SBML Model Report

Model name: "Qu2003_CellCycle"

May 6, 2016

1 General Overview

This is a document in SBML Level 2 Version 4 format. This model was created by the following two authors: Enuo He[1] and Lukas Endler[2] at September 29th 2008 at one o' clock in the afternoon. and last time modified at February 25th 2015 at 11:11 a. m. Table 1 gives an overview of the quantities of all components of this model.

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	15
events	0	constraints	0
reactions	22	function definitions	0
global parameters	30	unit definitions	2
rules	2	initial assignments	0

Model Notes

This model is from the article:
Dynamics of the cell cycle: checkpoints, sizers, and timers.
Qu Z, MacLellan WR, Weiss JN Biophys. J.2003 Dec; 85(6): 3600-11 14645053,
Abstract:
We have developed a generic mathematical model of a cell cycle signaling network in higher

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eukaryotes that can be used to simulate both the G1/S and G2/M transitions. In our model, the positive feedback facilitated by CDC25 and wee1 causes bistability in cyclin-dependent kinase activity, whereas the negative feedback facilitated by SKP2 or anaphase-promoting-complex turns this bistable behavior into limit cycle behavior. The cell cycle checkpoint is a Hopf bifurcation point. These behaviors are coordinated by growth and division to maintain normal cell cycle and size homeostasis. This model successfully reproduces sizer, timer, and the restriction point features of the eukaryotic cell cycle, in addition to other experimental findings.

Figure6B has been reproduced by both SBMLodeSolver online and MathSBML. We do not include the synthesis of cyclins is proportional to cell size (Equation 2 in Page3604 of the paper) in this model. The author of the paper keep all the variables and parameters dimensionless. But in the model, we choose to use default units of SBML.

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To cite BioModels Database, please use Le Novre N., Bornstein B., Broicher A., Courtot M., Donizelli M., Dharuri H., Li L., Sauro H., Schilstra M., Shapiro B., Snoep J.L., Hucka M. (2006) BioModels Database: A Free, Centralized Database of Curated, Published, Quantitative Kinetic Models of Biochemical and Cellular Systems Nucleic Acids Res., 34: D689-D691.

2 Unit Definitions

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

2.1 Unit `substance`

Name arbitrary subst.

Definition dimensionless

2.2 Unit `volume`

Name arbitrary vol

Definition dimensionless

2.3 Unit `area`

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

Definition m^2

2.4 Unit `length`

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

Definition m

2.5 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	dimensionless	☑	

3.1 Compartment `cell`

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

Name cell

4 Species

This model contains 15 species. Section 8 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
x1	Inactive Cyclin:CDK complex	cell	dimensionless · dimensionless^{-1}	⊟	⊟
x	Active Cyclin:CDK complex	cell	dimensionless · dimensionless^{-1}	⊟	⊟
c0	Total CDK	cell	dimensionless · dimensionless^{-1}	⊟	⊟
c	Free CDK	cell	dimensionless · dimensionless^{-1}	⊟	⊟
z0	Unphosphorylated CDC25	cell	dimensionless · dimensionless^{-1}	⊟	⊟
z1	One-site phosphorylated CDC25	cell	dimensionless · dimensionless^{-1}	⊟	⊟
z2	Two-site phosphorylated CDC25	cell	dimensionless · dimensionless^{-1}	⊟	⊟
w0	Unphosphorylated wee1	cell	dimensionless · dimensionless^{-1}	⊟	⊟
w1	phosphorylated wee1	cell	dimensionless · dimensionless^{-1}	⊟	⊟
u	Active SKP2 or APC	cell	dimensionless · dimensionless^{-1}	⊟	⊟
i	Free CKI	cell	dimensionless · dimensionless^{-1}	⊟	⊟

Id	Name	Compartment	Derived Unit	Constant	Boundary Condition
ix	Cyclin:CDK:CKI complex with CKI unphosphorylated	cell	dimensionless · dimensionless^{-1}	⊟	⊟
ixp	Cyclin:CDK:CKI complex with CKI phosphorylated	cell	dimensionless · dimensionless^{-1}	⊟	⊟
y	Free cyclin	cell	dimensionless · dimensionless^{-1}	⊟	⊟
totalCyclin		cell	dimensionless · dimensionless^{-1}	⊟	⊟

5 Parameters

This model contains 30 global parameters.

Table 4: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
k1			300.0		☑
k2			5.0		☑
k3			30.0		☑
k4			30.0		☑
k5			0.1		☑
k6			1.0		☑
k7			10.0		☑
k8			100.0		☑
k9			1.0		☑
k10			10.0		☑
k11			1.0		☑
k12			0.0		☑
k13			1.0		☑
k14			1.0		☑
k15			1.0		☑
k16			2.0		☑
k2u			50.0		☑
k7u			0.0		☑
k16u			25.0		☑
a			4.0		☑
az			10.0		☑
aw			10.0		☑
ai			10.0		☑
bz			0.1		☑
bw			0.1		☑
bi			0.1		☑
cz			1.0		☑
cw			1.0		☑
ci			1.0		☑
Tau			25.0		☑

6 Rules

This is an overview of two rules.

6.1 Rule c

Rule c is an assignment rule for species c:

$$c = \frac{[c0] - ([x] + [x1] + [ix] + [ixp])}{[c0] \cdot \mathrm{vol}(cell)} \tag{1}$$

Derived unit dimensionless

Notes Free CDK (normalized with c0)c=(c0-x-x1-ix-ixp)/c0.

6.2 Rule totalCyclin

Rule totalCyclin is an assignment rule for species totalCyclin:

$$totalCyclin = [x] + [x1] + [y] \tag{2}$$

Derived unit $\mathrm{dimensionless}^{-1}$

Notes Total cyclin (x+x1+y)

7 Reactions

This model contains 22 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	reaction_0000001	Free cyclin synthesis	$\emptyset \longrightarrow y$	
2	reaction_0000002	Cyclin binding with CDK	$y \overset{c}{\rightleftharpoons} x1$	
3	reaction_0000003	Cyclin degradation	$y \overset{u}{\longrightarrow} \emptyset$	
4	reaction_0000004	z0 phosphorylation	$z0 \overset{x}{\rightleftharpoons} z1$	
5	reaction_0000005	x phosphorylation	$x \overset{z2,\ w0}{\rightleftharpoons} x1$	
6	reaction_0000006	z1 phosphorylation	$z1 \overset{x}{\rightleftharpoons} z2$	
7	reaction_0000007	unphosphorylated wee1 synthesis	$\emptyset \longrightarrow w0$	
8	reaction_000008	wee1 phosphorylation	$w0 \overset{x}{\rightleftharpoons} w1$	
9	reaction_000009	SKP2 synthesis	$\emptyset \overset{x}{\longrightarrow} u$	
10	reaction_0000010	CKI synthesis	$\emptyset \longrightarrow i$	
11	reaction_0000011	CKI binding to Active Cyclin:CDK complex	$i + x \rightleftharpoons ix$	

№	Id	Name	Reaction Equation	SBO
12	reaction_0000014	ix phosphorylation	$ix \overset{x}{\rightleftharpoons} ixp$	
13	reaction_0000013	SKP2 degradation	$u \longrightarrow \emptyset$	
14	reaction_0000015	CKI degradation	$i \longrightarrow \emptyset$	
15	reaction_0000016	Cyclin:CDK:CKIp degradation	$ixp \longrightarrow x$	
16	reaction_0000017	unphosphorylated wee1 degradation	$w0 \longrightarrow \emptyset$	
17	reaction_0000018	phosphorylated wee1 degradation	$w1 \longrightarrow \emptyset$	
18	reaction_0000019	Unphosphorylated CDC25 degradation	$z0 \longrightarrow \emptyset$	
19	reaction_0000020	One site phosphorylated CDC25 degradaton	$z1 \longrightarrow \emptyset$	
20	reaction_0000021	Two site phosphorylated CDC25 degradation	$z2 \rightleftharpoons \emptyset$	
21	reaction_0000022	Unphosphorylation CDC25 synthesis	$\emptyset \longrightarrow z0$	
22	reaction_0000023	Active cyclin:CDK complex degradation	$x \overset{u}{\longrightarrow} \emptyset$	

7.1 Reaction reaction_0000001

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

Name Free cyclin synthesis

Reaction equation

$$\emptyset \longrightarrow \mathrm{y} \tag{3}$$

Product

Table 6: Properties of each product.

Id	Name	SBO
y	Free cyclin	

Kinetic Law

Derived unit contains undeclared units

$$v_1 = \mathrm{k1} \cdot \mathrm{vol}\left(\mathrm{cell}\right) \tag{4}$$

7.2 Reaction reaction_0000002

This is a reversible reaction of one reactant forming one product influenced by one modifier.

Name Cyclin binding with CDK

Reaction equation

$$\mathrm{y} \overset{\mathrm{c}}{\rightleftharpoons} \mathrm{x1} \tag{5}$$

Reactant

Table 7: Properties of each reactant.

Id	Name	SBO
y	Free cyclin	

Modifier

Table 8: Properties of each modifier.

Id	Name	SBO
c	Free CDK	

Product

Table 9: Properties of each product.

Id	Name	SBO
x1	Inactive Cyclin:CDK complex	

Kinetic Law

Derived unit contains undeclared units

$$v_2 = \mathrm{vol}\,(\mathrm{cell}) \cdot (\mathrm{k3} \cdot [\mathrm{c}] \cdot [\mathrm{y}] - [\mathrm{x1}] \cdot \mathrm{k4}) \tag{6}$$

7.3 Reaction reaction_0000003

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

Name Cyclin degradation

Reaction equation

$$\mathrm{y} \xrightarrow{\mathrm{u}} \emptyset \tag{7}$$

Reactant

Table 10: Properties of each reactant.

Id	Name	SBO
y	Free cyclin	

Modifier

Table 11: Properties of each modifier.

Id	Name	SBO
u	Active SKP2 or APC	

Kinetic Law

Derived unit contains undeclared units

$$v_3 = \mathrm{vol}\,(\mathrm{cell}) \cdot (\mathrm{k2} + \mathrm{k2u} \cdot [\mathrm{u}]) \cdot [\mathrm{y}] \tag{8}$$

7.4 Reaction `reaction_0000004`

This is a reversible reaction of one reactant forming one product influenced by one modifier.

Name z0 phosphorylation

Reaction equation

$$\mathrm{z0} \overset{\mathrm{x}}{\rightleftharpoons} \mathrm{z1} \tag{9}$$

Reactant

Table 12: Properties of each reactant.

Id	Name	SBO
`z0`	Unphosphorylated CDC25	

Modifier

Table 13: Properties of each modifier.

Id	Name	SBO
`x`	Active Cyclin:CDK complex	

Product

Table 14: Properties of each product.

Id	Name	SBO
`z1`	One-site phosphorylated CDC25	

Kinetic Law

Derived unit contains undeclared units

$$v_4 = \mathrm{vol}\,(\mathrm{cell}) \cdot ((\mathrm{bz} + \mathrm{cz} \cdot [\mathrm{x}]) \cdot [\mathrm{z0}] - [\mathrm{z1}] \cdot \mathrm{az}) \tag{10}$$

7.5 Reaction reaction_0000005

This is a reversible reaction of one reactant forming one product influenced by two modifiers.

Name x phosphorylation

Reaction equation

$$\mathrm{x} \overset{\mathrm{z2,\ w0}}{\rightleftharpoons} \mathrm{x1} \tag{11}$$

Reactant

Table 15: Properties of each reactant.

Id	Name	SBO
x	Active Cyclin:CDK complex	

Modifiers

Table 16: Properties of each modifier.

Id	Name	SBO
z2	Two-site phosphorylated CDC25	
w0	Unphosphorylated wee1	

Product

Table 17: Properties of each product.

Id	Name	SBO
x1	Inactive Cyclin:CDK complex	

Kinetic Law

Derived unit contains undeclared units

$$v_5 = \mathrm{vol}\,(\mathrm{cell}) \cdot ((\mathrm{k6} + [\mathrm{w0}]) \cdot [\mathrm{x}] - (\mathrm{k5} + [\mathrm{z2}]) \cdot [\mathrm{x1}]) \tag{12}$$

7.6 Reaction reaction_0000006

This is a reversible reaction of one reactant forming one product influenced by one modifier.

Name z1 phosphorylation

Reaction equation

$$\mathrm{z1} \overset{\mathrm{x}}{\rightleftharpoons} \mathrm{z2} \tag{13}$$

Reactant

Table 18: Properties of each reactant.

Id	Name	SBO
z1	One-site phosphorylated CDC25	

Modifier

Table 19: Properties of each modifier.

Id	Name	SBO
x	Active Cyclin:CDK complex	

Product

Table 20: Properties of each product.

Id	Name	SBO
z2	Two-site phosphorylated CDC25	

Kinetic Law

Derived unit contains undeclared units

$$v_6 = \mathrm{vol}\,(\mathrm{cell}) \cdot ((\mathrm{bz} + \mathrm{cz} \cdot [\mathrm{x}]) \cdot [\mathrm{z1}] - \mathrm{az} \cdot [\mathrm{z2}]) \tag{14}$$

7.7 Reaction reaction_0000007

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

Name unphosphorylated wee1 synthesis

Reaction equation

$$\emptyset \longrightarrow \mathrm{w0} \tag{15}$$

Product

Table 21: Properties of each product.

Id	Name	SBO
w0	Unphosphorylated wee1	

Kinetic Law

Derived unit contains undeclared units

$$v_7 = \mathrm{k10} \cdot \mathrm{vol}\,(\mathrm{cell}) \tag{16}$$

7.8 Reaction reaction_000008

This is a reversible reaction of one reactant forming one product influenced by one modifier.

Name wee1 phosphorylation

Reaction equation

$$\mathrm{w0} \overset{\mathrm{x}}{\rightleftharpoons} \mathrm{w1} \tag{17}$$

Reactant

Table 22: Properties of each reactant.

Id	Name	SBO
w0	Unphosphorylated wee1	

Modifier

Table 23: Properties of each modifier.

Id	Name	SBO
x	Active Cyclin:CDK complex	

Product

Table 24: Properties of each product.

Id	Name	SBO
w1	phosphorylated wee1	

Kinetic Law

Derived unit contains undeclared units

$$v_8 = \mathrm{vol}\,(\mathrm{cell}) \cdot ((\mathrm{bw} + \mathrm{cw} \cdot [\mathrm{x}]) \cdot [\mathrm{w0}] - \mathrm{aw} \cdot [\mathrm{w1}]) \tag{18}$$

7.9 Reaction reaction_000009

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

Name SKP2 synthesis

Reaction equation

$$\emptyset \xrightarrow{\mathrm{x}} \mathrm{u} \tag{19}$$

Modifier

Table 25: Properties of each modifier.

Id	Name	SBO
x	Active Cyclin:CDK complex	

Product

Table 26: Properties of each product.

Id	Name	SBO
u	Active SKP2 or APC	

Kinetic Law

Derived unit contains undeclared units

$$v_9 = \frac{\frac{\mathrm{vol(cell)} \cdot [\mathrm{x}]^2}{\mathrm{a}^2 + [\mathrm{x}]^2}}{\mathrm{Tau}} \tag{20}$$

7.10 Reaction reaction_0000010

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

Name CKI synthesis

Reaction equation

$$\emptyset \longrightarrow \mathrm{i} \tag{21}$$

Product

Table 27: Properties of each product.

Id	Name	SBO
i	Free CKI	

Kinetic Law

Derived unit contains undeclared units

$$v_{10} = \mathrm{k12} \cdot \mathrm{vol}\,(\mathrm{cell}) \tag{22}$$

7.11 Reaction reaction_0000011

This is a reversible reaction of two reactants forming one product.

Name CKI binding to Active Cyclin:CDK complex

Reaction equation

$$\mathrm{i} + \mathrm{x} \rightleftharpoons \mathrm{ix} \tag{23}$$

Reactants

Table 28: Properties of each reactant.

Id	Name	SBO
i	Free CKI	
x	Active Cyclin:CDK complex	

Product

Table 29: Properties of each product.

Id	Name	SBO
ix	Cyclin:CDK:CKI complex with CKI unphosphorylated	

Kinetic Law

Derived unit contains undeclared units

$$v_{11} = (\mathrm{k14} \cdot [\mathrm{x}] \cdot [\mathrm{i}] - \mathrm{k15} \cdot [\mathrm{ix}]) \cdot \mathrm{vol}(\mathrm{cell}) \tag{24}$$

7.12 Reaction `reaction_0000014`

This is a reversible reaction of one reactant forming one product influenced by one modifier.

Name ix phosphorylation

Reaction equation

$$\mathrm{ix} \overset{\mathrm{x}}{\rightleftharpoons} \mathrm{ixp} \tag{25}$$

Reactant

Table 30: Properties of each reactant.

Id	Name	SBO
`ix`	Cyclin:CDK:CKI complex with CKI unphosphorylated	

Modifier

Table 31: Properties of each modifier.

Id	Name	SBO
`x`	Active Cyclin:CDK complex	

Product

Table 32: Properties of each product.

Id	Name	SBO
`ixp`	Cyclin:CDK:CKI complex with CKI phosphorylated	

Kinetic Law

Derived unit contains undeclared units

$$v_{12} = \mathrm{vol}(\mathrm{cell}) \cdot ((\mathrm{bi} + \mathrm{ci} \cdot [\mathrm{x}]) \cdot [\mathrm{ix}] - \mathrm{ai} \cdot [\mathrm{ixp}]) \tag{26}$$

7.13 Reaction reaction_0000013

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

Name SKP2 degradation

Reaction equation

$$\mathrm{u} \longrightarrow \emptyset \tag{27}$$

Reactant

Table 33: Properties of each reactant.

Id	Name	SBO
u	Active SKP2 or APC	

Kinetic Law

Derived unit contains undeclared units

$$v_{13} = \frac{\mathrm{vol}\,(\mathrm{cell}) \cdot [\mathrm{u}]}{\mathrm{Tau}} \tag{28}$$

7.14 Reaction reaction_0000015

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

Name CKI degradation

Reaction equation

$$\mathrm{i} \longrightarrow \emptyset \tag{29}$$

Reactant

Table 34: Properties of each reactant.

Id	Name	SBO
i	Free CKI	

Kinetic Law

Derived unit contains undeclared units

$$v_{14} = \mathrm{vol}\,(\mathrm{cell}) \cdot \mathrm{k13} \cdot [\mathrm{i}] \tag{30}$$

7.15 Reaction reaction_0000016

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

Name Cyclin:CDK:CKIp degradation

Reaction equation

$$\mathrm{ixp} \longrightarrow \mathrm{x} \tag{31}$$

Reactant

Table 35: Properties of each reactant.

Id	Name	SBO
ixp	Cyclin:CDK:CKI complex with CKI phosphorylated	

Product

Table 36: Properties of each product.

Id	Name	SBO
x	Active Cyclin:CDK complex	

Kinetic Law

Derived unit contains undeclared units

$$v_{15} = \mathrm{vol}\,(\mathrm{cell}) \cdot \mathrm{k16} \cdot \mathrm{k16u} \cdot [\mathrm{ixp}] \tag{32}$$

7.16 Reaction reaction_0000017

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

Name unphosphorylated wee1 degradation

Reaction equation

$$\mathrm{w0} \longrightarrow \emptyset \tag{33}$$

Reactant

Table 37: Properties of each reactant.

Id	Name	SBO
w0	Unphosphorylated wee1	

Kinetic Law

Derived unit contains undeclared units

$$v_{16} = \mathrm{vol}\,(\mathrm{cell}) \cdot [\mathrm{w0}] \cdot \mathrm{k11} \tag{34}$$

7.17 Reaction reaction_0000018

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

Name phosphorylated wee1 degradation

Reaction equation

$$\mathrm{w1} \longrightarrow \emptyset \tag{35}$$

Reactant

Table 38: Properties of each reactant.

Id	Name	SBO
w1	phosphorylated wee1	

Kinetic Law

Derived unit contains undeclared units

$$v_{17} = \mathrm{vol}\,(\mathrm{cell}) \cdot \mathrm{k11} \cdot [\mathrm{w1}] \tag{36}$$

7.18 Reaction reaction_0000019

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

Name Unphosphorylated CDC25 degradation

Reaction equation

$$\mathrm{z0} \longrightarrow \emptyset \tag{37}$$

Reactant

Table 39: Properties of each reactant.

Id	Name	SBO
z0	Unphosphorylated CDC25	

Kinetic Law

Derived unit contains undeclared units

$$v_{18} = \mathrm{vol}\,(\mathrm{cell}) \cdot \mathrm{k9} \cdot [\mathrm{z0}] \tag{38}$$

7.19 Reaction reaction_0000020

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

Name One site phosphorylated CDC25 degradaton

Reaction equation

$$\mathrm{z1} \longrightarrow \emptyset \tag{39}$$

Reactant

Table 40: Properties of each reactant.

Id	Name	SBO
z1	One-site phosphorylated CDC25	

Kinetic Law

Derived unit contains undeclared units

$$v_{19} = \mathrm{vol}\,(\mathrm{cell}) \cdot \mathrm{k9} \cdot [\mathrm{z1}] \tag{40}$$

7.20 Reaction reaction_0000021

This is a reversible reaction of one reactant forming no product.

Name Two site phosphorylated CDC25 degradation

Reaction equation

$$\mathrm{z2} \rightleftharpoons \emptyset \tag{41}$$

Reactant

Table 41: Properties of each reactant.

Id	Name	SBO
z2	Two-site phosphorylated CDC25	

Kinetic Law

Derived unit contains undeclared units

$$v_{20} = \mathrm{vol}\,(\mathrm{cell}) \cdot \mathrm{k9} \cdot [\mathrm{z2}] \tag{42}$$

7.21 Reaction reaction_0000022

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

Name Unphosphorylation CDC25 synthesis

Reaction equation

$$\emptyset \longrightarrow \mathrm{z0} \tag{43}$$

Product

Table 42: Properties of each product.

Id	Name	SBO
z0	Unphosphorylated CDC25	

Kinetic Law

Derived unit contains undeclared units

$$v_{21} = \mathrm{vol}\,(\mathrm{cell}) \cdot \mathrm{k8} \tag{44}$$

7.22 Reaction reaction_0000023

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

Name Active cyclin:CDK complex degradation

Reaction equation

$$\mathrm{x} \xrightarrow{\mathrm{u}} \emptyset \tag{45}$$

Reactant

Table 43: Properties of each reactant.

Id	Name	SBO
x	Active Cyclin:CDK complex	

Modifier

Table 44: Properties of each modifier.

Id	Name	SBO
u	Active SKP2 or APC	

Kinetic Law

Derived unit contains undeclared units

$$v_{22} = \mathrm{vol}\,(\mathrm{cell}) \cdot (\mathrm{k7} + \mathrm{k7u} \cdot [\mathrm{u}]) \cdot [\mathrm{x}] \tag{46}$$

8 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.

8.1 Species x1

Name Inactive Cyclin:CDK complex

Initial concentration $0.1\ \mathrm{dimensionless} \cdot \mathrm{dimensionless}^{-1}$

This species takes part in two reactions (as a product in `reaction_0000002`, `reaction_0000005`).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{x1} = v_2 + v_5 \tag{47}$$

8.2 Species x

Name Active Cyclin:CDK complex

Initial concentration 0.1 dimensionless · dimensionless^{-1}

This species takes part in nine reactions (as a reactant in reaction_0000005, reaction_0000011, reaction_0000023 and as a product in reaction_0000016 and as a modifier in reaction_0000004, reaction_0000006, reaction_000008, reaction_000009, reaction_0000014).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{x} = v_{15} - v_5 - v_{11} - v_{22} \tag{48}$$

8.3 Species c0

Name Total CDK

Initial concentration 200 dimensionless · dimensionless^{-1}

This species does not take part in any reactions. Its quantity does hence not change over time:

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{c0} = 0 \tag{49}$$

8.4 Species c

Name Free CDK

Initial concentration 0 dimensionless · dimensionless^{-1}

Involved in rule c

This species takes part in one reaction (as a modifier in reaction_0000002) and is also involved in one rule which determines this species' quantity.

8.5 Species z0

Name Unphosphorylated CDC25

Initial concentration 0 dimensionless · dimensionless^{-1}

This species takes part in three reactions (as a reactant in reaction_0000004, reaction_0000019 and as a product in reaction_0000022).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{z0} = v_{21} - v_4 - v_{18} \tag{50}$$

8.6 Species z1

Name One-site phosphorylated CDC25

Initial concentration $0\ \text{dimensionless} \cdot \text{dimensionless}^{-1}$

This species takes part in three reactions (as a reactant in reaction_0000006, reaction_0000020 and as a product in reaction_0000004).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{z1} = v_4 - v_6 - v_{19} \tag{51}$$

8.7 Species z2

Name Two-site phosphorylated CDC25

Initial concentration $0\ \text{dimensionless} \cdot \text{dimensionless}^{-1}$

This species takes part in three reactions (as a reactant in reaction_0000021 and as a product in reaction_0000006 and as a modifier in reaction_0000005).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{z2} = v_6 - v_{20} \tag{52}$$

8.8 Species w0

Name Unphosphorylated wee1

Initial concentration $0\ \text{dimensionless} \cdot \text{dimensionless}^{-1}$

This species takes part in four reactions (as a reactant in reaction_000008, reaction_0000017 and as a product in reaction_0000007 and as a modifier in reaction_0000005).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{w0} = v_7 - v_8 - v_{16} \tag{53}$$

8.9 Species w1

Name phosphorylated wee1

Initial concentration $0\ \text{dimensionless} \cdot \text{dimensionless}^{-1}$

This species takes part in two reactions (as a reactant in reaction_0000018 and as a product in reaction_000008).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{w1} = v_8 - v_{17} \tag{54}$$

8.10 Species u

Name Active SKP2 or APC

Initial concentration $0\ \text{dimensionless} \cdot \text{dimensionless}^{-1}$

This species takes part in four reactions (as a reactant in reaction_0000013 and as a product in reaction_000009 and as a modifier in reaction_0000003, reaction_0000023).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{u} = v_9 - v_{13} \tag{55}$$

8.11 Species i

Name Free CKI

Initial concentration $0\ \text{dimensionless} \cdot \text{dimensionless}^{-1}$

This species takes part in three reactions (as a reactant in reaction_0000011, reaction_0000015 and as a product in reaction_0000010).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{i} = v_{10} - v_{11} - v_{14} \tag{56}$$

8.12 Species ix

Name Cyclin:CDK:CKI complex with CKI unphosphorylated

Initial concentration $0\ \text{dimensionless} \cdot \text{dimensionless}^{-1}$

This species takes part in two reactions (as a reactant in reaction_0000014 and as a product in reaction_0000011).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{ix} = v_{11} - v_{12} \tag{57}$$

8.13 Species ixp

Name Cyclin:CDK:CKI complex with CKI phosphorylated

Initial concentration $0\ \text{dimensionless} \cdot \text{dimensionless}^{-1}$

This species takes part in two reactions (as a reactant in reaction_0000016 and as a product in reaction_0000014).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{ixp} = v_{12} - v_{15} \tag{58}$$

8.14 Species y

Name Free cyclin

Initial concentration $0\ \text{dimensionless} \cdot \text{dimensionless}^{-1}$

This species takes part in three reactions (as a reactant in reaction_0000002, reaction_0000003 and as a product in reaction_0000001).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{y} = v_1 - v_2 - v_3 \tag{59}$$

8.15 Species totalCyclin

Initial concentration $0\ \text{dimensionless} \cdot \text{dimensionless}^{-1}$

Involved in rule totalCyclin

One rule which determines this species' quantity.

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