Problem 17.3:

Given the conductances and Nernst potentials of Na and K, what must the total conductance, g and equivalent Nernst potential, V_N be for the circuits to be equivalent. The total current must be the sum of the two currents. Assume the voltage is not changing, so the current is entirely Ohmic.

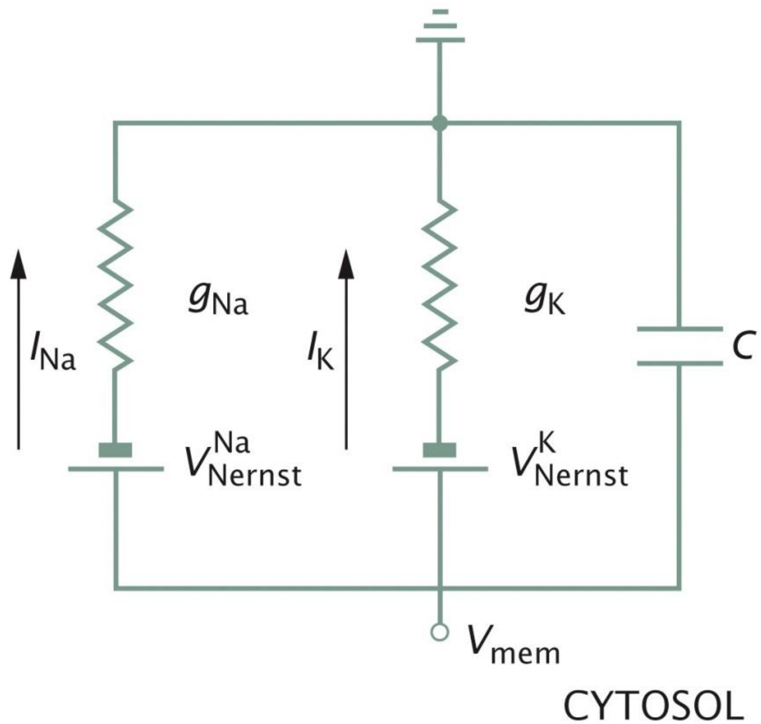
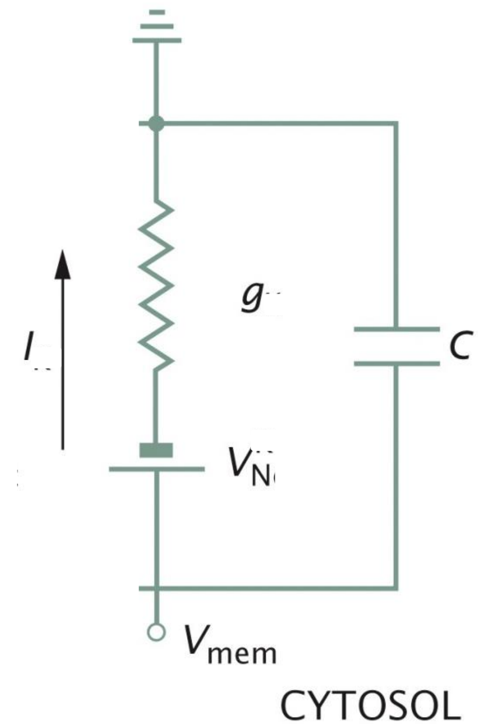


Figure 17.11 Physical Biology of the Cell, 2ed. (© Garland Science 2013)



Garland Science 2013)

Problem 17.3:

Given the conductances and Nernst potentials of Na and K, what must the total conductance, g and equivalent Nernst potential, V_N be for the circuits to be equivalent. The total current must be the sum of the two currents. Assume the voltage is not changing, so the current is entirely Ohmic.

$g = g_K + g_{NA}$ (conductances add in series)

$I = I_{NA} + I_K$

$I = g\,(Vmem - V_N)$

$I_{NA} = gNA\,(Vmem - V_{NA})$

$IK = gK\,(Vmem - VK)$

combining the above equations gives us one equation for VN

$gNA(Vmem - VNA) + gK(Vmem - VK) = (gK + gNA)(Vmem - VN)$

An ion with charge q is in a potential $V(x)$. Use Boltzmann to determine the ratio of the concentration of ion $c(x)/c(0)$ in terms of V. Use this to derive the expression for the Nernst potential $dV = V(x) – V(0)$.

An ion with charge q is in a potential V(x). Use Boltzmann to determine the ratio of the concentration of ion c(x)/c(0) in terms of V. Use this to derive the expression for the Nernst potential $V_N = V(x) – V(0)$.

from Boltzmann:

$c(x)/c(0) = \exp(-E(x)/kT)/\exp(-E(0)/kT)$

a charge q has energy $E(x) = q*V(x)$. So,

$c(x)/c(0) = \exp[-q(V(x) – V(0))/kT] = \exp(-q\ dV/kT)$

So Nernst potential is:

$V_N = - kT/q\ \ \log[\ c(x)/c(0)\ ]$

Problem 17.4:

Suppose the pumps in an axon get switched off. What is the Ohmic current per unit area immediately after the pumps are turned off for Na ions if the concentration inside is 12 mM and the concentration outside is 145 mM. The membrane potential is Vmem = -90 mV. Take the conductance per unit area for Na to be g = 0.13 $\Omega^{-1}m^{-2}$. Na has a charge of +1e and take kT/e = 25.6 mV.

Problem 17.4:

Suppose the pumps in an axon get switched off. What is the Ohmic current per unit area immediately after the pumps are turned off for Na ions if the concentration inside is 12 mM and the concentration outside is 145 mM. The membrane potential is Vmem = -90 mV. Take the conductance per unit area for Na to be g = 0.13 $\Omega^{-1}m^{-2}$. Na has a charge of +1e and take kT/e = 25.6 mV.

I = g (Vmem – VN)

now VN = -kT/e log(145/12) = - 63 mV

so I = (0.13)*(-0.023) = - 0.003 amps/m^2