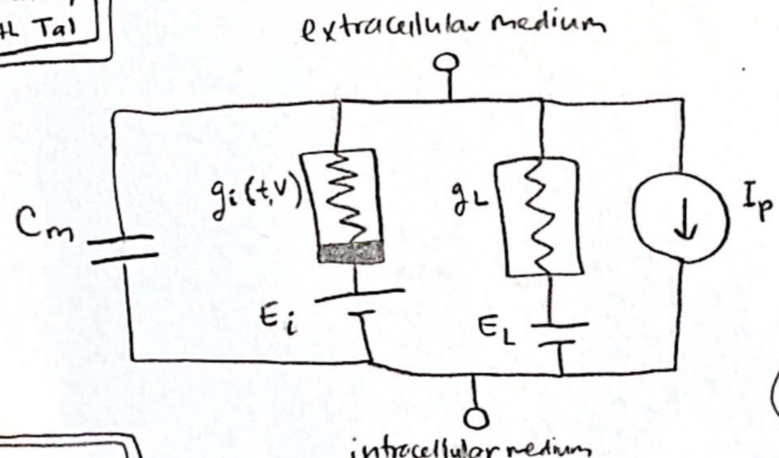
2023_11022

# hodgkin-huxley (1952)

- how action potentials initiated & propagated → math model
- continuous-time dynamical system, set of nonlin diffeq

as explained by Science with Tal




**key**

- $\boxed{C_m}$ capacitance = lipid bilayer
- $\boxed{g_i(t,V)}$ electrical conductance = voltage-gated ion channels; $i$ ion, $t$ time, $V$ voltage
- $\boxed{g_L}$ linear conductance = leak channels
- $\boxed{E_i}$ voltage sources = electrochem gradient det by intra/extra cell $[i]$
- $\boxed{I_p}$ current sources = ion pumps
- $\boxed{V_m}$ membrane potential

alt drawing

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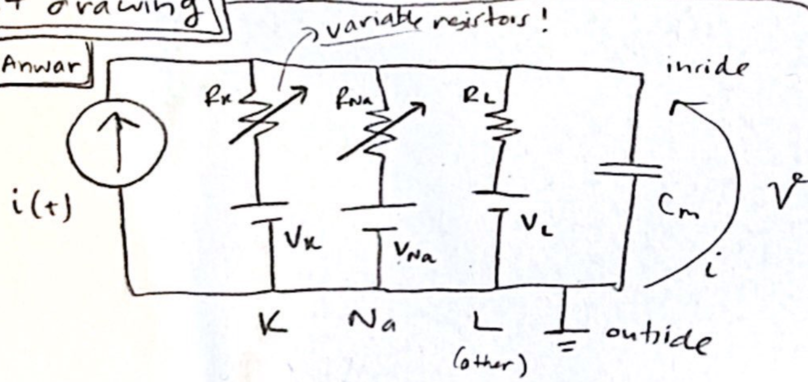


$V_K \approx -75\,mV$ $\quad V_{Na} \approx +55\,mV$

$V_L \approx -50\,mV$ (signs reflect grad)

$\frac{1}{R_K} = G_K$ ; $\frac{1}{R_{Na}} = G_{Na}$ ; etc.

$$I_c = C_m \frac{dV}{dt}$$ [capacitor's current-voltage relationship]

$$I_i = g_i (V_m - E_i)$$ [$V = IR = I\frac{1}{G}$ so $I = VG$]

$$I_m = C_m \frac{dV_m}{dt} + g_L (V_m - E_L) + g_K (V_m - E_K) + g_{Na} (V_m - E_{Na})$$

We can solve for $g_K = \bar{g}_K (n^4(V,t))$ $\quad g_{Na} = \bar{g}_{Na} (m^3 h(V,t))$ ($\bar{g}_i$ = max conductance)

by solving for $X \in \{n, m, h\}$

from its differential eqn:

$$\frac{dx}{dt} = \alpha_x (1-x) - \beta_x (x)$$ [will use $x_\infty$ & $\tau_x$]

⟹ Then finally we can solve for $\frac{dV_m}{dt}$ $\nabla_c$

$$\frac{dV_m}{dt} = \frac{I_m - \bar{g}_K n^4 (V_m - E_K) - \bar{g}_{Na} m^3 h (V_m - E_{Na}) - \bar{g}_L (V_m - E_L)}{C_m}$$