7.29 J 9.09
Cellular Neurobiology
Midterm Test
17 March, 2004

Answer **Question 1** and **four of the five others**. Each answer is worth 20 points. If you answer all six questions the first five will be graded.

No books, no notes, no cooperation permitted. Calculators are allowed.

All lettered subsections of a question have equal point value unless otherwise specified.

All questions have specific answers. It is to your advantage to be brief.
You may use telegraphic rather than grammatical English if you wish, so long as your reasoning is made clear.

Question 1.
Identify the following terms and indicate how they relate to the course, : (2 points each)

a) 2-amino-5-phosphonovaleric acid (APV)
b) Adenylyl Cyclase
c) Sarin
d) Belladonna
e) Norepinephrine (= Noradrenaline)
f) Tetraethylammonium (TEA)
g) Differential Amplifier
h) Schaeffer Collateral
i) Tetanus toxin
j) Succinylcholine

Question 2
In a particular synapse in the central nervous system of Charles Vest, there are (always) five vesicles available for release. If an action potential is fired, the probability of any individual vesicle exocytosing is 1/3 (33%).

A. What is the mean quantal content of this synapse? (7 points)

B. What is the predicted frequency of failure of synaptic transmission , $P_{(0)}$, at this synapse? (7 points)

C. How well does this agree or disagree with the prediction from the Poisson distribution? (6 points)

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Question 3. In the sea hare *Aplysia californica*, it turns out that a peptide neurotransmitter SCP (for "small cardiac peptide") is also released (like serotonin) in the abdominal ganglion consequent to behavioral sensitization and applied SCP induces a synaptic facilitation that is quantitatively similar to that of serotonin in the synapses we discussed (between sensory and motor neurons in the gill-withdrawal circuit.

A, B. How would you determine whether the effect of SCP was on the sensory neuron or the motor neuron? (two experimental ways, 5 points each)

C, D. How would you determine whether or not serotonin and SCP effected synaptic facilitation by the same pathway or by pathways with shared elements? (Two experimental ways , 5 points each)

Question 4

The "Toothpaste-tube" experiment of Baker, Hodgkin, and Shaw (1962) involved a squid axon and a rubber roller.

A., B. Describe two important findings from the experiment. (5 points each)

C. Describe how you would modify this experiment to find out how much potassium flows outward across the axon membrane during an action potential. (5 points)

D. Describe how you would use purely electrophysiological data to obtain an approximate check of your answer in C. (5 points)

Question 5. Describe the original experiments that indicate the synaptic neurotransmitter release is caused by:

A. Calcium ions (5 points)

B. Entering the cytoplasm of the presynaptic terminal from outside (5 points)

C. Through voltage-gated channels in the membrane (5 points)

D. To induce vesicle fusion with the presynaptic cell membrane. (5 points)

[CONTINUE]

Question 6. A particular squid axon, 0.5mm in diameter, contains 5×10^{10} sodium channels per square centimeter of membrane. The conductance of each sodium channel in the open state is 5×10^{-12} Siemens/channel. Its membrane capacitance is 1 microfarad/cm^2. The concentration of sodium ions in the axon's cytoplasm is 40 millimolar, and the concentration of sodium ions in the bathing solution is 400 millimolar.

A. What is the maximum rate of depolarization that this axon could exhibit during an action potential, at membrane voltage = -22 millivolts? Give your answer in millivolts/millisec. (10 points)

B. Would doubling the diameter of the axon affect this value? Why or why not? (5 points)

C. Does this value seem high or low? What properties of membrane conductance and membrane currents might affect the rate of depolarization in a real action potential? Would they make the rate larger or smaller? (5 points)