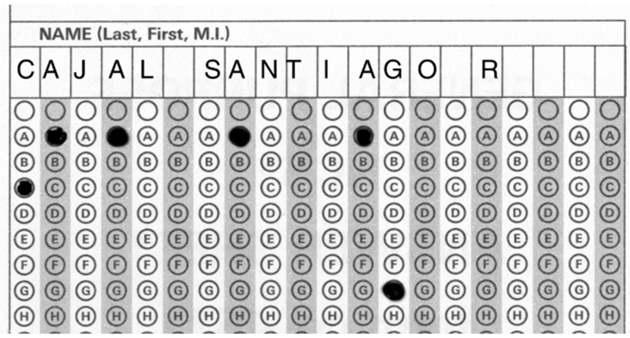
Last name:____________________ First:______________ MI:___ Cornell ID number:____________

Exam 1 - KEY

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 **9** 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: ____

Q10	Q11	Q12	Q13	Q14	Q15	Q16	**SA**	**MC**	**TOTAL**
7	**7**	**8**	**8**	**8**	**7**	**10**	**55**	**45**	**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.

<table>
<tr><td>Nernst Equation (@ 20 °C):
$$V_X = \frac{58}{z} \cdot \log_{10}\left(\frac{[X]_{out}}{[X]_{in}}\right)$$</td><td>Goldman-Hodgkin-Katz equation (@ 20 °C):
$$V = 58 \cdot \log_{10}\left(\frac{p_K[K]_{out} + p_{Na} \cdot [Na]_{out} + p_{Cl} \cdot [Cl]_{in}}{p_K[K]_{in} + p_{Na} \cdot [Na]_{in} + p_{Cl} \cdot [Cl]_{out}}\right)$$</td></tr>
<tr><td>Length/space constant of neuron:
$$\lambda = \sqrt{\frac{r_m}{r_a}}$$</td><td>Time constant of a cell:
$$\tau = r_m \cdot c_m$$</td></tr>
<tr><td>Ohm's Law
$$V = I \cdot R$$
Reminder:
$Log_{10}(0.1)=-1$; $\log_{10}1=0$;
$\log_{10}10=1$</td><td>Ion concentrations inside and outside a typical neuron:
$[K^+]$ 125 mM in 5 mM out
$[Na^+]$ 12 120
$[Cl^-]$ 5 125
[Anions] 108 0</td></tr>
<tr><td>e = 2.718…
1/e ≈ 0.37</td><td></td></tr>
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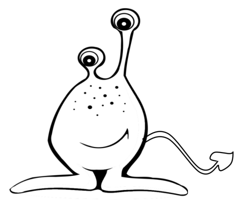
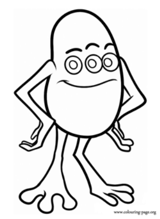
MULTIPLE CHOICE (5 points each)

1. Your colleague in animal behavior has discovered two new species and needs you to map the brains of both.

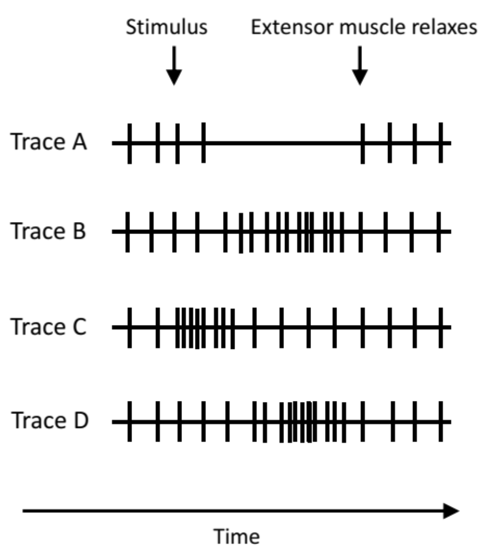
A 

B 

Which body part is **most likely** to be **underrepresented** in the sensory homunculus of species A relative to species B?

a) Feet
b) Arms
c) Lips
d) Tail

2. The neurophysiological traces below show relative frequency of action potentials recorded during a knee jerk reflex motor movement in a human. The exact times of the sensory stimulus delivery and the onset of the extensor muscle relaxation are marked by arrows. Which trace most likely shows the firing of the **sensory neuron**?



a) Trace A.
b) Trace B.
c) Trace C.
d) Trace D.

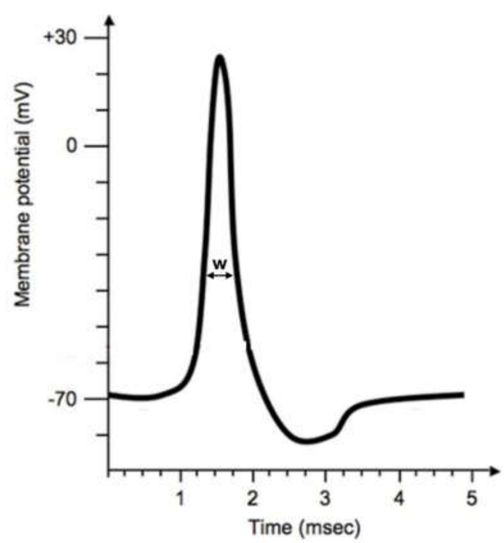
3.

	Inside (mM)	Outside (mM)
Potassium (K valence+1)	100	10
Chloride (Cl valence -1)	10	100
Sodium (Na valence +1)	100	10
Impermeant anions (valence -1)	190	0
Impermeant cations (valence +1)	0	80

Given the above ion distributions of a HYPOTHETICAL NEURON, if the neuron was initially permeable to potassium and suddenly also became very permeable to chloride and sodium, the membrane potential would…

a) Not change
b) Depolarize
c) Hyperpolarize
d) Generate an action potential

4.



Which of the following changes in the neuron producing the action potential above would lead to an **increase** in the width of the action potential (w) (shown by the length of double arrowhead line)?

a) Fewer positive charges on the h (inactivation) gates of the voltage sensitive sodium channels.
b) A decrease in the total number of voltage sensitive potassium channels (fewer open for a given depolarization).
c) The voltage sensitive potassium channels open more rapidly in response to a depolarization.
d) a and b.
e) a, b and c.

5. An individual suffering from a disorder with thinner myelin sheaths comes to you for help. Suppose I gave you a choice of drugs to try to help the individual. Which of these might help, given what you know about myelinated axon function?

a) A drug that increases the voltage sensitivity of the voltage gated sodium channel
b) A drug that blocks a portion of voltage gated sodium channels
c) A drug that blocks a portion of voltage gated potassium channels
d) a and c
e) None of the above.

6. You are examining two neurons connected by a strong excitatory chemical synapse and you would like to record EPSPs (excitatory post-synaptic potentials). The neurons are bathed in an ion solution to keep them healthy during your experiment. Strangely, you are detecting action potentials in the first cell, but no change in the membrane potential of the second cell. Which of the following could cause this?

a) The resting potential of the post-synaptic cell is -80 mV.
b) The extracellular ion solution is deficient in Ca^{2+}
c) The extracellular ion solution is deficient in Na^{+}
d) The resting potential of the post-synaptic cell is at the equilibrium potential for Cl-

7. We know that in prefrontal cortex, there are two types of inhibitory neurons, A and B. They both form synapses onto excitatory neurons. B forms synapses mainly on the dendrites of excitatory neurons and A forms synapses on the soma of excitatory neurons. If both types release the **same** amount of transmitter which opens the **same** number and type of ion channel, which type of inhibitory neuron has a stronger effect on the AP firing frequency of excitatory neurons?

a) A
b) B
c) A and B have the same effect.
d) Excitatory neurons cannot fire APs at all if they receive inhibitory synapses.

8. You apply the neuromodulator dopamine (DA) to a cell and discover that it **increases** the cell's excitability. What is the most probable mechanism for the observed DA action?

a) DA binds to and decreases the permeability of a sodium channel.
b) DA binds to and increases the permeability of a chloride channel.
c) DA binds to intracellular receptors to release intracellular calcium.
d) DA acts via second messenger systems to open a chloride channel.
e) DA acts via second messenger systems to block a leak potassium channel.

9. Which structural feature provided the first definitive evidence that the nervous system is composed of discrete units?

a) Synapse
b) Axon
c) Golgi Body
d) Glial cells

SHORT ANSWER

10. (7 points). You are observing two neurons in the same extracellular solution and both are only permeable to K+. One fairly normal cell "Fetcho" has a membrane potential of -50 mV and one unusual cell "Bass" has a membrane potential of +30 mV. Which cell has a higher internal concentration of K+? **Explain** your answer (2-3 sentences).

If Fetcho has a membrane potential of -50mV, then K+ must be moving out of the cell to hyperpolarize it to -50mV. Cell Bass must have K+ moving into the cell to make the membrane potential positive. Since the outside concentration is the same for both, and ions move down a diffusion gradient, Fetcho must have more K+ than Bass.

11. (7 points). If we keep the number of open ion channels in the membrane constant but make the total membrane area of the cell larger, would the time constant get smaller, larger, or not change? **Explain** your answer.

Circle one: SMALLER LARGER NO CHANGE

Why (1 sentence):

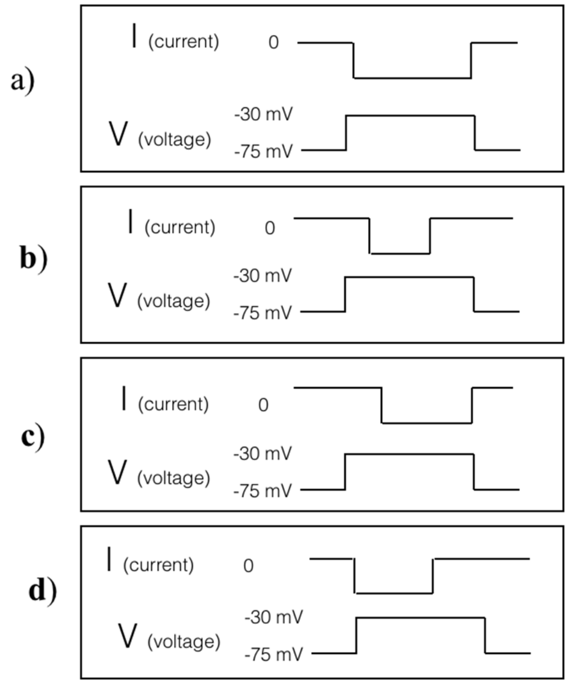
Capacitance will increase (capacitance $\propto$ total membrane area), therefore the time constant will increase (time constant $\propto$ capacitance).

12. (8 points). You are testing whether the addition of GABA would inhibit spontaneous muscle contractions in an invertebrate. The results are not what you expect – instead of inhibiting the spontaneous activity, GABA appears to be exciting the muscles even further. What concept might explain this change? **Explain** in 1-2 sentences.

Inhibitory/Excitatory effects of a neurotransmitter are determined by receptor type, not the transmitter itself. The invertebrate model might have different receptors (insects have both excitatory and inhibitory GABA receptors).

13. (8 points). The panels a-d below show patch clamp recordings from four different patches taken from **typical** neurons with **typical** concentrations of Na and K ions on the two sides of the

membrane. Each patch has only a single channel in it. The bottom trace in each pair shows the voltage change you apply to each patch (a jump from resting potential at -75 mV to -30 mV), and the upper trace shows the single channel current recorded in response to the step. Circle, on the right, the ion (Na **or** K) that is **most likely** permeable through each channel in a to d.



Circle Na or K to indicate single channel type.

a) Na or K

b) Na or K

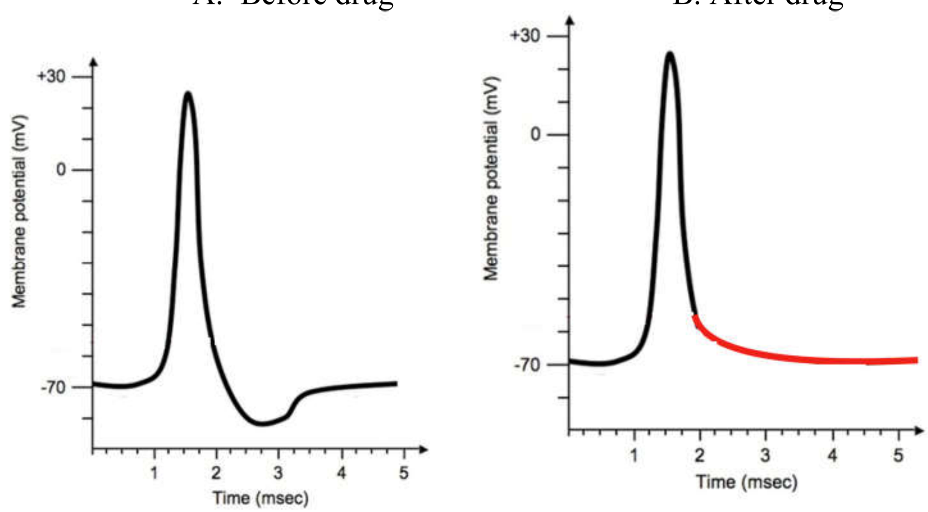
c) Na or K

d) Na or K

All are Na – current is inward. Differences in a-d are due to each channel opening probabilistically when voltage changes.

14. (8 points).

A. Before drug B. After drug



The pictures above show an action potential before (A) and after (B) application of a drug. The only part that differs in the two is colored red. WHAT did the drug do and WHY would it have this effect? **Explain** in 2-3 sentences.

Drug blocks or closes voltage-dependent K+ channels, which leads to less K+ efflux and blocks after hyperpolarization.

15. (7 points). Why are unmyelinated neuronal axons in invertebrates that need to conduct APs fast typically large in diameter? **Explain** your answer (1-2 sentences)

Neurons can conduct faster with myelination. Without myelination, neurons need to have a large diameter to reduce the internal resistance of AP current spread in order to conduct action potentials with a higher speed.

16. (10 points).

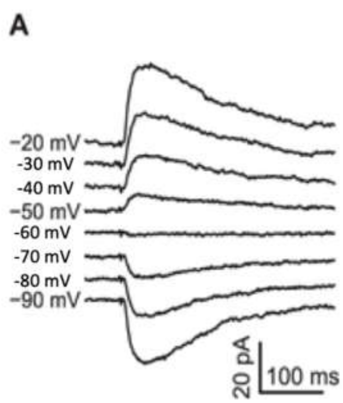


Figure A is the result of a **voltage clamp** experiment where the synaptic current was measured in a post-synaptic cell at different membrane voltages.

a) What is the reversal potential of the channels you are measuring? (~ -60mV)

b) Given the **typical** ion concentrations, if these channels are only permeable to one type of ion, what is the most likely ion that these channels are permeable to? **Explain** your answer (1 sentence)

(Cl- or K+ because the ion's Erev is near the Erev of the channel.)

c) The resting potential of this neuron is -70 mV, and the threshold for spike generation is -45 mV. Is this synapse excitatory or inhibitory? **Explain** your answer (1 sentence).

Inhibitory, because its reversal potential is more hyperpolarized than the threshold of action potential.

End of Exam 1