Practice Problems for Basic Form and Function of Neurons:

1. General epilepsy with febrile seizures can be caused by a mutation in a gene for a voltage-gated Na^+ channel. The seizures caused by this condition are characterized by involuntary movement or convulsions caused by excessive neuronal activity.
a) One possible effect of a mutation to a gene for a voltage-gated Na^+ channel could be a voltage-gated Na^+ channel with a lower voltage threshold than normal. How would this mutation affect the excitability of this neuron? Explain.

b) This condition can be treated with retigabine, an anticonvulsant drug that decreases the threshold potential required to open voltage-gated K^+ channels in neurons. Voltage-gated K^+ channels treated with retigabine will open at resting membrane potential. Clearly explain how opening voltage-gated K^+ channels could prevent excessive neuronal activity.

2. Consider a "typical" motor neuron with a resting membrane potential of -70mV and a threshold potential of -55mV. This neuron receives two signals, X and Y, at the same time. Signal X arrives at the far end of a dendrite, and causes ten neurotransmitter-gated K^+ channels to open. Signal Y arrives at the cell body and causes three neurotransmitter-gated Na^+ channels to open.
a) How will signal X affect the membrane potential at its reception site? Explain.

b) How will signal Y affect the membrane potential at its reception site? Explain.

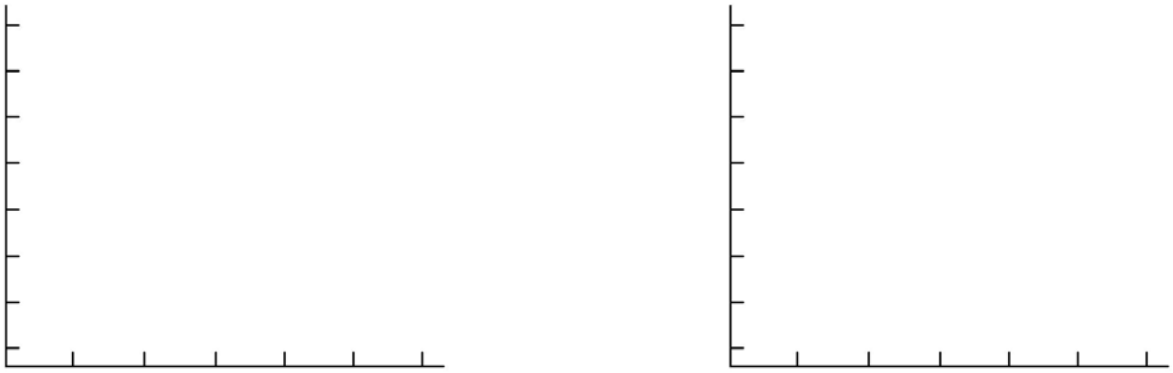
c) Both of these signals arrive at the axon hillock at exactly the same time. Will the neuron fire an action potential? Yes, no, or maybe? Explain your answer.

3. Consider a "typical" motor neuron with a resting membrane potential of -70mV and a threshold potential of -55mV. Five graded potentials arrive at the axon hillock at the same time. Three of these graded potentials depolarize the cell membrane of the axon hillock. These three graded potentials have the following magnitudes: 5mV, 10mV, and 12mV at the axon hillock. The other two graded potentials hyperpolarize the axon hillock cell membrane. These two graded potentials have the following magnitudes: -11mV and -3mV at the axon hillock. Will the neuron fire an action potential? Yes, no, or maybe? Explain your answer.

4. The magnitude of a graded potential decreases the further it travels from its reception site. Explain why graded potentials decay.

5. Several deadly toxins act on voltage-gated ion channels. Consider the effect of the following neurotoxins.
a) Tetrodotoxin is a highly potent neurotoxin that can be isolated from skin and liver of pufferfish (among other animal sources). It blocks voltage-gated Na^+ channels. Ingestion of even relatively small quantities of tetrodotoxin can be lethal. Explain why tetrodotoxin could kill you.

b) Some vanillotoxins, present in the venom of some spiders such as tarantulas, inhibit voltage-gated K^+ channels, preventing them from opening. Using the axes provided below, draw a "typical" action potential from a "typical" neuron (resting membrane potential = -70mV), and beside it, the action potential that you would expect from a neuron affected by this vanillotoxin.



6. One type of ligand-gated Na^+ channel found in many neurons will open when it binds to acetylcholine (ACh). You are doing an experiment on a "typical" vertebrate neuron that has ACh-gated Na^+ channels on its dendrites.
a) For your first treatment, X, you expose a localized site on one dendrite to a low concentration of ACh. Predict what will happen to the membrane potential at this reception site. Explain your prediction.

b) For treatment Y, several hours later, you will expose the same site on the same neuron to a very large concentration of ACh. How will the magnitude of the graded potential triggered by Y compare to the magnitude of the graded potential triggered by X? Will the magnitude be larger, identical, or smaller? Explain your answer.

c) If both X and Y trigger an action potential, how will the magnitude of the action potential triggered by Y compare to the magnitude of the action potential triggered by X? Will the magnitude be larger, identical, or smaller? Explain your answer.