

# ECE C143A Homework 6

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April 13, 2022

## Problem 1

(a)

False, the number of neurons in a brain is around  $100 \times 10^9$  not  $10^{12}$ .

(b)

False, the frontal lobe is in the front of the brain and the occipital lobe is in the back.

(c)

True

**(d)**

False, "Each hemisphere is concerned primarily with sensory and motor processing of the contralateral (opposite) side of the body."

**(e)**

True

**(f)**

False, astrocytes form the blood brain barrier not the myelin sheets, the myelin sheets are created by Oligodendrocytes.

**(g)**

True

**(h)**

False, neurons transmit information at the synapse chemically.

**(i)**

False, Action potentials are all or nothing therefore the amplitude does not matter

**(j)**

False they are more 10x more concentrated on the extracellular side.

**(k)**

False, neurons fire at around 200Hz

**(l)**

False, it is an increase

**(m)**

True

**(n)**

True

**(o)**

False it will increase action potential speed.

**(p)**

True

**(q)**

True

**(r)**

True

**(s)**

True

**(t)**

False, Anionic proteins residing in the cytoplasm are not as permeable to the membrane as sodium and potassium ions.

## **Problem 2**

**(a)**

$$E_K = \frac{58mV}{1} \log \frac{42}{336} = -52.379mV$$

$$E_{NA} = \frac{58mV}{1} \log \frac{300}{50} = 45.132mV$$

(b)

I would tell her to remeasure her results, because from Goldman's equation we would have that

$$V_m = \frac{RT}{F} \log \left( \frac{P_K[K^+]_o + P_{NA}[NA^+]_o + P_{CL}[CL^+]_o}{P_K[K^+]_i + P_{NA}[NA^+]_i + P_{CL}[CL^+]_i} \right)$$

Since the membrane is only permeable to Sodium and Potassium we have

$$V_m = 58mV \log \left( \frac{[K^+]_o + \alpha[NA^+]_o}{[K^+]_i + \alpha[NA^+]_i} \right)$$

Where  $\alpha = \frac{P_{NA}}{P_K}$ . Thus  $V_m$  has a minimum at  $E_K = -52.379mV$  when  $\alpha = 0$  and a maximum  $E_{NA} = 45.132mV$  when  $\alpha = \infty$ . Therefore there is no way for  $V_m = 110mV$

(c)

A higher value because that would result in a greater  $E_{NA}$  and thus a greater maximum for  $V_m$ .

### Problem 3

(a)

$$g_K = \frac{I_K}{(V_m - E_k)} = \frac{1pA}{45mV} = 22.222pS$$

$$g_{NA} = \frac{I_{NA}}{(V_m - E_{NA})} = \frac{1pA}{50mV} = 20pS$$

**(b)**

$$g_{IN} = g_K + g_{NA}$$

$$R_{IN} = \frac{1}{g_{IN}} = 23.684G\Omega$$

**(c)**

$$C = \epsilon_0 \frac{A}{d} = \epsilon_0 \frac{4(10\mu m)^2 \pi}{100pm} = 111.265pF$$

**(d)**

The time constant for this Alien neuron is

$$\tau = R_{IN}C = 2.635s$$

So this Alien lower will fire much more slowly than a human neuron

## Problem 4

**(a)**

No they don't need to be equal and opposite, outside forces, such as the electrical fields caused by the flow of other ions.

(b)

Through NA+-K+ pump.

## Problem 5

(a)

we have

$$r_a = \frac{\rho}{\pi r^2}$$

$$c_m \propto \frac{r}{d}$$

and that the action potential speed  $\propto \frac{1}{r_a c_m}$

For species A we have

$$r_a = \frac{\rho}{\pi r^2} = \frac{\rho}{\pi (490 \mu m)^2}$$

$$c_m \propto \frac{490 \mu m}{10 \mu m}$$

Therefore the action potential speed for species A  $\propto 4900 \mu m^2$

For species B we have

$$r_a = \frac{\rho}{\pi r^2} = \frac{\rho}{\pi (250 \mu m)^2}$$

$$c_m \propto \frac{250 \mu m}{250 \mu m}$$

Therefore the action potential speed for species B  $\propto (250 \mu m)^2$

Therefore species B would transmit faster.

**(b)**

Yes, since the neurons take up the same space, but they transmit faster, since the contribution from the area in  $r_m$  and  $c_m$  will cancel out.

**(c)**

Nodes of Ranvier, are bare patches in a myelinated axon that are densely populated with voltage-gated Na<sup>+</sup> channels. These help boost the amplitude of an action potential so it doesn't die out.