Nerves and Signals

- Axon membrane surrounded by myelin sheath
- Signal is amplified at the nodes and passes without amplification in internode spaces
- Ion concentration differences across membrane
- Nernst equation explains potential difference of ~70 mV across membrane

Why should we care?
- Many diseases affect nerves in different ways
  - Multiple Sclerosis is the planned focus of the project
  - Myelin sheath gets damaged
  - Signals get lost in the axon
- Others include Parkinson’s disease and ALS (Lou Gehrig’s disease)
  - Include chemical and structural disruptions to the nerve

Circuit translated into equations

From the basic circuit model

\[ I_M = C_M \frac{dV}{dt} + g_{Na}(V-V_{Na}) + g_K(V-V_K) + g_l(V-V_l) \]

To the Hodgkin-Huxley model

\[ I_M = C_M \frac{dV}{dt} + g_{Na}m^3h(V-V_{Na}) + g_Kn^4(V-V_K) + g_l(V-V_l) \]

Beyond Hodgkin and Huxley

- Basic simplifications
  - m as instantaneous: m0
  - n and h similar enough to be modeled together as w

\[ I_w = C_w \frac{dV}{dt} + \frac{1}{3} \left[ F(V,w) + F(V,-w) + F(V'-w) + F(V'-w) \right] \]

Fitzhugh-Nagumo model, 1960s
  - Took basic simplification and reduced it into two other functions F and G
  - Defined experimentally

\[ \frac{dV}{dt} = \frac{1}{r} [F(V,w) + RT] \]

\[ \frac{dw}{dt} = \frac{1}{r_w} [G(V,w) - \omega_1 (V-w)] \]

Morris-Lecar model
  - Reduced to voltage variation with time and a defined "recovery variable"

\[ \frac{dV}{dt} = -g_l[\delta_a(V(w))] + g_N(V(w) - V_l) + g(V'-w) + g(V'-w) + g(V'-w) \]

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Bibliography