7.29 J 9.09

Cellular Neurobiology

Midterm Test

16 March, 2005

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 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 and indicate how they relate to the course, : (2 points each)

a)Bacterial toxin (What bacterium or bacteria?)
b) Calmodulin
c) Node of Ranvier
d) Orbelli Effect
e) Yeast mutants
f) Snake Toxin (What snake or snakes?)
g) DDT
h) Cobalt
i) B Cell
j) Freeze Fracture

Question 2

Shown below is a (detached)patch-clamp recording from an Aplysia sensory neuron (The data were shown in class).

A. Do you think the parch clamp was inside-out or outside-out? Why? (2 points)
B. What is the function of the electronics in such a patch-clamp recording? (3 points)

C. The horizontal axis on the recording indicates time. What quantity does the vertical axis indicate? (2 points)

D. Why does the trace fluctuate between defined states indicated by the added horizontal lines? (2 points)

E. At one point the graph indicates "cAMP-PK." What experimental operation was done here? (3 points)

F. What is the conclusion to be drawn from the experiment? (3 points)

G. What is the importance of the conclusion? (5 points)

Question 3

Deep within the Abominable Ganglion of the Snot Puppy, lies an identified neuron, #66-144. This spherical cell, 100 microns in diameter, has a resting potential of –58 mV, and it responds to the neurotransmitter norepinephrine. Norepinephrine acts via a second messenger system to **close** a species of channel which (when open) has an equilibrium potential (reversal potential) of –58 mV.

A. How would you verify the reversal potential of this channel? Describe your experimental setup and your critical experimental finding. (4 points)

B. For this cell, $[K^+]_o$ = 400 mM.; $[K^+]_i$ = 40 mM; $[Cl^-]_o$ = 66 mM; $[Cl^-]_i$ = 660 mM. What are E_K and E_{Cl}? (4 points)

C. Consider the ligand-gated channel on the postsynaptic membrane that is closed by norepinephrine. Does this channel conduct chloride ions, potassium ions, both types of ions, or is there insufficient information? If you have insufficient information, what experiments would you carry out to decide? (9 points.)

D Is the action of norepinephrine on this channel excitatory or inhibitory? Why? (4points)

Question 4.

Describe the NMDA receptor. Identify:

a) its natural agonist (1 point)

b) a specific agonist (1 point)

c) a specific antagonist (1 point)

d) The ion or ions it conducts (1 point)

e) necessary conditions for its efficient ion conductance. Explain how these arise. (3 points)

f) the location of the molecule (anatomical locus, cellular locus) **in the system described in the lectures** [the molecule is generally very widely distributed] (3 points)

g) Its role in synaptic transmission there. (4 points)

h) Its putative role in the animal's behavior. What two lines of experimental evidence argue for such a role? (6 points)

Question 5.

A In Hodgkin and Huxley's studies of the squid giant axon, what is the evidence that the early, inward current is purely sodium (2 experimental findings)? (4 points)

B. Suppose the early, inward current were not purely sodium. How would you detect this? (4 points)

C What other ion or ions seem likely candidate(s) for the inward experiment? (2 points)

D. How would you confirm or disprove their role in the early phase of the action potential? (3 points)

E. Suppose two ion species were involved in the early current. How would you quantitatively determine their relative contributions? (7 points)

Question 6.

In a particular squid axon, the Nernst equilibrium potential for potassium is -80mV. The Nernst equilibrium potential for sodium is +40mV. Wires are threaded down the inside and along the outside of the axon, and a voltage clamp is hooked up. The axon is clamped for a long time to a steady voltage of 0mV.

At this point, g_{Na} is 1 milliSiemen/cm^2 and the g_K = 9 milliSiemens/cm^2. The axon is 1mm in diameter and 64mm long.

[OVER]

A. What is the sodium current density (in nA/cm^2) under these conditions? (2 pointsP

B. What is the potassium current density under these conditions? (2 points)

C. How much current must the voltage clamp provide to maintain the axon at a steady 0mV? Does the amplifier provide positive or negative charge flow to the wire inside the axon? (6 points)

D. Would the axon be depolaarizing or hyperpolarizing under these circumstances if the output voltage clamp were suddenly shut off? (2 points)

E. How fast in millivolts per millisecond (8 points)