Bioengineering/Physiology 6000 Sample Quiz, 2014

Date: Friday, March 7, 2014

1) Answer the following true/false questions and provide a short (1-3 sentences) explanation for each answer: Value 50%

   1. Confocal microscopy is an important technique in physiological studies because it allows much higher magnification than other types of light microscopy.

      False. Confocal microscopy is an important technique but because of the very sharp focal plane it achieves rather than the magnification, which is the same as convention light microscopy.

   2. A feature common to the action potentials of all cells in the heart is that they require a sodium (Na^+) current for the upstroke.

      False: Not all cells require a sodium current, e.g., *the cells of the sinoatrial node or the atrio-ventricular node depend not on sodium but on calcium for inward current.*

   3. The heart is capable of beating regularly without input from the brain.

      True: the heart has intrinsic pacemaker cells throughout the conduction system which spontaneously reach threshold and could initiate a heart beat. The brain modulates the heart rate and strength of contraction but is not needed.

2) An electrophysiologist wishes to determine whether calcium (Ca^+2) plays an meaningful role in determining the resting potential of a cell from the sino-atrial (SA) node in the heart. Describe the type of experiment the electrophysiologist might reasonably carry out to determine this relationship. Value 50%

   The mechanism by with all ions influence resting potential is by establishing an equilibrium potential due to differences in concentration across the cell membrane (the Nernst potential). The influence of each ion on resting potential is a function of the relative permeability of the membrane to each ion and the Goldmann-Hidgkin-Katz equation describes the resting potential as a weighted average of all the equilibrium potentials of all relevant ions. The weights in this equation are a function of the relative permeability of the ions. The dominant ion in most cells is potassium as it has the highest resting permeability.

   One experimental approach to determine whether Ca^+2 *plays a role in the resting potential would be to alter external concentration of this ion while measuring transmembrane potential. Altering external concentration is relatively simple as experiments with cellular preparations allow complete control of the electrolyte bathing solution. It is possible to measure transmembrane potentials by means of a fine glass microelectrode impaled into the cell. By altering extracellular* Ca^+2 *and monitoring the associated resting potential, one could answer the question and even quantify the relationship between ion concentration and resting potential.*

   Altering internal cellular Ca^+2 *concentration is also possible by including it in high concentration in the solution within the glass microelectrode and allowing it to diffuse into the cell. A challenge in this setting is monitoring the intracellular* Ca^+2 *concentration, which is possible through optical techniques and special fluorescent molecules. A further challenge in the setting of altered intracellular* Ca^+2 *concentration is the interaction with contractile proteins, which could cause the cell to contract.*