580.422 System Bioengineering II: Neurosciences (Spring 2015)

Recitation #4 Review Questions

February 20th, 2015

Question 1

The wimple synapse, when activated, produces an outward potassium current. Is this enough evidence to conclude that it is an ionotropic channel? If yes, give your reasoning. If no, give a counterexample

Question 2

Dendrites have active conductances, meaning voltage-gated ion channels in their membrane. What effect should a Na+ channel have on the amplitude of an EPSP produced by an excitatory receptor channel? Should it increase the amplitude of the EPSP or decrease it? Justify your answer. A qualitative answer is sufficient.

Question 3

Suppose a steady D.C. current I0 is injected into a very long membrane cylinder (like an unmyelinated axon), long enough that it can be approximated as infinite in length. The current is injected at point x=0. After the system comes to steady-state (meaning no time variation in the membrane potential), the membrane potential is given by $V(x) = r_i \lambda I_0 e^{-x/\lambda}$, where r_i is the resistance/length of the cytoplasm and λ is the length constant of the cylinder, as defined in class.

Part a)
What is the input conductance of the cylinder in steady state, i.e. the conductance as seen by the electrode through which the current is injected? This value is called G_∞ and is a useful parameter of the cylinder, whether it is infinite or not.

Part b)
How does G_∞ vary with the radius a of the membrane cylinder?

Part c)
Suppose a (finite) cylinder with conductance G_∞ branches into to two smaller cylinders. What should be the radii a_{branch} (assumed equal for the two branches) of the smaller cylinders so that the sum of the G_∞s of the branches is equal to the G_∞ of the main cylinder? Surprisingly dendritic trees seem to branch in this way.