Synaptic transmission of Nerve impulse

Synapses are special zones of contact between two neurons, or a neuron and a non neuronal element such as those between a receptor and neuron, or with an effector cell, or with a muscle (myoneural junction). Thus synapses can be defined as the region of neuron anatomically differentiated and functionally specialized for the transmission excitatory and inhibitory from one part of neuron to other neurons. Synaptic transmission includes a specific neurochemical mechanism in which transmitter, receptor protein, synthetic and hydrolytic enzymes etc. DuBois-Reymond (1877) was the first to suggest that transmission could be either electrical or chemical.

Electrical transmission → In this type of synapse the membrane contact acts as an efficient rectifier, allowing current to pass relatively easily from the pre to post synaptic element. The arriving nerve impulse is passed without delay and can depolarise directly and excite the post synaptic neuron. The electrical transmission is unidirectional. This type of electrical transmission of nerve impulse take place in the neurons having a distance below 0.2 nm.

Chemical transmission - In chemical transmission an specific chemical transmitter is synthesized and stored at the nerve terminal and is liberated by nerve impulse. The transmitter produces a change in ions permeability at the post synaptic component that causes a biochemical change. Modern electrical

Studies on chemical synaptic transmission have revealed that synapses are the sites of a transducing mechanism in which the electrical signals are converted into chemical signals, and these in turn, again into electrical signals. Active substances of low molecular weight (eg Acetylcholine, nor adrenaline, dopamine, glutamate, γ aminobutyrate and others are produced at the nerve endings and packages in synaptic vesicles in multimolecular quantities.

These transmittars are released when the activation is produced by the nerve impulse. The transmitter reacts with special receptor proteins, present at the post synaptic membrane. This transmitter receptor interaction produces a change in permeability to certain ions, creating a synaptic potential in the post synaptic cell.

Transfer of Information from nerve to target cell at Synapse.

An action potential, passing down an axon eventually reaches the end of the axon that may be branched or may be associated with several dendrites or an axon or a perikaryon or cell body of the nerve cell, with muscles or secretory cells.

In a synapse there is a narrow intercellular gap 10-20 nanometers seperating the axon tip and target cell. This gap is called synaptic cleft. The number

of synapses is usually very large, providing a large surface area for the transfer of information for instance over 1000 Synapses may be found on the dendrites and the cell body of a motor neuron in the spinal cord. In chemical synapses which is the most common a bulbous expansion of the nerve terminal called synaptic Knob is present. The cytoplasm of the synaptic Knob contains numerous tiny, spherical sacs called synaptic vesicles

The membrane of the synaptic Knob on the axon side is thickened as a result of cytoplasmic condensation and is called pre synaptic membrane. When a wave of depolarisation reaches the pre synaptic membrane, voltage gated calcium channels concentrated at the synapse open. Ca^{2+} ions then diffuse into the terminal from the surrounding fluid. The ca^{2+} ions stimulate synaptic vesicles to move towards terminal membrane fuse with it and rupture resulting into release of Neurotransmitters from vesicles at tip by the process of exocytosis into the cleft.

These neurotransmitters rapidly pass to the other side of the gap then combine with specific receptor molecules on the membrane of target cells, called the post synaptic membrane. by doing so they cause a second electric current, passing on its signal. To end the signal the synaptic bulbs reabsorbs some Neuro

neurotransmitters and enzymes in synapse neutralises them.

The chemical synapse is more efficient than the electrical synapse due to presence of more variety variety of neurotransmitters. At least 30 biochemicals (biogenic amine and derivatives of amino acids) and over 60 neuropeptides have been discovered and identified that act as specific neurotransmitters. There may are two types of responses by neurotransmitter

(1) Excitatory synapses induce a depolarisation of the post synaptic membrane, which, upon reaching a certain critical level causes the neuron to discharge an impulse. The excitatory post synaptic potential (EPSP) is due to the action of transmitter released by the ending. This causes a change in permeability of the sub synaptic membrane allowing a free passage of sodium and Potassium and chlorine ions.

(2) Inhibitory synapses affect the sub synaptic membrane, the neurotransmitters causes a transient increase in the membrane potential (IPSP) or the so called inhibitory post synaptic potential. This hyper polarising effect induces a depression of the neuronal excitibility and an inhibitory action.

Dr Bibha Verma
PG Dept of Zoology
Maharaja College, Ara