Excitable Cell Physiology – Additional Brain-Teasing (or Freezing) Review Questions on Membrane Potentials, Voltage Clamp & Traveling Potentials

Animal Physiology
Spring 2015

You should be able to answer these questions – if you have questions, ask specific ones – not "go over #1." Remember that the point of this course is not to memorize all possible answers but instead to be able to work with your knowledge base and apply it to specific problems.

1. (a) During an action potential, which variables in the current equation (Ohm's law) are essentially constant with respect to time for Na^+, K^+ and Cl^-? Which vary with respect to time?
(b) What accounts for the reason that a particular variable is either constant or variable?
(c) Draw a graph of an AP with an expanded time base (i.e., make the AP take up the entire time domain of your graph).
Using your answer in (a) and (b) draw, with respect to time, the current for each ion, ΔE for each ion, and G for each ion so that they match the graph of the AP (E_M vs. time). These can be qualitative graphs although in fact, you should be able to quantitative versions.
(d) Explain briefly how the Goldman-Field equation gives you a snapshot of the membrane potential at a given moment in time. For a given cell, what the variables and what are the constants in the three univalent ion form of the equation that we considered in class?

2. Complete the same analysis as above for a nicotinic neuromuscular receptor that is gated in restored in a normal fashion (what do I mean by this?). Remember that the potential generated by the NNMR will not look the same as an AP.

3. Using a membrane model, discuss the membrane currents in a resting cell in the presence of a functional Na^+/K^+ ATPase. What would happen to the currents if ouabain were added – immediately and over a long term. You will probably need to consider the current equation Goldman-Field equation when considering your answer.

4. What are uses of the Goldman-Field equation as compared to the Nernst equation?

5. Discuss the operation of a voltage clamp using the membrane circuit model – once the clamp is set, what is constant and what varies for the (i) a clamp value set below threshold and (ii) a clamp value set somewhere beyond (more positive than) threshold.
6. How do voltage gated channels communicate with each other?

7. What the relationship between electronic response velocity and the radius of a cell? Explain? What is the relationship between electronic response velocity and AP velocity? Why?

8. In a typical cell, what should be far more important in determining conduction velocity – the membrane time constant or the voltage decay constant? Explain.

9. Why do AP but not electrotonic response velocities show a strong Q_{10} over the narrow range of body temperatures where animals exist (i.e., >0 and < about 42 °C)?

10. Is the velocity of an electrotonic response the same in the node of Ranvier and under myelin? Explain.

11. Why does a muscarinic receptor hyperpolarize a cell? Explain using the Goldman equation.

12. What would be the effect of a voltage-gated Cl^- channel on E_m? Use a typical cell such as the one we discussed when we considered resting potentials to make your answer – once again, use the Goldman-Field equation to assist your answer.

That's plenty – these are tough and if you can answer them, you are a good e-physiologist.