SBML Model Report

Model name: “Tyson1991 - Cell Cycle 2 var”

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 Lukas Endler[2] at February eighth 2005 at 6:36 p. m. and last time modified at May 16th 2013 at 2:38 p. m. Table 1 provides 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	4
events	0	constraints	0
reactions	3	function definitions	0
global parameters	5	unit definitions	0
rules	4	initial assignments	0

Model Notes

Tyson1991 - Cell Cycle 2 var

Mathematical model of the interactions of cdc2 and cyclin.

Description taken from the original Cellerator version of the model (Tyson (1991, 2 variables) at http://www.cellerator.org).

This model is described in the article:Modeling the cell division cycle: cdc2 and cyclin interactions.Tyson JJ.Proc. Natl. Acad. Sci. U.S.A. 1991; 88(16); 7328-32

[1]NASA Jet Propulsion Laboratory, bshapiro@jpl.nasa.gov
[2]EMBL-EBI, lukas@ebi.ac.uk

Abstract:

The proteins cdc2 and cyclin form a heterodimer (maturation promoting factor) that controls the major events of the cell cycle. A mathematical model for the interactions of cdc2 and cyclin is constructed. Simulation and analysis of the model show that the control system can operate in three modes: as a steady state with high maturation promoting factor activity, as a spontaneous oscillator, or as an excitable switch. We associate the steady state with metaphase arrest in unfertilized eggs, the spontaneous oscillations with rapid division cycles in early embryos, and the excitable switch with growth-controlled division cycles typical of nonembryonic cells.

This is a two variable reduction of the larger 6-variable model published in the same paper. The equations are:

u'= k4(v-u)(alpha+u^2)-k6*u
v'=kappa-k6*u
z= v-u
with kappa = k1[aa]/[CT]

In the present implementation, an additional variable z is introduced with z = v-u is made, so that the different variables be interpreted as follows:

u=[activeMPF]/[CT]
v=([cyclin]+[preMPF]+[activeMPF])/[CT]
z=([cyclin]+[preMPF])/[CT]
with [CT]=[CDC2]+{CDC2P]+[preMPF]+[aMPF].

The reactions included are only to show the flows between z and u, and do not influence the species, as they all are set to boundaryCondition=True , meaning, that they are only determined by the rate rules (explicit differential equations) and assignment rules.

If you set boundaryCondition=False and remove the rate rules for v, u and the the assignment rule for z, you get the more symmetrical, but equivalent, version from the Cellerator repository:

u'= k4*z*(alpha+u^2)-k6*u
z'=kappa-z*(alpha+u^2)

This model is hosted on BioModels Database and identified by: BIOMD0000000006 .

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			3	1	litre	☑	

3.1 Compartment cell

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

4 Species

This model contains four species. The boundary condition of four of these species is set to `true` so that these species' amount cannot be changed by any reaction. 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
`EmptySet`		`cell`	mol	⊟	☑
`u`		`cell`	mol	⊟	☑
`z`		`cell`	mol	⊟	☑
`v`		`cell`	mol	⊟	☑

5 Parameters

This model contains five global parameters.

Table 4: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
kappa			0.015		☑
k6			1.000		☑
k4			180.000		☑
k4prime			0.018		☑
alpha			0.000		☐

6 Rules

This is an overview of four rules.

6.1 Rule u

Rule u is a rate rule for species u:

$$\frac{\mathrm{d}}{\mathrm{d}t}[\mathrm{u}] = \mathrm{k4} \cdot (\mathrm{v} - \mathrm{u}) \cdot \left(\mathrm{alpha} + \mathrm{u}^2\right) - \mathrm{k6} \cdot \mathrm{u} \tag{1}$$

6.2 Rule z

Rule z is an assignment rule for species z:

$$[\mathrm{z}] = \mathrm{v} - \mathrm{u} \tag{2}$$

Derived unit mol

6.3 Rule v

Rule v is a rate rule for species v:

$$\frac{\mathrm{d}}{\mathrm{d}t}[\mathrm{v}] = \mathrm{kappa} - \mathrm{k6} \cdot \mathrm{u} \tag{3}$$

6.4 Rule alpha

Rule alpha is an assignment rule for parameter alpha:

$$\mathrm{alpha} = \frac{\mathrm{k4prime}}{\mathrm{k4}} \tag{4}$$

7 Reactions

This model contains three 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`		EmptySet ⟶ z	0000205
2	`Reaction2`		u ⟶ EmptySet	0000179
3	`Reaction3`		z ⟶ u	0000176

7.1 Reaction `Reaction1`

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

SBO:0000205 composite biochemical process

Reaction equation

$$\text{EmptySet} \longrightarrow \text{z} \tag{5}$$

Reactant

Table 6: Properties of each reactant.

Id	Name	SBO
`EmptySet`		

Product

Table 7: Properties of each product.

Id	Name	SBO
`z`		

Kinetic Law

Derived unit not available

$$v_1 = \text{kappa} \tag{6}$$

7.2 Reaction `Reaction2`

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

SBO:0000179 degradation

Reaction equation

$$\text{u} \longrightarrow \text{EmptySet} \tag{7}$$

Reactant

Table 8: Properties of each reactant.

Id	Name	SBO
u		

Product

Table 9: Properties of each product.

Id	Name	SBO
EmptySet		

Kinetic Law

Derived unit contains undeclared units

$$v_2 = \mathrm{k6} \cdot \mathrm{u} \tag{8}$$

7.3 Reaction Reaction3

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

SBO:0000176 biochemical reaction

Reaction equation

$$\mathrm{z} \longrightarrow \mathrm{u} \tag{9}$$

Reactant

Table 10: Properties of each reactant.

Id	Name	SBO
z		

Product

Table 11: Properties of each product.

Id	Name	SBO
u		

Kinetic Law

Derived unit contains undeclared units

$$v_3 = \mathrm{k4} \cdot \mathrm{z} \cdot \left(\frac{\mathrm{k4prime}}{\mathrm{k4}} + \mathrm{u}^2 \right) \tag{10}$$

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 `EmptySet`

SBO:0000291 empty set

Initial amount 1 mol

This species takes part in two reactions (as a reactant in `Reaction1` and as a product in `Reaction2`), which do not influence its rate of change because this species is on the boundary of the reaction system:

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{EmptySet} = 0 \tag{11}$$

8.2 Species `u`

SBO:0000297 protein complex

Initial amount 0 mol

Involved in rule `u`

This species takes part in two reactions (as a reactant in `Reaction2` and as a product in `Reaction3`). Not these but one rule determines the species' quantity because this species is on the boundary of the reaction system.

8.3 Species z

SBO:0000297 protein complex

Initial amount 0 mol

Involved in rule z

This species takes part in two reactions (as a reactant in Reaction3 and as a product in Reaction1). Not these but one rule determines the species' quantity because this species is on the boundary of the reaction system.

8.4 Species v

SBO:0000297 protein complex

Initial amount 0 mol

Involved in rule v

One rule determines the species' quantity.

A Glossary of Systems Biology Ontology Terms

SBO:0000176 biochemical reaction: An event involving one or more chemical entities that modifies the electrochemical structure of at least one of the participants.

SBO:0000179 degradation: Complete disappearance of a physical entity

SBO:0000205 composite biochemical process: Process that involves the participation of chemical or biological entities and is composed of several elementary steps or reactions.

SBO:0000291 empty set: Entity defined by the absence of any actual object. An empty set is often used to represent the source of a creation process or the result of a degradation process.

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

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