Biomedical Instrumentation

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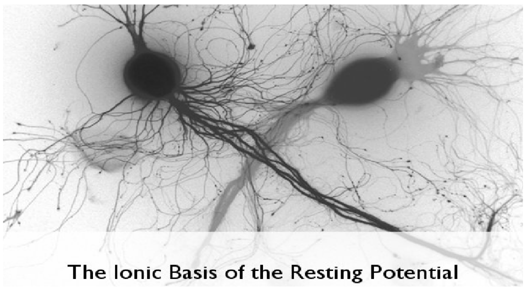
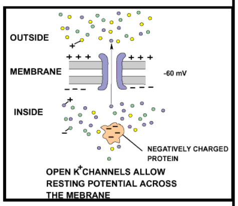
Bioelectric potentials

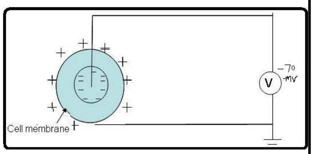


RESTING POTENTIAL-BASIC CONCEPT

- Cell membranes are typically permeable to only a subset of ionic species like pottasium(K+),Chloride(Cl-) & effectively blocks the entry of sodium(Na+) ions.
- The various ions seeks a balance between inside & outside the cell according to concentration & electric charge.
- Two effects result from inability of Na+ ions to penetrate membrane-
- Concentration of Na+ ions inside cell is much lower than outside. Hence,outside of cell becomes more positive than inside.
- In an attempt to to balance electric charge,additional K+ ions enters the cell,causing higher concentration of K+ ion inside the cell.
- Charge balance can never be reached.
- Equilibrium is reached with a potential difference across the membrane, negative on inside and positive on outside called Resting Potential.

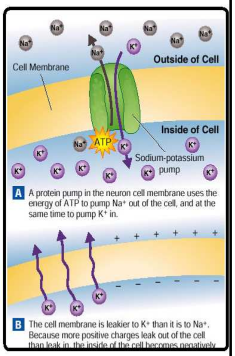


Polarized Cell during RP →

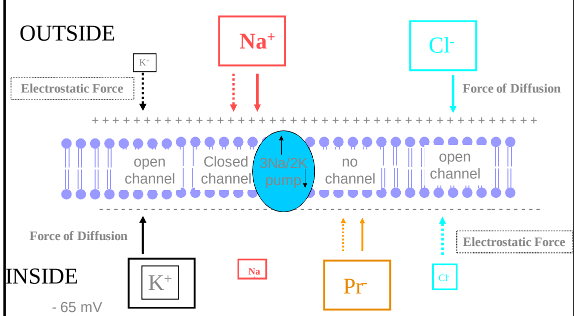


RESTING POTENTIAL IN NERVE CELL

- A nerve cell has an electrical potential, or voltage, across its cell membrane of approximately 70 millivolts (mV). This means that this tiny cell produces a voltage roughly equal to 1/20th that of a flashlight battery (1.5 volts).
- The potential is produced by the actions of a cell membrane pump, powered by the energy of ATP.
- As shown in Figure, this membrane protein forces sodium ions (Na+) out of the cell, and pumps potassium ions (K+) in. As a result of this active transport, the cytoplasm of the neuron contains more K+ ions and fewer Na+ ions than the surrounding medium. However, the neuron cell membrane is much leakier to K+ than it is to Na+. As a result, K+ ions leak out of the cell to produce a negative charge on the inside of the membrane.
- This charge difference is known as the Resting Potential of the neuron. The neuron is not actually "resting" because it must produce a constant supply of ATP to fuel active transport.



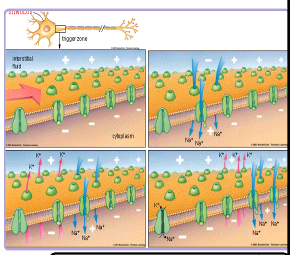
RESTING POTENTIAL PROPOGATION



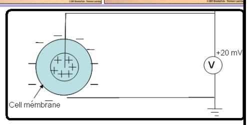
K^+ = Potassium; Na^+ = Sodium; Cl^- = Chloride; Pr^- = proteins

ACTION POTENTIAL-BASIC CONCEPT

- When section of cell membrane is excited by some form of externally applied energy, membrane characteristics changes & begins to allow some sodium ions to enter.
- This movement of Na+ ions constitutes an ionic current that further reduces the barrier of the membrane to Na+ ions.
- Result-Avalanche effect, Na+ ions rush into the cell to balance with the ions outside .
- At the same time K+ ions which were in higher concentration inside the cell during resting state, try to leave the cell but are unable to move as rapidly as Na+ ions.
- As a result the cell has slightly positive potential on inside due to imbalance of K+ ions.
- This potential is called as Action Potential .

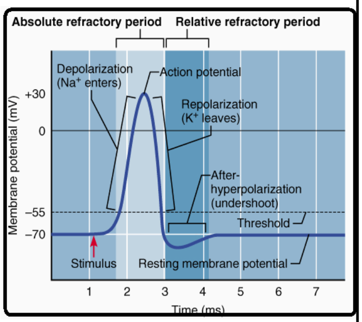


Depolarized cell during AP →



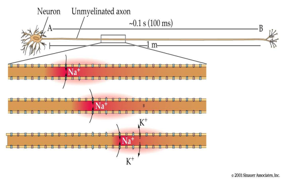
WAVEFORM SHOWING DEPOLARIZATION & REPOLARIZATION IN ACTION POTENTIAL

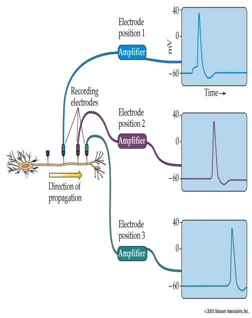
- The cell that displays an action Potential is said to be depolarized;
- The process of changing from resting state to action potential is called Depolarization.
- Once the rush of Na+ ions through the cell membrane has stopped, the membrane reverts back to its original condition wherein the passage of Na+ ions from outside to inside is blocked
- This process is called Repolarization.



ACTION POTENTIAL PROPOGATION

- **It "travels" down the axon**
  - Actually, it does not move. Rather the potential change resulting from Na+ influx disperses to the next voltage-gated channel, triggering another action potential there.





PROPOGATION OF POTENTIALS IN NERVE IMPULSE

- The Moving Impulse

  An impulse begins when a neuron is stimulated by another neuron or by the environment. Once it begins, the impulse travels rapidly down the axon away from the cell body and towards the axon terminals.
- As **Figure** shows, an impulse is a sudden reversal of the membrane potential. *What causes the reversal?*

  The neuron membrane contains thousands of protein channels or gates, that allow ions to pass through. Generally, these gates are closed. At the leading edge of an impulse, however, sodium gates open, allowing positively charged Na+ ions to flow inside. The inside of the membrane temporarily becomes more positive than the outside, reversing the resting potential. This reversal of charges is called an Action Potential. As the action potential, potassium gates open, allowing positively charged K+ ions to flow out. This restores the Resting Potential so that the neuron is once again negatively charged on the inside of the cell membrane and positively charged on the outside.
- A nerve impulse is *self-propagating.*

  That is, an impulse at any point on the membrane causes an impulse at the next point along the membrane. We might compare the flow of an impulse to the fall of a row of dominoes. As each domino falls, it causes its neighbour to fall. Then, as the impulse passes, the dominoes set themselves up again, ready for another Action Potential.