**Neuron Anatomy and Cell Physiology**

**Dr. Gary Mumaugh**

**Major Parts of Neurons**

* Dendrites
* Cell Body or Soma
* Axons
* Axon Terminals

**Dendrites**

* Short (usually, about 100 microns in length) protoplasmic extensions that arise from body
* Primarily involved in receiving neural signals from other neurons
* Extensions of the cell body of the neuron that act as neurotransmitter receptors at a synapse
* Dendritic cell membranes contain different types of Channels and receptors:
  + Ligand-gated ion channels
    - Quick response
    - Neurotransmitter binds to allosteric site, opening up channel
* G-Protein Coupled Receptors (GPCR)
  + Slower response
  + Neurotransmitter binds to receptor
* These receptors work by allowing positive or negative ions to enter the cell:
  + Positive Ions
    - Excitatory Postsynaptic Potential (**EPSP**)
    - EPSPs cause **depolarization** 
      * Negative on outside and positive on inside
  + Negative Ions
    - Inhibitory Postsynaptic Potential (**IPSP**)
    - IPSPs cause **hyperpolarization**
      * Positive on inside and negative on inside

**Cell Body / Soma**

* Also called a soma (= “body”; plural = somata)
* Contains nucleus, nucleic acids, and the usual organelles
* Typically, neurons are very active metabolically in order to support neural signaling and the synthetic requirements that are necessary to maintain the intricate protoplasmic processes that arise from the body
* The functions of the cell body include:
  + Receiving graded potentials through receptors on its membrane (same as dendrites)
  + Synthesizing the proteins necessary for cell function: DNA from the nucleus is transcribed into mRNA mRNA travels to the rough endoplasmic reticulum
* Proteins travel to the Golgi apparatus where they are packaged into vesicles
* Types of proteins synthesized in the cell body include:
  + Neurotransmitters
  + Enzymes
  + Membrane proteins
* Neurons constantly receive hundreds of both IPSPs and ESPs through dendrites and cell body receptors.
  + These are known as graded potentials.
  + In order for a neuron to be able to process action potentials, the sum of these voltages must reach a threshold of -55mV

**Axons**

* Long protoplasmic extension that arises from body
  + For some neurons, the axons are very short (<100 μm)
  + For others, axons can be very long (> 1 meter!)
* Involved in the transmission or sending of neural signals away from the cell body and toward other neurons or effector cells
  + Other Nerves, Muscles and Glands
* The main function of the axon is to conduct an Action Potential.
* EPSPs cause the membrane potential to reach the threshold of -55mV
* Voltage-gated Sodium Channels open, allowing Na+ ions into the cell and further depolarizing it
* This depolarization wave is transmitted down the axon to the axon terminal where it causes release of neurotransmitters
* When the voltage inside the cell reaches +30mV, Voltage-gated Potassium channels open, allowing K+ to leave the cell and repolarizing it
* This repolarization wave also travels down the axon
* The other major function of the axon is to perform Axonal Transport
  + The movement of molecules between the cell body and the axon terminal via microtubules

**Axons**

**Diagram, schematic

Description automatically generated**

**Anterograde Axonal Transport**

* From cell body to axon terminal
* Transports:
* Proteins in vesicles
* Neurotransmitters, enzymes, membrane proteins
* Mitochondria
* Dormant pathogens that have been activated (Example shingles)

**Retrograde Axonal Transport**

* From axon terminal to cell body
* Transports:
  + Vesicles + mitochondria to be degraded/recycled
  + Nerve Growth Factors (produced at damaged parts of a neuron to stimulate repair/growth)
  + Pathogens
    - Polio, Rabies, Herpes simplex, Herpes Zooster

**Axon Terminal**

* Specialized contacts among neurons and between neurons and effector cells
* Synapses may be “electrical” (the small minority in the mature CNS)
* Synapses may be “chemical” (the vast majority in the mature CNS)
* Usually found at the end of axons, with an axon terminal contacting a dendrite of another neuron
* Axon terminals may contact cell bodies or even other axon terminals

**Functions of Synapse**

* Neurotransmitter release
  + When a depolarization wave from an action potential reaches the axon terminal, it activates Voltage-gated Calcium channels
  + Ca++ enters the cell and allows the fusion of neurotransmitter-containing vesicles with the cell membrane
* Snare proteins in vesicles and snare proteins on the cell membrane connect and pull toward each other
* Neurotransmitters are released into the synapse

**Function of Synapse**

* Neurotransmitter reuptake
* After the neurotransmitters pass on the action potential to the next neuron, they need to be removed from the synapse
* This can be done through either:
  + Degradation - Enzyme on the cell membrane/synapse breaks neurotransmitters down
  + Reuptake - Reuptake protein on the cell membrane picks up neurotransmitters and brings them back into the cell to be recycled
* Neurotransmitter reuptake
* Some drugs (SSRIs - Selective Serotonin Reuptake Inhibiter) block these reuptake proteins resulting in more neurotransmitters available to stimulate post-synaptic neurons