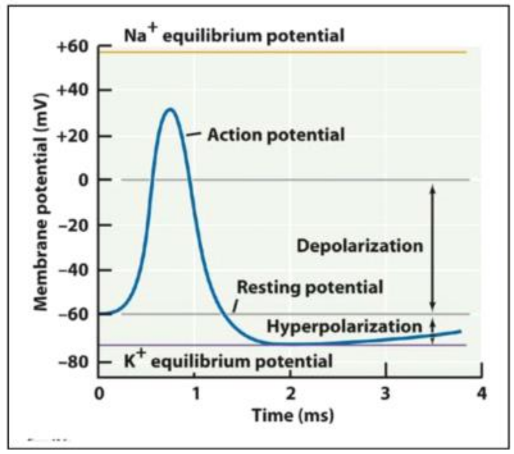
MembraneTransportKey

Thursday, October 20, 2016 7:49 AM

Membrane Transport - Understanding Ion Gradients and Potentials in Action Potentials

1. Examine the image below (Fig 10-6 from your book). This shows us that the equilibrium potential of Na^+ is +60 mV and K^+ is -75 mV. This means that at this potential, the chemical and electrochemical gradients are in balance…so mathematically, $\Delta G = 0$ in the equation below.



$$\Delta G = RT\ln\left(\frac{[A]_{in}}{[A]_{out}}\right) + Z\Im\Delta\Psi$$

a. Using the resting potential for each ion, determine the ratio of $[A]_{in}$:$[A]_{out}$ (so solve for the term in the ln(x)).

$\Delta G = 0 = RT\ln\frac{[A]in}{[A]out} + ZF\Psi$

Na^+: $Z = +1$

$\Psi = 0.06V$

K^+: $-8.314(310..)\ln x = 96485(-0.075)$

$x = 16.55$

$-8.314(300.15K)\ln x = (1)(96485)(0.06)$

$x = 0.11 = \frac{[in]}{[out]}$

b. The ratios calculated in part A tell you about the resting chemical gradient for a neuron cell.

i. Which ion has a higher intracellular concentration? K^+

ii. Which ion has a higher extracellular concentration? Na^+

iii. For each of the following membrane potentials, identify which direction the ions will flow (in, out, or no net flow) and the sign on ΔG (< 0, > 0, = 0).

Membrane Potential	Na^+ flow	K^+ flow	ΔG
+80 mV	out	out	Na : > 0 K < 0
+ 60 mV	no net flow	out	Na = 0 K < 0
0 mV	in	out	Na < 0 K < 0
-60 mV	in	out	Na < 0 K < 0
-75 mV	in	no net flow	Na < 0 K = 0
-80 mV	in	in	Na < 0 K > 0

2. The action potential begins by nerve cell stimulation. This stimulation triggers the Na^+ channel to open.

a. Which direction will sodium ions flow?

in. The resting potential is -60 mV, so Na^+ moves in

b. As you see in the graph, this causes the membrane potential to become more positive. Why?

cations flood in, so the charge inside the cell becomes more (+). a (-) ΔΨ means inside is more (-), so neutralizing the charge makes ΔΨ go up charge makes ΔΨ go up

c. Sodium ions quickly rush into the cell but stop after roughly 0.75 ms – this is shown as a peak in the action potential. Why does the ion channel close? Hint, remember that this is a voltage-gated ion channel.

It is voltage gated - so it closes & opens based on Ψ. If Ψ is changing, it must trigger the close

d. The change in membrane potential triggers voltage gated potassium channel to open. At this membrane potential (~30 mV), which direction does the potassium flow?

out

e. Why does the membrane potential become more negative as the potassium channel is active?

cations are flowing out so cytosol is becoming more negative

f. How do you think that this action potential is propagated down the neuron?

diffusion. The changing Ψ triggers adjacent Na^+ or K^+ channels. This in turn triggers more channels

3. Using the voltage gated potassium channel as a guide, discuss how the voltage-gated sodium channel in a nerve cell might work.

There may be a sensory helix that responds to the (+) / (-) charge in or out of the cell. This makes it slightly change position and open or close the poor