

Important instructions:

1. Even if you can't answer a question completely, write down whatever you know about it. Give as much of an answer as you can. Partial credit is better than no credit!
2. For many of the questions, there is more than one correct answer.
3. A thoughtful explanation is worth partial credit even if the answer isn't exactly correct.

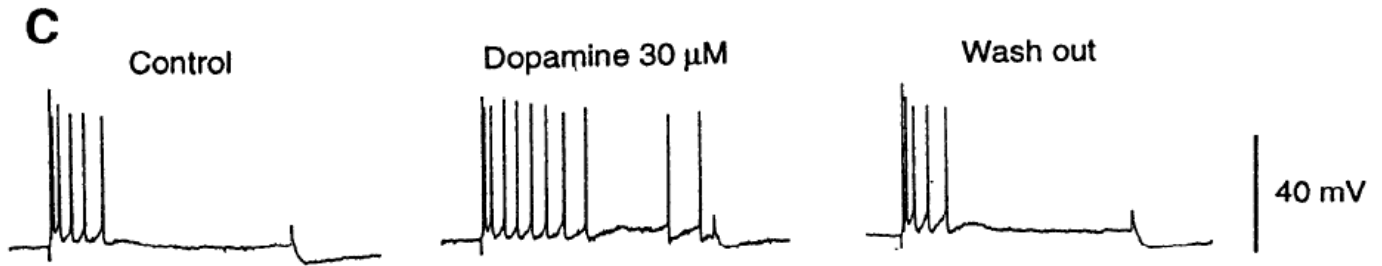
Question 1. (5 points) What combination of passive properties would be best for a neuron to integrate multiple inputs over time? (That is, would lead to better summation of its inputs). Explain why.

Question 2 (5 points). What determines the neuron's membrane potential at any point in time? (There are LOTS of ways that you could answer this correctly – go with as much as you know).

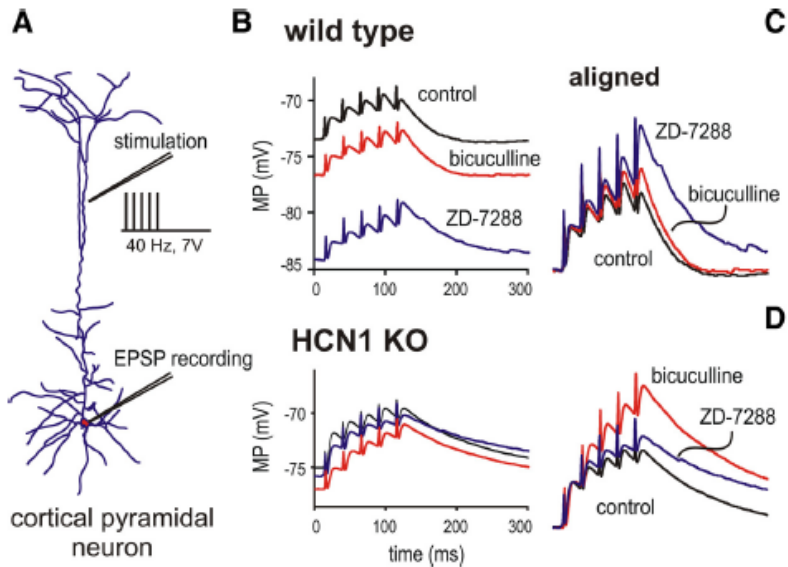
Question 3. (5 points). After you have had a long day at school and then work, your roommate is bragging about how much he/she knows about neurons and action potentials. To show off, he/she explains that the action potential is caused by sodium entering the neuron until and this sodium current reaches its peak when the membrane voltage is at its maximum. After that, the sodium channels close and the sodium current diminishes steadily as the membrane voltage returns to resting potential. Explain why he/she could be totally wrong.

Question 4. (10 points) What general strategies can a neuron use to have a broad dynamic range and high frequency firing? What general strategy allows a neuron to have different functional states depending on changes in resting potential? (Explain each briefly).

Question 5 (10 points) Below is part of a figure from a 2005 publication that examined the effects of dopamine on the firing patterns of neurons from the hippocampus. The researchers delivered 200 millisecond stimulus currents of 3nA to cells and recorded the voltage responses and action potential patterns in normal conditions (Control) then after they exposed the cells to dopamine (center) and then again after they removed dopamine from the experimental preparation for 20 minutes (wash out). What effect(s) does dopamine have on the firing pattern of the cell? How could dopamine be changing the levels or types of ion channels present in the cell to produce these changes?



Question 6. (10 points) Below is a figure from an article in The Journal of Neuroscience. The experimenters recorded from neurons in the cortex of normal mice (wild type) and mice that were missing the gene for a particular type of ion channel (HCN1 KO). The experiment delivered a train of five excitatory postsynaptic currents to the cell and measured membrane potential (MP). From the data shown in Panel B, what do you think bicuculline and ZD-7288 are doing to sodium leak channels in the cells of wild-type mice? From the data shown in Panel D, what do you think were the effects of the drug bicuculline in cells from the HCN1 KO mice? Be sure to explain your answers.



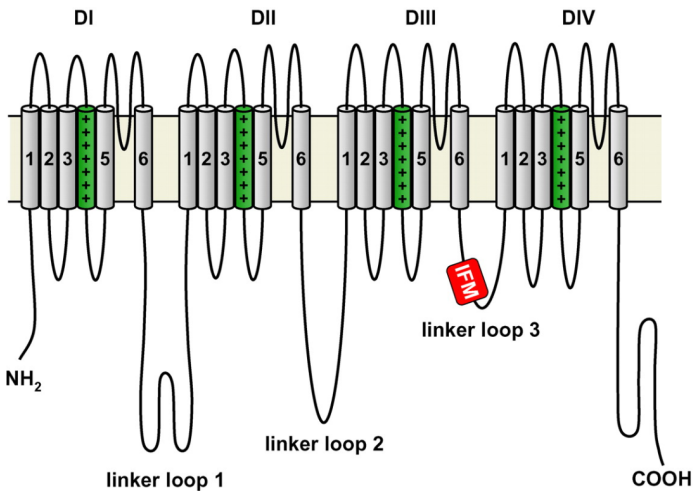
Question 7. (15 points) The three images below show three different representations of a voltage-gated sodium channel. Explain what you know about the structure and function of voltage gated sodium channels using these illustrations. You can write answers as text, draw pictures, label the images, draw arrows or connections between the images, or any way that you can best demonstrate what you know about the structure and function of this ion channel. NOTE: This page is repeated three times so that you have additional space to write, draw, or expand your answers.

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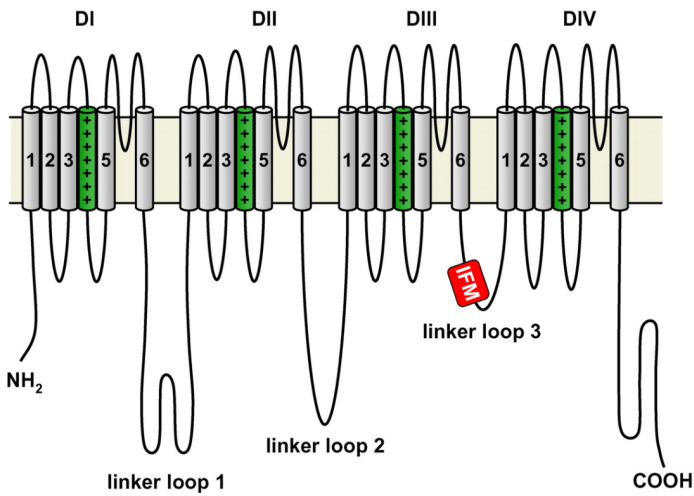


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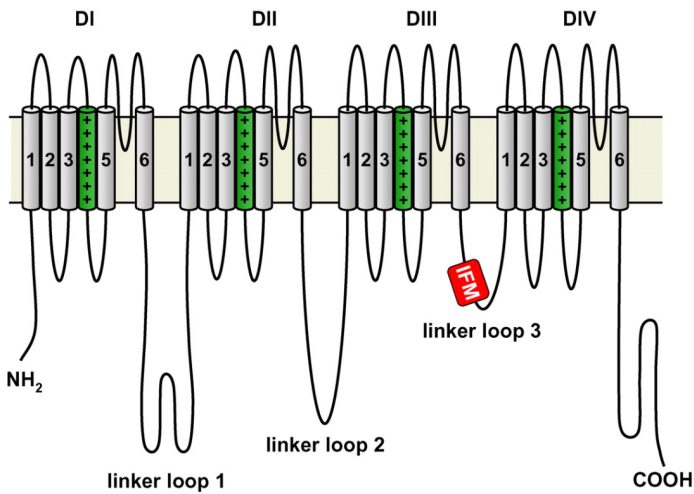


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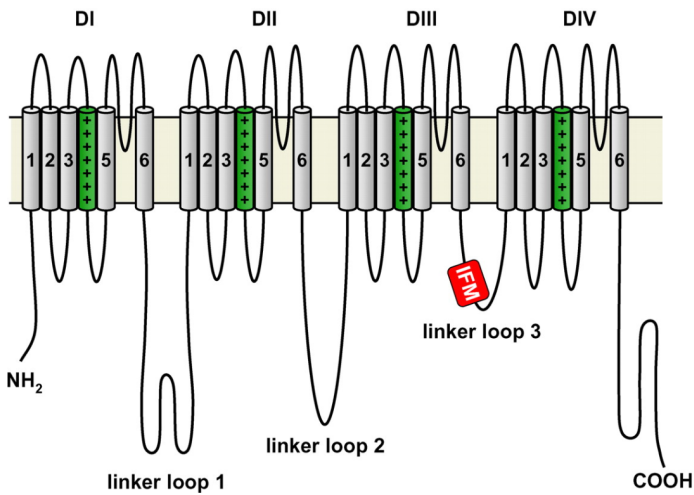


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