Principles of Neural Design - Sterling & Laughlin (Library Database)

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Potassium ions are leaving the cell, Sodium is entering the cell

This is a probability gradient

We can recreate the changing gradient effect by not altering the current, but instead the conductances of the channels

$$C\frac{dv}{dt} = -G_{NaV}(V - E_{Na}) - G_{KV}(V - E_K) - G_L(V - E_L) - G_S(V - E_S)$$

In which our channels are

GNa - Sodium Conductance GK - Potassion Conductance GL - Resting Conductance GS - Synaptic Conductance

Es are equilibrium points for each

$$\frac{P_o}{P_c} = e^{-\Delta E/K_B Temp}$$

Probability of being open over being closed is proportional to the difference in energy between thoose two energy states, divided by Boltzman constant and temperature

$$\Delta E = E_o - E_c$$

E*o and* Ec are both constants of the energy states of being open or closed

The the rate at which our open probability increases over time is proportinal to the number that are currently closed * the rate at which they will open (constant), minus the number than are open * the rate at which the will close (constant)

$$\frac{dP_o}{dt} = r_o P_c - r_c P_o$$

This is a simplification, as there are slightly more states than simply open and clsed

g = gbar, which is G when all channels are open

$$C\frac{dv}{dt} = -G_{Nam(v)^3h}(V - E_{Na}) - G_{KVn(v)^4}(V - E_K) - G_L(V - E_L)$$

where $m(v)^3h$ & $n(v)^4$ are the probability that each of those channels are open)

$n(v)^4$ is important, as it tells us that actually there are four protein molecules controlling the ion chnnel, and all four (probability ^{4}) must be open at the same time to open the potassium ion channel

$m(v)^3h$ tells us that there are also four proteins on the sodium ion channel, three oof which need to be open (^3), but one needs to be closed, which has its own different probability which is higher (h)

The h is a special case in which a magnesium ion on the outside has its own probability of holding the ion channel closed - attached to one of the proteins which has its own special probability of happening. In actuality there are four normal gates on the sodium channel itself, but we account for this magnesium ball/chain with h instead of one

Sodiim & Potassium channels are more cmplex, this is simplified

So the Hodgkin Huxley equation is:

$$C\frac{dv}{dt} = -G_{Na}(m(v)^3h)(v - v_{Na}) - G_K(n(v)^4)(v - E_K) - G_L(v - v_L)$$

But m, n and h all have a delay in the order of millisecnds on them we must accouont for over time:

$$\frac{dm}{dt} = \alpha m(1 - m) - \beta m^m$$

$$\alpha m(1 - m) = \beta m^m$$

$$m(\beta$$

Hodgkin and huxley ended up having actually four equations, which are dependant on the probabilities m h and n, which are themselves approaching an equilibrium which is changing based on