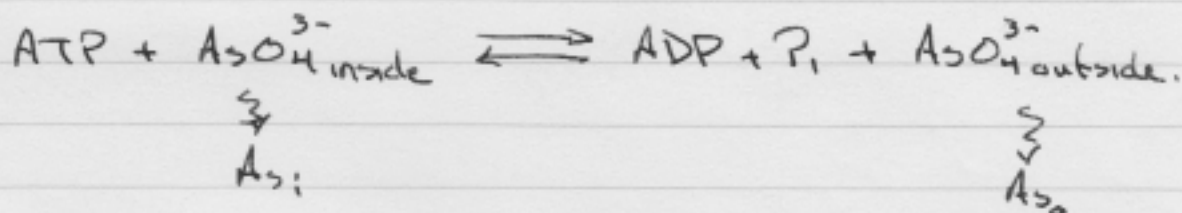


To understand how effective the AsO_4^{3-} arsenate pump is. That is, how well it can remove arsenate from the cytoplasm, we need to consider the energetics.

Our starting point is to consider the arsenate efflux as a vectorial chemical reaction.



At equilibrium, the total Gibbs free energy is the sum of the Gibbs free energy for ATP hydrolysis and the chemical potential for "As".

$$\Delta G_{\text{TOT}} = n \cdot \Delta \mu_{\text{As}} + \Delta G_{\text{ATP}} = 0 \quad (\text{equilibrium})$$

↑
stoichiometry (= 1 in our case)

$$\text{now, } \Delta G_{\text{ATP}} = \Delta G^\circ + 2.3 RT \log_{10} \frac{[\text{ADP}][\text{P}_i]}{[\text{ATP}]}$$

(reactant)

The standard Gibbs free energy will vary with $[\text{Mg}^{2+}]$ and pH. It is in the range of 7-10 kcal/mole.

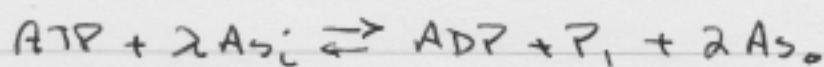
$$\Delta \mu_{\text{As}} = n \cdot 2.3 RT \log_{10} \frac{[\text{As}_i]}{[\text{As}_o]} = \frac{zF \Delta \psi}{\text{valence}}$$

↑
valence

Since $\Delta G_{TOT} = 0$, we can equate the two ($\Delta G_{ATP} = n \Delta \mu_{As}$)

$$\Delta G^\circ + 2.3 RT \log_{10} \frac{[ADP][P_i]}{[ATP]} = 2.3 RT \log_{10} \frac{[As_i]}{[As_o]} + \cancel{2.3} \Delta \psi$$

Now, there are real complications associated with the use of energetics. First, the reactants and products are more complex than "just" ADP, P_i , ATP, and we are often challenged to get accurate quantitation of concentrations in the cytoplasm. Second, we don't know the stoichiometry. If two "As" are transported:



The equilibrium $\frac{\text{products}}{\text{reactants}}$ is

$$\frac{[ADP][P_i][As_o]^2}{[ATP][As_i]^2}$$

Finally, H_3AsO_4 , $H_2AsO_4^-$, $HA_2O_4^{2-}$ or AsO_4^{3-} ?
Which?

It makes a big difference in the equilibrium concentrations of As_i at a given ΔG_{ATP} .

The energetics

Even so, it offers insight into the relative ability of the bacterial cell to exclude As.