Membrane Energetics

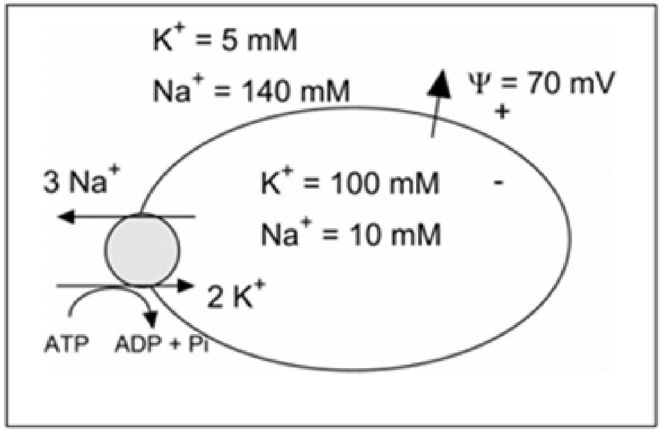
$\Delta G = RT2.303 \log (C2/C1) + nF\psi$
$= 5.7(KJ/mol) \log (C2/C1) + n96.5(KJ/mol)\psi$

$= 1.36(Kcal/mol) \log (C2/C1) + n23.1(Kcal/mol)\psi$

1. To pump Na^+ out, both forces work against.

$\Delta G = 5.7 \log(140/10) + 1x\ 96.5\ x\ (0.07\ V) = 6.5 + 6.8 = 13.3$ KJ/mol

2. To pump K^+ in, concentration gradient opposes, but electrostatic field favors import



$\Delta G = 5.7 \log(100/5) + 1x96.5\ x\ (-0.07\ V) = 7.4 - 6.8 = 0.6$ KJ/mol

3. To pump 3 Na^+ out and 2 K^+ in:

3 x 13.3 KJ/mol + 2 x 0.6 KJ/mol = 42 KJ/mol = 10 Kcal/mol

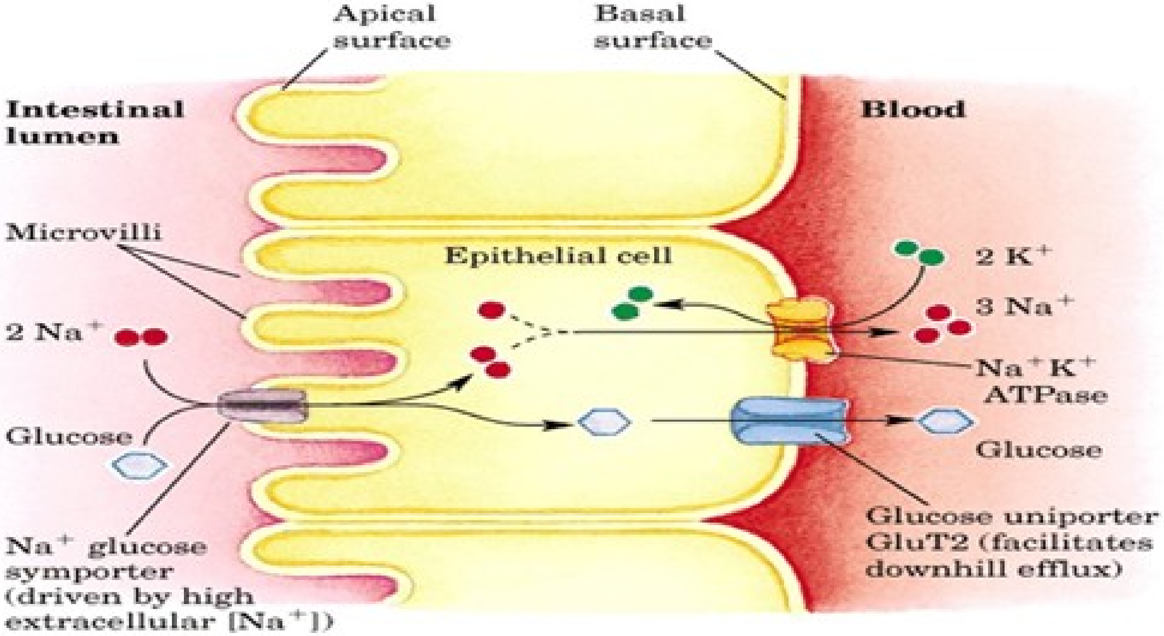
4. ATP hydrolysis: standard state give -31 KJ/mol = –7.5 Kcal/mol

However, steady state conditions (ie ATP $\approx$ 8 mM, ADP $\approx$ 1 mM, and Pi $\approx$ 8 mM) gives

-49 KJ/mol = -11.7 Kcal/mol

more than enough to carry out the pumping.

Na+/glucose symporter



For charged ion transport: $\Delta G = RT\ln [Na^+]_{in}/[Na^+]_{out} + n\,F\Delta E$

$= 5.7$ KJ $\log [Na^+]_{in}/[Na^+]_{out} + n \times 96.5\ \Delta E$

Moving a Na^+ ion into the cell releases $= 5.7 \log(12/145) + 1 \times 96.5 \times (-0.05)$
$= -6.2$ KJ/mol $- 4.8$ KJ/mol $= -11$ KJ/mol

If two Na^+ ions move, energy available to pump glucose is -22 KJ/mol.

This energy could transport glucose against a concentration gradient;
it's magnitude would be governed by the available energy:

$\Delta G = 22$ KJ/mol $= 5.7$ kJ/mol $\times \log[\text{glucose}]_{in}/[\text{glucose}]_{out}$

$3.86 = \log [\text{glucose}]_{in}/[\text{glucose}]_{out}$ therefore $[\text{glucose}]_{in}/[\text{glucose}]_{out} = 7000$.