Section B1: The Nature Of Nerve Signals

1. Every cell has a voltage, or membrane potential, across its plasma membrane
2. Changes in the membrane potential of a neuron give rise to nerve impulses
3. Nerve impulses propagate themselves along an axon
1. Every cell has a voltage, or membrane potential, across its plasma membrane

- A **membrane potential** is a localized electrical gradient across membrane.
  - Anions are more concentrated within a cell.
  - Cations are more concentrated in the extracellular fluid.
• Measuring Membrane Potentials.

Fig. 48.6a

• An unstimulated cell usually have a resting potential of -70mV.
• How a Cell Maintains a Membrane Potential.

• Cations.
  • K\(^+\) the principal intracellular cation.
  • Na\(^+\) is the principal extracellular cation.

• Anions.
  • Proteins, amino acids, sulfate, and phosphate are the principal intracellular anions.
  • Cl\(^-\) is principal extracellular anion.
• **Ungated ion channels** allow ions to diffuse across the plasma membrane.

• These channels are always open.

• This diffusion does not achieve an equilibrium since sodium-potassium pump transports these ions against their concentration gradients.

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**Fig. 48.7**

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2. Changes in the membrane potential of a neuron give rise to nerve impulses

- **Excitable cells** have the ability to generate large changes in their membrane potentials.
  - **Gated ion channels** open or close in response to stimuli.
    - The subsequent diffusion of ions leads to a change in the membrane potential.
Types of gated ions.

- **Chemically-gated ion channels** open or close in response to a chemical stimulus.

- **Voltage-gated ion channels** open or close in response to a change in membrane potential.
• Graded Potentials: Hyperpolarization and Depolarization
  • **Graded potentials** are changes in membrane potential
• Hyperpolarization.

• Gated $K^+$ channels open $\rightarrow$ $K^+$ diffuses out of the cell $\rightarrow$ the membrane potential becomes more negative.
• **Depolarization.**

  • Gated Na\(^+\) channels open → Na\(^+\) diffuses into the cell → the membrane potential becomes less negative.

![Fig. 48.8b](image-url)
• The Action Potential: All or Nothing Depolarization.

  • If graded potentials sum to ≈-55mV a **threshold potential** is achieved.

    • This triggers an **action potential**.

    • Axons only.

Fig. 48.8c
• In the resting state closed voltage-gated $K^+$ channels open slowly in response to depolarization.

• Voltage-gated $Na^+$ channels have two gates.
  • Closed activation gates open rapidly in response to depolarization.
  • Open inactivation gates close slowly in response to depolarization.
• Step 1: Resting State.
• Step 2: Threshold.
• Step 3: **Depolarization** phase of the action potential.
• Step 4: Repolarizing phase of the action potential.

Fig. 48.9
• Step 5: Undershoot.
• During the undershoot both the Na\(^+\) channel’s activation and inactivation gates are closed.
  • At this time the neuron cannot depolarize in response to another stimulus: **refractory period**.
3. Nerve impulses propagate themselves along an axon

- The action potential is repeatedly regenerated along the length of the axon.
  - An action potential achieved at one region of the membrane is sufficient to depolarize a neighboring region above threshold.
    - Thus triggering a new action potential.
    - The refractory period assures that impulse conduction is unidirectional.
• **Saltatory conduction.**
  
  • In myelinated neurons only unmyelinated regions of the axon depolarize.
  
  • Thus, the impulse moves faster than in unmyelinated neurons.

*Fig. 48.11*