APPENDIXES

Appendix A

The rate equations of the model of photosynthetic carbon metabolism. The subscripts of v_1, v_2 ……v_{131} correspond to the numbers in Fig. 1. The kinetic parameters in the rate equations are listed in Appendices C and D. See Appendix G for definitions of abbreviations.

$$v_1 = \frac{RuBP \times Wc \times \min(1, \frac{RuBP}{E_t})}{(RuBP + K_r(1 + \frac{PGA}{K_{I11}} + \frac{FBP}{K_{I12}} + \frac{SBP}{K_{I13}} + \frac{Pi}{K_{I14}} + \frac{NADPH}{K_{I15}}))}$$

$$W_C = \frac{V_{Cmax} \times CO_2}{CO_2 + K_{M11}(1 + \frac{O_2}{K_{M12}})}$$

$$v_2 = \frac{V_2 \times (PGA \times ATP - \frac{DPGA \times ADP}{K_{E2}})}{(PGA + K_{M21})(ATP + K_{M22}(1 + \frac{ADP}{K_{M23}}))}$$

$$v_3 = \frac{V_3 \times DPGA \times NADPH}{(DPGA + K_{M31})(NADPH + K_{M32})}$$

$$v_5 = \frac{V_5 \times (GAP \times DHAP - \frac{FBP}{K_{E5}})}{K_{M51}K_{M52}(1 + \frac{GAP}{K_{M51}} + \frac{DHAP}{K_{M52}} + \frac{FBP}{K_{M53}} + \frac{GAP \times DHAP}{K_{M51}K_{M52}})}$$

$$v_6 = \frac{V_6 \times (\mathrm{FBP} - \frac{\mathrm{F6P} \times \mathrm{Pi}}{K_{E6}})}{\mathrm{FBP} + K_{M61}(1 + \frac{\mathrm{F6P}}{K_{I61}} + \frac{\mathrm{Pi}}{K_{I62}})}$$

$$\mathrm{TEMP1} = \mathrm{Xu5P} \times (1 + \frac{\mathrm{E4P} \times \mathrm{Ri5P}}{\mathrm{Km71}}) + \mathrm{E4P} + \mathrm{Ri5P}$$

$$\mathrm{Den} = 1 + (1 + \frac{\mathrm{GAP}}{K_{M72}}) \times (\frac{\mathrm{F6P}}{K_{M104}} + \frac{\mathrm{S7P}}{K_{M103}}) + \frac{\mathrm{GAP}}{K_{M102}} + \frac{\mathrm{TEMP1}}{K_{M101}}$$

$$v_7 = \frac{V_7 \times (\mathrm{F6P} \times \mathrm{GAP} \times K_{E7} - \mathrm{Xu5P} \times \mathrm{E4P})}{(K_{M71} \times K_{M101} \times \mathrm{Den})}$$

$$v_8 = \frac{V_8 \times (\mathrm{DHAP} \times \mathrm{E4P} - \frac{\mathrm{SBP}}{K_{E8}})}{(\mathrm{E4P} + K_{M82})(\mathrm{DHAP} + K_{M81})}$$

$$v_9 = \frac{V_9 \times (\mathrm{SBP} - \frac{\mathrm{Pi} \times \mathrm{S7P}}{K_{E9}})}{\mathrm{SBP} + K_{M9}(1 + \frac{\mathrm{Pi}}{K_{I9}})}$$

$$v_{10} = \frac{V_{10} \times (\mathrm{GAP} \times \mathrm{S7P} \times K_{E10} - \mathrm{Ri5P} \times \mathrm{Xu5P})}{(K_{M71} \times K_{M101} \times \mathrm{Den})}$$

Alternate simplified equations for v_7 and v_{10} can also be used following Poolman et al (2000).

$$v_{13} = \frac{V_{13} \times (\mathrm{ATP} \times \mathrm{Ru5P} - \frac{\mathrm{ADP} \times \mathrm{RuBP}}{K_{E13}})}{(\mathrm{ATP} \times (1 + \frac{\mathrm{ADP}}{K_{I134}}) + K_{M132}(1 + \frac{\mathrm{ADP}}{K_{I135}}))(\mathrm{Ru5P} + K_{M131}(1 + \frac{\mathrm{GAP}}{K_{I131}} + \frac{\mathrm{RuBP}}{K_{I132}} + \frac{\mathrm{Pi}}{K_{I133}}))}$$

$$v_{16} = \frac{V_{16} \times (\mathrm{ADP} \times \mathrm{Pi} - \frac{\mathrm{ATP}}{K_{E13}})}{(\mathrm{ADP} + K_{M161})(\mathrm{Pi} + K_{M162})}$$

$$v_{23} = \frac{V_{23} \times \mathrm{G1P} \times \mathrm{ATP}}{(\mathrm{G1P} + K_{M231})((1 + \frac{\mathrm{ADP}}{K_{I23}})(\mathrm{ATP} + K_{M232}) + \frac{K_{M232} \times \mathrm{Pi}}{K_{A231} \times \mathrm{PGA} + K_{A232} \times \mathrm{F6P} + K_{A233} \times \mathrm{FBP}})}$$

$$N = 1 + (1 + \frac{K_{M313}}{P_{ext}})(\frac{\mathrm{Pi}}{K_{M312}} + \frac{\mathrm{PGA}}{K_{M32}} + \frac{\mathrm{GAP}}{K_{M33}} + \frac{\mathrm{DHAP}}{K_{M311}})$$

$$v_{31} = \frac{V_{31} \times \mathrm{DHAP}}{K_{M311} N}$$

$$v_{32} = \frac{V_{32} \times \mathrm{PGA}}{K_{M32} N}$$

$$v_{33} = \frac{V_{33} \times \mathrm{GAP}}{K_{M33} N}$$

$$\mathrm{v_{55}} = \frac{\mathrm{V_{55} \times (UTPc \times G1Pc - \dfrac{UDPGc \times OPOPc}{K_{E551}})}}{\mathrm{K_{m551}K_{m552}(1 + \dfrac{UTPc}{K_{m551}} + \dfrac{G1Pc}{K_{m552}} + \dfrac{UDPGc}{K_{m553}} + \dfrac{OPOPc}{K_{m554}} + \dfrac{UTPc \times G1Pc}{K_{m551}K_{m552}} + \dfrac{UDPGc \times OPOPc}{K_{m553}K_{m554}})}}$$

$$\mathrm{v_{56}} = \frac{\mathrm{V_{56} \times (F6Pc \times UDPGc - \dfrac{SUCPc \times UDPc}{K_{E56}})}}{\mathrm{(F6Pc + K_{m561}(1 + \dfrac{FBPc}{K_{I562}}))(UDPGc + K_{m562}(1 + \dfrac{UDPc}{K_{I561}})(1 + \dfrac{SUCPc}{K_{I563}})(1 + \dfrac{SUCc}{K_{I565}})(1 + \dfrac{Pic}{K_{I564}}))}}$$

$$\mathrm{v_{57}} = \frac{\mathrm{V_{57} \times (SUCPc - \dfrac{SUCc \times Pic}{K_{E57}})}}{\mathrm{SUCPc + K_{m571} \times (1 + \dfrac{SUCc}{K_{m572}})}}$$

$$\mathrm{v_{58}} = \frac{\mathrm{V_{58} \times F26BPc}}{\mathrm{K_{m581} \times (1 + \dfrac{F26BPc}{K_{m581}})(1 + \dfrac{Pic}{K_{I582}})(1 + \dfrac{F6Pc}{K_{I581}})}}$$

$$\mathrm{v_{59}} = \frac{\mathrm{V_{59} \times (ATPc \times F6Pc - \dfrac{ADPc \times F26BPc}{K_{E59}})}}{\mathrm{(F6Pc + K_{m593} \times (1 + \dfrac{F26BPc}{K_{m592}})(1 + \dfrac{DHAPc}{K_{I592}}))((ATPc + K_{m591} \times (1 + \dfrac{ADPc}{K_{I591}}))}}$$

$$\mathrm{v60} = \frac{\mathrm{V_{60} \times (ATPc \times UDPc - ADPc \times UTPc/KE60)}}{\mathrm{K_{m602}K_{m603} \times (1 + \dfrac{ATPc}{K_{m602}} + \dfrac{UDPc}{K_{m603}} + \dfrac{ATPc \times UDPc}{K_{m602} \times K_{m603}} + \dfrac{ADPc}{K_{m601}} + \dfrac{UTPc}{K_{m604}} + \dfrac{ADPc \times UTPc}{K_{m601}K_{m604}})}}$$

$$v_{111} = \frac{\mathrm{RuBP} \times W_o \times \min(1, \frac{\mathrm{RuBP}}{E_t})}{(\mathrm{RuBP} + K_r(1 + \frac{\mathrm{PGA}}{K_{I11}} + \frac{\mathrm{FBP}}{K_{I12}} + \frac{\mathrm{SBP}}{K_{I13}} + \frac{\mathrm{PI}}{K_{I14}} + \frac{\mathrm{NADPH}}{K_{I15}}))}$$

$$W_o = \frac{V_{111} \times O_2}{O_2 + K_o(1 + \frac{CO_2}{k_C})}$$

$$v_{112} = \frac{V_{112} \times \mathrm{PGCA}}{\mathrm{PGCA} + K_{m112}(1 + \mathrm{GCA}/K_{i1121})(1 + \mathrm{Pi}/K_{I1122})}$$

$$v_{113} = \frac{V_{113} \times (\mathrm{ATP} \times \mathrm{GCEA} - \frac{\mathrm{ADP} \times \mathrm{PGA}}{K_{E113}})}{(\mathrm{ATP} + Km_{1131}(1 + \frac{\mathrm{PGA}}{K_{i113}}))(\mathrm{GCEA} + K_{m1132})}$$

$$v_{121} = \frac{V_{121} \times \mathrm{GCAc}}{\mathrm{GCAc} + K_{m121}}$$

$$v_{122} = \frac{V_{122} \times (\mathrm{GOAc} \times \mathrm{SERc} - \frac{\mathrm{HPRc} \times \mathrm{GLYc}}{K_{E122}})}{(\mathrm{GOAc} + K_{m1221})(\mathrm{SERc} + K_{m1222}(1 + \frac{\mathrm{GLYc}}{K_{i1221}}))}$$

$$v_{123} = \frac{V_{123} \times (\mathrm{HPRc} \times \mathrm{NADHc} - \frac{\mathrm{NADc} \times \mathrm{Gcea}}{K_{E123}})}{\mathrm{HPRc} + K_{m1231}(1 + \mathrm{HPRc}/K_{I123})}$$

$$v_{124} = \frac{V_{124} \times (\mathrm{GOAc} \times \mathrm{GLUc} - \frac{\mathrm{KGc} \times \mathrm{GLYc}}{K_{E124}})}{(\mathrm{GOAc} + K_{m1241})(\mathrm{GLUc} + K_{m1242}(1 + \mathrm{GLYc}/K_{I124}))}$$

$$v_{131} = \frac{V_{131} \times \mathrm{GLYc}}{\mathrm{GLYc} + K_{m1311}(1 + \mathrm{SERc}/K_{I1311})}$$

1

$$v_{1in} = V_{1T}\frac{GCEAc}{GCEAc + K_{M1011}(1+\frac{GCAc}{K_{I1011}})}$$

$$v_{1out} = V_{1T}\frac{GCEA}{GCEA + K_{M1011}(1+\frac{GCA}{K_{I1011}})}$$

$$v_{2out} = V_{2T}\frac{GCA}{GCA + K_{M1012}(1+\frac{GCEA}{K_{I1012}})}$$

$$v_{2in} = V_{2T}\frac{GCAc}{GCAc + K_{M1012}(1+\frac{GCEAc}{K_{I1012}})}$$

$$T3P = GAP + DHAP$$

$$Pent = Ru5P + Ri5P + Xu5P$$

$$HexP = G6P + F6P + G1P$$

$$GAP = \frac{T3P}{1 + K_{e4}}$$

$$DHAP = \frac{K_{e3} \times T3P}{1 + K_{e4}}$$

$$G6P = \frac{HexP}{\frac{1}{K_{E21}} + K_{E22} + 1}$$

$$F6P = \frac{\frac{1}{KE21} \times HexP}{\frac{1}{K_{E21}} + K_{E22} + 1}$$

$$G1P = \frac{K_{E22} \times HexP}{\frac{1}{K_{E21}} + K_{E22} + 1}$$

$$Ru5P = \frac{Pent}{\frac{1}{K_{E11}} + \frac{1}{K_{E12}} + 1}$$

$$Ri5P = \frac{\frac{1}{K_{E11}} \times Pent}{\frac{1}{K_{E11}} + \frac{1}{K_{E12}} + 1}$$

$$Xu5P = \frac{\frac{1}{K_{E12}} \times Pent}{\frac{1}{K_{E11}} + \frac{1}{K_{E12}} + 1}$$

2

$$[CA] = [ADP] + [ATP]$$

$$[CN] = [NADP] + [NADPH]$$

$$\begin{aligned}[CP] = {} & [Pi] + [PGA] + 2[BPGA] + [GAP] + [DHAP] + 2[FBP] + [F6P] + [E4P] + 2[SBP] \\ & + [S7P] + [Xu5P] + [Ri5P] + [Ru5P] + 2[RuBP] + [G6P] + [G1P] + [ATP] + [PGCA]\end{aligned}$$

3

$$[CA_c] = [ADP_c] + [ATP_c]$$

$$[CP_c] = 2*([FBP_c] + [F26BP_c]) + [PGA_c] + [T3P_c] + [HexP_c] + [SUCP] + [UTP_c] + [ATP_c] + [Pi]$$

$$[CN_c] = [NAD_c] + [NADH_c]$$

$$[CU_c] = [UDP_c] + [UTP_c]$$

Appendix B

Differential equations to describe rates of change in each intermediate of carbon metabolism. See Appendix A for definition of v_1, v_2 ……v_{131}.

$$\frac{d[RuBP]}{dt} = v_{13} - v_1 - v_{111};$$

$$\frac{d[PGA]}{dt} = 2v_1 - v_2 - v_{32} + v_{111} + v_{113};$$

$$\frac{d[DPGA]}{dt} = v_2 - v_3;$$

$$\frac{d[T3P]}{dt} = v_3 - 2v_5 - v_7 - v_8 - v_{10} - v_{31} - v_{33};$$

$$\frac{d[FBP]}{dt} = v_5 - v_6;$$

$$\frac{d[E4P]}{dt} = v_7 - v_8;$$

$$\frac{d[S7P]}{dt} = v_9 - v_{10};$$

$$\frac{d[SBP]}{dt} = v_8 - v_9;$$

$$\frac{d[ATP]}{dt} = v_{16} - v_2 - v_{23} - v_{13} - v_{113};$$

$$\frac{d[HexP]}{dt} = v_6 - v_7 - v_{23};$$

$$\frac{d[PenP]}{dt} = v_7 + 2v_{10} - v_{13};$$

$$\frac{d[GOAc]}{dt} = v_{121} - {}_{122} - {}_{124}$$

$$\frac{d[SERc]}{dt} = v_{131} - v_{122}$$

$$\frac{d[GLYc]}{dt} = v_{122} + v_{124} - 2v_{131}$$

$$\frac{d[HPRc]}{dt} = v_{122} - v_{123}$$

$$\frac{d[GCEAc]}{dt} = v_{123} - v_{1in} + v_{1out}$$

$$\frac{d[GCEA]}{dt} = v_{1in} - v_{113} - v_{1out}$$

$$\frac{d[GCA]}{dt} = v_{112} - v_{2out} + v_{2in}$$

$$\frac{d[PGCA]}{dt} = v_{111} - v_{112}$$

$$\frac{d[GCAc]}{dt} = v_{2out} - v_{121} - v_{2in}$$

$$\frac{d[OPOPc]}{dt} = v_{55} - v_{61}$$

$$\frac{d[UTPc]}{dt} = v_{60} - v_{55}$$

$$\frac{d[SUCPc]}{dt} = v_{56} - v_{57}$$

$$\frac{d[SUCc]}{dt} = v_{57} - v_{62}$$

$$\frac{d[PGAc]}{dt} = v_{32} - v_{pga\_use}$$

$$\frac{d(T3Pc)}{dt} = v_{31} + v_{33} - 2v_{51}$$

$$\frac{d(FBPc)}{dt} = v_{51} - v_{52}$$

$$\frac{d[HexPc]}{dt} = v_{52} - v_{55} - v_{59} + v_{58} - v_{56}$$

$$\frac{d[F26BPc]}{dt} = v_{59} - v_{58}$$

$$\frac{d[UDPGc]}{dt} = v_{55} - v_{56}$$

$$\frac{d[ATPc]}{dt} = v_{atpf} - v_{59} - v_{60}$$

Appendix C

Kinetic parameters of the enzymes of the Calvin cycle, starch synthesis and triose phosphate export illustrated in Fig. 1.

Table C1

The Michaelis-Menten constants, inhibition constants and activation constants of the enzymes in the Calvin cycle, starch synthesis and triose phosphate export. The response coefficient of each parameter was calculated for the initial nitrogen distribution (See text).

RN[a]	Reaction	Par[b]	Value (mM)[c]	Description[d]	CC[e]	Reference
1	$RuBP+CO_2 \rightarrow 2PGA$	K_{M11}	0.0115	CO_2	-0.60	Jordan and Ogren (1981), Tcherkez *et al.* (Tcherkez et al., 2006)
1	$RuBP+CO_2 \rightarrow 2PGA$	K_{M12}	0.222	O_2	0.54	Jordan and Ogren (1981), von Caemmerer (2000)
1	$RuBP+CO_2 \rightarrow 2PGA$	K_{M13}	0.020	RuBP	-0.07	Farquhar (1979)
1	$RuBP+CO_2 \rightarrow 2PGA$	K_{I11}	0.84	PGA	8×10^{-4}	Badger and Lorimer (1981)
1	$RuBP+CO_2 \rightarrow 2PGA$	K_{I12}	0.04	FBP	1×10^{-3}	Badger and Lorimer (1981)
1	$RuBP+CO_2 \rightarrow 2PGA$	K_{I13}	0.075	SBP	0.02	Badger and Lorimer (1981)
1	$RuBP+CO_2 \rightarrow 2PGA$	K_{I14}	0.9	Pi	2×10^{-4}	Badger and Lorimer (1981)
1	$RuBP+CO_2 \rightarrow 2PGA$	K_{I15}	0.07	NADPH	0.004	Badger and Lorimer (1981)
2	$PGA+ATP \leftrightarrow ADP + DPGA$	K_{M21}	0.240	PGA	6×10^{-4}	Larsson-Raznikiewicz (1967), Kopkesecundo et al. (1990)
2	$PGA+ATP \leftrightarrow ADP + DPGA$	K_{M22}	0.390	ATP	2×10^{-3}	Larsson-Raznikiewicz (1967), Kopkesecundo et al. (1990)
2	$PGA+ATP \leftrightarrow ADP + DPGA$	K_{M23}	0.23	ADP	-1×10^{-3}	Lee (1982)
2	$PGA+ATP \leftrightarrow ADP + DPGA$	K_{E2}	7.6×10^{-4}	Equ. Const.		Laisk *et al.* (1989); Dietz et al (1984); Heber et al (1986)
3	$DPGA+NADPH+H^+ \leftrightarrow GAP + Pi+NADP$	K_{M31}	0.004	BPGA	-5×10^{-5}	Trost et al. (1993)
3	$DPGA+NADPH +H^+ \leftrightarrow GAP + Pi+NADP$	K_{M32}	0.100	NADPH	-4×10^{-5}	Cerf (1978), Ferri et al (1978), Trost (1993), Macioszek and Anderson (1987)
4	$DHAP \leftrightarrow GAP$	K_{E4}	0.05	Equ. Const.	6×10^{-3}	Bassham and Krause (1969)
5	$GAP+DHAP \leftrightarrow FBP$	K_{M51}	0.3	GAP	-2×10^{-3}	Iwaki et al (1991)
5	$GAP+DHAP \leftrightarrow FBP$	K_{M52}	0.4	DHAP	-9×10^{-4}	Iwaki et al (1991)
5	$GAP+DHAP \leftrightarrow FBP$	K_{M53}	0.02	FBP	3×10^{-4}	Brooks and Criddle (1966), Schnarrenberger and Kruger (1986)
5	$GAP+DHAP \leftrightarrow FBP$	K_{E5}	7.1	Equ. Const.	5×10^{-5}	Bassham and Krause (1969), Iwaki et al (1991)
6	$FBP \rightarrow F6P+Pi$	K_{M61}	0.033	FBP	-2×10^{-3}	Charles and Halliwell (1981)
6	$FBP \rightarrow F6P+Pi$	K_{I61}	0.7	F6P	4×10^{-4}	Heldt (1983)
6	$FBP \rightarrow F6P+Pi$	K_{I62}	12	Pi	1×10^{-5}	Charles and Halliwell (1981)
6	$FBP \rightarrow F6P+Pi$	K_{E6}	6.7×10^{5}	Equ	4×10^{-9}	Bassham and Krause (1969) , Laisk *et al.*(1989)

				Const.		
7	F6P+GAP→E4P+Xu5P	K_{M71}	0.1	Xu5P	4×10^{-4}	Murphy and Walker (1982), Laisk *et al* (1989)
7	F6P+GAP→E4P+Xu5P	K_{M72}	0.1	GAP	2×10^{-3}	Sprenger et al (1995), Schenk et al (1998)
7	F6P+GAP→E4P+Xu5P	K_{E7}	10	Equ. Const.	9×10^{-4}	Bassham and Krause (1969), Laisk *et al.*(1989)
8	E4P+DHAP→SBP	K_{M8}	0.02	SBP	0	Brooks and Criddle (1966)
8	E4P+DHAP→SBP	K_{M81}	0.4	DHAP	-3×10^{-4}	Iwaki et al (1991)
8	E4P+DHAP→SBP	K_{M82}	0.2	E4P	-6×10^{-4}	Estimate
8	E4P+DHAP→SBP	K_{E8}	1.07	Equ. Const.	4×10^{-34}	Bassham and Krause (1969) , Laisk *et al.*(1989)
9	SBP→S7P+Pi	K_{M9}	0.05	SBP	-0.03	Woodrow et al (1983), Cadet and Meunier (1988)
9	SBP→S7P+Pi	K_{I9}	12	Pi	3×10^{-4}	Woodrow et al(1983)
9	SBP→S7P+Pi	K_{E9}	6.7×10^{5}	Equ. Const.	4×10^{-8}	Bassham and Krause (1969), Laisk *et al.*(1989)
10	S7P+GAP→Ri5P+Xu5P	K_{M101}	0.118	P5P	2×10^{-4}	Racher (1961), Laisk *et al* (1989)
10	S7P+GAP→Ri5P+Xu5P	K_{M102}	0.072	GAP	-4×10^{-4}	Albe (1991); Laisk *et al* (1989)
10	S7P+GAP→Ri5P+Xu5P	K_{M103}	0.46	S7P	-5×10^{-4}	Albe (1991); Laisk *et al* (1989)
10	S7P+GAP→Ri5P+Xu5P	K_{M104}	1.54	F6P	3×10^{-5}	Albe (1991); Laisk *et al* (1989)
10	S7P+GAP→Ri5P+Xu5P	K_{E10}	1.17	Equ. Const.	8×10^{-4}	Bassham and Krause (1969), Laisk *et al.*(1989)
11	Ri5P↔Ru5P	K_{E11}	0.4	Equ. Const.	2×10^{-3}	Bassham and Krause (1969)
12	Xu5P↔Ru5P	K_{E12}	0.67	Equ. Const.	3×10^{-3}	Bassham and Krause, (1969)
13	Ru5P+ATP→RuBP+ADP	K_{M131}	0.05	Ru5P	-4×10^{-3}	Gardemann et al (1983), Omnaas et al (1985)
13	Ru5P+ATP→RuBP+ADP	K_{M132}	0.059	ATP	-2×10^{-3}	Laing et al (1981), Gardemann et al (1983), Omnaas et al (1985)
13	Ru5P+ATP→RuBP+ADP	K_{I131}	2	PGA	2×10^{-4}	Gardemann et al (1983)
13	Ru5P+ATP→RuBP+ADP	K_{I132}	0.7	RuBP	4×10^{-3}	Gardemann et al (1983)
13	Ru5P+ATP→RuBP+ADP	K_{I133}	4	Pi	2×10^{-5}	Gardemann et al (1983)
13	Ru5P+ATP→RuBP+ADP	K_{I134}	2.5	ADP	1×10^{-3}	Gardemann et al (1983)
13	Ru5P+ATP→RuBP+ADP	K_{E13}	0.4	ADP	2×10^{-4}	Gardemann et al (1983)
13	Ru5P+ATP→RuBP+ADP	K_{I135}	6846	Equ. Const.	2×10^{-3}	Bassham and Krause (1969), Laisk *et al.*(1989)
16	ADP+Pi→ATP	K_{M161}	0.014	ADP	-1×10^{-5}	Davenport and Mccarty (1986)
16	ADP+Pi→ATP	K_{M162}	0.3	Pi	-6×10^{-4}	Aflalo and Shavit (1983)
16	ADP+Pi→ATP	K_{M163}	0.3	ATP	5×10^{-6}	r.f. Laisk *et al.* (1989)
16	ADP+Pi→ATP	K_{E16}	5.7	Equ. Const.	0	Bassham and Krause (1969), Laisk *et al.*(1989)
21	F6P↔G6P	K_{E21}	2.3	Equ. Const.	-2×10^{-3}	Bassham and Krause (1969)
22	G6P↔G1P	K_{E22}	0.058	Equ. Const.	-5×10^{-5}	Colowick and Sutherland (1942)
23	G1P+ATP+Gn→PPi+ADP+ G_{n+1}	K_{M231}	0.08	G1P	-6×10^{-5}	Pettersson and Ryde-Pettersson (1988)
23	G1P+ATP+Gn→PPi+ADP+	K_{M232}	0.08	ATP	-4×10^{-5}	Pettersson and Ryde-Pettersson (1988)

	G_{n+1}					
23	$G1P+ATP+Gn \rightarrow PPi+ADP+G_{n+1}$	K_{A231}	0.1	PGA	2×10^{-5}	Pettersson and Ryde-Pettersson (1988)
23	$G1P+ATP+Gn \rightarrow PPi+ADP+G_{n+1}$	K_{A232}	0.02	F6P	2×10^{-6}	Pettersson and Ryde-Pettersson (1988)
23	$G1P+ATP+Gn \rightarrow PPi+ADP+G_{n+1}$	K_{A233}	0.02	FBP	3×10^{-7}	Pettersson and Ryde-Pettersson (1988)
23	$G1P+ATP+Gn \rightarrow PPi+ADP+G_{n+1}$	K_{I23}	10	ADP	7×10^{-6}	Pettersson and Ryde-Pettersson (1988)
31	$P_{ext}+DHAP_i \rightarrow Pi+DHAP_o$	K_{M311}	0.077	DHAP	-6×10^{-5}	Fliege et al (1978), Portis Jr. (1983)
31	$P_{ext}+DHAP_i \rightarrow Pi+DHAP_o$	K_{M312}	0.63	Pi	1×10^{-5}	Fliege et al (1978), Portis Jr. (1983)
31	$P_{ext}+DHAP_i \rightarrow Pi+DHAP_o$	K_{M313}	0.74	P_{ext}	-4×10^{-4}	Fliege et al (1978), Portis Jr. (1983)
32	$P_{ext}+PGA_i \rightarrow Pi+PGA_o$	K_{M32}	0.25	PGA	-9×10^{-6}	Fliege et al (1978), Portis Jr. (1983)
33	$P_{ext}+GAP_i \rightarrow Pi+GAP_o$	K_{M33}	0.075	GAP	-3×10^{-6}	Fliege et al (1978), Portis Jr. (1983)

[a] RN: Reaction number corresponding to the number in Fig. 1.

[b] Parameters beginning K_M represent the Michaelis-Menten constant of the metabolite listed in the *description* column
Parameters beginning with K_I represent the inhibition constant of the inhibitor listed in the *description* column.
Parameters beginning with K_A represent the activation constant of the activator listed in the *description* column.

[c] The units of the equilibrium constant are mM (which is equivalent to mmol l^{-1}) for all constants, except K_e. The unit of K_e for reactions with one substrate and one product, or reactions with two substrates and two products is dimensionless. The unit of K_e for reactions with one substrate and two products is mM. The unit for reactions with two substrates and one product is $(mM)^{-1}$.

[d] The description column lists the compounds to which the kinetic constant applies.

[e] Response coefficients for different parameters used in the model

Table C2

The maximum rate of each enzyme (V_m) normalized on maximum Rubisco carboxylation activity (V_1)

Maximum Velocity	Enzyme	Reaction	V_m/V_1	Reference
V_1	Rubisco	$RuBP+CO_2 \rightarrow 2PGA$	1	Latzko et al (1981), Woodrow (1986), Geiger et al. (1999), Haake et al.(1999), Chen et al. (2005), Strand et al. (2000), Strand et al (1999), Tamoi et al (2006), Peterkofsky and Racher (1961), Chen et al (2005)
V_2	PGA Kinase	$PGA+ATP \rightarrow ADP + DPGA$	10.3	Same as above
V_3	GAP dehydragenase	$DPGA+NADPH \rightarrow GAP + Pi+NADP$	1.39	Same as above
V_5	FBP Aldolase	$GAP+DHAP \rightarrow FBP$	0.42	Same as above
V_6	FBPase	$FBP \rightarrow F6P+Pi$	0.25	Same as above
V_7	Transketolase	$F6P+GAP \rightarrow E4P+Xu5P$	1.07	Same as above
V_8	Aldolase	$E4P+DHAP \rightarrow SBP$	0.42	Same as above
V_9	SBPase	$SBP \rightarrow S7P+Pi$	0.11	Same as above
V_{10}	Transketolase	$S7P+GAP \rightarrow Ri5P+Xu5P$	1.07	Same as above
V_{13}	Ribulosebiphosphate kinase	$Ru5P+ATP \rightarrow RuBP+ADP$	3.71	Same as above
V_{16}	ATP synthase	$ADP+Pi \rightarrow ATP$	5.5	Same as above
V_{23}	ADP-glucose pyrophosphorylase and Starch Synthase	$ADPG+G_n \rightarrow G_{(n+1)}+ADP$	0.1	Same as above
V_{31}	Phosphate translocator	$DHAP_i \rightarrow DHAP_o$	0.3	Lilley et al (1977)
V_{32}	Phosphate translocator	$PGA_i \rightarrow PGA_o$	0.3	Lilley et al (1977)
V_{33}	Phosphate translocator	$GAP_i \rightarrow GAP_o$	0.3	Lilley et al (1977)

Table C3 The concentrations of the metabolites used in the model. The range of values found in the literature are given in the adjacent column, together with their source.

Metabolite name	Model default (mmol l^{-1})	Concentration range (mmol l^{-1})	Reference
RuBP	2.000	0.6-6	Bassham and Krause (1969), Dietz and Heber (1984), Schimkat et al (1990), Woodrow and Mott (1993)
PGA	2.400	1.4-12	Schimkat et al (1990), Woodrow and Mott (1993)
DPGA	0.0011	0.8-1.4	Dietz and Heber (1984), Woodrow and Mott (1993)
GAP	0.02	0.032-0.04	Bassham and Krause (1969), Dietz and Heber (1984), Woodrow and Mott (1993)
DHAP	0.48	0.37-0.7	Bassham and Krause (1969), Dietz and Heber (1984), Schimkat et al (1990)
FBP	0.670	0.067-0.52	Bassham and Krause (1969), Dietz and Heber (1984), Schimkat et al (1990), Woodrow and Mott (1993)
E4P	0.050	0.02-0.05	Bassham and Krause (1969), Woodrow and Mott (1993)
S7P	2.0	0.248- 0.4	Bassham and Krause (1969), Woodrow and Mott (1993)
SBP	0.30	0.114-0.3	Bassham and Krause (1969), Schimkat et al (1990), Woodrow and Mott (1993)
ATP	0.68	0.2-2.5	Bassham and Krause (1969), Woodrow and Mott (1993), Igamberdiev et al (2001)
NADPH	0.21	0.21	Giersch et al (1980), Woodrow and Mott (1993)
CO_2	0.012	0.006	Dietz and Heber (1984)
O_2	0.26	0.25	Model estimate
HexP	2.2	3.2-4.85	Schimkat et al (1990), Woodrow and Mott (1993), Winter et al (1994)
PenP	0.25	0.05-0.3	Bassham and Krause (1969), Schimkat et al (1990), Woodrow and Mott (1993)
Pi	5	4-10	Dietz and Heber (1984), Schimkat et al (1990), Woodrow and Mott (1993)
CP	15	15	Lilley et al (1977)
CA	1.5	1.5	Igamberdiev et al (2001)
CN	0.5	0.5	Giersch et al (1980)
P_{ext}	0.5	5	Bligny et al (1990), Woodrow and Mott (1993)

Appendix D

Kinetic parameters of the enzymes of photorespiration (PCOP). The source of each value is given in the final column.

Table D1

The Michaelis-Menten constants and inhibition constants for enzymes in PCOP

RN[a]	Reaction	Param.[b]	Value (mM)[c]	Description[d]	CC[e]	Reference
112	$2\text{-}PGCA + H_2O \rightarrow GCA + Pi$	K_{M112}	0.026	PGCA	-5×10^{-7}	Christeller and Tolbert (1978)
112	$2\text{-}PGCA + H_2O \rightarrow GCA + Pi$	K_{I1121}	94	GCA, competitive with PGCA	5×10^{-9}	Christeller and Tolbert (1978)
112	$2\text{-}PGCA + H_2O \rightarrow GCA + Pi$	K_{I1122}	2.55	Pi, competitive with PGCA	7×10^{-9}	Christeller and Tolbert (1978)
113	$GCEA + ATP \rightarrow PGA + ADP$	K_{M1131}	0.21	ATP	1×10^{-8}	Kleczkowski et al (1985)
113	$GCEA + ATP \rightarrow PGA + ADP$	K_{M1132}	0.25	GCEA	-3×10^{-10}	Kleczkowski et al (1985)
113	$GCEA + ATP \rightarrow PGA + ADP$	K_{I113}	0.36	PGA, competitive with ATP	-2×10^{-8}	Kleczkowski and Randall (1988)
113	$GCEA + ATP \rightarrow PGA + ADP$	K_{E113}	300	Equil. Const.	6×10^{-8}	Kleczkowski et al (1985)
121	$GCA_C + 0_2 \rightarrow H_2O_2 + GOAc$	K_{M121}	0.1	GCAc	-8×10^{-9}	Tolbert (1981)
122	$GOAc + SERc \rightarrow HPRc + GLYc$	K_{M1221}	0.15	GOAc	-1×10^{-8}	Nakamura and Tolbert (1983)
122	$GOAc + SERc \rightarrow HPRc + GLYc$	K_{M1222}	2.7	SERc	4×10^{-12}	Nakamura and Tolbert (1983)
122	$GOAc + SERc \rightarrow HPRc + GLYc$	K_{I1221}	33	GLYc, competitive with SERc	2×10^{-14}	Nakamura and Tolbert (1983)
122	$GOAc + SERc \rightarrow HPRc + GLYc$	K_{E122}	0.24	Equil. Const.	-2×10^{-8}	Guynn (1982)
123	$HPRc + NADc \rightarrow NADHc + GCEAc$	K_{M123}	0.09	HPRc	-2×10^{-11}	Kleczkowski and Edwards (1989)
123	$HPRc + NADc \rightarrow NADHc + GCEAc$	K_{I123}	12	HPRc, self inibition	-1.5×10^{-9}	Kleczkowski and Edwards (1989)
123	$HPRc + NADc \rightarrow NADHc + GCEAc$	K_{E123}	2.5×10^{5}	Equil. Const.	-6×10^{-10}	Guynn (1982)
124	$GOAc + GLUc \rightarrow KGc + GLYc$	K_{M1241}	0.15	GOAc	1×10^{-7}	Nakamura and Tolbert (1983)
124	$GOAc + GLUc \rightarrow KGc + GLYc$	K_{M1242}	1.7	GLUc	-2×10^{-8}	Nakamura and Tolbert (1983)
124	$GOAc + GLUc \rightarrow KGc + GLYc$	K_{I124}	2	GLYc competitive	-2×10^{-13}	Calibrated

				with GLU		
124	GOAc + GLUc→ KGc + GLYc	K_{E124}	607	Equi. Const.	-3×10^{-14}	Cooper and Meister (1972)
131	GLYc + NADc→ CO2 + NH3 + SERc +NADHc	K_{M1311}	6	GLYc	-2×10^{-13}	Douce et al (2001)
131	GLYc + NADc → CO2 + NH3 + SERc +NADHc	K_{I1311}	4	SERc, competitive with GLYc	6×10^{-9}	Douce et al (2001)
101a	GCEAc → GCEA	K_{M1011}	0.39	GCEA	-4×10^{-8}	Howitz and McCarty (1986)
101a	GCEAc→GCEA	K_{I1011}	0.28	GCA, competitive with GCEA	-2×10^{-11}	Howitz and McCarty (1986)
101b	GCA→GCAc	K_{M1012}	0.2	GCA	-4×10^{-9}	Howitz and McCarty (1985)
101b	GCA→GCAc	K_{I1012}	0.22	GCEA, competitive with GCA	-1×10^{-10}	Howitz and McCarty (1985)

[a b c d e] The description is same as in the Table C1.

Table D2 The maximum rate of each enzyme (V_m) of the PCOP as given in Table 1, but here normalized on the maximum Rubisco carboxylation activity (V_1).

Max. Velocity	Enzyme name	Reaction	V_m/V_1	Reference
V_{111}	Rubisco	RuBP + O_2 → PGA + PGCA	0.24	Ueno et al (2005); Marek and Sspalding (1991); Ku et al (1991), Devi and Raghavendra (1993), Devi et al. (Devi et al., 1995)
V_{112}	Phosphoglycolate phosphatase	2-PGCA +H_2O → GCA + Pi	18.0	Same as above
V_{113}	Glycerate kinase	GCEA + ATP → PGA + ADP	1.96	Same as above
V_{121}	Glycolate oxidase	GCA_C+0_2 → H_2O_2+GOAc	0.45	Same as above
V_{122}	Serine glyoxylate aminotransferase	GOAc +SERc → HPRc + GLYc	1.13	Same as above
V_{123}	NADH-hydroxypyruvate reductase	HPRc + NADc → NADHc + GCEAc	3.44	Same as above
V_{124}	Glutamate glyoxylate aminotransferase (GGAT)	GOAc + GLUc → KGc + GLYc	0.94	Same as above
V_{131}	Glycine decarboxylase	GLYc + NADc → CO_2 + NH3 + SERc +NADHc	0.86	Same as above
V_{1T}	Glycerate/glycolate transporter	GCEAc ↔ GCEA	0.4	Howitz and McCarty (1986)
V_{2T}	Glycerate/glycolate transporter	GCAc ↔ GCA	0.4	Howitz and McCarty (1985)

[a] **see table C2**

Table D3

The concentrations of the metabolites of photorespiration (PCOP). The range of values found in the literature are given in the adjacent column, together with their source.

Metabolite	Locat-ion[a]	Concentration (mM)	Assumptions	Reference
NADH	Chl	0.22	This was kept constant in the preliminary model	Igamberdiev et al (2001)
NADHc	Cyto	0.47	As for NADH	Igamberdiev et al (2001)
NAD	Chl	0.08	As for NADH	Igamberdiev et al (2001)
NADc	Cyt	0.02	As for NADH	Igamberdiev et al (2001)
ATP	Chl	0.68		Igamberdiev et al (2001)
ATPc	Cyt	0.36	As for NADH	Igamberdiev et al (2001)
ADP	Chl	0.82		Igamberdiev et al (2001)
ADPc	Cyt	0.64	As for NADH	Igamberdiev et al (2001)
GLUc	Cyt	24	As for NADH	Winter et al (1993)
KGc	Cyt	0.4	As for NADH	Winter et al (1993)
Pic	Chl	5	As for NADH	Pieters et al (2001)
SERc	Cyt	7.5		Winter et al (1993)
GLYc	Cyt	1.8		Winter et al (1993)
PGA	Chl	4.3		Winter et al(1994)
GOAc	Cyt	0.028	30 µl cytosol per mg chlorophyll	Winter et al (1993), Wingler et al (1997)
GCA	Chl	0.36		Coombs and Whittingham (1966)
GCAc	Cyt	0.36		Coombs and Whittingham (1966)
PGCA	Chl	0.003	Based on the Michaelis-Menton equation for reaction 112 [b]	
HPRc	Cyt	0.004	Based on the Michaelis-Menton equation for reaction 123 [b]	
GCEA	Chl	0.18	Based on the Michaelis-Menton equation for reaction 113 [b]	
GCEAc	Cyt	0.18	Assume equilibrium with stromal Glycerate concentration	

Comment: [a] Chl: chloroplast stroma; Mit: Mitochondrion; Cyt: Cytosol;

Appendix E

Kinetic parameters of enzymes in the metabolic pathway leading to sucrose synthesis in the cytosol.

Table E1

The Michaelis-Menten constants and inhibition constants for enzymes in the metabolic pathway leading to sucrose synthesis in the cytosol.

RN[a]	Reaction	Param[b]	Value (mmol l^{-1})[d]	Descri-ption[c]	CC[e]	Literature
51	DHAPc + PGAc ↔ FBPc	K_{m511}	.020	FBPc	4×10^{-6}	Anderson et al. (1975)
51	DHAPc + PGAc ↔ FBPc	K_{m512}	.300	GAPc	-4×10^{-6}	Iwaki et al. (1991)
51	DHAPc + PGAc ↔ FBPc	K_{m513}	.400	DHAPc	-4×10^{-6}	Iwaki et al. (1991)
51	DHAPc + PGAc ↔ FBPc	K_{m514}	.014	SBPc	0	Harris and Koniger (1997)
51	DHAPc + PGAc ↔ FBPc	K_{E51}	12		2×10^{-6}	Thomas et al. (1997)
52	FBPc ↔ F6Pc + Pic	K_{m521}	.0025	FBPc	-8×10^{-5}	Jang et al. (2003)
52	FBPc ↔ F6Pc + Pic	K_{I521}	.7	F6Pc	4×10^{-5}	Heldt et al. (1983)
52	FBPc ↔ F6Pc + Pic	K_{I522}	12	Pic	2×10^{-5}	Charles & Halliwell (1981)
52	FBPc ↔ F6Pc + Pic	K_{I523}	$7*10^{-5}$	F26BPc	8×10^{-5}	Jang et al. (2003)
52	FBPc ↔ F6Pc + Pic	K_{E52}	6663		4×10^{-8}	Bassham and Krause (1969)
55	G1Pc + UTPc↔GDPc +UDPGc	K_{m551}	.14	G1Pc	-1×10^{-7}	Nakano et al. (1989)
55	G1Pc + UTPc↔GDPc +UDPGc	K_{m552}	.1	UTPc	-1×10^{-7}	Nakano et al. (1989)
55	G1Pc + UTPc↔GDPc +UDPGc	K_{m553}	.11	OPOPc	6×10^{-8}	Nakano et al. (1989)
55	G1Pc + UTPc↔GDPc+UDPGc	K_{m554}	.12	UDPGc	7×10^{-8}	Nakano et al. (1989)
55	G1Pc + UTPc↔ GDPc+UDPGc	K_{E55}	0.31	Equi	1×10^{-4}	Lunn and Rees (1990)
56	UDPGc + F6Pc ↔ SUCPc + UDPc	K_{m561}	0.8	F6Pc	-8×10^{-5}	Lunn and Rees (1990)
56	UDPGc + F6Pc ↔ SUCPc + UDPc	K_{m562}	2.4	UDPGc	-1×10^{-4}	Lunn and Rees (1990)
56	UDPGc + F6Pc ↔ SUCPc + UDPc	K_{I561}	.7	UDPc	1×10^{-4}	Harbron et al. (1981)
56	UDPGc + F6Pc ↔ SUCPc + UDPc	K_{I562}	.8	FBPc	5×10^{-5}	Harbron et al. (1981)
56	UDPGc + F6Pc ↔ SUCPc + UDPc	K_{I563}	0.4	SUCPc	3×10^{-5}	Harbron et al. (1981)
56	UDPGc + F6Pc ↔ SUCPc + UDPc	K_{I564}	11	Pic	3×10^{-5}	Harbron et al. (1981)
56	UDPGc + F6Pc ↔ SUCPc + UDPc	K_{I565}	50	Sucrose	2×10^{-7}	Salermo and Pontis (1978)
56	UDPGc + F6Pc ↔ SUCPc +	K_{E56}	10	Equl.	4×10^{-6}	Lunn and Rees (1990)

	UDPc			Const.		
57	SUCPc ↔ Pic + SUCc	K_{m571}	.35	SUCPc	-2×10^{-5}	Whitaker (1984)
57	SUCPc ↔ Pic + SUCc	K_{i572}	80	SUCc	3×10^{-8}	Whitaker (1984)
57	SUCPc ↔ Pic + SUCc	K_{E57}	780	Equil. Const.	3×10^{-7}	Lunn and Rees (1990)
58	F26BPc ↔ F6Pc + Pic	K_{m581}	.032	F26BPc	-9×10^{-6}	Macdonald et al. (1989)
58	F26BPc ↔ F6Pc + Pic	K_{I581}	.1	F6Pc	8×10^{-5}	Villadsen and Nielsen (2001)
58	F26BPc ↔ F6Pc + Pic	K_{I582}	.5	Pic	8×10^{-5}	Villadsen and Nielsen (2001)
59	F6Pc + ATPc ↔ F26BPc + ADPc	K_{m591}	0.5	ATPc	8×10^{-5}	Walker and Huber (Walker and Huber, 1987)
59	F6Pc + ATPc ↔ F26BPc + ADPc	K_{m592}	.021	F26BPc	-7×10^{-4}	Garcia de Frutos and Baanante (1995)
59	F6Pc + ATPc ↔ F26BPc + ADPc	K_{m593}	0.5	F6Pc	8×10^{-5}	Walker and Huber (1987)
59	F6Pc + ATPc ↔ F26BPc + ADPc	K_{I591}	.16	ADPc	-6×10^{-5}	Kretschmer and Hofmann (1984)
59	F6Pc + ATPc ↔ F26BPc + ADPc	K_{I592}	0.7	DHAPc	-1×10^{-5}	Markham and Kruger (2002)
59	F6Pc + ATPc ↔ F26BPc + ADPc	K_{E59}	590		-1×10^{-7}	Cornish-Bowden (1997)
60	F6Pc + ATPc ↔ F26BPc + ADPc	K_{m601}	0.042	ADPc	NA	Kimura and Shimada (1988)
60	F6Pc + ATPc ↔ F26BPc + ADPc	K_{m602}	1.66	ATPc	NA	Kimura and Shimada (1988)
60	F6Pc + ATPc ↔ F26BPc + ADPc	K_{m603}	0.28	UDPc	NA	Jong and Ma (1991)
60	F6Pc + ATPc ↔ F26BPc + ADPc	K_{m604}	16	UTPc	NA	Fukuchi et al (1994)
60	F6Pc + ATPc ↔ F26BPc + ADPc	K_{E60}	16	Equili.	NA	Lynn and Guynn (1978)
61	SUCPc ↔ SUCc + Pic	K_{E61}	$1.2*10^{7}$	Equili.	-4×10^{-3}	Flodgaard and Fleron (1974)
62	SUCc ↔ Sink	K_{m621}	5	Sucrose	-5×10^{-7}	Weschke et al. (2000)

[a b c d e] The description is same as in the Table C1.

Table E2

The maximum rate of each enzyme (V_m) as given in Table 1 for enzymes in the metabolic pathway leading to sucrose synthesis, but here normalized on the maximum Rubisco carboxylation activity (V_1).

Maximum Velocity	Reaction	V_m/V_1	Reference
V_{51}	DHAPc + PGAc ↔ FBPc	0.037	Chen et al (2005), Strand et al. (2000), Strand et al (1999), Chen et al. (2005)
V_{52}	FBPc ↔ F6Pc + Pic	0.022	Same as above
V_{55}	G1Pc + UTPc ↔ GDPc + UDPGc	0.040	Same as above
V_{56}	UDPGc + F6Pc ↔ SUCPc + UDPc	0.019	Same as above
V_{57}	SUCPc ↔ Pic + SUCc	0.19	Same as above
V_{58}	F26BPc ↔ F6Pc + Pic	0.007	Same as above
V_{59}	F6Pc + ATPc ↔ F26BPc + ADPc	0.002	Villadsen and Nielsen (2001)
V_{60}	ATPc + UDPc ↔ UTPc + ADPc	1	Villadsen and Nielsen (2001)

[a] **see Table C2**

Table E3

The concentrations of metabolites in the metabolic pathway leading to sucrose synthesis in the cytosol.

Metabolite	Location[a]	Concentration (mmol l^{-1})	Reference
TPc	Cyt	2.3	Stitt et al. (1980), Stitt et al. (1985), Gerhardt et al. (1987), Laisk et al. (1989)
FBPc	Cyt	2	As above
F26BPc	Cyt	7×10^{-6}	As above
UTc	Cyt	1	As above
HexPc	Cyt	6	As above
UDPG	Cyt	0.6	As above
PTc	Cyt	15	As above
ATc	Cyt	1	As above

Comment: [a] Chl: chloroplast stroma; Mit: Mitochondrion; Cyt: Cytosol;

Appendix F

Molecular weight and catalytic number of the enzymes in photosynthetic carbon metabolism

Enzyme Name	EC	Molecular Weight (D)	Catalytic number[1] (s^{-1})	Reference
Rubisco	4.1.1.39	588000	2[*]	Spreitzer and Salvucci (2002)
PGA Kinase	2.7.2.3	45000	540	Fifis and Scopes (1978), Bentahir et al (2000)
GAP Dehydrogenase	1.2.1.12	180000	50	Speranza and Ferri (1982)
Aldolase	4.1.2.13	143000	65	Krueger and Sschnarrenberger (1983), Moorhead and Pplaxton (1990)
FBPase	3.1.3.11	160000	22.9	Tang et al. (2000), Reichert et al.(2000)
Transketolase	2.2.1.1	160000	69	Nilsson et al (1998) Teige et al. (1989)
SBPase	3.1.3.37	66000	81	Cadet et al. (1988), Cadet and Meunier (1987)
PRK	2.7.1.19	90000	615	Surek et al. (1985), Porter et al. (1986)
ADPG Pyrophosphorylase	2.7.7.27	210000	546	Kleczkowski et al. (1991), Li and Preiss(1992)
Phosphoglycolate phosphatase	3.1.3.18	100000	292	Kim et al. (2004), Kerr and Gear (1974)
Glycerate Kinase	2.7.1.31	47000	200	Kleczkowski et al. (1985), Kleczkowski and Randall (1988)
Glycolalate oxidase	1.1.1.79	125000	437	Kleczkowski et al. (1986), Zelitch(1955)
Serine Glyoxylate aminotransferase	2.6.1.45	85000	97	Ireland and Joy (1983; Paszkowski and Niedzielska, 1990)
Glycerate dehydrogenase	1.1.1.29	90000	1629	Julliard and Breton-Gilet (1997), Izumi et al.(1990)
Glutamate Glyoxylate aminotransferase	2.6.1.44	70800	54	Paszkowski and Niedzielska (1989)
Glycine decarboxylase	1.4.4.2	270000	18	Hiraga and Kikuchi (1980), Kochi and Kikuchi (1974)
6-phosphofructo-2-kinase	2.7.1.105	390000	9300	Villadsen and Nielsen (2001), Baez et al. (2003)
fructose-2,6-bisphosphate 2-phosphatase	3.1.3.46	390000	1550	Pilkis et al. (1987), Villadsen and Nielsen (2001),
UDP Glucose pyrophosphorylase	2.7.7.9	53000	400	Gustafson and Gander (1972), Sowokinos et al (1993)
Sucrose phosphate synthase	2.4.1.14	480000	640	Sonnewald et al. (1993)
Sucrose phosphatase	3.1.3.24	120000	2500	Echeverria and Salerno (1994), Lunn et al. (2000)

Appendix G: List of Abbreviations and their units

Abbreviation[a]	Full Name	Units
A	The photosynthetic CO$_2$ uptake rate	μmol m^{-2} s^{-1}
ADPG	ADP-glucose	mmol l^{-1}
ADPGPP	ADP glucose pyrophosphorylase	NA
ATc	Total ADP and ATP concentration in cytosol	mmol l^{-1}
ATPase	ATP synthase	NA[b]
[CO$_2$]	CO$_2$ concentration	μmol mol^{-1} or mmol l^{-1}
CA	Total adenylate nucleotide in the chloroplast stroma including ATP and ADP	mmol l^{-1}
CN	Total of NADP$^+$ and NADPH in chloroplast stroma	mmol l^{-1}
CP	The total concentration of phosphate in chloroplast stroma	mmol l^{-1}
DHAP	Dihydroxyacetone-phosphate	mmol l^{-1}
DPGA	1,3-bisphosphoglycerate	mmol l^{-1}
E4P	Erythrose 4-phosphate	mmol l^{-1}
E$_t$	Total Rubisco concentration	mmol l^{-1}
F6P	Fructose 6-phosphate	mmol l^{-1}
FBP	Fructose 1,6–bisphosphate	mmol l^{-1}
F26BP	Fructose 2,6–bisphosphate	mmol l^{-1}
G1P	Glucose 1-phosphate	mmol l^{-1}
G6P	Glucose 6-phosphate	mmol l^{-1}
GAP	Glyceraldehyde 3-phosphate	mmol l^{-1}
GAPDH	Glyceraldehyde 3-phosphate dehydogenase	NA
GCA	Glycollate	mmol l^{-1}
GCEA	Glycerate	mmol l^{-1}
GDC	Glycine decarboxylase	NA
GLUc	Glutamate	mmol l^{-1}
GLYc	Glycine in cytosol	mmol l^{-1}
GOA	Glyoxylate	mmol l^{-1}
HexP	Hexose phosphate, includes F6P, G6P, and G1P	NA
GGAT	Glycine glyoxylate aminotransferase	NA
GSAT	Glyoxylate serine aminotransferase	NA
HPR	Hydroxypyruvate	mmol l^{-1}
KGc	α-Ketoglutarate	mmol l^{-1}
ODE	Ordinary differential equation	NA
[O$_2$]	Oxygen concentration in atmosphere	mmol mol^{-1}
OPOP	Pyrophosphate	mmol l^{-1}
PCOP	Photosynthetic carbon oxidation pathway	NA
PCRC	Photosynthetic carbon reduction cycle	NA
PenP	Pentose phosphate including Ri5P, Ru5P, Xu5P	mmol l^{-1}
3-PGA	3-Phosphoglycerate	mmol l^{-1}
PGCA	3-Phosphoglycollate	mmol l^{-1}
PRK	Ribulose-5-phosphate kinase	NA
PGCA Pase	Phosphoglycollate phosphotase	NA

PGA Kinase	3-phosphoglycerate kinase	NA
Ri5P	Ribose 5-phosphate	mmol l^{-1}
PRK	Phosphoribulose kinase	mmol l^{-1}
PTc	Total phosphate concentration in cytosol	mmol l^{-1}
Ru5P	Ribulose 5-phosphate	mmol l^{-1}
Rubisco	Ribulose1,5-bisphosphate Carboxylase/Oxygenase	NA
R_t	Total RuBP concentration in stroma	mmol l^{-1}
RuBP	Ribulose 1,5-biphosphate	mmol l^{-1}
S7P	Sedoheptulose 7-phosphate	mmol l^{-1}
SBP	Sedoheptulose 1,7-bisphosphate	mmol l^{-1}
SBPase	Sedoheptulosebisphosphatase	NA
SERc	Serine in cytosol	mmol l^{-1}
SPP	Sucrose phosphate phosphatase	NA
SPS	Sucrose phosphate synthetase	NA
TPU	Triose phosphate utilization	NA
SUCc	Sucrose in cytosol	mmol l^{-1}
SUCPc	Sucrose phosphate in cytosol	mmol l^{-1}
T3P	Triose phosphate including DHAP and GAP	mmol l^{-1}
v_{111}	The rate of RuBP oxygenation	µmol m^{-2} s^{-1} or mmol l^{-1} s^{-1}
UDPGc	Uridine Diphosphate Glucose	mmol l^{-1}
UDPGP	UDP glucose pyrophosphorylase	NA
UT	Total UDP and UTP concentration in cytosol	mmol l^{-1}
v_1	The rate of RuBP carboxylation	µmol m^{-2} s^{-1} or mmol l^{-1} s^{-1}
v_{atpg}	The rate of ATP formation in cytosol	µmol m^{-2} s^{-1} or mmol l^{-1} s^{-1}
v_{pga_use}	The rate of PGA utilization in cytosol	µmol m^{-2} s^{-1} or mmol l^{-1} s^{-1}
Xu5P	Xylulose 5-phosphate	mmol l^{-1}

[a] A suffix c was added to the name of metabolites appeared in cytosol if the metabolite also exists in stroma. For example, PGA is the phosphoglycerate in stroma; while PGAc is the phosphoglycerate in cytosol.

[b] NA: Not applicable