INTRODUCTION TO COMPUTATIONAL NEUROSCIENCE AND SEIZURE MODELS IN DROSOPHILA

Georgia Gwinnett College
By: Elijah Noisin, Eman Zaki, Don Charles Sugatapala
Supervisor: Dr Cengiz Gunay

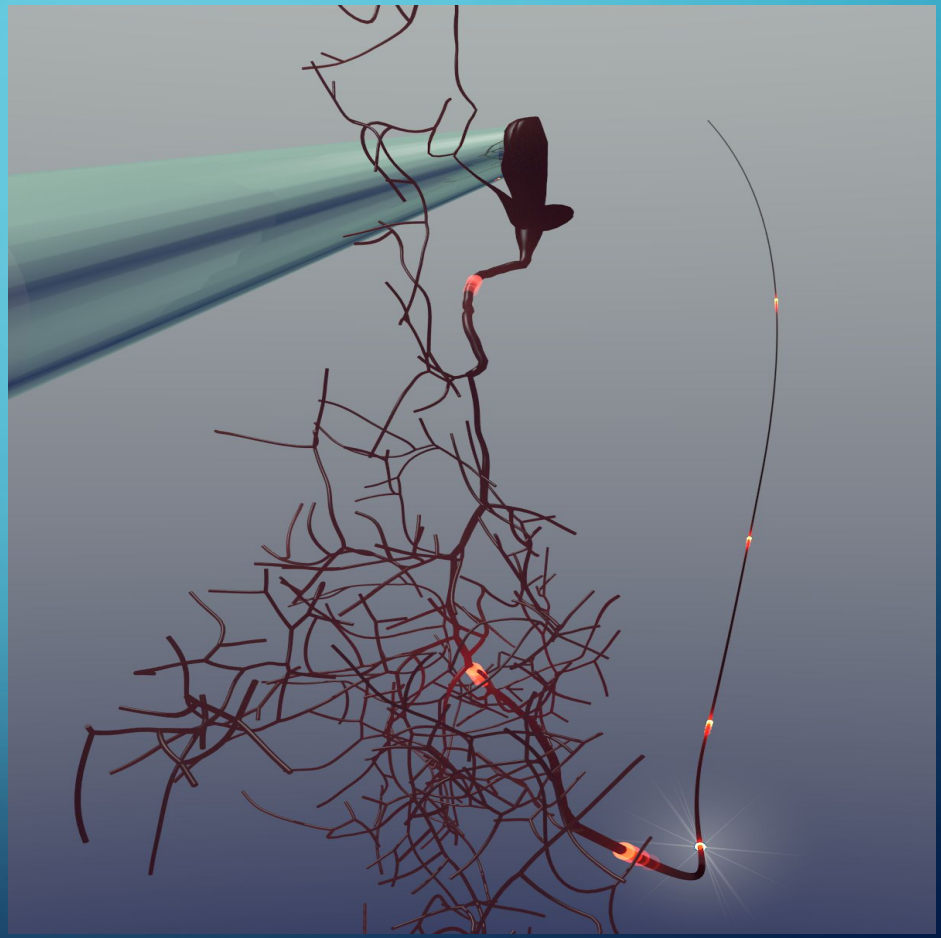
SiNEG

ABSTRACT

The SiNEG (Simulating Neuronal Electrophysiology and Genetics) Lab under Dr. Cengiz Günay's supervision aims to study seizure disorders in Drosophila using computational neuronal modeling. In this presentation, we will explain the fundamentals of computational neuroscience that are required to reach our primary goal. The main concepts needed include Ohm's Law, synaptic transmission, membrane conductance, and action potentials. We will explain each concept separately, then show how they are interlinked and work together.

THE GOAL

The goal of computational seizure models in Drosophila is to accurately model Drosophila aCC motor neurons.



TOPICS

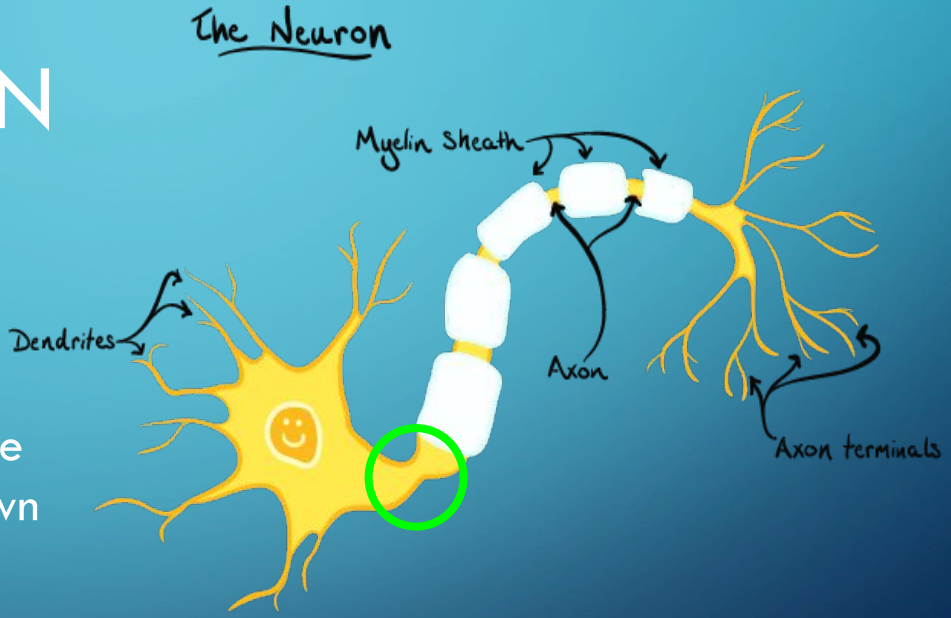
- Action Potentials
- Synaptic Transmission
- Membrane Conductance
- Ohm's Law

WHAT IS AN ACTION POTENTIAL?

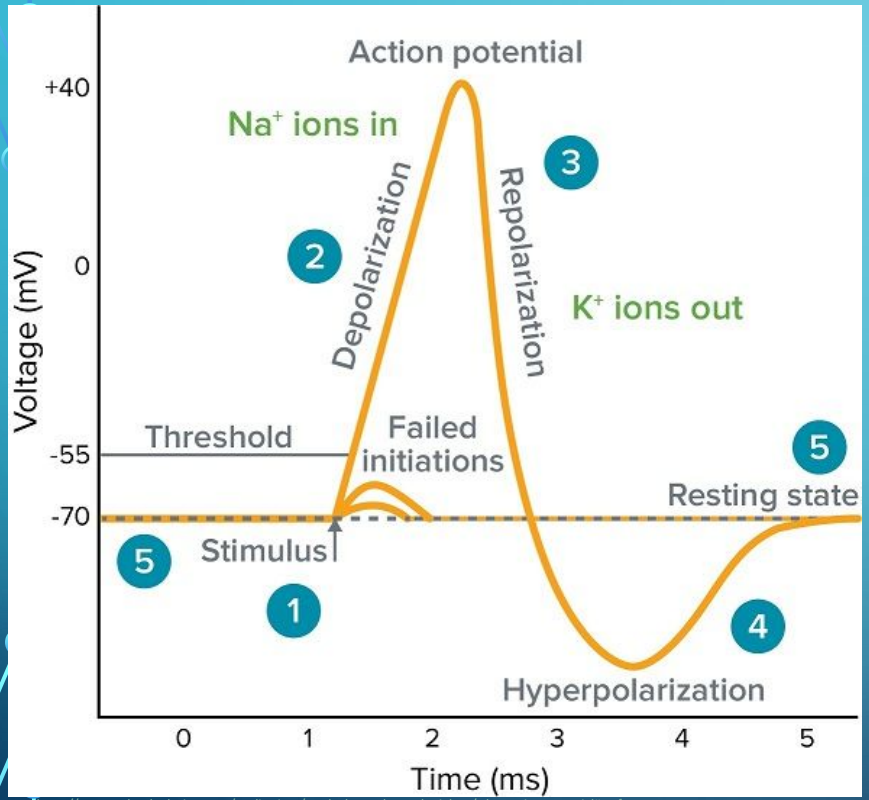
An action potential is the rapid rise and fall of voltage which causes depolarization inside of a neuron.

WHERE DO ACTION POTENTIALS ORIGINATE?

An action potential originates at the axon hillock, travels all the way down the axon, and ends at the axon terminal.



https://towardsdatascience.com/a-brief-introduction-to-computational-neuroscience-part-1-42171791f613



https://www.moleculardevices.com/applications/patch-clamp-electrophysiology/what-action-potential#gref

HOW DO ACTION POTENTIALS WORK?

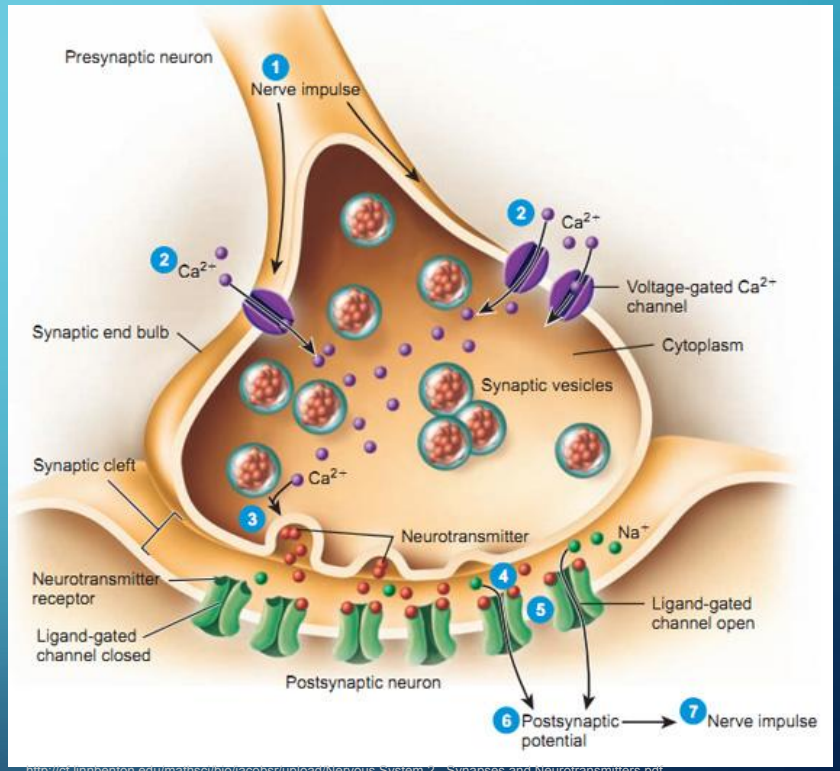
An action potential works in three phases:

1. Depolarization
2. Repolarization
3. Hyperpolarization

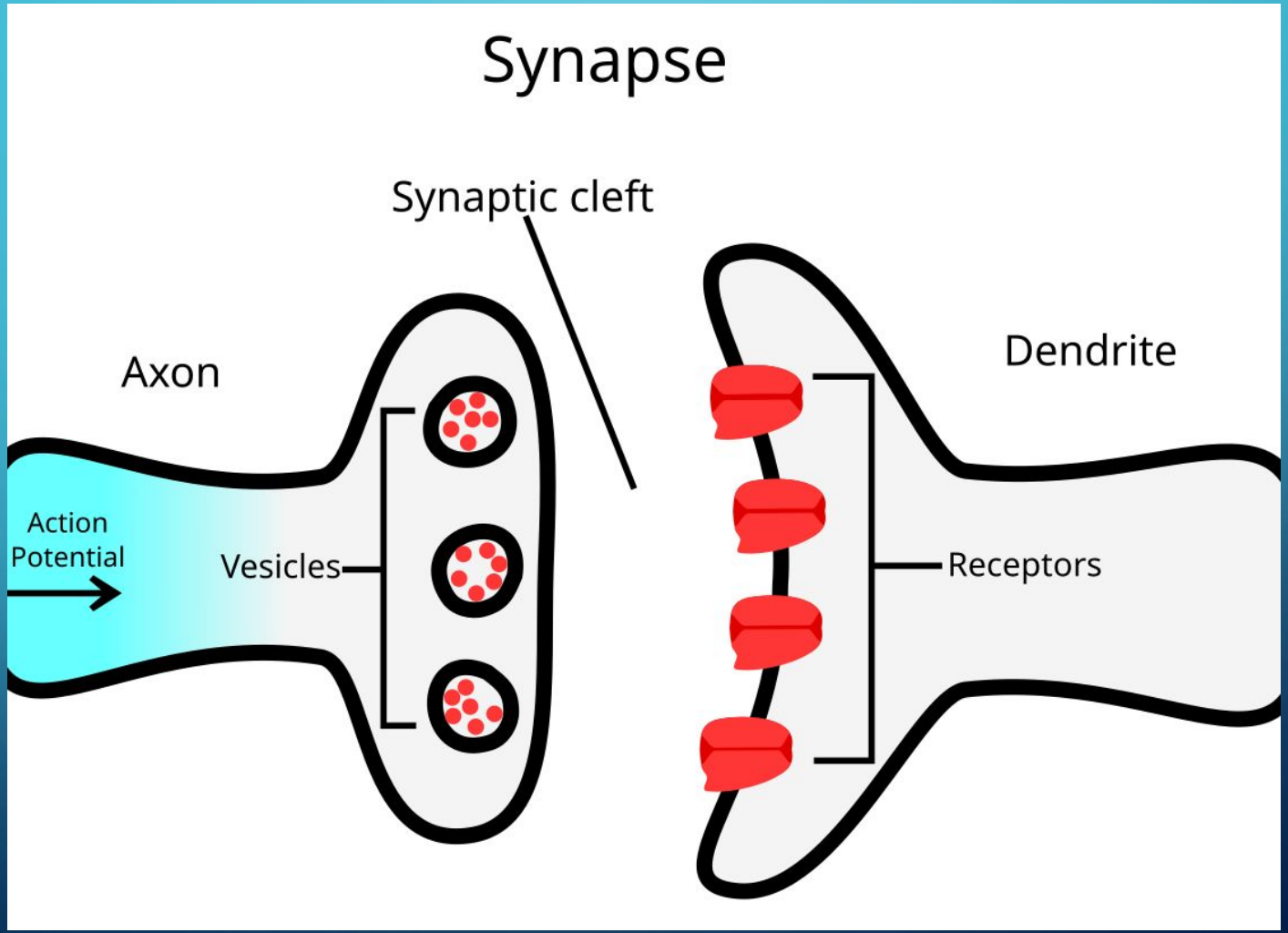
SYNAPTIC TRANSMISSION

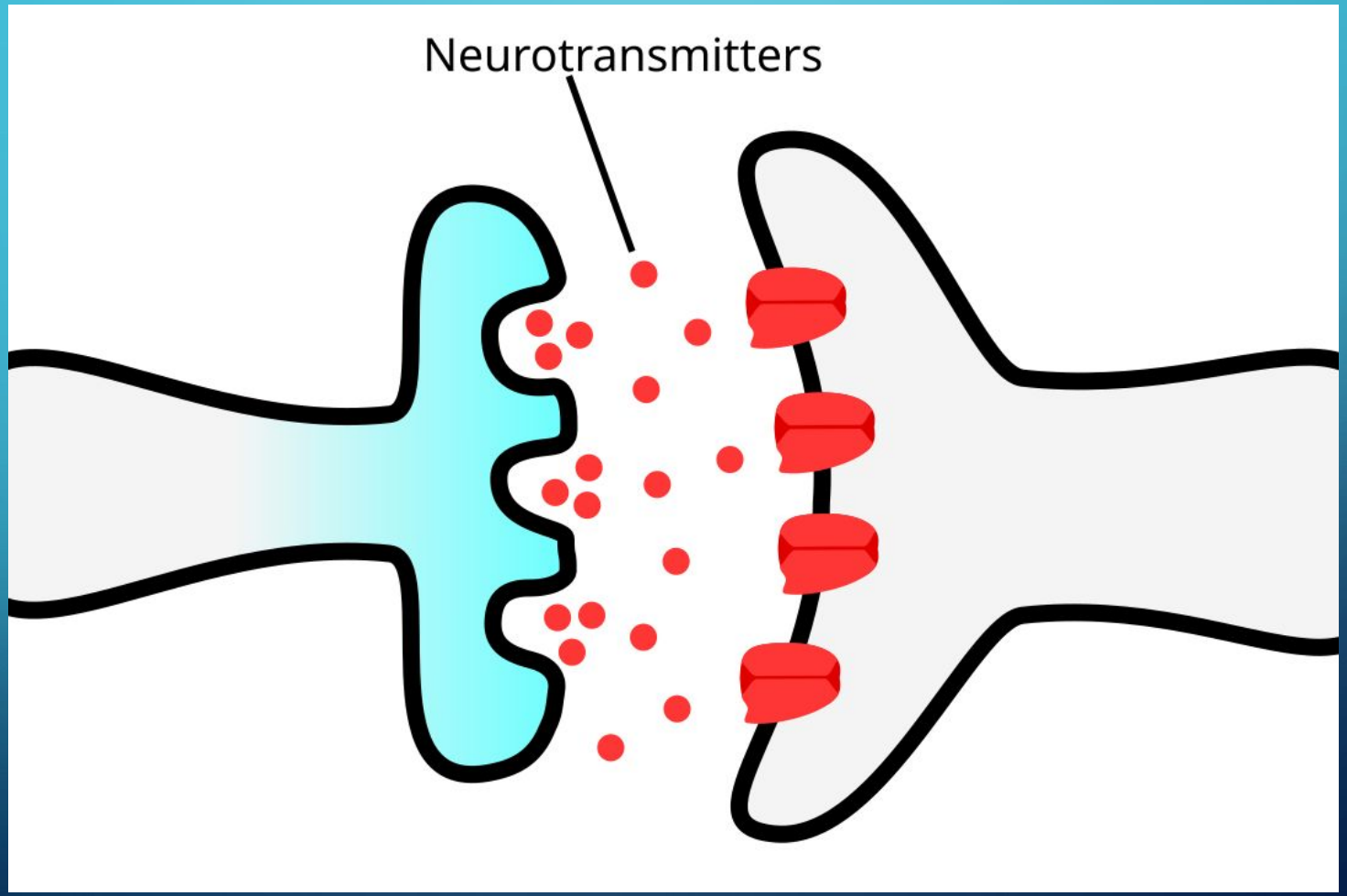
Synaptic transmission is the releasing of neurotransmitters from the synapse of one neuron to the receptor sites of the neighboring dendrite.

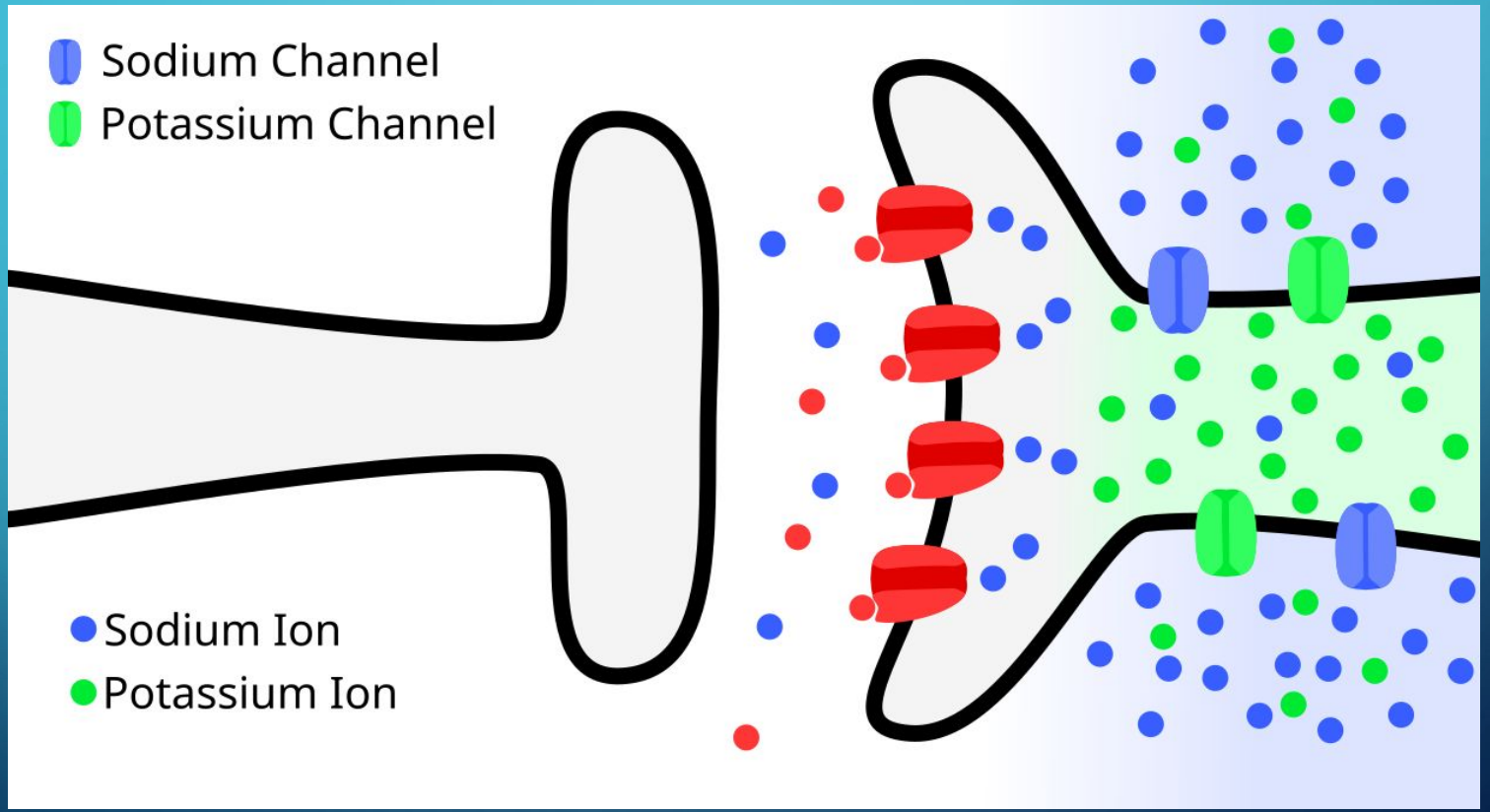
This cause an action potential in the neighboring receiving neuron

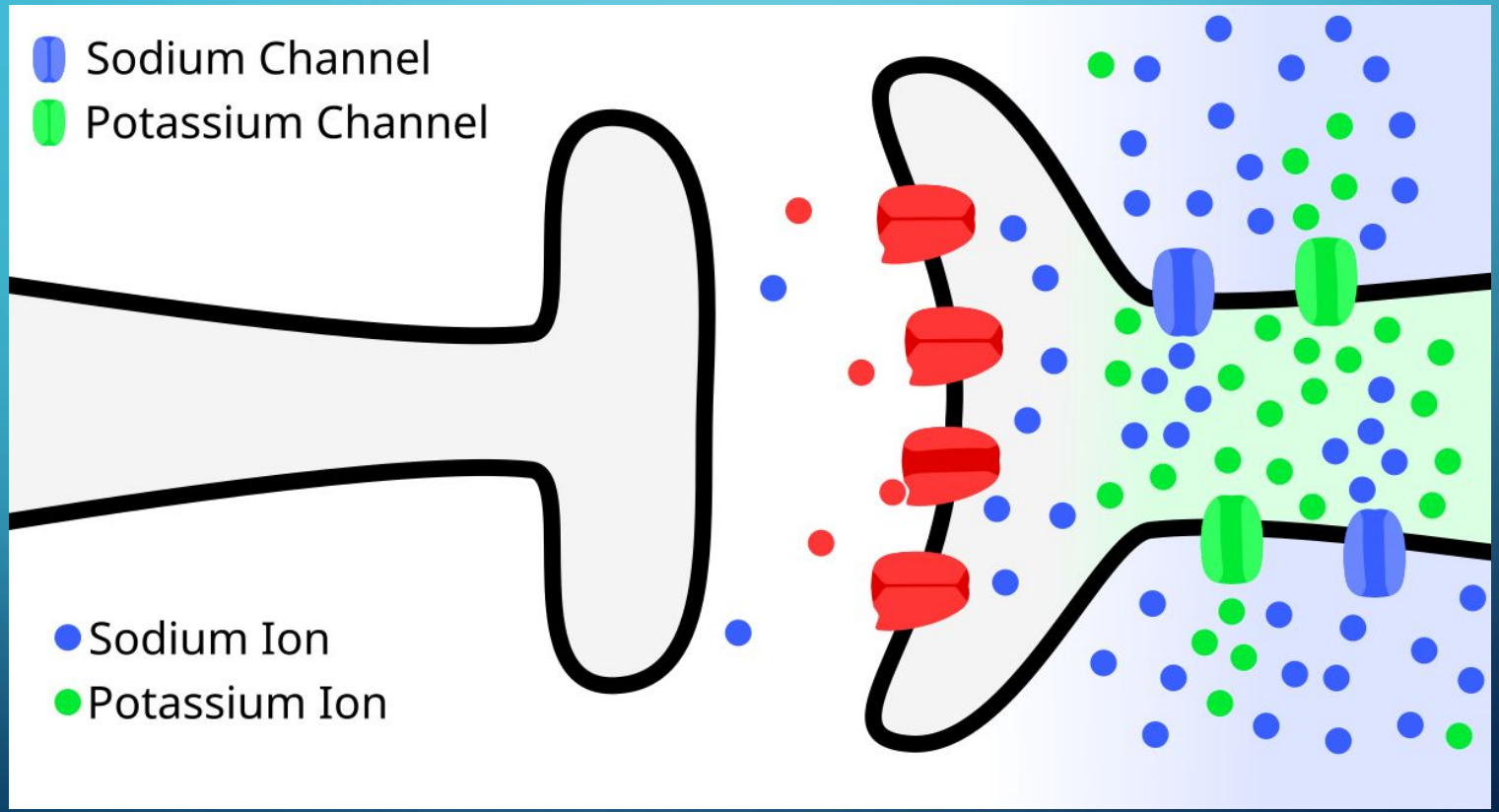


http://cf.linnbenton.edu/mathsci/bio/jacobsr/upload/Nervous System 2 - Synapses and Neurotransmitters.pdf


Synapse
Synaptic cleft
Axon
Dendrite
Action Potential
Vesicles
Receptors


Neurotransmitters


Sodium Channel
Potassium Channel
Sodium Ion
Potassium Ion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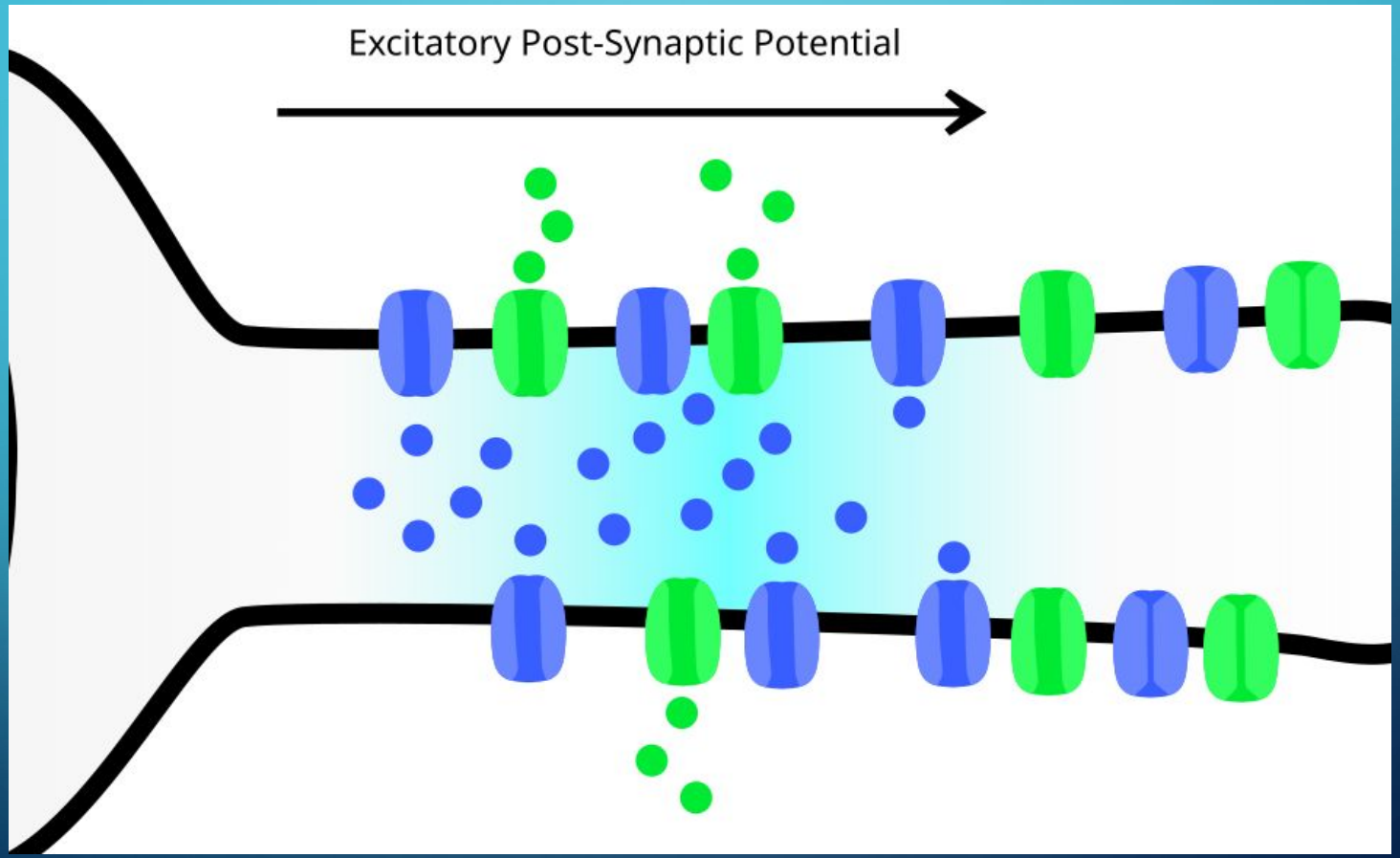
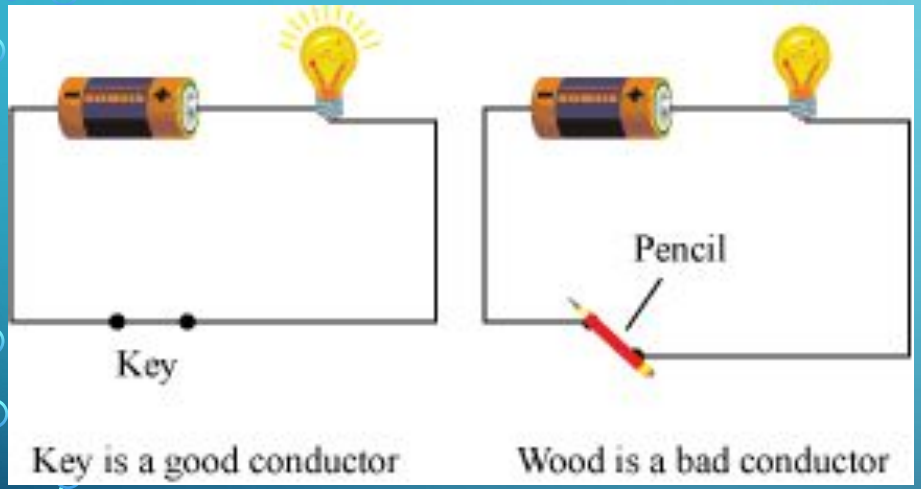

Excitatory Post-Synaptic Potential

MEMBRANE CONDUCTANCE



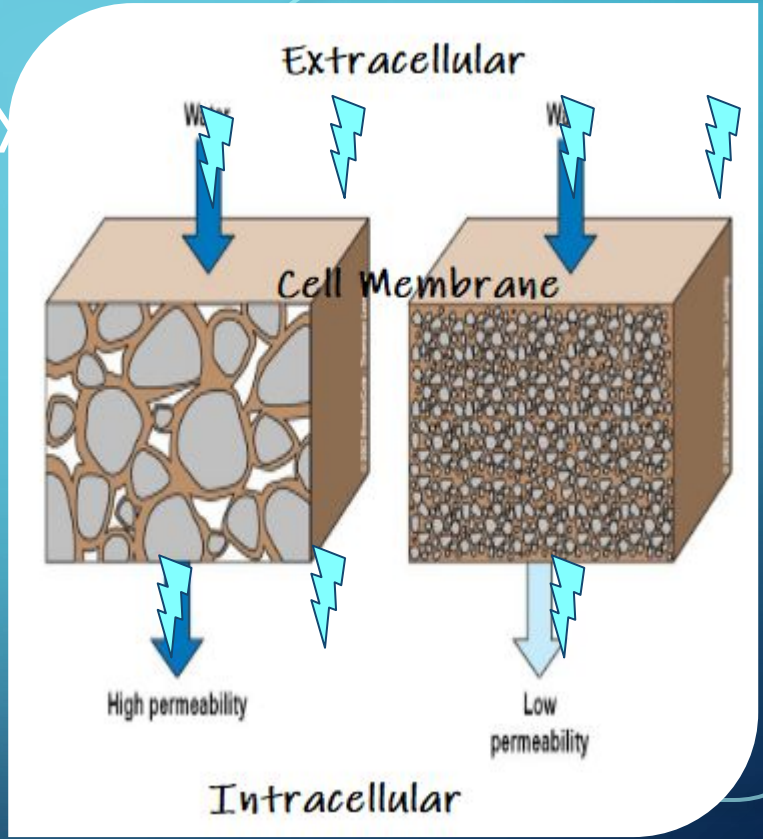
Conductance

The ease of an electrical current to flow through a path.

https://www.online-sciences.com/the-electricity/the-electric-conductivity-of-substances-and-life-application-on-it/

Membrane Permeability

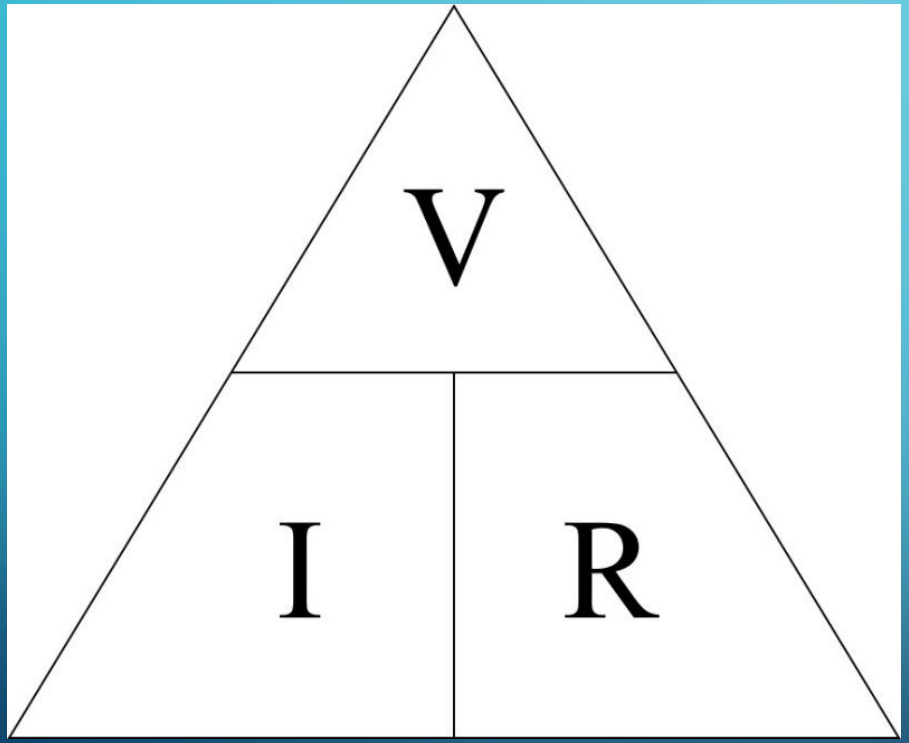
- Membrane permeability is the rate of passive movement of molecules (charge/ current).
- A high membrane permeability increases the membranes conductance.



Conductance + Membrane Permeability

= Membrane Conductance

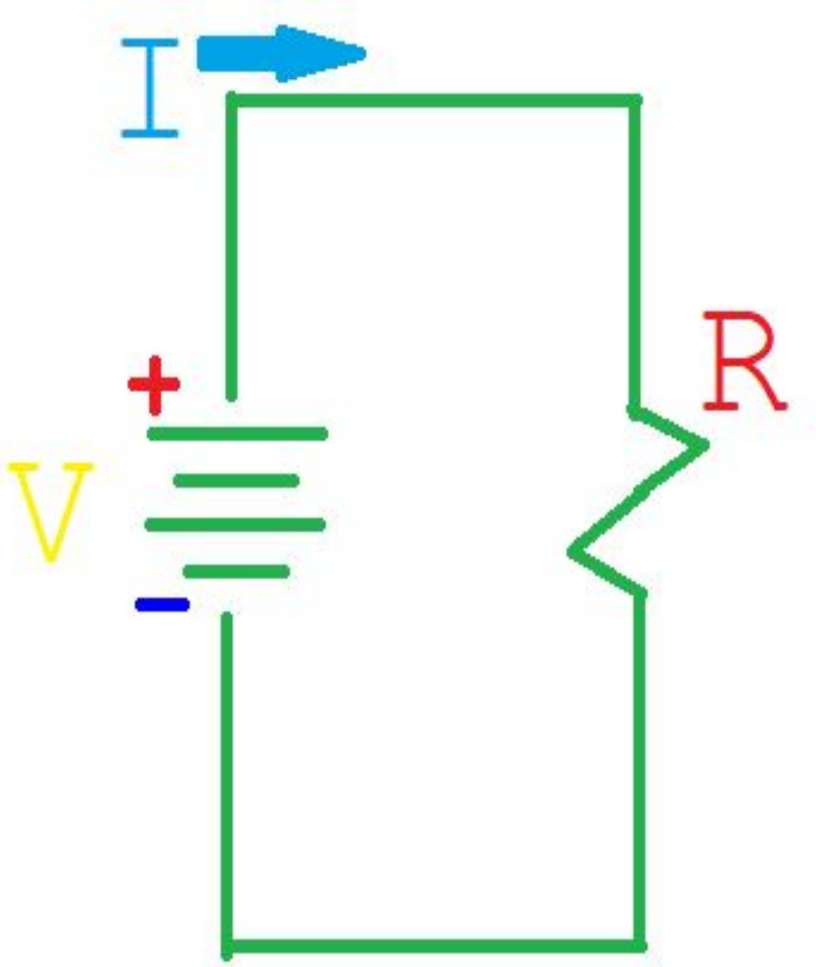
OHM'S LAW



WHAT IS OHM'S LAW?

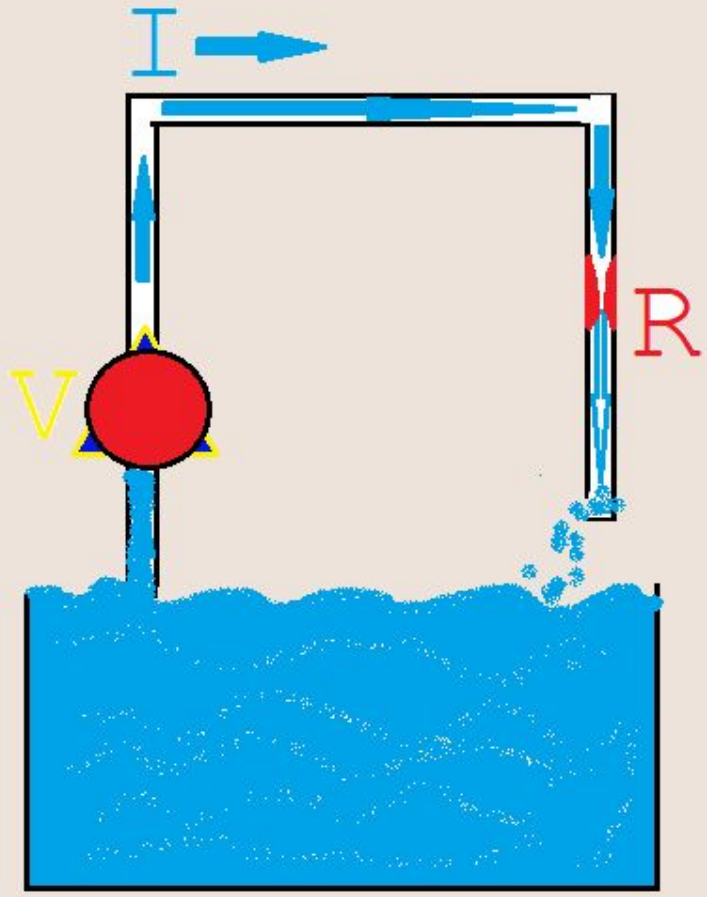
HOW THEY RELATE

- If Voltage increases, then Current increases.
- If Resistance increases, then Current decreases.

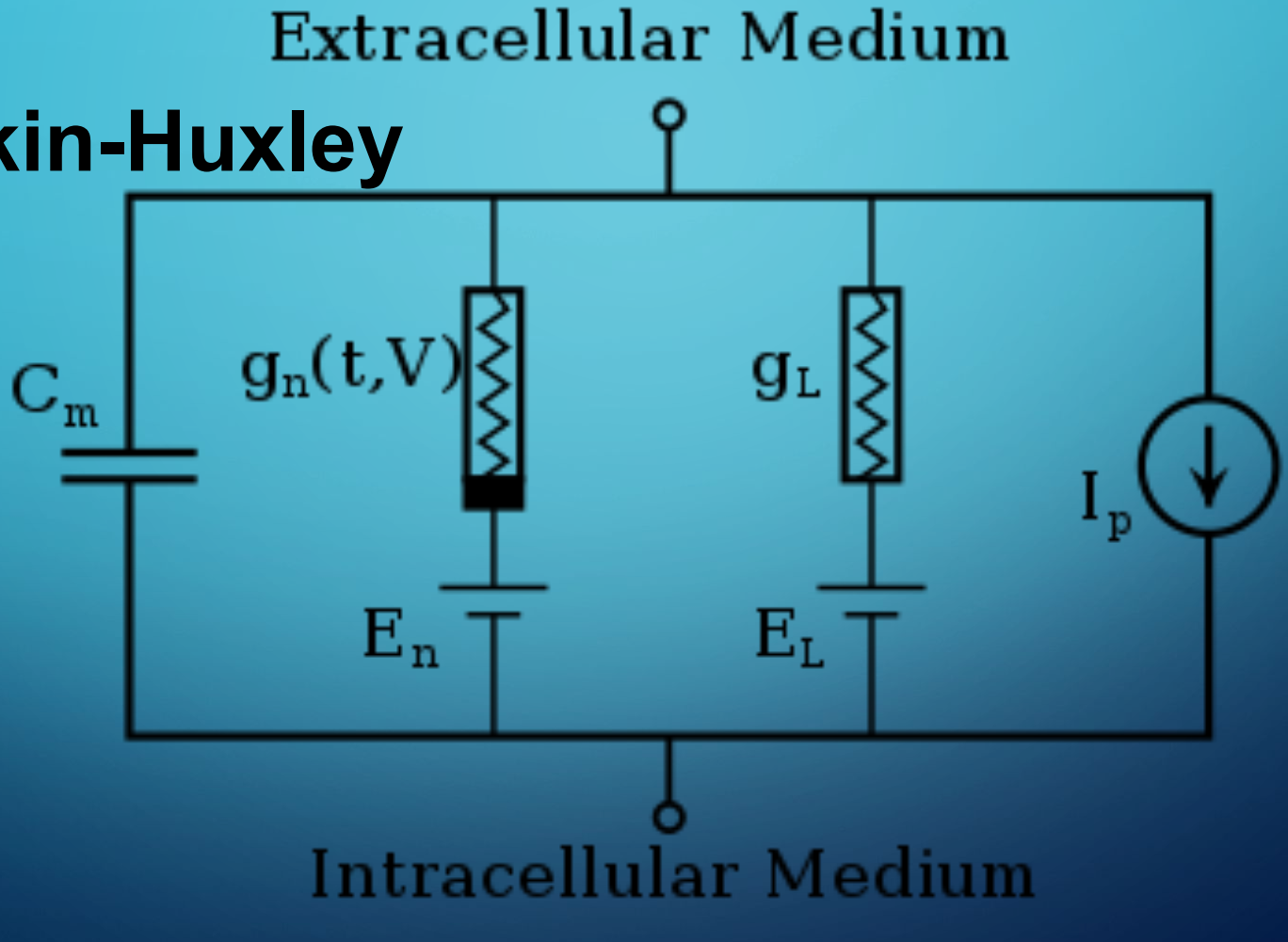


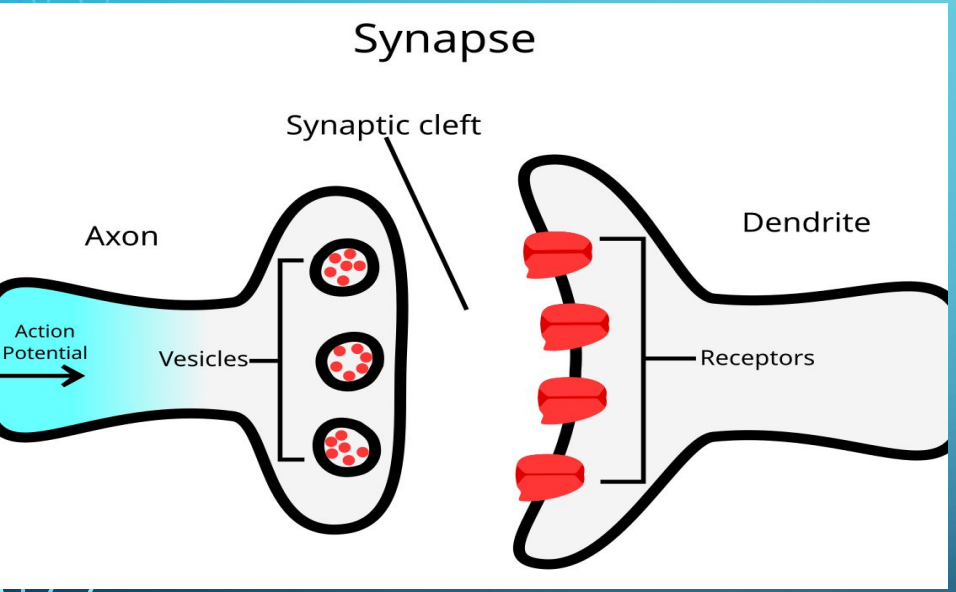
WATER TANK ANALOGY

- Pressure at the end of the hose: voltage
- Water in the tank: charge
- The more water in the tank, the higher the charge, the more pressure is measured at the end of the hose



Hodgkin-Huxley Model

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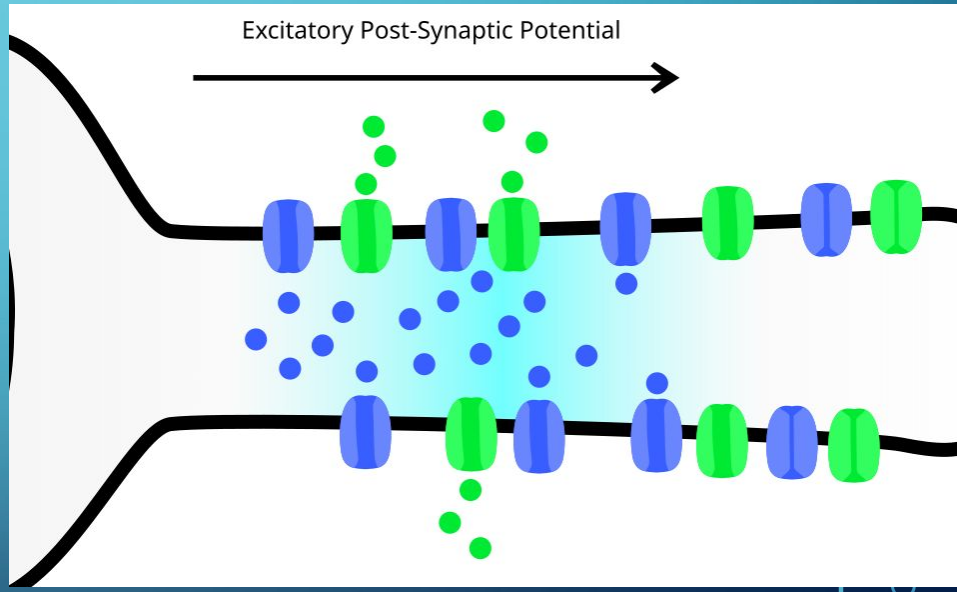
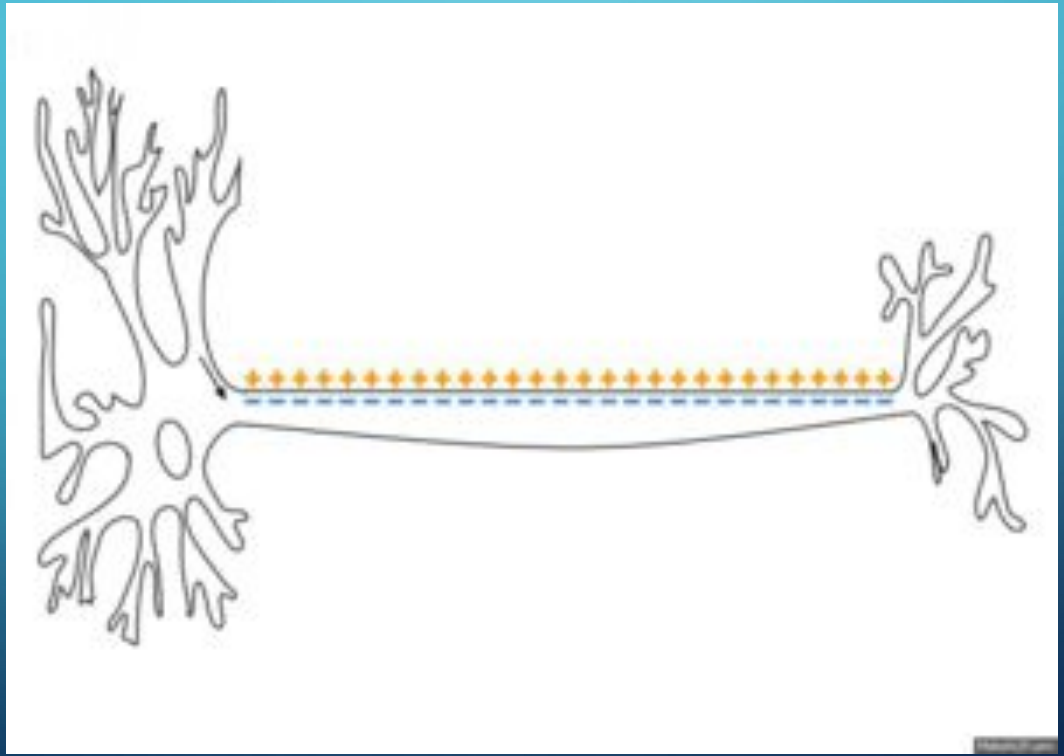

Excitatory Post-Synaptic Potential

Action Potential Animation



https://gifer.com/en/3p4G

REFERENCES

- http://neuroscience.pitt.edu/
- https://www.khanacademy.org/test-prep/mcat/organ-systems/neuron-membrane-potentials/a/neuron-action-potentials-the-creation-of-a-brain-signal
- https://teaching.ncl.ac.uk/bms/wiki/index.php/Synaptic_transmission
- https://www.tutor2u.net/psychology/topics/synaptic-transmission#:~:text=Synaptic%20transmission%20is%20the%20process,impulse%20known%20as%20action%20potential.&text=When%20the%20electrical%20impulse%20(action,release%20their%20contents%20of%20neurotransmitters.
- https://www.khanacademy.org/science/biology/human-biology/neuron-nervous-system/a/the-membrane-potential
- https://www.ncbi.nlm.nih.gov/books/NBK441875/figure/article-26142.image.f1/
- https://www.universetoday.com/82339/conductance/