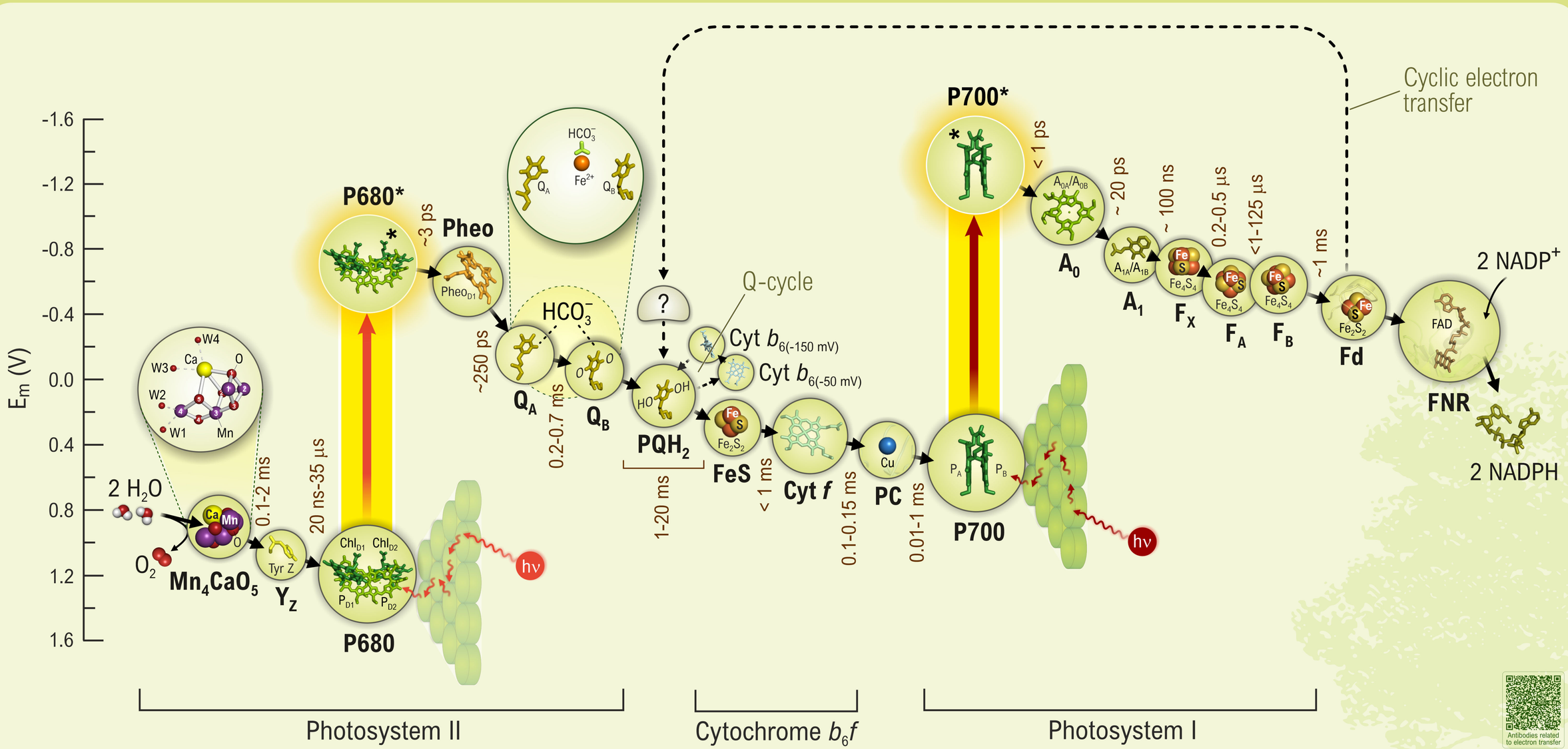
Best wishes for your research
Govindjee

Z-Scheme of Electron Transport in Photosynthesis



The Z-scheme Poster: A diagram for linear electron transfer from water to $NADP^+$, plotted according to midpoint redox potentials at pH 7.0 (E_m, 7), based partly on a similar poster, printed vertically in 2017. For a historical review, see [1]; for teaching basic versions of this scheme, see [2, 3]. In the diagram, shown in this poster, we have not included proton transport and the consequent formation of ATP; for further information on this part and all other aspects of photosynthesis, see [4, 5]. Send questions and comments to Govindjee Govindjee (gov@illinois.edu) or to Dmitry Shevela (info@scigrafik.se).

Abbreviations: Mn_4CaO_5, manganese-calcium-oxygen complex; W1-W4, metal bound water molecules; Y_Z, redox-active tyrosine (Tyr Z); P680 and P700, primary electron donors of Photosystem II (PSII) and Photosystem I (PSI), 680 and 700 are wavelengths, in nanometers (nm), of the first excited states of special reaction center Chl *a* molecules. P680 includes an ensemble of Chl a molecules (P_{D1}, P_{D2}, Chl_{D1}, and Chl_{D2}, but only P_{D1} and Chl_{D1} are shown). P700 is a pair of Chls *a*, P_A and P_B); P680*and P700*, first singlet excited states of P680 and P700 (the first step after excitation is charge separation, conversion of excitonic energy into chemical energy); Pheo, pheophytin, primary electron acceptor of PSII, $Pheo_{D1}$; Q_A and Q_B, primary and secondary quinone (plastoquinone) electron acceptors (Q_A is tightly bound, whereas Q_B is loosely bound; the latter accepts two electrons and two protons; bicarbonate ion (HCO_3^-), bound to non-heme iron, located between Q_A and Q_B, plays an essential role here); PQ, mobile plastoquinone molecules; FeS, Rieske iron-sulfur protein; Cyt *f*, cytochrome *f*; PC, mobile copper protein, plastocyanin; A_0, primary electron acceptor of PSI (a special pair of Chl *a* molecules, A_{0A} and A_{0B}); A_1, pair of phylloquinone (vitamin K) molecules, A_{1A} and A_{1B}; F_X, F_A, and F_B, bound iron-sulfur clusters of PSI; Fd, ferredoxin; FNR, ferredoxin-NADP oxidoreductase.

Notes: The above representation is not meant to imply that PSII, Cyt b_6f complex, and PSI are necessary in 1:1:1 ratio. These may be physically distant from each other in the thylakoid membrane, their functional connection is accomplished through diffusible PQ (between PSII and Cyt b_6f) or PC (between Cyt b_6f and PSI). Several cyclic electron pathways, around PSI, have been suggested; for simplicity we show here only one, which may involve one or more proteins. All shown cofactors were generated using coordinates from available PDB entries: 1sm4, 1vf5, 2gim, 2mh7, 3arc, 4y28, and 6w1o. Phytyl tails of Chls and Pheo, and the isoprenyl chains of the quinones have been cut for clarity.

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Poster 2 - Z Scheme of Electron Transport in Photosynthesis, 2018 (updated 2025)

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