Action potential and resting potential (CC4 Unit-7)

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INTRODUCTION

- In a cell membrane, the outside fluid is extra-cellular fluid and inside fluid is intra-cellular fluid.
- The extra-cellular fluid has a large concentration of sodium ions and chloride ions but less concentration of potassium ions.
- The intra-cellular fluid has a high concentration of potassium ions than the sodium ions. In our body, neuron sends electrochemical messages, which produces an electrical signal.
- Chemicals in our body are “electrically charged”, and when they have an electrical charge, they are “ions”. Sodium and Potassium ions have one positive charge. Calcium ions have two positive charges.
- Chloride ions have one negative charge.
- The cell membrane is semi-permeable.
- It allows few ions to pass through and stops passage of other ions.

Resting Membrane Potential

- Transport of substances across the cell membrane is “diffusion”.
- Diffusion generates membrane potential. The ions try to balance between inside and outside cell during diffusion.
- When a cell does not send a signal, it is at “resting state”. At resting state, the inside of the cell is negative when compared to outside of the cell.
- This permits the entry of potassium (K^+) and chloride (CL^-) ions and stops Sodium ions (Na^+).
- Since the cell has semi-permeable membrane sodium ion concentration inside the cell is lower than the outside the cell. Na+ ions are positive, so the outside of the cell is positive than the inside.
- Inside the cell, potassium and chloride ion concentration is more than the outside the cell.
- Hence, the cell does not meet the charge balance. Yet a potential difference occurs across the cell membrane an equilibrium occurs.

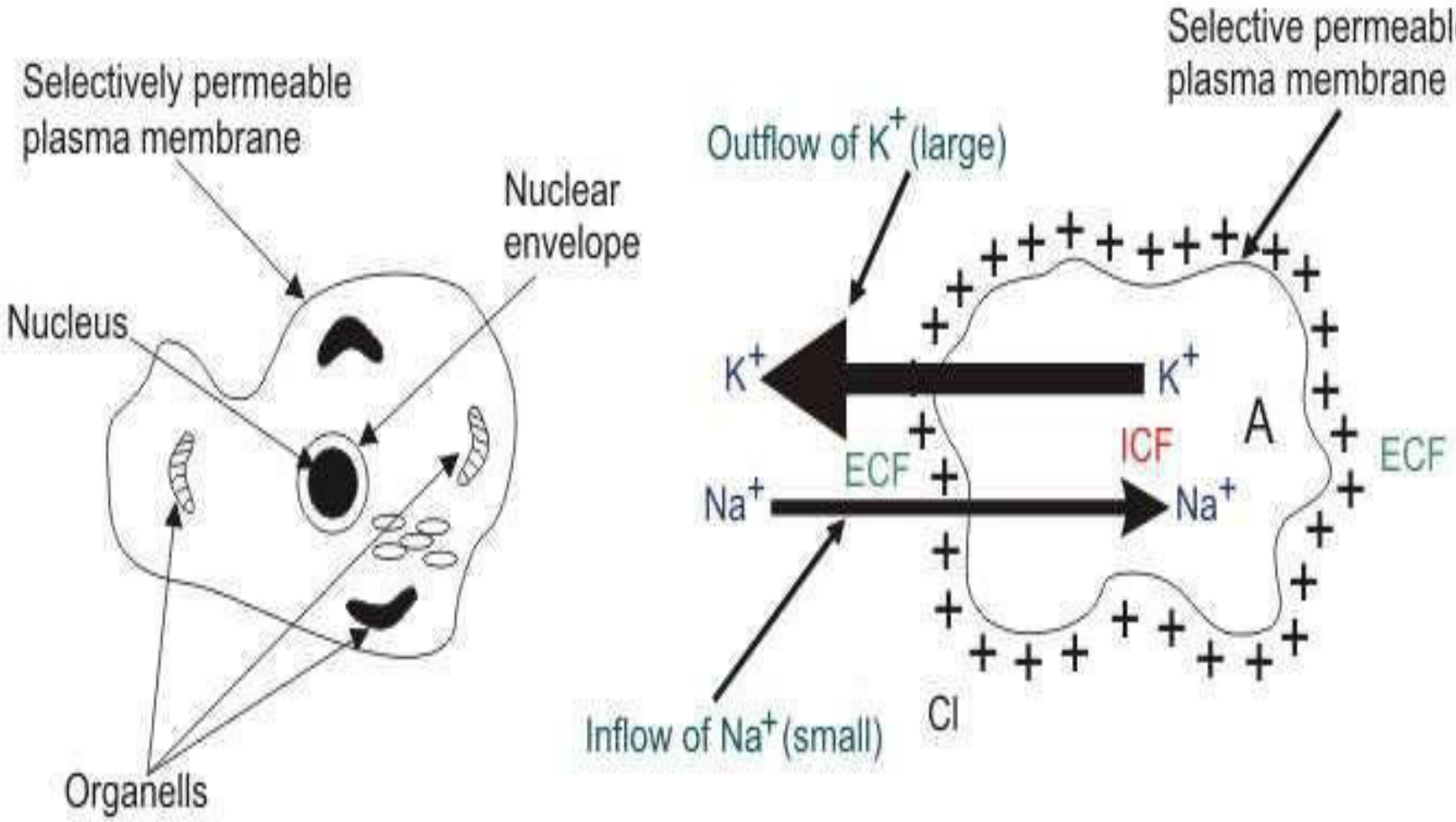
Resting Membrane Potential

- The cell membrane is negative inside and positive outside.
- The difference in ion concentration results in the Resting Membrane Potential of the cell.
- The value of resting potential is between – 60mV to – 100mV.
- The value remains constant until an external factor disturbs the cell membrane.
- At the resting state, the cell is polarised.

Resting Membrane Potential

- Consider an example of our blood plasma (serum).

  If sodium ion concentration increases, renal damage and dehydration occur. If reduced, renal failure and adrenocortical hypofunction occur. If potassium ion concentration increases shock and acidosis occurs. Acidosis is a medical condition where a patient loses his consciousness, tachycardia develops resulting in a decrease in blood pressure. Similarly, an increase in chloride ions produces respiratory problems.

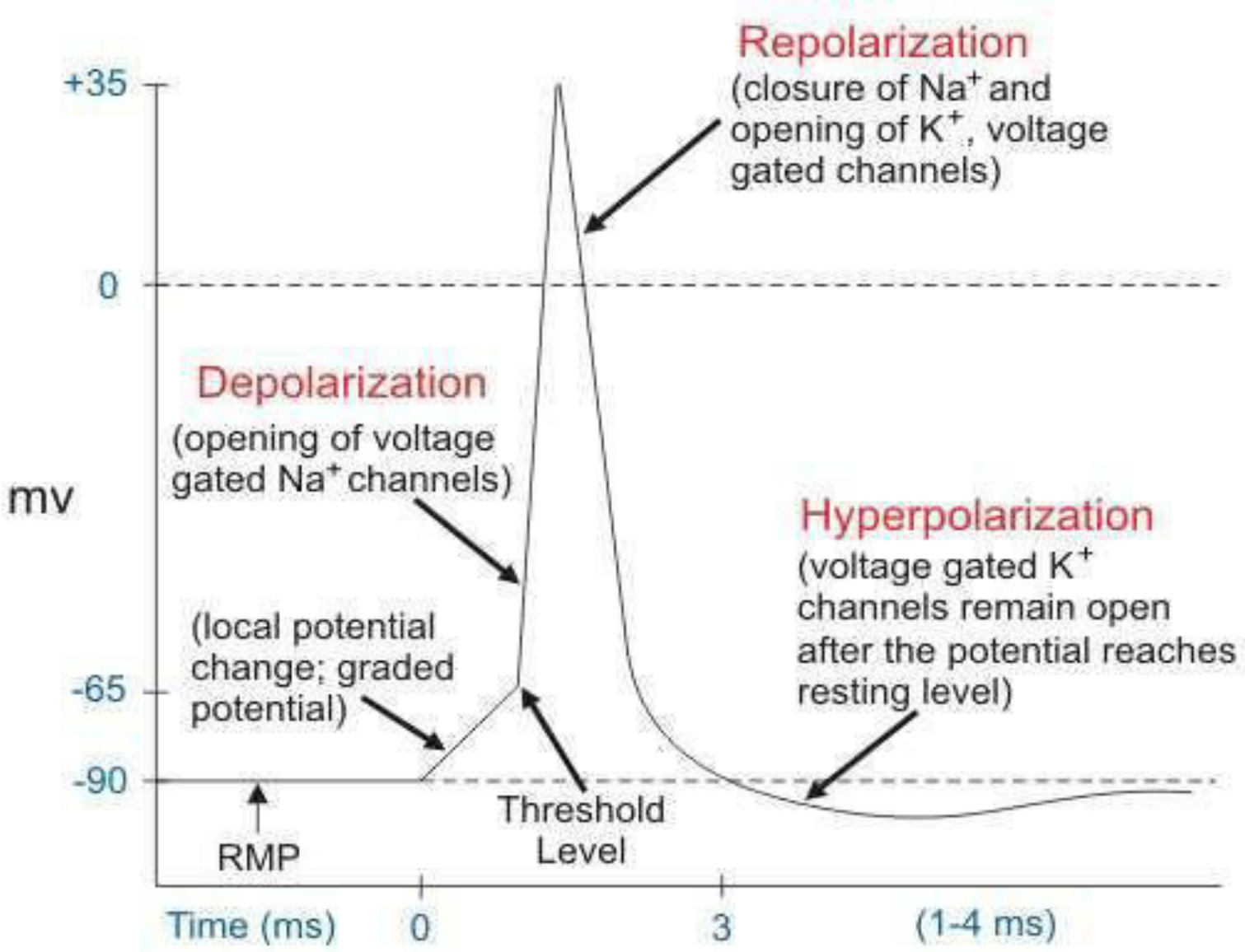

Selectively permeable plasma membrane
Nuclear envelope
Nucleus
Organelles
Selective permeable plasma membrane
Outflow of K+ (large)
K+
K+
ICF
A
ECF
ECF
Na+
Na+
Inflow of Na+ (small)
Cl

Action Membrane Potential

- When ionic current or external energy excites the portion of a cell membrane, permeability changes.
- Now the sodium ions flow inside the cell and generate ionic current.
- This reduces the membrane barrier.
- It allows sodium ions to flow into the cell and try to balance with the ions outside. Meanwhile, potassium ions flow outside the cell.
- Thus, the cell has positive potential inside the cell and negative potential outside the cell due to the imbalance of potassium ions.
- The positive potential of the cell membrane is Action Membrane Potential.
- The value of action potential is 20mV. Now the cell is depolarised.

Action Membrane Potential

- When the sodium ions stop flowing into the cell, ionic currents reduces the barrier to the cell wall membrane.
- So the cell returns to polarised (original condition).
- In resting state of the cell, sodium ions rush to outside the cell using Sodium Pump.
  In nerve and muscle, cell repolarisation occurs fast after depolarization.
- Action potential appears as a spike for one millisecond.
  In heart muscle, an action potential occurs for 150 to 300 milliseconds.
- Therefore, repolarization occurs slowly in the heart.


Repolarization
(closure of Na+ and opening of K+, voltage gated channels)
+35
0
Depolarization
(opening of voltage gated Na+ channels)
mv
Hyperpolarization
(voltage gated K+ channels remain open after the potential reaches resting level)
(local potential change; graded potential)
-65
-90
RMP
Threshold Level
Time (ms)
0
3
(1-4 ms)