NEUROSCI 613: Neurophysiology and Computational Neuroscience
Fall 2020
Computer Lab 3: Action Potential Propagation

1. In the Unmyelinated Axon tutorial, investigate the dependence of the velocity of action potential propagation on the diameter of the axon. Follow the suggestions in the tutorial for measuring action potential velocity in the dual voltage traces plot and remember to change the amplitude of the IClamp current pulse as you decrease the diameter to minimize the current "shock artifact" (excessively high voltage levels) during the stimulus.
    a. Make a plot of velocity in m/sec as a function of axon diameter in μm for diameters between [1, 500] μm. Include enough points so that the curve is smooth.
    b. Does the curve follow the predicted relationship that velocity v increases in proportion to the square root of diameter? Try to fit a curve of the form $v = K\sqrt{d}$ for some constant K through your data points to test this prediction.
2. In the Myelinated Axon tutorial, investigate the dependence of the velocity of action potential propagation on the number of myelin wraps in the internodes. Follow the suggestions in the tutorial for measuring velocity and remember to change the amplitude of the IClamp current pulse as the number of myelin wraps is varied to minimize the current "shock artifact".
    a. Make a plot of velocity in m/sec as a function of the number of myelin wraps between 0 and 300. Include enough points so that the curve is smooth.
    b. Describe the effect of increasing the thickness of the myelin sheath on velocity. Is there an optimal thickness or is thicker always better for the fastest velocity? Do the increases in velocity with thicker myelin always outweigh any physiological burdens from larger Schwann cells and thicker nerve fibers?
3. In the Partial Demyelination tutorial, investigate how properties of the bare portion of the axon and of the first myelinated internode next to the bare portion affect propagation of action potentials from the myelinated portion into the bare portion. Follow the suggestions in the tutorial for inserting the IClamp stimulus electrode near the end of the myelinated portion to give a brief (0.1 ms) current pulse of amplitude of 2 nA, and for varying the parameters governing properties of the bare axon and the Myelin[0] internode. Analyze how changes in the following properties affect propagation in the bare portion. For each property, (1) identify the minimum change necessary to enable propagation in the bare portion; (2) explain your finding; (3) describe how action potential propagation changes as you make larger magnitude changes; and (4) provide plots to support your answer.
    a. Change the K+ channel density in the bare axon.
    b. Change the diameter of the bare axon
    c. Change the length of internode Myelin[0]
    d. Change the thickness of the myelin sheath in Myelin[0] by varying the capacitance