Neurodynamics

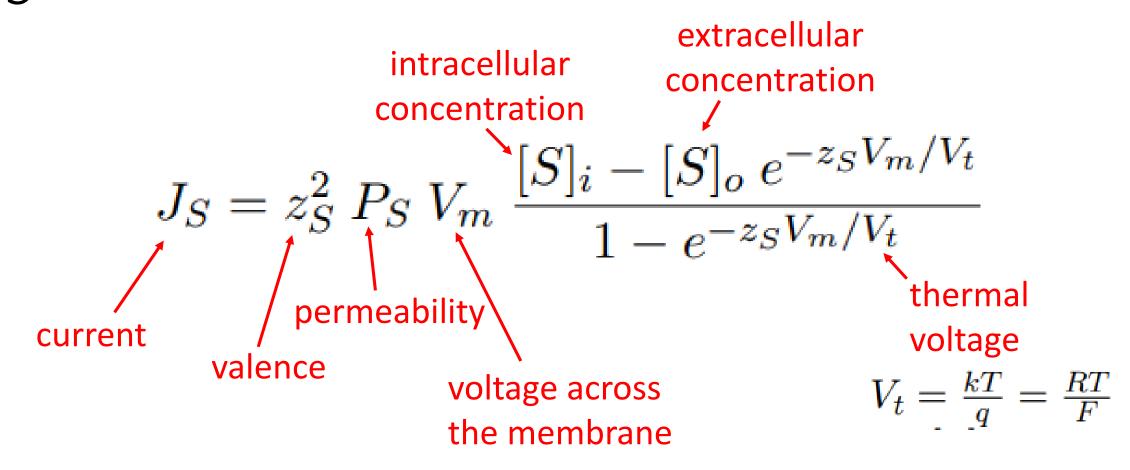
Computer Lab Week 1

(1) Linear and nonlinear current

Current density carried by single ionic species S

$$J_S = z_S^2 P_S V_m \frac{[S]_i - [S]_o e^{-z_S V_m/V_t}}{1 - e^{-z_S V_m/V_t}}$$

Current density carried by single ionic species



For potassium (K+), the current becomes:

$$J_K = P_K V_m \frac{[K]_i - [K]_o e^{-V_m/V_t}}{1 - e^{-V_m/V_t}}$$

because valence (ionic charge) of $\zeta_k = +1$

For potassium (K+) current, given constants are

$$J_K = P_K V_m \frac{[K]_i - [K]_o e^{-V_m/V_t}}{1 - e^{-V_m/V_t}}$$

For potassium (K+) current, membrane voltage

$$J_K = P_K V_m \frac{[K]_i - [K]_o e^{-V_m/V_t}}{1 - e^{-V_m/V_t}}$$

ranges between -150 mV and +150 mV (Q1)

For potassium (K+) current,

$$J_K = P_K V_m \frac{[K]_i - [K]_o e^{-V_m/V_t}}{1 - e^{-V_m/V_t}}$$

What is the permeability, P?

Next, do the linear approximation...

$$J_K' = g_K \left(V_m - E_K \right)$$

Constants given:

$$J_K' = g_K \left(V_m - E_K \right)$$

$$E_K = V_t \ln \frac{[K]_o}{[K]_i}$$

and Vm ranges between -150 mV and +150 mV (Q1)

(2) The resting potential

At equilibrium...

$$0 = J_{Na}(V_r) + J_K(V_r) + J_{Cl}(V_r)$$

where Vr is the resting membrane potential

What are the currents (J) for each ion as a function of voltage?

Simplify and solve for Vr

(3) GHK membrane dynamics

$$C_m \frac{dV_m}{dt} = -J_{Na} - J_K - J_{Cl}$$

$$J_K = P_K V_m \frac{[K]_i - [K]_o e^{-V_m/V_t}}{1 - e^{-V_m/V_t}} \qquad J_K' = g_K (V_m - E_K)$$

where each ion current, J, can be written with GHK or as a linear approximation of GHK

Each ion conductance g_{on} has a specific behavior

$$g_{Na^+}(t) = \begin{cases} 13mS/cm^2 & 0 < t \le 500ms \\ 0mS/cm^2 & 500 < t \le 1000ms \end{cases}$$

$$g_{K^+}(t) = \begin{cases} 5mS/cm^2 & 0 < t \le 250ms \\ 0mS/cm^2 & 250 < t \le 500ms \\ 5mS/cm^2 & 500 < t \le 1000ms \end{cases}$$

$$g_{Cl^{-}}(t) = \begin{cases} 0.15mS/cm^{2} & 0 < t \le 250ms \\ 0mS/cm^{2} & 250 < t \le 500ms \\ 0.15mS/cm^{2} & 500 < t \le 1000ms \end{cases}$$

** Use built-in ODE solver function