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SBML Model Report

Model name: “Erguler2013 - Unfolded protein stress response”

June 18, 2013

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 Kamil Erguler[2] at March 25th 2013 at 12:25 a. m. and last time modified at May 20th 2013 at 11:06 a. m. Table 1 gives an overview of the quantities of all components of this model.

Table 1: Number of components in this model, which are described in the following sections.

Element	Quantity	Element	Quantity
compartment types	0	compartments	4
species types	0	species	27
events	0	constraints	0
reactions	62	function definitions	3
global parameters	94	unit definitions	8
rules	11	initial assignments	0

Model Notes

Erguler2013 - Unfolded protein stress response

The model investigates the mechanism by which UPR (unfolded protein response) outcome switches between survival and death.

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This model is described in the article:A mathematical model of the unfolded protein stress response reveals the decision mechanism for recovery, adaptation and apoptosis.Erguler K, Pieri M, Deltas C.BMC Syst Biol. 2013 Feb 21;7(1):16.

Abstract:

BACKGROUND: The unfolded protein response (UPR) is a major signalling cascade acting in the quality control ofprotein folding in the endoplasmic reticulum (ER). The cascade is known to play an accessory rolein a range of genetic and environmental disorders including neurodegenerative and cardiovasculardiseases, diabetes and kidney diseases. The three major receptors of the ER stress involved withthe UPR, i.e. IRE1a, PERK and ATF6, signal through a complex web of pathways to convey anappropriate response. The emerging behaviour ranges from adaptive to maladaptive depending on theseverity of unfolded protein accumulation in the ER; however, the decision mechanism for the switchand its timing have so far been poorly understood.

RESULTS:Here, we propose a mechanism by which the UPR outcome switches between survival and death.We compose a mathematical model integrating the three signalling branches, and perform a comprehensivebifurcation analysis to investigate possible responses to stimuli. The analysis reveals threedistinct states of behaviour, low, high and intermediate activity, associated with stress adaptation, tolerance,and the initiation of apoptosis. The decision to adapt or destruct can, therefore, be understoodas a dynamic process where the balance between the stress and the folding capacity of the ER playsa pivotal role in managing the delivery of the most appropriate response. The model demonstratesfor the first time that the UPR is capable of generating oscillations in translation attenuation and theapoptotic signals, and this is supplemented with a Bayesian sensitivity analysis identifying a set ofparameters controlling this behaviour.

CONCLUSIONS:This work contributes largely to the understanding of one of the most ubiquitous signalling pathwaysinvolved in protein folding quality control in the metazoan ER. The insights gained have direct consequenceson the management of many UPR-related diseases, revealing, in addition, an extended listof candidate disease modifiers. Demonstration of stress adaptation sheds light to how preconditioningmight be beneficial in manifesting the UPR outcome to prevent untimely apoptosis, and paves the wayto novel approaches for the treatment of many UPR-related conditions.

In the paper, PERKA refers to the amount of phosphorylated PERK monomer. However, it refers to the active complex in the model. The complex with the model parameterization is formed of 4 monomers (n=4). So, the value of PERKA should be multiplied by 4, in order to generate the figures in the paper (eg. Figure 12).

An additional parameter (tmr=10)) is used in the model. This parameter is not mentioned in the paper. The model values of kf(=10) and kr(=1) are not consistent with that of the paper (kf=100, kr=10, in the paper). However, this is corrected by the introduction of „tmr„ in the model, which is multiplied with kf and kr to get the resulting values.

The term „tmr„ was missing in the kinetic laws of the reactions reu7 and reu8, in the original model. This has been corrected as per the author's request.

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coded model have been dedicated to the publicdomain worldwide. Please refer to CC0 Public DomainDedication for more information.

2 Unit Definitions

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

2.1 Unit `substance`

Name acu

Definition mol

2.2 Unit `volume`

Name volume

Definition l

2.3 Unit `time`

Name atu

Definition s

2.4 Unit `rate`

Name aru = acu.atu^1

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

2.5 Unit `rate2`

Name aru2 = acu^1.atu^1

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

2.6 Unit `rate1`

Name aru1 = atu^1

Definition s^{-1}

2.7 Unit substance1

Name acu1 = acu^1

Definition mol^{-1}

2.8 Unit rate3

Name aru3 = acu^3.atu^1

Definition $\mathrm{mol}^{-3} \cdot \mathrm{s}^{-1}$

2.9 Unit area

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

Definition m^2

2.10 Unit length

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

Definition m

3 Compartments

This model contains four compartments.

Table 2: Properties of all compartments.

Id	Name	SBO	Spatial Dimensions	Size	Unit	Constant	Outside
ERlumen			3	1	litre	☑	
cytoplasm			3	1	litre	☑	
Golgi			3	1	litre	☑	
mitochondria			3	1	litre	☑	

3.1 Compartment ERlumen

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

3.2 Compartment cytoplasm

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

3.3 Compartment `Golgi`

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

3.4 Compartment `mitochondria`

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

4 Species

This model contains 27 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
UFPT	UFPT	ERlumen	mol	⊟	⊟
BiUFP	BiUFP	ERlumen	mol	⊟	⊟
BiRE1	BiRE1	ERlumen	mol	⊟	⊟
BiATF	BiATF	ERlumen	mol	⊟	⊟
BiPER	BiPER	ERlumen	mol	⊟	⊟
IRE1A	IRE1A	ERlumen	mol	⊟	⊟
PERKA	PERKA	ERlumen	mol	⊟	⊟
mXbp1u	mXbp1u	cytoplasm	mol	⊟	⊟
mXbp1s	mXbp1s	cytoplasm	mol	⊟	⊟
Xbp1s	Xbp1s	cytoplasm	mol	⊟	⊟
mBiPT	mBiPT	cytoplasm	mol	⊟	⊟
BiPT	BiPT	ERlumen	mol	⊟	⊟
ATF6T	ATF6T	ERlumen	mol	⊟	⊟
ATF6GB	ATF6GB	Golgi	mol	⊟	⊟
ATF6p50	ATF6p50	cytoplasm	mol	⊟	⊟
mWFS1	mWFS1	cytoplasm	mol	⊟	⊟
WFS1	WFS1	ERlumen	mol	⊟	⊟
ATF4	ATF4	cytoplasm	mol	⊟	⊟
mCHOP	mCHOP	cytoplasm	mol	⊟	⊟
CHOP	CHOP	cytoplasm	mol	⊟	⊟
mGADD34	mGADD34	cytoplasm	mol	⊟	⊟
GADD34	GADD34	cytoplasm	mol	⊟	⊟

Id	Name	Compartment	Derived Unit	Constant	Boundary Condition
BCL2T	BCL2T	mitochondria	mol	⊟	⊟
BAXmT	BAXmT	mitochondria	mol	⊟	⊟
BH3T	BH3T	cytoplasm	mol	⊟	⊟
BAXmBCL2	BAXmBCL2	mitochondria	mol	⊟	⊟
BH3BCL2	BH3BCL2	mitochondria	mol	⊟	⊟

5 Parameters

This model contains 94 global parameters.

Table 4: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
UFP			0.000	mol	☐
BiP			0.000	mol	☐
IRE1			0.000	mol	☐
PERK			0.000	mol	☐
ATF6			0.000	mol	☐
eIF2a			0.000	mol	☐
spliceRate			0.000	$\mathrm{mol} \cdot \mathrm{s}^{-1}$	☐
BCL2			0.000	mol	☐
BH3			0.000	mol	☐
BAXm			0.000	mol	☐
tmr			10.000	dimensionless	☑
IRE1T			1.000	mol	☑
PERKT			1.000	mol	☑
eIF2aT			1.000	mol	☑
CReP			0.100	mol	☑
kf			10.000	$\mathrm{mol}^{-1} \cdot \mathrm{s}^{-1}$	☑
kr			1.000	s^{-1}	☑
n			4.000	dimensionless	☑
nh			2.000	dimensionless	☑
extATT			0.000	dimensionless	☑
extPERK			0.000	mol^{-1}	☑
basalXBP			1.000	mol	☑
basalBiP			1.000	mol	☑
krcXU			5.000	mol	☑
krcBiP			5.000	mol	☑
krcWFS			1.000	mol	☑
krcCHOP			1.000	mol	☑
krcGADD34			1.000	mol	☑
kmXbp			10.000	dimensionless	☑
kmAtfsXBP			10.000	dimensionless	☑
kmAtfsBiP			1.000	dimensionless	☑
kmAtff			0.050	dimensionless	☑
kmChop			0.050	dimensionless	☑
kmAtfs			0.100	dimensionless	☑
ksplice			10.000	s^{-1}	☑
krcSplice			1.000	mol	☑
trcXU			1.000	$\mathrm{mol} \cdot \mathrm{s}^{-1}$	☑

Id	Name	SBO	Value	Unit	Constant
trcBiP			1.000	$\mathrm{mol} \cdot \mathrm{s}^{-1}$	☑
trcWFS			1.000	$\mathrm{mol} \cdot \mathrm{s}^{-1}$	☑
trcCHOP			1.000	$\mathrm{mol} \cdot \mathrm{s}^{-1}$	☑
trcGADD34			1.000	$\mathrm{mol} \cdot \mathrm{s}^{-1}$	☑
ktrUFP			1.000	s^{-1}	☑
ktrXS			1.000	s^{-1}	☑
ktrBiP			1.000	s^{-1}	☑
ktrATF6			1.000	s^{-1}	☑
ktrWFS			1.000	s^{-1}	☑
ktrATF4			1.000	s^{-1}	☑
ktrCHOP			1.000	s^{-1}	☑
ktrGADD34			1.000	s^{-1}	☑
kdmXU			1.000	s^{-1}	☑
kdmXS			1.000	s^{-1}	☑
kdmBiP			1.000	s^{-1}	☑
kdmWFS			1.000	s^{-1}	☑
kdmCHOP			1.000	s^{-1}	☑
kdmGADD34			1.000	s^{-1}	☑
kdUFP			0.100	s^{-1}	☑
kdXS			0.100	s^{-1}	☑
kdBiP			0.010	s^{-1}	☑
kdATF6			0.100	s^{-1}	☑
kdATF6GB			0.100	s^{-1}	☑
kdATF6p50			0.100	s^{-1}	☑
kdWFS			0.100	s^{-1}	☑
kdATF4			0.100	s^{-1}	☑
kdCHOP			0.100	s^{-1}	☑
kdGADD34			0.100	s^{-1}	☑
mATF6T			5.000	mol	☑
mUFPT			0.000	mol	⊟
mATF4			1.000	mol	☑
ktrans			1.000	s^{-1}	☑
kcleave			10.000	s^{-1}	☑
kphos			5.000	s^{-1}	☑
kdephos			0.500	s^{-1}	☑
kdeAW			1.000	$\mathrm{mol}^{-1} \cdot \mathrm{s}^{-1}$	☑
kbu			0.000	$\mathrm{mol}^{-1} \cdot \mathrm{s}^{-1}$	☑
switch			0.000	dimensionless	☑
kATF4			0.100	mol	☑
J			0.001	mol	☑
K			0.001	mol	☑
kfbc			10.000	$\mathrm{mol} \cdot \mathrm{s}^{-1}$	☑

Id	Name	SBO	Value	Unit	Constant
kdbc			0.100	s^{-1}	☑
kmbc			0.030	mol^{-1}	☑
kstr			0.200	dimensionless	☑
BAXT			100.000	mol	☑
kfx			1.000	s^{-1}	☑
kfxp			3.000	$mol^{-1} \cdot s^{-1}$	☑
kbx			2.000	s^{-1}	☑
kasx			90.000	$mol^{-1} \cdot s^{-1}$	☑
kdsx			0.050	s^{-1}	☑
ks3			0.100	$mol \cdot s^{-1}$	☑
ks3p			0.600	s^{-1}	☑
kd3			0.010	s^{-1}	☑
kas3			10.000	$mol^{-1} \cdot s^{-1}$	☑
kds3			0.010	s^{-1}	☑
kff			10.000	$mol^{-3} \cdot s^{-1}$	☑

6 Function definitions

This is an overview of three function definitions.

6.1 Function definition EMM

Name EMM

Arguments St, Et, Km, kcat

Mathematical Expression

$$0.5 \cdot \mathrm{kcat} \cdot \left(\mathrm{St} + \mathrm{Et} + \mathrm{Km} - \sqrt{2}\right) \tag{1}$$

6.2 Function definition Gamma

Name Gamma

Arguments v, u, J, K

Mathematical Expression

$$\mathrm{v} - \mathrm{u} + \mathrm{v} \cdot \mathrm{J} + \mathrm{u} \cdot \mathrm{K} \tag{2}$$

6.3 Function definition fGK

Name fGK

Arguments v, u, J, K

Mathematical Expression

$$\begin{cases} 0 & \text{if } (\mathrm{v} = 0) \land (\mathrm{u} = 0) \\ \dfrac{2 \cdot \mathrm{u} \cdot \mathrm{K}}{\mathrm{Gamma}\left(\mathrm{v}, \mathrm{u}, \mathrm{J}, \mathrm{K}\right) + \sqrt{2}} & \text{otherwise} \end{cases} \tag{3}$$

7 Rules

This is an overview of eleven rules.

7.1 Rule UFP

Rule UFP is an assignment rule for parameter UFP:

$$\mathrm{UFP} = \mathrm{UFPT} - \mathrm{BiUFP} \tag{4}$$

Derived unit mol

7.2 Rule BiP

Rule BiP is an assignment rule for parameter BiP:

$$\mathrm{BiP} = \mathrm{BiPT} - \mathrm{BiRE1} - \mathrm{BiATF} - \mathrm{BiPER} - \mathrm{BiUFP} \tag{5}$$

Derived unit mol

7.3 Rule IRE1

Rule IRE1 is an assignment rule for parameter IRE1:

$$\mathrm{IRE1} = \mathrm{IRE1T} - \mathrm{BiRE1} - \mathrm{n} \cdot \mathrm{IRE1A} \tag{6}$$

Derived unit mol

7.4 Rule PERK

Rule PERK is an assignment rule for parameter PERK:

$$\mathrm{PERK} = \mathrm{PERKT} - \mathrm{BiPER} - \mathrm{n} \cdot \mathrm{PERKA} \tag{7}$$

Derived unit mol

7.5 Rule ATF6

Rule ATF6 is an assignment rule for parameter ATF6:

$$\mathrm{ATF6} = \mathrm{ATF6T} - \mathrm{BiATF} \tag{8}$$

Derived unit mol

7.6 Rule spliceRate

Rule spliceRate is an assignment rule for parameter spliceRate:

$$\mathrm{spliceRate} = \mathrm{EMM}\left(\mathrm{mXbp1u}, 0.5 \cdot \mathrm{n} \cdot \mathrm{IRE1A}, \mathrm{krcSplice}, \mathrm{ksplice}\right) \tag{9}$$

7.7 Rule eIF2a

Rule eIF2a is an assignment rule for parameter eIF2a:

$$\mathrm{eIF2a} = \mathrm{eIF2aT} \cdot \mathrm{fGK}\left(\mathrm{kphos} \cdot 0.5 \cdot \mathrm{n} \cdot \mathrm{PERKA}, \mathrm{kdephos} \cdot \left(\mathrm{GADD34} + \mathrm{CReP}\right), \frac{\mathrm{J}}{\mathrm{eIF2aT}}, \frac{\mathrm{K}}{\mathrm{eIF2aT}}\right) \tag{10}$$

7.8 Rule BCL2

Rule BCL2 is an assignment rule for parameter BCL2:

$$\mathrm{BCL2} = \mathrm{BCL2T} - \mathrm{BH3BCL2} - \mathrm{BAXmBCL2} \tag{11}$$

Derived unit mol

7.9 Rule BH3

Rule BH3 is an assignment rule for parameter BH3:

$$\mathrm{BH3} = \mathrm{BH3T} - \mathrm{BH3BCL2} \tag{12}$$

Derived unit mol

7.10 Rule BAXm

Rule BAXm is an assignment rule for parameter BAXm:

$$\mathrm{BAXm} = \mathrm{BAXmT} - \mathrm{BAXmBCL2} \tag{13}$$

Derived unit mol

7.11 Rule mUFPT

Rule mUFPT is an assignment rule for parameter mUFPT:

$$\mathrm{mUFPT} = 13 \tag{14}$$

8 Reactions

This model contains 62 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	re2		$\emptyset \longrightarrow$ UFPT	
2	re3		UFPT $\xrightarrow{\text{UFPT}} \emptyset$	
3	re4		UFPT $\xrightarrow{\text{BiUFP, BiUFP, UFPT}} \emptyset$	
4	reu1		$\emptyset \longrightarrow$ BiUFP	
5	reu2		BiUFP $\xrightarrow{\text{BiUFP}} \emptyset$	
6	reu3		$\emptyset \longrightarrow$ BiRE1	
7	reu4		BiRE1 $\xrightarrow{\text{BiRE1}} \emptyset$	
8	reu5		$\emptyset \longrightarrow$ BiATF	
9	reu6		BiATF $\xrightarrow{\text{BiATF}} \emptyset$	
10	reu7		$\emptyset \longrightarrow$ BiPER	
11	reu8		BiPER $\xrightarrow{\text{BiPER}} \emptyset$	
12	reu9		$\emptyset \longrightarrow$ IRE1A	
13	reu10		IRE1A $\xrightarrow{\text{IRE1A}} \emptyset$	
14	reu11		$\emptyset \longrightarrow$ PERKA	
15	reu12		PERKA $\xrightarrow{\text{PERKA}} \emptyset$	
16	re5		$\emptyset \longrightarrow$ ATF6T	
17	re6		ATF6T $\xrightarrow{\text{ATF6T}} \emptyset$	
18	re8		ATF6T $\longrightarrow$ ATF6GB	
19	rew1		ATF6T $\xrightarrow{\text{WFS1, WFS1, ATF6T}} \emptyset$	

№	Id	Name	Reaction Equation	SBO
20	re9		$\text{ATF6GB} \xrightarrow{\text{ATF6GB}} \emptyset$	
21	re10		$\text{ATF6GB} \xrightarrow{\text{ATF6GB}} \text{ATF6p50}$	
22	re11		$\text{ATF6p50} \xrightarrow{\text{ATF6p50}} \emptyset$	
23	rew2		$\emptyset \xrightarrow{\text{ATF6p50, ATF6p50}} \text{mWFS1}$	
24	rew3		$\text{mWFS1} \xrightarrow{\text{mWFS1}} \emptyset$	
25	rew4		$\emptyset \xrightarrow{\text{mWFS1, mWFS1}} \text{WFS1}$	
26	rew5		$\text{WFS1} \xrightarrow{\text{WFS1}} \emptyset$	
27	re12		$\emptyset \xrightarrow{\text{ATF6p50, ATF6p50}} \text{mXbp1u}$	
28	re13		$\text{mXbp1u} \xrightarrow{\text{mXbp1u}} \emptyset$	
29	re14		$\text{mXbp1u} \longrightarrow \text{mXbp1s}$	
30	re15		$\text{mXbp1s} \xrightarrow{\text{mXbp1s}} \emptyset$	
31	re16		$\emptyset \xrightarrow{\text{mXbp1s, mXbp1s}} \text{Xbp1s}$	
32	re17		$\text{Xbp1s} \xrightarrow{\text{Xbp1s}} \emptyset$	
33	re18		$\emptyset \xrightarrow{\text{Xbp1s, ATF6p50, Xbp1s, ATF6p50}} \text{mBiPT}$	
34	re19		$\text{mBiPT} \xrightarrow{\text{mBiPT}} \emptyset$	
35	re20		$\emptyset \xrightarrow{\text{mBiPT, mBiPT}} \text{BiPT}$	
36	re21		$\text{BiPT} \xrightarrow{\text{BiPT}} \emptyset$	
37	re23		$\emptyset \longrightarrow \text{ATF4}$	
38	re24		$\text{ATF4} \xrightarrow{\text{ATF4}} \emptyset$	
39	re25		$\emptyset \xrightarrow{\text{ATF4, ATF6p50, ATF4, ATF6p50}} \text{mCHOP}$	
40	re26		$\text{mCHOP} \xrightarrow{\text{mCHOP}} \emptyset$	

№	Id	Name	Reaction Equation	SBO
41	re27		$\emptyset \xrightarrow{\text{mCHOP, mCHOP}} \text{CHOP}$	
42	re28		$\text{CHOP} \xrightarrow{\text{CHOP}} \emptyset$	
43	re29		$\emptyset \xrightarrow{\text{CHOP, CHOP}} \text{mGADD34}$	
44	re30		$\text{mGADD34} \xrightarrow{\text{mGADD34}} \emptyset$	
45	re31		$\emptyset \xrightarrow{\text{mGADD34, mGADD34}} \text{GADD34}$	
46	re32		$\text{GADD34} \xrightarrow{\text{GADD34}} \emptyset$	
47	rea1		$\emptyset \xrightarrow{\text{CHOP, CHOP}} \text{BCL2T}$	
48	rea2		$\text{BCL2T} \xrightarrow{\text{BCL2T}} \emptyset$	
49	rea3		$\emptyset \longrightarrow \text{BAXmT}$	
50	rea4		$\emptyset \longrightarrow \text{BAXmT}$	
51	rea5		$\text{BAXmT} \xrightarrow{\text{BAXmT}} \emptyset$	
52	rea6		$\text{BAXmT} \xrightarrow{\text{BAXmT}} \emptyset$	
53	rea7		$\text{BAXmT} \xrightarrow{\text{BAXmT}} \emptyset$	
54	rea8		$\emptyset \longrightarrow \text{BH3T}$	
55	rea9		$\emptyset \xrightarrow{\text{CHOP, CHOP}} \text{BH3T}$	
56	rea10		$\text{BH3T} \xrightarrow{\text{BH3T}} \emptyset$	
57	rea11		$\emptyset \longrightarrow \text{BAXmBCL2}$	
58	rea12		$\text{BAXmBCL2} \xrightarrow{\text{BAXmBCL2}} \emptyset$	
59	rea13		$\text{BAXmBCL2} \xrightarrow{\text{BAXmBCL2}} \emptyset$	
60	rea14		$\emptyset \longrightarrow \text{BH3BCL2}$	
61	rea15		$\text{BH3BCL2} \xrightarrow{\text{BH3BCL2}} \emptyset$	
62	rea16		$\text{BH3BCL2} \xrightarrow{\text{BH3BCL2}} \emptyset$	

8.1 Reaction re2

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

Reaction equation

$$\emptyset \longrightarrow \mathrm{UFPT} \tag{15}$$

Product

Table 6: Properties of each product.

Id	Name	SBO
UFPT	UFPT	

Kinetic Law

Derived unit contains undeclared units

$$v_1 = \mathrm{ktrUFP} \cdot \mathrm{mUFPT} \cdot \begin{cases} \dfrac{\mathrm{eIF2a}}{\mathrm{eIF2aT}} & \text{if extATT} = 1 \\ 1 & \text{otherwise} \end{cases} \tag{16}$$

8.2 Reaction re3

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

Reaction equation

$$\mathrm{UFPT} \xrightarrow{\mathrm{UFPT}} \emptyset \tag{17}$$

Reactant

Table 7: Properties of each reactant.

Id	Name	SBO
UFPT	UFPT	

Modifier

Table 8: Properties of each modifier.

Id	Name	SBO
UFPT	UFPT	

Kinetic Law

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

$$v_2 = \mathrm{kdUFP} \cdot \mathrm{UFPT} \tag{18}$$

8.3 Reaction re4

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

Reaction equation

$$\mathrm{UFPT} \xrightarrow{\mathrm{BiUFP,\ BiUFP,\ UFPT}} \emptyset \tag{19}$$

Reactant

Table 9: Properties of each reactant.

Id	Name	SBO
UFPT	UFPT	

Modifiers

Table 10: Properties of each modifier.

Id	Name	SBO
BiUFP	BiUFP	
BiUFP	BiUFP	
UFPT	UFPT	

Kinetic Law

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

$$v_3 = \mathrm{kbu} \cdot \mathrm{BiUFP} \cdot \mathrm{UFPT} \tag{20}$$

8.4 Reaction reu1

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

Reaction equation

$$\emptyset \longrightarrow \mathrm{BiUFP} \tag{21}$$

Product

Table 11: Properties of each product.

Id	Name	SBO
BiUFP	BiUFP	

Kinetic Law

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

$$v_4 = \mathrm{tmr} \cdot \mathrm{kf} \cdot \mathrm{BiP} \cdot \mathrm{UFP} \tag{22}$$

8.5 Reaction reu2

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

Reaction equation

$$\mathrm{BiUFP} \xrightarrow{\mathrm{BiUFP}} \emptyset \tag{23}$$

Reactant

Table 12: Properties of each reactant.

Id	Name	SBO
BiUFP	BiUFP	

Modifier

Table 13: Properties of each modifier.

Id	Name	SBO
BiUFP	BiUFP	

Kinetic Law

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

$$v_5 = \mathrm{tmr} \cdot \mathrm{kr} \cdot \mathrm{BiUFP} \tag{24}$$

8.6 Reaction `reu3`

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

Reaction equation

$$\emptyset \longrightarrow \mathrm{BiRE1} \tag{25}$$

Product

Table 14: Properties of each product.

Id	Name	SBO
`BiRE1`	BiRE1	

Kinetic Law

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

$$v_6 = \mathrm{tmr} \cdot \mathrm{kf} \cdot \mathrm{BiP} \cdot \mathrm{IRE1} \tag{26}$$

8.7 Reaction `reu4`

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

Reaction equation

$$\mathrm{BiRE1} \xrightarrow{\mathrm{BiRE1}} \emptyset \tag{27}$$

Reactant

Table 15: Properties of each reactant.

Id	Name	SBO
`BiRE1`	BiRE1	

Modifier

Table 16: Properties of each modifier.

Id	Name	SBO
BiRE1	BiRE1	

Kinetic Law

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

$$v_7 = \mathrm{tmr} \cdot \mathrm{kr} \cdot \mathrm{BiRE1} \tag{28}$$

8.8 Reaction reu5

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

Reaction equation

$$\emptyset \longrightarrow \mathrm{BiATF} \tag{29}$$

Product

Table 17: Properties of each product.

Id	Name	SBO
BiATF	BiATF	

Kinetic Law

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

$$v_8 = \mathrm{tmr} \cdot \mathrm{kf} \cdot \mathrm{BiP} \cdot \mathrm{ATF6} \tag{30}$$

8.9 Reaction reu6

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

Reaction equation

$$\mathrm{BiATF} \xrightarrow{\mathrm{BiATF}} \emptyset \tag{31}$$

Reactant

Table 18: Properties of each reactant.

Id	Name	SBO
BiATF	BiATF	

Modifier

Table 19: Properties of each modifier.

Id	Name	SBO
BiATF	BiATF	

Kinetic Law

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

$$v_9 = \mathrm{tmr} \cdot \mathrm{kr} \cdot \mathrm{BiATF} \tag{32}$$

8.10 Reaction reu7

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

Reaction equation

$$\emptyset \longrightarrow \mathrm{BiPER} \tag{33}$$

Product

Table 20: Properties of each product.

Id	Name	SBO
BiPER	BiPER	

Kinetic Law

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

$$v_{10} = \mathrm{tmr} \cdot \mathrm{kf} \cdot \mathrm{BiP} \cdot \mathrm{PERK} \tag{34}$$

8.11 Reaction reu8

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

Reaction equation

$$\text{BiPER} \xrightarrow{\text{BiPER}} \emptyset \tag{35}$$

Reactant

Table 21: Properties of each reactant.

Id	Name	SBO
BiPER	BiPER	

Modifier

Table 22: Properties of each modifier.

Id	Name	SBO
BiPER	BiPER	

Kinetic Law

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

$$v_{11} = \text{kr} \cdot \text{tmr} \cdot \text{BiPER} \tag{36}$$

8.12 Reaction reu9

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

Reaction equation

$$\emptyset \longrightarrow \text{IRE1A} \tag{37}$$

Product

Table 23: Properties of each product.

Id	Name	SBO
IRE1A	IRE1A	

Kinetic Law

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

$$v_{12} = \text{tmr} \cdot \text{kff} \cdot \text{IRE1}^{\text{n}} \tag{38}$$

8.13 Reaction reu10

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

Reaction equation

$$\text{IRE1A} \xrightarrow{\text{IRE1A}} \emptyset \tag{39}$$

Reactant

Table 24: Properties of each reactant.

Id	Name	SBO
IRE1A	IRE1A	

Modifier

Table 25: Properties of each modifier.

Id	Name	SBO
IRE1A	IRE1A	

Kinetic Law

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

$$v_{13} = \text{tmr} \cdot \text{kr} \cdot \text{IRE1A} \tag{40}$$

8.14 Reaction reu11

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

Reaction equation

$$\emptyset \longrightarrow \text{PERKA} \tag{41}$$

Product

Table 26: Properties of each product.

Id	Name	SBO
PERKA	PERKA	

Kinetic Law

Derived unit contains undeclared units

$$v_{14} = \text{tmr} \cdot \text{kff} \cdot \begin{cases} \text{UFP} & \text{if switch} = 1 \\ 1 & \text{otherwise} \end{cases} \cdot \text{PERK}^{\text{n}} \tag{42}$$

8.15 Reaction reu12

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

Reaction equation

$$\text{PERKA} \xrightarrow{\text{PERKA}} \emptyset \tag{43}$$

Reactant

Table 27: Properties of each reactant.

Id	Name	SBO
PERKA	PERKA	

Modifier

Table 28: Properties of each modifier.

Id	Name	SBO
PERKA	PERKA	

Kinetic Law

Derived unit contains undeclared units

$$v_{15} = \frac{\text{tmr} \cdot \text{kr} \cdot \text{PERKA}}{1 + \text{extPERK} \cdot \text{UFP}} \tag{44}$$

8.16 Reaction re5

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

Reaction equation

$$\emptyset \longrightarrow \text{ATF6T} \tag{45}$$

Product

Table 29: Properties of each product.

Id	Name	SBO
ATF6T	ATF6T	

Kinetic Law

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

$$v_{16} = \text{ktrATF6} \cdot \text{mATF6T} \tag{46}$$

8.17 Reaction re6

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

Reaction equation

$$\text{ATF6T} \xrightarrow{\text{ATF6T}} \emptyset \tag{47}$$

Reactant

Table 30: Properties of each reactant.

Id	Name	SBO
ATF6T	ATF6T	

Modifier

Table 31: Properties of each modifier.

Id	Name	SBO
ATF6T	ATF6T	

Kinetic Law

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

$$v_{17} = \mathrm{kdATF6} \cdot \mathrm{ATF6T} \tag{48}$$

8.18 Reaction `re8`

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

Reaction equation

$$\mathrm{ATF6T} \longrightarrow \mathrm{ATF6GB} \tag{49}$$

Reactant

Table 32: Properties of each reactant.

Id	Name	SBO
`ATF6T`	ATF6T	

Product

Table 33: Properties of each product.

Id	Name	SBO
`ATF6GB`	ATF6GB	

Kinetic Law

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

$$v_{18} = \mathrm{ktrans} \cdot \mathrm{ATF6} \tag{50}$$

8.19 Reaction `rew1`

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

Reaction equation

$$\mathrm{ATF6T} \xrightarrow{\mathrm{WFS1},\ \mathrm{WFS1},\ \mathrm{ATF6T}} \emptyset \tag{51}$$

Reactant

Table 34: Properties of each reactant.

Id	Name	SBO
ATF6T	ATF6T	

Modifiers

Table 35: Properties of each modifier.

Id	Name	SBO
WFS1	WFS1	
WFS1	WFS1	
ATF6T	ATF6T	

Kinetic Law

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

$$v_{19} = \mathrm{kdeAW} \cdot \mathrm{WFS1} \cdot \mathrm{ATF6T} \tag{52}$$

8.20 Reaction re9

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

Reaction equation

$$\mathrm{ATF6GB} \xrightarrow{\mathrm{ATF6GB}} \emptyset \tag{53}$$

Reactant

Table 36: Properties of each reactant.

Id	Name	SBO
ATF6GB	ATF6GB	

Modifier

Table 37: Properties of each modifier.

Id	Name	SBO
ATF6GB	ATF6GB	

Kinetic Law

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

$$v_{20} = \mathrm{kdATF6GB} \cdot \mathrm{ATF6GB} \tag{54}$$

8.21 Reaction `re10`

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

Reaction equation

$$\mathrm{ATF6GB} \xrightarrow{\mathrm{ATF6GB}} \mathrm{ATF6p50} \tag{55}$$

Reactant

Table 38: Properties of each reactant.

Id	Name	SBO
`ATF6GB`	ATF6GB	

Modifier

Table 39: Properties of each modifier.

Id	Name	SBO
`ATF6GB`	ATF6GB	

Product

Table 40: Properties of each product.

Id	Name	SBO
`ATF6p50`	ATF6p50	

Kinetic Law

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

$$v_{21} = \mathrm{kcleave} \cdot \mathrm{ATF6GB} \tag{56}$$

8.22 Reaction re11

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

Reaction equation

$$\mathrm{ATF6p50} \xrightarrow{\mathrm{ATF6p50}} \emptyset \tag{57}$$

Reactant

Table 41: Properties of each reactant.

Id	Name	SBO
ATF6p50	ATF6p50	

Modifier

Table 42: Properties of each modifier.

Id	Name	SBO
ATF6p50	ATF6p50	

Kinetic Law

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

$$v_{22} = \mathrm{kdATF6p50} \cdot \mathrm{ATF6p50} \tag{58}$$

8.23 Reaction rew2

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

Reaction equation

$$\emptyset \xrightarrow{\mathrm{ATF6p50,\ ATF6p50}} \mathrm{mWFS1} \tag{59}$$

Modifiers

Table 43: Properties of each modifier.

Id	Name	SBO
ATF6p50	ATF6p50	

Id	Name	SBO
ATF6p50	ATF6p50	

Product

Table 44: Properties of each product.

Id	Name	SBO
mWFS1	mWFS1	

Kinetic Law

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

$$v_{23} = \frac{\mathrm{trcWFS} \cdot \mathrm{ATF6p50}}{\mathrm{krcWFS} + \mathrm{ATF6p50}} \tag{60}$$

8.24 Reaction rew3

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

Reaction equation

$$\mathrm{mWFS1} \xrightarrow{\mathrm{mWFS1}} \emptyset \tag{61}$$

Reactant

Table 45: Properties of each reactant.

Id	Name	SBO
mWFS1	mWFS1	

Modifier

Table 46: Properties of each modifier.

Id	Name	SBO
mWFS1	mWFS1	

Kinetic Law

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

$$v_{24} = \mathrm{kdmWFS} \cdot \mathrm{mWFS1} \tag{62}$$

8.25 Reaction `rew4`

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

Reaction equation

$$\emptyset \xrightarrow{\mathrm{mWFS1,\ mWFS1}} \mathrm{WFS1} \tag{63}$$

Modifiers

Table 47: Properties of each modifier.

Id	Name	SBO
`mWFS1`	mWFS1	
`mWFS1`	mWFS1	

Product

Table 48: Properties of each product.

Id	Name	SBO
`WFS1`	WFS1	

Kinetic Law

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

$$v_{25} = \mathrm{ktrWFS} \cdot \mathrm{mWFS1} \tag{64}$$

8.26 Reaction `rew5`

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

Reaction equation

$$\mathrm{WFS1} \xrightarrow{\mathrm{WFS1}} \emptyset \tag{65}$$

Reactant

Table 49: Properties of each reactant.

Id	Name	SBO
WFS1	WFS1	

Modifier

Table 50: Properties of each modifier.

Id	Name	SBO
WFS1	WFS1	

Kinetic Law

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

$$v_{26} = \mathrm{kdWFS} \cdot \mathrm{WFS1} \tag{66}$$

8.27 Reaction re12

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

Reaction equation

$$\emptyset \xrightarrow{\text{ATF6p50, ATF6p50}} \mathrm{mXbp1u} \tag{67}$$

Modifiers

Table 51: Properties of each modifier.

Id	Name	SBO
ATF6p50	ATF6p50	
ATF6p50	ATF6p50	

Product

Table 52: Properties of each product.

Id	Name	SBO
mXbp1u	mXbp1u	

Kinetic Law

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

$$v_{27} = \frac{\mathrm{trcXU} \cdot (\mathrm{basalXBP} + \mathrm{kmAtfsXBP} \cdot \mathrm{ATF6p50})}{\mathrm{krcXU} + \mathrm{basalXBP} + \mathrm{kmAtfsXBP} \cdot \mathrm{ATF6p50}} \tag{68}$$

8.28 Reaction re13

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

Reaction equation

$$\mathrm{mXbp1u} \xrightarrow{\mathrm{mXbp1u}} \emptyset \tag{69}$$

Reactant

Table 53: Properties of each reactant.

Id	Name	SBO
mXbp1u	mXbp1u	

Modifier

Table 54: Properties of each modifier.

Id	Name	SBO
mXbp1u	mXbp1u	

Kinetic Law

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

$$v_{28} = \mathrm{kdmXU} \cdot \mathrm{mXbp1u} \tag{70}$$

8.29 Reaction re14

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

Reaction equation

$$\text{mXbp1u} \longrightarrow \text{mXbp1s} \tag{71}$$

Reactant

Table 55: Properties of each reactant.

Id	Name	SBO
mXbp1u	mXbp1u	

Product

Table 56: Properties of each product.

Id	Name	SBO
mXbp1s	mXbp1s	

Kinetic Law

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

$$v_{29} = \text{spliceRate} \tag{72}$$

8.30 Reaction re15

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

Reaction equation

$$\text{mXbp1s} \xrightarrow{\text{mXbp1s}} \emptyset \tag{73}$$

Reactant

Table 57: Properties of each reactant.

Id	Name	SBO
mXbp1s	mXbp1s	

Modifier

Table 58: Properties of each modifier.

Id	Name	SBO
mXbp1s	mXbp1s	

Kinetic Law

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

$$v_{30} = \mathrm{kdmXS} \cdot \mathrm{mXbp1s} \tag{74}$$

8.31 Reaction re16

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

Reaction equation

$$\emptyset \xrightarrow{\mathrm{mXbp1s},\ \mathrm{mXbp1s}} \mathrm{Xbp1s} \tag{75}$$

Modifiers

Table 59: Properties of each modifier.

Id	Name	SBO
mXbp1s	mXbp1s	
mXbp1s	mXbp1s	

Product

Table 60: Properties of each product.

Id	Name	SBO
Xbp1s	Xbp1s	

Kinetic Law

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

$$v_{31} = \mathrm{ktrXS} \cdot \mathrm{mXbp1s} \tag{76}$$

8.32 Reaction re17

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

Reaction equation

$$\mathrm{Xbp1s} \xrightarrow{\mathrm{Xbp1s}} \emptyset \tag{77}$$

Reactant

Table 61: Properties of each reactant.

Id	Name	SBO
Xbp1s	Xbp1s	

Modifier

Table 62: Properties of each modifier.

Id	Name	SBO
Xbp1s	Xbp1s	

Kinetic Law

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

$$v_{32} = \mathrm{kdXS} \cdot \mathrm{Xbp1s} \tag{78}$$

8.33 Reaction re18

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

Reaction equation

$$\emptyset \xrightarrow{\mathrm{Xbp1s,\ ATF6p50,\ Xbp1s,\ ATF6p50}} \mathrm{mBiPT} \tag{79}$$

Modifiers

Table 63: Properties of each modifier.

Id	Name	SBO
Xbp1s	Xbp1s	
ATF6p50	ATF6p50	
Xbp1s	Xbp1s	
ATF6p50	ATF6p50	

Product

Table 64: Properties of each product.

Id	Name	SBO
mBiPT	mBiPT	

Kinetic Law

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

$$v_{33} = \frac{\mathrm{trcBiP} \cdot (\mathrm{basalBiP} + \mathrm{kmXbp} \cdot \mathrm{Xbp1s} + \mathrm{kmAtfsBiP} \cdot \mathrm{ATF6p50})}{\mathrm{krcBiP} + \mathrm{basalBiP} + \mathrm{kmXbp} \cdot \mathrm{Xbp1s} + \mathrm{kmAtfsBiP} \cdot \mathrm{ATF6p50}} \tag{80}$$

8.34 Reaction re19

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

Reaction equation

$$\mathrm{mBiPT} \xrightarrow{\mathrm{mBiPT}} \emptyset \tag{81}$$

Reactant

Table 65: Properties of each reactant.

Id	Name	SBO
mBiPT	mBiPT	

Modifier

Table 66: Properties of each modifier.

Id	Name	SBO
mBiPT	mBiPT	

Kinetic Law

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

$$v_{34} = \mathrm{kdmBiP} \cdot \mathrm{mBiPT} \tag{82}$$

8.35 Reaction re20

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

Reaction equation

$$\emptyset \xrightarrow{\text{mBiPT, mBiPT}} \text{BiPT} \tag{83}$$

Modifiers

Table 67: Properties of each modifier.

Id	Name	SBO
mBiPT	mBiPT	
mBiPT	mBiPT	

Product

Table 68: Properties of each product.

Id	Name	SBO
BiPT	BiPT	

Kinetic Law

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

$$v_{35} = \text{ktrBiP} \cdot \text{mBiPT} \tag{84}$$

8.36 Reaction re21

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

Reaction equation

$$\text{BiPT} \xrightarrow{\text{BiPT}} \emptyset \tag{85}$$

Reactant

Table 69: Properties of each reactant.

Id	Name	SBO
BiPT	BiPT	

Modifier

Table 70: Properties of each modifier.

Id	Name	SBO
BiPT	BiPT	

Kinetic Law

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

$$v_{36} = \mathrm{kdBiP} \cdot \mathrm{BiPT} \tag{86}$$

8.37 Reaction re23

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

Reaction equation

$$\emptyset \longrightarrow \mathrm{ATF4} \tag{87}$$

Product

Table 71: Properties of each product.

Id	Name	SBO
ATF4	ATF4	

Kinetic Law

Derived unit contains undeclared units

$$v_{37} = \frac{\mathrm{ktrATF4} \cdot \mathrm{mATF4}}{1 + \left(\frac{\mathrm{eIF2a}}{\mathrm{kATF4}}\right)^{\mathrm{nh}}} \tag{88}$$

8.38 Reaction re24

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

Reaction equation

$$\mathrm{ATF4} \xrightarrow{\mathrm{ATF4}} \emptyset \tag{89}$$

Reactant

Table 72: Properties of each reactant.

Id	Name	SBO
ATF4	ATF4	

Modifier

Table 73: Properties of each modifier.

Id	Name	SBO
ATF4	ATF4	

Kinetic Law

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

$$v_{38} = \mathrm{kdATF4} \cdot \mathrm{ATF4} \tag{90}$$

8.39 Reaction re25

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

Reaction equation

$$\emptyset \xrightarrow{\mathrm{ATF4,\ ATF6p50,\ ATF4,\ ATF6p50}} \mathrm{mCHOP} \tag{91}$$

Modifiers

Table 74: Properties of each modifier.

Id	Name	SBO
ATF4	ATF4	
ATF6p50	ATF6p50	
ATF4	ATF4	
ATF6p50	ATF6p50	

Product

Table 75: Properties of each product.

Id	Name	SBO
mCHOP	mCHOP	

Kinetic Law

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

$$v_{39} = \frac{\mathrm{trcCHOP} \cdot (\mathrm{kmAtff} \cdot \mathrm{ATF4} + \mathrm{kmAtfs} \cdot \mathrm{ATF6p50})}{\mathrm{krcCHOP} + \mathrm{kmAtff} \cdot \mathrm{ATF4} + \mathrm{kmAtfs} \cdot \mathrm{ATF6p50}} \tag{92}$$

8.40 Reaction re26

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

Reaction equation

$$\mathrm{mCHOP} \xrightarrow{\mathrm{mCHOP}} \emptyset \tag{93}$$

Reactant

Table 76: Properties of each reactant.

Id	Name	SBO
mCHOP	mCHOP	

Modifier

Table 77: Properties of each modifier.

Id	Name	SBO
mCHOP	mCHOP	

Kinetic Law

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

$$v_{40} = \mathrm{kdmCHOP} \cdot \mathrm{mCHOP} \tag{94}$$

8.41 Reaction re27

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

Reaction equation

$$\emptyset \xrightarrow{\text{mCHOP, mCHOP}} \text{CHOP} \tag{95}$$

Modifiers

Table 78: Properties of each modifier.

Id	Name	SBO
mCHOP	mCHOP	
mCHOP	mCHOP	

Product

Table 79: Properties of each product.

Id	Name	SBO
CHOP	CHOP	

Kinetic Law

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

$$v_{41} = \text{ktrCHOP} \cdot \text{mCHOP} \tag{96}$$

8.42 Reaction re28

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

Reaction equation

$$\text{CHOP} \xrightarrow{\text{CHOP}} \emptyset \tag{97}$$

Reactant

Table 80: Properties of each reactant.

Id	Name	SBO
CHOP	CHOP	

Modifier

Table 81: Properties of each modifier.

Id	Name	SBO
CHOP	CHOP	

Kinetic Law

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

$$v_{42} = \mathrm{kdCHOP} \cdot \mathrm{CHOP} \tag{98}$$

8.43 Reaction re29

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

Reaction equation

$$\emptyset \xrightarrow{\mathrm{CHOP},\ \mathrm{CHOP}} \mathrm{mGADD34} \tag{99}$$

Modifiers

Table 82: Properties of each modifier.

Id	Name	SBO
CHOP	CHOP	
CHOP	CHOP	

Product

Table 83: Properties of each product.

Id	Name	SBO
mGADD34	mGADD34	

Kinetic Law

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

$$v_{43} = \frac{\mathrm{trcGADD34} \cdot \mathrm{kmChop} \cdot \mathrm{CHOP}}{\mathrm{krcGADD34} + \mathrm{kmChop} \cdot \mathrm{CHOP}} \tag{100}$$

8.44 Reaction re30

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

Reaction equation

$$\mathrm{mGADD34} \xrightarrow{\mathrm{mGADD34}} \emptyset \tag{101}$$

Reactant

Table 84: Properties of each reactant.

Id	Name	SBO
mGADD34	mGADD34	

Modifier

Table 85: Properties of each modifier.

Id	Name	SBO
mGADD34	mGADD34	

Kinetic Law

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

$$v_{44} = \mathrm{kdmGADD34} \cdot \mathrm{mGADD34} \tag{102}$$

8.45 Reaction re31

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

Reaction equation

$$\emptyset \xrightarrow{\mathrm{mGADD34,\ mGADD34}} \mathrm{GADD34} \tag{103}$$

Modifiers

Table 86: Properties of each modifier.

Id	Name	SBO
mGADD34	mGADD34	
mGADD34	mGADD34	

Product

Table 87: Properties of each product.

Id	Name	SBO
GADD34	GADD34	

Kinetic Law

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

$$v_{45} = \mathrm{ktrGADD34} \cdot \mathrm{mGADD34} \tag{104}$$

8.46 Reaction re32

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

Reaction equation

$$\mathrm{GADD34} \xrightarrow{\mathrm{GADD34}} \emptyset \tag{105}$$

Reactant

Table 88: Properties of each reactant.

Id	Name	SBO
GADD34	GADD34	

Modifier

Table 89: Properties of each modifier.

Id	Name	SBO
GADD34	GADD34	

Kinetic Law

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

$$v_{46} = \mathrm{kdGADD34} \cdot \mathrm{GADD34} \tag{106}$$

8.47 Reaction rea1

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

Reaction equation

$$\emptyset \xrightarrow{\mathrm{CHOP,\ CHOP}} \mathrm{BCL2T} \tag{107}$$

Modifiers

Table 90: Properties of each modifier.

Id	Name	SBO
CHOP	CHOP	
CHOP	CHOP	

Product

Table 91: Properties of each product.

Id	Name	SBO
BCL2T	BCL2T	

Kinetic Law

Derived unit contains undeclared units

$$v_{47} = \frac{\mathrm{kfbc}}{1 + \mathrm{kmbc} \cdot \mathrm{CHOP}} \tag{108}$$

8.48 Reaction rea2

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

Reaction equation

$$\mathrm{BCL2T} \xrightarrow{\mathrm{BCL2T}} \emptyset \tag{109}$$

Reactant

Table 92: Properties of each reactant.

Id	Name	SBO
BCL2T	BCL2T	

Modifier

Table 93: Properties of each modifier.

Id	Name	SBO
BCL2T	BCL2T	

Kinetic Law

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

$$v_{48} = \mathrm{kdbc} \cdot \mathrm{BCL2T} \tag{110}$$

8.49 Reaction rea3

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

Reaction equation

$$\emptyset \longrightarrow \mathrm{BAXmT} \tag{111}$$

Product

Table 94: Properties of each product.

Id	Name	SBO
BAXmT	BAXmT	

Kinetic Law

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

$$v_{49} = \mathrm{kfx} \cdot \mathrm{BAXT} \tag{112}$$

8.50 Reaction `rea4`

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

Reaction equation

$$\emptyset \longrightarrow \mathrm{BAXmT} \tag{113}$$

Product

Table 95: Properties of each product.

Id	Name	SBO
`BAXmT`	BAXmT	

Kinetic Law

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

$$v_{50} = \mathrm{kfxp} \cdot \mathrm{BH3} \cdot \mathrm{BAXT} \tag{114}$$

8.51 Reaction `rea5`

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

Reaction equation

$$\mathrm{BAXmT} \xrightarrow{\mathrm{BAXmT}} \emptyset \tag{115}$$

Reactant

Table 96: Properties of each reactant.

Id	Name	SBO
`BAXmT`	BAXmT	

Modifier

Table 97: Properties of each modifier.

Id	Name	SBO
BAXmT	BAXmT	

Kinetic Law

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

$$v_{51} = \mathrm{kfx} \cdot \mathrm{BAXmT} \tag{116}$$

8.52 Reaction rea6

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

Reaction equation

$$\mathrm{BAXmT} \xrightarrow{\mathrm{BAXmT}} \emptyset \tag{117}$$

Reactant

Table 98: Properties of each reactant.

Id	Name	SBO
BAXmT	BAXmT	

Modifier

Table 99: Properties of each modifier.

Id	Name	SBO
BAXmT	BAXmT	

Kinetic Law

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

$$v_{52} = \mathrm{kfxp} \cdot \mathrm{BH3} \cdot \mathrm{BAXmT} \tag{118}$$

8.53 Reaction rea7

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

Reaction equation

$$\mathrm{BAXmT} \xrightarrow{\mathrm{BAXmT}} \emptyset \tag{119}$$

Reactant

Table 100: Properties of each reactant.

Id	Name	SBO
BAXmT	BAXmT	

Modifier

Table 101: Properties of each modifier.

Id	Name	SBO
BAXmT	BAXmT	

Kinetic Law

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

$$v_{53} = \mathrm{kbx} \cdot \mathrm{BAXmT} \tag{120}$$

8.54 Reaction rea8

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

Reaction equation

$$\emptyset \longrightarrow \mathrm{BH3T} \tag{121}$$

Product

Table 102: Properties of each product.

Id	Name	SBO
BH3T	BH3T	

Kinetic Law

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

$$v_{54} = \mathrm{ks3} \tag{122}$$

8.55 Reaction `rea9`

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

Reaction equation

$$\emptyset \xrightarrow{\mathrm{CHOP,\ CHOP}} \mathrm{BH3T} \tag{123}$$

Modifiers

Table 103: Properties of each modifier.

Id	Name	SBO
`CHOP`	CHOP	
`CHOP`	CHOP	

Product

Table 104: Properties of each product.

Id	Name	SBO
`BH3T`	BH3T	

Kinetic Law

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

$$v_{55} = \mathrm{ks3p} \cdot \mathrm{kstr} \cdot \mathrm{CHOP} \tag{124}$$

8.56 Reaction `rea10`

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

Reaction equation

$$\mathrm{BH3T} \xrightarrow{\mathrm{BH3T}} \emptyset \tag{125}$$

Reactant

Table 105: Properties of each reactant.

Id	Name	SBO
BH3T	BH3T	

Modifier

Table 106: Properties of each modifier.

Id	Name	SBO
BH3T	BH3T	

Kinetic Law

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

$$v_{56} = \mathrm{kd3} \cdot \mathrm{BH3T} \tag{126}$$

8.57 Reaction rea11

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

Reaction equation

$$\emptyset \longrightarrow \mathrm{BAXmBCL2} \tag{127}$$

Product

Table 107: Properties of each product.

Id	Name	SBO
BAXmBCL2	BAXmBCL2	

Kinetic Law

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

$$v_{57} = \mathrm{kasx} \cdot \mathrm{BAXm} \cdot \mathrm{BCL2} \tag{128}$$

8.58 Reaction rea12

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

Reaction equation

$$\text{BAXmBCL2} \xrightarrow{\text{BAXmBCL2}} \emptyset \tag{129}$$

Reactant

Table 108: Properties of each reactant.

Id	Name	SBO
BAXmBCL2	BAXmBCL2	

Modifier

Table 109: Properties of each modifier.

Id	Name	SBO
BAXmBCL2	BAXmBCL2	

Kinetic Law

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

$$v_{58} = \text{kdsx} \cdot \text{BAXmBCL2} \tag{130}$$

8.59 Reaction rea13

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

Reaction equation

$$\text{BAXmBCL2} \xrightarrow{\text{BAXmBCL2}} \emptyset \tag{131}$$

Reactant

Table 110: Properties of each reactant.

Id	Name	SBO
BAXmBCL2	BAXmBCL2	

Modifier

Table 111: Properties of each modifier.

Id	Name	SBO
BAXmBCL2	BAXmBCL2	

Kinetic Law

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

$$v_{59} = \mathrm{kbx} \cdot \mathrm{BAXmBCL2} \tag{132}$$

8.60 Reaction rea14

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

Reaction equation

$$\emptyset \longrightarrow \mathrm{BH3BCL2} \tag{133}$$

Product

Table 112: Properties of each product.

Id	Name	SBO
BH3BCL2	BH3BCL2	

Kinetic Law

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

$$v_{60} = \mathrm{kas3} \cdot \mathrm{BH3} \cdot \mathrm{BCL2} \tag{134}$$

8.61 Reaction rea15

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

Reaction equation

$$\mathrm{BH3BCL2} \xrightarrow{\mathrm{BH3BCL2}} \emptyset \tag{135}$$

Reactant

Table 113: Properties of each reactant.

Id	Name	SBO
BH3BCL2	BH3BCL2	

Modifier

Table 114: Properties of each modifier.

Id	Name	SBO
BH3BCL2	BH3BCL2	

Kinetic Law

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

$$v_{61} = \mathrm{kds3} \cdot \mathrm{BH3BCL2} \tag{136}$$

8.62 Reaction rea16

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

Reaction equation

$$\mathrm{BH3BCL2} \xrightarrow{\mathrm{BH3BCL2}} \emptyset \tag{137}$$

Reactant

Table 115: Properties of each reactant.

Id	Name	SBO
BH3BCL2	BH3BCL2	

Modifier

Table 116: Properties of each modifier.

Id	Name	SBO
BH3BCL2	BH3BCL2	

Kinetic Law

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

$$v_{62} = \mathrm{kd3} \cdot \mathrm{BH3BCL2} \tag{138}$$

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 `UFPT`

Name UFPT

Initial amount 0

This species takes part in five reactions (as a reactant in `re3`, `re4` and as a product in `re2` and as a modifier in `re3`, `re4`).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{UFPT} = v_1 - v_2 - v_3 \tag{139}$$

9.2 Species `BiUFP`

Name BiUFP

Initial amount 0

This species takes part in five reactions (as a reactant in `reu2` and as a product in `reu1` and as a modifier in `re4`, `re4`, `reu2`).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{BiUFP} = v_4 - v_5 \tag{140}$$

9.3 Species BiRE1

Name BiRE1

Initial amount 0

This species takes part in three reactions (as a reactant in reu4 and as a product in reu3 and as a modifier in reu4).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{BiRE1} = v_6 - v_7 \tag{141}$$

9.4 Species BiATF

Name BiATF

Initial amount 0

This species takes part in three reactions (as a reactant in reu6 and as a product in reu5 and as a modifier in reu6).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{BiATF} = v_8 - v_9 \tag{142}$$

9.5 Species BiPER

Name BiPER

Initial amount 0

This species takes part in three reactions (as a reactant in reu8 and as a product in reu7 and as a modifier in reu8).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{BiPER} = v_{10} - v_{11} \tag{143}$$

9.6 Species IRE1A

Name IRE1A

Initial amount 0

This species takes part in three reactions (as a reactant in reu10 and as a product in reu9 and as a modifier in reu10).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{IRE1A} = v_{12} - v_{13} \tag{144}$$

9.7 Species PERKA

Name PERKA

Initial amount 0

This species takes part in three reactions (as a reactant in reu12 and as a product in reu11 and as a modifier in reu12).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{PERKA} = v_{14} - v_{15} \tag{145}$$

9.8 Species mXbp1u

Name mXbp1u

Initial amount 0

This species takes part in four reactions (as a reactant in re13, re14 and as a product in re12 and as a modifier in re13).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{mXbp1u} = v_{27} - v_{28} - v_{29} \tag{146}$$

9.9 Species mXbp1s

Name mXbp1s

Initial amount 0

This species takes part in five reactions (as a reactant in re15 and as a product in re14 and as a modifier in re15, re16, re16).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{mXbp1s} = v_{29} - v_{30} \tag{147}$$

9.10 Species Xbp1s

Name Xbp1s

Initial amount 0

This species takes part in five reactions (as a reactant in re17 and as a product in re16 and as a modifier in re17, re18, re18).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{Xbp1s} = v_{31} - v_{32} \tag{148}$$

9.11 Species mBiPT

Name mBiPT

Initial amount 0

This species takes part in five reactions (as a reactant in re19 and as a product in re18 and as a modifier in re19, re20, re20).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{mBiPT} = v_{33} - v_{34} \tag{149}$$

9.12 Species BiPT

Name BiPT

Initial amount 0

This species takes part in three reactions (as a reactant in re21 and as a product in re20 and as a modifier in re21).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{BiPT} = v_{35} - v_{36} \tag{150}$$

9.13 Species ATF6T

Name ATF6T

Initial amount 0

This species takes part in six reactions (as a reactant in re6, re8, rew1 and as a product in re5 and as a modifier in re6, rew1).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{ATF6T} = v_{16} - v_{17} - v_{18} - v_{19} \tag{151}$$

9.14 Species ATF6GB

Name ATF6GB

Initial amount 0

This species takes part in five reactions (as a reactant in re9, re10 and as a product in re8 and as a modifier in re9, re10).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{ATF6GB} = v_{18} - v_{20} - v_{21} \tag{152}$$

9.15 Species ATF6p50

Name ATF6p50

Initial amount 0

This species takes part in eleven reactions (as a reactant in re11 and as a product in re10 and as a modifier in re11, rew2, rew2, re12, re12, re18, re18, re25, re25).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{ATF6p50} = v_{21} - v_{22} \tag{153}$$

9.16 Species mWFS1

Name mWFS1

Initial amount 0

This species takes part in five reactions (as a reactant in rew3 and as a product in rew2 and as a modifier in rew3, rew4, rew4).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{mWFS1} = v_{23} - v_{24} \tag{154}$$

9.17 Species WFS1

Name WFS1

Initial amount 0

This species takes part in five reactions (as a reactant in rew5 and as a product in rew4 and as a modifier in rew1, rew1, rew5).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{WFS1} = v_{25} - v_{26} \tag{155}$$

9.18 Species ATF4

Name ATF4

Initial amount 0

This species takes part in five reactions (as a reactant in re24 and as a product in re23 and as a modifier in re24, re25, re25).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{ATF4} = v_{37} - v_{38} \tag{156}$$

9.19 Species mCHOP

Name mCHOP

Initial amount 0

This species takes part in five reactions (as a reactant in re26 and as a product in re25 and as a modifier in re26, re27, re27).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{mCHOP} = v_{39} - v_{40} \tag{157}$$

9.20 Species CHOP

Name CHOP

Initial amount 0

This species takes part in nine reactions (as a reactant in re28 and as a product in re27 and as a modifier in re28, re29, re29, rea1, rea1, rea9, rea9).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{CHOP} = v_{41} - v_{42} \tag{158}$$

9.21 Species mGADD34

Name mGADD34

Initial amount 0

This species takes part in five reactions (as a reactant in re30 and as a product in re29 and as a modifier in re30, re31, re31).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{mGADD34} = v_{43} - v_{44} \tag{159}$$

9.22 Species GADD34

Name GADD34

Initial amount 0

This species takes part in three reactions (as a reactant in re32 and as a product in re31 and as a modifier in re32).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{GADD34} = v_{45} - v_{46} \tag{160}$$

9.23 Species BCL2T

Name BCL2T

Initial amount 0

This species takes part in three reactions (as a reactant in rea2 and as a product in rea1 and as a modifier in rea2).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{BCL2T} = v_{47} - v_{48} \tag{161}$$

9.24 Species BAXmT

Name BAXmT

Initial amount 0

This species takes part in eight reactions (as a reactant in rea5, rea6, rea7 and as a product in rea3, rea4 and as a modifier in rea5, rea6, rea7).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{BAXmT} = v_{49} + v_{50} - v_{51} - v_{52} - v_{53} \tag{162}$$

9.25 Species BH3T

Name BH3T

Initial amount 0

This species takes part in four reactions (as a reactant in rea10 and as a product in rea8, rea9 and as a modifier in rea10).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{BH3T} = v_{54} + v_{55} - v_{56} \tag{163}$$

9.26 Species BAXmBCL2

Name BAXmBCL2

Initial amount 0

This species takes part in five reactions (as a reactant in rea12, rea13 and as a product in rea11 and as a modifier in rea12, rea13).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{BAXmBCL2} = v_{57} - v_{58} - v_{59} \tag{164}$$

9.27 Species BH3BCL2

Name BH3BCL2

Initial amount 0

This species takes part in five reactions (as a reactant in rea15, rea16 and as a product in rea14 and as a modifier in rea15, rea16).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{BH3BCL2} = v_{60} - v_{61} - v_{62} \tag{165}$$

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