Bi150 Problem Set 1

Due: Tuesday, October 13th 2009 at 4:30 P.M.
At the "Bi 150 Box"
3rd floor of Kerckhoff in front of Room 326

(The building may be locked after 5 P.M.)

INSTRUCTIONS

Please:

1) Turn in your work with this cover page.
2) Use separate sheets of paper for the answer to each question, so that grading can proceed in parallel
3) Write or type your answers neatly.
4) Put your name on each page of your answers.

Name: ____
Section #: ____
Mail Code: ____
TA Name: ____
Date and Time turned in: ________________________________
Number of pages including this one:_________________________
There are 2 questions.
Grade and Comments:
1___________________
2___________________

Total: _______________

Problem 1. Membrane Potentials (1.5 points)

You have learned about ionic components of resting and action potentials in the NaCl-rich oceans of Earth. Recently, images from the Cassini spacecraft provided intriguing evidence that there might be a water ocean underneath the surface ice of Saturn's moon, Enceladus. Suppose that there is indeed life on Enceladus in the form of a marine squid, *Loligo frazier*. Let's postulate that Enceladus's oceans have KCl as the primary salt (as well as a small amount of NaCl). We will then derive the ionic bases of action potentials that might have evolved there.

A. (0.6 points).

a. Which ion's conductance would dominate the *L. frazier* resting membrane potential?

b. Which ion would flux most during the *L. frazier* action potential?

c. Once an action potential is triggered, does the membrane potential become more positive or more negative? Explain.

B. (0.3 points). Given the following cellular ion concentrations and conductances of an Enceladan *L. frazier* squid, calculate the resting membrane potential. Note that Enceladus's ocean temperature is roughly 0° C. (Show your work)

	Extracellular (mM)	Intracellular (mM)	Conductance mS/cm^2
Na^+	5 mM	450 mM	1
K^+	100 mM	10 mM	.1
Cl^-	105 mM	50 mM	.01
Ca^{2+}	2 mM	10^{-5} mM	0
Mg^{2+}	2 mM	0.5 mM	0
Protein Anions	0	High	0

$R = 8.314\ J\ K^{-1}\ mol^{-1}$

$F = 9.65 \times 10^4\ C\ mol^{-1}$

C. (0.6 points). It would be a gross violation of the 1967 Treaty on Planetary Protection (and yes, such a treaty does in fact exist), but suppose a squid from Enceladus were brought to Earth and placed in Santa Monica Bay where the water temperature is 20° C. Assume that Santa Monica Bay has suitable osmolarity and pH.

a. Give the cell's approximate (i.e. no need to calculate) new resting membrane potential.

b. If the membrane is clamped at +50 mV, describe the direction and magnitude of the resultant electrochemical driving force (ECDF) acting on Na^+ ions.

c. How might the Na^+/K^+ ATPase differ between the Enceladan squid and the Earth squid? (one sentence)

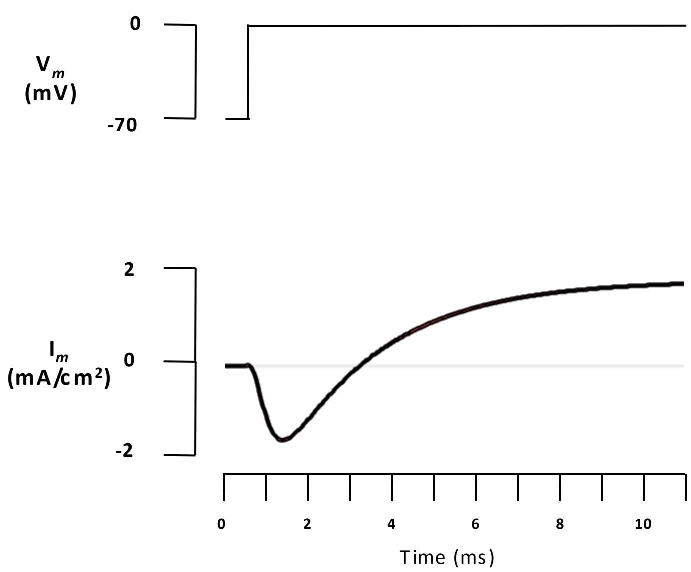
Problem 2: TTX & Single Ion Channels (1.5 point)

A. (0.9 point) Tetrodotoxin (TTX) is a potent neurotoxin found in pufferfish and some salamanders.

a. Describe how TTX acts in the nervous system.
Which channels are affected by the toxin and by what mechanism does it exert an effect on the channel?
How does this affect neuronal activity?

b. When a normal axon of the California olive tree rat (*Rattus pasadensis*) is voltage-clamped in normal extracellular solution, one obtains the following membrane current record in response to a voltage jump from Vm = -70 mV to Vm = 0 mV.

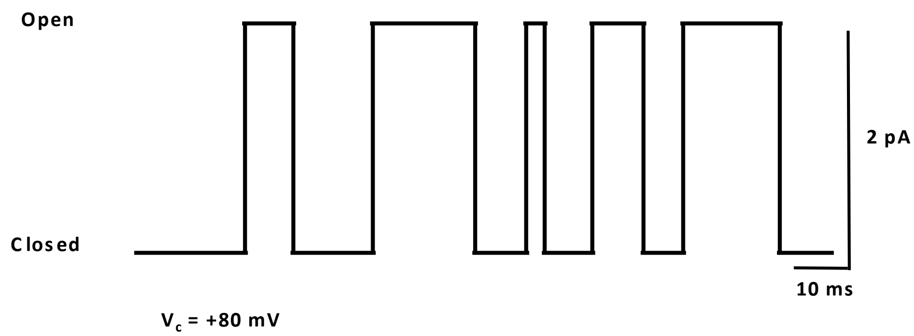
Draw, superimpose and label ("control", "TTX", "wash") plots of I_m vs t when the recordings are made before, during TTX application, and after TTX is washed from the bath surrounding the axon. Assume that the washout is perfect (i. e., the drug completely leaves the protein). Explain in one or two sentences.



c. Describe at least two types of information that can be learned by using tetrodotoxin to understand channels.

B. (0.6 point) Tapenadin is a newly identified component of tapenade (see Chameau, *J. Bi150 Prob. Sets*, in “press”).

The figure below shows the single-channel current of the tapenadin-gated Oily ion channel in a postysnaptic membrane in the CNS of *R. pasadensis*, in the presence of tapenadin. The Oily channel is permeable to K^+ and Na^+ ions. The voltage across the patch of membrane was clamped at +80 mV.



a. Kadambin, a channel blocker that blocks current in the Oily channel in its open state, was added. Draw the traces, with labels “tapenadin” and “tapenadin + kadambin”. For this problem, note that kadambin dissociates in ~0.5 ms. Explain.

b. Techrin, an agonist that binds to the tapenadin binding site and activates the Oily channel, was added. Techrin has the same binding affinity to the Oily channel as tapenadin, but dissociates from its binding site in ~40 ms. Draw and label the traces (“tapenadin”, “techrin”). Explain.