SBML Model Report

Model name: “Novak1997 - Cell Cycle”

May 5, 2016

1 General Overview

This is a document in SBML Level 2 Version 3 format. This model was created by the following two authors: Nicolas Le Novre[1] and Bruce Shapiro[2] at October 15th 2009 at 1:21 p. m. and last time modified at March 26th 2014 at 2:20 p. 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	22
events	2	constraints	0
reactions	25	function definitions	0
global parameters	49	unit definitions	1
rules	15	initial assignments	0

Model Notes

Novak1997 - Cell Cycle

Modeling the control of DNA replication in fission yeast.

This model is described in the article:Modeling the control of DNA replication in fission yeast.Novak B., Tyson JJ.Proc. Natl. Acad. Sci. U.S.A. 1997:94(17):9147-52

Abstract:

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A central event in the eukaryotic cell cycle is the decision to commence DNA replication (S phase). Strict controls normally operate to prevent repeated rounds of DNA replication without intervening mitoses („endoreplication„) or initiation of mitosis before DNA is fully replicated („mitotic catastrophe„). Some of the genetic interactions involved in these controls have recently been identified in yeast. From this evidence we propose a molecular mechanism of „Start„ control in Schizosaccharomyces pombe. Using established principles of biochemical kinetics, we compare the properties of this model in detail with the observed behavior of various mutant strains of fission yeast: wee1(-) (size control at Start), cdc13Delta and rum1(OP) (endoreplication), and wee1(-) rum1Delta (rapid division cycles of diminishing cell size). We discuss essential features of the mechanism that are responsible for characteristic properties of Start control in fission yeast, to expose our proposal to crucial experimental tests.

This model is hosted on BioModels Database and identified by: BIOMD0000000007 .

To cite BioModels Database, please use: BioModels Database: An enhanced, curated and annotated resource for published quantitative kinetic models .

2 Unit Definitions

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

2.1 Unit `time`

Name minutes

Definition 60 s

2.2 Unit `substance`

Notes Mole is the predefined SBML unit for `substance`.

Definition mol

2.3 Unit `volume`

Notes Litre is the predefined SBML unit for `volume`.

Definition l

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

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 22 species. The boundary condition of five of these species is set to `true` so that these species' amount cannot be changed by any reaction. Section 9 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
UbE	ubiquitinProtease1	Cell	mol	⊟	⊟
UbE2	ubiquitinProtease2	Cell	mol	⊟	⊟
Wee1	Wee1	Cell	mol	⊟	⊟
Cdc25	Cdc25	Cell	mol	⊟	⊟
G2K	Cdc13_Cdc2	Cell	mol	⊟	⊟
R	FreeRum1	Cell	mol	⊟	⊟
G1K	Cig2_Cdc2	Cell	mol	⊟	⊟
IE	IntermediaryEnzyme	Cell	mol	⊟	⊟
PG2	Cdc13_P-Cdc2	Cell	mol	⊟	⊟
G1R	Cig2_Cdc2_Rum1	Cell	mol	⊟	⊟
G2R	Cdc13_Cdc2_Rum1	Cell	mol	⊟	⊟
PG2R	Cdc13_P-Cdc2_Rum1	Cell	mol	⊟	⊟
SPF	S-phasePromotingFactor	Cell	mol	⊟	⊟
MPF	M-phasePromotingFactor	Cell	mol	⊟	⊟
IEB	BoundIntermediaryEnzyme	Cell	mol	⊟	☑
UbEB	BoundUbiquitinProtease1	Cell	mol	⊟	☑
UbE2B	BoundUbiquitinProtease2	Cell	mol	⊟	☑
Wee1B	BoundWee1	Cell	mol	⊟	☑
Cdc25B	BoundCdc25	Cell	mol	⊟	☑
Rum1Total	TotalRum1	Cell	mol	⊟	⊟
Cdc13Total	TotalCdc13	Cell	mol	⊟	⊟

Id	Name	Compartment	Derived Unit	Constant	Boundary Condition
Cig2Total	TotalCig2	Cell	mol	⊟	⊟

5 Parameters

This model contains 49 global parameters.

Table 4: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
mu	mu		0.005		☑
Mass	Mass		0.490		☐
k1	k1		0.015		☑
k2prime	k2’		0.050		☑
k3	k3		0.094		☑
k4	k4		0.188		☑
k5	k5		0.002		☑
k6prime	k6’		0.000		☑
k7	k7		100.000		☑
k7r	k7r		0.100		☑
k8	k8		10.000		☑
k8r	k8r		0.100		☑
kc	kc		1.000		☑
kcr	kcr		0.250		☑
ki	ki		0.400		☑
kir	kir		0.100		☑
kp	kp		3.250		☐
ku	ku		0.200		☑
kur	kur		0.100		☑
ku2	ku2		1.000		☑
kur2	kur2		0.300		☑
kw	kw		1.000		☑
kwr	kwr		0.250		☑
V2	V2		0.250		☑
V2prime	V2’		0.008		☑
V6	V6		7.500		☑
V6prime	V6’		0.038		☑
V25	V25		0.500		☑
V25prime	V25’		0.025		☑
Vw	Vw		0.350		☑
Vwprime	Vw’		0.035		☑
Kmc	Kmc		0.100		☑
Kmcr	Kmcr		0.100		☑
Kmi	Kmi		0.010		☑
Kmir	Kmir		0.010		☑
Kmp	Kmp		0.001		☑
Kmu	Kmu		0.010		☑

Id	Name	SBO	Value	Unit	Constant
Kmur	Kmur		0.010		☑
Kmu2	Kmu2		0.050		☑
Kmur2	Kmur2		0.050		☑
Kmw	Kmw		0.100		☑
Kmwr	Kmwr		0.100		☑
alpha	alpha		0.250		☑
beta	beta		0.050		☑
Cig1	Cig1		0.000		☑
k2	k2		0.000		☐
k6	k6		0.000		☐
kwee	kwee		0.000		☐
k25	k25		0.000		☐

6 Rules

This is an overview of 15 rules.

6.1 Rule Mass

Rule Mass is a rate rule for parameter Mass:

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{Mass} = \mathrm{Mass} \cdot \mathrm{mu} \tag{1}$$

6.2 Rule IEB

Rule IEB is an assignment rule for species IEB:

$$[\mathrm{IEB}] = 1 - \mathrm{IE} \tag{2}$$

6.3 Rule UbEB

Rule UbEB is an assignment rule for species UbEB:

$$[\mathrm{UbEB}] = 1 - \mathrm{UbE} \tag{3}$$

6.4 Rule UbE2B

Rule UbE2B is an assignment rule for species UbE2B:

$$[\mathrm{UbE2B}] = 1 - \mathrm{UbE2} \tag{4}$$

6.5 Rule Wee1B

Rule Wee1B is an assignment rule for species Wee1B:

$$[\text{Wee1B}] = 1 - \text{Wee1} \tag{5}$$

6.6 Rule Cdc25B

Rule Cdc25B is an assignment rule for species Cdc25B:

$$[\text{Cdc25B}] = 1 - \text{Cdc25} \tag{6}$$

6.7 Rule Rum1Total

Rule Rum1Total is an assignment rule for species Rum1Total:

$$[\text{Rum1Total}] = \text{G1R} + \text{G2R} + \text{PG2R} + \text{R} \tag{7}$$

Derived unit mol

6.8 Rule Cdc13Total

Rule Cdc13Total is an assignment rule for species Cdc13Total:

$$[\text{Cdc13Total}] = \text{G2K} + \text{G2R} + \text{PG2} + \text{PG2R} \tag{8}$$

Derived unit mol

6.9 Rule Cig2Total

Rule Cig2Total is an assignment rule for species Cig2Total:

$$[\text{Cig2Total}] = \text{G1K} + \text{G1R} \tag{9}$$

Derived unit mol

6.10 Rule k2

Rule k2 is an assignment rule for parameter k2:

$$\text{k2} = \text{UbE} \cdot \text{V2} + (1 - \text{UbE}) \cdot \text{V2prime} \tag{10}$$

6.11 Rule k6

Rule k6 is an assignment rule for parameter k6:

$$\text{k6} = \text{UbE2} \cdot \text{V6} + (1 - \text{UbE2}) \cdot \text{V6prime} \tag{11}$$

6.12 Rule kwee

Rule kwee is an assignment rule for parameter kwee:

$$\text{kwee} = \text{Vwprime} \cdot (1 - \text{Wee1}) + \text{Vw} \cdot \text{Wee1} \tag{12}$$

6.13 Rule k25

Rule k25 is an assignment rule for parameter k25:

$$\text{k25} = \text{Cdc25} \cdot \text{V25} + (1 - \text{Cdc25}) \cdot \text{V25prime} \tag{13}$$

6.14 Rule MPF

Rule MPF is an assignment rule for species MPF:

$$[\text{MPF}] = \text{G2K} + \text{beta} \cdot \text{PG2} \tag{14}$$

6.15 Rule SPF

Rule SPF is an assignment rule for species SPF:

$$[\text{SPF}] = \text{Cig1} + \text{alpha} \cdot \text{G1K} + \text{MPF} \tag{15}$$

7 Events

This is an overview of two events. 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.

7.1 Event Start

Name S-Phase Start

Trigger condition

$$\text{SPF} \geq 0.1 \tag{16}$$

Delay

$$60 \tag{17}$$

Assignment

$$\text{kp} = \frac{\text{kp}}{2} \tag{18}$$

7.2 Event `Division`

Name Cell Division

Trigger condition

$$\mathrm{UbE} \leq 0.1 \tag{19}$$

Assignments

$$\mathrm{kp} = 2 \cdot \mathrm{kp} \tag{20}$$

$$\mathrm{Mass} = \frac{\mathrm{Mass}}{2} \tag{21}$$

8 Reactions

This model contains 25 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	G2K_Creation	Cdc13_Cdc2 creation	$\emptyset \longrightarrow \text{G2K}$	
2	G1K_Creation	Cig2_Cdc2 creation	$\emptyset \longrightarrow \text{G1K}$	
3	Cdc2Phos	Cdc2 phosphorylation	$\text{G2K} \overset{\text{Wee1, Cdc25}}{\rightleftharpoons} \text{PG2}$	
4	G2R_Creation	binding of Rum1 with Cdc13_Cdc2	$\text{G2K} + \text{R} \rightleftharpoons \text{G2R}$	
5	PG2R_Creation	binding of Rum1 with Cdc13_P-Cdc2	$\text{PG2} + \text{R} \rightleftharpoons \text{PG2R}$	
6	Rum1DegInG2R	Rum1 degradation in Rum1_Cdc13_Cdc2	$\text{G2R} \longrightarrow \text{G2K}$	
7	Rum1Deg	Rum1 degradation in solution	$\text{R} \longrightarrow \emptyset$	
8	Rum1DegInPG2R	Rum1 degradation in Rum1_Cdc13_P-Cdc2	$\text{PG2R} \longrightarrow \text{PG2}$	
9	RumDegInG1R	Rum1 degradation in Rum1_Cig2_Cdc2	$\text{G1R} \longrightarrow \text{G1K}$	
10	G2K_dissoc	Cdc13 degradation in Cdc13_Cdc2	$\text{G2K} \overset{\text{UbE}}{\longrightarrow} \emptyset$	
11	PG2_dissoc	Cdc13 degradation in Cdc13_P-Cdc2	$\text{PG2} \overset{\text{UbE}}{\longrightarrow} \emptyset$	
12	G1K-_Dissociation	Cig2 degradation in Cig2_Cdc2	$\text{G1K} \overset{\text{UbE2}}{\longrightarrow} \emptyset$	
13	PG2R-_Dissociation	Cdc13 degradation in Rum1_Cdc13_P-Cdc2	$\text{PG2R} \longrightarrow \text{R}$	
14	G2R-_Dissociation	Cdc13 degradation in Rum1_Cdc13_Cdc2	$\text{G2R} \longrightarrow \text{R}$	
15	G1R-_Dissociation	Cig2 degradation in Rum1_Cig2_Cdc2	$\text{G1R} \longrightarrow \text{R}$	
16	G1R_Binding	Binding of Rum1 to Cig2_Cdc2	$\text{G1K} + \text{R} \rightleftharpoons \text{G1R}$	

№	Id	Name	Reaction Equation	SBO
17	G2R-_Dissociation-_UbE	UbE mediated degradation of Cdc13_Cdc2 in Rum1_Cdc13_Cdc2	$\mathrm{G2R} \xrightarrow{\mathrm{UbE}} \mathrm{R}$	
18	PG2R-_Dissociation-_UbE	UbE mediated degradation of Cdc13_Cdc2 in Rum1_Cdc13_P-Cdc2	$\mathrm{PG2R} \xrightarrow{\mathrm{UbE}} \mathrm{R}$	
19	Rum1_Production	Rum1 creation	$\emptyset \longrightarrow \mathrm{R}$	
20	Rum1_Deg_SPF	Rum1 degradation by SPF	$\mathrm{R} \xrightarrow{\mathrm{SPF}} \emptyset$	
21	IE_Reaction	IE production & degradation	$\mathrm{IEB} \underset{}{\overset{\mathrm{MPF}}{\rightleftharpoons}} \mathrm{IE}$	
22	UbE_Reaction	UbE production & degradation	$\mathrm{UbEB} \underset{}{\overset{\mathrm{IE}}{\rightleftharpoons}} \mathrm{UbE}$	
23	UbE2_Reaction	UbE2 production & degradation	$\mathrm{UbE2B} \underset{}{\overset{\mathrm{MPF}}{\rightleftharpoons}} \mathrm{UbE2}$	
24	Wee1_Reaction	Wee1 production & degradation	$\mathrm{Wee1B} \underset{}{\overset{\mathrm{MPF}}{\rightleftharpoons}} \mathrm{Wee1}$	
25	Cdc25_Reaction	Cdc25 production & degradation	$\mathrm{Cdc25B} \underset{}{\overset{\mathrm{MPF}}{\rightleftharpoons}} \mathrm{Cdc25}$	

8.1 Reaction G2K_Creation

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

Name Cdc13_Cdc2 creation

Reaction equation

$$\emptyset \longrightarrow \mathrm{G2K} \tag{22}$$

Product

Table 6: Properties of each product.

Id	Name	SBO
G2K	Cdc13_Cdc2	

Kinetic Law

Derived unit not available

$$v_1 = \mathrm{k1} \tag{23}$$

8.2 Reaction G1K_Creation

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

Name Cig2_Cdc2 creation

Reaction equation

$$\emptyset \longrightarrow \mathrm{G1K} \tag{24}$$

Product

Table 7: Properties of each product.

Id	Name	SBO
G1K	Cig2_Cdc2	

Kinetic Law

Derived unit not available

$$v_2 = \mathrm{k5} \tag{25}$$

8.3 Reaction Cdc2Phos

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

Name Cdc2 phosphorylation

Reaction equation

$$\mathrm{G2K} \overset{\mathrm{Wee1,\ Cdc25}}{\rightleftharpoons} \mathrm{PG2} \tag{26}$$

Reactant

Table 8: Properties of each reactant.

Id	Name	SBO
G2K	Cdc13_Cdc2	

Modifiers

Table 9: Properties of each modifier.

Id	Name	SBO
Wee1	Wee1	
Cdc25	Cdc25	

Product

Table 10: Properties of each product.

Id	Name	SBO
PG2	Cdc13_P-Cdc2	

Kinetic Law

Derived unit contains undeclared units

$$v_3 = \mathrm{G2K} \cdot \mathrm{kwee} - \mathrm{k25} \cdot \mathrm{PG2} \tag{27}$$

8.4 Reaction G2R_Creation

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

Name binding of Rum1 with Cdc13_Cdc2

Reaction equation

$$\mathrm{G2K} + \mathrm{R} \rightleftharpoons \mathrm{G2R} \tag{28}$$

Reactants

Table 11: Properties of each reactant.

Id	Name	SBO
G2K	Cdc13_Cdc2	
R	FreeRum1	

Product

Table 12: Properties of each product.

Id	Name	SBO
G2R	Cdc13_Cdc2_Rum1	

Kinetic Law

Derived unit contains undeclared units

$$v_4 = \mathrm{G2K} \cdot \mathrm{k7} \cdot \mathrm{R} - \mathrm{G2R} \cdot \mathrm{k7r} \tag{29}$$

8.5 Reaction PG2R_Creation

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

Name binding of Rum1 with Cdc13_P-Cdc2

Reaction equation

$$\mathrm{PG2} + \mathrm{R} \rightleftharpoons \mathrm{PG2R} \tag{30}$$

Reactants

Table 13: Properties of each reactant.

Id	Name	SBO
PG2	Cdc13_P-Cdc2	
R	FreeRum1	

Product

Table 14: Properties of each product.

Id	Name	SBO
PG2R	Cdc13_P-Cdc2_Rum1	

Kinetic Law

Derived unit contains undeclared units

$$v_5 = \mathrm{k7} \cdot \mathrm{PG2} \cdot \mathrm{R} - \mathrm{k7r} \cdot \mathrm{PG2R} \tag{31}$$

8.6 Reaction Rum1DegInG2R

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

Name Rum1 degradation in Rum1_Cdc13_Cdc2

Reaction equation

$$\mathrm{G2R} \longrightarrow \mathrm{G2K} \tag{32}$$

Reactant

Table 15: Properties of each reactant.

Id	Name	SBO
G2R	Cdc13_Cdc2_Rum1	

Product

Table 16: Properties of each product.

Id	Name	SBO
G2K	Cdc13_Cdc2	

Kinetic Law

Derived unit contains undeclared units

$$v_6 = \mathrm{G2R} \cdot \mathrm{k4} \tag{33}$$

8.7 Reaction Rum1Deg

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

Name Rum1 degradation in solution

Reaction equation

$$\mathrm{R} \longrightarrow \emptyset \tag{34}$$

Reactant

Table 17: Properties of each reactant.

Id	Name	SBO
R	FreeRum1	

Kinetic Law

Derived unit contains undeclared units

$$v_7 = \mathrm{k4} \cdot \mathrm{R} \tag{35}$$

8.8 Reaction Rum1DegInPG2R

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

Name Rum1 degradation in Rum1_Cdc13_P-Cdc2

Reaction equation

$$\mathrm{PG2R} \longrightarrow \mathrm{PG2} \tag{36}$$

Reactant

Table 18: Properties of each reactant.

Id	Name	SBO
PG2R	Cdc13_P-Cdc2_Rum1	

Product

Table 19: Properties of each product.

Id	Name	SBO
PG2	Cdc13_P-Cdc2	

Kinetic Law

Derived unit contains undeclared units

$$v_8 = \text{k4} \cdot \text{PG2R} \tag{37}$$

8.9 Reaction RumDegInG1R

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

Name Rum1 degradation in Rum1_Cig2_Cdc2

Reaction equation

$$\text{G1R} \longrightarrow \text{G1K} \tag{38}$$

Reactant

Table 20: Properties of each reactant.

Id	Name	SBO
G1R	Cig2_Cdc2_Rum1	

Product

Table 21: Properties of each product.

Id	Name	SBO
G1K	Cig2_Cdc2	

Kinetic Law

Derived unit contains undeclared units

$$v_9 = \text{G1R} \cdot \text{k4} \tag{39}$$

8.10 Reaction G2K_dissoc

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

Name Cdc13 degradation in Cdc13_Cdc2

Reaction equation

$$\mathrm{G2K} \xrightarrow{\mathrm{UbE}} \emptyset \tag{40}$$

Reactant

Table 22: Properties of each reactant.

Id	Name	SBO
G2K	Cdc13_Cdc2	

Modifier

Table 23: Properties of each modifier.

Id	Name	SBO
UbE	ubiquitinProtease1	

Kinetic Law

Derived unit contains undeclared units

$$v_{10} = \mathrm{G2K} \cdot \mathrm{k2} \tag{41}$$

8.11 Reaction PG2_dissoc

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

Name Cdc13 degradation in Cdc13_P-Cdc2

Reaction equation

$$\mathrm{PG2} \xrightarrow{\mathrm{UbE}} \emptyset \tag{42}$$

Reactant

Table 24: Properties of each reactant.

Id	Name	SBO
PG2	Cdc13_P-Cdc2	

Modifier

Table 25: Properties of each modifier.

Id	Name	SBO
UbE	ubiquitinProtease1	

Kinetic Law

Derived unit contains undeclared units

$$v_{11} = \mathrm{k2} \cdot \mathrm{PG2} \tag{43}$$

8.12 Reaction G1K_Dissociation

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

Name Cig2 degradation in Cig2_Cdc2

Reaction equation

$$\mathrm{G1K} \xrightarrow{\mathrm{UbE2}} \emptyset \tag{44}$$

Reactant

Table 26: Properties of each reactant.

Id	Name	SBO
G1K	Cig2_Cdc2	

Modifier

Table 27: Properties of each modifier.

Id	Name	SBO
UbE2	ubiquitinProtease2	

Kinetic Law

Derived unit contains undeclared units

$$v_{12} = \mathrm{G1K} \cdot \mathrm{k6} \tag{45}$$

8.13 Reaction PG2R_Dissociation

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

Name Cdc13 degradation in Rum1_Cdc13_P-Cdc2

Reaction equation

$$\mathrm{PG2R} \longrightarrow \mathrm{R} \tag{46}$$

Reactant

Table 28: Properties of each reactant.

Id	Name	SBO
PG2R	Cdc13_P-Cdc2_Rum1	

Product

Table 29: Properties of each product.

Id	Name	SBO
R	FreeRum1	

Kinetic Law

Derived unit contains undeclared units

$$v_{13} = \mathrm{k2prime} \cdot \mathrm{PG2R} \tag{47}$$

8.14 Reaction G2R_Dissociation

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

Name Cdc13 degradation in Rum1_Cdc13_Cdc2

Reaction equation

$$\mathrm{G2R} \longrightarrow \mathrm{R} \tag{48}$$

Reactant

Table 30: Properties of each reactant.

Id	Name	SBO
G2R	Cdc13_Cdc2_Rum1	

Product

Table 31: Properties of each product.

Id	Name	SBO
R	FreeRum1	

Kinetic Law

Derived unit contains undeclared units

$$v_{14} = \text{G2R} \cdot \text{k2prime} \tag{49}$$

8.15 Reaction G1R_Dissociation

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

Name Cig2 degradation in Rum1_Cig2_Cdc2

Reaction equation

$$\text{G1R} \longrightarrow \text{R} \tag{50}$$

Reactant

Table 32: Properties of each reactant.

Id	Name	SBO
G1R	Cig2_Cdc2_Rum1	

Product

Table 33: Properties of each product.

Id	Name	SBO
R	FreeRum1	

Kinetic Law

Derived unit contains undeclared units

$$v_{15} = \mathrm{G1R} \cdot \mathrm{k6prime} \tag{51}$$

8.16 Reaction G1R_Binding

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

Name Binding of Rum1 to Cig2_Cdc2

Reaction equation

$$\mathrm{G1K} + \mathrm{R} \rightleftharpoons \mathrm{G1R} \tag{52}$$

Reactants

Table 34: Properties of each reactant.

Id	Name	SBO
G1K	Cig2_Cdc2	
R	FreeRum1	

Product

Table 35: Properties of each product.

Id	Name	SBO
G1R	Cig2_Cdc2_Rum1	

Kinetic Law

Derived unit contains undeclared units

$$v_{16} = \mathrm{G1K} \cdot \mathrm{k8} \cdot \mathrm{R} - \mathrm{G1R} \cdot \mathrm{k8r} \tag{53}$$

8.17 Reaction G2R_Dissociation_UbE

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

Name UbE mediated degradation of Cdc13_Cdc2 in Rum1_Cdc13_Cdc2

Reaction equation

$$\mathrm{G2R} \xrightarrow{\mathrm{UbE}} \mathrm{R} \tag{54}$$

Reactant

Table 36: Properties of each reactant.

Id	Name	SBO
G2R	Cdc13_Cdc2_Rum1	

Modifier

Table 37: Properties of each modifier.

Id	Name	SBO
UbE	ubiquitinProtease1	

Product

Table 38: Properties of each product.

Id	Name	SBO
R	FreeRum1	

Kinetic Law

Derived unit contains undeclared units

$$v_{17} = \mathrm{G2R} \cdot \mathrm{k2} \tag{55}$$

8.18 Reaction PG2R_Dissociation_UbE

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

Name UbE mediated degradation of Cdc13_Cdc2 in Rum1_Cdc13_P-Cdc2

Reaction equation

$$\mathrm{PG2R} \xrightarrow{\mathrm{UbE}} \mathrm{R} \tag{56}$$

Reactant

Table 39: Properties of each reactant.

Id	Name	SBO
PG2R	Cdc13_P-Cdc2_Rum1	

Modifier

Table 40: Properties of each modifier.

Id	Name	SBO
UbE	ubiquitinProtease1	

Product

Table 41: Properties of each product.

Id	Name	SBO
R	FreeRum1	

Kinetic Law

Derived unit contains undeclared units

$$v_{18} = \mathrm{k2} \cdot \mathrm{PG2R} \tag{57}$$

8.19 Reaction Rum1_Production

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

Name Rum1 creation

Reaction equation

$$\emptyset \longrightarrow \mathrm{R} \tag{58}$$

Product

Table 42: Properties of each product.

Id	Name	SBO
R	FreeRum1	

Kinetic Law

Derived unit not available

$$v_{19} = \mathrm{k3} \tag{59}$$

8.20 Reaction Rum1_Deg_SPF

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

Name Rum1 degradation by SPF

Reaction equation

$$\mathrm{R} \xrightarrow{\mathrm{SPF}} \emptyset \tag{60}$$

Reactant

Table 43: Properties of each reactant.

Id	Name	SBO
R	FreeRum1	

Modifier

Table 44: Properties of each modifier.

Id	Name	SBO
SPF	S-phasePromotingFactor	

Kinetic Law

Derived unit contains undeclared units

$$v_{20} = \frac{\mathrm{kp} \cdot \mathrm{Mass} \cdot \mathrm{R} \cdot \mathrm{SPF}}{\mathrm{Kmp} + \mathrm{R}} \tag{61}$$

8.21 Reaction IE_Reaction

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

Name IE production & degradation

Reaction equation

$$\mathrm{IEB} \overset{\mathrm{MPF}}{\rightleftharpoons} \mathrm{IE} \tag{62}$$

Reactant

Table 45: Properties of each reactant.

Id	Name	SBO
IEB	BoundIntermediaryEnzyme	

Modifier

Table 46: Properties of each modifier.

Id	Name	SBO
MPF	M-phasePromotingFactor	

Product

Table 47: Properties of each product.

Id	Name	SBO
IE	IntermediaryEnzyme	

Kinetic Law

Derived unit contains undeclared units

$$v_{21} = \frac{\mathrm{IEB} \cdot \mathrm{ki} \cdot \mathrm{MPF}}{\mathrm{IEB} + \mathrm{Kmi}} - \frac{\mathrm{IE} \cdot \mathrm{kir}}{\mathrm{IE} + \mathrm{Kmir}} \tag{63}$$

8.22 Reaction UbE_Reaction

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

Name UbE production & degradation

Reaction equation

$$\mathrm{UbEB} \overset{\mathrm{IE}}{\rightleftharpoons} \mathrm{UbE} \tag{64}$$

Reactant

Table 48: Properties of each reactant.

Id	Name	SBO
UbEB	BoundUbiquitinProtease1	

Modifier

Table 49: Properties of each modifier.

Id	Name	SBO
IE	IntermediaryEnzyme	

Product

Table 50: Properties of each product.

Id	Name	SBO
UbE	ubiquitinProtease1	

Kinetic Law

Derived unit contains undeclared units

$$v_{22} = \frac{\mathrm{IE} \cdot \mathrm{ku} \cdot \mathrm{UbEB}}{\mathrm{Kmu} + \mathrm{UbEB}} - \frac{\mathrm{kur} \cdot \mathrm{UbE}}{\mathrm{Kmur} + \mathrm{UbE}} \tag{65}$$

8.23 Reaction UbE2_Reaction

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

Name UbE2 production & degradation

Reaction equation

$$\mathrm{UbE2B} \overset{\mathrm{MPF}}{\rightleftharpoons} \mathrm{UbE2} \tag{66}$$

Reactant

Table 51: Properties of each reactant.

Id	Name	SBO
UbE2B	BoundUbiquitinProtease2	

Modifier

Table 52: Properties of each modifier.

Id	Name	SBO
MPF	M-phasePromotingFactor	

Product

Table 53: Properties of each product.

Id	Name	SBO
UbE2	ubiquitinProtease2	

Kinetic Law

Derived unit contains undeclared units

$$v_{23} = \frac{\mathrm{ku2} \cdot \mathrm{MPF} \cdot \mathrm{UbE2B}}{\mathrm{Kmu2} + \mathrm{UbE2B}} - \frac{\mathrm{kur2} \cdot \mathrm{UbE2}}{\mathrm{Kmur2} + \mathrm{UbE2}} \tag{67}$$

8.24 Reaction Wee1_Reaction

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

Name Wee1 production & degradation

Reaction equation

$$\mathrm{Wee1B} \overset{\mathrm{MPF}}{\rightleftharpoons} \mathrm{Wee1} \tag{68}$$

Reactant

Table 54: Properties of each reactant.

Id	Name	SBO
Wee1B	BoundWee1	

Modifier

Table 55: Properties of each modifier.

Id	Name	SBO
MPF	M-phasePromotingFactor	

Product

Table 56: Properties of each product.

Id	Name	SBO
Wee1	Wee1	

Kinetic Law

Derived unit contains undeclared units

$$v_{24} = \frac{\text{kwr} \cdot \text{Wee1B}}{\text{Kmwr} + \text{Wee1B}} - \frac{\text{kw} \cdot \text{MPF} \cdot \text{Wee1}}{\text{Kmw} + \text{Wee1}} \tag{69}$$

8.25 Reaction Cdc25_Reaction

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

Name Cdc25 production & degradation

Reaction equation

$$\text{Cdc25B} \overset{\text{MPF}}{\rightleftharpoons} \text{Cdc25} \tag{70}$$

Reactant

Table 57: Properties of each reactant.

Id	Name	SBO
Cdc25B	BoundCdc25	

Modifier

Table 58: Properties of each modifier.

Id	Name	SBO
MPF	M-phasePromotingFactor	

Product

Table 59: Properties of each product.

Id	Name	SBO
Cdc25	Cdc25	

Kinetic Law

Derived unit contains undeclared units

$$v_{25} = \frac{\text{Cdc25B} \cdot \text{kc} \cdot \text{MPF}}{\text{Cdc25B} + \text{Kmc}} - \frac{\text{Cdc25} \cdot \text{kcr}}{\text{Cdc25} + \text{Kmcr}} \tag{71}$$

9 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.

9.1 Species UbE

Name ubiquitinProtease1

Initial amount 0.11 mol

This species takes part in five reactions (as a product in UbE_Reaction and as a modifier in G2K_dissoc, PG2_dissoc, G2R_Dissociation_UbE, PG2R_Dissociation_UbE).

$$\frac{\mathrm{d}}{\mathrm{d}t}\text{UbE} = v_{22} \tag{72}$$

9.2 Species UbE2

Name ubiquitinProtease2

Initial amount 0 mol

This species takes part in two reactions (as a product in UbE2_Reaction and as a modifier in G1K_Dissociation).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{UbE2} = v_{23} \tag{73}$$

9.3 Species Wee1

Name Wee1

Initial amount 0 mol

This species takes part in two reactions (as a product in Wee1_Reaction and as a modifier in Cdc2Phos).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{Wee1} = v_{24} \tag{74}$$

9.4 Species Cdc25

Name Cdc25

Initial amount 0 mol

This species takes part in two reactions (as a product in Cdc25_Reaction and as a modifier in Cdc2Phos).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{Cdc25} = v_{25} \tag{75}$$

9.5 Species G2K

Name Cdc13_Cdc2

Initial amount 0 mol

This species takes part in five reactions (as a reactant in Cdc2Phos, G2R_Creation, G2K_dissoc and as a product in G2K_Creation, Rum1DegInG2R).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{G2K} = v_1 + v_6 - v_3 - v_4 - v_{10} \tag{76}$$

9.6 Species R

Name FreeRum1

Initial amount 0.4 mol

This species takes part in eleven reactions (as a reactant in G2R_Creation, PG2R_Creation, Rum1Deg, G1R_Binding, Rum1_Deg_SPF and as a product in PG2R_Dissociation, G2R_Dissociation, G1R_Dissociation, G2R_Dissociation_UbE, PG2R_Dissociation_UbE, Rum1_Production).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{R} = v_{13} + v_{14} + v_{15} + v_{17} + v_{18} + v_{19} - v_4 - v_5 - v_7 - v_{16} - v_{20} \quad (77)$$

9.7 Species G1K

Name Cig2_Cdc2

Initial amount 0 mol

This species takes part in four reactions (as a reactant in G1K_Dissociation, G1R_Binding and as a product in G1K_Creation, RumDegInG1R).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{G1K} = v_2 + v_9 - v_{12} - v_{16} \quad (78)$$

9.8 Species IE

Name IntermediaryEnzyme

Initial amount 0 mol

This species takes part in two reactions (as a product in IE_Reaction and as a modifier in UbE_Reaction).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{IE} = v_{21} \quad (79)$$

9.9 Species PG2

Name Cdc13_P-Cdc2

Initial amount 0 mol

This species takes part in four reactions (as a reactant in PG2R_Creation, PG2_dissoc and as a product in Cdc2Phos, Rum1DegInPG2R).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{PG2} = v_3 + v_8 - v_5 - v_{11} \quad (80)$$

9.10 Species G1R

Name Cig2_Cdc2_Rum1

Initial amount 0 mol

This species takes part in three reactions (as a reactant in RumDegInG1R, G1R_Dissociation and as a product in G1R_Binding).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{G1R} = v_{16} - v_9 - v_{15} \tag{81}$$

9.11 Species G2R

Name Cdc13_Cdc2_Rum1

Initial amount 0 mol

This species takes part in four reactions (as a reactant in Rum1DegInG2R, G2R_Dissociation, G2R_Dissociation_UbE and as a product in G2R_Creation).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{G2R} = v_4 - v_6 - v_{14} - v_{17} \tag{82}$$

9.12 Species PG2R

Name Cdc13_P-Cdc2_Rum1

Initial amount 0 mol

This species takes part in four reactions (as a reactant in Rum1DegInPG2R, PG2R_Dissociation, PG2R_Dissociation_UbE and as a product in PG2R_Creation).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{PG2R} = v_5 - v_8 - v_{13} - v_{18} \tag{83}$$

9.13 Species SPF

Name S-phasePromotingFactor

Initial amount 0 mol

Involved in rule SPF

This species takes part in one reaction (as a modifier in Rum1_Deg_SPF) and is also involved in one rule which determines this species' quantity.

9.14 Species MPF

Name M-phasePromotingFactor

Initial amount 0 mol

Involved in rule MPF

This species takes part in four reactions (as a modifier in IE_Reaction, UbE2_Reaction, Wee1-_Reaction, Cdc25_Reaction) and is also involved in one rule which determines this species' quantity.

9.15 Species IEB

Name BoundIntermediaryEnzyme

Initial amount 0 mol

Involved in rule IEB

This species takes part in one reaction (as a reactant in IE_Reaction). Not this but one rule determines the species' quantity because this species is on the boundary of the reaction system.

9.16 Species UbEB

Name BoundUbiquitinProtease1

Initial amount 0 mol

Involved in rule UbEB

This species takes part in one reaction (as a reactant in UbE_Reaction). Not this but one rule determines the species' quantity because this species is on the boundary of the reaction system.

9.17 Species UbE2B

Name BoundUbiquitinProtease2

Initial amount 0 mol

Involved in rule UbE2B

This species takes part in one reaction (as a reactant in UbE2_Reaction). Not this but one rule determines the species' quantity because this species is on the boundary of the reaction system.

9.18 Species Wee1B

Name BoundWee1

Initial amount 0 mol

Involved in rule Wee1B

This species takes part in one reaction (as a reactant in Wee1_Reaction). Not this but one rule determines the species' quantity because this species is on the boundary of the reaction system.

9.19 Species Cdc25B

Name BoundCdc25

Initial amount 0 mol

Involved in rule Cdc25B

This species takes part in one reaction (as a reactant in Cdc25_Reaction). Not this but one rule determines the species' quantity because this species is on the boundary of the reaction system.

9.20 Species Rum1Total

Name TotalRum1

Involved in rule Rum1Total

One rule which determines this species' quantity.

9.21 Species Cdc13Total

Name TotalCdc13

Involved in rule Cdc13Total

One rule which determines this species' quantity.

9.22 Species Cig2Total

Name TotalCig2

Involved in rule Cig2Total

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.

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