580.422 System Bioengineering II: Neurosciences (Spring 2015)

Recitation #3 Review Questions

February 12th, 2015

Question 1

Calcium ions are removed from the cytoplasm by ______________.

1) Calcium channels
2) ATP-dependent active transport.
3) SERCA pumps into the endoplasmic reticulum.
4) All the above.
5) (1) and (2) above.
6) (2) and (3) above.

Question 2

Inhibitory synapses usually contain a chloride channel. However, sometimes synaptic activation can lead to inhibition or excitation through the gating of potassium by a metabotropic mechanism. Give a possible sequence of steps for such a mechanism. (4 pts)

Question 3

Part a)
To model bursting in neurons, we used a modified HH model in which a calcium-dependent potassium channel *KCa* was added to the system, giving the set of differential equations below.

$$C\frac{dV}{dt} = I_{ext} - G_K(V - E_K) - G_{KCa}(V - E_{KCa}) - G_{Ca}m_\infty(V)(V - E_{Ca}) - G_L(V - E_L)$$

$$\frac{dw}{dt} = \frac{w_\infty(V) - w}{\tau_w(V)} \qquad G_K = \bar{G}_K w$$

$$\frac{dCa}{dt} = A\left(-\frac{ICa}{2F} - B * Ca\right) \qquad G_{KCa} = \bar{G}_{KCa}\frac{Ca}{Ca+1}$$

In this model, bursting is terminated by the increase in the conductance of the *KCa* channel as *Ca* accumulates. There is some evidence that voltage or Ca-dependent inactivation of the calcium channel participates in burst termination. Suppose that there is no *KCa* channel in the system and bursting is terminated instead by voltage and Ca-dependent inactivation of the *Ca* channel. Rewrite the equations above to model this system. (Hint: this is easier than it sounds; delete a couple of things and add inactivation to the calcium current and an inactivation model.)

Part b)
There should be a function *h*∞(*V*,*Ca*) in your model above. Given that this is an inactivation function that should terminate bursting in response to depolarization and the rise in *Ca* during the burst, which of the following are possible *h*∞(*V*,*Ca*) functions, in the sense that the qualitative change (increase or decrease) in *h*∞(*V*,*Ca*) is correct as *V* and *Ca* increase from zero?

(1) $h_\infty(V, Ca) = \frac{Ca\left(1 - e^{-(V - E_{rest})}\right)}{Ca + K_I}$

(2) $h_\infty(V, Ca) = \frac{2K_I}{(Ca + K_I)\left(1 + e^{(V - E_{rest})}\right)}$

(3) $h_\infty(V, Ca) = \frac{K_I\left(1 - e^{-(V - E_{rest})}\right)}{Ca + K_I}$