Neurobiology 360: Membrane Potential

1) What is the difference between permeability and conductance?

Conductance measures the movement of charge across the membrane. Permeability measures the capability of ions to flow across the membrane, regardless of whether they are moving across the membrane.

From the additional problem sets:

What are the differences between permeability, conductance, and current? Explain each in terms of its relationship to ions and membrane properties.

Answer: Permeability, conductance, and current are terms that describe different aspects of the relationship between an ion and the cellular membrane. Permeability is a proportionality (number between 0 and 1) that describes the ease with which an ion flows across a membrane, relative to the permeability of other ions. Permeability is proportional to the number of open channels for the particular ion. A membrane can be highly permeable to an ion however if there are none of those ions present then there is no movement of those ions across the membrane. Therefore permeability does not require the movement of ions across the membrane but allows for it if the ions are present with a non-zero gradient. Current is expressed as the movement of charge across the membrane in time (coulombs / second). Current is a measure of the rate of charge flow through the membrane. Without the net movement of charged ions across the membrane the current is zero. Current ($I_{ion}$) = $g_{ion}$ * ($V_m$ - $E_{ion}$). The difference between the $V_m$ and $E_{ion}$ is called the “driving force” for a particular ion. Remember that there is no net flow of a particular ion if $V_m$ is equal to the equilibrium potential. So the existence of an ionic current relies on the existence of a driving force ($V_m$ not equal to $E_{ion}$) and a conductance for that ion. If either the driving force or conductance is zero then there is no current. Conductance is an electrical term that is the reciprocal of resistance ($G = 1/R$) and has units of siemens. Conductance describes in quantifiable terms (different than permeability which is a term of proportionality) the amount of a particular charged ion that can flow across a membrane or single channel in a given amount of time at a particular membrane potential if the equilibrium potential is known. $g_{ion}$ = $I_{ion}$ / ($V_m$-$E_{ion}$).

2a) What is the Na+ equilibrium potential ($E_{Na}$) for a cell in which the extracellular concentration of sodium ions is 150mM and the intracellular concentration is 15mM?

$E_{Na} = 58 \ log (150 \ mM/15 \ mM)$

$= 58 \ mV$
2b) What would the Na+ equilibrium potential ($E_{Na}$) be if the intracellular concentration of Na+ was increased 10 fold? What does this mean?

$$E_{Na} = 58 \log \left( \frac{150 \text{ mM}}{150 \text{ mM}} \right)$$
$$= 0 \text{ mV}$$

Sodium ions are in equilibrium across the membrane.