SBML Model Report

Model name: “Leloup2003_CircClock_LD”

May 6, 2016

1 General Overview

This is a document in SBML Level 2 Version 1 format. This model was created by Enuo He[1] at October 17th 2006 at 3:43 p. m. and last time modified at July eleventh 2012 at 6:31 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	16
events	0	constraints	0
reactions	48	function definitions	5
global parameters	2	unit definitions	2
rules	2	initial assignments	0

Model Notes

This model is described in the paper *Toward a detailed computational model for the mammalian circadian clock* . In this model only interlocked negative and positive regulation of Per, Cry, Bmal gene are involved. Some initial values were not provided, therefore they were chosen to fit the curves from the paper.

Figure2C is re-produced by odeSolver.

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To cite BioModels Database, please use: Li C, Donizelli M, Rodriguez N, Dharuri H, Endler L, Chelliah V, Li L, He E, Henry A, Stefan MI, Snoep JL, Hucka M, Le Novre N, Laibe C (2010) BioModels Database: An enhanced, curated and annotated resource for published quantitative kinetic models. BMC Syst Biol., 4:92.

2 Unit Definitions

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

2.1 Unit `time`

Definition 3600 s

2.2 Unit `substance`

Definition nmol

2.3 Unit `volume`

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

Definition l

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

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 16 species. Section 9 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
species_0	Mb	cell	$\mathrm{nmol} \cdot \mathrm{l}^{-1}$	⊟	⊟
species_1	Bc	cell	$\mathrm{nmol} \cdot \mathrm{l}^{-1}$	⊟	⊟
species_2	Bcp	cell	$\mathrm{nmol} \cdot \mathrm{l}^{-1}$	⊟	⊟
species_3	Bn	cell	$\mathrm{nmol} \cdot \mathrm{l}^{-1}$	⊟	⊟
species_4	Cc	cell	$\mathrm{nmol} \cdot \mathrm{l}^{-1}$	⊟	⊟
species_5	Mc	cell	$\mathrm{nmol} \cdot \mathrm{l}^{-1}$	⊟	⊟
species_6	Ccp	cell	$\mathrm{nmol} \cdot \mathrm{l}^{-1}$	⊟	⊟
species_7	Mp	cell	$\mathrm{nmol} \cdot \mathrm{l}^{-1}$	⊟	⊟
species_8	Pc	cell	$\mathrm{nmol} \cdot \mathrm{l}^{-1}$	⊟	⊟
species_9	Pcp	cell	$\mathrm{nmol} \cdot \mathrm{l}^{-1}$	⊟	⊟
species_10	PCc	cell	$\mathrm{nmol} \cdot \mathrm{l}^{-1}$	⊟	⊟
species_11	PCcp	cell	$\mathrm{nmol} \cdot \mathrm{l}^{-1}$	⊟	⊟
species_12	PCn	cell	$\mathrm{nmol} \cdot \mathrm{l}^{-1}$	⊟	⊟
species_13	Bnp	cell	$\mathrm{nmol} \cdot \mathrm{l}^{-1}$	⊟	⊟
species_14	PCnp	cell	$\mathrm{nmol} \cdot \mathrm{l}^{-1}$	⊟	⊟
species_15	In	cell	$\mathrm{nmol} \cdot \mathrm{l}^{-1}$	⊟	⊟

5 Parameters

This model contains two global parameters.

Table 4: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
parameter_0000081	LD		0.0		⊟
parameter_0000082	vsp		0.0		⊟

6 Function definitions

This is an overview of five function definitions.

6.1 Function definition function_3

Name Activation of gene

Arguments Vs, B, n, K

Mathematical Expression

$$\frac{\mathrm{Vs} \cdot \mathrm{B}^{\mathrm{n}}}{\mathrm{K}^{\mathrm{n}} + \mathrm{B}^{\mathrm{n}}} \tag{1}$$

6.2 Function definition function_2

Name Michaelis-Menten(irreversible)

Arguments V, substrate, Km

Mathematical Expression

$$\frac{\mathrm{V} \cdot \mathrm{substrate}}{\mathrm{Km} + \mathrm{substrate}} \tag{2}$$

6.3 Function definition function_1

Name mRNA translated into protein

Arguments k, mRNA

Mathematical Expression

$$\mathrm{k} \cdot \mathrm{mRNA} \tag{3}$$

6.4 Function definition function_0

Name Inhibition of gene

Arguments vsb, K, m, Bn

Mathematical Expression

$$\frac{\mathrm{vsb} \cdot \mathrm{K}^{\mathrm{m}}}{\mathrm{K}^{\mathrm{m}} + \mathrm{Bn}^{\mathrm{m}}} \tag{4}$$

6.5 Function definition functionDefinition_0000005

Name ceiling

Argument length

Mathematical Expression

$$\left\lceil \frac{\sin\left(\frac{\pi \cdot \mathrm{time}}{\mathrm{length}} + 0.0010\right)}{2} \right\rceil \tag{5}$$

7 Rules

This is an overview of two rules.

7.1 Rule parameter_0000081

Rule parameter_0000081 is an assignment rule for parameter parameter_0000081:

$$\mathrm{parameter\_0000081} = \mathrm{functionDefinition\_0000005}\,(12) \tag{6}$$

Derived unit dimensionless

7.2 Rule parameter_0000082

Rule parameter_0000082 is an assignment rule for parameter parameter_0000082:

$$\mathrm{parameter\_0000082} = 1.5 + (1.8 - 1.5) \cdot \mathrm{parameter\_0000081} \tag{7}$$

8 Reactions

This model contains 48 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	reaction_0	Mb synthesized	$\emptyset \xrightarrow{\text{species\_3}} \text{species\_0}$	
2	reaction_1	Mb translated into protein	$\emptyset \xrightarrow{\text{species\_0}} \text{species\_1}$	
3	reaction_2	Mb nonspecific degradation	$\text{species\_0} \longrightarrow \emptyset$	
4	reaction_3	Bc phosphorylation	$\text{species\_1} \longrightarrow \text{species\_2}$	
5	reaction_4	Bc transfered from cytosolic to nuclear	$\text{species\_1} \rightleftharpoons \text{species\_3}$	
6	reaction_5	Mc translated into protein	$\emptyset \xrightarrow{\text{species\_5}} \text{species\_4}$	
7	reaction_6	Mc nonspecific degradation	$\text{species\_5} \longrightarrow \emptyset$	
8	reaction_7	Cc phosphorylation	$\text{species\_4} \longrightarrow \text{species\_6}$	
9	reaction_8	Ccp specific degradation	$\text{species\_6} \longrightarrow \emptyset$	
10	reaction_9	Mp synthesis	$\emptyset \xrightarrow{\text{species\_3}} \text{species\_7}$	
11	reaction_10	Mp translated into protein	$\emptyset \xrightarrow{\text{species\_7}} \text{species\_8}$	
12	reaction_11	Pcp specific degradation	$\text{species\_9} \longrightarrow \emptyset$	
13	reaction_12	Pc phosphorylation	$\text{species\_8} \longrightarrow \text{species\_9}$	
14	reaction_13	Cc and Pc produce complex Per_Cry	$\text{species\_4} + \text{species\_8} \rightleftharpoons \text{species\_10}$	
15	reaction_14	PCc phosphorylation	$\text{species\_10} \longrightarrow \text{species\_11}$	
16	reaction_15	PCcp specific degradation	$\text{species\_11} \longrightarrow \emptyset$	
17	reaction_16	PCc transfered into nuclear	$\text{species\_10} \rightleftharpoons \text{species\_12}$	
18	reaction_17	PCnp nonspecific degradation	$\text{species\_14} \longrightarrow \emptyset$	
19	reaction_18	Bcp nonspecific degradation	$\text{species\_2} \longrightarrow \emptyset$	
20	reaction_19	Bnp nonspecific degradation	$\text{species\_13} \longrightarrow \emptyset$	

№	Id	Name	Reaction Equation	SBO
21	reaction_20	Mc synthesis	$\emptyset \xrightarrow{\text{species\_3}} \text{species\_5}$	
22	reaction_21	PCn phosphorylation	$\text{species\_12} \longrightarrow \text{species\_14}$	
23	reaction_22	Mp nonspecific degradation	$\text{species\_7} \longrightarrow \emptyset$	
24	reaction_23	Per_Cry and Clock_Bmal form inactive complex	$\text{species\_12} + \text{species\_3} \rightleftharpoons \text{species\_15}$	
25	reaction_24	Mb specific degradation	$\text{species\_0} \longrightarrow \emptyset$	
26	reaction_25	Mc specific degradation	$\text{species\_5} \longrightarrow \emptyset$	
27	reaction_26	Mp specific degradation	$\text{species\_7} \longrightarrow \emptyset$	
28	reaction_27	Pc nonspecific degradation	$\text{species\_8} \longrightarrow \emptyset$	
29	reaction_28	Cc nonspecific degradation	$\text{species\_4} \longrightarrow \emptyset$	
30	reaction_29	Pcp nonspecific degradation	$\text{species\_9} \longrightarrow \emptyset$	
31	reaction_30	Ccp nonspecific degradation	$\text{species\_6} \longrightarrow \emptyset$	
32	reaction_31	PCcp nonspecific degradation	$\text{species\_11} \longrightarrow \emptyset$	
33	reaction_32	PCc nonspecific degradation	$\text{species\_10} \longrightarrow \emptyset$	
34	reaction_33	PCnp specific degradation	$\text{species\_14} \longrightarrow \emptyset$	
35	reaction_34	Bc nonspecific degradation	$\text{species\_1} \longrightarrow \emptyset$	
36	reaction_35	Bcp specific degradation	$\text{species\_2} \longrightarrow \emptyset$	
37	reaction_36	Bn phosphorylation	$\text{species\_3} \longrightarrow \text{species\_13}$	
38	reaction_37	Bnp specific degradation	$\text{species\_13} \longrightarrow \emptyset$	
39	reaction_38	In nonspecific degration	$\text{species\_15} \longrightarrow \emptyset$	
40	reaction_39	In specific degradation	$\text{species\_15} \longrightarrow \emptyset$	
41	reaction_40	Bn nonspecific degradation	$\text{species\_3} \longrightarrow \emptyset$	
42	reaction_41	Bcp dephosphorylation	$\text{species\_2} \longrightarrow \text{species\_1}$	
43	reaction_42	Bnp dephosphorylation	$\text{species\_13} \longrightarrow \text{species\_3}$	
44	reaction_43	Ccp dephosphorylation	$\text{species\_6} \longrightarrow \text{species\_4}$	
45	reaction_44	Pcp dephosphorylation	$\text{species\_9} \longrightarrow \text{species\_8}$	
46	reaction_45	PCnp dephosphorylation	$\text{species\_14} \longrightarrow \text{species\_12}$	
47	reaction_46	PCn nonspecific degradation	$\text{species\_12} \longrightarrow \emptyset$	

№	Id	Name	Reaction Equation	SBO
48	`reaction_47`	PCcp dephosphorylation	species_11 ⟶ species_10	

8.1 Reaction reaction_0

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

Name Mb synthesized

Reaction equation

$$\emptyset \xrightarrow{\text{species\_3}} \text{species\_0} \tag{8}$$

Modifier

Table 6: Properties of each modifier.

Id	Name	SBO
species_3	Bn	

Product

Table 7: Properties of each product.

Id	Name	SBO
species_0	Mb	

Kinetic Law

Derived unit contains undeclared units

$$v_1 = \text{vol}(\text{cell}) \cdot \text{function\_0}(\text{vsb}, \text{K}, \text{m}, [\text{species\_3}]) \tag{9}$$

$$\text{function\_0}(\text{vsb}, \text{K}, \text{m}, \text{Bn}) = \frac{\text{vsb} \cdot \text{K}^{\text{m}}}{\text{K}^{\text{m}} + \text{Bn}^{\text{m}}} \tag{10}$$

$$\text{function\_0}(\text{vsb}, \text{K}, \text{m}, \text{Bn}) = \frac{\text{vsb} \cdot \text{K}^{\text{m}}}{\text{K}^{\text{m}} + \text{Bn}^{\text{m}}} \tag{11}$$

Table 8: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
vsb			1.0		☑
K	Kib		2.2		☑
m			2.0		☑

8.2 Reaction `reaction_1`

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

Name Mb translated into protein

Reaction equation

$$\emptyset \xrightarrow{\text{species\_0}} \text{species\_1} \tag{12}$$

Modifier

Table 9: Properties of each modifier.

Id	Name	SBO
`species_0`	Mb	

Product

Table 10: Properties of each product.

Id	Name	SBO
`species_1`	Bc	

Kinetic Law

Derived unit contains undeclared units

$$v_2 = \text{vol}\left(\text{cell}\right) \cdot \text{function\_1}\left(\text{k}, [\text{species\_0}]\right) \tag{13}$$

$$\text{function\_1}\left(\text{k}, \text{mRNA}\right) = \text{k} \cdot \text{mRNA} \tag{14}$$

$$\text{function\_1}\left(\text{k}, \text{mRNA}\right) = \text{k} \cdot \text{mRNA} \tag{15}$$

Table 11: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
k	ksb		0.12		☑

8.3 Reaction reaction_2

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

Name Mb nonspecific degradation

Reaction equation

$$\text{species\_0} \longrightarrow \emptyset \tag{16}$$

Reactant

Table 12: Properties of each reactant.

Id	Name	SBO
species_0	Mb	

Kinetic Law

Derived unit contains undeclared units

$$v_3 = \text{vol}(\text{cell}) \cdot \text{k1} \cdot [\text{species\_0}] \tag{17}$$

Table 13: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
k1	kdmb		0.01		☑

8.4 Reaction reaction_3

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

Name Bc phosphorylation

Reaction equation

$$\text{species\_1} \longrightarrow \text{species\_2} \tag{18}$$

Reactant

Table 14: Properties of each reactant.

Id	Name	SBO
species_1	Bc	

Product

Table 15: Properties of each product.

Id	Name	SBO
species_2	Bcp	

Kinetic Law

Derived unit contains undeclared units

$$v_4 = \mathrm{vol}\,(\mathrm{cell}) \cdot \mathrm{function\_2}\,(\mathrm{V}, [\mathrm{species\_1}], \mathrm{Km}) \tag{19}$$

$$\mathrm{function\_2}\,(\mathrm{V}, \mathrm{substrate}, \mathrm{Km}) = \frac{\mathrm{V} \cdot \mathrm{substrate}}{\mathrm{Km} + \mathrm{substrate}} \tag{20}$$

$$\mathrm{function\_2}\,(\mathrm{V}, \mathrm{substrate}, \mathrm{Km}) = \frac{\mathrm{V} \cdot \mathrm{substrate}}{\mathrm{Km} + \mathrm{substrate}} \tag{21}$$

Table 16: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
V	V1b		0.5		☑
Km	Kp		0.1		☑

8.5 Reaction reaction_4

This is a reversible reaction of one reactant forming one product.

Name Bc transfered from cytosolic to nuclear

Reaction equation

$$\mathrm{species\_1} \rightleftharpoons \mathrm{species\_3} \tag{22}$$

Reactant

Table 17: Properties of each reactant.

Id	Name	SBO
species_1	Bc	

Product

Table 18: Properties of each product.

Id	Name	SBO
species_3	Bn	

Kinetic Law

Derived unit contains undeclared units

$$v_5 = \mathrm{vol}\,(\mathrm{cell}) \cdot (\mathrm{k1} \cdot [\mathrm{species\_1}] - \mathrm{k2} \cdot [\mathrm{species\_3}]) \tag{23}$$

Table 19: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
k1	k5		0.4		☑
k2	k6		0.2		☑

8.6 Reaction reaction_5

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

Name Mc translated into protein

Reaction equation

$$\emptyset \xrightarrow{\text{species\_5}} \text{species\_4} \tag{24}$$

Modifier

Table 20: Properties of each modifier.

Id	Name	SBO
species_5	Mc	

Product

Table 21: Properties of each product.

Id	Name	SBO
species_4	Cc	

Kinetic Law

Derived unit contains undeclared units

$$v_6 = \text{vol}\,(\text{cell}) \cdot \text{function\_1}\,(\text{k}, [\text{species\_5}]) \tag{25}$$

$$\text{function\_1}\,(\text{k}, \text{mRNA}) = \text{k} \cdot \text{mRNA} \tag{26}$$

$$\text{function\_1}\,(\text{k}, \text{mRNA}) = \text{k} \cdot \text{mRNA} \tag{27}$$

Table 22: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
k	ksc		1.6		☑

8.7 Reaction reaction_6

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

Name Mc nonspecific degradation

Reaction equation

$$\text{species\_5} \longrightarrow \emptyset \tag{28}$$

Reactant

Table 23: Properties of each reactant.

Id	Name	SBO
species_5	Mc	

Kinetic Law

Derived unit contains undeclared units

$$v_7 = \mathrm{vol}\,(\mathrm{cell}) \cdot \mathrm{k1} \cdot [\mathrm{species\_5}] \tag{29}$$

Table 24: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
k1	kdmc		0.01		☑

8.8 Reaction reaction_7

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

Name Cc phosphorylation

Reaction equation

$$\mathrm{species\_4} \longrightarrow \mathrm{species\_6} \tag{30}$$

Reactant

Table 25: Properties of each reactant.

Id	Name	SBO
species_4	Cc	

Product

Table 26: Properties of each product.

Id	Name	SBO
species_6	Ccp	

Kinetic Law

Derived unit contains undeclared units

$$v_8 = \mathrm{vol}\,(\mathrm{cell}) \cdot \mathrm{function\_2}\,(\mathrm{V}, [\mathrm{species\_4}], \mathrm{Km}) \tag{31}$$

$$\mathrm{function\_2}\,(\mathrm{V}, \mathrm{substrate}, \mathrm{Km}) = \frac{\mathrm{V} \cdot \mathrm{substrate}}{\mathrm{Km} + \mathrm{substrate}} \tag{32}$$

$$\mathrm{function\_2}\,(\mathrm{V}, \mathrm{substrate}, \mathrm{Km}) = \frac{\mathrm{V} \cdot \mathrm{substrate}}{\mathrm{Km} + \mathrm{substrate}} \tag{33}$$

Table 27: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
`V`	V1c		0.6		☑
`Km`	Kp		0.1		☑

8.9 Reaction `reaction_8`

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

Name Ccp specific degradation

Reaction equation

$$\mathrm{species\_6} \longrightarrow \emptyset \tag{34}$$

Reactant

Table 28: Properties of each reactant.

Id	Name	SBO
`species_6`	Ccp	

Kinetic Law

Derived unit contains undeclared units

$$v_9 = \mathrm{vol}\,(\mathrm{cell}) \cdot \mathrm{function\_2}\,(\mathrm{V}, [\mathrm{species\_6}], \mathrm{Km}) \tag{35}$$

$$\mathrm{function\_2}\,(\mathrm{V}, \mathrm{substrate}, \mathrm{Km}) = \frac{\mathrm{V} \cdot \mathrm{substrate}}{\mathrm{Km} + \mathrm{substrate}} \tag{36}$$

$$\text{function\_2}\left(\text{V}, \text{substrate}, \text{Km}\right) = \frac{\text{V} \cdot \text{substrate}}{\text{Km} + \text{substrate}} \tag{37}$$

Table 29: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
V	vdcc		0.7		☑
Km	Kd		0.3		☑

8.10 Reaction reaction_9

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

Name Mp synthesis

Reaction equation

$$\emptyset \xrightarrow{\text{species\_3}} \text{species\_7} \tag{38}$$

Modifier

Table 30: Properties of each modifier.

Id	Name	SBO
species_3	Bn	

Product

Table 31: Properties of each product.

Id	Name	SBO
species_7	Mp	

Kinetic Law

Derived unit contains undeclared units

$$v_{10} = \text{vol}\left(\text{cell}\right) \cdot \text{function\_3}\left(\text{parameter\_0000082}, \left[\text{species\_3}\right], \text{n}, \text{K}\right) \tag{39}$$

$$\text{function\_3}\left(\text{Vs}, \text{B}, \text{n}, \text{K}\right) = \frac{\text{Vs} \cdot \text{B}^{\text{n}}}{\text{K}^{\text{n}} + \text{B}^{\text{n}}} \tag{40}$$

$$\text{function\_3}\left(\text{Vs}, \text{B}, \text{n}, \text{K}\right) = \frac{\text{Vs} \cdot \text{B}^{\text{n}}}{\text{K}^{\text{n}} + \text{B}^{\text{n}}} \tag{41}$$

Table 32: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
n			4.0		☑
K	Kap		0.7		☑

8.11 Reaction reaction_10

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

Name Mp translated into protein

Reaction equation

$$\emptyset \xrightarrow{\text{species\_7}} \text{species\_8} \tag{42}$$

Modifier

Table 33: Properties of each modifier.

Id	Name	SBO
species_7	Mp	

Product

Table 34: Properties of each product.

Id	Name	SBO
species_8	Pc	

Kinetic Law

Derived unit contains undeclared units

$$v_{11} = \text{vol}\left(\text{cell}\right) \cdot \text{function\_1}\left(\text{k}, [\text{species\_7}]\right) \tag{43}$$

$$\text{function\_1}\left(\text{k}, \text{mRNA}\right) = \text{k} \cdot \text{mRNA} \tag{44}$$

$$\text{function\_1}\left(\text{k}, \text{mRNA}\right) = \text{k} \cdot \text{mRNA} \tag{45}$$

Table 35: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
k	ksp		0.6		☑

8.12 Reaction reaction_11

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

Name Pcp specific degradation

Reaction equation

$$\text{species\_9} \longrightarrow \emptyset \tag{46}$$

Reactant

Table 36: Properties of each reactant.

Id	Name	SBO
species_9	Pcp	

Kinetic Law

Derived unit contains undeclared units

$$v_{12} = \text{vol}(\text{cell}) \cdot \text{function\_2}(\text{V}, [\text{species\_9}], \text{Km}) \tag{47}$$

$$\text{function\_2}(\text{V}, \text{substrate}, \text{Km}) = \frac{\text{V} \cdot \text{substrate}}{\text{Km} + \text{substrate}} \tag{48}$$

$$\text{function\_2}(\text{V}, \text{substrate}, \text{Km}) = \frac{\text{V} \cdot \text{substrate}}{\text{Km} + \text{substrate}} \tag{49}$$

Table 37: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
V	vdpc		0.7		☑
Km	Kd		0.3		☑

8.13 Reaction reaction_12

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

Name Pc phosphorylation

Reaction equation

$$\text{species\_8} \longrightarrow \text{species\_9} \tag{50}$$

Reactant

Table 38: Properties of each reactant.

Id	Name	SBO
species_8	Pc	

Product

Table 39: Properties of each product.

Id	Name	SBO
species_9	Pcp	

Kinetic Law

Derived unit contains undeclared units

$$v_{13} = \text{vol}(\text{cell}) \cdot \text{function\_2}(\text{V}, [\text{species\_8}], \text{Km}) \tag{51}$$

$$\text{function\_2}(\text{V}, \text{substrate}, \text{Km}) = \frac{\text{V} \cdot \text{substrate}}{\text{Km} + \text{substrate}} \tag{52}$$

$$\text{function\_2}(\text{V}, \text{substrate}, \text{Km}) = \frac{\text{V} \cdot \text{substrate}}{\text{Km} + \text{substrate}} \tag{53}$$

Table 40: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
V	V1p		0.4		☑
Km	Kp		0.1		☑

8.14 Reaction reaction_13

This is a reversible reaction of two reactants forming one product.

Name Cc and Pc produce complex Per_Cry

Reaction equation

$$\text{species\_4} + \text{species\_8} \rightleftharpoons \text{species\_10} \tag{54}$$

Reactants

Table 41: Properties of each reactant.

Id	Name	SBO
species_4	Cc	
species_8	Pc	

Product

Table 42: Properties of each product.

Id	Name	SBO
species_10	PCc	

Kinetic Law

Derived unit contains undeclared units

$$v_{14} = \text{vol}(\text{cell}) \cdot (\text{k1} \cdot [\text{species\_4}] \cdot [\text{species\_8}] - \text{k2} \cdot [\text{species\_10}]) \tag{55}$$

Table 43: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
k1	k3		0.4		☑
k2	k4		0.2		☑

8.15 Reaction reaction_14

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

Name PCc phosphorylation

Reaction equation

$$\text{species\_10} \longrightarrow \text{species\_11} \tag{56}$$

Reactant

Table 44: Properties of each reactant.

Id	Name	SBO
species_10	PCc	

Product

Table 45: Properties of each product.

Id	Name	SBO
species_11	PCcp	

Kinetic Law

Derived unit contains undeclared units

$$v_{15} = \text{vol}(\text{cell}) \cdot \text{function\_2}(\text{V}, [\text{species\_10}], \text{Km}) \tag{57}$$

$$\text{function\_2}(\text{V}, \text{substrate}, \text{Km}) = \frac{\text{V} \cdot \text{substrate}}{\text{Km} + \text{substrate}} \tag{58}$$

$$\text{function\_2}(\text{V}, \text{substrate}, \text{Km}) = \frac{\text{V} \cdot \text{substrate}}{\text{Km} + \text{substrate}} \tag{59}$$

Table 46: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
V	V1pc		0.4		☑
Km	Kp		0.1		☑

8.16 Reaction reaction_15

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

Name PCcp specific degradation

Reaction equation

$$\text{species\_11} \longrightarrow \emptyset \tag{60}$$

Reactant

Table 47: Properties of each reactant.

Id	Name	SBO
species_11	PCcp	

Kinetic Law

Derived unit contains undeclared units

$$v_{16} = \text{vol}(\text{cell}) \cdot \text{function\_2}(\text{V}, [\text{species\_11}], \text{Km}) \tag{61}$$

$$\text{function\_2}(\text{V}, \text{substrate}, \text{Km}) = \frac{\text{V} \cdot \text{substrate}}{\text{Km} + \text{substrate}} \tag{62}$$

$$\text{function\_2}(\text{V}, \text{substrate}, \text{Km}) = \frac{\text{V} \cdot \text{substrate}}{\text{Km} + \text{substrate}} \tag{63}$$

Table 48: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
V	vdpcc		0.7		☑
Km	Kd		0.3		☑

8.17 Reaction reaction_16

This is a reversible reaction of one reactant forming one product.

Name PCc transfered into nuclear

Reaction equation

$$\text{species\_10} \rightleftharpoons \text{species\_12} \tag{64}$$

Reactant

Table 49: Properties of each reactant.

Id	Name	SBO
species_10	PCc	

Product

Table 50: Properties of each product.

Id	Name	SBO
species_12	PCn	

Kinetic Law

Derived unit contains undeclared units

$$v_{17} = \mathrm{vol}\,(\mathrm{cell}) \cdot (\mathrm{k1} \cdot [\mathrm{species\_10}] - \mathrm{k2} \cdot [\mathrm{species\_12}]) \tag{65}$$

Table 51: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
k1	k1		0.4		☑
k2	k2		0.2		☑

8.18 Reaction reaction_17

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

Name PCnp nonspecific degradation

Reaction equation

$$\mathrm{species\_14} \longrightarrow \emptyset \tag{66}$$

Reactant

Table 52: Properties of each reactant.

Id	Name	SBO
species_14	PCnp	

Kinetic Law

Derived unit contains undeclared units

$$v_{18} = \mathrm{vol}\,(\mathrm{cell}) \cdot \mathrm{k1} \cdot [\mathrm{species\_14}] \tag{67}$$

Table 53: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
k1	kdn		0.01		☑

8.19 Reaction reaction_18

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

Name Bcp nonspecific degradation

Reaction equation

$$\mathrm{species\_2} \longrightarrow \emptyset \tag{68}$$

Reactant

Table 54: Properties of each reactant.

Id	Name	SBO
species_2	Bcp	

Kinetic Law

Derived unit contains undeclared units

$$v_{19} = \mathrm{vol}\,(\mathrm{cell}) \cdot \mathrm{k1} \cdot [\mathrm{species\_2}] \tag{69}$$

Table 55: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
k1	kdn		0.01		☑

8.20 Reaction reaction_19

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

Name Bnp nonspecific degradation

Reaction equation

$$\text{species\_13} \longrightarrow \emptyset \tag{70}$$

Reactant

Table 56: Properties of each reactant.

Id	Name	SBO
species_13	Bnp	

Kinetic Law

Derived unit contains undeclared units

$$v_{20} = \text{vol}\,(\text{cell}) \cdot \text{k1} \cdot [\text{species\_13}] \tag{71}$$

Table 57: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
k1	kdn		0.01		☑

8.21 Reaction reaction_20

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

Name Mc synthesis

Reaction equation

$$\emptyset \xrightarrow{\text{species\_3}} \text{species\_5} \tag{72}$$

Modifier

Table 58: Properties of each modifier.

Id	Name	SBO
species_3	Bn	

Product

Table 59: Properties of each product.

Id	Name	SBO
species_5	Mc	

Kinetic Law

Derived unit contains undeclared units

$$v_{21} = \mathrm{vol}\,(\mathrm{cell}) \cdot \mathrm{function\_3}\,(\mathrm{Vs}, [\mathrm{species\_3}], \mathrm{n}, \mathrm{K}) \tag{73}$$

$$\mathrm{function\_3}\,(\mathrm{Vs}, \mathrm{B}, \mathrm{n}, \mathrm{K}) = \frac{\mathrm{Vs} \cdot \mathrm{B}^{\mathrm{n}}}{\mathrm{K}^{\mathrm{n}} + \mathrm{B}^{\mathrm{n}}} \tag{74}$$

$$\mathrm{function\_3}\,(\mathrm{Vs}, \mathrm{B}, \mathrm{n}, \mathrm{K}) = \frac{\mathrm{Vs} \cdot \mathrm{B}^{\mathrm{n}}}{\mathrm{K}^{\mathrm{n}} + \mathrm{B}^{\mathrm{n}}} \tag{75}$$

Table 60: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
Vs	vsc		1.1		☑
n			4.0		☑
K	Kac		0.6		☑

8.22 Reaction reaction_21

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

Name PCn phosphorylation

Reaction equation

$$\mathrm{species\_12} \longrightarrow \mathrm{species\_14} \tag{76}$$

Reactant

Table 61: Properties of each reactant.

Id	Name	SBO
species_12	PCn	

Product

Table 62: Properties of each product.

Id	Name	SBO
species_14	PCnp	

Kinetic Law

Derived unit contains undeclared units

$$v_{22} = \text{vol}\,(\text{cell}) \cdot \text{function\_2}\,(\text{V}, [\text{species\_12}], \text{Km}) \tag{77}$$

$$\text{function\_2}\,(\text{V}, \text{substrate}, \text{Km}) = \frac{\text{V} \cdot \text{substrate}}{\text{Km} + \text{substrate}} \tag{78}$$

$$\text{function\_2}\,(\text{V}, \text{substrate}, \text{Km}) = \frac{\text{V} \cdot \text{substrate}}{\text{Km} + \text{substrate}} \tag{79}$$

Table 63: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
V	V3pc		0.4		☑
Km	Kp		0.1		☑

8.23 Reaction reaction_22

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

Name Mp nonspecific degradation

Reaction equation

$$\text{species\_7} \longrightarrow \emptyset \tag{80}$$

Reactant

Table 64: Properties of each reactant.

Id	Name	SBO
species_7	Mp	

Kinetic Law

Derived unit contains undeclared units

$$v_{23} = \mathrm{vol}\,(\mathrm{cell}) \cdot \mathrm{k1} \cdot [\mathrm{species\_7}] \tag{81}$$

Table 65: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
k1	kdmp		0.01		☑

8.24 Reaction reaction_23

This is a reversible reaction of two reactants forming one product.

Name Per_Cry and Clock_Bmal form inactive complex

Reaction equation

$$\mathrm{species\_12} + \mathrm{species\_3} \rightleftharpoons \mathrm{species\_15} \tag{82}$$

Reactants

Table 66: Properties of each reactant.

Id	Name	SBO
species_12	PCn	
species_3	Bn	

Product

Table 67: Properties of each product.

Id	Name	SBO
species_15	In	

Kinetic Law

Derived unit contains undeclared units

$$v_{24} = \mathrm{vol}(\mathrm{cell}) \cdot (\mathrm{k1} \cdot [\mathrm{species\_12}] \cdot [\mathrm{species\_3}] - \mathrm{k2} \cdot [\mathrm{species\_15}]) \tag{83}$$

Table 68: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
k1	k7		0.5		☑
k2	k8		0.1		☑

8.25 Reaction reaction_24

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

Name Mb specific degradation

Reaction equation

$$\mathrm{species\_0} \longrightarrow \emptyset \tag{84}$$

Reactant

Table 69: Properties of each reactant.

Id	Name	SBO
species_0	Mb	

Kinetic Law

Derived unit contains undeclared units

$$v_{25} = \mathrm{vol}(\mathrm{cell}) \cdot \mathrm{function\_2}(\mathrm{V}, [\mathrm{species\_0}], \mathrm{Km}) \tag{85}$$

$$\mathrm{function\_2}(\mathrm{V}, \mathrm{substrate}, \mathrm{Km}) = \frac{\mathrm{V} \cdot \mathrm{substrate}}{\mathrm{Km} + \mathrm{substrate}} \tag{86}$$

$$\text{function\_2}\left(\text{V}, \text{substrate}, \text{Km}\right) = \frac{\text{V} \cdot \text{substrate}}{\text{Km} + \text{substrate}} \tag{87}$$

Table 70: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
V	vmb		0.8		☑
Km	Kmb		0.4		☑

8.26 Reaction reaction_25

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

Name Mc specific degradation

Reaction equation

$$\text{species\_5} \longrightarrow \emptyset \tag{88}$$

Reactant

Table 71: Properties of each reactant.

Id	Name	SBO
species_5	Mc	

Kinetic Law

Derived unit contains undeclared units

$$v_{26} = \text{vol}\left(\text{cell}\right) \cdot \text{function\_2}\left(\text{V}, [\text{species\_5}], \text{Km}\right) \tag{89}$$

$$\text{function\_2}\left(\text{V}, \text{substrate}, \text{Km}\right) = \frac{\text{V} \cdot \text{substrate}}{\text{Km} + \text{substrate}} \tag{90}$$

$$\text{function\_2}\left(\text{V}, \text{substrate}, \text{Km}\right) = \frac{\text{V} \cdot \text{substrate}}{\text{Km} + \text{substrate}} \tag{91}$$

Table 72: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
V	vmc		1.0		☑
Km	Kmc		0.4		☑

8.27 Reaction reaction_26

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

Name Mp specific degradation

Reaction equation

$$\text{species\_7} \longrightarrow \emptyset \tag{92}$$

Reactant

Table 73: Properties of each reactant.

Id	Name	SBO
species_7	Mp	

Kinetic Law

Derived unit contains undeclared units

$$v_{27} = \text{vol}(\text{cell}) \cdot \text{function\_2}(\text{V}, [\text{species\_7}], \text{Km}) \tag{93}$$

$$\text{function\_2}(\text{V}, \text{substrate}, \text{Km}) = \frac{\text{V} \cdot \text{substrate}}{\text{Km} + \text{substrate}} \tag{94}$$

$$\text{function\_2}(\text{V}, \text{substrate}, \text{Km}) = \frac{\text{V} \cdot \text{substrate}}{\text{Km} + \text{substrate}} \tag{95}$$

Table 74: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
V	vmp		1.10		☑
Km	Kmp		0.31		☑

8.28 Reaction reaction_27

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

Name Pc nonspecific degradation

Reaction equation

$$\text{species\_8} \longrightarrow \emptyset \tag{96}$$

Reactant

Table 75: Properties of each reactant.

Id	Name	SBO
species_8	Pc	

Kinetic Law

Derived unit contains undeclared units

$$v_{28} = \text{vol}(\text{cell}) \cdot \text{k1} \cdot [\text{species\_8}] \tag{97}$$

Table 76: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
k1	kdn		0.01		☑

8.29 Reaction reaction_28

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

Name Cc nonspecific degradation

Reaction equation

$$\text{species\_4} \longrightarrow \emptyset \tag{98}$$

Reactant

Table 77: Properties of each reactant.

Id	Name	SBO
species_4	Cc	

Kinetic Law

Derived unit contains undeclared units

$$v_{29} = \mathrm{vol}\,(\mathrm{cell}) \cdot \mathrm{k1} \cdot [\mathrm{species\_4}] \tag{99}$$

Table 78: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
k1	kdnc		0.12		☑

8.30 Reaction reaction_29

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

Name Pcp nonspecific degradation

Reaction equation

$$\mathrm{species\_9} \longrightarrow \emptyset \tag{100}$$

Reactant

Table 79: Properties of each reactant.

Id	Name	SBO
species_9	Pcp	

Kinetic Law

Derived unit contains undeclared units

$$v_{30} = \mathrm{vol}\,(\mathrm{cell}) \cdot \mathrm{k1} \cdot [\mathrm{species\_9}] \tag{101}$$

Table 80: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
k1	kdn		0.01		☑

8.31 Reaction reaction_30

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

Name Ccp nonspecific degradation

Reaction equation

$$\text{species\_6} \longrightarrow \emptyset \tag{102}$$

Reactant

Table 81: Properties of each reactant.

Id	Name	SBO
species_6	Ccp	

Kinetic Law

Derived unit contains undeclared units

$$v_{31} = \text{vol}\,(\text{cell}) \cdot \text{k1} \cdot [\text{species\_6}] \tag{103}$$

Table 82: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
k1	kdn		0.01		☑

8.32 Reaction reaction_31

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

Name PCcp nonspecific degradation

Reaction equation

$$\text{species\_11} \longrightarrow \emptyset \tag{104}$$

Reactant

Table 83: Properties of each reactant.

Id	Name	SBO
species_11	PCcp	

Kinetic Law

Derived unit contains undeclared units

$$v_{32} = \mathrm{vol}(\mathrm{cell}) \cdot \mathrm{k1} \cdot [\mathrm{species\_11}] \tag{105}$$

Table 84: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
k1	kdn		0.01		☑

8.33 Reaction reaction_32

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

Name PCc nonspecific degradation

Reaction equation

$$\mathrm{species\_10} \longrightarrow \emptyset \tag{106}$$

Reactant

Table 85: Properties of each reactant.

Id	Name	SBO
species_10	PCc	

Kinetic Law

Derived unit contains undeclared units

$$v_{33} = \mathrm{vol}(\mathrm{cell}) \cdot \mathrm{k1} \cdot [\mathrm{species\_10}] \tag{107}$$

Table 86: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
k1	kdn		0.01		☑

8.34 Reaction reaction_33

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

Name PCnp specific degradation

Reaction equation

$$\text{species\_14} \longrightarrow \emptyset \tag{108}$$

Reactant

Table 87: Properties of each reactant.

Id	Name	SBO
species_14	PCnp	

Kinetic Law

Derived unit contains undeclared units

$$v_{34} = \text{vol}\,(\text{cell}) \cdot \text{function\_2}\,(\text{V}, [\text{species\_14}], \text{Km}) \tag{109}$$

$$\text{function\_2}\,(\text{V}, \text{substrate}, \text{Km}) = \frac{\text{V} \cdot \text{substrate}}{\text{Km} + \text{substrate}} \tag{110}$$

$$\text{function\_2}\,(\text{V}, \text{substrate}, \text{Km}) = \frac{\text{V} \cdot \text{substrate}}{\text{Km} + \text{substrate}} \tag{111}$$

Table 88: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
V	vdpcn		0.7		☑
Km	Kd		0.3		☑

8.35 Reaction reaction_34

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

Name Bc nonspecific degradation

Reaction equation

$$\text{species\_1} \longrightarrow \emptyset \tag{112}$$

Reactant

Table 89: Properties of each reactant.

Id	Name	SBO
species_1	Bc	

Kinetic Law

Derived unit contains undeclared units

$$v_{35} = \text{vol}\,(\text{cell}) \cdot \text{k1} \cdot [\text{species\_1}] \tag{113}$$

Table 90: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
k1	kdn		0.01		☑

8.36 Reaction reaction_35

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

Name Bcp specific degradation

Reaction equation

$$\text{species\_2} \longrightarrow \emptyset \tag{114}$$

Reactant

Table 91: Properties of each reactant.

Id	Name	SBO
species_2	Bcp	

Kinetic Law

Derived unit contains undeclared units

$$v_{36} = \mathrm{vol}\,(\mathrm{cell}) \cdot \mathrm{function\_2}\,(\mathrm{V}, [\mathrm{species\_2}], \mathrm{Km}) \tag{115}$$

$$\mathrm{function\_2}\,(\mathrm{V}, \mathrm{substrate}, \mathrm{Km}) = \frac{\mathrm{V} \cdot \mathrm{substrate}}{\mathrm{Km} + \mathrm{substrate}} \tag{116}$$

$$\mathrm{function\_2}\,(\mathrm{V}, \mathrm{substrate}, \mathrm{Km}) = \frac{\mathrm{V} \cdot \mathrm{substrate}}{\mathrm{Km} + \mathrm{substrate}} \tag{117}$$

Table 92: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
V	vdbc		0.5		☑
Km	Kd		0.3		☑

8.37 Reaction reaction_36

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

Name Bn phosphorylation

Reaction equation

$$\mathrm{species\_3} \longrightarrow \mathrm{species\_13} \tag{118}$$

Reactant

Table 93: Properties of each reactant.

Id	Name	SBO
species_3	Bn	

Product

Table 94: Properties of each product.

Id	Name	SBO
species_13	Bnp	

Kinetic Law

Derived unit contains undeclared units

$$v_{37} = \text{vol}(\text{cell}) \cdot \text{function\_2}(\text{V}, [\text{species\_3}], \text{Km}) \tag{119}$$

$$\text{function\_2}(\text{V}, \text{substrate}, \text{Km}) = \frac{\text{V} \cdot \text{substrate}}{\text{Km} + \text{substrate}} \tag{120}$$

$$\text{function\_2}(\text{V}, \text{substrate}, \text{Km}) = \frac{\text{V} \cdot \text{substrate}}{\text{Km} + \text{substrate}} \tag{121}$$

Table 95: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
V	V3b		0.5		☑
Km	Kp		0.1		☑

8.38 Reaction reaction_37

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

Name Bnp specific degradation

Reaction equation

$$\text{species\_13} \longrightarrow \emptyset \tag{122}$$

Reactant

Table 96: Properties of each reactant.

Id	Name	SBO
species_13	Bnp	

Kinetic Law

Derived unit contains undeclared units

$$v_{38} = \mathrm{vol}\,(\mathrm{cell}) \cdot \mathrm{function\_2}\,(\mathrm{V}, [\mathrm{species\_13}], \mathrm{Km}) \tag{123}$$

$$\mathrm{function\_2}\,(\mathrm{V}, \mathrm{substrate}, \mathrm{Km}) = \frac{\mathrm{V} \cdot \mathrm{substrate}}{\mathrm{Km} + \mathrm{substrate}} \tag{124}$$

$$\mathrm{function\_2}\,(\mathrm{V}, \mathrm{substrate}, \mathrm{Km}) = \frac{\mathrm{V} \cdot \mathrm{substrate}}{\mathrm{Km} + \mathrm{substrate}} \tag{125}$$

Table 97: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
V	vdbn		0.6		☑
Km	Kd		0.3		☑

8.39 Reaction reaction_38

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

Name In nonspecific degration

Reaction equation

$$\mathrm{species\_15} \longrightarrow \emptyset \tag{126}$$

Reactant

Table 98: Properties of each reactant.

Id	Name	SBO
species_15	In	

Kinetic Law

Derived unit contains undeclared units

$$v_{39} = \mathrm{vol}\,(\mathrm{cell}) \cdot \mathrm{k1} \cdot [\mathrm{species\_15}] \tag{127}$$

Table 99: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
k1	kdn		0.01		☑

8.40 Reaction reaction_39

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

Name In specific degradation

Reaction equation

$$\text{species\_15} \longrightarrow \emptyset \tag{128}$$

Reactant

Table 100: Properties of each reactant.

Id	Name	SBO
species_15	In	

Kinetic Law

Derived unit contains undeclared units

$$v_{40} = \text{vol}(\text{cell}) \cdot \text{function\_2}(\text{V}, [\text{species\_15}], \text{Km}) \tag{129}$$

$$\text{function\_2}(\text{V}, \text{substrate}, \text{Km}) = \frac{\text{V} \cdot \text{substrate}}{\text{Km} + \text{substrate}} \tag{130}$$

$$\text{function\_2}(\text{V}, \text{substrate}, \text{Km}) = \frac{\text{V} \cdot \text{substrate}}{\text{Km} + \text{substrate}} \tag{131}$$

Table 101: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
V	vdin		0.8		☑
Km	Kd		0.3		☑

8.41 Reaction reaction_40

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

Name Bn nonspecific degradation

Reaction equation

$$\text{species\_3} \longrightarrow \emptyset \tag{132}$$

Reactant

Table 102: Properties of each reactant.

Id	Name	SBO
species_3	Bn	

Kinetic Law

Derived unit contains undeclared units

$$v_{41} = \text{vol}\,(\text{cell}) \cdot \text{k1} \cdot [\text{species\_3}] \tag{133}$$

Table 103: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
k1	kdn		0.01		☑

8.42 Reaction reaction_41

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

Name Bcp dephosphorylation

Reaction equation

$$\text{species\_2} \longrightarrow \text{species\_1} \tag{134}$$

Reactant

Table 104: Properties of each reactant.

Id	Name	SBO
species_2	Bcp	

Product

Table 105: Properties of each product.

Id	Name	SBO
species_1	Bc	

Kinetic Law

Derived unit contains undeclared units

$$v_{42} = \text{vol}\,(\text{cell}) \cdot \text{function\_2}\,(\text{V}, [\text{species\_2}], \text{Km}) \tag{135}$$

$$\text{function\_2}\,(\text{V}, \text{substrate}, \text{Km}) = \frac{\text{V} \cdot \text{substrate}}{\text{Km} + \text{substrate}} \tag{136}$$

$$\text{function\_2}\,(\text{V}, \text{substrate}, \text{Km}) = \frac{\text{V} \cdot \text{substrate}}{\text{Km} + \text{substrate}} \tag{137}$$

Table 106: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
V	V2b		0.1		☑
Km	Kdp		0.1		☑

8.43 Reaction reaction_42

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

Name Bnp dephosphorylation

Reaction equation

$$\text{species\_13} \longrightarrow \text{species\_3} \tag{138}$$

Reactant

Table 107: Properties of each reactant.

Id	Name	SBO
species_13	Bnp	

Product

Table 108: Properties of each product.

Id	Name	SBO
species_3	Bn	

Kinetic Law

Derived unit contains undeclared units

$$v_{43} = \text{vol}\,(\text{cell}) \cdot \text{function\_2}\,(\text{V}, [\text{species\_13}], \text{Km}) \tag{139}$$

$$\text{function\_2}\,(\text{V}, \text{substrate}, \text{Km}) = \frac{\text{V} \cdot \text{substrate}}{\text{Km} + \text{substrate}} \tag{140}$$

$$\text{function\_2}\,(\text{V}, \text{substrate}, \text{Km}) = \frac{\text{V} \cdot \text{substrate}}{\text{Km} + \text{substrate}} \tag{141}$$

Table 109: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
V	V4b		0.2		☑
Km	Kdp		0.1		☑

8.44 Reaction reaction_43

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

Name Ccp dephosphorylation

Reaction equation

$$\text{species\_6} \longrightarrow \text{species\_4} \tag{142}$$

Reactant

Table 110: Properties of each reactant.

Id	Name	SBO
species_6	Ccp	

Product

Table 111: Properties of each product.

Id	Name	SBO
species_4	Cc	

Kinetic Law

Derived unit contains undeclared units

$$v_{44} = \mathrm{vol}\,(\mathrm{cell}) \cdot \mathrm{function\_2}\,(\mathrm{V}, [\mathrm{species\_6}], \mathrm{Km}) \tag{143}$$

$$\mathrm{function\_2}\,(\mathrm{V}, \mathrm{substrate}, \mathrm{Km}) = \frac{\mathrm{V} \cdot \mathrm{substrate}}{\mathrm{Km} + \mathrm{substrate}} \tag{144}$$

$$\mathrm{function\_2}\,(\mathrm{V}, \mathrm{substrate}, \mathrm{Km}) = \frac{\mathrm{V} \cdot \mathrm{substrate}}{\mathrm{Km} + \mathrm{substrate}} \tag{145}$$

Table 112: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
V	V2c		0.1		☑
Km	Kdp		0.1		☑

8.45 Reaction reaction_44

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

Name Pcp dephosphorylation

Reaction equation

$$\mathrm{species\_9} \longrightarrow \mathrm{species\_8} \tag{146}$$

Reactant

Table 113: Properties of each reactant.

Id	Name	SBO
species_9	Pcp	

Product

Table 114: Properties of each product.

Id	Name	SBO
species_8	Pc	

Kinetic Law

Derived unit contains undeclared units

$$v_{45} = \mathrm{vol}\,(\mathrm{cell}) \cdot \mathrm{function\_2}\,(\mathrm{V}, [\mathrm{species\_9}], \mathrm{Km}) \tag{147}$$

$$\mathrm{function\_2}\,(\mathrm{V}, \mathrm{substrate}, \mathrm{Km}) = \frac{\mathrm{V} \cdot \mathrm{substrate}}{\mathrm{Km} + \mathrm{substrate}} \tag{148}$$

$$\mathrm{function\_2}\,(\mathrm{V}, \mathrm{substrate}, \mathrm{Km}) = \frac{\mathrm{V} \cdot \mathrm{substrate}}{\mathrm{Km} + \mathrm{substrate}} \tag{149}$$

Table 115: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
V	V2p		0.3		☑
Km	Kdp		0.1		☑

8.46 Reaction reaction_45

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

Name PCnp dephosphorylation

Reaction equation

$$\mathrm{species\_14} \longrightarrow \mathrm{species\_12} \tag{150}$$

Reactant

Table 116: Properties of each reactant.

Id	Name	SBO
species_14	PCnp	

Product

Table 117: Properties of each product.

Id	Name	SBO
species_12	PCn	

Kinetic Law

Derived unit contains undeclared units

$$v_{46} = \mathrm{vol}\,(\mathrm{cell}) \cdot \mathrm{function\_2}\,(\mathrm{V}, [\mathrm{species\_14}], \mathrm{Km}) \tag{151}$$

$$\mathrm{function\_2}\,(\mathrm{V}, \mathrm{substrate}, \mathrm{Km}) = \frac{\mathrm{V} \cdot \mathrm{substrate}}{\mathrm{Km} + \mathrm{substrate}} \tag{152}$$

$$\mathrm{function\_2}\,(\mathrm{V}, \mathrm{substrate}, \mathrm{Km}) = \frac{\mathrm{V} \cdot \mathrm{substrate}}{\mathrm{Km} + \mathrm{substrate}} \tag{153}$$

Table 118: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
V	V4pc		0.1		☑
Km	Kdp		0.1		☑

8.47 Reaction reaction_46

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

Name PCn nonspecific degradation

Reaction equation

$$\mathrm{species\_12} \longrightarrow \emptyset \tag{154}$$

Reactant

Table 119: Properties of each reactant.

Id	Name	SBO
species_12	PCn	

Kinetic Law

Derived unit contains undeclared units

$$v_{47} = \mathrm{vol}(\mathrm{cell}) \cdot \mathrm{k1} \cdot [\mathrm{species\_12}] \tag{155}$$

Table 120: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
k1	kdn		0.01		☑

8.48 Reaction reaction_47

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

Name PCcp dephosphorylation

Reaction equation

$$\mathrm{species\_11} \longrightarrow \mathrm{species\_10} \tag{156}$$

Reactant

Table 121: Properties of each reactant.

Id	Name	SBO
species_11	PCcp	

Product

Table 122: Properties of each product.

Id	Name	SBO
species_10	PCc	

Id	Name	SBO

Kinetic Law

Derived unit contains undeclared units

$$v_{48} = \mathrm{vol}\,(\mathrm{cell}) \cdot \mathrm{function\_2}\,(\mathrm{V}, [\mathrm{species\_11}], \mathrm{Km}) \tag{157}$$

$$\mathrm{function\_2}\,(\mathrm{V}, \mathrm{substrate}, \mathrm{Km}) = \frac{\mathrm{V} \cdot \mathrm{substrate}}{\mathrm{Km} + \mathrm{substrate}} \tag{158}$$

$$\mathrm{function\_2}\,(\mathrm{V}, \mathrm{substrate}, \mathrm{Km}) = \frac{\mathrm{V} \cdot \mathrm{substrate}}{\mathrm{Km} + \mathrm{substrate}} \tag{159}$$

Table 123: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
`V`	V2pc		0.1		☑
`Km`	Kdp		0.1		☑

9 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.

9.1 Species `species_0`

Name Mb

Notes The initial concentration of Mb got from the curve in the paper at time=0

Initial concentration $9.5\ \mathrm{nmol} \cdot \mathrm{l}^{-1}$

This species takes part in four reactions (as a reactant in reaction_2, reaction_24 and as a product in reaction_0 and as a modifier in reaction_1).

$$\frac{\mathrm{d}}{\mathrm{d}t}\text{species\_0} = v_1 - v_3 - v_{25} \tag{160}$$

9.2 Species species_1

Name Bc

Notes In order to get the similar shape of the plot,we assigned 2nM as initial concentration for Bc

Initial concentration $2\ \mathrm{nmol}\cdot\mathrm{l}^{-1}$

This species takes part in five reactions (as a reactant in reaction_3, reaction_4, reaction_34 and as a product in reaction_1, reaction_41).

$$\frac{\mathrm{d}}{\mathrm{d}t}\text{species\_1} = v_2 + v_{42} - v_4 - v_5 - v_{35} \tag{161}$$

9.3 Species species_2

Name Bcp

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

This species takes part in four reactions (as a reactant in reaction_18, reaction_35, reaction_41 and as a product in reaction_3).

$$\frac{\mathrm{d}}{\mathrm{d}t}\text{species\_2} = v_4 - v_{19} - v_{36} - v_{42} \tag{162}$$

9.4 Species species_3

Name Bn

Initial concentration $1.9\ \mathrm{nmol}\cdot\mathrm{l}^{-1}$

This species takes part in eight reactions (as a reactant in reaction_23, reaction_36, reaction_40 and as a product in reaction_4, reaction_42 and as a modifier in reaction_0, reaction_9, reaction_20).

$$\frac{\mathrm{d}}{\mathrm{d}t}\text{species\_3} = v_5 + v_{43} - v_{24} - v_{37} - v_{41} \tag{163}$$

9.5 Species species_4

Name Cc

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

This species takes part in five reactions (as a reactant in reaction_7, reaction_13, reaction_28 and as a product in reaction_5, reaction_43).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{species\_4} = v_6 + v_{44} - v_8 - v_{14} - v_{29} \tag{164}$$

9.6 Species species_5

Name Mc

Notes Initial concentration for Mc got from the value of the curve at time=0 in the paper.

Initial concentration $1.7\ \mathrm{nmol}\cdot\mathrm{l}^{-1}$

This species takes part in four reactions (as a reactant in reaction_6, reaction_25 and as a product in reaction_20 and as a modifier in reaction_5).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{species\_5} = v_{21} - v_7 - v_{26} \tag{165}$$

9.7 Species species_6

Name Ccp

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

This species takes part in four reactions (as a reactant in reaction_8, reaction_30, reaction_43 and as a product in reaction_7).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{species\_6} = v_8 - v_9 - v_{31} - v_{44} \tag{166}$$

9.8 Species species_7

Name Mp

Notes Initial concentration for Mp got from the value of curve at time=0 in the paper.

Initial concentration $2.5\ \mathrm{nmol}\cdot\mathrm{l}^{-1}$

This species takes part in four reactions (as a reactant in reaction_22, reaction_26 and as a product in reaction_9 and as a modifier in reaction_10).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{species\_7} = v_{10} - v_{23} - v_{27} \tag{167}$$

9.9 Species species_8

Name Pc

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

This species takes part in five reactions (as a reactant in reaction_12, reaction_13, reaction_27 and as a product in reaction_10, reaction_44).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{species\_8} = v_{11} + v_{45} - v_{13} - v_{14} - v_{28} \tag{168}$$

9.10 Species species_9

Name Pcp

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

This species takes part in four reactions (as a reactant in reaction_11, reaction_29, reaction_44 and as a product in reaction_12).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{species\_9} = v_{13} - v_{12} - v_{30} - v_{45} \tag{169}$$

9.11 Species species_10

Name PCc

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

This species takes part in five reactions (as a reactant in reaction_14, reaction_16, reaction_32 and as a product in reaction_13, reaction_47).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{species\_10} = v_{14} + v_{48} - v_{15} - v_{17} - v_{33} \tag{170}$$

9.12 Species species_11

Name PCcp

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

This species takes part in four reactions (as a reactant in reaction_15, reaction_31, reaction_47 and as a product in reaction_14).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{species\_11} = v_{15} - v_{16} - v_{32} - v_{48} \tag{171}$$

9.13 Species species_12

Name PCn

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

This species takes part in five reactions (as a reactant in reaction_21, reaction_23, reaction_46 and as a product in reaction_16, reaction_45).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{species\_12} = v_{17} + v_{46} - v_{22} - v_{24} - v_{47} \tag{172}$$

9.14 Species species_13

Name Bnp

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

This species takes part in four reactions (as a reactant in reaction_19, reaction_37, reaction_42 and as a product in reaction_36).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{species\_13} = v_{37} - v_{20} - v_{38} - v_{43} \tag{173}$$

9.15 Species species_14

Name PCnp

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

This species takes part in four reactions (as a reactant in reaction_17, reaction_33, reaction_45 and as a product in reaction_21).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{species\_14} = v_{22} - v_{18} - v_{34} - v_{46} \tag{174}$$

9.16 Species species_15

Name In

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

This species takes part in three reactions (as a reactant in reaction_38, reaction_39 and as a product in reaction_23).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{species\_15} = v_{24} - v_{39} - v_{40} \tag{175}$$

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