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Homework #1

C143a

1.)

a) False: There are an order of ~100 billion neurons or ~10^11 neurons
b) False: the frontal lobe is anterior to the occipital lobe
c) True
d) False: Both have sensory and motor processing, however each half of the brain controls the opposite side of the body (for the most part)
e) True
f) False: myelin is produced by oligodendrocytes and Schwann cells
g) True
h) False: At the synapse communication is generally done chemically through neurotransmitters
i) False: Action potential are binary (all or nothing) and thus frequency contains more information
j) False: Sodium is more abundant on the extracellular side
k) False: The refractory period limits the frequency to around 200Hz max
l) False: though the potential can be both positive and negative, depolarization leads to a more positive membrane potential
m) False: depolarization occurs when an action potential is triggers and so only a repolarized cell can fire an action potential.
n) True
o) False: it will increase its speed as it will decrease the overall capacitance
p) True
q) True
r) True
s) True
t) False: they are less permeable in general due to size and polarity

2.)

2A) at Room Temp

$$E_i = \frac{25mV}{z} \ln\left(\frac{X_o}{X_i}\right) \Rightarrow$$

Ion	Internal Conc	External Conc	Equilibrium Potential (mV)
K^+	336mM	42mM	-52 mV
Na^+	50mM	300mM	45

$\boxed{E_k = -52mV}$ $\boxed{E_{NA} = 45mV}$

2B)

$$E_{Na} - E_k = 45 - (-52) = 97\ mV$$

I don't think so....

The maximum possible peak to peak given $E_k = -52mV$ and $E_{Na} = 45mV$ is 97 mV and 110mV is more than the possible limit

c.)

Answer: The Eternal Na+ concentration would be decreased from our original measurement. **Explanation**: The sauce is likely to have high concentration of ions and thus likely would have increased the measured Na+ eternal concentration but kept everything else the same. If we then recalculated the equilibrium potential with a decreased k+ eternal concentration, the equilibrium potential would decrease to a more negative number and thus the peak-to-peak amplitude potential for an action potential would increase and allow for a greater difference between the equilibrium potentials for each ion and thus potential for greater possible peak to peak amplitude explaining my partners measurements.

3)

3)

a) Na^+: $i = 1\,pA$ $V = 45\,mV$ $G = \frac{I}{V} = \frac{1\times10^{-12}}{45\times10^{-3}} = \boxed{22\,pS \Rightarrow Na^+}$

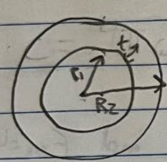
K^+: $i = 1\,pa$ $V = 50\,mV$ $G = \frac{I}{V} = \frac{1\times10^{-12}}{50\,mV} = \boxed{20\,pS = K^+}$

b) $R = \frac{1}{G}$ $R_{Na^+} = \frac{1}{22\,pS} = \underline{45.45\ G\Omega} = Na^+$

$R_{K^+} = \frac{1}{20\,pS} = \underline{50\ G\Omega} = K^+$

$R_{tot} = \frac{1}{\frac{1}{R_{Na}} + \frac{1}{R_K}} = \boxed{24\ G\Omega}$ = membrane resistance

c)



$t = R_2 - R_1 = 100\,pm$

$R_2 = 10\,um$

$R_1 = R_2 - t = \sim$

$$C_{in} = 4\pi\epsilon_0\frac{(r_1\cdot r_2)}{t} = \frac{4\pi\epsilon_0(10\,um^2)}{100\,pm} = \frac{4\pi\cdot 8.85\times10^{-12}\cdot(10\times10^{-6})}{100\times10^{-12}}$$

$$\boxed{C_{in} = 111\,pF}$$

D) $\tau_{alien} = R_{in}C_{in} = (111\times10^{-12})\cdot(24\times10^{9}) = 2.66\,s = \tau_{alien}$

$\tau_{human} < \tau_{alien} \Rightarrow$ $\boxed{\text{Human Neuron will fire more quickly}}$

4).

a) Yes, the definition of equilibrium meansthat there is no net movement of ions into or out of the cell for all ions and means that for each ion there is and equal and opposite balance of drift and diffusion currents occurring. Even though the chemical and electrical force magnitudes will change as you add multiple ions and the resting membrane potential changes, it will still result in equal and opposite forces for each ion.
b) They use active pumping (ATP energy) to bring the concentrations to the levels and work against gradients.

5).

#5)

5a)

SPECIES	Radius	Membrane
A	490 μm	10 μm
B	250 μm	250 μm

$$\tau \approx R_a C_m = \frac{\rho L}{A} \cdot \frac{\varepsilon A}{d} = \frac{\rho L}{\pi r^2} \cdot \frac{\varepsilon}{d} 2\pi r L = \underbrace{2\rho\varepsilon L^2}_{\text{constant}} \cdot \frac{1}{rd}$$

$$\tau \approx k \cdot \frac{1}{rd}$$

$$\tau_a = k \cdot \frac{1}{490\mu m \cdot 10\mu m} = \left((204.1) \times 10^6\right) k$$

$$\tau_b = k \frac{1}{250\mu m \cdot 250\mu m} \approx \left((16.) \times 10^6\right) k$$

$\boxed{\text{Answer: I expect axon B to have a faster action potential}}$

When we calculate the time constant for both and add a constant of $2\rho\varepsilon L^2$ we can see that the time constant for species b is smaller and thus able to propagate faster

5b) $\boxed{\text{No}}$: Losing speed of firing could be very dangerous in situations where fast processing is neccesary. Most Importantly the myelin is necessary to decrease capacitance and insulate the nerves as without it nerve firing could be stopped or slowed such as in MS.

5c). Nodes of Ranvier are spaces between myelin on an axon. The purpose is to insulate the neuron but at the nodes of Ranvier allow for ion gates to recharge electric/chemical signal propagation down the axon