ORIGIN OF BIOPOTENTIAL AND ITS PROPAGATION

Bioelectric potentials are produced as a result of electrochemical activity of a criteria class of cells known as excitable cells that are components of nerves, muscular and glandular tissue. The origins of biopotentials can be traced to the electric activity at the cellular cell. The electric potential across a cell membrane is the result of different ionic concentrations that exist inside and outside the cell. There are two types of biopotentials are given below,

- Action Potential
- Resting Potential

Resting Potential:

The diffusion and drift process gives rise to a balance of ions between inside and outside of the cell. Generally, the nerves and muscle cells readily permit the entry of potassium and chloride ions. But it blocks the entry of sodium ions. Due to the difference in permeability of different ions, charge balance is not achieved. So that an equilibrium condition is reached with the potential difference across the membrane, such that the negative potential on the inside and positive potential on the outside.

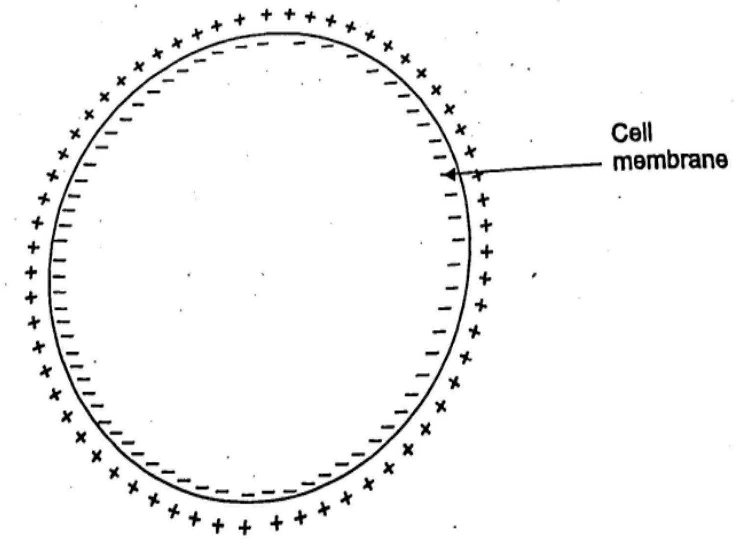

Fig: Resting Potential

Characteristics of resting potential:

- The value of the resting potential is maintained as a constant until some kind of the disturbances will upset the equilibrium.
- It strongly depends on the temperature.

- The permeability of different cell types should vary. Hence the corresponding resting potential should also vary.
- The range of resting potential is -60 to -100mV.

Action potential:

When the cell membrane is excited by some external energy, then the permeability changes. So that the medium ions are allowed to enter inside the cell. So that the cell has a slightly positive potential on the inside due to the imbalance of the potassium ions. The positive potential of the cell membrane during excitation is called as the action potential in the range of 20mV.

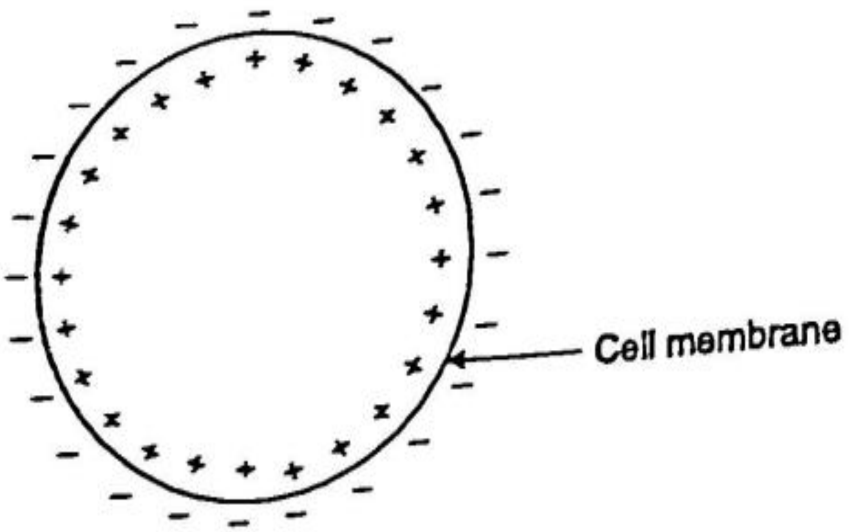

Fig: Action Potential

Origin of bioelectric signal:

Bioelectric potentials are generated at a cellular level and the source of these potentials is ionic in nature. A cell consists of an ionic conductor separated from the outside environment by a semipermeable membrane which acts as a selective ionic filter to the ions. These means that some ions can pass through the membrane freely whereas others cannot do so. The principal ions involved with the phenomena of producing cell potentials are sodium (Na^+), potassium (K^+) and chloride (Cl^-).

The membrane of excitable cells readily permits the entry of K^+ and Cl^- but impedes the flow of Na^+ even though there may be a very high concentration gradient of sodium across the cell membrane. This results in the concentration of the sodium ion more on the outside of the cell membrane from the inside. Since sodium is a positive ion, in its resting state, a cell has a negative charge along the inner surface of its membrane and a positive charge along the outer portion.

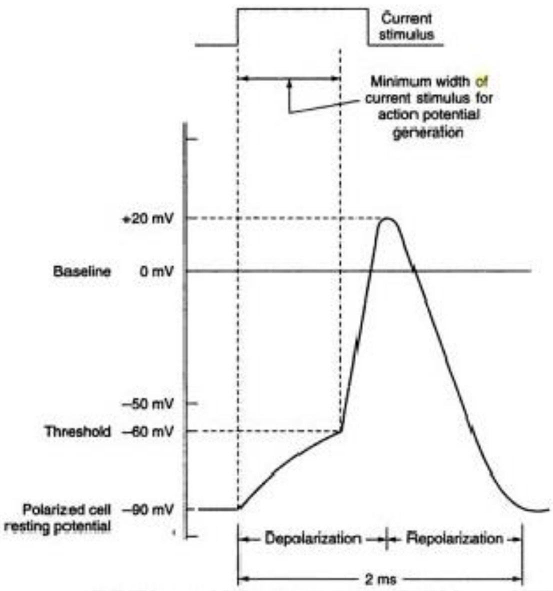

Fig: A typical cell potential waveform

The distribution of positively charged ions on the outer surface and negatively charged ions inside the cell membrane results in the difference of potential across it and the cell becomes, in effect, a tiny biological battery. Experiments have shown that the internal resting potential within a cell is approximately -90mV with reference to the outside of the cell. When the cell is excited or stimulated, the outer side of the cell membrane becomes momentarily negative with respect to the interior. This process is called repolarization and the cell potential changes to approximately +20mV.

The bioelectric signals of clinical interest, which are often recorded, are produced by the coordinated activity of large groups of cells. In this type of synchronized excitation of many cells, the charges tend to migrate through the body fluids towards the still unexcited cell areas. Such charge migration constitutes an electric current and hence sets up potential differences between various portions of the body, including its outer surface. The primary characteristics of typical bioelectric signals are shown in table.

Parameter	Primary signal characteristics	Type of Electrode
Electrocardiography (ECG)	Frequency range: 0.05 to 120 Hz Signal amplitude: 0.1 to 5 μV Typical signal: 1 μ V	Skin electrodes
Electroencephalography (ECG)	Frequency range: 0.1 to 100 Hz Signal amplitude: 2 to 200 μV Typical signal: 50 μ V	Scalp electrodes
Electromyography (EMG)	Frequency range: 5 to 2000 Hz Signal amplitude: 0.1 to 5 μV	
Electroretinography (ERG)	Frequency range: dc to 20 Hz Signal amplitude: 5 μV to 1 μ V Typical signal: 0.5 μ V	Contact electrodes

Propagation of Bio Potential:

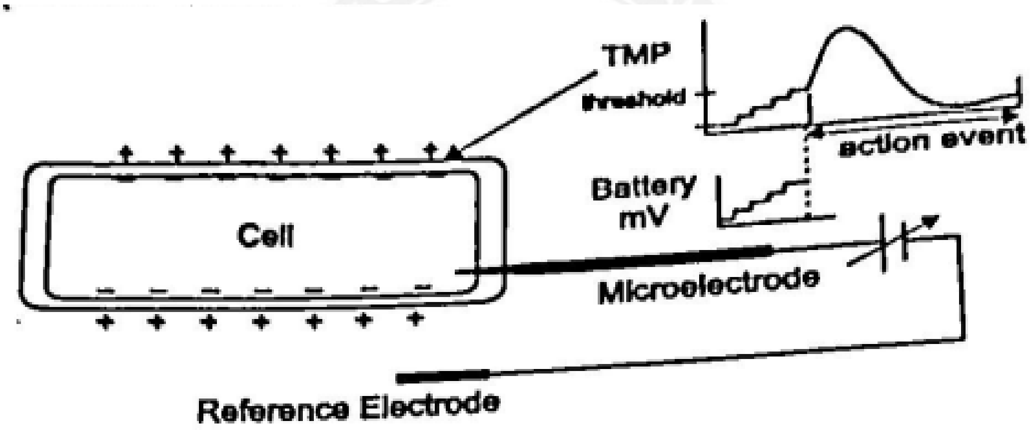

Fig: Illustration of a cell punctured by a microelectrode connected to a stepwise current source that drives the cell membrane potential above threshold

The figure shows the setup where a battery is used to step wise drive the cell trans membrane potential more positive. During an action event, membrane sodium conductance abruptly increases allowing the higher concentration of sodium in the extra cellular medium to rush into the cell. The net negative electric field inside the cell is there by reduced toward zero through the positive charge on sodium. This is known as depolarization.

Shortly after the sodium in rush, there is an increase in membrane potassium conductance. This allows the higher concentration of potassium ions inside the cell to move outside of the cell, the net negative charge inside the cell is restored. This is known as repolarization. The changes in sodium and potassium membrane conductance are illustrated in figure.

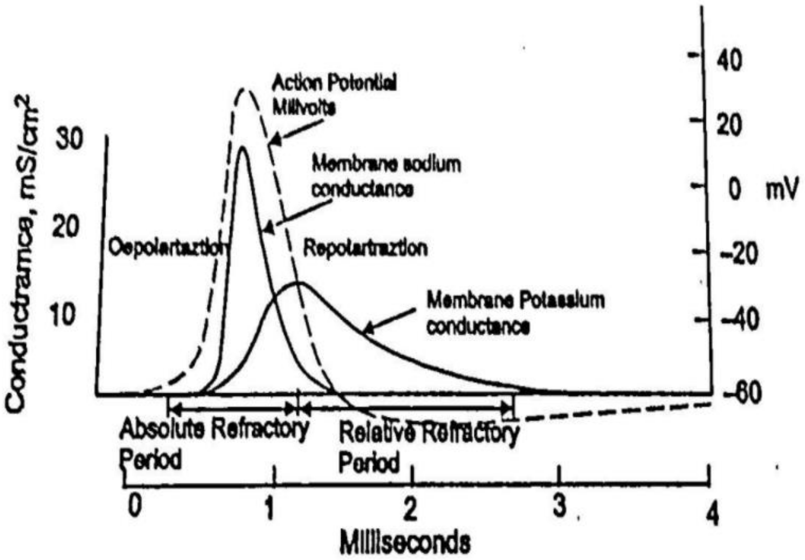

Fig: Illustration of the cycle of ionic conductance's associated with action events

The depolarization and repolarization phases of action events can occur quickly over the intervals of tens of microseconds, although the actual durations depend very much on the cell type. During the time when the cell is depolarized, it cannot be restimulated to another action event. This interval is known as the cell's absolute refractory period.