A.P. Conduction Characteristics

1. Conduction results from *recreating* Action potentials
   - Each action potential is:

2. Conduction *without decrement*:
   - Action potentials are *same in*:
   - Due to:

3. Conduction is *Unidirectional*:
   - Conducted:
   - Due to:

**A.P. Conduction Velocity:** “*How fast do AP travel?’”

Dependent upon 2 Properties:

a. Axon:

b. Axon Insulation:

A. Axon Diameter:
   - Ion diffusion dependent on axon *internal resistance*
     - *Larger Axons: LESS*:
       - Better Cable Properties:
       - Result:

B. Insulation: *Myelination*
   - Produced by:
     - Peripheral NS:
     - Central NS:
   - Glial Cells wrap around axon:
     - Produce an *ALMOST continuous* insulation
     - Gaps in insulation:
       - Insulation *inhibits* ion movement across membrane
         - Insulated areas:
         - Non-insulated areas:
           - *ONLY* produced in:
• Nodes contain HIGH concentrations of:

• Nodes spacing:
  ➔ Short enough to allow cabling of Na⁺
  ➔ Depolarization to threshold:

• Action Potential bypasses:
  ➔ Saltatory:
  ➔ “Jumps” from:

• Result: Faster conduction velocities without:
  ➔ Myelination: Uses:
  ➔ Node: Regenerates AP thus maintaining:
    ➔ Functionally:
      ✓ FEWER
      ✓ Unmyelinated neurons =
      ✓ Myelinated neurons =

Neuron Communication: Synapse
• Functional connection between a neuron &:
  a.
  b.
  c.

• Synaptic Cleft: Physical space between:
  ➔ Less than:
  ➔ Effective diffusion distance for:

• Neuron to Neuron communication:
  a. Presynaptic neuron: Neuron before the:
    ➔
  b. Postsynaptic neuron: Neuron after the:
    ➔

* Mechanism of Communication:
Events of Synaptic Communication

1. Start:
   a. Carries Action Potentials to:

2. Neurotransmitters housed in
   a. Synaptic Vesicles “docked” to:

   b. Vesicles “held” by membrane:

   ➔ SNARE proteins mediate:
   (Soluble NSF attachment receptor)

3. Action Potentials stimulate fusion of Synaptic vesicles to:
   a. Neurotransmitters released into:
   b. Neurotransmitters diffuse across the cleft to:

4. Neurotransmitters bind:

5. Binding initiates opening of:
   ✓ Chemical =

   ➔ Ions flux across postsynaptic cell membrane

6. RESULT:

   ➔ Significance:
   ✓ Postsynaptic potentials may depolarize the:

   ✓ If the Axon Hillock depolarization is:

   ➔ Location of:

   ➔ Then an:
Mechanism of Neurotransmitter Release

1. **Action Potentials** travel to terminal ending of:
   - Action Potential:

2. Depolarization OPENS:

3. Calcium diffuses into Presynaptic Cell
   - Calcium binds synaptic vesicle membrane protein:

4. Ca²⁺ binds synaptotagmin causing:
   - Result:
   - Release & diffusion of:

✓ Frequency of Action Potentials determines

Clinical Application: Neurotoxins:

1. **Botulinum Toxin**: Botulism Bacterial product
   - **Protease**:
     - Digests motor neuron:
     - Inhibits release of:
   - Result:

2. **Tetanus Toxin**: Tetanus Bacterial product
   - **Protease**:
     - Digests Inhibitory motor neuron:
     - Blocks muscle:
   - Result:

Post-synaptic Membrane Affects

1. Neurotransmitters bind:
   - Form:

2. Receptor Complex results in OPENING of:
   - Two Types of chemical gated ion channels:
     - a. **Direct Opening**: Receptor Complex IS the:
     - b. **Indirect Opening**: Receptor Complex causes opening of:
3. Result: Ion Channels OPEN in Post-synaptic:

- RESULT: Ions flux across membrane changing the:

* Potential Changes:

Post-Synaptic Potentials Changes

1. **Excitatory Post Synaptic Potentials (EPSP)**
   
   Receptor complex causes post synaptic membrane:
   
   - Move membrane potential closer to:
   
   ![Action Potentials (1 & 2) Diagram]
   
   - IF axon hillock is depolarized to *threshold* THEN an:
   
   **NOTE:** Not all EPSP result in Action Potentials

2. **Inhibitory Post Synaptic Potentials (IPSP)**
   
   Receptor complex causes post synaptic membrane:
   
   - Move membrane potential AWAY from:
   
   - Make it MORE difficult to reach:
   
   ![Membrane potential diagram]

Post-synaptic Cell Integration:

* Accomplished by:

  - Location of Neurotransmitter:

    - Result: Location of:

  - Soma "SUMS" all incoming:

    - Collective Ion influxes and effluxes affect:

  - Axon Hillock: First location of:

    - First location of:
Synaptic Potential Summation

1. Spatial Summation: Multiple Pre-synaptic Neurons connect with one:

⇒ Action Potential production is dependent on cumulative depolarization at:

2. Temporal Summation: Frequency of Action Potentials arriving at the:

⇒ “Frequency Modulated” : Single pre-synaptic cell stimulated:

⇒ Add all EPSPs & IPSP at:

☆ IF -55mV is reached; Voltage gated ion channels:

Study Questions:

1) Describe why Action Potentials physiologically only travel in one direction (Explain the cellular events resulting in this phenomena). From a functional standpoint, why is it essential that action potentials are only unidirectional.
2) In a lab setting; could a neuron conduct an action potential from the terminal portion of the axon to the axon hillock if an external depolarization began at the terminal ending?
3) Multiple Sclerosis (MS), has been linked to a defect in the immune system. MS results in the demyelination of nervous tissue cells by the body’s immune system. The disease results in muscle paralysis, and sensory losses. Explain why demyelination of the nerves within the spinal cord columns and tracts result in these symptoms. (Hint: use your knowledge of the significance of myelination).
4) Explain how an insulating sheath of myelin can function to increase action potential conduction.
5) What is the affect of increasing size of the axon diameter on the action potential conduction velocity?
6) How do neurons communicate the intensity of a signal? How do Nerves (Many neurons) communicate the intensity of a signal?
7) Define Synapse. Provide some specific examples of synapses.
8) What is the synaptic cleft? What are the difference between the pre-synaptic and the postsynaptic cell? Which one releases neurotransmitter? Which one binds neurotransmitter?
9) Provide a brief overview of events resulting in the release of neurotransmitter. What does the neurotransmitter do when it is released? What do neurotransmitters cause in the postsynaptic cells?
10) Describe the specific events resulting in the release of neurotransmitter. What are the SNARE proteins? How does calcium released and what does calcium specifically do in this process which eventually results in the release of neurotransmitters?
11) Clinically the fusion complexes are relevant to how some specific neurotoxins function. Describe how Botulism toxin (BOTOX) and Tetanus toxin exert their effects. How is BOTOX being used clinically to release muscle tension?
12) If extra-cellular calcium was diminished, what affect would this have on a neuron (if any)?
13) What do the neurotransmitters bind to in the postsynaptic cell? What complex is formed? What will this binding cause to happen in the postsynaptic cell?
14) Describe the basic difference between direct opening of postsynaptic membrane channels and indirect membrane channels?
15) What is the difference between an Excitatory and an Inhibitory postsynaptic potential (EPSP & IPSP)?
16) Explain why a postsynaptic potential is NOT an action potential. Where do postsynaptic potential occur? Where do Action potentials occur? What types of channels are required for Action Potentials? What types of channels are required for Postsynaptic Potentials?
17) What do inhibitory post-synaptic potentials do to the membrane? What exactly are they inhibiting?
18) What types of channels would function to depolarize; What type of channels might function to hyperpolarize?
19) If the sciatic nerve was electrically stimulated (as was done in lab) BUT remained attached to its target muscles (i.e., gastrocnemius) what affect would this have on the muscle? Explain.
20) What must happen at the axon hillock in order for an action potential to result in the postsynaptic neuron? Do all excitatory postsynaptic potentials result in action potentials? Explain.
21) What is the difference between spatial and temporal summation? What is meant by the term “frequency moderated”?
22) A postsynaptic neuron is connected to many different presynaptic neurons, explain why a postsynaptic neuron might NOT generate an action potential even if ALL presynaptic neurons are releasing neurotransmitters.