Module 3:Neural conduction and transmission

Lecture 14:Resting membrane potential, Action potential

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Resting membrane potential and Action potential

At rest (not transmitting an action potential) neuron maintains a voltage difference across its plasma membrane. The cytoplasmic fluid next to the membrane is negatively charged whereas the interstitial fluid outside the membrane is positively charged. This voltage difference is called the resting membrane potential. The resting membrane potential is –70 mv. The concentration of Na+ as well as K+ is higher outside the membrane and at the onset of conduction permeability of Na+ increases. This is the first event of action potential. Figure 3.4 illustrates the process of spike generation.

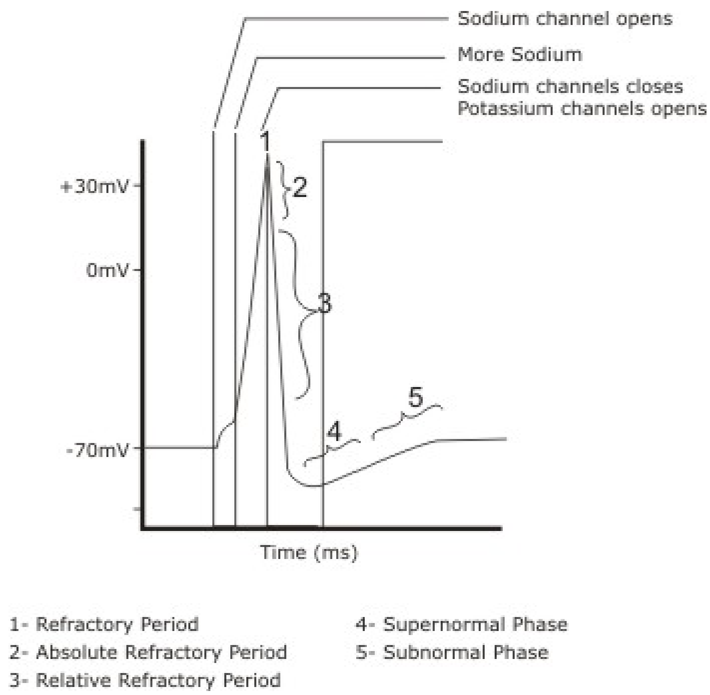

Figure 3.4: Spike generation

This is followed by a gradient change of voltage from –70 mv to +35 mv, which in turn activates Na+-K+ pump. During the first phase, called as absolute refractory period, Na+ ions cannot enter the membrane and hence no current excites the neuron. It lasts for 1-10 milliseconds and is followed by relative refractory period which is 2-3 times that of the absolute refractory period. Only superthresholds are received during this period. The third phase is known as supernormal phase and its duration is 12 ms. During this phase stimulus at sub-threshold level are received. This is followed by the supernormal phase that lasts for 70 ms. and finally the nerve fiber attains resting membrane potential (-70 mv) and gets ready to receive incoming signals. Figure 3.5 illustrates the mechanism of Na+- K+ pump.

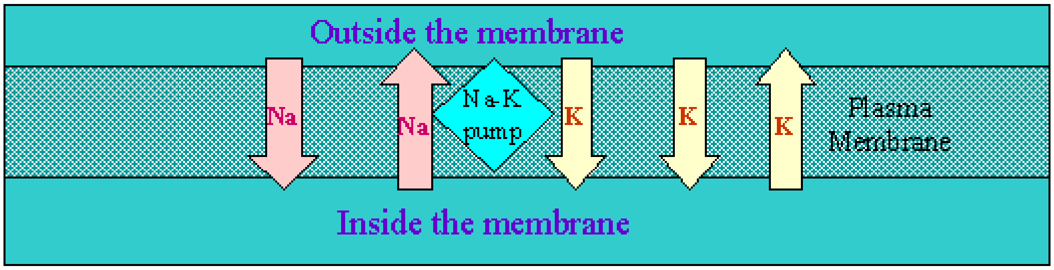

Figure 3.5: Na+- K+ pump

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Synapse

The junction between two neurons or neuron and muscle or gland is termed as synapse. Physically it is a cleft, a microscopic gap. The terminal ends of the axon and soma or dentrites of another neuron forms contact-points with each other. The initial end of synapse is called presynaptic terminal whereas postsynaptic terminals are the other end of synapse. A cleft of an average width of 200Å separates the two terminals. A wide variety of possibilities exist in terms of nature of the synapse. A single neuron may form synapse with the other neuron or many presynaptic end of neurons may converge on a single neuron's postsynaptic terminal or the presynaptic end of a neuron may branchoff and form synapse at multiple postsynaptic terminals.

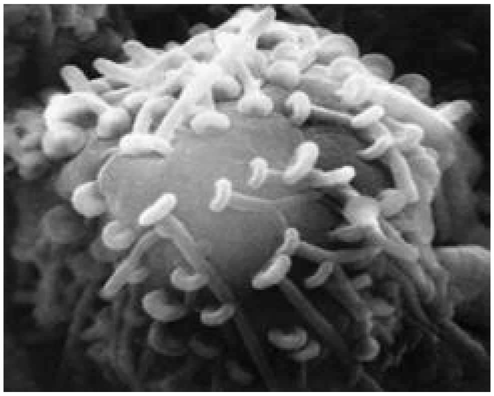

Figure 3.6: Scanning electron microscopic photograph of synaptic knobs at the end of an axon.

Based on the nature of connection, synapses are classified as axosomatic, axodendritic, and axo-axonic. As reflected in the nomenclature, axosomatic synapse is the junction of presynaptic axon of the first neuron and soma of the other neuron. The connection between basket and Purkinje cells in the cerebellum is an example of axosomatic synapse. Axodendritic synapse is the junction of presynaptic axon and dendrites of the postsynaptic cell. The climbing fibres and the dendrites of the Purkinje cells form axodendritic connection in the cerebellum. When the axon of the presynaptic cell ends in the axon of postsynaptic neuron it is called axo-axonic synapse. On the other hand, they are categorized as chemical and electrical synapse on the basis of functional characteristics. There are small protein tubular structures that allow ions to move from interior of one neuron to the other one. They are known as gap junctions. Action potentials are transmitted from a smooth muscle fibre to another visceral smooth muscle by way of such gap junctions. Such junctions are electrical synapses. In case of chemical synapses the presynaptic end of the neuron secretes a neurotransmitter which acts on receptor proteins in the membrane of the postsynaptic neuron.

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