Resting Membrane Potential

The human organism is composed of multiple cells, all of them with different components and therefore with differents **resting membrane potentials**. Some of these cells are excitable (e. g.: cells; neurons; muscle fibers), generating an action potential when subjected to an external stimulus, causing its membrane depolarization. The **resting membrane potential (RMP)** is due to changes in membrane permeability for potassium, sodium, calcium, and chloride, which results from the movement of these ions across it. Once the membrane is *polarized*, it acquires a voltage, which is the difference of potentials between intra and extracellular spaces.

What is a RMP?

Resting membrane potential is:

- the unequal distribution of ions on the both sides of the cell membrane;
- the *voltage difference* of quiescent cells;
- the membrane potential that would be maintained if there weren't any stimuli or conducting impulses across it;
- determined by the concentrations of ions on both sides of the membrane;
- a *negative value*, which means that there is an excess of negative charge inside of the cell, compared to the outside.
- much depended on intracellular potassium level as the membrane permeability to potassium is about 100 times higher than that to sodium.

Producing and maintaining RMP

RMP is produced and maintained by:

Donnan effect
: described as large impermeable negatively charged intracellular molecules attracting positively charged ions (e. g.: Na^+ and K^+) and repelling negative ones (e. g.: Cl^-)

Membrane selectivity
: is the difference of permeabilites between different ions

Active transport (Na^+/K^+ ATPase pump)
: is the mediated process of moving particles across a biological membrane, against the concentration gradient.

- *Primary active transport* – if it spends energy. This is how the Na^+/K^+ ATPase pump functions.
- *Secondary active transport* – if it involves an electrochemical gradient. This is not involved in maintaining RMP.

Ion affection of resting membrane potential

RMP is created by the distribution of ions and its diffusion across the membrane. Potassium ions are important for **RMP** because of its *active transport*, which increase more its concentration inside the cell. However, the *potassium-selective ion channels* are always open, producing an accumulation of negative charge inside the cell. Its outward movement is due to random molecular motion and continues until enough excess negative charge accumulates inside the cell to form a membrane potential.

Na^+/K^+ ATPase pump affection of the RMP

The ***Na^+/K^+ ATPase pump*** creates a concentration gradient by moving $3Na^+$ out of the cell and $2K^+$ into the cell. Na^+ is being pumped out and K^+ pumped in against their concentration gradients. Because this pump is moving ions against their concentration gradients, it *requires energy*.

Ion channels affection of resting membrane potential

The cell membrane contains *protein channels* that allow ions to diffuse passively without direct expenditure of metabolic energy. These channels allow Na^+ and K^+ to move across the cell membrane from a higher concentration toward a lower. As these channels have selectivity for certain ions, there are *potassium-* and *sodium-selective ion channels*. All cell membranes are more permeable to K^+ than to Na^+ because they have more K^+ channels than Na^+.

The Nernst Equation

Ihhs a mathematical equation applied in physiology, to calculate equilibrium potentials for certain ions.

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- **R** = Gas Constant
- **T** = Absolute temperature (K)
- **E** = The potential difference across the membrane

- **F** = Faradays Constant (96,500 coulombs/mole)
- **z** = Valency of ion

The Goldman-Hodgkin-Katz Equation

Is a mathematical equation applied in Physiology, to determine the potential across a cell's membrane, taking in account all the ions that are permeable through it.

$$Em = 58log(\frac{PNa \cdot [Na]out + PK \cdot [K]out}{PNa \cdot [Na]in + PK \cdot [K]in})$$

- **E** = The potential difference across the membrane
- **P** = Permeability of the membrane to sodium or potassium
- **[ ]** = Concentration of sodium or potassium inside or outside

Measuring resting potentials

In some cells, the **RPM** is always changing. For such, there is never any ***resting potential***, which is only a theoretical concept. Other cells with membrane transport functions that change potential with time, have a resting potential. This can be measured by inserting an electrode into the cell. Transmembrane potentials can also be measured optically with dyes that change their optical properties according to the membrane potential.

Resting membrane potential varies according to types of cells

For example:

- **Skeletal muscle cells:** −95 mV
- **Smooth muscle cells:** −50 mV
- **Astrocytes:** −80/−90 mV
- **Neurons:** −70 mV
- **Erythrocytes:** −12 mV

Links

Related articles

Sources

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