Department of Aesthetic and Laser Techniques
Medical Physiology lec2: plasma membrane
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Lecture3: Medical Physiology

Cellular membrane potential

BY

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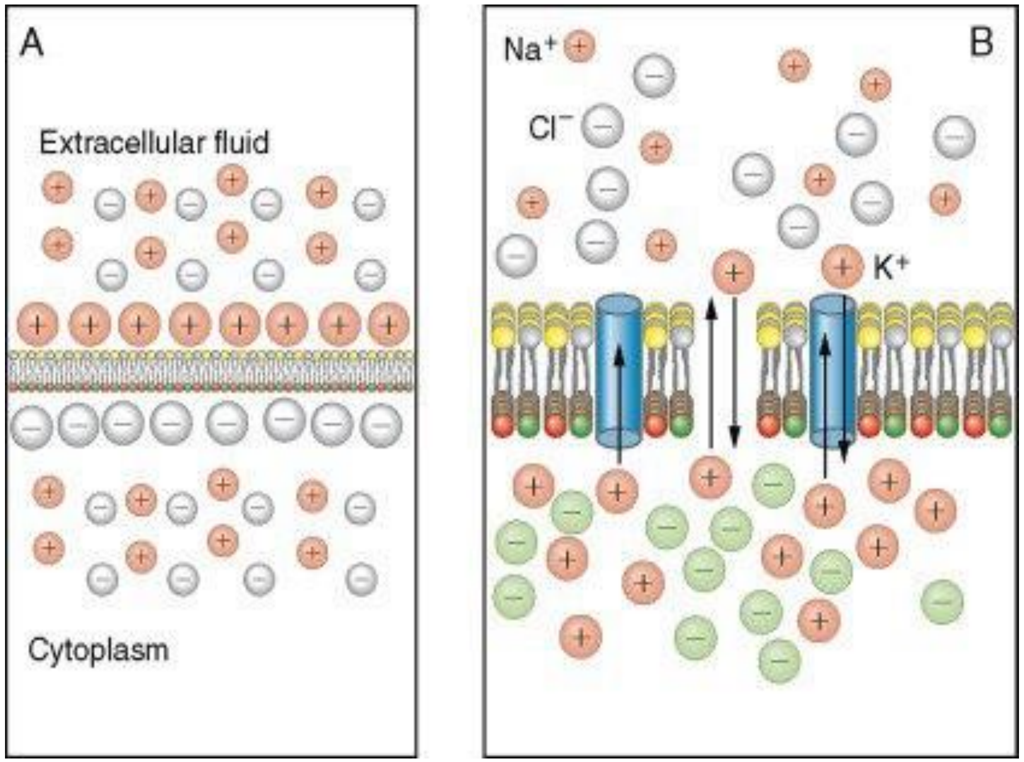
Learning Objectives

By the end of this lecture, students should be able to:

1. Define cellular membrane potential
2. Key components that generate membrane potential
3. Action potential.

The membrane potential

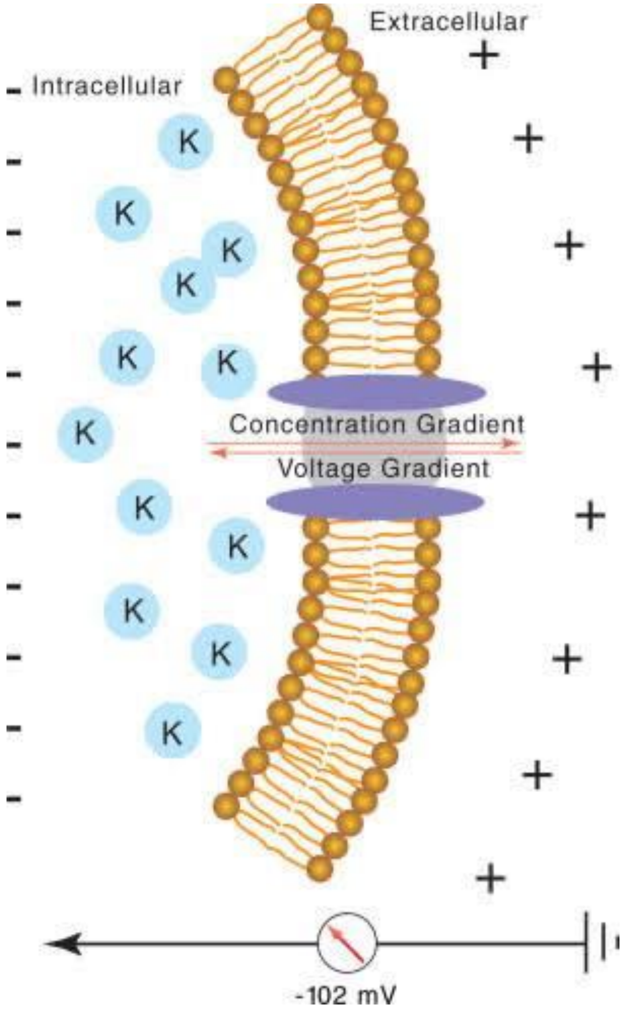
- Is the difference in electrical charge across a cell's plasma membrane,
- resulting from an unequal distribution of ions inside versus outside the cell.
- This voltage difference is fundamental to all cells and is especially crucial for **excitable cells like neurons and muscle cells**, which use rapid, controlled changes in membrane potential to generate electrical signals.



Key components that generate membrane potential

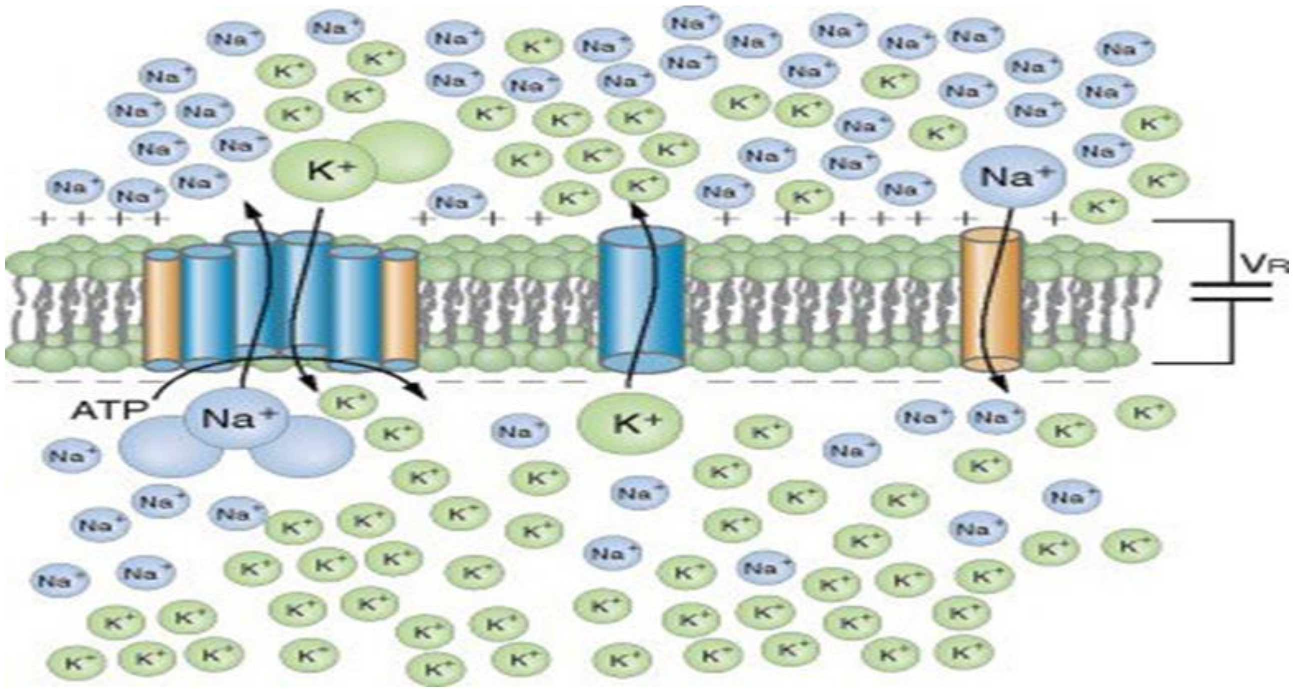
1. Ion concentration gradients: In a typical neuron, sodium (Na+) and chloride (Cl−) ions are more concentrated outside the cell, while potassium (K+) and large, negatively charged proteins (organic anions) are more concentrated inside.

2. Selective permeability: The cell membrane, **a lipid bilayer**, is naturally resistant to ions. However, embedded protein channels provide specific pathways for ions to cross the membrane.



3. Sodium-potassium (Na+ /K +) pump: This actively transports ions against their concentration gradients, using ATP for energy. It pumps three **Na+ ions out** of the cell for every **two K+ ions** it pumps in.

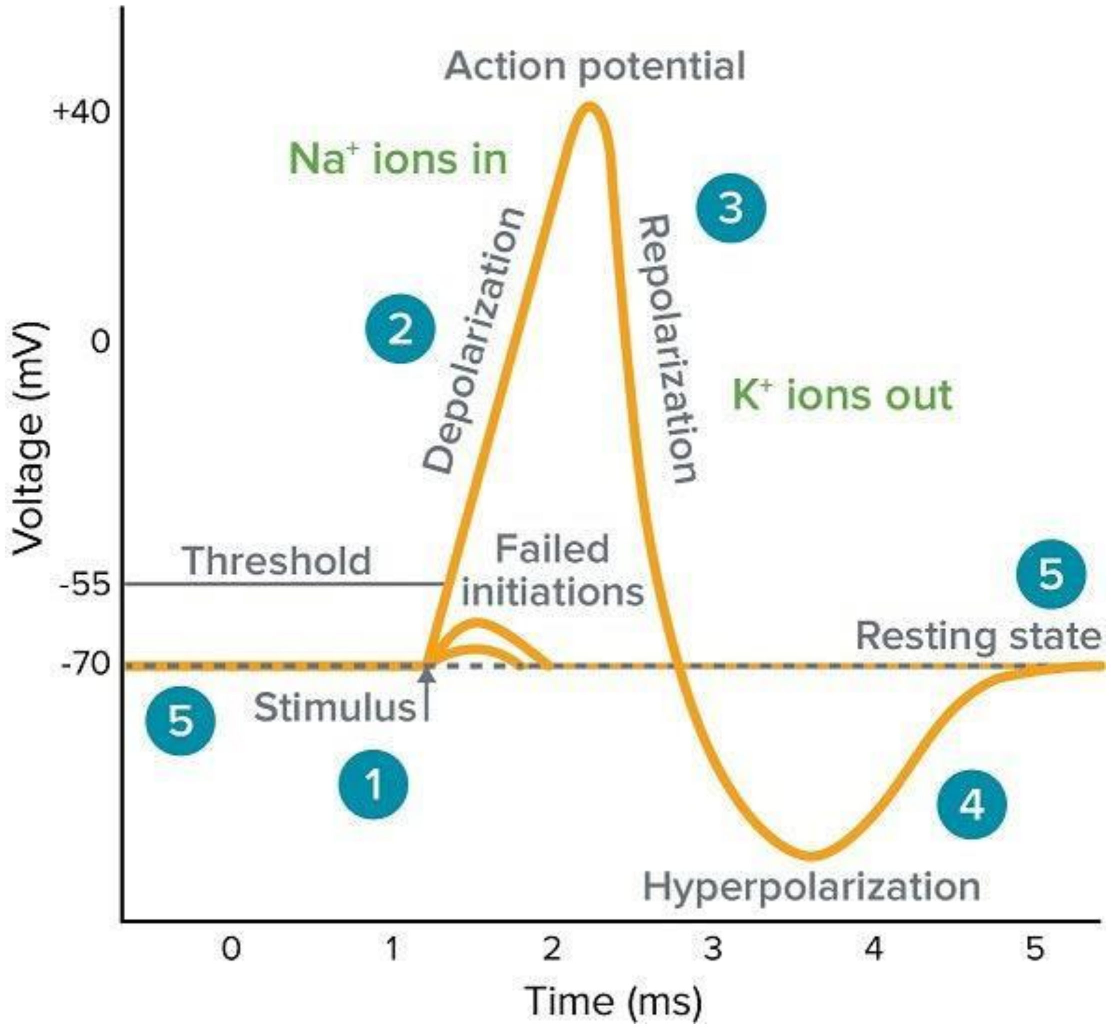
4. Potassium leak channels: At rest, the membrane is far more permeable to K+ than to Na+ due to a greater number of open potassium leak channels. This allows K+ to exit the cell, making the inside more negative.



States of membrane potential in excitable cells (nerve and muscle cells)

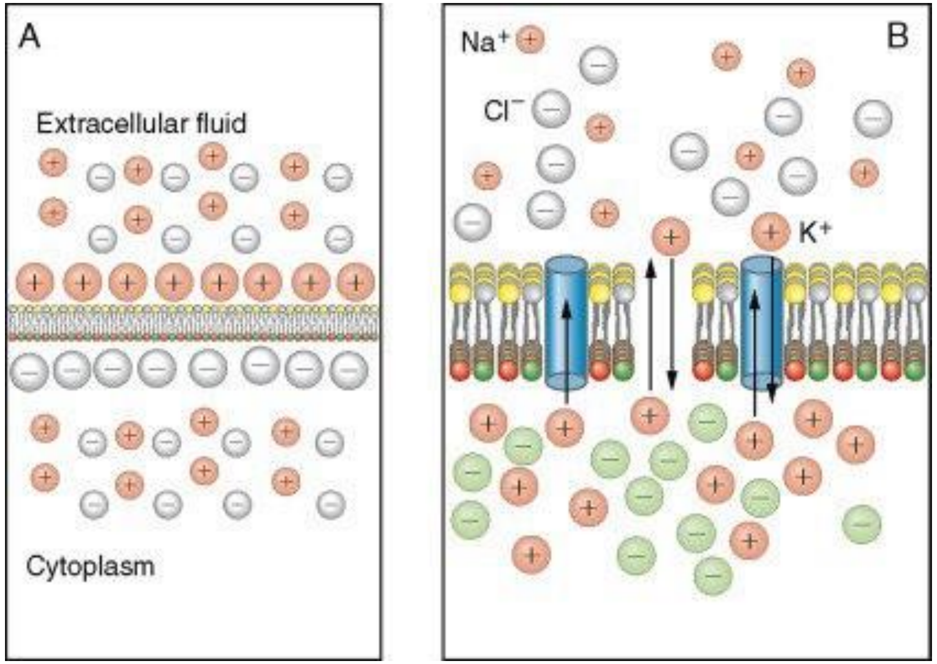
Resting potential:

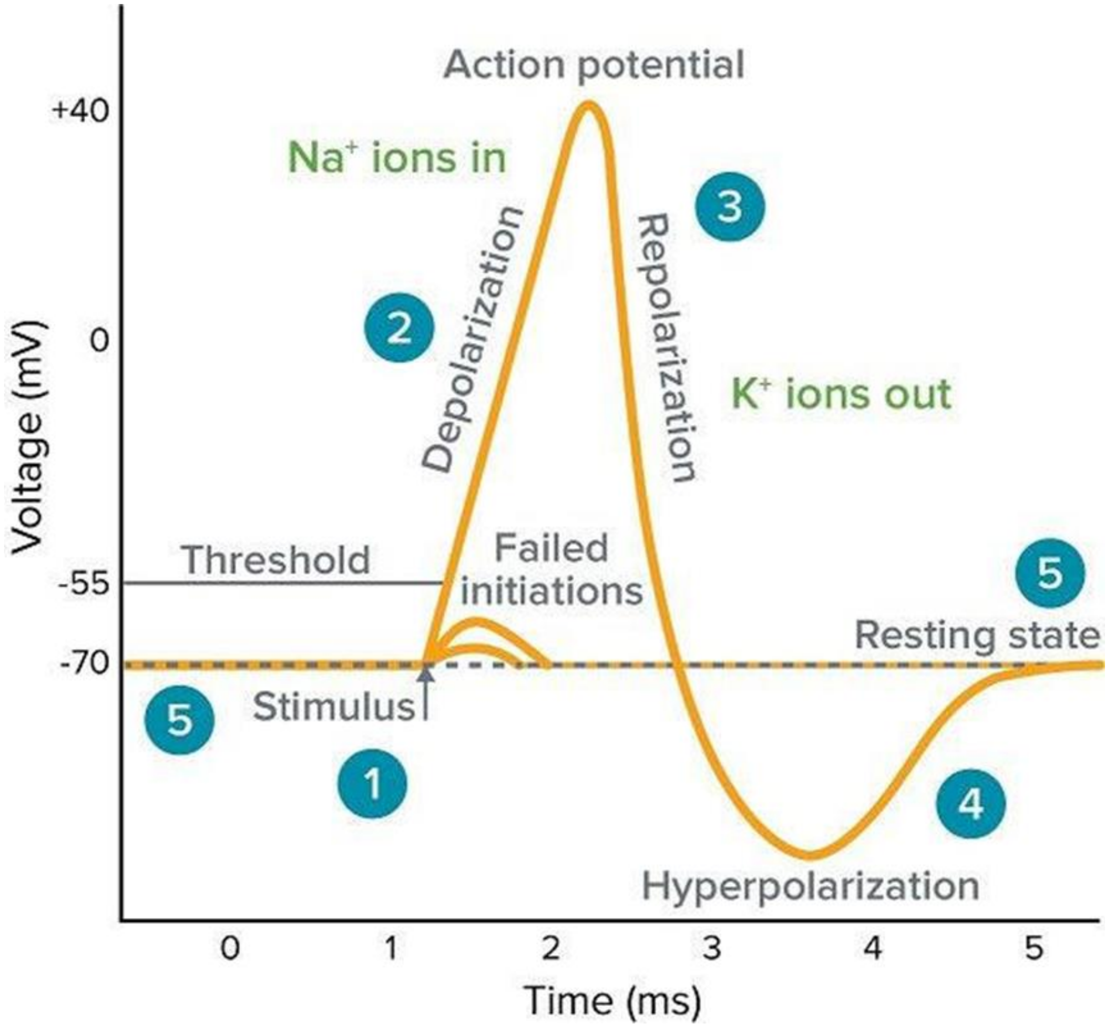
This is the stable, baseline membrane potential of an excitable cell, around −70 mV in a neuron. The negative value indicates the inside of the cell is more negative than the outside. The resting potential is primarily maintained by the constant outward leak of K+ ions and the action of the Na+ /K+ pump.



Depolarization:

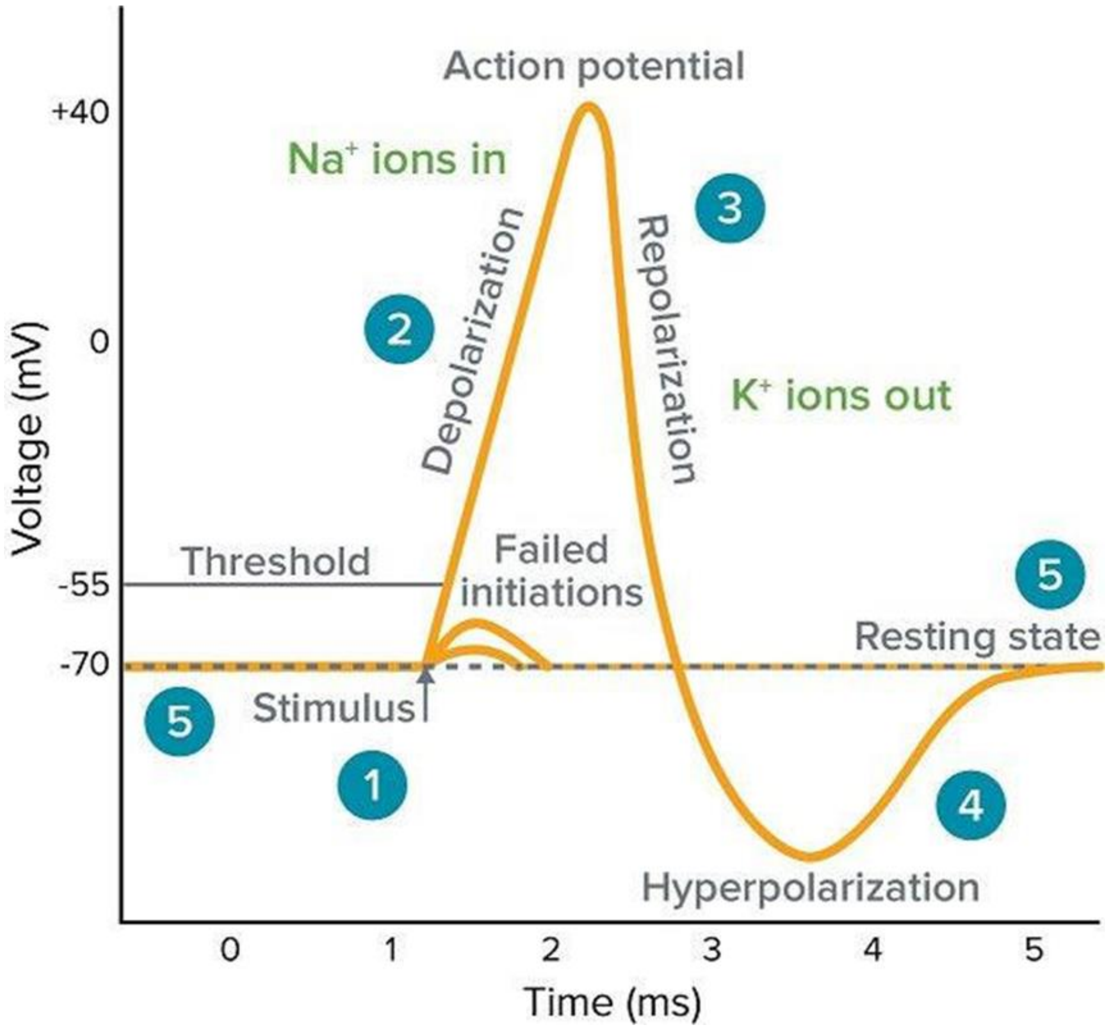
A decrease in the charge difference across the membrane, making the inside of the cell less negative and moving the potential closer to 0 mV. This can be triggered by a stimulus opening voltage-gated Na+ channels, allowing a rapid **influx of positive Na+ ions.**





Hyperpolarization:

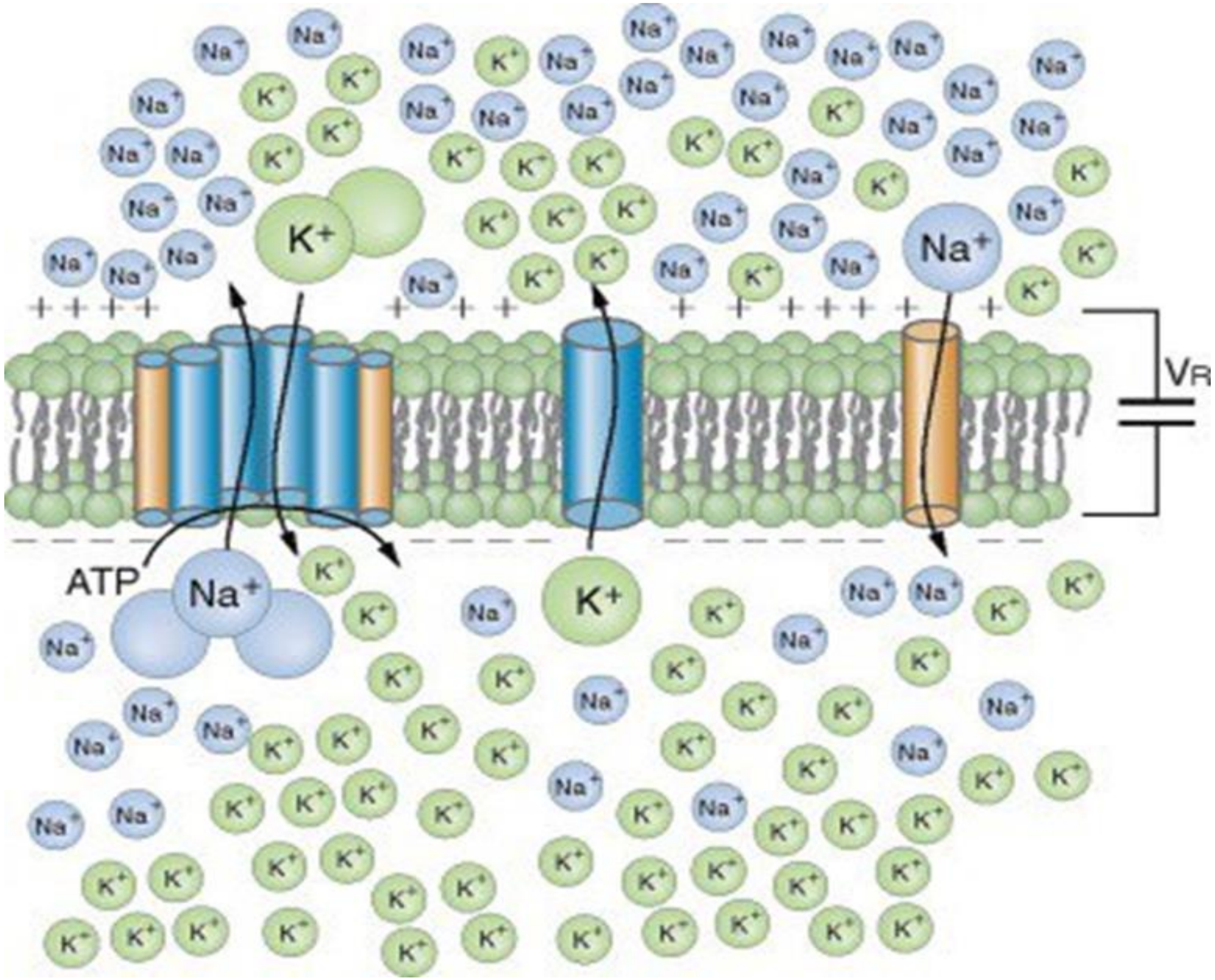
An increase in the charge difference, making the inside of the cell more negative and moving the potential further away from 0 mV. This can occur when K+ channels remain open for a moment after repolarization, allowing **excess K+ to exit**, or by the influx of negative ions like Cl



Action Potential:

- An action potential is a rapid sequence of changes in the voltage across a membrane. That is determined at any time by the relative ratio of **ions**, extracellular to intracellular, **and the permeability of each ion.**

- **Before stimulation**, a neuron has a slightly negative charge inside the cell due to high concentration of negatively charged chloride ions (as well as a lower concentration of positively charged potassium) inside compared with high concentration of positively charged sodium ions outside the cell.



K+
Na+
ATP
Na+
K+
VR

Nerve cell Action potential

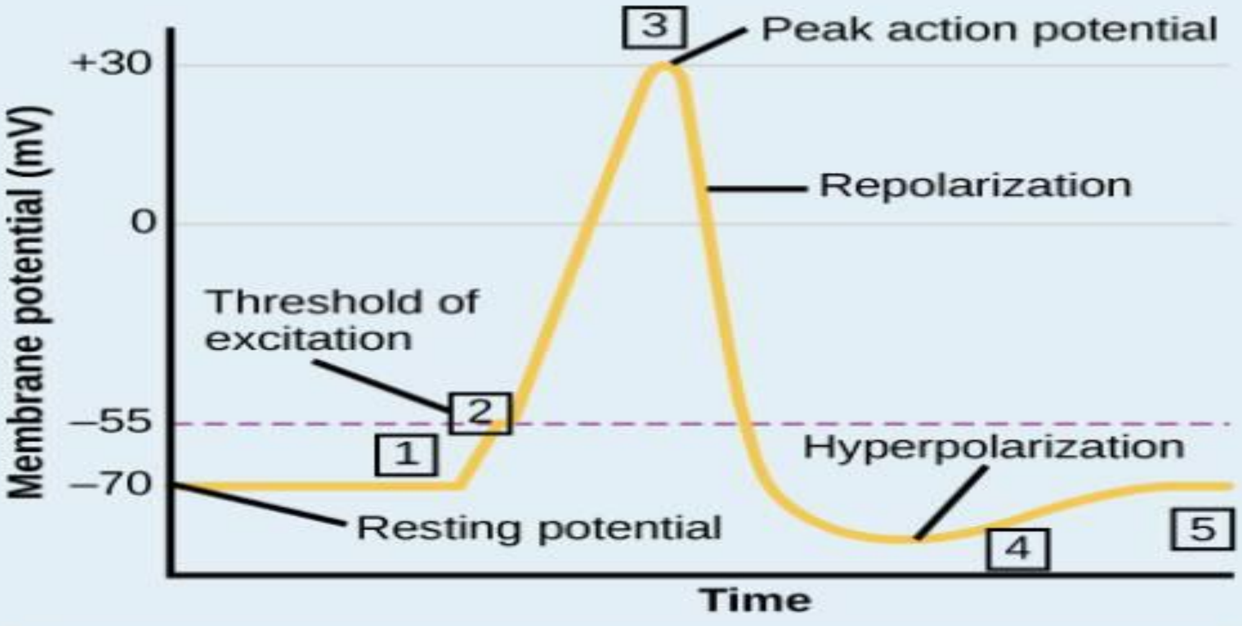


Figure 1. Action Potential

1. A stimulus from a sensory cell or another neuron causes the target cell to depolarize toward the threshold potential.
2. If the threshold of excitation is reached, all Na^+ channels open and the membrane depolarizes.
3. At the peak action potential, K^+ channels open and K^+ begins to leave the cell. At the same time, Na^+ channels close.
4. The membrane becomes hyperpolarized as K^+ ions continue to leave the cell. The hyperpolarized membrane is in a refractory period and cannot fire.
5. The K^+ channels close and the Na^+/K^+ transporter restores the resting potential.

THANKS FOR LISTENING