SBML Model Report

Model name: "Hui2014 - Age-related changes in articular cartilage"

May 6, 2016

1 General Overview

This is a document in SBML Level 2 Version 4 format. This model was created by the following two authors: Vijayalakshmi Chelliah[1] and Carole Proctor[2] at December fifth 2014 at 5:02 p.m. and last time modified at April eighth 2016 at 5:51 p.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	4
species types	0	species	65
events	0	constraints	0
reactions	117	function definitions	0
global parameters	113	unit definitions	1
rules	0	initial assignments	0

Model Notes

Hui2014 - Age-related changes in articularcartilage

This model is described in the article:Oxidative changes and signalling pathways are pivotal in initiating age-related changes in articular cartilageWang Hui1, David A Young1, Andrew D Rowan1, Xin Xu2, Tim E Cawston1, Carole J Proctor1,3Annals of the Rheumatic Diseases

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Abstract:

Objective: To use a computational approach to investigate the cellular and extracellular matrix changes that occur with age in the knee joints of mice. Methods: Knee joints from an inbred C57/BL1/6 (ICRFa) mouse colony were harvested at 330?months of age. Sections were stained with H&E, Safranin-O, Picro-sirius red and antibodies to matrix metalloproteinase-13 (MMP-13), nitrotyrosine, LC-3B, Bcl-2, and cleaved type II collagen used for immunohistochemistry. Based on this and other data from the literature, a computer simulation model was built using the Systems Biology Markup Language using an iterative approach of data analysis and modelling. Individual parameters were subsequently altered to assess their effect on the model. Results: A progressive loss of cartilage matrix occurred with age. Nitrotyrosine, MMP-13 and anaplastic lymphoma kinase (ALK1) staining in cartilage increased with age with a concomitant decrease in LC-3B and Bcl-2. Stochastic simulations from the computational model showed a good agreement with these data, once transforming growth factor-? signalling via ALK1/ALK5 receptors was included. Oxidative stress and the interleukin 1 pathway were identified as key factors in driving the cartilage breakdown associated with ageing. Conclusions: A progressive loss of cartilage matrix and cellularity occurs with age. This is accompanied with increased levels of oxidative stress, apoptosis and MMP-13 and a decrease in chondrocyte autophagy. These changes explain the marked predisposition of joints to develop osteoarthritis with age. Computational modelling provides useful insights into the underlying mechanisms involved in age-related changes in musculoskeletal tissues.

This model is hosted on BioModels Database and identified by: BIOMD0000000560.

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 four are predefined by SBML and not mentioned in the model.

2.1 Unit substance

Definition item

2.2 Unit volume

Notes Litre is the predefined SBML unit for volume.

Definition l

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 Compartments

This model contains four compartments.

Table 2: Properties of all compartments.

Id	Name	SBO	Spatial Dimensions	Size	Unit	Constant	Outside
cell			3	1	litre	✓	
nucleus			3	1	litre	✓	
membrane			3	1	litre	✓	
ecm			3	1	litre	✓	

3.1 Compartment `cell`

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

3.2 Compartment `nucleus`

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

3.3 Compartment `membrane`

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

3.4 Compartment `ecm`

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

Produced by SBML2LATEX

4 Species

This model contains 65 species. The boundary condition of three of these species is set to `true` so that these species' amount cannot be changed by any reaction. Section 7 provides further details and the derived rates of change of each species.

<div align="center">

Table 3: Properties of each species.

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Id	Name	Compartment	Derived Unit	Constant	Boundary Condition
AcanmRNA		cell	item	⊟	⊟
ADAMTS5		cell	item	⊟	⊟
AGEprod		cell	item	⊟	⊟
Alk1		cell	item	⊟	⊟
Alk1_Alk5		cell	item	⊟	⊟
Alk5		cell	item	⊟	⊟
Alk5_dimer		cell	item	⊟	⊟
Bax		cell	item	⊟	⊟
Bax_Bcl2		cell	item	⊟	⊟
Bax_Bcl2_Beclin		cell	item	⊟	⊟
Bax_Bcl2_Beclin_I		cell	item	⊟	⊟
Bcl2		cell	item	⊟	⊟
Bcl2_Beclin		cell	item	⊟	⊟
Bcl2_Beclin_I		cell	item	⊟	⊟
Beclin		cell	item	⊟	⊟
Beclin_I		cell	item	⊟	⊟
Caspase_A		cell	item	⊟	⊟
Caspase_I		cell	item	⊟	⊟
Col2mRNA		cell	item	⊟	⊟
DamP		cell	item	⊟	⊟
IkB		cell	item	⊟	⊟

Id	Name	Compartment	Derived Unit	Constant	Boundary Condition
IkB_NFkB		cell	item	⊟	⊟
IL1		cell	item	⊟	⊟
Lys_A		cell	item	⊟	⊟
Lys_I		cell	item	⊟	⊟
MMP13		cell	item	⊟	⊟
MMP2		cell	item	⊟	⊟
NatP		cell	item	✓	✓
NFkB		cell	item	⊟	⊟
NFkB_P		cell	item	⊟	⊟
p38		cell	item	⊟	⊟
p38_P		cell	item	⊟	⊟
proMMP13		cell	item	⊟	⊟
proMMP2		cell	item	⊟	⊟
RAGE		cell	item	⊟	⊟
ROS		cell	item	⊟	⊟
Runx2_A		cell	item	⊟	⊟
Runx2_I		cell	item	⊟	⊟
Smad1		cell	item	⊟	⊟
Smad1_P		cell	item	⊟	⊟
Smad1_P_Smad4		cell	item	⊟	⊟
Smad2		cell	item	⊟	⊟
Smad2_P		cell	item	⊟	⊟
Smad2_P_Smad4		cell	item	⊟	⊟
Smad4		cell	item	⊟	⊟
Smad7		cell	item	⊟	⊟
SOD		cell	item	⊟	⊟
Sox9		cell	item	⊟	⊟

Id	Name	Compartment	Derived Unit	Constant	Boundary Condition
Sox9_A		cell	item	⊟	⊟
Sox9mRNA		cell	item	⊟	⊟
Tgfb_A		cell	item	⊟	⊟
Tgfb_Alk1_Alk5		cell	item	⊟	⊟
Tgfb_Alk1_Alk5-_Smad7		cell	item	⊟	⊟
Tgfb_Alk5_dimer		cell	item	⊟	⊟
Tgfb_Alk5_dimer-_Smad7		cell	item	⊟	⊟
AggFrag		ecm	item	⊟	⊟
Aggrecan		ecm	item	⊟	⊟
Aggrecan-_Collagen2		ecm	item	⊟	⊟
ColFrag		ecm	item	⊟	⊟
Collagen2		ecm	item	⊟	⊟
Integrin		ecm	item	⊟	⊟
Tgfb_I		ecm	item	⊟	⊟
Sink		cell	item	☑	☑
Source		cell	item	☑	☑
IntegrinCount		ecm	item	⊟	⊟

5 Parameters

This model contains 113 global parameters.

Table 4: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
kactCasp			10^{-7}		☑
kactCaspBecI			$8.3 \cdot 10^{-7}$		☑
kactCaspp38			$8 \cdot 10^{-7}$		☑
kactIntegrin			$4 \cdot 10^{-7}$		☑
kactLys			10^{-8}		☑
kactMMP13			10^{-4}		☑
kactMMP2			10^{-7}		☑
kactNFkB			10^{-4}		☑
kactRAGE			0.001		☑
kactRunx2			0.001		☑
kactSox9			$5 \cdot 10^{-6}$		☑
kactTgfbIntegrin			0.001		☑
kactTgfbMMP2			10^{-7}		☑
kbinAggrecanCollagen2			10^{-4}		☑
kbinAlk1Alk5			$5 \cdot 10^{-5}$		☑
kbinBaxBcl2			1.670		☑
kbinBaxToBcl2Bec			$1.67 \cdot 10^{-4}$		☑
kbinBcl2Beclin			$7.5 \cdot 10^{-5}$		☑
kbinBecToBaxBcl2			$1.67 \cdot 10^{-5}$		☑
kbinSmad1Smad4			$5 \cdot 10^{-5}$		☑
kbinSmad2Smad4			10^{-4}		☑
kbinSmad7Alk1			0.500		☑
kbinSmad7Alk5			$2 \cdot 10^{-5}$		☑
kbinTgfbAlk1			$2 \cdot 10^{-5}$		☑
kbinTgfbAlk5			$3 \cdot 10^{-5}$		☑
kdamLys			$5 \cdot 10^{-6}$		☑
kdamNatP			$8 \cdot 10^{-6}$		☑
kdedimerAlk5			0.001		☑
kdegAcanmRNA			$9 \cdot 10^{-6}$		☑
kdegADAMTS5			$5 \cdot 10^{-5}$		☑
kdegAggrecan			10^{-9}		☑
kdegAlk1			$1.2 \cdot 10^{-8}$		☑
kdegAlk5			$4 \cdot 10^{-7}$		☑
kdegBcl2			$1.67 \cdot 10^{-4}$		☑
kdegBcl2Casp			0.002		☑
kdegBcl2ROS			0.002		☑
kdegCol2mRNA			$1.07 \cdot 10^{-5}$		☑

Id	Name	SBO	Value	Unit	Constant
kdegCollagen			10^{-8}		☑
kdegDamP			$4 \cdot 10^{-5}$		☑
kdegIkB			10^{-6}		☑
kdegIL1			0.005		☑
kdegMMP13			$6.4 \cdot 10^{-6}$		☑
kdegMMP2			$6.4 \cdot 10^{-6}$		☑
kdegSmad7			0.005		☑
kdegSmad7Alk1			$5 \cdot 10^{-6}$		☑
kdegSmad7Alk5			10^{-5}		☑
kdegSOD			0.001		☑
kdegSox9			$4.8 \cdot 10^{-5}$		☑
kdegSox9mRNA			10^{-4}		☑
kdegTgfb			0.006		☑
kdephosNFkB			0.010		☑
kdephosp38			0.010		☑
kdephosSmad1			$5 \cdot 10^{-4}$		☑
kdephosSmad1Smad7			$6 \cdot 10^{-4}$		☑
kdephosSmad2			0.006		☑
kdimerAlk5			$2 \cdot 10^{-4}$		☑
kgenROS			$5 \cdot 10^{-4}$		☑
kgenROSbyDamP			10^{-4}		☑
kgenROSbyp38			10^{-4}		☑
kgenROSbyRAGE			$4 \cdot 10^{-4}$		☑
kinactBec			$5 \cdot 10^{-10}$		☑
kinactBecCasp			10^{-8}		☑
kinactCasp			$3 \cdot 10^{-4}$		☑
kinactCaspBcl2			$3 \cdot 10^{-4}$		☑
kinactIntegrin			$5 \cdot 10^{-4}$		☑
kinactNFkB			0.100		☑
kinactRAGE			0.001		☑
kinactRunx2			$5 \cdot 10^{-4}$		☑
kinactSox9			0.002		☑
kinactTgfb			0.050		☑
kinhibLys			$7 \cdot 10^{-6}$		☑
kphosNFkB			0.001		☑
kphosp38			10^{-7}		☑
kphosp38ROS			10^{-4}		☑
kphosSmad1			$2 \cdot 10^{-5}$		☑
kphosSmad2			$4 \cdot 10^{-5}$		☑
kprodAGE			10^{-6}		☑
krelAlk1Alk5			0.010		☑
krelBaxBcl2			0.002		☑

Id	Name	SBO	Value	Unit	Constant
krelBaxBcl2Bec			0.002		☑
krelBcl2Beclin			$5 \cdot 10^{-4}$		☑
krelBecBaxBcl2			0.017		☑
krelSmad1Smad4			0.017		☑
krelSmad2Smad4			0.017		☑
krelSmad7Alk1			0.001		☑
krelSmad7Alk5			10^{-6}		☑
krelTgfbAlk1			10^{-6}		☑
krelTgfbAlk5			10^{-6}		☑
kremROS			$3.83 \cdot 10^{-4}$		☑
kremROSbySOD			10^{-4}		☑
ksynAcanmRNA			0.000		☑
ksynAcanmRNASox9A			$4.6 \cdot 10^{-6}$		☑
ksynADAMTS5			$5 \cdot 10^{-4}$		☑
ksynAggrecan			10^{-6}		☑
ksynAlk1			$5 \cdot 10^{-6}$		☑
ksynAlk5			$5 \cdot 10^{-6}$		☑
ksynBcl2			0.002		☑
ksynCol2			10^{-7}		☑
ksynCol2mRNA			0.000		☑
ksynCol2mRNASmad			10^{-6}		☑
ksynCol2mRNASox9A			10^{-6}		☑
ksynIkB			0.001		☑
ksynIL1			0.005		☑
ksynMMP13			$3.2 \cdot 10^{-5}$		☑
ksynMMP13Runx2			$1.5 \cdot 10^{-6}$		☑
ksynMMP2			$5 \cdot 10^{-6}$		☑
ksynNatP			0.000		☑
ksynRAGE			10^{-4}		☑
ksynSmad7			10^{-5}		☑
ksynSOD			0.002		☑
ksynSox9			$4.8 \cdot 10^{-4}$		☑
ksynSox9mRNA			10^{-5}		☑
ksynSox9mRNASox9A			$5 \cdot 10^{-6}$		☑

6 Reactions

This model contains 117 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	CaspaseActivation		$\text{Caspase\_I} + \text{Bax} \xrightarrow{\text{Caspase\_I, Bax}} \text{Caspase\_A} + \text{Bax}$	
2	CaspaseActivationByBeclin-_I		$\text{Caspase\_I} + \text{Beclin\_I} \xrightarrow{\text{Caspase\_I, Beclin\_I}} \text{Caspase\_A} + \text{Beclin\_I}$	
3	CaspaseActivationBy-_p38		$\text{Caspase\_I} + \text{p38\_P} \xrightarrow{\text{Caspase\_I, p38\_P}} \text{Caspase\_A} + \text{p38\_P}$	
4	CaspaseInactivation1		$\text{Caspase\_A} \xrightarrow{\text{Caspase\_A}} \text{Caspase\_I}$	
5	InhibitCaspase2		$\text{Caspase\_A} + \text{Bcl2\_Beclin} \xrightarrow{\text{Caspase\_A, Bcl2\_Beclin}} \text{Caspase\_I} + \text{Bcl2\_Beclin}$	
6	InhibitCaspase3		$\text{Caspase\_A} + \text{Bcl2} \xrightarrow{\text{Caspase\_A, Bcl2}} \text{Caspase\_I} + \text{Bcl2}$	
7	ActivateLysosome		$\text{Lys\_I} + \text{Beclin} \xrightarrow{\text{Lys\_I, Beclin}} \text{Lys\_A} + \text{Beclin}$	
8	InhibitLysosome		$\text{Lys\_A} \xrightarrow{\text{Lys\_A}} \text{Lys\_I}$	
9	Bcl2Synthesis		$\text{Source} \xrightarrow{\text{Source}} \text{Bcl2}$	
10	Bcl2Degradation		$\text{Bcl2} \xrightarrow{\text{Bcl2}} \text{Sink}$	
11	Bcl2DegradationStressInduced		$\text{Bcl2} + \text{ROS} \xrightarrow{\text{Bcl2, ROS}} \text{Sink} + \text{ROS}$	
12	Bcl2DegradationCaspaseInduced		$\text{Bcl2} + \text{Caspase\_A} \xrightarrow{\text{Bcl2, Caspase\_A}} \text{Sink} + \text{Caspase\_A}$	

№	Id	Name	Reaction Equation	SBO
13	Bax_Bcl2Binding		$\mathrm{Bax} + \mathrm{Bcl2} \xrightarrow{\mathrm{Bax,\ Bcl2}} \mathrm{Bax\_Bcl2}$	
14	Bax_Bcl2Release		$\mathrm{Bax\_Bcl2} \xrightarrow{\mathrm{Bax\_Bcl2}} \mathrm{Bax} + \mathrm{Bcl2}$	
15	Bcl2-_BeclinBinding		$\mathrm{Bcl2} + \mathrm{Beclin} \xrightarrow{\mathrm{Bcl2,\ Beclin}} \mathrm{Bcl2\_Beclin}$	
16	Bcl2-_BeclinRelease		$\mathrm{Bcl2\_Beclin} \xrightarrow{\mathrm{Bcl2\_Beclin}} \mathrm{Bcl2} + \mathrm{Beclin}$	
17	Bcl2_Beclin_I-_Binding		$\mathrm{Bcl2} + \mathrm{Beclin\_I} \xrightarrow{\mathrm{Bcl2,\ Beclin\_I}} \mathrm{Bcl2\_Beclin\_I}$	
18	Bcl2_Beclin_I-_Release		$\mathrm{Bcl2\_Beclin\_I} \xrightarrow{\mathrm{Bcl2\_Beclin\_I}} \mathrm{Bcl2} + \mathrm{Beclin\_I}$	
19	BeclinInactivation		$\mathrm{Beclin} \xrightarrow{\mathrm{Beclin}} \mathrm{Beclin\_I}$	
20	BeclinInactivationByCaspase		$\mathrm{Beclin} + \mathrm{Caspase\_A} \xrightarrow{\mathrm{Beclin,\ Caspase\_A}} \mathrm{Beclin\_I} + \mathrm{Caspase\_A}$	
21	BeclinBindingToBax-_Bcl2		$\mathrm{Beclin} + \mathrm{Bax\_Bcl2} \xrightarrow{\mathrm{Beclin,\ Bax\_Bcl2}} \mathrm{Bax\_Bcl2\_Beclin}$	
22	BeclinIBindingToBax-_Bcl2		$\mathrm{Beclin\_I} + \mathrm{Bax\_Bcl2} \xrightarrow{\mathrm{Beclin\_I,\ Bax\_Bcl2}} \mathrm{Bax\_Bcl2\_Beclin\_I}$	
23	BaxBindingToBcl2-_Beclin		$\mathrm{Bax} + \mathrm{Bcl2\_Beclin} \xrightarrow{\mathrm{Bax,\ Bcl2\_Beclin}} \mathrm{Bax\_Bcl2\_Beclin}$	
24	BaxBindingToBcl2-_BeclinI		$\mathrm{Bax} + \mathrm{Bcl2\_Beclin\_I} \xrightarrow{\mathrm{Bax,\ Bcl2\_Beclin\_I}} \mathrm{Bax\_Bcl2\_Beclin\_I}$	
25	BaxDissociation-_Bax_Bcl2-_Beclin		$\mathrm{Bax\_Bcl2\_Beclin} \xrightarrow{\mathrm{Bax\_Bcl2\_Beclin}} \mathrm{Bax} + \mathrm{Bcl2\_Beclin}$	

№	Id	Name	Reaction Equation	SBO
26	BaxDissociation-_Bax_Bcl2-_Beclin_I		$\text{Bax\_Bcl2\_Beclin\_I} \xrightarrow{\text{Bax\_Bcl2\_Beclin\_I}} \text{Bax} + \text{Bcl2\_Beclin\_I}$	+
27	BeclinDissociation-_Bax_Bcl2-_Beclin		$\text{Bax\_Bcl2\_Beclin} \xrightarrow{\text{Bax\_Bcl2\_Beclin}} \text{Beclin} + \text{Bax\_Bcl2}$	+
28	Beclin_I-_Dissociation-_Bax_Bcl2-_Beclin		$\text{Bax\_Bcl2\_Beclin\_I} \xrightarrow{\text{Bax\_Bcl2\_Beclin\_I}} \text{Beclin\_I} + \text{Bax\_Bcl2}$	+
29	ROS_generation		$\text{Source} \xrightarrow{\text{Source}} \text{ROS}$	
30	ROS_removal		$\text{ROS} \xrightarrow{\text{ROS}} \text{Sink}$	
31	Protein_Damage-_by_ROS		$\text{NatP} + \text{ROS} \xrightarrow{\text{NatP, ROS}} \text{DamP} + \text{ROS}$	
32	Removal_DamP-_by_Autophagy		$\text{DamP} + \text{Lys\_A} \xrightarrow{\text{DamP, Lys\_A}} \text{Lys\_A}$	
33	Production_of-_AGEproducts		$\text{Source} \xrightarrow{\text{Source}} \text{AGEprod}$	
34	RAGE_activation		$\text{AGEprod} \xrightarrow{\text{AGEprod}} \text{AGEprod} + \text{RAGE}$	
35	ROS_production-_by_RAGE		$\text{RAGE} \xrightarrow{\text{RAGE}} \text{RAGE} + \text{ROS}$	
36	IkB-_degradation-_via_ROS		$\text{ROS} + \text{IkB\_NFkB} \xrightarrow{\text{ROS, IkB\_NFkB}} \text{ROS} + \text{NFkB}$	

№	Id	Name	Reaction Equation	SBO
37	IkB-_degradation-_via_IL1		$\text{IL1} + \text{IkB\_NFkB} \xrightarrow{\text{IL1, IkB\_NFkB}} \text{IL1} + \text{NFkB}$	
38	NFkB-_inactivation		$\text{NFkB} + \text{IkB} \xrightarrow{\text{NFkB, IkB}} \text{IkB\_NFkB}$	
39	RAGE-_inactivation		$\text{RAGE} \xrightarrow{\text{RAGE}} \text{Sink}$	
40	RAGE-_upregulation-_byNFkB		$\text{NFkB\_P} \xrightarrow{\text{NFkB\_P}} \text{NFkB\_P} + \text{RAGE}$	
41	IL1_production		$\text{NFkB\_P} \xrightarrow{\text{NFkB\_P}} \text{NFkB\_P} + \text{IL1}$	
42	IL1_degradation		$\text{IL1} \xrightarrow{\text{IL1}} \text{Sink}$	
43	IkB_production		$\text{NFkB\_P} \xrightarrow{\text{NFkB\_P}} \text{NFkB\_P} + \text{IkB}$	
44	MMP13-_production		$\text{IL1} \xrightarrow{\text{IL1}} \text{IL1} + \text{proMMP13}$	
45	MMP13_removal		$\text{MMP13} \xrightarrow{\text{MMP13}} \text{Sink}$	
46	MMP2_production		$\text{IL1} \xrightarrow{\text{IL1}} \text{IL1} + \text{proMMP2}$	
47	MMP_activation		$\text{proMMP2} \xrightarrow{\text{proMMP2}} \text{MMP2}$	
48	MMP2-_degradation		$\text{MMP2} \xrightarrow{\text{MMP2}} \text{Sink}$	
49	ADAMTS5-_production		$\text{IL1} \xrightarrow{\text{IL1}} \text{IL1} + \text{ADAMTS5}$	
50	ADAMTS5_removal		$\text{ADAMTS5} \xrightarrow{\text{ADAMTS5}} \text{Sink}$	

№	Id	Name	Reaction Equation	SBO
51	Aggrecan-_degradation		Aggrecan_Collagen2 + ADAMTS5 $\xrightarrow{\text{Aggrecan\_Collagen2, ADAMTS5}}$ Collagen2 + ADAMTS5 + AggFrag	
52	Collagen-_degradation		Collagen2 + MMP13 $\xrightarrow{\text{Collagen2, MMP13}}$ MMP13 + ColFrag	
53	ROS_production-_by_DamP		DamP $\xrightarrow{\text{DamP}}$ DamP + ROS	
54	Protein-_synthesis		Source $\xrightarrow{\text{Source}}$ NatP	
55	SOD_synthesis		NFkB_P $\xrightarrow{\text{NFkB\_P}}$ NFkB_P + SOD	
56	SOD_degradation		SOD $\xrightarrow{\text{SOD}}$ Sink	
57	ROS_removal_by-_SOD		ROS + SOD $\xrightarrow{\text{SOD, ROS}}$ SOD	
58	p38-_phosphorylation		p38 + IL1 $\xrightarrow{\text{p38, IL1}}$ p38_P + IL1	
59	p38-_phosphorylation-_via_ROS		p38 + ROS $\xrightarrow{\text{p38, ROS}}$ p38_P + ROS	
60	p38-_dephosphorylation		p38_P $\xrightarrow{\text{p38\_P}}$ p38	
61	NFkB_activation		NFkB + p38_P $\xrightarrow{\text{NFkB, p38\_P}}$ NFkB_P + p38_P	
62	NFkB-_dephosphorylation		NFkB_P $\xrightarrow{\text{NFkB\_P}}$ NFkB	

№	Id	Name	Reaction Equation	SBO
63	ROS_production-_by_p38_P		$\text{p38\_P} \xrightarrow{\text{p38\_P}} \text{p38\_P} + \text{ROS}$	
64	Lysosome-_damage_by_ROS		$\text{Lys\_A} + \text{ROS} \xrightarrow{\text{Lys\_A, ROS}} \text{Lys\_I} + \text{ROS}$	
65	IntegrinActivationByMechanicalStress		$\text{Source} \xrightarrow{\text{Source}} \text{Integrin} + \text{IntegrinCount}$	
66	IntegrinInactivation		$\text{Integrin} \xrightarrow{\text{Integrin}} \text{Sink}$	
67	Alk5Synthesis		$\text{Source} \xrightarrow{\text{Source}} \text{Alk5}$	
68	TgfbActivationByIntegrin		$\text{Tgfb\_I} + \text{Integrin} \xrightarrow{\text{Tgfb\_I, Integrin}} \text{Tgfb\_A} + \text{Integrin}$	
69	TgfbActivationByMMP2		$\text{Tgfb\_I} + \text{MMP2} \xrightarrow{\text{Tgfb\_I, MMP2}} \text{Tgfb\_A} + \text{MMP2}$	
70	TgfbInactivation		$\text{Tgfb\_A} \xrightarrow{\text{Tgfb\_A}} \text{Tgfb\_I}$	
71	Alk5Dimerisation		$2\,\text{Alk5} \xrightarrow{\text{Alk5}} \text{Alk5\_dimer}$	
72	Alk5Dedimerisation		$\text{Alk5\_dimer} \xrightarrow{\text{Alk5\_dimer}} 2\,\text{Alk5}$	
73	Alk1Alk5Binding		$\text{Alk1} + \text{Alk5} \xrightarrow{\text{Alk1, Alk5}} \text{Alk1\_Alk5}$	
74	Alk1Alk5Release		$\text{Alk1\_Alk5} \xrightarrow{\text{Alk1\_Alk5}} \text{Alk1} + \text{Alk5}$	
75	TgfbReceptorBindingAlk5		$\text{Tgfb\_A} + \text{Alk5\_dimer} \xrightarrow{\text{Tgfb\_A, Alk5\_dimer}} \text{Tgfb\_Alk5\_dimer}$	
76	TgfbReceptorRelease		$\text{Tgfb\_Alk5\_dimer} \xrightarrow{\text{Tgfb\_Alk5\_dimer}} \text{Tgfb\_A} + \text{Alk5\_dimer}$	
77	Tgfb_Alk5-_BindingSmad7		$\text{Tgfb\_Alk5\_dimer} + \text{Smad7} \xrightarrow{\text{Tgfb\_Alk5\_dimer, Smad7}} \text{Tgfb\_Alk5\_dimer\_Smad7}$	
78	Tgfb_Alk5-_Smad7Release		$\text{Tgfb\_Alk5\_dimer\_Smad7} \xrightarrow{\text{Tgfb\_Alk5\_dimer\_Smad7}} \text{Tgfb\_Alk5\_dimer} + \text{Smad7}$	

№	Id	Name	Reaction Equation	SBO
79	`Alk5-_Smad7Degradation`		$\text{Tgfb\_Alk5\_dimer\_Smad7} \xrightarrow{\text{Tgfb\_Alk5\_dimer\_Smad7}} \text{Tgfb\_I}$	
80	`TgfbReceptorBindingAlk1`		$\text{Tgfb\_A} + \text{Alk1\_Alk5} \xrightarrow{\text{Tgfb\_A, Alk1\_Alk5}} \text{Tgfb\_Alk1\_Alk5}$	
81	`TgfbAlk1Release`		$\text{Tgfb\_Alk1\_Alk5} \xrightarrow{\text{Tgfb\_Alk1\_Alk5}} \text{Tgfb\_A} + \text{Alk1\_Alk5}$	
82	`Smad2Phosphorylation`		$\text{Tgfb\_Alk5\_dimer} + \text{Smad2} \xrightarrow{\text{Tgfb\_Alk5\_dimer, Smad2}} \text{Tgfb\_Alk5\_dimer} + \text{Smad2\_P}$	
83	`Smad2Smad4Binding`		$\text{Smad2\_P} + \text{Smad4} \xrightarrow{\text{Smad2\_P, Smad4}} \text{Smad2\_P\_Smad4}$	
84	`Smad2PSmad4Release`		$\text{Smad2\_P\_Smad4} \xrightarrow{\text{Smad2\_P\_Smad4}} \text{Smad2\_P} + \text{Smad4}$	
85	`Smad2DephosphorylationNuc`		$\text{Smad2\_P} \xrightarrow{\text{Smad2\_P}} \text{Smad2}$	
86	`Smad7Synthesis`		$\text{Smad2\_P\_Smad4} \xrightarrow{\text{Smad2\_P\_Smad4}} \text{Smad2\_P\_Smad4} + \text{Smad7}$	
87	`Sox9Activation`		$\text{Smad2\_P\_Smad4} + \text{Sox9} \xrightarrow{\text{Smad2\_P\_Smad4, Sox9}} \text{Smad2\_P\_Smad4} + \text{Sox9\_A}$	
88	`Sox9Inactivation`		$\text{Sox9\_A} \xrightarrow{\text{Sox9\_A}} \text{Sox9}$	
89	`Sox9BasalTranscription`		$\text{Source} \xrightarrow{\text{Source}} \text{Sox9mRNA}$	
90	`Sox9EnhancedTranscription`		$\text{Sox9\_A} \xrightarrow{\text{Sox9\_A}} \text{Sox9\_A} + \text{Sox9mRNA}$	
91	`Sox9mRNA-_Degradation`		$\text{Sox9mRNA} \xrightarrow{\text{Sox9mRNA}} \text{Sink}$	
92	`Sox9Translation`		$\text{Sox9mRNA} \xrightarrow{\text{Sox9mRNA}} \text{Sox9mRNA} + \text{Sox9}$	

№	Id	Name	Reaction Equation	SBO
93	Sox9Degradation		Sox9 $\xrightarrow{\text{Sox9}}$ Sink	
94	Collagen2EnhancedTranscriptionBySox9		Sox9_A $\xrightarrow{\text{Sox9\_A}}$ Sox9_A + Col2mRNA	
95	Collagen2TranscriptionBySmad2Smad4		Smad2_P_Smad4 $\xrightarrow{\text{Smad2\_P\_Smad4}}$ Smad2_P_Smad4 + Col2mRNA	
96	Col2mRNA-_Degradation		Col2mRNA $\xrightarrow{\text{Col2mRNA}}$ Sink	
97	Collagen2Translation		Col2mRNA $\xrightarrow{\text{Col2mRNA}}$ Col2mRNA + Collagen2	
98	AggrecanEnhancedTranscription		Sox9_A $\xrightarrow{\text{Sox9\_A}}$ Sox9_A + AcanmRNA	
99	AcanmRNA-_Degradation		AcanmRNA $\xrightarrow{\text{AcanmRNA}}$ Sink	
100	AggrecanTranslation		AcanmRNA $\xrightarrow{\text{AcanmRNA}}$ AcanmRNA + Aggrecan	
101	AggrecanCollagen2Binding		Aggrecan + Collagen2 $\xrightarrow{\text{Aggrecan, Collagen2}}$ Aggrecan_Collagen2	
102	Runx2-_InhibitionBySmad2		Runx2_A + Smad2_P_Smad4 $\xrightarrow{\text{Runx2\_A, Smad2\_P\_Smad4}}$ Runx2_I + Smad2_P_Smad4	
103	Alk5Degradation		Alk5 $\xrightarrow{\text{Alk5}}$ Sink	
104	Smad1Activation		Tgfb_Alk1_Alk5 + Smad1 $\xrightarrow{\text{Tgfb\_Alk1\_Alk5, Smad1}}$ Tgfb_Alk1_Alk5 + Smad1_P	
105	Smad1Dephosphorylation		Smad1_P $\xrightarrow{\text{Smad1\_P}}$ Smad1	
106	Smad1DephosphorylationViaSmad7		Smad1_P + Smad7 $\xrightarrow{\text{Smad1\_P, Smad7}}$ Smad1 + Smad7	
107	Smad1Smad4Binding		Smad1_P + Smad4 $\xrightarrow{\text{Smad1\_P, Smad4}}$ Smad1_P_Smad4	

№	Id	Name	Reaction Equation	SBO
108	`Smad1Smad4Release`		$\text{Smad1\_P\_Smad4} \xrightarrow{\text{Smad1\_P\_Smad4}} \text{Smad1\_P} + \text{Smad4}$	+
109	`Runx2ActivationBySmad1`		$\text{Runx2\_I} + \text{Smad1\_P\_Smad4} \xrightarrow{\text{Runx2\_I, Smad1\_P\_Smad4}} \text{Runx2\_A} + \text{Smad1\_P\_Smad4}$	
110	`MMP13InductionByRunx2`		$\text{Runx2\_A} \xrightarrow{\text{Runx2\_A}} \text{proMMP13} + \text{Runx2\_A}$	
111	`Alk1Synthesis`		$\text{Source} \xrightarrow{\text{Source}} \text{Alk1}$	
112	`Alk1Degradation`		$\text{Alk1} \xrightarrow{\text{Alk1}} \text{Sink}$	
113	`MMP13Activation`		$\text{proMMP13} \xrightarrow{\text{proMMP13}} \text{MMP13}$	
114	`Tgfb_Alk1_Alk5-_BindingSmad7`		$\text{Tgfb\_Alk1\_Alk5} + \text{Smad7} \xrightarrow{\text{Tgfb\_Alk1\_Alk5, Smad7}} \text{Tgfb\_Alk1\_Alk5\_Smad7}$	+
115	`Tgfb_Alk1_Alk5-_Smad7Release`		$\text{Tgfb\_Alk1\_Alk5\_Smad7} \xrightarrow{\text{Tgfb\_Alk1\_Alk5\_Smad7}} \text{Tgfb\_Alk1\_Alk5} + \text{Smad7}$	
116	`Alk1-_Smad7Degradation`		$\text{Tgfb\_Alk1\_Alk5\_Smad7} \xrightarrow{\text{Tgfb\_Alk1\_Alk5\_Smad7}} \text{Tgfb\_I}$	
117	`Smad7Degradation`		$\text{Smad7} \xrightarrow{\text{Smad7}} \text{Sink}$	

6.1 Reaction `CaspaseActivation`

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

Reaction equation

$$\text{Caspase\_I} + \text{Bax} \xrightarrow{\text{Caspase\_I, Bax}} \text{Caspase\_A} + \text{Bax} \tag{1}$$

Reactants

Table 6: Properties of each reactant.

Id	Name	SBO
Caspase_I		
Bax		

Modifiers

Table 7: Properties of each modifier.

Id	Name	SBO
Caspase_I		
Bax		

Products

Table 8: Properties of each product.

Id	Name	SBO
Caspase_A		
Bax		

Kinetic Law

Derived unit contains undeclared units

$$v_1 = \text{kactCasp} \cdot \text{Caspase\_I} \cdot \text{Bax} \tag{2}$$

6.2 Reaction `CaspaseActivationByBeclin_I`

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

Reaction equation

$$\text{Caspase\_I} + \text{Beclin\_I} \xrightarrow{\text{Caspase\_I, Beclin\_I}} \text{Caspase\_A} + \text{Beclin\_I} \tag{3}$$
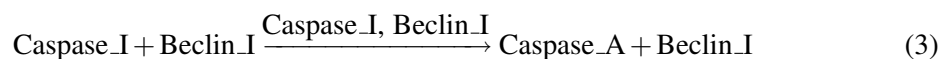
Reactants

Table 9: Properties of each reactant.

Id	Name	SBO
Caspase_I		
Beclin_I		

Modifiers

Table 10: Properties of each modifier.

Id	Name	SBO
Caspase_I		
Beclin_I		

Products

Table 11: Properties of each product.

Id	Name	SBO
Caspase_A		
Beclin_I		

Kinetic Law

Derived unit contains undeclared units

$$v_2 = \text{kactCaspBecI} \cdot \text{Caspase\_I} \cdot \text{Beclin\_I} \tag{4}$$

6.3 Reaction `CaspaseActivationBy_p38`

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

Reaction equation

$$\text{Caspase\_I} + \text{p38\_P} \xrightarrow{\text{Caspase\_I, p38\_P}} \text{Caspase\_A} + \text{p38\_P} \tag{5}$$

Reactants

Table 12: Properties of each reactant.

Id	Name	SBO
Caspase_I		
p38_P		

Modifiers

Table 13: Properties of each modifier.

Id	Name	SBO
Caspase_I		
p38_P		

Products

Table 14: Properties of each product.

Id	Name	SBO
Caspase_A		
p38_P		

Kinetic Law

Derived unit contains undeclared units

$$v_3 = \text{kactCaspp38} \cdot \text{Caspase\_I} \cdot \text{p38\_P} \tag{6}$$

6.4 Reaction `CaspaseInactivation1`

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

Reaction equation

$$\text{Caspase\_A} \xrightarrow{\text{Caspase\_A}} \text{Caspase\_I} \qquad (7)$$

Reactant

Table 15: Properties of each reactant.

Id	Name	SBO
Caspase_A		

Modifier

Table 16: Properties of each modifier.

Id	Name	SBO
Caspase_A		

Product

Table 17: Properties of each product.

Id	Name	SBO
Caspase_I		

Kinetic Law

Derived unit contains undeclared units

$$v_4 = \text{kinactCasp} \cdot \text{Caspase\_A} \qquad (8)$$

6.5 Reaction `InhibitCaspase2`

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

Reaction equation

$$\text{Caspase\_A} + \text{Bcl2\_Beclin} \xrightarrow{\text{Caspase\_A, Bcl2\_Beclin}} \text{Caspase\_I} + \text{Bcl2\_Beclin} \qquad (9)$$
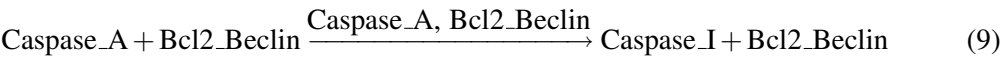
Reactants

Table 18: Properties of each reactant.

Id	Name	SBO
Caspase_A		
Bcl2_Beclin		

Modifiers

Table 19: Properties of each modifier.

Id	Name	SBO
Caspase_A		
Bcl2_Beclin		

Products

Table 20: Properties of each product.

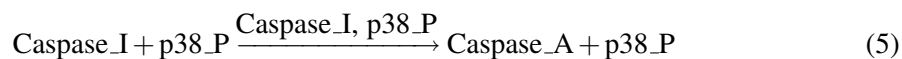| Id	Name	SBO
Caspase_I		
Bcl2_Beclin		

Kinetic Law

Derived unit contains undeclared units

$$v_5 = \text{kinactCaspBcl2} \cdot \text{Caspase\_A} \cdot \text{Bcl2\_Beclin} \tag{10}$$

6.6 Reaction `InhibitCaspase3`

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

Reaction equation

$$\text{Caspase\_A} + \text{Bcl2} \xrightarrow{\text{Caspase\_A, Bcl2}} \text{Caspase\_I} + \text{Bcl2} \tag{11}$$
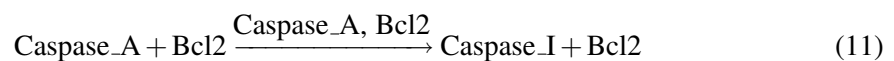
Reactants

Table 21: Properties of each reactant.

Id	Name	SBO
Caspase_A		
Bcl2		

Modifiers

Table 22: Properties of each modifier.

Id	Name	SBO
Caspase_A		
Bcl2		

Products

Table 23: Properties of each product.

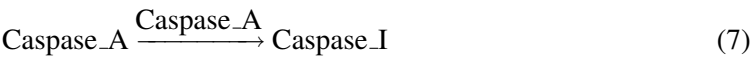| Id	Name	SBO
Caspase_I		
Bcl2		

Kinetic Law

Derived unit contains undeclared units

$$v_6 = \text{kinactCaspBcl2} \cdot \text{Caspase\_A} \cdot \text{Bcl2} \tag{12}$$

6.7 Reaction `ActivateLysosome`

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

Reaction equation

$$\text{Lys\_I} + \text{Beclin} \xrightarrow{\text{Lys\_I, Beclin}} \text{Lys\_A} + \text{Beclin} \tag{13}$$

Reactants

Table 24: Properties of each reactant.

Id	Name	SBO
Lys_I		
Beclin		

Modifiers

Table 25: Properties of each modifier.

Id	Name	SBO
Lys_I		
Beclin		

Products

Table 26: Properties of each product.

Id	Name	SBO
Lys_A		
Beclin		

Kinetic Law

Derived unit contains undeclared units

$$v_7 = \text{kactLys} \cdot \text{Lys\_I} \cdot \text{Beclin} \tag{14}$$

6.8 Reaction `InhibitLysosome`

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

Reaction equation

$$\text{Lys\_A} \xrightarrow{\text{Lys\_A}} \text{Lys\_I} \tag{15}$$

Reactant

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Table 27: Properties of each reactant.

Id	Name	SBO
Lys_A		

Modifier

Table 28: Properties of each modifier.

Id	Name	SBO
Lys_A		

Product

Table 29: Properties of each product.

Id	Name	SBO
Lys_I		

Kinetic Law

Derived unit contains undeclared units

$$v_8 = \text{kinhibLys} \cdot \text{Lys\_A} \tag{16}$$

6.9 Reaction `Bcl2Synthesis`

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

Reaction equation

$$\text{Source} \xrightarrow{\text{Source}} \text{Bcl2} \tag{17}$$

Reactant

Table 30: Properties of each reactant.

Id	Name	SBO
Source		

Modifier

Table 31: Properties of each modifier.

Id	Name	SBO
Source		

Product

Table 32: Properties of each product.

Id	Name	SBO
Bcl2		

Kinetic Law

Derived unit contains undeclared units

$$v_9 = \text{ksynBcl2} \cdot \text{Source} \qquad (18)$$

6.10 Reaction `Bcl2Degradation`

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

Reaction equation

$$\text{Bcl2} \xrightarrow{\text{Bcl2}} \text{Sink} \qquad (19)$$

Reactant

Table 33: Properties of each reactant.

Id	Name	SBO
Bcl2		

Modifier

Table 34: Properties of each modifier.

Id	Name	SBO
Bcl2		

Id	Name	SBO

Product

Table 35: Properties of each product.

Id	Name	SBO
Sink		

Kinetic Law

Derived unit contains undeclared units

$$v_{10} = \text{kdegBcl2} \cdot \text{Bcl2} \tag{20}$$

6.11 Reaction `Bcl2DegradationStressInduced`

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

Reaction equation

$$\text{Bcl2} + \text{ROS} \xrightarrow{\text{Bcl2, ROS}} \text{Sink} + \text{ROS} \tag{21}$$

Reactants

Table 36: Properties of each reactant.

Id	Name	SBO
Bcl2		
ROS		

Modifiers

Table 37: Properties of each modifier.

Id	Name	SBO
Bcl2		
ROS		

Products

Table 38: Properties of each product.

Id	Name	SBO
Sink		
ROS		

Kinetic Law

Derived unit contains undeclared units

$$v_{11} = \text{kdegBcl2ROS} \cdot \text{Bcl2} \cdot \text{ROS} \qquad (22)$$

6.12 Reaction `Bcl2DegradationCaspaseInduced`

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

Reaction equation

$$\text{Bcl2} + \text{Caspase\_A} \xrightarrow{\text{Bcl2, Caspase\_A}} \text{Sink} + \text{Caspase\_A} \qquad (23)$$
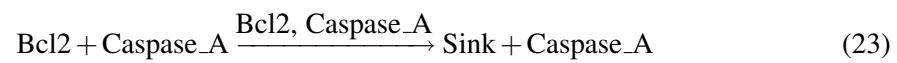
Reactants

Table 39: Properties of each reactant.

Id	Name	SBO
Bcl2		
Caspase_A		

Modifiers

Table 40: Properties of each modifier.

Id	Name	SBO
Bcl2		
Caspase_A		

Products

Table 41: Properties of each product.

Id	Name	SBO
Sink		
Caspase_A		

Kinetic Law

Derived unit contains undeclared units

$$v_{12} = \text{kdegBcl2Casp} \cdot \text{Bcl2} \cdot \text{Caspase\_A} \tag{24}$$

6.13 Reaction `Bax_Bcl2Binding`

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

Reaction equation

$$\text{Bax} + \text{Bcl2} \xrightarrow{\text{Bax, Bcl2}} \text{Bax\_Bcl2} \tag{25}$$
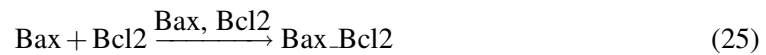
Reactants

Table 42: Properties of each reactant.

Id	Name	SBO
Bax		
Bcl2		

Modifiers

Table 43: Properties of each modifier.

Id	Name	SBO
Bax		
Bcl2		

Product

Table 44: Properties of each product.

Id	Name	SBO
Bax_Bcl2		

Kinetic Law

Derived unit contains undeclared units

$$v_{13} = \text{kbinBaxBcl2} \cdot \text{Bax} \cdot \text{Bcl2} \tag{26}$$

6.14 Reaction `Bax_Bcl2Release`

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

Reaction equation

$$\text{Bax\_Bcl2} \xrightarrow{\text{Bax\_Bcl2}} \text{Bax} + \text{Bcl2} \tag{27}$$
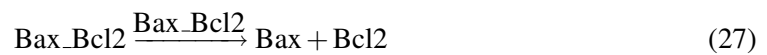
Reactant

Table 45: Properties of each reactant.

Id	Name	SBO
Bax_Bcl2		

Modifier

Table 46: Properties of each modifier.

Id	Name	SBO
Bax_Bcl2		

Products

Table 47: Properties of each product.

Id	Name	SBO
Bax		
Bcl2		

Kinetic Law

Derived unit contains undeclared units

$$v_{14} = \text{krelBaxBcl2} \cdot \text{Bax\_Bcl2} \tag{28}$$

6.15 Reaction `Bcl2_BeclinBinding`

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

Reaction equation

$$\text{Bcl2} + \text{Beclin} \xrightarrow{\text{Bcl2, Beclin}} \text{Bcl2\_Beclin} \tag{29}$$
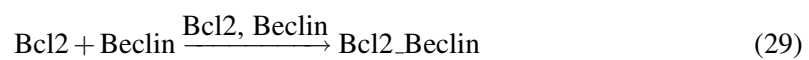
Reactants

Table 48: Properties of each reactant.

Id	Name	SBO
Bcl2		
Beclin		

Modifiers

Table 49: Properties of each modifier.

Id	Name	SBO
Bcl2		
Beclin		

Product

Table 50: Properties of each product.

Id	Name	SBO
Bcl2_Beclin		

Kinetic Law

Derived unit contains undeclared units

$$v_{15} = \text{kbinBcl2Beclin} \cdot \text{Bcl2} \cdot \text{Beclin} \tag{30}$$

6.16 Reaction `Bcl2_BeclinRelease`

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

Reaction equation

$$Bcl2\_Beclin \xrightarrow{Bcl2\_Beclin} Bcl2 + Beclin \tag{31}$$

Reactant

Table 51: Properties of each reactant.

Id	Name	SBO
Bcl2_Beclin		

Modifier

Table 52: Properties of each modifier.

Id	Name	SBO
Bcl2_Beclin		

Products

Table 53: Properties of each product.

Id	Name	SBO
Bcl2		
Beclin		

Kinetic Law

Derived unit contains undeclared units

$$v_{16} = \text{krelBcl2Beclin} \cdot \text{Bcl2\_Beclin} \tag{32}$$

6.17 Reaction `Bcl2_Beclin_I_Binding`

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

Reaction equation

$$Bcl2 + Beclin\_I \xrightarrow{Bcl2,\ Beclin\_I} Bcl2\_Beclin\_I \tag{33}$$

Reactants

Table 54: Properties of each reactant.

Id	Name	SBO
Bcl2		
Beclin_I		

Modifiers

Table 55: Properties of each modifier.

Id	Name	SBO
Bcl2		
Beclin_I		

Product

Table 56: Properties of each product.

Id	Name	SBO
Bcl2_Beclin_I		

Kinetic Law

Derived unit contains undeclared units

$$v_{17} = \text{kbinBcl2Beclin} \cdot \text{Bcl2} \cdot \text{Beclin\_I} \tag{34}$$

6.18 Reaction `Bcl2_Beclin_I_Release`

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

Reaction equation

$$\text{Bcl2\_Beclin\_I} \xrightarrow{\text{Bcl2\_Beclin\_I}} \text{Bcl2} + \text{Beclin\_I} \tag{35}$$
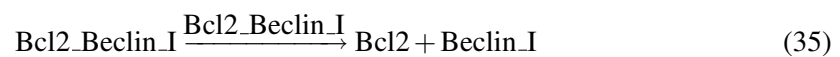
Reactant

Table 57: Properties of each reactant.

Id	Name	SBO
Bcl2_Beclin_I		

Modifier

Table 58: Properties of each modifier.

Id	Name	SBO
Bcl2_Beclin_I		

Products

Table 59: Properties of each product.

Id	Name	SBO
Bcl2		
Beclin_I		

Kinetic Law

Derived unit contains undeclared units

$$v_{18} = \text{krelBcl2Beclin} \cdot \text{Bcl2\_Beclin\_I} \tag{36}$$

6.19 Reaction `BeclinInactivation`

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

Reaction equation

$$\text{Beclin} \xrightarrow{\text{Beclin}} \text{Beclin\_I} \tag{37}$$

Reactant

Table 60: Properties of each reactant.

Id	Name	SBO
Beclin		

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Modifier

Table 61: Properties of each modifier.

Id	Name	SBO
Beclin		

Product

Table 62: Properties of each product.

Id	Name	SBO
Beclin_I		

Kinetic Law

Derived unit contains undeclared units

$$v_{19} = \text{kinactBec} \cdot \text{Beclin} \tag{38}$$

6.20 Reaction `BeclinInactivationByCaspase`

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

Reaction equation

$$\text{Beclin} + \text{Caspase\_A} \xrightarrow{\text{Beclin, Caspase\_A}} \text{Beclin\_I} + \text{Caspase\_A} \tag{39}$$
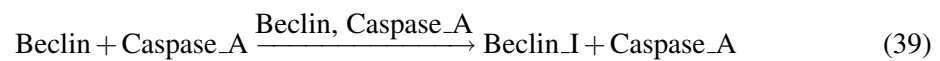
Reactants

Table 63: Properties of each reactant.

Id	Name	SBO
Beclin		
Caspase_A		

Modifiers

Table 64: Properties of each modifier.

Id	Name	SBO
Beclin		
Caspase_A		

Products

Table 65: Properties of each product.

Id	Name	SBO
Beclin_I		
Caspase_A		

Kinetic Law

Derived unit contains undeclared units

$$v_{20} = \text{kinactBecCasp} \cdot \text{Beclin} \cdot \text{Caspase\_A} \tag{40}$$

6.21 Reaction `BeclinBindingToBax_Bcl2`

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

Reaction equation

$$\text{Beclin} + \text{Bax\_Bcl2} \xrightarrow{\text{Beclin, Bax\_Bcl2}} \text{Bax\_Bcl2\_Beclin} \tag{41}$$
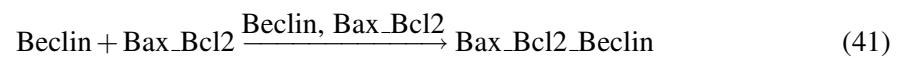
Reactants

Table 66: Properties of each reactant.

Id	Name	SBO
Beclin		
Bax_Bcl2		

Modifiers

Produced by SBML2LATEX

Table 67: Properties of each modifier.

Id	Name	SBO
Beclin		
Bax_Bcl2		

Product

Table 68: Properties of each product.

Id	Name	SBO
Bax_Bcl2_Beclin		

Kinetic Law

Derived unit contains undeclared units

$$v_{21} = \text{kbinBecToBaxBcl2} \cdot \text{Beclin} \cdot \text{Bax\_Bcl2} \tag{42}$$

6.22 Reaction `BeclinIBindingToBax_Bcl2`

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

Reaction equation

$$\text{Beclin\_I} + \text{Bax\_Bcl2} \xrightarrow{\text{Beclin\_I, Bax\_Bcl2}} \text{Bax\_Bcl2\_Beclin\_I} \tag{43}$$

Reactants

Table 69: Properties of each reactant.

Id	Name	SBO
Beclin_I		
Bax_Bcl2		

Modifiers

Table 70: Properties of each modifier.

Id	Name	SBO
Beclin_I		

Id	Name	SBO
Bax_Bcl2		

Product

Table 71: Properties of each product.

Id	Name	SBO
Bax_Bcl2_Beclin_I		

Kinetic Law

Derived unit contains undeclared units

$$v_{22} = \text{kbinBecToBaxBcl2} \cdot \text{Beclin\_I} \cdot \text{Bax\_Bcl2} \tag{44}$$

6.23 Reaction `BaxBindingToBcl2_Beclin`

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

Reaction equation

$$\text{Bax} + \text{Bcl2\_Beclin} \xrightarrow{\text{Bax, Bcl2\_Beclin}} \text{Bax\_Bcl2\_Beclin} \tag{45}$$
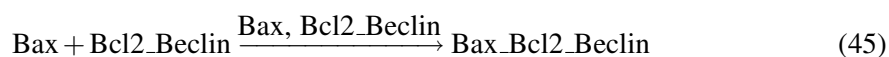
Reactants

Table 72: Properties of each reactant.

Id	Name	SBO
Bax		
Bcl2_Beclin		

Modifiers

Table 73: Properties of each modifier.

Id	Name	SBO
Bax		
Bcl2_Beclin		

Product

Table 74: Properties of each product.

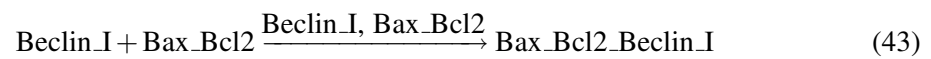| Id	Name	SBO
Bax_Bcl2_Beclin		

Kinetic Law

Derived unit contains undeclared units

$$v_{23} = \text{kbinBaxToBcl2Bec} \cdot \text{Bax} \cdot \text{Bcl2\_Beclin} \qquad (46)$$

6.24 Reaction `BaxBindingToBcl2_BeclinI`

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

Reaction equation

$$\text{Bax} + \text{Bcl2\_Beclin\_I} \xrightarrow{\text{Bax, Bcl2\_Beclin\_I}} \text{Bax\_Bcl2\_Beclin\_I} \qquad (47)$$
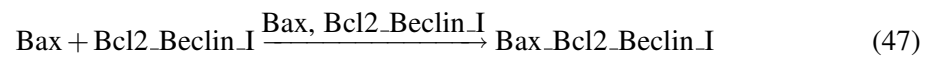
Reactants

Table 75: Properties of each reactant.

Id	Name	SBO
Bax		
Bcl2_Beclin_I		

Modifiers

Table 76: Properties of each modifier.

Id	Name	SBO
Bax		
Bcl2_Beclin_I		

Product

Table 77: Properties of each product.

Id	Name	SBO
Bax_Bcl2_Beclin_I		

Kinetic Law

Derived unit contains undeclared units

$$v_{24} = \text{kbinBaxToBcl2Bec} \cdot \text{Bax} \cdot \text{Bcl2\_Beclin\_I} \tag{48}$$

6.25 Reaction BaxDissociation_Bax_Bcl2_Beclin

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

Reaction equation

$$\text{Bax\_Bcl2\_Beclin} \xrightarrow{\text{Bax\_Bcl2\_Beclin}} \text{Bax} + \text{Bcl2\_Beclin} \tag{49}$$

Reactant

Table 78: Properties of each reactant.

Id	Name	SBO
Bax_Bcl2_Beclin		

Modifier

Table 79: Properties of each modifier.

Id	Name	SBO
Bax_Bcl2_Beclin		

Products

Table 80: Properties of each product.

Id	Name	SBO
Bax		
Bcl2_Beclin		

Kinetic Law

Derived unit contains undeclared units

$$v_{25} = \text{krelBaxBcl2Bec} \cdot \text{Bax\_Bcl2\_Beclin} \qquad (50)$$

6.26 Reaction `BaxDissociation_Bax_Bcl2_Beclin_I`

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

Reaction equation

$$\text{Bax\_Bcl2\_Beclin\_I} \xrightarrow{\text{Bax\_Bcl2\_Beclin\_I}} \text{Bax} + \text{Bcl2\_Beclin\_I} \qquad (51)$$
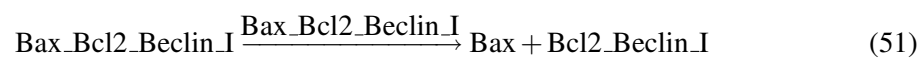
Reactant

Table 81: Properties of each reactant.

Id	Name	SBO
Bax_Bcl2_Beclin_I		

Modifier

Table 82: Properties of each modifier.

Id	Name	SBO
Bax_Bcl2_Beclin_I		

Products

Table 83: Properties of each product.

Id	Name	SBO
Bax		
Bcl2_Beclin_I		

Kinetic Law
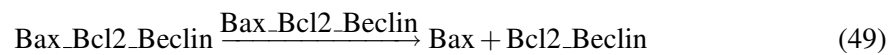
Derived unit contains undeclared units

$$v_{26} = \text{krelBaxBcl2Bec} \cdot \text{Bax\_Bcl2\_Beclin\_I} \qquad (52)$$

6.27 Reaction BeclinDissociation_Bax_Bcl2_Beclin

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

Reaction equation

$$Bax\_Bcl2\_Beclin \xrightarrow{Bax\_Bcl2\_Beclin} Beclin + Bax\_Bcl2 \tag{53}$$

Reactant

Table 84: Properties of each reactant.

Id	Name	SBO
Bax_Bcl2_Beclin		

Modifier

Table 85: Properties of each modifier.

Id	Name	SBO
Bax_Bcl2_Beclin		

Products

Table 86: Properties of each product.

Id	Name	SBO
Beclin		
Bax_Bcl2		

Kinetic Law

Derived unit contains undeclared units

$$v_{27} = krelBecBaxBcl2 \cdot Bax\_Bcl2\_Beclin \tag{54}$$

6.28 Reaction Beclin_I_Dissociation_Bax_Bcl2_Beclin

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

Reaction equation

$$Bax\_Bcl2\_Beclin\_I \xrightarrow{Bax\_Bcl2\_Beclin\_I} Beclin\_I + Bax\_Bcl2 \tag{55}$$

Reactant

Table 87: Properties of each reactant.

Id	Name	SBO
Bax_Bcl2_Beclin_I		

Modifier

Table 88: Properties of each modifier.

Id	Name	SBO
Bax_Bcl2_Beclin_I		

Products

Table 89: Properties of each product.

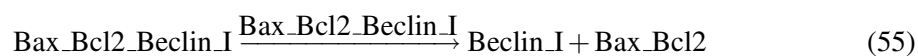| Id	Name	SBO
Beclin_I		
Bax_Bcl2		

Kinetic Law

Derived unit contains undeclared units

$$v_{28} = \text{krelBecBaxBcl2} \cdot \text{Bax\_Bcl2\_Beclin\_I} \tag{56}$$

6.29 Reaction ROS_generation

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

Reaction equation

$$\text{Source} \xrightarrow{\text{Source}} \text{ROS} \tag{57}$$
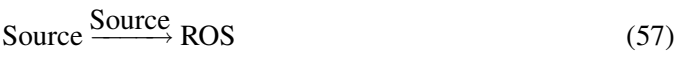
Reactant

Table 90: Properties of each reactant.

Id	Name	SBO
Source		

Modifier

Table 91: Properties of each modifier.

Id	Name	SBO
Source		

Product

Table 92: Properties of each product.

Id	Name	SBO
ROS		

Kinetic Law

Derived unit contains undeclared units

$$v_{29} = \text{kgenROS} \cdot \text{Source} \tag{58}$$

6.30 Reaction `ROS_removal`

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

Reaction equation

$$\text{ROS} \xrightarrow{\text{ROS}} \text{Sink} \tag{59}$$

Reactant

Table 93: Properties of each reactant.

Id	Name	SBO
ROS		

Modifier

Table 94: Properties of each modifier.

Id	Name	SBO
ROS		

Product

Table 95: Properties of each product.

Id	Name	SBO
Sink		

Kinetic Law

Derived unit contains undeclared units

$$v_{30} = \text{kremROS} \cdot \text{ROS} \tag{60}$$

6.31 Reaction `Protein_Damage_by_ROS`

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

Reaction equation

$$\text{NatP} + \text{ROS} \xrightarrow{\text{NatP, ROS}} \text{DamP} + \text{ROS} \tag{61}$$
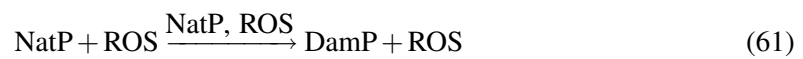
Reactants

Table 96: Properties of each reactant.

Id	Name	SBO
NatP		
ROS		

Modifiers

Table 97: Properties of each modifier.

Id	Name	SBO
NatP		
ROS		

Products

Table 98: Properties of each product.

Id	Name	SBO
DamP		
ROS		

Kinetic Law

Derived unit contains undeclared units

$$v_{31} = \frac{\text{kdamNatP} \cdot \text{NatP} \cdot \text{ROS}}{10 + \text{ROS}} \tag{62}$$

6.32 Reaction `Removal_DamP_by_Autophagy`

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

Reaction equation

$$\text{DamP} + \text{Lys\_A} \xrightarrow{\text{DamP, Lys\_A}} \text{Lys\_A} \tag{63}$$

Reactants

Table 99: Properties of each reactant.

Id	Name	SBO
DamP		
Lys_A		

Modifiers

Table 100: Properties of each modifier.

Id	Name	SBO
DamP		
Lys_A		

Product

Table 101: Properties of each product.

Id	Name	SBO
Lys_A		

Kinetic Law

Derived unit contains undeclared units

$$v_{32} = \text{kdegDamP} \cdot \text{DamP} \cdot \text{Lys\_A} \tag{64}$$

6.33 Reaction `Production_of_AGEproducts`

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

Reaction equation

$$\text{Source} \xrightarrow{\text{Source}} \text{AGEprod} \tag{65}$$

Reactant

Table 102: Properties of each reactant.

Id	Name	SBO
Source		

Modifier

Table 103: Properties of each modifier.

Id	Name	SBO
Source		

Product

Table 104: Properties of each product.

Id	Name	SBO
AGEprod		

Kinetic Law

Derived unit contains undeclared units

$$v_{33} = \text{kprodAGE} \cdot \text{Source} \tag{66}$$

6.34 Reaction `RAGE_activation`

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

Reaction equation

$$\text{AGEprod} \xrightarrow{\text{AGEprod}} \text{AGEprod} + \text{RAGE} \tag{67}$$

Reactant

Table 105: Properties of each reactant.

Id	Name	SBO
AGEprod		

Modifier

Table 106: Properties of each modifier.

Id	Name	SBO
AGEprod		

Products

Table 107: Properties of each product.

Id	Name	SBO
AGEprod		

Id	Name	SBO
RAGE		

Kinetic Law

Derived unit contains undeclared units

$$v_{34} = \text{kactRAGE} \cdot \text{AGEprod} \tag{68}$$

6.35 Reaction `ROS_production_by_RAGE`

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

Reaction equation

$$\text{RAGE} \xrightarrow{\text{RAGE}} \text{RAGE} + \text{ROS} \tag{69}$$

Reactant

Table 108: Properties of each reactant.

Id	Name	SBO
RAGE		

Modifier

Table 109: Properties of each modifier.

Id	Name	SBO
RAGE		

Products

Table 110: Properties of each product.

Id	Name	SBO
RAGE		
ROS		

Kinetic Law

Derived unit contains undeclared units

$$v_{35} = \text{kgenROSbyRAGE} \cdot \text{RAGE} \qquad (70)$$

6.36 Reaction `IkB_degradation_via_ROS`

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

Reaction equation

$$\text{ROS} + \text{IkB\_NFkB} \xrightarrow{\text{ROS, IkB\_NFkB}} \text{ROS} + \text{NFkB} \qquad (71)$$
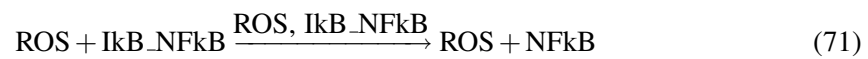
Reactants

Table 111: Properties of each reactant.

Id	Name	SBO
ROS		
IkB_NFkB		

Modifiers

Table 112: Properties of each modifier.

Id	Name	SBO
ROS		
IkB_NFkB		

Products

Table 113: Properties of each product.

Id	Name	SBO
ROS		
NFkB		

Kinetic Law

Derived unit contains undeclared units

$$v_{36} = \text{kdegIkB} \cdot \text{ROS} \cdot \text{IkB\_NFkB} \tag{72}$$

6.37 Reaction `IkB_degradation_via_IL1`

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

Reaction equation

$$\text{IL1} + \text{IkB\_NFkB} \xrightarrow{\text{IL1, IkB\_NFkB}} \text{IL1} + \text{NFkB} \tag{73}$$
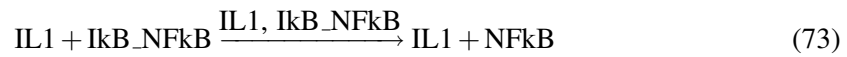
Reactants

Table 114: Properties of each reactant.

Id	Name	SBO
IL1		
IkB_NFkB		

Modifiers

Table 115: Properties of each modifier.

Id	Name	SBO
IL1		
IkB_NFkB		

Products

Table 116: Properties of each product.

Id	Name	SBO
IL1		
NFkB		

Kinetic Law

Derived unit contains undeclared units

$$v_{37} = \text{kdegIkB} \cdot \text{IL1} \cdot \text{IkB\_NFkB} \tag{74}$$

6.38 Reaction `NFkB_inactivation`

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

Reaction equation

$$NFkB + IkB \xrightarrow{NFkB,\ IkB} IkB\_NFkB \tag{75}$$

Reactants

Table 117: Properties of each reactant.

Id	Name	SBO
NFkB		
IkB		

Modifiers

Table 118: Properties of each modifier.

Id	Name	SBO
NFkB		
IkB		

Product

Table 119: Properties of each product.

Id	Name	SBO
IkB_NFkB		

Kinetic Law

Derived unit contains undeclared units

$$v_{38} = \text{kinactNFkB} \cdot \text{NFkB} \cdot \text{IkB} \tag{76}$$

6.39 Reaction `RAGE_inactivation`

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

Reaction equation

$$\text{RAGE} \xrightarrow{\text{RAGE}} \text{Sink} \tag{77}$$

Reactant

Table 120: Properties of each reactant.

Id	Name	SBO
RAGE		

Modifier

Table 121: Properties of each modifier.

Id	Name	SBO
RAGE		

Product

Table 122: Properties of each product.

Id	Name	SBO
Sink		

Kinetic Law

Derived unit contains undeclared units

$$v_{39} = \text{kinactRAGE} \cdot \text{RAGE} \tag{78}$$

6.40 Reaction `RAGE_upregulation_byNFkB`

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

Reaction equation

$$\text{NFkB\_P} \xrightarrow{\text{NFkB\_P}} \text{NFkB\_P} + \text{RAGE} \tag{79}$$

Reactant

Table 123: Properties of each reactant.

Id	Name	SBO
NFkB_P		

Modifier

Table 124: Properties of each modifier.

Id	Name	SBO
NFkB_P		

Products

Table 125: Properties of each product.

Id	Name	SBO
NFkB_P		
RAGE		

Kinetic Law

Derived unit contains undeclared units

$$v_{40} = \text{ksynRAGE} \cdot \text{NFkB\_P} \tag{80}$$

6.41 Reaction `IL1_production`

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

Reaction equation

$$\text{NFkB\_P} \xrightarrow{\text{NFkB\_P}} \text{NFkB\_P} + \text{IL1} \tag{81}$$

Reactant

Table 126: Properties of each reactant.

Id	Name	SBO
NFkB_P		

Modifier

Table 127: Properties of each modifier.

Id	Name	SBO
NFkB_P		

Products

Table 128: Properties of each product.

Id	Name	SBO
NFkB_P		
IL1		

Kinetic Law

Derived unit contains undeclared units

$$v_{41} = \text{ksynIL1} \cdot \text{NFkB\_P} \tag{82}$$

6.42 Reaction `IL1_degradation`

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

Reaction equation

$$\text{IL1} \xrightarrow{\text{IL1}} \text{Sink} \tag{83}$$

Reactant

Table 129: Properties of each reactant.

Id	Name	SBO
IL1		

Modifier

Table 130: Properties of each modifier.

Id	Name	SBO
IL1		

Product

Table 131: Properties of each product.

Id	Name	SBO
Sink		

Kinetic Law

Derived unit contains undeclared units

$$v_{42} = \text{kdegIL1} \cdot \text{IL1} \tag{84}$$

6.43 Reaction `IkB_production`

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

Reaction equation

$$\text{NFkB\_P} \xrightarrow{\text{NFkB\_P}} \text{NFkB\_P} + \text{IkB} \tag{85}$$

Reactant

Table 132: Properties of each reactant.

Id	Name	SBO
NFkB_P		

Modifier

Table 133: Properties of each modifier.

Id	Name	SBO
NFkB_P		

Products

Table 134: Properties of each product.

Id	Name	SBO
NFkB_P		
IkB		

Kinetic Law

Derived unit contains undeclared units

$$v_{43} = \text{ksynIkB} \cdot \text{NFkB\_P} \tag{86}$$

6.44 Reaction MMP13_production

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

Reaction equation

$$\text{IL1} \xrightarrow{\text{IL1}} \text{IL1} + \text{proMMP13} \tag{87}$$

Reactant

Table 135: Properties of each reactant.

Id	Name	SBO
IL1		

Modifier

Table 136: Properties of each modifier.

Id	Name	SBO
IL1		

Products

Table 137: Properties of each product.

Id	Name	SBO
IL1		
proMMP13		

Kinetic Law

Derived unit contains undeclared units

$$v_{44} = \text{ksynMMP13} \cdot \text{IL1} \tag{88}$$

6.45 Reaction MMP13_removal

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

Reaction equation

$$\text{MMP13} \xrightarrow{\text{MMP13}} \text{Sink} \tag{89}$$

Reactant

Table 138: Properties of each reactant.

Id	Name	SBO
MMP13		

Modifier

Table 139: Properties of each modifier.

Id	Name	SBO
MMP13		

Product

Table 140: Properties of each product.

Id	Name	SBO
Sink		

Kinetic Law

Derived unit contains undeclared units

$$v_{45} = \text{kdegMMP13} \cdot \text{MMP13} \tag{90}$$

6.46 Reaction `MMP2_production`

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

Reaction equation

$$\text{IL1} \xrightarrow{\text{IL1}} \text{IL1} + \text{proMMP2} \tag{91}$$

Reactant

Table 141: Properties of each reactant.

Id	Name	SBO
IL1		

Modifier

Table 142: Properties of each modifier.

Id	Name	SBO
IL1		

Products

Table 143: Properties of each product.

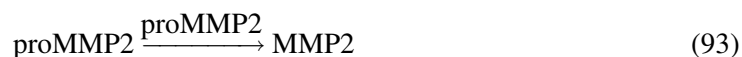| Id	Name	SBO
IL1		
proMMP2		

Kinetic Law

Derived unit contains undeclared units

$$v_{46} = \text{ksynMMP2} \cdot \text{IL1} \tag{92}$$

6.47 Reaction `MMP_activation`

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

Reaction equation

$$\text{proMMP2} \xrightarrow{\text{proMMP2}} \text{MMP2} \tag{93}$$

Reactant

Table 144: Properties of each reactant.

Id	Name	SBO
proMMP2		

Modifier

Table 145: Properties of each modifier.

Id	Name	SBO
proMMP2		

Product

Table 146: Properties of each product.

Id	Name	SBO
MMP2		

Kinetic Law

Derived unit contains undeclared units

$$v_{47} = \text{kactMMP2} \cdot \text{proMMP2} \tag{94}$$

6.48 Reaction `MMP2_degradation`

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

Reaction equation

$$\text{MMP2} \xrightarrow{\text{MMP2}} \text{Sink} \tag{95}$$

Produced by SBML2LATEX

Reactant

Table 147: Properties of each reactant.

Id	Name	SBO
MMP2		

Modifier

Table 148: Properties of each modifier.

Id	Name	SBO
MMP2		

Product

Table 149: Properties of each product.

Id	Name	SBO
Sink		

Kinetic Law

Derived unit contains undeclared units

$$v_{48} = \text{kdegMMP2} \cdot \text{MMP2} \tag{96}$$

6.49 Reaction `ADAMTS5_production`

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

Reaction equation

$$\text{IL1} \xrightarrow{\text{IL1}} \text{IL1} + \text{ADAMTS5} \tag{97}$$

Reactant

Table 150: Properties of each reactant.

Id	Name	SBO
IL1		

Modifier

Table 151: Properties of each modifier.

Id	Name	SBO
IL1		

Products

Table 152: Properties of each product.

Id	Name	SBO
IL1		
ADAMTS5		

Kinetic Law

Derived unit contains undeclared units

$$v_{49} = \text{ksynADAMTS5} \cdot \text{IL1} \tag{98}$$

6.50 Reaction `ADAMTS5_removal`

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

Reaction equation

$$\text{ADAMTS5} \xrightarrow{\text{ADAMTS5}} \text{Sink} \tag{99}$$

Reactant

Table 153: Properties of each reactant.

Id	Name	SBO
ADAMTS5		

Modifier

Table 154: Properties of each modifier.

Id	Name	SBO
ADAMTS5		

Product

Table 155: Properties of each product.

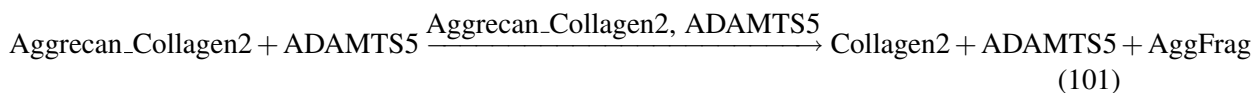| Id	Name	SBO
Sink		

Kinetic Law

Derived unit contains undeclared units

$$v_{50} = \text{kdegADAMTS5} \cdot \text{ADAMTS5} \tag{100}$$

6.51 Reaction `Aggrecan_degradation`

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

Reaction equation

$$\text{Aggrecan\_Collagen2} + \text{ADAMTS5} \xrightarrow{\text{Aggrecan\_Collagen2, ADAMTS5}} \text{Collagen2} + \text{ADAMTS5} + \text{AggFrag} \tag{101}$$

Reactants

Table 156: Properties of each reactant.

Id	Name	SBO
Aggrecan_Collagen2		
ADAMTS5		

Modifiers

Table 157: Properties of each modifier.

Id	Name	SBO
Aggrecan_Collagen2		
ADAMTS5		

Products

Table 158: Properties of each product.

Id	Name	SBO
Collagen2		
ADAMTS5		
AggFrag		

Kinetic Law

Derived unit contains undeclared units

$$v_{51} = \text{kdegAggrecan} \cdot \text{Aggrecan\_Collagen2} \cdot \text{ADAMTS5} \tag{102}$$

6.52 Reaction `Collagen_degradation`

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

Reaction equation

$$\text{Collagen2} + \text{MMP13} \xrightarrow{\text{Collagen2, MMP13}} \text{MMP13} + \text{ColFrag} \tag{103}$$

Reactants

Table 159: Properties of each reactant.

Id	Name	SBO
Collagen2		
MMP13		

Modifiers

Table 160: Properties of each modifier.

Id	Name	SBO
Collagen2		
MMP13		

Products

Table 161: Properties of each product.

Id	Name	SBO
MMP13		
ColFrag		

Kinetic Law

Derived unit contains undeclared units

$$v_{52} = \text{kdegCollagen} \cdot \text{Collagen2} \cdot \text{MMP13} \qquad (104)$$

6.53 Reaction `ROS_production_by_DamP`

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

Reaction equation

$$\text{DamP} \xrightarrow{\text{DamP}} \text{DamP} + \text{ROS} \qquad (105)$$

Reactant

Table 162: Properties of each reactant.

Id	Name	SBO
DamP		

Modifier

Table 163: Properties of each modifier.

Id	Name	SBO
DamP		

Products

Table 164: Properties of each product.

Id	Name	SBO
DamP		
ROS		

Kinetic Law

Derived unit contains undeclared units

$$v_{53} = \text{kgenROSbyDamP} \cdot \text{DamP} \tag{106}$$

6.54 Reaction `Protein_synthesis`

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

Reaction equation

$$\text{Source} \xrightarrow{\text{Source}} \text{NatP} \tag{107}$$

Reactant

Table 165: Properties of each reactant.

Id	Name	SBO
Source		

Modifier

Table 166: Properties of each modifier.

Id	Name	SBO
Source		

Product

Table 167: Properties of each product.

Id	Name	SBO
NatP		

Kinetic Law

Derived unit contains undeclared units

$$v_{54} = \text{ksynNatP} \cdot \text{Source} \tag{108}$$

6.55 Reaction SOD_synthesis

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

Reaction equation

$$\text{NFkB\_P} \xrightarrow{\text{NFkB\_P}} \text{NFkB\_P} + \text{SOD} \tag{109}$$

Reactant

Table 168: Properties of each reactant.

Id	Name	SBO
NFkB_P		

Modifier

Table 169: Properties of each modifier.

Id	Name	SBO
NFkB_P		

Products

Table 170: Properties of each product.

Id	Name	SBO
NFkB_P		
SOD		

Kinetic Law

Derived unit contains undeclared units

$$v_{55} = \text{ksynSOD} \cdot \text{NFkB\_P} \tag{110}$$

6.56 Reaction SOD_degradation

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

Reaction equation

$$\text{SOD} \xrightarrow{\text{SOD}} \text{Sink} \tag{111}$$

Reactant

Table 171: Properties of each reactant.

Id	Name	SBO
SOD		

Modifier

Table 172: Properties of each modifier.

Id	Name	SBO
SOD		

Product

Table 173: Properties of each product.

Id	Name	SBO
Sink		

Kinetic Law

Derived unit contains undeclared units

$$v_{56} = \text{kdegSOD} \cdot \text{SOD} \tag{112}$$

6.57 Reaction `ROS_removal_by_SOD`

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

Reaction equation

$$ROS + SOD \xrightarrow{SOD, ROS} SOD \tag{113}$$

Reactants

Table 174: Properties of each reactant.

Id	Name	SBO
ROS		
SOD		

Modifiers

Table 175: Properties of each modifier.

Id	Name	SBO
SOD		
ROS		

Product

Table 176: Properties of each product.

Id	Name	SBO
SOD		

Kinetic Law

Derived unit contains undeclared units

$$v_{57} = \text{kremROSbySOD} \cdot \text{SOD} \cdot \text{ROS} \tag{114}$$

6.58 Reaction `p38_phosphorylation`

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

Reaction equation

$$p38 + IL1 \xrightarrow{\text{p38, IL1}} p38\_P + IL1 \tag{115}$$

Reactants

Table 177: Properties of each reactant.

Id	Name	SBO
p38		
IL1		

Modifiers

Table 178: Properties of each modifier.

Id	Name	SBO
p38		
IL1		

Products

Table 179: Properties of each product.

Id	Name	SBO
p38_P		
IL1		

Kinetic Law

Derived unit contains undeclared units

$$v_{58} = \text{kphosp38} \cdot \text{p38} \cdot \text{IL1} \tag{116}$$

6.59 Reaction p38_phosphorylation_via_ROS

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

Reaction equation

$$p38 + ROS \xrightarrow{\text{p38, ROS}} p38\_P + ROS \tag{117}$$

Reactants

Table 180: Properties of each reactant.

Id	Name	SBO
p38		
ROS		

Modifiers

Table 181: Properties of each modifier.

Id	Name	SBO
p38		
ROS		

Products

Table 182: Properties of each product.

Id	Name	SBO
p38_P		
ROS		

Kinetic Law

Derived unit contains undeclared units

$$v_{59} = \text{kphosp38ROS} \cdot \text{p38} \cdot \text{ROS} \tag{118}$$

6.60 Reaction `p38_dephosphorylation`

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

Reaction equation

$$\text{p38\_P} \xrightarrow{\text{p38\_P}} \text{p38} \tag{119}$$

Reactant

Table 183: Properties of each reactant.

Id	Name	SBO
p38_P		

Modifier

Table 184: Properties of each modifier.

Id	Name	SBO
p38_P		

Product

Table 185: Properties of each product.

Id	Name	SBO
p38		

Kinetic Law

Derived unit contains undeclared units

$$v_{60} = \text{kdephosp38} \cdot \text{p38\_P} \tag{120}$$

6.61 Reaction `NFkB_activation`

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

Reaction equation

$$\text{NFkB} + \text{p38\_P} \xrightarrow{\text{NFkB, p38\_P}} \text{NFkB\_P} + \text{p38\_P} \tag{121}$$

Reactants

Table 186: Properties of each reactant.

Id	Name	SBO
NFkB		
p38_P		

Modifiers

Table 187: Properties of each modifier.

Id	Name	SBO
NFkB		
p38_P		

Products

Table 188: Properties of each product.

Id	Name	SBO
NFkB_P		
p38_P		

Kinetic Law

Derived unit contains undeclared units

$$v_{61} = \text{kphosNFkB} \cdot \text{NFkB} \cdot \text{p38\_P} \tag{122}$$

6.62 Reaction `NFkB_dephosphorylation`

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

Reaction equation

$$\text{NFkB\_P} \xrightarrow{\text{NFkB\_P}} \text{NFkB} \tag{123}$$

Reactant

Table 189: Properties of each reactant.

Id	Name	SBO
NFkB_P		

Modifier

Table 190: Properties of each modifier.

Id	Name	SBO
NFkB_P		

Product

Table 191: Properties of each product.

Id	Name	SBO
NFkB		

Kinetic Law

Derived unit contains undeclared units

$$v_{62} = \text{kdephosNFkB} \cdot \text{NFkB\_P} \qquad (124)$$

6.63 Reaction `ROS_production_by_p38_P`

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

Reaction equation

$$\text{p38\_P} \xrightarrow{\text{p38\_P}} \text{p38\_P} + \text{ROS} \qquad (125)$$

Reactant

Table 192: Properties of each reactant.

Id	Name	SBO
p38_P		

Modifier

Table 193: Properties of each modifier.

Id	Name	SBO
p38_P		

Products

Table 194: Properties of each product.

Id	Name	SBO
p38_P		
ROS		

Kinetic Law

Derived unit contains undeclared units

$$v_{63} = \text{kgenROSbyp38} \cdot \text{p38\_P} \tag{126}$$

6.64 Reaction `Lysosome_damage_by_ROS`

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

Reaction equation

$$\text{Lys\_A} + \text{ROS} \xrightarrow{\text{Lys\_A, ROS}} \text{Lys\_I} + \text{ROS} \tag{127}$$
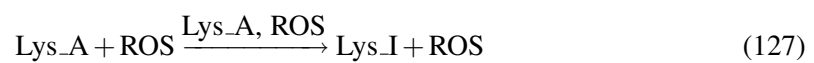
Reactants

Table 195: Properties of each reactant.

Id	Name	SBO
Lys_A		
ROS		

Modifiers

Table 196: Properties of each modifier.

Id	Name	SBO
Lys_A		
ROS		

Products

Table 197: Properties of each product.

Id	Name	SBO
Lys_I		
ROS		

Kinetic Law

Derived unit contains undeclared units

$$v_{64} = \frac{\text{kdamLys} \cdot \text{Lys\_A} \cdot \text{ROS}}{10 + \text{ROS}} \tag{128}$$

6.65 Reaction `IntegrinActivationByMechanicalStress`

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

Reaction equation

$$\text{Source} \xrightarrow{\text{Source}} \text{Integrin} + \text{IntegrinCount} \tag{129}$$

Reactant

Table 198: Properties of each reactant.

Id	Name	SBO
Source		

Modifier

Table 199: Properties of each modifier.

Id	Name	SBO
Source		

Products

Table 200: Properties of each product.

Id	Name	SBO
Integrin		

Id	Name	SBO
IntegrinCount		

Kinetic Law

Derived unit contains undeclared units

$$v_{65} = \text{kactIntegrin} \cdot \text{Source} \tag{130}$$

6.66 Reaction `IntegrinInactivation`

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

Reaction equation

$$\text{Integrin} \xrightarrow{\text{Integrin}} \text{Sink} \tag{131}$$

Reactant

Table 201: Properties of each reactant.

Id	Name	SBO
Integrin		

Modifier

Table 202: Properties of each modifier.

Id	Name	SBO
Integrin		

Product

Table 203: Properties of each product.

Id	Name	SBO
Sink		

Kinetic Law

Derived unit contains undeclared units

$$v_{66} = \text{kinactIntegrin} \cdot \text{Integrin} \tag{132}$$

6.67 Reaction `Alk5Synthesis`

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

Reaction equation

$$\text{Source} \xrightarrow{\text{Source}} \text{Alk5} \tag{133}$$

Reactant

Table 204: Properties of each reactant.

Id	Name	SBO
Source		

Modifier

Table 205: Properties of each modifier.

Id	Name	SBO
Source		

Product

Table 206: Properties of each product.

Id	Name	SBO
Alk5		

Kinetic Law

Derived unit contains undeclared units

$$v_{67} = \text{ksynAlk5} \cdot \text{Source} \tag{134}$$

6.68 Reaction `TgfbActivationByIntegrin`

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

Reaction equation

$$\text{Tgfb\_I} + \text{Integrin} \xrightarrow{\text{Tgfb\_I, Integrin}} \text{Tgfb\_A} + \text{Integrin} \tag{135}$$

Reactants

Table 207: Properties of each reactant.

Id	Name	SBO
Tgfb_I		
Integrin		

Modifiers

Table 208: Properties of each modifier.

Id	Name	SBO
Tgfb_I		
Integrin		

Products

Table 209: Properties of each product.

Id	Name	SBO
Tgfb_A		
Integrin		

Kinetic Law

Derived unit contains undeclared units

$$v_{68} = \text{kactTgfbIntegrin} \cdot \text{Tgfb\_I} \cdot \text{Integrin} \tag{136}$$

6.69 Reaction `TgfbActivationByMMP2`

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

Reaction equation

$$\text{Tgfb\_I} + \text{MMP2} \xrightarrow{\text{Tgfb\_I, MMP2}} \text{Tgfb\_A} + \text{MMP2} \tag{137}$$

Reactants

Table 210: Properties of each reactant.

Id	Name	SBO
Tgfb_I		
MMP2		

Modifiers

Table 211: Properties of each modifier.

Id	Name	SBO
Tgfb_I		
MMP2		

Products

Table 212: Properties of each product.

Id	Name	SBO
Tgfb_A		
MMP2		

Kinetic Law

Derived unit contains undeclared units

$$v_{69} = \text{kactTgfbMMP2} \cdot \text{Tgfb\_I} \cdot \text{MMP2} \tag{138}$$

6.70 Reaction `TgfbInactivation`

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

Reaction equation

$$\text{Tgfb\_A} \xrightarrow{\text{Tgfb\_A}} \text{Tgfb\_I} \tag{139}$$

Reactant

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Table 213: Properties of each reactant.

Id	Name	SBO
Tgfb_A		

Modifier

Table 214: Properties of each modifier.

Id	Name	SBO
Tgfb_A		

Product

Table 215: Properties of each product.

Id	Name	SBO
Tgfb_I		

Kinetic Law

Derived unit contains undeclared units

$$v_{70} = \text{kinactTgfb} \cdot \text{Tgfb\_A} \tag{140}$$

6.71 Reaction `Alk5Dimerisation`

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

Reaction equation

$$2\,\text{Alk5} \xrightarrow{\text{Alk5}} \text{Alk5\_dimer} \tag{141}$$

Reactant

Table 216: Properties of each reactant.

Id	Name	SBO
Alk5		

Modifier

Table 217: Properties of each modifier.

Id	Name	SBO
Alk5		

Product

Table 218: Properties of each product.

Id	Name	SBO
Alk5_dimer		

Kinetic Law

Derived unit contains undeclared units

$$v_{71} = \text{kdimerAlk5} \cdot \text{Alk5} \cdot (\text{Alk5} - 1) \cdot 0.5 \tag{142}$$

6.72 Reaction `Alk5Dedimerisation`

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

Reaction equation

$$\text{Alk5\_dimer} \xrightarrow{\text{Alk5\_dimer}} 2\,\text{Alk5} \tag{143}$$

Reactant

Table 219: Properties of each reactant.

Id	Name	SBO
Alk5_dimer		

Modifier

Table 220: Properties of each modifier.

Id	Name	SBO
Alk5_dimer		

Id	Name	SBO

Product

Table 221: Properties of each product.

Id	Name	SBO
Alk5		

Kinetic Law

Derived unit contains undeclared units

$$v_{72} = \text{kdedimerAlk5} \cdot \text{Alk5\_dimer} \qquad (144)$$

6.73 Reaction `Alk1Alk5Binding`

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

Reaction equation

$$\text{Alk1} + \text{Alk5} \xrightarrow{\text{Alk1, Alk5}} \text{Alk1\_Alk5} \qquad (145)$$

Reactants

Table 222: Properties of each reactant.

Id	Name	SBO
Alk1		
Alk5		

Modifiers

Table 223: Properties of each modifier.

Id	Name	SBO
Alk1		
Alk5		

Product

Table 224: Properties of each product.

Id	Name	SBO
Alk1_Alk5		

Kinetic Law

**Derived unit** contains undeclared units

$$v_{73} = \text{kbinAlk1Alk5} \cdot \text{Alk1} \cdot \text{Alk5} \qquad (146)$$

6.74 Reaction `Alk1Alk5Release`

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

Reaction equation

$$\text{Alk1\_Alk5} \xrightarrow{\text{Alk1\_Alk5}} \text{Alk1} + \text{Alk5} \qquad (147)$$

Reactant

Table 225: Properties of each reactant.

Id	Name	SBO
Alk1_Alk5		

Modifier

Table 226: Properties of each modifier.

Id	Name	SBO
Alk1_Alk5		

Products

Table 227: Properties of each product.

Id	Name	SBO
Alk1		
Alk5		

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Kinetic Law

Derived unit contains undeclared units

$$v_{74} = \text{krelAlk1Alk5} \cdot \text{Alk1\_Alk5} \tag{148}$$

6.75 Reaction `TgfbReceptorBindingAlk5`

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

Reaction equation

$$\text{Tgfb\_A} + \text{Alk5\_dimer} \xrightarrow{\text{Tgfb\_A, Alk5\_dimer}} \text{Tgfb\_Alk5\_dimer} \tag{149}$$
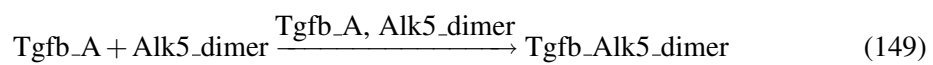
Reactants

Table 228: Properties of each reactant.

Id	Name	SBO
Tgfb_A		
Alk5_dimer		

Modifiers

Table 229: Properties of each modifier.

Id	Name	SBO
Tgfb_A		
Alk5_dimer		

Product

Table 230: Properties of each product.

Id	Name	SBO
Tgfb_Alk5_dimer		

Kinetic Law

Derived unit contains undeclared units

$$v_{75} = \text{kbinTgfbAlk5} \cdot \text{Tgfb\_A} \cdot \text{Alk5\_dimer} \tag{150}$$

6.76 Reaction `TgfbReceptorRelease`

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

Reaction equation

$$\text{Tgfb\_Alk5\_dimer} \xrightarrow{\text{Tgfb\_Alk5\_dimer}} \text{Tgfb\_A} + \text{Alk5\_dimer} \qquad (151)$$
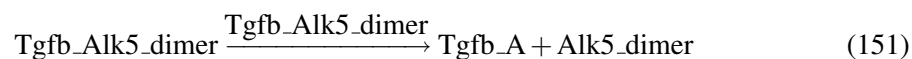
Reactant

Table 231: Properties of each reactant.

Id	Name	SBO
Tgfb_Alk5_dimer		

Modifier

Table 232: Properties of each modifier.

Id	Name	SBO
Tgfb_Alk5_dimer		

Products

Table 233: Properties of each product.

Id	Name	SBO
Tgfb_A		
Alk5_dimer		

Kinetic Law

Derived unit contains undeclared units

$$v_{76} = \text{krelTgfbAlk5} \cdot \text{Tgfb\_Alk5\_dimer} \qquad (152)$$

6.77 Reaction `Tgfb_Alk5_BindingSmad7`

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

Reaction equation

$$\text{Tgfb\_Alk5\_dimer} + \text{Smad7} \xrightarrow{\text{Tgfb\_Alk5\_dimer, Smad7}} \text{Tgfb\_Alk5\_dimer\_Smad7} \quad (153)$$
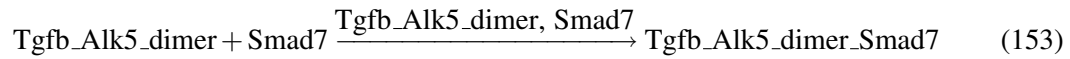
Reactants

Table 234: Properties of each reactant.

Id	Name	SBO
Tgfb_Alk5_dimer		
Smad7		

Modifiers

Table 235: Properties of each modifier.

Id	Name	SBO
Tgfb_Alk5_dimer		
Smad7		

Product

Table 236: Properties of each product.

Id	Name	SBO
Tgfb_Alk5_dimer_Smad7		

Kinetic Law

Derived unit contains undeclared units

$$v_{77} = \text{kbinSmad7Alk5} \cdot \text{Tgfb\_Alk5\_dimer} \cdot \text{Smad7} \quad (154)$$

6.78 Reaction `Tgfb_Alk5_Smad7Release`

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

Reaction equation

$$\text{Tgfb\_Alk5\_dimer\_Smad7} \xrightarrow{\text{Tgfb\_Alk5\_dimer\_Smad7}} \text{Tgfb\_Alk5\_dimer} + \text{Smad7} \quad (155)$$
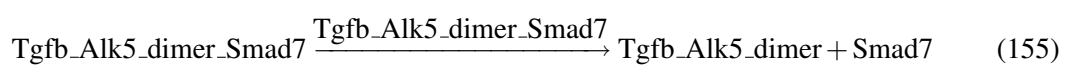
Reactant

Table 237: Properties of each reactant.

Id	Name	SBO
Tgfb_Alk5_dimer_Smad7		

Modifier

Table 238: Properties of each modifier.

Id	Name	SBO
Tgfb_Alk5_dimer_Smad7		

Products

Table 239: Properties of each product.

Id	Name	SBO
Tgfb_Alk5_dimer		
Smad7		

Kinetic Law

Derived unit contains undeclared units

$$v_{78} = \text{krelSmad7Alk5} \cdot \text{Tgfb\_Alk5\_dimer\_Smad7} \tag{156}$$

6.79 Reaction `Alk5_Smad7Degradation`

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

Reaction equation

$$\text{Tgfb\_Alk5\_dimer\_Smad7} \xrightarrow{\text{Tgfb\_Alk5\_dimer\_Smad7}} \text{Tgfb\_I} \tag{157}$$
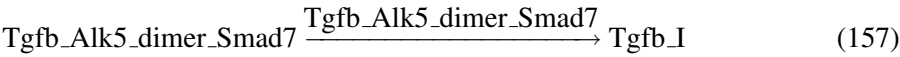
Reactant

Table 240: Properties of each reactant.

Id	Name	SBO
Tgfb_Alk5_dimer_Smad7		

Modifier

Table 241: Properties of each modifier.

Id	Name	SBO
Tgfb_Alk5_dimer_Smad7		

Product

Table 242: Properties of each product.

Id	Name	SBO
Tgfb_I		

Kinetic Law

Derived unit contains undeclared units

$$v_{79} = \text{kdegSmad7Alk5} \cdot \text{Tgfb\_Alk5\_dimer\_Smad7} \qquad (158)$$

6.80 Reaction `TgfbReceptorBindingAlk1`

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

Reaction equation

$$\text{Tgfb\_A} + \text{Alk1\_Alk5} \xrightarrow{\text{Tgfb\_A, Alk1\_Alk5}} \text{Tgfb\_Alk1\_Alk5} \qquad (159)$$

Reactants

Table 243: Properties of each reactant.

Id	Name	SBO
Tgfb_A		
Alk1_Alk5		

Modifiers

Table 244: Properties of each modifier.

Id	Name	SBO
Tgfb_A		
Alk1_Alk5		

Product

Table 245: Properties of each product.

Id	Name	SBO
Tgfb_Alk1_Alk5		

Kinetic Law

Derived unit contains undeclared units

$$v_{80} = \text{kbinTgfbAlk1} \cdot \text{Tgfb\_A} \cdot \text{Alk1\_Alk5} \tag{160}$$

6.81 Reaction `TgfbAlk1Release`

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

Reaction equation

$$\text{Tgfb\_Alk1\_Alk5} \xrightarrow{\text{Tgfb\_Alk1\_Alk5}} \text{Tgfb\_A} + \text{Alk1\_Alk5} \tag{161}$$

Reactant

Table 246: Properties of each reactant.

Id	Name	SBO
Tgfb_Alk1_Alk5		

Modifier

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Table 247: Properties of each modifier.

Id	Name	SBO
Tgfb_Alk1_Alk5		

Products

Table 248: Properties of each product.

Id	Name	SBO
Tgfb_A		
Alk1_Alk5		

Kinetic Law

Derived unit contains undeclared units

$$v_{81} = \text{krelTgfbAlk1} \cdot \text{Tgfb\_Alk1\_Alk5} \tag{162}$$

6.82 Reaction Smad2Phosphorylation

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

Reaction equation

$$\text{Tgfb\_Alk5\_dimer} + \text{Smad2} \xrightarrow{\text{Tgfb\_Alk5\_dimer, Smad2}} \text{Tgfb\_Alk5\_dimer} + \text{Smad2\_P} \tag{163}$$
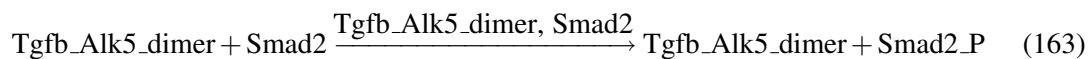
Reactants

Table 249: Properties of each reactant.

Id	Name	SBO
Tgfb_Alk5_dimer		
Smad2		

Modifiers

Table 250: Properties of each modifier.

Id	Name	SBO
Tgfb_Alk5_dimer		
Smad2		

Products

Table 251: Properties of each product.

Id	Name	SBO
Tgfb_Alk5_dimer		
Smad2_P		

Kinetic Law

Derived unit contains undeclared units

$$v_{82} = \text{kphosSmad2} \cdot \text{Tgfb\_Alk5\_dimer} \cdot \text{Smad2} \tag{164}$$

6.83 Reaction Smad2Smad4Binding

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

Reaction equation

$$\text{Smad2\_P} + \text{Smad4} \xrightarrow{\text{Smad2\_P, Smad4}} \text{Smad2\_P\_Smad4} \tag{165}$$
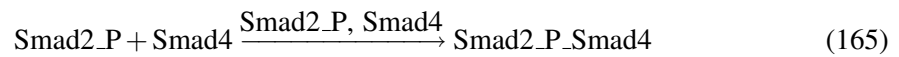
Reactants

Table 252: Properties of each reactant.

Id	Name	SBO
Smad2_P		
Smad4		

Modifiers

Produced by SBML2LATEX

Table 253: Properties of each modifier.

Id	Name	SBO
Smad2_P		
Smad4		

Product

Table 254: Properties of each product.

Id	Name	SBO
Smad2_P_Smad4		

Kinetic Law

Derived unit contains undeclared units

$$v_{83} = \text{kbinSmad2Smad4} \cdot \text{Smad2\_P} \cdot \text{Smad4} \tag{166}$$

6.84 Reaction `Smad2PSmad4Release`

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

Reaction equation

$$\text{Smad2\_P\_Smad4} \xrightarrow{\text{Smad2\_P\_Smad4}} \text{Smad2\_P} + \text{Smad4} \tag{167}$$

Reactant

Table 255: Properties of each reactant.

Id	Name	SBO
Smad2_P_Smad4		

Modifier

Table 256: Properties of each modifier.

Id	Name	SBO
Smad2_P_Smad4		

Products

Table 257: Properties of each product.

Id	Name	SBO
Smad2_P		
Smad4		

Kinetic Law

Derived unit contains undeclared units

$$v_{84} = \text{krelSmad2Smad4} \cdot \text{Smad2\_P\_Smad4} \qquad (168)$$

6.85 Reaction `Smad2DephosphorylationNuc`

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

Reaction equation

$$\text{Smad2\_P} \xrightarrow{\text{Smad2\_P}} \text{Smad2} \qquad (169)$$

Reactant

Table 258: Properties of each reactant.

Id	Name	SBO
Smad2_P		

Modifier

Table 259: Properties of each modifier.

Id	Name	SBO
Smad2_P		

Product

Table 260: Properties of each product.

Id	Name	SBO
Smad2		

Kinetic Law

Derived unit contains undeclared units

$$v_{85} = \text{kdephosSmad2} \cdot \text{Smad2\_P} \tag{170}$$

6.86 Reaction `Smad7Synthesis`

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

Reaction equation

$$\text{Smad2\_P\_Smad4} \xrightarrow{\text{Smad2\_P\_Smad4}} \text{Smad2\_P\_Smad4} + \text{Smad7} \tag{171}$$
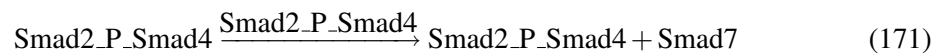
Reactant

Table 261: Properties of each reactant.

Id	Name	SBO
Smad2_P_Smad4		

Modifier

Table 262: Properties of each modifier.

Id	Name	SBO
Smad2_P_Smad4		

Products

Table 263: Properties of each product.

Id	Name	SBO
Smad2_P_Smad4		
Smad7		

Kinetic Law

Derived unit contains undeclared units

$$v_{86} = \text{ksynSmad7} \cdot \text{Smad2\_P\_Smad4} \tag{172}$$

6.87 Reaction `Sox9Activation`

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

Reaction equation

$$\text{Smad2\_P\_Smad4} + \text{Sox9} \xrightarrow{\text{Smad2\_P\_Smad4, Sox9}} \text{Smad2\_P\_Smad4} + \text{Sox9\_A} \tag{173}$$
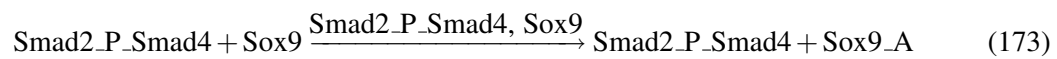
Reactants

Table 264: Properties of each reactant.

Id	Name	SBO
Smad2_P_Smad4		
Sox9		

Modifiers

Table 265: Properties of each modifier.

Id	Name	SBO
Smad2_P_Smad4		
Sox9		

Products

Table 266: Properties of each product.

Id	Name	SBO
Smad2_P_Smad4		
Sox9_A		

Kinetic Law

Derived unit contains undeclared units

$$v_{87} = \text{kactSox9} \cdot \text{Smad2\_P\_Smad4} \cdot \text{Sox9} \tag{174}$$

6.88 Reaction `Sox9Inactivation`

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

Reaction equation

$$\text{Sox9\_A} \xrightarrow{\text{Sox9\_A}} \text{Sox9} \tag{175}$$

Reactant

Table 267: Properties of each reactant.

Id	Name	SBO
Sox9_A		

Modifier

Table 268: Properties of each modifier.

Id	Name	SBO
Sox9_A		

Product

Table 269: Properties of each product.

Id	Name	SBO
Sox9		

Kinetic Law

Derived unit contains undeclared units

$$v_{88} = \text{kinactSox9} \cdot \text{Sox9\_A} \tag{176}$$

6.89 Reaction `Sox9BasalTranscription`

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

Reaction equation

$$\text{Source} \xrightarrow{\text{Source}} \text{Sox9mRNA} \tag{177}$$

Reactant

Table 270: Properties of each reactant.

Id	Name	SBO
Source		

Modifier

Table 271: Properties of each modifier.

Id	Name	SBO
Source		

Product

Table 272: Properties of each product.

Id	Name	SBO
Sox9mRNA		

Kinetic Law

Derived unit contains undeclared units

$$v_{89} = \text{ksynSox9mRNA} \cdot \text{Source} \tag{178}$$

6.90 Reaction `Sox9EnhancedTranscription`

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

Reaction equation

$$\text{Sox9\_A} \xrightarrow{\text{Sox9\_A}} \text{Sox9\_A} + \text{Sox9mRNA} \tag{179}$$
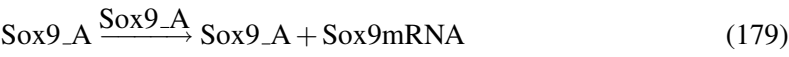
Reactant

Table 273: Properties of each reactant.

Id	Name	SBO
Sox9_A		

Modifier

Table 274: Properties of each modifier.

Id	Name	SBO
Sox9_A		

Products

Table 275: Properties of each product.

Id	Name	SBO
Sox9_A		
Sox9mRNA		

Kinetic Law

Derived unit contains undeclared units

$$v_{90} = \text{ksynSox9mRNASox9A} \cdot \text{Sox9\_A} \tag{180}$$

6.91 Reaction Sox9mRNA_Degradation

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

Reaction equation

$$\text{Sox9mRNA} \xrightarrow{\text{Sox9mRNA}} \text{Sink} \tag{181}$$
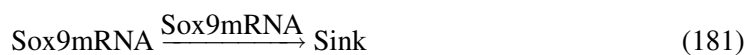
Reactant

Table 276: Properties of each reactant.

Id	Name	SBO
Sox9mRNA		

Modifier

Table 277: Properties of each modifier.

Id	Name	SBO
Sox9mRNA		

Product

Table 278: Properties of each product.

Id	Name	SBO
Sink		

Kinetic Law

Derived unit contains undeclared units

$$v_{91} = \text{kdegSox9mRNA} \cdot \text{Sox9mRNA} \tag{182}$$

6.92 Reaction Sox9Translation

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

Reaction equation

$$\text{Sox9mRNA} \xrightarrow{\text{Sox9mRNA}} \text{Sox9mRNA} + \text{Sox9} \tag{183}$$

Reactant

Table 279: Properties of each reactant.

Id	Name	SBO
Sox9mRNA		

Modifier

Table 280: Properties of each modifier.

Id	Name	SBO
Sox9mRNA		

Id	Name	SBO

Products

Table 281: Properties of each product.

Id	Name	SBO
Sox9mRNA		
Sox9		

Kinetic Law

Derived unit contains undeclared units

$$v_{92} = \text{ksynSox9} \cdot \text{Sox9mRNA} \tag{184}$$

6.93 Reaction `Sox9Degradation`

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

Reaction equation

$$\text{Sox9} \xrightarrow{\text{Sox9}} \text{Sink} \tag{185}$$

Reactant

Table 282: Properties of each reactant.

Id	Name	SBO
Sox9		

Modifier

Table 283: Properties of each modifier.

Id	Name	SBO
Sox9		

Product

Table 284: Properties of each product.

Id	Name	SBO
Sink		

Kinetic Law

Derived unit contains undeclared units

$$v_{93} = \text{kdegSox9} \cdot \text{Sox9} \tag{186}$$

6.94 Reaction `Collagen2EnhancedTranscriptionBySox9`

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

Reaction equation

$$\text{Sox9\_A} \xrightarrow{\text{Sox9\_A}} \text{Sox9\_A} + \text{Col2mRNA} \tag{187}$$
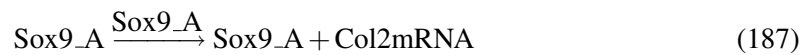
Reactant

Table 285: Properties of each reactant.

Id	Name	SBO
Sox9_A		

Modifier

Table 286: Properties of each modifier.

Id	Name	SBO
Sox9_A		

Products

Table 287: Properties of each product.

Id	Name	SBO
Sox9_A		
Col2mRNA		

Kinetic Law

Derived unit contains undeclared units

$$v_{94} = \text{ksynCol2mRNASox9A} \cdot \text{Sox9\_A} \tag{188}$$

6.95 Reaction `Collagen2TranscriptionBySmad2Smad4`

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

Reaction equation

$$\text{Smad2\_P\_Smad4} \xrightarrow{\text{Smad2\_P\_Smad4}} \text{Smad2\_P\_Smad4} + \text{Col2mRNA} \tag{189}$$

Reactant

Table 288: Properties of each reactant.

Id	Name	SBO
Smad2_P_Smad4		

Modifier

Table 289: Properties of each modifier.

Id	Name	SBO
Smad2_P_Smad4		

Products

Table 290: Properties of each product.

Id	Name	SBO
Smad2_P_Smad4		
Col2mRNA		

Kinetic Law

Derived unit contains undeclared units

$$v_{95} = \text{ksynCol2mRNASmad} \cdot \text{Smad2\_P\_Smad4} \tag{190}$$

6.96 Reaction `Col2mRNA_Degradation`

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

Reaction equation

$$\text{Col2mRNA} \xrightarrow{\text{Col2mRNA}} \text{Sink} \qquad (191)$$

Reactant

Table 291: Properties of each reactant.

Id	Name	SBO
Col2mRNA		

Modifier

Table 292: Properties of each modifier.

Id	Name	SBO
Col2mRNA		

Product

Table 293: Properties of each product.

Id	Name	SBO
Sink		

Kinetic Law

Derived unit contains undeclared units

$$v_{96} = \text{kdegCol2mRNA} \cdot \text{Col2mRNA} \qquad (192)$$

6.97 Reaction `Collagen2Translation`

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

Reaction equation

$$\text{Col2mRNA} \xrightarrow{\text{Col2mRNA}} \text{Col2mRNA} + \text{Collagen2} \qquad (193)$$

Reactant

Table 294: Properties of each reactant.

Id	Name	SBO
Col2mRNA		

Modifier

Table 295: Properties of each modifier.

Id	Name	SBO
Col2mRNA		

Products

Table 296: Properties of each product.

Id	Name	SBO
Col2mRNA		
Collagen2		

Kinetic Law

Derived unit contains undeclared units

$$v_{97} = \text{ksynCol2} \cdot \text{Col2mRNA} \tag{194}$$

6.98 Reaction `AggrecanEnhancedTranscription`

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

Reaction equation

$$\text{Sox9\_A} \xrightarrow{\text{Sox9\_A}} \text{Sox9\_A} + \text{AcanmRNA} \tag{195}$$

Reactant

Table 297: Properties of each reactant.

Id	Name	SBO
Sox9_A		

Modifier

Table 298: Properties of each modifier.

Id	Name	SBO
Sox9_A		

Products

Table 299: Properties of each product.

Id	Name	SBO
Sox9_A		
AcanmRNA		

Kinetic Law

Derived unit contains undeclared units

$$v_{98} = \text{ksynAcanmRNASox9A} \cdot \text{Sox9\_A} \tag{196}$$

6.99 Reaction `AcanmRNA_Degradation`

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

Reaction equation

$$\text{AcanmRNA} \xrightarrow{\text{AcanmRNA}} \text{Sink} \tag{197}$$
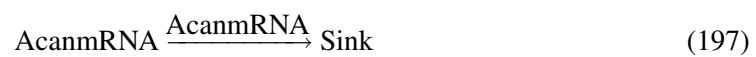
Reactant

Table 300: Properties of each reactant.

Id	Name	SBO
AcanmRNA		

Modifier

Table 301: Properties of each modifier.

Id	Name	SBO
AcanmRNA		

Product

Table 302: Properties of each product.

Id	Name	SBO
Sink		

Kinetic Law

Derived unit contains undeclared units

$$v_{99} = \text{kdegAcanmRNA} \cdot \text{AcanmRNA} \tag{198}$$

6.100 Reaction `AggrecanTranslation`

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

Reaction equation

$$\text{AcanmRNA} \xrightarrow{\text{AcanmRNA}} \text{AcanmRNA} + \text{Aggrecan} \tag{199}$$

Reactant

Table 303: Properties of each reactant.

Id	Name	SBO
AcanmRNA		

Modifier

Table 304: Properties of each modifier.

Id	Name	SBO
AcanmRNA		

Id	Name	SBO

Products

Table 305: Properties of each product.

Id	Name	SBO
AcanmRNA		
Aggrecan		

Kinetic Law

Derived unit contains undeclared units

$$v_{100} = \text{ksynAggrecan} \cdot \text{AcanmRNA} \tag{200}$$

6.101 Reaction `AggrecanCollagen2Binding`

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

Reaction equation

$$\text{Aggrecan} + \text{Collagen2} \xrightarrow{\text{Aggrecan, Collagen2}} \text{Aggrecan\_Collagen2} \tag{201}$$

Reactants

Table 306: Properties of each reactant.

Id	Name	SBO
Aggrecan		
Collagen2		

Modifiers

Table 307: Properties of each modifier.

Id	Name	SBO
Aggrecan		
Collagen2		

Product

Id	Name	SBO
Aggrecan_Collagen2		

Kinetic Law

Derived unit contains undeclared units

$$v_{101} = \text{kbinAggrecanCollagen2} \cdot \text{Aggrecan} \cdot \text{Collagen2} \tag{202}$$

6.102 Reaction Runx2_InhibitionBySmad2

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

Reaction equation

$$\text{Runx2\_A} + \text{Smad2\_P\_Smad4} \xrightarrow{\text{Runx2\_A, Smad2\_P\_Smad4}} \text{Runx2\_I} + \text{Smad2\_P\_Smad4} \tag{203}$$
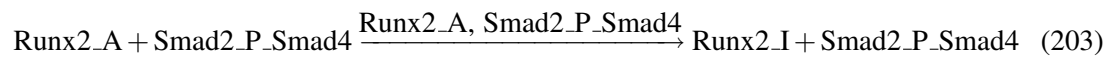
Reactants

Table 309: Properties of each reactant.

Id	Name	SBO
Runx2_A		
Smad2_P_Smad4		

Modifiers

Table 310: Properties of each modifier.

Id	Name	SBO
Runx2_A		
Smad2_P_Smad4		

Products

Table 311: Properties of each product.

Id	Name	SBO
Runx2_I		
Smad2_P_Smad4		

Kinetic Law

Derived unit contains undeclared units

$$v_{102} = \text{kinactRunx2} \cdot \text{Runx2\_A} \cdot \text{Smad2\_P\_Smad4} \tag{204}$$

6.103 Reaction `Alk5Degradation`

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

Reaction equation

$$\text{Alk5} \xrightarrow{\text{Alk5}} \text{Sink} \tag{205}$$

Reactant

Table 312: Properties of each reactant.

Id	Name	SBO
Alk5		

Modifier

Table 313: Properties of each modifier.

Id	Name	SBO
Alk5		

Product

Table 314: Properties of each product.

Id	Name	SBO
Sink		

Kinetic Law

Derived unit contains undeclared units

$$v_{103} = \text{kdegAlk5} \cdot \text{Alk5} \tag{206}$$

6.104 Reaction `Smad1Activation`

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

Reaction equation

$$\text{Tgfb\_Alk1\_Alk5} + \text{Smad1} \xrightarrow{\text{Tgfb\_Alk1\_Alk5, Smad1}} \text{Tgfb\_Alk1\_Alk5} + \text{Smad1\_P} \tag{207}$$
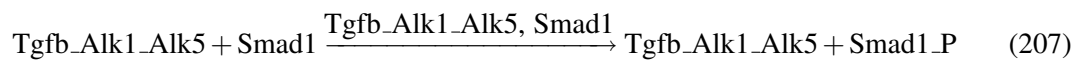
Reactants

Table 315: Properties of each reactant.

Id	Name	SBO
Tgfb_Alk1_Alk5		
Smad1		

Modifiers

Table 316: Properties of each modifier.

Id	Name	SBO
Tgfb_Alk1_Alk5		
Smad1		

Products

Table 317: Properties of each product.

Id	Name	SBO
Tgfb_Alk1_Alk5		
Smad1_P		

Kinetic Law

Derived unit contains undeclared units

$$v_{104} = \text{kphosSmad1} \cdot \text{Tgfb\_Alk1\_Alk5} \cdot \text{Smad1} \tag{208}$$

6.105 Reaction `Smad1Dephosphorylation`

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

Reaction equation

$$\text{Smad1\_P} \xrightarrow{\text{Smad1\_P}} \text{Smad1} \tag{209}$$

Reactant

Table 318: Properties of each reactant.

Id	Name	SBO
Smad1_P		

Modifier

Table 319: Properties of each modifier.

Id	Name	SBO
Smad1_P		

Product

Table 320: Properties of each product.

Id	Name	SBO
Smad1		

Kinetic Law

Derived unit contains undeclared units

$$v_{105} = \text{kdephosSmad1} \cdot \text{Smad1\_P} \tag{210}$$

6.106 Reaction `Smad1DephosphorylationViaSmad7`

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

Reaction equation

$$\text{Smad1\_P} + \text{Smad7} \xrightarrow{\text{Smad1\_P, Smad7}} \text{Smad1} + \text{Smad7} \qquad (211)$$
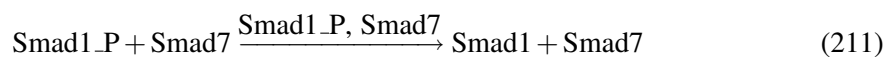
Reactants

Table 321: Properties of each reactant.

Id	Name	SBO
Smad1_P		
Smad7		

Modifiers

Table 322: Properties of each modifier.

Id	Name	SBO
Smad1_P		
Smad7		

Products

Table 323: Properties of each product.

Id	Name	SBO
Smad1		
Smad7		

Kinetic Law

Derived unit contains undeclared units

$$v_{106} = \text{kdephosSmad1Smad7} \cdot \text{Smad1\_P} \cdot \text{Smad7} \qquad (212)$$

6.107 Reaction `Smad1Smad4Binding`

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

Reaction equation

$$\text{Smad1\_P} + \text{Smad4} \xrightarrow{\text{Smad1\_P, Smad4}} \text{Smad1\_P\_Smad4} \qquad (213)$$
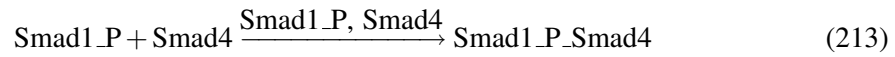
Reactants

Table 324: Properties of each reactant.

Id	Name	SBO
Smad1_P		
Smad4		

Modifiers

Table 325: Properties of each modifier.

Id	Name	SBO
Smad1_P		
Smad4		

Product

Table 326: Properties of each product.

Id	Name	SBO
Smad1_P_Smad4		

Kinetic Law

Derived unit contains undeclared units

$$v_{107} = \text{kbinSmad1Smad4} \cdot \text{Smad1\_P} \cdot \text{Smad4} \qquad (214)$$

6.108 Reaction `Smad1Smad4Release`

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

Reaction equation

$$\text{Smad1\_P\_Smad4} \xrightarrow{\text{Smad1\_P\_Smad4}} \text{Smad1\_P} + \text{Smad4} \qquad (215)$$

Reactant

Table 327: Properties of each reactant.

Id	Name	SBO
Smad1_P_Smad4		

Modifier

Table 328: Properties of each modifier.

Id	Name	SBO
Smad1_P_Smad4		

Products

Table 329: Properties of each product.

Id	Name	SBO
Smad1_P		
Smad4		

Kinetic Law

Derived unit contains undeclared units

$$v_{108} = \text{krelSmad1Smad4} \cdot \text{Smad1\_P\_Smad4} \tag{216}$$

6.109 Reaction `Runx2ActivationBySmad1`

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

Reaction equation

$$\text{Runx2\_I} + \text{Smad1\_P\_Smad4} \xrightarrow{\text{Runx2\_I, Smad1\_P\_Smad4}} \text{Runx2\_A} + \text{Smad1\_P\_Smad4} \tag{217}$$
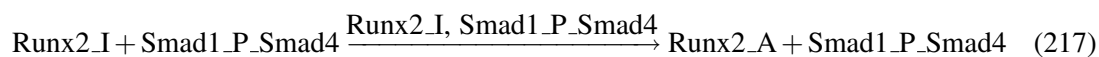
Reactants

Table 330: Properties of each reactant.

Id	Name	SBO
Runx2_I		
Smad1_P_Smad4		

Modifiers

Products

Table 332: Properties of each product.

Id	Name	SBO
Runx2_A		
Smad1_P_Smad4		

Kinetic Law

Derived unit contains undeclared units

$$v_{109} = \text{kactRunx2} \cdot \text{Runx2\_I} \cdot \text{Smad1\_P\_Smad4} \tag{218}$$

6.110 Reaction `MMP13InductionByRunx2`

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

Reaction equation

$$\text{Runx2\_A} \xrightarrow{\text{Runx2\_A}} \text{proMMP13} + \text{Runx2\_A} \tag{219}$$

Reactant

Table 333: Properties of each reactant.

Id	Name	SBO
Runx2_A		

Modifier

Table 334: Properties of each modifier.

Id	Name	SBO
Runx2_A		

Products

Table 335: Properties of each product.

Id	Name	SBO
proMMP13		
Runx2_A		

Kinetic Law

Derived unit contains undeclared units

$$v_{110} = \text{ksynMMP13Runx2} \cdot \text{Runx2\_A} \tag{220}$$

6.111 Reaction `Alk1Synthesis`

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

Reaction equation

$$\text{Source} \xrightarrow{\text{Source}} \text{Alk1} \tag{221}$$

Reactant

Table 336: Properties of each reactant.

Id	Name	SBO
Source		

Modifier

Table 337: Properties of each modifier.

Id	Name	SBO
Source		

Product

Table 338: Properties of each product.

Id	Name	SBO
Alk1		

Kinetic Law

Derived unit contains undeclared units

$$v_{111} = \text{ksynAlk1} \cdot \text{Source} \tag{222}$$

6.112 Reaction `Alk1Degradation`

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

Reaction equation

$$\text{Alk1} \xrightarrow{\text{Alk1}} \text{Sink} \tag{223}$$

Reactant

Table 339: Properties of each reactant.

Id	Name	SBO
Alk1		

Modifier

Table 340: Properties of each modifier.

Id	Name	SBO
Alk1		

Product

Table 341: Properties of each product.

Id	Name	SBO
Sink		

Id	Name	SBO

Kinetic Law

Derived unit contains undeclared units

$$v_{112} = \text{kdegAlk1} \cdot \text{Alk1} \tag{224}$$

6.113 Reaction `MMP13Activation`

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

Reaction equation

$$\text{proMMP13} \xrightarrow{\text{proMMP13}} \text{MMP13} \tag{225}$$
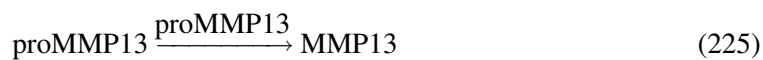
Reactant

Table 342: Properties of each reactant.

Id	Name	SBO
proMMP13		

Modifier

Table 343: Properties of each modifier.

Id	Name	SBO
proMMP13		

Product

Table 344: Properties of each product.

Id	Name	SBO
MMP13		

Kinetic Law

Derived unit contains undeclared units

$$v_{113} = \text{kactMMP13} \cdot \text{proMMP13} \tag{226}$$

6.114 Reaction `Tgfb_Alk1_Alk5_BindingSmad7`

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

Reaction equation

$$\text{Tgfb\_Alk1\_Alk5} + \text{Smad7} \xrightarrow{\text{Tgfb\_Alk1\_Alk5, Smad7}} \text{Tgfb\_Alk1\_Alk5\_Smad7} \tag{227}$$
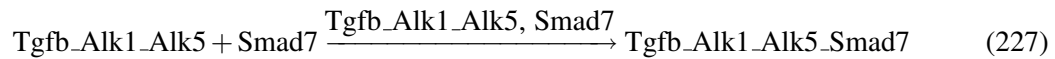
Reactants

Table 345: Properties of each reactant.

Id	Name	SBO
Tgfb_Alk1_Alk5		
Smad7		

Modifiers

Table 346: Properties of each modifier.

Id	Name	SBO
Tgfb_Alk1_Alk5		
Smad7		

Product

Table 347: Properties of each product.

Id	Name	SBO
Tgfb_Alk1_Alk5_Smad7		

Kinetic Law

Derived unit contains undeclared units

$$v_{114} = \text{kbinSmad7Alk1} \cdot \text{Tgfb\_Alk1\_Alk5} \cdot \text{Smad7} \tag{228}$$

6.115 Reaction `Tgfb_Alk1_Alk5_Smad7Release`

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

Reaction equation

$$\text{Tgfb\_Alk1\_Alk5\_Smad7} \xrightarrow{\text{Tgfb\_Alk1\_Alk5\_Smad7}} \text{Tgfb\_Alk1\_Alk5} + \text{Smad7} \qquad (229)$$
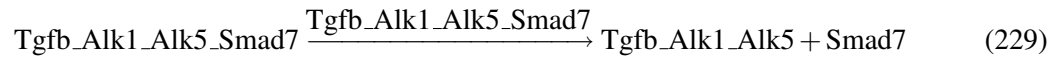
Reactant

Table 348: Properties of each reactant.

Id	Name	SBO
Tgfb_Alk1_Alk5_Smad7		

Modifier

Table 349: Properties of each modifier.

Id	Name	SBO
Tgfb_Alk1_Alk5_Smad7		

Products

Table 350: Properties of each product.

Id	Name	SBO
Tgfb_Alk1_Alk5 Smad7		

Kinetic Law

Derived unit contains undeclared units

$$v_{115} = \text{krelSmad7Alk1} \cdot \text{Tgfb\_Alk1\_Alk5\_Smad7} \qquad (230)$$

6.116 Reaction `Alk1_Smad7Degradation`

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

Reaction equation

$$\text{Tgfb\_Alk1\_Alk5\_Smad7} \xrightarrow{\text{Tgfb\_Alk1\_Alk5\_Smad7}} \text{Tgfb\_I} \qquad (231)$$

Reactant

Table 351: Properties of each reactant.

Id	Name	SBO
Tgfb_Alk1_Alk5_Smad7		

Modifier

Table 352: Properties of each modifier.

Id	Name	SBO
Tgfb_Alk1_Alk5_Smad7		

Product

Table 353: Properties of each product.

Id	Name	SBO
Tgfb_I		

Kinetic Law

Derived unit contains undeclared units

$$v_{116} = \text{kdegSmad7Alk1} \cdot \text{Tgfb\_Alk1\_Alk5\_Smad7} \qquad (232)$$

6.117 Reaction Smad7Degradation

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

Reaction equation

$$\text{Smad7} \xrightarrow{\text{Smad7}} \text{Sink} \qquad (233)$$

Reactant

Table 354: Properties of each reactant.

Id	Name	SBO
Smad7		

Modifier

Table 355: Properties of each modifier.

Id	Name	SBO
Smad7		

Product

Table 356: Properties of each product.

Id	Name	SBO
Sink		

Kinetic Law

Derived unit contains undeclared units

$$v_{117} = \text{kdegSmad7} \cdot \text{Smad7} \tag{234}$$

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 `AcanmRNA`

Initial amount 0 item

This species takes part in six reactions (as a reactant in `AcanmRNA_Degradation`, `AggrecanTranslation` and as a product in `AggrecanEnhancedTranscription`, `AggrecanTranslation` and as a modifier in `AcanmRNA_Degradation`, `AggrecanTranslation`).

$$\frac{\mathrm{d}}{\mathrm{d}t}\text{AcanmRNA} = v_{98} + v_{100} - v_{99} - v_{100} \tag{235}$$

7.2 Species `ADAMTS5`

Initial amount 0 item

This species takes part in six reactions (as a reactant in `ADAMTS5_removal`, `Aggrecan_degradation` and as a product in `ADAMTS5_production`, `Aggrecan_degradation` and as a modifier in `ADAMTS5_removal`, `Aggrecan_degradation`).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{ADAMTS5} = v_{49} + v_{51} - v_{50} - v_{51} \tag{236}$$

7.3 Species `AGEprod`

Initial amount 0 item

This species takes part in four reactions (as a reactant in `RAGE_activation` and as a product in `Production_of_AGEproducts`, `RAGE_activation` and as a modifier in `RAGE_activation`).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{AGEprod} = v_{33} + v_{34} - v_{34} \tag{237}$$

7.4 Species `Alk1`

Initial amount 500 item

This species takes part in six reactions (as a reactant in `Alk1Alk5Binding`, `Alk1Degradation` and as a product in `Alk1Alk5Release`, `Alk1Synthesis` and as a modifier in `Alk1Alk5Binding`, `Alk1Degradation`).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{Alk1} = v_{74} + v_{111} - v_{73} - v_{112} \tag{238}$$

7.5 Species `Alk1_Alk5`

Initial amount 0 item

This species takes part in six reactions (as a reactant in `Alk1Alk5Release`, `TgfbReceptorBindingAlk1` and as a product in `Alk1Alk5Binding`, `TgfbAlk1Release` and as a modifier in `Alk1Alk5Release`, `TgfbReceptorBindingAlk1`).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{Alk1\_Alk5} = v_{73} + v_{81} - v_{74} - v_{80} \tag{239}$$

7.6 Species `Alk5`

Initial amount 500 item

This species takes part in nine reactions (as a reactant in `Alk5Dimerisation`, `Alk1Alk5Binding`, `Alk5Degradation` and as a product in `Alk5Synthesis`, `Alk5Dedimerisation`, `Alk1Alk5Release` and as a modifier in `Alk5Dimerisation`, `Alk1Alk5Binding`, `Alk5Degradation`).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{Alk5} = v_{67} + 2\,v_{72} + v_{74} - 2\,v_{71} - v_{73} - v_{103} \tag{240}$$

7.7 Species `Alk5_dimer`

SBO:0000607 dimer

Initial amount 0 item

This species takes part in six reactions (as a reactant in `Alk5Dedimerisation`, `TgfbReceptorBindingAlk5` and as a product in `Alk5Dimerisation`, `TgfbReceptorRelease` and as a modifier in `Alk5Dedimerisation`, `TgfbReceptorBindingAlk5`).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{Alk5\_dimer} = v_{71} + v_{76} - v_{72} - v_{75} \tag{241}$$

7.8 Species `Bax`

Initial amount 0 item

This species takes part in twelve reactions (as a reactant in `CaspaseActivation`, `Bax_Bcl2Binding`, `BaxBindingToBcl2_Beclin`, `BaxBindingToBcl2_BeclinI` and as a product in `CaspaseActivation`, `Bax_Bcl2Release`, `BaxDissociation_Bax_Bcl2_Beclin`, `BaxDissociation_Bax_Bcl2_Beclin-_I` and as a modifier in `CaspaseActivation`, `Bax_Bcl2Binding`, `BaxBindingToBcl2_Beclin`, `BaxBindingToBcl2_BeclinI`).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{Bax} = v_1 + v_{14} + v_{25} + v_{26} - v_1 - v_{13} - v_{23} - v_{24} \tag{242}$$

7.9 Species `Bax_Bcl2`

Initial amount 90 item

This species takes part in nine reactions (as a reactant in `Bax_Bcl2Release`, `BeclinBindingToBax-_Bcl2`, `BeclinIBindingToBax_Bcl2` and as a product in `Bax_Bcl2Binding`, `BeclinDissociation-_Bax_Bcl2_Beclin`, `Beclin_I_Dissociation_Bax_Bcl2_Beclin` and as a modifier in `Bax-_Bcl2Release`, `BeclinBindingToBax_Bcl2`, `BeclinIBindingToBax_Bcl2`).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{Bax\_Bcl2} = v_{13} + v_{27} + v_{28} - v_{14} - v_{21} - v_{22} \tag{243}$$

7.10 Species `Bax_Bcl2_Beclin`

Initial amount 10 item

This species takes part in six reactions (as a reactant in `BaxDissociation_Bax_Bcl2_Beclin`, `BeclinDissociation_Bax_Bcl2_Beclin` and as a product in `BeclinBindingToBax_Bcl2`, `BaxBindingToBcl2_Beclin` and as a modifier in `BaxDissociation_Bax_Bcl2_Beclin`, `BeclinDissociation-_Bax_Bcl2_Beclin`).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{Bax\_Bcl2\_Beclin} = v_{21} + v_{23} - v_{25} - v_{27} \tag{244}$$

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7.11 Species Bax_Bcl2_Beclin_I

Initial amount 0 item

This species takes part in six reactions (as a reactant in BaxDissociation_Bax_Bcl2_Beclin-
_I, Beclin_I_Dissociation_Bax_Bcl2_Beclin and as a product in BeclinIBindingToBax-
_Bcl2, BaxBindingToBcl2_BeclinI and as a modifier in BaxDissociation_Bax_Bcl2_Beclin-
_I, Beclin_I_Dissociation_Bax_Bcl2_Beclin).

$$\frac{d}{dt}\text{Bax\_Bcl2\_Beclin\_I} = v_{22} + v_{24} - v_{26} - v_{28} \tag{245}$$

7.12 Species Bcl2

Initial amount 30 item

This species takes part in 19 reactions (as a reactant in InhibitCaspase3, Bcl2Degradation,
Bcl2DegradationStressInduced, Bcl2DegradationCaspaseInduced, Bax_Bcl2Binding,
Bcl2_BeclinBinding, Bcl2_Beclin_I_Binding and as a product in InhibitCaspase3, Bcl2Synthesis,
Bax_Bcl2Release, Bcl2_BeclinRelease, Bcl2_Beclin_I_Release and as a modifier in InhibitCaspase3,
Bcl2Degradation, Bcl2DegradationStressInduced, Bcl2DegradationCaspaseInduced,
Bax_Bcl2Binding, Bcl2_BeclinBinding, Bcl2_Beclin_I_Binding).

$$\frac{d}{dt}\text{Bcl2} = v_6 + v_9 + v_{14} + v_{16} + v_{18} - v_6 - v_{10} - v_{11} - v_{12} - v_{13} - v_{15} - v_{17} \tag{246}$$

7.13 Species Bcl2_Beclin

Initial amount 25 item

This species takes part in nine reactions (as a reactant in InhibitCaspase2, Bcl2_BeclinRelease,
BaxBindingToBcl2_Beclin and as a product in InhibitCaspase2, Bcl2_BeclinBinding,
BaxDissociation_Bax_Bcl2_Beclin and as a modifier in InhibitCaspase2, Bcl2_BeclinRelease,
BaxBindingToBcl2_Beclin).

$$\frac{d}{dt}\text{Bcl2\_Beclin} = v_5 + v_{15} + v_{25} - v_5 - v_{16} - v_{23} \tag{247}$$

7.14 Species Bcl2_Beclin_I

Initial amount 0 item

This species takes part in six reactions (as a reactant in Bcl2_Beclin_I_Release, BaxBindingToBcl2-
_BeclinI and as a product in Bcl2_Beclin_I_Binding, BaxDissociation_Bax_Bcl2_Beclin-
_I and as a modifier in Bcl2_Beclin_I_Release, BaxBindingToBcl2_BeclinI).

$$\frac{d}{dt}\text{Bcl2\_Beclin\_I} = v_{17} + v_{26} - v_{18} - v_{24} \tag{248}$$

7.15 Species `Beclin`

Initial amount 75 item

This species takes part in 13 reactions (as a reactant in `ActivateLysosome`, `Bcl2_BeclinBinding`, `BeclinInactivation`, `BeclinInactivationByCaspase`, `BeclinBindingToBax_Bcl2` and as a product in `ActivateLysosome`, `Bcl2_BeclinRelease`, `BeclinDissociation_Bax_Bcl2-`
`_Beclin` and as a modifier in `ActivateLysosome`, `Bcl2_BeclinBinding`, `BeclinInactivation`, `BeclinInactivationByCaspase`, `BeclinBindingToBax_Bcl2`).

$$\frac{d}{dt}\text{Beclin} = v_7 + v_{16} + v_{27} - v_7 - v_{15} - v_{19} - v_{20} - v_{21} \qquad (249)$$

7.16 Species `Beclin_I`

Initial amount 0 item

This species takes part in eleven reactions (as a reactant in `CaspaseActivationByBeclin_I`, `Bcl2_Beclin_I_Binding`, `BeclinIBindingToBax_Bcl2` and as a product in `CaspaseActivationByBeclin-`
`_I`, `Bcl2_Beclin_I_Release`, `BeclinInactivation`, `BeclinInactivationByCaspase`, `Beclin-`
`_I_Dissociation_Bax_Bcl2_Beclin` and as a modifier in `CaspaseActivationByBeclin_I`, `Bcl2_Beclin_I_Binding`, `BeclinIBindingToBax_Bcl2`).

$$\frac{d}{dt}\text{Beclin\_I} = v_2 + v_{18} + v_{19} + v_{20} + v_{28} - v_2 - v_{17} - v_{22} \qquad (250)$$

7.17 Species `Caspase_A`

Initial amount 0 item

This species takes part in 15 reactions (as a reactant in `CaspaseInactivation1`, `InhibitCaspase2`, `InhibitCaspase3`, `Bcl2DegradationCaspaseInduced`, `BeclinInactivationByCaspase` and as a product in `CaspaseActivation`, `CaspaseActivationByBeclin_I`, `CaspaseActivationBy-`
`_p38`, `Bcl2DegradationCaspaseInduced`, `BeclinInactivationByCaspase` and as a modi-
fier in `CaspaseInactivation1`, `InhibitCaspase2`, `InhibitCaspase3`, `Bcl2DegradationCaspaseInduced`, `BeclinInactivationByCaspase`).

$$\frac{d}{dt}\text{Caspase\_A} = v_1 + v_2 + v_3 + v_{12} + v_{20} - v_4 - v_5 - v_6 - v_{12} - v_{20} \qquad (251)$$

7.18 Species `Caspase_I`

Initial amount 100 item

This species takes part in nine reactions (as a reactant in `CaspaseActivation`, `CaspaseActivationByBeclin-`
`_I`, `CaspaseActivationBy_p38` and as a product in `CaspaseInactivation1`, `InhibitCaspase2`, `InhibitCaspase3` and as a modifier in `CaspaseActivation`, `CaspaseActivationByBeclin-`
`_I`, `CaspaseActivationBy_p38`).

$$\frac{d}{dt}\text{Caspase\_I} = v_4 + v_5 + v_6 - v_1 - v_2 - v_3 \qquad (252)$$

7.19 Species `Col2mRNA`

Initial amount 0 item

This species takes part in seven reactions (as a reactant in `Col2mRNA_Degradation`, `Collagen2Translation` and as a product in `Collagen2EnhancedTranscriptionBySox9`, `Collagen2TranscriptionBySmad2Smad4`, `Collagen2Translation` and as a modifier in `Col2mRNA_Degradation`, `Collagen2Translation`).

$$\frac{\mathrm{d}}{\mathrm{d}t}\text{Col2mRNA} = v_{94} + v_{95} + v_{97} - v_{96} - v_{97} \tag{253}$$

7.20 Species `DamP`

Initial amount 0 item

This species takes part in six reactions (as a reactant in `Removal_DamP_by_Autophagy`, `ROS_production_by_DamP` and as a product in `Protein_Damage_by_ROS`, `ROS_production_by_DamP` and as a modifier in `Removal_DamP_by_Autophagy`, `ROS_production_by_DamP`).

$$\frac{\mathrm{d}}{\mathrm{d}t}\text{DamP} = v_{31} + v_{53} - v_{32} - v_{53} \tag{254}$$

7.21 Species `IkB`

Initial amount 0 item

This species takes part in three reactions (as a reactant in `NFkB_inactivation` and as a product in `IkB_production` and as a modifier in `NFkB_inactivation`).

$$\frac{\mathrm{d}}{\mathrm{d}t}\text{IkB} = v_{43} - v_{38} \tag{255}$$

7.22 Species `IkB_NFkB`

Initial amount 100 item

This species takes part in five reactions (as a reactant in `IkB_degradation_via_ROS`, `IkB_degradation_via_IL1` and as a product in `NFkB_inactivation` and as a modifier in `IkB_degradation_via_ROS`, `IkB_degradation_via_IL1`).

$$\frac{\mathrm{d}}{\mathrm{d}t}\text{IkB\_NFkB} = v_{38} - v_{36} - v_{37} \tag{256}$$

7.23 Species IL1

Initial amount 0 item

This species takes part in 18 reactions (as a reactant in `IkB_degradation_via_IL1`, `IL1-_degradation`, `MMP13_production`, `MMP2_production`, `ADAMTS5_production`, `p38_phosphorylation` and as a product in `IkB_degradation_via_IL1`, `IL1_production`, `MMP13_production`, `MMP2-_production`, `ADAMTS5_production`, `p38_phosphorylation` and as a modifier in `IkB_degradation-_via_IL1`, `IL1_degradation`, `MMP13_production`, `MMP2_production`, `ADAMTS5_production`, `p38_phosphorylation`).

$$\frac{d}{dt}IL1 = v_{37} + v_{41} + v_{44} + v_{46} + v_{49} + v_{58} - v_{37} - v_{42} - v_{44} - v_{46} - v_{49} - v_{58}$$

(257)

7.24 Species Lys_A

Initial amount 40 item

This species takes part in eight reactions (as a reactant in `InhibitLysosome`, `Removal_DamP-_by_Autophagy`, `Lysosome_damage_by_ROS` and as a product in `ActivateLysosome`, `Removal-_DamP_by_Autophagy` and as a modifier in `InhibitLysosome`, `Removal_DamP_by_Autophagy`, `Lysosome_damage_by_ROS`).

$$\frac{d}{dt}Lys\_A = v_7 + v_{32} - v_8 - v_{32} - v_{64}$$

(258)

7.25 Species Lys_I

Initial amount 360 item

This species takes part in four reactions (as a reactant in `ActivateLysosome` and as a product in `InhibitLysosome`, `Lysosome_damage_by_ROS` and as a modifier in `ActivateLysosome`).

$$\frac{d}{dt}Lys\_I = v_8 + v_{64} - v_7$$

(259)

7.26 Species MMP13

Initial amount 0 item

This species takes part in six reactions (as a reactant in `MMP13_removal`, `Collagen_degradation` and as a product in `Collagen_degradation`, `MMP13Activation` and as a modifier in `MMP13-_removal`, `Collagen_degradation`).

$$\frac{d}{dt}MMP13 = v_{52} + v_{113} - v_{45} - v_{52}$$

(260)

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7.27 Species `MMP2`

Initial amount 0 item

This species takes part in six reactions (as a reactant in `MMP2_degradation`, `TgfbActivationByMMP2` and as a product in `MMP_activation`, `TgfbActivationByMMP2` and as a modifier in `MMP2-_degradation`, `TgfbActivationByMMP2`).

$$\frac{d}{dt}\text{MMP2} = v_{47} + v_{69} - v_{48} - v_{69} \tag{261}$$

7.28 Species `NatP`

Initial amount 1500 item

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

$$\frac{d}{dt}\text{NatP} = 0 \tag{262}$$

7.29 Species `NFkB`

Initial amount 0 item

This species takes part in seven reactions (as a reactant in `NFkB_inactivation`, `NFkB_activation` and as a product in `IkB_degradation_via_ROS`, `IkB_degradation_via_IL1`, `NFkB_dephosphorylation` and as a modifier in `NFkB_inactivation`, `NFkB_activation`).

$$\frac{d}{dt}\text{NFkB} = v_{36} + v_{37} + v_{62} - v_{38} - v_{61} \tag{263}$$

7.30 Species `NFkB_P`

Initial amount 0 item

This species takes part in 15 reactions (as a reactant in `RAGE_upregulation_byNFkB`, `IL1-_production`, `IkB_production`, `SOD_synthesis`, `NFkB_dephosphorylation` and as a product in `RAGE_upregulation_byNFkB`, `IL1_production`, `IkB_production`, `SOD_synthesis`, `NFkB_activation` and as a modifier in `RAGE_upregulation_byNFkB`, `IL1_production`, `IkB-_production`, `SOD_synthesis`, `NFkB_dephosphorylation`).

$$\frac{d}{dt}\text{NFkB\_P} = v_{40} + v_{41} + v_{43} + v_{55} + v_{61} - v_{40} - v_{41} - v_{43} - v_{55} - v_{62} \tag{264}$$

7.31 Species p38

Initial amount 100 item

This species takes part in five reactions (as a reactant in p38_phosphorylation, p38_phosphorylation-_via_ROS and as a product in p38_dephosphorylation and as a modifier in p38_phosphorylation, p38_phosphorylation_via_ROS).

$$\frac{d}{dt}\text{p38} = v_{60} - v_{58} - v_{59} \tag{265}$$

7.32 Species p38_P

Initial amount 0 item

This species takes part in 13 reactions (as a reactant in CaspaseActivationBy_p38, p38-_dephosphorylation, NFkB_activation, ROS_production_by_p38_P and as a product in CaspaseActivationBy_p38, p38_phosphorylation, p38_phosphorylation_via_ROS, NFkB-_activation, ROS_production_by_p38_P and as a modifier in CaspaseActivationBy_p38, p38_dephosphorylation, NFkB_activation, ROS_production_by_p38_P).

$$\frac{d}{dt}\text{p38\_P} = v_3 + v_{58} + v_{59} + v_{61} + v_{63} - v_3 - v_{60} - v_{61} - v_{63} \tag{266}$$

7.33 Species proMMP13

Initial amount 0 item

This species takes part in four reactions (as a reactant in MMP13Activation and as a product in MMP13_production, MMP13InductionByRunx2 and as a modifier in MMP13Activation).

$$\frac{d}{dt}\text{proMMP13} = v_{44} + v_{110} - v_{113} \tag{267}$$

7.34 Species proMMP2

Initial amount 0 item

This species takes part in three reactions (as a reactant in MMP_activation and as a product in MMP2_production and as a modifier in MMP_activation).

$$\frac{d}{dt}\text{proMMP2} = v_{46} - v_{47} \tag{268}$$

7.35 Species `RAGE`

Initial amount 0 item

This species takes part in seven reactions (as a reactant in `ROS_production_by_RAGE`, `RAGE-_inactivation` and as a product in `RAGE_activation`, `ROS_production_by_RAGE`, `RAGE-_upregulation_byNFkB` and as a modifier in `ROS_production_by_RAGE`, `RAGE_inactivation`).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{RAGE} = v_{34} + v_{35} + v_{40} - v_{35} - v_{39} \tag{269}$$

7.36 Species `ROS`

Initial amount 2 item

This species takes part in 23 reactions (as a reactant in `Bcl2DegradationStressInduced`, `ROS_removal`, `Protein_Damage_by_ROS`, `IkB_degradation_via_ROS`, `ROS_removal_by_SOD`, `p38_phosphorylation_via_ROS`, `Lysosome_damage_by_ROS` and as a product in `Bcl2DegradationStressInduc`, `ROS_generation`, `Protein_Damage_by_ROS`, `ROS_production_by_RAGE`, `IkB_degradation-_via_ROS`, `ROS_production_by_DamP`, `p38_phosphorylation_via_ROS`, `ROS_production-_by_p38_P`, `Lysosome_damage_by_ROS` and as a modifier in `Bcl2DegradationStressInduced`, `ROS_removal`, `Protein_Damage_by_ROS`, `IkB_degradation_via_ROS`, `ROS_removal_by_SOD`, `p38_phosphorylation_via_ROS`, `Lysosome_damage_by_ROS`).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{ROS} = v_{11} + v_{29} + v_{31} + v_{35} + v_{36} + v_{53} + v_{59} + v_{63}$$
$$+ v_{64} - v_{11} - v_{30} - v_{31} - v_{36} - v_{57} - v_{59} - v_{64} \tag{270}$$

7.37 Species `Runx2_A`

Initial amount 0 item

This species takes part in six reactions (as a reactant in `Runx2_InhibitionBySmad2`, `MMP13InductionByRunx2` and as a product in `Runx2ActivationBySmad1`, `MMP13InductionByRunx2` and as a modifier in `Runx2_InhibitionBySmad2`, `MMP13InductionByRunx2`).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{Runx2\_A} = v_{109} + v_{110} - v_{102} - v_{110} \tag{271}$$

7.38 Species `Runx2_I`

Initial amount 100 item

This species takes part in three reactions (as a reactant in `Runx2ActivationBySmad1` and as a product in `Runx2_InhibitionBySmad2` and as a modifier in `Runx2ActivationBySmad1`).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{Runx2\_I} = v_{102} - v_{109} \tag{272}$$

7.39 Species Smad1

Initial amount 600 item

This species takes part in four reactions (as a reactant in Smad1Activation and as a product in Smad1Dephosphorylation, Smad1DephosphorylationViaSmad7 and as a modifier in Smad1Activation).

$$\frac{d}{dt}\text{Smad1} = v_{105} + v_{106} - v_{104} \tag{273}$$

7.40 Species Smad1_P

Initial amount 0 item

This species takes part in eight reactions (as a reactant in Smad1Dephosphorylation, Smad1DephosphorylationV Smad1Smad4Binding and as a product in Smad1Activation, Smad1Smad4Release and as a modifier in Smad1Dephosphorylation, Smad1DephosphorylationViaSmad7, Smad1Smad4Binding).

$$\frac{d}{dt}\text{Smad1\_P} = v_{104} + v_{108} - v_{105} - v_{106} - v_{107} \tag{274}$$

7.41 Species Smad1_P_Smad4

Initial amount 0 item

This species takes part in six reactions (as a reactant in Smad1Smad4Release, Runx2ActivationBySmad1 and as a product in Smad1Smad4Binding, Runx2ActivationBySmad1 and as a modifier in Smad1Smad4Release, Runx2ActivationBySmad1).

$$\frac{d}{dt}\text{Smad1\_P\_Smad4} = v_{107} + v_{109} - v_{108} - v_{109} \tag{275}$$

7.42 Species Smad2

Initial amount 600 item

This species takes part in three reactions (as a reactant in Smad2Phosphorylation and as a product in Smad2DephosphorylationNuc and as a modifier in Smad2Phosphorylation).

$$\frac{d}{dt}\text{Smad2} = v_{85} - v_{82} \tag{276}$$

7.43 Species Smad2_P

Initial amount 0 item

This species takes part in six reactions (as a reactant in Smad2Smad4Binding, Smad2DephosphorylationNuc and as a product in Smad2Phosphorylation, Smad2PSmad4Release and as a modifier in Smad2Smad4Binding, Smad2DephosphorylationNuc).

$$\frac{d}{dt}\text{Smad2\_P} = v_{82} + v_{84} - v_{83} - v_{85} \tag{277}$$

Produced by SBML2LATEX

7.44 Species Smad2_P_Smad4

Initial amount 0 item

This species takes part in 15 reactions (as a reactant in Smad2PSmad4Release, Smad7Synthesis, Sox9Activation, Collagen2TranscriptionBySmad2Smad4, Runx2_InhibitionBySmad2 and as a product in Smad2Smad4Binding, Smad7Synthesis, Sox9Activation, Collagen2TranscriptionBySma... Runx2_InhibitionBySmad2 and as a modifier in Smad2PSmad4Release, Smad7Synthesis, Sox9Activation, Collagen2TranscriptionBySmad2Smad4, Runx2_InhibitionBySmad2).

$$\frac{\mathrm{d}}{\mathrm{d}t}\text{Smad2\_P\_Smad4} = v_{83} + v_{86} + v_{87} + v_{95} + v_{102} - v_{84} - v_{86} - v_{87} - v_{95} - v_{102}$$

(278)

7.45 Species Smad4

Initial amount 600 item

This species takes part in six reactions (as a reactant in Smad2Smad4Binding, Smad1Smad4Binding and as a product in Smad2PSmad4Release, Smad1Smad4Release and as a modifier in Smad2Smad4Binding, Smad1Smad4Binding).

$$\frac{\mathrm{d}}{\mathrm{d}t}\text{Smad4} = v_{84} + v_{108} - v_{83} - v_{107}$$

(279)

7.46 Species Smad7

Initial amount 0 item

This species takes part in twelve reactions (as a reactant in Tgfb_Alk5_BindingSmad7, Smad1DephosphorylationV... Tgfb_Alk1_Alk5_BindingSmad7, Smad7Degradation and as a product in Tgfb_Alk5_Smad7Release, Smad7Synthesis, Smad1DephosphorylationViaSmad7, Tgfb_Alk1_Alk5_Smad7Release and as a modifier in Tgfb_Alk5_BindingSmad7, Smad1DephosphorylationViaSmad7, Tgfb-_Alk1_Alk5_BindingSmad7, Smad7Degradation).

$$\frac{\mathrm{d}}{\mathrm{d}t}\text{Smad7} = v_{78} + v_{86} + v_{106} + v_{115} - v_{77} - v_{106} - v_{114} - v_{117}$$

(280)

7.47 Species SOD

Initial amount 2 item

This species takes part in six reactions (as a reactant in SOD_degradation, ROS_removal_by-_SOD and as a product in SOD_synthesis, ROS_removal_by_SOD and as a modifier in SOD-_degradation, ROS_removal_by_SOD).

$$\frac{\mathrm{d}}{\mathrm{d}t}\text{SOD} = v_{55} + v_{57} - v_{56} - v_{57}$$

(281)

7.48 Species Sox9

Initial amount 100 item

This species takes part in six reactions (as a reactant in Sox9Activation, Sox9Degradation and as a product in Sox9Inactivation, Sox9Translation and as a modifier in Sox9Activation, Sox9Degradation).

$$\frac{d}{dt}Sox9 = v_{88} + v_{92} - v_{87} - v_{93} \tag{282}$$

7.49 Species Sox9_A

Initial amount 0 item

This species takes part in twelve reactions (as a reactant in Sox9Inactivation, Sox9EnhancedTranscription, Collagen2EnhancedTranscriptionBySox9, AggrecanEnhancedTranscription and as a product in Sox9Activation, Sox9EnhancedTranscription, Collagen2EnhancedTranscriptionBySox9, AggrecanEnhancedTranscription and as a modifier in Sox9Inactivation, Sox9EnhancedTranscription, Collagen2EnhancedTranscriptionBySox9, AggrecanEnhancedTranscription).

$$\frac{d}{dt}Sox9\_A = v_{87} + v_{90} + v_{94} + v_{98} - v_{88} - v_{90} - v_{94} - v_{98} \tag{283}$$

7.50 Species Sox9mRNA

Initial amount 10 item

This species takes part in seven reactions (as a reactant in Sox9mRNA_Degradation, Sox9Translation and as a product in Sox9BasalTranscription, Sox9EnhancedTranscription, Sox9Translation and as a modifier in Sox9mRNA_Degradation, Sox9Translation).

$$\frac{d}{dt}Sox9mRNA = v_{89} + v_{90} + v_{92} - v_{91} - v_{92} \tag{284}$$

7.51 Species Tgfb_A

Initial amount 0 item

This species takes part in ten reactions (as a reactant in TgfbInactivation, TgfbReceptorBindingAlk5, TgfbReceptorBindingAlk1 and as a product in TgfbActivationByIntegrin, TgfbActivationByMMP2, TgfbReceptorRelease, TgfbAlk1Release and as a modifier in TgfbInactivation, TgfbReceptorBindingAlk TgfbReceptorBindingAlk1).

$$\frac{d}{dt}Tgfb\_A = v_{68} + v_{69} + v_{76} + v_{81} - v_{70} - v_{75} - v_{80} \tag{285}$$

Produced by SBML2LATEX

7.52 Species `Tgfb_Alk1_Alk5`

Initial amount 0 item

This species takes part in nine reactions (as a reactant in `TgfbAlk1Release`, `Smad1Activation`, `Tgfb_Alk1_Alk5_BindingSmad7` and as a product in `TgfbReceptorBindingAlk1`, `Smad1Activation`, `Tgfb_Alk1_Alk5_Smad7Release` and as a modifier in `TgfbAlk1Release`, `Smad1Activation`, `Tgfb_Alk1_Alk5_BindingSmad7`).

$$\frac{\mathrm{d}}{\mathrm{d}t}\text{Tgfb\_Alk1\_Alk5} = v_{80} + v_{104} + v_{115} - v_{81} - v_{104} - v_{114} \tag{286}$$

7.53 Species `Tgfb_Alk1_Alk5_Smad7`

Initial amount 0 item

This species takes part in five reactions (as a reactant in `Tgfb_Alk1_Alk5_Smad7Release`, `Alk1_Smad7Degradation` and as a product in `Tgfb_Alk1_Alk5_BindingSmad7` and as a modifier in `Tgfb_Alk1_Alk5_Smad7Release`, `Alk1_Smad7Degradation`).

$$\frac{\mathrm{d}}{\mathrm{d}t}\text{Tgfb\_Alk1\_Alk5\_Smad7} = v_{114} - v_{115} - v_{116} \tag{287}$$

7.54 Species `Tgfb_Alk5_dimer`

Initial amount 0 item

This species takes part in nine reactions (as a reactant in `TgfbReceptorRelease`, `Tgfb_Alk5-_BindingSmad7`, `Smad2Phosphorylation` and as a product in `TgfbReceptorBindingAlk5`, `Tgfb_Alk5_Smad7Release`, `Smad2Phosphorylation` and as a modifier in `TgfbReceptorRelease`, `Tgfb_Alk5_BindingSmad7`, `Smad2Phosphorylation`).

$$\frac{\mathrm{d}}{\mathrm{d}t}\text{Tgfb\_Alk5\_dimer} = v_{75} + v_{78} + v_{82} - v_{76} - v_{77} - v_{82} \tag{288}$$

7.55 Species `Tgfb_Alk5_dimer_Smad7`

Initial amount 0 item

This species takes part in five reactions (as a reactant in `Tgfb_Alk5_Smad7Release`, `Alk5-_Smad7Degradation` and as a product in `Tgfb_Alk5_BindingSmad7` and as a modifier in `Tgfb_Alk5_Smad7Release`, `Alk5_Smad7Degradation`).

$$\frac{\mathrm{d}}{\mathrm{d}t}\text{Tgfb\_Alk5\_dimer\_Smad7} = v_{77} - v_{78} - v_{79} \tag{289}$$

7.56 Species `AggFrag`

Initial amount 0 item

This species takes part in one reaction (as a product in `Aggrecan_degradation`).

$$\frac{d}{dt}\text{AggFrag} = v_{51} \tag{290}$$

7.57 Species `Aggrecan`

Initial amount 0 item

This species takes part in three reactions (as a reactant in `AggrecanCollagen2Binding` and as a product in `AggrecanTranslation` and as a modifier in `AggrecanCollagen2Binding`).

$$\frac{d}{dt}\text{Aggrecan} = v_{100} - v_{101} \tag{291}$$

7.58 Species `Aggrecan_Collagen2`

Initial amount 1000 item

This species takes part in three reactions (as a reactant in `Aggrecan_degradation` and as a product in `AggrecanCollagen2Binding` and as a modifier in `Aggrecan_degradation`).

$$\frac{d}{dt}\text{Aggrecan\_Collagen2} = v_{101} - v_{51} \tag{292}$$

7.59 Species `ColFrag`

Initial amount 0 item

This species takes part in one reaction (as a product in `Collagen_degradation`).

$$\frac{d}{dt}\text{ColFrag} = v_{52} \tag{293}$$

7.60 Species `Collagen2`

Initial amount 0 item

This species takes part in six reactions (as a reactant in `Collagen_degradation`, `AggrecanCollagen2Binding` and as a product in `Aggrecan_degradation`, `Collagen2Translation` and as a modifier in `Collagen_degradation`, `AggrecanCollagen2Binding`).

$$\frac{d}{dt}\text{Collagen2} = v_{51} + v_{97} - v_{52} - v_{101} \tag{294}$$

Produced by SBML2LATEX

7.61 Species `Integrin`

Initial amount 0 item

This species takes part in six reactions (as a reactant in `IntegrinInactivation`, `TgfbActivationByIntegrin` and as a product in `IntegrinActivationByMechanicalStress`, `TgfbActivationByIntegrin` and as a modifier in `IntegrinInactivation`, `TgfbActivationByIntegrin`).

$$\frac{d}{dt}\text{Integrin} = v_{65} + v_{68} - v_{66} - v_{68} \tag{295}$$

7.62 Species `Tgfb_I`

Initial amount 200 item

This species takes part in seven reactions (as a reactant in `TgfbActivationByIntegrin`, `TgfbActivationByMMP2` and as a product in `TgfbInactivation`, `Alk5_Smad7Degradation`, `Alk1_Smad7Degradation` and as a modifier in `TgfbActivationByIntegrin`, `TgfbActivationByMMP2`).

$$\frac{d}{dt}\text{Tgfb\_I} = v_{70} + v_{79} + v_{116} - v_{68} - v_{69} \tag{296}$$

7.63 Species `Sink`

SBO:0000291 empty set

Initial amount 0 item

This species takes part in 18 reactions (as a product in `Bcl2Degradation`, `Bcl2DegradationStressInduced`, `Bcl2DegradationCaspaseInduced`, `ROS_removal`, `RAGE_inactivation`, `IL1_degradation`, `MMP13_removal`, `MMP2_degradation`, `ADAMTS5_removal`, `SOD_degradation`, `IntegrinInactivation`, `Sox9mRNA_Degradation`, `Sox9Degradation`, `Col2mRNA_Degradation`, `AcanmRNA_Degradation`, `Alk5Degradation`, `Alk1Degradation`, `Smad7Degradation`), which do not influence its rate of change because this constant species is on the boundary of the reaction system:

$$\frac{d}{dt}\text{Sink} = 0 \tag{297}$$

7.64 Species `Source`

SBO:0000291 empty set

Initial amount 1 item

This species takes part in 16 reactions (as a reactant in `Bcl2Synthesis`, `ROS_generation`, `Production_of_AGEproducts`, `Protein_synthesis`, `IntegrinActivationByMechanicalStress`, `Alk5Synthesis`, `Sox9BasalTranscription`, `Alk1Synthesis` and as a modifier in `Bcl2Synthesis`, `ROS_generation`, `Production_of_AGEproducts`, `Protein_synthesis`, `IntegrinActivationByMechanicalS`

`Alk5Synthesis`, `Sox9BasalTranscription`, `Alk1Synthesis`), which do not influence its rate of change because this constant species is on the boundary of the reaction system:

$$\frac{\mathrm{d}}{\mathrm{d}t}\text{Source} = 0 \tag{298}$$

7.65 Species `IntegrinCount`

Initial amount 0 item

This species takes part in one reaction (as a product in `IntegrinActivationByMechanicalStress`).

$$\frac{\mathrm{d}}{\mathrm{d}t}\text{IntegrinCount} = v_{65} \tag{299}$$

A Glossary of Systems Biology Ontology Terms

SBO:0000291 empty set: Entity defined by the absence of any actual object. An empty set is often used to represent the source of a creation process or the result of a degradation process.

SBO:0000607 dimer: A macromolecular complex composed of two monomeric units, which may or may not be identical. Monomers are usually non-covalently bound