SC/BIOL 4151 Membrane Transport: Second Hour Test

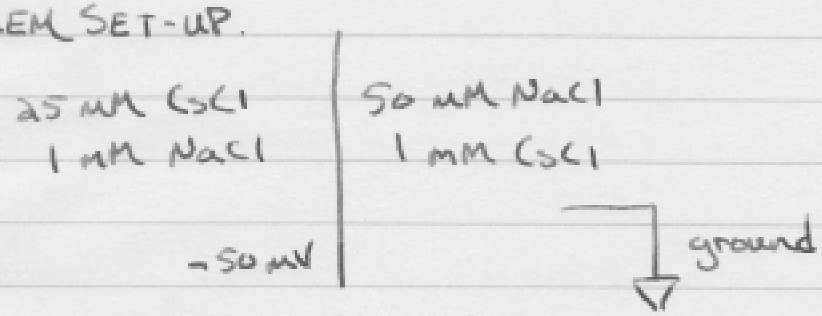
To assess the selectivity of the gramicidin channel to different cations, you add 25 mM CsCl plus 1 mM NaCl to one side (*cis*) of the bilayer chamber setup, and 50 mM NaCl plus 1 mM CsCl to the other side (*trans*). The *trans* chamber containing NaCl is the 'ground', with a voltage of zero relative to the *cis* chamber containing CsCl. You measure a zero current potential (where flux is zero) of –50 mV.

Determine the ratio of P_{Cs}/P_{Na}. And, interpret your result based upon the diffusion coefficients for Cs^+ ($2.06 \cdot 10^{-5}$ cm/sec) and Na^+ ($1.33 \cdot 10^{-5}$ cm/sec)

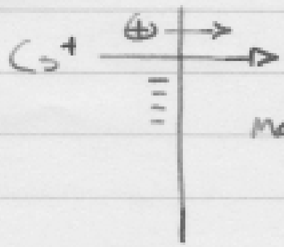
Please assume (correctly) that when the *cis* chamber contains 100 mM KCl and the *trans* chamber contains 10 mM KCl, the zero current potential is about –55 mV.

POINTS

PROBLEM SET-UP.



(4)



more permeant to Cs. (2)

EQUATION SET-UP

$$\psi = \frac{RT}{F} \ln \frac{P_{Na}[Na^{trans}] + P_{Cs}[Cs^{trans}]}{P_{Na}[Na^{cis}] + P_{Cs}[Cs^{cis}]}$$ (4)

$P_{Cl}[Cl]$ is not included. KCl experiment demonstrates $\underline{P_{Cl} = 0}$ (1)

ALGEBRA. $$\frac{[Na^{trans}] + {}^{P_{Cs}}/_{P_{Na}}[Cs^{trans}]}{[Na^{cis}] + {}^{P_{Cs}}/_{P_{Na}}[Cs^{cis}]}.$$ (1)

RESULT: ${}^{P_{Cs}}/_{P_{Na}} \sim 20$ (1)

(1)

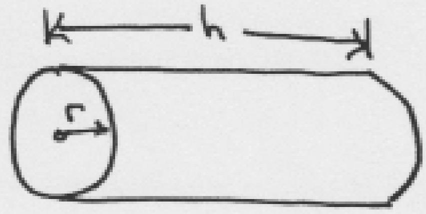
INTERPRETATION. Ratio significantly higher than ${}^{D_{Cs}}/_{D_{Na}}$. evidence of selectivity by the channel, separate from properties of the ions alone.

(14)

EQUATIONS

Sphere Area: $4\pi r^2$
Sphere Volume: $4/3\pi r^3$

Cylinder Area: $2\pi r h$
Cylinder Volume: $\pi r^2 h$



GOLDMAN EQUATION

$$J = -P \frac{zF\psi}{RT} \left[\frac{c^o - c^i e^{\left(\frac{zF\psi}{RT}\right)}}{1 - e^{\left(\frac{zF\psi}{RT}\right)}} \right]$$

zero flux $\psi = \frac{RT}{zF} \ln\left[\frac{c^o}{c^i}\right]$

zero potential $J = -P(c^o - c^i)$

net charge $Q = C\Delta E$

C: (coulombs/volt); Q: (coulombs); ΔE: (volt)

for a spherical cell: $C = 4\pi r^2 C'$

C': capacitance per unit area (~ 1 µF/cm²)

$Q = 4/3\pi r^3 cF$

c: concentration

Goldman-Hodgkin-Katz equation (assuming only Na^+, K^+, and Cl^- are present):

$$\psi = \frac{RT}{F} \ln \left[\frac{P_{Na} C_{Na}^{o} + P_{K} C_{K}^{o} + P_{Cl} C_{Cl}^{i}}{P_{Na} C_{Na}^{i} + P_{K} C_{K}^{i} + P_{Cl} C_{Cl}^{o}} \right]$$

Goldman-Hodgkins-Katz equation (assuming a single cation (M^+) and anion (A^-) are present):

$$\psi = \frac{RT}{F} \ln \left[\frac{[M^+_i] + {}^{P_{A^-}}/_{P_{M^+}} [A^-_o]}{[M^+_o] + {}^{P_{A^-}}/_{P_{M^+}} [A^-_i]} \right]$$