University of Idaho

Membrane Neurophysiology

Overview of the Neuronal Membrane, Associated Ions, and Ion Channels

Psychology 372

Physiological Psychology

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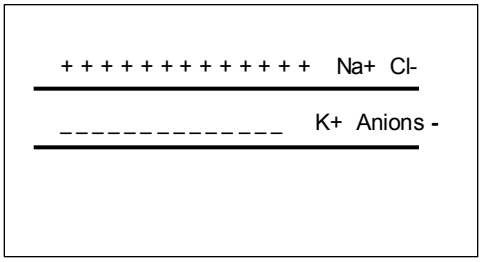
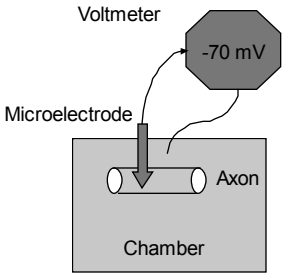
Structure of a Neuron at Rest



Measuring the Difference Between the Inside and Outside of a Neuron

- A axon from a giant squid is placed in seawater in a recording chamber.
- Glass microelectrode is inserted into axon.
  - **Voltage measures inside with respect to outside**



Resting Membrane Potential

- Is the difference in voltage between the inside and outside of the axon membrane.

Concept

- Influx Material (Ions) moving to the inside of a membrane.
- Efflux Material (Ions) moving from the inside to the outside of a membrane.
- Equilibrium
  - Where material (ions, concentrations, etc.) are equal on both sides of a membrane.

Why do Ion's Move?

- Concentration Differences
  - Compounds move from high concentrations to lower concentrations.
- Electrostatic Pressure
  - Like charges repel each other
  - Opposite charges attract each other.

Why is There a Resting State?

- The neuron membrane is selectively permeable to certain ions.
- Sodium Na+
- Potassium K +
- Chloride Cl –
- Calcium Ca++

Resting State

- At rest, K+ ions can leave the axon while few Na ions can enter the axon
- Causes the exterior of the nerve cell membrane to be more positive than the inside of the axon

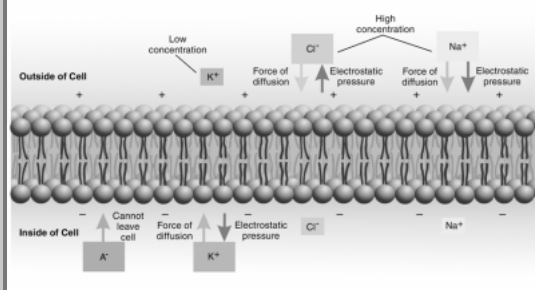
Result

- Have high concentrations of Na and Cl on the outside of the axon
- High concentrations of K and Anions on the inside of the axon.

Ion Concentrations at Rest

High Na+	High Cl-	Low K
High K+	Anions -	Low Na

Relative Ion Concentrations Across the Axon Membrane

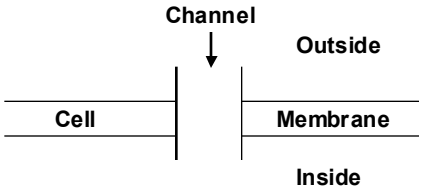


Channels

- Axons have two types of channels or pores for different ions.
  - Passive Channels
    - Are open all of the time and allow ions to pass through the membrane.
  - Voltage Gated Channels
    - Are activated by changes in voltage
    - E.g., voltage-gated Na channels

Passive

- Are open all the time



Passive

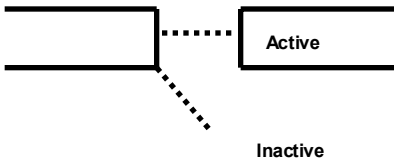
- Many K passive channels are open
- Some Na passive channels are also open
- Channels are ion selective.
  - Na channels are only selective for Na, K doesn't get through.
  - K channels are only selective for K, Na does not get through.
  - Ions also go through channels at different rates.
    - 12 K to 1 Na

Some ions are moving but not many. If lots of movement, you get equilibrium.

Voltage-Gated Channels

- Are needed for the action potential.
- Several types – Na, K, Ca
- Channels are ion specific
- Open at some level of depolarizaton, then inactive gate closes a bit later.
- After inactive gate closes, active gate closes, inactive gate then reopens.
- Repeat

Sodium Voltage Gated Channel



Active Gates are Usually Closed

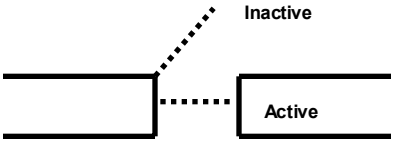
With Depolariztion, Active Gates open

Steps

- Get Depolarization
- If depolarize 15mV – Active gate opens
  - Sodium enters
  - Get an action potential
- If does not depolarize 15mV – Nothing

So, all or nothing is happening at the Axon Hillock.

Potassium Voltage Gated Channel



Active Gates are Usually Closed

With Depolariztion, Active Gates open

Points

- Like the Na Channel, the inactive gate is sluggish
- It takes awhile for them to close