Table 3
Estimated redox midpoint potentials in photosystems

Rps. viridis RC		PSI		PSII	
Cofactor [a]	E_m	Cofactor [a]	E_m	Cofactor [a]	E_m
$BChl_2$	0.50 [101]	P700	0.45 [102]	Chl_{D1}	1.26 [91]
$BChl_2^*$	−0.79	P700*	−1.17 [103]	Chl_{D1}^*	−0.57 [91]
$BChl_A$	−0.71	^{3}P700	−0.82[104]	P_{D1}	1.20 [88]
$BChl_B$	−0.85	Chl_{1A}	−1.29 [97]	P_{D2}	1.24 [88]
BPh_A	−0.63 [105]	Chl_{1B}	−1.29 [97]	Chl_{D2}	1.26 [92]
BPh_B	−0.63	Chl_{2A}	−1.05 [106]	Ph_{D1}	−0.39 [91]
Q_A	−0.15 [107]	Chl_{2B}	−1.05 [106]	Ph_{D2}	−0.39 [92]
Q_B	0.04 [108]	Q_A	−0.70 [97]	Q_A (w/o OEC)	−0.03 (0.065) [109, 110]
Heme 1	0.38 [111]	Q_B	−0.74[112]	Q_B	0.04 [113]
Heme 2	0.02 [111]	F_X	−0.67 [114]	Tyr_Z (w/o OEC)	1.075 (~0.95) [91]
Heme 3	0.32 [111]	F_A	−0.54 [97]	Tyr_D	0.75 [115]
Heme 4	−0.06 [111]	F_B	−0.56 [97]	OEC-Mn S1/S2	1.02 [91]
				$^3(P^+Ph^-)$	−0.42 [91]
				carotenoid	~1.06 in micelles (~0.927 calc) [116]
				b559 (w/o OEC)	0.35 (0–0.08) [117, 118]
				Chl_{ZD2}	0.916 [119]
				Chl_{ZD1}	0.920 [119]
				c550	−0.08 [120]

[a] See Fig. 7.

[88] B.A. Diner, E. Schlodder, P.J. Nixon, W.J. Coleman, F. Rappaport, J. Lavergne, W.F.J. Vermaas, D.A. Chisholm, Site-directed mutations at D1-His198 and D2-His 97 of photosystem II in synechocystis PCC 6803: sites of primary charge separation and cation and triplet stabilization, Biochemistry 40 (2001) 9265–9281.

[91] F. Rappaport, M. Guergova-Kuras, P.J. Nixon, B.A. Diner, J. Lavergne, Kinetics and pathways of charge recombination in photosystem II, Biochemistry 41 (2002) 8518–8527.

[92] C.C. Moser, C.C. Page, P.L. Dutton, Tunneling in PSII, Photochem. Photobiol. Sci. 4 (2005) 933–939.

[97] C.C. Moser, P.L. Dutton, Application of Marcus theory to photosystem I electron transfer, in: J.H. Golbeck (Ed.), Photosystem I: the plastocyanin: ferredoxin oxidoreductase in photosynthesis, Kluwer/Springer, New York, in press.

[101] J.L. Gao, R.J. Shopes, C.A. Wraight, Charge recombination between the oxidized high-potential C-type cytochromes and Qa- in reaction centers from Rhodopseudomonas viridis, Biochim. Biophys. Acta 1015 (1990) 96–108.

[102] L. Krabben, E. Schlodder, R. Jordan, D. Carbonera, G. Giacometti, H. Lee, A.N. Webber, W. Lubitz, Influence of the axial ligands on the spectral properties of P700 of photosystem I: a study of site-directed mutants, Biochemistry 39 (2000) 13012–13025.

[103] A.W. Rutherford, A. Krieger-Liszkay, Herbicide-induced oxidative stress in photosystem II, Trends Biochem. Sci. 26 (2001) 648–653.

[104] V.A. Shuvalov, The study of the primary photoprocesses in photosystem I of chloroplasts. Recombination luminescence, chlorophyll triplet state and triplet–triplet annihilation, Biochim. Biophys. Acta 430 (1976) 113–121.

[105] N.W.T.Woodbury,W.W. Parson, Nanosecond fluorescence from isolated photosynthetic reaction centers of Rhodopseudomonas sphaeroides, Biochim. Biophys. Acta 767 (1984) 345–361.

[106] F.A.M. Kleinherenbrink, G. Hastings, B.P. Wittmershaus, R.E. Blankenship, Delayed fluorescence from Fe–S type photosynthetic reaction centers at low redox potential, Biochemistry 33 (1994) 3096–3105.

[107] R.C. Prince, J.S. Leigh Jr., P.L. Dutton, Thermodynamic properties of the reaction center of Rhodopseudomonas viridis. In vivo measurement of the reaction center bacteriochlorophyll-primary acceptor intermediary electron carrier, Biochim. Biophys. Acta 440 (1976) 622–636.

[108] C.A. Wraight, Photochem. Photobiol. 30 (1979) 767–776.

[109] G.N. Johnson, A.W. Rutherford, A. Krieger, A change in the midpoint potential of the quinone Q(a) in photosystem II associated with photoactivation of oxygen evolution, Biochim. Biophys. Acta 1229 (1995) 202–207.

[110] A. Krieger, A.W. Rutherford, G.N. Johnson, On the determination of redox midpoint potential of the primary quinone electron-acceptor, Q(a), in Photosystem II, Biochim. Biophys. Acta 1229 (1995) 193–201.

[111] G. Alegria, P.L. Dutton, Langmuir-blodgett monolayer films of bacterial photosynthetic membranes and isolated reaction centers—Preparation, spectrophotometric and electrochemical characterization 1, Biochim. Biophys. Acta 1057 (1991) 239–257.

[112] K. Brettel, Electron transfer and arrangement of the redox cofactors in photosystem I, Biochim. Biophys. Acta 1318 (1997) 322–373.

[113] H.H. Robinson, A.R. Crofts, Kinetics of the oxidation-reduction reactions of the photosystem II quinone acceptor complex, and the pathway for deactivation, FEBS Lett. 153 (1983) 221–226.

[114] S.K. Chamorovsky, R. Cammack, Direct determination of the midpoint potential of the acceptor-X in chloroplast photosystem—I by electrochemical reduction and electron-spin-resonance spectroscopy, Photobiochem. Photobiophys. 4 (1982) 195–200.

[115] I. Vass, S. Styring, Ph-dependent charge equilibria between tyrosine-D and the S-states in photosystem. 2. Estimation of relative midpoint redox potentials, Biochemistry 30 (1991) 830–839.

[116] R. Edge, E.J. Land, D.J. McGarvey, M. Burke, T.G. Truscott, The reduction potential of the beta-carotene+·/beta-carotene couple in an aqueous micro-heterogeneous environment, FEBS Lett. 471 (2000) 125–127.

[117] D.H. Stewart, G.W. Brudvig, Cytochrome b(559) of photosystem II, Biochim. Biophys. Acta 1367 (1998) 63–87.

[118] W.A. Cramer, J. Whitmarsh, Photosynthetic cytochromes, Annu. Rev Plant Physiol. 28 (1977) 133–172.

[119] H. Ishikita, E.W. Knapp, Redox potentials of chlorophylls and betacarotene betacarotene in the antenna complexes of photosystem, J. Am. Chem. Soc. 127 (2005) 1963–1968.

[120] M. Roncel, A. Boussac, J.L. Zurita, H. Bottin, M. Sugiura, D. Kirilovsky, J.M. Ortega, Redox properties of the photosystem II cytochromes b559 and c550 in the cyanobacterium Thermosynechococcus elongatus, J. Biol. Inorg. Chem. 8 (2003) 206–216.