SBML Model Report

Model name: "Tyson2003_NegFB_Oscillator"

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: Lukas Endler[1] and John J Tyson[2] at February tenth 2011 at 3:49 a. m. and last time modified at April sixth 2014 at 8:03 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	6
events	0	constraints	0
reactions	6	function definitions	0
global parameters	14	unit definitions	6
rules	2	initial assignments	0

Model Notes

Originally created by libAntimony v1.4 (using libSBML 3.4.1)

This is an SBML implementation the model of negative feedback oscillator (figure 2a) described in the article:

Sniffers, buzzers, toggles and blinkers: dynamics of regulatory and signaling pathways in the cell.

[1]EMBL-EBI, lukas@ebi.ac.uk

[2]Department of Biology, Virginia Polytechnic Institute and State University, Blacksburg, VA 24061, USA, tyson@vt.edu

Tyson JJ, Chen KC, Novak B. Curr Opin Cell Biol. 2003 Apr;15(2):221-31. PubmedID:12648679; DOI:10.1016/S0955-0674(03)00017-6;

Abstract:
The physiological responses of cells to external and internal stimuli are governed by genes and proteins interacting in complex networks whose dynamical properties are impossible to understand by intuitive reasoning alone. Recent advances by theoretical biologists have demonstrated that molecular regulatory networks can be accurately modeled in mathematical terms. These models shed light on the design principles of biological control systems and make predictions that have been verified experimentally.

Originally created by libAntimony v1.4 (using libSBML 3.4.1)

2 Unit Definitions

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

2.1 Unit `time`

Name s

Definition s

2.2 Unit `substance`

Name mole

Definition mol

2.3 Unit `per_s`

Name per_s

Definition s^{-1}

2.4 Unit M_per_s

Name M_per_s

Definition $\mathrm{mol} \cdot \mathrm{s}^{-1} \cdot \mathrm{l}^{-1}$

2.5 Unit M

Name M

Definition $\mathrm{mol} \cdot \mathrm{l}^{-1}$

2.6 Unit per_M_per_s

Name per_M_per_s

Definition $\mathrm{mol}^{-1} \cdot \mathrm{l} \cdot \mathrm{s}^{-1}$

2.7 Unit volume

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

Definition l

2.8 Unit area

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

Definition m^2

2.9 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
env		0000290	3	1	litre	☑	

3.1 Compartment `env`

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

SBO:0000290 physical compartment

4 Species

This model contains six species. The boundary condition of three 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
`Rp`		`env`	$\mathrm{mol} \cdot \mathrm{l}^{-1}$	☐	☐
`X`		`env`	$\mathrm{mol} \cdot \mathrm{l}^{-1}$	☐	☐
`Yp`		`env`	$\mathrm{mol} \cdot \mathrm{l}^{-1}$	☐	☐
`S`		`env`	$\mathrm{mol} \cdot \mathrm{l}^{-1}$	☐	☑
`Y`		`env`	$\mathrm{mol} \cdot \mathrm{l}^{-1}$	☐	☑
`R`		`env`	$\mathrm{mol} \cdot \mathrm{l}^{-1}$	☐	☑

5 Parameters

This model contains 14 global parameters.

Table 4: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
k0		0000485	0.00	$\mathrm{mol} \cdot \mathrm{s}^{-1} \cdot \mathrm{l}^{-1}$	☑
k1		0000035	1.00	s^{-1}	☑
k2		0000035	0.01	s^{-1}	☑
k2_prime		0000036	10.00	$\mathrm{mol}^{-1} \cdot \mathrm{l} \cdot \mathrm{s}^{-1}$	☑
k3		0000186	0.10	s^{-1}	☑
Yt		0000196	1.00	$\mathrm{mol} \cdot \mathrm{l}^{-1}$	☑
Km3		0000027	0.01	$\mathrm{mol} \cdot \mathrm{l}^{-1}$	☑
k4		0000485	0.20	$\mathrm{mol} \cdot \mathrm{s}^{-1} \cdot \mathrm{l}^{-1}$	☑
Km4		0000196	0.01	$\mathrm{mol} \cdot \mathrm{l}^{-1}$	☑
k5		0000025	0.10	s^{-1}	☑
Rt		0000196	1.00	$\mathrm{mol} \cdot \mathrm{l}^{-1}$	☑
Km5		0000196	0.01	$\mathrm{mol} \cdot \mathrm{l}^{-1}$	☑
k6		0000485	0.05	$\mathrm{mol} \cdot \mathrm{s}^{-1} \cdot \mathrm{l}^{-1}$	☑
Km6		0000196	0.01	$\mathrm{mol} \cdot \mathrm{l}^{-1}$	☑

6 Rules

This is an overview of two rules.

6.1 Rule Y

Rule Y is an assignment rule for species Y:

$$\mathrm{Y} = \mathrm{Yt} - [\mathrm{Yp}] \tag{1}$$

Derived unit $\mathrm{mol} \cdot \mathrm{l}^{-1}$

6.2 Rule R

Rule R is an assignment rule for species R:

$$\mathrm{R} = \mathrm{Rt} - [\mathrm{Rp}] \tag{2}$$

Derived unit $\mathrm{mol} \cdot \mathrm{l}^{-1}$

7 Reactions

This model contains six 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	r1		$\emptyset \xrightarrow{S} X$	0000176
2	r2		$X \xrightarrow{Rp} \emptyset$	0000179
3	r3		$Y \xrightarrow{X} Yp$	0000216
4	r4		$Yp \longrightarrow Y$	0000330
5	r5		$R \xrightarrow{Yp} Rp$	0000216
6	r6		$Rp \longrightarrow R$	0000330

7.1 Reaction r1

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

SBO:0000176 biochemical reaction

Reaction equation

$$\emptyset \xrightarrow{\mathrm{S}} \mathrm{X} \tag{3}$$

Modifier

Table 6: Properties of each modifier.

Id	Name	SBO
S		0000462

Product

Table 7: Properties of each product.

Id	Name	SBO
X		

Kinetic Law

SBO:0000001 rate law

Derived unit $\mathrm{mol} \cdot \mathrm{s}^{-1}$

$$v_1 = \mathrm{vol}\,(\mathrm{env}) \cdot (\mathrm{k0} + \mathrm{k1} \cdot [\mathrm{S}]) \tag{4}$$

7.2 Reaction r2

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

SBO:0000179 degradation

Reaction equation

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

Reactant

Table 8: Properties of each reactant.

Id	Name	SBO
X		

Modifier

Table 9: Properties of each modifier.

Id	Name	SBO
Rp		0000462

Kinetic Law

SBO:0000001 rate law

Derived unit $\mathrm{s}^{-1} \cdot \mathrm{mol}$

$$v_2 = \mathrm{vol}\,(\mathrm{env}) \cdot (\mathrm{k2} + \mathrm{k2\_prime} \cdot [\mathrm{Rp}]) \cdot [\mathrm{X}] \tag{6}$$

7.3 Reaction r3

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

SBO:0000216 phosphorylation

Reaction equation

$$\mathrm{Y} \xrightarrow{\mathrm{X}} \mathrm{Yp} \tag{7}$$

Reactant

Table 10: Properties of each reactant.

Id	Name	SBO
Y		

Modifier

Table 11: Properties of each modifier.

Id	Name	SBO
X		0000461

Product

Table 12: Properties of each product.

Id	Name	SBO
Yp		

Kinetic Law

SBO:0000430 enzymatic rate law for modulated unireactant enzymes

Derived unit $\mathrm{s}^{-1} \cdot \mathrm{mol}$

$$v_3 = \frac{\mathrm{vol\,(env)} \cdot \mathrm{k3} \cdot [\mathrm{X}] \cdot (\mathrm{Yt} - [\mathrm{Yp}])}{\mathrm{Km3} + (\mathrm{Yt} - [\mathrm{Yp}])} \tag{8}$$

7.4 Reaction r4

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

SBO:0000330 dephosphorylation

Reaction equation

$$\mathrm{Yp} \longrightarrow \mathrm{Y} \tag{9}$$

Reactant

Table 13: Properties of each reactant.

Id	Name	SBO
Yp		

Product

Table 14: Properties of each product.

Id	Name	SBO
Y		

Kinetic Law

SBO:0000029 Henri-Michaelis-Menten rate law

Derived unit $\mathrm{mol} \cdot \mathrm{s}^{-1}$

$$v_4 = \frac{\mathrm{vol}\,(\mathrm{env}) \cdot \mathrm{k4} \cdot [\mathrm{Yp}]}{\mathrm{Km4} + [\mathrm{Yp}]} \tag{10}$$

7.5 Reaction r5

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

SBO:0000216 phosphorylation

Reaction equation

$$\mathrm{R} \xrightarrow{\mathrm{Yp}} \mathrm{Rp} \tag{11}$$

Reactant

Table 15: Properties of each reactant.

Id	Name	SBO
R		

Modifier

Table 16: Properties of each modifier.

Id	Name	SBO
Yp		0000460

Product

Table 17: Properties of each product.

Id	Name	SBO
Rp		

Kinetic Law

SBO:0000029 Henri-Michaelis-Menten rate law

Derived unit $\mathrm{s}^{-1} \cdot \mathrm{mol}$

$$v_5 = \frac{\mathrm{vol}\,(\mathrm{env}) \cdot \mathrm{k5} \cdot [\mathrm{Yp}] \cdot (\mathrm{Rt} - [\mathrm{Rp}])}{\mathrm{Km5} + (\mathrm{Rt} - [\mathrm{Rp}])} \tag{12}$$

7.6 Reaction r6

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

SBO:0000330 dephosphorylation

Reaction equation

$$\mathrm{Rp} \longrightarrow \mathrm{R} \tag{13}$$

Reactant

Table 18: Properties of each reactant.

Id	Name	SBO
Rp		

Product

Table 19: Properties of each product.

Id	Name	SBO
R		

Kinetic Law

SBO:0000029 Henri-Michaelis-Menten rate law

Derived unit $\mathrm{mol} \cdot \mathrm{s}^{-1}$

$$v_6 = \frac{\mathrm{vol}\,(\mathrm{env}) \cdot \mathrm{k6} \cdot [\mathrm{Rp}]}{\mathrm{Km6} + [\mathrm{Rp}]} \tag{14}$$

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.

8.1 Species `Rp`

SBO:0000252 polypeptide chain

Initial concentration $0\ \mathrm{mol} \cdot \mathrm{l}^{-1}$

This species takes part in three reactions (as a reactant in `r6` and as a product in `r5` and as a modifier in `r2`).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{Rp} = v_5 - v_6 \tag{15}$$

8.2 Species `X`

SBO:0000252 polypeptide chain

Initial concentration $0\ \mathrm{mol} \cdot \mathrm{l}^{-1}$

This species takes part in three reactions (as a reactant in `r2` and as a product in `r1` and as a modifier in `r3`).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{X} = v_1 - v_2 \tag{16}$$

8.3 Species `Yp`

SBO:0000252 polypeptide chain

Initial concentration $0\ \mathrm{mol} \cdot \mathrm{l}^{-1}$

This species takes part in three reactions (as a reactant in `r4` and as a product in `r3` and as a modifier in `r5`).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{Yp} = v_3 - v_4 \tag{17}$$

8.4 Species S

SBO:0000285 material entity of unspecified nature

Initial concentration $0\ \mathrm{mol}\cdot\mathrm{l}^{-1}$

This species takes part in one reaction (as a modifier in r1), which does not influence its rate of change because this species is on the boundary of the reaction system:

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{S} = 0 \tag{18}$$

8.5 Species Y

SBO:0000252 polypeptide chain

Involved in rule Y

This species takes part in two reactions (as a reactant in r3 and as a product in r4). Not these but one rule determines the species' quantity because this species is on the boundary of the reaction system.

8.6 Species R

SBO:0000252 polypeptide chain

Involved in rule R

This species takes part in two reactions (as a reactant in r5 and as a product in r6). Not these but one rule determines the species' quantity because this species is on the boundary of the reaction system.

A Glossary of Systems Biology Ontology Terms

SBO:0000001 rate law: mathematical description that relates quantities of reactants to the reaction velocity

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:0000029 Henri-Michaelis-Menten rate law: First general rate equation for reactions involving enzymes, it was presented in"Victor Henri. Lois Gnrales de l'Action des Diastases. Paris, Hermann, 1903". The reaction is assumed to be made of a reversible of the binding of the substrate to the enzyme, followed by the breakdown of the complex generating the product. Ten years after Henri, Michaelis and Menten presented a variant of his equation, based on the hypothesis that the dissociation rate of the substrate was much larger than the rate of the product generation. Leonor Michaelis, Maud Menten (1913). Die Kinetik der Invertinwirkung, Biochem. Z. 49:333-369.

SBO:0000035 forward unimolecular rate constant, continuous case: 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. It is to be used in a reaction modelled using a continuous framework

SBO:0000036 forward bimolecular rate constant, continuous case: Numerical parameter that quantifies the forward velocity of a chemical reaction involving two reactants. This parameter encompasses all the contributions to the velocity except the quantity of the reactants. It is to be used in a reaction modelled using a continuous framework

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: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:0000196 concentration of an entity pool: The amount of an entity per unit of volume.

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:0000285 material entity of unspecified nature: Material entity whose nature is unknown or irrelevant

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

SBO:0000430 enzymatic rate law for modulated unireactant enzymes: Kinetics of enzymes that react with one substance, and whose activity may be positively or negatively modulated

SBO:0000460 enzymatic catalyst: A substance that accelerates the velocity of a chemical reaction without itself being consumed or transformed, by lowering the free energy of the transition state. The substance acting as a catalyst is an enzyme

SBO:0000461 essential activator: A substance that is absolutely required for occurrence and stimulation of a reaction

SBO:0000462 non-essential activator: An activator which is not necessary for an enzymatic reaction, but whose presence will further increase enzymatic activity.

SBO:0000485 basal rate constant: The minimal velocity observed under defined conditions, which may or may not include the presence of an effector. For example in an inhibitory system, this would be the residual velocity observed under full inhibition. In non-essential activation, this would be the velocity in the absence of any activator

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