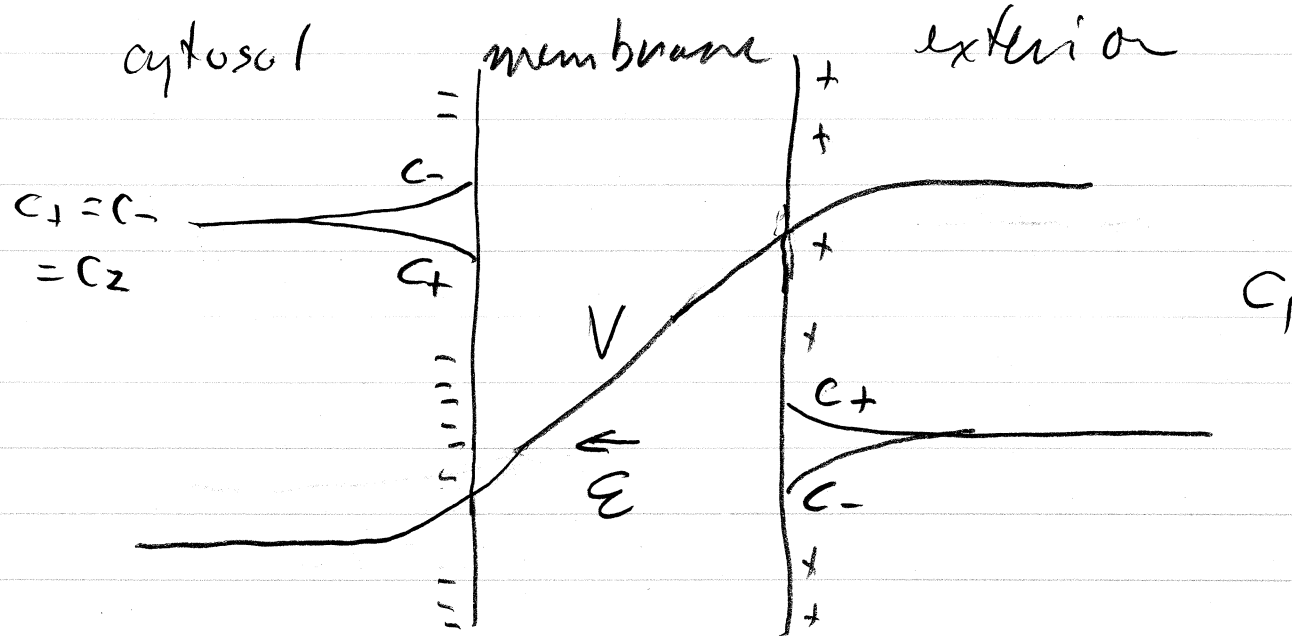
Ch 11



Assume Cl^- trapped, but K^+ can escape.

$$V_N = -\frac{kT}{ze} \ln \frac{c_2}{c_1}$$

because

$$\frac{c_2}{c_1} = e^{-\frac{V_N ze}{kT}}$$

Take $c_{1Na^+} = 140\ mM$

$c_{1K^+} = 10\ mM$

$c_{1Cl^-} = 150\ mM$

} neutral solution far from membrane.

Neutrality in cell requires

$$C_{2\,Na^+} + C_{2\,K^+} - C_{2\,Cl^-} + \frac{\rho_{DNA}}{e} = 0$$

Here ρ_{DNA} is the (negative) charge density of the macromolecules DNA, RNA, etc.

$$\Delta V = -\frac{kT}{e} \ln \frac{c_2 Na^+}{c_1 Na^+}$$

$$= -\frac{kT}{e} \ln \frac{c_2 K^+}{c_1 K^+}$$

$$= -\frac{kT}{-e} \ln \frac{c_2 Cl^-}{c_1 Cl^-}$$

So

$$\frac{c_1 Na^+}{c_2 Na^+} = \frac{c_1 K^+}{c_2 K^+} = \frac{c_2 Cl^-}{c_1 Cl^-}$$

in equilibrium — <u>Gibbs-Donnan relations</u>.

$$\Delta c_{tot} = c_{2tot} - c_{1tot} = 25 \text{ mM}$$

gives osmotic pressure of

$$25 \text{ mM} \times kT = 6\, 10^4 \text{ Pa}$$

which would burst the cell.

A real cell has

	c_2 mM	c_1	$\mathcal{V}^N$
K^+	400	20	-75
Na^+	50	440	54
Cl^-	52	560	-59

which is far from equilibrium,

$\Delta V = -60$ mV : sodium anomaly,

$$j_{q_i} = z e j_i = (\Delta V - \mathcal{V}^N) g_i$$

g_i is conductance / area of ion i

$[g] = m^{-2} \Omega^{-1}$ $\quad g_{K^+} = 25 g_{Na^+} = 2 g_{Cl^-}$

cell pumps $3Na^+$ out

$2K^+$ in

uses 1 ATP