**POE #3: Botulinum Toxin**

**Topic**

Unit 3- Nervous Tissue (Neurotransmitter Dysfunction, Membrane Potentials, Synapses, Action Potentials)

The scenario below has been simplified for the purposes of this introductory anatomy and physiology course. As you progress in your academic and professional careers you may learn more extensive details related to this scenario.

**Introduction to the Scenario**

*As you read through the scenario below underline specific facts and information you find important to the situation*

Fred works on a farm every day of the week. To perform his daily farming tasks, he uses a number of tools and machines that require skillful handling. One day Fred was feeling fatigued, and as he was working with a pickax to dig up soil, he accidently swung the pickax and sliced his leg. Since Fred was working in deep soil, his open wound was exposed to bacteria living in the soil. Before being able to get back to his house, he had to trudge through another 50 feet of deep soil, which continued to expose his wound to bacteria. Unfortunately, his body was unable to defend against this prolonged exposure, and several days after Fred’s incident, the clostridium botulinum bacteria produced a dangerous toxin. When large amounts of this bacteria infiltrate the body, they begin to produce a toxin called botulinum toxin, which leads to numerous nerve and muscle complications. Fred didn’t realize he had been infected by this bacterium until he began experiencing numbness, tingling, and pain throughout his body and especially in his face. He also began to experience weakness in his muscles, and mild muscle paralysis. Upon experiencing these symptoms, Fred immediately called for medical assistance, and after hospitalizing Fred, the medical staff began to administer antitoxin in an attempt to rid his body of the botulinum toxin. Luckily Fred’s botulism was treated early enough to prevent further nerve and muscle damage, but if he had not been hospitalized, he would have experienced worse symptoms and potentially flaccid paralysis of his respiratory muscles.

**Driving Question(s)**

Why did the botulinum toxin cause nerve complications and mild flaccid muscle paralysis in Fred? If Fred did not receive medical attention immediately, would he have survived?

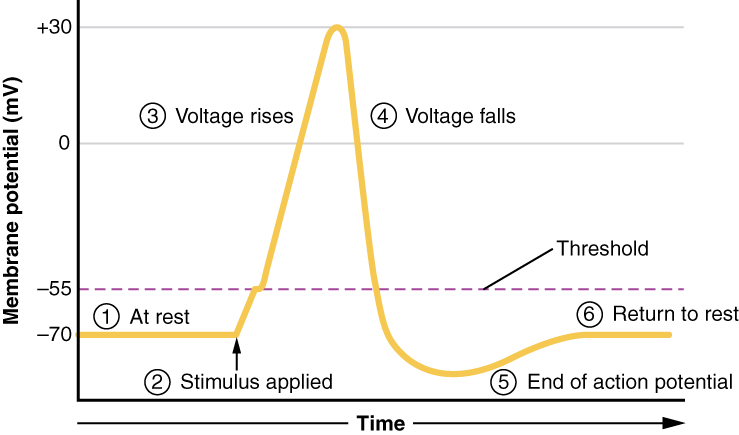
**Initial Hypotheses/Predictions**

*In the box below, please provide your initial ideas about a possible answer to the driving question(s) above.*

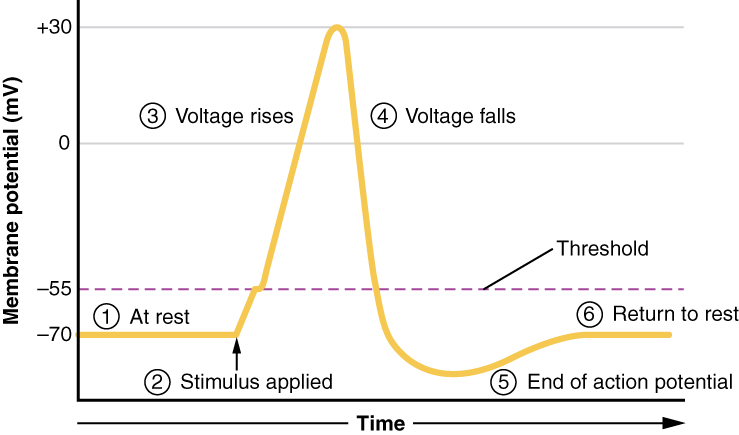
**Relevant Data & Analysis Questions**

***ALL analysis questions are italicized in the pages below***

**Normal Action Potential Graphs**



Action Potential Sent Down Presynaptic Neuron

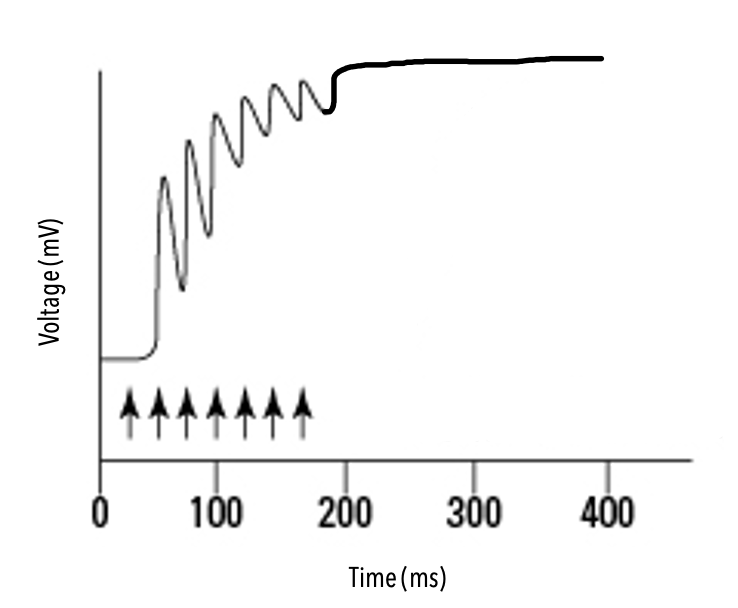


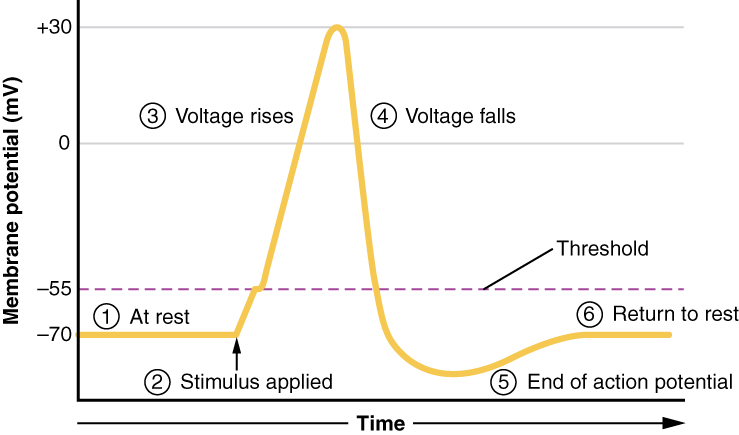
Normal Action Potential Initiated in Postsynaptic Nerves and Muscle Fibers

Acetylcholine

Released

**Sandy’s (our friend from POE Unit #2 is making a guest appearance) Action Potential Graphs**

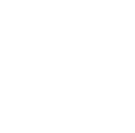
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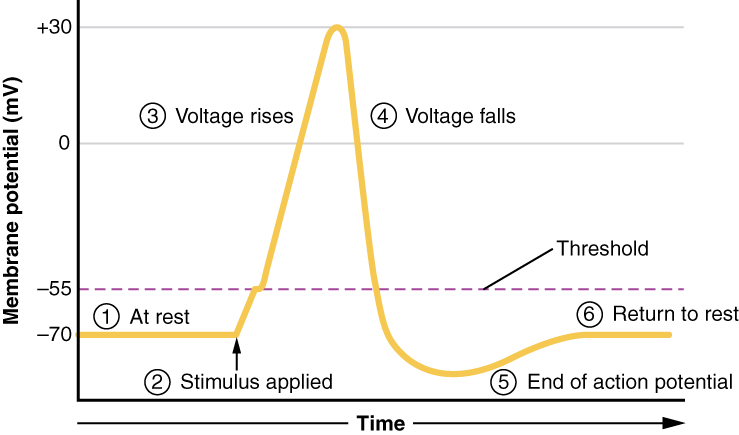
Action Potential Sent Down Presynaptic Neuron

Continual action potentials occurring in the postsynaptic nerve or muscle causing dysfunction and spasms due to constant sodium influx (Low Ca2+= Na+ channels open)

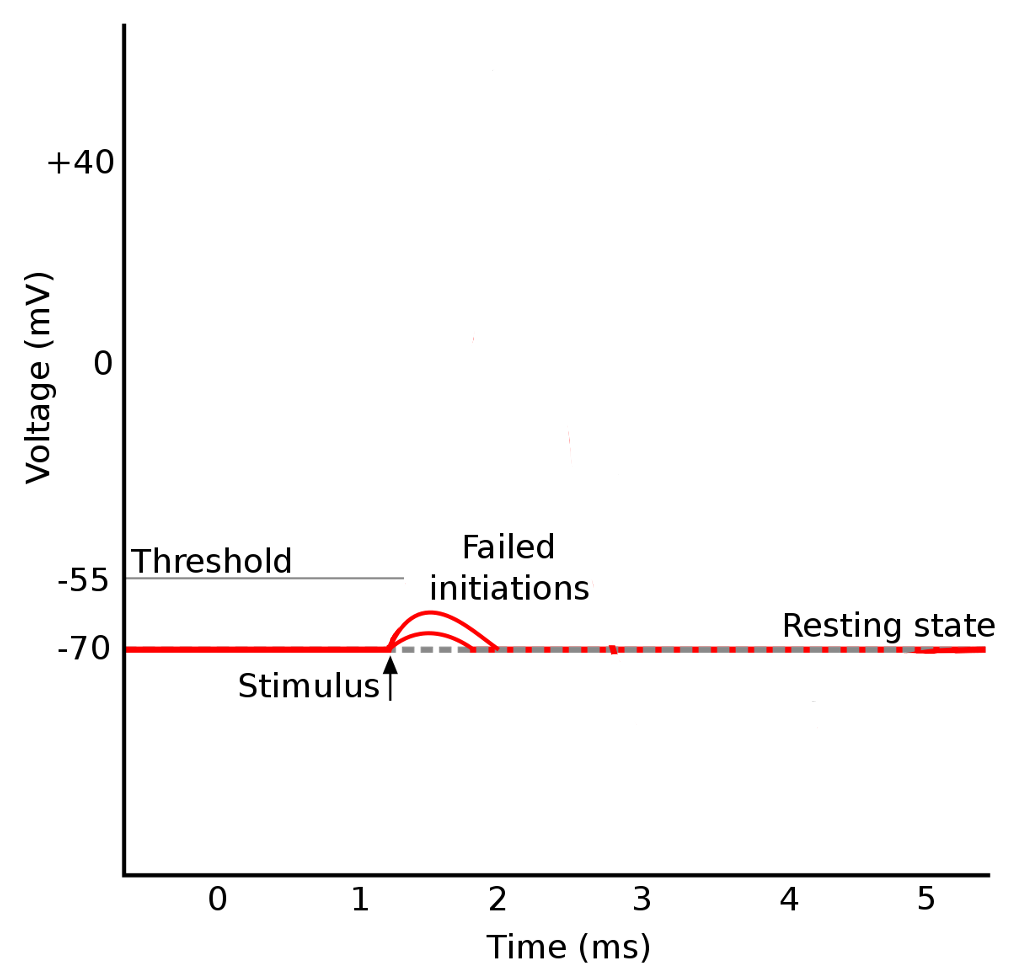
Acetylcholine Not Released (Due to lack of calcium)



**Fred’s Action Potential Graphs**



Action Potential Sent Down Presynaptic Neuron

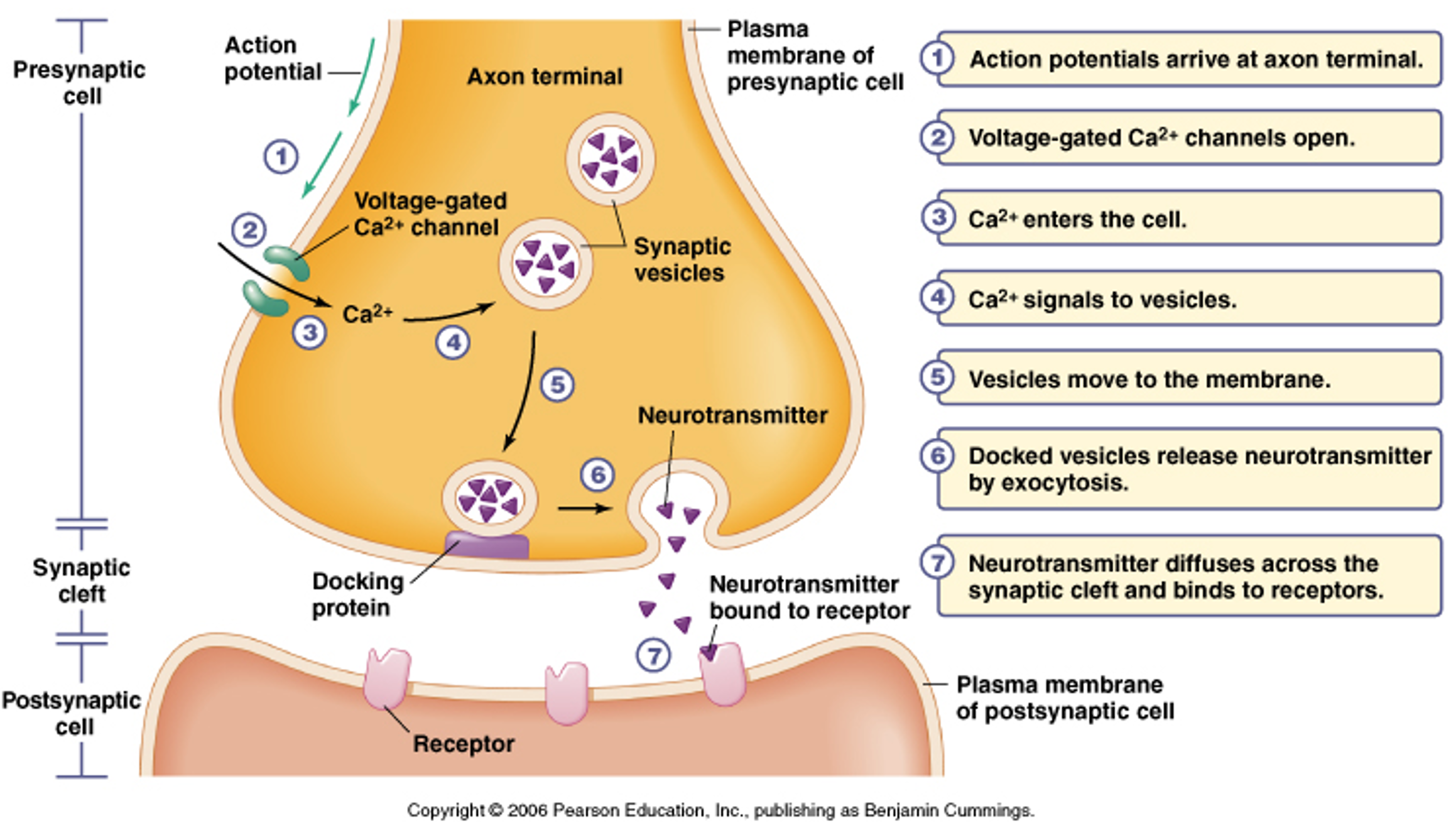


*Why is there no action potential occurring in the graph above?*

Acetylcholine Not Released



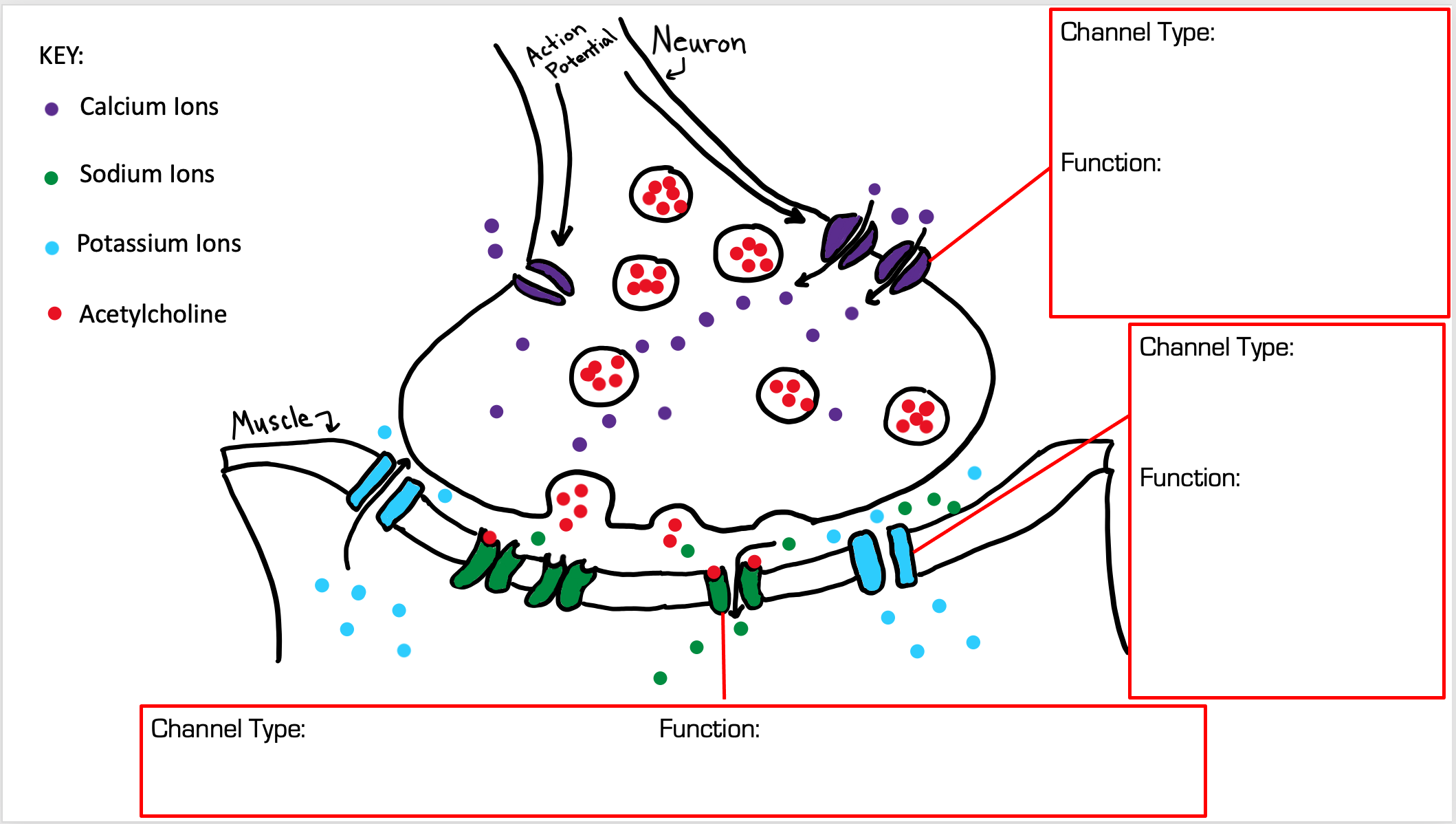
*Remember from the unit 2 POE when Sandy experienced nerve dysfunction and muscle cramping/spasming due to low levels of Ca2+ in her body? Her issue was more related to calcium’s role in regulating sodium channels and neurotransmitters, because low calcium led to an increase in sodium entering the cell and a decrease in NTs being released. How is Fred’s situation different? What is happening to his action potentials and nerve/muscle communication? (Use the graphs above to help answer the questions)*

****Normal Neuromuscular Junction**

*Which* ***one*** *of the 7 steps above would be affected by botulinum toxin? Why? (Hint: Botulinum toxin can be found in the presynaptic neuron)*

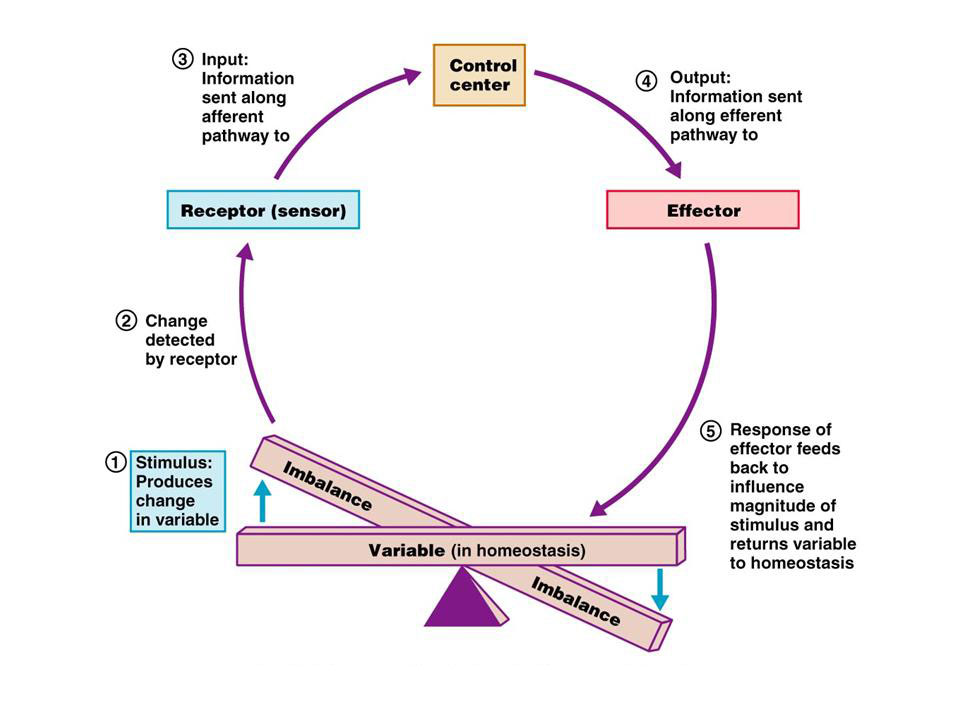
*In the graphic below, label the channel type and how that channel functions in the red boxes. Describe how the channels allow different ions to move within the neuromuscular junction:*

*(****HINT: Channel type options: Ion Leak Channel, Voltage-Gated Ion Channel, Ligand-Gated Ion Channel****)*



**Voltage Change**

***Circle*** *where botulinum toxin would affect the neuromuscular junction in the image above.*

**General Homeostasis Pathway**

**Homeostasis Examples**

*Complete the table (Fill in the blanks)*

|  |  |  |
| --- | --- | --- |
| **Stimulus** | **Sensor/Control Center** | **Effector/Response** |
| Low Blood Glucose | Pancreas (Alpha Cells) |  |
|  | Parathyroid Gland (PTH) | Osteoclasts break down bone to release calcium into the blood |
| Decrease in body temperature |  | Vasoconstriction of blood vessels  Increased muscle contractions (Shivering)  No secretion from sweat glands |
|  | Nociceptors (in hand/skin)  Sensory Neurons  Brain/Spinal Cord | Signals sent down motor neurons to signal muscles to remove hand from the hot surface |

*In the unit 1 & 2 POEs we discussed examples of hormonal homeostasis. In this POE what type of homeostatic regulation is occurring? (i.e. is it hormonally driven or CNS driven?) Explain.*

**Observations**

*After examining the data and answering the analysis questions above, describe interesting observations and patterns you believe are relevant to explaining the scenario. You can include both textual and visual observations in order to help organize the data from above. (Include at least 10 important pieces of data and evidence that will aid in your final explanation of the scenario below)*

**Explanation**

*Based on your observation and analysis question responses, please provide an answer to the driving question in the box below. Remember to include data from above as evidence, important ideas from the previous unit, and the concept of homeostasis in your response.*

**Driving Question(s)**

*Why did the botulinum toxin cause nerve complications and mild flaccid muscle paralysis in Fred? If Fred did not receive* *medical attention immediately, would he have survived? Why or why not?*