### ATP synthase: An enzyme machine and more. Perhaps much more!

This talk underscores the biological role of the electric potentials of enzymes beyond their roles as catalysts. Recent structures of ATP synthase from 5 species are used to compare their electrostatic potentials (ESP) and fields. Striking patterns emerge including a role of ATP synthase beyond its known catalytic function in mitochondrial energy transduction. ATP synthase’s intrinsic ESP is of the order of magnitude of the chemiosmotic ESP and hence cannot be ignored. It is suggested that an additional term must, thus, be added in the traditional ΔG expression of chemiosmotic theory:

\[
\Delta G = \Delta G_{\text{chem.}} + \Delta G_{\text{elec.}} + \Delta G_{\text{ATPase}} = 2.3 nRT \Delta p + n \zeta Z \Delta \psi + n \zeta Z \Delta \psi_{\text{ATPase}}
\]

Thus, we can assign three complementary roles to ATP synthase:

1. Its putative role, and that is the catalysis (lowering the ΔG‡) of the reaction:
   \[
   \text{ADP + P} \rightleftharpoons \text{ATP + H}_2\text{O}. 
   \]

2. A novel role, which is, altering the ΔG of the reaction of translocation of protons from the intermembrane gap to the mitochondrial matrix.

3. Another novel role, and that it to create a potential barrier regulating the rate of proton translocation itself. Said differently, due to the enzyme’s very structure, ATP synthase functions over and above its role as an enzyme as a biological catalyst. How this term has been overlooked will be discussed in the context of a larger research programme.

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**References**