SBML Model Report

Model name: "NguyenLK2011 - Ubiquitination dynamics in Ring1B/Bmi1 system"

November 24, 2016

1 General Overview

This is a document in SBML Level 2 Version 4 format. This model was created by Thawfeek Varusai[1] at November 15th 2016 at 1:03 p. m. and last time modified at November 24th 2016 at 11:25 a. m. Table 1 shows 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	11
events	0	constraints	0
reactions	17	function definitions	5
global parameters	0	unit definitions	2
rules	0	initial assignments	0

Model Notes

NguyenLK2011 - Ubiquitination dynamics inRing1B-Bmi1 systemThis theoretical model investigates thedynamics of Ring1B/Bmi1 ubiquitination to identify bistableswitch-like and oscillatory behaviour in thesystem.Michaelis-Menten (MM) equations are used to formulatethe model.

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

However, the authors show that the dynamics persist evenfor Mass-Action kinetics. This SBML file is the MM version of themodel.

This model is described in the article:Switches, excitable responses and oscillations in the Ring1B/Bmi1 ubiquitination system.Nguyen LK, Muoz-Garca J, Maccario H, Ciechanover A, Kolch W, Kholodenko BN.PLoS Comput. Biol. 2011 Dec; 7(12): e1002317

Abstract:

In an active, self-ubiquitinated state, the Ring1B ligase monoubiquitinates histone H2A playing a critical role in Polycomb-mediated gene silencing. Following ubiquitination by external ligases, Ring1B is targeted for proteosomal degradation. Using biochemical data and computational modeling, we show that the Ring1B ligase can exhibit abrupt switches, overshoot transitions and self-perpetuating oscillations between its distinct ubiquitination and activity states. These different Ring1B states display canonical or multiply branched, atypical polyubiquitin chains and involve association with the Polycomb-group protein Bmi1. Bistable switches and oscillations may lead to all-or-none histone H2A monoubiquitination rates and result in discrete periods of gene (in)activity. Switches, overshoots and oscillations in Ring1B catalytic activity and proteosomal degradation are controlled by the abundances of Bmi1 and Ring1B, and the activities and abundances of external ligases and deubiquitinases, such as E6-AP and USP7.

This model is hosted on BioModels Database and identified by: BIOMD0000000622.

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

2 Unit Definitions

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

2.1 Unit `volume`

Name volume

Definition ml

2.2 Unit `substance`

Name substance

Definition mmol

2.3 Unit `area`

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

Definition m^2

2.4 Unit `length`

Notes Metre is the predefined SBML unit for `length` since SBML Level 2 Version 1.

Definition m

2.5 Unit `time`

Notes Second is the predefined SBML unit for `time`.

Definition s

3 Compartment

This model contains one compartment.

Table 2: Properties of all compartments.

Id	Name	SBO	Spatial Dimensions	Size	Unit	Constant	Outside
`compartment`	compartment	0000410	3	1	litre	☑	

3.1 Compartment `compartment`

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

Name compartment

SBO:0000410 implicit compartment

4 Species

This model contains eleven species. The boundary condition of one of these species is set to `true` so that this 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
`Bmi1`	Bmi1	`compartment`	$\mathrm{mmol} \cdot \mathrm{ml}^{-1}$	☐	☐
`Bmi1ubd`	Bmi1ubd	`compartment`	$\mathrm{mmol} \cdot \mathrm{ml}^{-1}$	☐	☐
`R1B`	R1B	`compartment`	$\mathrm{mmol} \cdot \mathrm{ml}^{-1}$	☐	☐
`R1Bubd`	R1Bubd	`compartment`	$\mathrm{mmol} \cdot \mathrm{ml}^{-1}$	☐	☐
`USP7tot`	USP7tot	`compartment`	$\mathrm{mmol} \cdot \mathrm{ml}^{-1}$	☑	☑
`Z`	Z	`compartment`	$\mathrm{mmol} \cdot \mathrm{ml}^{-1}$	☐	☐
`Zub`	Zub	`compartment`	$\mathrm{mmol} \cdot \mathrm{ml}^{-1}$	☐	☐
`R1Buba`	R1Buba	`compartment`	$\mathrm{mmol} \cdot \mathrm{ml}^{-1}$	☐	☐
`R1Bub`	R1Bub	`compartment`	$\mathrm{mmol} \cdot \mathrm{ml}^{-1}$	☐	☐
`H2A`	H2A	`compartment`	$\mathrm{mmol} \cdot \mathrm{ml}^{-1}$	☐	☐
`H2Auba`	H2Auba	`compartment`	$\mathrm{mmol} \cdot \mathrm{ml}^{-1}$	☐	☐

5 Function definitions

This is an overview of five function definitions.

5.1 Function definition Constant_flux__irreversible

Name Constant flux (irreversible)

Argument v

Mathematical Expression

$$\mathrm{v} \tag{1}$$

5.2 Function definition R6_Rate

Name R6_Rate

Arguments subs, k1, k2, prod

Mathematical Expression

$$\mathrm{subs} \cdot (\mathrm{k1} \cdot \mathrm{subs} + \mathrm{k2} \cdot \mathrm{prod}) \tag{2}$$

5.3 Function definition R12_Rate

Name R12_Rate

Arguments subs, k1, mod1, k2, mod2, k3, mod3

Mathematical Expression

$$\mathrm{subs} \cdot (\mathrm{k1} \cdot \mathrm{mod1} + \mathrm{k2} \cdot \mathrm{mod2} + \mathrm{k3} \cdot \mathrm{mod3}) \tag{3}$$

5.4 Function definition MM_mod

Name MM_mod

Arguments kc, mod, subs, Km

Mathematical Expression

$$\frac{\mathrm{kc} \cdot \mathrm{mod} \cdot \mathrm{subs}}{\mathrm{Km} + \mathrm{subs}} \tag{4}$$

5.5 Function definition Mod_MA1

Name Mod_MA1

Arguments k, mod, subs

Mathematical Expression

$$\mathrm{k} \cdot \mathrm{mod} \cdot \mathrm{subs} \tag{5}$$

6 Reactions

This model contains 17 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 4: Overview of all reactions

№	Id	Name	Reaction Equation	SBO
1	R1	R1	$\mathrm{Bmi1} \longrightarrow \mathrm{Bmi1ubd}$	
2	R2	R2	$\mathrm{Bmi1ubd} \longrightarrow \mathrm{Bmi1}$	
3	R3	R3	$\mathrm{R1B} \longrightarrow \mathrm{R1Bubd}$	
4	R4	R4	$\mathrm{R1Bubd} \xrightarrow{\mathrm{USP7tot}} \mathrm{R1B}$	
5	R5	R5	$\mathrm{Bmi1} + \mathrm{R1B} \rightleftharpoons \mathrm{Z}$	
6	R6	R6	$\mathrm{Z} \longrightarrow \mathrm{Zub}$	
7	R7	R7	$\mathrm{Zub} \xrightarrow{\mathrm{USP7tot}} \mathrm{Z}$	
8	R8	R8	$\mathrm{Zub} \rightleftharpoons \mathrm{R1Buba} + \mathrm{Bmi1}$	
9	R9	R9	$\mathrm{R1B} \longrightarrow \mathrm{R1Bub}$	
10	R10	R10	$\mathrm{R1Bub} \xrightarrow{\mathrm{USP7tot}} \mathrm{R1B}$	
11	R11	R11	$\mathrm{R1Buba} \xrightarrow{\mathrm{USP7tot}} \mathrm{R1B}$	
12	R12	R12	$\mathrm{H2A} \xrightarrow{\mathrm{R1Bub,\ Zub,\ R1Buba}} \mathrm{H2Auba}$	
13	R13	R13	$\mathrm{H2Auba} \longrightarrow \mathrm{H2A}$	
14	R1Bprod	R1Bprod	$\emptyset \longrightarrow \mathrm{R1B}$	
15	R1Bdeg	R1Bdeg	$\mathrm{R1Bubd} \longrightarrow \emptyset$	
16	Bmi1prod	Bmi1prod	$\emptyset \longrightarrow \mathrm{Bmi1}$	
17	Bmi1deg	Bmi1deg	$\mathrm{Bmi1ubd} \longrightarrow \emptyset$	

6.1 Reaction R1

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

Name R1

Reaction equation

$$\text{Bmi1} \longrightarrow \text{Bmi1ubd} \tag{6}$$

Reactant

Table 5: Properties of each reactant.

Id	Name	SBO
Bmi1	Bmi1	

Product

Table 6: Properties of each product.

Id	Name	SBO
Bmi1ubd	Bmi1ubd	

Kinetic Law

Derived unit contains undeclared units

$$v_1 = \text{vol}\,(\text{compartment}) \cdot \text{k1} \cdot [\text{Bmi1}] \tag{7}$$

Table 7: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
k1	k1		0.002		☑

6.2 Reaction R2

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

Name R2

Reaction equation

$$\text{Bmi1ubd} \longrightarrow \text{Bmi1} \tag{8}$$

Reactant

Table 8: Properties of each reactant.

Id	Name	SBO
`Bmi1ubd`	Bmi1ubd	

Product

Table 9: Properties of each product.

Id	Name	SBO
`Bmi1`	Bmi1	

Kinetic Law

Derived unit contains undeclared units

$$v_2 = \text{vol}(\text{compartment}) \cdot \text{k1} \cdot [\text{Bmi1ubd}] \tag{9}$$

Table 10: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
`k1`	k1		0.002		☑

6.3 Reaction `R3`

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

Name R3

Reaction equation

$$\text{R1B} \longrightarrow \text{R1Bubd} \tag{10}$$

Reactant

Table 11: Properties of each reactant.

Id	Name	SBO
R1B	R1B	

Product

Table 12: Properties of each product.

Id	Name	SBO
R1Bubd	R1Bubd	

Kinetic Law

Derived unit contains undeclared units

$$v_3 = \mathrm{vol}\,(\mathrm{compartment}) \cdot \mathrm{k1} \cdot [\mathrm{R1B}] \tag{11}$$

Table 13: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
k1	k1		0.01		☑

6.4 Reaction R4

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

Name R4

Reaction equation

$$\mathrm{R1Bubd} \xrightarrow{\mathrm{USP7tot}} \mathrm{R1B} \tag{12}$$

Reactant

Table 14: Properties of each reactant.

Id	Name	SBO
R1Bubd	R1Bubd	

Modifier

Table 15: Properties of each modifier.

Id	Name	SBO
USP7tot	USP7tot	

Product

Table 16: Properties of each product.

Id	Name	SBO
R1B	R1B	

Kinetic Law

Derived unit contains undeclared units

$$v_4 = \text{vol}\left(\text{compartment}\right) \cdot \text{Mod\_MA1}\left(\text{k}, [\text{USP7tot}], [\text{R1Bubd}]\right) \tag{13}$$

$$\text{Mod\_MA1}\left(\text{k}, \text{mod}, \text{subs}\right) = \text{k} \cdot \text{mod} \cdot \text{subs} \tag{14}$$

$$\text{Mod\_MA1}\left(\text{k}, \text{mod}, \text{subs}\right) = \text{k} \cdot \text{mod} \cdot \text{subs} \tag{15}$$

Table 17: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
k	k		0.001		☑

6.5 Reaction R5

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

Name R5

Reaction equation

$$\text{Bmi1} + \text{R1B} \rightleftharpoons \text{Z} \tag{16}$$

Reactants

Table 18: Properties of each reactant.

Id	Name	SBO
Bmi1	Bmi1	
R1B	R1B	

Product

Table 19: Properties of each product.

Id	Name	SBO
Z	Z	

Kinetic Law

Derived unit contains undeclared units

$$v_5 = \mathrm{vol}\,(\mathrm{compartment}) \cdot (\mathrm{k1} \cdot [\mathrm{Bmi1}] \cdot [\mathrm{R1B}] - \mathrm{k2} \cdot [\mathrm{Z}]) \tag{17}$$

Table 20: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
k1	k1		2.0		☑
k2	k2		0.2		☑

6.6 Reaction R6

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

Name R6

Reaction equation

$$\mathrm{Z} \longrightarrow \mathrm{Zub} \tag{18}$$

Reactant

Table 21: Properties of each reactant.

Id	Name	SBO
Z	Z	

Product

Table 22: Properties of each product.

Id	Name	SBO
Zub	Zub	

Kinetic Law

Derived unit contains undeclared units

$$v_6 = \mathrm{vol}\,(\mathrm{compartment}) \cdot \mathrm{R6\_Rate}\,([\mathrm{Z}], \mathrm{k1}, \mathrm{k2}, [\mathrm{Zub}]) \tag{19}$$

$$\mathrm{R6\_Rate}\,(\mathrm{subs}, \mathrm{k1}, \mathrm{k2}, \mathrm{prod}) = \mathrm{subs} \cdot (\mathrm{k1} \cdot \mathrm{subs} + \mathrm{k2} \cdot \mathrm{prod}) \tag{20}$$

$$\mathrm{R6\_Rate}\,(\mathrm{subs}, \mathrm{k1}, \mathrm{k2}, \mathrm{prod}) = \mathrm{subs} \cdot (\mathrm{k1} \cdot \mathrm{subs} + \mathrm{k2} \cdot \mathrm{prod}) \tag{21}$$

Table 23: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
k1	k1		0.02		☑
k2	k2		0.20		☑

6.7 Reaction R7

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

Name R7

Reaction equation

$$\mathrm{Zub} \xrightarrow{\mathrm{USP7tot}} \mathrm{Z} \tag{22}$$

Reactant

Table 24: Properties of each reactant.

Id	Name	SBO
Zub	Zub	

Modifier

Table 25: Properties of each modifier.

Id	Name	SBO
USP7tot	USP7tot	

Product

Table 26: Properties of each product.

Id	Name	SBO
Z	Z	

Kinetic Law

Derived unit contains undeclared units

$$v_7 = \text{vol}\,(\text{compartment}) \cdot \text{MM\_mod}\,(\text{kc}, [\text{USP7tot}], [\text{Zub}], \text{Km}) \tag{23}$$

$$\text{MM\_mod}\,(\text{kc}, \text{mod}, \text{subs}, \text{Km}) = \frac{\text{kc} \cdot \text{mod} \cdot \text{subs}}{\text{Km} + \text{subs}} \tag{24}$$

$$\text{MM\_mod}\,(\text{kc}, \text{mod}, \text{subs}, \text{Km}) = \frac{\text{kc} \cdot \text{mod} \cdot \text{subs}}{\text{Km} + \text{subs}} \tag{25}$$

Table 27: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
kc	kc		0.005		☑
Km	Km		0.003		☑

6.8 Reaction R8

This is a reversible reaction of one reactant forming two products.

Name R8

Reaction equation

$$\text{Zub} \rightleftharpoons \text{R1Buba} + \text{Bmi1} \tag{26}$$

Reactant

Table 28: Properties of each reactant.

Id	Name	SBO
Zub	Zub	

Products

Table 29: Properties of each product.

Id	Name	SBO
R1Buba	R1Buba	
Bmi1	Bmi1	

Kinetic Law

Derived unit contains undeclared units

$$v_8 = \mathrm{vol}\,(\mathrm{compartment}) \cdot (\mathrm{k1} \cdot [\mathrm{Zub}] - \mathrm{k2} \cdot [\mathrm{R1Buba}] \cdot [\mathrm{Bmi1}]) \tag{27}$$

Table 30: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
k1	k1		0.012		☑
k2	k2		$2 \cdot 10^{-5}$		☑

6.9 Reaction R9

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

Name R9

Reaction equation

$$\mathrm{R1B} \longrightarrow \mathrm{R1Bub} \tag{28}$$

Reactant

Table 31: Properties of each reactant.

Id	Name	SBO
R1B	R1B	

Product

Table 32: Properties of each product.

Id	Name	SBO
R1Bub	R1Bub	

Kinetic Law

Derived unit contains undeclared units

$$v_9 = \text{vol}(\text{compartment}) \cdot \text{R6\_Rate}([\text{R1B}], \text{k1}, \text{k2}, [\text{R1Bub}]) \tag{29}$$

$$\text{R6\_Rate}(\text{subs}, \text{k1}, \text{k2}, \text{prod}) = \text{subs} \cdot (\text{k1} \cdot \text{subs} + \text{k2} \cdot \text{prod}) \tag{30}$$

$$\text{R6\_Rate}(\text{subs}, \text{k1}, \text{k2}, \text{prod}) = \text{subs} \cdot (\text{k1} \cdot \text{subs} + \text{k2} \cdot \text{prod}) \tag{31}$$

Table 33: Properties of each parameter.

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

6.10 Reaction R10

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

Name R10

Reaction equation

$$\text{R1Bub} \xrightarrow{\text{USP7tot}} \text{R1B} \tag{32}$$

Reactant

Table 34: Properties of each reactant.

Id	Name	SBO
R1Bub	R1Bub	

Modifier

Table 35: Properties of each modifier.

Id	Name	SBO
USP7tot	USP7tot	

Product

Table 36: Properties of each product.

Id	Name	SBO
R1B	R1B	

Kinetic Law

Derived unit contains undeclared units

$$v_{10} = \text{vol}\left(\text{compartment}\right) \cdot \text{Mod\_MA1}\left(\text{k}, [\text{USP7tot}], [\text{R1Bub}]\right) \tag{33}$$

$$\text{Mod\_MA1}\left(\text{k}, \text{mod}, \text{subs}\right) = \text{k} \cdot \text{mod} \cdot \text{subs} \tag{34}$$

$$\text{Mod\_MA1}\left(\text{k}, \text{mod}, \text{subs}\right) = \text{k} \cdot \text{mod} \cdot \text{subs} \tag{35}$$

Table 37: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
k	k		0.008		☑

6.11 Reaction R11

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

Name R11

Reaction equation

$$\text{R1Buba} \xrightarrow{\text{USP7tot}} \text{R1B} \tag{36}$$

Reactant

Table 38: Properties of each reactant.

Id	Name	SBO
R1Buba	R1Buba	

Modifier

Table 39: Properties of each modifier.

Id	Name	SBO
USP7tot	USP7tot	

Product

Table 40: Properties of each product.

Id	Name	SBO
R1B	R1B	

Kinetic Law

Derived unit contains undeclared units

$$v_{11} = \text{vol}\left(\text{compartment}\right) \cdot \text{Mod\_MA1}\left(\text{k}, [\text{USP7tot}], [\text{R1Buba}]\right) \tag{37}$$

$$\text{Mod\_MA1}\left(\text{k}, \text{mod}, \text{subs}\right) = \text{k} \cdot \text{mod} \cdot \text{subs} \tag{38}$$

$$\text{Mod\_MA1}\left(\text{k}, \text{mod}, \text{subs}\right) = \text{k} \cdot \text{mod} \cdot \text{subs} \tag{39}$$

Table 41: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
k	k		0.005		☑

6.12 Reaction R12

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

Name R12

Reaction equation

$$\mathrm{H2A} \xrightarrow{\mathrm{R1Bub,\ Zub,\ R1Buba}} \mathrm{H2Auba} \tag{40}$$

Reactant

Table 42: Properties of each reactant.

Id	Name	SBO
H2A	H2A	

Modifiers

Table 43: Properties of each modifier.

Id	Name	SBO
R1Bub	R1Bub	
Zub	Zub	
R1Buba	R1Buba	

Product

Table 44: Properties of each product.

Id	Name	SBO
H2Auba	H2Auba	

Kinetic Law

Derived unit contains undeclared units

$$v_{12} = \mathrm{vol}\,(\mathrm{compartment}) \cdot \mathrm{R12\_Rate}\,([\mathrm{H2A}], \mathrm{k1}, [\mathrm{R1Bub}], \mathrm{k2}, [\mathrm{Zub}], \mathrm{k3}, [\mathrm{R1Buba}]) \tag{41}$$

$$\mathrm{R12\_Rate}\,(\mathrm{subs}, \mathrm{k1}, \mathrm{mod1}, \mathrm{k2}, \mathrm{mod2}, \mathrm{k3}, \mathrm{mod3}) = \mathrm{subs} \cdot (\mathrm{k1} \cdot \mathrm{mod1} + \mathrm{k2} \cdot \mathrm{mod2} + \mathrm{k3} \cdot \mathrm{mod3}) \tag{42}$$

$$\mathrm{R12\_Rate}\left(\mathrm{subs}, \mathrm{k1}, \mathrm{mod1}, \mathrm{k2}, \mathrm{mod2}, \mathrm{k3}, \mathrm{mod3}\right) = \mathrm{subs} \cdot \left(\mathrm{k1} \cdot \mathrm{mod1} + \mathrm{k2} \cdot \mathrm{mod2} + \mathrm{k3} \cdot \mathrm{mod3}\right) \tag{43}$$

Table 45: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
k1	k1		0.002		☑
k2	k2		2.000		☑
k3	k3		0.200		☑

6.13 Reaction R13

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

Name R13

Reaction equation

$$\mathrm{H2Auba} \longrightarrow \mathrm{H2A} \tag{44}$$

Reactant

Table 46: Properties of each reactant.

Id	Name	SBO
H2Auba	H2Auba	

Product

Table 47: Properties of each product.

Id	Name	SBO
H2A	H2A	

Kinetic Law

Derived unit contains undeclared units

$$v_{13} = \mathrm{vol}\left(\mathrm{compartment}\right) \cdot \mathrm{k1} \cdot \left[\mathrm{H2Auba}\right] \tag{45}$$

Table 48: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
k1	k1		0.01		☑

6.14 Reaction R1Bprod

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

Name R1Bprod

Reaction equation

$$\emptyset \longrightarrow \mathrm{R1B} \tag{46}$$

Product

Table 49: Properties of each product.

Id	Name	SBO
R1B	R1B	

Kinetic Law

Derived unit contains undeclared units

$$v_{14} = \mathrm{vol}\left(\mathrm{compartment}\right) \cdot \mathrm{Constant\_flux\_\_irreversible}\left(\mathrm{v}\right) \tag{47}$$

$$\mathrm{Constant\_flux\_\_irreversible}\left(\mathrm{v}\right) = \mathrm{v} \tag{48}$$

$$\mathrm{Constant\_flux\_\_irreversible}\left(\mathrm{v}\right) = \mathrm{v} \tag{49}$$

Table 50: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
v	v		$7.5 \cdot 10^{-6}$		☑

6.15 Reaction R1Bdeg

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

Name R1Bdeg

Reaction equation

$$\text{R1Bubd} \longrightarrow \emptyset \tag{50}$$

Reactant

Table 51: Properties of each reactant.

Id	Name	SBO
R1Bubd	R1Bubd	

Kinetic Law

Derived unit contains undeclared units

$$v_{15} = \text{vol}\,(\text{compartment}) \cdot \text{k1} \cdot [\text{R1Bubd}] \tag{51}$$

Table 52: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
k1	k1		$3 \cdot 10^{-5}$		☑

6.16 Reaction Bmi1prod

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

Name Bmi1prod

Reaction equation

$$\emptyset \longrightarrow \text{Bmi1} \tag{52}$$

Product

Table 53: Properties of each product.

Id	Name	SBO
Bmi1	Bmi1	

Kinetic Law

Derived unit contains undeclared units

$$v_{16} = \mathrm{vol}\,(\mathrm{compartment}) \cdot \mathrm{Constant\_flux\_\_irreversible}\,(\mathrm{v}) \tag{53}$$

$$\mathrm{Constant\_flux\_\_irreversible}\,(\mathrm{v}) = \mathrm{v} \tag{54}$$

$$\mathrm{Constant\_flux\_\_irreversible}\,(\mathrm{v}) = \mathrm{v} \tag{55}$$

Table 54: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
v	v		$7.5 \cdot 10^{-6}$		☑

6.17 Reaction `Bmi1deg`

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

Name Bmi1deg

Reaction equation

$$\mathrm{Bmi1ubd} \longrightarrow \emptyset \tag{56}$$

Reactant

Table 55: Properties of each reactant.

Id	Name	SBO
`Bmi1ubd`	Bmi1ubd	

Kinetic Law

Derived unit contains undeclared units

$$v_{17} = \mathrm{vol}\,(\mathrm{compartment}) \cdot \mathrm{k1} \cdot [\mathrm{Bmi1ubd}] \tag{57}$$

Table 56: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
k1	k1		$3 \cdot 10^{-5}$		☑

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 Bmi1

Name Bmi1

SBO:0000252 polypeptide chain

Notes `RING finger protein`

Initial concentration $1.1\ \mathrm{mmol} \cdot \mathrm{ml}^{-1}$

This species takes part in five reactions (as a reactant in R1, R5 and as a product in R2, R8, Bmi1prod).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{Bmi1} = v_2 + v_8 + v_{16} - v_1 - v_5 \tag{58}$$

7.2 Species Bmi1ubd

Name Bmi1ubd

SBO:0000252 polypeptide chain

Notes `Ubiquitinated Bmi1 targeted to degradation`

Initial concentration $1.08\ \mathrm{mmol} \cdot \mathrm{ml}^{-1}$

This species takes part in three reactions (as a reactant in R2, Bmi1deg and as a product in R1).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{Bmi1ubd} = v_1 - v_2 - v_{17} \tag{59}$$

7.3 Species R1B

Name R1B

SBO:0000252 polypeptide chain

Notes Ring1B ligase

Initial concentration $0.1\ \mathrm{mmol \cdot ml^{-1}}$

This species takes part in seven reactions (as a reactant in R3, R5, R9 and as a product in R4, R10, R11, R1Bprod).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{R1B} = v_4 + v_{10} + v_{11} + v_{14} - v_3 - v_5 - v_9 \tag{60}$$

7.4 Species R1Bubd

Name R1Bubd

SBO:0000252 polypeptide chain

Notes Ubiquitinated Ring1B by external ligases targeted to degradation

Initial concentration $0.12\ \mathrm{mmol \cdot ml^{-1}}$

This species takes part in three reactions (as a reactant in R4, R1Bdeg and as a product in R3).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{R1Bubd} = v_3 - v_4 - v_{15} \tag{61}$$

7.5 Species USP7tot

Name USP7tot

SBO:0000252 polypeptide chain

Notes Total ubiquitin-proteasome system 7

Initial concentration $1\ \mathrm{mmol \cdot ml^{-1}}$

This species takes part in four reactions (as a modifier in R4, R7, R10, R11), which do not influence its rate of change because this constant species is on the boundary of the reaction system:

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{USP7tot} = 0 \tag{62}$$

7.6 Species Z

Name Z

SBO:0000252 polypeptide chain

Notes Heterodimeric complex of Ring1B and Bmi1

Initial concentration $0.2\ \mathrm{mmol} \cdot \mathrm{ml}^{-1}$

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

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{Z} = v_5 + v_7 - v_6 \tag{63}$$

7.7 Species Zub

Name Zub

SBO:0000252 polypeptide chain

Notes Ubiquitinated for of Ring1B-Bmi1 complex

Initial concentration $0.12\ \mathrm{mmol} \cdot \mathrm{ml}^{-1}$

This species takes part in four reactions (as a reactant in R7, R8 and as a product in R6 and as a modifier in R12).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{Zub} = v_6 - v_7 - v_8 \tag{64}$$

7.8 Species R1Buba

Name R1Buba

SBO:0000252 polypeptide chain

Notes Alternative ubiquitinated form of Ring1B

Initial concentration $0.44\ \mathrm{mmol} \cdot \mathrm{ml}^{-1}$

This species takes part in three reactions (as a reactant in R11 and as a product in R8 and as a modifier in R12).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{R1Buba} = v_8 - v_{11} \tag{65}$$

7.9 Species R1Bub

Name R1Bub

SBO:0000252 polypeptide chain

Notes Auto-ubiquitination of Ring1B

Initial concentration $0.02\ \mathrm{mmol} \cdot \mathrm{ml}^{-1}$

This species takes part in three reactions (as a reactant in R10 and as a product in R9 and as a modifier in R12).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{R1Bub} = v_9 - v_{10} \tag{66}$$

7.10 Species H2A

Name H2A

SBO:0000252 polypeptide chain

Notes histone H2A

Initial concentration $0.1\ \mathrm{mmol} \cdot \mathrm{ml}^{-1}$

This species takes part in two reactions (as a reactant in R12 and as a product in R13).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{H2A} = v_{13} - v_{12} \tag{67}$$

7.11 Species H2Auba

Name H2Auba

SBO:0000252 polypeptide chain

Notes Ubiquitinated H2A

Initial concentration $0\ \mathrm{mmol} \cdot \mathrm{ml}^{-1}$

This species takes part in two reactions (as a reactant in R13 and as a product in R12).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{H2Auba} = v_{12} - v_{13} \tag{68}$$

A Glossary of Systems Biology Ontology Terms

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

SBO:0000410 implicit compartment: A compartment whose existence is inferred due to the presence of known material entities which must be bounded, allowing the creation of material entity pools

SBML2LaTeX was developed by Andreas Dräger[a], Hannes Planatscher[a], Dieudonné M Wouamba[a], Adrian Schröder[a], Michael Hucka[b], Lukas Endler[c], Martin Golebiewski[d] and Andreas Zell[a]. Please see http://www.ra.cs.uni-tuebingen.de/software/SBML2LaTeX for more information.

[a]Center for Bioinformatics Tübingen (ZBIT), Germany
[b]California Institute of Technology, Beckman Institute BNMC, Pasadena, United States
[c]European Bioinformatics Institute, Wellcome Trust Genome Campus, Hinxton, United Kingdom
[d]EML Research gGmbH, Heidelberg, Germany