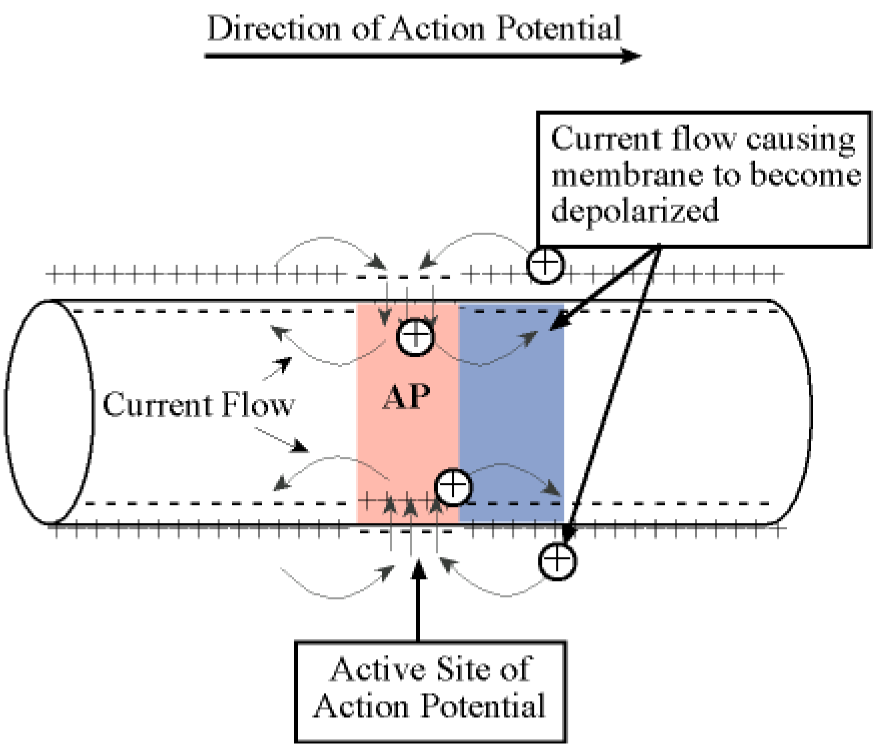
Physiology

The Nervous System

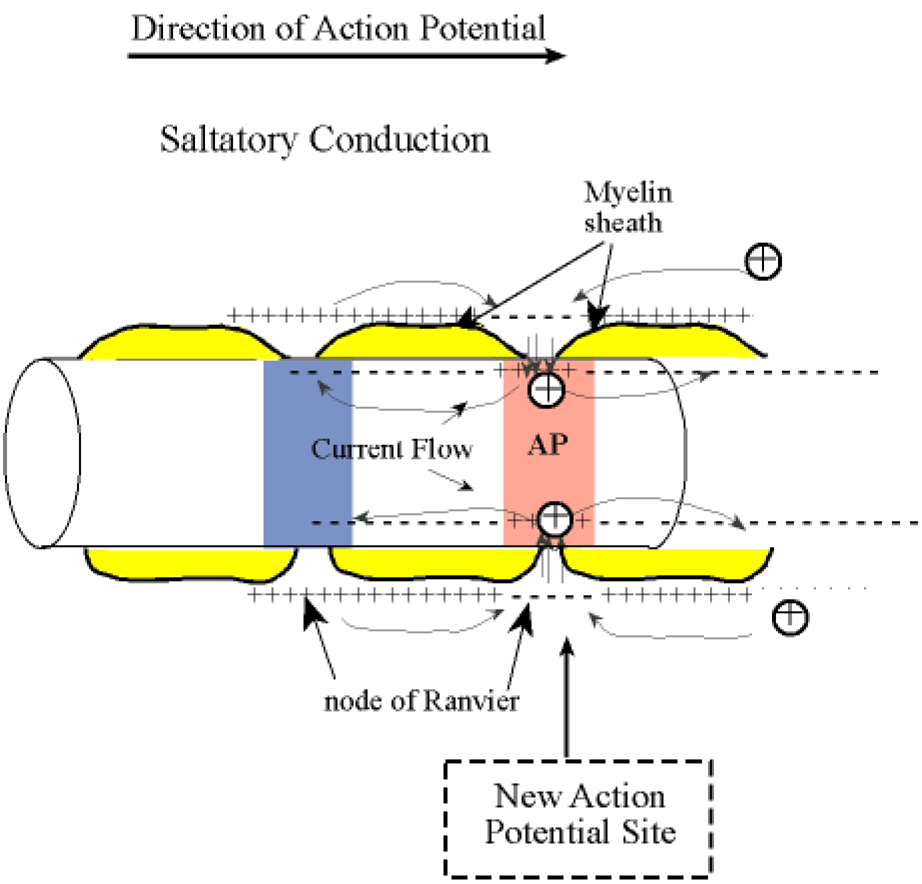
Impulse conduction – an impulse is simply the movement of action potentials along a nerve cell. Action potentials are localized (only affect a small area of nerve cell membrane). So, when one occurs, only a small area of membrane depolarizes (or 'reverses' potential). As a result, for a split second, areas of membrane adjacent to each other have opposite charges (the depolarized membrane is negative on the outside & positive on the inside, while the adjacent areas are still positive on the outside and negative on the inside). An electrical circuit (or 'mini-circuit') develops between these oppositely-charged areas (or, in other words, electrons flow between these areas). This 'mini-circuit' stimulates the adjacent area and, therefore, an action potential occurs. This process repeats itself and action potentials move down the nerve cell membrane. This 'movement' of action potentials is called an impulse.



Conduction Velocity:

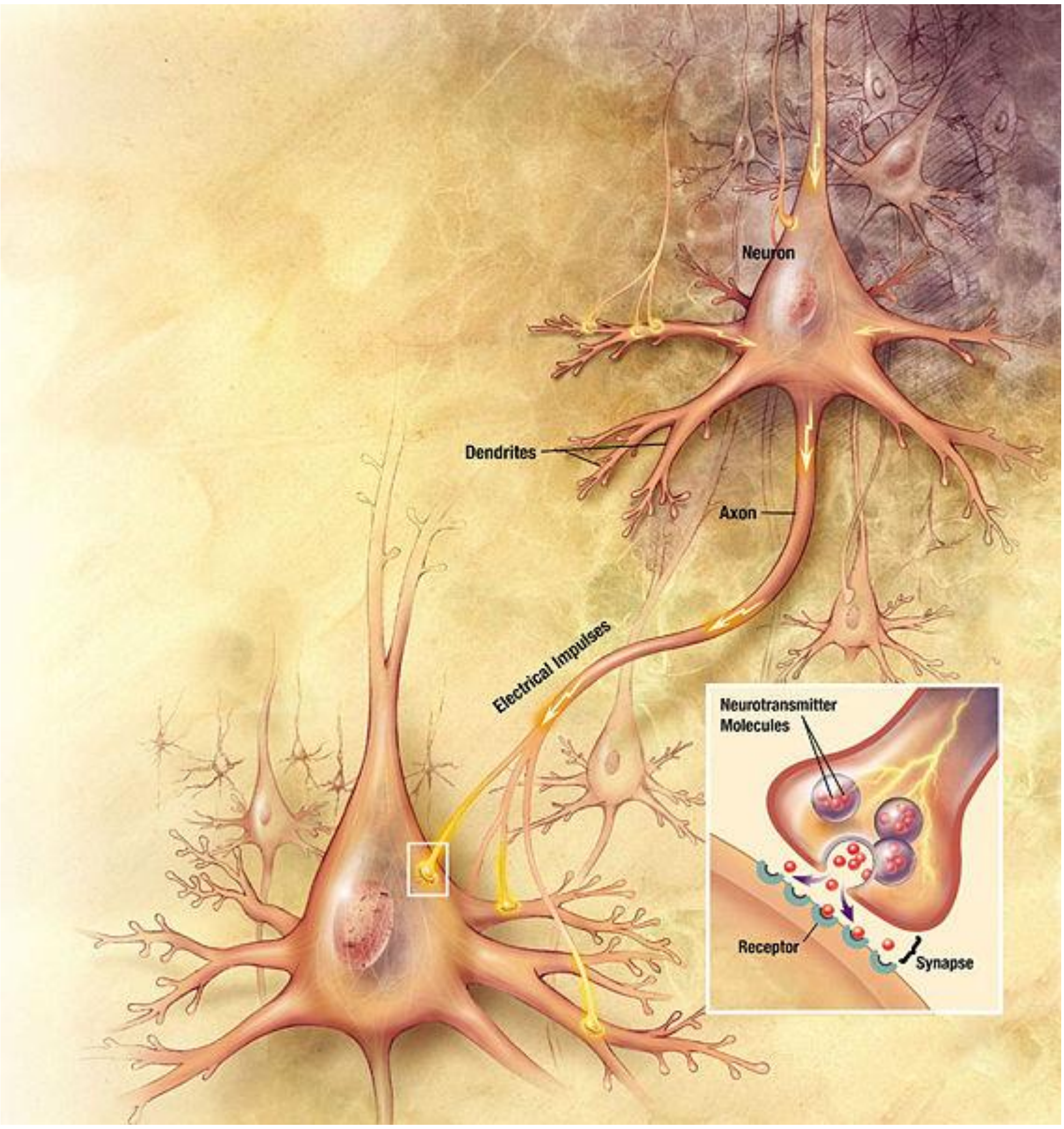
- impulses typically travel along neurons at a speed of anywhere from 1 to 120 meters per second
- the speed of conduction can be influenced by:
  - the diameter of a fiber
  - the presence or absence of myelin

Neurons with myelin (or myelinated neurons) conduct impulses much faster than those without myelin (Between areas of myelin are non-myelinated areas called the nodes of Ranvier. Because fat (myelin) acts as an insulator, membrane coated with myelin will not conduct an impulse. So, in a myelinated neuron, action potentials only occur along the nodes and, therefore, impulses 'jump' over the areas of myelin - going from node to node in a process called saltatory conduction (with the word saltatory meaning 'jumping'), Because the impulse 'jumps' over areas of myelin, an impulse travels much faster along a myelinated neuron than along a non-myelinated neuron.



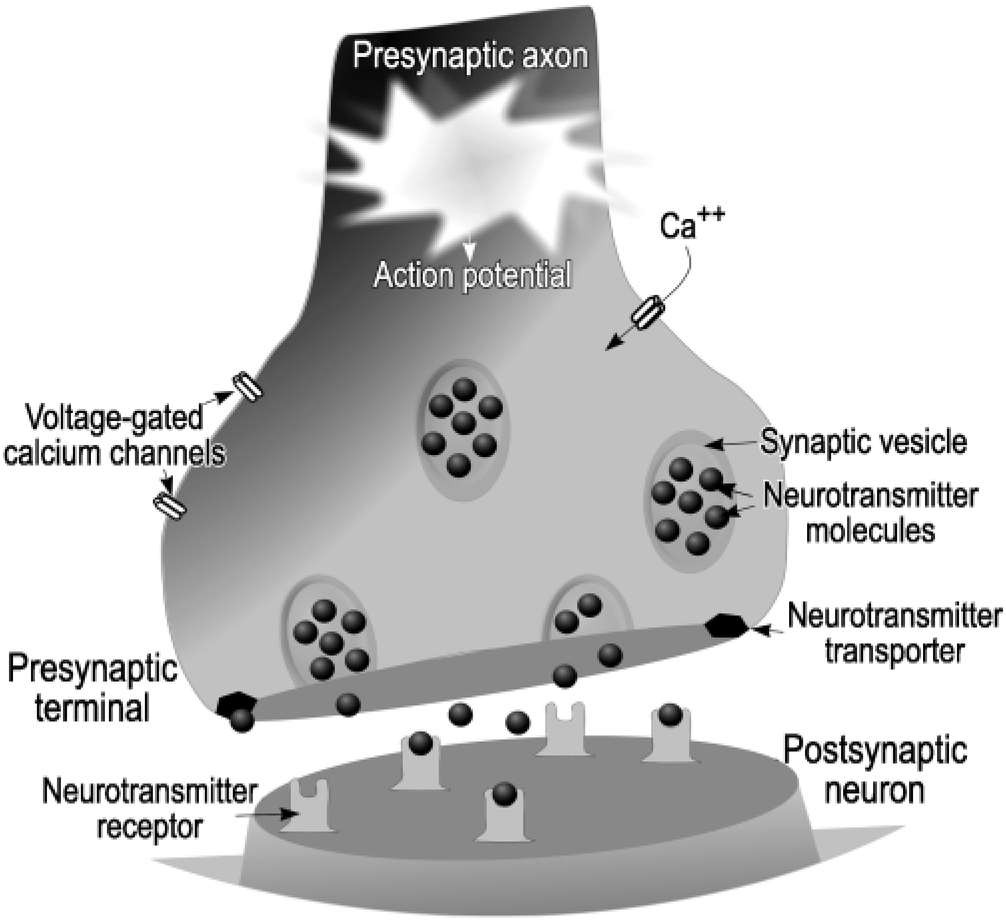
Synapse = point of impulse transmission between neurons; impulses are transmitted from pre-synaptic neurons to post-synaptic neurons

Synapses usually occur between the axon of a pre-synaptic neuron & a dendrite or cell body of a post-synaptic neuron. At a synapse, the end of the axon is 'swollen' and referred to as an end bulb or synaptic knob. Within the end bulb are found lots of synaptic vesicles (which contain neurotransmitter chemicals) and mitochondria (which provide ATP to make more neurotransmitter). Between the end bulb and the dendrite (or cell body) of the post-synaptic neuron, there is a gap commonly referred to as the synaptic cleft. So, pre- and post-synaptic membranes do not actually come in contact. That means that the impulse cannot be transmitted directly. Rather, the impulse is transmitted by the release of chemicals called chemical transmitters (or neurotransmitters).



When an impulse arrives at the end bulb, the end bulb membrane becomes more permeable to calcium. Calcium diffuses into the end bulb & activates enzymes that cause the synaptic vesicles to move toward the synaptic cleft.

Some vesicles fuse with the membrane and release their neurotransmitter (a good example of exocytosis). The neurotransmitter molecules diffuse across the cleft and fit into receptor sites in the postsynaptic membrane. When these sites are filled, sodium channels open & permit an inward diffusion of sodium ions. This, of course, causes the membrane potential to become less negative (or, in other words, to approach the threshold potential). If enough neurotransmitter is released, and enough sodium channels are opened, then the membrane potential will reach threshold. If so, an action potential occurs and spreads along the membrane of the post-synaptic neuron (in other words, the impulse will be transmitted). Of course, if insufficient neurotransmitter is released, the impulse will not be transmitted.



Impulse transmission - The nerve impulse (action potential) travels down the presynaptic axon towards the synapse, where it activates voltage-gated calcium channels leading to calcium influx, which triggers the simultaneous release of neurotransmitter molecules from many synaptic vesicles by fusing the membranes of the vesicles to that of the nerve terminal. The neurotransmitter molecules diffuse across the synaptic cleft, bind briefly to receptors on the postsynaptic neuron to activate them, causing physiological responses that may be excitatory or inhibitory depending on the receptor. The neurotransmitter molecules are then either quickly pumped back into the presynaptic nerve terminal via transporters, are destroyed by enzymes near the receptors (e.g. breakdown of acetylcholine by cholinesterase), or diffuse into the surrounding area.