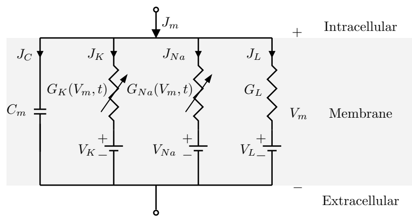
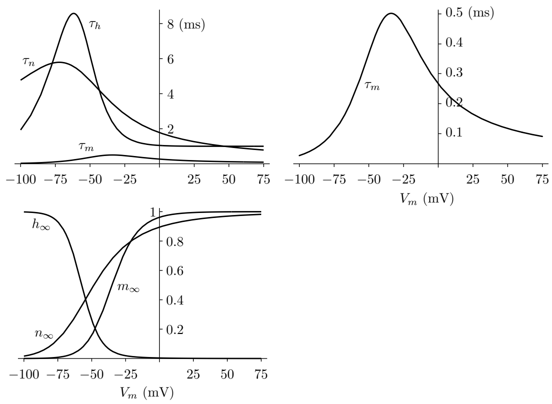
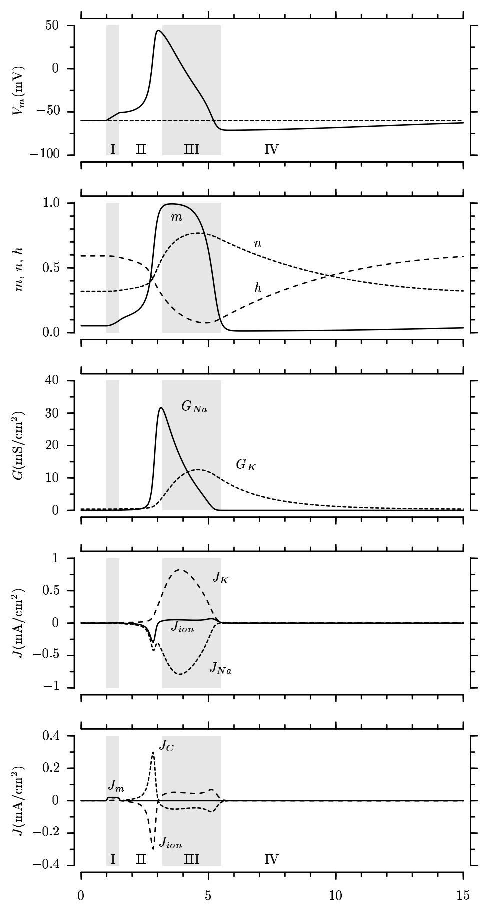
Hodgkin Huxley model



$$G_K(V_m,t) = \overline{G}_K n^4(V_m,t)$$
$$G_{Na}(V_m,t) = \overline{G}_{Na} m^3(V_m,t)h(V_m,t)$$
$$n(V_m,t) + \tau_n(V_m)\frac{dn(V_m,t)}{dt} = n_\infty(V_m)$$
$$m(V_m,t) + \tau_m(V_m)\frac{dm(V_m,t)}{dt} = m_\infty(V_m)$$
$$h(V_m,t) + \tau_h(V_m)\frac{dh(V_m,t)}{dt} = h_\infty(V_m)$$



$\overline{G}_{Na} = 120$, $\overline{G}_K = 36$, and $G_L = 0.3$ mS/cm^2; $C_m = 1$ μF/cm^2; $c^o_{Na} = 491$, $c^i_{Na} = 50$, $c^o_K = 20.11$, $c^i_K = 400$ mmol/L; $V_L = -49$ mV; temperature is 6.3°C.

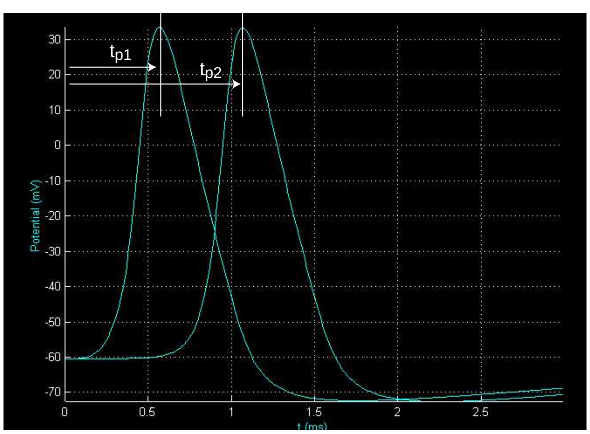


Approved Proposal: Effects of Temperature on Conduction Velocity of a Propagated Action Potential Produced by the Hodgkin-Huxley Model

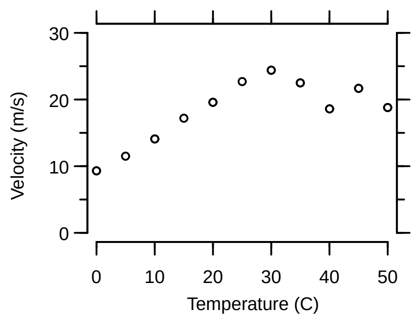
Hypothesis: The conduction velocity of a propagated action potential produced by the Hodgkin-Huxley model will increase as temperature increases.

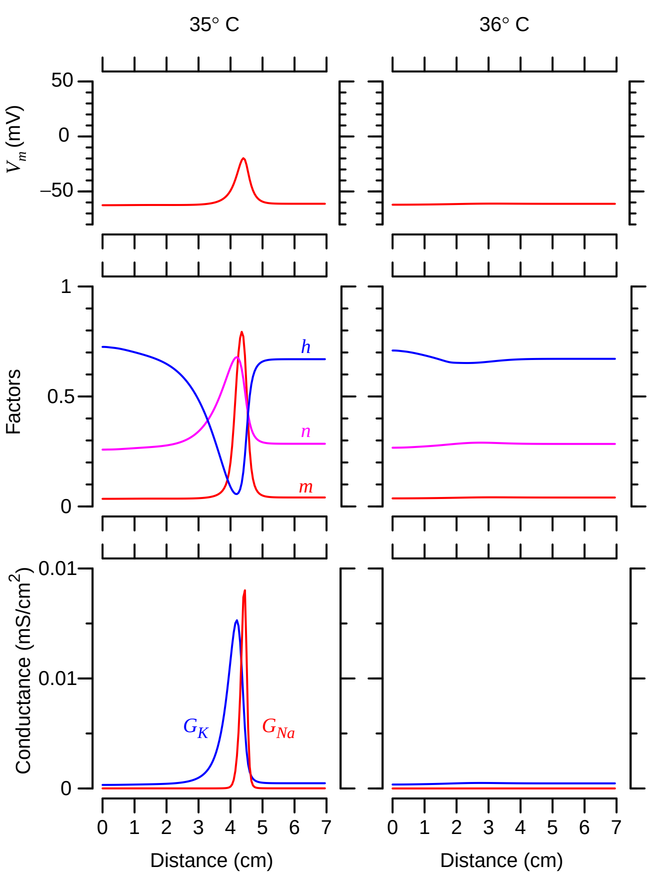
Background: According to the software manual (Equations 5.14 to 5.20), the rate constants for the Hodgkin Huxley model increase exponentially with temperature. Hence, we expect that the time course for *m*, *n*, and *h* will be faster at higher temperatures. Since these factors determine the sodium and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

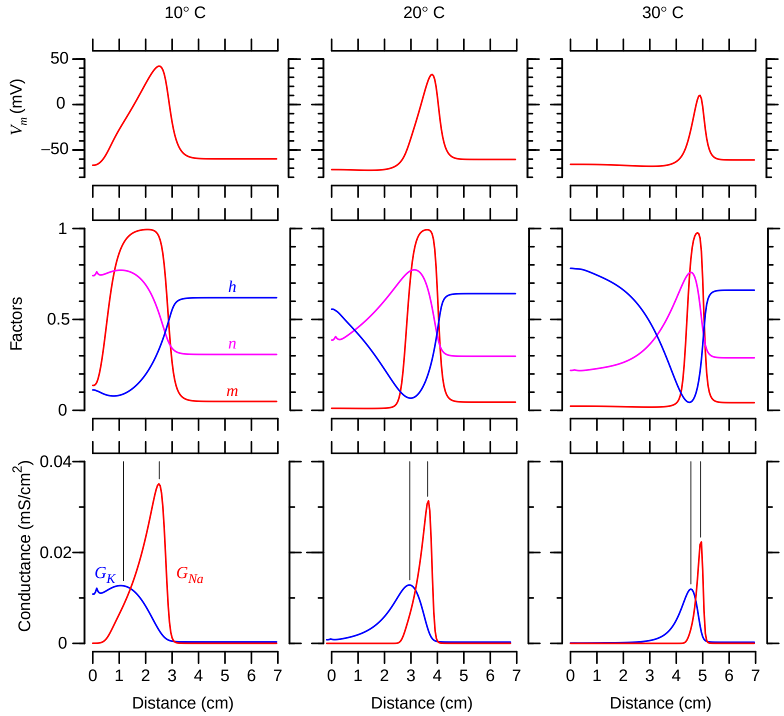
Procedure: We will perform simulations at different temperatures starting at 0 degrees (freezing point of water) and incrementing by 10 degrees up to 50 degrees (half way to the boiling point). For each simulation, we will determine how long it takes the peak of the action potential to travel 1 cm. The 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.

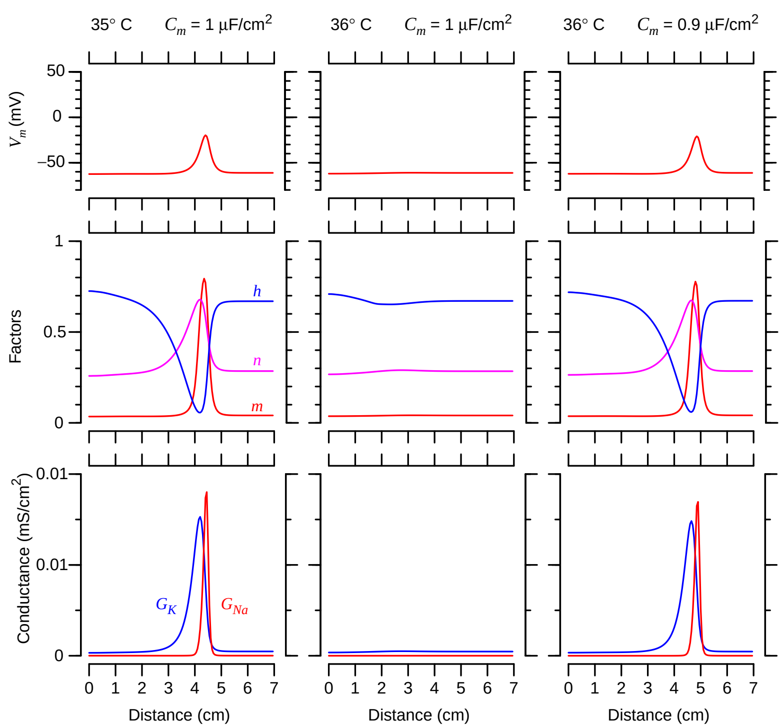


T (C)	t_{p1} (ms)	t_{p2} (ms)	velocity (m/s)
0	1.52	2.60	9.25
5	1.15	2.02	11.49
10	0.89	1.60	14.08
15	0.71	1.29	17.24
20	0.56	1.07	19.60
25	0.47	0.91	22.72
30	0.40	0.81	24.39
35	0.37	0.81	22.72
40	0.31	0.85	18.51
45	0.56	1.01	22.22
50	0.58	1.11	18.86






10° C
20° C
30° C
Vm (mV)
50
0
–50
Factors
1
0.5
0
h
n
m
Conductance (mS/cm2)
0.04
0.02
0
GK
GNa
0 1 2 3 4 5 6 7
Distance (cm)


35° C Cm = 1 µF/cm2
36° C Cm = 1 µF/cm2
36° C Cm = 0.9 µF/cm2
Vm (mV)
50
0
–50
Factors
1
0.5
0
h
n
m
Conductance (mS/cm2)
0.01
0.01
0
GK
GNa
0 1 2 3 4 5 6 7
Distance (cm)