Impulse Propagation

Bioeng 6460
Electrophysiology and Bioelectricity

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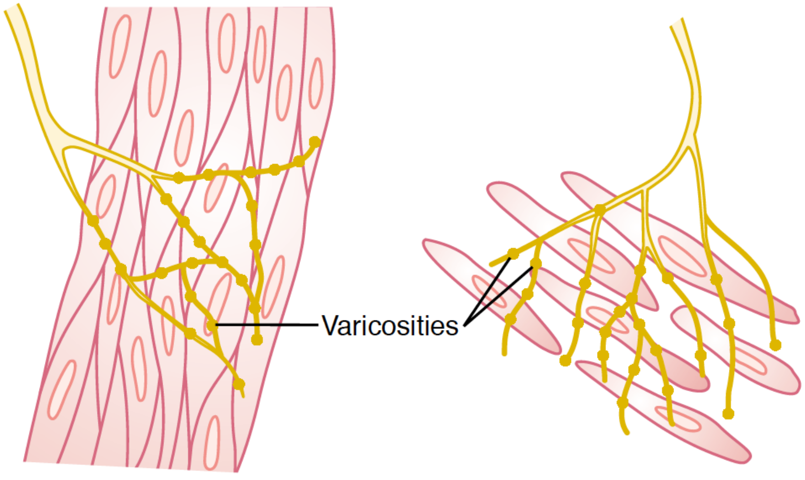
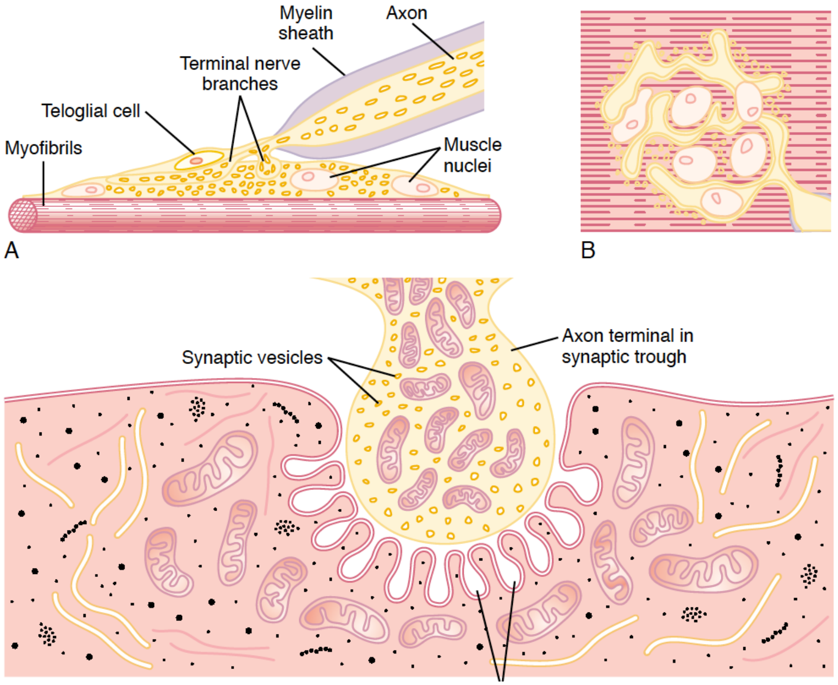
Activation Spread by Tissue Type

- Smooth muscle
- Skeletal muscle



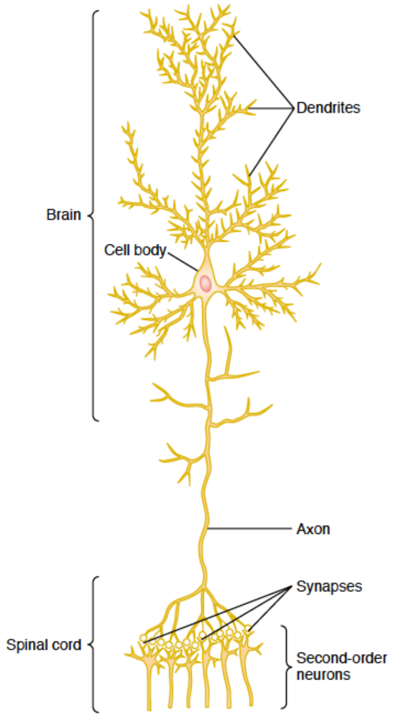
Visceral

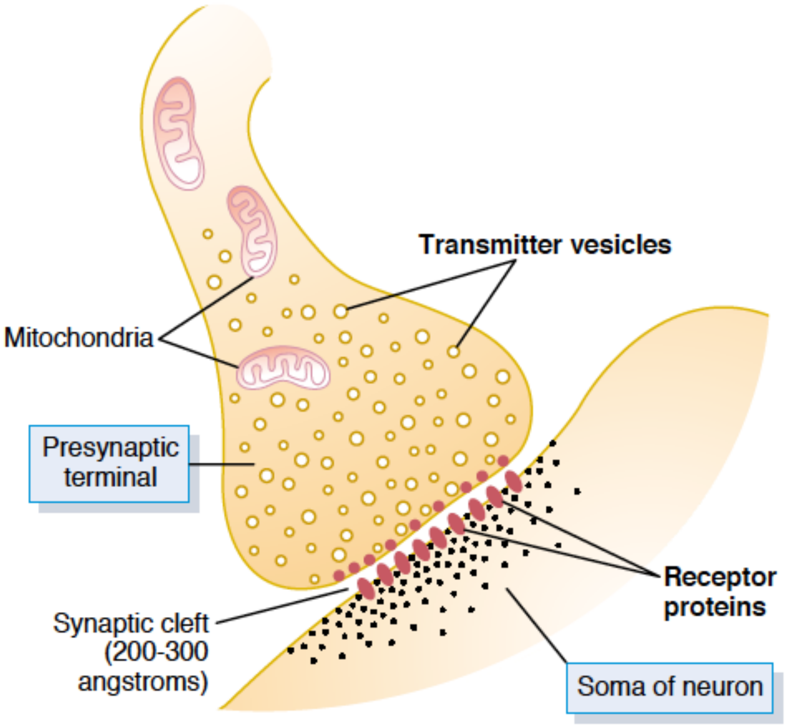
Multi-unit



Tissue Types Continued

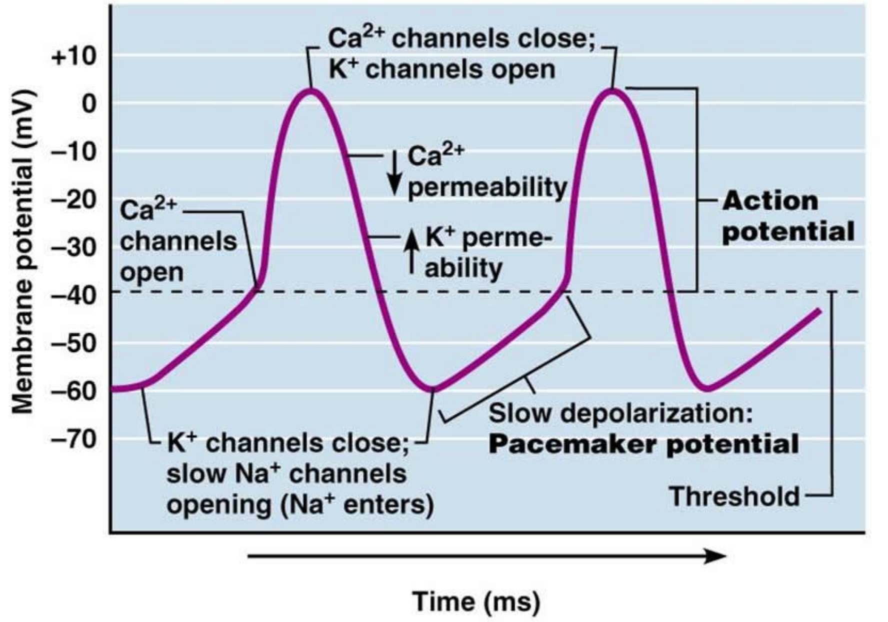
- Neuron to neuron conduction

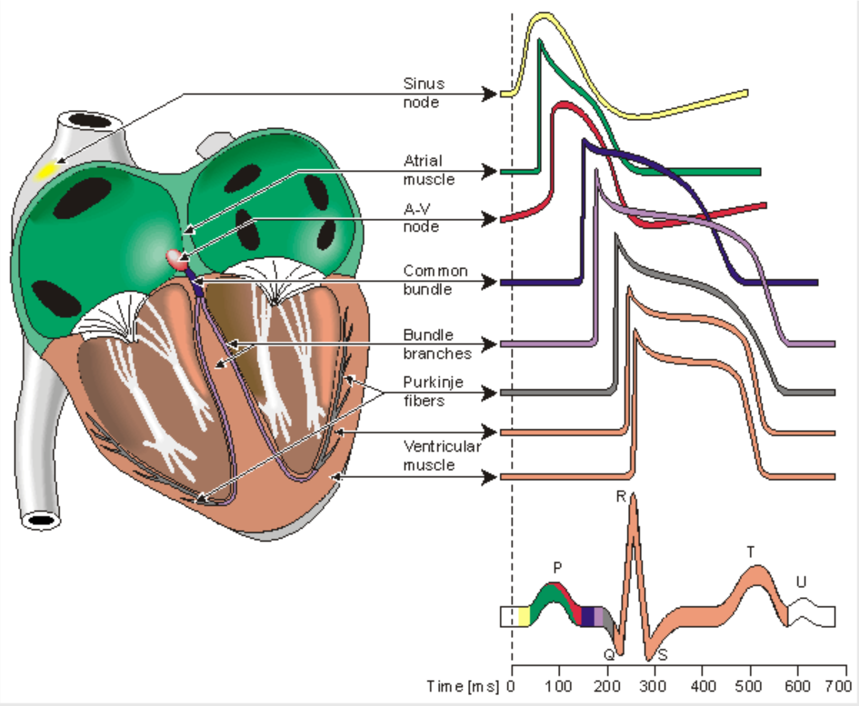




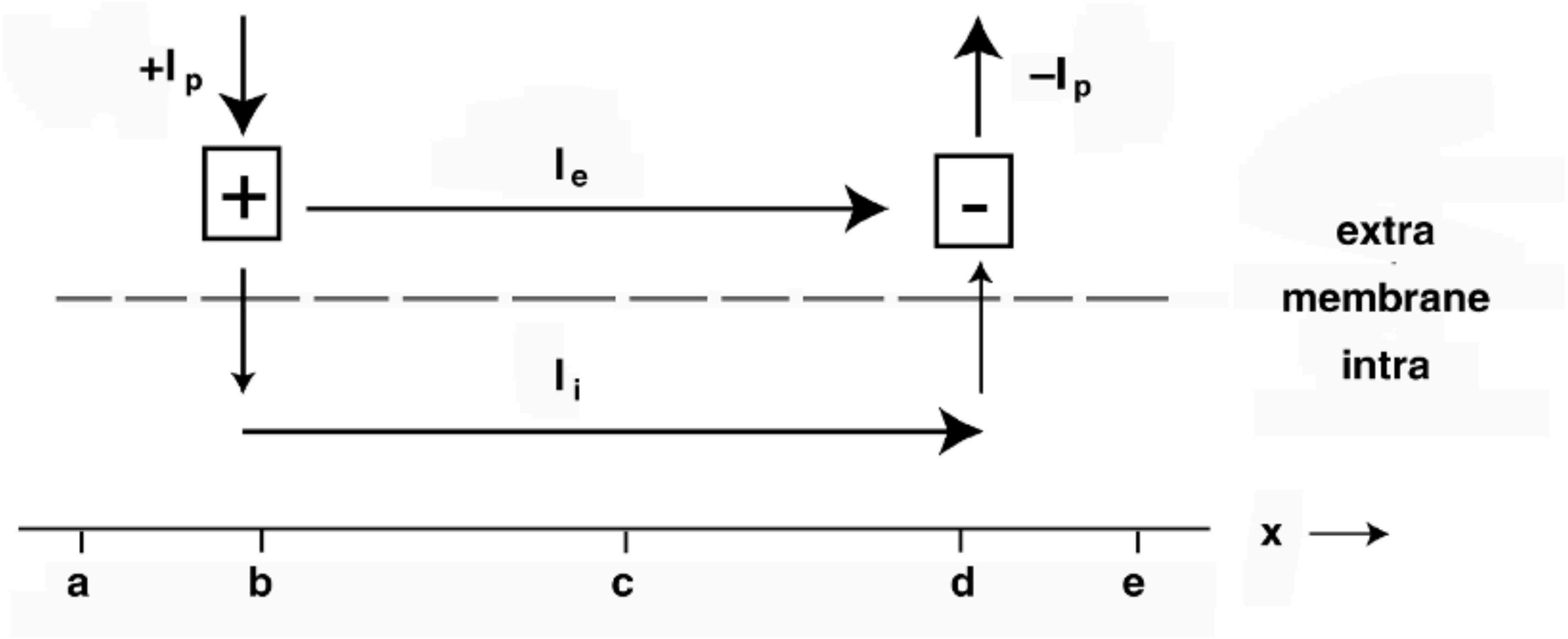
Tissue Types Continued

- Cardiac





Electrical Stimulation

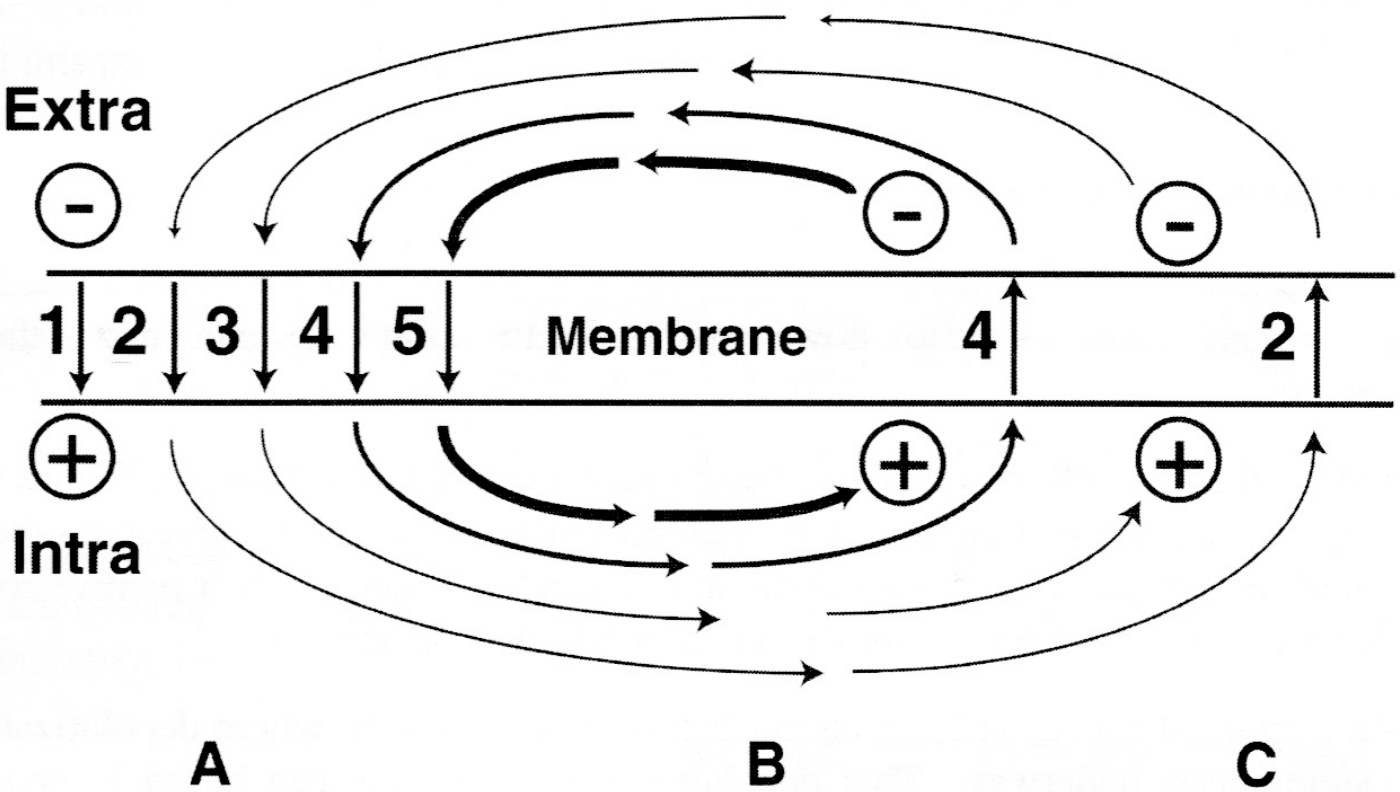


I at a and e = 0

I_m at b = -I_m at d

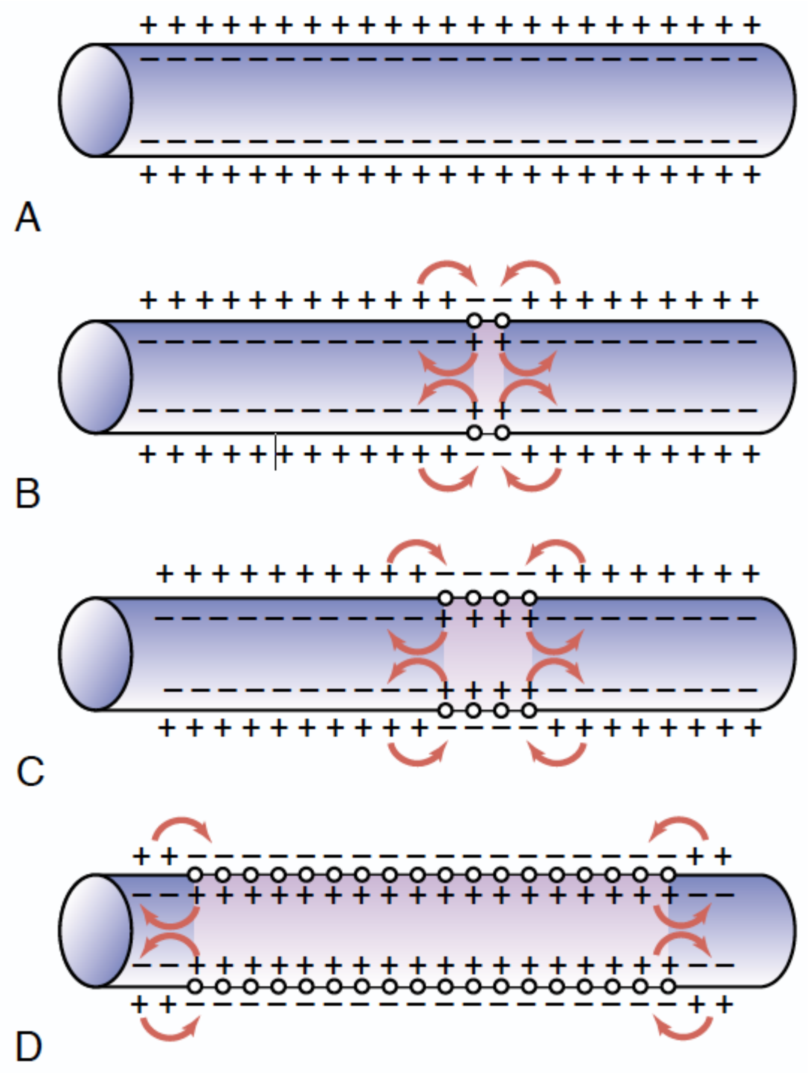
I_m at c = 0

After activation starts…



I_i causes propagation

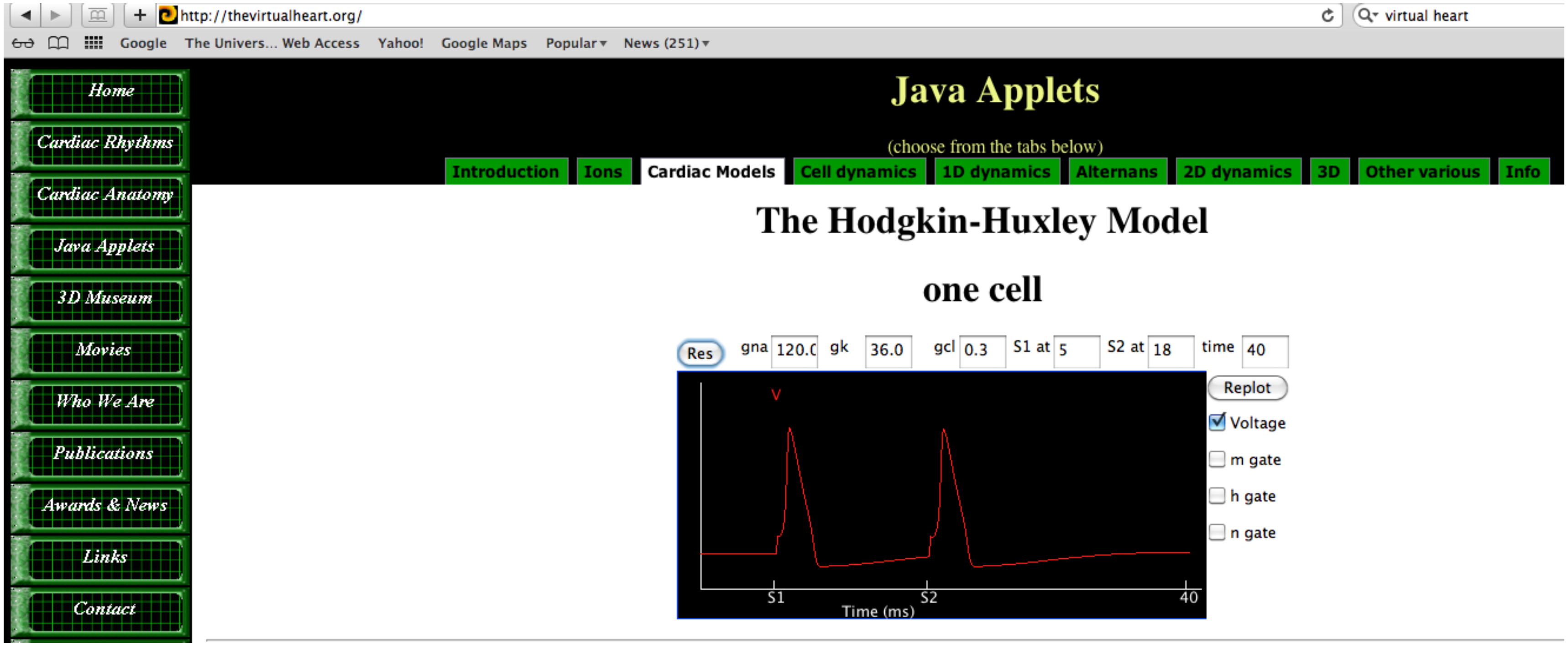
- One area of I_m causes adjacent Na channels to open
- Activation can spread in both directions



Propagation Models

Thevirtualheart.org

Java scripts, modify ion conductance



http://thevirtualheart.org/

Java Applets

(choose from the tabs below)

The Hodgkin-Huxley Model

one cell

gna 120.(gk 36.0 gcl 0.3 S1 at 5 S2 at 18 time 40

☑ Voltage
☐ m gate
☐ h gate
☐ n gate

Relationship between V_m and I_i

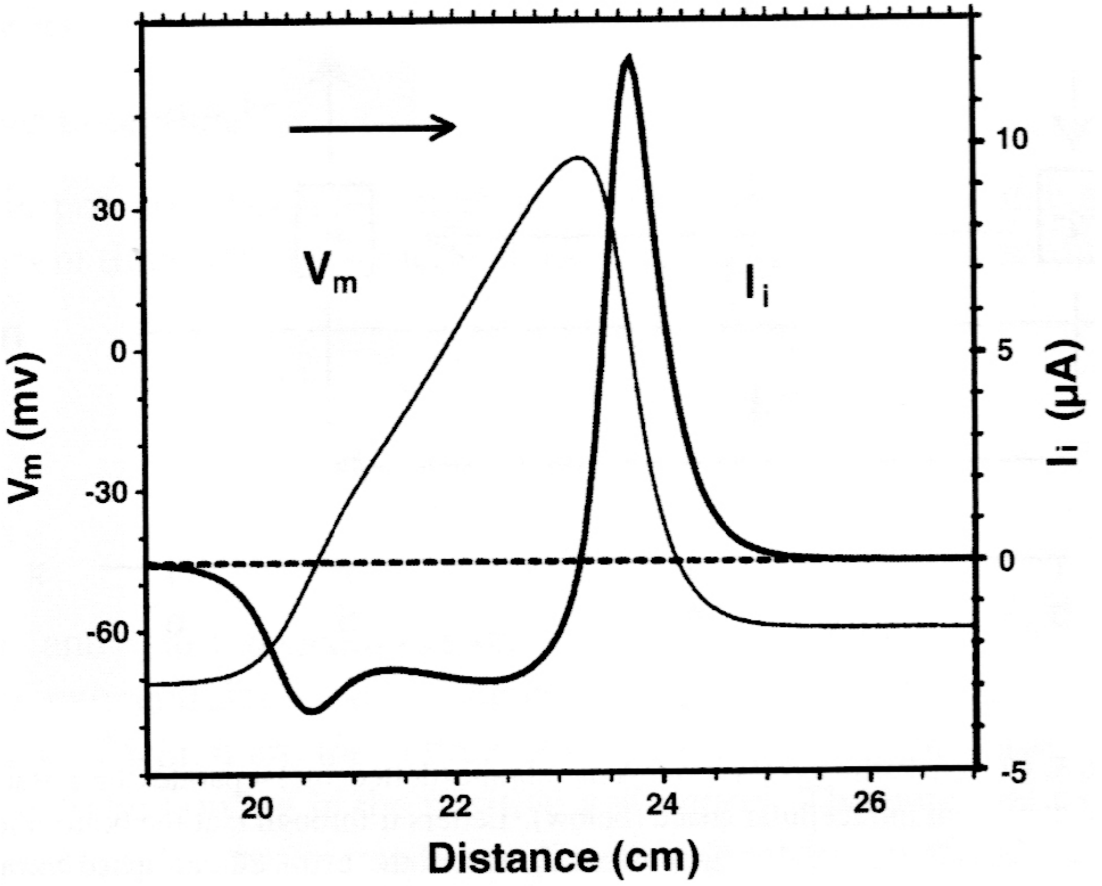
$V_m \equiv \phi_i + \phi_e$ Taking the first spatial derivative…

$$\frac{\partial V_m}{\partial x} = \frac{\partial \phi_i}{\partial x} + \frac{\partial \phi_e}{\partial x} = -r_i I_i + r_e I_e$$

$$\frac{\partial V_m}{\partial x} = -r_i I_i + r_e (I - I_i) = -(r_i + r_e) I_i + I r_e$$

$$I_i = \frac{-1}{(r_i + r_e)} \left[\frac{\partial V_m}{\partial x} - I r_e \right]$$

V_m and I_i (Fig 6.6)



$$I_i = \frac{-1}{(r_i + r_e)}\left[\frac{\partial V_m}{\partial x} - I r_e\right]$$ When I=0 (no stimulation) $$I_i \propto \frac{\partial V_m}{\partial x}$$

Relationship between V_m and i_m

$$\frac{\partial V_m}{\partial x} = -(r_i + r_e)I_i + Ir_e$$

Take 2nd derivative

$$\frac{\partial^2 V_m}{\partial x^2} = -(r_i + r_e)\frac{\partial I_i}{\partial x} + r_e\frac{\partial I}{\partial x}$$

Remember that:

$$\frac{\partial I_i}{\partial x} = -i_m$$

and

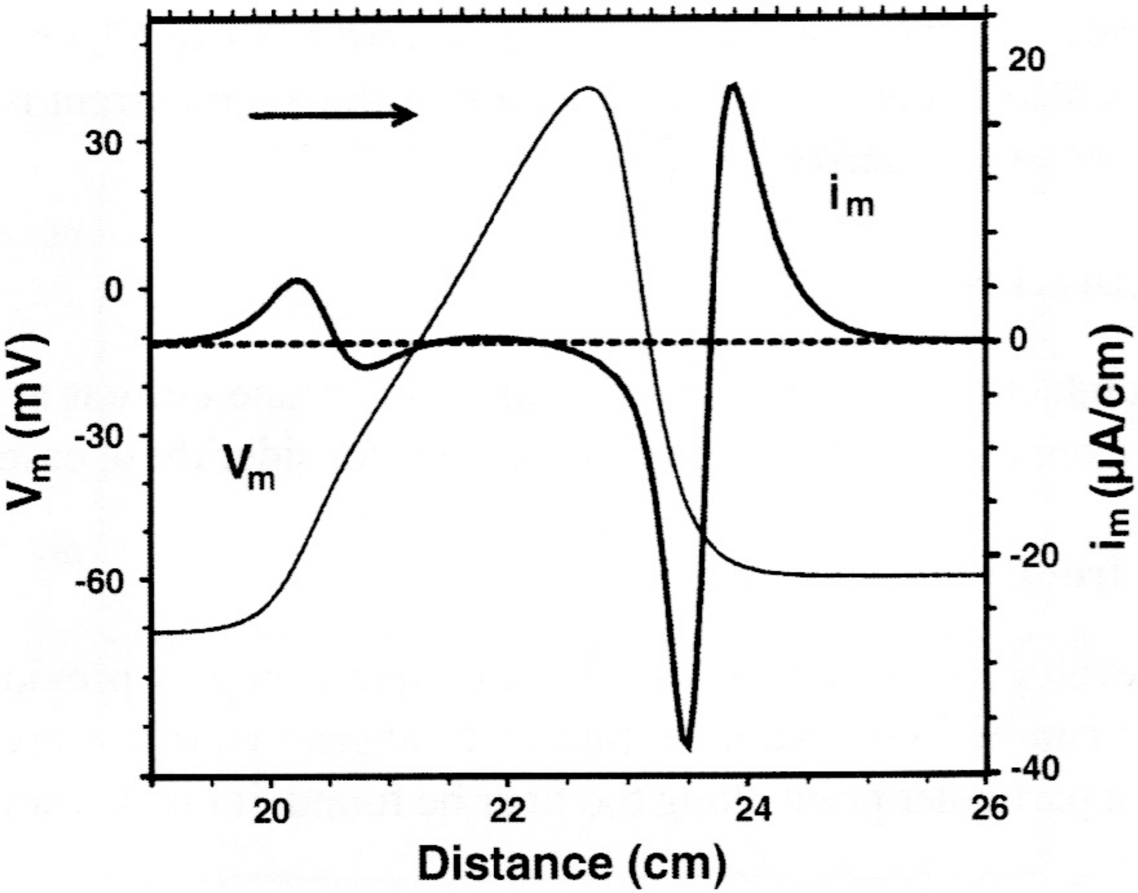
$$\frac{\partial I}{\partial x} = i_p$$

So…

$$\frac{\partial^2 V_m}{\partial x^2} = (r_i + r_e)i_m + r_e i_p$$

$$i_m = \frac{1}{(r_i + r_e)}\left(\frac{\partial^2 V_m}{\partial x^2} - r_e i_p\right)$$

V_m and i_m



$$i_m = \frac{1}{(r_i + r_e)}\left[\frac{\partial^2 V_m}{\partial x^2} - r_e i_p\right]$$

If i_p=0 (no stimulation) $i_m \propto \frac{\partial^2 V_m}{\partial x^2}$

Conduction Velocity

Hodgkin and Huxley found that:

$$\theta \propto \sqrt{a}$$

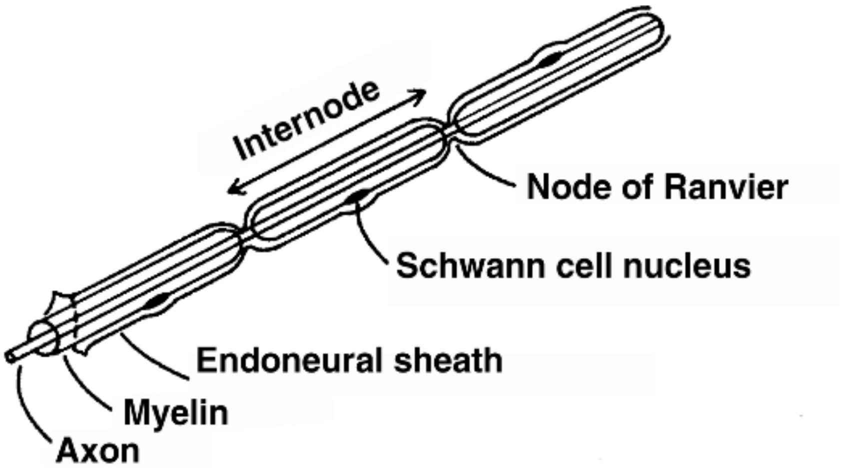
And

$$\theta \approx \sqrt{d}$$

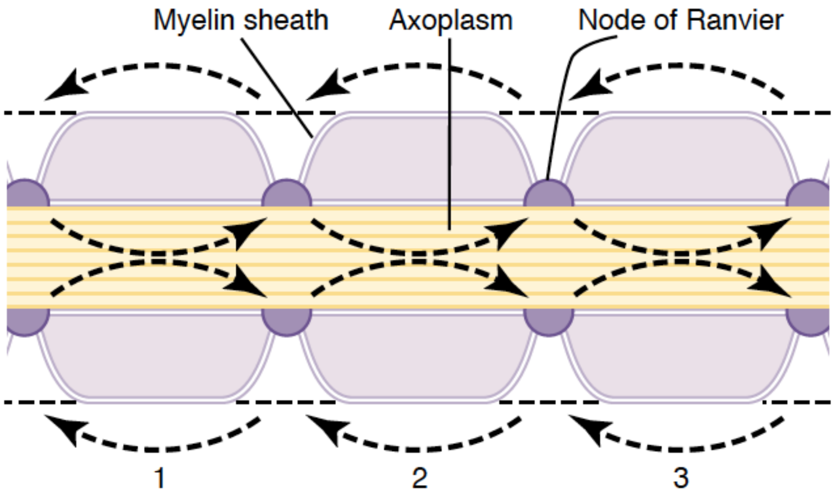
Where *d* is fiber diameter in µm and θ is m/s

Myelination

- Myelinated axon



- Saltatory conduction



$$\theta \approx 6 \times D$$