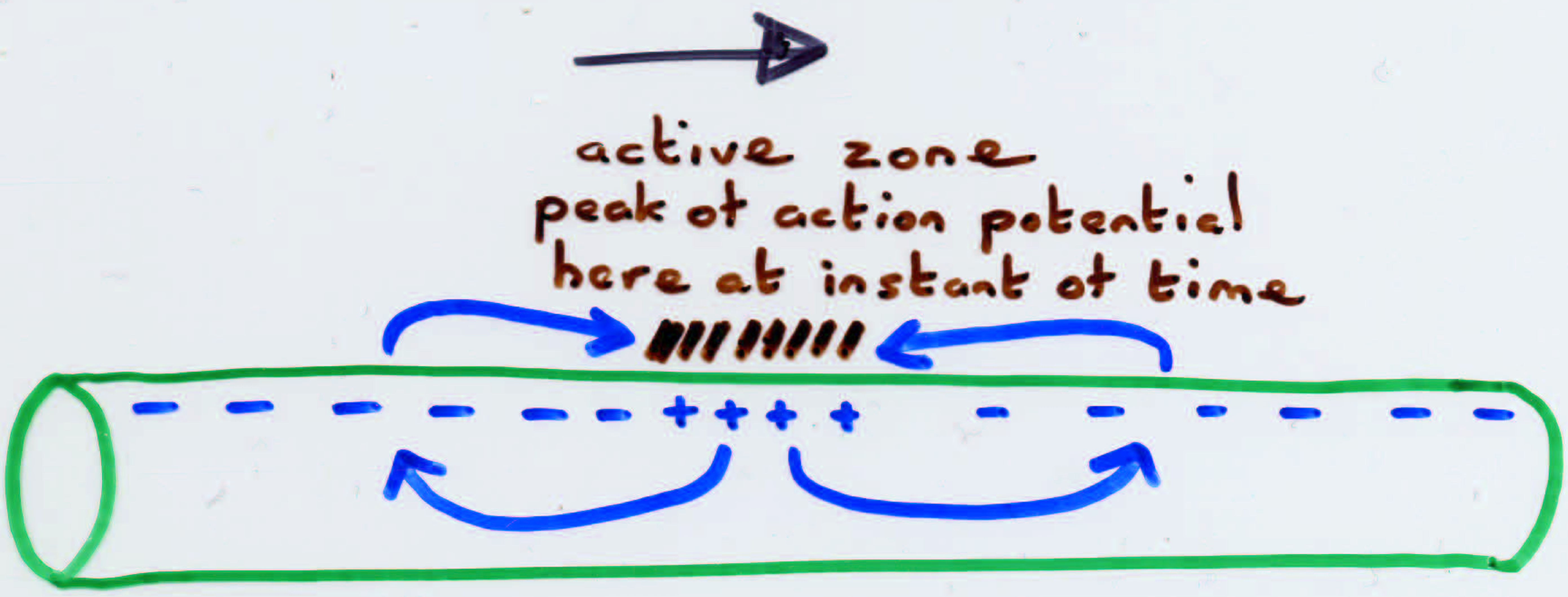
Why does an action potential propagate?

Local circuit theory

Axon behaves like passive electric cable to transmit depolarization.



local current flow will tend to depolarize axon on either side of action potential, thus triggering action potential there.

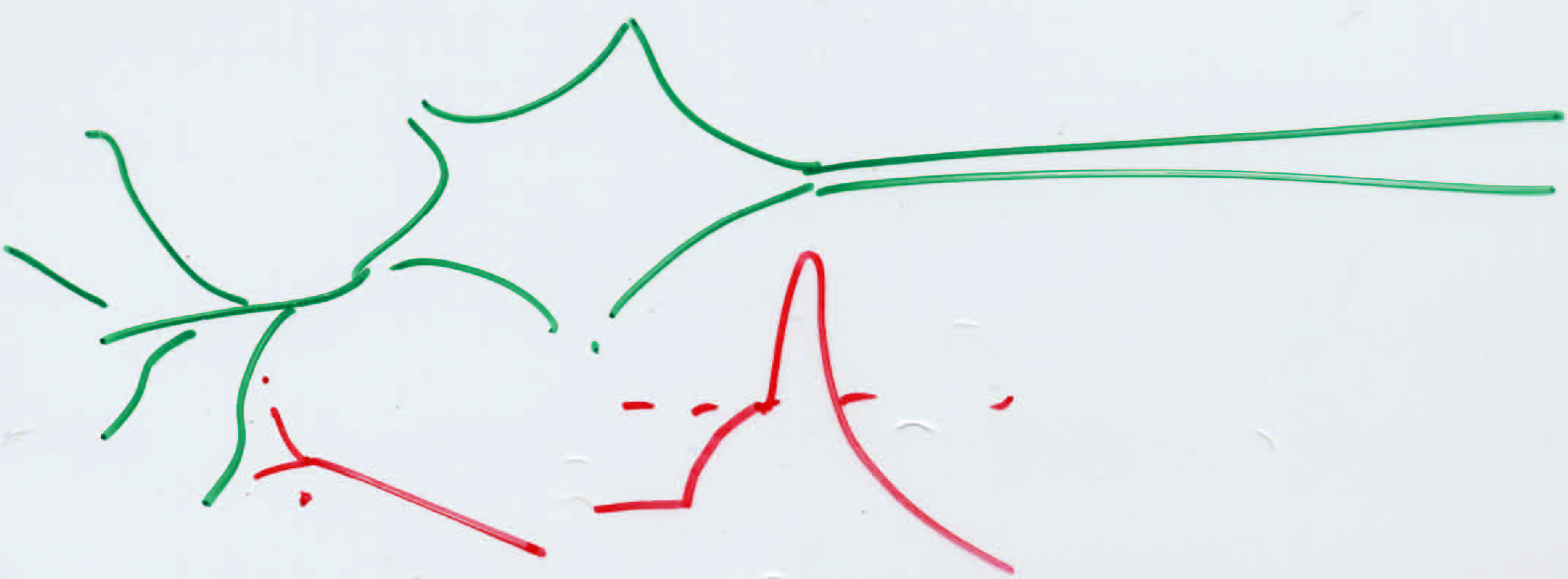
Why does action potential travel only one way?

Because axon behind action potential is refractory (Na^+ channels are still inactivated)

Thus, only region ahead of action potential can be stimulated.

Nervous system designed so nerves normally excited only at one end – thus action potential always go in one direction : orthodromic

But : can artificially stimulate to get 'backward' action potential : antidromic



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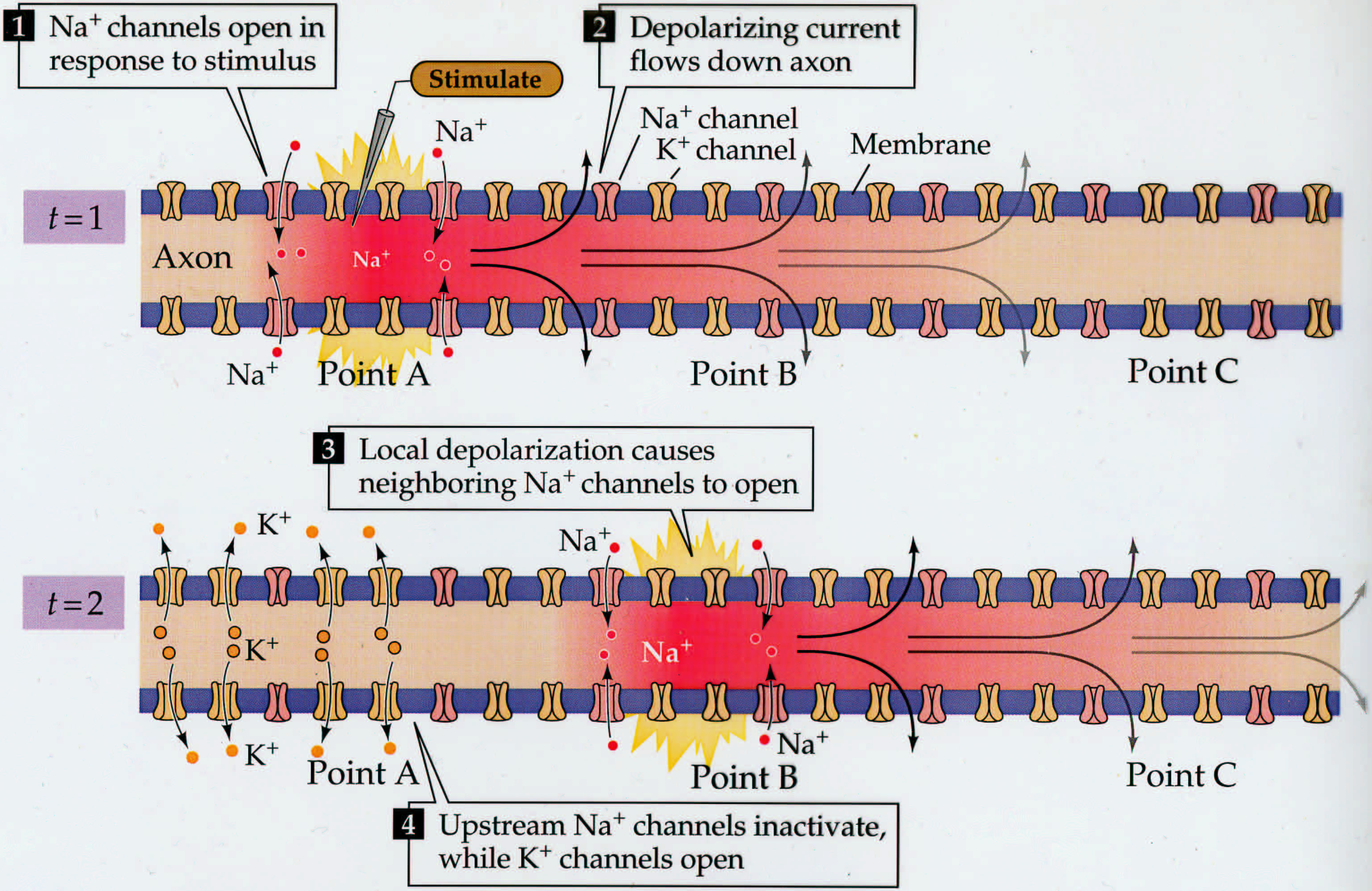

Figure 3.12 (Part 1) Action Potential Conduction

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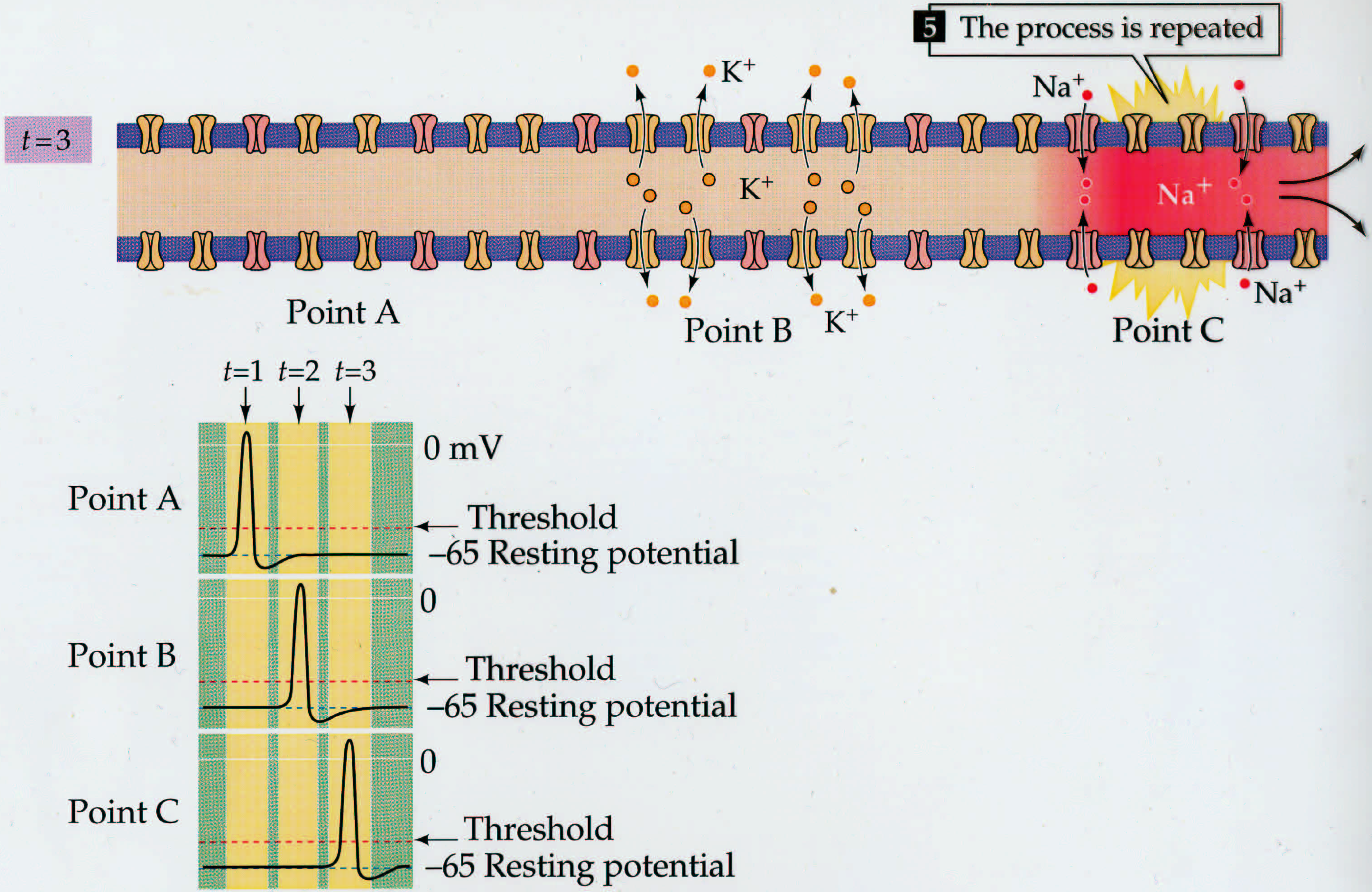

Figure 3.12 (Part 2) Action Potential Conduction

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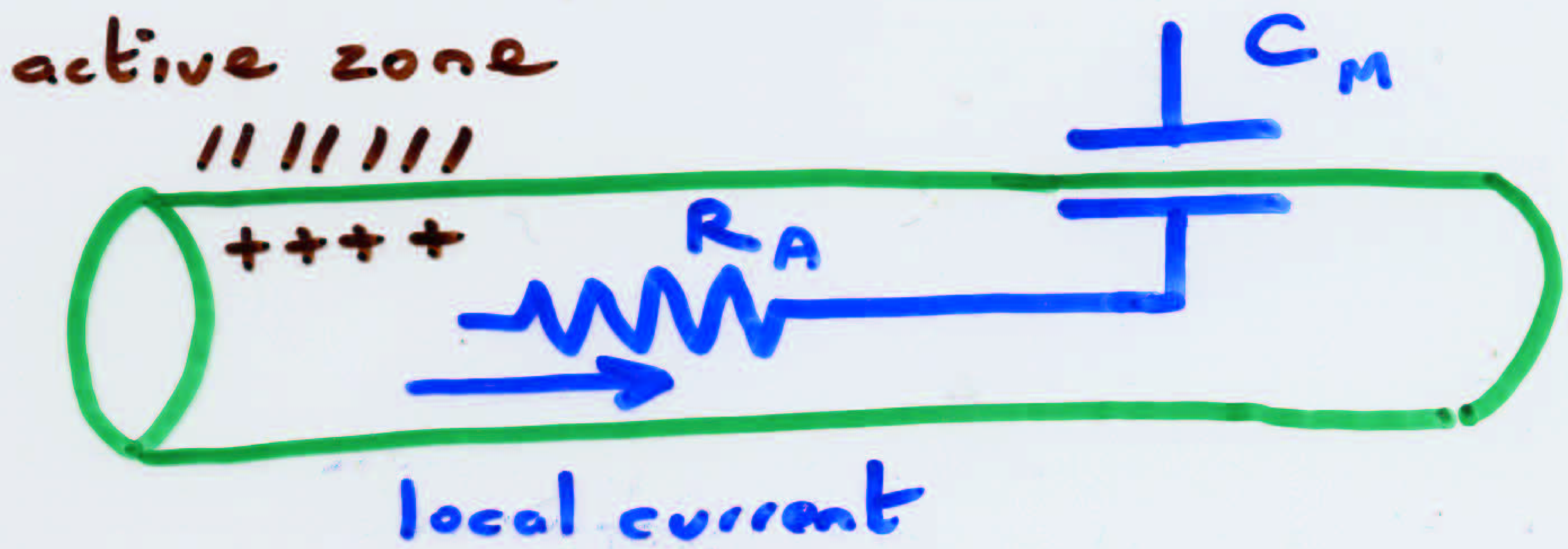
Q. What determines speed of propagation of action potential?

A. How fast the next region of the axon can be depolarized to threshold for it to generate an action potential.



local current from active zone must flow through axoplasmic resistance (R) to charge up capacitance (C) of next region of membrane.

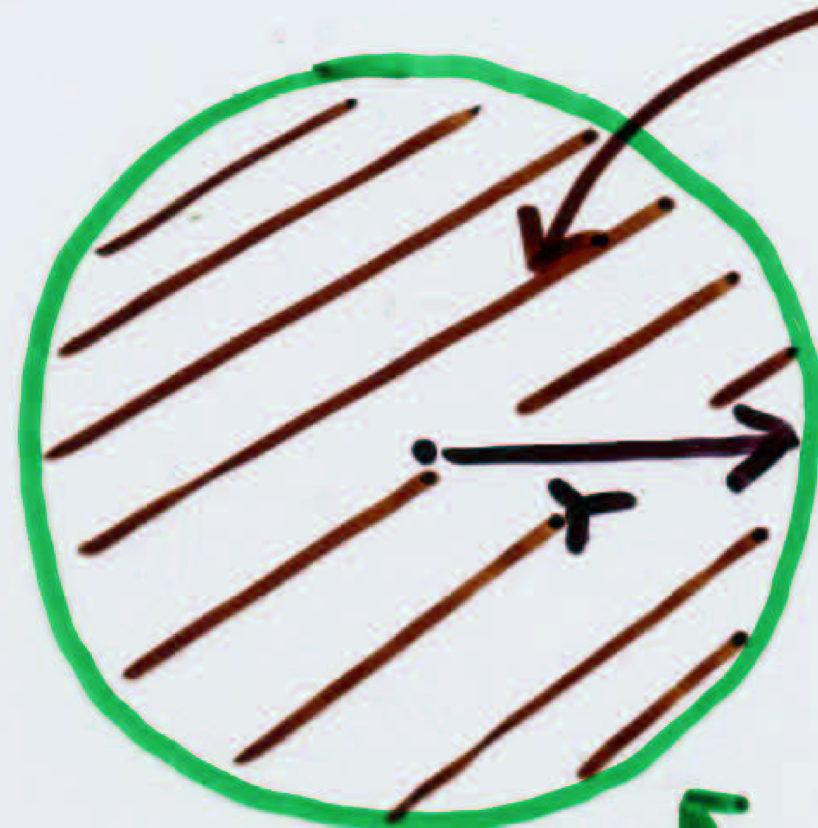
This will be faster if;

R_A is smaller

C_M is smaller

Two ways to make an axon transmit action potentials faster

① Make it fatter. (like the squid axon)



axoplasmic resistance R varies with cross-sectional area of axon

capacitance C varies with circumference of axon

thus R_A will vary as $\frac{1}{r^2}$

C_M will vary as r

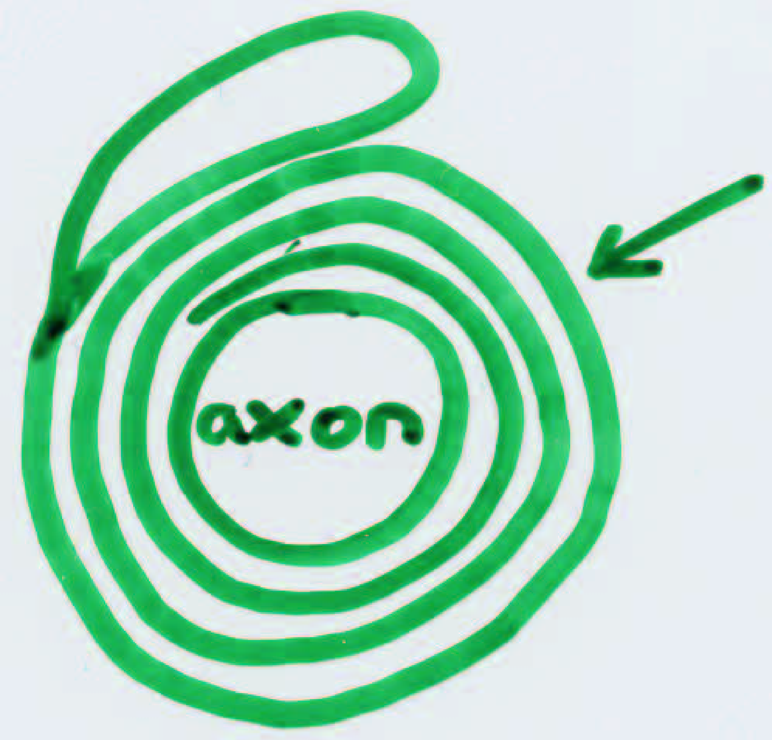
axon radius

net effect is that as r increases

$R_A * C_M$ decreases

so that conduction velocity increases.

② Wrap myelin around axon.

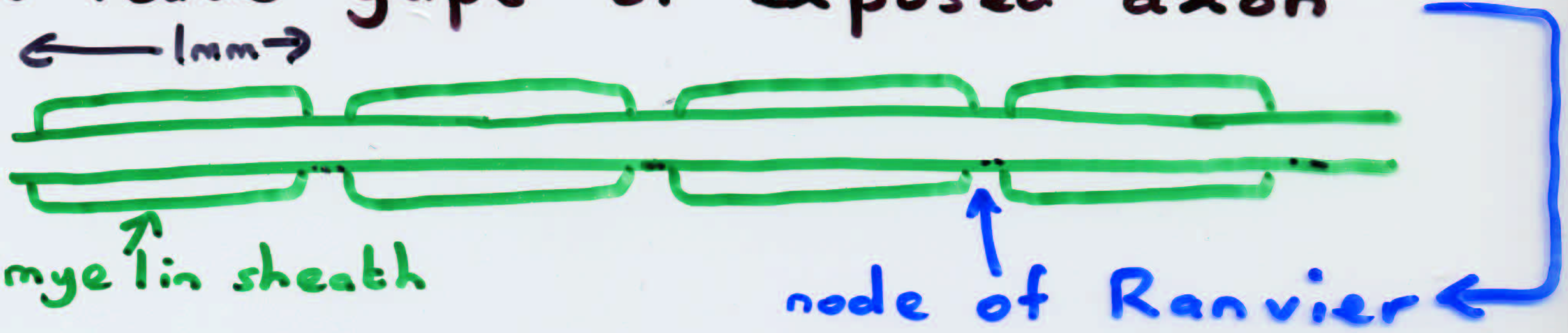


myelin sheath increases effective thickness of axon membrane many-fold. Thus capacitance is greatly reduced, speeding action potential.

Very efficient – as overall diameter of nerve increased only slightly.

Saltatory conduction

If all axon were wrapped in myelin, no space left for Na^+ channels. Solution is to leave gaps of exposed axon



Action potential 'jumps' rapidly from node to node.

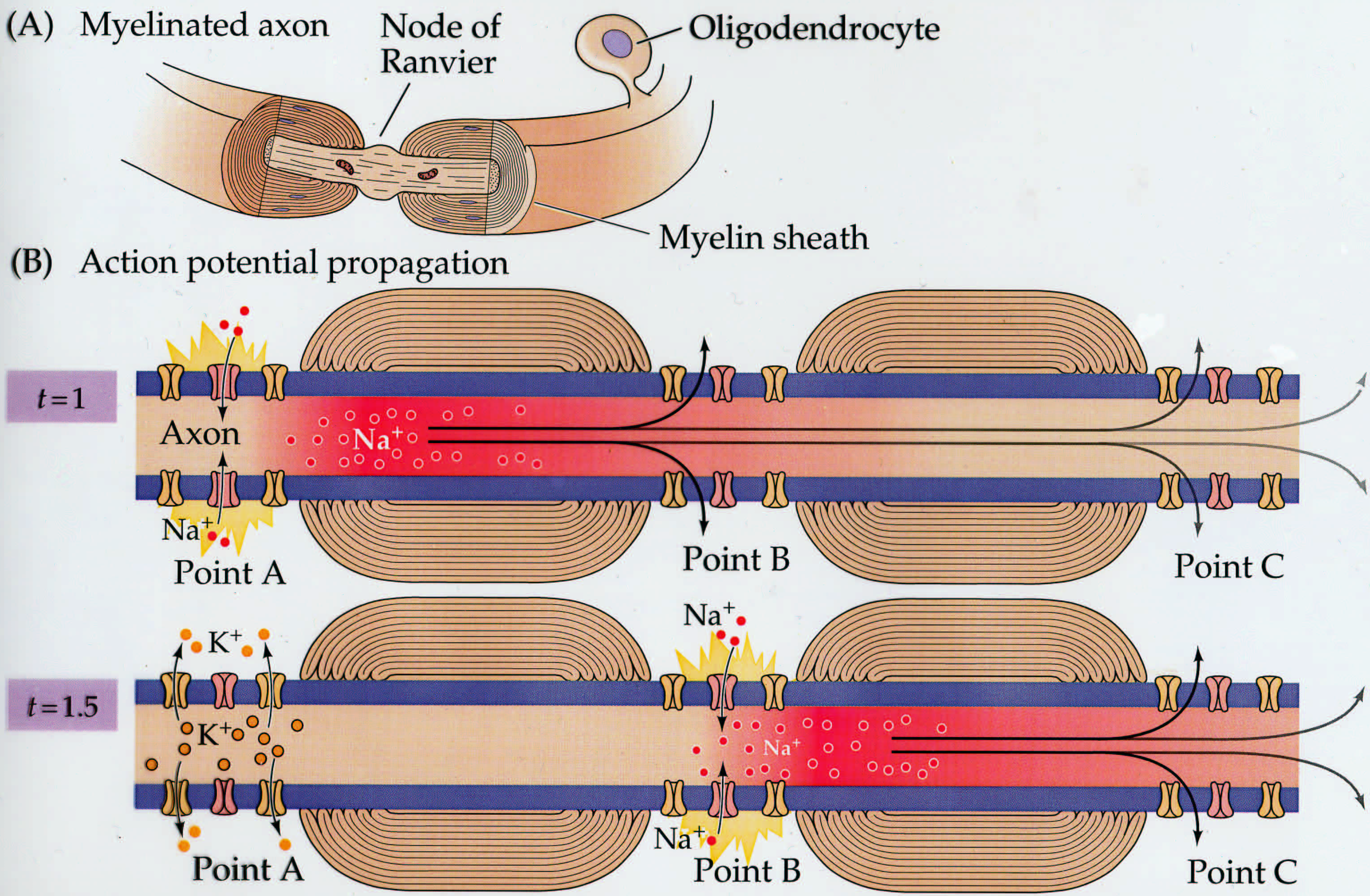


Figure 3.13 (Part 1) Saltatory Action Potential Conduction along a Myelinated Axon

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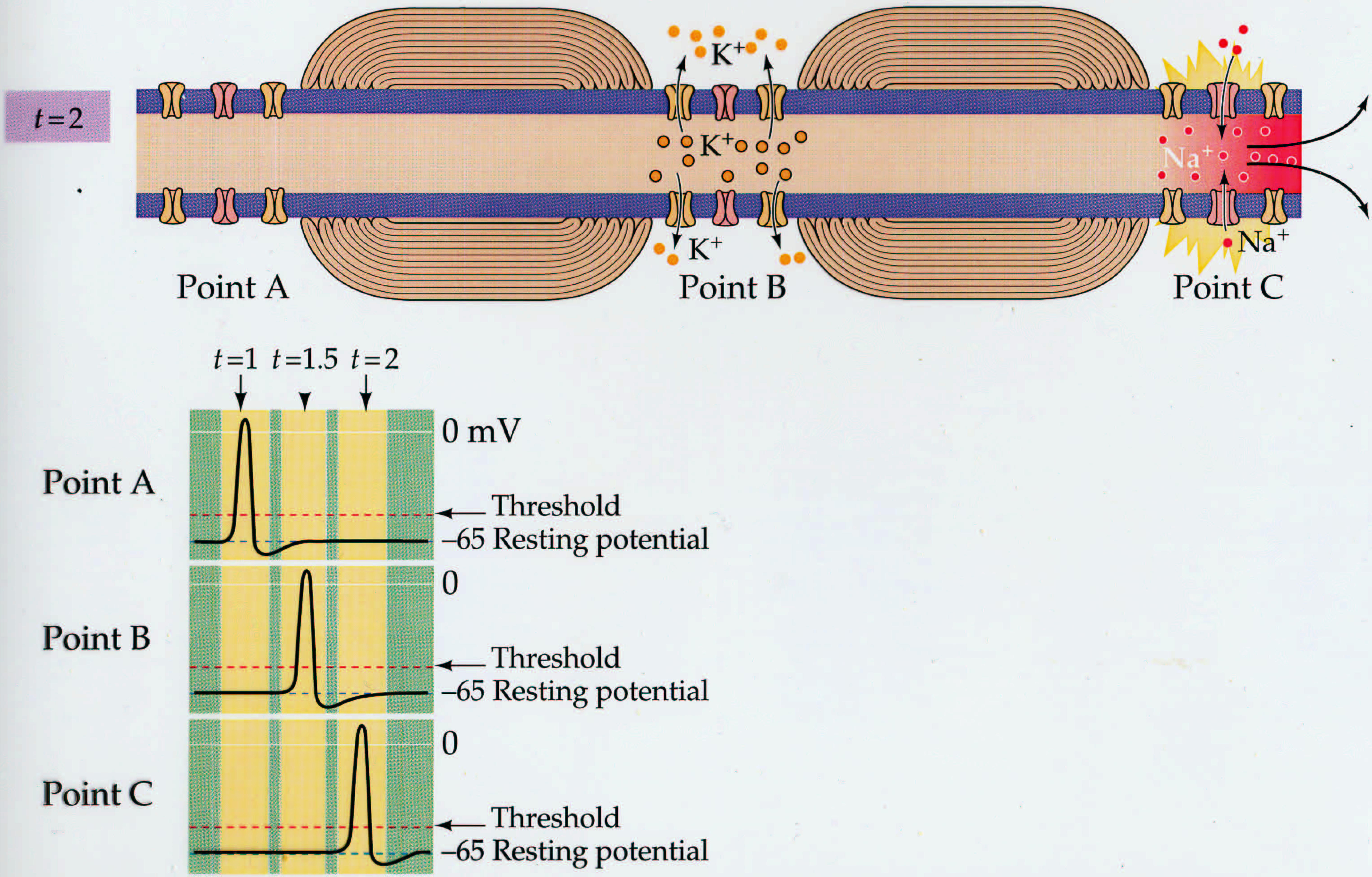

Figure 3.13 (Part 2) Saltatory Action Potential Conduction along a Myelinated Axon

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