Agenda

- Membrane potentials – what they are
- Formation of membrane potentials
- Types and uses of membrane potentials
- The significance of membrane potentials

Membrane Potentials   What They Are

Membrane Potential

Any animal cell's phospholipid bi-layer membrane and associated structures

A difference in electrical charge across (ECF – ICF) this membrane, representing potential energy.

Can also be called a transmembrane potential.

Formation of Membrane Potentials

- Requires a selectively permeable membrane
  - Due to membrane components
- Force involved is electrochemical
  - "Electro" due to the charges of the ions on either side of the membrane
  - "chemical" due to the number and types of ions on either side of the membrane
  - Main components?
    - Na^+ & K^+
    - Cl^-
    - A^- negatively charged anions
    - H^+ (proton gradient) – specialized use

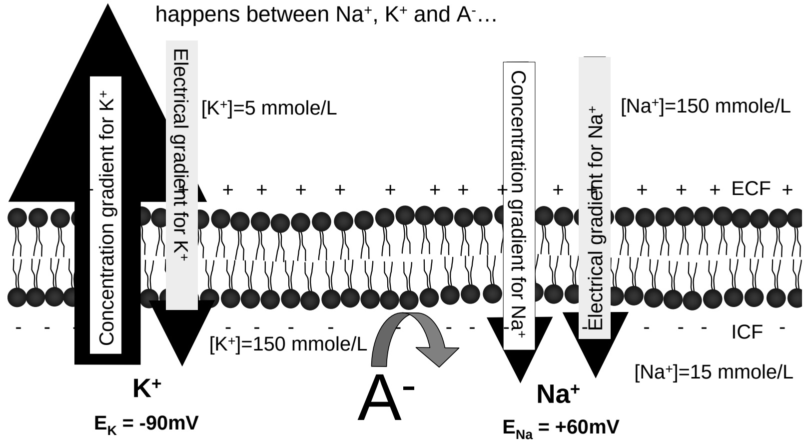
Formation of Membrane Potential

- Ion Concentrations (millimoles/liter)

Ion	ECF	ICF	E_{ion} at 37° C	Permeability
Na^+	150	15	+60mV	.04
K^+	5	150	-90mV	1
Ca^{2+}	1	.0001	+122mV	negligible
Cl^-	108	10	-63mV	negligible

Formation of Membrane Potential

So, if we take those numbers and look graphically at what happens between Na^+, K^+ and A^-…



Formation of Membrane Potential

- The cell membrane is about 40 times less permeable to Na^+ than K^+, putting the resting potential closer to E_{K+} (which is -90mV)
- The equilibrium potentials of K^+, Na^+, Cl^- and A^- result in a membrane potential of -70mV
  - This determined by the Goldman-Hodgkin-Katz equation

$$V_m = 61 \log \frac{P_{K+}[K^+]o + P_{Na+}[Na^+]o}{P_{K+}[K^+]i + P_{Na+}[Na^+]i}$$

This equation boils down to – the resting membrane potential is calculated by the combined effects of concentration gradients times membrane permeability for each ion, and really just concerning Na and K.

Formation of Membrane Potential

$$V_m = 61 \log \frac{P_{K+}[K^+]_o + P_{Na+}[Na^+]_o}{P_{K+}[K^+]_i + P_{Na+}[Na^+]_i}$$

Here’s How it Works…

$$V_m = 61 \log \frac{1(5) + .04(150)}{1(150) + .04(15)} = 61 \log \frac{5 + 6}{150 + .6} = 61 \log \frac{11}{150.6}$$

$\mathbf{V_m}$ = 61(log of .073) = 61 (-1.37) = -69mV +1mV (for the Na^+/K^+ pump effect) = **-70mV**

P_{K+} = permeability for Potassium = 1
P_{Na+} = permeability for Sodium = .04

$[K^+]_o$ = concentration of Potassium outside the cell = 5
$[K^+]_i$ = concentraiton of Potassium inside the cell = 150

$[Na^+]_o$ = concentration of Sodium outside the cell = 150
$[Na^+]_i$ = concentration of Sodium inside the cell = 15

Maintenance of Membrane Potential

- Without energy, the membrane potential would eventually be destroyed as
  - K^+ leaks out the cell due to membrane leakage channels
    - There are just more of the K^+ leakage channels than Na^+, giving us the difference in membrane permeability
  - Na^+ leaks in due to membrane leakage channels
- Na^+/K^+ ATPase (Sodium-Potassium Pump) restores the balance pumping Na^+ out and K^+ back in.

Types and Uses of Membrane Potentials

- Resting membrane potential
  - Just described at -70mV
- Threshold membrane potential
  - The electrical change that causes specialized channels to cycle through open/close confirmations
  - This occurs in mot excitable tissues at -55mV
- Action potentials
  - This is a change in the membrane potential due to rapid influxes and effluxes of ions (Na^+ and K^+)
  - Causes adjacent cell membrane to undergo same rapid change
  - Continues on to end of the membrane
  - Used for communication
- Graded potentials
  - Change in membrane potential that is variable based on the rate of and location of stimuli on the membrane
  - Used for integration

The Significance of Membrane Potentials

- Why do we care?
  - What would happen if membrane potentials didn't exist?
  - What would happen if the membrane potentials were different? (higher or lower)