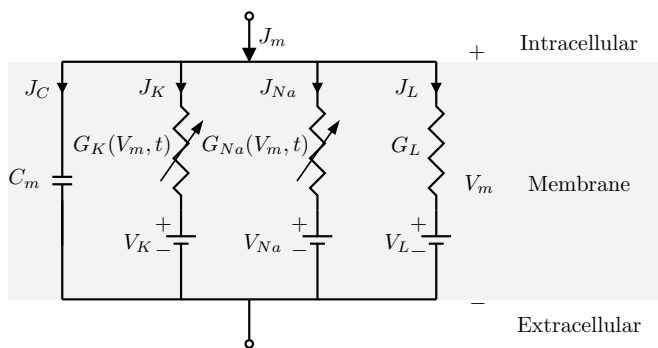


Hodgkin Huxley model



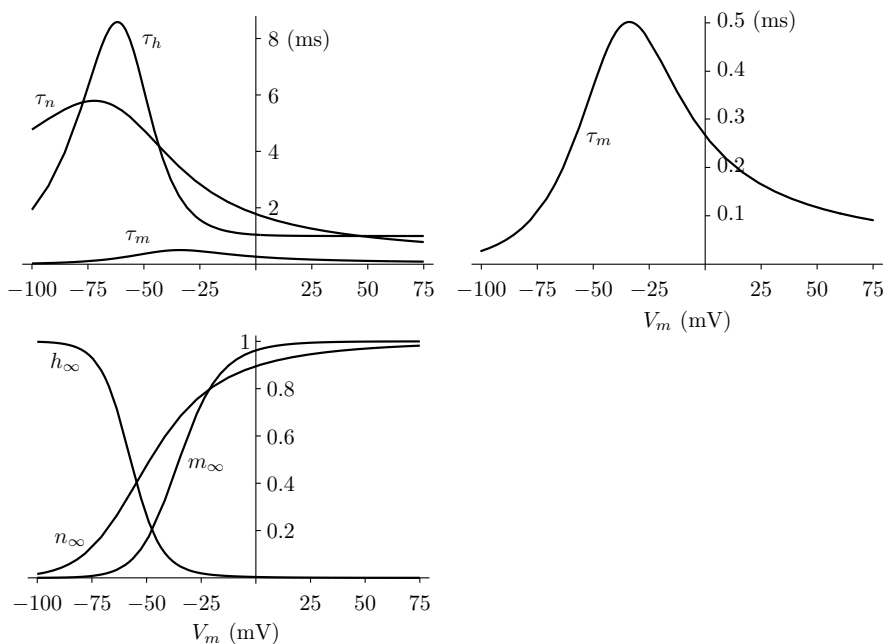
$$G_K(V_m, t) = \bar{G}_K n^4(V_m, t)$$

$$G_{Na}(V_m, t) = \bar{G}_{Na} m^3(V_m, t) h(V_m, t)$$

$$n(V_m, t) + \tau_n(V_m) \frac{dn(V_m, t)}{dt} = n_\infty(V_m)$$

$$m(V_m, t) + \tau_m(V_m) \frac{dm(V_m, t)}{dt} = m_\infty(V_m)$$

$$h(V_m, t) + \tau_h(V_m) \frac{dh(V_m, t)}{dt} = h_\infty(V_m)$$



$\bar{G}_{Na} = 120$, $\bar{G}_K = 36$, and $G_L = 0.3$ mS/cm²; $C_m = 1$ μF/cm²; $c_{Na}^o = 491$, $c_{Na}^i = 50$, $c_K^o = 20.11$, $c_K^i = 400$ mmol/L; $V_L = -49$ mV; temperature is 6.3°C.

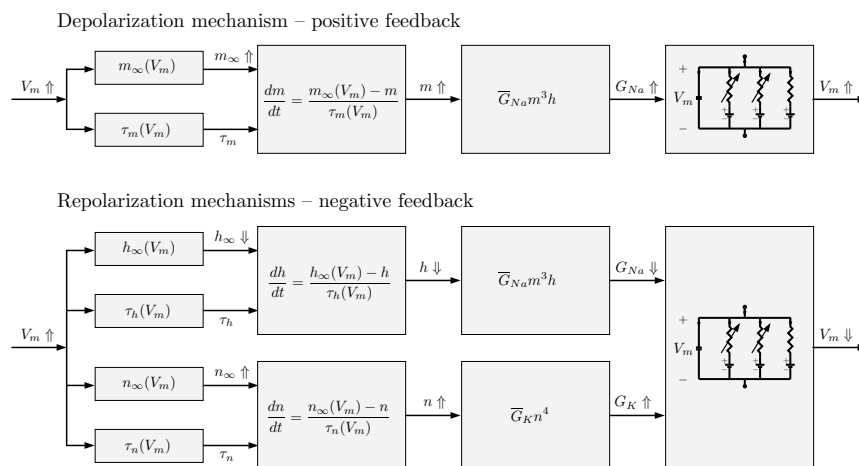
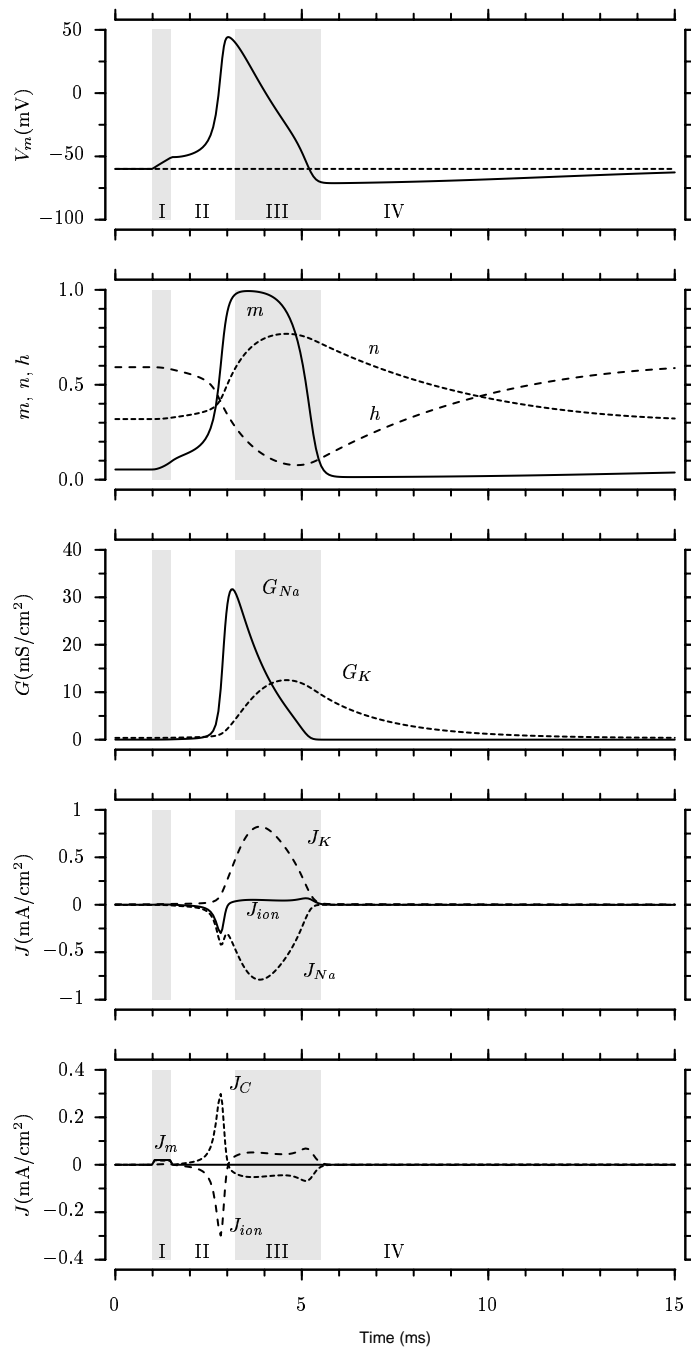


Figure 4.33

Draft Proposal: Effects of Temperature

Hypothesis: Changing temperature will change the polarization/repolarization thresholds for a neuron and will thereby change the conduction velocity.

Rationale: The intracellular potential of a neuron is determined by integral membrane proteins that conduct ions through the cell membrane. The state of these proteins depends on temperature, so that more ions tend to flow for higher temperatures than for lower temperatures. It follows that increasing temperature will increase the probability that the membrane is polarized and decreasing temperature will increase the probability that the membrane is repolarized. Thus, as temperature increases, the membrane potential will also increase. Higher membrane potentials lead to shorter refractory times. And shorter refractory times lead to faster conduction velocities. Thus increasing temperature will make action potentials conduct more rapidly.

Procedure: We will analyze the effects of temperature by changing the temperature in the Hodgkin Huxley model simulation software package. We expect that the membrane potential will increase with temperature, refractory time will decrease with temperature, and conduction velocity will increase with temperature. Therefore, we will measure the changes in these parameters and plot them versus temperature to demonstrate their dependence on temperature. To demonstrate that we understand why these changes are occurring, we will plot the change in amplitude versus the change in these parameters. If we get a large correlation coefficient, that will show that we understand the effect.

**Approved Proposal: Effects of Temperature on Conduction Velocity
of a Propagated Action Potential Produced by the Hodgkin-Huxley Model**

Hypothesis: The conduction velocity of a propagated action potential produced by the Hodgkin-Huxley model will increase as temperature increases.

Background: According to the software manual (Equations 5.14 to 5.20), the rate constants for the Hodgkin Huxley model increase exponentially with temperature. Hence, we expect that the time course for m , n , and h will be faster at higher temperatures. Since these factors determine the sodium and potassium conductances that generate the action potentials, increasing temperature should increase the speed of action potentials.

Procedure: We will perform simulations at different temperatures starting at 0 degrees (freezing point of water) and incrementing by 10 degrees up to 50 degrees (half way to the boiling point). For each simulation, we will determine how long it takes the peak of the action potential to travel 1 cm. The time for the peak to reach a point 1 cm from the stimulus electrode will be determined by plotting membrane potential versus time at the 1 cm place. The time to reach a point 2 cm from the stimulus electrode will be determined from a similar plot at the 2 cm place. The velocity will be computed by dividing 1 cm by the difference in times. In addition to showing a plot of velocity versus temperature, we will also show plots of m , n , and h to show that our reasoning is correct.