Name: _____ **Student #: _____**

1. **(9 marks)** Assume you are recording at several different locations along a single axon. A specific stimulation protocol allows you to determine the length constant of this axon while performing various experimental manipulations. Determine whether each of the following statements is TRUE or FALSE. **Please circle the correct answer.**

(a) TRUE or FALSE | Increasing the number of "leak" (or background) potassium channels in the axon membrane will decrease the length constant.

(b) TRUE or FALSE | Decreasing the resistance of the intracellular fluid will decrease the length constant.

(c) TRUE or FALSE | Applying a drug that degrades myelin will increase the length constant.

2. **(9 marks)** Consider (yet again!) the case of the flashing crustacean that we discussed in class. Recall that the membrane potential changes from -30mV at rest to -50mV during the flash. Now, you wish to understand the synaptic basis of these changes. Determine whether each of the following statements is TRUE or FALSE. **Please circle the correct answer.**

(a) TRUE or FALSE | If the Cl^- equilibrium potential (E_{Cl}) was normally -30mV, then the membrane potential changes could be due to ionotropic receptors permeable to Cl^- ions.

(b) TRUE or FALSE | If an electrical synapse mediated the membrane potential changes, then blocking action potentials in the presynaptic neuron would eliminate these changes.

(c) TRUE or FALSE | If the membrane potential changes were mediated by an ionotropic receptor permeable to both Na^+ and K^+ ions, you could set the membrane potential to some value between E_K and E_{Na} for which the membrane potential changes would be eliminated.

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3. **(a) (6 marks)** In one sentence, define "synaptic plasticity".

PSP amplitude/size is variable/dynamic and depends on stimulus history i.e. pattern or frequency of presynaptic inputs/APs

(b) (6 marks) Briefly explain one mechanism that can underlie synaptic plasticity.

A number of possibilities, for example:

- *Residual Ca+2 hypothesis – build-up/accumulation of Ca+2, increased transmitter release, then increased PSP amplitude*
- *Depression – depletion of neurotransmitter, decrease transmitter release, then decreased PSP amplitude*
- *Postsynaptic receptor desensitization, but must link this to decreases in PSP amplitude (i.e. requires discussion of receptor to conductance change)*

4. **(14 marks)** Choose one type of sensory signal (sound, light, chemical, etc) and propose a complete mechanism that would allow a single cell to transduce this stimulus into an action potential. Include in your proposed mechanism a feature that enhances the detection of very weak (small amplitude) stimuli (i.e. some form of cellular amplification).

A number of possibilities, including those provided in class, are acceptable and must:

- *Clearly indicate Stimulus/signal to receptor (i.e. if GPCR then signaling pathway required)*
- *Link to conductance change and how AP threshold is reached i.e. must be depolarization*
- *Amplification mechanism that makes sense (e.g. as in olfactory or hair cell examples)*

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5. **(16 marks)** You have recently discovered an ultra-fast escape response in a newly-identified species of cricket. Your initial anatomical studies find that the neural pathway mediating this behaviour involves only two neurons: one (presynaptic neuron) forms a synapse onto the other (postsynaptic neuron). These studies also show there is no myelin (or myelin-like) sheath on either of the neurons.

(a) Propose two possible mechanisms that could allow this two-neuron pathway to transmit information with such high speed.

For example:

- *Increase conduction velocity (or length constant) due to increased diameter, decreased leak conductance (increased R_m), or increased V-gated Na+ channels, etc*
- *Shorter path length (I.e. lengths of axons in pathway)*
- *Fast synapse – electrical, or "specialized" chemical (but must explain what is special about the chemical synapse that makes it fast)*

(b) Describe an experimental test for ONE of these hypotheses; include a description of the predicted outcome of your manipulation.

Must include:

- *specific manipulation related to property/mechanism proposed above*
- *predicted effect of manipulation on speed*

For example, if mechanism is related to leak conductance, then must manipulate leak (increase or decrease) and predict that speed decreases or increases, respectively.