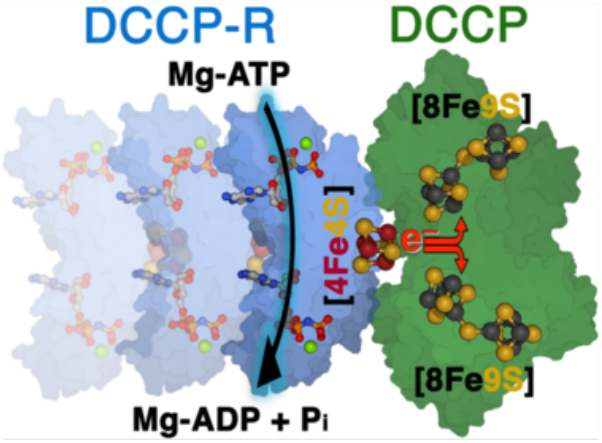
Coupled catalytic reactions: How are ATP hydrolysis and electron transfer coupled?

Start Time: Wednesday, August 10, 2022

End Time:



Making electrons highly reactive is a challenge in biology and chemistry. In enzymes, this can be done by transferring electrons to cofactors with very negative reduction potentials. An attractive energy source for this process is the hydrolysis of adenosine triphosphate (ATP): in this reaction, chemical energy is released by breaking certain bonds in ATP. This process can generate such highly reducing electrons that it is also used to drive the biological reduction of dinitrogen (N_2) to ammonia (NH_3) - a reaction that requires a lot of energy.

Electron transfers coupled to the hydrolysis of ATP allow various metalloenzymes to catalyze reductions at very negative reduction potentials. How exactly ATP-driven electron transfer occurs is not known. Therefore, one of the goals of UniSysCat is to figure out how ATP hydrolysis and electron transfer might be coupled.

In their current study, a team of researchers from the UniSysCat group of Prof. Holger Dobbek studied the ATP-driven electron transfer in the double-cubane cluster protein (DCCP). This protein and its associated metallo-ATPase (DCCP-R) use ATP hydrolysis to reduce substrates such as acetylene and hydrazine. By studying the interaction between the two proteins, particularly the complex formation and crystal structures of the complex in three different states, Jae-Hun Jeoung and co-workers discovered hydrogen bond networks that connect the site of ATP hydrolysis to the electron-donating [4Fe4S] cluster. This architecture allows conformational changes to propagate between sites within the complex to achieve coupling of the processes.

An analogous arrangement is found in the complex between nitrogenase and its ATP-

dependent reductase, suggesting a convergent evolution of catalytic strategies to couple ATP hydrolysis and electron transfer.

This study has been published in *PNAS:* J. H. Jeoung S. Nicklisch and H. Dobbek (2022). Structural basis for coupled ATP-driven electron transfer in the double-cubane cluster protein. *Proc Natl Acad Sci U S A*, *119*(31), e2203576119. https://doi.org/10.1073/pnas.2203576119