ELEC ENG 3BB3 – Cellular Bioelectricity (2014)

Tutorial 7

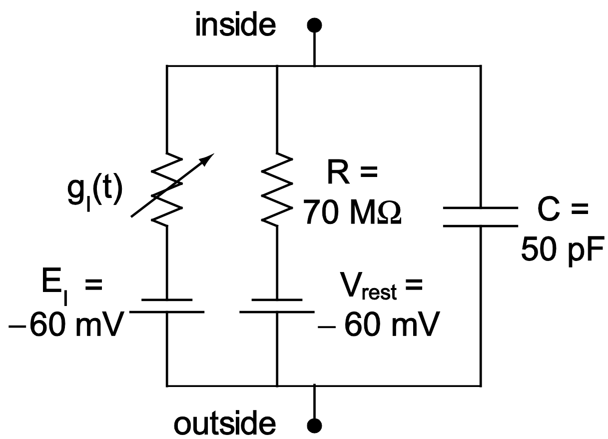
1. A patch of membrane at 21°C has the following intra- and extra-cellular ionic concentrations:

Ion	$[C]_{in}$ (mM)	$[C]_{out}$ (mM)
K^+	200	5
Na^+	10	150

   a. If the resting conductances of voltage-gated potassium and sodium channels in this patch of membrane are $g_K = 2.0\ \mathrm{mS/cm^2}$ and $g_{Na} = 0.05\ \mathrm{mS/cm^2}$, respectively, find the resting potential V_{rest} for this patch of membrane.

   b. If a postsynaptic receptor in this patch of membrane has maximum conductances for potassium and sodium of $g_{syn,K} = 10\ \mathrm{mS/cm^2}$ and $g_{syn,Na} = 5\ \mathrm{mS/cm^2}$, respectively, determine whether the synapse is excitatory or inhibitory.

2. The subthreshold behaviour of a neural soma can be described by the circuit diagram shown below.



The neuron has a threshold potential of $V_{th} = -40\ \mathrm{mV}$. Synaptic input onto this soma consists of one inhibitory synapse that produces the current:

$$I_I = g_I(t)\left[V_m - E_I\right].$$

Consider the case where the membrane is at rest (i.e., $V_m = V_{rest}$) and the inhibitory conductance $g_I = 0\ \mathrm{nS}$ for time $t < 0$. At time $t = 0$, a step current of $I_{inj} = 0.5\ \mathrm{nA}$ is injected into the interior of the soma. Assume that the inhibitory synaptic conductance g_I steps instantaneously at time $t = 2\ \mathrm{ms}$ to a new value in response to neurotransmitter binding and remains at that value until at least $t = 4\ \mathrm{ms}$.

What is the minimum value to which the inhibitory conductance g_I can step at time $t = 2\ \mathrm{ms}$ in order to stop the membrane potential V_m from reaching the threshold potential V_{th} by time $t = 4\ \mathrm{ms}$?