SBML Model Report

Model name: "Csikasz-Nagy2006_Cell_Cycle"

May 6, 2016

1 General Overview

This is a document in SBML Level 2 Version 1 format. This model was created by the following twelve authors: Lukas Endler[1], Vijayalakshmi Chelliah[2], Attila Csikasz-Nagy[3], Lukas Endler[4], Vijayalakshmi Chelliah[5], Attila Csikasz-Nagy[6], Lukas Endler[7], Vijayalakshmi Chelliah[8], Attila Csikasz-Nagy[9], Lukas Endler[10], Vijayalakshmi Chelliah[11] and Attila Csikasz-Nagy[12] at November 28th 2008 at 3:31 p. m. and last time modified at July 20th 2012 at 11:39 a. m. Table 1 gives an overview of the quantities of all components of this model.

Model Notes

This model originates from the Cell Cycle Database . It is described in:
Analysis of a generic model of eukaryotic cell-cycle regulation. Csiksz-Nagy A , Battogtokh D , Chen KC , Novk B , Tyson JJ Biophys. J. [2006 Jun],90(12):4361-79
PMID: 16581849
Abstract:

[1]EMBL-EBI, lukas@ebi.ac.uk
[2]EMBL-EBI, viji@ebi.ac.uk
[3]University of Trento Centre for Computational and Systems Biology, csikasz@cosbi.eu
[4]EMBL-EBI, lukas@ebi.ac.uk
[5]EMBL-EBI, viji@ebi.ac.uk
[6]University of Trento Centre for Computational and Systems Biology, csikasz@cosbi.eu
[7]EMBL-EBI, lukas@ebi.ac.uk
[8]EMBL-EBI, viji@ebi.ac.uk
[9]University of Trento Centre for Computational and Systems Biology, csikasz@cosbi.eu
[10]EMBL-EBI, lukas@ebi.ac.uk
[11]EMBL-EBI, viji@ebi.ac.uk
[12]University of Trento Centre for Computational and Systems Biology, csikasz@cosbi.eu

Table 1: Number of components in this model, which are described in the following sections.

Element	Quantity	Element	Quantity
compartment types	0	compartments	1
species types	0	species	30
events	1	constraints	0
reactions	39	function definitions	6
global parameters	106	unit definitions	3
rules	30	initial assignments	0

We propose a protein interaction network for the regulation of DNA synthesis and mitosis that emphasizes the universality of the regulatory system among eukaryotic cells. The idiosyncrasies of cell cycle regulation in particular organisms can be attributed, we claim, to specific settings of rate constants in the dynamic network of chemical reactions. The values of these rate constants are determined ultimately by the genetic makeup of an organism. To support these claims, we convert the reaction mechanism into a set of governing kinetic equations and provide parameter values (specific to budding yeast, fission yeast, frog eggs, and mammalian cells) that account for many curious features of cell cycle regulation in these organisms. Using one-parameter bifurcation diagrams, we show how overall cell growth drives progression through the cell cycle, how cell-size homeostasis can be achieved by two different strategies, and how mutations remodel bifurcation diagrams and create unusual cell-division phenotypes. The relation between gene dosage and phenotype can be summarized compactly in two-parameter bifurcation diagrams. Our approach provides a theoretical framework in which to understand both the universality and particularity of cell cycle regulation, and to construct, in modular fashion, increasingly complex models of the networks controlling cell growth and division.

To cite BioModels Database, please use: Li C, Donizelli M, Rodriguez N, Dharuri H, Endler L, Chelliah V, Li L, He E, Henry A, Stefan MI, Snoep JL, Hucka M, Le Novre N, Laibe C (2010) BioModels Database: An enhanced, curated and annotated resource for published quantitative kinetic models. BMC Syst Biol., 4:92.

2 Unit Definitions

This is an overview of six unit definitions of which three are predefined by SBML and not mentioned in the model.

2.1 Unit substance

Name normalized subst

Notes both substance and and volume are normalized and actually should be dimensionless. Due to restrictions in SBML level2 version1 They are set to items and litres.

Definition item

2.2 Unit volume

Name normalized volume

Definition l

2.3 Unit per6minute

Name per6min

Definition $(360\ \mathrm{s})^{-1}$

2.4 Unit area

Notes Square metre is the predefined SBML unit for `area` since SBML Level 2 Version 1.

Definition m^2

2.5 Unit length

Notes Metre is the predefined SBML unit for `length` since SBML Level 2 Version 1.

Definition m

2.6 Unit time

Notes Second is the predefined SBML unit for `time`.

Definition s

3 Compartment

This model contains one compartment.

Table 2: Properties of all compartments.

Id	Name	SBO	Spatial Dimensions	Size	Unit	Constant	Outside
`cell`	cell		3	1	litre	☑	

3.1 Compartment `cell`

This is a three dimensional compartment with a constant size of one litre.

Name cell

4 Species

This model contains 30 species. The boundary condition of two of these species is set to `true` so that these species' amount cannot be changed by any reaction. Section 10 provides further details and the derived rates of change of each species.

Table 3: Properties of each species.

Id	Name	Compartment	Derived Unit	Constant	Boundary Condition
APC	APC	cell	item · l^{-1}	⊟	☑
APCP	APCP	cell	item · l^{-1}	⊟	⊟
BCKI	BCKI	cell	item · l^{-1}	⊟	⊟
Cdc14	Cdc14	cell	item · l^{-1}	⊟	⊟
Cdc20A	Cdc20A	cell	item · l^{-1}	⊟	⊟
Cdc20i	Cdc20i	cell	item · l^{-1}	⊟	⊟
Cdc20T	Cdc20T	cell	item · l^{-1}	⊟	⊟
Cdc25P	Cdc25P	cell	item · l^{-1}	⊟	⊟
Cdh1	Cdh1	cell	item · l^{-1}	⊟	⊟
Cdh1i	Cdh1i	cell	item · l^{-1}	⊟	☑
CKI	CKI	cell	item · l^{-1}	⊟	⊟
CKIT	CKIT	cell	item · l^{-1}	⊟	⊟
CycA	CycA	cell	item · l^{-1}	⊟	⊟
CycAT	CycAT	cell	item · l^{-1}	⊟	⊟
CycB	CycB	cell	item · l^{-1}	⊟	⊟
CycBT	CycBT	cell	item · l^{-1}	⊟	⊟
CycD	CycD	cell	item · l^{-1}	⊟	⊟
CycE	CycE	cell	item · l^{-1}	⊟	⊟
CycET	CycET	cell	item · l^{-1}	⊟	⊟
Mass	Mass	cell	item · l^{-1}	⊟	⊟
pB	pB	cell	item · l^{-1}	⊟	⊟

Id	Name	Compartment	Derived Unit	Constant	Boundary Condition
pBCKI	pBCKI	cell	$\mathrm{item} \cdot \mathrm{l}^{-1}$	⊟	⊟
preMPF	preMPF	cell	$\mathrm{item} \cdot \mathrm{l}^{-1}$	⊟	⊟
TFB	TFB	cell	$\mathrm{item} \cdot \mathrm{l}^{-1}$	⊟	⊟
TFE	TFE	cell	$\mathrm{item} \cdot \mathrm{l}^{-1}$	⊟	⊟
TFI	TFI	cell	$\mathrm{item} \cdot \mathrm{l}^{-1}$	⊟	⊟
TriA	TriA	cell	$\mathrm{item} \cdot \mathrm{l}^{-1}$	⊟	⊟
TriB	TriB	cell	$\mathrm{item} \cdot \mathrm{l}^{-1}$	⊟	⊟
TriE	TriE	cell	$\mathrm{item} \cdot \mathrm{l}^{-1}$	⊟	⊟
Wee1	Wee1	cell	$\mathrm{item} \cdot \mathrm{l}^{-1}$	⊟	⊟

5 Parameters

This model contains 106 global parameters.

Table 4: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
V25	V25		0.000		☐
Vah1	Vah1		0.000		☐
Vatf	Vatf		0.000		☐
Vda	Vda		0.000		☐
Vdb	Vdb		0.000		☐
Vde	Vde		0.000		☐
Vdi	Vdi		0.000		☐
Vih1	Vih1		0.000		☐
Vitf	Vitf		0.000		☐
Vsa	Vsa		0.000		☐
Vsb	Vsb		0.000		☐
Vse	Vse		0.000		☐
Vsi	Vsi		0.000		☐
Vwee	Vwee		0.000		☐
APCT	APCT		1.000		☑
Cdh1T	Cdh1T		1.000		☑
CycD0	CycD0		0.050		☑
J20	J20		1.000		☑
Ja20	Ja20		0.005		☑
Ja25	Ja25		0.100		☑
Jafb	Jafb		0.100		☑
Jafi	Jafi		88.000		☑
Jah1	Jah1		0.010		☑
Jaie	Jaie		0.010		☑
Jatf	Jatf		0.010		☑
Jawee	Jawee		0.050		☑
Ji20	Ji20		0.005		☑
Ji25	Ji25		0.100		☑
Jifb	Jifb		0.100		☑
Jifi	Jifi		88.000		☑
Jih1	Jih1		0.010		☑
Jiie	Jiie		0.010		☑
Jitf	Jitf		0.010		☑
Jiwee	Jiwee		0.050		☑
k14di	k14di		0.000		☑
k25b	k25b		5.000		☑
k25a	k25a		0.010		☑

Id	Name	SBO	Value	Unit	Constant
ka20	ka20		0.500		☑
ka25b	ka25b		1.000		☑
ka25a	ka25a		0.000		☑
kafb	kafb		1.000		☑
kafi	kafi		88.000		☑
kah1b	kah1b		3.500		☑
kah1a	kah1a		0.180		☑
kaie	kaie		0.070		☑
kassa	kassa		25.000		☑
kassb	kassb		0.000		☑
kasse	kasse		50.000		☑
katf	katf		0.000		☑
katfa	katfa		0.300		☑
katfd	katfd		3.000		☑
katfe	katfe		0.500		☑
kaweeb	kaweeb		0.000		☑
kaweea	kaweea		0.300		☑
kd20	kd20		0.150		☑
kdab	kdab		2.000		☑
kdaa	kdaa		0.020		☑
kdac	kdac		0.000		☑
kdb	kdb		0.005		☑
kdbc	kdbc		0.100		☑
kdbh	kdbh		2.000		☑
kde	kde		0.010		☑
kdea	kdea		0.500		☑
kdeb	kdeb		0.500		☑
kdee	kdee		0.100		☑
kdi	kdi		0.800		☑
kdia	kdia		5.000		☑
kdib	kdib		5.000		☑
kdid	kdid		0.000		☑
kdie	kdie		5.000		☑
kdissa	kdissa		1.000		☑
kdissb	kdissb		0.000		☑
kdisse	kdisse		1.000		☑
KEZ	KEZ		0.200		☑
ki20	ki20		0.250		☑
ki25b	ki25b		0.000		☑
ki25a	ki25a		0.300		☑
kifb	kifb		0.100		☑
kifi	kifi		88.000		☑

Id	Name	SBO	Value	Unit	Constant
kifib	kifib		88.000		☑
kih1	kih1		0.000		☑
kih1a	kih1a		0.200		☑
kih1b	kih1b		1.000		☑
kih1d	kih1d		0.000		☑
kih1e	kih1e		0.100		☑
kiie	kiie		0.180		☑
kitf	kitf		0.250		☑
kitfa	kitfa		0.100		☑
kitfb	kitfb		0.100		☑
kiweeb	kiweeb		1.000		☑
kiweea	kiweea		0.000		☑
ks20b	ks20b		0.150		☑
ks20a	ks20a		0.000		☑
ksab	ksab		0.025		☑
ksaa	ksaa		0.000		☑
ksbb	ksbb		0.030		☑
ksba	ksba		0.010		☑
kseb	kseb		0.180		☑
ksea	ksea		0.010		☑
ksib	ksib		0.000		☑
ksia	ksia		1.800		☑
kweeb	kweeb		0.200		☑
kweea	kweea		0.020		☑
MaxMass	MaxMass		10000.000		☑
mu	mu		0.005		☑
n20	n20		1.000		☑

6 Function definitions

This is an overview of six function definitions.

6.1 Function definition BB

Name BB

Arguments A1, A2, A3, A4

Mathematical Expression

$$\mathrm{A2} - \mathrm{A1} + \mathrm{A3} \cdot \mathrm{A2} + \mathrm{A4} \cdot \mathrm{A1} \tag{1}$$

6.2 Function definition GK

Name GK

Arguments A1, A2, A3, A4

Mathematical Expression

$$\frac{2 \cdot \mathrm{A4} \cdot \mathrm{A1}}{\mathrm{A2} - \mathrm{A1} + \mathrm{A3} \cdot \mathrm{A2} + \mathrm{A4} \cdot \mathrm{A1} + \sqrt{(\mathrm{A2} - \mathrm{A1} + \mathrm{A3} \cdot \mathrm{A2} + \mathrm{A4} \cdot \mathrm{A1})^2 - 4 \cdot (\mathrm{A2} - \mathrm{A1}) \cdot \mathrm{A4} \cdot \mathrm{A1}}} \tag{2}$$

6.3 Function definition MichaelisMenten

Name Michaelis-Menten

Arguments M1, J1, k1, S1

Mathematical Expression

$$\frac{\mathrm{k1} \cdot \mathrm{S1} \cdot \mathrm{M1}}{\mathrm{J1} + \mathrm{S1}} \tag{3}$$

6.4 Function definition Mass_Action_2

Name Mass_Action_2

Arguments k1, S1, S2

Mathematical Expression

$$\mathrm{k1} \cdot \mathrm{S1} \cdot \mathrm{S2} \tag{4}$$

6.5 Function definition Mass_Action_1

Name Mass_Action_1

Arguments k1, S1

Mathematical Expression

$$\mathrm{k1} \cdot \mathrm{S1} \tag{5}$$

6.6 Function definition Mass_Action_0

Name Mass_Action_0

Argument k1

Mathematical Expression

$$\mathrm{k1} \tag{6}$$

7 Rules

This is an overview of 30 rules.

7.1 Rule preMPF

Rule preMPF is an assignment rule for species preMPF:

$$\text{preMPF} = [\text{pB}] + [\text{pBCKI}] \tag{7}$$

Derived unit $\text{item} \cdot \text{l}^{-1}$

7.2 Rule TriB

Rule TriB is an assignment rule for species TriB:

$$\text{TriB} = [\text{BCKI}] + [\text{pBCKI}] \tag{8}$$

Derived unit $\text{item} \cdot \text{l}^{-1}$

7.3 Rule CycBT

Rule CycBT is an assignment rule for species CycBT:

$$\text{CycBT} = [\text{CycB}] + [\text{pB}] + [\text{BCKI}] + [\text{pBCKI}] \tag{9}$$

Derived unit $\text{item} \cdot \text{l}^{-1}$

7.4 Rule CycAT

Rule CycAT is an assignment rule for species CycAT:

$$\text{CycAT} = [\text{CycA}] + [\text{TriA}] \tag{10}$$

Derived unit $\text{item} \cdot \text{l}^{-1}$

7.5 Rule CycET

Rule CycET is an assignment rule for species CycET:

$$\text{CycET} = [\text{CycE}] + [\text{TriE}] \tag{11}$$

Derived unit $\text{item} \cdot \text{l}^{-1}$

7.6 Rule CycD

Rule CycD is an assignment rule for species CycD:

$$\text{CycD} = \text{CycD0} \cdot [\text{Mass}] \tag{12}$$

7.7 Rule CKIT

Rule CKIT is an assignment rule for species CKIT:

$$\mathrm{CKIT} = [\mathrm{CKI}] + [\mathrm{BCKI}] + [\mathrm{pBCKI}] + [\mathrm{TriA}] + [\mathrm{TriE}] \tag{13}$$

Derived unit $\mathrm{item} \cdot \mathrm{l}^{-1}$

7.8 Rule Cdc20T

Rule Cdc20T is an assignment rule for species Cdc20T:

$$\mathrm{Cdc20T} = [\mathrm{Cdc20i}] + [\mathrm{Cdc20A}] \tag{14}$$

Derived unit $\mathrm{item} \cdot \mathrm{l}^{-1}$

7.9 Rule Cdc14

Rule Cdc14 is an assignment rule for species Cdc14:

$$\mathrm{Cdc14} = [\mathrm{Cdc20A}] \tag{15}$$

Derived unit $\mathrm{item} \cdot \mathrm{l}^{-1}$

7.10 Rule Wee1

Rule Wee1 is an assignment rule for species Wee1:

$$\mathrm{Wee1} = \mathrm{GK}\left(\mathrm{kaweea} + \mathrm{kaweeb} \cdot [\mathrm{Cdc14}], \mathrm{kiweea} + \mathrm{kiweeb} \cdot [\mathrm{CycB}], \mathrm{Jawee}, \mathrm{Jiwee}\right) \tag{16}$$

7.11 Rule Vwee

Rule Vwee is an assignment rule for parameter Vwee:

$$\mathrm{Vwee} = \mathrm{kweea} + \mathrm{kweeb} \cdot [\mathrm{Wee1}] \tag{17}$$

7.12 Rule Cdc25P

Rule Cdc25P is an assignment rule for species Cdc25P:

$$\mathrm{Cdc25P} = \mathrm{GK}\left(\mathrm{ka25a} + \mathrm{ka25b} \cdot [\mathrm{CycB}], \mathrm{ki25a} + \mathrm{ki25b} \cdot [\mathrm{Cdc14}], \mathrm{Ja25}, \mathrm{Ji25}\right) \tag{18}$$

7.13 Rule V25

Rule V25 is an assignment rule for parameter V25:

$$\mathrm{V25} = \mathrm{k25a} + \mathrm{k25b} \cdot [\mathrm{Cdc25P}] \tag{19}$$

7.14 Rule TFB

Rule TFB is an assignment rule for species TFB:

$$\mathrm{TFB} = \mathrm{GK}\left(\mathrm{kafb} \cdot [\mathrm{CycB}], \mathrm{kifb}, \mathrm{Jafb}, \mathrm{Jifb}\right) \tag{20}$$

7.15 Rule Vatf

Rule Vatf is an assignment rule for parameter Vatf:

$$\mathrm{Vatf} = \mathrm{katf} + \mathrm{katfa} \cdot [\mathrm{CycA}] + \mathrm{katfe} \cdot [\mathrm{CycE}] + \mathrm{katfd} \cdot [\mathrm{CycD}] \tag{21}$$

7.16 Rule Vitf

Rule Vitf is an assignment rule for parameter Vitf:

$$\mathrm{Vitf} = \mathrm{kitf} + \mathrm{kitfa} \cdot [\mathrm{CycA}] + \mathrm{kitfb} \cdot [\mathrm{CycB}] \tag{22}$$

7.17 Rule TFE

Rule TFE is an assignment rule for species TFE:

$$\mathrm{TFE} = \mathrm{GK}\left(\mathrm{Vatf}, \mathrm{Vitf}, \mathrm{Jatf}, \mathrm{Jitf}\right) \tag{23}$$

7.18 Rule Vsb

Rule Vsb is an assignment rule for parameter Vsb:

$$\mathrm{Vsb} = \left(\mathrm{ksba} + \mathrm{ksbb} \cdot [\mathrm{TFB}]\right) \cdot [\mathrm{Mass}] \tag{24}$$

7.19 Rule Vsa

Rule Vsa is an assignment rule for parameter Vsa:

$$\mathrm{Vsa} = \left(\mathrm{ksaa} + \mathrm{ksab} \cdot [\mathrm{TFE}]\right) \cdot [\mathrm{Mass}] \tag{25}$$

7.20 Rule Vse

Rule Vse is an assignment rule for parameter Vse:

$$\mathrm{Vse} = \left(\mathrm{ksea} + \mathrm{kseb} \cdot [\mathrm{TFE}]\right) \cdot [\mathrm{Mass}] \tag{26}$$

7.21 Rule Vah1

Rule Vah1 is an assignment rule for parameter Vah1:

$$\mathrm{Vah1} = \mathrm{kah1a} + \mathrm{kah1b} \cdot [\mathrm{Cdc14}] \tag{27}$$

7.22 Rule Vih1

Rule Vih1 is an assignment rule for parameter Vih1:

$$\mathrm{Vih1} = \mathrm{kih1} + \mathrm{kih1a} \cdot [\mathrm{CycA}] + \mathrm{kih1b} \cdot [\mathrm{CycB}] + \mathrm{kih1e} \cdot [\mathrm{CycE}] + \mathrm{kih1d} \cdot [\mathrm{CycD}] \quad (28)$$

7.23 Rule Vdb

Rule Vdb is an assignment rule for parameter Vdb:

$$\mathrm{Vdb} = \mathrm{kdb} + \mathrm{kdbh} \cdot [\mathrm{Cdh1}] + \mathrm{kdbc} \cdot [\mathrm{Cdc20A}] \quad (29)$$

7.24 Rule Vda

Rule Vda is an assignment rule for parameter Vda:

$$\mathrm{Vda} = \mathrm{kdaa} + (\mathrm{kdab} + \mathrm{kdac}) \cdot [\mathrm{Cdc20A}] + \mathrm{kdac} \cdot [\mathrm{Cdc20i}] \quad (30)$$

7.25 Rule Vde

Rule Vde is an assignment rule for parameter Vde:

$$\mathrm{Vde} = \mathrm{kde} + \mathrm{kdee} \cdot [\mathrm{CycE}] + \mathrm{kdea} \cdot [\mathrm{CycA}] + \mathrm{kdeb} \cdot [\mathrm{CycB}] \quad (31)$$

7.26 Rule TFI

Rule TFI is an assignment rule for species TFI:

$$\mathrm{TFI} = \mathrm{GK}\left(\mathrm{kafi} \cdot [\mathrm{Cdc14}], \mathrm{kifi} + \mathrm{kifib} \cdot [\mathrm{CycB}], \mathrm{Jafi}, \mathrm{Jifi}\right) \quad (32)$$

7.27 Rule Vsi

Rule Vsi is an assignment rule for parameter Vsi:

$$\mathrm{Vsi} = \mathrm{ksia} + \mathrm{ksib} \cdot [\mathrm{TFI}] \quad (33)$$

7.28 Rule Vdi

Rule Vdi is an assignment rule for parameter Vdi:

$$\mathrm{Vdi} = \frac{\mathrm{kdi} + \mathrm{kdia} \cdot [\mathrm{CycA}] + \mathrm{kdib} \cdot [\mathrm{CycB}] + \mathrm{kdie} \cdot [\mathrm{CycE}] + \mathrm{kdid} \cdot [\mathrm{CycD}]}{1 + \mathrm{k14di} \cdot [\mathrm{Cdc14}]} \quad (34)$$

7.29 Rule APC

Rule APC is an assignment rule for species APC:

$$\mathrm{APC} = \mathrm{APCT} - [\mathrm{APCP}] \quad (35)$$

7.30 Rule Cdh1i

Rule Cdh1i is an assignment rule for species Cdh1i:

$$\mathrm{Cdh1i} = \mathrm{Cdh1T} - [\mathrm{Cdh1}] \tag{36}$$

8 Event

This is an overview of one event. Each event is initiated whenever its trigger condition switches from false to true. A delay function postpones the effects of an event to a later time point. At the time of execution, an event can assign values to species, parameters or compartments if these are not set to constant.

8.1 Event event_0

Trigger condition

$$[\mathrm{CycB}] - \mathrm{KEZ} < 0 \tag{37}$$

Delay

$$0 \tag{38}$$

Assignment

$$\mathrm{Mass} = 0.5 \cdot [\mathrm{Mass}] \tag{39}$$

9 Reactions

This model contains 39 reactions. All reactions are listed in the following table and are subsequently described in detail. If a reaction is affected by a modifier, the identifier of this species is written above the reaction arrow.

Table 5: Overview of all reactions

№	Id	Name	Reaction Equation	SBO
1	Mass_accumulation	Mass accumulation	$\emptyset \longrightarrow$ Mass	
2	Synthesis_of_MPF	Synthesis of MPF	$\emptyset \longrightarrow$ CycB	
3	Deg_of_MPF	Deg. of MPF	CycB $\longrightarrow \emptyset$	
4	activation_of_MPF_from_pB_by_Cdc25	activation of MPF from pB by Cdc25	pB $\longrightarrow$ CycB	
5	inactivation_of_MPFby_Wee1	inactivation of MPFby Wee1	CycB $\longrightarrow$ pB	
6	assoc_of_MPF_with_CKI	assoc. of MPF with CKI	CycB + CKI $\longrightarrow$ BCKI	
7	dissoc_1	dissoc1	BCKI $\longrightarrow$ CycB + CKI	
8	deg_of_pB	deg. of pB	pB $\longrightarrow \emptyset$	
9	assoc_of_pB_with_CKI	assoc. of pB with CKI	pB + CKI $\longrightarrow$ pBCKI	
10	dissoc_2	dissoc2	pBCKI $\longrightarrow$ pB + CKI	
11	Cdc25_action	Cdc25 action	pBCKI $\longrightarrow$ BCKI	
12	Wee1_action	Wee1 action	BCKI $\longrightarrow$ pBCKI	
13	Deg_of_CycB_moeity__in_BCKI	Deg. of CycB moeity in BCKI	BCKI $\longrightarrow$ CKI	
14	Deg_of_CKI_moeity_in_BCKI	Deg. of CKI moeity in BCKI	BCKI $\longrightarrow$ CycB	

№	Id	Name	Reaction Equation	SBO
15	Deg_of_pB-_moeity_in-_pBCKI	Deg. of pB moeity in pBCKI	pBCKI $\longrightarrow$ CKI	
16	Deg_of_CKI-_moeity_in-_pBCKI	Deg. of CKI moeity in pBCKI	pBCKI $\longrightarrow$ pB	
17	Synthesis_of-_CKI	Synthesis of CKI	$\emptyset \longrightarrow$ CKI	
18	Deg_of_CKI	Deg. of CKI	CKI $\longrightarrow \emptyset$	
19	Assoc_of_CKI-_with_CycA	Assoc. of CKI with CycA	CKI + CycA $\longrightarrow$ TriA	
20	dissoc_3	dissoc3	TriA $\longrightarrow$ CKI + CycA	
21	Deg_of_CKI-_moeity_in_TriA	Deg. of CKI moeity in TriA	TriA $\longrightarrow$ CycA	
22	Deg_of_CycA-_moeity_in_TriA	Deg. of CycA moeity in TriA	TriA $\longrightarrow$ CKI	
23	Assoc_of_CKI-_with_CycE	Assoc. of CKI with CycE	CKI + CycE $\longrightarrow$ TriE	
24	dissoc_4	dissoc4	TriE $\longrightarrow$ CKI + CycE	
25	Deg_of_CKI-_moeity_in_TriE	Deg. of CKI moeity in TriE	TriE $\longrightarrow$ CycE	
26	Deg_of_CycE-_moeity_in_TriE	Deg. of CycE moeity in TriE	TriE $\longrightarrow$ CKI	
27	Synthesis_of-_CycA_by_TFE	Synthesis of CycA by TFE	$\emptyset \longrightarrow$ CycA	
28	Deg_of_CycA	Deg. of CycA	CycA $\longrightarrow \emptyset$	
29	Synthesis_of-_CycE_by_TFE	Synthesis of CycE by TFE	$\emptyset \longrightarrow$ CycE	
30	Deg_of_CycE	Deg. of CycE	CycE $\longrightarrow \emptyset$	

№	Id	Name	Reaction Equation	SBO
31	activation_of_APCP	activation of APCP	$\mathrm{APC} \xrightarrow{\mathrm{CycB}} \mathrm{APCP}$	
32	inactivation_1	inactivation1	$\mathrm{APCP} \longrightarrow \mathrm{APC}$	
33	Synthesis_of_Cdc20i	Synthesis of Cdc20i	$\emptyset \xrightarrow{\mathrm{CycB}} \mathrm{Cdc20i}$	
34	Deg_of_Cdc20i	Deg. of Cdc20i	$\mathrm{Cdc20i} \longrightarrow \emptyset$	
35	activation_of_Cdc20i	activation of Cdc20i	$\mathrm{Cdc20i} \xrightarrow{\mathrm{APCP}} \mathrm{Cdc20A}$	
36	inactivation_2	inactivation2	$\mathrm{Cdc20A} \longrightarrow \mathrm{Cdc20i}$	
37	degradation	degradation	$\mathrm{Cdc20A} \longrightarrow \emptyset$	
38	activation_of_Cdh1	activation of Cdh1	$\mathrm{Cdh1i} \longrightarrow \mathrm{Cdh1}$	
39	inactivation_of_Cdh1	inactivation of Cdh1	$\mathrm{Cdh1} \longrightarrow \mathrm{Cdh1i}$	

9.1 Reaction `Mass_accumulation`

This is an irreversible reaction of no reactant forming one product.

Name Mass accumulation

Reaction equation

$$\emptyset \longrightarrow \text{Mass} \tag{40}$$

Product

Table 6: Properties of each product.

Id	Name	SBO
`Mass`	Mass	

Kinetic Law

Derived unit contains undeclared units

$$v_1 = \text{Mass\_Action\_0}\left(\text{mu} \cdot [\text{Mass}] \cdot \left(1 - \frac{[\text{Mass}]}{\text{MaxMass}}\right)\right) \tag{41}$$

$$\text{Mass\_Action\_0}(\text{k1}) = \text{k1} \tag{42}$$

9.2 Reaction `Synthesis_of_MPF`

This is an irreversible reaction of no reactant forming one product.

Name Synthesis of MPF

Reaction equation

$$\emptyset \longrightarrow \text{CycB} \tag{43}$$

Product

Table 7: Properties of each product.

Id	Name	SBO
`CycB`	CycB	

Kinetic Law

Derived unit not available

$$v_2 = \mathrm{Vsb} \tag{44}$$

9.3 Reaction Deg_of_MPF

This is an irreversible reaction of one reactant forming no product.

Name Deg. of MPF

Reaction equation

$$\mathrm{CycB} \longrightarrow \emptyset \tag{45}$$

Reactant

Table 8: Properties of each reactant.

Id	Name	SBO
CycB	CycB	

Kinetic Law

Derived unit contains undeclared units

$$v_3 = \mathrm{Mass\_Action\_1}\left(\mathrm{Vdb}, [\mathrm{CycB}]\right) \tag{46}$$

$$\mathrm{Mass\_Action\_1}\left(\mathrm{k1}, \mathrm{S1}\right) = \mathrm{k1} \cdot \mathrm{S1} \tag{47}$$

9.4 Reaction activation_of_MPF_from_pB_by_Cdc25

This is an irreversible reaction of one reactant forming one product.

Name activation of MPF from pB by Cdc25

Reaction equation

$$\mathrm{pB} \longrightarrow \mathrm{CycB} \tag{48}$$

Reactant

Table 9: Properties of each reactant.

Id	Name	SBO
pB	pB	

Product

Table 10: Properties of each product.

Id	Name	SBO
CycB	CycB	

Kinetic Law

Derived unit contains undeclared units

$$v_4 = \text{Mass\_Action\_1}\,(\text{V25}, [\text{pB}]) \tag{49}$$

$$\text{Mass\_Action\_1}\,(\text{k1}, \text{S1}) = \text{k1} \cdot \text{S1} \tag{50}$$

9.5 Reaction inactivation_of_MPFby_Wee1

This is an irreversible reaction of one reactant forming one product.

Name inactivation of MPFby Wee1

Reaction equation

$$\text{CycB} \longrightarrow \text{pB} \tag{51}$$

Reactant

Table 11: Properties of each reactant.

Id	Name	SBO
CycB	CycB	

Product

Table 12: Properties of each product.

Id	Name	SBO
pB	pB	

Kinetic Law

Derived unit contains undeclared units

$$v_5 = \text{Mass\_Action\_1}\,(\text{Vwee}, [\text{CycB}]) \tag{52}$$

$$\text{Mass\_Action\_1}\,(\text{k1}, \text{S1}) = \text{k1} \cdot \text{S1} \tag{53}$$

9.6 Reaction assoc_of_MPF_with_CKI

This is an irreversible reaction of two reactants forming one product.

Name assoc. of MPF with CKI

Reaction equation

$$\text{CycB} + \text{CKI} \longrightarrow \text{BCKI} \tag{54}$$

Reactants

Table 13: Properties of each reactant.

Id	Name	SBO
CycB	CycB	
CKI	CKI	

Product

Table 14: Properties of each product.

Id	Name	SBO
BCKI	BCKI	

Kinetic Law

Derived unit contains undeclared units

$$v_6 = \text{Mass\_Action\_2}\,(\text{kassb}, [\text{CycB}], [\text{CKI}]) \tag{55}$$

$$\text{Mass\_Action\_2}\,(\text{k1}, \text{S1}, \text{S2}) = \text{k1} \cdot \text{S1} \cdot \text{S2} \tag{56}$$

9.7 Reaction `dissoc_1`

This is an irreversible reaction of one reactant forming two products.

Name dissoc1

Reaction equation

$$\text{BCKI} \longrightarrow \text{CycB} + \text{CKI} \tag{57}$$

Reactant

Table 15: Properties of each reactant.

Id	Name	SBO
`BCKI`	BCKI	

Products

Table 16: Properties of each product.

Id	Name	SBO
`CycB`	CycB	
`CKI`	CKI	

Kinetic Law

Derived unit contains undeclared units

$$v_7 = \text{Mass\_Action\_1}\,(\text{kdissb}, [\text{BCKI}]) \tag{58}$$

$$\text{Mass\_Action\_1}\,(\text{k1}, \text{S1}) = \text{k1} \cdot \text{S1} \tag{59}$$

9.8 Reaction `deg_of_pB`

This is an irreversible reaction of one reactant forming no product.

Name deg. of pB

Reaction equation

$$\text{pB} \longrightarrow \emptyset \tag{60}$$

Reactant

Table 17: Properties of each reactant.

Id	Name	SBO
pB	pB	

Kinetic Law

Derived unit contains undeclared units

$$v_8 = \text{Mass\_Action\_1}\,(\text{Vdb}, [\text{pB}]) \tag{61}$$

$$\text{Mass\_Action\_1}\,(\text{k1}, \text{S1}) = \text{k1} \cdot \text{S1} \tag{62}$$

9.9 Reaction assoc_of_pB_with_CKI

This is an irreversible reaction of two reactants forming one product.

Name assoc. of pB with CKI

Reaction equation

$$\text{pB} + \text{CKI} \longrightarrow \text{pBCKI} \tag{63}$$

Reactants

Table 18: Properties of each reactant.

Id	Name	SBO
pB	pB	
CKI	CKI	

Product

Table 19: Properties of each product.

Id	Name	SBO
pBCKI	pBCKI	

Kinetic Law

Derived unit contains undeclared units

$$v_9 = \text{Mass\_Action\_2}\,(\text{kassb}, [\text{pB}], [\text{CKI}]) \tag{64}$$

$$\text{Mass\_Action\_2}\,(\text{k1}, \text{S1}, \text{S2}) = \text{k1} \cdot \text{S1} \cdot \text{S2} \tag{65}$$

9.10 Reaction `dissoc_2`

This is an irreversible reaction of one reactant forming two products.

Name dissoc2

Reaction equation

$$\text{pBCKI} \longrightarrow \text{pB} + \text{CKI} \tag{66}$$

Reactant

Table 20: Properties of each reactant.

Id	Name	SBO
`pBCKI`	pBCKI	

Products

Table 21: Properties of each product.

Id	Name	SBO
`pB`	pB	
`CKI`	CKI	

Kinetic Law

Derived unit contains undeclared units

$$v_{10} = \text{Mass\_Action\_1}\,(\text{kdissb}, [\text{pBCKI}]) \tag{67}$$

$$\text{Mass\_Action\_1}\,(\text{k1}, \text{S1}) = \text{k1} \cdot \text{S1} \tag{68}$$

9.11 Reaction Cdc25_action

This is an irreversible reaction of one reactant forming one product.

Name Cdc25 action

Reaction equation

$$\text{pBCKI} \longrightarrow \text{BCKI} \tag{69}$$

Reactant

Table 22: Properties of each reactant.

Id	Name	SBO
pBCKI	pBCKI	

Product

Table 23: Properties of each product.

Id	Name	SBO
BCKI	BCKI	

Kinetic Law

Derived unit contains undeclared units

$$v_{11} = \text{Mass\_Action\_1}\left(\text{V25}, [\text{pBCKI}]\right) \tag{70}$$

$$\text{Mass\_Action\_1}\left(\text{k1}, \text{S1}\right) = \text{k1} \cdot \text{S1} \tag{71}$$

9.12 Reaction Wee1_action

This is an irreversible reaction of one reactant forming one product.

Name Wee1 action

Reaction equation

$$\text{BCKI} \longrightarrow \text{pBCKI} \tag{72}$$

Reactant

Table 24: Properties of each reactant.

Id	Name	SBO
BCKI	BCKI	

Product

Table 25: Properties of each product.

Id	Name	SBO
pBCKI	pBCKI	

Kinetic Law

Derived unit contains undeclared units

$$v_{12} = \text{Mass\_Action\_1}\left(\text{Vwee}, [\text{BCKI}]\right) \tag{73}$$

$$\text{Mass\_Action\_1}\left(\text{k1}, \text{S1}\right) = \text{k1} \cdot \text{S1} \tag{74}$$

9.13 Reaction Deg_of_CycB_moeity__in_BCKI

This is an irreversible reaction of one reactant forming one product.

Name Deg. of CycB moeity in BCKI

Reaction equation

$$\text{BCKI} \longrightarrow \text{CKI} \tag{75}$$

Reactant

Table 26: Properties of each reactant.

Id	Name	SBO
BCKI	BCKI	

Product

Table 27: Properties of each product.

Id	Name	SBO
CKI	CKI	

Kinetic Law

Derived unit contains undeclared units

$$v_{13} = \text{Mass\_Action\_1}\,(\text{Vdb}, [\text{BCKI}]) \tag{76}$$

$$\text{Mass\_Action\_1}\,(\text{k1}, \text{S1}) = \text{k1} \cdot \text{S1} \tag{77}$$

9.14 Reaction Deg_of_CKI_moeity_in_BCKI

This is an irreversible reaction of one reactant forming one product.

Name Deg. of CKI moeity in BCKI

Reaction equation

$$\text{BCKI} \longrightarrow \text{CycB} \tag{78}$$

Reactant

Table 28: Properties of each reactant.

Id	Name	SBO
BCKI	BCKI	

Product

Table 29: Properties of each product.

Id	Name	SBO
CycB	CycB	

Kinetic Law

Derived unit contains undeclared units

$$v_{14} = \text{Mass\_Action\_1}\,(\text{Vdi}, [\text{BCKI}]) \tag{79}$$

$$\text{Mass\_Action\_1}\left(\text{k1}, \text{S1}\right) = \text{k1} \cdot \text{S1} \tag{80}$$

9.15 Reaction Deg_of_pB_moeity_in_pBCKI

This is an irreversible reaction of one reactant forming one product.

Name Deg. of pB moeity in pBCKI

Reaction equation

$$\text{pBCKI} \longrightarrow \text{CKI} \tag{81}$$

Reactant

Table 30: Properties of each reactant.

Id	Name	SBO
pBCKI	pBCKI	

Product

Table 31: Properties of each product.

Id	Name	SBO
CKI	CKI	

Kinetic Law

Derived unit contains undeclared units

$$v_{15} = \text{Mass\_Action\_1}\left(\text{Vdb}, [\text{pBCKI}]\right) \tag{82}$$

$$\text{Mass\_Action\_1}\left(\text{k1}, \text{S1}\right) = \text{k1} \cdot \text{S1} \tag{83}$$

9.16 Reaction Deg_of_CKI_moeity_in_pBCKI

This is an irreversible reaction of one reactant forming one product.

Name Deg. of CKI moeity in pBCKI

Reaction equation

$$\text{pBCKI} \longrightarrow \text{pB} \tag{84}$$

Reactant

Table 32: Properties of each reactant.

Id	Name	SBO
pBCKI	pBCKI	

Product

Table 33: Properties of each product.

Id	Name	SBO
pB	pB	

Kinetic Law

Derived unit contains undeclared units

$$v_{16} = \text{Mass\_Action\_1}\left(\text{Vdi}, [\text{pBCKI}]\right) \tag{85}$$

$$\text{Mass\_Action\_1}\left(\text{k1}, \text{S1}\right) = \text{k1} \cdot \text{S1} \tag{86}$$

9.17 Reaction Synthesis_of_CKI

This is an irreversible reaction of no reactant forming one product.

Name Synthesis of CKI

Reaction equation

$$\emptyset \longrightarrow \text{CKI} \tag{87}$$

Product

Table 34: Properties of each product.

Id	Name	SBO
CKI	CKI	

Kinetic Law

Derived unit not available

$$v_{17} = \text{Vsi} \tag{88}$$

9.18 Reaction Deg_of_CKI

This is an irreversible reaction of one reactant forming no product.

Name Deg. of CKI

Reaction equation

$$\mathrm{CKI} \longrightarrow \emptyset \tag{89}$$

Reactant

Table 35: Properties of each reactant.

Id	Name	SBO
CKI	CKI	

Kinetic Law

Derived unit contains undeclared units

$$v_{18} = \mathrm{Mass\_Action\_1}\left(\mathrm{Vdi}, [\mathrm{CKI}]\right) \tag{90}$$

$$\mathrm{Mass\_Action\_1}\left(\mathrm{k1}, \mathrm{S1}\right) = \mathrm{k1} \cdot \mathrm{S1} \tag{91}$$

9.19 Reaction Assoc_of_CKI_with_CycA

This is an irreversible reaction of two reactants forming one product.

Name Assoc. of CKI with CycA

Reaction equation

$$\mathrm{CKI} + \mathrm{CycA} \longrightarrow \mathrm{TriA} \tag{92}$$

Reactants

Table 36: Properties of each reactant.

Id	Name	SBO
CKI	CKI	
CycA	CycA	

Product

Table 37: Properties of each product.

Id	Name	SBO
TriA	TriA	

Kinetic Law

Derived unit contains undeclared units

$$v_{19} = \text{Mass\_Action\_2}\,(\text{kassa}, [\text{CKI}], [\text{CycA}]) \tag{93}$$

$$\text{Mass\_Action\_2}\,(\text{k1}, \text{S1}, \text{S2}) = \text{k1} \cdot \text{S1} \cdot \text{S2} \tag{94}$$

9.20 Reaction dissoc_3

This is an irreversible reaction of one reactant forming two products.

Name dissoc3

Reaction equation

$$\text{TriA} \longrightarrow \text{CKI} + \text{CycA} \tag{95}$$

Reactant

Table 38: Properties of each reactant.

Id	Name	SBO
TriA	TriA	

Products

Table 39: Properties of each product.

Id	Name	SBO
CKI	CKI	
CycA	CycA	

Kinetic Law

Derived unit contains undeclared units

$$v_{20} = \text{Mass\_Action\_1}\left(\text{kdissa}, [\text{TriA}]\right) \tag{96}$$

$$\text{Mass\_Action\_1}\left(\text{k1}, \text{S1}\right) = \text{k1} \cdot \text{S1} \tag{97}$$

9.21 Reaction Deg_of_CKI_moeity_in_TriA

This is an irreversible reaction of one reactant forming one product.

Name Deg. of CKI moeity in TriA

Reaction equation

$$\text{TriA} \longrightarrow \text{CycA} \tag{98}$$

Reactant

Table 40: Properties of each reactant.

Id	Name	SBO
TriA	TriA	

Product

Table 41: Properties of each product.

Id	Name	SBO
CycA	CycA	

Kinetic Law

Derived unit contains undeclared units

$$v_{21} = \text{Mass\_Action\_1}\left(\text{Vdi}, [\text{TriA}]\right) \tag{99}$$

$$\text{Mass\_Action\_1}\left(\text{k1}, \text{S1}\right) = \text{k1} \cdot \text{S1} \tag{100}$$

9.22 Reaction Deg_of_CycA_moeity_in_TriA

This is an irreversible reaction of one reactant forming one product.

Name Deg. of CycA moeity in TriA

Reaction equation

$$\mathrm{TriA} \longrightarrow \mathrm{CKI} \tag{101}$$

Reactant

Table 42: Properties of each reactant.

Id	Name	SBO
TriA	TriA	

Product

Table 43: Properties of each product.

Id	Name	SBO
CKI	CKI	

Kinetic Law

Derived unit contains undeclared units

$$v_{22} = \mathrm{Mass\_Action\_1}\left(\mathrm{Vda}, [\mathrm{TriA}]\right) \tag{102}$$

$$\mathrm{Mass\_Action\_1}\left(\mathrm{k1}, \mathrm{S1}\right) = \mathrm{k1} \cdot \mathrm{S1} \tag{103}$$

9.23 Reaction Assoc_of_CKI_with_CycE

This is an irreversible reaction of two reactants forming one product.

Name Assoc. of CKI with CycE

Reaction equation

$$\mathrm{CKI} + \mathrm{CycE} \longrightarrow \mathrm{TriE} \tag{104}$$

Reactants

Table 44: Properties of each reactant.

Id	Name	SBO
CKI	CKI	
CycE	CycE	

Product

Table 45: Properties of each product.

Id	Name	SBO
TriE	TriE	

Kinetic Law

Derived unit contains undeclared units

$$v_{23} = \text{Mass\_Action\_2}\,(\text{kasse}, [\text{CKI}], [\text{CycE}]) \tag{105}$$

$$\text{Mass\_Action\_2}\,(\text{k1}, \text{S1}, \text{S2}) = \text{k1} \cdot \text{S1} \cdot \text{S2} \tag{106}$$

9.24 Reaction dissoc_4

This is an irreversible reaction of one reactant forming two products.

Name dissoc4

Reaction equation

$$\text{TriE} \longrightarrow \text{CKI} + \text{CycE} \tag{107}$$

Reactant

Table 46: Properties of each reactant.

Id	Name	SBO
TriE	TriE	

Products

Table 47: Properties of each product.

Id	Name	SBO
CKI	CKI	
CycE	CycE	

Kinetic Law

Derived unit contains undeclared units

$$v_{24} = \text{Mass\_Action\_1}\left(\text{kdisse}, [\text{TriE}]\right) \tag{108}$$

$$\text{Mass\_Action\_1}\left(\text{k1}, \text{S1}\right) = \text{k1} \cdot \text{S1} \tag{109}$$

9.25 Reaction `Deg_of_CKI_moeity_in_TriE`

This is an irreversible reaction of one reactant forming one product.

Name Deg. of CKI moeity in TriE

Reaction equation

$$\text{TriE} \longrightarrow \text{CycE} \tag{110}$$

Reactant

Table 48: Properties of each reactant.

Id	Name	SBO
`TriE`	TriE	

Product

Table 49: Properties of each product.

Id	Name	SBO
`CycE`	CycE	

Kinetic Law

Derived unit contains undeclared units

$$v_{25} = \text{Mass\_Action\_1}\left(\text{Vdi}, [\text{TriE}]\right) \tag{111}$$

$$\text{Mass\_Action\_1}\left(\text{k1}, \text{S1}\right) = \text{k1} \cdot \text{S1} \tag{112}$$

9.26 Reaction `Deg_of_CycE_moeity_in_TriE`

This is an irreversible reaction of one reactant forming one product.

Name Deg. of CycE moeity in TriE

Reaction equation

$$\text{TriE} \longrightarrow \text{CKI} \tag{113}$$

Reactant

Table 50: Properties of each reactant.

Id	Name	SBO
TriE	TriE	

Product

Table 51: Properties of each product.

Id	Name	SBO
CKI	CKI	

Kinetic Law

Derived unit contains undeclared units

$$v_{26} = \text{Mass\_Action\_1}\left(\text{Vde}, [\text{TriE}]\right) \tag{114}$$

$$\text{Mass\_Action\_1}\left(\text{k1}, \text{S1}\right) = \text{k1} \cdot \text{S1} \tag{115}$$

9.27 Reaction Synthesis_of_CycA_by_TFE

This is an irreversible reaction of no reactant forming one product.

Name Synthesis of CycA by TFE

Reaction equation

$$\emptyset \longrightarrow \text{CycA} \tag{116}$$

Product

Table 52: Properties of each product.

Id	Name	SBO
CycA	CycA	

Kinetic Law

Derived unit not available

$$v_{27} = \mathrm{Vsa} \tag{117}$$

9.28 Reaction Deg_of_CycA

This is an irreversible reaction of one reactant forming no product.

Name Deg. of CycA

Reaction equation

$$\mathrm{CycA} \longrightarrow \emptyset \tag{118}$$

Reactant

Table 53: Properties of each reactant.

Id	Name	SBO
CycA	CycA	

Kinetic Law

Derived unit contains undeclared units

$$v_{28} = \mathrm{Mass\_Action\_1}\left(\mathrm{Vda}, [\mathrm{CycA}]\right) \tag{119}$$

$$\mathrm{Mass\_Action\_1}\left(\mathrm{k1}, \mathrm{S1}\right) = \mathrm{k1} \cdot \mathrm{S1} \tag{120}$$

9.29 Reaction Synthesis_of_CycE_by_TFE

This is an irreversible reaction of no reactant forming one product.

Name Synthesis of CycE by TFE

Reaction equation

$$\emptyset \longrightarrow \mathrm{CycE} \tag{121}$$

Product

Table 54: Properties of each product.

Id	Name	SBO
CycE	CycE	

Kinetic Law

Derived unit not available

$$v_{29} = \text{Vse} \tag{122}$$

9.30 Reaction Deg_of_CycE

This is an irreversible reaction of one reactant forming no product.

Name Deg. of CycE

Reaction equation

$$\text{CycE} \longrightarrow \emptyset \tag{123}$$

Reactant

Table 55: Properties of each reactant.

Id	Name	SBO
CycE	CycE	

Kinetic Law

Derived unit contains undeclared units

$$v_{30} = \text{Mass\_Action\_1}\left(\text{Vde}, [\text{CycE}]\right) \tag{124}$$

$$\text{Mass\_Action\_1}\left(\text{k1}, \text{S1}\right) = \text{k1} \cdot \text{S1} \tag{125}$$

9.31 Reaction activation_of_APCP

This is an irreversible reaction of one reactant forming one product influenced by one modifier.

Name activation of APCP

Reaction equation

$$\text{APC} \xrightarrow{\text{CycB}} \text{APCP} \tag{126}$$

Reactant

Table 56: Properties of each reactant.

Id	Name	SBO
APC	APC	

Modifier

Table 57: Properties of each modifier.

Id	Name	SBO
CycB	CycB	

Product

Table 58: Properties of each product.

Id	Name	SBO
APCP	APCP	

Kinetic Law

Derived unit contains undeclared units

$$v_{31} = \text{MichaelisMenten}\left([\text{CycB}], \text{Jaie}, \text{kaie}, [\text{APC}]\right) \tag{127}$$

$$\text{MichaelisMenten}\left(\text{M1}, \text{J1}, \text{k1}, \text{S1}\right) = \frac{\text{k1} \cdot \text{S1} \cdot \text{M1}}{\text{J1} + \text{S1}} \tag{128}$$

9.32 Reaction inactivation_1

This is an irreversible reaction of one reactant forming one product.

Name inactivation1

Reaction equation

$$\text{APCP} \longrightarrow \text{APC} \tag{129}$$

Reactant

Table 59: Properties of each reactant.

Id	Name	SBO
APCP	APCP	

Product

Table 60: Properties of each product.

Id	Name	SBO
APC	APC	

Kinetic Law

Derived unit contains undeclared units

$$v_{32} = \text{MichaelisMenten}\,(1, \text{Jiie}, \text{kiie}, [\text{APCP}]) \tag{130}$$

$$\text{MichaelisMenten}\,(\text{M1}, \text{J1}, \text{k1}, \text{S1}) = \frac{\text{k1} \cdot \text{S1} \cdot \text{M1}}{\text{J1} + \text{S1}} \tag{131}$$

9.33 Reaction Synthesis_of_Cdc20i

This is an irreversible reaction of no reactant forming one product influenced by one modifier.

Name Synthesis of Cdc20i

Reaction equation

$$\emptyset \xrightarrow{\text{CycB}} \text{Cdc20i} \tag{132}$$

Modifier

Table 61: Properties of each modifier.

Id	Name	SBO
CycB	CycB	

Product

Table 62: Properties of each product.

Id	Name	SBO
Cdc20i	Cdc20i	

Kinetic Law

Derived unit contains undeclared units

$$v_{33} = \text{Mass\_Action\_0}\left(\text{ks20a} + \frac{\text{ks20b} \cdot [\text{CycB}]^{\text{n20}}}{\text{J20}^{\text{n20}} + [\text{CycB}]^{\text{n20}}}\right) \tag{133}$$

$$\text{Mass\_Action\_0}\,(\text{k1}) = \text{k1} \tag{134}$$

9.34 Reaction Deg_of_Cdc20i

This is an irreversible reaction of one reactant forming no product.

Name Deg. of Cdc20i

Reaction equation

$$\text{Cdc20i} \longrightarrow \emptyset \tag{135}$$

Reactant

Table 63: Properties of each reactant.

Id	Name	SBO
Cdc20i	Cdc20i	

Kinetic Law

Derived unit contains undeclared units

$$v_{34} = \text{Mass\_Action\_1}\,(\text{kd20}, [\text{Cdc20i}]) \tag{136}$$

$$\text{Mass\_Action\_1}\,(\text{k1}, \text{S1}) = \text{k1} \cdot \text{S1} \tag{137}$$

9.35 Reaction activation_of_Cdc20i

This is an irreversible reaction of one reactant forming one product influenced by one modifier.

Name activation of Cdc20i

Reaction equation

$$\text{Cdc20i} \xrightarrow{\text{APCP}} \text{Cdc20A} \tag{138}$$

Reactant

Table 64: Properties of each reactant.

Id	Name	SBO
Cdc20i	Cdc20i	

Modifier

Table 65: Properties of each modifier.

Id	Name	SBO
APCP	APCP	

Product

Table 66: Properties of each product.

Id	Name	SBO
Cdc20A	Cdc20A	

Kinetic Law

Derived unit contains undeclared units

$$v_{35} = \text{MichaelisMenten}\left([\text{APCP}], \text{Ja20}, \text{ka20}, [\text{Cdc20i}]\right) \tag{139}$$

$$\text{MichaelisMenten}\left(\text{M1}, \text{J1}, \text{k1}, \text{S1}\right) = \frac{\text{k1} \cdot \text{S1} \cdot \text{M1}}{\text{J1} + \text{S1}} \tag{140}$$

9.36 Reaction inactivation_2

This is an irreversible reaction of one reactant forming one product.

Name inactivation2

Reaction equation

$$\text{Cdc20A} \longrightarrow \text{Cdc20i} \tag{141}$$

Reactant

Table 67: Properties of each reactant.

Id	Name	SBO
Cdc20A	Cdc20A	

Product

Table 68: Properties of each product.

Id	Name	SBO
Cdc20i	Cdc20i	

Kinetic Law

Derived unit contains undeclared units

$$v_{36} = \text{MichaelisMenten}\,(1, \text{Ji20}, \text{ki20}, [\text{Cdc20A}]) \tag{142}$$

$$\text{MichaelisMenten}\,(\text{M1}, \text{J1}, \text{k1}, \text{S1}) = \frac{\text{k1} \cdot \text{S1} \cdot \text{M1}}{\text{J1} + \text{S1}} \tag{143}$$

9.37 Reaction degradation

This is an irreversible reaction of one reactant forming no product.

Name degradation

Reaction equation

$$\text{Cdc20A} \longrightarrow \emptyset \tag{144}$$

Reactant

Table 69: Properties of each reactant.

Id	Name	SBO
Cdc20A	Cdc20A	

Kinetic Law

Derived unit contains undeclared units

$$v_{37} = \text{Mass\_Action\_1}\left(\text{kd20}, [\text{Cdc20A}]\right) \tag{145}$$

$$\text{Mass\_Action\_1}\left(\text{k1}, \text{S1}\right) = \text{k1} \cdot \text{S1} \tag{146}$$

9.38 Reaction `activation_of_Cdh1`

This is an irreversible reaction of one reactant forming one product.

Name activation of Cdh1

Reaction equation

$$\text{Cdh1i} \longrightarrow \text{Cdh1} \tag{147}$$

Reactant

Table 70: Properties of each reactant.

Id	Name	SBO
`Cdh1i`	Cdh1i	

Product

Table 71: Properties of each product.

Id	Name	SBO
`Cdh1`	Cdh1	

Kinetic Law

Derived unit contains undeclared units

$$v_{38} = \text{MichaelisMenten}\left(\text{Vah1}, \text{Jah1}, 1, [\text{Cdh1i}]\right) \tag{148}$$

$$\text{MichaelisMenten}\left(\text{M1}, \text{J1}, \text{k1}, \text{S1}\right) = \frac{\text{k1} \cdot \text{S1} \cdot \text{M1}}{\text{J1} + \text{S1}} \tag{149}$$

9.39 Reaction inactivation__of_Cdh1

This is an irreversible reaction of one reactant forming one product.

Name inactivation of Cdh1

Reaction equation

$$\text{Cdh1} \longrightarrow \text{Cdh1i} \tag{150}$$

Reactant

Table 72: Properties of each reactant.

Id	Name	SBO
Cdh1	Cdh1	

Product

Table 73: Properties of each product.

Id	Name	SBO
Cdh1i	Cdh1i	

Kinetic Law

Derived unit contains undeclared units

$$v_{39} = \text{MichaelisMenten}\left(\text{Vih1}, \text{Jih1}, 1, [\text{Cdh1}]\right) \tag{151}$$

$$\text{MichaelisMenten}\left(\text{M1}, \text{J1}, \text{k1}, \text{S1}\right) = \frac{\text{k1} \cdot \text{S1} \cdot \text{M1}}{\text{J1} + \text{S1}} \tag{152}$$

10 Derived Rate Equations

When interpreted as an ordinary differential equation framework, this model implies the following set of equations for the rates of change of each species.

Identifiers for kinetic laws highlighted in gray cannot be verified to evaluate to units of SBML `substance` per `time`. As a result, some SBML interpreters may not be able to verify the consistency of the units on quantities in the model. Please check if

- parameters without an unit definition are involved or
- volume correction is necessary because the `hasOnlySubstanceUnits` flag may be set to `false` and `spacialDimensions`> 0 for certain species.

10.1 Species APC

Name APC

Involved in rule APC

This species takes part in two reactions (as a reactant in activation_of_APCP and as a product in inactivation_1). Not these but one rule determines the species' quantity because this species is on the boundary of the reaction system.

10.2 Species APCP

Name APCP

Initial amount 0.671626567840576 item

This species takes part in three reactions (as a reactant in inactivation_1 and as a product in activation_of_APCP and as a modifier in activation_of_Cdc20i).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{APCP} = v_{31} - v_{32} \tag{153}$$

10.3 Species BCKI

Name BCKI

Initial amount 0 item

This species takes part in six reactions (as a reactant in dissoc_1, Wee1_action, Deg_of_CycB-_moeity__in_BCKI, Deg_of_CKI_moeity_in_BCKI and as a product in assoc_of_MPF_with-_CKI, Cdc25_action).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{BCKI} = v_6 + v_{11} - v_7 - v_{12} - v_{13} - v_{14} \tag{154}$$

10.4 Species Cdc14

Name Cdc14

Involved in rule Cdc14

One rule which determines this species' quantity.

10.5 Species Cdc20A

Name Cdc20A

Initial amount 0.660586714744568 item

This species takes part in three reactions (as a reactant in inactivation_2, degradation and as a product in activation_of_Cdc20i).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{Cdc20A} = v_{35} - v_{36} - v_{37} \tag{155}$$

10.6 Species Cdc20i

Name Cdc20i

Initial amount 0.018553527072072 item

This species takes part in four reactions (as a reactant in Deg_of_Cdc20i, activation_of_Cdc20i and as a product in Synthesis_of_Cdc20i, inactivation_2).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{Cdc20i} = v_{33} + v_{36} - v_{34} - v_{35} \tag{156}$$

10.7 Species Cdc20T

Name Cdc20T

Involved in rule Cdc20T

One rule which determines this species' quantity.

10.8 Species Cdc25P

Name Cdc25P

Involved in rule Cdc25P

One rule which determines this species' quantity.

10.9 Species Cdh1

Name Cdh1

Initial amount 0.99923574924469 item

This species takes part in two reactions (as a reactant in inactivation__of_Cdh1 and as a product in activation_of_Cdh1).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{Cdh1} = v_{38} - v_{39} \tag{157}$$

10.10 Species Cdh1i

Name Cdh1i

Involved in rule Cdh1i

This species takes part in two reactions (as a reactant in activation_of_Cdh1 and as a product in inactivation__of_Cdh1). Not these but one rule determines the species' quantity because this species is on the boundary of the reaction system.

10.11 Species CKI

Name CKI

Initial amount 0.295407682657242 item

This species takes part in 14 reactions (as a reactant in assoc_of_MPF_with_CKI, assoc-_of_pB_with_CKI, Deg_of_CKI, Assoc_of_CKI_with_CycA, Assoc_of_CKI_with_CycE and as a product in dissoc_1, dissoc_2, Deg_of_CycB_moeity__in_BCKI, Deg_of_pB_moeity_in-_pBCKI, Synthesis_of_CKI, dissoc_3, Deg_of_CycA_moeity_in_TriA, dissoc_4, Deg_of-_CycE_moeity_in_TriE).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{CKI} = v_7 + v_{10} + v_{13} + v_{15} + v_{17} + v_{20} + v_{22} + v_{24} + v_{26} - v_6 - v_9 - v_{18} - v_{19} - v_{23} \tag{158}$$

10.12 Species CKIT

Name CKIT

Involved in rule CKIT

One rule which determines this species' quantity.

10.13 Species CycA

Name CycA

Initial amount 0.00994044542312622 item

This species takes part in five reactions (as a reactant in Assoc_of_CKI_with_CycA, Deg_of-_CycA and as a product in dissoc_3, Deg_of_CKI_moeity_in_TriA, Synthesis_of_CycA_by-_TFE).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{CycA} = v_{20} + v_{21} + v_{27} - v_{19} - v_{28} \tag{159}$$

10.14 Species CycAT

Name CycAT

Involved in rule CycAT

One rule which determines this species' quantity.

10.15 Species CycB

Name CycB

Initial amount 0.166841372847557 item

This species takes part in nine reactions (as a reactant in Deg_of_MPF, inactivation_of_MPFby_Wee1, assoc_of_MPF_with_CKI and as a product in Synthesis_of_MPF, activation_of_MPF_from_pB_by_Cdc25, dissoc_1, Deg_of_CKI_moeity_in_BCKI and as a modifier in activation_of_APCP, Synthesis_of_Cdc20i).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{CycB} = v_2 + v_4 + v_7 + v_{14} - v_3 - v_5 - v_6 \tag{160}$$

10.16 Species CycBT

Name CycBT

Involved in rule CycBT

One rule which determines this species' quantity.

10.17 Species CycD

Name CycD

Involved in rule CycD

One rule which determines this species' quantity.

10.18 Species CycE

Name CycE

Initial amount 0.077605128288269 item

This species takes part in five reactions (as a reactant in Assoc_of_CKI_with_CycE, Deg_of_CycE and as a product in dissoc_4, Deg_of_CKI_moeity_in_TriE, Synthesis_of_CycE_by_TFE).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{CycE} = v_{24} + v_{25} + v_{29} - v_{23} - v_{30} \tag{161}$$

10.19 Species CycET

Name CycET

Involved in rule CycET

One rule which determines this species' quantity.

10.20 Species Mass

Name Mass

Initial amount 1.17421686649323 item

Involved in event event_0

This species takes part in one reaction (as a product in Mass_accumulation).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{Mass} = v_1 \tag{162}$$

Furthermore, one event influences this species' rate of change.

10.21 Species pB

Name pB

Initial amount 0.00981487054377794 item

This species takes part in six reactions (as a reactant in activation_of_MPF_from_pB_by_Cdc25, deg_of_pB, assoc_of_pB_with_CKI and as a product in inactivation_of_MPFby_Wee1, dissoc_2, Deg_of_CKI_moeity_in_pBCKI).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{pB} = v_5 + v_{10} + v_{16} - v_4 - v_8 - v_9 \tag{163}$$

10.22 Species pBCKI

Name pBCKI

Initial amount 0 item

This species takes part in six reactions (as a reactant in dissoc_2, Cdc25_action, Deg_of_pB_moeity_in_pBCKI, Deg_of_CKI_moeity_in_pBCKI and as a product in assoc_of_pB_with_CKI, Wee1_action).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{pBCKI} = v_9 + v_{12} - v_{10} - v_{11} - v_{15} - v_{16} \tag{164}$$

10.23 Species preMPF

Name preMPF

Involved in rule preMPF

One rule which determines this species' quantity.

10.24 Species TFB

Name TFB

Involved in rule TFB

One rule which determines this species' quantity.

10.25 Species TFE

Name TFE

Involved in rule TFE

One rule which determines this species' quantity.

10.26 Species TFI

Name TFI

Involved in rule TFI

One rule which determines this species' quantity.

10.27 Species TriA

Name TriA

Initial amount 0.017153799533844 item

This species takes part in four reactions (as a reactant in dissoc_3, Deg_of_CKI_moeity_in_TriA, Deg_of_CycA_moeity_in_TriA and as a product in Assoc_of_CKI_with_CycA).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{TriA} = v_{19} - v_{20} - v_{21} - v_{22} \tag{165}$$

10.28 Species TriB

Name TriB

Involved in rule TriB

One rule which determines this species' quantity.

10.29 Species TriE

Name TriE

Initial amount 0.311726331710815 item

This species takes part in four reactions (as a reactant in dissoc_4, Deg_of_CKI_moeity_in_TriE, Deg_of_CycE_moeity_in_TriE and as a product in Assoc_of_CKI_with_CycE).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{TriE} = v_{23} - v_{24} - v_{25} - v_{26} \tag{166}$$

10.30 Species Wee1

Name Wee1

Involved in rule Wee1

One rule which determines this species' quantity.

SBML2LaTeX was developed by Andreas Dräger[a], Hannes Planatscher[a], Dieudonné M Wouamba[a], Adrian Schröder[a], Michael Hucka[b], Lukas Endler[c], Martin Golebiewski[d] and Andreas Zell[a]. Please see http://www.ra.cs.uni-tuebingen.de/software/SBML2LaTeX for more information.

[a]Center for Bioinformatics Tübingen (ZBIT), Germany
[b]California Institute of Technology, Beckman Institute BNMC, Pasadena, United States
[c]European Bioinformatics Institute, Wellcome Trust Genome Campus, Hinxton, United Kingdom
[d]EML Research gGmbH, Heidelberg, Germany