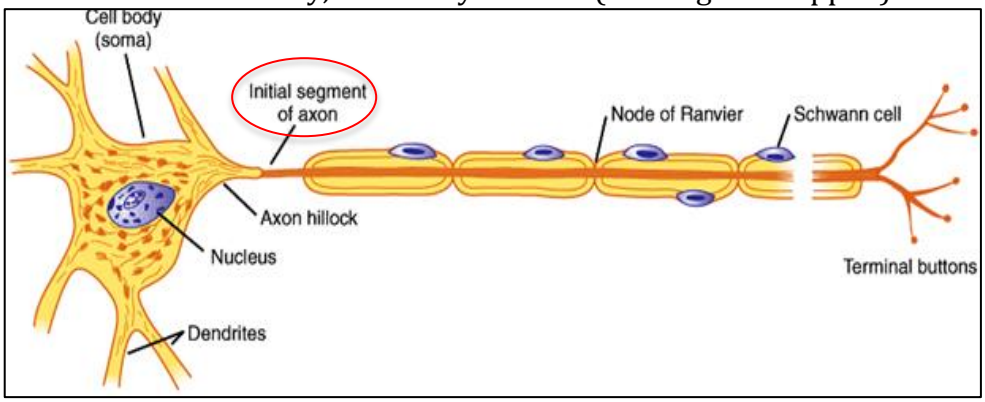
Unit VII – Problem 3 – Physiology: Nerve fibers

- **We have 3 classes of nerve fibers**: A, B and C. We classify them depending on their function and conduction velocity.
- **The velocity of conduction depends** on the **thickness** (or the diameter) of the nerve fibers (nerves with larger diameters → less resistance → more conduction and faster impulse transmission).
- **Example**: type A nerve fibers is sub-classified to: Aα, Aβ, Aγ and Aδ. The sub-classification Aα has the largest diameter because it supplies skeletal muscles which require fast conduction of impulses.

Fiber Types	Function	Avg. fiber diameters (µm)	Avg. cond. Velocity (m/s)
Aα	Primary muscle spindle afferents, motor to skeletal muscle	15	100 (70-120)
Aβ	Cutaneous touch and pressure afferents	8	50 (30-70)
Aγ	motor to muscle spindle	5	20 (15-30)
Aδ	Cutaneous temperature and pain afferents	<3	15 (12-30)
B	Sympathetic preganglionic	3	7 (3-15)
C	Cutaneous pain afferents, sympathetic postganglionic (unmyelinated)	1	1 (02-2)

- **Myelinated Vs un-myelinated nerve fibers**: they have the same properties and sharing the same characteristics except that myelinated nerve fibers have myelin sheath surrounding their axons.
- It is the initial segment of the axon where action potential summation occurs and then travels along the axon of the nerve.
- **Schwan cells** → they are responsible for myelin production, which will cover the axon fibers (Why?) → To preserve the loss of energy during transmission of electrical signals along the axons.
- **Function of neurons**: they receive signals from other neurons. Then, they will integrate and process signals in order to provide and output which can be: excitatory, inhibitory or none (nothing will happen).

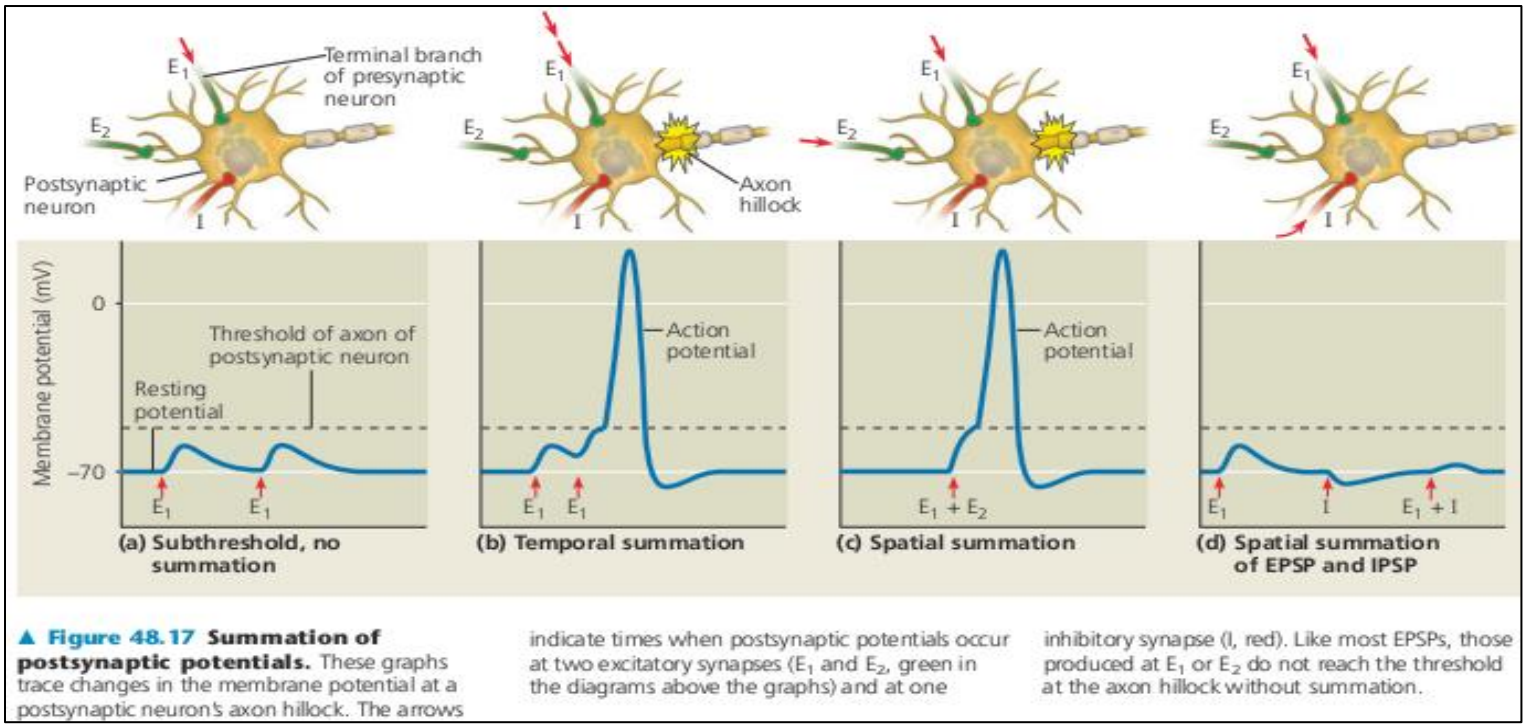


- **Types of neuron synapses:**
  - Dander-somatic
  - Dander-axonal
  - Presynaptic
  - Dander-synaptic

OR

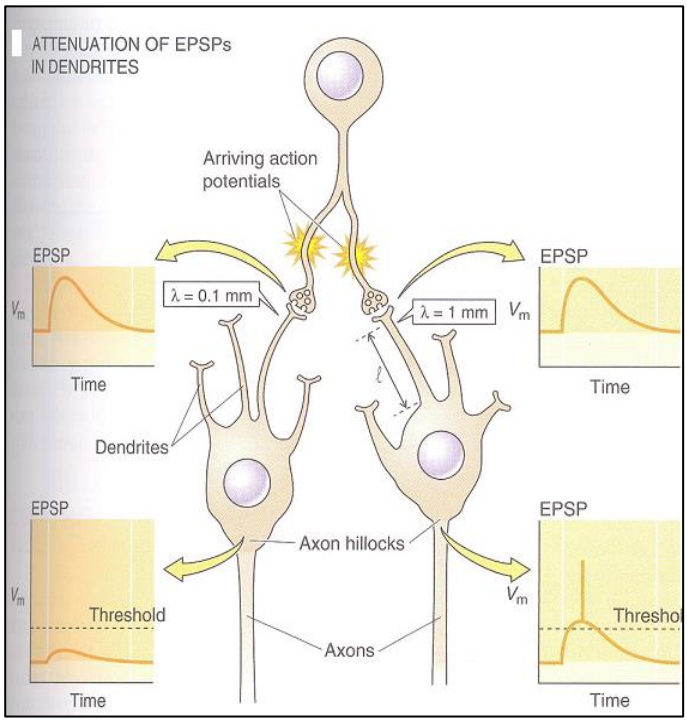
  - Axo-dandretic
  - Axo-somatic
  - Axo-axonal
  - Axo-synaptic

- **Spatial Summation**: it occurs when excitatory potentials from many different pre-synaptic neurons cause the post-synaptic neuron to reach its threshold and fire.
- **Temporal summation**: it occurs when a single pre-synaptic neuron fires many times in succession causing the postsynaptic neuron to reach its threshold and fire.
- **Single synapse**: only one signal arrives and travels along the axon. There might not be a summation because we are dealing with one signal instead of a sum of signals. This one signal will pass along the nerve fiber until it dies and another signal will be regenerated.
- **Two dendritic synapses**: they will deliver (excitatory or inhibitory) action potentials from different cells.
- **IF WE HAVE HIGH FREQUANCY SUMMATION**: a lot of signals will be delivered to the neuron from a single synapse. The neuron will sum all of this synaptic input within a period of time (temporal summation). This will go beyond the threshold and action potential will be generated



▲ **Figure 48.17 Summation of postsynaptic potentials.** These graphs trace changes in the membrane potential at a postsynaptic neuron's axon hillock. The arrows indicate times when postsynaptic potentials occur at two excitatory synapses (E_1 and E_2, green in the diagrams above the graphs) and at one inhibitory synapse (I, red). Like most EPSPs, those produced at E_1 or E_2 do not reach the threshold at the axon hillock without summation.

- **Lambda parameter Ratio?**
  - Lambda is a critical parameter defining the length over which the electric potential will spread along a cable of infinite length. Lambda is the characteristic length or space constant of the spread of the potential.
  - This ratio will regulate the dynamic of propagation of signals passing along the neuron.
  - The space constant λ depends not only on the internal and membrane resistance, but also on the diameter of the process.
  - The smaller the parameter (λ) → the less action potential will reach the post-synaptic region → no propagation of signals.



- Different cells have different ion channels which aid in the generation of action potentials.
- Purkinje cells are brain cells. Calcium-channels are predominant in dendrites (patients can be treated by blocking or stimulating these channels).
- The spikes of dendritic calcium-channels alone will be lower than the summation of dendritic calcium-channels and somatic sodium-channels (which reaches 60 mV).

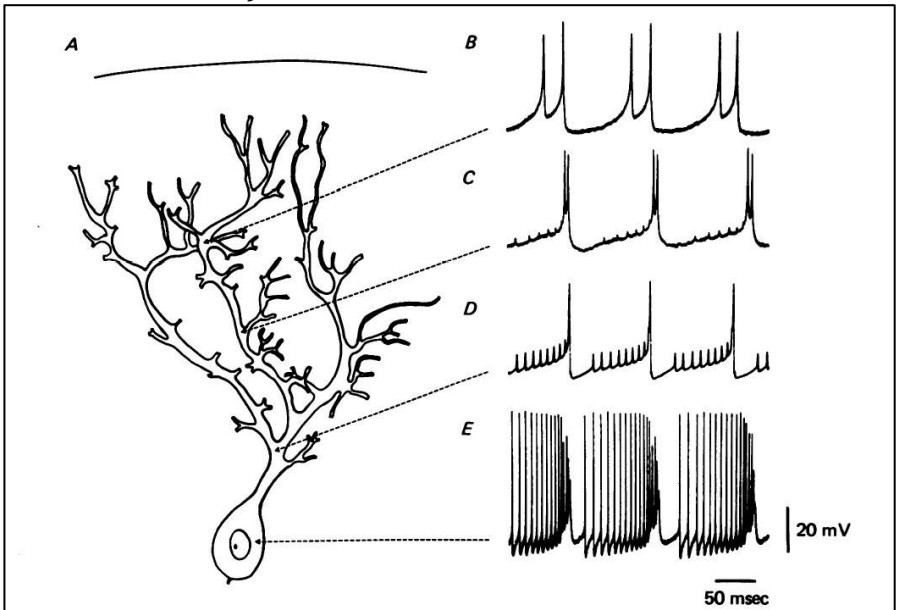
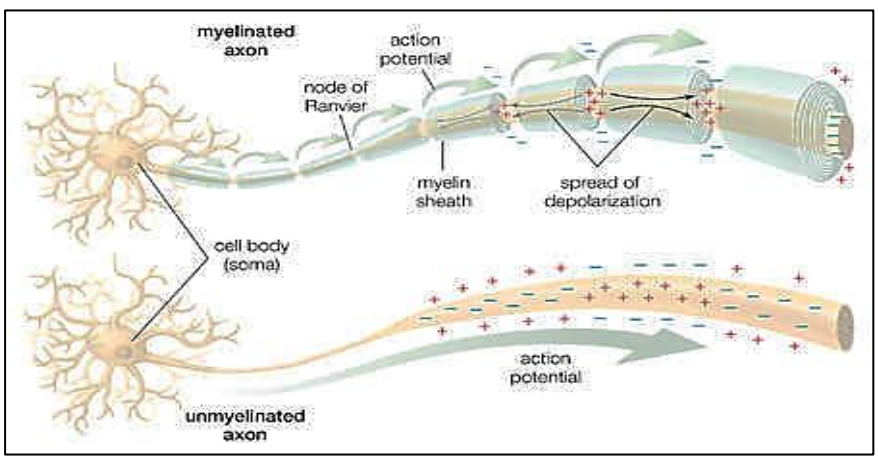
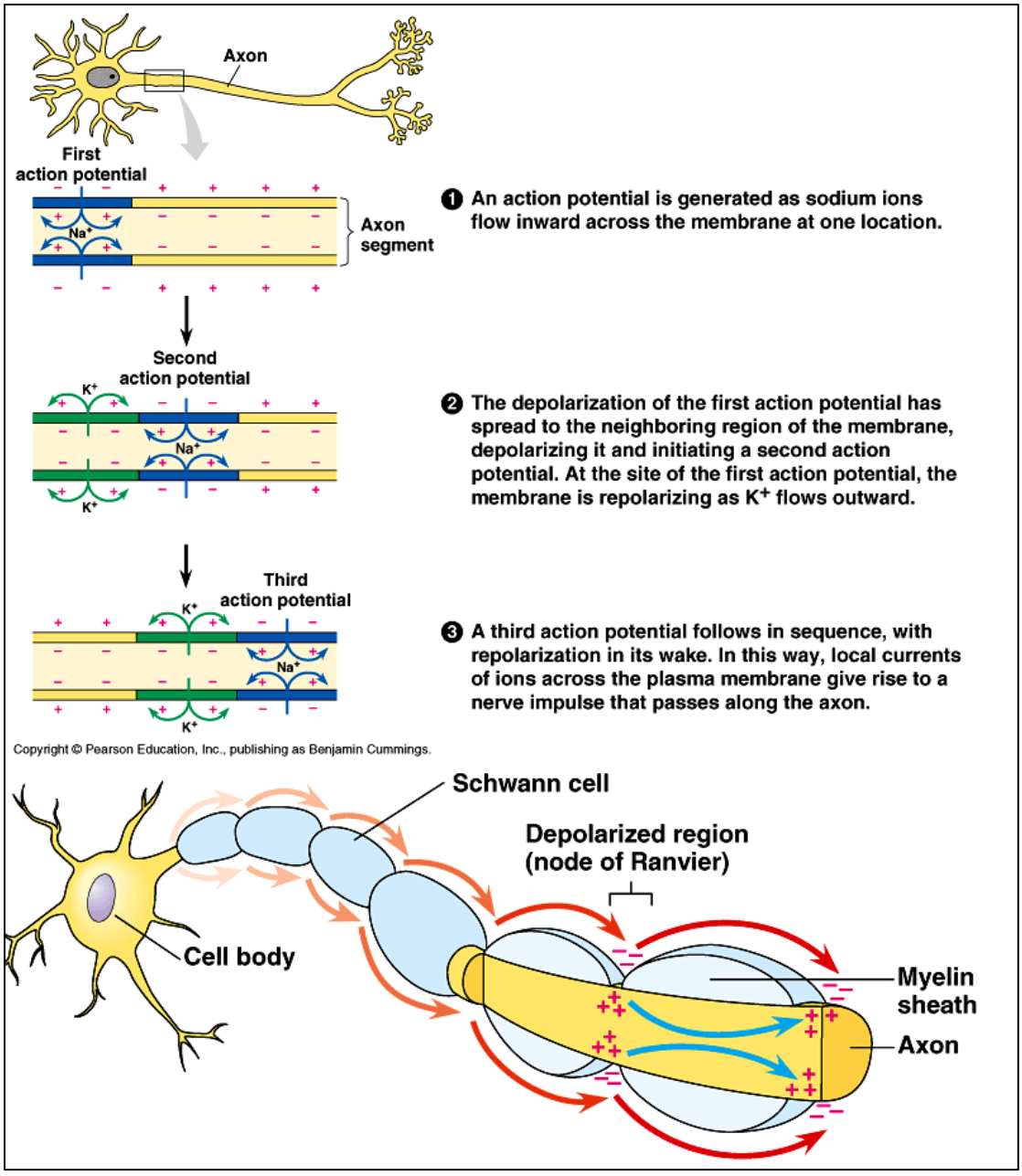


Fig. 4. Composite picture showing the relationship between somatic and dendritic action potentials following DC depolarization through the recording electrode. A clear shift in amplitude of the s.s. against the dendritic Ca-dependent potentials is seen when comparing the more superficial recording in *B* with the somatic recording in *E*. Note that at increasing distances from the soma the fast spikes are reduced in amplitude and are barely noticeable in the more peripheral recordings. However, the prolonged and slow-rising burst spikes are more prominent at dendritic level.

- **Un-myelinated Vs Myelinated nerve fibers:**
  - **Trans-membrane ion current**: K and Ca channels are important for generation of action potential which will propagate transversely along the axon.
  - **Unmyelinated nerve fibers**: there is energy loss during the transmission of electrical signals due to the lack of insulation of axons with myelin sheath.
  - Velocity of propagation does not only depend on nerve fibers diameter, but also on the amount of energy which will be lost.
  - **In Myelinated axons**: energy loss will decline because of the presence of myelin sheaths (insulation) around the axons. Propagation will be faster along the axons and between the sheaths (in the node of Ranvier) where electrical action takes place. These nodes are rich with sodium-channels which are responsible for the generation of action potentials.



- In the initial segment, propagation will take place (So how will electrical signals continue along the axons?)
    - In myelinated axons, electrical signals will jump along the axons and there will be no energy loss because these axons are insulated with myelin sheath → **salutatory propagation.**



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