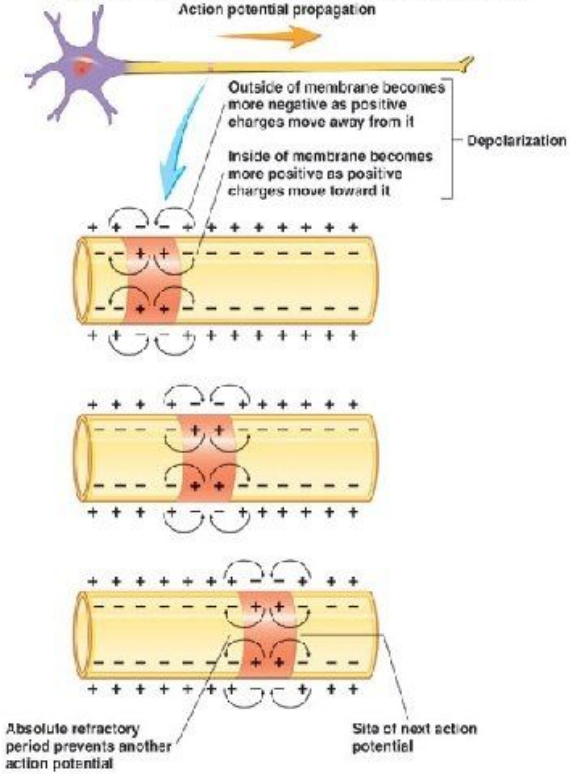


- Generally -70 mV
- More negative inside & more positive outside
- Established in part by Na-K pump, which actively transport 3 Na+ out and 2 K+ in
- Highly **POLARIZED** -- ready to “fire”

Sodium-Potassium Pump

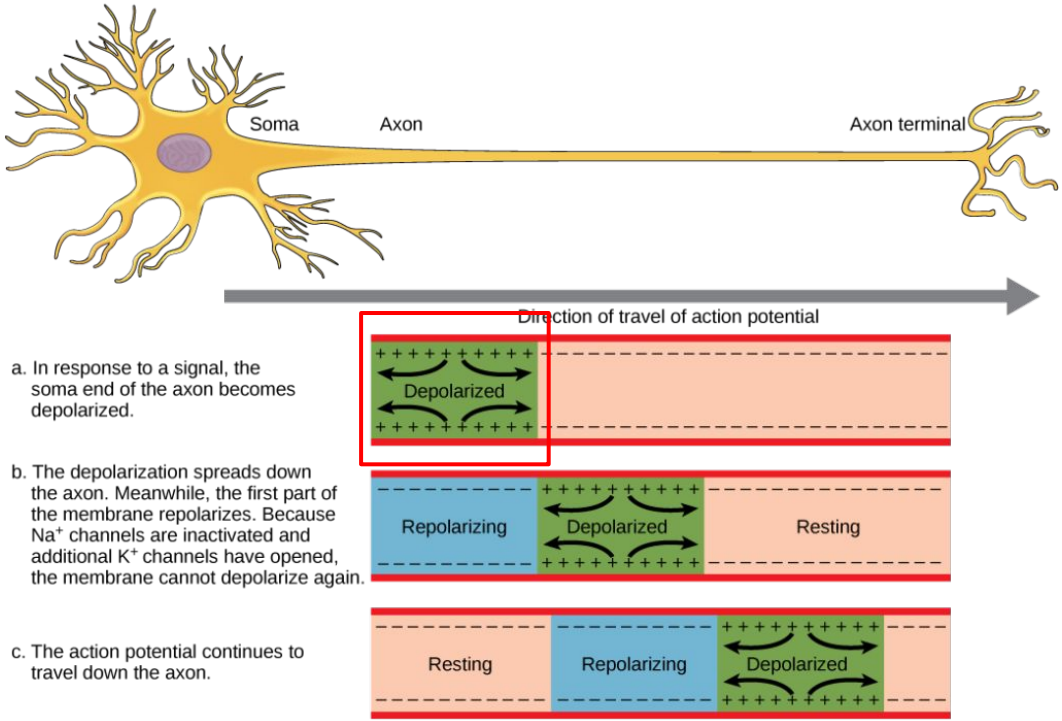


Action Potential



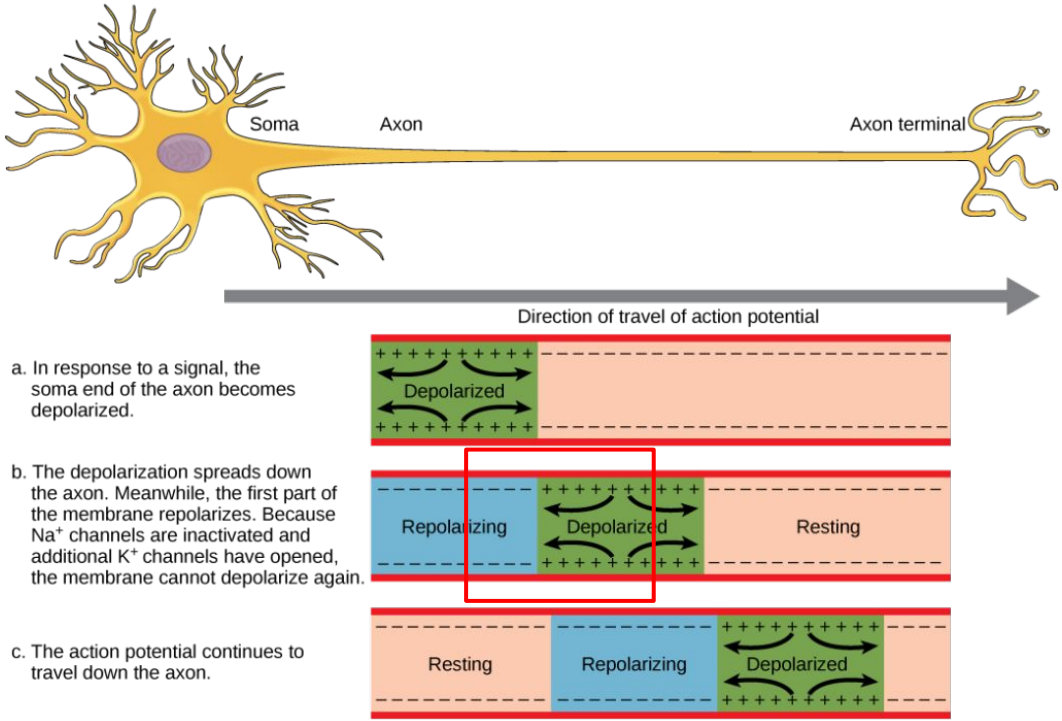
- **DEPOLARIZATION** of neuron
- Triggered by neurotransmitters from other neuron, electrical stimulation, or other stimuli
- Starting at Axon Hillock

Action Potential



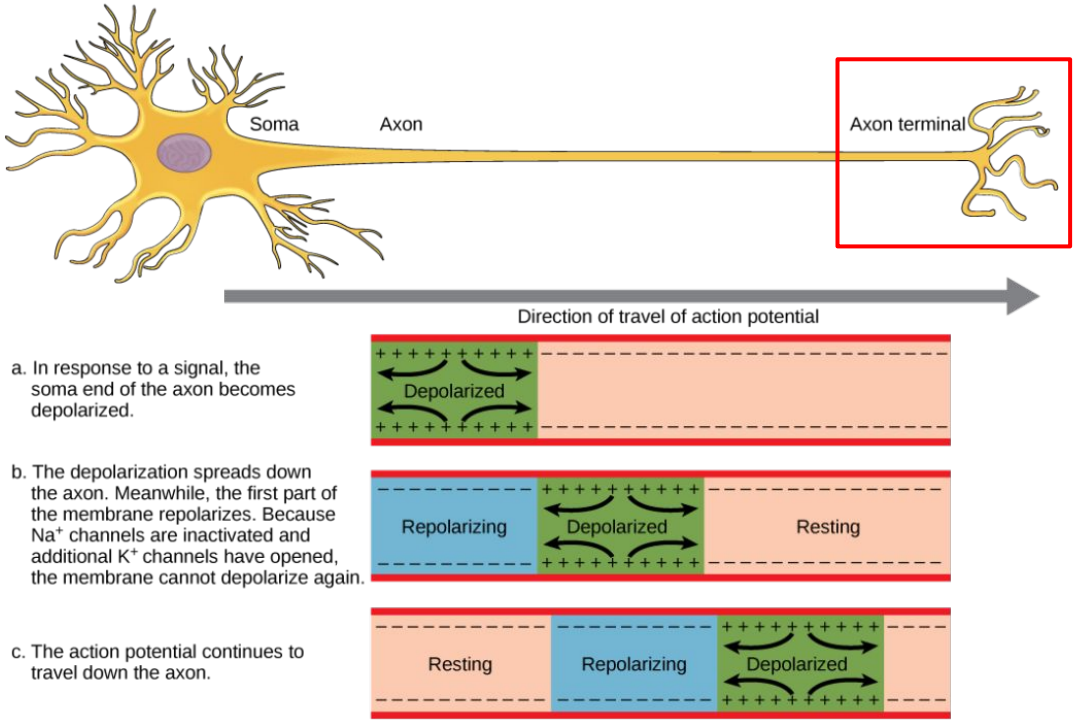
- Voltage-activated Na+ gates open -- Na+ in
- Reverse local polarization to ~ +50 mV
- Na+ influx causes adjacent Na+ voltage-activated gates to open & previously opened gates close
- Propagation of the action potential to the terminal

Action Potential



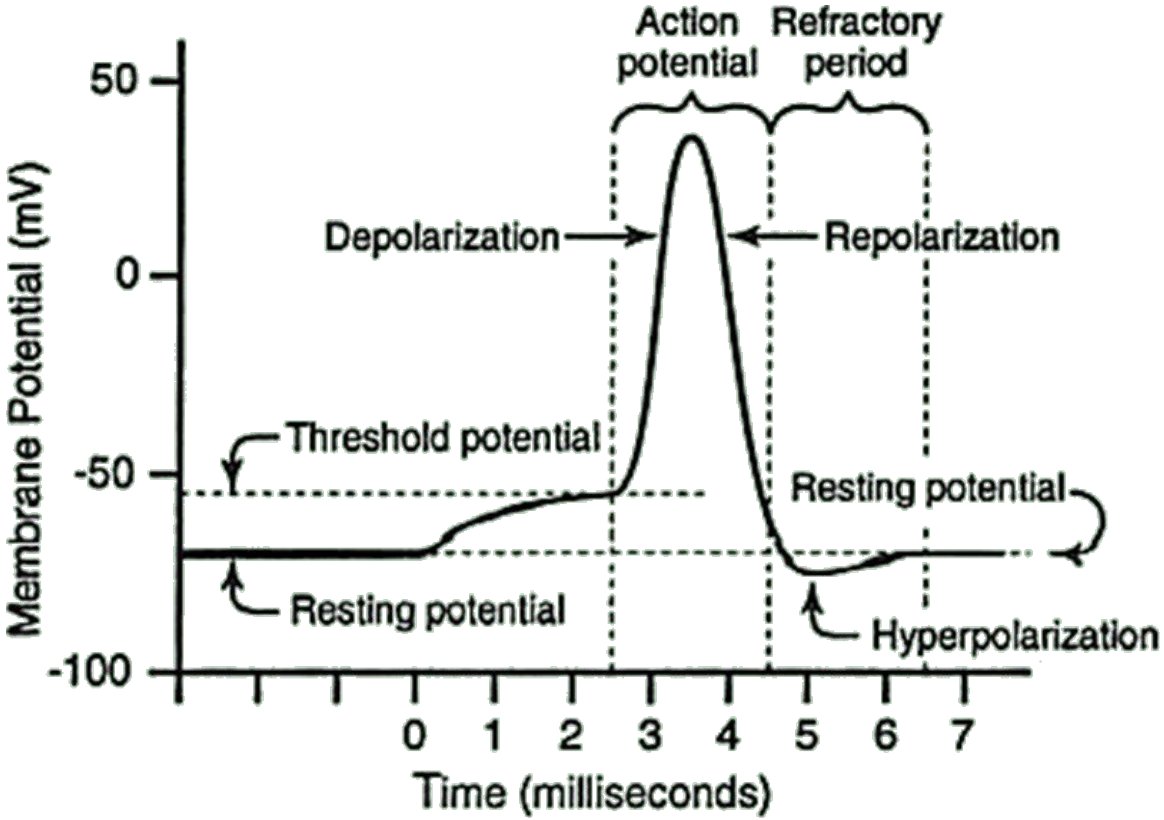
- As previous Na+ gates close, local K+ gates open -- K+ leaves the cell
- Because of opened K+ channels & closed Na+ channels, the membrane **cannot** depolarize again
- Refractory period -- **prevents backflow** of action potential

Action Potential



- When reaches terminal, Ca2+ enters cell & Neurotransmitter released
- When outside becomes more positive again, K+ channels close
- Na-K pumps restore resting potential to -70 mV
- Ca pump reject Ca2+ from terminal
- Pumps **require energy**

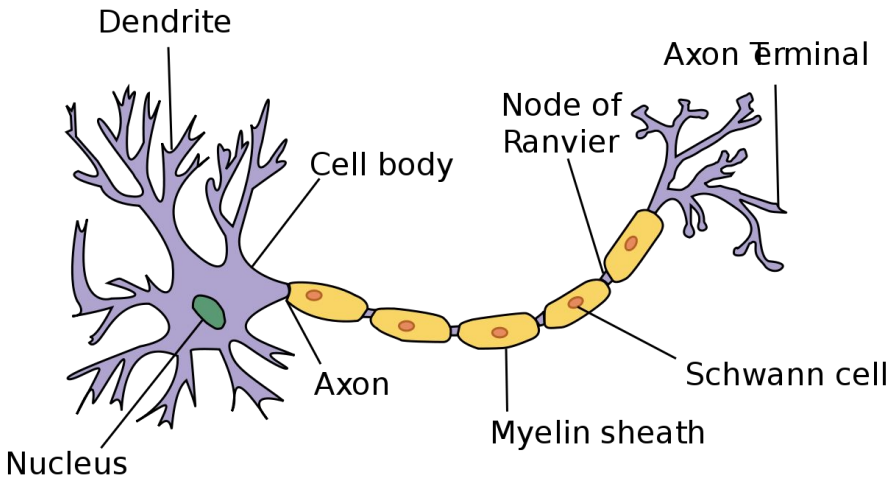
All-or-none Law



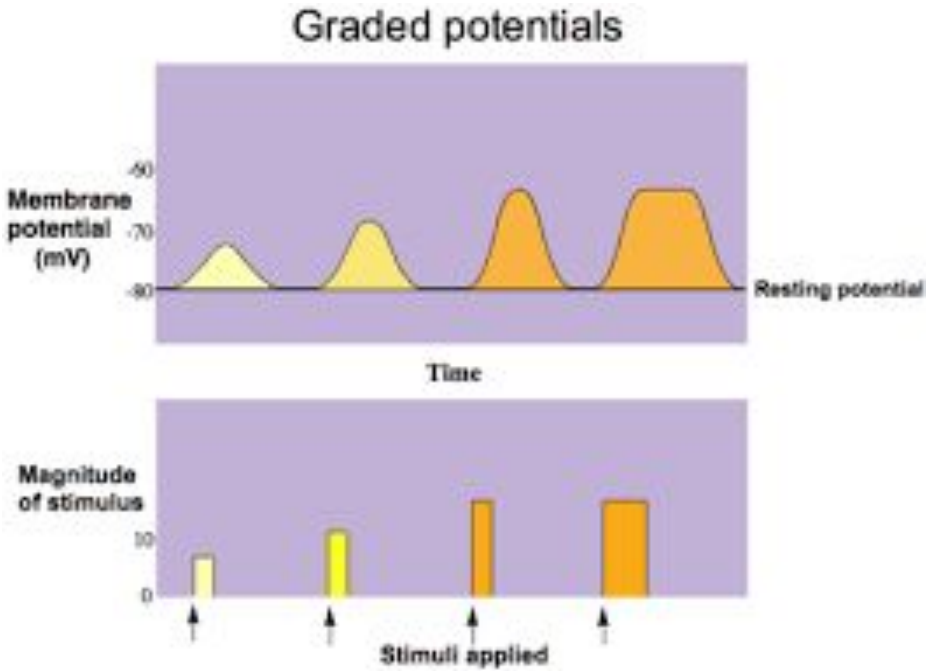
- An Action Potential always has the same amplitude and velocity,**regardless** of the intensity of the stimulus that triggered it
- Either full response or no response at all

Myelination and Saltatory Conduction

- Increase the speed of propagation
- Glial cells form **insulating sheaths** around axons, with small gaps in between sheaths
- **Electrical** conduction -- fast, but degrades as it moves
- Node of Ranvier -- **ionic** conduction, **reboost** the signal to original strength and pass it to next shealth
- Saltatory Conduction -- **“Jumping”** of the signal from node to node along axon

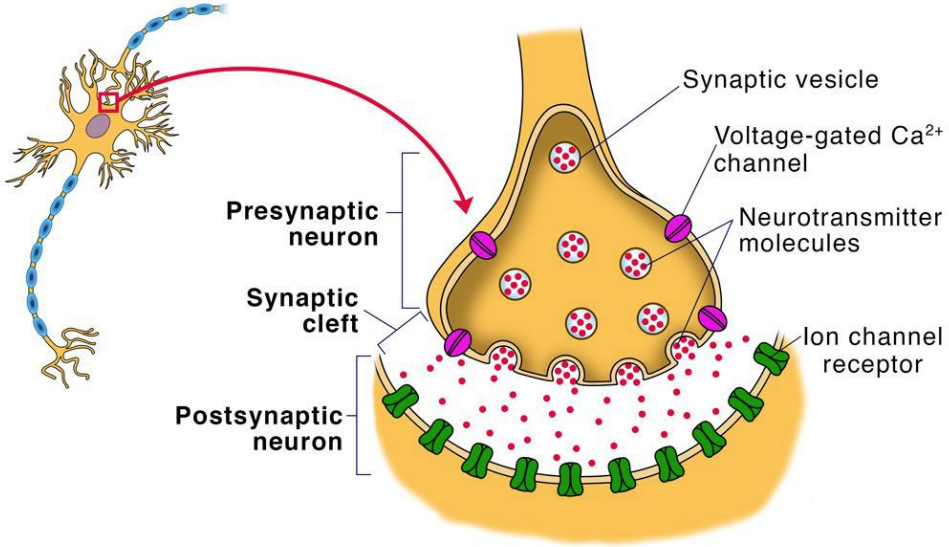


Graded potentials



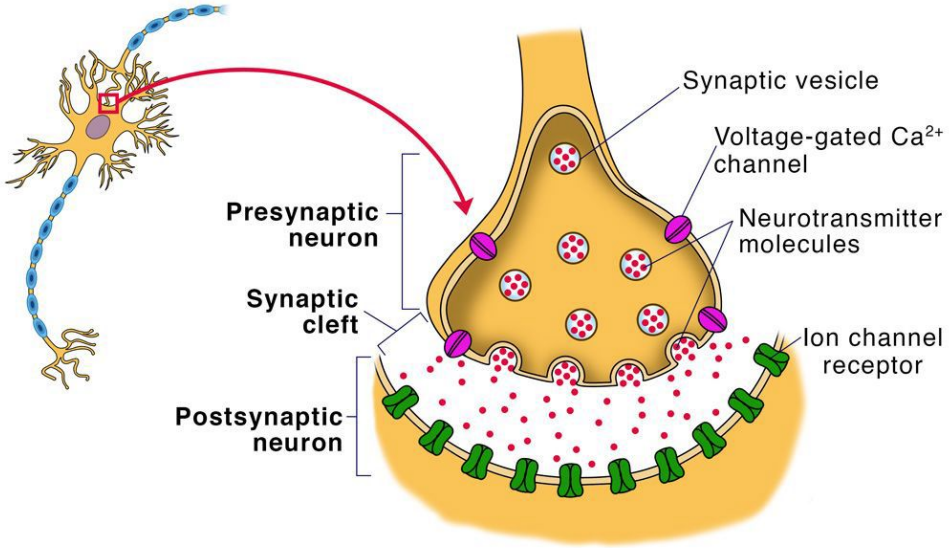
- Releasing NT from a Neuron does **NOT** always require an Action Potential
- Can vary in amplitude
- i.e. Strong response due to strong stimulus; weak response due to weak stimulus
- Examples: some receptor cells (e.g. retina), lateral inhibitors, local Neurons, etc.

The synapse



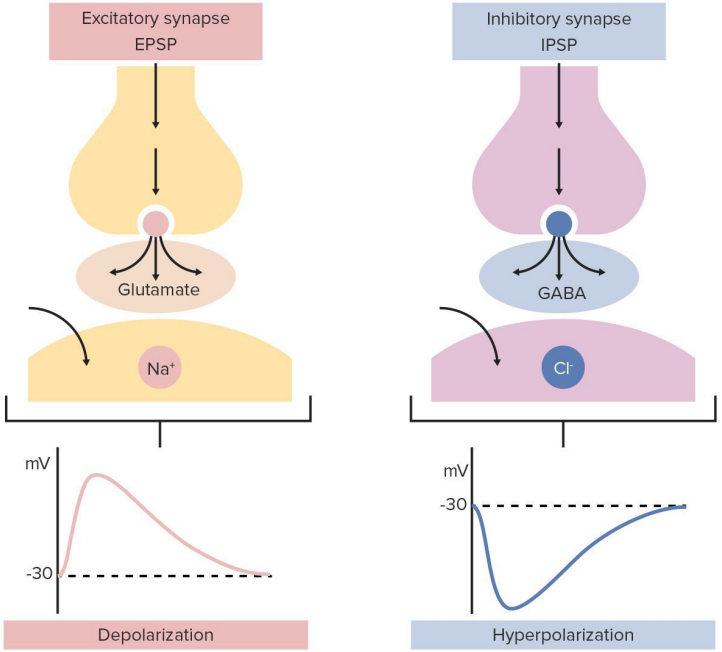
- Presynaptic cell releases NT into synaptic cleft, affects postsynaptic cell via **Exocytosis** (release of vesicles of NT).
- When membrane depolarization reaches the axon terminal, voltage-gated Ca++ channels open, causes influx of Ca++

The synapse



- NT **passively** diffuses across synaptic cleft
- NT binds to **NT-specific** receptor site on (usually) dendrites of postsynaptic cell
- Postsynaptic cell may fire its NT, etc.
- NT soon **detaches** from receptor
- NT is often then **deactivated** by enzymes or Glia cells

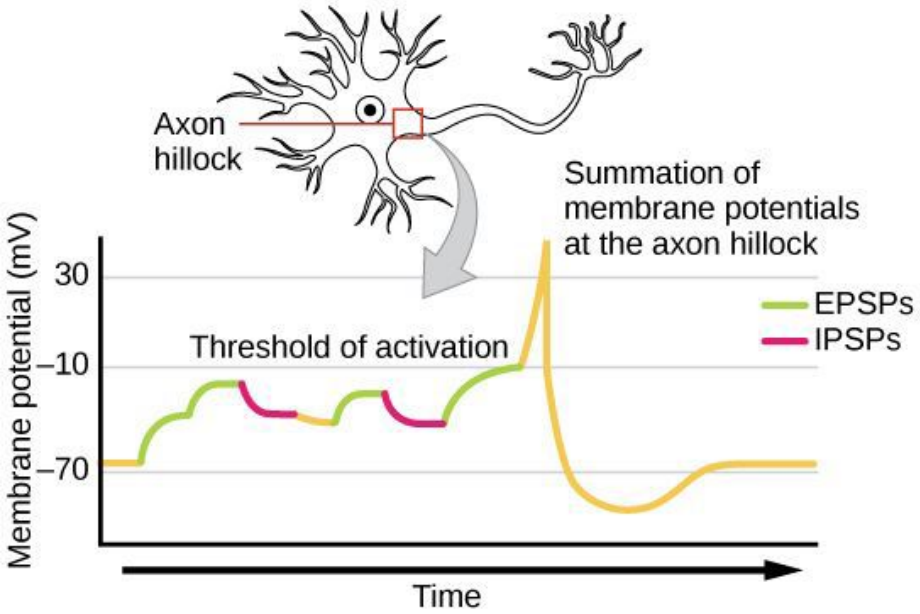
EPSP VS. IPSP



- EPSP: **Excitatory** Postsynaptic Potential - postsynaptic cells become hypopolarized.

- IPSP: **Inhibitory** Postsynaptic Potential - postsynaptic cells become hyperpolarized.

Summation



- The response of a given neuron is nearly always the product of a **summation of EPSPs and/or IPSPs**
- Two types of summation: **Spatial** summation and **Temporal** summation

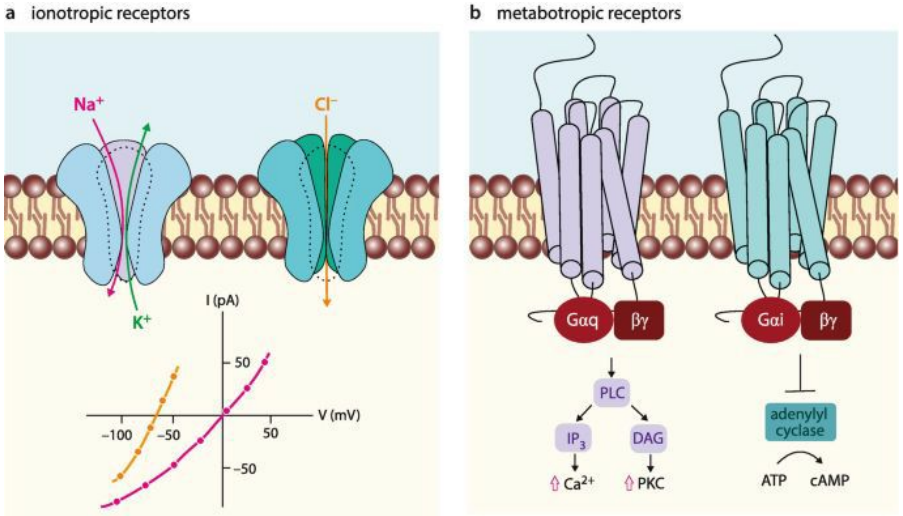
Ionotropic Vs. Metabotropic

- Ionotropic: NT **directly** affects ion gates

  -Effects are **rapid, short-lived**

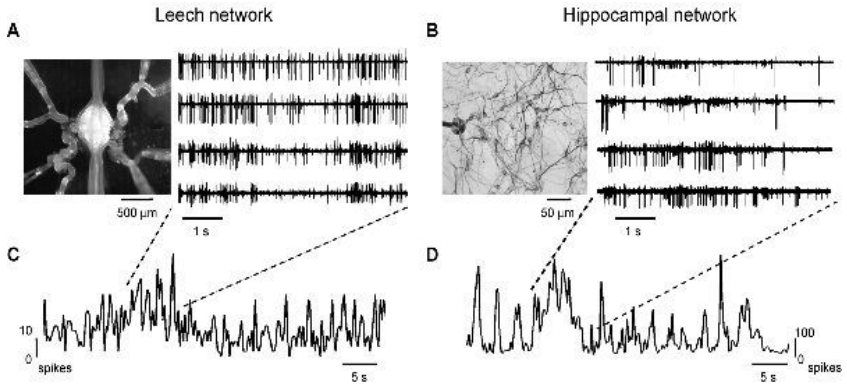
- Metabotropic: Triggers **metabolic changes** in Postsynaptic cell

  -Activates/triggers production of **Secondary Messenger**, which binds w/**G-Protein** to open separate ion gate, **requires energy, slower and long-lasting**



Spontaneous Activity

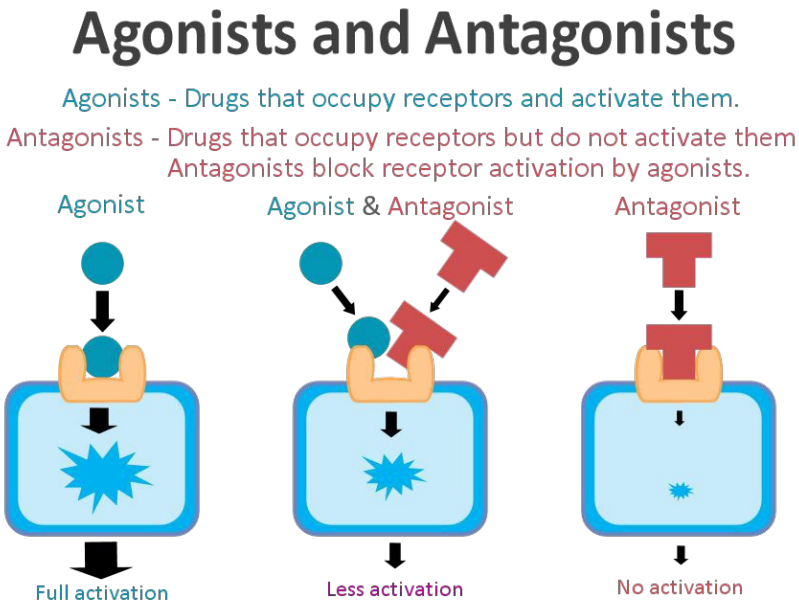
- Some Neurons show spontaneous Firing, **in absence of incoming NT**
- Usually graded potentials
- Converging NTs increase or decrease such cells' activity, modifying how much NT they will then release



Agonism Vs. Antagonism

- Agonist: chemicals that **increase** the effect of a NT

- Antagonist: chemicals that **decrease** the effect of a NT



Questions?

Office Hours: Mon 5-6 pm

To get the section slides: https://github.com/JasonC1217/COGS17-A03-Sp24

OR: