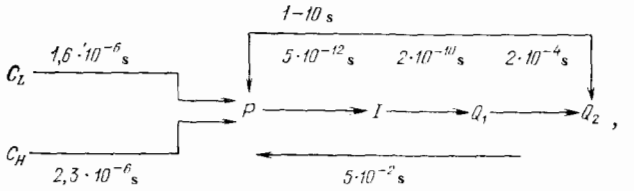
A. B. Rubin. *Molecular mechanisms for electron transport in biological systems.*. The two basic bioenergetic processes, namely, photosynthesis and respiration, rely on the transport of electrons between macromolecular carriers within the membrane. Direct measurements performed by fluorescence and absorption (laser) spectroscopy have yielded the characteristic times for the transfer of electrons in reaction centers (RC) of the photosynthesizing purple bacteria.[1-4]

The general scheme of transport in reaction centers and the immediate donor-acceptor environment has the form



where C_H and C_L are the high- and low-potential cytochromes, P is the photoactive dimer of bacteriochlorophyll, I is bacteriopheophytin, and Q_1 and Q_2 are the primary and secondary acceptors of quinone origin. The excitation of P results in the detachment of quinone origin. The excitation of P results in the detachment of an elecron in 5×10^{-12} s from the primary singlet state and its transport to the acceptor Q_1 in 2×10^{-10} s through the intermediate molecule I and then onto Q_2. The positive hole in P is filled by an electron from cytochromes C_H and C_L in a time of the order of 10^{-6} s. The quantum yield of charge separation in the reaction $PQ_1\rightarrow P^+Q_1^-$ is about 100% (Ref. 5). The inverse transport reactions are much slower than the direct reactions, which ensures that electron transport along the chain proceeds with high efficiency.[1,4]

The temperature dependence of the direct electron transport reactions over the links $C_L\rightarrow P$, $Q_1\rightarrow Q_2$ is characterized by a two-phase curve with a turning point in the range $-100°$ to -140 °C and $-50°$ and $-70°$, respectively, and electron transport below this point is practically temperature-independent.[1,6] In the temperature region in which changes in the efficiency of the $Q_1\rightarrow Q_2$ process have been observed, a change has been found in the intramolecular mobility of the RC protein, as measured by Mössbauer spectros-

copy, ESR (spin probes), and fluorescent traces.[7,8] Analysis shows that electron transport in the RC occurs by inelastic tunneling when electron transitions are associated with vibrational and confirmational degrees of freedom.[6,7,8,10]

An electron tunneling into the carrier molecules is slowed down by it, losing part of its energy to vibrational degrees of freedom of the acceptor mode in 10^{-12} s (approximately 0.1 eV). However, the change in the charge state of the carrier may produce more or less deep conformational changes in the polymer structure, which occur in about 10^{-4}–10^{-5} s. It has been found that this type of change occurs in the RC when the electron returns to P (Ref. 1). The conformational change can be sharply slowed down by reducing the temperature and the amount of water in the RC. One then observes an anomalous temperature dependence for which the rate of the inverse reaction $P \leftarrow Q_1$ is increased by a factor of 1.5–3 as the temperature is reduced from $+25°$ to $-150°$ and the humidity is reduced to 10% or less. The transport of the electron during the $Q_1 \rightarrow Q_2$ stage is regulated to an even greater degree by the conformational mobility of the second quinone Q_2. This carrier executes motion within the portion of the RC polymer near Q_1 and forms with it a contact configuration assuring electron transport from Q_1 to Q_2 (Refs. 7 and 8). On those segments of the chain ($P \rightarrow I$, $Ch_H \rightarrow P$) on which the contact configuration between the carriers has already been formed, electron transport is practically independent of temperature (Refs. 1, 7, 8, 10). The mechanism of intramolecular protein mobility, which lies at the basis of conformational rearrangement, has the character of restricted diffusion. Thus, electron-conformational interactions ensure effective tunneling transport, accompanied simultaneously by conformational changes in the polymer structure of the carriers, which facilitate the formation between them of functionally active contact configurations.[1,7–10]

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