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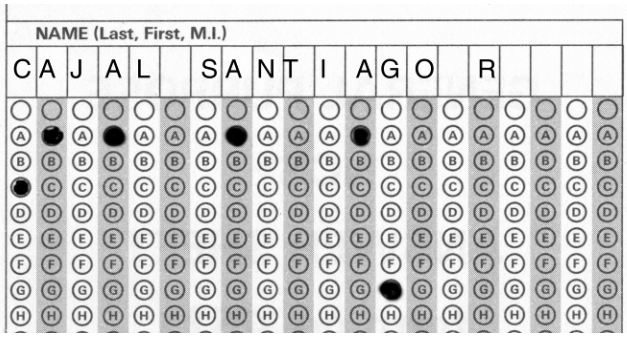
Exam 1

BioNB 2220: Introduction to Neuroscience

1. Write your name on this exam **AND** on your scantron sheet.

2. Answers to all multiple choice questions should be recorded on the **SCANTRON** in pen/pencil. Short answer questions should be written on this EXAM PAPER IN PEN. The examples to the right show you how to fill in the scantron "bubbles" properly.



3. **Write legibly. If we cannot read your answer, we cannot grade it.** Use ONLY the space provided. Do NOT use calculators or any other electronic device.

4. Check to see that your exam paper is complete. This exam packet has **8** pages.

5. Fill the answer circles completely. If you make a mistake either erase completely **OR put an X over the incorrect bubble**.

"By signing below, I acknowledge that I am abiding by Cornell University's Code of Academic Integrity."

Signature: _____

Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16	SA	MC	TOTAL
6	**6**	**7**	**8**	**10**	**6**	**7**	**7**	**8**	**65**	**35**	**100**

EQUATIONS and TABLES. Some of the questions on this exam may require use of a set of standard equations and concentrations, which are provided here for your convenience.

Nernst Equation (@ 20 °C):

$$V_X = \frac{58}{z} \cdot \log_{10}\left(\frac{[X]_{out}}{[X]_{in}}\right)$$

Goldman-Hodgkin-Katz equation (@ 20 °C):

$$V = 58 \cdot \log_{10}\left(\frac{p_K[K]_{out} + p_{Na} \cdot [Na]_{out} + p_{Cl} \cdot [Cl]_{in}}{p_K[K]_{in} + p_{Na} \cdot [Na]_{in} + p_{Cl} \cdot [Cl]_{out}}\right)$$

Length/space constant of neuron:

$$\lambda = \sqrt{\frac{r_m}{r_a}}$$

Time constant of a cell:

$$\tau = r_m \cdot c_m$$

Ohm's Law

$$V = I \cdot R$$

Reminder:
$\text{Log}_{10}(0.1)=-1$; $\log_{10}1=0$;
$\log_{10}10=1$

e = 2.718…
1/e ≈ 0.37

Ion concentrations inside and outside a typical neuron:

$[K^+]$	125 mM in	5 mM out
$[Na^+]$	12	120
$[Cl^-]$	5	125
[Anions]	108	0

MULTIPLE CHOICE (5 pts. each)

1. You are recording from an alien cell that contains three ions; Q and W are positively charged and Z is negatively charged; the ion concentrations inside and outside the cell are shown below.

	Intracellular concentration (mM)	Extracellular concentration (mM)
Q+	10	100
W+	100	10
Z-	10	100

Which of the following combinations of permeabilities could explain a resting membrane potential of -50 mV?

a) The membrane is permeable only to Z at rest
b) The membrane is permeable to both W and Z at rest, but not to Q
c) The membrane is permeable only to Q at rest
d) The membrane is highly permeable to Z and slightly permeable to Q
e) The membrane is highly permeable to Q and slightly permeable to W

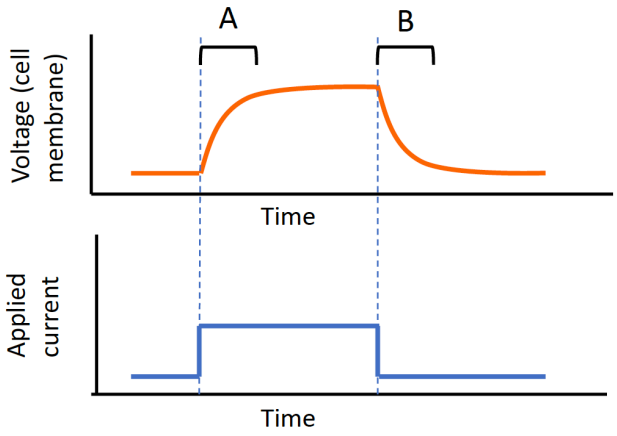
$Q^+ \left\{ \frac{58}{1} \log_{10}\left[\frac{100}{10}\right] = +58 \right.$

$W^+ \left\{ 58 \log_{10}\left(\frac{1}{10}\right) = -58 \right.$

$Z^- \left\{ -58 \log_{10}\left[\frac{100}{10}\right] = -58 \right.$

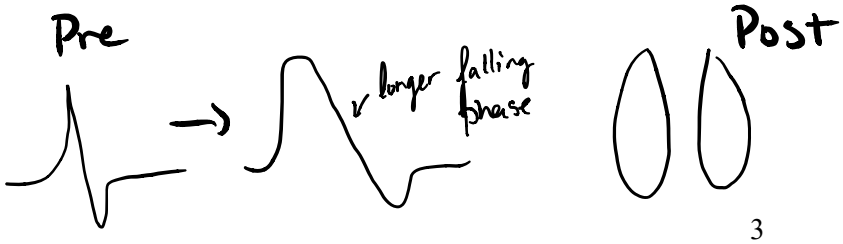
2. In the figure below, what is occurring in region A and B?

a) Increasing and decreasing the membrane capacitance
b) Charging the lipid bilayer and increasing membrane resistance.
c) Charging the lipid bilayer and discharging the lipid bilayer.
d) Discharging the lipid bilayer and decreasing membrane resistance.



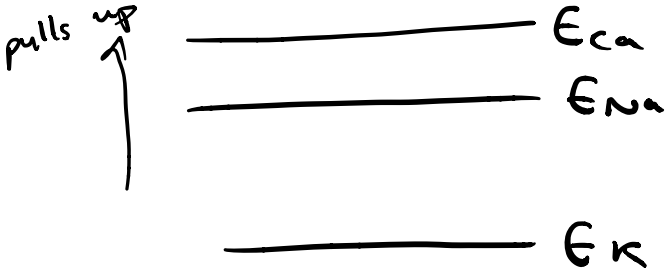
3. A simple form of learning in the marine invertebrate *Aplysia* results from a decrease in voltage-gated potassium channel current at a pre-synaptic nerve terminal. What effect will this have on the amplitude of the spike-evoked EPSP?

a) It will become larger.
b) It will become smaller.
c) It will not change.
d) It will become "pixelated" so you can see the contribution of each m-EPSP on top of the previous one.



4. A neuronal variant of the nicotinic acetylcholine receptor is roughly equally permeant to sodium, potassium **and calcium**. E^{Na} = +50 mV; E^{k} = -80 mV; E^{Ca} = +150 mV. How does the V_{Rev} of this variant compare to the muscle AChR we discussed in class?

a) It is more depolarized.
b) It is more hyperpolarized.
c) It is not changed.
d) It is -10 mV.
e) Unable to tell from this information.



5. You are studying two synaptic inputs to a neuron. You stimulate each of the synapses separately, and then simultaneously, and record the post-synaptic voltage response as shown below. How is this possible?

Stimulate synapse 1 Stimulate synapse 2 Stimulate synapses 1 and 2

a) Synapse 2 is an electrical synapse.
b) Synapse 2 releases an excitatory transmitter onto the pre-synaptic terminal of synapse 1.
c) Synapse 1 and 2 are located far apart on the dendritic arborization of the post-synaptic neuron.
d) Synapse 2 activates a conductance decrease of leak K^+ channels.
e) Synapse 2's V_{Rev} is at the resting potential of the post-synaptic neuron.

6. Norepinephrine (NE) acts via cAMP to strengthen heartbeat. You give an animal a drug that blocks the phosphodiesterase in heart muscle. What effect will this have on NE's actions on the heart?

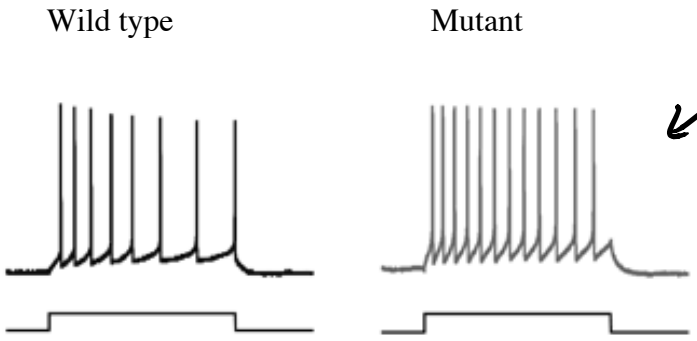
breaks down cAMP

a) It will reduce the NE effect.
b) It will not change the NE effect
c) It will enhance the NE effect
d) It will prolong the duration of the NE effect
e) C and D.

So cAMP levels ↑ and NE working through cAMP has increased impact

7. You are studying a cell that displays the wild type firing properties in response to a 30-second depolarizing current injection. When you record from the same cell type in a

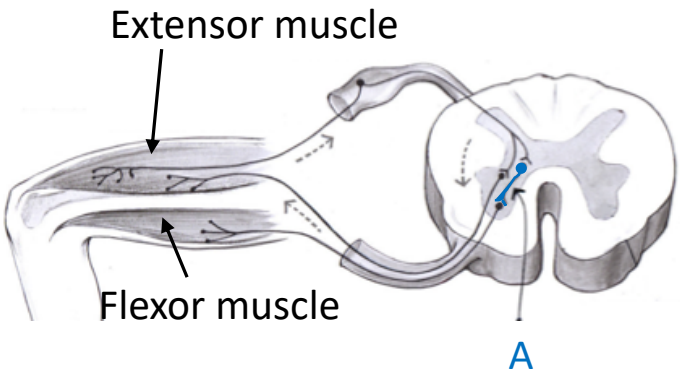
mutant animal, you see the second firing pattern. You theorize that the mutation causes the **loss of function** in an ion channel. What type of current, when lost, could cause this change in firing properties?



a) A fast-inactivating depolarizing current.
~~b)~~ A slow-inactivating hyperpolarizing current.
~~c)~~ A slow-activating depolarizing current.
d) A slow-activating hyperpolarizing current. ← lose this ⇒ fast-activating hyperpolarizing current
~~e)~~ A combination of slow-activating depolarizing and hyperpolarizing currents.

Short Answer

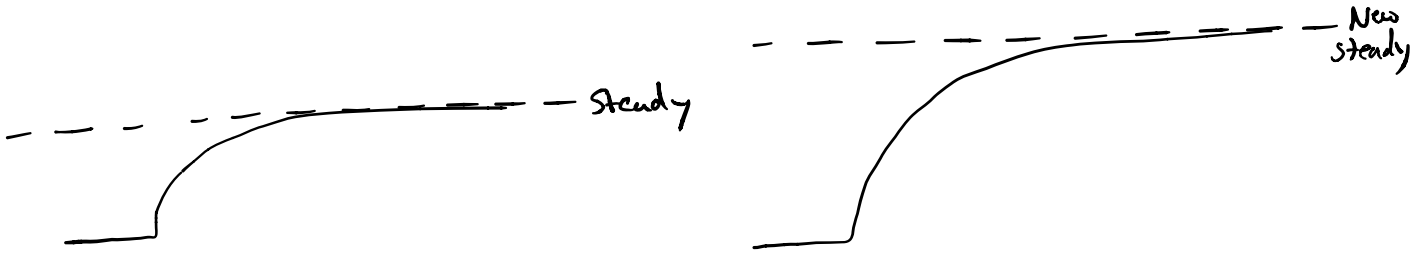
8. (6 points). In the knee jerk reflex arc shown to the right, describe what type of neuron A is and why is it crucial for a successful jerk reaction (1-2 sentences).



Neuron A is a motor neuron.
It conducts an action potential to synapses on extensor muscle fibers, causing contradiction.

9. (6 points). Using a current clamp, you inject a square pulse of current into a neuron and note that it takes 10 milliseconds for the voltage across the membrane to reach a new steady state. If you use the same procedure with a cell that has twice the surface area but

is otherwise identical, it will take more time to arrive at the same steady state voltage. Why? (Provide a logical explanation in 2-3 sentences, no calculations necessary.)



A larger cell ⇒ larger capacitance or resitance ⇒ ↑ τ

10. (7 points). Imagine a disease where myelin grows over too much of the axons' surface and covers some Nodes of Ranvier. People who suffer from the disease experience symptoms including numbness and difficulty walking. How do you think excessive myelin could cause these symptoms? (1-2 sentences)

11. (8 points). Identify and explain two mechanisms that ion channels can use to make themselves selective for only certain ions (2-3 sentences):

12. (10 points). A calcium pump in mitochondrial membranes normally removes calcium from the cytoplasm after an action potential. You mutate this pump in a presynaptic cell so that it acts twice as slowly as normal. What are the consequences of this mutation for the following (explain your answers in 1-2 sentences each):

A) The peak amplitude of an EPSP:

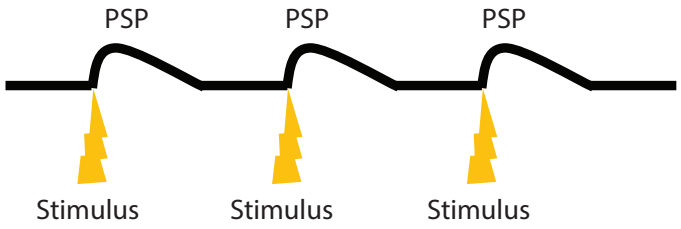
Same amount of Ca^{2+} present so similar peak EPSP amplitude

B) The duration of an EPSP:

Since Ca^{2+} is being removed more slowly the duration is increased

C) Facilitation during short train of pre-synaptic action potentials:

13. (6 points). You are recording from a post-synaptic neuron while stimulating a pre-synaptic neuron. Each time you stimulate the presynaptic neuron, you see the post synaptic potential (PSP) shown below. Using only this information, is this synapse excitatory or inhibitory? If so, which is it, and how can you tell? If not, what additional information would you need (1-2 sentences)?

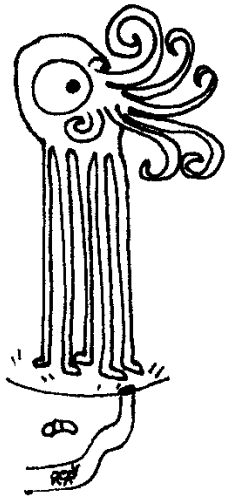


Can't tell! Need V_{rev} and action potential firing threshold for post-synaptic neuron

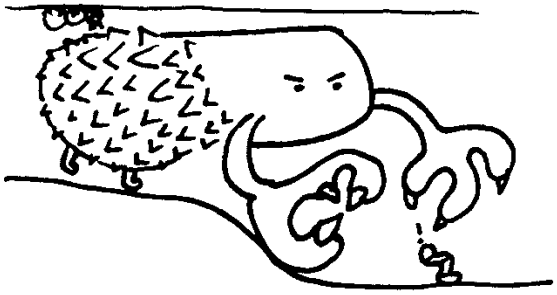
14. (7 points). Dopamine acts by a conductance decrease mechanism to close half of the resting leak sodium channels in a neuron. What will happen to the resting potential when this occurs? Explain your answer in 2-3 sentences.

15. (7 points). You discover a mutant that has twice as many NMDA receptors on its post-synaptic membranes. What effect will this have on the ability of synapses to show LTD or LTP as the stimulation frequency is changed (2-3 sentences)?

16. (8 points)



A



B

The above animals A and B are two key predators recently discovered by scientists. Species A uses its many feet to shuffle along the ground and gather vibrational information on its prey. Species B enters tunnels used by its prey and uses its many fleshy spikes to gather tactile information on prey it crawls over. Species A is nocturnal and has large eyes that allows it to see in the dark. Species B is essentially blind and relies on touch. Species A uses its face tentacles to dig into the earth and capture prey it locates. Species B uses its large hands to grab prey.

How would the above two animals be similar or different in the relative proportion of body regions represented in the somatosensory cortex? (1-2 sentences)

How would they be similar or different in the relative proportion of body regions represented in the motor cortex? (1-2 sentences)