Fall 2015 * Math 430 * Math 635 * Prof. Victor Matveev

The Hodgkin-Huxley Model of Squid Giant Axon (1952)

$$\begin{cases} C\dfrac{dV}{dt} = I_{app} - g_{Na}m^3h\left(V - V_{Na}\right) - g_K n^4\left(V - V_K\right) - g_L\left(V - V_L\right) \\ \dfrac{dn}{dt} = \alpha_n\left(V\right)\left[1 - n\left(t\right)\right] - \beta_n\left(V\right)n\left(t\right) \quad = \dfrac{n_\infty(V) - n}{\tau_n\left(V\right)} \\ \dfrac{dm}{dt} = \alpha_m\left(V\right)\left[1 - m\left(t\right)\right] - \beta_m\left(V\right)m\left(t\right) \quad = \dfrac{m_\infty(V) - m}{\tau_m\left(V\right)} \\ \dfrac{dh}{dt} = \alpha_h\left(V\right)\left[1 - h\left(t\right)\right] - \beta_h\left(V\right)h\left(t\right) \quad = \dfrac{h_\infty(V) - h}{\tau_h\left(V\right)} \end{cases}$$

$$\text{where } x_\infty\left(V\right) = \frac{\alpha_x(V)}{\alpha_x(V) + \beta_x(V)}, \quad \tau_x(V) = \frac{1}{\alpha_x(V) + \beta_x(V)}; \quad x \in \{m,\ n,\ h\}$$

$$\alpha_n\left(V\right) = 0.01\frac{V + 55}{1 - \exp\left(-\dfrac{V + 55}{10}\right)}; \qquad \beta_n\left(V\right) = 0.125\exp\left(-\frac{V + 65}{80}\right)$$

$$\alpha_m\left(V\right) = 0.1\frac{V + 40}{1 - \exp\left(-\dfrac{V + 40}{10}\right)}; \qquad \beta_m\left(V\right) = 4\exp\left(-\frac{V + 65}{18}\right)$$

$$\alpha_h\left(V\right) = 0.07\exp\left(-\frac{V + 65}{20}\right); \qquad \beta_h\left(V\right) = \frac{1}{1 + \exp\left(-\dfrac{V + 35}{10}\right)}$$

C = 1 μF/cm^2 *I* = 0

$V_K = -77$ mV $V_{Na} = +55$ mV; $V_L = -54.4$ mV

$g_K = 36$ mS/cm^2 $g_{Na} = 120$ mS/cm^2 $g_L = 0.3$ mS/cm^2