SBML Model Report

Model name: “Besozzi2012 - Oscillatory regimes in the Ras/cAMP/PKA pathway in S.cerevisiae”

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: Vijayalakshmi Chelliah[1] and Daniela Besozzi[2] at September eleventh 2013 at 11:38 a. m. and last time modified at March tenth 2014 at 3:38 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	33
events	0	constraints	0
reactions	39	function definitions	0
global parameters	39	unit definitions	3
rules	0	initial assignments	0

Model Notes

Besozzi2012 - Oscillatory regimes in the Ras/cAMP/PKA pathway in S.cerevisiae

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Mechanistic model of the Ras/cAMP/PKA in yeast S.cerevisiae. The Ras/cAMP/PKA pathway plays a major role in the regulation of metabolism, stress resistance and cell cycle progress and is tightly regulated by multiple feedback loops, exerted by the protein kinase A (PKA). This model investigates the dynamics of the second messenger cAMP on Ras/cAMP/PKA pathway, to determine the effects of the feedback mechanisms on establising stable oscillatory regimes.

The model has been defined according to the stochastic formulation of chemical kinetics [Gillespie DT, 1977] , which requires to specify the set of molecular species occurring in the pathway and their respective interactions, formally described as a set of biochemical reactions.

The volume considered for this system is 30fL; this value can be used to convert the model into the deterministic formulation.

This model is described in the article:The role of feedback control mechanisms on the establishment of oscillatory regimes in the Ras/cAMP/PKA pathway in S. cerevisiae.Besozzi D, Cazzaniga P, Pescini D, Mauri G, Colombo S, Martegani E.EURASIP J Bioinform Syst Biol. 2012 Jul 20;2012(1):10.

Abstract:

In the yeast Saccharomyces cerevisiae, the Ras/cAMP/PKA pathway is involved in the regulation of cell growth and proliferation in response to nutritional sensing and stress conditions. The pathway is tightly regulated by multiple feedback loops, exerted by the protein kinase A (PKA) on a few pivotal components of the pathway. In this article, we investigate the dynamics of the second messenger cAMP by performing stochastic simulations and parameter sweep analysis of a mechanistic model of the Ras/cAMP/PKA pathway, to determine the effects that the modulation of these feedback mechanisms has on the establishment of stable oscillatory regimes. In particular, we start by studying the role of phosphodiesterases, the enzymes that catalyze the degradation of cAMP, which represent the major negative feedback in this pathway. Then, we show the results on cAMP oscillations when perturbing the amount of protein Cdc25 coupled with the alteration of the intracellular ratio of the guanine nucleotides (GTP/GDP), which are known to regulate the switch of the GTPase Ras protein. This multi-level regulation of the amplitude and frequency of oscillations in the Ras/cAMP/PKA pathway might act as a fine tuning mechanism for the downstream targets of PKA, as also recently evidenced by some experimental investigations on the nucleocytoplasmic shuttling of the transcription factor Msn2 in yeast cells.

This model is hosted on BioModels Database and identifiedby: BIOMD0000000478 .

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

2 Unit Definitions

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

2.1 Unit volume

Name volume

Definition dimensionless

2.2 Unit substance

Name substance

Definition dimensionless

2.3 Unit per_second

Definition s^{-1}

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

2.6 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
compartment01		0000290	3	1	dimensionless	☑	

3.1 Compartment `compartment01`

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

SBO:0000290 physical compartment

4 Species

This model contains 33 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 7 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
Ras2_GDP		compartment01	dimensionless · dimensionless^{-1}	☐	☐
Cdc25		compartment01	dimensionless · dimensionless^{-1}	☐	☐
Ras2_GDP_Cdc25		compartment01	dimensionless · dimensionless^{-1}	☐	☐
Ras2_Cdc25		compartment01	dimensionless · dimensionless^{-1}	☐	☐
GDP		compartment01	dimensionless · dimensionless^{-1}	☑	☑
GTP		compartment01	dimensionless · dimensionless^{-1}	☑	☑
Ras2_GTP_Cdc25		compartment01	dimensionless · dimensionless^{-1}	☐	☐
Ras2_GTP		compartment01	dimensionless · dimensionless^{-1}	☐	☐
Ira2		compartment01	dimensionless · dimensionless^{-1}	☐	☐
Ras2_GTP_Ira2		compartment01	dimensionless · dimensionless^{-1}	☐	☐

Id	Name	Compartment	Derived Unit	Constant	Boundary Condition
CYR1		compartment01	dimensionless · dimensionless^{-1}	⊟	⊟
Ras2_GTP_CYR1		compartment01	dimensionless · dimensionless^{-1}	⊟	⊟
ATP		compartment01	dimensionless · dimensionless^{-1}	☑	☑
cAMP		compartment01	dimensionless · dimensionless^{-1}	⊟	⊟
PKA		compartment01	dimensionless · dimensionless^{-1}	⊟	⊟
cAMP_PKA		compartment01	dimensionless · dimensionless^{-1}	⊟	⊟
IIcAMP_PKA		compartment01	dimensionless · dimensionless^{-1}	⊟	⊟
IIIcAMP_PKA		compartment01	dimensionless · dimensionless^{-1}	⊟	⊟
IVcAMP_PKA		compartment01	dimensionless · dimensionless^{-1}	⊟	⊟
C		compartment01	dimensionless · dimensionless^{-1}	⊟	⊟
R_2cAMP		compartment01	dimensionless · dimensionless^{-1}	⊟	⊟
R		compartment01	dimensionless · dimensionless^{-1}	⊟	⊟
R_C		compartment01	dimensionless · dimensionless^{-1}	⊟	⊟

Id	Name	Compartment	Derived Unit	Constant	Boundary Condition
Pde1		compartment01	dimensionless · dimensionless^{-1}	⊟	⊟
Pde1f		compartment01	dimensionless · dimensionless^{-1}	⊟	⊟
cAMP_Pde1f		compartment01	dimensionless · dimensionless^{-1}	⊟	⊟
AMP		compartment01	dimensionless · dimensionless^{-1}	⊟	⊟
PPA2		compartment01	dimensionless · dimensionless^{-1}	⊟	⊟
Pde2		compartment01	dimensionless · dimensionless^{-1}	⊟	⊟
cAMP_Pde2		compartment01	dimensionless · dimensionless^{-1}	⊟	⊟
Cdc25f		compartment01	dimensionless · dimensionless^{-1}	⊟	⊟
Ira2P		compartment01	dimensionless · dimensionless^{-1}	⊟	⊟
Ras2_GTP_Ira2P		compartment01	dimensionless · dimensionless^{-1}	⊟	⊟

5 Parameters

This model contains 39 global parameters.

Table 4: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
K0			1.000	s^{-1}	☑
K1			1.000	s^{-1}	☑
K2			1.500	s^{-1}	☑
K3			1.000	s^{-1}	☑
K4			1.000	s^{-1}	☑
K5			1.000	s^{-1}	☑
K6			1.000	s^{-1}	☑
K7			1.000	s^{-1}	☑
K8			0.010	s^{-1}	☑
K9			0.250	s^{-1}	☑
K10			0.001	s^{-1}	☑
K11			$2.1 \cdot 10^{-6}$	s^{-1}	☑
K12			0.001	s^{-1}	☑
K13			10^{-5}	s^{-1}	☑
K14			10^{-5}	s^{-1}	☑
K15			10^{-5}	s^{-1}	☑
K16			10^{-5}	s^{-1}	☑
K17			0.100	s^{-1}	☑
K18			0.100	s^{-1}	☑
K19			0.100	s^{-1}	☑
K20			0.100	s^{-1}	☑
K21			1.000	s^{-1}	☑
K22			1.000	s^{-1}	☑
K23			0.750	s^{-1}	☑
K24			1.000	s^{-1}	☑
K25			10^{-6}	s^{-1}	☑
K26			0.100	s^{-1}	☑
K27			0.100	s^{-1}	☑
K28			7.500	s^{-1}	☑
K29			10^{-4}	s^{-1}	☑
K30			10^{-4}	s^{-1}	☑
K31			1.000	s^{-1}	☑
K32			1.700	s^{-1}	☑
K33			1.000	s^{-1}	☑
K34			0.010	s^{-1}	☑
K35			0.001	s^{-1}	☑
K36			1.250	s^{-1}	☑

Id	Name	SBO	Value	Unit	Constant
K37			2.500	s^{-1}	☑
K38			10.000	s^{-1}	☑

6 Reactions

This model contains 39 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	R0		$\text{Ras2\_GDP} + \text{Cdc25} \xrightarrow{\text{Ras2\_GDP, Cdc25}} \text{Ras2\_GDP\_Cdc25}$	
2	R1		$\text{Ras2\_GDP\_Cdc25} \xrightarrow{\text{Ras2\_GDP\_Cdc25}} \text{Ras2\_GDP} + \text{Cdc25}$	
3	R2		$\text{Ras2\_GDP\_Cdc25} \xrightarrow{\text{Ras2\_GDP\_Cdc25}} \text{Ras2\_Cdc25} + \text{GDP}$	
4	R3		$\text{Ras2\_Cdc25} + \text{GDP} \xrightarrow{\text{Ras2\_Cdc25, GDP}} \text{Ras2\_GDP\_Cdc25}$	
5	R4		$\text{Ras2\_Cdc25} + \text{GTP} \xrightarrow{\text{Ras2\_Cdc25, GTP}} \text{Ras2\_GTP\_Cdc25}$	
6	R5		$\text{Ras2\_GTP\_Cdc25} \xrightarrow{\text{Ras2\_GTP\_Cdc25}} \text{Ras2\_Cdc25} + \text{GTP}$	
7	R6		$\text{Ras2\_GTP\_Cdc25} \xrightarrow{\text{Ras2\_GTP\_Cdc25}} \text{Cdc25} + \text{Ras2\_GTP}$	
8	R7		$\text{Cdc25} + \text{Ras2\_GTP} \xrightarrow{\text{Cdc25, Ras2\_GTP}} \text{Ras2\_GTP\_Cdc25}$	
9	R8		$\text{Ras2\_GTP} + \text{Ira2} \xrightarrow{\text{Ras2\_GTP, Ira2}} \text{Ras2\_GTP\_Ira2}$	
10	R9		$\text{Ras2\_GTP\_Ira2} \xrightarrow{\text{Ras2\_GTP\_Ira2}} \text{Ras2\_GDP} + \text{Ira2}$	
11	R10		$\text{Ras2\_GTP} + \text{CYR1} \xrightarrow{\text{Ras2\_GTP, CYR1}} \text{Ras2\_GTP\_CYR1}$	
12	R11		$\text{Ras2\_GTP\_CYR1} + \text{ATP} \xrightarrow{\text{Ras2\_GTP\_CYR1, ATP}} \text{Ras2\_GTP\_CYR1} + \text{cAMP}$	

№	Id	Name	Reaction Equation	SBO
13	R12		$\mathrm{Ira2} + \mathrm{Ras2\_GTP\_CYR1} \xrightarrow{\mathrm{Ira2,\ Ras2\_GTP\_CYR1}} \mathrm{Ras2\_GDP} + \mathrm{Ira2} + \mathrm{CYR1}$	
14	R13		$\mathrm{cAMP} + \mathrm{PKA} \xrightarrow{\mathrm{cAMP,\ PKA}} \mathrm{cAMP\_PKA}$	
15	R14		$\mathrm{cAMP} + \mathrm{cAMP\_PKA} \xrightarrow{\mathrm{cAMP,\ cAMP\_PKA}} \mathrm{IIcAMP\_PKA}$	
16	R15		$\mathrm{cAMP} + \mathrm{IIcAMP\_PKA} \xrightarrow{\mathrm{cAMP,\ IIcAMP\_PKA}} \mathrm{IIIcAMP\_PKA}$	
17	R16		$\mathrm{cAMP} + \mathrm{IIIcAMP\_PKA} \xrightarrow{\mathrm{cAMP,\ IIIcAMP\_PKA}} \mathrm{IVcAMP\_PKA}$	
18	R17		$\mathrm{IVcAMP\_PKA} \xrightarrow{\mathrm{IVcAMP\_PKA}} \mathrm{cAMP} + \mathrm{IIIcAMP\_PKA}$	
19	R18		$\mathrm{IIIcAMP\_PKA} \xrightarrow{\mathrm{IIIcAMP\_PKA}} \mathrm{cAMP} + \mathrm{IIcAMP\_PKA}$	
20	R19		$\mathrm{IIcAMP\_PKA} \xrightarrow{\mathrm{IIcAMP\_PKA}} \mathrm{cAMP} + \mathrm{cAMP\_PKA}$	
21	R20		$\mathrm{cAMP\_PKA} \xrightarrow{\mathrm{cAMP\_PKA}} \mathrm{cAMP} + \mathrm{PKA}$	
22	R21		$\mathrm{IVcAMP\_PKA} \xrightarrow{\mathrm{IVcAMP\_PKA}} 2\,\mathrm{C} + 2\,\mathrm{R\_2cAMP}$	
23	R22		$\mathrm{R\_2cAMP} \xrightarrow{\mathrm{R\_2cAMP}} 2\,\mathrm{cAMP} + \mathrm{R}$	
24	R23		$\mathrm{C} + \mathrm{R} \xrightarrow{\mathrm{C,\ R}} \mathrm{R\_C}$	
25	R24		$2\,\mathrm{R\_C} \xrightarrow{\mathrm{R\_C}} \mathrm{PKA}$	
26	R25		$\mathrm{C} + \mathrm{Pde1} \xrightarrow{\mathrm{C,\ Pde1}} \mathrm{C} + \mathrm{Pde1f}$	
27	R26		$\mathrm{cAMP} + \mathrm{Pde1f} \xrightarrow{\mathrm{cAMP,\ Pde1f}} \mathrm{cAMP\_Pde1f}$	
28	R27		$\mathrm{cAMP\_Pde1f} \xrightarrow{\mathrm{cAMP\_Pde1f}} \mathrm{cAMP} + \mathrm{Pde1f}$	
29	R28		$\mathrm{cAMP\_Pde1f} \xrightarrow{\mathrm{cAMP\_Pde1f}} \mathrm{Pde1f} + \mathrm{AMP}$	
30	R29		$\mathrm{Pde1f} + \mathrm{PPA2} \xrightarrow{\mathrm{Pde1f,\ PPA2}} \mathrm{Pde1} + \mathrm{PPA2}$	

№	Id	Name	Reaction Equation	SBO
31	R30		$\mathrm{cAMP} + \mathrm{Pde2} \xrightarrow{\mathrm{cAMP,\ Pde2}} \mathrm{cAMP\_Pde2}$	
32	R31		$\mathrm{cAMP\_Pde2} \xrightarrow{\mathrm{cAMP\_Pde2}} \mathrm{cAMP} + \mathrm{Pde2}$	
33	R32		$\mathrm{cAMP\_Pde2} \xrightarrow{\mathrm{cAMP\_Pde2}} \mathrm{AMP} + \mathrm{Pde2}$	
34	R33		$\mathrm{Cdc25} + \mathrm{C} \xrightarrow{\mathrm{Cdc25,\ C}} \mathrm{C} + \mathrm{Cdc25f}$	
35	R34		$\mathrm{PPA2} + \mathrm{Cdc25f} \xrightarrow{\mathrm{PPA2,\ Cdc25f}} \mathrm{Cdc25} + \mathrm{PPA2}$	
36	R35		$\mathrm{Ira2} + \mathrm{C} \xrightarrow{\mathrm{Ira2,\ C}} \mathrm{C} + \mathrm{Ira2P}$	
37	R36		$\mathrm{Ras2\_GTP} + \mathrm{Ira2P} \xrightarrow{\mathrm{Ras2\_GTP,\ Ira2P}} \mathrm{Ras2\_GTP\_Ira2P}$	
38	R37		$\mathrm{Ras2\_GTP\_Ira2P} \xrightarrow{\mathrm{Ras2\_GTP\_Ira2P}} \mathrm{Ras2\_GDP} + \mathrm{Ira2P}$	
39	R38		$\mathrm{Ira2P} \xrightarrow{\mathrm{Ira2P}} \mathrm{Ira2}$	

6.1 Reaction R0

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

Reaction equation

$$\text{Ras2\_GDP} + \text{Cdc25} \xrightarrow{\text{Ras2\_GDP, Cdc25}} \text{Ras2\_GDP\_Cdc25} \tag{1}$$

Reactants

Table 6: Properties of each reactant.

Id	Name	SBO
Ras2_GDP		
Cdc25		

Modifiers

Table 7: Properties of each modifier.

Id	Name	SBO
Ras2_GDP		
Cdc25		

Product

Table 8: Properties of each product.

Id	Name	SBO
Ras2_GDP_Cdc25		

Kinetic Law

Derived unit s^{-1}

$$v_1 = \mathrm{K0} \cdot [\text{Ras2\_GDP}] \cdot [\text{Cdc25}] \tag{2}$$

6.2 Reaction R1

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

Reaction equation

$$\text{Ras2\_GDP\_Cdc25} \xrightarrow{\text{Ras2\_GDP\_Cdc25}} \text{Ras2\_GDP} + \text{Cdc25} \tag{3}$$

Reactant

Table 9: Properties of each reactant.

Id	Name	SBO
Ras2_GDP_Cdc25		

Modifier

Table 10: Properties of each modifier.

Id	Name	SBO
Ras2_GDP_Cdc25		

Products

Table 11: Properties of each product.

Id	Name	SBO
Ras2_GDP		
Cdc25		

Kinetic Law

Derived unit s^{-1}

$$v_2 = \mathrm{K1} \cdot [\text{Ras2\_GDP\_Cdc25}] \tag{4}$$

6.3 Reaction R2

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

Reaction equation

$$\text{Ras2\_GDP\_Cdc25} \xrightarrow{\text{Ras2\_GDP\_Cdc25}} \text{Ras2\_Cdc25} + \text{GDP} \tag{5}$$

Reactant

Table 12: Properties of each reactant.

Id	Name	SBO
Ras2_GDP_Cdc25		

Modifier

Table 13: Properties of each modifier.

Id	Name	SBO
Ras2_GDP_Cdc25		

Products

Table 14: Properties of each product.

Id	Name	SBO
Ras2_Cdc25		
GDP		

Kinetic Law

Derived unit s^{-1}

$$v_3 = \mathrm{K2} \cdot [\mathrm{Ras2\_GDP\_Cdc25}] \tag{6}$$

6.4 Reaction R3

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

Reaction equation

$$\mathrm{Ras2\_Cdc25} + \mathrm{GDP} \xrightarrow{\mathrm{Ras2\_Cdc25,\ GDP}} \mathrm{Ras2\_GDP\_Cdc25} \tag{7}$$

Reactants

Table 15: Properties of each reactant.

Id	Name	SBO
Ras2_Cdc25		
GDP		

Modifiers

Table 16: Properties of each modifier.

Id	Name	SBO
Ras2_Cdc25		
GDP		

Product

Table 17: Properties of each product.

Id	Name	SBO
Ras2_GDP_Cdc25		

Kinetic Law

Derived unit s^{-1}

$$v_4 = \mathrm{K3} \cdot [\mathrm{Ras2\_Cdc25}] \cdot [\mathrm{GDP}] \tag{8}$$

6.5 Reaction R4

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

Reaction equation

$$\mathrm{Ras2\_Cdc25} + \mathrm{GTP} \xrightarrow{\mathrm{Ras2\_Cdc25,\ GTP}} \mathrm{Ras2\_GTP\_Cdc25} \tag{9}$$

Reactants

Table 18: Properties of each reactant.

Id	Name	SBO
Ras2_Cdc25		
GTP		

Modifiers

Table 19: Properties of each modifier.

Id	Name	SBO
Ras2_Cdc25		
GTP		

Product

Table 20: Properties of each product.

Id	Name	SBO
Ras2_GTP_Cdc25		

Kinetic Law

Derived unit s^{-1}

$$v_5 = \mathrm{K4} \cdot [\mathrm{Ras2\_Cdc25}] \cdot [\mathrm{GTP}] \tag{10}$$

6.6 Reaction R5

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

Reaction equation

$$\mathrm{Ras2\_GTP\_Cdc25} \xrightarrow{\mathrm{Ras2\_GTP\_Cdc25}} \mathrm{Ras2\_Cdc25} + \mathrm{GTP} \tag{11}$$

Reactant

Table 21: Properties of each reactant.

Id	Name	SBO
Ras2_GTP_Cdc25		

Modifier

Table 22: Properties of each modifier.

Id	Name	SBO
Ras2_GTP_Cdc25		

Products

Table 23: Properties of each product.

Id	Name	SBO
Ras2_Cdc25		
GTP		

Kinetic Law

Derived unit s^{-1}

$$v_6 = K5 \cdot [Ras2\_GTP\_Cdc25] \tag{12}$$

6.7 Reaction R6

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

Reaction equation

$$Ras2\_GTP\_Cdc25 \xrightarrow{Ras2\_GTP\_Cdc25} Cdc25 + Ras2\_GTP \tag{13}$$

Reactant

Table 24: Properties of each reactant.

Id	Name	SBO
Ras2_GTP_Cdc25		

Modifier

Table 25: Properties of each modifier.

Id	Name	SBO
Ras2_GTP_Cdc25		

Products

Table 26: Properties of each product.

Id	Name	SBO
Cdc25		
Ras2_GTP		

Kinetic Law

Derived unit s^{-1}

$$v_7 = \mathrm{K6} \cdot [\mathrm{Ras2\_GTP\_Cdc25}] \tag{14}$$

6.8 Reaction R7

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

Reaction equation

$$\mathrm{Cdc25} + \mathrm{Ras2\_GTP} \xrightarrow{\mathrm{Cdc25,\ Ras2\_GTP}} \mathrm{Ras2\_GTP\_Cdc25} \tag{15}$$

Reactants

Table 27: Properties of each reactant.

Id	Name	SBO
Cdc25		
Ras2_GTP		

Modifiers

Table 28: Properties of each modifier.

Id	Name	SBO
Cdc25		
Ras2_GTP		

Product

Table 29: Properties of each product.

Id	Name	SBO
Ras2_GTP_Cdc25		

Kinetic Law

Derived unit s^{-1}

$$v_8 = \mathrm{K7} \cdot [\mathrm{Cdc25}] \cdot [\mathrm{Ras2\_GTP}] \tag{16}$$

6.9 Reaction R8

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

Reaction equation

$$\mathrm{Ras2\_GTP} + \mathrm{Ira2} \xrightarrow{\mathrm{Ras2\_GTP,\ Ira2}} \mathrm{Ras2\_GTP\_Ira2} \tag{17}$$

Reactants

Table 30: Properties of each reactant.

Id	Name	SBO
Ras2_GTP		
Ira2		

Modifiers

Table 31: Properties of each modifier.

Id	Name	SBO
Ras2_GTP		
Ira2		

Product

Table 32: Properties of each product.

Id	Name	SBO
Ras2_GTP_Ira2		

Kinetic Law

Derived unit s^{-1}

$$v_9 = \mathrm{K8} \cdot [\mathrm{Ras2\_GTP}] \cdot [\mathrm{Ira2}] \tag{18}$$

6.10 Reaction R9

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

Reaction equation

$$\mathrm{Ras2\_GTP\_Ira2} \xrightarrow{\mathrm{Ras2\_GTP\_Ira2}} \mathrm{Ras2\_GDP} + \mathrm{Ira2} \tag{19}$$

Reactant

Table 33: Properties of each reactant.

Id	Name	SBO
Ras2_GTP_Ira2		

Modifier

Table 34: Properties of each modifier.

Id	Name	SBO
Ras2_GTP_Ira2		

Products

Table 35: Properties of each product.

Id	Name	SBO
Ras2_GDP		
Ira2		

Kinetic Law

Derived unit s^{-1}

$$v_{10} = \mathrm{K9} \cdot [\mathrm{Ras2\_GTP\_Ira2}] \tag{20}$$

6.11 Reaction R10

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

Reaction equation

$$\text{Ras2\_GTP} + \text{CYR1} \xrightarrow{\text{Ras2\_GTP, CYR1}} \text{Ras2\_GTP\_CYR1} \tag{21}$$

Reactants

Table 36: Properties of each reactant.

Id	Name	SBO
Ras2_GTP		
CYR1		

Modifiers

Table 37: Properties of each modifier.

Id	Name	SBO
Ras2_GTP		
CYR1		

Product

Table 38: Properties of each product.

Id	Name	SBO
Ras2_GTP_CYR1		

Kinetic Law

Derived unit s^{-1}

$$v_{11} = \text{K10} \cdot [\text{Ras2\_GTP}] \cdot [\text{CYR1}] \tag{22}$$

6.12 Reaction R11

This is an irreversible reaction of two reactants forming two products influenced by two modifiers.

Reaction equation

$$\text{Ras2\_GTP\_CYR1} + \text{ATP} \xrightarrow{\text{Ras2\_GTP\_CYR1, ATP}} \text{Ras2\_GTP\_CYR1} + \text{cAMP} \tag{23}$$

Reactants

Table 39: Properties of each reactant.

Id	Name	SBO
Ras2_GTP_CYR1		
ATP		

Modifiers

Table 40: Properties of each modifier.

Id	Name	SBO
Ras2_GTP_CYR1		
ATP		

Products

Table 41: Properties of each product.

Id	Name	SBO
Ras2_GTP_CYR1		
cAMP		

Kinetic Law

Derived unit s^{-1}

$$v_{12} = \mathrm{K11} \cdot [\text{Ras2\_GTP\_CYR1}] \cdot [\text{ATP}] \tag{24}$$

6.13 Reaction R12

This is an irreversible reaction of two reactants forming three products influenced by two modifiers.

Reaction equation

$$\text{Ira2} + \text{Ras2\_GTP\_CYR1} \xrightarrow{\text{Ira2, Ras2\_GTP\_CYR1}} \text{Ras2\_GDP} + \text{Ira2} + \text{CYR1} \tag{25}$$

Reactants

Table 42: Properties of each reactant.

Id	Name	SBO
Ira2		
Ras2_GTP_CYR1		

Modifiers

Table 43: Properties of each modifier.

Id	Name	SBO
Ira2		
Ras2_GTP_CYR1		

Products

Table 44: Properties of each product.

Id	Name	SBO
Ras2_GDP		
Ira2		
CYR1		

Kinetic Law

Derived unit s^{-1}

$$v_{13} = \mathrm{K12} \cdot [\mathrm{Ira2}] \cdot [\mathrm{Ras2\_GTP\_CYR1}] \tag{26}$$

6.14 Reaction R13

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

Reaction equation

$$\mathrm{cAMP} + \mathrm{PKA} \xrightarrow{\mathrm{cAMP,\ PKA}} \mathrm{cAMP\_PKA} \tag{27}$$

Reactants

Table 45: Properties of each reactant.

Id	Name	SBO
cAMP		
PKA		

Modifiers

Table 46: Properties of each modifier.

Id	Name	SBO
cAMP		
PKA		

Product

Table 47: Properties of each product.

Id	Name	SBO
cAMP_PKA		

Kinetic Law

Derived unit s^{-1}

$$v_{14} = \mathrm{K13} \cdot [\mathrm{cAMP}] \cdot [\mathrm{PKA}] \tag{28}$$

6.15 Reaction R14

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

Reaction equation

$$\mathrm{cAMP} + \mathrm{cAMP\_PKA} \xrightarrow{\mathrm{cAMP,\ cAMP\_PKA}} \mathrm{IIcAMP\_PKA} \tag{29}$$

Reactants

Table 48: Properties of each reactant.

Id	Name	SBO
cAMP		
cAMP_PKA		

Modifiers

Table 49: Properties of each modifier.

Id	Name	SBO
cAMP		
cAMP_PKA		

Product

Table 50: Properties of each product.

Id	Name	SBO
IIcAMP_PKA		

Kinetic Law

Derived unit s^{-1}

$$v_{15} = \mathrm{K14} \cdot [\mathrm{cAMP}] \cdot [\mathrm{cAMP\_PKA}] \tag{30}$$

6.16 Reaction R15

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

Reaction equation

$$\mathrm{cAMP} + \mathrm{IIcAMP\_PKA} \xrightarrow{\mathrm{cAMP,\ IIcAMP\_PKA}} \mathrm{IIIcAMP\_PKA} \tag{31}$$

Reactants

Table 51: Properties of each reactant.

Id	Name	SBO
cAMP		
IIcAMP_PKA		

Modifiers

Table 52: Properties of each modifier.

Id	Name	SBO
cAMP		
IIcAMP_PKA		

Product

Table 53: Properties of each product.

Id	Name	SBO
IIIcAMP_PKA		

Kinetic Law

Derived unit s^{-1}

$$v_{16} = \mathrm{K15} \cdot [\mathrm{cAMP}] \cdot [\mathrm{IIcAMP\_PKA}] \tag{32}$$

6.17 Reaction R16

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

Reaction equation

$$\mathrm{cAMP} + \mathrm{IIIcAMP\_PKA} \xrightarrow{\mathrm{cAMP,\ IIIcAMP\_PKA}} \mathrm{IVcAMP\_PKA} \tag{33}$$

Reactants

Table 54: Properties of each reactant.

Id	Name	SBO
cAMP		
IIIcAMP_PKA		

Modifiers

Table 55: Properties of each modifier.

Id	Name	SBO
cAMP		

Id	Name	SBO
IIIcAMP_PKA		

Product

Table 56: Properties of each product.

Id	Name	SBO
IVcAMP_PKA		

Kinetic Law

Derived unit s^{-1}

$$v_{17} = \mathrm{K16} \cdot [\mathrm{cAMP}] \cdot [\mathrm{IIIcAMP\_PKA}] \tag{34}$$

6.18 Reaction R17

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

Reaction equation

$$\mathrm{IVcAMP\_PKA} \xrightarrow{\mathrm{IVcAMP\_PKA}} \mathrm{cAMP} + \mathrm{IIIcAMP\_PKA} \tag{35}$$

Reactant

Table 57: Properties of each reactant.

Id	Name	SBO
IVcAMP_PKA		

Modifier

Table 58: Properties of each modifier.

Id	Name	SBO
IVcAMP_PKA		

Products

Table 59: Properties of each product.

Id	Name	SBO
cAMP		
IIIcAMP_PKA		

Kinetic Law

Derived unit s^{-1}

$$v_{18} = \mathrm{K17} \cdot [\mathrm{IVcAMP\_PKA}] \tag{36}$$

6.19 Reaction R18

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

Reaction equation

$$\mathrm{IIIcAMP\_PKA} \xrightarrow{\mathrm{IIIcAMP\_PKA}} \mathrm{cAMP} + \mathrm{IIcAMP\_PKA} \tag{37}$$

Reactant

Table 60: Properties of each reactant.

Id	Name	SBO
IIIcAMP_PKA		

Modifier

Table 61: Properties of each modifier.

Id	Name	SBO
IIIcAMP_PKA		

Products

Table 62: Properties of each product.

Id	Name	SBO
cAMP		
IIcAMP_PKA		

Kinetic Law

Derived unit s^{-1}

$$v_{19} = \mathrm{K18} \cdot [\mathrm{IIIcAMP\_PKA}] \tag{38}$$

6.20 Reaction R19

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

Reaction equation

$$\mathrm{IIcAMP\_PKA} \xrightarrow{\mathrm{IIcAMP\_PKA}} \mathrm{cAMP} + \mathrm{cAMP\_PKA} \tag{39}$$

Reactant

Table 63: Properties of each reactant.

Id	Name	SBO
IIcAMP_PKA		

Modifier

Table 64: Properties of each modifier.

Id	Name	SBO
IIcAMP_PKA		

Products

Table 65: Properties of each product.

Id	Name	SBO
cAMP		
cAMP_PKA		

Kinetic Law

Derived unit s^{-1}

$$v_{20} = \mathrm{K19} \cdot [\mathrm{IIcAMP\_PKA}] \tag{40}$$

6.21 Reaction R20

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

Reaction equation

$$\text{cAMP\_PKA} \xrightarrow{\text{cAMP\_PKA}} \text{cAMP} + \text{PKA} \tag{41}$$

Reactant

Table 66: Properties of each reactant.

Id	Name	SBO
cAMP_PKA		

Modifier

Table 67: Properties of each modifier.

Id	Name	SBO
cAMP_PKA		

Products

Table 68: Properties of each product.

Id	Name	SBO
cAMP		
PKA		

Kinetic Law

Derived unit s^{-1}

$$v_{21} = \text{K20} \cdot [\text{cAMP\_PKA}] \tag{42}$$

6.22 Reaction R21

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

Reaction equation

$$\mathrm{IVcAMP\_PKA} \xrightarrow{\mathrm{IVcAMP\_PKA}} 2\,\mathrm{C} + 2\,\mathrm{R\_2cAMP} \tag{43}$$

Reactant

Table 69: Properties of each reactant.

Id	Name	SBO
IVcAMP_PKA		

Modifier

Table 70: Properties of each modifier.

Id	Name	SBO
IVcAMP_PKA		

Products

Table 71: Properties of each product.

Id	Name	SBO
C		
R_2cAMP		

Kinetic Law

Derived unit s^{-1}

$$v_{22} = \mathrm{K21} \cdot [\mathrm{IVcAMP\_PKA}] \tag{44}$$

6.23 Reaction R22

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

Reaction equation

$$\mathrm{R\_2cAMP} \xrightarrow{\mathrm{R\_2cAMP}} 2\,\mathrm{cAMP} + \mathrm{R} \tag{45}$$

Reactant

Table 72: Properties of each reactant.

Id	Name	SBO
R_2cAMP		

Modifier

Table 73: Properties of each modifier.

Id	Name	SBO
R_2cAMP		

Products

Table 74: Properties of each product.

Id	Name	SBO
cAMP		
R		

Kinetic Law

Derived unit s^{-1}

$$v_{23} = \mathrm{K22} \cdot [\mathrm{R\_2cAMP}] \tag{46}$$

6.24 Reaction R23

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

Reaction equation

$$\mathrm{C} + \mathrm{R} \xrightarrow{\mathrm{C,\ R}} \mathrm{R\_C} \tag{47}$$

Reactants

Table 75: Properties of each reactant.

Id	Name	SBO
C		
R		

Modifiers

Table 76: Properties of each modifier.

Id	Name	SBO
C		
R		

Product

Table 77: Properties of each product.

Id	Name	SBO
R_C		

Kinetic Law

Derived unit s^{-1}

$$v_{24} = \mathrm{K23} \cdot [\mathrm{C}] \cdot [\mathrm{R}] \tag{48}$$

6.25 Reaction R24

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

Reaction equation

$$2\,\mathrm{R\_C} \xrightarrow{\mathrm{R\_C}} \mathrm{PKA} \tag{49}$$

Reactant

Table 78: Properties of each reactant.

Id	Name	SBO
R_C		

Modifier

Table 79: Properties of each modifier.

Id	Name	SBO
R_C		

Product

Table 80: Properties of each product.

Id	Name	SBO
PKA		

Kinetic Law

Derived unit contains undeclared units

$$v_{25} = \mathrm{K24} \cdot \frac{[\mathrm{R\_C}] \cdot ([\mathrm{R\_C}] - 1)}{2} \tag{50}$$

6.26 Reaction R25

This is an irreversible reaction of two reactants forming two products influenced by two modifiers.

Reaction equation

$$\mathrm{C} + \mathrm{Pde1} \xrightarrow{\mathrm{C,\ Pde1}} \mathrm{C} + \mathrm{Pde1f} \tag{51}$$

Reactants

Table 81: Properties of each reactant.

Id	Name	SBO
C		
Pde1		

Modifiers

Table 82: Properties of each modifier.

Id	Name	SBO
C		
Pde1		

Products

Table 83: Properties of each product.

Id	Name	SBO
C		
Pde1f		

Kinetic Law

Derived unit s^{-1}

$$v_{26} = \mathrm{K25} \cdot [\mathrm{C}] \cdot [\mathrm{Pde1}] \tag{52}$$

6.27 Reaction R26

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

Reaction equation

$$\mathrm{cAMP} + \mathrm{Pde1f} \xrightarrow{\mathrm{cAMP,\ Pde1f}} \mathrm{cAMP\_Pde1f} \tag{53}$$

Reactants

Table 84: Properties of each reactant.

Id	Name	SBO
cAMP		
Pde1f		

Modifiers

Table 85: Properties of each modifier.

Id	Name	SBO
cAMP		
Pde1f		

Product

Table 86: Properties of each product.

Id	Name	SBO
cAMP_Pde1f		

Kinetic Law

Derived unit s^{-1}

$$v_{27} = \mathrm{K26} \cdot [\mathrm{cAMP}] \cdot [\mathrm{Pde1f}] \tag{54}$$

6.28 Reaction R27

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

Reaction equation

$$\mathrm{cAMP\_Pde1f} \xrightarrow{\mathrm{cAMP\_Pde1f}} \mathrm{cAMP} + \mathrm{Pde1f} \tag{55}$$

Reactant

Table 87: Properties of each reactant.

Id	Name	SBO
cAMP_Pde1f		

Modifier

Table 88: Properties of each modifier.

Id	Name	SBO
cAMP_Pde1f		

Products

Table 89: Properties of each product.

Id	Name	SBO
cAMP		
Pde1f		

Kinetic Law

Derived unit s^{-1}

$$v_{28} = \mathrm{K27} \cdot [\mathrm{cAMP\_Pde1f}] \tag{56}$$

6.29 Reaction R28

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

Reaction equation

$$\mathrm{cAMP\_Pde1f} \xrightarrow{\mathrm{cAMP\_Pde1f}} \mathrm{Pde1f} + \mathrm{AMP} \tag{57}$$

Reactant

Table 90: Properties of each reactant.

Id	Name	SBO
cAMP_Pde1f		

Modifier

Table 91: Properties of each modifier.

Id	Name	SBO
cAMP_Pde1f		

Products

Table 92: Properties of each product.

Id	Name	SBO
Pde1f		
AMP		

Kinetic Law

Derived unit s^{-1}

$$v_{29} = \mathrm{K28} \cdot [\mathrm{cAMP\_Pde1f}] \tag{58}$$

6.30 Reaction R29

This is an irreversible reaction of two reactants forming two products influenced by two modifiers.

Reaction equation

$$\mathrm{Pde1f} + \mathrm{PPA2} \xrightarrow{\mathrm{Pde1f,\ PPA2}} \mathrm{Pde1} + \mathrm{PPA2} \tag{59}$$

Reactants

Table 93: Properties of each reactant.

Id	Name	SBO
Pde1f		
PPA2		

Modifiers

Table 94: Properties of each modifier.

Id	Name	SBO
Pde1f		
PPA2		

Products

Table 95: Properties of each product.

Id	Name	SBO
Pde1		
PPA2		

Kinetic Law

Derived unit s^{-1}

$$v_{30} = \mathrm{K29} \cdot [\mathrm{Pde1f}] \cdot [\mathrm{PPA2}] \tag{60}$$

6.31 Reaction R30

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

Reaction equation

$$\mathrm{cAMP} + \mathrm{Pde2} \xrightarrow{\mathrm{cAMP,\ Pde2}} \mathrm{cAMP\_Pde2} \tag{61}$$

Reactants

Table 96: Properties of each reactant.

Id	Name	SBO
cAMP		
Pde2		

Modifiers

Table 97: Properties of each modifier.

Id	Name	SBO
cAMP		
Pde2		

Product

Table 98: Properties of each product.

Id	Name	SBO
cAMP_Pde2		

Kinetic Law

Derived unit s^{-1}

$$v_{31} = \mathrm{K30} \cdot [\mathrm{cAMP}] \cdot [\mathrm{Pde2}] \tag{62}$$

6.32 Reaction R31

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

Reaction equation

$$\mathrm{cAMP\_Pde2} \xrightarrow{\mathrm{cAMP\_Pde2}} \mathrm{cAMP} + \mathrm{Pde2} \tag{63}$$

Reactant

Table 99: Properties of each reactant.

Id	Name	SBO
cAMP_Pde2		

Modifier

Table 100: Properties of each modifier.

Id	Name	SBO
cAMP_Pde2		

Products

Table 101: Properties of each product.

Id	Name	SBO
cAMP		
Pde2		

Kinetic Law

Derived unit s^{-1}

$$v_{32} = \mathrm{K31} \cdot [\mathrm{cAMP\_Pde2}] \tag{64}$$

6.33 Reaction R32

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

Reaction equation

$$\mathrm{cAMP\_Pde2} \xrightarrow{\mathrm{cAMP\_Pde2}} \mathrm{AMP} + \mathrm{Pde2} \tag{65}$$

Reactant

Table 102: Properties of each reactant.

Id	Name	SBO
cAMP_Pde2		

Modifier

Table 103: Properties of each modifier.

Id	Name	SBO
cAMP_Pde2		

Products

Table 104: Properties of each product.

Id	Name	SBO
AMP		
Pde2		

Kinetic Law

Derived unit s^{-1}

$$v_{33} = \mathrm{K32} \cdot [\mathrm{cAMP\_Pde2}] \tag{66}$$

6.34 Reaction R33

This is an irreversible reaction of two reactants forming two products influenced by two modifiers.

Reaction equation

$$\mathrm{Cdc25} + \mathrm{C} \xrightarrow{\mathrm{Cdc25,\ C}} \mathrm{C} + \mathrm{Cdc25f} \tag{67}$$

Reactants

Table 105: Properties of each reactant.

Id	Name	SBO
Cdc25		
C		

Modifiers

Table 106: Properties of each modifier.

Id	Name	SBO
Cdc25		
C		

Products

Table 107: Properties of each product.

Id	Name	SBO
C		
Cdc25f		

Kinetic Law

Derived unit s^{-1}

$$v_{34} = \mathrm{K33} \cdot [\mathrm{Cdc25}] \cdot [\mathrm{C}] \tag{68}$$

6.35 Reaction R34

This is an irreversible reaction of two reactants forming two products influenced by two modifiers.

Reaction equation

$$\mathrm{PPA2} + \mathrm{Cdc25f} \xrightarrow{\mathrm{PPA2,\ Cdc25f}} \mathrm{Cdc25} + \mathrm{PPA2} \tag{69}$$

Reactants

Table 108: Properties of each reactant.

Id	Name	SBO
PPA2		
Cdc25f		

Modifiers

Table 109: Properties of each modifier.

Id	Name	SBO
PPA2		
Cdc25f		

Products

Table 110: Properties of each product.

Id	Name	SBO
Cdc25		
PPA2		

Kinetic Law

Derived unit s^{-1}

$$v_{35} = \mathrm{K34} \cdot [\mathrm{PPA2}] \cdot [\mathrm{Cdc25f}] \tag{70}$$

6.36 Reaction R35

This is an irreversible reaction of two reactants forming two products influenced by two modifiers.

Reaction equation

$$\mathrm{Ira2} + \mathrm{C} \xrightarrow{\mathrm{Ira2,\ C}} \mathrm{C} + \mathrm{Ira2P} \tag{71}$$

Reactants

Table 111: Properties of each reactant.

Id	Name	SBO
Ira2		
C		

Modifiers

Table 112: Properties of each modifier.

Id	Name	SBO
Ira2		
C		

Products

Table 113: Properties of each product.

Id	Name	SBO
C		
Ira2P		

Kinetic Law

Derived unit s^{-1}

$$v_{36} = \mathrm{K35} \cdot [\mathrm{Ira2}] \cdot [\mathrm{C}] \tag{72}$$

6.37 Reaction R36

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

Reaction equation

$$\text{Ras2\_GTP} + \text{Ira2P} \xrightarrow{\text{Ras2\_GTP, Ira2P}} \text{Ras2\_GTP\_Ira2P} \tag{73}$$

Reactants

Table 114: Properties of each reactant.

Id	Name	SBO
Ras2_GTP		
Ira2P		

Modifiers

Table 115: Properties of each modifier.

Id	Name	SBO
Ras2_GTP		
Ira2P		

Product

Table 116: Properties of each product.

Id	Name	SBO
Ras2_GTP_Ira2P		

Kinetic Law

Derived unit s^{-1}

$$v_{37} = \mathrm{K36} \cdot [\text{Ras2\_GTP}] \cdot [\text{Ira2P}] \tag{74}$$

6.38 Reaction R37

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

Reaction equation

$$\text{Ras2\_GTP\_Ira2P} \xrightarrow{\text{Ras2\_GTP\_Ira2P}} \text{Ras2\_GDP} + \text{Ira2P} \tag{75}$$

Reactant

Table 117: Properties of each reactant.

Id	Name	SBO
Ras2_GTP_Ira2P		

Modifier

Table 118: Properties of each modifier.

Id	Name	SBO
Ras2_GTP_Ira2P		

Products

Table 119: Properties of each product.

Id	Name	SBO
Ras2_GDP		
Ira2P		

Kinetic Law

Derived unit s^{-1}

$$v_{38} = \mathrm{K37} \cdot [\mathrm{Ras2\_GTP\_Ira2P}] \tag{76}$$

6.39 Reaction R38

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

Reaction equation

$$\mathrm{Ira2P} \xrightarrow{\mathrm{Ira2P}} \mathrm{Ira2} \tag{77}$$

Reactant

Table 120: Properties of each reactant.

Id	Name	SBO
Ira2P		

Modifier

Table 121: Properties of each modifier.

Id	Name	SBO
Ira2P		

Product

Table 122: Properties of each product.

Id	Name	SBO
Ira2		

Kinetic Law

Derived unit s^{-1}

$$v_{39} = \mathrm{K38} \cdot [\mathrm{Ira2P}] \tag{78}$$

7 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.

7.1 Species Ras2_GDP

Initial amount 20000 dimensionless

This species takes part in six reactions (as a reactant in R0 and as a product in R1, R9, R12, R37 and as a modifier in R0).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{Ras2\_GDP} = v_2 + v_{10} + v_{13} + v_{38} - v_1 \tag{79}$$

7.2 Species Cdc25

Initial amount 300 dimensionless

This species takes part in nine reactions (as a reactant in R0, R7, R33 and as a product in R1, R6, R34 and as a modifier in R0, R7, R33).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{Cdc25} = v_2 + v_7 + v_{35} - v_1 - v_8 - v_{34} \tag{80}$$

7.3 Species Ras2_GDP_Cdc25

Initial amount 0 dimensionless

This species takes part in six reactions (as a reactant in R1, R2 and as a product in R0, R3 and as a modifier in R1, R2).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{Ras2\_GDP\_Cdc25} = v_1 + v_4 - v_2 - v_3 \tag{81}$$

7.4 Species Ras2_Cdc25

Initial amount 0 dimensionless

This species takes part in six reactions (as a reactant in R3, R4 and as a product in R2, R5 and as a modifier in R3, R4).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{Ras2\_Cdc25} = v_3 + v_6 - v_4 - v_5 \tag{82}$$

7.5 Species GDP

Initial amount 1500000 dimensionless

This species takes part in three reactions (as a reactant in R3 and as a product in R2 and as a modifier in R3), which do not influence its rate of change because this constant species is on the boundary of the reaction system:

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{GDP} = 0 \tag{83}$$

7.6 Species GTP

Initial amount 5000000 dimensionless

This species takes part in three reactions (as a reactant in R4 and as a product in R5 and as a modifier in R4), which do not influence its rate of change because this constant species is on the boundary of the reaction system:

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{GTP} = 0 \tag{84}$$

7.7 Species Ras2_GTP_Cdc25

Initial amount 0 dimensionless

This species takes part in six reactions (as a reactant in R5, R6 and as a product in R4, R7 and as a modifier in R5, R6).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{Ras2\_GTP\_Cdc25} = v_5 + v_8 - v_6 - v_7 \tag{85}$$

7.8 Species Ras2_GTP

Initial amount 0 dimensionless

This species takes part in nine reactions (as a reactant in R7, R8, R10, R36 and as a product in R6 and as a modifier in R7, R8, R10, R36).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{Ras2\_GTP} = v_7 - v_8 - v_9 - v_{11} - v_{37} \tag{86}$$

7.9 Species Ira2

Initial amount 200 dimensionless

This species takes part in nine reactions (as a reactant in R8, R12, R35 and as a product in R9, R12, R38 and as a modifier in R8, R12, R35).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{Ira2} = v_{10} + v_{13} + v_{39} - v_9 - v_{13} - v_{36} \tag{87}$$

7.10 Species Ras2_GTP_Ira2

Initial amount 0 dimensionless

This species takes part in three reactions (as a reactant in R9 and as a product in R8 and as a modifier in R9).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{Ras2\_GTP\_Ira2} = v_9 - v_{10} \tag{88}$$

7.11 Species CYR1

Initial amount 200 dimensionless

This species takes part in three reactions (as a reactant in R10 and as a product in R12 and as a modifier in R10).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{CYR1} = v_{13} - v_{11} \tag{89}$$

7.12 Species Ras2_GTP_CYR1

Initial amount 0 dimensionless

This species takes part in six reactions (as a reactant in R11, R12 and as a product in R10, R11 and as a modifier in R11, R12).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{Ras2\_GTP\_CYR1} = v_{11} + v_{12} - v_{12} - v_{13} \tag{90}$$

7.13 Species ATP

Initial amount $2.4 \cdot 10^7$ dimensionless

This species takes part in two reactions (as a reactant in R11 and as a modifier in R11), which do not influence its rate of change because this constant species is on the boundary of the reaction system:

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{ATP} = 0 \tag{91}$$

7.14 Species cAMP

Initial amount 0 dimensionless

This species takes part in 20 reactions (as a reactant in R13, R14, R15, R16, R26, R30 and as a product in R11, R17, R18, R19, R20, R22, R27, R31 and as a modifier in R13, R14, R15, R16, R26, R30).

$$\begin{aligned}\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{cAMP} = {} & v_{12} + v_{18} + v_{19} + v_{20} + v_{21} + 2\,v_{23} + v_{28} \\ & + v_{32} - v_{14} - v_{15} - v_{16} - v_{17} - v_{27} - v_{31}\end{aligned} \tag{92}$$

7.15 Species PKA

Initial amount 2500 dimensionless

This species takes part in four reactions (as a reactant in R13 and as a product in R20, R24 and as a modifier in R13).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{PKA} = v_{21} + v_{25} - v_{14} \tag{93}$$

7.16 Species cAMP_PKA

Initial amount 0 dimensionless

This species takes part in six reactions (as a reactant in R14, R20 and as a product in R13, R19 and as a modifier in R14, R20).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{cAMP\_PKA} = v_{14} + v_{20} - v_{15} - v_{21} \tag{94}$$

7.17 Species IIcAMP_PKA

Initial amount 0 dimensionless

This species takes part in six reactions (as a reactant in R15, R19 and as a product in R14, R18 and as a modifier in R15, R19).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{IIcAMP\_PKA} = v_{15} + v_{19} - v_{16} - v_{20} \tag{95}$$

7.18 Species IIIcAMP_PKA

Initial amount 0 dimensionless

This species takes part in six reactions (as a reactant in R16, R18 and as a product in R15, R17 and as a modifier in R16, R18).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{IIIcAMP\_PKA} = v_{16} + v_{18} - v_{17} - v_{19} \tag{96}$$

7.19 Species IVcAMP_PKA

Initial amount 0 dimensionless

This species takes part in five reactions (as a reactant in R17, R21 and as a product in R16 and as a modifier in R17, R21).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{IVcAMP\_PKA} = v_{17} - v_{18} - v_{22} \tag{97}$$

7.20 Species C

Initial amount 0 dimensionless

This species takes part in twelve reactions (as a reactant in R23, R25, R33, R35 and as a product in R21, R25, R33, R35 and as a modifier in R23, R25, R33, R35).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{C} = 2\,v_{22} + v_{26} + v_{34} + v_{36} - v_{24} - v_{26} - v_{34} - v_{36} \tag{98}$$

7.21 Species R_2cAMP

Initial amount 0 dimensionless

This species takes part in three reactions (as a reactant in R22 and as a product in R21 and as a modifier in R22).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{R\_2cAMP} = 2\,v_{22} - v_{23} \tag{99}$$

7.22 Species R

Initial amount 0 dimensionless

This species takes part in three reactions (as a reactant in R23 and as a product in R22 and as a modifier in R23).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{R} = v_{23} - v_{24} \tag{100}$$

7.23 Species R_C

Initial amount 0 dimensionless

This species takes part in three reactions (as a reactant in R24 and as a product in R23 and as a modifier in R24).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{R\_C} = v_{24} - 2\,v_{25} \tag{101}$$

7.24 Species Pde1

Initial amount 1400 dimensionless

This species takes part in three reactions (as a reactant in R25 and as a product in R29 and as a modifier in R25).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{Pde1} = v_{30} - v_{26} \tag{102}$$

7.25 Species Pde1f

Initial amount 0 dimensionless

This species takes part in seven reactions (as a reactant in R26, R29 and as a product in R25, R27, R28 and as a modifier in R26, R29).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{Pde1f} = v_{26} + v_{28} + v_{29} - v_{27} - v_{30} \tag{103}$$

7.26 Species cAMP_Pde1f

Initial amount 0 dimensionless

This species takes part in five reactions (as a reactant in R27, R28 and as a product in R26 and as a modifier in R27, R28).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{cAMP\_Pde1f} = v_{27} - v_{28} - v_{29} \tag{104}$$

7.27 Species AMP

Initial amount 0 dimensionless

This species takes part in two reactions (as a product in R28, R32).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{AMP} = v_{29} + v_{33} \tag{105}$$

7.28 Species PPA2

Initial amount 4000 dimensionless

This species takes part in six reactions (as a reactant in R29, R34 and as a product in R29, R34 and as a modifier in R29, R34).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{PPA2} = v_{30} + v_{35} - v_{30} - v_{35} \tag{106}$$

7.29 Species Pde2

Initial amount 6500 dimensionless

This species takes part in four reactions (as a reactant in R30 and as a product in R31, R32 and as a modifier in R30).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{Pde2} = v_{32} + v_{33} - v_{31} \tag{107}$$

7.30 Species cAMP_Pde2

Initial amount 0 dimensionless

This species takes part in five reactions (as a reactant in R31, R32 and as a product in R30 and as a modifier in R31, R32).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{cAMP\_Pde2} = v_{31} - v_{32} - v_{33} \tag{108}$$

7.31 Species Cdc25f

Initial amount 0 dimensionless

This species takes part in three reactions (as a reactant in R34 and as a product in R33 and as a modifier in R34).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{Cdc25f} = v_{34} - v_{35} \tag{109}$$

7.32 Species Ira2P

Initial amount 0 dimensionless

This species takes part in six reactions (as a reactant in R36, R38 and as a product in R35, R37 and as a modifier in R36, R38).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{Ira2P} = v_{36} + v_{38} - v_{37} - v_{39} \tag{110}$$

7.33 Species Ras2_GTP_Ira2P

Initial amount 0 dimensionless

This species takes part in three reactions (as a reactant in R37 and as a product in R36 and as a modifier in R37).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{Ras2\_GTP\_Ira2P} = v_{37} - v_{38} \tag{111}$$

A Glossary of Systems Biology Ontology Terms

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

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