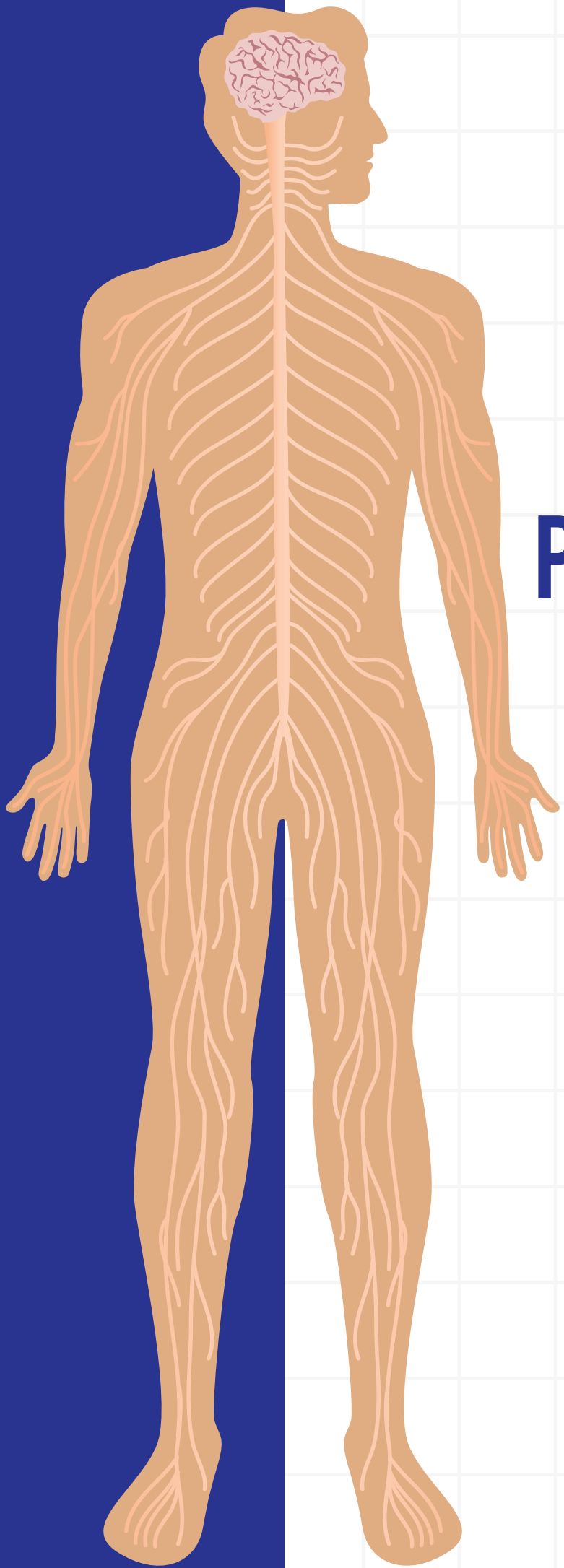
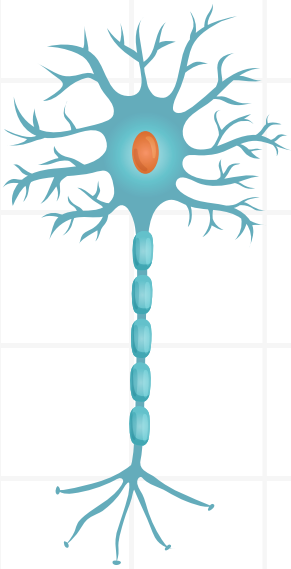
ARKAN
STUDY HOUSE



PHYSIOLOGY

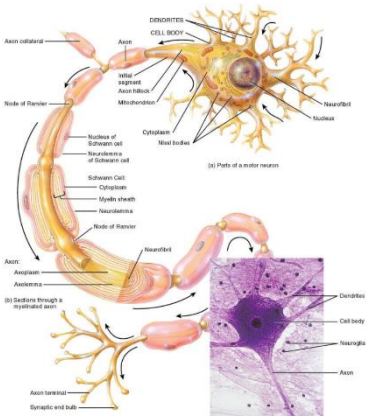
2024



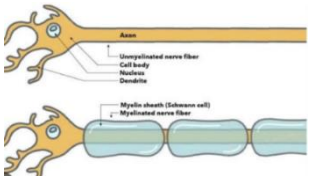
DR. AHMAD AL-QAWASMI

❖ Neural Structure

- The nervous system is formed of neurons and supportive cells
- The main parts of the Neuron (Neural cell):

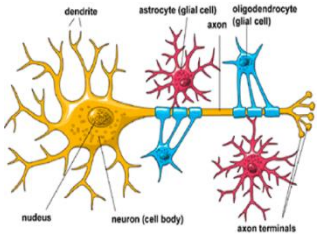


  - ➢ ***Cell body (Soma)*** contains most organelles such as nucleus, ER, mitochondria, Nissl bodies (site of protein synthesis)
    - ✓ Neurons can't divide or regenerate so they *lack centriole*
  - ➢ ***Dendrites*** which are short projections from the cell body that *receive inputs* (collect signals) from neighboring neurons
    - ✓ Dendrites ***can't generate*** action potential, because they have a *very high threshold* due to the *lack of voltage gated Na^+ channels* in addition to their *small diameter* (*high resistance*)
  - ➢ ***Axon (Nerve fiber)***



    - ✓ A long tubular like structure which projects from the cell body
    - ✓ Axons can be either myelinated or un-myelinated
      - ▪ ***Myelin sheath*** is composed mainly of glycolipids, and it appears white
      - ▪ ***Nodes of Ranvier:*** **gaps** in the myelin sheath, appear at intervals along the axon
    - ✓ At the end of the axon there are fine processes called ***Axon terminals***
    - ✓ Some of these terminals end with bulb-shaped structures called ***synaptic end bulb (Knob)***
      - o At these end the neurotransmitters are stored in vesicles and ready for the release
  - ➢ ***Axon hillock (trigger zone)***
    - ✓ It is the junction between the cell body and axon, where ***action potential is generated*** because it has the *largest number* (density) of voltage gated sodium channels & the *lowest threshold*

- **Supportive cells (neuroglia)** include *microglia*, *astrocytes*, *Schwan* cells and *oligodendrocytes*
  - ➢ **Astrocytes** form the *blood brain barrier (BBB)* between the blood and the cerebrospinal fluid (in the brain)



- The functions of supportive cells:
  - ➢ Maintenance of neural environment, by the uptake of K^+ and neurotransmitters from the interstitial fluid around the neurons
  - ➢ Synthesize and release neurotrophic factors to maintain the survival and protection of neurons
  - ➢ Other specialized supportive cells are responsible for myelination of axons
    - ✓ In the **CNS**, *oligodendrogliocytes* are the responsible for the myelination process
    - ✓ In the **peripheral** nervous system, *Schwan cells* are the responsible for the myelination process

- Action potential propagation (conduction) along the axon (nerve fiber) occurs by:

1- Continuous conduction (Slow)

- Occurs in ***unmyelinated*** fibers
  - ➢ Local ionic currents flow between the adjacent regions (from + to –), causing activation of Na+ channels, which can bring potential to threshold and causing action potential generation in this region
  - ➢ This process is repeated ***all along the nerve fiber*** until the impulse has reached nerve terminals

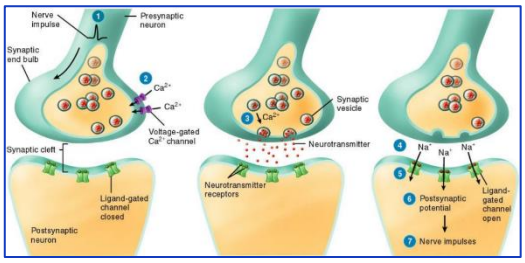
2- Salutatory conduction (Fast)

- Occurs in ***myelinated*** fibers

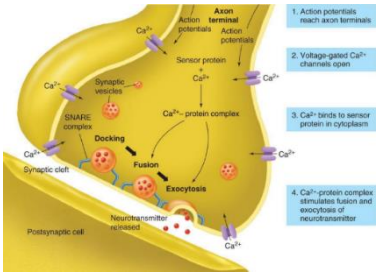
- The ionic current flow between two adjacent ***nodes of Ranvier***
- The impulse skips the myelinated regions in the axon and ***jumps*** from one node of Ranvier to the other
- It is 50 times faster than in unmyelinated fibers of the same size
- Velocity of action potential conduction depends on *myelination* and the *diameter of nerve fibers*
  - Larger fiber has lower resistance → higher velocity (faster)

❖ Transmission of action potential between neurons

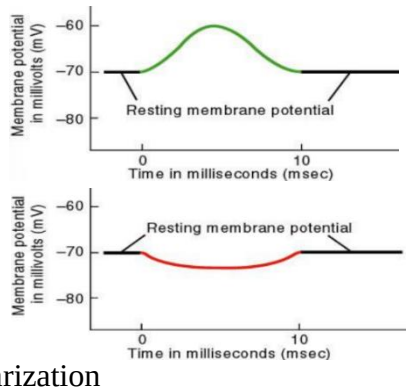
- Synapse: The connection between a neuron and another cell
  - Presynaptic membrane: The membrane of the synaptic bulbs of the axon terminal of the first neuron
  - Postsynaptic (subsynaptic) membrane: The membrane of the dendrites & cell body of the second neuron
  - Synaptic cleft: The gap between the 2 cells



- When the impulse from the presynaptic neuron reaches the synaptic knob, it causes **activation** of ***voltage dependent Ca^{++} channels***, causing diffuse of Ca^{+2} into the synaptic knob, increasing its concentration inside the terminals which triggers the ***fusion of the neurotransmitter vesicles*** with the presynaptic membrane, ***releasing*** NTs into the cleft by ***exocytosis***
  - Ca^{+2} triggers exocytosis by *reducing (decreasing) the repulsion* between the membranes of the vesicles and the plasma membrane

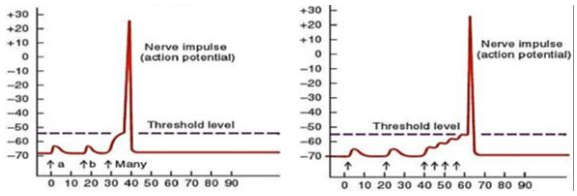


- ***Bind of NTs to their receptors*** on the postsynaptic membrane, inducing ***changes in the membrane potential*** (activity of ion channels), which can be excitatory or inhibitory
  - *EPSPs (Excitatory Post Synaptic Potentials)*
    - ✓ It ***decreases*** the membrane potential (become less negative, small depolarization), due to the activation of a few ***Na^+ channels***
    - ✓ A single EPSP can ***not reach threshold***
  - *IPSPs (Inhibitory Post Synaptic Potentials)*
    - ✓ It ***increases*** the membrane potential (become more negative, hyperpolarization), due to the activation of ***K^+ channels***
    - ✓ Activating ***Cl^- channels*** is considered as inhibitory but it doesn't induce hyperpolarization where this inhibition is achieved by holding the membrane at its resting potential and preventing depolarization



- IPSP & EPSP are **graded potentials**
  - The channels on the postsynaptic membrane are **chemical** gated channels
  - ***Acetylcholine*** is a neurotransmitter causes **EPSP** by the activation of chemical gated Na^+ channels
    - ✓ 2 molecules of Ach are required to bind & activate Na^+ channels
- ***Synaptic delay:*** The period required to induce changes in membrane potential in the postsynaptic neuron
- After inducing the appropriate response at the postsynaptic membrane, the transmitter is *inactivated* (destroyed) or *removed*, allowing the postsynaptic membrane to receive additional messages
  - *Acetylcholine esterase* an enzyme that destroys acetylcholine (Ach) into acetyl and choline, which then transported back to the presynaptic knob, where they combine again to form new Ach
- ***Blockers*** are drugs can combine with receptor and **prevent** binding of transmitter to its receptor
  - ***Hexamethonium*** blocks the binding of acetylcholine (Ach) to its receptor

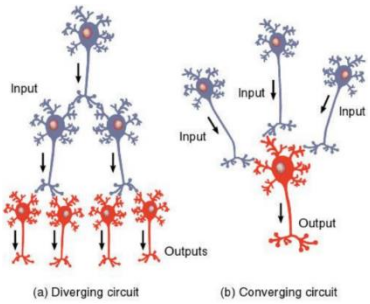
- **Summation:** is the addition and combination of many signals, producing a stronger signal which can reach threshold (in EPSPs) or cause more inhibition (in IPSPs)
- **Spatial summation:** 2 or more responses from *2 or more different presynaptic neurons* have appeared *simultaneously (at the same time)* at the same site of postsynaptic membrane
- **Temporal summation:** 2 or more postsynaptic potentials, which were elicited by *one presynaptic neuron (single input)* at *different times (repetitive excitation)*



- Summation can occur between EPSPs or IPSPs or between both (results in ***cancellation***)

❖ Synaptic organizations

- Neurons are connected together forming neural networks, including:
  - ***Convergence:*** synapse of many axonal terminals from different neurons to one neural cell body
    - ✓ Many inputs (presynaptic) with 1 output (postsynaptic)
  - ***Divergence:*** It is the branching of 1 fiber (axon) to many terminals
    - ✓ One input (presynaptic) with many outputs (postsynaptic)

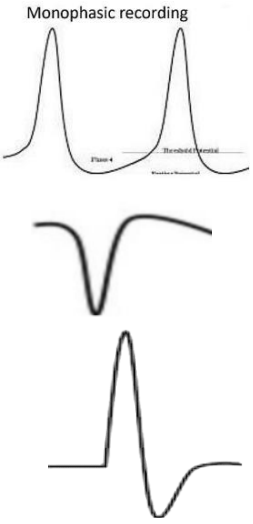


❖ Action Potential Recording

- There are 2 methods of recording action potential:

1) Monophasic action potential:

- We place one electrode ***outside*** and one electrode ***inside*** the cell
- The recording would be either positive or negative but **not both**
  - It records potential in one region (one phase) [depolarization +, repolarization -]

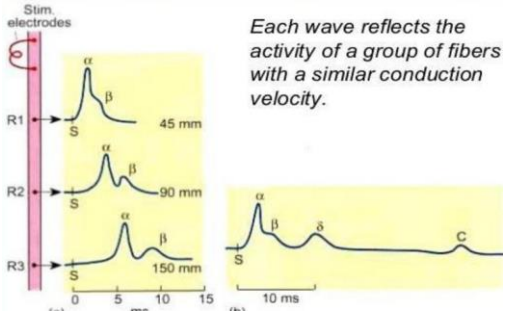


2) Biphasic action potential:

- We place **both** electrodes **outside** but in 2 different regions
  - It records potential in 2 regions (2 different phases)

❖ Compound action potentials

- It is the sum of **all** recorded action potentials generated by all nerve fibers at a certain point on the nerve
  - It is done by placing one electrode at a source of zero voltage (high resistance source) and the other one at a point on the nerve, by sensing the voltage difference
  - It is used to check the ***integrity*** of the fibers



- *Aα* Fibers is the **fastest** in the conduction (transmission) of action potential
- *C* fibers are the **slowest**