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Double Cross Electron Transfer from [2Fe-2S] Cluster to Heme f (or c1) in the Low Amplitude Cyclic Swelling-Shrinkage

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Editorial

Energy transformation is a fundamental process needed for existence and activity of living organisms. ATP is a major chemical energy - containing intermediate, which release energy upon hydrolysis. Most of ATPs are synthesized by ATP synthases (F_OF_1-ATPases) in energy-transforming membranes of mitochondria, chloroplasts and bacteria. In redox reactions, during respiration and photosynthesis, a vectorial transfer of charges occurs from the (electron) donor side to the (electron) acceptor side, along an electron transport chain (ETC).

The steps in the inner membrane of mitochondria include electron transport from one intermediate to the next: Dehydrogenase (Deh)→flavoprotein (Fp)→ubiquinone (CoQ)→cytochrome (Cyt) bc_1→Cyt c→Cyt aa_3. However, in the thylakoid membranes, electron transport begins at PSII, ending at NADP: Photosystem II (PSII)→plastoquinone (PQ)→Cyt b_6f→plastocyanin (PC)→Photosystem I (PSI) →ferredoxin (Fd) →ferredoxin-NADP reductase (FNR). In the both photosynthetic and respiratory electron transport pathway in the thylakoid membrane of cyanobacteria, they are: Deh and PSII→PQ→Cyt b_6f→PC →oxidase (Ox) and (PSI→Fd→FNR) [1] We note that cytochrome complex (Cyt b_6f or Cyt bc_1) has a central position in the electron transport chain of all energy-transducing organelles and organisms, and it performs an important function.

We have already suggested a mechano-chemiosmotic model of coupling of electron transfer to ATP synthesis, where the electron transfer along electron transfer chain, proton transfer, transport of cations, low-amplitude swelling–shrinkage, and ATP synthesis are coupled processes [2]. This model indeed uses the chemiosmotic model of Peter Mitchell [3] as its basis, and supplements it by dynamic properties characteristic of biological structures with particular attention to a regulatory role of a low-amplitude swelling-shrinkage of organelles.

During proton transport from intermembrane space to matrix, shrinkage of intracristal space and a shift of pH value up to 7.0 takes place in the intracristal space. Dimers of Cyt bc_1 complexes on the opposite sides of the membrane are asymmetrically contacted during shrinkage. This contact takes place due to electrostatic interactions of negatively and positively charged amino acid residues which are localized in big and small domains of cytochrome c_1. These conditions are favorable for heme reduction of Cyt c_1, because this heme is reduced maximally at pH> 7 [4]. Moreover, during this time, opposite dimers of cytochrome bc_1 complexes come into contact with each other, and active centers of cytochromes c_1 and [2Fe-2S]-clusters become close to each other [5].

The cyt b_6f complexs on the opposite sides of the membrane are in asymmetric contacts, where active sites of monomers I and III (first dimer consists of monomers I and II; second dimer consists of monomers III and IV are accessible to each other, i.e. [2Fe-2S] cluster of the monomer I and heme f of the monomer III and vice, [2Fe-2S] cluster of the monomer III and heme f of the monomer I. In our opinion, there is also cyclical asymmetric contacts between the two opposing monomers dimers, ie, in the first cycle the [2Fe-2S] clusters of monomers I and III are reduced, in the second cycle the [2Fe-2S] clusters of monomers II and IV are reduced.

So, we propose that the electron transfer from one monomer into other monomer inside of one dimer and from one dimer to other dimer occurs by pathway of double cross electron transfer from [2Fe-2S] cluster to heme f (or c1) in the low amplitude cyclic swelling-shrinkage.

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