RESTING MEMBRANE POTENTIAL AND ACTION POTENTIAL

INTRODUCTION

All cells under resting conditions have an electrical potential difference across the plasma membrane such that the inside of the cell is negatively charged with respect to the outside. This potential is the resting membrane potential(RMP); its magnitude depends on the type of cell, but usually ranges between -60 and -90 mV. By convention the polarity (positive or negative) of the membrane potential is stated in terms of the sign of the excess charge on the inside of the cell. In addition, some cells, such as nerve and muscle cells are capable of generating rapidly changing electrochemical impulses at their membranes, and these impulses are used to transmit signals along the nerve or muscle membranes. In still other types of cells, such as glandular cells, macrophages, and ciliated cells, local changes in membrane potentials also activate many of the cells' functions.

The membrane potential can be accounted for by the fact that there are a slightly greater number of negative charges than positive charges inside the cell and a slightly greater number of positive charges than negative charge outside. The excess negative charges inside the cell are electrically attracted to the excess positive charges outside the cell, and vice versa. Thus, these excess ions collect along a thin shell on the inner and outer surfaces of the plasma membrane, whereas the bulk of the intracellular and extracellular fluid is electrically neutral. The total number of positive and negative charges that have to be separated across the membrane to account for the potential is an insignificant fraction of the total number of charges actually in the cell. When a microelectrode penetrates a membrane, it records a negative potential with respect to an external reference electrode caused by different permeability of anions and cations. The resting membrane potential is determined mainly by two factors:

- the differences in ion concentration of the intracellular and extracellular fluids and
- the relative permeability of the plasma membrane to different ion species.

and it is an essential mechanism in storing and processing information in neurons and other cells.

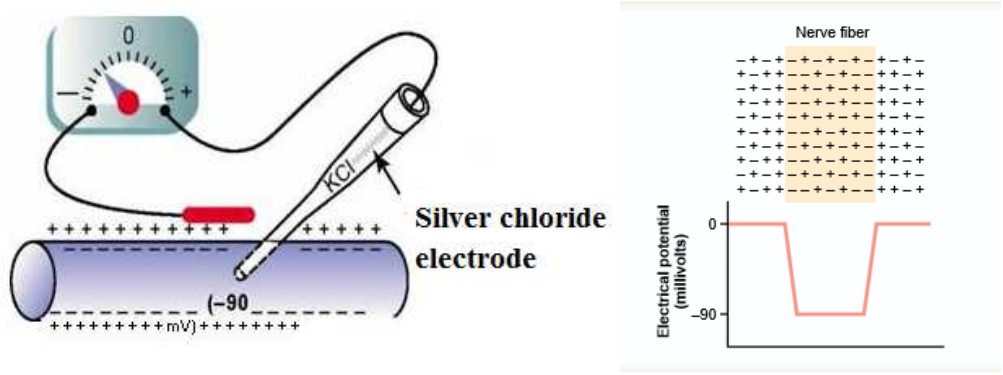
The method for measuring the membrane potential is simple in theory but often difficult in practice because of the small size of most of the fibers. Figures shows a small pipette filled with an electrolyte solution impaled through the cell membrane to the interior of the fiber. Then another electrode, called the "indifferent electrode," is placed in the extracellular fluid, and the potential difference between the inside and outside of the fiber is measured using an appropriate voltmeter. It is capable of measuring very small voltages despite extremely high resistance to electrical flow through the tip of the micropipette, which has a lumen diameter usually less than 1 micrometer and a resistance more than a million ohms. For recording rapid changes in the membrane potential during transmission of nerve impulses, the microelectrode is connected to an oscilloscope.

MEASUREMENT OF THE MEMBRANE POTENTIAL OF THE NERVE FIBER USING A MICROELECTRODE

As long as the electrode is outside the nerve membrane, the recorded potential is zero, which is the potential of the extracellular fluid. Then, as the recording electrode passes through the voltage change area at the cell membrane (called the electrical dipole layer), the potential decreases abruptly to -90 millivolts. Moving across the center of the fiber, the potential remains at a steady -90-millivolt level but reverses back to zero the instant it passes through the membrane on the opposite side of the fiber.

To create a negative potential inside the membrane, only enough positive ions to develop the electrical dipole layer at the membrane itself must be transported outward. All the remaining ions inside the nerve fiber can be both positive and negative, as shown in the upper panel of next figure. Therefore, an incredibly small number of ions need to be transferred through the membrane to establish the normal

"resting potential" of -90 millivolts inside the nerve fiber; this means that only about 1/3,000,000 to 1/100,000,000 of the total positive charges inside the fiber need to be transferred. Also, an equally small number of positive ions moving from outside to inside the fiber can reverse the potential from -90 millivolts to as much as +35 millivolts within as little as 1/10,000 of a second. Rapid shifting of ions in this manner causes the nerve signals.



A B

Figure 3 A Measurement of the membrane potential using a microelectrode B Distribution of charged ions in the extracellular and intracellular fluid in a nerve fiber

RESTING MEMBRANE POTENTIAL AND ACTION POTENTIAL OF MUSCLE

Excitation of the nerve cell membrane by electric stimuli cause's changes in resting membrane potential, depolarization occurs. When the rate and magnitude of depolarization are large enough, action potential (AP) is generated, which is propagated along the nerve fiber. The amplitude and the shape of the AP are constant, they do not depend on the intensity of the stimulus applied and they are not changed even during propagation. This phenomenon is called the all or nothing principle.

MATERIALS: frog, frog board**,** dissection kit**,** pins, needle**,** electric source with exciter, electric wires glass stick, physiological salt solution

PROCEDURE: The frog is washed under the tap water to not be sticky. After that, it is immobilized by destroying the medulla oblongata and the spinal marrow with a needle. The needle is introduced into the medullary canal; the frog should become limp and show no signs of reflexes. Fix the frog with pins on the frog board.

Strip the skin off the right or left hind leg. With a sharp dissecting needle tear through the fascia and muscle tissue to the tight to expose the sciatic nerve. The nerve has to be isolated distally until the knee joint and proximally until its origin, where it is cut. The thigh is cut above the knee joint taking care to not injure the sciatic nerve. The frog must be carefully prepared to keep the tissues viable.

Using a glass stick, the nerve is put/settled on the thigh of the frog so that to touch both the intact surface and that injured by sectioning. When the nerve touches the two surfaces, the muscle contracts due to the lesion potential of sectioned muscle.

In resting conditions the surface of muscle is electropositive by comparison with the sectioned surface, which is electronegative. It has been demonstrated the resting membrane potential or lesion potential , at whose producing participate physical, chemical and biological factors, which carry out between the exterior of the cell and interior, an unequal repartition of the electric charges.

For demonstrate the action potential the same procedure is applied, but the second thigh is not cut at the level of knee. The sciatic nerve of the first leg is settled on the thigh of the second leg and the second

sciatic nerve is stimulated electrically using an exciter. Every contraction of the second muscle (the muscle from the second thigh) induces also the contraction of the of the gastrocnemian muscle of the first leg. The action current of the second muscle (thigh) excited also the sciatic nerve of the first leg, determining the contraction of its gastrocnemius muscle.