EE 243 HOMEWORK #1.

PROBLEM #1

a. False. The human brain has on the order of 10^{11} neurons.

b. False. The frontal lobe of the brain is anterior to the occipital lobe.

c. True

d. False. The left hemisphere of the brain in general deals with the sensory and motor processing of the right side of the body.

e. True

f. False. A type of glial cell, called astrocytes, form a blood brain barrier. Schwann cells produce myelin to insulate neural axons.

g. True

h. False. At the synapse, neurons transmit information exclusively through chemical transduction.

i. True

j. False. Potassium ions are far more concentrated within the cytoplasmic side of a neuron.

k. False. It is possible for a neuron to fire action potentials at a rate of 1000 Hz.

l. False. A depolarization corresponds to an increase in membrane potential.

m. True

n. True

o. False. Increasing the thickness of myelin sheaths will increase action potential speeds.

p. True

q. True

r. True

s. True

t. False. Anionic proteins residing in the cytoplasm are as non-permeable to the membrane as sodium and potassium ions.

PROBLEM #2

a. $E_K = 58mV \cdot \log \frac{42}{336} = -52.38mV$

$E_{Na} = 58mV \cdot \log \frac{300}{50} = 45.13mV$

b. (ii) → ANSWER.

This is because the maximum peak to peak voltage from E_K to E_{Na} is $45.13 + 52.38 = 97.51mV$ which is no where close to the 110mV that the fellow researcher is claiming.

c. (i) → ANSWER.

This is because the researcher has verified the peak to peak voltage to be 110mV. If E_K stays the same at -52.38mV as there was no sauce in the equipment, the value for E_{Na} has to be higher, such that the peak to peak voltage can be 110mV. The value for E_{Na} would be around 57.62mV for a peak to peak of 110mV meaning that it will be higher than the 45.13mV we measured.

PROBLEM #3

a. $V = IR$; $G = \frac{1}{R}$

$G = \frac{I}{V}$

$G_{Na} = \frac{1pA}{50mV} = 20 p\Omega^{-1}$

$G_K = \frac{1pA}{45mV} = 22.22 p\Omega^{-1}$

b. $V = IR$.

$R = \frac{1}{G}$

$R_{Na} = \frac{1}{20p\Omega^{-1}} = 50 G\Omega$

$R_K = \frac{1}{22.22p\Omega^{-1}} = 45 G\Omega$

$\frac{1}{R_T} = \frac{1}{R_{Na}} + \frac{1}{R_K}$; R_T is R_{in} from now on...

$\frac{1}{R_{in}} = 20 p\Omega^{-1} + 22.22 p\Omega^{-1}$

$\frac{1}{R_{in}} = 42.22 p\Omega^{-1}$

$R_{in} = 23.686 G\Omega$

c. $C = \frac{\varepsilon A}{d}$; $\varepsilon = 8.8542 \times 10^{-12}\ F \cdot m^{-1}$

$A = 4\pi r^2 = 4\pi (10 \mu m)^2$

$d = 100pm$

$$C = \frac{(8.8542 \times 10^{-12})(4\pi (10\mu m)^2)}{100pm} = (8.8542 \times 10^{-12})(4\pi)$$

$= 1.113 \times 10^{-10} F$

$C = 111.3 pF$

d. The alien neuron will fire slowly than a human neuron. This is because $\tau_{alien} > \tau_{human}$ where τ is $R_{in} \cdot C_{in}$.

PROBLEM #4

a. NO. In the multiple species case, the diffusion current and drift current of each ionic species are not equal and opposite to eachother. For the neuron as a whole, the diffusion and drift current are equal and opposite but, for each ionic species this does not have to hold.

b. To maintain their concentration gradients, there are pumps such as the Na-K pumps which push sodium out of the cytoplasm and potassium back into the cytoplasm.

PROBLEM #5

a. A - radius = $490 \mu m$ thickness = $10 \mu m$

B - radius = $250 \mu m$ thickness = $250 \mu m$

Neuron B would have a faster action potential. This is because the action potential is $\propto$ to $\frac{1}{\text{radius}}$ & $\propto$ to $\frac{1}{\text{thickness}}$. In neuron B, $\frac{1}{\text{radius} \cdot \text{thickness}} > \frac{1}{\text{radius} \cdot \text{thickness}}$ of neuron A.

$\frac{1}{(250 \mu m)(250 \mu m)} > \frac{1}{(490 \mu m)(10 \mu m)}$. Hence, B would have faster AP.

b. Yes, myelin sheaths are worth to put into a neuron even when the space is limited. As in part a, the diameter of both species are the same but the AP for the neuron w/ a larger thickness is greater than the AP for a neuron w/ smaller thickness.

c. Nodes of Ranvier - their function is to boost the amplitude of APs and keep them from dying out. They function because they are dense in voltage gated Na^+ channels meaning that as the AP is traversing down the axon from one neuron to the next, the densely voltage gated Na^+ Channels allow for a lot of Na^+ to enter the cytoplasm causing a chain reaction to occur and the AP is boosted from almost dying out.