RESTING MEMBRANE POTENTIAL & ACTION POTENTIAL

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1. RESTING MEMBRANE POTENTIAL (RMP)

1.1 Definition

Resting Membrane Potential (RMP) is the **electrical potential difference** across the cell membrane when the cell is **not actively sending signals**.

It represents the **baseline electrical charge** of a neuron or muscle cell at rest.

Typical value: Approximately **–70 millivolts (mV)** in neurons.

The **inside of the cell is more negative** than the outside.

1.2 Ionic Distribution

At rest, ions are **unevenly distributed** across the cell membrane:

Location	Sodium (Na^+)	Potassium (K^+)
Inside Cell	Low	High
Outside Cell	High	Low

Other intracellular ions: **Negatively charged proteins and anions** also contribute to the negative internal charge.

1.3 Mechanism of RMP Maintenance

1. Sodium-Potassium Pump (Na^+/K^+ ATPase)

Active transport mechanism that uses ATP.

Pumps:

3 Na^+ out of the cell.

2 K^+ into the cell.

Creates and maintains the **electrochemical gradient**.

2. Selective Membrane Permeability

The **cell membrane is more permeable to K^+** than Na^+.

K^+ tends to **leak out**, but negative proteins remain inside.

Result: **Inside becomes more negative** compared to the outside.

Combined Effect

RMP is established due to:

Active ion pumping (Na^+/K^+ ATPase).

Passive ion movement through leak channels.

1.4 Importance in Stimulation

RMP is **critical for excitability**.

Sets the stage for **depolarization**, which is needed to initiate an **action potential**.

Without RMP, **nerve and muscle cells cannot respond** to stimuli.

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2. ACTION POTENTIAL (AP)

2.1 Definition

An **Action Potential** is a **brief, rapid, and self-propagating electrical event** in which the membrane potential reverses (becomes positive inside) and then restores.

Enables **signal transmission** in nerves and muscle fibers.

2.2 Phases of Action Potential

Phase	Events
Resting Phase	- Cell at –70 mV. - Na^+ and K^+ channels are closed. - RMP maintained.
Depolarization	- Stimulus causes **Na^+ channels to open**. - **Na^+ rushes into** the cell. - Inside becomes **positive (~+30 mV)**.
Repolarization	- **Na^+ channels close**, **K^+ channels open**.

Phase	Events
	- **K^+ exits** the cell. - Membrane potential returns to **negative**.
Hyperpolarization	- **Excess K^+ leaves**, overshooting RMP. - Membrane potential may drop to **–80 to –90 mV**. - **Na^+/K^+ pump restores RMP**.

2.3 Threshold Potential

The **minimum membrane potential** required to initiate an action potential.

Typically around **–55 mV**.

If threshold is not reached → **no action potential** occurs.

2.4 All-or-None Principle

An action potential either **occurs completely or not at all**.

Once threshold is reached:

Full depolarization happens.

Cannot be stopped midway.

Stimulus **stronger than threshold** does not increase the strength of AP — only frequency of firing may increase.

2.5 Refractory Periods

After an AP, the cell undergoes recovery phases during which **firing is limited or impossible**.

1. Absolute Refractory Period

No new action potential can be generated, no matter the strength of the stimulus.

Occurs during:

Late depolarization.

Most of repolarization.

Due to inactivation of Na^+ channels.

2. Relative Refractory Period

A stronger-than-normal stimulus can trigger a new action potential.

Occurs during:

Late repolarization and hyperpolarization.

Na^+ channels start to recover.

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3. CLINICAL AND FUNCTIONAL RELEVANCE

3.1 In Nerve Stimulation (e.g., TENS, NMES)

External current can **alter RMP**, bringing it to threshold and triggering an AP.

Devices are designed to target:

Sensory nerves (for pain relief).

Motor nerves (for muscle activation).

3.2 In Muscle Contraction

AP travels down **motor neurons**, triggering **acetylcholine release** at neuromuscular junction.

Leads to **muscle fiber depolarization** and **contraction**.

3.3 In Pharmacology and Pathology

Certain drugs alter Na^+ or K^+ channel function (e.g., **local anesthetics** block Na^+ channels → no AP).

Diseases like **multiple sclerosis** disrupt AP conduction due to **myelin damage**.

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4. SUMMARY TABLE: RMP vs. AP

Feature	Resting Membrane Potential (RMP)	Action Potential (AP)
State	Cell at rest	Cell excited/stimulated
Typical Value	–70 mV	Peaks at +30 mV
Ion Movement	K^+ leaks out	Na^+ in (depolarization), K^+ out (repolarization)
Pump Involved	Na^+/K^+ ATPase maintains it	Na^+/K^+ ATPase restores after AP
Stimulus Requirement	Not required	Requires threshold stimulus
Function	Maintains readiness for response	Enables signal transmission