SBML Model Report

Model name: “Proctor2010 - a link between GSK3 and p53 in Alzheimer’s Disease”

May 6, 2016

1 General Overview

This is a document in SBML Level 2 Version 4 format. This model was created by the following three authors: Lukas Endler[1], Vijayalakshmi Chelliah[2] and Carole J Proctor[3] at January 27th 2010 at 11:31 a. m. and last time modified at October tenth 2014 at 11:16 a. m. Table 1 gives an overview of the quantities of all components of this model.

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

Element	Quantity	Element	Quantity
compartment types	0	compartments	1
species types	0	species	59
events	0	constraints	0
reactions	93	function definitions	0
global parameters	58	unit definitions	1
rules	3	initial assignments	0

Model Notes

This is the model described the article:
GSK3 and p53 - is there a link in Alzheimer’s disease?

[1]EMBL-EBI, lukas@ebi.ac.uk
[2]EMBL-EBI, viji@ebi.ac.uk
[3]Centre for Integrated Systems Biology of Ageing and Nutrition, Institute for Ageing and Health, Newcastle University, UK, c.j.proctor@newcastle.ac.uk

Carole J Proctor and Douglas A Gray Molecular Neurodegeneration 2010, 5:7; doi: 10.1186/1750-1326-5-7
Abstract:
Background: Recent evidence suggests that glycogen synthase kinase-3beta (GSK3beta) is implicated in both sporadic and familial forms of Alzheimer's disease. The transcription factor, p53 also plays a role and has been linked to an increase in tau hyperphosphorylation although the effect is indirect. There is also evidence that GSK3beta and p53 interact and that the activity of both proteins is increased as a result of this interaction. Under normal cellular conditions, p53 is kept at low levels by Mdm2 but when cells are stressed, p53 is stabilised and may then interact with GSK3beta. We propose that this interaction has an important contribution to cellular outcomes and to test this hypothesis we developed a stochastic simulation model.
Results: The model predicts that high levels of DNA damage leads to increased activity of p53 and GSK3beta and low levels of aggregation but if DNA damage is repaired, the aggregates are eventually cleared. The model also shows that over long periods of time, aggregates may start to form due to stochastic events leading to increased levels of ROS and damaged DNA. This is followed by increased activity of p53 and GSK3beta and a vicious cycle ensues.
Conclusions: Since p53 and GSK3beta are both involved in the apoptotic pathway, and GSK3beta overactivity leads to increased levels of plaques and tangles, our model might explain the link between protein aggregation and neuronal loss in neurodegeneration.

Notes: The original model submitted by the author had events in it. Since, this model is intended for Stochastic Simulation run and Copasi cannot handle events in Stochastic run, I have replaced the events with piecewise assignment rule. -Viji

This model is an extension of Proctor_p53_Mdm2_ATM (BIOMD0000000188).

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 Compartment

This model contains one compartment.

Table 2: Properties of all compartments.

Id	Name	SBO	Spatial Dimensions	Size	Unit	Constant	Outside
cell		0000290	3	1	litre	☑	

3.1 Compartment cell

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

SBO:0000290 physical compartment

4 Species

This model contains 59 species. The boundary condition of five of these species is set to `true` so that these species' amount cannot be changed by any reaction. Section 8 provides further details and the derived rates of change of each species.

Table 3: Properties of each species.

Id	Name	Compartment	Derived Unit	Constant	Boundary Condition
Mdm2		cell	item	⊟	⊟
p53		cell	item	⊟	⊟
Mdm2_p53		cell	item	⊟	⊟
Mdm2_mRNA		cell	item	⊟	⊟
p53_mRNA		cell	item	⊟	⊟
ATMA		cell	item	⊟	⊟
ATMI		cell	item	⊟	⊟
p53_P		cell	item	⊟	⊟
Mdm2_P		cell	item	⊟	⊟
IR		cell	$\text{item} \cdot \text{l}^{-1}$	⊟	⊟
ROS		cell	item	⊟	⊟
basalROS		cell	item	⊟	⊟
damDNA		cell	item	⊟	⊟
E1		cell	item	⊟	⊟
E2		cell	item	⊟	⊟
E1_Ub		cell	item	⊟	⊟
E2_Ub		cell	item	⊟	⊟
Proteasome		cell	item	⊟	⊟
Ub		cell	item	⊟	⊟
p53DUB		cell	item	⊟	⊟
Mdm2DUB		cell	item	⊟	⊟

Id	Name	Compartment	Derived Unit	Constant	Boundary Condition
DUB		cell	item	⊟	⊟
Mdm2_p53_Ub		cell	item	⊟	⊟
Mdm2_p53_Ub2		cell	item	⊟	⊟
Mdm2_p53_Ub3		cell	item	⊟	⊟
Mdm2_p53_Ub4		cell	item	⊟	⊟
Mdm2_P1_p53_Ub4		cell	item	⊟	⊟
Mdm2_Ub		cell	item	⊟	⊟
Mdm2_Ub2		cell	item	⊟	⊟
Mdm2_Ub3		cell	item	⊟	⊟
Mdm2_Ub4		cell	item	⊟	⊟
Mdm2_P_Ub		cell	item	⊟	⊟
Mdm2_P_Ub2		cell	item	⊟	⊟
Mdm2_P_Ub3		cell	item	⊟	⊟
Mdm2_P_Ub4		cell	item	⊟	⊟
p53_Ub4-_Proteasome		cell	item	⊟	⊟
Mdm2_Ub4-_Proteasome		cell	item	⊟	⊟
Mdm2_P_Ub4-_Proteasome		cell	item	⊟	⊟
GSK3b		cell	item	⊟	⊟
GSK3b_p53		cell	item	⊟	⊟
GSK3b_p53_P		cell	item	⊟	⊟
Abeta		cell	item	⊟	⊟
AggAbeta-_Proteasome		cell	item	⊟	⊟
AggAbeta		cell	item	⊟	⊟

Id	Name	Compartment	Derived Unit	Constant	Boundary Condition
AbetaPlaque		cell	item	⊟	⊟
Tau		cell	item	⊟	⊟
Tau_P1		cell	item	⊟	⊟
Tau_P2		cell	item	⊟	⊟
MT_Tau		cell	item	⊟	⊟
AggTau		cell	item	⊟	⊟
AggTau_Proteasome		cell	item	⊟	⊟
Proteasome_Tau		cell	item	⊟	⊟
PP1		cell	item	⊟	⊟
NFT		cell	item	⊟	⊟
ATP		cell	item	☑	☑
ADP		cell	item	☑	☑
AMP		cell	item	☑	☑
Source		cell	item	☑	☑
Sink		cell	item	☑	☑

5 Parameters

This model contains 58 global parameters.

Table 4: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
ksynp53mRNA		0000009	0.001		☑
kdegp53mRNA		0000356	10^{-4}		☑
ksynMdm2mRNA		0000009	$5 \cdot 10^{-4}$		☑
kdegMdm2mRNA		0000356	$5 \cdot 10^{-4}$		☑
ksynMdm2mRNAGSK3bp53		0000009	$7 \cdot 10^{-4}$		☑
ksynp53		0000009	0.007		☑
kdegp53		0000356	0.005		☑
kbinMdm2p53		0000337	0.001		☑
krelMdm2p53		0000282	$1.155 \cdot 10^{-5}$		☑
kbinGSK3bp53		0000337	$2 \cdot 10^{-6}$		☑
krelGSK3bp53		0000282	0.002		☑
ksynMdm2		0000009	$4.95 \cdot 10^{-4}$		☑
kdegMdm2		0000356	0.010		☑
kbinE1Ub		0000337	$2 \cdot 10^{-4}$		☑
kbinE2Ub		0000337	0.001		☑
kp53Ub		0000337	$5 \cdot 10^{-5}$		☑
kp53PolyUb		0000337	0.010		☑
kbinProt		0000337	$2 \cdot 10^{-6}$		☑
kactDUBp53		0000282	10^{-7}		☑
kactDUBProtp53		0000282	10^{-4}		☑
kactDUBMdm2		0000282	10^{-7}		☑
kMdm2Ub		0000337	$4.56 \cdot 10^{-6}$		☑
kMdm2PUb		0000337	$6.84 \cdot 10^{-6}$		☑
kMdm2PolyUb		0000337	0.005		☑
kdam		0000009	0.080		☑
krepair		0000009	$2 \cdot 10^{-5}$		☑
kactATM		0000363	10^{-4}		☑
kinactATM		0000349	$5 \cdot 10^{-4}$		☑
kphosp53		0000009	$2 \cdot 10^{-4}$		☑
kdephosp53		0000009	0.500		☑
kphosMdm2		0000009	2.000		☑
kdephosMdm2		0000009	0.500		☑
kphosMdm2GSK3b		0000009	0.005		☑
kphosMdm2GSK3bp53		0000009	0.500		☑
kphospTauGSK3bp53		0000009	0.100		☑
kphospTauGSK3b		0000009	$2 \cdot 10^{-4}$		☑
kdephospTau		0000009	0.010		☑

Id	Name	SBO	Value	Unit	Constant
kbinMTTau		0000337	0.100		☑
krelMTTau		0000282	10^{-4}		☑
ksynTau		0000009	$8 \cdot 10^{-5}$		☑
kbinTauProt		0000337	$1.925 \cdot 10^{-7}$		☑
kdegTau20SProt		0000356	0.010		☑
kaggTau		0000337	10^{-8}		☑
kaggTauP1		0000337	10^{-8}		☑
kaggTauP2		0000337	10^{-7}		☑
ktangfor		0000337	0.001		☑
kprodAbeta		0000337	$5 \cdot 10^{-5}$		☑
kinhibprot		0000261	10^{-5}		☑
kdegAbeta		0000282	10^{-4}		☑
kaggAbeta		0000337	10^{-8}		☑
kpf		0000337	0.001		☑
ksynp53mRNAAbeta		0000337	10^{-5}		☑
kdamROS		0000009	10^{-5}		☑
kdamBasalROS		0000009	10^{-9}		☑
kgenROSAbeta		0000009	10^{-5}		☑
kproteff		0000009	1.000		⊟
tot_mdm2	tot_mdm2		0.000		⊟
tot_p53	tot_p53		0.000		⊟

6 Rules

This is an overview of three rules.

6.1 Rule IR

Rule IR is an assignment rule for species IR:

$$\mathrm{IR} = \begin{cases} 25 & \text{if } (\mathrm{t} \geq 3600) \wedge (\mathrm{t} \leq 3660) \\ 0 & \text{otherwise} \end{cases} \tag{1}$$

6.2 Rule tot_mdm2

Rule tot_mdm2 is an assignment rule for parameter tot_mdm2:

$$\begin{aligned} \mathrm{tot\_mdm2} = {} & \mathrm{Mdm2} + \mathrm{Mdm2\_p53} + \mathrm{Mdm2\_P} + \mathrm{Mdm2\_p53\_Ub} + \mathrm{Mdm2\_p53\_Ub2} \\ & + \mathrm{Mdm2\_p53\_Ub3} + \mathrm{Mdm2\_p53\_Ub4} + \mathrm{Mdm2\_P1\_p53\_Ub4} \\ & + \mathrm{Mdm2\_Ub} + \mathrm{Mdm2\_Ub2} + \mathrm{Mdm2\_Ub3} + \mathrm{Mdm2\_Ub4} \\ & + \mathrm{Mdm2\_P\_Ub} + \mathrm{Mdm2\_P\_Ub2} + \mathrm{Mdm2\_P\_Ub3} + \mathrm{Mdm2\_P\_Ub4} \\ & + \mathrm{Mdm2\_Ub4\_Proteasome} + \mathrm{Mdm2\_P\_Ub4\_Proteasome} \end{aligned} \tag{2}$$

Derived unit item

6.3 Rule tot_p53

Rule tot_p53 is an assignment rule for parameter tot_p53:

$$\begin{aligned}\text{tot\_p53} = {} & \text{p53} + \text{Mdm2\_p53} + \text{p53\_P} + \text{Mdm2\_p53\_Ub} + \text{Mdm2\_p53\_Ub2} + \text{Mdm2\_p53\_Ub3} \\ & + \text{Mdm2\_p53\_Ub4} + \text{Mdm2\_P1\_p53\_Ub4} + \text{p53\_Ub4\_Proteasome}\end{aligned} \tag{3}$$

Derived unit item

7 Reactions

This model contains 93 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	p53mRNASynthesis		Source ⟶ p53_mRNA	0000183
2	p53mRNADegradation		p53_mRNA ⟶ Sink	0000179
3	Mdm2Synthesis		Mdm2_mRNA ⟶ Mdm2_mRNA + Mdm2	0000393
4	Mdm2mRNASynthesis1		p53 ⟶ p53 + Mdm2_mRNA	0000183
5	Mdm2mRNASynthesis2		p53_P ⟶ p53_P + Mdm2_mRNA	0000183
6	Mdm2mRNASynthesis3		GSK3b_p53 ⟶ GSK3b_p53 + Mdm2_mRNA	0000183
7	Mdm2mRNASynthesis4		GSK3b_p53_P ⟶ GSK3b_p53_P + Mdm2_mRNA	0000183
8	Mdm2mRNADegradation		Mdm2_mRNA ⟶ Sink	0000279
9	P53Mdm2Binding		p53 + Mdm2 ⟶ Mdm2_p53	0000526
10	P53Mdm2Release		Mdm2_p53 ⟶ p53 + Mdm2	0000180
11	GSK3p53Binding		GSK3b + p53 ⟶ GSK3b_p53	0000526
12	GSK3p53Release		GSK3b_p53 ⟶ GSK3b + p53	0000180
13	GSK3p53PBinding		GSK3b + p53_P ⟶ GSK3b_p53_P	0000526
14	GSK3-_p53PRelease		GSK3b_p53_P ⟶ GSK3b + p53_P	0000180
15	E1UbBinding		E1 + Ub + ATP ⟶ E1_Ub + AMP	0000526
16	E2UbBinding		E2 + E1_Ub ⟶ E2_Ub + E1	0000526
17	Mdm2Ubiquitination		Mdm2 + E2_Ub ⟶ Mdm2_Ub + E2	0000526
18	Mdm2polyUbiquitination1		Mdm2_Ub + E2_Ub ⟶ Mdm2_Ub2 + E2	0000526
19	Mdm2polyUbiquitination2		Mdm2_Ub2 + E2_Ub ⟶ Mdm2_Ub3 + E2	0000526
20	Mdm2polyUbiquitination3		Mdm2_Ub3 + E2_Ub ⟶ Mdm2_Ub4 + E2	0000526
21	Mdm2Deubiquitination4		Mdm2_Ub4 + Mdm2DUB ⟶ Mdm2_Ub3 + Mdm2DUB + Ub	0000526

№	Id	Name	Reaction Equation	SBO
22	Mdm2Deubiquitination3		Mdm2_Ub3 + Mdm2DUB ⟶ Mdm2_Ub2 + Mdm2DUB + Ub	0000526
23	Mdm2Deubiquitination2		Mdm2_Ub2 + Mdm2DUB ⟶ Mdm2_Ub + Mdm2DUB + Ub	0000526
24	Mdm2Deubiquitination1		Mdm2_Ub + Mdm2DUB ⟶ Mdm2 + Mdm2DUB + Ub	0000526
25	Mdm2ProteasomeBinding1		Mdm2_Ub4 + Proteasome ⟶ Mdm2_Ub4_Proteasome	0000526
26	Mdm2Degradation		Mdm2_Ub4_Proteasome ⟶ Proteasome + 4 Ub	0000179
27	p53Synthesis		p53_mRNA ⟶ p53 + p53_mRNA	0000393
28	p53Monoubiquitination		E2_Ub + Mdm2_p53 ⟶ Mdm2_p53_Ub + E2	0000526
29	p53Polyubiquitination1		Mdm2_p53_Ub + E2_Ub ⟶ Mdm2_p53_Ub2 + E2	0000526
30	p53Polyubiquitination2		Mdm2_p53_Ub2 + E2_Ub ⟶ Mdm2_p53_Ub3 + E2	0000526
31	p53Polyubiquitination3		Mdm2_p53_Ub3 + E2_Ub ⟶ Mdm2_p53_Ub4 + E2	0000526
32	p53Deubiqutination4		Mdm2_p53_Ub4 + p53DUB ⟶ Mdm2_p53_Ub3 + p53DUB + Ub	0000526
33	p53Deubiquitination3		Mdm2_p53_Ub3 + p53DUB ⟶ Mdm2_p53_Ub2 + p53DUB + Ub	0000526
34	p53Deubiquitination2		Mdm2_p53_Ub2 + p53DUB ⟶ Mdm2_p53_Ub + p53DUB + Ub	0000526
35	p53Deubiquitination1		Mdm2_p53_Ub + p53DUB ⟶ Mdm2_p53 + p53DUB + Ub	0000526
36	Mdm2GSK3phosphorylation1		Mdm2_p53_Ub4 + GSK3b ⟶ Mdm2_P1_p53_Ub4 + GSK3b	0000216
37	Mdm2GSK3phosphorylation2		Mdm2_p53_Ub4 + GSK3b_p53 ⟶ Mdm2_P1_p53_Ub4 + GSK3b_p53	0000216

№	Id	Name	Reaction Equation	SBO
38	Mdm2GSK3phosphorylation3		Mdm2_p53_Ub4 + GSK3b_p53_P ⟶ Mdm2_P1_p53_Ub4 + GSK3b_p53_P	0000216
39	p53ProteasomeBinding1		Mdm2_P1_p53_Ub4 + Proteasome ⟶ p53_Ub4_Proteasome + Mdm2	0000526
40	Degradationp53-_Ub4		p53_Ub4_Proteasome + ATP ⟶ 4 Ub + Proteasome + ADP	0000180
41	TauMTbinding		Tau ⟶ MT_Tau	0000526
42	TauMTrelease		MT_Tau ⟶ Tau	0000180
43	Tauphosphorylation1		GSK3b_p53 + Tau ⟶ GSK3b_p53 + Tau_P1	0000216
44	Tauphosphorylation2		GSK3b_p53 + Tau_P1 ⟶ GSK3b_p53 + Tau_P2	0000216
45	Tauphosphorylation3		GSK3b_p53_P + Tau ⟶ GSK3b_p53_P + Tau_P1	0000216
46	Tauphosphorylation4		GSK3b_p53_P + Tau_P1 ⟶ GSK3b_p53_P + Tau_P2	0000216
47	Tauphosphorylation5		GSK3b + Tau ⟶ GSK3b + Tau_P1	0000216
48	Tauphosphorylation6		GSK3b + Tau_P1 ⟶ GSK3b + Tau_P2	0000216
49	Taudephosphorylation1		Tau_P2 + PP1 ⟶ Tau_P1 + PP1	0000330
50	Taudephosphorylation2		Tau_P1 + PP1 ⟶ Tau + PP1	0000330
51	TauP1Aggregation1		2 Tau_P1 ⟶ 2 AggTau	0000526
52	TauP1Aggregation2		Tau_P1 + AggTau ⟶ 2 AggTau	0000526
53	TauP2Aggregation1		2 Tau_P2 ⟶ 2 AggTau	0000526
54	TauP2Aggregation2		Tau_P2 + AggTau ⟶ 2 AggTau	0000526
55	TauAggregation1		2 Tau ⟶ 2 AggTau	0000526
56	TauAggregation2		Tau + AggTau ⟶ 2 AggTau	0000526
57	TangleFormation1		2 AggTau ⟶ 2 NFT	0000526
58	TangleFormation2		AggTau + NFT ⟶ 2 NFT	0000526
59	ProteasomeInhibitionAggTau		AggTau + Proteasome ⟶ AggTau_Proteasome	0000169
60	Abetaproduction1		GSK3b_p53 ⟶ Abeta + GSK3b_p53	0000393
61	Abetaproduction2		GSK3b_p53_P ⟶ Abeta + GSK3b_p53_P	0000393

№	Id	Name	Reaction Equation	SBO
62	ProteasomeInhibitionAbeta		AggAbeta + Proteasome ⟶ AggAbeta_Proteasome	0000169
63	AbetaDegradation		Abeta ⟶ Sink	0000179
64	AbetaAggregation1		2 Abeta ⟶ AggAbeta	0000526
65	AbetaAggregation2		Abeta + AggAbeta ⟶ 2 AggAbeta	0000526
66	AbetaPlaqueFormation1		2 AggAbeta ⟶ 2 AbetaPlaque	0000526
67	AbetaPlaqueFormation2		AggAbeta + AbetaPlaque ⟶ 2 AbetaPlaque	0000526
68	p53transcriptionViaAbeta		Abeta ⟶ p53_mRNA + Abeta	0000183
69	DNAdamage		$\emptyset \xrightarrow{\text{IR}}$ damDNA	0000357
70	DNArepair		damDNA ⟶ Sink	0000179
71	ATMactivation		damDNA + ATMI ⟶ damDNA + ATMA	0000176
72	p53phosphorylation		p53 + ATMA ⟶ p53_P + ATMA	0000216
73	p53dephosphorylation		p53_P ⟶ p53	0000330
74	Mdm2phosphorylation		Mdm2 + ATMA ⟶ Mdm2_P + ATMA	0000216
75	Mdm2dephosphorylation		Mdm2_P ⟶ Mdm2	0000330
76	Mdm2PUbiquitination		Mdm2_P + E2_Ub ⟶ Mdm2_P_Ub + E2	0000526
77	Mdm2PpolyUbiquitination1		Mdm2_P_Ub + E2_Ub ⟶ Mdm2_P_Ub2 + E2	0000526
78	Mdm2PpolyUbiquitination2		Mdm2_P_Ub2 + E2_Ub ⟶ Mdm2_P_Ub3 + E2	0000526
79	Mdm2PpolyUbiquitination3		Mdm2_P_Ub3 + E2_Ub ⟶ Mdm2_P_Ub4 + E2	0000526
80	Mdm2PDeubiquitination4		Mdm2_P_Ub4 + Mdm2DUB ⟶ Mdm2_P_Ub3 + Mdm2DUB + Ub	0000526
81	Mdm2PDeubiquitination3		Mdm2_P_Ub3 + Mdm2DUB ⟶ Mdm2_P_Ub2 + Mdm2DUB + Ub	0000526
82	Mdm2PDeubiquitination2		Mdm2_P_Ub2 + Mdm2DUB ⟶ Mdm2_P_Ub + Mdm2DUB + Ub	0000526
83	Mdm2PDeubiquitination1		Mdm2_P_Ub + Mdm2DUB ⟶ Mdm2_P + Mdm2DUB + Ub	0000526
84	Mdm2PProteasomeBinding1		Mdm2_P_Ub4 + Proteasome ⟶ Mdm2_P_Ub4_Proteasome	0000526
85	Mdm2PDegradation		Mdm2_P_Ub4_Proteasome ⟶ Proteasome + 4 Ub	0000179
86	ATMInactivation		ATMA ⟶ ATMI	0000176

№	Id	Name	Reaction Equation	SBO
87	AggAbetaROSproduction1		AggAbeta ⟶ AggAbeta + ROS	0000393
88	AggAbetaROSproduction2		AggAbeta_Proteasome ⟶ AggAbeta_Proteasome + ROS	0000393
89	ROSDNAdamage		ROS ⟶ ROS + damDNA	0000176
90	basalROSDNAdamage		basalROS ⟶ basalROS + damDNA	0000176
91	TauSynthesis		Source ⟶ Tau	0000393
92	TauProteasomeBinding		Tau + Proteasome ⟶ Proteasome_Tau	0000526
93	Tau20SProteasomeDegradation		Proteasome_Tau ⟶ Proteasome	0000179

7.1 Reaction p53mRNASynthesis

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

SBO:0000183 transcription

Reaction equation

$$\text{Source} \longrightarrow \text{p53\_mRNA} \tag{4}$$

Reactant

Table 6: Properties of each reactant.

Id	Name	SBO
Source		

Product

Table 7: Properties of each product.

Id	Name	SBO
p53_mRNA		

Kinetic Law

Derived unit contains undeclared units

$$v_1 = \text{ksynp53mRNA} \cdot \text{Source} \tag{5}$$

7.2 Reaction p53mRNADegradation

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

SBO:0000179 degradation

Reaction equation

$$\text{p53\_mRNA} \longrightarrow \text{Sink} \tag{6}$$

Reactant

Table 8: Properties of each reactant.

Id	Name	SBO
p53_mRNA		

Product

Table 9: Properties of each product.

Id	Name	SBO
Sink		

Kinetic Law

Derived unit contains undeclared units

$$v_2 = \text{kdegp53mRNA} \cdot \text{p53\_mRNA} \tag{7}$$

7.3 Reaction Mdm2Synthesis

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

SBO:0000393 production

Reaction equation

$$\text{Mdm2\_mRNA} \longrightarrow \text{Mdm2\_mRNA} + \text{Mdm2} \tag{8}$$

Reactant

Table 10: Properties of each reactant.

Id	Name	SBO
Mdm2_mRNA		

Products

Table 11: Properties of each product.

Id	Name	SBO
Mdm2_mRNA		
Mdm2		

Id	Name	SBO

Kinetic Law

Derived unit contains undeclared units

$$v_3 = \text{ksynMdm2} \cdot \text{Mdm2\_mRNA} \tag{9}$$

7.4 Reaction `Mdm2mRNASynthesis1`

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

SBO:0000183 transcription

Reaction equation

$$\text{p53} \longrightarrow \text{p53} + \text{Mdm2\_mRNA} \tag{10}$$

Reactant

Table 12: Properties of each reactant.

Id	Name	SBO
`p53`		

Products

Table 13: Properties of each product.

Id	Name	SBO
`p53`		
`Mdm2_mRNA`		

Kinetic Law

Derived unit contains undeclared units

$$v_4 = \text{ksynMdm2mRNA} \cdot \text{p53} \tag{11}$$

7.5 Reaction `Mdm2mRNASynthesis2`

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

SBO:0000183 transcription

Reaction equation

$$\text{p53\_P} \longrightarrow \text{p53\_P} + \text{Mdm2\_mRNA} \tag{12}$$

Reactant

Table 14: Properties of each reactant.

Id	Name	SBO
p53_P		

Products

Table 15: Properties of each product.

Id	Name	SBO
p53_P		
Mdm2_mRNA		

Kinetic Law

Derived unit contains undeclared units

$$v_5 = \text{ksynMdm2mRNA} \cdot \text{p53\_P} \tag{13}$$

7.6 Reaction Mdm2mRNASynthesis3

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

SBO:0000183 transcription

Reaction equation

$$\text{GSK3b\_p53} \longrightarrow \text{GSK3b\_p53} + \text{Mdm2\_mRNA} \tag{14}$$

Reactant

Table 16: Properties of each reactant.

Id	Name	SBO
GSK3b_p53		

Products

Table 17: Properties of each product.

Id	Name	SBO
GSK3b_p53		
Mdm2_mRNA		

Kinetic Law

Derived unit contains undeclared units

$$v_6 = \text{ksynMdm2mRNAGSK3bp53} \cdot \text{GSK3b\_p53} \tag{15}$$

7.7 Reaction Mdm2mRNASynthesis4

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

SBO:0000183 transcription

Reaction equation

$$\text{GSK3b\_p53\_P} \longrightarrow \text{GSK3b\_p53\_P} + \text{Mdm2\_mRNA} \tag{16}$$

Reactant

Table 18: Properties of each reactant.

Id	Name	SBO
GSK3b_p53_P		

Products

Table 19: Properties of each product.

Id	Name	SBO
GSK3b_p53_P		
Mdm2_mRNA		

Kinetic Law

Derived unit contains undeclared units

$$v_7 = \text{ksynMdm2mRNAGSK3bp53} \cdot \text{GSK3b\_p53\_P} \tag{17}$$

7.8 Reaction Mdm2mRNADegradation

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

SBO:0000279 pressure

Reaction equation

$$\text{Mdm2\_mRNA} \longrightarrow \text{Sink} \tag{18}$$

Reactant

Table 20: Properties of each reactant.

Id	Name	SBO
Mdm2_mRNA		

Product

Table 21: Properties of each product.

Id	Name	SBO
Sink		

Kinetic Law

Derived unit contains undeclared units

$$v_8 = \text{kdegMdm2mRNA} \cdot \text{Mdm2\_mRNA} \tag{19}$$

7.9 Reaction P53Mdm2Binding

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

SBO:0000526 protein complex formation

Reaction equation

$$\text{p53} + \text{Mdm2} \longrightarrow \text{Mdm2\_p53} \tag{20}$$

Reactants

Table 22: Properties of each reactant.

Id	Name	SBO
p53		
Mdm2		

Product

Table 23: Properties of each product.

Id	Name	SBO
Mdm2_p53		

Kinetic Law

Derived unit contains undeclared units

$$v_9 = \text{kbinMdm2p53} \cdot \text{p53} \cdot \text{Mdm2} \tag{21}$$

7.10 Reaction P53Mdm2Release

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

SBO:0000180 dissociation

Reaction equation

$$\text{Mdm2\_p53} \longrightarrow \text{p53} + \text{Mdm2} \tag{22}$$

Reactant

Table 24: Properties of each reactant.

Id	Name	SBO
Mdm2_p53		

Products

Table 25: Properties of each product.

Id	Name	SBO
p53		

Id	Name	SBO
Mdm2		

Kinetic Law

Derived unit contains undeclared units

$$v_{10} = \text{krelMdm2p53} \cdot \text{Mdm2\_p53} \tag{23}$$

7.11 Reaction GSK3p53Binding

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

SBO:0000526 protein complex formation

Reaction equation

$$\text{GSK3b} + \text{p53} \longrightarrow \text{GSK3b\_p53} \tag{24}$$

Reactants

Table 26: Properties of each reactant.

Id	Name	SBO
GSK3b		
p53		

Product

Table 27: Properties of each product.

Id	Name	SBO
GSK3b_p53		

Kinetic Law

Derived unit contains undeclared units

$$v_{11} = \text{kbinGSK3bp53} \cdot \text{GSK3b} \cdot \text{p53} \tag{25}$$

7.12 Reaction GSK3p53Release

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

SBO:0000180 dissociation

Reaction equation

$$\text{GSK3b\_p53} \longrightarrow \text{GSK3b} + \text{p53} \tag{26}$$

Reactant

Table 28: Properties of each reactant.

Id	Name	SBO
GSK3b_p53		

Products

Table 29: Properties of each product.

Id	Name	SBO
GSK3b		
p53		

Kinetic Law

Derived unit contains undeclared units

$$v_{12} = \text{krelGSK3bp53} \cdot \text{GSK3b\_p53} \tag{27}$$

7.13 Reaction GSK3p53PBinding

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

SBO:0000526 protein complex formation

Reaction equation

$$\text{GSK3b} + \text{p53\_P} \longrightarrow \text{GSK3b\_p53\_P} \tag{28}$$

Reactants

Table 30: Properties of each reactant.

Id	Name	SBO
GSK3b		
p53_P		

Product

Table 31: Properties of each product.

Id	Name	SBO
GSK3b_p53_P		

Kinetic Law

Derived unit contains undeclared units

$$v_{13} = \text{kbinGSK3bp53} \cdot \text{GSK3b} \cdot \text{p53\_P} \tag{29}$$

7.14 Reaction GSK3_p53PRelease

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

SBO:0000180 dissociation

Reaction equation

$$\text{GSK3b\_p53\_P} \longrightarrow \text{GSK3b} + \text{p53\_P} \tag{30}$$

Reactant

Table 32: Properties of each reactant.

Id	Name	SBO
GSK3b_p53_P		

Products

Table 33: Properties of each product.

Id	Name	SBO
GSK3b		
p53_P		

Kinetic Law

Derived unit contains undeclared units

$$v_{14} = \text{krelGSK3bp53} \cdot \text{GSK3b\_p53\_P} \tag{31}$$

7.15 Reaction E1UbBinding

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

SBO:0000526 protein complex formation

Reaction equation

$$\mathrm{E1} + \mathrm{Ub} + \mathrm{ATP} \longrightarrow \mathrm{E1\_Ub} + \mathrm{AMP} \tag{32}$$

Reactants

Table 34: Properties of each reactant.

Id	Name	SBO
E1		
Ub		
ATP		

Products

Table 35: Properties of each product.

Id	Name	SBO
E1_Ub		
AMP		

Kinetic Law

Derived unit contains undeclared units

$$v_{15} = \frac{\mathrm{kbinE1Ub} \cdot \mathrm{E1} \cdot \mathrm{Ub} \cdot \mathrm{ATP}}{5000 + \mathrm{ATP}} \tag{33}$$

7.16 Reaction E2UbBinding

This is an irreversible reaction of two reactants forming two products.

SBO:0000526 protein complex formation

Reaction equation

$$\mathrm{E2} + \mathrm{E1\_Ub} \longrightarrow \mathrm{E2\_Ub} + \mathrm{E1} \tag{34}$$

Reactants

Table 36: Properties of each reactant.

Id	Name	SBO
E2		
E1_Ub		

Products

Table 37: Properties of each product.

Id	Name	SBO
E2_Ub		
E1		

Kinetic Law

Derived unit contains undeclared units

$$v_{16} = \text{kbinE2Ub} \cdot \text{E2} \cdot \text{E1\_Ub} \tag{35}$$

7.17 Reaction Mdm2Ubiquitination

This is an irreversible reaction of two reactants forming two products.

SBO:0000526 protein complex formation

Reaction equation

$$\text{Mdm2} + \text{E2\_Ub} \longrightarrow \text{Mdm2\_Ub} + \text{E2} \tag{36}$$

Reactants

Table 38: Properties of each reactant.

Id	Name	SBO
Mdm2		
E2_Ub		

Products

Table 39: Properties of each product.

Id	Name	SBO
Mdm2_Ub		
E2		

Kinetic Law

Derived unit contains undeclared units

$$v_{17} = \text{kMdm2Ub} \cdot \text{Mdm2} \cdot \text{E2\_Ub} \tag{37}$$

7.18 Reaction Mdm2polyUbiquitination1

This is an irreversible reaction of two reactants forming two products.

SBO:0000526 protein complex formation

Reaction equation

$$\text{Mdm2\_Ub} + \text{E2\_Ub} \longrightarrow \text{Mdm2\_Ub2} + \text{E2} \tag{38}$$

Reactants

Table 40: Properties of each reactant.

Id	Name	SBO
Mdm2_Ub		
E2_Ub		

Products

Table 41: Properties of each product.

Id	Name	SBO
Mdm2_Ub2		
E2		

Kinetic Law

Derived unit contains undeclared units

$$v_{18} = \text{kMdm2PolyUb} \cdot \text{Mdm2\_Ub} \cdot \text{E2\_Ub} \tag{39}$$

7.19 Reaction Mdm2polyUbiquitination2

This is an irreversible reaction of two reactants forming two products.

SBO:0000526 protein complex formation

Reaction equation

$$\text{Mdm2\_Ub2} + \text{E2\_Ub} \longrightarrow \text{Mdm2\_Ub3} + \text{E2} \tag{40}$$

Reactants

Table 42: Properties of each reactant.

Id	Name	SBO
Mdm2_Ub2		
E2_Ub		

Products

Table 43: Properties of each product.

Id	Name	SBO
Mdm2_Ub3		
E2		

Kinetic Law

Derived unit contains undeclared units

$$v_{19} = \text{kMdm2PolyUb} \cdot \text{Mdm2\_Ub2} \cdot \text{E2\_Ub} \tag{41}$$

7.20 Reaction Mdm2polyUbiquitination3

This is an irreversible reaction of two reactants forming two products.

SBO:0000526 protein complex formation

Reaction equation

$$\text{Mdm2\_Ub3} + \text{E2\_Ub} \longrightarrow \text{Mdm2\_Ub4} + \text{E2} \tag{42}$$

Reactants

Table 44: Properties of each reactant.

Id	Name	SBO
Mdm2_Ub3		
E2_Ub		

Products

Table 45: Properties of each product.

Id	Name	SBO
Mdm2_Ub4		
E2		

Kinetic Law

Derived unit contains undeclared units

$$v_{20} = \text{kMdm2PolyUb} \cdot \text{Mdm2\_Ub3} \cdot \text{E2\_Ub} \tag{43}$$

7.21 Reaction Mdm2Deubiquitination4

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

SBO:0000526 protein complex formation

Reaction equation

$$\text{Mdm2\_Ub4} + \text{Mdm2DUB} \longrightarrow \text{Mdm2\_Ub3} + \text{Mdm2DUB} + \text{Ub} \tag{44}$$

Reactants

Table 46: Properties of each reactant.

Id	Name	SBO
Mdm2_Ub4		
Mdm2DUB		

Products

Table 47: Properties of each product.

Id	Name	SBO
Mdm2_Ub3		
Mdm2DUB		
Ub		

Kinetic Law

Derived unit contains undeclared units

$$v_{21} = \text{kactDUBMdm2} \cdot \text{Mdm2\_Ub4} \cdot \text{Mdm2DUB} \tag{45}$$

7.22 Reaction Mdm2Deubiquitination3

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

SBO:0000526 protein complex formation

Reaction equation

$$\text{Mdm2\_Ub3} + \text{Mdm2DUB} \longrightarrow \text{Mdm2\_Ub2} + \text{Mdm2DUB} + \text{Ub} \tag{46}$$

Reactants

Table 48: Properties of each reactant.

Id	Name	SBO
Mdm2_Ub3		
Mdm2DUB		

Products

Table 49: Properties of each product.

Id	Name	SBO
Mdm2_Ub2		
Mdm2DUB		
Ub		

Kinetic Law

Derived unit contains undeclared units

$$v_{22} = \text{kactDUBMdm2} \cdot \text{Mdm2\_Ub3} \cdot \text{Mdm2DUB} \tag{47}$$

7.23 Reaction Mdm2Deubiquitination2

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

SBO:0000526 protein complex formation

Reaction equation

$$\text{Mdm2\_Ub2} + \text{Mdm2DUB} \longrightarrow \text{Mdm2\_Ub} + \text{Mdm2DUB} + \text{Ub} \tag{48}$$

Reactants

Table 50: Properties of each reactant.

Id	Name	SBO
Mdm2_Ub2		
Mdm2DUB		

Products

Table 51: Properties of each product.

Id	Name	SBO
Mdm2_Ub		
Mdm2DUB		
Ub		

Kinetic Law

Derived unit contains undeclared units

$$v_{23} = \text{kactDUBMdm2} \cdot \text{Mdm2\_Ub2} \cdot \text{Mdm2DUB} \tag{49}$$

7.24 Reaction Mdm2Deubiquitination1

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

SBO:0000526 protein complex formation

Reaction equation

$$\text{Mdm2\_Ub} + \text{Mdm2DUB} \longrightarrow \text{Mdm2} + \text{Mdm2DUB} + \text{Ub} \tag{50}$$

Reactants

Table 52: Properties of each reactant.

Id	Name	SBO
Mdm2_Ub		
Mdm2DUB		

Products

Table 53: Properties of each product.

Id	Name	SBO
Mdm2		
Mdm2DUB		
Ub		

Kinetic Law

Derived unit contains undeclared units

$$v_{24} = \text{kactDUBMdm2} \cdot \text{Mdm2\_Ub} \cdot \text{Mdm2DUB} \tag{51}$$

7.25 Reaction Mdm2ProteasomeBinding1

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

SBO:0000526 protein complex formation

Reaction equation

$$\text{Mdm2\_Ub4} + \text{Proteasome} \longrightarrow \text{Mdm2\_Ub4\_Proteasome} \tag{52}$$

Reactants

Table 54: Properties of each reactant.

Id	Name	SBO
Mdm2_Ub4		
Proteasome		

Product

Table 55: Properties of each product.

Id	Name	SBO
Mdm2_Ub4_Proteasome		

Kinetic Law

Derived unit contains undeclared units

$$v_{25} = \text{kbinProt} \cdot \text{Mdm2\_Ub4} \cdot \text{Proteasome} \tag{53}$$

7.26 Reaction Mdm2Degradation

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

SBO:0000179 degradation

Reaction equation

$$\text{Mdm2\_Ub4\_Proteasome} \longrightarrow \text{Proteasome} + 4\,\text{Ub} \tag{54}$$

Reactant

Table 56: Properties of each reactant.

Id	Name	SBO
Mdm2_Ub4_Proteasome		

Products

Table 57: Properties of each product.

Id	Name	SBO
Proteasome		
Ub		

Kinetic Law

Derived unit contains undeclared units

$$v_{26} = \text{kdegMdm2} \cdot \text{Mdm2\_Ub4\_Proteasome} \cdot \text{kproteff} \tag{55}$$

7.27 Reaction p53Synthesis

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

SBO:0000393 production

Reaction equation

$$\text{p53\_mRNA} \longrightarrow \text{p53} + \text{p53\_mRNA} \tag{56}$$

Reactant

Table 58: Properties of each reactant.

Id	Name	SBO
p53_mRNA		

Products

Table 59: Properties of each product.

Id	Name	SBO
p53		
p53_mRNA		

Kinetic Law

Derived unit contains undeclared units

$$v_{27} = \text{ksynp53} \cdot \text{p53\_mRNA} \tag{57}$$

7.28 Reaction p53Monoubiquitination

This is an irreversible reaction of two reactants forming two products.

SBO:0000526 protein complex formation

Reaction equation

$$\text{E2\_Ub} + \text{Mdm2\_p53} \longrightarrow \text{Mdm2\_p53\_Ub} + \text{E2} \tag{58}$$

Reactants

Table 60: Properties of each reactant.

Id	Name	SBO
E2_Ub		
Mdm2_p53		

Products

Table 61: Properties of each product.

Id	Name	SBO
Mdm2_p53_Ub		
E2		

Kinetic Law

Derived unit contains undeclared units

$$v_{28} = \text{kp53Ub} \cdot \text{E2\_Ub} \cdot \text{Mdm2\_p53} \tag{59}$$

7.29 Reaction p53Polyubiquitination1

This is an irreversible reaction of two reactants forming two products.

SBO:0000526 protein complex formation

Reaction equation

$$\text{Mdm2\_p53\_Ub} + \text{E2\_Ub} \longrightarrow \text{Mdm2\_p53\_Ub2} + \text{E2} \tag{60}$$

Reactants

Table 62: Properties of each reactant.

Id	Name	SBO
Mdm2_p53_Ub		
E2_Ub		

Products

Table 63: Properties of each product.

Id	Name	SBO
Mdm2_p53_Ub2		
E2		

Kinetic Law

Derived unit contains undeclared units

$$v_{29} = \text{kp53PolyUb} \cdot \text{Mdm2\_p53\_Ub} \cdot \text{E2\_Ub} \tag{61}$$

7.30 Reaction p53Polyubiquitination2

This is an irreversible reaction of two reactants forming two products.

SBO:0000526 protein complex formation

Reaction equation

$$\text{Mdm2\_p53\_Ub2} + \text{E2\_Ub} \longrightarrow \text{Mdm2\_p53\_Ub3} + \text{E2} \tag{62}$$

Reactants

Table 64: Properties of each reactant.

Id	Name	SBO
Mdm2_p53_Ub2		
E2_Ub		

Products

Table 65: Properties of each product.

Id	Name	SBO
Mdm2_p53_Ub3		
E2		

Kinetic Law

Derived unit contains undeclared units

$$v_{30} = \text{kp53PolyUb} \cdot \text{Mdm2\_p53\_Ub2} \cdot \text{E2\_Ub} \tag{63}$$

7.31 Reaction p53Polyubiquitination3

This is an irreversible reaction of two reactants forming two products.

SBO:0000526 protein complex formation

Reaction equation

$$\text{Mdm2\_p53\_Ub3} + \text{E2\_Ub} \longrightarrow \text{Mdm2\_p53\_Ub4} + \text{E2} \tag{64}$$

Reactants

Table 66: Properties of each reactant.

Id	Name	SBO
Mdm2_p53_Ub3		
E2_Ub		

Products

Table 67: Properties of each product.

Id	Name	SBO
Mdm2_p53_Ub4		
E2		

Kinetic Law

Derived unit contains undeclared units

$$v_{31} = \text{kp53PolyUb} \cdot \text{Mdm2\_p53\_Ub3} \cdot \text{E2\_Ub} \tag{65}$$

7.32 Reaction p53Deubiqutination4

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

SBO:0000526 protein complex formation

Reaction equation

$$\text{Mdm2\_p53\_Ub4} + \text{p53DUB} \longrightarrow \text{Mdm2\_p53\_Ub3} + \text{p53DUB} + \text{Ub} \tag{66}$$

Reactants

Table 68: Properties of each reactant.

Id	Name	SBO
Mdm2_p53_Ub4		
p53DUB		

Products

Table 69: Properties of each product.

Id	Name	SBO
Mdm2_p53_Ub3		
p53DUB		
Ub		

Kinetic Law

Derived unit contains undeclared units

$$v_{32} = \text{kactDUBp53} \cdot \text{Mdm2\_p53\_Ub4} \cdot \text{p53DUB} \tag{67}$$

7.33 Reaction p53Deubiquitination3

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

SBO:0000526 protein complex formation

Reaction equation

$$\text{Mdm2\_p53\_Ub3} + \text{p53DUB} \longrightarrow \text{Mdm2\_p53\_Ub2} + \text{p53DUB} + \text{Ub} \tag{68}$$

Reactants

Table 70: Properties of each reactant.

Id	Name	SBO
Mdm2_p53_Ub3		
p53DUB		

Products

Table 71: Properties of each product.

Id	Name	SBO
Mdm2_p53_Ub2		
p53DUB		
Ub		

Kinetic Law

Derived unit contains undeclared units

$$v_{33} = \text{kactDUBp53} \cdot \text{Mdm2\_p53\_Ub3} \cdot \text{p53DUB} \tag{69}$$

7.34 Reaction p53Deubiquitination2

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

SBO:0000526 protein complex formation

Reaction equation

$$\text{Mdm2\_p53\_Ub2} + \text{p53DUB} \longrightarrow \text{Mdm2\_p53\_Ub} + \text{p53DUB} + \text{Ub} \tag{70}$$

Reactants

Table 72: Properties of each reactant.

Id	Name	SBO
Mdm2_p53_Ub2		
p53DUB		

Products

Table 73: Properties of each product.

Id	Name	SBO
Mdm2_p53_Ub		
p53DUB		
Ub		

Kinetic Law

Derived unit contains undeclared units

$$v_{34} = \text{kactDUBp53} \cdot \text{Mdm2\_p53\_Ub2} \cdot \text{p53DUB} \tag{71}$$

7.35 Reaction p53Deubiquitination1

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

SBO:0000526 protein complex formation

Reaction equation

$$\text{Mdm2\_p53\_Ub} + \text{p53DUB} \longrightarrow \text{Mdm2\_p53} + \text{p53DUB} + \text{Ub} \tag{72}$$

Reactants

Table 74: Properties of each reactant.

Id	Name	SBO
Mdm2_p53_Ub		
p53DUB		

Products

Table 75: Properties of each product.

Id	Name	SBO
Mdm2_p53		
p53DUB		
Ub		

Kinetic Law

Derived unit contains undeclared units

$$v_{35} = \text{kactDUBp53} \cdot \text{Mdm2\_p53\_Ub} \cdot \text{p53DUB} \tag{73}$$

7.36 Reaction Mdm2GSK3phosphorylation1

This is an irreversible reaction of two reactants forming two products.

SBO:0000216 phosphorylation

Reaction equation

$$\text{Mdm2\_p53\_Ub4} + \text{GSK3b} \longrightarrow \text{Mdm2\_P1\_p53\_Ub4} + \text{GSK3b} \tag{74}$$

Reactants

Table 76: Properties of each reactant.

Id	Name	SBO
Mdm2_p53_Ub4		
GSK3b		

Products

Table 77: Properties of each product.

Id	Name	SBO
Mdm2_P1_p53_Ub4		
GSK3b		

Kinetic Law

Derived unit contains undeclared units

$$v_{36} = \text{kphosMdm2GSK3b} \cdot \text{Mdm2\_p53\_Ub4} \cdot \text{GSK3b} \tag{75}$$

7.37 Reaction Mdm2GSK3phosphorylation2

This is an irreversible reaction of two reactants forming two products.

SBO:0000216 phosphorylation

Reaction equation

$$\text{Mdm2\_p53\_Ub4} + \text{GSK3b\_p53} \longrightarrow \text{Mdm2\_P1\_p53\_Ub4} + \text{GSK3b\_p53} \tag{76}$$

Reactants

Table 78: Properties of each reactant.

Id	Name	SBO
Mdm2_p53_Ub4		
GSK3b_p53		

Products

Table 79: Properties of each product.

Id	Name	SBO
Mdm2_P1_p53_Ub4		
GSK3b_p53		

Kinetic Law

Derived unit contains undeclared units

$$v_{37} = \text{kphosMdm2GSK3bp53} \cdot \text{Mdm2\_p53\_Ub4} \cdot \text{GSK3b\_p53} \tag{77}$$

7.38 Reaction Mdm2GSK3phosphorylation3

This is an irreversible reaction of two reactants forming two products.

SBO:0000216 phosphorylation

Reaction equation

$$\text{Mdm2\_p53\_Ub4} + \text{GSK3b\_p53\_P} \longrightarrow \text{Mdm2\_P1\_p53\_Ub4} + \text{GSK3b\_p53\_P} \tag{78}$$

Reactants

Table 80: Properties of each reactant.

Id	Name	SBO
Mdm2_p53_Ub4		
GSK3b_p53_P		

Products

Table 81: Properties of each product.

Id	Name	SBO
Mdm2_P1_p53_Ub4		
GSK3b_p53_P		

Kinetic Law

Derived unit contains undeclared units

$$v_{38} = \text{kphosMdm2GSK3bp53} \cdot \text{Mdm2\_p53\_Ub4} \cdot \text{GSK3b\_p53\_P} \tag{79}$$

7.39 Reaction p53ProteasomeBinding1

This is an irreversible reaction of two reactants forming two products.

SBO:0000526 protein complex formation

Reaction equation

$$\text{Mdm2\_P1\_p53\_Ub4} + \text{Proteasome} \longrightarrow \text{p53\_Ub4\_Proteasome} + \text{Mdm2} \tag{80}$$

Reactants

Table 82: Properties of each reactant.

Id	Name	SBO
Mdm2_P1_p53_Ub4		
Proteasome		

Products

Table 83: Properties of each product.

Id	Name	SBO
p53_Ub4_Proteasome		
Mdm2		

Kinetic Law

Derived unit contains undeclared units

$$v_{39} = \text{kbinProt} \cdot \text{Mdm2\_P1\_p53\_Ub4} \cdot \text{Proteasome} \tag{81}$$

7.40 Reaction Degradationp53_Ub4

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

SBO:0000180 dissociation

Reaction equation

$$\text{p53\_Ub4\_Proteasome} + \text{ATP} \longrightarrow 4\,\text{Ub} + \text{Proteasome} + \text{ADP} \tag{82}$$

Reactants

Table 84: Properties of each reactant.

Id	Name	SBO
p53_Ub4_Proteasome		
ATP		

Products

Table 85: Properties of each product.

Id	Name	SBO
Ub		
Proteasome		
ADP		

Kinetic Law

Derived unit contains undeclared units

$$v_{40} = \frac{\text{kdegp53} \cdot \text{kproteff} \cdot \text{p53\_Ub4\_Proteasome} \cdot \text{ATP}}{5000 + \text{ATP}} \tag{83}$$

7.41 Reaction TauMTbinding

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

SBO:0000526 protein complex formation

Reaction equation

$$\text{Tau} \longrightarrow \text{MT\_Tau} \tag{84}$$

Reactant

Table 86: Properties of each reactant.

Id	Name	SBO
Tau		

Product

Table 87: Properties of each product.

Id	Name	SBO
MT_Tau		

Kinetic Law

Derived unit contains undeclared units

$$v_{41} = \text{kbinMTTau} \cdot \text{Tau} \tag{85}$$

7.42 Reaction TauMTrelease

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

SBO:0000180 dissociation

Reaction equation

$$\text{MT\_Tau} \longrightarrow \text{Tau} \tag{86}$$

Reactant

Table 88: Properties of each reactant.

Id	Name	SBO
MT_Tau		

Product

Table 89: Properties of each product.

Id	Name	SBO
Tau		

Kinetic Law

Derived unit contains undeclared units

$$v_{42} = \text{krelMTTau} \cdot \text{MT\_Tau} \tag{87}$$

7.43 Reaction Tauphosphorylation1

This is an irreversible reaction of two reactants forming two products.

SBO:0000216 phosphorylation

Reaction equation

$$\text{GSK3b\_p53} + \text{Tau} \longrightarrow \text{GSK3b\_p53} + \text{Tau\_P1} \tag{88}$$

Reactants

Table 90: Properties of each reactant.

Id	Name	SBO
GSK3b_p53		
Tau		

Products

Table 91: Properties of each product.

Id	Name	SBO
GSK3b_p53		
Tau_P1		

Kinetic Law

Derived unit contains undeclared units

$$v_{43} = \text{kphospTauGSK3bp53} \cdot \text{GSK3b\_p53} \cdot \text{Tau} \tag{89}$$

7.44 Reaction Tauphosphorylation2

This is an irreversible reaction of two reactants forming two products.

SBO:0000216 phosphorylation

Reaction equation

$$\text{GSK3b\_p53} + \text{Tau\_P1} \longrightarrow \text{GSK3b\_p53} + \text{Tau\_P2} \tag{90}$$

Reactants

Table 92: Properties of each reactant.

Id	Name	SBO
GSK3b_p53		
Tau_P1		

Products

Table 93: Properties of each product.

Id	Name	SBO
GSK3b_p53		
Tau_P2		

Kinetic Law

Derived unit contains undeclared units

$$v_{44} = \text{kphospTauGSK3bp53} \cdot \text{GSK3b\_p53} \cdot \text{Tau\_P1} \tag{91}$$

7.45 Reaction Tauphosphorylation3

This is an irreversible reaction of two reactants forming two products.

SBO:0000216 phosphorylation

Reaction equation

$$\text{GSK3b\_p53\_P} + \text{Tau} \longrightarrow \text{GSK3b\_p53\_P} + \text{Tau\_P1} \tag{92}$$

Reactants

Table 94: Properties of each reactant.

Id	Name	SBO
GSK3b_p53_P		
Tau		

Products

Table 95: Properties of each product.

Id	Name	SBO
GSK3b_p53_P		
Tau_P1		

Kinetic Law

Derived unit contains undeclared units

$$v_{45} = \text{kphospTauGSK3bp53} \cdot \text{GSK3b\_p53\_P} \cdot \text{Tau} \tag{93}$$

7.46 Reaction Tauphosphorylation4

This is an irreversible reaction of two reactants forming two products.

SBO:0000216 phosphorylation

Reaction equation

$$\text{GSK3b\_p53\_P} + \text{Tau\_P1} \longrightarrow \text{GSK3b\_p53\_P} + \text{Tau\_P2} \tag{94}$$

Reactants

Table 96: Properties of each reactant.

Id	Name	SBO
GSK3b_p53_P		
Tau_P1		

Products

Table 97: Properties of each product.

Id	Name	SBO
GSK3b_p53_P		
Tau_P2		

Kinetic Law

Derived unit contains undeclared units

$$v_{46} = \text{kphospTauGSK3bp53} \cdot \text{GSK3b\_p53\_P} \cdot \text{Tau\_P1} \tag{95}$$

7.47 Reaction Tauphosphorylation5

This is an irreversible reaction of two reactants forming two products.

SBO:0000216 phosphorylation

Reaction equation

$$\text{GSK3b} + \text{Tau} \longrightarrow \text{GSK3b} + \text{Tau\_P1} \tag{96}$$

Reactants

Table 98: Properties of each reactant.

Id	Name	SBO
GSK3b		
Tau		

Products

Table 99: Properties of each product.

Id	Name	SBO
GSK3b		
Tau_P1		

Kinetic Law

Derived unit contains undeclared units

$$v_{47} = \text{kphospTauGSK3b} \cdot \text{GSK3b} \cdot \text{Tau} \tag{97}$$

7.48 Reaction Tauphosphorylation6

This is an irreversible reaction of two reactants forming two products.

SBO:0000216 phosphorylation

Reaction equation

$$\mathrm{GSK3b} + \mathrm{Tau\_P1} \longrightarrow \mathrm{GSK3b} + \mathrm{Tau\_P2} \tag{98}$$

Reactants

Table 100: Properties of each reactant.

Id	Name	SBO
GSK3b		
Tau_P1		

Products

Table 101: Properties of each product.

Id	Name	SBO
GSK3b		
Tau_P2		

Kinetic Law

Derived unit contains undeclared units

$$v_{48} = \mathrm{kphospTauGSK3b} \cdot \mathrm{GSK3b} \cdot \mathrm{Tau\_P1} \tag{99}$$

7.49 Reaction Taudephosphorylation1

This is an irreversible reaction of two reactants forming two products.

SBO:0000330 dephosphorylation

Reaction equation

$$\mathrm{Tau\_P2} + \mathrm{PP1} \longrightarrow \mathrm{Tau\_P1} + \mathrm{PP1} \tag{100}$$

Reactants

Table 102: Properties of each reactant.

Id	Name	SBO
Tau_P2		
PP1		

Products

Table 103: Properties of each product.

Id	Name	SBO
Tau_P1		
PP1		

Kinetic Law

Derived unit contains undeclared units

$$v_{49} = \text{kdephospTau} \cdot \text{Tau\_P2} \cdot \text{PP1} \tag{101}$$

7.50 Reaction Taudephosphorylation2

This is an irreversible reaction of two reactants forming two products.

SBO:0000330 dephosphorylation

Reaction equation

$$\text{Tau\_P1} + \text{PP1} \longrightarrow \text{Tau} + \text{PP1} \tag{102}$$

Reactants

Table 104: Properties of each reactant.

Id	Name	SBO
Tau_P1		
PP1		

Products

Table 105: Properties of each product.

Id	Name	SBO
Tau		
PP1		

Kinetic Law

Derived unit contains undeclared units

$$v_{50} = \text{kdephospTau} \cdot \text{Tau\_P1} \cdot \text{PP1} \tag{103}$$

7.51 Reaction TauP1Aggregation1

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

SBO:0000526 protein complex formation

Reaction equation

$$2\,\text{Tau\_P1} \longrightarrow 2\,\text{AggTau} \tag{104}$$

Reactant

Table 106: Properties of each reactant.

Id	Name	SBO
Tau_P1		

Product

Table 107: Properties of each product.

Id	Name	SBO
AggTau		

Kinetic Law

Derived unit contains undeclared units

$$v_{51} = \text{kaggTauP1} \cdot \text{Tau\_P1} \cdot (\text{Tau\_P1} - 1) \cdot 0.5 \tag{105}$$

7.52 Reaction TauP1Aggregation2

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

SBO:0000526 protein complex formation

Reaction equation

$$\text{Tau\_P1} + \text{AggTau} \longrightarrow 2\,\text{AggTau} \tag{106}$$

Reactants

Table 108: Properties of each reactant.

Id	Name	SBO
Tau_P1		
AggTau		

Product

Table 109: Properties of each product.

Id	Name	SBO
AggTau		

Kinetic Law

Derived unit contains undeclared units

$$v_{52} = \text{kaggTauP1} \cdot \text{Tau\_P1} \cdot \text{AggTau} \tag{107}$$

7.53 Reaction TauP2Aggregation1

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

SBO:0000526 protein complex formation

Reaction equation

$$2\,\text{Tau\_P2} \longrightarrow 2\,\text{AggTau} \tag{108}$$

Reactant

Table 110: Properties of each reactant.

Id	Name	SBO
Tau_P2		

Product

Table 111: Properties of each product.

Id	Name	SBO
AggTau		

Kinetic Law

Derived unit contains undeclared units

$$v_{53} = \text{kaggTauP2} \cdot \text{Tau\_P2} \cdot (\text{Tau\_P2} - 1) \cdot 0.5 \tag{109}$$

7.54 Reaction TauP2Aggregation2

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

SBO:0000526 protein complex formation

Reaction equation

$$\text{Tau\_P2} + \text{AggTau} \longrightarrow 2\,\text{AggTau} \tag{110}$$

Reactants

Table 112: Properties of each reactant.

Id	Name	SBO
Tau_P2		
AggTau		

Product

Table 113: Properties of each product.

Id	Name	SBO
AggTau		

Kinetic Law

Derived unit contains undeclared units

$$v_{54} = \text{kaggTauP2} \cdot \text{Tau\_P2} \cdot \text{AggTau} \tag{111}$$

7.55 Reaction TauAggregation1

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

SBO:0000526 protein complex formation

Reaction equation

$$2\,\mathrm{Tau} \longrightarrow 2\,\mathrm{AggTau} \tag{112}$$

Reactant

Table 114: Properties of each reactant.

Id	Name	SBO
Tau		

Product

Table 115: Properties of each product.

Id	Name	SBO
AggTau		

Kinetic Law

Derived unit contains undeclared units

$$v_{55} = \mathrm{kaggTau} \cdot \mathrm{Tau} \cdot (\mathrm{Tau} - 1) \cdot 0.5 \tag{113}$$

7.56 Reaction TauAggregation2

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

SBO:0000526 protein complex formation

Reaction equation

$$\mathrm{Tau} + \mathrm{AggTau} \longrightarrow 2\,\mathrm{AggTau} \tag{114}$$

Reactants

Table 116: Properties of each reactant.

Id	Name	SBO
Tau		
AggTau		

Product

Table 117: Properties of each product.

Id	Name	SBO
AggTau		

Kinetic Law

Derived unit contains undeclared units

$$v_{56} = \text{kaggTau} \cdot \text{Tau} \cdot \text{AggTau} \tag{115}$$

7.57 Reaction TangleFormation1

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

SBO:0000526 protein complex formation

Reaction equation

$$2\,\text{AggTau} \longrightarrow 2\,\text{NFT} \tag{116}$$

Reactant

Table 118: Properties of each reactant.

Id	Name	SBO
AggTau		

Product

Table 119: Properties of each product.

Id	Name	SBO
NFT		

Id	Name	SBO

Kinetic Law

Derived unit contains undeclared units

$$v_{57} = \text{ktangfor} \cdot \text{AggTau} \cdot (\text{AggTau} - 1) \cdot 0.5 \tag{117}$$

7.58 Reaction `TangleFormation2`

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

SBO:0000526 protein complex formation

Reaction equation

$$\text{AggTau} + \text{NFT} \longrightarrow 2\,\text{NFT} \tag{118}$$

Reactants

Table 120: Properties of each reactant.

Id	Name	SBO
AggTau		
NFT		

Product

Table 121: Properties of each product.

Id	Name	SBO
NFT		

Kinetic Law

Derived unit contains undeclared units

$$v_{58} = \text{ktangfor} \cdot \text{AggTau} \cdot \text{NFT} \tag{119}$$

7.59 Reaction `ProteasomeInhibitionAggTau`

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

SBO:0000169 inhibition

Reaction equation

$$\text{AggTau} + \text{Proteasome} \longrightarrow \text{AggTau\_Proteasome} \tag{120}$$

Reactants

Table 122: Properties of each reactant.

Id	Name	SBO
AggTau		
Proteasome		

Product

Table 123: Properties of each product.

Id	Name	SBO
AggTau_Proteasome		

Kinetic Law

Derived unit contains undeclared units

$$v_{59} = \text{kinhibprot} \cdot \text{AggTau} \cdot \text{Proteasome} \tag{121}$$

7.60 Reaction Abetaproduction1

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

SBO:0000393 production

Reaction equation

$$\text{GSK3b\_p53} \longrightarrow \text{Abeta} + \text{GSK3b\_p53} \tag{122}$$

Reactant

Table 124: Properties of each reactant.

Id	Name	SBO
GSK3b_p53		

Products

Table 125: Properties of each product.

Id	Name	SBO
Abeta		
GSK3b_p53		

Kinetic Law

Derived unit contains undeclared units

$$v_{60} = \text{kprodAbeta} \cdot \text{GSK3b\_p53} \tag{123}$$

7.61 Reaction Abetaproduction2

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

SBO:0000393 production

Reaction equation

$$\text{GSK3b\_p53\_P} \longrightarrow \text{Abeta} + \text{GSK3b\_p53\_P} \tag{124}$$

Reactant

Table 126: Properties of each reactant.

Id	Name	SBO
GSK3b_p53_P		

Products

Table 127: Properties of each product.

Id	Name	SBO
Abeta		
GSK3b_p53_P		

Kinetic Law

Derived unit contains undeclared units

$$v_{61} = \text{kprodAbeta} \cdot \text{GSK3b\_p53\_P} \tag{125}$$

7.62 Reaction ProteasomeInhibitionAbeta

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

SBO:0000169 inhibition

Reaction equation

$$\text{AggAbeta} + \text{Proteasome} \longrightarrow \text{AggAbeta\_Proteasome} \tag{126}$$

Reactants

Table 128: Properties of each reactant.

Id	Name	SBO
AggAbeta		
Proteasome		

Product

Table 129: Properties of each product.

Id	Name	SBO
AggAbeta_Proteasome		

Kinetic Law

Derived unit contains undeclared units

$$v_{62} = \text{kinhibprot} \cdot \text{AggAbeta} \cdot \text{Proteasome} \tag{127}$$

7.63 Reaction AbetaDegradation

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

SBO:0000179 degradation

Reaction equation

$$\text{Abeta} \longrightarrow \text{Sink} \tag{128}$$

Reactant

Table 130: Properties of each reactant.

Id	Name	SBO
Abeta		

Product

Table 131: Properties of each product.

Id	Name	SBO
Sink		

Kinetic Law

Derived unit contains undeclared units

$$v_{63} = \text{kdegAbeta} \cdot \text{Abeta} \tag{129}$$

7.64 Reaction AbetaAggregation1

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

SBO:0000526 protein complex formation

Reaction equation

$$2\,\text{Abeta} \longrightarrow \text{AggAbeta} \tag{130}$$

Reactant

Table 132: Properties of each reactant.

Id	Name	SBO
Abeta		

Product

Table 133: Properties of each product.

Id	Name	SBO
AggAbeta		

Kinetic Law

Derived unit contains undeclared units

$$v_{64} = \text{kaggAbeta} \cdot \text{Abeta} \cdot (\text{Abeta} - 1) \cdot 0.5 \tag{131}$$

7.65 Reaction AbetaAggregation2

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

SBO:0000526 protein complex formation

Reaction equation

$$\text{Abeta} + \text{AggAbeta} \longrightarrow 2\,\text{AggAbeta} \tag{132}$$

Reactants

Table 134: Properties of each reactant.

Id	Name	SBO
Abeta		
AggAbeta		

Product

Table 135: Properties of each product.

Id	Name	SBO
AggAbeta		

Kinetic Law

Derived unit contains undeclared units

$$v_{65} = \text{kaggAbeta} \cdot \text{Abeta} \cdot \text{AggAbeta} \tag{133}$$

7.66 Reaction AbetaPlaqueFormation1

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

SBO:0000526 protein complex formation

Reaction equation

$$2\,\mathrm{AggAbeta} \longrightarrow 2\,\mathrm{AbetaPlaque} \tag{134}$$

Reactant

Table 136: Properties of each reactant.

Id	Name	SBO
AggAbeta		

Product

Table 137: Properties of each product.

Id	Name	SBO
AbetaPlaque		

Kinetic Law

Derived unit contains undeclared units

$$v_{66} = \mathrm{kpf} \cdot \mathrm{AggAbeta} \cdot (\mathrm{AggAbeta} - 1) \cdot 0.5 \tag{135}$$

7.67 Reaction AbetaPlaqueFormation2

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

SBO:0000526 protein complex formation

Reaction equation

$$\mathrm{AggAbeta} + \mathrm{AbetaPlaque} \longrightarrow 2\,\mathrm{AbetaPlaque} \tag{136}$$

Reactants

Table 138: Properties of each reactant.

Id	Name	SBO
AggAbeta		
AbetaPlaque		

Product

Table 139: Properties of each product.

Id	Name	SBO
AbetaPlaque		

Kinetic Law

Derived unit contains undeclared units

$$v_{67} = \text{kpf} \cdot \text{AggAbeta} \cdot \text{AbetaPlaque} \tag{137}$$

7.68 Reaction p53transcriptionViaAbeta

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

SBO:0000183 transcription

Reaction equation

$$\text{Abeta} \longrightarrow \text{p53\_mRNA} + \text{Abeta} \tag{138}$$

Reactant

Table 140: Properties of each reactant.

Id	Name	SBO
Abeta		

Products

Table 141: Properties of each product.

Id	Name	SBO
p53_mRNA		
Abeta		

Kinetic Law

Derived unit contains undeclared units

$$v_{68} = \text{ksynp53mRNAAbeta} \cdot \text{Abeta} \tag{139}$$

7.69 Reaction DNAdamage

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

SBO:0000357 biological effect of a perturbation

Reaction equation

$$\emptyset \xrightarrow{\text{IR}} \text{damDNA} \tag{140}$$

Modifier

Table 142: Properties of each modifier.

Id	Name	SBO
IR		

Product

Table 143: Properties of each product.

Id	Name	SBO
damDNA		

Kinetic Law

Derived unit contains undeclared units

$$v_{69} = \text{kdam} \cdot [\text{IR}] \tag{141}$$

7.70 Reaction DNArepair

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

SBO:0000179 degradation

Reaction equation

$$\text{damDNA} \longrightarrow \text{Sink} \tag{142}$$

Reactant

Table 144: Properties of each reactant.

Id	Name	SBO
damDNA		

Product

Table 145: Properties of each product.

Id	Name	SBO
Sink		

Kinetic Law

Derived unit contains undeclared units

$$v_{70} = \text{krepair} \cdot \text{damDNA} \tag{143}$$

7.71 Reaction ATMactivation

This is an irreversible reaction of two reactants forming two products.

SBO:0000176 biochemical reaction

Reaction equation

$$\text{damDNA} + \text{ATMI} \longrightarrow \text{damDNA} + \text{ATMA} \tag{144}$$

Reactants

Table 146: Properties of each reactant.

Id	Name	SBO
damDNA		
ATMI		

Products

Table 147: Properties of each product.

Id	Name	SBO
damDNA		

Id	Name	SBO
ATMA		

Kinetic Law

Derived unit contains undeclared units

$$v_{71} = \text{kactATM} \cdot \text{damDNA} \cdot \text{ATMI} \tag{145}$$

7.72 Reaction p53phosphorylation

This is an irreversible reaction of two reactants forming two products.

SBO:0000216 phosphorylation

Reaction equation

$$\text{p53} + \text{ATMA} \longrightarrow \text{p53\_P} + \text{ATMA} \tag{146}$$

Reactants

Table 148: Properties of each reactant.

Id	Name	SBO
p53		
ATMA		

Products

Table 149: Properties of each product.

Id	Name	SBO
p53_P		
ATMA		

Kinetic Law

Derived unit contains undeclared units

$$v_{72} = \text{kphosp53} \cdot \text{p53} \cdot \text{ATMA} \tag{147}$$

7.73 Reaction p53dephosphorylation

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

SBO:0000330 dephosphorylation

Reaction equation

$$\text{p53\_P} \longrightarrow \text{p53} \tag{148}$$

Reactant

Table 150: Properties of each reactant.

Id	Name	SBO
p53_P		

Product

Table 151: Properties of each product.

Id	Name	SBO
p53		

Kinetic Law

Derived unit contains undeclared units

$$v_{73} = \text{kdephosp53} \cdot \text{p53\_P} \tag{149}$$

7.74 Reaction Mdm2phosphorylation

This is an irreversible reaction of two reactants forming two products.

SBO:0000216 phosphorylation

Reaction equation

$$\text{Mdm2} + \text{ATMA} \longrightarrow \text{Mdm2\_P} + \text{ATMA} \tag{150}$$

Reactants

Table 152: Properties of each reactant.

Id	Name	SBO
Mdm2		
ATMA		

Products

Table 153: Properties of each product.

Id	Name	SBO
Mdm2_P		
ATMA		

Kinetic Law

Derived unit contains undeclared units

$$v_{74} = \text{kphosMdm2} \cdot \text{Mdm2} \cdot \text{ATMA} \tag{151}$$

7.75 Reaction Mdm2dephosphorylation

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

SBO:0000330 dephosphorylation

Reaction equation

$$\text{Mdm2\_P} \longrightarrow \text{Mdm2} \tag{152}$$

Reactant

Table 154: Properties of each reactant.

Id	Name	SBO
Mdm2_P		

Product

Table 155: Properties of each product.

Id	Name	SBO
Mdm2		

Kinetic Law

Derived unit contains undeclared units

$$v_{75} = \text{kdephosMdm2} \cdot \text{Mdm2\_P} \tag{153}$$

7.76 Reaction Mdm2PUbiquitination

This is an irreversible reaction of two reactants forming two products.

SBO:0000526 protein complex formation

Reaction equation

$$\text{Mdm2\_P} + \text{E2\_Ub} \longrightarrow \text{Mdm2\_P\_Ub} + \text{E2} \tag{154}$$

Reactants

Table 156: Properties of each reactant.

Id	Name	SBO
Mdm2_P		
E2_Ub		

Products

Table 157: Properties of each product.

Id	Name	SBO
Mdm2_P_Ub		
E2		

Kinetic Law

Derived unit contains undeclared units

$$v_{76} = \text{kMdm2PUb} \cdot \text{Mdm2\_P} \cdot \text{E2\_Ub} \tag{155}$$

7.77 Reaction Mdm2PpolyUbiquitination1

This is an irreversible reaction of two reactants forming two products.

SBO:0000526 protein complex formation

Reaction equation

$$\text{Mdm2\_P\_Ub} + \text{E2\_Ub} \longrightarrow \text{Mdm2\_P\_Ub2} + \text{E2} \tag{156}$$

Reactants

Table 158: Properties of each reactant.

Id	Name	SBO
Mdm2_P_Ub		
E2_Ub		

Products

Table 159: Properties of each product.

Id	Name	SBO
Mdm2_P_Ub2		
E2		

Kinetic Law

Derived unit contains undeclared units

$$v_{77} = \text{kMdm2PolyUb} \cdot \text{Mdm2\_P\_Ub} \cdot \text{E2\_Ub} \tag{157}$$

7.78 Reaction Mdm2PpolyUbiquitination2

This is an irreversible reaction of two reactants forming two products.

SBO:0000526 protein complex formation

Reaction equation

$$\text{Mdm2\_P\_Ub2} + \text{E2\_Ub} \longrightarrow \text{Mdm2\_P\_Ub3} + \text{E2} \tag{158}$$

Reactants

Table 160: Properties of each reactant.

Id	Name	SBO
Mdm2_P_Ub2		
E2_Ub		

Products

Table 161: Properties of each product.

Id	Name	SBO
Mdm2_P_Ub3		
E2		

Kinetic Law

Derived unit contains undeclared units

$$v_{78} = \text{kMdm2PolyUb} \cdot \text{Mdm2\_P\_Ub2} \cdot \text{E2\_Ub} \tag{159}$$

7.79 Reaction Mdm2PpolyUbiquitination3

This is an irreversible reaction of two reactants forming two products.

SBO:0000526 protein complex formation

Reaction equation

$$\text{Mdm2\_P\_Ub3} + \text{E2\_Ub} \longrightarrow \text{Mdm2\_P\_Ub4} + \text{E2} \tag{160}$$

Reactants

Table 162: Properties of each reactant.

Id	Name	SBO
Mdm2_P_Ub3		
E2_Ub		

Products

Table 163: Properties of each product.

Id	Name	SBO
Mdm2_P_Ub4		
E2		

Kinetic Law

Derived unit contains undeclared units

$$v_{79} = \text{kMdm2PolyUb} \cdot \text{Mdm2\_P\_Ub3} \cdot \text{E2\_Ub} \tag{161}$$

7.80 Reaction Mdm2PDeubiquitination4

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

SBO:0000526 protein complex formation

Reaction equation

$$\text{Mdm2\_P\_Ub4} + \text{Mdm2DUB} \longrightarrow \text{Mdm2\_P\_Ub3} + \text{Mdm2DUB} + \text{Ub} \tag{162}$$

Reactants

Table 164: Properties of each reactant.

Id	Name	SBO
Mdm2_P_Ub4		
Mdm2DUB		

Products

Table 165: Properties of each product.

Id	Name	SBO
Mdm2_P_Ub3		
Mdm2DUB		
Ub		

Kinetic Law

Derived unit contains undeclared units

$$v_{80} = \text{kactDUBMdm2} \cdot \text{Mdm2\_P\_Ub4} \cdot \text{Mdm2DUB} \tag{163}$$

7.81 Reaction Mdm2PDeubiquitination3

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

SBO:0000526 protein complex formation

Reaction equation

$$\text{Mdm2\_P\_Ub3} + \text{Mdm2DUB} \longrightarrow \text{Mdm2\_P\_Ub2} + \text{Mdm2DUB} + \text{Ub} \tag{164}$$

Reactants

Table 166: Properties of each reactant.

Id	Name	SBO
Mdm2_P_Ub3		
Mdm2DUB		

Products

Table 167: Properties of each product.

Id	Name	SBO
Mdm2_P_Ub2		
Mdm2DUB		
Ub		

Kinetic Law

Derived unit contains undeclared units

$$v_{81} = \text{kactDUBMdm2} \cdot \text{Mdm2\_P\_Ub3} \cdot \text{Mdm2DUB} \tag{165}$$

7.82 Reaction Mdm2PDeubiquitination2

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

SBO:0000526 protein complex formation

Reaction equation

$$\text{Mdm2\_P\_Ub2} + \text{Mdm2DUB} \longrightarrow \text{Mdm2\_P\_Ub} + \text{Mdm2DUB} + \text{Ub} \tag{166}$$

Reactants

Table 168: Properties of each reactant.

Id	Name	SBO
Mdm2_P_Ub2		
Mdm2DUB		

Products

Table 169: Properties of each product.

Id	Name	SBO
Mdm2_P_Ub		
Mdm2DUB		
Ub		

Kinetic Law

Derived unit contains undeclared units

$$v_{82} = \text{kactDUBMdm2} \cdot \text{Mdm2\_P\_Ub2} \cdot \text{Mdm2DUB} \tag{167}$$

7.83 Reaction Mdm2PDeubiquitination1

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

SBO:0000526 protein complex formation

Reaction equation

$$\text{Mdm2\_P\_Ub} + \text{Mdm2DUB} \longrightarrow \text{Mdm2\_P} + \text{Mdm2DUB} + \text{Ub} \tag{168}$$

Reactants

Table 170: Properties of each reactant.

Id	Name	SBO
Mdm2_P_Ub		
Mdm2DUB		

Products

Table 171: Properties of each product.

Id	Name	SBO
Mdm2_P		
Mdm2DUB		
Ub		

Kinetic Law

Derived unit contains undeclared units

$$v_{83} = \text{kactDUBMdm2} \cdot \text{Mdm2\_P\_Ub} \cdot \text{Mdm2DUB} \tag{169}$$

7.84 Reaction Mdm2PProteasomeBinding1

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

SBO:0000526 protein complex formation

Reaction equation

$$\text{Mdm2\_P\_Ub4} + \text{Proteasome} \longrightarrow \text{Mdm2\_P\_Ub4\_Proteasome} \tag{170}$$

Reactants

Table 172: Properties of each reactant.

Id	Name	SBO
Mdm2_P_Ub4		
Proteasome		

Product

Table 173: Properties of each product.

Id	Name	SBO
Mdm2_P_Ub4_Proteasome		

Kinetic Law

Derived unit contains undeclared units

$$v_{84} = \text{kbinProt} \cdot \text{Mdm2\_P\_Ub4} \cdot \text{Proteasome} \tag{171}$$

7.85 Reaction Mdm2PDegradation

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

SBO:0000179 degradation

Reaction equation

$$\text{Mdm2\_P\_Ub4\_Proteasome} \longrightarrow \text{Proteasome} + 4\,\text{Ub} \tag{172}$$

Reactant

Table 174: Properties of each reactant.

Id	Name	SBO
Mdm2_P_Ub4_Proteasome		

Products

Table 175: Properties of each product.

Id	Name	SBO
Proteasome		
Ub		

Kinetic Law

Derived unit contains undeclared units

$$v_{85} = \text{kdegMdm2} \cdot \text{Mdm2\_P\_Ub4\_Proteasome} \cdot \text{kproteff} \tag{173}$$

7.86 Reaction ATMInactivation

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

SBO:0000176 biochemical reaction

Reaction equation

$$\text{ATMA} \longrightarrow \text{ATMI} \tag{174}$$

Reactant

Table 176: Properties of each reactant.

Id	Name	SBO
ATMA		

Product

Table 177: Properties of each product.

Id	Name	SBO
ATMI		

Kinetic Law

Derived unit contains undeclared units

$$v_{86} = \text{kinactATM} \cdot \text{ATMA} \tag{175}$$

7.87 Reaction AggAbetaROSproduction1

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

SBO:0000393 production

Reaction equation

$$\text{AggAbeta} \longrightarrow \text{AggAbeta} + \text{ROS} \tag{176}$$

Reactant

Table 178: Properties of each reactant.

Id	Name	SBO
AggAbeta		

Products

Table 179: Properties of each product.

Id	Name	SBO
AggAbeta		
ROS		

Kinetic Law

Derived unit contains undeclared units

$$v_{87} = \text{kgenROSAbeta} \cdot \text{AggAbeta} \tag{177}$$

7.88 Reaction AggAbetaROSproduction2

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

SBO:0000393 production

Reaction equation

$$\text{AggAbeta\_Proteasome} \longrightarrow \text{AggAbeta\_Proteasome} + \text{ROS} \tag{178}$$

Reactant

Table 180: Properties of each reactant.

Id	Name	SBO
AggAbeta_Proteasome		

Products

Table 181: Properties of each product.

Id	Name	SBO
AggAbeta_Proteasome		
ROS		

Kinetic Law

Derived unit contains undeclared units

$$v_{88} = \text{kgenROSAbeta} \cdot \text{AggAbeta\_Proteasome} \tag{179}$$

7.89 Reaction ROSDNAdamage

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

SBO:0000176 biochemical reaction

Reaction equation

$$\mathrm{ROS} \longrightarrow \mathrm{ROS} + \mathrm{damDNA} \tag{180}$$

Reactant

Table 182: Properties of each reactant.

Id	Name	SBO
ROS		

Products

Table 183: Properties of each product.

Id	Name	SBO
ROS		
damDNA		

Kinetic Law

Derived unit contains undeclared units

$$v_{89} = \mathrm{kdamROS} \cdot \mathrm{ROS} \tag{181}$$

7.90 Reaction basalROSDNAdamage

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

SBO:0000176 biochemical reaction

Reaction equation

$$\mathrm{basalROS} \longrightarrow \mathrm{basalROS} + \mathrm{damDNA} \tag{182}$$

Reactant

Table 184: Properties of each reactant.

Id	Name	SBO
basalROS		

Products

Table 185: Properties of each product.

Id	Name	SBO
basalROS		
damDNA		

Kinetic Law

Derived unit contains undeclared units

$$v_{90} = \text{kdamBasalROS} \cdot \text{basalROS} \tag{183}$$

7.91 Reaction TauSynthesis

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

SBO:0000393 production

Reaction equation

$$\text{Source} \longrightarrow \text{Tau} \tag{184}$$

Reactant

Table 186: Properties of each reactant.

Id	Name	SBO
Source		

Product

Table 187: Properties of each product.

Id	Name	SBO
Tau		

Id	Name	SBO

Kinetic Law

Derived unit contains undeclared units

$$v_{91} = \text{ksynTau} \cdot \text{Source} \tag{185}$$

7.92 Reaction TauProteasomeBinding

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

SBO:0000526 protein complex formation

Reaction equation

$$\text{Tau} + \text{Proteasome} \longrightarrow \text{Proteasome\_Tau} \tag{186}$$

Reactants

Table 188: Properties of each reactant.

Id	Name	SBO
Tau		
Proteasome		

Product

Table 189: Properties of each product.

Id	Name	SBO
Proteasome_Tau		

Kinetic Law

Derived unit contains undeclared units

$$v_{92} = \text{kbinTauProt} \cdot \text{Tau} \cdot \text{Proteasome} \tag{187}$$

7.93 Reaction Tau20SProteasomeDegradation

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

SBO:0000179 degradation

Reaction equation

$$\text{Proteasome\_Tau} \longrightarrow \text{Proteasome} \tag{188}$$

Reactant

Table 190: Properties of each reactant.

Id	Name	SBO
Proteasome_Tau		

Product

Table 191: Properties of each product.

Id	Name	SBO
Proteasome		

Kinetic Law

Derived unit contains undeclared units

$$v_{93} = \text{kdegTau20SProt} \cdot \text{Proteasome\_Tau} \tag{189}$$

8 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.

8.1 Species `Mdm2`

SBO:0000245 macromolecule

Initial amount 5 item

This species takes part in eight reactions (as a reactant in P53Mdm2Binding, Mdm2Ubiquitination, Mdm2phosphorylation and as a product in Mdm2Synthesis, P53Mdm2Release, Mdm2Deubiquitination1, p53ProteasomeBinding1, Mdm2dephosphorylation).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{Mdm2} = v_3 + v_{10} + v_{24} + v_{39} + v_{75} - v_9 - v_{17} - v_{74} \tag{190}$$

8.2 Species p53

SBO:0000245 macromolecule

Initial amount 5 item

This species takes part in nine reactions (as a reactant in Mdm2mRNASynthesis1, P53Mdm2Binding, GSK3p53Binding, p53phosphorylation and as a product in Mdm2mRNASynthesis1, P53Mdm2Release, GSK3p53Release, p53Synthesis, p53dephosphorylation).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{p53} = v_4 + v_{10} + v_{12} + v_{27} + v_{73} - v_4 - v_9 - v_{11} - v_{72} \tag{191}$$

8.3 Species Mdm2_p53

SBO:0000296 macromolecular complex

Initial amount 95 item

This species takes part in four reactions (as a reactant in P53Mdm2Release, p53Monoubiquitination and as a product in P53Mdm2Binding, p53Deubiquitination1).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{Mdm2\_p53} = v_9 + v_{35} - v_{10} - v_{28} \tag{192}$$

8.4 Species Mdm2_mRNA

SBO:0000278 messenger RNA

Initial amount 10 item

This species takes part in seven reactions (as a reactant in Mdm2Synthesis, Mdm2mRNADegradation and as a product in Mdm2Synthesis, Mdm2mRNASynthesis1, Mdm2mRNASynthesis2, Mdm2mRNASynthesis3, Mdm2mRNASynthesis4).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{Mdm2\_mRNA} = v_3 + v_4 + v_5 + v_6 + v_7 - v_3 - v_8 \tag{193}$$

8.5 Species p53_mRNA

SBO:0000278 messenger RNA

Initial amount 10 item

This species takes part in five reactions (as a reactant in p53mRNADegradation, p53Synthesis and as a product in p53mRNASynthesis, p53Synthesis, p53transcriptionViaAbeta).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{p53\_mRNA} = v_1 + v_{27} + v_{68} - v_2 - v_{27} \tag{194}$$

8.6 Species ATMA

SBO:0000245 macromolecule

Initial amount 0 item

This species takes part in six reactions (as a reactant in p53phosphorylation, Mdm2phosphorylation, ATMInactivation and as a product in ATMactivation, p53phosphorylation, Mdm2phosphorylation).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{ATMA} = v_{71} + v_{72} + v_{74} - v_{72} - v_{74} - v_{86} \tag{195}$$

8.7 Species ATMI

SBO:0000245 macromolecule

Initial amount 200 item

This species takes part in two reactions (as a reactant in ATMactivation and as a product in ATMInactivation).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{ATMI} = v_{86} - v_{71} \tag{196}$$

8.8 Species p53_P

SBO:0000245 macromolecule

Initial amount 0 item

This species takes part in six reactions (as a reactant in Mdm2mRNASynthesis2, GSK3p53PBinding, p53dephosphorylation and as a product in Mdm2mRNASynthesis2, GSK3_p53PRelease, p53phosphorylation).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{p53\_P} = v_5 + v_{14} + v_{72} - v_5 - v_{13} - v_{73} \tag{197}$$

8.9 Species Mdm2_P

SBO:0000245 macromolecule

Initial amount 0 item

This species takes part in four reactions (as a reactant in Mdm2dephosphorylation, Mdm2PUbiquitination and as a product in Mdm2phosphorylation, Mdm2PDeubiquitination1).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{Mdm2\_P} = v_{74} + v_{83} - v_{75} - v_{76} \tag{198}$$

8.10 Species IR

SBO:0000405 perturbing agent

Initial amount 0 item

Involved in rule IR

This species takes part in one reaction (as a modifier in DNAdamage) and is also involved in one rule which determines this species' quantity.

8.11 Species ROS

SBO:0000245 macromolecule

Initial amount 0 item

This species takes part in four reactions (as a reactant in ROSDNAdamage and as a product in AggAbetaROSproduction1, AggAbetaROSproduction2, ROSDNAdamage).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{ROS} = v_{87} + v_{88} + v_{89} - v_{89} \tag{199}$$

8.12 Species basalROS

SBO:0000245 macromolecule

Initial amount 10 item

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

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{basalROS} = v_{90} - v_{90} \tag{200}$$

8.13 Species damDNA

SBO:0000251 deoxyribonucleic acid

Initial amount 0 item

This species takes part in six reactions (as a reactant in DNArepair, ATMactivation and as a product in DNAdamage, ATMactivation, ROSDNAdamage, basalROSDNAdamage).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{damDNA} = v_{69} + v_{71} + v_{89} + v_{90} - v_{70} - v_{71} \tag{201}$$

8.14 Species E1

SBO:0000014 enzyme

Initial amount 100 item

This species takes part in two reactions (as a reactant in E1UbBinding and as a product in E2UbBinding).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{E1} = v_{16} - v_{15} \tag{202}$$

8.15 Species E2

SBO:0000014 enzyme

Initial amount 100 item

This species takes part in 13 reactions (as a reactant in E2UbBinding and as a product in Mdm2Ubiquitination, Mdm2polyUbiquitination1, Mdm2polyUbiquitination2, Mdm2polyUbiquitination p53Monoubiquitination, p53Polyubiquitination1, p53Polyubiquitination2, p53Polyubiquitination Mdm2PUbiquitination, Mdm2PpolyUbiquitination1, Mdm2PpolyUbiquitination2, Mdm2PpolyUbiquitina

$$\begin{aligned}\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{E2} = {} & v_{17} + v_{18} + v_{19} + v_{20} + v_{28} + v_{29} + v_{30} \\ & + v_{31} + v_{76} + v_{77} + v_{78} + v_{79} - v_{16}\end{aligned} \tag{203}$$

8.16 Species E1_Ub

SBO:0000296 macromolecular complex

Initial amount 0 item

This species takes part in two reactions (as a reactant in E2UbBinding and as a product in E1UbBinding).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{E1\_Ub} = v_{15} - v_{16} \tag{204}$$

8.17 Species E2_Ub

SBO:0000296 macromolecular complex

Initial amount 0 item

This species takes part in 13 reactions (as a reactant in Mdm2Ubiquitination, Mdm2polyUbiquitination1, Mdm2polyUbiquitination2, Mdm2polyUbiquitination3, p53Monoubiquitination, p53Polyubiquitinati p53Polyubiquitination2, p53Polyubiquitination3, Mdm2PUbiquitination, Mdm2PpolyUbiquitination Mdm2PpolyUbiquitination2, Mdm2PpolyUbiquitination3 and as a product in E2UbBinding).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{E2\_Ub} = v_{16} - v_{17} - v_{18} - v_{19} - v_{20} - v_{28} - v_{29} - v_{30} - v_{31} - v_{76} - v_{77} - v_{78} - v_{79} \tag{205}$$

8.18 Species Proteasome

SBO:0000245 macromolecule

Initial amount 500 item

This species takes part in ten reactions (as a reactant in Mdm2ProteasomeBinding1, p53ProteasomeBinding1, ProteasomeInhibitionAggTau, ProteasomeInhibitionAbeta, Mdm2PProteasomeBinding1, TauProteasomeBinding and as a product in Mdm2Degradation, Degradationp53_Ub4, Mdm2PDegradation, Tau20SProteasomeDegradation).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{Proteasome} = v_{26} + v_{40} + v_{85} + v_{93} - v_{25} - v_{39} - v_{59} - v_{62} - v_{84} - v_{92} \tag{206}$$

8.19 Species Ub

SBO:0000245 macromolecule

Initial amount 4000 item

This species takes part in 16 reactions (as a reactant in E1UbBinding and as a product in Mdm2Deubiquitination4, Mdm2Deubiquitination3, Mdm2Deubiquitination2, Mdm2Deubiquitination1, Mdm2Degradation, p53Deubiqutination4, p53Deubiquitination3, p53Deubiquitination2, p53Deubiquitination1, Degradationp53_Ub4, Mdm2PDeubiquitination4, Mdm2PDeubiquitination3, Mdm2PDeubiquitination2, Mdm2PDeubiquitination1, Mdm2PDegradation).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{Ub} = v_{21} + v_{22} + v_{23} + v_{24} + 4\,v_{26} + v_{32} + v_{33} + v_{34} + v_{35} + 4\,v_{40} + v_{80} + v_{81} + v_{82} + v_{83} + 4\,v_{85} - v_{15} \tag{207}$$

8.20 Species p53DUB

SBO:0000014 enzyme

Initial amount 200 item

This species takes part in eight reactions (as a reactant in p53Deubiqutination4, p53Deubiquitination3, p53Deubiquitination2, p53Deubiquitination1 and as a product in p53Deubiqutination4, p53Deubiquitination3, p53Deubiquitination2, p53Deubiquitination1).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{p53DUB} = v_{32} + v_{33} + v_{34} + v_{35} - v_{32} - v_{33} - v_{34} - v_{35} \tag{208}$$

8.21 Species Mdm2DUB

SBO:0000014 enzyme

Initial amount 200 item

This species takes part in 16 reactions (as a reactant in Mdm2Deubiquitination4, Mdm2Deubiquitination3, Mdm2Deubiquitination2, Mdm2Deubiquitination1, Mdm2PDeubiquitination4, Mdm2PDeubiquitination3 Mdm2PDeubiquitination2, Mdm2PDeubiquitination1 and as a product in Mdm2Deubiquitination4, Mdm2Deubiquitination3, Mdm2Deubiquitination2, Mdm2Deubiquitination1, Mdm2PDeubiquitination4, Mdm2PDeubiquitination3, Mdm2PDeubiquitination2, Mdm2PDeubiquitination1).

$$\begin{aligned}\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{Mdm2DUB} = {} & v_{21} + v_{22} + v_{23} + v_{24} + v_{80} + v_{81} + v_{82} + v_{83} \\ & - v_{21} - v_{22} - v_{23} - v_{24} - v_{80} - v_{81} - v_{82} - v_{83}\end{aligned} \tag{209}$$

8.22 Species DUB

SBO:0000014 enzyme

Initial amount 200 item

This species does not take part in any reactions. Its quantity does hence not change over time:

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{DUB} = 0 \tag{210}$$

8.23 Species Mdm2_p53_Ub

SBO:0000296 macromolecular complex

Initial amount 0 item

This species takes part in four reactions (as a reactant in p53Polyubiquitination1, p53Deubiquitination1 and as a product in p53Monoubiquitination, p53Deubiquitination2).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{Mdm2\_p53\_Ub} = v_{28} + v_{34} - v_{29} - v_{35} \tag{211}$$

8.24 Species Mdm2_p53_Ub2

SBO:0000296 macromolecular complex

Initial amount 0 item

This species takes part in four reactions (as a reactant in p53Polyubiquitination2, p53Deubiquitination2 and as a product in p53Polyubiquitination1, p53Deubiquitination3).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{Mdm2\_p53\_Ub2} = v_{29} + v_{33} - v_{30} - v_{34} \tag{212}$$

8.25 Species Mdm2_p53_Ub3

SBO:0000296 macromolecular complex

Initial amount 0 item

This species takes part in four reactions (as a reactant in p53Polyubiquitination3, p53Deubiquitination3 and as a product in p53Polyubiquitination2, p53Deubiqutination4).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{Mdm2\_p53\_Ub3} = v_{30} + v_{32} - v_{31} - v_{33} \tag{213}$$

8.26 Species Mdm2_p53_Ub4

SBO:0000296 macromolecular complex

Initial amount 0 item

This species takes part in five reactions (as a reactant in p53Deubiqutination4, Mdm2GSK3phosphorylation1, Mdm2GSK3phosphorylation2, Mdm2GSK3phosphorylation3 and as a product in p53Polyubiquitination3).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{Mdm2\_p53\_Ub4} = v_{31} - v_{32} - v_{36} - v_{37} - v_{38} \tag{214}$$

8.27 Species Mdm2_P1_p53_Ub4

SBO:0000296 macromolecular complex

Initial amount 0 item

This species takes part in four reactions (as a reactant in p53ProteasomeBinding1 and as a product in Mdm2GSK3phosphorylation1, Mdm2GSK3phosphorylation2, Mdm2GSK3phosphorylation3).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{Mdm2\_P1\_p53\_Ub4} = v_{36} + v_{37} + v_{38} - v_{39} \tag{215}$$

8.28 Species Mdm2_Ub

SBO:0000296 macromolecular complex

Initial amount 0 item

This species takes part in four reactions (as a reactant in Mdm2polyUbiquitination1, Mdm2Deubiquitination1 and as a product in Mdm2Ubiquitination, Mdm2Deubiquitination2).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{Mdm2\_Ub} = v_{17} + v_{23} - v_{18} - v_{24} \tag{216}$$

8.29 Species Mdm2_Ub2

SBO:0000296 macromolecular complex

Initial amount 0 item

This species takes part in four reactions (as a reactant in Mdm2polyUbiquitination2, Mdm2Deubiquitination2 and as a product in Mdm2polyUbiquitination1, Mdm2Deubiquitination3).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{Mdm2\_Ub2} = v_{18} + v_{22} - v_{19} - v_{23} \tag{217}$$

8.30 Species Mdm2_Ub3

SBO:0000296 macromolecular complex

Initial amount 0 item

This species takes part in four reactions (as a reactant in Mdm2polyUbiquitination3, Mdm2Deubiquitination3 and as a product in Mdm2polyUbiquitination2, Mdm2Deubiquitination4).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{Mdm2\_Ub3} = v_{19} + v_{21} - v_{20} - v_{22} \tag{218}$$

8.31 Species Mdm2_Ub4

SBO:0000296 macromolecular complex

Initial amount 0 item

This species takes part in three reactions (as a reactant in Mdm2Deubiquitination4, Mdm2ProteasomeBinding1 and as a product in Mdm2polyUbiquitination3).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{Mdm2\_Ub4} = v_{20} - v_{21} - v_{25} \tag{219}$$

8.32 Species Mdm2_P_Ub

SBO:0000296 macromolecular complex

Initial amount 0 item

This species takes part in four reactions (as a reactant in Mdm2PpolyUbiquitination1, Mdm2PDeubiquitination1 and as a product in Mdm2PUbiquitination, Mdm2PDeubiquitination2).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{Mdm2\_P\_Ub} = v_{76} + v_{82} - v_{77} - v_{83} \tag{220}$$

8.33 Species Mdm2_P_Ub2

SBO:0000296 macromolecular complex

Initial amount 0 item

This species takes part in four reactions (as a reactant in Mdm2PpolyUbiquitination2, Mdm2PDeubiquitination2 and as a product in Mdm2PpolyUbiquitination1, Mdm2PDeubiquitination3).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{Mdm2\_P\_Ub2} = v_{77} + v_{81} - v_{78} - v_{82} \tag{221}$$

8.34 Species Mdm2_P_Ub3

SBO:0000296 macromolecular complex

Initial amount 0 item

This species takes part in four reactions (as a reactant in Mdm2PpolyUbiquitination3, Mdm2PDeubiquitination3 and as a product in Mdm2PpolyUbiquitination2, Mdm2PDeubiquitination4).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{Mdm2\_P\_Ub3} = v_{78} + v_{80} - v_{79} - v_{81} \tag{222}$$

8.35 Species Mdm2_P_Ub4

SBO:0000296 macromolecular complex

Initial amount 0 item

This species takes part in three reactions (as a reactant in Mdm2PDeubiquitination4, Mdm2PProteasomeBinding1 and as a product in Mdm2PpolyUbiquitination3).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{Mdm2\_P\_Ub4} = v_{79} - v_{80} - v_{84} \tag{223}$$

8.36 Species p53_Ub4_Proteasome

SBO:0000296 macromolecular complex

Initial amount 0 item

This species takes part in two reactions (as a reactant in Degradationp53_Ub4 and as a product in p53ProteasomeBinding1).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{p53\_Ub4\_Proteasome} = v_{39} - v_{40} \tag{224}$$

8.37 Species Mdm2_Ub4_Proteasome

SBO:0000296 macromolecular complex

Initial amount 0 item

This species takes part in two reactions (as a reactant in Mdm2Degradation and as a product in Mdm2ProteasomeBinding1).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{Mdm2\_Ub4\_Proteasome} = v_{25} - v_{26} \tag{225}$$

8.38 Species Mdm2_P_Ub4_Proteasome

SBO:0000296 macromolecular complex

Initial amount 0 item

This species takes part in two reactions (as a reactant in Mdm2PDegradation and as a product in Mdm2PProteasomeBinding1).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{Mdm2\_P\_Ub4\_Proteasome} = v_{84} - v_{85} \tag{226}$$

8.39 Species GSK3b

SBO:0000245 macromolecule

Initial amount 500 item

This species takes part in ten reactions (as a reactant in GSK3p53Binding, GSK3p53PBinding, Mdm2GSK3phosphorylation1, Tauphosphorylation5, Tauphosphorylation6 and as a product in GSK3p53Release, GSK3_p53PRelease, Mdm2GSK3phosphorylation1, Tauphosphorylation5, Tauphosphorylation6).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{GSK3b} = v_{12} + v_{14} + v_{36} + v_{47} + v_{48} - v_{11} - v_{13} - v_{36} - v_{47} - v_{48} \tag{227}$$

8.40 Species GSK3b_p53

SBO:0000296 macromolecular complex

Initial amount 0 item

This species takes part in twelve reactions (as a reactant in Mdm2mRNASynthesis3, GSK3p53Release, Mdm2GSK3phosphorylation2, Tauphosphorylation1, Tauphosphorylation2, Abetaproduction1 and as a product in Mdm2mRNASynthesis3, GSK3p53Binding, Mdm2GSK3phosphorylation2, Tauphosphorylation1, Tauphosphorylation2, Abetaproduction1).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{GSK3b\_p53} = v_6 + v_{11} + v_{37} + v_{43} + v_{44} + v_{60} - v_6 - v_{12} - v_{37} - v_{43} - v_{44} - v_{60} \tag{228}$$

8.41 Species GSK3b_p53_P

SBO:0000296 macromolecular complex

Initial amount 0 item

This species takes part in twelve reactions (as a reactant in Mdm2mRNASynthesis4, GSK3-_p53PRelease, Mdm2GSK3phosphorylation3, Tauphosphorylation3, Tauphosphorylation4, Abetaproduction2 and as a product in Mdm2mRNASynthesis4, GSK3p53PBinding, Mdm2GSK3phosphorylation Tauphosphorylation3, Tauphosphorylation4, Abetaproduction2).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{GSK3b\_p53\_P} = v_7 + v_{13} + v_{38} + v_{45} + v_{46} + v_{61} - v_7 - v_{14} - v_{38} - v_{45} - v_{46} - v_{61} \tag{229}$$

8.42 Species Abeta

SBO:0000245 macromolecule

Initial amount 0 item

This species takes part in seven reactions (as a reactant in AbetaDegradation, AbetaAggregation1, AbetaAggregation2, p53transcriptionViaAbeta and as a product in Abetaproduction1, Abetaproduction2, p53transcriptionViaAbeta).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{Abeta} = v_{60} + v_{61} + v_{68} - v_{63} - 2\,v_{64} - v_{65} - v_{68} \tag{230}$$

8.43 Species AggAbeta_Proteasome

SBO:0000296 macromolecular complex

Initial amount 0 item

This species takes part in three reactions (as a reactant in AggAbetaROSproduction2 and as a product in ProteasomeInhibitionAbeta, AggAbetaROSproduction2).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{AggAbeta\_Proteasome} = v_{62} + v_{88} - v_{88} \tag{231}$$

8.44 Species AggAbeta

SBO:0000296 macromolecular complex

Initial amount 0 item

This species takes part in eight reactions (as a reactant in ProteasomeInhibitionAbeta, AbetaAggregation2, AbetaPlaqueFormation1, AbetaPlaqueFormation2, AggAbetaROSproduction1 and as a product in AbetaAggregation1, AbetaAggregation2, AggAbetaROSproduction1).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{AggAbeta} = v_{64} + 2\,v_{65} + v_{87} - v_{62} - v_{65} - 2\,v_{66} - v_{67} - v_{87} \tag{232}$$

8.45 Species AbetaPlaque

SBO:0000296 macromolecular complex

Initial amount 0 item

This species takes part in three reactions (as a reactant in AbetaPlaqueFormation2 and as a product in AbetaPlaqueFormation1, AbetaPlaqueFormation2).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{AbetaPlaque} = 2\,v_{66} + 2\,v_{67} - v_{67} \tag{233}$$

8.46 Species Tau

SBO:0000245 macromolecule

Initial amount 0 item

This species takes part in ten reactions (as a reactant in TauMTbinding, Tauphosphorylation1, Tauphosphorylation3, Tauphosphorylation5, TauAggregation1, TauAggregation2, TauProteasomeBind and as a product in TauMTrelease, Taudephosphorylation2, TauSynthesis).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{Tau} = v_{42} + v_{50} + v_{91} - v_{41} - v_{43} - v_{45} - v_{47} - 2\,v_{55} - v_{56} - v_{92} \tag{234}$$

8.47 Species Tau_P1

SBO:0000245 macromolecule

Initial amount 0 item

This species takes part in ten reactions (as a reactant in Tauphosphorylation2, Tauphosphorylation4, Tauphosphorylation6, Taudephosphorylation2, TauP1Aggregation1, TauP1Aggregation2 and as a product in Tauphosphorylation1, Tauphosphorylation3, Tauphosphorylation5, Taudephosphorylation1).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{Tau\_P1} = v_{43} + v_{45} + v_{47} + v_{49} - v_{44} - v_{46} - v_{48} - v_{50} - 2\,v_{51} - v_{52} \quad (235)$$

8.48 Species Tau_P2

SBO:0000245 macromolecule

Initial amount 0 item

This species takes part in six reactions (as a reactant in Taudephosphorylation1, TauP2Aggregation1, TauP2Aggregation2 and as a product in Tauphosphorylation2, Tauphosphorylation4, Tauphosphorylation6).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{Tau\_P2} = v_{44} + v_{46} + v_{48} - v_{49} - 2\,v_{53} - v_{54} \quad (236)$$

8.49 Species MT_Tau

SBO:0000296 macromolecular complex

Initial amount 100 item

This species takes part in two reactions (as a reactant in TauMTrelease and as a product in TauMTbinding).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{MT\_Tau} = v_{41} - v_{42} \quad (237)$$

8.50 Species AggTau

SBO:0000296 macromolecular complex

Initial amount 0 item

This species takes part in twelve reactions (as a reactant in TauP1Aggregation2, TauP2Aggregation2, TauAggregation2, TangleFormation1, TangleFormation2, ProteasomeInhibitionAggTau and as a product in TauP1Aggregation1, TauP1Aggregation2, TauP2Aggregation1, TauP2Aggregation2, TauAggregation1, TauAggregation2).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{AggTau} = 2\,v_{51} + 2\,v_{52} + 2\,v_{53} + 2\,v_{54} + 2\,v_{55} + 2\,v_{56} - v_{52} - v_{54} - v_{56} - 2\,v_{57} - v_{58} - v_{59} \tag{238}$$

8.51 Species AggTau_Proteasome

SBO:0000296 macromolecular complex

Initial amount 0 item

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

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{AggTau\_Proteasome} = v_{59} \tag{239}$$

8.52 Species Proteasome_Tau

SBO:0000296 macromolecular complex

Initial amount 0 item

This species takes part in two reactions (as a reactant in Tau20SProteasomeDegradation and as a product in TauProteasomeBinding).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{Proteasome\_Tau} = v_{92} - v_{93} \tag{240}$$

8.53 Species PP1

SBO:0000245 macromolecule

Initial amount 50 item

This species takes part in four reactions (as a reactant in Taudephosphorylation1, Taudephosphorylation2 and as a product in Taudephosphorylation1, Taudephosphorylation2).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{PP1} = v_{49} + v_{50} - v_{49} - v_{50} \tag{241}$$

8.54 Species NFT

Initial amount 0 item

This species takes part in three reactions (as a reactant in TangleFormation2 and as a product in TangleFormation1, TangleFormation2).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{NFT} = 2\,v_{57} + 2\,v_{58} - v_{58} \tag{242}$$

8.55 Species ATP

SBO:0000296 macromolecular complex

Initial amount 10000 item

This species takes part in two reactions (as a reactant in E1UbBinding, Degradationp53_Ub4), which do not influence its rate of change because this constant species is on the boundary of the reaction system:

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{ATP} = 0 \tag{243}$$

8.56 Species ADP

Initial amount 1000 item

This species takes part in one reaction (as a product in Degradationp53_Ub4), which does not influence its rate of change because this constant species is on the boundary of the reaction system:

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{ADP} = 0 \tag{244}$$

8.57 Species AMP

SBO:0000247 simple chemical

Initial amount 1000 item

This species takes part in one reaction (as a product in E1UbBinding), which does not influence its rate of change because this constant species is on the boundary of the reaction system:

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{AMP} = 0 \tag{245}$$

8.58 Species Source

SBO:0000291 empty set

Initial amount 1 item

This species takes part in two reactions (as a reactant in p53mRNASynthesis, TauSynthesis), which do not influence its rate of change because this constant species is on the boundary of the reaction system:

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{Source} = 0 \tag{246}$$

8.59 Species Sink

SBO:0000291 empty set

Initial amount 0 item

This species takes part in four reactions (as a product in p53mRNADegradation, Mdm2mRNADegradation, AbetaDegradation, DNArepair), which do not influence its rate of change because this constant species is on the boundary of the reaction system:

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{Sink} = 0 \tag{247}$$

A Glossary of Systems Biology Ontology Terms

SBO:0000009 kinetic constant: Numerical parameter that quantifies the velocity of a chemical reaction

SBO:0000014 enzyme: A protein that catalyzes a chemical reaction. The word comes from en “a” or“i”) and simo “leave” or“yeas”)

SBO:0000169 inhibition: Negative modulation of the execution of a process

SBO:0000176 biochemical reaction: An event involving one or more chemical entities that modifies the electrochemical structure of at least one of the participants.

SBO:0000179 degradation: Complete disappearance of a physical entity

SBO:0000180 dissociation: Transformation of a non-covalent complex that results in the formation of several independent biochemical entitie

SBO:0000183 transcription: Process through which a DNA sequence is copied to produce a complementary RNA

SBO:0000216 phosphorylation: Addition of a phosphate group (-H2PO4) to a chemical entity

SBO:0000245 macromolecule: Molecular entity mainly built-up by the repetition of pseudo-identical units. CHEBI:3383

SBO:0000247 simple chemical: Simple, non-repetitive chemical entity

SBO:0000251 deoxyribonucleic acid: Polymer composed of nucleotides containing deoxyribose and linked by phosphodiester bonds. CHEBI:16991

SBO:0000261 inhibitory constant: Dissociation constant of a compound from a target of which it inhibits the function.

SBO:0000278 messenger RNA: A messenger RNA is a ribonucleic acid synthesized during the transcription of a gene, and that carries the information to encode one or several proteins

SBO:0000279 pressure: Pressure (symbol: p) is the force per unit area applied on a surface in a direction perpendicular to that surface. The unit of pressure is the Pascal (Pa), that is equal to 1 Newton per square meter

SBO:0000282 dissociation constant: Equilibrium constant that measures the propensity of a larger object to separate (dissociate) reversibly into smaller components, as when a complex falls apart into its component molecules, or when a salt splits up into its component ions. The dissociation constant is usually denoted Kd and is the inverse of the affinity constant.

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

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:0000296 macromolecular complex: Non-covalent complex of one or more macromolecules and zero or more simple chemicals

SBO:0000330 dephosphorylation: Removal of a phosphate group (-H2PO4) from a chemical entity.

SBO:0000337 association constant: Equilibrium constant that measures the propensity of two objects to assemble (associate) reversibly into a larger component. The association constant is usually denoted Ka and is the inverse of the dissociation constant.

SBO:0000349 inactivation rate constant: Kinetic constant describing the rate of an irreversible enzyme inactivation by decay of the active enzyme into its inactive form

SBO:0000356 decay constant: Kinetic constant characterising a mono-exponential decay. It is the inverse of the mean lifetime of the continuant being decayed. Its unit is“per tim”.

SBO:0000357 biological effect of a perturbation: Biochemical networks can be affected by external influences. Those influences can be well-defined physical perturbations, such as a light pulse, or a change in temperature but also more complex of not well defined phenomena, for instance a biological process, an experimental setup, or a mutation

SBO:0000363 activation constant: Dissociation constant of a potentiator (activator) from a target (e.g. an enzyme) of which it activates the function

SBO:0000393 production: Generation of a material or conceptual entity.

SBO:0000405 perturbing agent: A material entity that is responsible for a perturbing effec

SBO:0000526 protein complex formation: The process by which two or more proteins interact non-covalently to form a protein complex (SBO:0000297)

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

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