

BIOL 455 – Midterm exam #1 Practice #1 **NAME:**

Important Equations:

Nernst equation (at 20°C):
$$E_{\text{ion}} = \frac{58}{z} \log \frac{[\text{ion}]_{\text{out}}}{[\text{ion}]_{\text{in}}}$$

Goldman equation (at 20°C):
$$V_m = 58 \log \frac{(P_{\text{K}^+}[\text{K}^+]_{\text{out}} + P_{\text{Na}^+}[\text{Na}^+]_{\text{out}} + P_{\text{Cl}^-}[\text{Cl}^-]_{\text{in}})}{(P_{\text{K}^+}[\text{K}^+]_{\text{in}} + P_{\text{Na}^+}[\text{Na}^+]_{\text{in}} + P_{\text{Cl}^-}[\text{Cl}^-]_{\text{out}})}$$

Please make sure you have all 6 pages. There are 9 questions and 25 total points.

Answer all of the following questions. You can write in full sentences or in point form, but whatever you write must consist of coherent thoughts. Calculators are permitted. There should be enough room to answer each question (ie try to be succinct), but if you absolutely need to, you may write on the back of the pages; however, you must make it absolutely clear which question any extra writing is answering.

Questions:

1. You are studying some proprioceptive neurons in centipedes to figure out how they keep track of all those legs. You find that they have somewhat unusual characteristics. You measure the V_m and ion concentrations inside and outside the neurons as follows:

$V_m = -70 \text{ mV}$

ion	[inside]	[outside]
K^+	30 mM	300 mM
Na^+	400 mM	4 mM
Cl^-	10 mM	100 mM

Important: for this question, assume that the neuron is only permeable to these three ions.

a) Draw the neuron equivalent circuit for this neuron at rest (no ion pumps or injected current), making sure to label each component. **(3 points)**

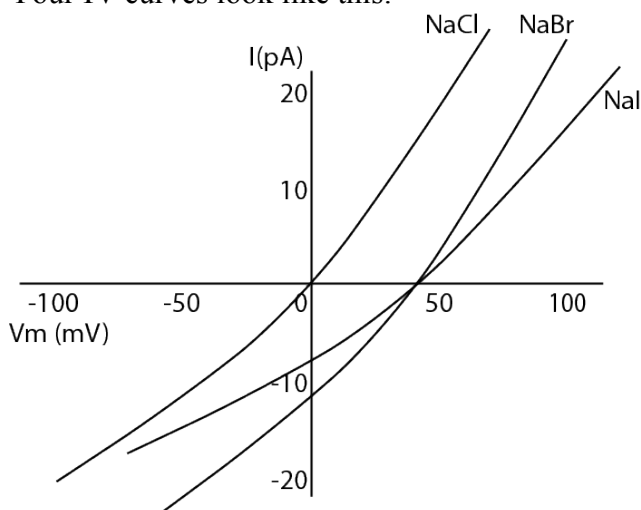
b) You dunk the caterpillar in a drug that completely eliminates Na^+ conductance for your neuron ($g_{\text{Na}} = 0$). With the information you have, what can you say about how the Cl^- current (I_{Cl}) will change after addition of the drug? Explain your answer (**2 points**).

c) At the moment you add the drug in part (b), you would expect any capacitive current? If so, would I_{cap} be positive or negative? (**1 point**)

2. You idolize David Julius, whose lab discovered the capsaicin receptor, VR1. So you set out to characterize the receptor for another very important culinary ligand, called caprisun. You discover the caprisun receptor, which you call CSR1. In order to determine the ion permeability for CSR1, you express it in HEK 293 cells (just like the Julius lab did for VR1), and perform whole-cell patch clamp with 140 mM NaCl in your pipette. You have previously determined that CSR1 is only permeable to anions, so you make IV curves with the following extracellular solutions:

- 1) 140 mM NaCl
- 2) 140 mM NaBr (sodium bromide)
- 3) 140 mM NaI (sodium iodide)

Your IV curves look like this:



a) Using $<$, $>$, or $+$ signs, describe the relative permeability of CSR1 to Cl^- , Br^- and I^- . Briefly explain your answer. (2 marks).

b) Imagine that CSR1 is expressed in a neuron with the following characteristics:

$V_m = -65 \text{ mV}$; threshold = -50 mV

$E_K = -80 \text{ mV}$; $E_{\text{Na}} = +55 \text{ mV}$; $E_{\text{Cl}} = -55 \text{ mV}$; $E_{\text{Br}} = -53 \text{ mV}$; $E_{\text{I}} = -58 \text{ mV}$.

Would binding of caprisun to CSR1 be inhibitory or excitatory? Explain (2 points)

3. You want to test the involvement of octopaminergic (another monoamine neurotransmitter) neurons in fruit fly learning. To do this, you generate the following two types (genotypes) of flies to test:

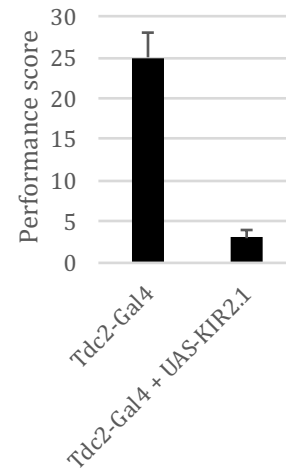
- i) flies carrying only Tdc2-Gal4
- ii) flies carrying Tdc2-Gal4 and UAS-KIR2.1

Tdc2-Gal4 drives Gal4 in octopaminergic neurons.

KIR2.1 is an inward rectifying potassium channel.

a) What do you expect to be the effect of KIR2.1 expression on membrane potential and action potential firing? Explain. (2 points)

b) You then expose each genotype to odour A in the presence of sugar and then to odour B alone (you repeat this 3 times). Then you test them for preference of A versus B in a T-maze. You get the results shown to the right. State the conclusion of your experiment in one sentence, **using the terminology we've discussed in class. (1 point)**



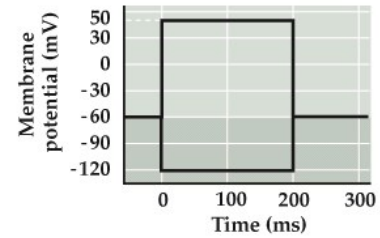
4. What ionic current is largely responsible for the undershoot portion of the action potential? **(1 point)**

5. Ketamine is known to impair memory. Explain why this may be the case. **(2 points)**

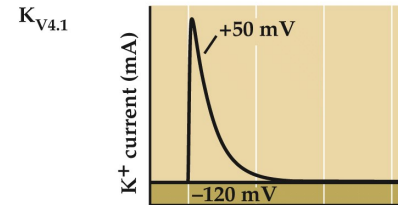
6. One of the main ingredients of “Icy Hot” is menthol. What part of the Icy Hot experience do you think menthol contributes to, and how does it do this? **(2 points)**

7. The image to the right shows the currents from the $K_{v4.1}$ channel during the two illustrated voltage steps.

a) State two gating properties of the $K_{v4.1}$ channel that account for this current shape. **(2 points)**



b) Draw what you would expect **5** single channel recordings of $K_{v4.1}$ might look like during the + 50 mV voltage step. Assume the conditions are the same as the experiment illustrated, and try to make your 5 representative of the whole population. **(1 point)**



8. In class, we discussed that serotonin has been implicated in regulating mood.

a) What fact, presented in class, could be taken as evidence that serotonin is sufficient to increase mood? **(1 point)**

b) In 1-2 sentences, propose one “right time and place” type of experiment that would connect serotonin with mood regulation. *note: your experiment does not have to demonstrate both time and place. One of those would be fine. **(1 point)**

9. In class we discussed a paper identifying the capsaicin receptor.

a) Which of the three major research aims we discussed (necessity, sufficiency, right time and place) was *not* demonstrated in the paper. **(1 point)**

b) **Briefly** describe a subsequent follow-up experiment/result from the same group that satisfies the missing aim from above. **(1 point)**.