SBML Model Report

Model name: "Gardner1998 - Cell Cycle Goldbeter"

May 6, 2016

1 General Overview

This is a document in SBML Level 2 Version 4 format. This model was created by Bruce Shapiro[1] at January 30th 2005 at 1:02 p. m. and last time modified at June third 2014 at 2:33 p. m. Table 1 shows 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	5
events	0	constraints	0
reactions	13	function definitions	0
global parameters	5	unit definitions	0
rules	2	initial assignments	0

Model Notes

Gardner1998 - Cell Cycle Goldbeter

Mathematical modeling of cell division cycle (CDC) dynamics.

The SBML file has been generated by MathSBML 2.6.0.p960929 (Prerelease Version of 29-Sept-2006) 1-October-2006 15:36:36.076517.

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This model is described in the article:A theory for controlling cell cycle dynamics using a reversibly binding inhibitor.Gardner TS, Dolnik M, Collins JJ.Proc. Natl. Acad. Sci. U.S.A. 1998 Nov; 95(24): 14190-14195

Abstract:

We demonstrate, by using mathematical modeling of cell division cycle (CDC) dynamics, a potential mechanism for precisely controlling the frequency of cell division and regulating the size of a dividing cell. Control of the cell cycle is achieved by artificially expressing a protein that reversibly binds and inactivates any one of the CDC proteins. In the simplest case, such as the checkpoint-free situation encountered in early amphibian embryos, the frequency of CDC oscillations can be increased or decreased by regulating the rate of synthesis, the binding rate, or the equilibrium constant of the binding protein. In a more complex model of cell division, where size-control checkpoints are included, we show that the same reversible binding reaction can alter the mean cell mass in a continuously dividing cell. Because this control scheme is general and requires only the expression of a single protein, it provides a practical means for tuning the characteristics of the cell cycle in vivo.

This model is hosted on BioModels Database and identified by: BIOMD0000000008.

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 which are all predefined by SBML and not mentioned in the model.

2.1 Unit `substance`

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

Definition mol

2.2 Unit `volume`

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

Definition l

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	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 five 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
C	cyclin	Cell	$\mathrm{mol} \cdot \mathrm{l}^{-1}$	⊟	⊟
X	protease	Cell	$\mathrm{mol} \cdot \mathrm{l}^{-1}$	⊟	⊟
M	cdc2k	Cell	$\mathrm{mol} \cdot \mathrm{l}^{-1}$	⊟	⊟
Y	cyclin inhibitor	Cell	$\mathrm{mol} \cdot \mathrm{l}^{-1}$	⊟	⊟
Z	complex inhibitor-cyclin	Cell	$\mathrm{mol} \cdot \mathrm{l}^{-1}$	⊟	⊟

5 Parameters

This model contains five global parameters.

Table 4: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
V1	V1		0.00		☐
K6	K6		0.30		☑
V1p	V1p		0.75		☑
V3	V3		0.00		☐
V3p	V3p		0.30		☑

6 Rules

This is an overview of two rules.

6.1 Rule V1

Rule V1 is an assignment rule for parameter V1:

$$\mathrm{V1} = [\mathrm{C}] \cdot \mathrm{V1p} \cdot ([\mathrm{C}] + \mathrm{K6})^{-1} \tag{1}$$

6.2 Rule V3

Rule V3 is an assignment rule for parameter V3:

$$\mathrm{V3} = [\mathrm{M}] \cdot \mathrm{V3p} \tag{2}$$

7 Reactions

This model contains 13 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	`reaction1`	creation of cyclin	$\emptyset \longrightarrow C$	
2	`reaction2`	cdc2 kinase triggered degration of cyclin	$C \xrightarrow{X} \emptyset$	
3	`reaction3`	default degradation of cyclin	$C \longrightarrow \emptyset$	
4	`reaction4`	activation of cdc2 kinase	$\emptyset \longrightarrow M$	
5	`reaction5`	deactivation of cdc2 kinase	$M \longrightarrow \emptyset$	
6	`reaction6`	activation of cyclin protease	$\emptyset \longrightarrow X$	
7	`reaction7`	deactivation of cyclin protease	$X \longrightarrow \emptyset$	
8	`reaction8`	reaction8	$C + Y \longrightarrow Z$	
9	`reaction9`	reaction9	$Z \longrightarrow C + Y$	
10	`reaction10`	desinhibition of cyclin	$Z \longrightarrow C$	
11	`reaction11`	degradation of inhibited cyclin	$Z \longrightarrow Y$	
12	`reaction12`	creation of cyclin inhibitor	$\emptyset \longrightarrow Y$	
13	`reaction13`	degradation of cyclin inhibitor	$Y \longrightarrow \emptyset$	

7.1 Reaction `reaction1`

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

Name creation of cyclin

Reaction equation

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

Product

Table 6: Properties of each product.

Id	Name	SBO
`C`	cyclin	

Kinetic Law

Derived unit not available

$$v_1 = \mathrm{vi} \tag{4}$$

Table 7: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
`vi`			0.1		☑

7.2 Reaction `reaction2`

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

Name cdc2 kinase triggered degration of cyclin

Reaction equation

$$\mathrm{C} \xrightarrow{\mathrm{X}} \emptyset \tag{5}$$

Reactant

Table 8: Properties of each reactant.

Id	Name	SBO
C	cyclin	

Modifier

Table 9: Properties of each modifier.

Id	Name	SBO
X	protease	

Kinetic Law

Derived unit contains undeclared units

$$v_2 = [\mathrm{C}] \cdot \mathrm{k1} \cdot [\mathrm{X}] \cdot ([\mathrm{C}] + \mathrm{K5})^{-1} \tag{6}$$

Table 10: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
k1			0.50		☑
K5			0.02		☑

7.3 Reaction reaction3

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

Name default degradation of cyclin

Reaction equation

$$\mathrm{C} \longrightarrow \emptyset \tag{7}$$

Reactant

Table 11: Properties of each reactant.

Id	Name	SBO
C	cyclin	

Kinetic Law

Derived unit contains undeclared units

$$v_3 = [\mathrm{C}] \cdot \mathrm{kd} \tag{8}$$

Table 12: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
kd			0.02		☑

7.4 Reaction reaction4

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

Name activation of cdc2 kinase

Reaction equation

$$\emptyset \longrightarrow \mathrm{M} \tag{9}$$

Product

Table 13: Properties of each product.

Id	Name	SBO
M	cdc2k	

Kinetic Law

Derived unit contains undeclared units

$$v_4 = (1 + -1 \cdot [\mathrm{M}]) \cdot \mathrm{V1} \cdot (\mathrm{K1} + -1 \cdot [\mathrm{M}] + 1)^{-1} \tag{10}$$

Table 14: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
K1			0.1		☑

7.5 Reaction `reaction5`

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

Name deactivation of cdc2 kinase

Reaction equation

$$\mathrm{M} \longrightarrow \emptyset \tag{11}$$

Reactant

Table 15: Properties of each reactant.

Id	Name	SBO
`M`	cdc2k	

Kinetic Law

Derived unit contains undeclared units

$$v_5 = [\mathrm{M}] \cdot \mathrm{V2} \cdot (\mathrm{K2} + [\mathrm{M}])^{-1} \tag{12}$$

Table 16: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
`V2`			0.25		☑
`K2`			0.10		☑

7.6 Reaction `reaction6`

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

Name activation of cyclin protease

Reaction equation

$$\emptyset \longrightarrow \mathrm{X} \tag{13}$$

Product

Table 17: Properties of each product.

Id	Name	SBO
X	protease	

Kinetic Law

Derived unit contains undeclared units

$$v_6 = \mathrm{V3} \cdot (1 + -1 \cdot [\mathrm{X}]) \cdot (\mathrm{K3} + -1 \cdot [\mathrm{X}] + 1)^{-1} \tag{14}$$

Table 18: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
K3			0.2		☑

7.7 Reaction reaction7

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

Name deactivation of cyclin protease

Reaction equation

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

Reactant

Table 19: Properties of each reactant.

Id	Name	SBO
X	protease	

Kinetic Law

Derived unit contains undeclared units

$$v_7 = \mathrm{V4} \cdot [\mathrm{X}] \cdot (\mathrm{K4} + [\mathrm{X}])^{-1} \tag{16}$$

Table 20: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
K4			0.1		☑
V4			0.1		☑

7.8 Reaction reaction8

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

Name reaction8

Reaction equation

$$\mathrm{C} + \mathrm{Y} \longrightarrow \mathrm{Z} \tag{17}$$

Reactants

Table 21: Properties of each reactant.

Id	Name	SBO
C	cyclin	
Y	cyclin inhibitor	

Product

Table 22: Properties of each product.

Id	Name	SBO
Z	complex inhibitor-cyclin	

Kinetic Law

Derived unit contains undeclared units

$$v_8 = \mathrm{a1} \cdot [\mathrm{C}] \cdot [\mathrm{Y}] \tag{18}$$

Table 23: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
a1			0.05		☑

7.9 Reaction reaction9

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

Name reaction9

Reaction equation

$$\mathrm{Z} \longrightarrow \mathrm{C} + \mathrm{Y} \tag{19}$$

Reactant

Table 24: Properties of each reactant.

Id	Name	SBO
Z	complex inhibitor-cyclin	

Products

Table 25: Properties of each product.

Id	Name	SBO
C	cyclin	
Y	cyclin inhibitor	

Kinetic Law

Derived unit contains undeclared units

$$v_9 = \mathrm{a2} \cdot [\mathrm{Z}] \tag{20}$$

Table 26: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
a2			0.05		☑

7.10 Reaction reaction10

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

Name desinhibition of cyclin

Reaction equation

$$\mathrm{Z} \longrightarrow \mathrm{C} \tag{21}$$

Reactant

Table 27: Properties of each reactant.

Id	Name	SBO
Z	complex inhibitor-cyclin	

Product

Table 28: Properties of each product.

Id	Name	SBO
C	cyclin	

Kinetic Law

Derived unit contains undeclared units

$$v_{10} = \mathrm{alpha} \cdot \mathrm{d1} \cdot [\mathrm{Z}] \tag{22}$$

Table 29: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
alpha			0.10		☑
d1			0.05		☑

7.11 Reaction reaction11

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

Name degradation of inhibited cyclin

Reaction equation

$$\mathrm{Z} \longrightarrow \mathrm{Y} \tag{23}$$

Reactant

Table 30: Properties of each reactant.

Id	Name	SBO
Z	complex inhibitor-cyclin	

Product

Table 31: Properties of each product.

Id	Name	SBO
Y	cyclin inhibitor	

Kinetic Law

Derived unit contains undeclared units

$$v_{11} = \text{alpha} \cdot \text{kd} \cdot [\text{Z}] \tag{24}$$

Table 32: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
kd			0.02		☑
alpha			0.10		☑

7.12 Reaction reaction12

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

Name creation of cyclin inhibitor

Reaction equation

$$\emptyset \longrightarrow \text{Y} \tag{25}$$

Product

Table 33: Properties of each product.

Id	Name	SBO
Y	cyclin inhibitor	

Kinetic Law

Derived unit not available

$$v_{12} = \mathrm{vs} \tag{26}$$

Table 34: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
vs			0.2		☑

7.13 Reaction reaction13

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

Name degradation of cyclin inhibitor

Reaction equation

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

Reactant

Table 35: Properties of each reactant.

Id	Name	SBO
Y	cyclin inhibitor	

Kinetic Law

Derived unit contains undeclared units

$$v_{13} = \mathrm{d1} \cdot [\mathrm{Y}] \tag{28}$$

Table 36: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
d1			0.05		☑

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 `C`

Name cyclin

Initial amount 0

This species takes part in six reactions (as a reactant in `reaction2`, `reaction3`, `reaction8` and as a product in `reaction1`, `reaction9`, `reaction10`).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{C} = v_1 + v_9 + v_{10} - v_2 - v_3 - v_8 \tag{29}$$

8.2 Species `X`

Name protease

Initial amount 0

This species takes part in three reactions (as a reactant in `reaction7` and as a product in `reaction6` and as a modifier in `reaction2`).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{X} = v_6 - v_7 \tag{30}$$

8.3 Species `M`

Name cdc2k

Initial amount 0

This species takes part in two reactions (as a reactant in `reaction5` and as a product in `reaction4`).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{M} = v_4 - v_5 \tag{31}$$

8.4 Species Y

Name cyclin inhibitor

Initial amount 1

This species takes part in five reactions (as a reactant in reaction8, reaction13 and as a product in reaction9, reaction11, reaction12).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{Y} = v_9 + v_{11} + v_{12} - v_8 - v_{13} \tag{32}$$

8.5 Species Z

Name complex inhibitor-cyclin

Initial amount 1

This species takes part in four reactions (as a reactant in reaction9, reaction10, reaction11 and as a product in reaction8).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{Z} = v_8 - v_9 - v_{10} - v_{11} \tag{33}$$

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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