Marks – 12

~~What do you mean by conduction~~ What is action potential and how it is generated. Describe the mechanism of nerve impulse propagation through non-myelinated nerve fibre.

Ans

All cells under resting conditions have a potential difference across their plasma membranes oriented with the inside of the cell negatively charged with respect to the outside. This potential is the resting membrane potential. In neurons it is generally in the range of −70 to −90 mv. The membrane potential can be accounted for by the fact that there is a net excess of negative ions inside the cell and a net excess of positive ions outside. These ionic gradients are generated by an ATP-driven pump. If the axon is stimulated and a conducted impulse occurs, a characteristic series of potential changes known as the action potential is observed.

Definition of Nerve impulse:

A nerve impulse is an electric signal produced by the flow of ions across the plasma membrane of a neuron and is the fundamental means of communication in the nervous system.

Events of Action potential:

The action potential results from a transient change in membrane ion permeability whereas the concentration gradients remain unchanged. In resting state the inside of the nerve is negative and the outside of the nerve is positive. Na^+ concentration outside the membrane is higher than that of inside the membrane. K^+ concentration inside the membrane is also higher than that of outside the membrane.

In the resting state the open channels in the plasma membrane are predominantly those that are permeable to potassium and chloride ions. Almost all the sodium ion channels are closed, and the resting potential is therefore much closer to the potassium equilibrium potential than to the sodium equilibrium potential.

During an action potential, however, the membrane permeabilities to sodium and potassium ions are altered; Permeability of Na^+ to membrane is increased only after excitation. It is first event of the action potential. The action potential occurs in successive stages — depolarization, replication, negative after potential and positive after potential.

(1) Depolarization:

During excitation, Sodium channels open increasing the membrane permeability to sodium ions several hundred folds. This allows sodium ions to rush into the cell. During this period more positive charge enters the cell in the form of sodium ions than leaves in the form of potassium ions, and thus the membrane potential becomes less negative and eventually reverses polarity, becoming positive on the inside and negative on the outside of the membrane. This is called depolarization. In large nerve fibres, the membrane potential actually overshoots

beyond the zero level and becomes ~~some~~ somewhat positive, but in some smaller fibres as well as many central nervous system neurons, the potential merely approaches the zero level and does not overshoot to the positive state.

If the stimulus causes the membrane to depolarize by only a few millivolts from −70 to −60 mV, the membrane rapidly returns to its resting potential. As soon as the stimulus depolarizes the membrane beyond a certain point, called the threshold, which occurs at about −50 mV, then a new series of events is launched. The change in voltage causes the voltage gated sodium channels to open. As a result, sodium ions diffuse freely into the cells to establish depolarization. After an initial slow rise, depolarization rapidly overshoots and reaches the isopotential line (zero line) to approximately +35 mV.

② Repolarization, negative after and positive after potential

But as soon as the action potential attains the voltage approximately +35 mV, the sodium channels spontaneously inactivate, blocking further influx of Na^+ ions and the potassium channels open more than they normally do. Then, rapid diffusion of potassium ions to the exterior re-establishes the normal negative resting membrane potential. This is called repolarization of the membrane.

When repolarization is about 70% completed, the rate of repolarization decreases and the tracings approaches the resting level more slowly. The sharp rise and rapid fall are the spike potential of the axon, and the slower fall at the end of the process is the after depolarization or negative after potential. With the disappearance of the negative after potential, the resting membrane potential is achieved.

The membrane potential becomes even more negative than the original ~~resting~~ resting membrane potential for a few milliseconds, after the action potential is over, This is called the "positive" after potential.

The cause of the ~~post~~ positive after potential is mainly that many potassium channels remain open for several milliseconds after repolarization of the membrane is complete. This allows excess potassium ions to diffuse out of the nerve fibre, leaving for a millisecond or more an extra deficit of positive ions on the inside, which means more intracellular negativity.

The sodium ions that have diffused to the interior of the cell during the action potentials and ~~the~~ the potassium ions that have diffused to the exterior must be returned to their original state by the Na^+-K^+ pump.