

# Modeling the START transition in the budding yeast cell cycle

Janani Ravi, Kewalin Samart, Jason Zwolak

DOI: <https://doi.org/10.1101/2023.11.05.564806>

## START BYCC Model Differential Equations

### Functions

$$Mass_{Act}(k_1) = k_1$$

$$Mass_{0001}(k_1, S_1) = k_1 \times S_1$$

$$Mass_{0002}(k_1, S_1, S_2) = k_1 \times S_1 \times S_2$$

$$Michaeli(M_1, J_1, k_1, S_1) = \frac{k_1 \times M_1 \times S_1}{(J_1 + S_1)}$$

$$BB(A_1, A_2, A_3, A_4) = A_2 - A_1 + (A_3 \times A_2) + (A_4 \times A_1)$$

$$GK(A_1, A_2, A_3, A_4) = \frac{2.0 \times A_4 \times A_1}{BB(A_1, A_2, A_3, A_4) + \sqrt{(BB(A_1, A_2, A_3, A_4))^2 - 4.0 \times ((A_2 - A_1) \times A_4 \times A_1)}}$$

### Compartment Equations

#### Variables

$$T19 = 1.0 \times IEP + 1.0 \times IE$$

$$T18 = 1.0 \times TEM1GDP + 1.0 \times TEM1GTP$$

$$T17 = 1.0 \times CDC15 + 1.0 \times CDC15i$$

$$T16 = 1.0 \times ESP1 + 1.0 \times PE$$

$$T15 = 1.0 \times PROM2 + 1.0 \times SBFB6PQ + 1.0 \times SBFB6P + 1.0 \times SBFB + 1.0 \times SWI4B + 1.0 \times W4B + 1.0 \times WSB56P + 1.0 \times WSB5P + 1.0 \times WSB6PQ + 1.0 \times WSB6P + 1.0 \times WSB$$

$$T14 = 1.0 \times SBFB6PQ + 1.0 \times SBFB6P + 1.0 \times SBFB + 1.0 \times SBFF46PQ + 1.0 \times SBFF46P + 1.0 \times SBFF4P + 1.0 \times SBFF6PQ + 1.0 \times SBFF6P + 1.0 \times SBFF + 1.0 \times SWI4B + 4.0 \times SWI4C + 1.0 \times SWI4F + 4.0 \times SWI4PC + 1.0 \times SWI4P + 1.0 \times SWI4 + 1.0 \times W4B + 1.0 \times WSB56P + 1.0 \times WSB5P + 1.0 \times WSB6PQ + 1.0 \times WSB6P + 1.0 \times WSB + 1.0 \times WSF45P + 1.0 \times WSF46PQ + 1.0 \times WSF46P + 1.0 \times WSF4P + 1.0 \times WSF56P + 1.0 \times WSF5P + 1.0 \times WSF6PQ + 1.0 \times WSF6P + 1.0 \times WSF$$

$$T13 = 1.0 \times W4B + 4.0 \times WHI5C + 4.0 \times WHI5PC + 1.0 \times WHI5PN + 1.0 \times WHI5 + 1.0 \times WMB + 1.0 \times WSB56P + 1.0 \times WSB5P + 1.0 \times WSB6PQ + 1.0 \times WSB6P + 1.0 \times WSB + 1.0 \times WSF45P + 1.0 \times WSF46PQ + 1.0 \times WSF46P + 1.0 \times WSF4P + 1.0 \times WSF56P + 1.0 \times WSF5P + 1.0 \times WSF6PQ + 1.0 \times WSF6P + 1.0 \times WSF$$

$$T12 = 1.0 \times MBFa + 1.0 \times MBFi + 1.0 \times MBFo + 1.0 \times MBFp + 1.0 \times MBFpo + 1.0 \times PROM5 + 1.0 \times WMB$$

$$T11 = 1.0 \times MBFF + 1.0 \times MBFa + 1.0 \times MBFi + 1.0 \times MBFo + 1.0 \times MBFp + 1.0 \times MBFpo + 1.0 \times MBP1 + 1.0 \times WMB$$

$$T10 = 1.0 \times MBFF + 1.0 \times MBFa + 1.0 \times MBFi + 1.0 \times MBFo + 1.0 \times MBFp + 1.0 \times MBFpo + 1.0 \times SBFB6PQ + 1.0 \times SBFB6P + 1.0 \times SBFB + 1.0 \times SBFF46PQ + 1.0 \times SBFF46P + 1.0 \times SBFF4P + 1.0 \times SBFF6PQ + 1.0 \times SBFF6P + 1.0 \times SBFF + 4.0 \times SWI6C + 4.0 \times SWI6PQC + 1.0 \times SWI6PQ +$$



$$SWI6T = 1.0 \times MBFF + 1.0 \times MBFa + 1.0 \times MBFi + 1.0 \times MBFo + 1.0 \times MBFp + 1.0 \times MBFpo + 1.0 \times SBFB6PQ + 1.0 \times SBFB6P + 1.0 \times SBFB + 1.0 \times SBFF46PQ + 1.0 \times SBFF46P + 1.0 \times SBFF4P + 1.0 \times SBFF6PQ + 1.0 \times SBFF6P + 1.0 \times SBFF + 4.0 \times SWI6C + 4.0 \times SWI6PQC + 1.0 \times SWI6PQ + 1.0 \times SWI6P + 4.0 \times SWI6QC + 1.0 \times SWI6 + 1.0 \times WMB + 1.0 \times WSB56P + 1.0 \times WSB5P + 1.0 \times WSB6PQ + 1.0 \times WSB6P + 1.0 \times WSB + 1.0 \times WSF45P + 1.0 \times WSF46PQ + 1.0 \times WSF46P + 1.0 \times WSF4P + 1.0 \times WSF56P + 1.0 \times WSF5P + 1.0 \times WSF6PQ + 1.0 \times WSF6P + 1.0 \times WSF$$

$$D = \frac{1.026}{\mu} - 32.0$$

$$F = e^{(-\mu) \times D}$$

$$YDJ1 = k_{y dj1} \times MASS$$

$$SSA1 = (k_{ssa0} + k_{ssab2} \times CLB2 + k_{ssaw5} \times SWI5) \times \frac{90.0}{mdt}$$

$$Vacln3 = k_{gkcln3} \times YDJ1$$

$$CLN3 = \begin{cases} 0.0 \\ CLN3T \times MASS \times GK(Vacln3, SSA1, Jacln3 \times CLN3T, Jicl3 \times CLN3T) \end{cases} \begin{matrix} , if \quad CLN3T = 0.0 \\ , otherwise \end{matrix}$$

$$BCK2 = \begin{cases} 0.0 \\ BCK2T \times MASS \times GK(Vacln3, SSA1, Jabck2 \times BCK2T, Jibck2 \times BCK2T) \end{cases} \begin{matrix} , if \quad BCK2T = 0.0 \\ , otherwise \end{matrix}$$

$$MCM1 = GK(k_{amcm} \times CLB2, k_{imcm}, J_{amcm}, J_{imcm})$$

$$Vdb2 = k_{db2p} + k_{db2pp} \times CDH1 + k_{db2ppp} \times CDC20$$

$$Vdb5 = k_{db5p} + k_{db5pp} \times CDC20$$

$$Vd2c1 = k_{d2c1} \times (ec1n3 \times CLN3 + ec1k2 \times BCK2 + ec1n2 \times CLN2 + ec1b5 \times CLB5 + ec1b2 \times CLB2)$$

$$Vd2f6 = k_{d2f6} \times (ef6n3 \times CLN3 + ef6k2 \times BCK2 + ef6n2 \times CLN2 + ef6b5 \times CLB5 + ef6b2 \times CLB2)$$

$$Vppc1 = k_{ppc1} \times CDC14$$

$$Vppf6 = k_{ppf6} \times CDC14$$

$$V_{kpc1} = k_{d1c1} + V_{d2c1} / (J_{d2c1} + SIC1 + C2 + C5)$$

$$V_{kpf6} = \frac{k_{d1f6} + V_{d2f6}}{(J_{d2f6} + CDC6 + F2 + F5)}$$

$$V_{aiep} = k_{aiep} \times CLB2$$

$$V_{d20} = k_{d20} + k_{d20p} \times CDH1$$

$$V_{acdh} = k_{acdh_p} + k_{acdh_{pp}} \times CDC14$$

$$V_{icdh} = k_{icdh_p} + k_{icdh_{pp}} \times (eicdhn3 \times CLN3 + eicdhn2 \times CLN2 + eicdhh5 \times CLB5 + eicdhh2 \times CLB2)$$

$$V_{kpnet} = k_{kpnet_p} + k_{kpnet_{pp}} \times CDC15$$

$$PP2A = PP2AT \times (1.0 + k_i \times k_{pp} \times ESP1) / (1.0 + k_i \times ESP1)$$

$$V_{ppnet} = k_{ppnet_p} + k_{ppnet_{0001}} \times PP2A$$

$$V_{dpds} = k_{dpds_p} + k_{dpds_{pp}} \times CDC20 + k_{dpd_{0001}} \times CDH1$$

$$V_{pn} = epn3 \times CLN3 + epn2 \times CLN2 + epb5 \times CLB5 + epk2 \times BCK2$$

$$V_{pcln} = V_{pnmax} \times (V_{pn}^N / (J_{pn}^N + V_{pn}^N))$$

$$V_{ppcln} = k_{ppcln} + k_{ppcln_p} \times CDC14$$

$$V_{pnm} = epn3m \times CLN3 + epn2m \times CLN2 + epb5m \times CLB5 + epk2m \times BCK2$$

$$V_{pclnm} = \frac{V_{pmax} \times V_{pnm}^N}{(J_{pn}^N + V_{pnm}^N)}$$

$$V_{pnw} = epn3w \times CLN3 + epn2w \times CLN2 + epb5w \times CLB5 + epk2w \times BCK2$$

$$V_{pclnw} = \frac{V_{pnmax} \times V_{pnw}^N}{(J_{pn}^N + V_{pnw}^N)}$$

$$V_{pclb} = k_{pp} + k_{ppp} \times CLB2$$

$$V_{pp14} = k_{pp14} \times CDC14$$

$$V_{pclb26} = k_{pp} + k_{ppp} \times CLB2 + epb5q \times CLB5$$

$$V_{ppase} = PPase$$

$$CLB2T = CLB2 + C2 + F2 + C2P + F2P$$

$$CLB5T = CLB5 + C5 + F5 + C5P + F5P$$

$$CDC14T = CDC14 + RENT + RENTP$$

$$NET1T = NET1 + NET1P + RENT + RENTP$$

$$SIC1T = SIC1 + C2 + C5 + SIC1P + C2P + C5P$$

$$CDC6T = CDC6 + F2 + F5 + CDC6P + F2P + F5P$$

$$KIT = SIC1T + CDC6T$$

$$SBFact = k_{asbf1} \times SBFB + k_{asbf2} \times (SBFB6P + SBFB6PQ) + k_{asbf3} \times (WSB6P + WSB6PQ) + k_{asbf4} \times WSB5P + k_{asbf5} \times SWI4B$$

$$MBFact = MBFa$$

$$SWI6CTOT = SWI6C + SWI6QC + SWI6PQC$$

$$SBFa1 = k_{asbf1} \times SBFB$$

$$SBFa2 = k_{asbf2} \times (SBFB6P + SBFB6PQ)$$

$$SBFa3 = k_{asbf3} \times (WSB6P + WSB6PQ)$$

$$SBFa4 = k_{asbf4} \times WSB5P$$

$$SBFa5 = k_{asbf5} \times SWI4B$$

$$SWI4nucf = \begin{cases} 0.0, & \text{if } SWI4T < 1.0 \times 10^{-8} \\ \frac{SWI4T - 4.0 \times (SWI4C + SWI4PC)}{SWI4T} & , otherwise \end{cases}$$

$$WHI5nucf = \begin{cases} 0.0, & \text{if } WHI5T < 1.0 \times 10^{-8} \\ \frac{WHI5T - 4.0 \times (WHI5C + WHI5PC)}{WHI5T} & , otherwise \end{cases}$$

$$SWI6nucf = \begin{cases} 0.0, & \text{if } SWI6T < 1.0 \times 10^{-8} \\ \frac{SWI6T - 4.0 \times (SWI6C + SWI6QC + SWI6PQC)}{SWI6T} & , otherwise \end{cases}$$

$$SWI4cycf = 1.0 - SWI4nucf$$

$$WHI5cycf = 1.0 - WHI5nucf$$

$$SWI6cycf = 1.0 - SWI6nucf$$

$$CLN310x = 10.0 \times CLN3$$

## Parameter Equations

$$\mu = \frac{\log(2.0)}{mdt}$$

$$\text{Independent Species} \quad \frac{d}{dt} MASS = (\mu \times MASS \times (1.0 - \frac{MASS}{MASS_{max}}))$$

$$\frac{d}{dt} CLN2 = (k_{sn2_p} + k_{sn2_{pp}} \times SBFact + k_{sn2_{ppp}} \times MBFact) - (k_{dn2} \times CLN2)$$

$$\frac{d}{dt} CLB5 = ((k_{sb5_p} + k_{sb5_{pp}} \times SBFact + k_{sb5_{ppp}} \times MBFact) \times MASS) - (V_{db5} \times CLB5) - (k_{asb5} \times CLB5 \times SIC1) + (k_{dib5} \times C5) + (k_{d3c1} \times C5P) - (k_{asf5} \times CLB5 \times CDC6) + (k_{dif5} \times F5) + (k_{d3f6} \times F5P)$$

$$\frac{d}{dt} CLB2 = ((k_{sb2_p} + k_{sb2_{pp}} \times MCM1) \times MASS) - (V_{db2} \times CLB2) - (k_{asb2} \times CLB2 \times SIC1) + (k_{dib2} \times C2) + (k_{d3c1} \times C2P) - (k_{asf2} \times CLB2 \times CDC6) + (k_{dif2} \times F2) + (k_{d3f6} \times F2P)$$

$$\frac{d}{dt} SIC1 = (k_{sc1_p} + k_{sc1_{pp}} \times SWI5) - (k_{dc1} \times SIC1) - (V_{kpc1} \times SIC1) + (V_{ppc1} \times SIC1P) - (k_{asb2} \times CLB2 \times SIC1) + (k_{dib2} \times C2) - (k_{asb5} \times CLB5 \times SIC1) + (k_{dib5} \times C5) + (V_{db2} \times C2) + (V_{db5} \times C5)$$

$$\frac{d}{dt} SIC1P = (V_{kpc1} \times SIC1) - (V_{ppc1} \times SIC1P) - (k_{d3c1} \times SIC1P) + (V_{db2} \times C2P) + (V_{db5} \times C5P)$$

$$\frac{d}{dt} C2 = (k_{asb2} \times CLB2 \times SIC1) - (k_{dib2} \times C2) - (V_{kpc1} \times C2) + (V_{ppc1} \times C2P) - (V_{db2} \times C2)$$

$$\frac{d}{dt} C5 = (k_{asb5} \times CLB5 \times SIC1) - (k_{dib5} \times C5) - (V_{kpc1} \times C5) + (V_{ppc1} \times C5P) - (V_{db5} \times C5)$$

$$\frac{d}{dt} C2P = (V_{kpc1} \times C2) - (V_{ppc1} \times C2P) - (k_{d3c1} \times C2P) - (V_{db2} \times C2P)$$

$$\frac{d}{dt} C5P = (V_{kpc1} \times C5) - (V_{ppc1} \times C5P) - (k_{d3c1} \times C5P) - (V_{db5} \times C5P)$$

$$\frac{d}{dt} CDC6 = (k_{sf6_p} + k_{sf6_{pp}} \times SWI5 + k_{sf6_{ppp}} \times SBFact) - (k_{df6} \times CDC6) - (V_{kpf6} \times CDC6) + (V_{ppf6} \times CDC6P) - (k_{asf2} \times CLB2 \times CDC6) + (k_{dif2} \times F2) - (k_{asf5} \times CLB5 \times CDC6) + (k_{dif5} \times F5) + (V_{db2} \times F2) + (V_{db5} \times F5)$$

$$\frac{d}{dt} CDC6P = (V_{kpf6} \times CDC6) - (V_{ppf6} \times CDC6P) - (k_{d3f6} \times CDC6P) + (V_{db2} \times F2P) + (V_{db5} \times F5P)$$

$$\frac{d}{dt} F2 = (k_{asf2} \times CLB2 \times CDC6) - (k_{dif2} \times F2) - (V_{kpf6} \times F2) + (V_{ppf6} \times F2P) - (V_{db2} \times F2)$$

$$\frac{d}{dt} F5 = (k_{asf5} \times CLB5 \times CDC6) - (k_{dif5} \times F5) - (V_{kpf6} \times F5) + (V_{ppf6} \times F5P) - (V_{db5} \times F5)$$

$$\frac{d}{dt} F2P = (V_{kpf6} \times F2) - (V_{ppf6} \times F2P) - (k_{d3f6} \times F2P) - (V_{db2} \times F2P)$$

$$\frac{d}{dt} F5P = (V_{kpf6} \times F5) - (V_{ppf6} \times F5P) - (k_{d3f6} \times F5P) - (V_{db5} \times F5P)$$

$$SWI5 = (k_{sswi_p} + k_{sswi_{pp}} \times MCM1) - (k_{dswi} \times SWI5) - ((k_{iswi} \times CLB2) \times SWI5) + (k_{aswi} \times CDC14) \times SWI5P$$

$$\frac{d}{dt} SWI5P = (k_{iswi} \times CLB2) \times SWI5 - ((k_{aswi} \times CDC14) \times SWI5P) - (k_{dswi} \times SWI5P)$$

$$\frac{d}{dt} IE = -(V_{aiep} \times IE \times 1.0 / (J_{aiep} + IE)) + (k_{iiep} \times IEP \times 1.0 / (J_{iiep} + IEP))$$

$$\frac{d}{dt} IEP = \frac{V_{aiep} \times IE}{J_{aiep} + IE} - \frac{k_{iiep} \times IEP}{J_{iiep} + IEP}$$

$$\frac{d}{dt} CDC20i = (k_{s20_p} + k_{s20_{pp}} \times MCM1) - (V_{d20} \times CDC20i) - ((k_{a20_p} + k_{a20_{pp}} \times IEP) \times CDC20i) + (MAD2 \times CDC20)$$

$$\frac{d}{dt} CDC20 = (k_{a20_p} + k_{a20_{pp}} \times IEP) \times CDC20i - (MAD2 \times CDC20) - (V_{d20} \times CDC20)$$

$$\frac{d}{dt} CDH1 = k_{scdh} - (k_{dcdh} \times CDH1) - \frac{V_{icdh} \times CDH1}{J_{icdh} + CDH1} + \frac{V_{acdh} \times CDH1i}{J_{acdh} + CDH1i}$$

$$\frac{d}{dt} CDH1i = \frac{V_{icdh} \times CDH1}{J_{icdh} + CDH1} - (V_{acdh} \times CDH1i \times 1.0 / (J_{acdh} + CDH1i)) - (k_{dcdh} \times CDH1i)$$

$$\frac{d}{dt} CDC14 = k_{s14} - (k_{d14} \times CDC14) - (k_{asrent} \times CDC14 \times NET1) + (k_{dirent} \times RENT) - (k_{asrentp} \times CDC14 \times NET1P) + (k_{direntp} \times RENTP) + (k_{dnet} \times RENT) + (k_{dnet} \times RENTP)$$

$$\frac{d}{dt} NET1 = (k_{snet}) - (k_{dnet} \times NET1) - (V_{kpnet} \times NET1) + (V_{ppnet} \times NET1P) - (k_{asrent} \times CDC14 \times NET1) + (k_{dirent} \times RENT) + (k_{d14} \times RENT)$$

$$\begin{aligned}
\frac{d}{dt}RENT &= (k_{asrent} \times CDC14 \times NET1) - (k_{dirent} \times RENT) - (V_{kpnet} \times RENT) + (V_{ppnet} \times RENTP) - \\
&\quad (k_{dnet} \times RENT) - (k_{d14} \times RENT) \\
\frac{d}{dt}NET1P &= (V_{kpnet} \times NET1) - (V_{ppnet} \times NET1P) - (k_{dnet} \times NET1P) - (k_{asrent_p} \times CDC14 \times NET1P) + \\
&\quad (k_{dirent_p} \times RENTP) + (k_{d14} \times RENTP) \\
\frac{d}{dt}RENTP &= (k_{asrent_p} \times CDC14 \times NET1P) - (k_{dirent_p} \times RENTP) + (V_{kpnet} \times RENT) - (V_{ppnet} \times RENTP) - \\
&\quad (k_{dnet} \times RENTP) - (k_{d14} \times RENTP) \\
\frac{d}{dt}TEM1GDP &= \frac{-LTE1 \times TEM1GDP}{J_{atem} + TEM1GDP} + \frac{BUB2 \times TEM1GTP}{J_{item} + TEM1GTP} \\
\frac{d}{dt}TEM1GTP &= \frac{LTE1 \times TEM1GDP}{J_{atem} + TEM1GDP} - \frac{BUB2 \times TEM1GTP}{J_{item} + TEM1GTP} \\
\frac{d}{dt}CDC15i &= -k_{a15_p} \times TEM1GDP + k_{a15_{pp}} \times TEM1GTP + k_{a15_{ppp}} \times CDC14 \times CDC15i + k_{i15} \times CDC15 \\
\frac{d}{dt}CDC15 &= (k_{a15_p} \times TEM1GDP) + (k_{a15_{pp}} \times TEM1GTP) + (k_{a15_{ppp}} \times CDC14 \times CDC15i) - (k_{i15} \times CDC15) \\
\frac{d}{dt}PDS1 &= (k_{spds_p}) - (V_{dpds} \times PDS1) - (k_{asesp} \times PDS1 \times ESP1) + (k_{diesp} \times PE) \\
\frac{d}{dt}ESP1 &= -(k_{asesp} \times PDS1 \times ESP1) + (k_{diesp} \times PE) + (V_{dpds} \times PE) \\
\frac{d}{dt}PE &= (k_{asesp} \times PDS1 \times ESP1) - (k_{diesp} \times PE) - (V_{dpds} \times PE) \\
\frac{d}{dt}ORI &= (k_{sori} \times (eorib5 \times CLB5 + eorib2 \times CLB2)) - (k_{dori} \times ORI) \\
\frac{d}{dt}BUD &= (k_{sbud} \times (ebudn2 \times CLN2 + ebudn3 \times CLN3 + ebudb5 \times CLB5)) - (k_{dbud} \times BUD) \\
\frac{d}{dt}SPN &= \frac{k_{sspn} \times CLB2}{J_{spn} + CLB2 - (k_{dspn} \times SPN)} \\
\frac{d}{dt}MAD2 &= 0.0 \\
\frac{d}{dt}LTE1 &= 0.0 \\
\frac{d}{dt}BUB2 &= 0.0 \\
\frac{d}{dt}SWI4 &= -(k_{as46} \times SWI4 \times SWI6) + (k_{di46} \times SBFF) - ((k_{sbs4} \times BCK2) \times SWI4) + (k_{dbs4} \times SWI4F) - \\
&\quad (k_{as46} \times SWI4 \times SWI6P) + (k_{di46} \times SBFF6P) - (k_{as46} \times SWI4 \times SWI6PQ) + (k_{di46} \times SBFF6PQ) - \\
&\quad ((ef4p \times V_{pclb}) \times SWI4) + (V_{pp14} \times SWI4P) + (k_{imp} \times SWI4C) \times \frac{cytoplas}{nucleus} \\
\frac{d}{dt}SWI6 &= -(k_{as46} \times SWI4 \times SWI6) + (k_{di46} \times SBFF) - ((ef6p \times V_{pcln}) \times SWI6) + (V_{ppcln} \times SWI6P) - \\
&\quad (k_{as46} \times SWI4P \times SWI6) + (k_{di46} \times SBFF4P) + (k_{imp} \times SWI6C) \times \frac{cytoplas}{nucleus} - (k_{asmbf} \times MBP1 \times SWI6) + \\
&\quad (k_{dimbf} \times MBFF) \\
\frac{d}{dt}WHI5 &= -(k_{asws} \times WHI5 \times SBFF) + (k_{diws} \times WSF) - (k_{asws} \times WHI5 \times SBFB) + (k_{diws} \times WSB) - \\
&\quad (k_{asw4} \times SWI4B \times WHI5) + (k_{diw4} \times W4B) - ((ef5p \times V_{pclnw}) \times WHI5) + (V_{ppcln} \times WHI5PN) - (k_{asws} \times \\
&\quad WHI5 \times SBFF6P) + (k_{diws} \times WSF6P) - (k_{asws} \times WHI5 \times SBFF6PQ) + (k_{diws} \times WSF6PQ) + (k_{imp} \times \\
&\quad WHI5C) \times \frac{cytoplas}{nucleus} - (k_{aswm} \times MBFa \times WHI5) + (k_{diwm} \times WMB) \\
\frac{d}{dt}MBP1 &= -(k_{asmbf} \times MBP1 \times SWI6) + (k_{dimbf} \times MBFF) \\
\frac{d}{dt}PROM2 &= -(k_{asprom} \times SBFF \times PROM2) + (k_{diprom} \times SBFB) - (k_{asprom} \times WSF \times PROM2) + (k_{diprom} \times \\
&\quad WSB) - (k_{asprom} \times SWI4F \times PROM2) + (k_{diprom} \times SWI4B) + (ef4p \times V_{pclb}) \times SBFB + (ef4p \times V_{pclb}) \times \\
&\quad SBFB6P + (ef4p \times V_{pclb}) \times SBFB6PQ + (ef4p \times V_{pclb}) \times WSB + (ef4p \times V_{pclb}) \times WSB5P + (ef4p \times \\
&\quad V_{pclb}) \times WSB6P + (ef4p \times V_{pclb}) \times WSB6PQ + (V_{pclb} \times SWI4B) \\
\frac{d}{dt}PROM5 &= -(k_{asprom} \times MBFF \times PROM5) + (k_{diprom} \times MBFi) \\
\frac{d}{dt}NRM1/dt &= (k_{snrm1_p} \times MBFact) - (k_{dnrm1} \times NRM1) \\
\frac{d}{dt}SWI4C &= (MSN5 \times SBFF6PQ) \times \frac{nucleus}{cytoplas} + (MSN5 \times WSF6PQ) \times \frac{nucleus}{cytoplas} + (V_{ppase} \times SWI4PC) - \\
&\quad (k_{imp} \times SWI4C)
\end{aligned}$$

$$\frac{d}{dt}SWI4P = (MSN5 \times SBFF46PQ) \times \frac{nucleus}{cytoplas} + (MSN5 \times WSF46PQ) \times \frac{nucleus}{cytoplas} + (MSN5 \times WSF45P) \times \frac{nucleus}{cytoplas} - (V_{ppase} \times SWI4PC)$$

$$\frac{d}{dt}SWI4P = -(k_{as46} \times SWI4P \times SWI6) + (k_{di46} \times SBFF4P) - (k_{as46} \times SWI4P \times SWI6P) + (k_{di46} \times SBFF46P) - (k_{as46} \times SWI4P \times SWI6PQ) + (k_{di46} \times SBFF46PQ) + (ef4p \times V_{pclb}) \times SWI4 - (V_{pp14} \times SWI4P) + (V_{pclb} \times SWI4B)$$

$$\frac{d}{dt}SWI4B = (k_{asprom} \times SWI4F \times PROM2) - (k_{diprom} \times SWI4B) - (k_{asw4} \times SWI4B \times WHI5) + (k_{diw4} \times W4B) + (ef5p \times V_{pclnw}) \times W4B - (V_{pclb} \times SWI4B)$$

$$\frac{d}{dt}SWI4F = (k_{bs4} \times BCK2) \times SWI4 - (k_{bs4} \times SWI4F) - (k_{asprom} \times SWI4F \times PROM2) + (k_{diprom} \times SWI4B)$$

$$\frac{d}{dt}W4B = (k_{asw4} \times SWI4B \times WHI5) - (k_{diw4} \times W4B) - ((ef5p \times V_{pclnw}) \times W4B)$$

$$\frac{d}{dt}SBFF = (k_{as46} \times SWI4 \times SWI6) - (k_{di46} \times SBFF) - (k_{asws} \times WHI5 \times SBFF) + (k_{diws} \times WSF) - (k_{asprom} \times SBFF \times PROM2) + (k_{diprom} \times SBFF) - ((ef6p \times V_{pcln}) \times SBFF) + (V_{ppcln} \times SBFF6P) + (k_{diwp} \times WSF5P) - ((ef4p \times V_{pclb}) \times SBFF) + (V_{pp14} \times SBFF4P)$$

$$\frac{d}{dt}SBFF4P = (k_{as46} \times SWI4P \times SWI6) - (k_{di46} \times SBFF4P) + (ef4p \times V_{pclb}) \times SBFF - (V_{pp14} \times SBFF4P) + (V_{ppcln} \times SBFF46P) + (ef4p \times V_{pclb}) \times SBFF - ((ef6p \times V_{pcln}) \times SBFF4P)$$

$$\frac{d}{dt}SBFF6P = (ef6p \times V_{pcln}) \times SBFF - (V_{ppcln} \times SBFF6P) + (k_{diwp} \times WSF56P) - ((ef6q \times V_{pclb26}) \times SBFF6P) + (V_{pp14} \times SBFF6PQ) + (k_{as46} \times SWI4 \times SWI6P) - (k_{di46} \times SBFF6P) - (k_{asws} \times WHI5 \times SBFF6P) + (k_{diws} \times WSF6P) - ((ef4p \times V_{pclb}) \times SBFF6P) + (V_{pp14} \times SBFF46P)$$

$$\frac{d}{dt}SBFF6PQ = (ef6q \times V_{pclb26}) \times SBFF6P - (V_{pp14} \times SBFF6PQ) + (k_{as46} \times SWI4 \times SWI6PQ) - (k_{di46} \times SBFF6PQ) - (k_{asws} \times WHI5 \times SBFF6PQ) + (k_{diws} \times WSF6PQ) - ((ef4p \times V_{pclb}) \times SBFF6PQ) + (V_{pp14} \times SBFF46PQ) - (MSN5 \times SBFF6PQ)$$

$$\frac{d}{dt}SBFF46P = (k_{as46} \times SWI4P \times SWI6P) - (k_{di46} \times SBFF46P) + (ef4p \times V_{pclb}) \times SBFF6P - (V_{pp14} \times SBFF46P) - (V_{ppcln} \times SBFF46P) - ((ef6q \times V_{pclb26}) \times SBFF46P) + (V_{pp14} \times SBFF46PQ) + (ef4p \times V_{pclb}) \times SBFF6P + (ef6p \times V_{pcln}) \times SBFF4P$$

$$\frac{d}{dt}SBFF46PQ = (k_{as46} \times SWI4P \times SWI6PQ) - (k_{di46} \times SBFF46PQ) + (ef4p \times V_{pclb}) \times SBFF6PQ - (V_{pp14} \times SBFF46PQ) + (ef6q \times V_{pclb26}) \times SBFF46P - (V_{pp14} \times SBFF46PQ) + (ef4p \times V_{pclb}) \times SBFF6PQ - (MSN5 \times SBFF46PQ)$$

$$\frac{d}{dt}SBFB = (k_{asprom} \times SBFF \times PROM2) - (k_{diprom} \times SBFB) - (k_{asws} \times WHI5 \times SBFB) + (k_{diws} \times WSB) - ((ef6p \times V_{pcln}) \times SBFB) + (V_{ppcln} \times SBFB6P) - ((ef4p \times V_{pclb}) \times SBFB)$$

$$\frac{d}{dt}SBFB6P = (ef6p \times V_{pcln}) \times SBFB - (V_{ppcln} \times SBFB6P) + (k_{diwp} \times WSB56P) - ((ef6q \times V_{pclb26}) \times SBFB6P) + (V_{pp14} \times SBFB6PQ) - ((ef4p \times V_{pclb}) \times SBFB6P)$$

$$\frac{d}{dt}SBFB6PQ = (ef6q \times V_{pclb26}) \times SBFB6P - (V_{pp14} \times SBFB6PQ) - ((ef4p \times V_{pclb}) \times SBFB6PQ)$$

$$\frac{d}{dt}WSF = (k_{asws} \times WHI5 \times SBFF) - (k_{diws} \times WSF) - (k_{asprom} \times WSF \times PROM2) + (k_{diprom} \times WSB) - ((ef5p \times V_{pclnw}) \times WSF) + (V_{ppcln} \times WSF5P) - ((ef6p \times V_{pcln}) \times WSF) + (V_{ppcln} \times WSF6P) - ((ef4p \times V_{pclb}) \times WSF) + (V_{pp14} \times WSF4P)$$

$$\frac{d}{dt}WSF4P = (ef4p \times V_{pclb}) \times WSF - (V_{pp14} \times WSF4P) + (V_{ppcln} \times WSF46P) + (ef4p \times V_{pclb}) \times WSB - ((ef6p \times V_{pcln}) \times WSF4P) - ((ef5p \times V_{pclnw}) \times WSF4P)$$

$$\frac{d}{dt}WSF5P = (ef5p \times V_{pclnw}) \times WSF - (V_{ppcln} \times WSF5P) - (k_{diwp} \times WSF5P)$$

$$\frac{d}{dt}WSF6P = (ef6p \times V_{pcln}) \times WSF - (V_{ppcln} \times WSF6P) - ((ef5p \times V_{pclnw}) \times WSF6P) - ((ef6q \times V_{pclb26}) \times WSF6P) + (V_{pp14} \times WSF6PQ) + (k_{asws} \times WHI5 \times SBFF6P) - (k_{diws} \times WSF6P) - ((ef4p \times V_{pclb}) \times WSF6P) + (V_{pp14} \times WSF46P)$$

$$\frac{d}{dt}WSF6PQ = (ef6q \times V_{pclb26}) \times WSF6P - (V_{pp14} \times WSF6PQ) + (k_{asws} \times WHI5 \times SBFF6PQ) - (k_{diws} \times WSF6PQ) - ((ef4p \times V_{pclb}) \times WSF6PQ) + (V_{pp14} \times WSF46PQ) - (MSN5 \times WSF6PQ)$$

$$\frac{d}{dt}WSF45P = (ef4p \times V_{pclb}) \times WSB5P - (MSN5 \times WSF45P) + (ef5p \times V_{pclnw}) \times WSF4P$$

$$\frac{d}{dt}WSF46P = (ef4p \times V_{pclb}) \times WSF6P - (V_{pp14} \times WSF46P) - (V_{ppcln} \times WSF46P) - ((ef6q \times V_{pclb26}) \times WSF46P) + (V_{pp14} \times WSF46PQ) + (ef4p \times V_{pclb}) \times WSB6P + (ef6p \times V_{pcln}) \times WSF4P$$

$$\frac{d}{dt}WSF46PQ = (ef4p \times V_{pclb}) \times WSF6PQ - (V_{pp14} \times WSF46PQ) + (ef6q \times V_{pclb26}) \times WSF46P - (V_{pp14} \times WSF46PQ) + (ef4p \times V_{pclb}) \times WSB6PQ - (MSN5 \times WSF46PQ)$$

$$\frac{d}{dt}WSF56P = (ef5p \times V_{pclnw}) \times WSF6P - (k_{diwp} \times WSF56P)$$

$$\frac{d}{dt}WSB = (k_{asprom} \times WSF \times PROM2) - (k_{diprom} \times WSB) + (k_{asws} \times WHI5 \times SBFb) - (k_{diws} \times WSB) - ((ef5p \times V_{pclnw}) \times WSB) + (V_{ppcln} \times WSB5P) - ((ef6p \times V_{pcln}) \times WSB) + (V_{ppcln} \times WSB6P) - ((ef4p \times V_{pclb}) \times WSB)$$

$$\frac{d}{dt}WSB5P = (ef5p \times V_{pclnw}) \times WSB - (V_{ppcln} \times WSB5P) - ((ef6p \times V_{pcln}) \times WSB5P) + (V_{ppcln} \times WSB56P) - ((ef4p \times V_{pclb}) \times WSB5P)$$

$$\frac{d}{dt}WSB6P = (ef6p \times V_{pcln}) \times WSB - (V_{ppcln} \times WSB6P) - ((ef5p \times V_{pclnw}) \times WSB6P) + (V_{ppcln} \times WSB56P) - ((ef6q \times V_{pclb26}) \times WSB6P) + (V_{pp14} \times WSB6PQ) - ((ef4p \times V_{pclb}) \times WSB6P)$$

$$\frac{d}{dt}WSB6PQ = (ef6q \times V_{pclb26}) \times WSB6P - (V_{pp14} \times WSB6PQ) - ((ef4p \times V_{pclb}) \times WSB6PQ)$$

$$\frac{d}{dt}WSB56P = (ef6p \times V_{pcln}) \times WSB5P - (V_{ppcln} \times WSB56P) + (ef5p \times V_{pclnw}) \times WSB6P - (V_{ppcln} \times WSB56P) - (k_{diwp} \times WSB56P)$$

$$\frac{d}{dt}SWI6C = (MSN5 \times WSF45P) \times \frac{nucleus}{cytoplas} + (V_{pp14} \times SWI6QC) - (k_{imp} \times SWI6C)$$

$$\frac{d}{dt}SWI6QC = (V_{ppase} \times SWI6PQC) - (V_{pp14} \times SWI6QC)$$

$$\frac{d}{dt}SWI6PQC = (MSN5 \times SBFF6PQ) \times \frac{nucleus}{cytoplas} + (MSN5 \times SBFF46PQ) \times \frac{nucleus}{cytoplas} + (MSN5 \times WSF6PQ) \times \frac{nucleus}{cytoplas} + (MSN5 \times WSF46PQ) \times \frac{nucleus}{cytoplas} - (V_{ppase} \times SWI6PQC)$$

$$\frac{d}{dt}SWI6P = (ef6p \times V_{pcln}) \times SWI6 - (V_{ppcln} \times SWI6P) - ((ef6q \times V_{pclb26}) \times SWI6P) + (V_{pp14} \times SWI6PQ) - (k_{as46} \times SWI4 \times SWI6P) + (k_{di46} \times SBFF6P) - (k_{as46} \times SWI4P \times SWI6P) + (k_{di46} \times SBFF46P)$$

$$\frac{d}{dt}SWI6PQ = (ef6q \times V_{pclb26}) \times SWI6P - (V_{pp14} \times SWI6PQ) - (k_{as46} \times SWI4 \times SWI6PQ) + (k_{di46} \times SBFF6PQ) - (k_{as46} \times SWI4P \times SWI6PQ) + (k_{di46} \times SBFF46PQ)$$

$$\frac{d}{dt}MBFF = (k_{asmbf} \times MBP1 \times SWI6) - (k_{dimbf} \times MBFF) - (k_{asprom} \times MBFF \times PROM5) + (k_{diprom} \times MBFi)$$

$$\frac{d}{dt}MBFi = (k_{asprom} \times MBFF \times PROM5) - (k_{diprom} \times MBFi) - (V_{pclnm} \times MBFi) + (V_{ppcln} \times MBFa)$$

$$\frac{d}{dt}MBFa = (V_{pclnm} \times MBFi) - (V_{ppcln} \times MBFa) - ((k_{imbf01} \times CLB2) \times MBFa) + (k_{mbf10} \times MBFp) - ((k_{imbf02} \times NRM1) \times MBFa) + (k_{mbf20} \times MBFo) - (k_{aswm} \times MBFa \times WHI5) + (k_{diwm} \times WMB) + (ef5p \times V_{pclnw}) \times WMB$$

$$\frac{d}{dt}MBFp = (k_{imbf01} \times CLB2) \times MBFa - (k_{mbf10} \times MBFp) - ((k_{imbf02} \times NRM1) \times MBFp) + (k_{mbf20} \times MBFpo)$$

$$\frac{d}{dt}MBFo = (k_{imbf02} \times NRM1) \times MBFa - (k_{mbf20} \times MBFo) - ((k_{imbf01} \times CLB2) \times MBFo) + (k_{mbf10} \times MBFpo)$$

$$\frac{d}{dt}MBFpo = (k_{imbf01} \times CLB2) \times MBFo - (k_{mbf10} \times MBFpo) + (k_{imbf02} \times NRM1) \times MBFp - (k_{mbf20} \times MBFpo)$$

$$\frac{d}{dt}WMB = (k_{aswm} \times MBFa \times WHI5) - (k_{diwm} \times WMB) - ((ef5p \times V_{pclnw}) \times WMB)$$

$$\frac{d}{dt}WHI5PC = (MSN5 \times WHI5PN) \times \frac{nucleus}{cytoplas} + (MSN5 \times WSF45P) \times \frac{nucleus}{cytoplas} - (V_{pp14} \times WHI5PC)$$

$$\frac{d}{dt}WHI5C = (MSN5 \times WSF6PQ) \times \frac{nucleus}{cytoplas} + (MSN5 \times WSF46PQ) \times \frac{nucleus}{cytoplas} + (V_{pp14} \times WHI5PC) - (k_{imp} \times WHI5C)$$

$$\frac{d}{dt}WHI5PN = (ef5p \times V_{pclnw}) \times W4B + (ef5p \times V_{pclnw}) \times WHI5 - (V_{ppcln} \times WHI5PN) + (k_{diwp} \times WSF5P) + (k_{diwp} \times WSF56P) + (k_{diwp} \times WSB56P) - (MSN5 \times WHI5PN) + (ef5p \times V_{pclnw}) \times WMB$$



$$\frac{d}{dt}TCYCLE = 1.0$$

$$\frac{d}{dt}ORIFLAG = 0.0$$

$$\frac{d}{dt}Twhi5 = 0.0$$

$$\frac{d}{dt}Mwhi5 = 0.0$$

$$\frac{d}{dt}TBUD = 0.0$$

$$\frac{d}{dt}MBUD = 0.0$$

$$\frac{d}{dt}TORI = 0.0$$

$$\frac{d}{dt}UDNA = 0.0$$

$$\frac{d}{dt}REPDNA = 0.0$$

$$\frac{d}{dt}TSPN = 0.0$$

$$\frac{d}{dt}SPNALIGN = 0.0$$

$$\frac{d}{dt}SACOFF = 0.0$$

$$\frac{d}{dt}MASSBIRT = 0.0$$

$$\frac{d}{dt}MitCat = 0.0$$

### Implicit Species

**Globals (conditional expressions)** *global* -1  $CLB2 + CLB5 - KEZ2 - 0.0ORI = 0.0; ORIFLAG = 1.0$

*global* 1  $WHI5_{cycf} - 0.5Twhi5 = TCYCLE; Mwhi5 = MASS$

*global* 1  $BUD - 1.0TBUD = TCYCLE; MBUD = MASS$

*global* 1  $ORI - 1.0 - 0.0TORI = TCYCLE \times ORIFLAG; UDNA = 1.0 \times ORIFLAG; MAD2 = mad2h \times ORIFLAG$

*global* 1  $TCYCLE - TORI - DNATIMER - 0.0REPDNA = UDNA; SACOFF = SPNALIGN \times ORIFLAG; UDNA$

*global* 1  $TCYCLE - TORI - DNATIMER - 0.0MAD2 = mad2l \times SACOFF + mad2h \times (1.0 - SACOFF); BUB2 =$

*global* 1  $SPN - 1.0 - 0.0SPNALIGN = 1.0; TSPN = TCYCLE; SACOFF = REPDNA; MitCat = if(ESP1 > 0.1)$

*global* 1  $SPN - 1.0 - 0.0MAD2 = mad2l \times SACOFF + mad2h \times (1.0 - SACOFF); BUB2 = bub2l \times SACOFF + bub$

*global* -1  $CLB2 - KEZ - 0.0MASS = F \times MASS \times REPDNA + MASS \times (1.0 - REPDNA); LTE1 = lte1l \times REP$

### Initial Conditions

*init*  $BUB2 = 0.2$

*init*  $BUD = 0.0154110243593788$

*init*  $C2 = 0.197341247757461$

*init*  $C2P = 0.0128083052673014$

*init*  $C5 = 0.0796549412241655$

*init*  $C5P = 0.00476745860363818$

*init*  $CDC14 = 0.685695353660066$

*init*  $CDC15 = 0.652434722390971$

*init*  $CDC15i = 0.347565277609012$

*init*  $CDC20 = 0.706006222058708$   
*init*  $CDC20i = 0.787592468079176$   
*init*  $CDC6 = 0.133968163981639$   
*init*  $CDC6P = 0.035631491948781$   
*init*  $CDH1 = 0.996005362927922$   
*init*  $CDH1i = 0.00399463707207933$   
*init*  $CLB2 = 0.0694306531794237$   
*init*  $CLB5 = 0.0767894202634312$   
*init*  $CLN2 = 0.195608226760332$   
*init*  $ESP1 = 0.520542070433101$   
*init*  $F2 = 0.117541959300578$   
*init*  $F2P = 0.0280767101884002$   
*init*  $F5 = 1.04809529563752 \times 10^{-4}$   
*init*  $F5P = 2.1402315582442 \times 10^{-5}$   
*init*  $IE = 0.51615152340183$   
*init*  $IEP = 0.483848476598174$   
*init*  $LTE1 = 0.1$   
*init*  $MAD2 = 0.01$   
*init*  $MASS = 1.13467475183963$   
*init*  $MASSBIRT = 1.12860662640626$   
*init*  $MBFa = 0.0$   
*init*  $MBFF = 0.0$   
*init*  $MBFi = 0.0$   
*init*  $MBFo = 0.0$   
*init*  $MBFp = 0.0$   
*init*  $MBFpo = 0.0$   
*init*  $MBP1 = 5.5$   
*init*  $MBUD = 0.0$   
*init*  $MitCat = 0.0$   
*init*  $Mwhi5 = 0.0$   
*init*  $NET1 = 0.00656818878723094$   
*init*  $NET1P = 1.27912716487284$   
*init*  $NRM1 = 0.0$   
*init*  $ORI = 0.0291412146656156$   
*init*  $ORIFLAG = 1.0$   
*init*  $PDS1 = 0.0118584914876254$

*init*  $PE = 0.479457929566942$   
*init*  $PROM2 = 2.0$   
*init*  $PROM5 = 2.0$   
*init*  $RENT = 0.643416336728071$   
*init*  $RENTP = 0.870888309611862$   
*init*  $REPDNA = 0.0$   
*init*  $SACOFF = 0.0$   
*init*  $SBFB6P = 0.0$   
*init*  $SBFB6PQ = 0.0$   
*init*  $SBFB = 0.0$   
*init*  $SBFF46P = 0.0$   
*init*  $SBFF46PQ = 0.0$   
*init*  $SBFF4P = 0.0$   
*init*  $SBFF6P = 0.0$   
*init*  $SBFF6PQ = 0.0$   
*init*  $SBFF = 0.0$   
*init*  $SIC1 = 0.0368176074794449$   
*init*  $SIC1P = 0.00518981723970555$   
*init*  $SPN = 0.0325795571004625$   
*init*  $SPNALIGN = 0.0$   
*init*  $SWI4 = 5.5$   
*init*  $SWI4B = 0.0$   
*init*  $SWI4C = 0.0$   
*init*  $SWI4F = 0.0$   
*init*  $SWI4P = 0.0$   
*init*  $SWI4PC = 0.0$   
*init*  $SWI5 = 0.80343911939325$   
*init*  $SWI5P = 0.0170776220724791$   
*init*  $SWI6 = 30.0$   
*init*  $SWI6C = 0.0$   
*init*  $SWI6P = 0.0$   
*init*  $SWI6PQ = 0.0$   
*init*  $SWI6PQC = 0.0$   
*init*  $SWI6QC = 0.0$   
*init*  $TBUD = 0.0$   
*init*  $TCYCLE = 0.72557268620405$

*init*  $TEM1GDP = 0.123253068346797$   
*init*  $TEM1GTP = 0.876746931653158$   
*init*  $TORI = 1000.0$   
*init*  $TSPN = 0.0$   
*init*  $Twbi5 = 0.0$   
*init*  $UDNA = 0.0$   
*init*  $W4B = 0.0$   
*init*  $WHI5 = 10.0$   
*init*  $WHI5C = 0.0$   
*init*  $WHI5PC = 0.0$   
*init*  $WHI5PN = 0.0$   
*init*  $WMB = 0.0$   
*init*  $WSB56P = 0.0$   
*init*  $WSB5P = 0.0$   
*init*  $WSB6P = 0.0$   
*init*  $WSB6PQ = 0.0$   
*init*  $WSB = 0.0$   
*init*  $WSF45P = 0.0$   
*init*  $WSF46P = 0.0$   
*init*  $WSF46PQ = 0.0$   
*init*  $WSF4P = 0.0$   
*init*  $WSF56P = 0.0$   
*init*  $WSF5P = 0.0$   
*init*  $WSF6P = 0.0$   
*init*  $WSF6PQ = 0.0$   
*init*  $WSF = 0.0$   
*param*  $BCK2T = 0.075$   
*param*  $bub2h = 1.0$   
*param*  $bub2l = 0.2$   
*param*  $cell = 1.0$   
*param*  $CLN3T = 0.075$   
*param*  $cytoplas = 0.8$   
*param*  $DNATIMER = 20.0$   
*param*  $ebudb5 = 0.5$   
*param*  $ebudn2 = 0.28$   
*param*  $ebudn3 = 0.25$

*param*  $ec1b2 = 0.4$   
*param*  $ec1b5 = 0.23$   
*param*  $ec1k2 = 0.0$   
*param*  $ec1n2 = 0.09$   
*param*  $ec1n3 = 0.0$   
*param*  $ef4p = 1.0$   
*param*  $ef5p = 1.0$   
*param*  $ef6b2 = 1.5$   
*param*  $ef6b5 = 0.45$   
*param*  $ef6k2 = 0.0$   
*param*  $ef6n2 = 0.23$   
*param*  $ef6n3 = 0.0$   
*param*  $ef6p = 1.0$   
*param*  $ef6q = 1.0$   
*param*  $eidhb2 = 0.72$   
*param*  $eidhb5 = 4.2$   
*param*  $eidhn2 = 0.22$   
*param*  $eidhn3 = 0.0$   
*param*  $eorib2 = 0.45$   
*param*  $eorib5 = 0.85$   
*param*  $epb5 = 0.07$   
*param*  $epb5m = 0.16$   
*param*  $epb5q = 1.0$   
*param*  $epb5w = 0.075$   
*param*  $epk2 = 0.56$   
*param*  $epk2m = 0.61$   
*param*  $epk2w = 0.3$   
*param*  $epn2 = 0.083$   
*param*  $epn2m = 0.04$   
*param*  $epn2w = 0.08$   
*param*  $epn3 = 1.0$   
*param*  $epn3m = 1.0$   
*param*  $epn3w = 1.0$   
*param*  $J_{abck2} = 1.0$   
*param*  $J_{acdh} = 0.03$   
*param*  $J_{acln3} = 1.0$

*param*  $J_{aiep} = 0.1$   
*param*  $J_{amcm} = 0.1$   
*param*  $J_{atem} = 0.1$   
*param*  $J_{d2c1} = 0.05$   
*param*  $J_{d2f6} = 0.05$   
*param*  $J_{ibck2} = 1.0$   
*param*  $J_{icdh} = 0.032$   
*param*  $J_{icln3} = 1.0$   
*param*  $J_{iiep} = 0.1$   
*param*  $J_{imcm} = 0.1$   
*param*  $J_{item} = 0.1$   
*param*  $J_{pn} = 0.4$   
*param*  $J_{spn} = 0.15$   
*param*  $k_{a15_p} = 0.002$   
*param*  $k_{a15_{pp}} = 1.0$   
*param*  $k_{a15_{ppp}} = 0.001$   
*param*  $k_{a20_p} = 0.06$   
*param*  $k_{a20_{pp}} = 0.15$   
*param*  $k_{acdh_p} = 0.01$   
*param*  $k_{acdh_{pp}} = 0.55$   
*param*  $k_{aiep} = 0.1$   
*param*  $k_{amcm} = 1.0$   
*param*  $k_{as46} = 30.0$   
*param*  $k_{asb2} = 50.0$   
*param*  $k_{asb5} = 30.0$   
*param*  $k_{asbf1} = 0.14$   
*param*  $k_{asbf2} = 1.0$   
*param*  $k_{asbf3} = 1.0$   
*param*  $k_{asbf4} = 1.0$   
*param*  $k_{asbf5} = 0.11$   
*param*  $k_{asesp} = 50.0$   
*param*  $k_{asf2} = 15.0$   
*param*  $k_{asf5} = 0.015$   
*param*  $k_{asmbf} = 30.0$   
*param*  $k_{asprom} = 50.0$   
*param*  $k_{asrent} = 300.0$

*param*  $k_{asrentp} = 1.0$   
*param*  $k_{asw4} = 0.0$   
*param*  $k_{aswi} = 2.0$   
*param*  $k_{aswm} = 1.5$   
*param*  $k_{asws} = 30.0$   
*param*  $k_{d14} = 0.1$   
*param*  $k_{d1c1} = 0.01$   
*param*  $k_{d1f6} = 0.01$   
*param*  $k_{d20} = 0.255$   
*param*  $k_{d20_p} = 0.05$   
*param*  $k_{d2c1} = 1.0$   
*param*  $k_{d2f6} = 1.0$   
*param*  $k_{d3c1} = 1.0$   
*param*  $k_{d3f6} = 1.0$   
*param*  $k_{db2_p} = 0.003$   
*param*  $k_{db2_{pp}} = 0.4$   
*param*  $k_{db2_{ppp}} = 0.285$   
*param*  $k_{db5_p} = 0.015$   
*param*  $k_{db5_{pp}} = 0.17$   
*param*  $k_{dbs4} = 5.0$   
*param*  $k_{dbud} = 0.06$   
*param*  $k_{dc1} = 0.001$   
*param*  $k_{dcdh} = 0.01$   
*param*  $k_{df6} = 0.001$   
*param*  $k_{di46} = 0.5$   
*param*  $k_{dib2} = 0.05$   
*param*  $k_{dib5} = 0.06$   
*param*  $k_{diesp} = 0.5$   
*param*  $k_{dif2} = 0.5$   
*param*  $k_{dif5} = 0.03$   
*param*  $k_{dimbf} = 1.0$   
*param*  $k_{diprom} = 1.0$   
*param*  $k_{dirent} = 1.0$   
*param*  $k_{direntp} = 1.6$   
*param*  $k_{diw4} = 1.0$   
*param*  $k_{diwm} = 1.0$

*param*  $k_{diwp} = 15.0$   
*param*  $k_{diws} = 1.0$   
*param*  $k_{dn2} = 0.14$   
*param*  $k_{dnet} = 0.03$   
*param*  $k_{dnrm1} = 0.08$   
*param*  $k_{dori} = 0.06$   
*param*  $k_{dpd_{0001}} = 0.03$   
*param*  $k_{dpds_p} = 0.01$   
*param*  $k_{dpds_{pp}} = 0.25$   
*param*  $k_{dspn} = 0.06$   
*param*  $k_{dswi} = 0.08$   
*param*  $k_{EZ2} = 0.2$   
*param*  $k_{EZ} = 0.3$   
*param*  $k_{galbck2} = 3.0$   
*param*  $k_{galcdc6} = 0.4$   
*param*  $k_{galclb2} = 0.38$   
*param*  $k_{galclb5} = 0.016$   
*param*  $k_{galcln2} = 0.165$   
*param*  $k_{galcln3} = 15.0$   
*param*  $k_{galsic1} = 0.132$   
*param*  $k_{gk_{cln3}} = 1.0$   
*param*  $k_{i15} = 0.5$   
*param*  $k_i = 40.0$   
*param*  $k_{icdh_p} = 0.005$   
*param*  $k_{icdh_{pp}} = 0.08$   
*param*  $k_{iiep} = 0.15$   
*param*  $k_{imb_{f01}} = 0.6$   
*param*  $k_{imb_{f02}} = 1.2$   
*param*  $k_{imcm} = 0.49$   
*param*  $k_{imp} = 4.0$   
*param*  $k_{iswi} = 0.1$   
*param*  $k_{mb_{f10}} = 0.12$   
*param*  $k_{mb_{f20}} = 0.12$   
*param*  $k_{mc_{bck2}} = 5.0$   
*param*  $k_{mccdc6} = 5.0$   
*param*  $k_{mcclb5} = 4.0$



*param*  $k_{mccln2} = 4.0$   
*param*  $k_{mccln3} = 15.0$   
*param*  $k_{mcsic1} = 4.0$   
*param*  $k_{mcwhi5} = 10.0$   
*param*  $k_{pp} = 0.01$   
*param*  $k_{ppp} = 1.0$   
*param*  $k_{pnet_p} = 0.01$   
*param*  $k_{pnet_pp} = 2.4$   
*param*  $k_{pp14} = 1.0$   
*param*  $k_{pp} = 0.1$   
*param*  $k_{ppc1} = 4.0$   
*param*  $k_{ppcln} = 1.0$   
*param*  $k_{ppcln_p} = 0.5$   
*param*  $k_{ppf6} = 4.0$   
*param*  $k_{ppn_{0001}} = 2.8$   
*param*  $k_{ppnet_p} = 0.05$   
*param*  $k_{s14} = 0.22$   
*param*  $k_{s20_p} = 0.006$   
*param*  $k_{s20_{pp}} = 0.6$   
*param*  $k_{sb2_p} = 0.006$   
*param*  $k_{sb2_{pp}} = 0.12$   
*param*  $k_{sb5_p} = 2.0 \times 10^{-4}$   
*param*  $k_{sb5_{pp}} = 0.004$   
*param*  $k_{sb5_{ppp}} = 0.04$   
*param*  $k_{sb4} = 5.0$   
*param*  $k_{sbud} = 0.2$   
*param*  $k_{sc1_p} = 0.0132$   
*param*  $k_{sc1_{pp}} = 0.132$   
*param*  $k_{scdh} = 0.01$   
*param*  $k_{sf6_p} = 0.02$   
*param*  $k_{sf6_{pp}} = 0.2$   
*param*  $k_{sf6_{ppp}} = 0.004$   
*param*  $k_{sn2_p} = 0.0$   
*param*  $k_{sn2_{pp}} = 0.38$   
*param*  $k_{sn2_{ppp}} = 0.3$   
*param*  $k_{snet} = 0.084$

*param*  $k_{snrm1_p} = 0.08$

*param*  $k_{sori} = 1.5$

*param*  $k_{spds_p} = 0.07$

*param*  $k_{ssa0} = 0.6$

*param*  $k_{ssab2} = 0.5$

*param*  $k_{ssaw5} = 7.0$

*param*  $k_{sspn} = 0.09$

*param*  $k_{sswi_p} = 0.005$

*param*  $k_{sswi_{pp}} = 0.08$

*param*  $k_{y_{dj1}} = 1.0$

*param*  $lte1h = 1.0$

*param*  $lte1l = 0.1$

*param*  $mad2h = 8.0$

*param*  $mad2l = 0.01$

*param*  $maxmass = 28.0$

*param*  $mdt = 90.0$

*param*  $msn5 = 25.0$

*param*  $n = 5.0$

*param*  $nucleus = 0.2$

*param*  $pp2at = 1.0$

*param*  $ppase = 1.0$

*param*  $vnmaxw = 3.0$

*param*  $vpmaxm = 5.8$

*param*  $vpnmax = 3.0$

*param*  $whi5op = 10.0$

$dt = 1.0, total = 500.0, maxstor = 50000, bound = 10000, toler = 1.0 \times 10^{-4}, njmp = 1, t_0 = 0.0, meth =$   
*stiff*