Compound action potentials

Yentl Smith BIOL 3810-504 Compound Action Potentials Date Performed: 15FEB2011 Date Due: 01MAR2011 Introduction Neurons are the cells that receive and transmit electrical signals (University of North Texas, 2010). The ability of the neuron to conduct these impulses is because of an electrochemical voltage across the plasma membrane of that neuron. An action potential is an all or nothing response to a stimulus along a single axon. A compound action potential is a graded response that results from the stimulation of more than one axon.

Action potentials can be broken down into five different phases: resting potential, threshold, rising, falling, and recovery. The inside of a cell is negatively charged and the potential difference across the plasma membrane is between 50 and 90 mV. In a resting cell, the membrane is more permeable to potassium than sodium. When synaptic activity makes the cell less negative, the sodium channels open. If the cell voltage goes past a certain level, an action potential is produced.

Action potentials, changes in the membrane potential that happen when a nerve cell membrane is stimulated (Ritchison), happen within milliseconds. After the voltage has reached the threshold potential, more voltage-gated sodium channels open and the voltage of the membrane reaches its most positive value. The voltage-gated sodium channels close soon after opening, and with that, the potassium channels open. Now potassium is rushing back into the cell, repolarizing the cell back to its resting level. Now, because there are many more potassium gates are open than there were when the cell was resting, the cell hyperpolarizes.

Finally, the extra potassium gates that were open, close and the sodium channels are ready to open again. There is no such thing as a weak or a partial action potential because action potentials are all-or-none (Randall, French, & Burggren, 2002). Either the threshold is reached, causing an action potential, or it’s not (Ritchison). Right after an action potential, the membrane does not respond to any stimulation because the sodium gates aren’t activated, but the potassium gates are active. This period is called the absolute refractory period (University of North Texas, 2010).

A little later, another action potential can be produced, but the stimulus must be greater than the threshold because during this time, not all of the sodium gates are activated. This is the relative refractory period. At the beginning of this period, a stimulus largely greater than the threshold is required to produce an action potential, but as time goes on the nerve cell membrane will need a smaller and smaller stimulus to cause an action potential. By the end of the relative refractory period, only a slightly above threshold stimulus will get the job done.

Once initiated near the soma, action potentials grow and distribute down the axons (Sasaki, Matsuki, & Ikegaya). The movement of action potentials all the way down an axon is caused by positive charges in the cell leaking to an unstimulated region. Action potentials only take place in the nodes of myelinated cells because the insulation keeps the action potential currents from leaking out of the membrane. Materials and Methods Frog Dissecting board Forceps Scissors Fine tipped glass rod Ringer’s Solution Thread Recording Nerve Bath with lid Power Lab Lab Tutor Computer Stimulating Electrodes Recording Electrodes

The frog was dissected in order to expose the sciatic nerve. The sciatic nerve was then removed and placed in a bath of Ringer's solution. The nerve is then placed in a nerve bath that is connected to the Power Lab in order to receive stimuli. The computer recorded the data. There were three parts to this experiment: threshold voltage and maximal compound action potential amplitude, refractory period, and conduction velocity of the nerve. Results The first part of this experiment was to dissect a frog and remove it's sciatic nerve. The animal was secured to a dissecting board with its ventral side up and placed in a dissecting pan.

With scissors, the frog's skin was cut around its abdomen and peeled downward and off of the legs. Using the forceps, the urostyle was grabbed and cut free, exposing the nerve plexus just below it. With the glass hook, the sciatic nerve was located and lifted from the sciatic artery and cut from the spinal cord. Thread was tied around the free end and after cutting the leg from the abdomen, the rest of the nerve was cut from the calf muscle. The second step to this experiment was the proper set up of the equipment (ie nerve bath and power lab). The stimulating electrodes are connected to the nerve bath first.

They are connected at the end where the coils are closer together and the BNC connectors plug into the Power Lab output connectors. There are two sets of recording electrodes that need to be connected to the nerve bath as well. The first set are connected here: The second set of recording electrodes are connected here: The positive and negative BNC connectors of the stimulating leads shoud be connected to the analog outputs on the Power

Lab. The first set of recording electrodes should be connected to Input 1, and the second set should be connected to Input 2 on the Power Lab as shown:

Finally, the experiment can begin. In exercise 1, the threshold voltage and maximal compound action potential amplitude were determined. Set stimulus voltage to 10mV in Lab Tutor. Click start, and after a delay of 1ms, the computer program will stimulate the nerve and record for 5ms. Continue to increase voltage by 10 mv until there are at least three consecutive responses that don’t increase in amplitude. If you don’t get three consecutive responses, stop when 400 mV is reached. Stimulus (mV)| Compound Action Potential (mV)| 10| | 20| 2. 79| 30| 4. 17| 40| 5. 8| 50| 6. 92| 60| 8. 24| 70| 9. 63| 80| 10. 99| 90| 12. 30| 100| 13. 67| 110| 15. 09| 120| 14. 89| 130| 16. 42| 140| 17. 71| 150| 19. 15| 160| 20. 62| 170| 21. 94| 180| 23. 31| 190| 24. 15| 200| 26. 01| 210| 27. 17| 220| 28. 31| 230| 28. 87| 240| 30. 52| 250| 31. 70| 260| 32. 71| 270| 33. 47| 280| 34. 33| 290| 34. 84| 300| 36. 05| 310| 36. 81| 320| 37. 49| 330| 37. 94| 340| 38. 34| 350| 38. 64| 360| 39. 10| 370| 39. 30| 380| 39. 41| 390| 39. 56| 400| 39. 65| After 43 trials of increasing amplitude, the maximal compound action potential was never reached.

The compound action potential continued to increase until the stimulus was 500 mV, where the compound action potential was recorded as 21 mV. This is what the graph looked like after experiment 1. The X-axis is the stimulus voltage (mV) and the Y-axis is the response (mV). As the stimulus voltage got bigger, so did the response from the nerve. In exercise 2, the refractory period of the nerve is determined. The stimulus voltage was set to the smallest voltage that was required for a maximal CAP in the previous exercise, which was 20 mV, and the interval was set at 4. ms. After clicking start, the Lab Tutor stimulated the nerve twice and it recorded for 10 ms. Now the interval needed to be decreased by 0. 5 ms until 2. 0 ms was reached. After that, the interval was decreased by 0. 1 ms until 1. 0 ms was reached. Stimulus Interval| Amplitude 2nd CAP| 4. 0| 2. 93| 3. 5| 2. 92| 3. 0| 2. 94| 2. 5| 2. 84| 2. 0| 2. 90| 1. 9| 2. 94| 1. 8| 2. 89| 1. 7| 2. 87| 1. 6| 2. 80| 1. 5| 2. 86| 1. 4| 2. 90| 1. 3| 2. 81| 1. 2| 2. 88| 1. 1| 2. 91| 1. 0| 2. 86| As the stimulus interval decreased, the amplitude of the CAP stayed within a +/- 0. mV range of the initial 2. 93 mV. In exercise 3, conduction velocity of the nerve was determined. In the stimulator panel, 40 mV was entered. After clicking start, Lab Tutor recorded on two different channels for 5 ms. A ruler was used to measure the distance in millimeters between the negative leads of the two recording electrodes. The waveform cursor and the marker were used to determine the time interval for the CAP to travel between the two electrodes. The nerve used for this particular lab died on this part of the experiment, which is why there is no second peak on this graph.

Discussion The result of exercise 1 was not what it should have been. There should have been a point where the amplitude of the compound action potential stopped increasing. The maximal stimulus, however, was never reached. The constant increasing of the amplitude at higher stimulus voltages is because of additional axons within the nerve reaching their individual threshold (University of North Texas, 2010). In exercise 2, the results were fine. In the graph, you can clearly see the intervals increasing as the amplitude was staying mostly the same.

The use of two stimuli both of which are near maximal, helped determine both refractory periods. At the beginning of the refractory period, a big stimulus was needed in order to trigger an action potential. Gradually, the stimulus needed was weaker and weaker. In exercise 3, the nerve used for this experiment died during the test. Conduction velocity was supposed to be determined. This sciatic nerve contains several different types of nerve fibers, each having their own conduction velocity. The difference varies according to different diameters as well as different levels of myelination of the nerve fibers.

The difference between type A and B fibers is due to the difference in diameter (Type A 18-11um; Type B 3um), and the difference in conductance velocity between type B and C fibers is based on different states of myelination (University of North Texas, 2010). With this exercise, the differences in conduction velocity amongst the different types of nerve fibers should have been apparent. Conclusion Action potentials and their creation is one of the most important aspects of the nervous system. It is the basis of neuronal communication. Thoughts, feelings, and movement are only a few of the important things that require action potential.

Nerves are made of different nerve fibers, all of which have their own threshold voltage. The frog’s sciatic nerve represents this. Taking the sciatic nerve from a “ living” frog made sure that the nerve was viable and would serve the purpose of these experiments. Each experiment was supposed to show different things. Being able to determine the threshold voltage, the maximal compound action potential, the absolute and relative refractory periods, and the conduction velocity with one nerve is truly advancement in science. Works Cited Randall, D. , French, K. , & Burggren, W. 2002). Eckert Animal Physiology Mechanisms and Adaptations. New York, New York: W. H. Freeman and Company. Ritchison, G. (n. d.). Neurons & the Nervous System. Retrieved 02 24, 2011, from Neurons & the Nervous System: http://people. eku. edu/ritchisong/301notes2. htm Sasaki, T. , Matsuki, N. , & Ikegaya, Y. (n. d.). PubMed. Retrieved 02 25, 2011, from Action Potential modulation during axonal conduction: http://www. ncbi. nlm. nih. gov/pubmed/21292979 University of North Texas. (2010). Animal Physiology Lab. Denton, TX: University of North Texas.