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Cellular Neurobiology

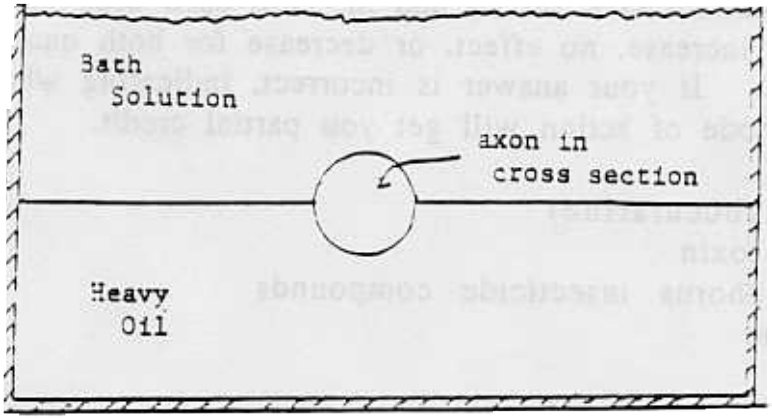
Problem Set II

1. A squid axon, 1 mm in diameter has a resting potential of -75 mV. A microelectrode is inserted into the axon near the middle. It is used to inject sufficient current to depolarize the axon membrane at that point to -70 mV.

A second (recording) microelectrode is inserted in the axon 1 cm away from the first. It records a membrane voltage of 74.32 mV.

a What is the space constant, λ, of the axon?

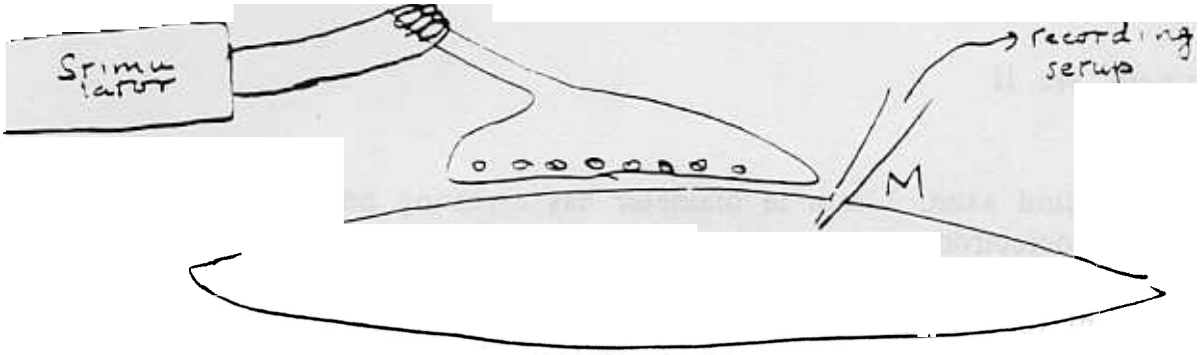
b The axon (horizontally extended) is then submerged in heavy, nonconductive fluorocarbon oil to half its diameter (see figure below). What is the new space constant?



c) What biological phenomenon resembles the fluorocarbon experiment above? In what way?

2 Quantal size, v_1 (measured in mV) and mean quantal content, m (in dimensionless numbers) have been extensively discussed in connection with synaptic physiology. You are given a frog sartorius neuromuscular junction as diagrammed on the next page.

With this preparation, you can stimulate the presynaptic nerve fiber at N and record from the muscle at M. The initial bath solution is frog ringers, i.e., a salt solution with sodium, potassium, calcium, and chloride in concentrations adjusted to match those in frog blood.



a) What changes would you have to make in your preparation or recording circuitry before you could do quantal analysis on synaptic (sometimes termed junctional) transmissions.

b) What effect would you expect the following drugs applied to the superfusion solution have on v_1 and m. For each drug indicate whether you expect an increase, no effect, or decrease for both quantal size and quantal content. If your answer is incorrect, indicating what you know about drug's mode of action will get you partial credit.

cobalt
curare (β-tubocurarine)
botulinum toxin
organophosphorus insecticide compounds
neostigmine
calcium
acetylcholinesterase
succinylcholine

A neuron in the human CNS has an E_k of -60 mV, an E_{Na} of + 40 mV, an E_{Cl} of -55 mV. The resting potential of this cell is -55 mV, and its threshold is -45 mV.

a. Synaptic channels in this neuron which are opened by the neurotransmitter glutamate are equally conductive to sodium or potassium ($g_K = g_{Na}$). What is the reversal potential of such

a GABA responsive synapse on this cell? Is it excitatiory or inhibitory?

b Other synapses on the neuron are responsive to the neurotransmitter GABA. The GABA-gated channels are selectively permeable to chloride ions. Would you expect the GABA synapses to be excitatory or inhibitory? Why?

c. Glycine-gated channels on this cell conduct both sodium and potassium ions. However, these channels are four times as conductive to potassium ions as to sodium ions. Would you expect glycine-responsive synapses on this neuron to be excitatory or inhibitory Why?