ECE C143A Homework 6

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Problem 1

(a)

False, the number of neurons in a brain is around $100\text{x}10^9$ 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 $E_N A$ 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

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

$$c_m = \frac{\epsilon A}{d}$$

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

For species A we have

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

$$c_m = \frac{\epsilon\pi(490\mu m)^2}{10\mu m}$$

Therefore the action potential speed for species A $\propto \frac{490\mu m}{\epsilon\rho}$

For species B we have

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

$$c_m = \frac{\epsilon\pi(250\mu m)^2}{250\mu m}$$

Therefore the action potential speed for species B $\propto \frac{250\mu m}{\epsilon\rho}$

Therefore species B would transmit faster.

(b)

Yes, since the neurons take up the same space, but they 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 that are densely populated with voltage-gated Na+ channels. These help boost the amplitude of a action potential so it doesn't die out.