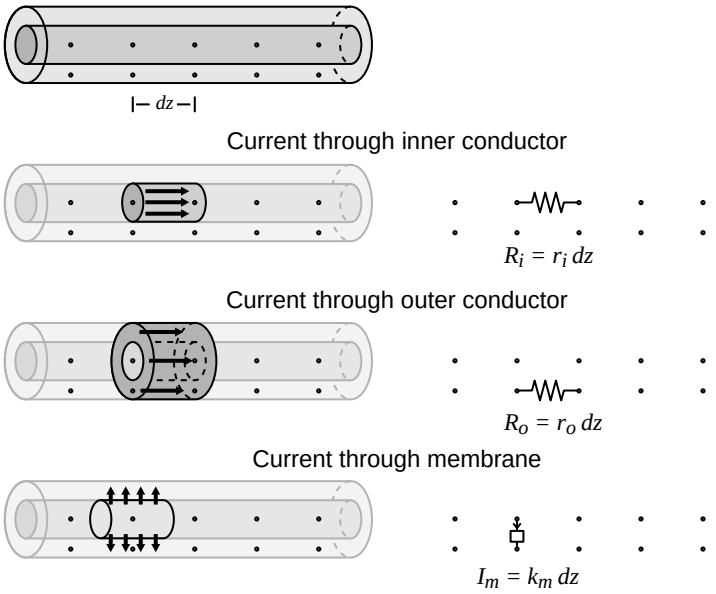
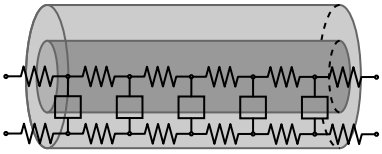
Core Conductor Model



Core Conductor Model



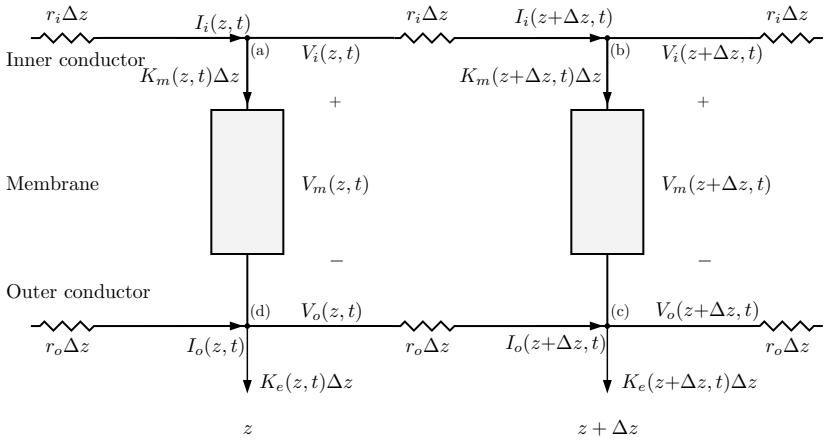


Figure 2.7

Core – Conductor Equations

$$\frac{\partial I_i(z,t)}{\partial z} = -K_m(z,t)$$

$$\frac{\partial I_o(z,t)}{\partial z} = K_m(z,t) - K_e(z,t)$$

$$\frac{\partial V_i(z,t)}{\partial z} = -r_i I_i(z,t)$$

$$\frac{\partial V_o(z,t)}{\partial z} = -r_o I_o(z,t)$$

$$V_m(z,t) = V_i(z,t) - V_o(z,t)$$

THE Core – Conductor Equation

$$\frac{\partial^2 V_m(z,t)}{\partial z^2} = (r_o + r_i)K_m(z,t) - r_o K_e(z,t)$$

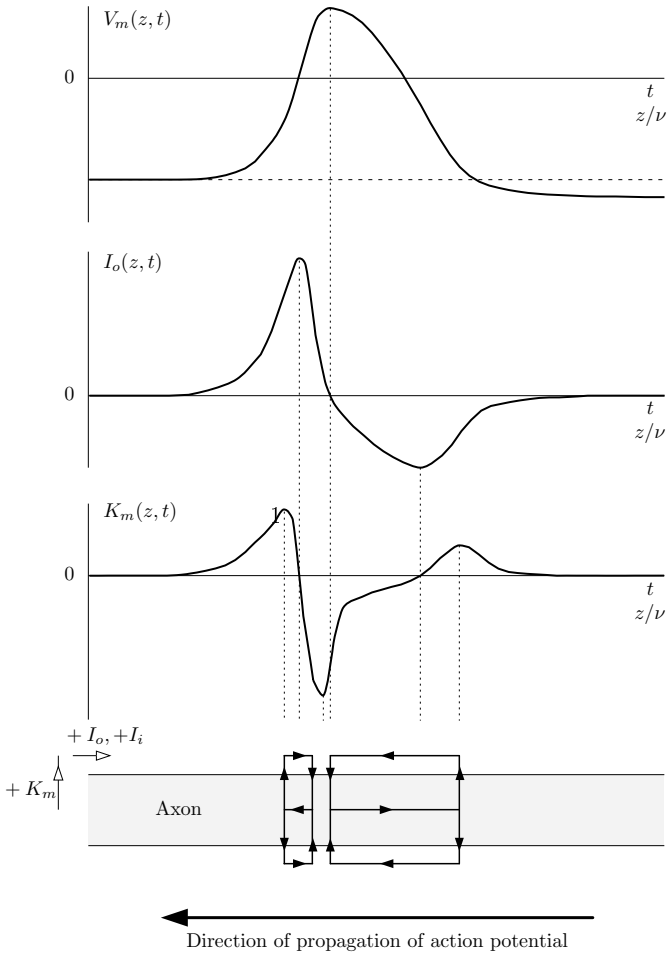


Figure 2.12

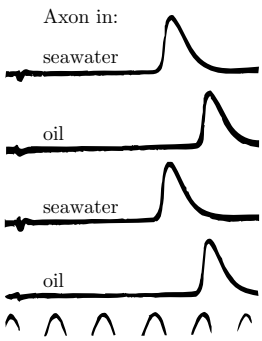


Figure 2.14

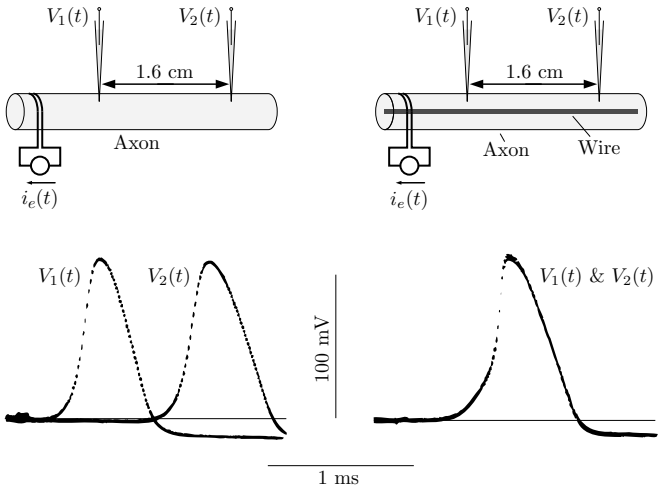


Figure 2.15

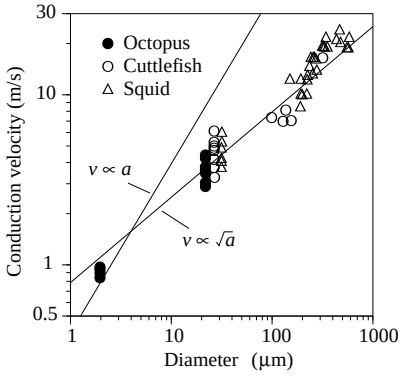
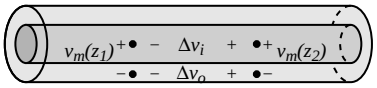


Figure 2.16

Relation between extracellular and intracellular potentials



KVL:

$$v_m(z_2) + \Delta v_o - v_m(z_1) - \Delta v_i = 0$$

$$\Delta v_o - \Delta v_i = v_m(z_1) - v_m(z_2)$$

$$\Delta v_i = -\int_{z_1}^{z_2} r_i I_i dz = -r_i \int_{z_1}^{z_2} I_i dz$$

$$\Delta v_o = -\int_{z_1}^{z_2} r_o I_o dz = -r_o \int_{z_1}^{z_2} I_o dz$$

$$I_o = -I_i$$

$$\Delta v_i = -r_i \int_{z_1}^{z_2} I_i dz = -r_i \int_{z_1}^{z_2} (-I_o) dz = -\frac{r_i}{r_o} \Delta v_o$$

$$\Delta v_o - \Delta v_i = \Delta v_o + \frac{r_i}{r_o} \Delta v_o = v_m(z_1) - v_m(z_2)$$

$$\Delta v_o = \frac{r_o}{r_o + r_i} \left(v_m(z_1) - v_m(z_2) \right)$$

let $z_1 \to -\infty$: then $v_o(z_1) \to 0$ and $v_m(z_1) \to V_m^o$

$$\Delta v_o = v_o(z_2) - v_o(z_1) = v_o(z_2) = \frac{r_o}{r_o + r_i} \left(V_m^o - v_m(z_2) \right)$$

$$v_o(z_2) = -\frac{r_o}{r_o + r_i} \left(v_m(z_2) - V_m^o \right)$$

Core Conductor Model: Summary

Few assumptions (Geometry + Ohm's law): surprising if it predicts anything
Interesting predictions:

- local flow of current during propagating AP
  - spatial extent related to temporal extent via speed
  - membrane current is INWARD at peak of AP (???)
  - membrane current is OUTWARD ahead of peak (self triggering?)
- speed of propagation depends on geometry (fat = fast)
- can predict membrane potentials from extracellular recordings

Few assumptions $\rightarrow$ Robust (must be true!)
Cell membranes have unusual electrical properties $\rightarrow$ Why? (next time)