Biol698/Math635/Biol498/Math430
Fall 2019
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Homework 4

Answer the following questions. Justify your answers, explain your results, and provide the necessary supporting graphs and Matlab codes. Make sure the graphs are properly labeled and include the information (title and parameter values) necessary to understand your explanations.

Question 1

Build an isopotential model of Hodgkin-Huxley type using the following parameters: $C = 1\,\mu F/cm^2$, $E_L = -52\,mV$, $E_{Na} = 55\,mV$, $E_K = -75\,mV$, $G_L = 0.3\,mS/cm^2$ $G_{na} = 120\,mS/cm^2$ and $G_K = 36\,mS/cm^2$. Leave I_{app} as a free parameter. The activation (m) and inactivation (h) gating variables for the Na-current have powers of 3 and 1 respectively. The activation gating variable (n) for the K-current has a power of 4. The voltage-dependent activation/inactivation curves and time-scales are given by

$$m_\infty(V) = \frac{1}{1+e^{-(V+40)/9}},$$

$$h_\infty(V) = \frac{1}{1+e^{(V+62)/10}},$$

$$n_\infty(V) = \frac{1}{1+e^{-(V+53)/16}},$$

$$\tau_m(V) = 0.3,$$

$$\tau_h(V) = 1 + \frac{11}{1+e^{(V+62)/10}},$$

and

$$\tau_n(V) = 1 + \frac{6}{1 + e^{(V+53)/16}}.$$

Apply a square pulse of applied current (I_{app}) of 2 sec duration and amplitude I_0 (μA). (Make sure that you allow a few msec pass before you apply the current pulse; depending on the initial conditions of the activation and inactivation variables you will get transients that you must disregard. A conservative value would be 1 sec.)

(a) Plot the activation/inactivation functions $m_\infty(V)$, $h_\infty(V)$ and $n_\infty(V)$ (one graph).

(b) Plot the voltage-dependent time constants $\tau_m(V)$, $\tau_h(V)$ and $\tau_n(V)$ (one graph)

(c) Plot the voltage traces (graphs of V vs. t) for $I_{app} = 0, 1, 2, 3, 4$.

(d) Plot a freq. vs. I_{app} graph for this current pulse duration and $I_{app} \in [0 : 4]$. The graph must contain at least 10 points.

Question 2

Build a code to model the inhibitory cell in the following paper: "Kopell, Ermentrout, Whittington, Traub; Gamma rhythms and beta rhythms have different synchronization properties; PNAS (1999)"

(a) Plot the activation/inactivation functions $m_\infty(V)$, $h_\infty(V)$ and $n_\infty(V)$ (one graph).

(b) Plot the voltage-dependent time constants $\tau_m(V)$, $\tau_h(V)$ and $\tau_n(V)$ (one graph)

(c) Simulate the model during 10 sec for values of I_{app} within the range $[0.1190, 0.12]$ (11 points at least) and then within the range $[0.12, 0.15]$ (11 points at least.

(d) Plot a freq. vs. I_{app} graph.

Question 3 (graduate)

What is the main difference between the voltage patterns of the two models? How can you explain them?