SBML Model Report

Model name: “Goldbeter1991 - Min Mit Oscil”

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: Bruce Shapiro[1] and Vijayalakshmi Chelliah[2] at February sixth 2005 at 11:39 p. m. and last time modified at May 16th 2013 at 2:38 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	3
events	0	constraints	0
reactions	7	function definitions	0
global parameters	5	unit definitions	0
rules	2	initial assignments	0

Model Notes

Goldbeter1991 - Min Mit Oscil

Minimal cascade model for the mitotic oscillator involving cyclin and cdc2 kinase.

This model has been generated by MathSBML 2.4.6 (14-January-2005) 14-January-2005 18:33:39.806932.

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This model is described in the article:A minimal cascade model for the mitotic oscillator involving cyclin and cdc2 kinase.Goldbeter A.Proc. Natl. Acad. Sci. U.S.A. 1991; 88(20):9107-11

Abstract:

A minimal model for the mitotic oscillator is presented. The model, built on recent experimental advances, is based on the cascade of post-translational modification that modulates the activity of cdc2 kinase during the cell cycle. The model pertains to the situation encountered in early amphibian embryos, where the accumulation of cyclin suffices to trigger the onset of mitosis. In the first cycle of the bicyclic cascade model, cyclin promotes the activation of cdc2 kinase through reversible dephosphorylation, and in the second cycle, cdc2 kinase activates a cyclin protease by reversible phosphorylation. That cyclin activates cdc2 kinase while the kinase triggers the degradation of cyclin has suggested that oscillations may originate from such a negative feedback loop [Flix, M. A., Labb, J. C., Dore, M., Hunt, T. & Karsenti, E. (1990) Nature (London) 346, 379-382]. This conjecture is corroborated by the model, which indicates that sustained oscillations of the limit cycle type can arise in the cascade, provided that a threshold exists in the activation of cdc2 kinase by cyclin and in the activation of cyclin proteolysis by cdc2 kinase. The analysis shows how miotic oscillations may readily arise from time lags associated with these thresholds and from the delayed negative feedback provided by cdc2-induced cyclin degradation. A mechanism for the origin of the thresholds is proposed in terms of the phenomenon of zero-order ultrasensitivity previously described for biochemical systems regulated by covalent modification.

This model is hosted on BioModels Database and identified by: BIOMD0000000003 .

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	0000290	3	1	litre	☑	

3.1 Compartment cell

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

Name cell

SBO:0000290 physical compartment

4 Species

This model contains three 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	$\mathrm{mol} \cdot \mathrm{l}^{-1}$	⊟	⊟
M	CDC-2 Kinase	cell	$\mathrm{mol} \cdot \mathrm{l}^{-1}$	⊟	⊟
X	Cyclin Protease	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	0000186	0.0		⊟
V3	V3	0000186	0.0		⊟
VM1	VM1	0000025	3.0		☑
VM3	VM3	0000186	1.0		☑
Kc	Kc	0000027	0.5		☑

6 Rules

This is an overview of two rules.

6.1 Rule V1

Rule V1 is an assignment rule for parameter V1:

$$\mathrm{V1} = [\mathrm{C}] \cdot \mathrm{VM1} \cdot ([\mathrm{C}] + \mathrm{Kc})^{-1} \tag{1}$$

6.2 Rule V3

Rule V3 is an assignment rule for parameter V3:

$$\mathrm{V3} = [\mathrm{M}] \cdot \mathrm{VM3} \tag{2}$$

7 Reactions

This model contains seven 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	$\emptyset \longrightarrow C$	0000393
2	`reaction2`	default degradation of cyclin	$C \longrightarrow \emptyset$	0000179
3	`reaction3`	cdc2 kinase triggered degration of cyclin	$C \xrightarrow{X} \emptyset$	0000179
4	`reaction4`	activation of cdc2 kinase	$\emptyset \longrightarrow M$	0000330
5	`reaction5`	deactivation of cdc2 kinase	$M \longrightarrow \emptyset$	0000216
6	`reaction6`	activation of cyclin protease	$\emptyset \longrightarrow X$	0000216
7	`reaction7`	deactivation of cyclin protease	$X \longrightarrow \emptyset$	0000330

7.1 Reaction `reaction1`

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

Name creation of cyclin

SBO:0000393 production

Reaction equation

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

Product

Table 6: Properties of each product.

Id	Name	SBO
C	Cyclin	

Kinetic Law

Derived unit contains undeclared units

$$v_1 = \mathrm{vol}\,(\mathrm{cell}) \cdot \mathrm{vi} \tag{4}$$

Table 7: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
vi		0000048	0.025		☑

7.2 Reaction `reaction2`

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

Name default degradation of cyclin

SBO:0000179 degradation

Reaction equation

$$\mathrm{C} \longrightarrow \emptyset \tag{5}$$

Reactant

Table 8: Properties of each reactant.

Id	Name	SBO
C	Cyclin	

Kinetic Law

Derived unit contains undeclared units

$$v_2 = [\mathrm{C}] \cdot \mathrm{vol}\,(\mathrm{cell}) \cdot \mathrm{kd} \tag{6}$$

Table 9: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
kd		0000022	0.01		☑

7.3 Reaction reaction3

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

Name cdc2 kinase triggered degration of cyclin

SBO:0000179 degradation

Reaction equation

$$\mathrm{C} \xrightarrow{\mathrm{X}} \emptyset \tag{7}$$

Reactant

Table 10: Properties of each reactant.

Id	Name	SBO
C	Cyclin	

Modifier

Table 11: Properties of each modifier.

Id	Name	SBO
X	Cyclin Protease	

Kinetic Law

Derived unit contains undeclared units

$$v_3 = [\mathrm{C}] \cdot \mathrm{vol}\,(\mathrm{cell}) \cdot \mathrm{vd} \cdot [\mathrm{X}] \cdot ([\mathrm{C}] + \mathrm{Kd})^{-1} \tag{8}$$

Table 12: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
vd		0000186	0.25		☑
Kd		0000027	0.02		☑

7.4 Reaction reaction4

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

Name activation of cdc2 kinase

SBO:0000330 dephosphorylation

Reaction equation

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

Product

Table 13: Properties of each product.

Id	Name	SBO
M	CDC-2 Kinase	

Kinetic Law

Derived unit contains undeclared units

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

Table 14: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
K1		0000027	0.005		☑

7.5 Reaction reaction5

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

Name deactivation of cdc2 kinase

SBO:0000216 phosphorylation

Reaction equation

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

Reactant

Table 15: Properties of each reactant.

Id	Name	SBO
M	CDC-2 Kinase	

Kinetic Law

Derived unit contains undeclared units

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

Table 16: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
V2		0000186	1.500		☑
K2		0000027	0.005		☑

7.6 Reaction reaction6

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

Name activation of cyclin protease

SBO:0000216 phosphorylation

Reaction equation

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

Product

Table 17: Properties of each product.

Id	Name	SBO
X	Cyclin Protease	

Kinetic Law

Derived unit contains undeclared units

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

Table 18: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
K3		0000027	0.005		☑

7.7 Reaction reaction7

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

Name deactivation of cyclin protease

SBO:0000330 dephosphorylation

Reaction equation

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

Reactant

Table 19: Properties of each reactant.

Id	Name	SBO
X	Cyclin Protease	

Kinetic Law

Derived unit contains undeclared units

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

Table 20: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
K4		0000027	0.005		☑
V4		0000186	0.500		☑

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

SBO:0000252 polypeptide chain

Initial concentration $0.01\ \mathrm{mol}\cdot\mathrm{l}^{-1}$

This species takes part in three reactions (as a reactant in `reaction2`, `reaction3` and as a product in `reaction1`).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{C} = v_1 - v_2 - v_3 \tag{17}$$

8.2 Species M

Name CDC-2 Kinase

SBO:0000252 polypeptide chain

Initial concentration $0.01\ \mathrm{mol}\cdot\mathrm{l}^{-1}$

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

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{M} = v_4 - v_5 \tag{18}$$

8.3 Species X

Name Cyclin Protease

SBO:0000297 protein complex

Initial concentration $0.01\ \mathrm{mol}\cdot\mathrm{l}^{-1}$

This species takes part in three reactions (as a reactant in reaction7 and as a product in reaction6 and as a modifier in reaction3).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{X} = v_6 - v_7 \tag{19}$$

A Glossary of Systems Biology Ontology Terms

SBO:0000022 forward unimolecular rate constant: Numerical parameter that quantifies the forward velocity of a chemical reaction involving only one reactant. This parameter encompasses all the contributions to the velocity except the quantity of the reactant

SBO:0000025 catalytic rate constant: Numerical parameter that quantifies the velocity of an enzymatic reaction

SBO:0000027 Michaelis constant: Substrate concentration at which the velocity of reaction is half its maximum. Michaelis constant is an experimental parameter. According to the underlying molecular mechanism it can be interpreted differently in terms of microscopic constants

SBO:0000048 forward zeroth order rate constant, continuous case: Numerical parameter that quantifies the forward velocity of a chemical reaction independant of the reactant quantities. This parameter encompasses all the contributions to the velocity. It is to be used in a reaction modelled using a continuous framework.

SBO:0000179 degradation: Complete disappearance of a physical entity

SBO:0000186 maximal velocity: Limiting maximal velocity of an enzymatic reaction, reached when the substrate is in large excess and all the enzyme is complexed.

SBO:0000216 phosphorylation: Addition of a phosphate group (-H2PO4) to a chemical entity

SBO:0000252 polypeptide chain: Naturally occurring macromolecule formed by the repetition of amino-acid residues linked by peptidic bonds. A polypeptide chain is synthesized by the ribosome. CHEBI:1654

SBO:0000290 physical compartment: Specific location of space, that can be bounded or not. A physical compartment can have 1, 2 or 3 dimensions

SBO:0000297 protein complex: Macromolecular complex containing one or more polypeptide chains possibly associated with simple chemicals. CHEBI:3608

SBO:0000330 dephosphorylation: Removal of a phosphate group (-H2PO4) from a chemical entity.

SBO:0000393 production: Generation of a material or conceptual entity.

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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