7.29 J 9.09
Cellular Neurobiology
Midterm Test
20 March, 2002

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.

A space-clamped squid axon is firing an action potential. The top of its overshoot is +50 millivolts, the bottom of its undershoot is –80 millivolts. The .membrane capacitance of the axon is 1 microfarad /$cm^{2.}$.

(a) At time t during the action potential, the membrane potential , V_m = -50 millivolts. At this time, g_{Na} = 2 milliSiemens/$cm^{2.}$, and g_K= 5 milliSiemens/$cm^{2.}$. What is the membrane potential 1 millisecond later. (15 points).

(b) What are the 3 principal approximations you made to get your answer? (5 points)

Question 2.

The triangle thingummy below is the symbol for an electronic device which is an essential component of a voltage clamp used by Hodgkin and Huxley.

1

3

2

(a) What are the inputs? Where do they come from?

(b) What is the output? Where does it go to?

(c) How are the inputs and the output related?

(d) How is the output of the device related to the properties of the axon?

(e) what would happen if you switched the input leads, one for the other?

Question 3.

(a) How was the first sodium channel cloned? What creatures (other than humans) contributed to the success of this effort? How were they used? (7 points)

(b) What four or five features of the amino acid sequence of the channel are of particular interest? (7 points)

(c) How was the first potassium channel cloned? Again, what creatures contributed and how? (six points)

Question 4.

Aplysia is a system in which changes at a particular class of synapses are hypothesized to contribute to **associative** learning (differential classical conditioning).

(a) Where are the synapses? What are the presynaptic and postsynaptic cells? Which of these cells is hypothesized to contribute most to the synaptic change?

(b) Associative learning involves the synergistic interaction of two behavioral stimuli, experienced by the animal close together in time, to produce a specific behavioral change. What are the **two behavioral stimuli** in the *Aplysia* model system?

(c,d) What are the **two relevant molecular changes** produced by the two behavioral stimuli in the critical cell or cells.

(e) On what piece of molecular machinery (protein) do these two changes converge to act synergistically) What is the molecular consequence of this convergent signalling.

Question 5.

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 0.5 (50%).

(a) what is the mean quantal content of this synapse?

(b) what is the predicted frequency of failure of synaptic transmission , $P_{(0)}$, at this synapse?

(c) How well does this agree or disagree with the prediction from the Poisson distribution? What difference(s) between the frog neuromuscular junction and the Vest synapse might account for any observed mismatch.

(d) What pharmacological agents (pick three) could you apply to this synapse to alter its mean quantal content?

(e) How might the preparation feel about this? (0 points)

Question 6.

Indicate how the following organisms or agents have contributed to our understanding of neurobiology. The examples should be from the lectures or the text.

(a) A mouse knockout mutant.
(b) A yeast mutant.
(c) A mushroom.
(d) An epileptic patient.
(e) Another epileptic patient.
(f) Rubidium
(g) Tetrodotoxin applied to the frog neuromuscular junction.
(h) Oligonucleotides containing the CRE sequence (…TGACGTCA…)
(i) Xenopus
(j) A voltage clamp – of something other than a squid axon.
(k) An antibody.