**SBML Model Report**

# Model name: "Proctor2013 - Effect of A immunisation in Alzheimer's disease"

SBML2LATEX

May 6, 2016

## 1 General Overview

This is a document in SBML Level 2 Version 4 format. This model was created by the following two authors: Vijayalakshmi Chelliah[1] and Carole Proctor[2] at September 24th 2013 at 11:45 a. m. and last time modified at September 29th 2014 at 2:48 p. m. Table 1 shows an overview of the quantities of all components of this model.

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

| Element | Quantity | Element | Quantity |
|---|---|---|---|
| compartment types | 0 | compartments | 1 |
| species types | 0 | species | 69 |
| events | 1 | constraints | 0 |
| reactions | 112 | function definitions | 0 |
| global parameters | 73 | unit definitions | 1 |
| rules | 0 | initial assignments | 0 |

### Model Notes

Proctor2013 - Effect of A immunisation in Alzheimer's disease

Extension of a previously published stochastic computer model (designed to examine some of the key pathways involved in the aggregation of amyloid-beta (A) and the micro-tubular binding

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

[2]Newcastle University, `carole.proctor@ncl.ac.uk`

protein tau) to include the main processes involved in passive and active immunisation against A and then demonstrate the effects of this intervention on soluble A.

This model is described in the article:Investigating interventions in Alzheimer's disease with computer simulation models.Proctor CJ, Boche D, Gray DA, Nicoll JAPLoS ONE 2013; 8(9): e73631

Abstract:

Progress in the development of therapeutic interventions to treat or slow the progression of Alzheimer's disease has been hampered by lack of efficacy and unforeseen side effects in human clinical trials. This setback highlights the need for new approaches for pre-clinical testing of possible interventions. Systems modelling is becoming increasingly recognised as a valuable tool for investigating molecular and cellular mechanisms involved in ageing and age-related diseases. However, there is still a lack of awareness of modelling approaches in many areas of biomedical research. We previously developed a stochastic computer model to examine some of the key pathways involved in the aggregation of amyloid-beta (A) and the micro-tubular binding protein tau. Here we show how we extended this model to include the main processes involved in passive and active immunisation against A and then demonstrate the effects of this intervention on soluble A, plaques, phosphorylated tau and tangles. The model predicts that immunisation leads to clearance of plaques but only results in small reductions in levels of soluble A, phosphorylated tau and tangles. The behaviour of this model is supported by neuropathological observations in Alzheimer patients immunised against A. Since, soluble A, phosphorylated tau and tangles more closely correlate with cognitive decline than plaques, our model suggests that immunotherapy against A may not be effective unless it is performed very early in the disease process or combined with other therapies.

This model is hosted on BioModels Database and identified by: BIOMD0000000488.

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

## 2 Unit Definitions

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

### 2.1 Unit substance

**Definition** item

### 2.2 Unit volume

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

**Definition** l

*Produced by* SBML2LATEX

## 2.3 Unit `area`

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

**Definition** $\text{m}^2$

## 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 | | | 3 | 1 | litre | ✓ | |

## 3.1 Compartment `cell`

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

# 4 Species

This model contains 69 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 | item | ⊟ | ⊟ |
| ROS | | 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 | ⊟ | ⊟ |
| DUB | | cell | item | ⊟ | ⊟ |

| Id | Name | Compartment | Derived Unit | Constant | Boundary Condition |
|---|---|---|---|---|---|
| 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 | ⊟ | ⊟ |
| AbetaPlaque | | cell | item | ⊟ | ⊟ |
| Tau | | cell | item | ⊟ | ⊟ |

| Id | Name | Compartment | Derived Unit | Constant | Boundary Condi- tion |
|---|---|---|---|---|---|
| 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 | ☑ | ☑ |
| AbetaDimer | | cell | item | ⊟ | ⊟ |
| AbetaPlaque_GliaA | | cell | item | ⊟ | ⊟ |
| GliaI | | cell | item | ⊟ | ⊟ |
| GliaM1 | | cell | item | ⊟ | ⊟ |
| GliaM2 | | cell | item | ⊟ | ⊟ |
| GliaA | | cell | item | ⊟ | ⊟ |
| antiAb | | cell | item | ⊟ | ⊟ |
| Abeta_antiAb | | cell | item | ⊟ | ⊟ |
| AbetaDimer_antiAb | | cell | item | ⊟ | ⊟ |
| degAbetaGlia | | cell | item | ⊟ | ⊟ |
| disaggPlaque1 | | cell | item | ⊟ | ⊟ |
| disaggPlaque2 | | cell | item | ⊟ | ⊟ |
| Source | | cell | item | ☑ | ☑ |
| Sink | | cell | item | ☑ | ☑ |

# 5 Parameters

This model contains 73 global parameters.

Table 4: Properties of each parameter.

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

| Id | Name | SBO | Value | Unit | Constant |
|---|---|---|---|---|---|
| kbinMTTau | | | 0.100 | | ☑ |
| krelMTTau | | | $10^{-4}$ | | ☑ |
| ksynTau | | | $8 \cdot 10^{-5}$ | | ☑ |
| kbinTauProt | | | $1.925 \cdot 10^{-7}$ | | ☑ |
| kdegTau20SProt | | | 0.010 | | ☑ |
| kaggTau | | | $10^{-8}$ | | ☑ |
| kaggTauP1 | | | $10^{-8}$ | | ☑ |
| kaggTauP2 | | | $10^{-7}$ | | ☑ |
| ktangfor | | | 0.001 | | ☑ |
| kinhibprot | | | $10^{-7}$ | | ☑ |
| ksynp53mRNAAbeta | | | $10^{-5}$ | | ☑ |
| kdamROS | | | $10^{-5}$ | | ☑ |
| kgenROSAbeta | | | $2 \cdot 10^{-5}$ | | ☑ |
| kgenROSPlaque | | | $10^{-5}$ | | ☑ |
| kgenROSGlia | | | $10^{-5}$ | | ☑ |
| kproteff | | | 1.000 | | ⊟ |
| kremROS | | | $7 \cdot 10^{-5}$ | | ☑ |
| kprodAbeta | | | $1.86 \cdot 10^{-5}$ | | ☑ |
| kprodAbeta2 | | | $1.86 \cdot 10^{-5}$ | | ☑ |
| kdegAbeta | | | $1.5 \cdot 10^{-5}$ | | ☑ |
| kaggAbeta | | | $3 \cdot 10^{-6}$ | | ☑ |
| kdisaggAbeta | | | $10^{-6}$ | | ☑ |
| kdisaggAbeta1 | | | $2 \cdot 10^{-4}$ | | ☑ |
| kdisaggAbeta2 | | | $10^{-6}$ | | ☑ |
| kdegAbetaGlia | | | 0.005 | | ☑ |
| kpf | | | 0.200 | | ☑ |
| kpg | | | 0.150 | | ☑ |
| kpghalf | | | 10.000 | | ☑ |
| kactglia1 | | | $6 \cdot 10^{-7}$ | | ☑ |
| kactglia2 | | | $6 \cdot 10^{-7}$ | | ☑ |
| kinactglia1 | | | $5 \cdot 10^{-6}$ | | ☑ |
| kinactglia2 | | | $5 \cdot 10^{-6}$ | | ☑ |
| kbinAbetaGlia | | | $10^{-5}$ | | ☑ |
| krelAbetaGlia | | | $5 \cdot 10^{-5}$ | | ☑ |
| kdegAntiAb | | | $2.75 \cdot 10^{-6}$ | | ☑ |
| kbinAbantiAb | | | $10^{-6}$ | | ☑ |

# 6 Event

This is an overview of one event. Each event is initiated whenever its trigger condition switches from false to true. A delay function postpones the effects of an event to a later time point.

At the time of execution, an event can assign values to species, parameters or compartments if these are not set to constant.

## 6.1 Event `ImmunizeCell`

**Trigger condition**

$$t \geq 345600 \tag{1}$$

**Assignment**

$$[\text{antiAb}] = 50 \tag{2}$$

# 7 Reactions

This model contains 112 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 $\xrightarrow{\text{Source}}$ p53_mRNA | |
| 2 | p53mRNADegradation | | p53_mRNA $\xrightarrow{\text{p53\_mRNA}}$ Sink | |
| 3 | Mdm2Synthesis | | Mdm2_mRNA $\xrightarrow{\text{Mdm2\_mRNA}}$ Mdm2_mRNA + Mdm2 | + |
| 4 | Mdm2mRNASynthesis1 | | p53 $\xrightarrow{\text{p53}}$ p53 + Mdm2_mRNA | |
| 5 | Mdm2mRNASynthesis2 | | p53_P $\xrightarrow{\text{p53\_P}}$ p53_P + Mdm2_mRNA | |
| 6 | Mdm2mRNASynthesis3 | | GSK3b_p53 $\xrightarrow{\text{GSK3b\_p53}}$ GSK3b_p53 + Mdm2_mRNA | + |
| 7 | Mdm2mRNASynthesis4 | | GSK3b_p53_P $\xrightarrow{\text{GSK3b\_p53\_P}}$ GSK3b_p53_P + Mdm2_mRNA | + |
| 8 | Mdm2mRNADegradation | | Mdm2_mRNA $\xrightarrow{\text{Mdm2\_mRNA}}$ Sink | |
| 9 | P53Mdm2Binding | | p53 + Mdm2 $\xrightarrow{\text{p53, Mdm2}}$ Mdm2_p53 | |
| 10 | P53Mdm2Release | | Mdm2_p53 $\xrightarrow{\text{Mdm2\_p53}}$ p53 + Mdm2 | |
| 11 | GSK3p53Binding | | GSK3b + p53 $\xrightarrow{\text{GSK3b, p53}}$ GSK3b_p53 | |
| 12 | GSK3p53Release | | GSK3b_p53 $\xrightarrow{\text{GSK3b\_p53}}$ GSK3b + p53 | |
| 13 | GSK3p53PBinding | | GSK3b + p53_P $\xrightarrow{\text{GSK3b, p53\_P}}$ GSK3b_p53_P | |

| № | Id | Name | Reaction Equation | SBO |
|---|-----|------|-------------------|-----|
| 14 | `GSK3-_p53PRelease` | | $\text{GSK3b\_p53\_P} \xrightarrow{\text{GSK3b\_p53\_P}} \text{GSK3b} + \text{p53\_P}$ | |
| 15 | `E1UbBinding` | | $\text{E1} + \text{Ub} + \text{ATP} \xrightarrow{\text{E1, Ub, ATP}} \text{E1\_Ub} + \text{AMP}$ | |
| 16 | `E2UbBinding` | | $\text{E2} + \text{E1\_Ub} \xrightarrow{\text{E2, E1\_Ub}} \text{E2\_Ub} + \text{E1}$ | |
| 17 | `Mdm2Ubiquitination` | | $\text{Mdm2} + \text{E2\_Ub} \xrightarrow{\text{Mdm2, E2\_Ub}} \text{Mdm2\_Ub} + \text{E2}$ | |
| 18 | `Mdm2polyUbiquitination1` | | $\text{Mdm2\_Ub} + \text{E2\_Ub} \xrightarrow{\text{Mdm2\_Ub, E2\_Ub}} \text{Mdm2\_Ub2} + \text{E2}$ | |
| 19 | `Mdm2polyUbiquitination2` | | $\text{Mdm2\_Ub2} + \text{E2\_Ub} \xrightarrow{\text{Mdm2\_Ub2, E2\_Ub}} \text{Mdm2\_Ub3} + \text{E2}$ | |
| 20 | `Mdm2polyUbiquitination3` | | $\text{Mdm2\_Ub3} + \text{E2\_Ub} \xrightarrow{\text{Mdm2\_Ub3, E2\_Ub}} \text{Mdm2\_Ub4} + \text{E2}$ | |
| 21 | `Mdm2Deubiquitination4` | | $\text{Mdm2\_Ub4} + \text{Mdm2DUB} \xrightarrow{\text{Mdm2\_Ub4, Mdm2DUB}} \text{Mdm2\_Ub3} + \text{Mdm2DUB} + \text{Ub}$ | |
| 22 | `Mdm2Deubiquitination3` | | $\text{Mdm2\_Ub3} + \text{Mdm2DUB} \xrightarrow{\text{Mdm2\_Ub3, Mdm2DUB}} \text{Mdm2\_Ub2} + \text{Mdm2DUB} + \text{Ub}$ | |
| 23 | `Mdm2Deubiquitination2` | | $\text{Mdm2\_Ub2} + \text{Mdm2DUB} \xrightarrow{\text{Mdm2\_Ub2, Mdm2DUB}} \text{Mdm2\_Ub} + \text{Mdm2DUB} + \text{Ub}$ | |
| 24 | `Mdm2Deubiquitination1` | | $\text{Mdm2\_Ub} + \text{Mdm2DUB} \xrightarrow{\text{Mdm2\_Ub, Mdm2DUB}} \text{Mdm2} + \text{Mdm2DUB} + \text{Ub}$ | |
| 25 | `Mdm2ProteasomeBinding1` | | $\text{Mdm2\_Ub4} + \text{Proteasome} \xrightarrow{\text{Mdm2\_Ub4, Proteasome}} \text{Mdm2\_Ub4\_Proteasome}$ | |
| 26 | `Mdm2Degradation` | | $\text{Mdm2\_Ub4\_Proteasome} \xrightarrow{\text{Mdm2\_Ub4\_Proteasome}} \text{Proteasome} + 4\,\text{Ub}$ | |
| 27 | `p53Synthesis` | | $\text{p53\_mRNA} \xrightarrow{\text{p53\_mRNA}} \text{p53} + \text{p53\_mRNA}$ | |

| № | Id | Name | Reaction Equation | SBO |
|---|---|---|---|---|
| 28 | `p53Monoubiquitination` | | $\text{E2\_Ub} + \text{Mdm2\_p53} \xrightarrow{\text{E2\_Ub, Mdm2\_p53}} \text{Mdm2\_p53\_Ub} + \text{E2}$ | |
| 29 | `p53Polyubiquitination1` | | $\text{Mdm2\_p53\_Ub} + \text{E2\_Ub} \xrightarrow{\text{Mdm2\_p53\_Ub, E2\_Ub}} \text{Mdm2\_p53\_Ub2} + \text{E2}$ | |
| 30 | `p53Polyubiquitination2` | | $\text{Mdm2\_p53\_Ub2} + \text{E2\_Ub} \xrightarrow{\text{Mdm2\_p53\_Ub2, E2\_Ub}} \text{Mdm2\_p53\_Ub3} + \text{E2}$ | |
| 31 | `p53Polyubiquitination3` | | $\text{Mdm2\_p53\_Ub3} + \text{E2\_Ub} \xrightarrow{\text{Mdm2\_p53\_Ub3, E2\_Ub}} \text{Mdm2\_p53\_Ub4} + \text{E2}$ | |
| 32 | `p53Deubiqutination4` | | $\text{Mdm2\_p53\_Ub4} + \text{p53DUB} \xrightarrow{\text{Mdm2\_p53\_Ub4, p53DUB}} \text{Mdm2\_p53\_Ub3} + \text{p53DUB} + \text{Ub}$ | |
| 33 | `p53Deubiquitination3` | | $\text{Mdm2\_p53\_Ub3} + \text{p53DUB} \xrightarrow{\text{Mdm2\_p53\_Ub3, p53DUB}} \text{Mdm2\_p53\_Ub2} + \text{p53DUB} + \text{Ub}$ | |
| 34 | `p53Deubiquitination2` | | $\text{Mdm2\_p53\_Ub2} + \text{p53DUB} \xrightarrow{\text{Mdm2\_p53\_Ub2, p53DUB}} \text{Mdm2\_p53\_Ub} + \text{p53DUB} + \text{Ub}$ | |
| 35 | `p53Deubiquitination1` | | $\text{Mdm2\_p53\_Ub} + \text{p53DUB} \xrightarrow{\text{Mdm2\_p53\_Ub, p53DUB}} \text{Mdm2\_p53} + \text{p53DUB} + \text{Ub}$ | |
| 36 | `Mdm2GSK3phosphorylation1` | | $\text{Mdm2\_p53\_Ub4} + \text{GSK3b} \xrightarrow{\text{Mdm2\_p53\_Ub4, GSK3b}} \text{Mdm2\_P1\_p53\_Ub4} + \text{GSK3b}$ | |

| № | Id | Name | Reaction Equation | SBO |
|---|----|------|-------------------|-----|
| 37 | Mdm2GSK3phosphorylation2 | | Mdm2_p53_Ub4 $+$ GSK3b_p53 $\xrightarrow{\text{Mdm2\_p53\_Ub4, GSK3b\_p53}}$ Mdm2_P1_p53_Ub4$+$ GSK3b_p53 | $+$ |
| 38 | Mdm2GSK3phosphorylation3 | | Mdm2_p53_Ub4 $+$ GSK3b_p53_P $\xrightarrow{\text{Mdm2\_p53\_Ub4, GSK3b\_p53\_P}}$ Mdm2_P1_p53_Ub4$+$ GSK3b_p53_P | $+$ |
| 39 | p53ProteasomeBinding1 | | Mdm2_P1_p53_Ub4 $+$ Proteasome $\xrightarrow{\text{Mdm2\_P1\_p53\_Ub4, Proteasome}}$ p53_Ub4_Proteasome$+$ Mdm2 | $+$ |
| 40 | Degradationp53- _Ub4 | | p53_Ub4_Proteasome $+$ ATP $\xrightarrow{\text{p53\_Ub4\_Proteasome, ATP}}$ 4 Ub $+$ Proteasome $+$ ADP | $+$ $+$ |
| 41 | TauMTbinding | | Tau $\xrightarrow{\text{Tau}}$ MT_Tau | |
| 42 | TauMTrelease | | MT_Tau $\xrightarrow{\text{MT\_Tau}}$ Tau | |
| 43 | Tauphosphorylation1 | | GSK3b_p53 + Tau $\xrightarrow{\text{GSK3b\_p53, Tau}}$ GSK3b_p53 + Tau_P1 | |
| 44 | Tauphosphorylation2 | | GSK3b_p53$+$Tau_P1 $\xrightarrow{\text{GSK3b\_p53, Tau\_P1}}$ GSK3b_p53$+$ Tau_P2 | |
| 45 | Tauphosphorylation3 | | GSK3b_p53_P$+$Tau $\xrightarrow{\text{GSK3b\_p53\_P, Tau}}$ GSK3b_p53_P$+$ Tau_P1 | |
| 46 | Tauphosphorylation4 | | GSK3b_p53_P$+$Tau_P1 $\xrightarrow{\text{GSK3b\_p53\_P, Tau\_P1}}$ GSK3b_p53_P$+$ Tau_P2 | |
| 47 | Tauphosphorylation5 | | GSK3b + Tau $\xrightarrow{\text{GSK3b, Tau}}$ GSK3b + Tau_P1 | |
| 48 | Tauphosphorylation6 | | GSK3b$+$Tau_P1 $\xrightarrow{\text{GSK3b, Tau\_P1}}$ GSK3b$+$Tau_P2 | |

| № | Id | Name | Reaction Equation | SBO |
|---|---|---|---|---|
| 49 | Taudephosphorylation1 | | $\text{Tau\_P2} + \text{PP1} \xrightarrow{\text{Tau\_P2, PP1}} \text{Tau\_P1} + \text{PP1}$ | |
| 50 | Taudephosphorylation2 | | $\text{Tau\_P1} + \text{PP1} \xrightarrow{\text{Tau\_P1, PP1}} \text{Tau} + \text{PP1}$ | |
| 51 | TauP1Aggregation1 | | $2\,\text{Tau\_P1} \xrightarrow{\text{Tau\_P1}} 2\,\text{AggTau}$ | |
| 52 | TauP1Aggregation2 | | $\text{Tau\_P1} + \text{AggTau} \xrightarrow{\text{Tau\_P1, AggTau}} 2\,\text{AggTau}$ | |
| 53 | TauP2Aggregation1 | | $2\,\text{Tau\_P2} \xrightarrow{\text{Tau\_P2}} 2\,\text{AggTau}$ | |
| 54 | TauP2Aggregation2 | | $\text{Tau\_P2} + \text{AggTau} \xrightarrow{\text{Tau\_P2, AggTau}} 2\,\text{AggTau}$ | |
| 55 | TauAggregation1 | | $2\,\text{Tau} \xrightarrow{\text{Tau}} 2\,\text{AggTau}$ | |
| 56 | TauAggregation2 | | $\text{Tau} + \text{AggTau} \xrightarrow{\text{Tau, AggTau}} 2\,\text{AggTau}$ | |
| 57 | TangleFormation1 | | $2\,\text{AggTau} \xrightarrow{\text{AggTau}} 2\,\text{NFT}$ | |
| 58 | TangleFormation2 | | $\text{AggTau} + \text{NFT} \xrightarrow{\text{AggTau, NFT}} 2\,\text{NFT}$ | |
| 59 | ProteasomeInhibitionAggTau | | $\text{AggTau} + \text{Proteasome} \xrightarrow{\text{AggTau, Proteasome}} \text{AggTau\_Proteasome}$ | |
| 60 | Abetaproduction1 | | $\text{Source} \xrightarrow{\text{Source}} \text{Abeta}$ | |
| 61 | Abetaproduction2 | | $\text{GSK3b\_p53} \xrightarrow{\text{GSK3b\_p53}} \text{Abeta} + \text{GSK3b\_p53}$ | |
| 62 | Abetaproduction3 | | $\text{GSK3b\_p53\_P} \xrightarrow{\text{GSK3b\_p53\_P}} \text{Abeta} + \text{GSK3b\_p53\_P}$ | |
| 63 | ProteasomeInhibitionAbeta | | $\text{AbetaDimer} + \text{Proteasome} \xrightarrow{\text{AbetaDimer, Proteasome}} \text{AggAbeta\_Proteasome}$ | |
| 64 | AbetaDegradation | | $\text{Abeta} \xrightarrow{\text{Abeta}} \text{Sink}$ | |
| 65 | p53transcriptionViaAbeta | | $\text{Abeta} \xrightarrow{\text{Abeta}} \text{p53\_mRNA} + \text{Abeta}$ | |
| 66 | DNAdamage | | $\text{IR} \xrightarrow{\text{IR}} \text{IR} + \text{damDNA}$ | |
| 67 | DNArepair | | $\text{damDNA} \xrightarrow{\text{damDNA}} \text{Sink}$ | |

| № | Id | Name | Reaction Equation | SBO |
|---|---|---|---|---|
| 68 | ATMactivation | | $\text{damDNA} + \text{ATMI} \xrightarrow{\text{damDNA, ATMI}} \text{damDNA} + \text{ATMA}$ | |
| 69 | p53phosphorylation | | $\text{p53} + \text{ATMA} \xrightarrow{\text{p53, ATMA}} \text{p53\_P} + \text{ATMA}$ | |
| 70 | p53dephosphorylation | | $\text{p53\_P} \xrightarrow{\text{p53\_P}} \text{p53}$ | |
| 71 | Mdm2phosphorylation | | $\text{Mdm2} + \text{ATMA} \xrightarrow{\text{Mdm2, ATMA}} \text{Mdm2\_P} + \text{ATMA}$ | |
| 72 | Mdm2dephosphorylation | | $\text{Mdm2\_P} \xrightarrow{\text{Mdm2\_P}} \text{Mdm2}$ | |
| 73 | Mdm2PUbiquitination | | $\text{Mdm2\_P} + \text{E2\_Ub} \xrightarrow{\text{Mdm2\_P, E2\_Ub}} \text{Mdm2\_P\_Ub} + \text{E2}$ | |
| 74 | Mdm2PpolyUbiquitination1 | | $\text{Mdm2\_P\_Ub} + \text{E2\_Ub} \xrightarrow{\text{Mdm2\_P\_Ub, E2\_Ub}} \text{Mdm2\_P\_Ub2} + \text{E2}$ | |
| 75 | Mdm2PpolyUbiquitination2 | | $\text{Mdm2\_P\_Ub2} + \text{E2\_Ub} \xrightarrow{\text{Mdm2\_P\_Ub2, E2\_Ub}} \text{Mdm2\_P\_Ub3} + \text{E2}$ | |
| 76 | Mdm2PpolyUbiquitination3 | | $\text{Mdm2\_P\_Ub3} + \text{E2\_Ub} \xrightarrow{\text{Mdm2\_P\_Ub3, E2\_Ub}} \text{Mdm2\_P\_Ub4} + \text{E2}$ | |
| 77 | Mdm2PDeubiquitination4 | | $\text{Mdm2\_P\_Ub4} + \text{Mdm2DUB} \xrightarrow{\text{Mdm2\_P\_Ub4, Mdm2DUB}} \text{Mdm2\_P\_Ub3} + \text{Mdm2DUB} + \text{Ub}$ | |
| 78 | Mdm2PDeubiquitination3 | | $\text{Mdm2\_P\_Ub3} + \text{Mdm2DUB} \xrightarrow{\text{Mdm2\_P\_Ub3, Mdm2DUB}} \text{Mdm2\_P\_Ub2} + \text{Mdm2DUB} + \text{Ub}$ | |
| 79 | Mdm2PDeubiquitination2 | | $\text{Mdm2\_P\_Ub2} + \text{Mdm2DUB} \xrightarrow{\text{Mdm2\_P\_Ub2, Mdm2DUB}} \text{Mdm2\_P\_Ub} + \text{Mdm2DUB} + \text{Ub}$ | |
| 80 | Mdm2PDeubiquitination1 | | $\text{Mdm2\_P\_Ub} + \text{Mdm2DUB} \xrightarrow{\text{Mdm2\_P\_Ub, Mdm2DUB}} \text{Mdm2\_P} + \text{Mdm2DUB} + \text{Ub}$ | |
| 81 | Mdm2PProteasomeBinding1 | | $\text{Mdm2\_P\_Ub4} + \text{Proteasome} \xrightarrow{\text{Mdm2\_P\_Ub4, Proteasome}} \text{Mdm2\_P\_Ub4\_Proteasome}$ | |

| № | Id | Name | Reaction Equation | SBO |
|---|----|------|-------------------|-----|
| 82 | Mdm2PDegradation | | Mdm2_P_Ub4_Proteasome $\xrightarrow{\text{Mdm2\_P\_Ub4\_Proteasome}}$ Proteasome $+$ 4 Ub | |
| 83 | ATMInactivation | | ATMA $\xrightarrow{\text{ATMA}}$ ATMI | |
| 84 | AbetaROSproduction1 | | Abeta $\xrightarrow{\text{Abeta}}$ Abeta $+$ ROS | |
| 85 | PlaqueROSproduction | | AbetaPlaque $\xrightarrow{\text{AbetaPlaque}}$ AbetaPlaque $+$ ROS | |
| 86 | AggAbetaROSproduction2 | | AggAbeta_Proteasome $\xrightarrow{\text{AggAbeta\_Proteasome}}$ AggAbeta_Proteasome $+$ ROS | |
| 87 | ROSDNAdamage | | ROS $\xrightarrow{\text{ROS}}$ ROS $+$ damDNA | |
| 88 | TauSynthesis | | Source $\xrightarrow{\text{Source}}$ Tau | |
| 89 | TauProteasomeBinding | | Tau $+$ Proteasome $\xrightarrow{\text{Tau, Proteasome}}$ Proteasome_Tau | |
| 90 | Tau20SProteasomeDegradation | | Proteasome_Tau $\xrightarrow{\text{Proteasome\_Tau}}$ Proteasome | |
| 91 | AbetaAggregation1 | | 2 Abeta $\xrightarrow{\text{Abeta}}$ AbetaDimer | |
| 92 | AbetaPlaqueFormation1 | | 2 AbetaDimer $\xrightarrow{\text{AbetaDimer}}$ AbetaPlaque | |
| 93 | AbetaPlaqueGrowth | | AbetaDimer $+$ AbetaPlaque $\xrightarrow{\text{AbetaDimer, AbetaPlaque}}$ 2 AbetaPlaque | |
| 94 | AbetaDisaggregation1 | | AbetaDimer $\xrightarrow{\text{AbetaDimer}}$ 2 Abeta | |
| 95 | AbetaDisaggregation3 | | AbetaPlaque $\xrightarrow{\text{AbetaPlaque}}$ AbetaDimer $+$ disaggPlaque1 | |
| 96 | AbetaDisaggregation4 | | AbetaPlaque $+$ antiAb $\xrightarrow{\text{antiAb, AbetaPlaque}}$ AbetaDimer $+$ antiAb $+$ disaggPlaque2 | |
| 97 | Abeta_antiAbBinding | | Abeta $+$ antiAb $\xrightarrow{\text{Abeta, antiAb}}$ Abeta_antiAb | |

| № | Id | Name | Reaction Equation | SBO |
|---|----|------|-------------------|-----|
| 98 | AbetaDimer_antiAbBinding | | AbetaDimer + antiAb $\xrightarrow{\text{AbetaDimer, antiAb}}$ AbetaDimer_antiAb | |
| 99 | Abeta_antiAbDegredation | | Abeta_antiAb $\xrightarrow{\text{Abeta\_antiAb}}$ antiAb | |
| 100 | AbetaDimer_antiAbDegredation | | AbetaDimer_antiAb $\xrightarrow{\text{AbetaDimer\_antiAb}}$ antiAb | |
| 101 | GliaActivationStep1 | | GliaI + AbetaPlaque $\xrightarrow{\text{GliaI, AbetaPlaque}}$ GliaM1 + AbetaPlaque | |
| 102 | GliaActivationStep2 | | GliaM1 + AbetaPlaque $\xrightarrow{\text{GliaM1, AbetaPlaque}}$ GliaM2 + AbetaPlaque | |
| 103 | GliaActivationStep3 | | GliaM2 + antiAb $\xrightarrow{\text{GliaM2, antiAb}}$ GliaA + antiAb | |
| 104 | GliaInactivationStep1 | | GliaA $\xrightarrow{\text{GliaA}}$ GliaM2 | |
| 105 | GliaInactivationStep2 | | GliaM2 $\xrightarrow{\text{GliaM2}}$ GliaM1 | |
| 106 | GliaInactivationStep3 | | GliaM1 $\xrightarrow{\text{GliaM1}}$ GliaI | |
| 107 | AbetaBindingToGlia | | AbetaPlaque + GliaA $\xrightarrow{\text{AbetaPlaque, GliaA}}$ AbetaPlaque_GliaA | |
| 108 | AbetaReleaseFromGlia | | AbetaPlaque_GliaA $\xrightarrow{\text{AbetaPlaque\_GliaA}}$ AbetaPlaque + GliaA | |
| 109 | AbetaPlaqueClearanceByGlia | | AbetaPlaque_GliaA $\xrightarrow{\text{AbetaPlaque\_GliaA}}$ GliaA + degAbetaGlia | |
| 110 | ROSgenerationByGlia | | AbetaPlaque_GliaA $\xrightarrow{\text{AbetaPlaque\_GliaA}}$ AbetaPlaque_GliaA + ROS | |
| 111 | antiAbRemoval | | antiAb $\xrightarrow{\text{antiAb}}$ Sink | |

| № | Id | Name | Reaction Equation | SBO |
|---|---|---|---|---|
| 112 | ROSremoval | | ROS $\xrightarrow{\text{ROS}}$ Sink | |

## 7.1 Reaction p53mRNASynthesis

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

**Reaction equation**

$$\text{Source} \xrightarrow{\text{Source}} \text{p53\_mRNA} \tag{3}$$

**Reactant**

Table 6: Properties of each reactant.

| Id | Name | SBO |
|----|------|-----|
| Source | | |

**Modifier**

Table 7: Properties of each modifier.

| Id | Name | SBO |
|----|------|-----|
| Source | | |

**Product**

Table 8: Properties of each product.

| Id | Name | SBO |
|----|------|-----|
| p53\_mRNA | | |

**Kinetic Law**

**Derived unit**  contains undeclared units

$$v_1 = \text{ksynp53mRNA} \cdot \text{Source} \tag{4}$$

## 7.2 Reaction p53mRNADegradation

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

**Reaction equation**

$$\text{p53\_mRNA} \xrightarrow{\text{p53\_mRNA}} \text{Sink} \tag{5}$$

**Reactant**

Table 9: Properties of each reactant.

| Id | Name | SBO |
|---|---|---|
| p53_mRNA | | |

**Modifier**

Table 10: Properties of each modifier.

| Id | Name | SBO |
|---|---|---|
| p53_mRNA | | |

**Product**

Table 11: Properties of each product.

| Id | Name | SBO |
|---|---|---|
| Sink | | |

**Kinetic Law**

**Derived unit** contains undeclared units

$$v_2 = \text{kdegp53mRNA} \cdot \text{p53\_mRNA} \tag{6}$$

## 7.3 Reaction `Mdm2Synthesis`

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

**Reaction equation**

$$\text{Mdm2\_mRNA} \xrightarrow{\text{Mdm2\_mRNA}} \text{Mdm2\_mRNA} + \text{Mdm2} \tag{7}$$
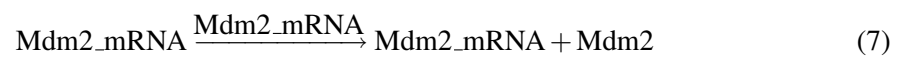
**Reactant**

Table 12: Properties of each reactant.

| Id | Name | SBO |
|---|---|---|
| Mdm2_mRNA | | |

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**Modifier**

Table 13: Properties of each modifier.

| Id | Name | SBO |
|---|---|---|
| Mdm2_mRNA | | |

**Products**

Table 14: Properties of each product.

| Id | Name | SBO |
|---|---|---|
| Mdm2_mRNA | | |
| Mdm2 | | |

**Kinetic Law**

**Derived unit**  contains undeclared units

$$v_3 = \text{ksynMdm2} \cdot \text{Mdm2\_mRNA} \tag{8}$$

## 7.4  Reaction `Mdm2mRNASynthesis1`

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

**Reaction equation**

$$\text{p53} \xrightarrow{\text{p53}} \text{p53} + \text{Mdm2\_mRNA} \tag{9}$$

**Reactant**

Table 15: Properties of each reactant.

| Id | Name | SBO |
|---|---|---|
| p53 | | |

**Modifier**

Table 16: Properties of each modifier.

| Id | Name | SBO |
|---|---|---|
| p53 | | |

## Products

Table 17: Properties of each product.

| Id | Name | SBO |
|---|---|---|
| p53 | | |
| Mdm2_mRNA | | |

## Kinetic Law

**Derived unit** contains undeclared units

$$v_4 = \text{ksynMdm2mRNA} \cdot \text{p53} \tag{10}$$

## 7.5 Reaction Mdm2mRNASynthesis2

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

## Reaction equation

$$\text{p53\_P} \xrightarrow{\text{p53\_P}} \text{p53\_P} + \text{Mdm2\_mRNA} \tag{11}$$

## Reactant

Table 18: Properties of each reactant.

| Id | Name | SBO |
|---|---|---|
| p53_P | | |

## Modifier

Table 19: Properties of each modifier.

| Id | Name | SBO |
|---|---|---|
| p53_P | | |

**Products**

Table 20: Properties of each product.

| Id | Name | SBO |
|----|------|-----|
| p53_P | | |
| Mdm2_mRNA | | |

**Kinetic Law**

**Derived unit**  contains undeclared units

$$v_5 = \text{ksynMdm2mRNA} \cdot \text{p53\_P} \tag{12}$$

## 7.6 Reaction `Mdm2mRNASynthesis3`

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

**Reaction equation**

$$\text{GSK3b\_p53} \xrightarrow{\text{GSK3b\_p53}} \text{GSK3b\_p53} + \text{Mdm2\_mRNA} \tag{13}$$
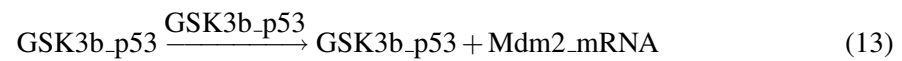
**Reactant**

Table 21: Properties of each reactant.

| Id | Name | SBO |
|----|------|-----|
| GSK3b_p53 | | |

**Modifier**

Table 22: Properties of each modifier.

| Id | Name | SBO |
|----|------|-----|
| GSK3b_p53 | | |

**Products**

Table 23: Properties of each product.

| Id | Name | SBO |
|---|---|---|
| GSK3b_p53 | | |
| Mdm2_mRNA | | |

## Kinetic Law

**Derived unit** contains undeclared units

$$v_6 = \text{ksynMdm2mRNAGSK3bp53} \cdot \text{GSK3b\_p53} \tag{14}$$

## 7.7 Reaction `Mdm2mRNASynthesis4`

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

## Reaction equation

$$\text{GSK3b\_p53\_P} \xrightarrow{\text{GSK3b\_p53\_P}} \text{GSK3b\_p53\_P} + \text{Mdm2\_mRNA} \tag{15}$$
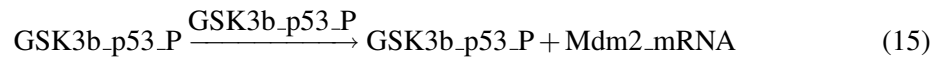
## Reactant

Table 24: Properties of each reactant.

| Id | Name | SBO |
|---|---|---|
| GSK3b_p53_P | | |

## Modifier

Table 25: Properties of each modifier.

| Id | Name | SBO |
|---|---|---|
| GSK3b_p53_P | | |

## Products

Table 26: Properties of each product.

| Id | Name | SBO |
|---|---|---|
| GSK3b_p53_P | | |
| Mdm2_mRNA | | |

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**Kinetic Law**

**Derived unit** contains undeclared units

$$v_7 = \text{ksynMdm2mRNAGSK3bp53} \cdot \text{GSK3b\_p53\_P} \qquad (16)$$

## 7.8 Reaction `Mdm2mRNADegradation`

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

**Reaction equation**

$$\text{Mdm2\_mRNA} \xrightarrow{\text{Mdm2\_mRNA}} \text{Sink} \qquad (17)$$
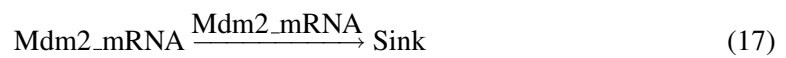
**Reactant**

Table 27: Properties of each reactant.

| Id | Name | SBO |
|---|---|---|
| Mdm2_mRNA | | |

**Modifier**

Table 28: Properties of each modifier.

| Id | Name | SBO |
|---|---|---|
| Mdm2_mRNA | | |

**Product**

Table 29: Properties of each product.

| Id | Name | SBO |
|---|---|---|
| Sink | | |

**Kinetic Law**

**Derived unit** contains undeclared units

$$v_8 = \text{kdegMdm2mRNA} \cdot \text{Mdm2\_mRNA} \qquad (18)$$

## 7.9 Reaction `P53Mdm2Binding`

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

**Reaction equation**

$$p53 + Mdm2 \xrightarrow{\text{p53, Mdm2}} Mdm2\_p53 \qquad (19)$$
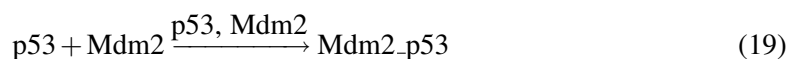
**Reactants**

Table 30: Properties of each reactant.

| Id | Name | SBO |
|----|------|-----|
| p53 | | |
| Mdm2 | | |

**Modifiers**

Table 31: Properties of each modifier.

| Id | Name | SBO |
|----|------|-----|
| p53 | | |
| Mdm2 | | |

**Product**

Table 32: Properties of each product.

| Id | Name | SBO |
|----|------|-----|
| Mdm2_p53 | | |

**Kinetic Law**

**Derived unit** contains undeclared units

$$v_9 = \text{kbinMdm2p53} \cdot \text{p53} \cdot \text{Mdm2} \qquad (20)$$

## 7.10 Reaction `P53Mdm2Release`

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

*Produced by SBML2LATEX*

**Reaction equation**

$$\text{Mdm2\_p53} \xrightarrow{\text{Mdm2\_p53}} \text{p53} + \text{Mdm2} \tag{21}$$

**Reactant**

Table 33: Properties of each reactant.

| Id | Name | SBO |
|---|---|---|
| Mdm2_p53 | | |

**Modifier**

Table 34: Properties of each modifier.

| Id | Name | SBO |
|---|---|---|
| Mdm2_p53 | | |

**Products**

Table 35: Properties of each product.

| Id | Name | SBO |
|---|---|---|
| p53 | | |
| Mdm2 | | |

**Kinetic Law**

**Derived unit**  contains undeclared units

$$v_{10} = \text{krelMdm2p53} \cdot \text{Mdm2\_p53} \tag{22}$$

## 7.11 Reaction `GSK3p53Binding`

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

**Reaction equation**

$$\text{GSK3b} + \text{p53} \xrightarrow{\text{GSK3b, p53}} \text{GSK3b\_p53} \tag{23}$$
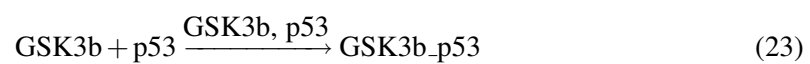
**Reactants**

Table 36: Properties of each reactant.

| Id | Name | SBO |
|---|---|---|
| GSK3b | | |
| p53 | | |

## Modifiers

Table 37: Properties of each modifier.

| Id | Name | SBO |
|---|---|---|
| GSK3b | | |
| p53 | | |

## Product

Table 38: Properties of each product.

| Id | Name | SBO |
|---|---|---|
| GSK3b_p53 | | |

## Kinetic Law

**Derived unit**  contains undeclared units

$$v_{11} = \text{kbinGSK3bp53} \cdot \text{GSK3b} \cdot \text{p53} \tag{24}$$

## 7.12 Reaction `GSK3p53Release`

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

**Reaction equation**

$$\text{GSK3b\_p53} \xrightarrow{\text{GSK3b\_p53}} \text{GSK3b} + \text{p53} \tag{25}$$
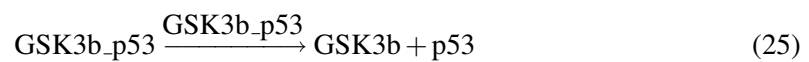
## Reactant

Table 39: Properties of each reactant.

| Id | Name | SBO |
|---|---|---|
| GSK3b_p53 | | |

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**Modifier**

Table 40: Properties of each modifier.

| Id | Name | SBO |
|---|---|---|
| GSK3b_p53 | | |

**Products**

Table 41: Properties of each product.

| Id | Name | SBO |
|---|---|---|
| GSK3b | | |
| p53 | | |

**Kinetic Law**

**Derived unit**  contains undeclared units

$$v_{12} = \text{krelGSK3bp53} \cdot \text{GSK3b\_p53} \tag{26}$$

## 7.13 Reaction `GSK3p53PBinding`

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

**Reaction equation**

$$\text{GSK3b} + \text{p53\_P} \xrightarrow{\text{GSK3b, p53\_P}} \text{GSK3b\_p53\_P} \tag{27}$$

**Reactants**

Table 42: Properties of each reactant.

| Id | Name | SBO |
|---|---|---|
| GSK3b | | |
| p53_P | | |

**Modifiers**

Table 43: Properties of each modifier.

| Id | Name | SBO |
|---|---|---|
| GSK3b | | |
| p53_P | | |

## Product

Table 44: Properties of each product.

| Id | Name | SBO |
|---|---|---|
| GSK3b_p53_P | | |

## Kinetic Law

**Derived unit**  contains undeclared units

$$v_{13} = \text{kbinGSK3bp53} \cdot \text{GSK3b} \cdot \text{p53\_P} \tag{28}$$

## 7.14 Reaction `GSK3_p53PRelease`

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

## Reaction equation

$$\text{GSK3b\_p53\_P} \xrightarrow{\text{GSK3b\_p53\_P}} \text{GSK3b} + \text{p53\_P} \tag{29}$$
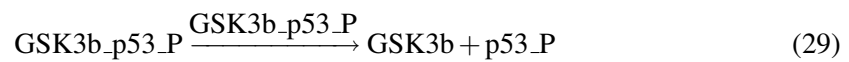
## Reactant

Table 45: Properties of each reactant.

| Id | Name | SBO |
|---|---|---|
| GSK3b_p53_P | | |

## Modifier

Table 46: Properties of each modifier.

| Id | Name | SBO |
|---|---|---|
| GSK3b_p53_P | | |

*Produced by* SBML2LATEX

**Products**

Table 47: Properties of each product.

| Id | Name | SBO |
|---|---|---|
| GSK3b | | |
| p53_P | | |

**Kinetic Law**

**Derived unit**  contains undeclared units

$$v_{14} = \text{krelGSK3bp53} \cdot \text{GSK3b\_p53\_P} \tag{30}$$

## 7.15 Reaction `E1UbBinding`

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

**Reaction equation**

$$\text{E1} + \text{Ub} + \text{ATP} \xrightarrow{\text{E1, Ub, ATP}} \text{E1\_Ub} + \text{AMP} \tag{31}$$
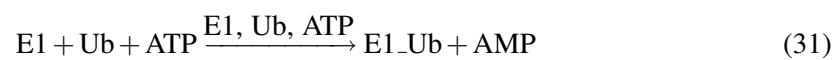
**Reactants**

Table 48: Properties of each reactant.

| Id | Name | SBO |
|---|---|---|
| E1 | | |
| Ub | | |
| ATP | | |

**Modifiers**

Table 49: Properties of each modifier.

| Id | Name | SBO |
|---|---|---|
| E1 | | |
| Ub | | |
| ATP | | |

**Products**

Table 50: Properties of each product.

| Id | Name | SBO |
|---|---|---|
| E1_Ub | | |
| AMP | | |

**Kinetic Law**

**Derived unit**  contains undeclared units

$$v_{15} = \frac{\text{kbinE1Ub} \cdot \text{E1} \cdot \text{Ub} \cdot \text{ATP}}{5000 + \text{ATP}} \tag{32}$$

## 7.16 Reaction `E2UbBinding`

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

**Reaction equation**

$$\text{E2} + \text{E1\_Ub} \xrightarrow{\text{E2, E1\_Ub}} \text{E2\_Ub} + \text{E1} \tag{33}$$
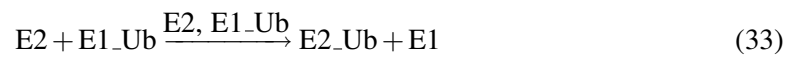
**Reactants**

Table 51: Properties of each reactant.

| Id | Name | SBO |
|---|---|---|
| E2 | | |
| E1_Ub | | |

**Modifiers**

Table 52: Properties of each modifier.

| Id | Name | SBO |
|---|---|---|
| E2 | | |
| E1_Ub | | |

**Products**

Table 53: Properties of each product.

| Id | Name | SBO |
|---|---|---|
| E2_Ub | | |
| E1 | | |

### Kinetic Law

**Derived unit** contains undeclared units

$$v_{16} = \text{kbinE2Ub} \cdot \text{E2} \cdot \text{E1\_Ub} \tag{34}$$

## 7.17 Reaction `Mdm2Ubiquitination`

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

### Reaction equation

$$\text{Mdm2} + \text{E2\_Ub} \xrightarrow{\text{Mdm2, E2\_Ub}} \text{Mdm2\_Ub} + \text{E2} \tag{35}$$

### Reactants

Table 54: Properties of each reactant.

| Id | Name | SBO |
|---|---|---|
| Mdm2 | | |
| E2_Ub | | |

### Modifiers

Table 55: Properties of each modifier.

| Id | Name | SBO |
|---|---|---|
| Mdm2 | | |
| E2_Ub | | |

### Products

Table 56: Properties of each product.

| Id | Name | SBO |
|---|---|---|
| Mdm2_Ub | | |
| E2 | | |

**Kinetic Law**

**Derived unit** contains undeclared units

$$v_{17} = \text{kMdm2Ub} \cdot \text{Mdm2} \cdot \text{E2\_Ub} \tag{36}$$

## 7.18 Reaction `Mdm2polyUbiquitination1`

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

**Reaction equation**

$$\text{Mdm2\_Ub} + \text{E2\_Ub} \xrightarrow{\text{Mdm2\_Ub, E2\_Ub}} \text{Mdm2\_Ub2} + \text{E2} \tag{37}$$
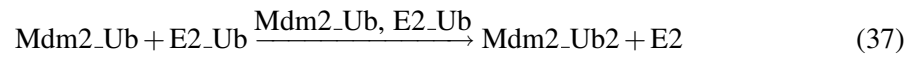
**Reactants**

Table 57: Properties of each reactant.

| Id | Name | SBO |
|---|---|---|
| Mdm2_Ub | | |
| E2_Ub | | |

**Modifiers**

Table 58: Properties of each modifier.

| Id | Name | SBO |
|---|---|---|
| Mdm2_Ub | | |
| E2_Ub | | |

**Products**

Table 59: Properties of each product.

| Id | Name | SBO |
|---|---|---|
| Mdm2_Ub2 | | |
| E2 | | |

**Kinetic Law**

**Derived unit**  contains undeclared units

$$v_{18} = \text{kMdm2PolyUb} \cdot \text{Mdm2\_Ub} \cdot \text{E2\_Ub} \tag{38}$$

## 7.19 Reaction `Mdm2polyUbiquitination2`

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

**Reaction equation**

$$\text{Mdm2\_Ub2} + \text{E2\_Ub} \xrightarrow{\text{Mdm2\_Ub2, E2\_Ub}} \text{Mdm2\_Ub3} + \text{E2} \tag{39}$$
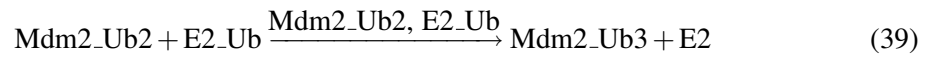
**Reactants**

Table 60: Properties of each reactant.

| Id | Name | SBO |
|---|---|---|
| Mdm2_Ub2 | | |
| E2_Ub | | |

**Modifiers**

Table 61: Properties of each modifier.

| Id | Name | SBO |
|---|---|---|
| Mdm2_Ub2 | | |
| E2_Ub | | |

**Products**

Table 62: Properties of each product.

| Id | Name | SBO |
|---|---|---|
| Mdm2_Ub3 | | |
| E2 | | |

**Kinetic Law**

**Derived unit** contains undeclared units

$$v_{19} = \text{kMdm2PolyUb} \cdot \text{Mdm2\_Ub2} \cdot \text{E2\_Ub} \tag{40}$$

## 7.20 Reaction `Mdm2polyUbiquitination3`

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

**Reaction equation**

$$\text{Mdm2\_Ub3} + \text{E2\_Ub} \xrightarrow{\text{Mdm2\_Ub3, E2\_Ub}} \text{Mdm2\_Ub4} + \text{E2} \tag{41}$$
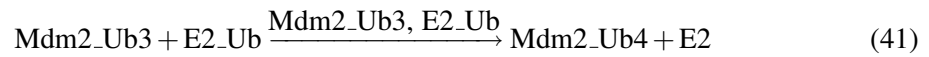
**Reactants**

Table 63: Properties of each reactant.

| Id | Name | SBO |
|---|---|---|
| Mdm2_Ub3 | | |
| E2_Ub | | |

**Modifiers**

Table 64: Properties of each modifier.

| Id | Name | SBO |
|---|---|---|
| Mdm2_Ub3 | | |
| E2_Ub | | |

**Products**

Table 65: Properties of each product.

| Id | Name | SBO |
|---|---|---|
| Mdm2_Ub4 | | |
| E2 | | |

### Kinetic Law

**Derived unit** contains undeclared units

$$v_{20} = \text{kMdm2PolyUb} \cdot \text{Mdm2\_Ub3} \cdot \text{E2\_Ub} \tag{42}$$

## 7.21 Reaction `Mdm2Deubiquitination4`

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

### Reaction equation

$$\text{Mdm2\_Ub4} + \text{Mdm2DUB} \xrightarrow{\text{Mdm2\_Ub4, Mdm2DUB}} \text{Mdm2\_Ub3} + \text{Mdm2DUB} + \text{Ub} \tag{43}$$
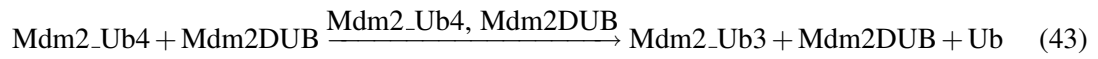
### Reactants

Table 66: Properties of each reactant.

| Id | Name | SBO |
|---|---|---|
| Mdm2_Ub4 | | |
| Mdm2DUB | | |

### Modifiers

Table 67: Properties of each modifier.

| Id | Name | SBO |
|---|---|---|
| Mdm2_Ub4 | | |
| Mdm2DUB | | |

### Products

Table 68: Properties of each product.

| Id | Name | SBO |
|---|---|---|
| Mdm2_Ub3 | | |
| Mdm2DUB | | |
| Ub | | |

### Kinetic Law

**Derived unit**  contains undeclared units

$$v_{21} = \text{kactDUBMdm2} \cdot \text{Mdm2\_Ub4} \cdot \text{Mdm2DUB} \tag{44}$$

## 7.22 Reaction `Mdm2Deubiquitination3`

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

### Reaction equation

$$\text{Mdm2\_Ub3} + \text{Mdm2DUB} \xrightarrow{\text{Mdm2\_Ub3, Mdm2DUB}} \text{Mdm2\_Ub2} + \text{Mdm2DUB} + \text{Ub} \tag{45}$$
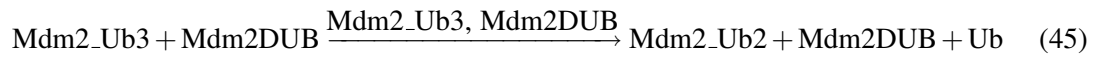
### Reactants

Table 69: Properties of each reactant.

| Id | Name | SBO |
|---|---|---|
| Mdm2_Ub3 | | |
| Mdm2DUB | | |

### Modifiers

Table 70: Properties of each modifier.

| Id | Name | SBO |
|---|---|---|
| Mdm2_Ub3 | | |
| Mdm2DUB | | |

### Products

Table 71: Properties of each product.

| Id | Name | SBO |
|---|---|---|
| Mdm2_Ub2 | | |
| Mdm2DUB | | |
| Ub | | |

**Kinetic Law**

**Derived unit**  contains undeclared units

$$v_{22} = \text{kactDUBMdm2} \cdot \text{Mdm2\_Ub3} \cdot \text{Mdm2DUB} \tag{46}$$

## 7.23 Reaction `Mdm2Deubiquitination2`

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

**Reaction equation**

$$\text{Mdm2\_Ub2} + \text{Mdm2DUB} \xrightarrow{\text{Mdm2\_Ub2, Mdm2DUB}} \text{Mdm2\_Ub} + \text{Mdm2DUB} + \text{Ub} \tag{47}$$
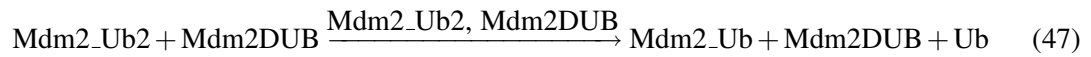
**Reactants**

Table 72: Properties of each reactant.

| Id | Name | SBO |
|---|---|---|
| Mdm2_Ub2 | | |
| Mdm2DUB | | |

**Modifiers**

Table 73: Properties of each modifier.

| Id | Name | SBO |
|---|---|---|
| Mdm2_Ub2 | | |
| Mdm2DUB | | |

**Products**

Table 74: Properties of each product.

| Id | Name | SBO |
|---|---|---|
| Mdm2_Ub | | |
| Mdm2DUB | | |
| Ub | | |

**Kinetic Law**

**Derived unit** contains undeclared units

$$v_{23} = \text{kactDUBMdm2} \cdot \text{Mdm2\_Ub2} \cdot \text{Mdm2DUB} \tag{48}$$

## 7.24 Reaction `Mdm2Deubiquitination1`

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

**Reaction equation**

$$\text{Mdm2\_Ub} + \text{Mdm2DUB} \xrightarrow{\text{Mdm2\_Ub, Mdm2DUB}} \text{Mdm2} + \text{Mdm2DUB} + \text{Ub} \tag{49}$$
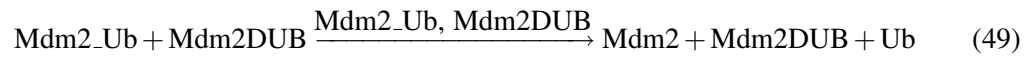
**Reactants**

Table 75: Properties of each reactant.

| Id | Name | SBO |
|---|---|---|
| Mdm2_Ub | | |
| Mdm2DUB | | |

**Modifiers**

Table 76: Properties of each modifier.

| Id | Name | SBO |
|---|---|---|
| Mdm2_Ub | | |
| Mdm2DUB | | |

**Products**

Table 77: Properties of each product.

| Id | Name | SBO |
|---|---|---|
| Mdm2 | | |
| Mdm2DUB | | |
| Ub | | |

**Kinetic Law**

**Derived unit**  contains undeclared units

$$v_{24} = \text{kactDUBMdm2} \cdot \text{Mdm2\_Ub} \cdot \text{Mdm2DUB} \tag{50}$$

## 7.25 Reaction `Mdm2ProteasomeBinding1`

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

**Reaction equation**

$$\text{Mdm2\_Ub4} + \text{Proteasome} \xrightarrow{\text{Mdm2\_Ub4, Proteasome}} \text{Mdm2\_Ub4\_Proteasome} \tag{51}$$

**Reactants**

Table 78: Properties of each reactant.

| Id | Name | SBO |
|---|---|---|
| Mdm2_Ub4 | | |
| Proteasome | | |

**Modifiers**

Table 79: Properties of each modifier.

| Id | Name | SBO |
|---|---|---|
| Mdm2_Ub4 | | |
| Proteasome | | |

**Product**

Table 80: Properties of each product.

| Id | Name | SBO |
|---|---|---|
| Mdm2_Ub4_Proteasome | | |

**Kinetic Law**

**Derived unit**  contains undeclared units

$$v_{25} = \text{kbinProt} \cdot \text{Mdm2\_Ub4} \cdot \text{Proteasome} \tag{52}$$

## 7.26 Reaction `Mdm2Degradation`

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

**Reaction equation**

$$\text{Mdm2\_Ub4\_Proteasome} \xrightarrow{\text{Mdm2\_Ub4\_Proteasome}} \text{Proteasome} + 4\,\text{Ub} \tag{53}$$

**Reactant**

Table 81: Properties of each reactant.

| Id | Name | SBO |
|---|---|---|
| Mdm2_Ub4_Proteasome | | |

**Modifier**

Table 82: Properties of each modifier.

| Id | Name | SBO |
|---|---|---|
| Mdm2_Ub4_Proteasome | | |

**Products**

Table 83: Properties of each product.

| Id | Name | SBO |
|---|---|---|
| Proteasome | | |
| Ub | | |

**Kinetic Law**

**Derived unit** contains undeclared units

$$v_{26} = \text{kdegMdm2} \cdot \text{Mdm2\_Ub4\_Proteasome} \cdot \text{kproteff} \tag{54}$$

## 7.27 Reaction `p53Synthesis`

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

**Reaction equation**

$$\text{p53\_mRNA} \xrightarrow{\text{p53\_mRNA}} \text{p53} + \text{p53\_mRNA} \tag{55}$$

**Reactant**

Table 84: Properties of each reactant.

| Id | Name | SBO |
|----|------|-----|
| p53_mRNA | | |

**Modifier**

Table 85: Properties of each modifier.

| Id | Name | SBO |
|----|------|-----|
| p53_mRNA | | |

**Products**

Table 86: Properties of each product.

| Id | Name | SBO |
|----|------|-----|
| p53 | | |
| p53_mRNA | | |

**Kinetic Law**

**Derived unit** contains undeclared units

$$v_{27} = \text{ksynp53} \cdot \text{p53\_mRNA} \tag{56}$$

## 7.28 Reaction `p53Monoubiquitination`

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

**Reaction equation**

$$\text{E2\_Ub} + \text{Mdm2\_p53} \xrightarrow{\text{E2\_Ub, Mdm2\_p53}} \text{Mdm2\_p53\_Ub} + \text{E2} \tag{57}$$
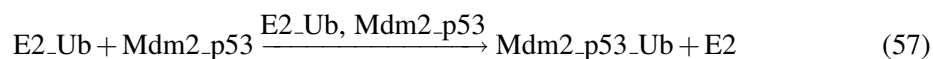
**Reactants**

Table 87: Properties of each reactant.

| Id | Name | SBO |
|---|---|---|
| E2_Ub | | |
| Mdm2_p53 | | |

**Modifiers**

Table 88: Properties of each modifier.

| Id | Name | SBO |
|---|---|---|
| E2_Ub | | |
| Mdm2_p53 | | |

**Products**

Table 89: Properties of each product.

| Id | Name | SBO |
|---|---|---|
| Mdm2_p53_Ub | | |
| E2 | | |

**Kinetic Law**

**Derived unit**  contains undeclared units

$$v_{28} = \text{kp53Ub} \cdot \text{E2\_Ub} \cdot \text{Mdm2\_p53} \tag{58}$$

## 7.29 Reaction `p53Polyubiquitination1`

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

**Reaction equation**

$$\text{Mdm2\_p53\_Ub} + \text{E2\_Ub} \xrightarrow{\text{Mdm2\_p53\_Ub, E2\_Ub}} \text{Mdm2\_p53\_Ub2} + \text{E2} \qquad (59)$$
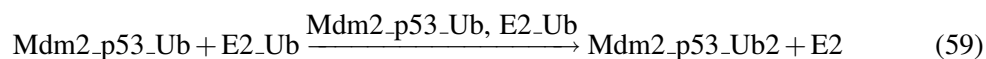
**Reactants**

Table 90: Properties of each reactant.

| Id | Name | SBO |
|---|---|---|
| Mdm2_p53_Ub | | |
| E2_Ub | | |

**Modifiers**

Table 91: Properties of each modifier.

| Id | Name | SBO |
|---|---|---|
| Mdm2_p53_Ub | | |
| E2_Ub | | |

**Products**

Table 92: Properties of each product.

| Id | Name | SBO |
|---|---|---|
| Mdm2_p53_Ub2 | | |
| E2 | | |

**Kinetic Law**

**Derived unit**  contains undeclared units

$$v_{29} = \text{kp53PolyUb} \cdot \text{Mdm2\_p53\_Ub} \cdot \text{E2\_Ub} \qquad (60)$$

## 7.30 Reaction p53Polyubiquitination2

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

**Reaction equation**

$$\text{Mdm2\_p53\_Ub2} + \text{E2\_Ub} \xrightarrow{\text{Mdm2\_p53\_Ub2, E2\_Ub}} \text{Mdm2\_p53\_Ub3} + \text{E2} \qquad (61)$$

**Reactants**

Table 93: Properties of each reactant.

| Id | Name | SBO |
|---|---|---|
| Mdm2_p53_Ub2 | | |
| E2_Ub | | |

**Modifiers**

Table 94: Properties of each modifier.

| Id | Name | SBO |
|---|---|---|
| Mdm2_p53_Ub2 | | |
| E2_Ub | | |

**Products**

Table 95: Properties of each product.

| Id | Name | SBO |
|---|---|---|
| Mdm2_p53_Ub3 | | |
| E2 | | |

**Kinetic Law**

**Derived unit** contains undeclared units

$$v_{30} = \text{kp53PolyUb} \cdot \text{Mdm2\_p53\_Ub2} \cdot \text{E2\_Ub} \qquad (62)$$

## 7.31 Reaction `p53Polyubiquitination3`

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

**Reaction equation**

$$\text{Mdm2\_p53\_Ub3} + \text{E2\_Ub} \xrightarrow{\text{Mdm2\_p53\_Ub3, E2\_Ub}} \text{Mdm2\_p53\_Ub4} + \text{E2} \qquad (63)$$
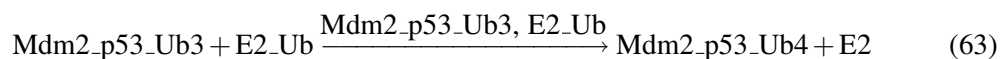
**Reactants**

Table 96: Properties of each reactant.

| Id | Name | SBO |
|----|------|-----|
| Mdm2_p53_Ub3 | | |
| E2_Ub | | |

**Modifiers**

Table 97: Properties of each modifier.

| Id | Name | SBO |
|----|------|-----|
| Mdm2_p53_Ub3 | | |
| E2_Ub | | |

**Products**

Table 98: Properties of each product.

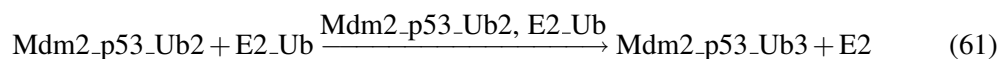| Id | Name | SBO |
|----|------|-----|
| Mdm2_p53_Ub4 | | |
| E2 | | |

**Kinetic Law**

**Derived unit** contains undeclared units

$$v_{31} = \text{kp53PolyUb} \cdot \text{Mdm2\_p53\_Ub3} \cdot \text{E2\_Ub} \qquad (64)$$

## 7.32 Reaction p53Deubiqutination4

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

**Reaction equation**

$$\text{Mdm2\_p53\_Ub4} + \text{p53DUB} \xrightarrow{\text{Mdm2\_p53\_Ub4, p53DUB}} \text{Mdm2\_p53\_Ub3} + \text{p53DUB} + \text{Ub} \tag{65}$$
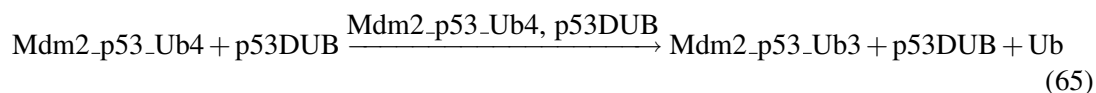
**Reactants**

Table 99: Properties of each reactant.

| Id | Name | SBO |
|----|------|-----|
| Mdm2_p53_Ub4 | | |
| p53DUB | | |

**Modifiers**

Table 100: Properties of each modifier.

| Id | Name | SBO |
|----|------|-----|
| Mdm2_p53_Ub4 | | |
| p53DUB | | |

**Products**

Table 101: Properties of each product.

| Id | Name | SBO |
|----|------|-----|
| Mdm2_p53_Ub3 | | |
| p53DUB | | |
| Ub | | |

**Kinetic Law**

**Derived unit** contains undeclared units

$$v_{32} = \text{kactDUBp53} \cdot \text{Mdm2\_p53\_Ub4} \cdot \text{p53DUB} \tag{66}$$

*Produced by SBML2LATEX*

## 7.33 Reaction `p53Deubiquitination3`

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

**Reaction equation**

$$\text{Mdm2\_p53\_Ub3} + \text{p53DUB} \xrightarrow{\text{Mdm2\_p53\_Ub3, p53DUB}} \text{Mdm2\_p53\_Ub2} + \text{p53DUB} + \text{Ub}$$

(67)

**Reactants**

Table 102: Properties of each reactant.

| Id | Name | SBO |
|---|---|---|
| Mdm2_p53_Ub3 | | |
| p53DUB | | |

**Modifiers**

Table 103: Properties of each modifier.

| Id | Name | SBO |
|---|---|---|
| Mdm2_p53_Ub3 | | |
| p53DUB | | |

**Products**

Table 104: Properties of each product.

| Id | Name | SBO |
|---|---|---|
| Mdm2_p53_Ub2 | | |
| p53DUB | | |
| Ub | | |

**Kinetic Law**

**Derived unit**  contains undeclared units

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

(68)

## 7.34 Reaction `p53Deubiquitination2`

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

**Reaction equation**

$$\text{Mdm2\_p53\_Ub2} + \text{p53DUB} \xrightarrow{\text{Mdm2\_p53\_Ub2, p53DUB}} \text{Mdm2\_p53\_Ub} + \text{p53DUB} + \text{Ub} \tag{69}$$

**Reactants**

Table 105: Properties of each reactant.

| Id | Name | SBO |
|----|------|-----|
| Mdm2_p53_Ub2 | | |
| p53DUB | | |

**Modifiers**

Table 106: Properties of each modifier.

| Id | Name | SBO |
|----|------|-----|
| Mdm2_p53_Ub2 | | |
| p53DUB | | |

**Products**

Table 107: Properties of each product.

| Id | Name | SBO |
|----|------|-----|
| Mdm2_p53_Ub | | |
| p53DUB | | |
| Ub | | |

**Kinetic Law**

**Derived unit**  contains undeclared units

$$v_{34} = \text{kactDUBp53} \cdot \text{Mdm2\_p53\_Ub2} \cdot \text{p53DUB} \tag{70}$$

## 7.35 Reaction `p53Deubiquitination1`

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

**Reaction equation**

$$\text{Mdm2\_p53\_Ub} + \text{p53DUB} \xrightarrow{\text{Mdm2\_p53\_Ub, p53DUB}} \text{Mdm2\_p53} + \text{p53DUB} + \text{Ub} \qquad (71)$$
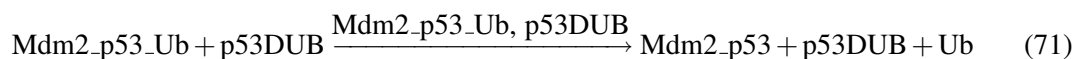
**Reactants**

Table 108: Properties of each reactant.

| Id | Name | SBO |
|---|---|---|
| Mdm2_p53_Ub | | |
| p53DUB | | |

**Modifiers**

Table 109: Properties of each modifier.

| Id | Name | SBO |
|---|---|---|
| Mdm2_p53_Ub | | |
| p53DUB | | |

**Products**

Table 110: Properties of each product.

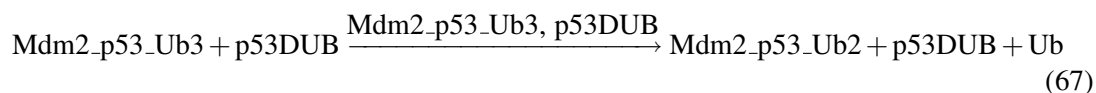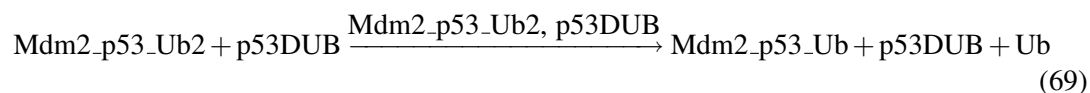| Id | Name | SBO |
|---|---|---|
| Mdm2_p53 | | |
| p53DUB | | |
| Ub | | |

**Kinetic Law**

**Derived unit** contains undeclared units

$$v_{35} = \text{kactDUBp53} \cdot \text{Mdm2\_p53\_Ub} \cdot \text{p53DUB} \qquad (72)$$

## 7.36 Reaction `Mdm2GSK3phosphorylation1`

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

### Reaction equation

$$\text{Mdm2\_p53\_Ub4} + \text{GSK3b} \xrightarrow{\text{Mdm2\_p53\_Ub4, GSK3b}} \text{Mdm2\_P1\_p53\_Ub4} + \text{GSK3b} \qquad (73)$$
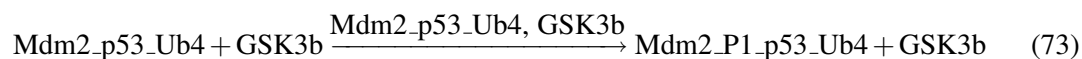
### Reactants

Table 111: Properties of each reactant.

| Id | Name | SBO |
|---|---|---|
| Mdm2_p53_Ub4 | | |
| GSK3b | | |

### Modifiers

Table 112: Properties of each modifier.

| Id | Name | SBO |
|---|---|---|
| Mdm2_p53_Ub4 | | |
| GSK3b | | |

### Products

Table 113: Properties of each product.

| Id | Name | SBO |
|---|---|---|
| Mdm2_P1_p53_Ub4 | | |
| GSK3b | | |

### Kinetic Law

**Derived unit** contains undeclared units

$$v_{36} = \text{kphosMdm2GSK3b} \cdot \text{Mdm2\_p53\_Ub4} \cdot \text{GSK3b} \qquad (74)$$

## 7.37 Reaction `Mdm2GSK3phosphorylation2`

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

### Reaction equation

$$\text{Mdm2\_p53\_Ub4} + \text{GSK3b\_p53} \xrightarrow{\text{Mdm2\_p53\_Ub4, GSK3b\_p53}} \text{Mdm2\_P1\_p53\_Ub4} + \text{GSK3b\_p53} \tag{75}$$
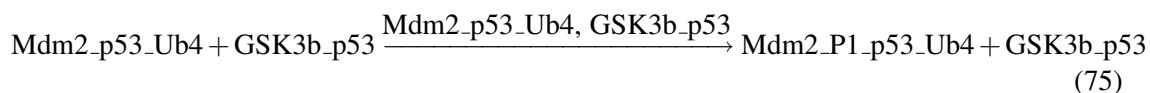
### Reactants

Table 114: Properties of each reactant.

| Id | Name | SBO |
|---|---|---|
| Mdm2_p53_Ub4 | | |
| GSK3b_p53 | | |

### Modifiers

Table 115: Properties of each modifier.

| Id | Name | SBO |
|---|---|---|
| Mdm2_p53_Ub4 | | |
| GSK3b_p53 | | |

### Products

Table 116: Properties of each product.

| Id | Name | SBO |
|---|---|---|
| Mdm2_P1_p53_Ub4 | | |
| GSK3b_p53 | | |

### Kinetic Law

**Derived unit**  contains undeclared units

$$v_{37} = \text{kphosMdm2GSK3bp53} \cdot \text{Mdm2\_p53\_Ub4} \cdot \text{GSK3b\_p53} \tag{76}$$

## 7.38 Reaction `Mdm2GSK3phosphorylation3`

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

**Reaction equation**

$$\text{Mdm2\_p53\_Ub4} + \text{GSK3b\_p53\_P} \xrightarrow{\text{Mdm2\_p53\_Ub4, GSK3b\_p53\_P}} \text{Mdm2\_P1\_p53\_Ub4} + \text{GSK3b\_p53\_P} \tag{77}$$
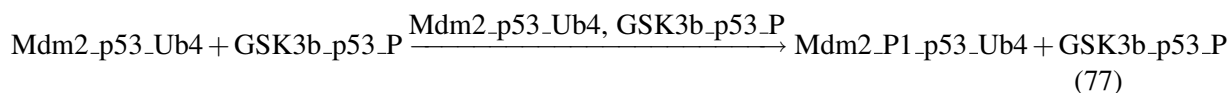
**Reactants**

Table 117: Properties of each reactant.

| Id | Name | SBO |
|----|------|-----|
| Mdm2_p53_Ub4 | | |
| GSK3b_p53_P | | |

**Modifiers**

Table 118: Properties of each modifier.

| Id | Name | SBO |
|----|------|-----|
| Mdm2_p53_Ub4 | | |
| GSK3b_p53_P | | |

**Products**

Table 119: Properties of each product.

| Id | Name | SBO |
|----|------|-----|
| Mdm2_P1_p53_Ub4 | | |
| GSK3b_p53_P | | |

**Kinetic Law**

**Derived unit**  contains undeclared units

$$v_{38} = \text{kphosMdm2GSK3bp53} \cdot \text{Mdm2\_p53\_Ub4} \cdot \text{GSK3b\_p53\_P} \tag{78}$$

### 7.39 Reaction p53ProteasomeBinding1

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

**Reaction equation**

$$\text{Mdm2\_P1\_p53\_Ub4} + \text{Proteasome} \xrightarrow{\text{Mdm2\_P1\_p53\_Ub4, Proteasome}} \text{p53\_Ub4\_Proteasome} + \text{Mdm2} \tag{79}$$
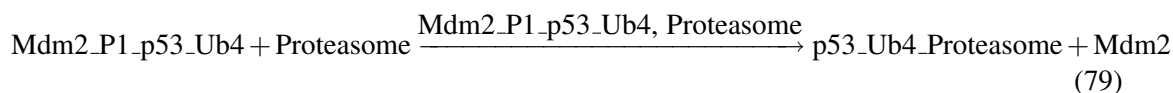
**Reactants**

Table 120: Properties of each reactant.

| Id | Name | SBO |
|---|---|---|
| Mdm2_P1_p53_Ub4 | | |
| Proteasome | | |

**Modifiers**

Table 121: Properties of each modifier.

| Id | Name | SBO |
|---|---|---|
| Mdm2_P1_p53_Ub4 | | |
| Proteasome | | |

**Products**

Table 122: Properties of each product.

| Id | Name | SBO |
|---|---|---|
| p53_Ub4_Proteasome | | |
| Mdm2 | | |

**Kinetic Law**

**Derived unit** contains undeclared units

$$v_{39} = \text{kbinProt} \cdot \text{Mdm2\_P1\_p53\_Ub4} \cdot \text{Proteasome} \tag{80}$$

## 7.40 Reaction `Degradationp53_Ub4`

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

**Reaction equation**

$$\text{p53\_Ub4\_Proteasome} + \text{ATP} \xrightarrow{\text{p53\_Ub4\_Proteasome, ATP}} 4\,\text{Ub} + \text{Proteasome} + \text{ADP} \qquad (81)$$
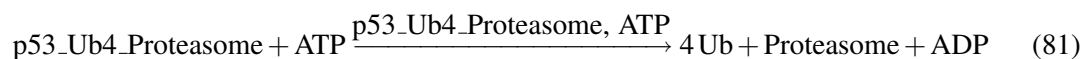
**Reactants**

Table 123: Properties of each reactant.

| Id | Name | SBO |
|---|---|---|
| p53_Ub4_Proteasome | | |
| ATP | | |

**Modifiers**

Table 124: Properties of each modifier.

| Id | Name | SBO |
|---|---|---|
| p53_Ub4_Proteasome | | |
| ATP | | |

**Products**

Table 125: Properties of each product.

| Id | Name | SBO |
|---|---|---|
| Ub | | |
| Proteasome | | |
| ADP | | |

**Kinetic Law**

**Derived unit**  contains undeclared units

$$v_{40} = \frac{\text{kdegp53} \cdot \text{kproteff} \cdot \text{p53\_Ub4\_Proteasome} \cdot \text{ATP}}{5000 + \text{ATP}} \qquad (82)$$

### 7.41 Reaction `TauMTbinding`

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

**Reaction equation**

$$Tau \xrightarrow{Tau} MT\_Tau \tag{83}$$

**Reactant**

Table 126: Properties of each reactant.

| Id | Name | SBO |
|----|------|-----|
| Tau | | |

**Modifier**

Table 127: Properties of each modifier.

| Id | Name | SBO |
|----|------|-----|
| Tau | | |

**Product**

Table 128: Properties of each product.

| Id | Name | SBO |
|----|------|-----|
| MT_Tau | | |

**Kinetic Law**

**Derived unit** contains undeclared units

$$v_{41} = \text{kbinMTTau} \cdot \text{Tau} \tag{84}$$

### 7.42 Reaction `TauMTrelease`

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

**Reaction equation**

$$MT\_Tau \xrightarrow{MT\_Tau} Tau \tag{85}$$

**Reactant**

Table 129: Properties of each reactant.

| Id | Name | SBO |
|---|---|---|
| MT_Tau | | |

**Modifier**

Table 130: Properties of each modifier.

| Id | Name | SBO |
|---|---|---|
| MT_Tau | | |

**Product**

Table 131: Properties of each product.

| Id | Name | SBO |
|---|---|---|
| Tau | | |

**Kinetic Law**

**Derived unit** contains undeclared units

$$v_{42} = \text{krelMTTau} \cdot \text{MT\_Tau} \tag{86}$$

## 7.43 Reaction `Tauphosphorylation1`

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

**Reaction equation**

$$\text{GSK3b\_p53} + \text{Tau} \xrightarrow{\text{GSK3b\_p53, Tau}} \text{GSK3b\_p53} + \text{Tau\_P1} \tag{87}$$

**Reactants**

Table 132: Properties of each reactant.

| Id | Name | SBO |
|---|---|---|
| GSK3b_p53 | | |
| Tau | | |

**Modifiers**

Table 133: Properties of each modifier.

| Id | Name | SBO |
|---|---|---|
| GSK3b_p53 | | |
| Tau | | |

**Products**

Table 134: Properties of each product.

| Id | Name | SBO |
|---|---|---|
| GSK3b_p53 | | |
| Tau_P1 | | |

**Kinetic Law**

**Derived unit**  contains undeclared units

$$v_{43} = \text{kphospTauGSK3bp53} \cdot \text{GSK3b\_p53} \cdot \text{Tau} \tag{88}$$

## 7.44 Reaction `Tauphosphorylation2`

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

**Reaction equation**

$$\text{GSK3b\_p53} + \text{Tau\_P1} \xrightarrow{\text{GSK3b\_p53, Tau\_P1}} \text{GSK3b\_p53} + \text{Tau\_P2} \tag{89}$$

**Reactants**

Table 135: Properties of each reactant.

| Id | Name | SBO |
|---|---|---|
| GSK3b_p53 | | |
| Tau_P1 | | |

**Modifiers**

Table 136: Properties of each modifier.

| Id | Name | SBO |
|---|---|---|
| GSK3b_p53 | | |
| Tau_P1 | | |

**Products**

Table 137: Properties of each product.

| Id | Name | SBO |
|---|---|---|
| GSK3b_p53 | | |
| Tau_P2 | | |

**Kinetic Law**

**Derived unit**  contains undeclared units

$$v_{44} = \text{kphospTauGSK3bp53} \cdot \text{GSK3b\_p53} \cdot \text{Tau\_P1} \tag{90}$$

## 7.45 Reaction `Tauphosphorylation3`

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

**Reaction equation**

$$\text{GSK3b\_p53\_P} + \text{Tau} \xrightarrow{\text{GSK3b\_p53\_P, Tau}} \text{GSK3b\_p53\_P} + \text{Tau\_P1} \tag{91}$$

**Reactants**

Table 138: Properties of each reactant.

| Id | Name | SBO |
|---|---|---|
| GSK3b_p53_P | | |
| Tau | | |

## Modifiers

Table 139: Properties of each modifier.

| Id | Name | SBO |
|---|---|---|
| GSK3b_p53_P | | |
| Tau | | |

## Products

Table 140: Properties of each product.

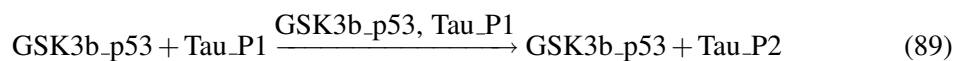| Id | Name | SBO |
|---|---|---|
| GSK3b_p53_P | | |
| Tau_P1 | | |

## Kinetic Law

**Derived unit** contains undeclared units

$$v_{45} = \text{kphospTauGSK3bp53} \cdot \text{GSK3b\_p53\_P} \cdot \text{Tau} \tag{92}$$

## 7.46 Reaction `Tauphosphorylation4`

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

## Reaction equation

$$\text{GSK3b\_p53\_P} + \text{Tau\_P1} \xrightarrow{\text{GSK3b\_p53\_P, Tau\_P1}} \text{GSK3b\_p53\_P} + \text{Tau\_P2} \tag{93}$$

## Reactants

Table 141: Properties of each reactant.

| Id | Name | SBO |
|---|---|---|
| GSK3b_p53_P | | |
| Tau_P1 | | |

**Modifiers**

Table 142: Properties of each modifier.

| Id | Name | SBO |
|---|---|---|
| GSK3b_p53_P | | |
| Tau_P1 | | |

**Products**

Table 143: Properties of each product.

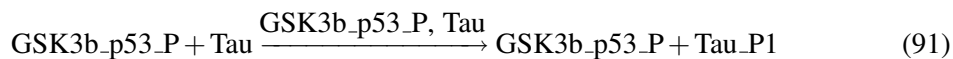| Id | Name | SBO |
|---|---|---|
| GSK3b_p53_P | | |
| Tau_P2 | | |

**Kinetic Law**

**Derived unit** contains undeclared units

$$v_{46} = \text{kphospTauGSK3bp53} \cdot \text{GSK3b\_p53\_P} \cdot \text{Tau\_P1} \tag{94}$$

## 7.47 Reaction `Tauphosphorylation5`

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

**Reaction equation**

$$\text{GSK3b} + \text{Tau} \xrightarrow{\text{GSK3b, Tau}} \text{GSK3b} + \text{Tau\_P1} \tag{95}$$

**Reactants**

Table 144: Properties of each reactant.

| Id | Name | SBO |
|---|---|---|
| GSK3b | | |
| Tau | | |

**Modifiers**

Table 145: Properties of each modifier.

| Id | Name | SBO |
|---|---|---|
| GSK3b | | |
| Tau | | |

**Products**

Table 146: Properties of each product.

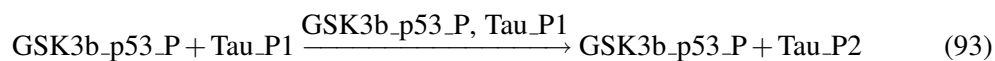| Id | Name | SBO |
|---|---|---|
| GSK3b | | |
| Tau_P1 | | |

**Kinetic Law**

**Derived unit** contains undeclared units

$$v_{47} = \text{kphospTauGSK3b} \cdot \text{GSK3b} \cdot \text{Tau} \tag{96}$$

## 7.48 Reaction `Tauphosphorylation6`

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

**Reaction equation**

$$\text{GSK3b} + \text{Tau\_P1} \xrightarrow{\text{GSK3b, Tau\_P1}} \text{GSK3b} + \text{Tau\_P2} \tag{97}$$

**Reactants**

Table 147: Properties of each reactant.

| Id | Name | SBO |
|---|---|---|
| GSK3b | | |
| Tau_P1 | | |

## Modifiers

Table 148: Properties of each modifier.

| Id | Name | SBO |
|---|---|---|
| GSK3b | | |
| Tau_P1 | | |

## Products

Table 149: Properties of each product.

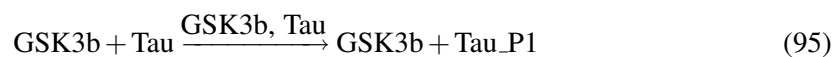| Id | Name | SBO |
|---|---|---|
| GSK3b | | |
| Tau_P2 | | |

## Kinetic Law

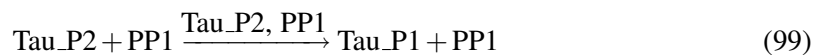**Derived unit**  contains undeclared units

$$v_{48} = \text{kphospTauGSK3b} \cdot \text{GSK3b} \cdot \text{Tau\_P1} \tag{98}$$

## 7.49 Reaction `Taudephosphorylation1`

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

## Reaction equation

$$\text{Tau\_P2} + \text{PP1} \xrightarrow{\text{Tau\_P2, PP1}} \text{Tau\_P1} + \text{PP1} \tag{99}$$

## Reactants

Table 150: Properties of each reactant.

| Id | Name | SBO |
|---|---|---|
| Tau_P2 | | |
| PP1 | | |

## Modifiers

Table 151: Properties of each modifier.

| Id | Name | SBO |
|---|---|---|
| Tau_P2 | | |
| PP1 | | |

## Products

Table 152: Properties of each product.

| Id | Name | SBO |
|---|---|---|
| Tau_P1 | | |
| PP1 | | |

## Kinetic Law

**Derived unit**  contains undeclared units

$$v_{49} = \text{kdephospTau} \cdot \text{Tau\_P2} \cdot \text{PP1} \tag{100}$$

## 7.50 Reaction `Taudephosphorylation2`

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

## Reaction equation

$$\text{Tau\_P1} + \text{PP1} \xrightarrow{\text{Tau\_P1, PP1}} \text{Tau} + \text{PP1} \tag{101}$$

## Reactants

Table 153: Properties of each reactant.

| Id | Name | SBO |
|----|------|-----|
| Tau_P1 | | |
| PP1 | | |

## Modifiers

Table 154: Properties of each modifier.

| Id | Name | SBO |
|----|------|-----|
| Tau_P1 | | |
| PP1 | | |

## Products

Table 155: Properties of each product.

| Id | Name | SBO |
|----|------|-----|
| Tau | | |
| PP1 | | |

## Kinetic Law

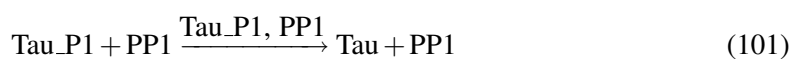**Derived unit** contains undeclared units

$$v_{50} = \text{kdephospTau} \cdot \text{Tau\_P1} \cdot \text{PP1} \tag{102}$$

## 7.51 Reaction `TauP1Aggregation1`

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

**Reaction equation**

$$2\,\text{Tau\_P1} \xrightarrow{\text{Tau\_P1}} 2\,\text{AggTau} \tag{103}$$

**Reactant**

Table 156: Properties of each reactant.

| Id | Name | SBO |
|---|---|---|
| Tau_P1 | | |

## Modifier

Table 157: Properties of each modifier.

| Id | Name | SBO |
|---|---|---|
| Tau_P1 | | |

## Product

Table 158: Properties of each product.

| Id | Name | SBO |
|---|---|---|
| AggTau | | |

## Kinetic Law

**Derived unit** contains undeclared units

$$v_{51} = \text{kaggTauP1} \cdot \text{Tau\_P1}^2 \cdot 0.5 \tag{104}$$

## 7.52 Reaction `TauP1Aggregation2`

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

## Reaction equation

$$\text{Tau\_P1} + \text{AggTau} \xrightarrow{\text{Tau\_P1, AggTau}} 2\,\text{AggTau} \tag{105}$$

## Reactants

Table 159: Properties of each reactant.

| Id | Name | SBO |
|---|---|---|
| Tau_P1 | | |
| AggTau | | |

**Modifiers**

Table 160: Properties of each modifier.

| Id | Name | SBO |
|---|---|---|
| Tau_P1 | | |
| AggTau | | |

**Product**

Table 161: Properties of each product.

| Id | Name | SBO |
|---|---|---|
| AggTau | | |

**Kinetic Law**

**Derived unit**  contains undeclared units

$$v_{52} = \text{kaggTauP1} \cdot \text{Tau\_P1} \cdot \text{AggTau} \tag{106}$$

## 7.53 Reaction `TauP2Aggregation1`

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

**Reaction equation**

$$2\,\text{Tau\_P2} \xrightarrow{\text{Tau\_P2}} 2\,\text{AggTau} \tag{107}$$

**Reactant**

Table 162: Properties of each reactant.

| Id | Name | SBO |
|---|---|---|
| Tau_P2 | | |

**Modifier**

Table 163: Properties of each modifier.

| Id | Name | SBO |
|---|---|---|
| Tau_P2 | | |

### Product

Table 164: Properties of each product.

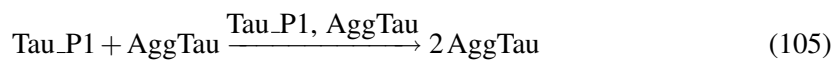| Id | Name | SBO |
|---|---|---|
| AggTau | | |

### Kinetic Law

**Derived unit**  contains undeclared units

$$v_{53} = \text{kaggTauP2} \cdot \text{Tau\_P2}^2 \cdot 0.5 \tag{108}$$

## 7.54 Reaction `TauP2Aggregation2`

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

### Reaction equation

$$\text{Tau\_P2} + \text{AggTau} \xrightarrow{\text{Tau\_P2, AggTau}} 2\,\text{AggTau} \tag{109}$$
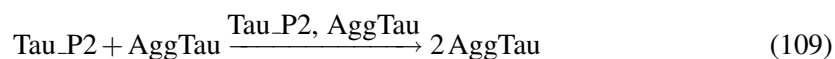
### Reactants

Table 165: Properties of each reactant.

| Id | Name | SBO |
|---|---|---|
| Tau_P2 | | |
| AggTau | | |

### Modifiers

Table 166: Properties of each modifier.

| Id | Name | SBO |
|---|---|---|
| Tau_P2 | | |
| AggTau | | |

| Id | Name | SBO |
|----|------|-----|

**Product**

Table 167: Properties of each product.

| Id | Name | SBO |
|----|------|-----|
| AggTau | | |

**Kinetic Law**

**Derived unit** contains undeclared units

$$v_{54} = \text{kaggTauP2} \cdot \text{Tau\_P2} \cdot \text{AggTau} \tag{110}$$

## 7.55 Reaction `TauAggregation1`

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

**Reaction equation**

$$2\,\text{Tau} \xrightarrow{\text{Tau}} 2\,\text{AggTau} \tag{111}$$

**Reactant**

Table 168: Properties of each reactant.

| Id | Name | SBO |
|----|------|-----|
| Tau | | |

**Modifier**

Table 169: Properties of each modifier.

| Id | Name | SBO |
|----|------|-----|
| Tau | | |

**Product**

Table 170: Properties of each product.

| Id | Name | SBO |
|---|---|---|
| AggTau | | |

**Kinetic Law**

**Derived unit** contains undeclared units

$$v_{55} = \text{kaggTau} \cdot \text{Tau}^2 \cdot 0.5 \tag{112}$$

## 7.56 Reaction `TauAggregation2`

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

**Reaction equation**

$$\text{Tau} + \text{AggTau} \xrightarrow{\text{Tau, AggTau}} 2\,\text{AggTau} \tag{113}$$

**Reactants**

Table 171: Properties of each reactant.

| Id | Name | SBO |
|---|---|---|
| Tau | | |
| AggTau | | |

**Modifiers**

Table 172: Properties of each modifier.

| Id | Name | SBO |
|---|---|---|
| Tau | | |
| AggTau | | |

**Product**

Table 173: Properties of each product.

| Id | Name | SBO |
|---|---|---|
| AggTau | | |

| Id | Name | SBO |
|----|------|-----|

### Kinetic Law

**Derived unit**  contains undeclared units

$$v_{56} = \text{kaggTau} \cdot \text{Tau} \cdot \text{AggTau} \tag{114}$$

## 7.57 Reaction `TangleFormation1`

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

### Reaction equation

$$2\,\text{AggTau} \xrightarrow{\text{AggTau}} 2\,\text{NFT} \tag{115}$$

### Reactant

Table 174: Properties of each reactant.

| Id | Name | SBO |
|----|------|-----|
| AggTau | | |

### Modifier

Table 175: Properties of each modifier.

| Id | Name | SBO |
|----|------|-----|
| AggTau | | |

### Product

Table 176: Properties of each product.

| Id | Name | SBO |
|----|------|-----|
| NFT | | |

### Kinetic Law

**Derived unit**  contains undeclared units

$$v_{57} = \text{ktangfor} \cdot \text{AggTau}^2 \cdot 0.5 \tag{116}$$

## 7.58 Reaction `TangleFormation2`

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

**Reaction equation**

$$\text{AggTau} + \text{NFT} \xrightarrow{\text{AggTau, NFT}} 2\,\text{NFT} \tag{117}$$

**Reactants**

Table 177: Properties of each reactant.

| Id | Name | SBO |
|---|---|---|
| AggTau | | |
| NFT | | |

**Modifiers**

Table 178: Properties of each modifier.

| Id | Name | SBO |
|---|---|---|
| AggTau | | |
| NFT | | |

**Product**

Table 179: Properties of each product.

| Id | Name | SBO |
|---|---|---|
| NFT | | |

**Kinetic Law**

**Derived unit**  contains undeclared units

$$v_{58} = \text{ktangfor} \cdot \text{AggTau} \cdot \text{NFT} \tag{118}$$

## 7.59 Reaction `ProteasomeInhibitionAggTau`

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

## Reaction equation

$$\text{AggTau} + \text{Proteasome} \xrightarrow{\text{AggTau, Proteasome}} \text{AggTau\_Proteasome} \qquad (119)$$
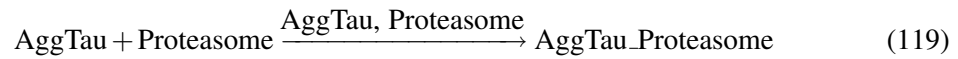
## Reactants

Table 180: Properties of each reactant.

| Id | Name | SBO |
|---|---|---|
| AggTau | | |
| Proteasome | | |

## Modifiers

Table 181: Properties of each modifier.

| Id | Name | SBO |
|---|---|---|
| AggTau | | |
| Proteasome | | |

## Product

Table 182: Properties of each product.

| Id | Name | SBO |
|---|---|---|
| AggTau_Proteasome | | |

## Kinetic Law

**Derived unit**  contains undeclared units

$$v_{59} = \text{kinhibprot} \cdot \text{AggTau} \cdot \text{Proteasome} \qquad (120)$$

## 7.60 Reaction `Abetaproduction1`

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

## Reaction equation

$$\text{Source} \xrightarrow{\text{Source}} \text{Abeta} \qquad (121)$$

**Reactant**

Table 183: Properties of each reactant.

| Id | Name | SBO |
|---|---|---|
| Source | | |

## Modifier

Table 184: Properties of each modifier.

| Id | Name | SBO |
|---|---|---|
| Source | | |

## Product

Table 185: Properties of each product.

| Id | Name | SBO |
|---|---|---|
| Abeta | | |

## Kinetic Law

**Derived unit**  contains undeclared units

$$v_{60} = \text{kprodAbeta} \cdot \text{Source} \tag{122}$$

## 7.61 Reaction `Abetaproduction2`

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

## Reaction equation

$$\text{GSK3b\_p53} \xrightarrow{\text{GSK3b\_p53}} \text{Abeta} + \text{GSK3b\_p53} \tag{123}$$

## Reactant

Table 186: Properties of each reactant.

| Id | Name | SBO |
|---|---|---|
| GSK3b_p53 | | |

**Modifier**

Table 187: Properties of each modifier.

| Id | Name | SBO |
|---|---|---|
| GSK3b_p53 | | |

**Products**

Table 188: Properties of each product.

| Id | Name | SBO |
|---|---|---|
| Abeta | | |
| GSK3b_p53 | | |

**Kinetic Law**

**Derived unit**  contains undeclared units

$$v_{61} = \text{kprodAbeta2} \cdot \text{GSK3b\_p53} \tag{124}$$

## 7.62 **Reaction** `Abetaproduction3`

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

**Reaction equation**

$$\text{GSK3b\_p53\_P} \xrightarrow{\text{GSK3b\_p53\_P}} \text{Abeta} + \text{GSK3b\_p53\_P} \tag{125}$$

**Reactant**

Table 189: Properties of each reactant.

| Id | Name | SBO |
|---|---|---|
| GSK3b_p53_P | | |

**Modifier**

## Products

Table 191: Properties of each product.

| Id | Name | SBO |
| --- | --- | --- |
| Abeta | | |
| GSK3b_p53_P | | |

## Kinetic Law

**Derived unit** contains undeclared units

$$v_{62} = \text{kprodAbeta2} \cdot \text{GSK3b\_p53\_P} \qquad (126)$$

## 7.63 Reaction `ProteasomeInhibitionAbeta`

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

## Reaction equation

$$\text{AbetaDimer} + \text{Proteasome} \xrightarrow{\text{AbetaDimer, Proteasome}} \text{AggAbeta\_Proteasome} \qquad (127)$$

## Reactants

Table 192: Properties of each reactant.

| Id | Name | SBO |
| --- | --- | --- |
| AbetaDimer | | |
| Proteasome | | |

## Modifiers

Table 193: Properties of each modifier.

| Id | Name | SBO |
| --- | --- | --- |
| AbetaDimer | | |

| Id | Name | SBO |
|---|---|---|
| Proteasome | | |

## Product

Table 194: Properties of each product.

| Id | Name | SBO |
|---|---|---|
| AggAbeta_Proteasome | | |

## Kinetic Law

**Derived unit** contains undeclared units

$$v_{63} = \text{kinhibprot} \cdot \text{AbetaDimer} \cdot \text{Proteasome} \tag{128}$$

## 7.64 Reaction `AbetaDegradation`

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

## Reaction equation

$$\text{Abeta} \xrightarrow{\text{Abeta}} \text{Sink} \tag{129}$$

## Reactant

Table 195: Properties of each reactant.

| Id | Name | SBO |
|---|---|---|
| Abeta | | |

## Modifier

Table 196: Properties of each modifier.

| Id | Name | SBO |
|---|---|---|
| Abeta | | |

## Product

Table 197: Properties of each product.

| Id | Name | SBO |
|----|------|-----|
| Sink | | |

**Kinetic Law**

**Derived unit** contains undeclared units

$$v_{64} = \text{kdegAbeta} \cdot \text{Abeta} \tag{130}$$

## 7.65 Reaction `p53transcriptionViaAbeta`

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

**Reaction equation**

$$\text{Abeta} \xrightarrow{\text{Abeta}} \text{p53\_mRNA} + \text{Abeta} \tag{131}$$

**Reactant**

Table 198: Properties of each reactant.

| Id | Name | SBO |
|----|------|-----|
| Abeta | | |

**Modifier**

Table 199: Properties of each modifier.

| Id | Name | SBO |
|----|------|-----|
| Abeta | | |

**Products**

Table 200: Properties of each product.

| Id | Name | SBO |
|----|------|-----|
| p53\_mRNA | | |
| Abeta | | |

*Produced by SBML2LATEX*

**Kinetic Law**

**Derived unit** contains undeclared units

$$v_{65} = \text{ksynp53mRNAAbeta} \cdot \text{Abeta} \tag{132}$$

## 7.66 Reaction `DNAdamage`

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

**Reaction equation**

$$\text{IR} \xrightarrow{\text{IR}} \text{IR} + \text{damDNA} \tag{133}$$

**Reactant**

Table 201: Properties of each reactant.

| Id | Name | SBO |
|----|------|-----|
| IR |      |     |

**Modifier**

Table 202: Properties of each modifier.

| Id | Name | SBO |
|----|------|-----|
| IR |      |     |

**Products**

Table 203: Properties of each product.

| Id | Name | SBO |
|----|------|-----|
| IR |      |     |
| damDNA | | |

**Kinetic Law**

**Derived unit** contains undeclared units

$$v_{66} = \text{kdam} \cdot \text{IR} \tag{134}$$

## 7.67 Reaction `DNArepair`

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

**Reaction equation**

$$\text{damDNA} \xrightarrow{\text{damDNA}} \text{Sink} \tag{135}$$

**Reactant**

Table 204: Properties of each reactant.

| Id | Name | SBO |
|----|------|-----|
| damDNA | | |

**Modifier**

Table 205: Properties of each modifier.

| Id | Name | SBO |
|----|------|-----|
| damDNA | | |

**Product**

Table 206: Properties of each product.

| Id | Name | SBO |
|----|------|-----|
| Sink | | |

**Kinetic Law**

**Derived unit**  contains undeclared units

$$v_{67} = \text{krepair} \cdot \text{damDNA} \tag{136}$$

## 7.68 Reaction `ATMactivation`

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

**Reaction equation**

$$\text{damDNA} + \text{ATMI} \xrightarrow{\text{damDNA, ATMI}} \text{damDNA} + \text{ATMA} \tag{137}$$

*Produced by SBML2LATEX*
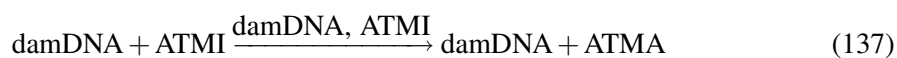
**Reactants**

Table 207: Properties of each reactant.

| Id | Name | SBO |
|----|------|-----|
| damDNA | | |
| ATMI | | |

**Modifiers**

Table 208: Properties of each modifier.

| Id | Name | SBO |
|----|------|-----|
| damDNA | | |
| ATMI | | |

**Products**

Table 209: Properties of each product.

| Id | Name | SBO |
|----|------|-----|
| damDNA | | |
| ATMA | | |

**Kinetic Law**

**Derived unit**  contains undeclared units

$$v_{68} = \text{kactATM} \cdot \text{damDNA} \cdot \text{ATMI} \tag{138}$$

## 7.69 Reaction p53phosphorylation

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

**Reaction equation**

$$\text{p53} + \text{ATMA} \xrightarrow{\text{p53, ATMA}} \text{p53\_P} + \text{ATMA} \tag{139}$$
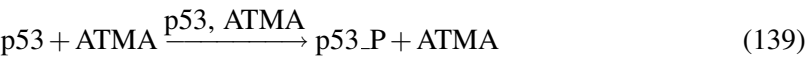
**Reactants**

Table 210: Properties of each reactant.

| Id | Name | SBO |
|----|------|-----|
| p53 | | |
| ATMA | | |

**Modifiers**

Table 211: Properties of each modifier.

| Id | Name | SBO |
|----|------|-----|
| p53 | | |
| ATMA | | |

**Products**

Table 212: Properties of each product.

| Id | Name | SBO |
|----|------|-----|
| p53_P | | |
| ATMA | | |

**Kinetic Law**

**Derived unit**  contains undeclared units

$$v_{69} = \text{kphosp53} \cdot \text{p53} \cdot \text{ATMA} \tag{140}$$

## 7.70 **Reaction** p53dephosphorylation

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

**Reaction equation**

$$\text{p53\_P} \xrightarrow{\text{p53\_P}} \text{p53} \tag{141}$$
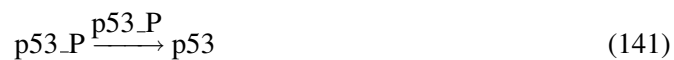
**Reactant**

Table 213: Properties of each reactant.

| Id | Name | SBO |
|---|---|---|
| p53_P | | |

## Modifier

Table 214: Properties of each modifier.

| Id | Name | SBO |
|---|---|---|
| p53_P | | |

## Product

Table 215: Properties of each product.

| Id | Name | SBO |
|---|---|---|
| p53 | | |

## Kinetic Law

**Derived unit**  contains undeclared units

$$v_{70} = \text{kdephosp53} \cdot \text{p53\_P} \tag{142}$$

## 7.71 Reaction `Mdm2phosphorylation`

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

## Reaction equation

$$\text{Mdm2} + \text{ATMA} \xrightarrow{\text{Mdm2, ATMA}} \text{Mdm2\_P} + \text{ATMA} \tag{143}$$
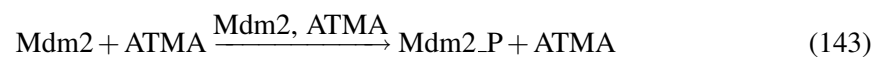
## Reactants

Table 216: Properties of each reactant.

| Id | Name | SBO |
|---|---|---|
| Mdm2 | | |
| ATMA | | |

**Modifiers**

Table 217: Properties of each modifier.

| Id | Name | SBO |
|---|---|---|
| Mdm2 | | |
| ATMA | | |

**Products**

Table 218: Properties of each product.

| Id | Name | SBO |
|---|---|---|
| Mdm2_P | | |
| ATMA | | |

**Kinetic Law**

**Derived unit**  contains undeclared units

$$v_{71} = \text{kphosMdm2} \cdot \text{Mdm2} \cdot \text{ATMA} \tag{144}$$

## 7.72 Reaction `Mdm2dephosphorylation`

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

**Reaction equation**

$$\text{Mdm2\_P} \xrightarrow{\text{Mdm2\_P}} \text{Mdm2} \tag{145}$$

**Reactant**

Table 219: Properties of each reactant.

| Id | Name | SBO |
|---|---|---|
| Mdm2_P | | |

**Modifier**

Table 220: Properties of each modifier.

| Id | Name | SBO |
|---|---|---|
| Mdm2_P | | |

## Product

Table 221: Properties of each product.

| Id | Name | SBO |
|---|---|---|
| Mdm2 | | |

## Kinetic Law

**Derived unit** contains undeclared units

$$v_{72} = \text{kdephosMdm2} \cdot \text{Mdm2\_P} \tag{146}$$

## 7.73 Reaction `Mdm2PUbiquitination`

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

## Reaction equation

$$\text{Mdm2\_P} + \text{E2\_Ub} \xrightarrow{\text{Mdm2\_P, E2\_Ub}} \text{Mdm2\_P\_Ub} + \text{E2} \tag{147}$$
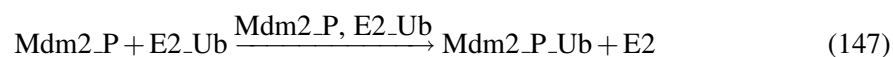
## Reactants

Table 222: Properties of each reactant.

| Id | Name | SBO |
|---|---|---|
| Mdm2_P | | |
| E2_Ub | | |

## Modifiers

Table 223: Properties of each modifier.

| Id | Name | SBO |
|---|---|---|
| Mdm2_P | | |

| Id | Name | SBO |
|---|---|---|
| E2_Ub | | |

## Products

Table 224: Properties of each product.

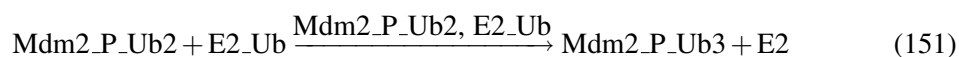| Id | Name | SBO |
|---|---|---|
| Mdm2_P_Ub | | |
| E2 | | |

## Kinetic Law

**Derived unit** contains undeclared units

$$v_{73} = \text{kMdm2PUb} \cdot \text{Mdm2\_P} \cdot \text{E2\_Ub} \tag{148}$$

## 7.74 Reaction `Mdm2PpolyUbiquitination1`

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

## Reaction equation

$$\text{Mdm2\_P\_Ub} + \text{E2\_Ub} \xrightarrow{\text{Mdm2\_P\_Ub, E2\_Ub}} \text{Mdm2\_P\_Ub2} + \text{E2} \tag{149}$$

## Reactants

Table 225: Properties of each reactant.

| Id | Name | SBO |
|---|---|---|
| Mdm2_P_Ub | | |
| E2_Ub | | |

## Modifiers

Table 226: Properties of each modifier.

| Id | Name | SBO |
|---|---|---|
| Mdm2_P_Ub | | |
| E2_Ub | | |

| Id | Name | SBO |
|---|---|---|

**Products**

Table 227: Properties of each product.

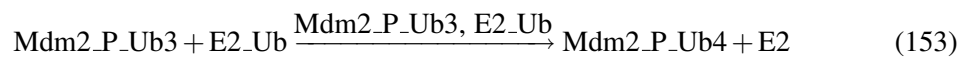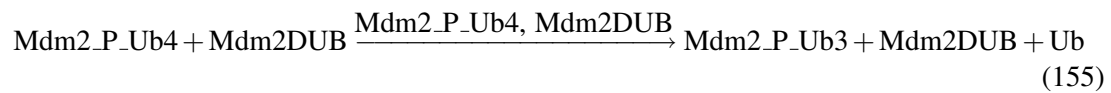| Id | Name | SBO |
|---|---|---|
| Mdm2_P_Ub2 | | |
| E2 | | |

**Kinetic Law**

**Derived unit**  contains undeclared units

$$v_{74} = \text{kMdm2PolyUb} \cdot \text{Mdm2\_P\_Ub} \cdot \text{E2\_Ub} \qquad (150)$$

## 7.75 Reaction `Mdm2PpolyUbiquitination2`

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

**Reaction equation**

$$\text{Mdm2\_P\_Ub2} + \text{E2\_Ub} \xrightarrow{\text{Mdm2\_P\_Ub2, E2\_Ub}} \text{Mdm2\_P\_Ub3} + \text{E2} \qquad (151)$$

**Reactants**

Table 228: Properties of each reactant.

| Id | Name | SBO |
|---|---|---|
| Mdm2_P_Ub2 | | |
| E2_Ub | | |

**Modifiers**

Table 229: Properties of each modifier.

| Id | Name | SBO |
|---|---|---|
| Mdm2_P_Ub2 | | |
| E2_Ub | | |

**Products**

Table 230: Properties of each product.

| Id | Name | SBO |
|---|---|---|
| Mdm2_P_Ub3 | | |
| E2 | | |

**Kinetic Law**

**Derived unit**  contains undeclared units

$$v_{75} = \text{kMdm2PolyUb} \cdot \text{Mdm2\_P\_Ub2} \cdot \text{E2\_Ub} \tag{152}$$

## 7.76 Reaction `Mdm2PpolyUbiquitination3`

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

**Reaction equation**

$$\text{Mdm2\_P\_Ub3} + \text{E2\_Ub} \xrightarrow{\text{Mdm2\_P\_Ub3, E2\_Ub}} \text{Mdm2\_P\_Ub4} + \text{E2} \tag{153}$$

**Reactants**

Table 231: Properties of each reactant.

| Id | Name | SBO |
|---|---|---|
| Mdm2_P_Ub3 | | |
| E2_Ub | | |

**Modifiers**

Table 232: Properties of each modifier.

| Id | Name | SBO |
|---|---|---|
| Mdm2_P_Ub3 | | |
| E2_Ub | | |

**Products**

Table 233: Properties of each product.

| Id | Name | SBO |
|----|------|-----|
| Mdm2_P_Ub4 | | |
| E2 | | |

**Kinetic Law**

**Derived unit** contains undeclared units

$$v_{76} = \text{kMdm2PolyUb} \cdot \text{Mdm2\_P\_Ub3} \cdot \text{E2\_Ub} \qquad (154)$$

## 7.77 Reaction `Mdm2PDeubiquitination4`

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

**Reaction equation**

$$\text{Mdm2\_P\_Ub4} + \text{Mdm2DUB} \xrightarrow{\text{Mdm2\_P\_Ub4, Mdm2DUB}} \text{Mdm2\_P\_Ub3} + \text{Mdm2DUB} + \text{Ub} \tag{155}$$

**Reactants**

Table 234: Properties of each reactant.

| Id | Name | SBO |
|----|------|-----|
| Mdm2_P_Ub4 | | |
| Mdm2DUB | | |

**Modifiers**

Table 235: Properties of each modifier.

| Id | Name | SBO |
|----|------|-----|
| Mdm2_P_Ub4 | | |
| Mdm2DUB | | |

**Products**

Table 236: Properties of each product.

| Id | Name | SBO |
|---|---|---|
| Mdm2_P_Ub3 | | |
| Mdm2DUB | | |
| Ub | | |

**Kinetic Law**

**Derived unit** contains undeclared units

$$v_{77} = \text{kactDUBMdm2} \cdot \text{Mdm2\_P\_Ub4} \cdot \text{Mdm2DUB} \qquad (156)$$

## 7.78 Reaction `Mdm2PDeubiquitination3`

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

**Reaction equation**

$$\text{Mdm2\_P\_Ub3} + \text{Mdm2DUB} \xrightarrow{\text{Mdm2\_P\_Ub3, Mdm2DUB}} \text{Mdm2\_P\_Ub2} + \text{Mdm2DUB} + \text{Ub}$$
$$(157)$$
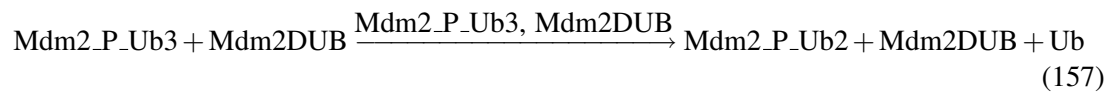
**Reactants**

Table 237: Properties of each reactant.

| Id | Name | SBO |
|---|---|---|
| Mdm2_P_Ub3 | | |
| Mdm2DUB | | |

**Modifiers**

Table 238: Properties of each modifier.

| Id | Name | SBO |
|---|---|---|
| Mdm2_P_Ub3 | | |
| Mdm2DUB | | |

**Products**

Table 239: Properties of each product.

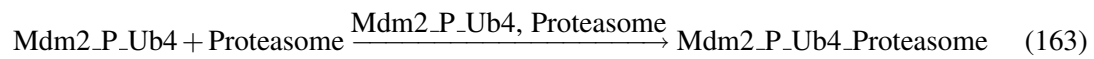| Id | Name | SBO |
|---|---|---|
| Mdm2_P_Ub2 | | |
| Mdm2DUB | | |
| Ub | | |

### Kinetic Law

**Derived unit** contains undeclared units

$$v_{78} = \text{kactDUBMdm2} \cdot \text{Mdm2\_P\_Ub3} \cdot \text{Mdm2DUB} \tag{158}$$

## 7.79 Reaction `Mdm2PDeubiquitination2`

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

### Reaction equation

$$\text{Mdm2\_P\_Ub2} + \text{Mdm2DUB} \xrightarrow{\text{Mdm2\_P\_Ub2, Mdm2DUB}} \text{Mdm2\_P\_Ub} + \text{Mdm2DUB} + \text{Ub} \tag{159}$$
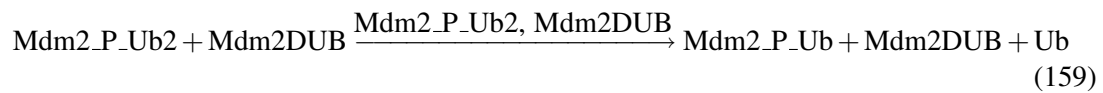
### Reactants

Table 240: Properties of each reactant.

| Id | Name | SBO |
|---|---|---|
| Mdm2_P_Ub2 | | |
| Mdm2DUB | | |

### Modifiers

Table 241: Properties of each modifier.

| Id | Name | SBO |
|---|---|---|
| Mdm2_P_Ub2 | | |
| Mdm2DUB | | |

### Products

Table 242: Properties of each product.

| Id | Name | SBO |
|----|------|-----|
| Mdm2_P_Ub | | |
| Mdm2DUB | | |
| Ub | | |

### Kinetic Law

**Derived unit** contains undeclared units

$$v_{79} = \text{kactDUBMdm2} \cdot \text{Mdm2\_P\_Ub2} \cdot \text{Mdm2DUB} \tag{160}$$

## 7.80 Reaction `Mdm2PDeubiquitination1`

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

### Reaction equation

$$\text{Mdm2\_P\_Ub} + \text{Mdm2DUB} \xrightarrow{\text{Mdm2\_P\_Ub, Mdm2DUB}} \text{Mdm2\_P} + \text{Mdm2DUB} + \text{Ub} \tag{161}$$
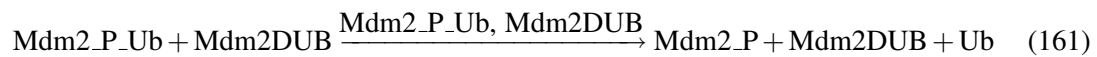
### Reactants

Table 243: Properties of each reactant.

| Id | Name | SBO |
|----|------|-----|
| Mdm2_P_Ub | | |
| Mdm2DUB | | |

### Modifiers

Table 244: Properties of each modifier.

| Id | Name | SBO |
|----|------|-----|
| Mdm2_P_Ub | | |
| Mdm2DUB | | |

### Products

Table 245: Properties of each product.

| Id | Name | SBO |
|---|---|---|
| Mdm2_P | | |
| Mdm2DUB | | |
| Ub | | |

**Kinetic Law**

**Derived unit**  contains undeclared units

$$v_{80} = \text{kactDUBMdm2} \cdot \text{Mdm2\_P\_Ub} \cdot \text{Mdm2DUB} \tag{162}$$

## 7.81 Reaction `Mdm2PProteasomeBinding1`

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

**Reaction equation**

$$\text{Mdm2\_P\_Ub4} + \text{Proteasome} \xrightarrow{\text{Mdm2\_P\_Ub4, Proteasome}} \text{Mdm2\_P\_Ub4\_Proteasome} \tag{163}$$

**Reactants**

Table 246: Properties of each reactant.

| Id | Name | SBO |
|---|---|---|
| Mdm2_P_Ub4 | | |
| Proteasome | | |

**Modifiers**

Table 247: Properties of each modifier.

| Id | Name | SBO |
|---|---|---|
| Mdm2_P_Ub4 | | |
| Proteasome | | |

**Product**

Table 248: Properties of each product.

| Id | Name | SBO |
|---|---|---|
| Mdm2_P_Ub4_Proteasome | | |

**Kinetic Law**

**Derived unit** contains undeclared units

$$v_{81} = \text{kbinProt} \cdot \text{Mdm2\_P\_Ub4} \cdot \text{Proteasome} \qquad (164)$$

## 7.82 Reaction Mdm2PDegradation

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

**Reaction equation**

$$\text{Mdm2\_P\_Ub4\_Proteasome} \xrightarrow{\text{Mdm2\_P\_Ub4\_Proteasome}} \text{Proteasome} + 4\,\text{Ub} \qquad (165)$$
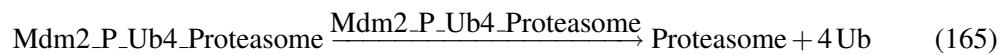
**Reactant**

Table 249: Properties of each reactant.

| Id | Name | SBO |
|---|---|---|
| Mdm2_P_Ub4_Proteasome | | |

**Modifier**

Table 250: Properties of each modifier.

| Id | Name | SBO |
|---|---|---|
| Mdm2_P_Ub4_Proteasome | | |

**Products**

Table 251: Properties of each product.

| Id | Name | SBO |
|---|---|---|
| Proteasome | | |
| Ub | | |

**Kinetic Law**

**Derived unit** contains undeclared units

$$v_{82} = \text{kdegMdm2} \cdot \text{Mdm2\_P\_Ub4\_Proteasome} \cdot \text{kproteff} \qquad (166)$$

## 7.83 Reaction `ATMInactivation`

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

**Reaction equation**

$$\text{ATMA} \xrightarrow{\text{ATMA}} \text{ATMI} \qquad (167)$$

**Reactant**

Table 252: Properties of each reactant.

| Id | Name | SBO |
|----|------|-----|
| ATMA | | |

**Modifier**

Table 253: Properties of each modifier.

| Id | Name | SBO |
|----|------|-----|
| ATMA | | |

**Product**

Table 254: Properties of each product.

| Id | Name | SBO |
|----|------|-----|
| ATMI | | |

**Kinetic Law**

**Derived unit** contains undeclared units

$$v_{83} = \text{kinactATM} \cdot \text{ATMA} \qquad (168)$$

## 7.84 Reaction `AbetaROSproduction1`

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

**Reaction equation**

$$\text{Abeta} \xrightarrow{\text{Abeta}} \text{Abeta} + \text{ROS} \tag{169}$$

**Reactant**

Table 255: Properties of each reactant.

| Id | Name | SBO |
|----|------|-----|
| Abeta | | |

**Modifier**

Table 256: Properties of each modifier.

| Id | Name | SBO |
|----|------|-----|
| Abeta | | |

**Products**

Table 257: Properties of each product.

| Id | Name | SBO |
|----|------|-----|
| Abeta | | |
| ROS | | |

**Kinetic Law**

**Derived unit**  contains undeclared units

$$v_{84} = \text{kgenROSAbeta} \cdot \text{Abeta} \tag{170}$$

## 7.85 Reaction `PlaqueROSproduction`

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

**Reaction equation**

$$\text{AbetaPlaque} \xrightarrow{\text{AbetaPlaque}} \text{AbetaPlaque} + \text{ROS} \tag{171}$$

**Reactant**

Table 258: Properties of each reactant.

| Id | Name | SBO |
|---|---|---|
| AbetaPlaque | | |

**Modifier**

Table 259: Properties of each modifier.

| Id | Name | SBO |
|---|---|---|
| AbetaPlaque | | |

**Products**

Table 260: Properties of each product.

| Id | Name | SBO |
|---|---|---|
| AbetaPlaque | | |
| ROS | | |

**Kinetic Law**

**Derived unit**  contains undeclared units

$$v_{85} = \text{kgenROSPlaque} \cdot \text{AbetaPlaque} \tag{172}$$

## 7.86 Reaction `AggAbetaROSproduction2`

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

**Reaction equation**

$$\text{AggAbeta\_Proteasome} \xrightarrow{\text{AggAbeta\_Proteasome}} \text{AggAbeta\_Proteasome} + \text{ROS} \tag{173}$$
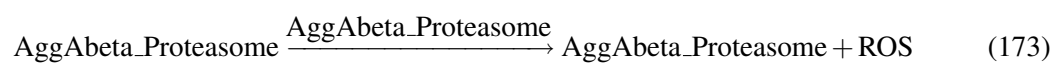
**Reactant**

Table 261: Properties of each reactant.

| Id | Name | SBO |
|---|---|---|
| AggAbeta_Proteasome | | |

**Modifier**

Table 262: Properties of each modifier.

| Id | Name | SBO |
|---|---|---|
| AggAbeta_Proteasome | | |

**Products**

Table 263: Properties of each product.

| Id | Name | SBO |
|---|---|---|
| AggAbeta_Proteasome | | |
| ROS | | |

**Kinetic Law**

**Derived unit**  contains undeclared units

$$v_{86} = \text{kgenROSAbeta} \cdot \text{AggAbeta\_Proteasome} \tag{174}$$

## 7.87 Reaction `ROSDNAdamage`

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

**Reaction equation**

$$\text{ROS} \xrightarrow{\text{ROS}} \text{ROS} + \text{damDNA} \tag{175}$$

**Reactant**

Table 264: Properties of each reactant.

| Id | Name | SBO |
|---|---|---|
| ROS | | |

**Modifier**

Table 265: Properties of each modifier.

| Id | Name | SBO |
|---|---|---|
| ROS | | |

**Products**

Table 266: Properties of each product.

| Id | Name | SBO |
|---|---|---|
| ROS | | |
| damDNA | | |

**Kinetic Law**

**Derived unit**  contains undeclared units

$$v_{87} = \text{kdamROS} \cdot \text{ROS} \qquad (176)$$

## 7.88 Reaction `TauSynthesis`

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

**Reaction equation**

$$\text{Source} \xrightarrow{\text{Source}} \text{Tau} \qquad (177)$$

**Reactant**

Table 267: Properties of each reactant.

| Id | Name | SBO |
|---|---|---|
| Source | | |

**Modifier**

Table 268: Properties of each modifier.

| Id | Name | SBO |
|----|------|-----|
| Source | | |

## Product

Table 269: Properties of each product.

| Id | Name | SBO |
|----|------|-----|
| Tau | | |

## Kinetic Law

**Derived unit**  contains undeclared units

$$v_{88} = \text{ksynTau} \cdot \text{Source} \tag{178}$$

## 7.89 Reaction `TauProteasomeBinding`

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

## Reaction equation

$$\text{Tau} + \text{Proteasome} \xrightarrow{\text{Tau, Proteasome}} \text{Proteasome\_Tau} \tag{179}$$
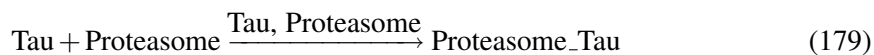
## Reactants

Table 270: Properties of each reactant.

| Id | Name | SBO |
|----|------|-----|
| Tau | | |
| Proteasome | | |

## Modifiers

Table 271: Properties of each modifier.

| Id | Name | SBO |
|----|------|-----|
| Tau | | |
| Proteasome | | |

**Product**

Table 272: Properties of each product.

| Id | Name | SBO |
|---|---|---|
| Proteasome_Tau | | |

**Kinetic Law**

**Derived unit** contains undeclared units

$$v_{89} = \text{kbinTauProt} \cdot \text{Tau} \cdot \text{Proteasome} \tag{180}$$

## 7.90 Reaction `Tau20SProteasomeDegradation`

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

**Reaction equation**

$$\text{Proteasome\_Tau} \xrightarrow{\text{Proteasome\_Tau}} \text{Proteasome} \tag{181}$$
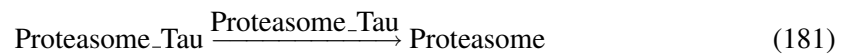
**Reactant**

Table 273: Properties of each reactant.

| Id | Name | SBO |
|---|---|---|
| Proteasome_Tau | | |

**Modifier**

Table 274: Properties of each modifier.

| Id | Name | SBO |
|---|---|---|
| Proteasome_Tau | | |

**Product**

Table 275: Properties of each product.

| Id | Name | SBO |
|---|---|---|
| Proteasome | | |

| Id | Name | SBO |
|----|------|-----|

### Kinetic Law

**Derived unit**  contains undeclared units

$$v_{90} = \text{kdegTau20SProt} \cdot \text{Proteasome\_Tau} \tag{182}$$

## 7.91 Reaction `AbetaAggregation1`

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

### Reaction equation

$$2\,\text{Abeta} \xrightarrow{\text{Abeta}} \text{AbetaDimer} \tag{183}$$

### Reactant

Table 276: Properties of each reactant.

| Id | Name | SBO |
|----|------|-----|
| Abeta | | |

### Modifier

Table 277: Properties of each modifier.

| Id | Name | SBO |
|----|------|-----|
| Abeta | | |

### Product

Table 278: Properties of each product.

| Id | Name | SBO |
|----|------|-----|
| AbetaDimer | | |

### Kinetic Law

**Derived unit**  contains undeclared units

$$v_{91} = \text{kaggAbeta} \cdot \text{Abeta}^2 \cdot 0.5 \qquad (184)$$

## 7.92 Reaction `AbetaPlaqueFormation1`

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

**Reaction equation**

$$2\,\text{AbetaDimer} \xrightarrow{\text{AbetaDimer}} \text{AbetaPlaque} \qquad (185)$$

**Reactant**

Table 279: Properties of each reactant.

| Id | Name | SBO |
|---|---|---|
| AbetaDimer | | |

**Modifier**

Table 280: Properties of each modifier.

| Id | Name | SBO |
|---|---|---|
| AbetaDimer | | |

**Product**

Table 281: Properties of each product.

| Id | Name | SBO |
|---|---|---|
| AbetaPlaque | | |

**Kinetic Law**

**Derived unit**  contains undeclared units

$$v_{92} = \text{kpf} \cdot \text{AbetaDimer}^2 \cdot 0.5 \qquad (186)$$

## 7.93 Reaction `AbetaPlaqueGrowth`

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

**Reaction equation**

$$\text{AbetaDimer} + \text{AbetaPlaque} \xrightarrow{\text{AbetaDimer, AbetaPlaque}} 2\,\text{AbetaPlaque} \qquad (187)$$
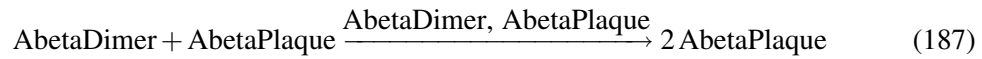
**Reactants**

Table 282: Properties of each reactant.

| Id | Name | SBO |
|---|---|---|
| AbetaDimer | | |
| AbetaPlaque | | |

**Modifiers**

Table 283: Properties of each modifier.

| Id | Name | SBO |
|---|---|---|
| AbetaDimer | | |
| AbetaPlaque | | |

**Product**

Table 284: Properties of each product.

| Id | Name | SBO |
|---|---|---|
| AbetaPlaque | | |

**Kinetic Law**

**Derived unit**  contains undeclared units

$$v_{93} = \frac{\text{kpg} \cdot \text{AbetaDimer} \cdot \text{AbetaPlaque}^2}{\text{kpghalf}^2 + \text{AbetaPlaque}^2} \qquad (188)$$

## 7.94 Reaction `AbetaDisaggregation1`

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

**Reaction equation**

$$\text{AbetaDimer} \xrightarrow{\text{AbetaDimer}} 2\,\text{Abeta} \qquad (189)$$

*Produced by SBML2LATEX*

**Reactant**

Table 285: Properties of each reactant.

| Id | Name | SBO |
|---|---|---|
| AbetaDimer | | |

**Modifier**

Table 286: Properties of each modifier.

| Id | Name | SBO |
|---|---|---|
| AbetaDimer | | |

**Product**

Table 287: Properties of each product.

| Id | Name | SBO |
|---|---|---|
| Abeta | | |

**Kinetic Law**

**Derived unit**  contains undeclared units

$$v_{94} = \text{kdisaggAbeta} \cdot \text{AbetaDimer} \tag{190}$$

## 7.95 Reaction `AbetaDisaggregation3`

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

**Reaction equation**

$$\text{AbetaPlaque} \xrightarrow{\text{AbetaPlaque}} \text{AbetaDimer} + \text{disaggPlaque1} \tag{191}$$
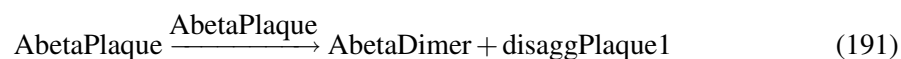
**Reactant**

Table 288: Properties of each reactant.

| Id | Name | SBO |
|---|---|---|
| AbetaPlaque | | |

**Modifier**

Table 289: Properties of each modifier.

| Id | Name | SBO |
|---|---|---|
| AbetaPlaque | | |

**Products**

Table 290: Properties of each product.

| Id | Name | SBO |
|---|---|---|
| AbetaDimer | | |
| disaggPlaque1 | | |

**Kinetic Law**

**Derived unit**  contains undeclared units

$$v_{95} = \text{kdisaggAbeta1} \cdot \text{AbetaPlaque} \tag{192}$$

## 7.96 Reaction `AbetaDisaggregation4`

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

**Reaction equation**

$$\text{AbetaPlaque} + \text{antiAb} \xrightarrow{\text{antiAb, AbetaPlaque}} \text{AbetaDimer} + \text{antiAb} + \text{disaggPlaque2} \tag{193}$$
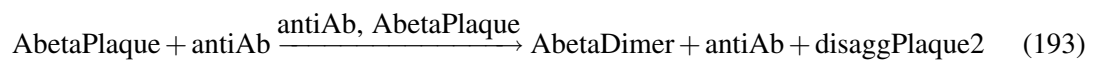
**Reactants**

Table 291: Properties of each reactant.

| Id | Name | SBO |
|---|---|---|
| AbetaPlaque | | |
| antiAb | | |

**Modifiers**

Table 292: Properties of each modifier.

| Id | Name | SBO |
|---|---|---|
| antiAb | | |
| AbetaPlaque | | |

**Products**

Table 293: Properties of each product.

| Id | Name | SBO |
|---|---|---|
| AbetaDimer | | |
| antiAb | | |
| disaggPlaque2 | | |

**Kinetic Law**

**Derived unit**  contains undeclared units

$$v_{96} = \text{kdisaggAbeta2} \cdot \text{antiAb} \cdot \text{AbetaPlaque} \tag{194}$$

## 7.97 Reaction Abeta_antiAbBinding

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

**Reaction equation**

$$\text{Abeta} + \text{antiAb} \xrightarrow{\text{Abeta, antiAb}} \text{Abeta\_antiAb} \tag{195}$$

**Reactants**

Table 294: Properties of each reactant.

| Id | Name | SBO |
|---|---|---|
| Abeta | | |
| antiAb | | |

**Modifiers**

Table 295: Properties of each modifier.

| Id | Name | SBO |
|---|---|---|
| Abeta | | |
| antiAb | | |

## Product

Table 296: Properties of each product.

| Id | Name | SBO |
|---|---|---|
| Abeta_antiAb | | |

## Kinetic Law

**Derived unit** contains undeclared units

$$v_{97} = \text{kbinAbantiAb} \cdot \text{Abeta} \cdot \text{antiAb} \tag{196}$$

## 7.98 Reaction `AbetaDimer_antiAbBinding`

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

## Reaction equation

$$\text{AbetaDimer} + \text{antiAb} \xrightarrow{\text{AbetaDimer, antiAb}} \text{AbetaDimer\_antiAb} \tag{197}$$

## Reactants

Table 297: Properties of each reactant.

| Id | Name | SBO |
|---|---|---|
| AbetaDimer | | |
| antiAb | | |

## Modifiers

Table 298: Properties of each modifier.

| Id | Name | SBO |
|---|---|---|
| AbetaDimer | | |

| Id | Name | SBO |
|---|---|---|
| `antiAb` | | |

## Product

Table 299: Properties of each product.

| Id | Name | SBO |
|---|---|---|
| `AbetaDimer_antiAb` | | |

## Kinetic Law

**Derived unit**  contains undeclared units

$$v_{98} = \text{kbinAbantiAb} \cdot \text{AbetaDimer} \cdot \text{antiAb} \tag{198}$$

## 7.99 Reaction `Abeta_antiAbDegredation`

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

## Reaction equation

$$\text{Abeta\_antiAb} \xrightarrow{\text{Abeta\_antiAb}} \text{antiAb} \tag{199}$$

## Reactant

Table 300: Properties of each reactant.

| Id | Name | SBO |
|---|---|---|
| `Abeta_antiAb` | | |

## Modifier

Table 301: Properties of each modifier.

| Id | Name | SBO |
|---|---|---|
| `Abeta_antiAb` | | |

## Product

Table 302: Properties of each product.

| Id | Name | SBO |
|---|---|---|
| antiAb | | |

### Kinetic Law

**Derived unit**  contains undeclared units

$$v_{99} = 10 \cdot \text{kdegAbeta} \cdot \text{Abeta\_antiAb} \tag{200}$$

## 7.100 Reaction `AbetaDimer_antiAbDegredation`

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

### Reaction equation

$$\text{AbetaDimer\_antiAb} \xrightarrow{\text{AbetaDimer\_antiAb}} \text{antiAb} \tag{201}$$
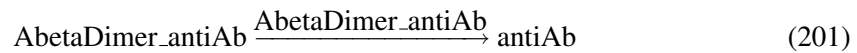
### Reactant

Table 303: Properties of each reactant.

| Id | Name | SBO |
|---|---|---|
| AbetaDimer_antiAb | | |

### Modifier

Table 304: Properties of each modifier.

| Id | Name | SBO |
|---|---|---|
| AbetaDimer_antiAb | | |

### Product

Table 305: Properties of each product.

| Id | Name | SBO |
|---|---|---|
| antiAb | | |

**Kinetic Law**

**Derived unit** contains undeclared units

$$v_{100} = 10 \cdot \text{kdegAbeta} \cdot \text{AbetaDimer\_antiAb} \tag{202}$$

## 7.101 Reaction `GliaActivationStep1`

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

**Reaction equation**

$$\text{GliaI} + \text{AbetaPlaque} \xrightarrow{\text{GliaI, AbetaPlaque}} \text{GliaM1} + \text{AbetaPlaque} \tag{203}$$
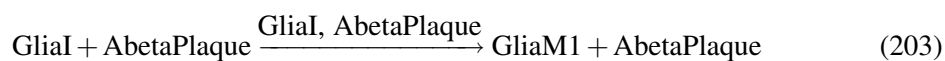
**Reactants**

Table 306: Properties of each reactant.

| Id | Name | SBO |
|----|------|-----|
| GliaI | | |
| AbetaPlaque | | |

**Modifiers**

Table 307: Properties of each modifier.

| Id | Name | SBO |
|----|------|-----|
| GliaI | | |
| AbetaPlaque | | |

**Products**

Table 308: Properties of each product.

| Id | Name | SBO |
|----|------|-----|
| GliaM1 | | |
| AbetaPlaque | | |

**Kinetic Law**

**Derived unit** contains undeclared units

$$v_{101} = \text{kactglia1} \cdot \text{GliaI} \cdot \text{AbetaPlaque} \tag{204}$$

## 7.102 Reaction `GliaActivationStep2`

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

**Reaction equation**

$$\text{GliaM1} + \text{AbetaPlaque} \xrightarrow{\text{GliaM1, AbetaPlaque}} \text{GliaM2} + \text{AbetaPlaque} \tag{205}$$
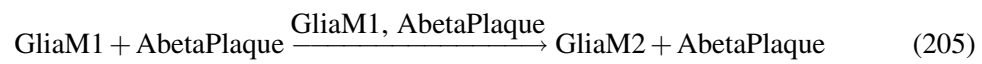
**Reactants**

Table 309: Properties of each reactant.

| Id | Name | SBO |
|----|------|-----|
| GliaM1 | | |
| AbetaPlaque | | |

**Modifiers**

Table 310: Properties of each modifier.

| Id | Name | SBO |
|----|------|-----|
| GliaM1 | | |
| AbetaPlaque | | |

**Products**

Table 311: Properties of each product.

| Id | Name | SBO |
|----|------|-----|
| GliaM2 | | |
| AbetaPlaque | | |

**Kinetic Law**

**Derived unit** contains undeclared units

$$v_{102} = \text{kactglia1} \cdot \text{GliaM1} \cdot \text{AbetaPlaque} \tag{206}$$

## 7.103 Reaction `GliaActivationStep3`

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

**Reaction equation**

$$\text{GliaM2} + \text{antiAb} \xrightarrow{\text{GliaM2, antiAb}} \text{GliaA} + \text{antiAb} \tag{207}$$

**Reactants**

Table 312: Properties of each reactant.

| Id | Name | SBO |
|----|------|-----|
| GliaM2 | | |
| antiAb | | |

**Modifiers**

Table 313: Properties of each modifier.

| Id | Name | SBO |
|----|------|-----|
| GliaM2 | | |
| antiAb | | |

**Products**

Table 314: Properties of each product.

| Id | Name | SBO |
|----|------|-----|
| GliaA | | |
| antiAb | | |

**Kinetic Law**

**Derived unit** contains undeclared units

$$v_{103} = \text{kactglia2} \cdot \text{GliaM2} \cdot \text{antiAb} \qquad (208)$$

## 7.104 Reaction `GliaInactivationStep1`

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

**Reaction equation**

$$\text{GliaA} \xrightarrow{\text{GliaA}} \text{GliaM2} \qquad (209)$$

**Reactant**

Table 315: Properties of each reactant.

| Id | Name | SBO |
|----|------|-----|
| GliaA | | |

**Modifier**

Table 316: Properties of each modifier.

| Id | Name | SBO |
|----|------|-----|
| GliaA | | |

**Product**

Table 317: Properties of each product.

| Id | Name | SBO |
|----|------|-----|
| GliaM2 | | |

**Kinetic Law**

**Derived unit**  contains undeclared units

$$v_{104} = \text{kinactglia1} \cdot \text{GliaA} \qquad (210)$$

## 7.105 Reaction `GliaInactivationStep2`

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

**Reaction equation**

$$\text{GliaM2} \xrightarrow{\text{GliaM2}} \text{GliaM1} \qquad (211)$$
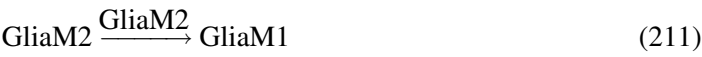
**Reactant**

Table 318: Properties of each reactant.

| Id | Name | SBO |
|----|------|-----|
| GliaM2 | | |

**Modifier**

Table 319: Properties of each modifier.

| Id | Name | SBO |
|----|------|-----|
| GliaM2 | | |

**Product**

Table 320: Properties of each product.

| Id | Name | SBO |
|----|------|-----|
| GliaM1 | | |

**Kinetic Law**

**Derived unit**  contains undeclared units

$$v_{105} = \text{kinactglia2} \cdot \text{GliaM2} \qquad (212)$$

## 7.106 Reaction `GliaInactivationStep3`

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

**Reaction equation**

$$\text{GliaM1} \xrightarrow{\text{GliaM1}} \text{GliaI} \qquad (213)$$
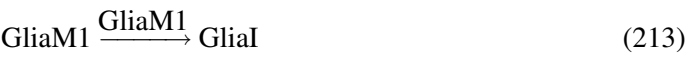
**Reactant**

Table 321: Properties of each reactant.

| Id | Name | SBO |
|---|---|---|
| GliaM1 | | |

## Modifier

Table 322: Properties of each modifier.

| Id | Name | SBO |
|---|---|---|
| GliaM1 | | |

## Product

Table 323: Properties of each product.

| Id | Name | SBO |
|---|---|---|
| GliaI | | |

## Kinetic Law

**Derived unit**  contains undeclared units

$$v_{106} = \text{kinactglia2} \cdot \text{GliaM1} \tag{214}$$

## 7.107 Reaction `AbetaBindingToGlia`

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

## Reaction equation

$$\text{AbetaPlaque} + \text{GliaA} \xrightarrow{\text{AbetaPlaque, GliaA}} \text{AbetaPlaque\_GliaA} \tag{215}$$

## Reactants

Table 324: Properties of each reactant.

| Id | Name | SBO |
|---|---|---|
| AbetaPlaque | | |
| GliaA | | |

**Modifiers**

Table 325: Properties of each modifier.

| Id | Name | SBO |
|---|---|---|
| AbetaPlaque | | |
| GliaA | | |

**Product**

Table 326: Properties of each product.

| Id | Name | SBO |
|---|---|---|
| AbetaPlaque_GliaA | | |

**Kinetic Law**

**Derived unit**  contains undeclared units

$$v_{107} = \text{kbinAbetaGlia} \cdot \text{AbetaPlaque} \cdot \text{GliaA} \qquad (216)$$

## 7.108 Reaction `AbetaReleaseFromGlia`

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

**Reaction equation**

$$\text{AbetaPlaque\_GliaA} \xrightarrow{\text{AbetaPlaque\_GliaA}} \text{AbetaPlaque} + \text{GliaA} \qquad (217)$$
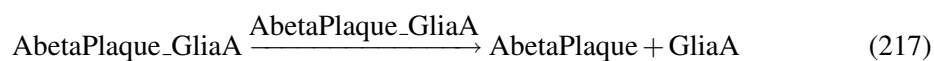
**Reactant**

Table 327: Properties of each reactant.

| Id | Name | SBO |
|---|---|---|
| AbetaPlaque_GliaA | | |

**Modifier**

Table 328: Properties of each modifier.

| Id | Name | SBO |
|---|---|---|
| AbetaPlaque_GliaA | | |

**Products**

Table 329: Properties of each product.

| Id | Name | SBO |
|---|---|---|
| AbetaPlaque | | |
| GliaA | | |

**Kinetic Law**

**Derived unit** contains undeclared units

$$v_{108} = \text{krelAbetaGlia} \cdot \text{AbetaPlaque\_GliaA} \qquad (218)$$

## 7.109 Reaction AbetaPlaqueClearanceByGlia

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

**Reaction equation**

$$\text{AbetaPlaque\_GliaA} \xrightarrow{\text{AbetaPlaque\_GliaA}} \text{GliaA} + \text{degAbetaGlia} \qquad (219)$$
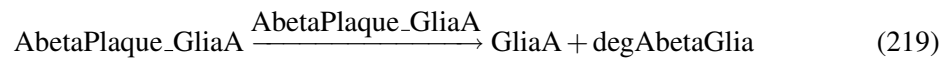
**Reactant**

Table 330: Properties of each reactant.

| Id | Name | SBO |
|---|---|---|
| AbetaPlaque_GliaA | | |

**Modifier**

Table 331: Properties of each modifier.

| Id | Name | SBO |
|---|---|---|
| AbetaPlaque_GliaA | | |

**Products**

Table 332: Properties of each product.

| Id | Name | SBO |
|---|---|---|
| GliaA | | |
| degAbetaGlia | | |

**Kinetic Law**

**Derived unit** contains undeclared units

$$v_{109} = \text{kdegAbetaGlia} \cdot \text{AbetaPlaque\_GliaA} \tag{220}$$

## 7.110 Reaction `ROSgenerationByGlia`

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

**Reaction equation**

$$\text{AbetaPlaque\_GliaA} \xrightarrow{\text{AbetaPlaque\_GliaA}} \text{AbetaPlaque\_GliaA} + \text{ROS} \tag{221}$$
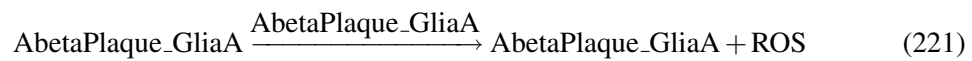
**Reactant**

Table 333: Properties of each reactant.

| Id | Name | SBO |
|---|---|---|
| AbetaPlaque_GliaA | | |

**Modifier**

Table 334: Properties of each modifier.

| Id | Name | SBO |
|---|---|---|
| AbetaPlaque_GliaA | | |

**Products**

Table 335: Properties of each product.

| Id | Name | SBO |
|---|---|---|
| AbetaPlaque_GliaA | | |
| ROS | | |

**Kinetic Law**

**Derived unit**  contains undeclared units

$$v_{110} = \text{kgenROSGlia} \cdot \text{AbetaPlaque\_GliaA} \tag{222}$$

## 7.111 Reaction `antiAbRemoval`

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

**Reaction equation**

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

**Reactant**

Table 336: Properties of each reactant.

| Id | Name | SBO |
|---|---|---|
| antiAb | | |

**Modifier**

Table 337: Properties of each modifier.

| Id | Name | SBO |
|---|---|---|
| antiAb | | |

**Product**

Table 338: Properties of each product.

| Id | Name | SBO |
|---|---|---|
| Sink | | |

*Produced by SBML2LATEX*

## Kinetic Law

**Derived unit** contains undeclared units

$$v_{111} = \text{kdegAntiAb} \cdot \text{antiAb} \tag{224}$$

## 7.112 Reaction `ROSremoval`

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

### Reaction equation

$$\text{ROS} \xrightarrow{\text{ROS}} \text{Sink} \tag{225}$$

### Reactant

Table 339: Properties of each reactant.

| Id | Name | SBO |
|----|------|-----|
| ROS | | |

### Modifier

Table 340: Properties of each modifier.

| Id | Name | SBO |
|----|------|-----|
| ROS | | |

### Product

Table 341: Properties of each product.

| Id | Name | SBO |
|----|------|-----|
| Sink | | |

### Kinetic Law

**Derived unit** contains undeclared units

$$v_{112} = \text{kremROS} \cdot \text{ROS} \tag{226}$$

# 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

**Initial amount** 5 item

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

$$\frac{d}{dt}\text{Mdm2} = v_3 + v_{10} + v_{24} + v_{39} + v_{72} - v_9 - v_{17} - v_{71} \qquad (227)$$

## 8.2 Species p53

**Initial amount** 5 item

This species takes part in 13 reactions (as a reactant in Mdm2mRNASynthesis1, P53Mdm2Binding, GSK3p53Binding, p53phosphorylation and as a product in Mdm2mRNASynthesis1, P53Mdm2Release, GSK3p53Release, p53Synthesis, p53dephosphorylation and as a modifier in Mdm2mRNASynthesis1, P53Mdm2Binding, GSK3p53Binding, p53phosphorylation).

$$\frac{d}{dt}\text{p53} = v_4 + v_{10} + v_{12} + v_{27} + v_{70} - v_4 - v_9 - v_{11} - v_{69} \qquad (228)$$

## 8.3 Species Mdm2_p53

**Initial amount** 95 item

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

$$\frac{d}{dt}\text{Mdm2\_p53} = v_9 + v_{35} - v_{10} - v_{28} \qquad (229)$$

## 8.4 Species `Mdm2_mRNA`

**Initial amount** 10 item

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

$$\frac{d}{dt}\text{Mdm2\_mRNA} = v_3 + v_4 + v_5 + v_6 + v_7 - v_3 - v_8 \qquad (230)$$

## 8.5 Species `p53_mRNA`

**Initial amount** 10 item

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

$$\frac{d}{dt}\text{p53\_mRNA} = v_1 + v_{27} + v_{65} - v_2 - v_{27} \qquad (231)$$

## 8.6 Species `ATMA`

**Initial amount** 0 item

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

$$\frac{d}{dt}\text{ATMA} = v_{68} + v_{69} + v_{71} - v_{69} - v_{71} - v_{83} \qquad (232)$$

## 8.7 Species `ATMI`

**Initial amount** 200 item

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

$$\frac{d}{dt}\text{ATMI} = v_{83} - v_{68} \qquad (233)$$

## 8.8 Species `p53_P`

**Initial amount** 0 item

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

$$\frac{d}{dt}\text{p53\_P} = v_5 + v_{14} + v_{69} - v_5 - v_{13} - v_{70} \qquad (234)$$

### 8.9 Species `Mdm2_P`

**Initial amount** 0 item

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

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{Mdm2\_P} = v_{71} + v_{80} - v_{72} - v_{73} \tag{235}$$

### 8.10 Species `IR`

**Initial amount** 0 item

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

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{IR} = v_{66} - v_{66} \tag{236}$$

### 8.11 Species `ROS`

**Initial amount** 0 item

This species takes part in nine reactions (as a reactant in `ROSDNAdamage`, `ROSremoval` and as a product in `AbetaROSproduction1`, `PlaqueROSproduction`, `AggAbetaROSproduction2`, `ROSDNAdamage`, `ROSgenerationByGlia` and as a modifier in `ROSDNAdamage`, `ROSremoval`).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{ROS} = v_{84} + v_{85} + v_{86} + v_{87} + v_{110} - v_{87} - v_{112} \tag{237}$$

### 8.12 Species `damDNA`

**Initial amount** 0 item

This species takes part in seven reactions (as a reactant in `DNArepair`, `ATMactivation` and as a product in `DNAdamage`, `ATMactivation`, `ROSDNAdamage` and as a modifier in `DNArepair`, `ATMactivation`).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{damDNA} = v_{66} + v_{68} + v_{87} - v_{67} - v_{68} \tag{238}$$

### 8.13 Species `E1`

**Initial amount** 100 item

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

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{E1} = v_{16} - v_{15} \tag{239}$$

## 8.14 Species E2

**Initial amount** 100 item

This species takes part in 14 reactions (as a reactant in E2UbBinding and as a product in Mdm2Ubiquitination, Mdm2polyUbiquitination1, Mdm2polyUbiquitination2, Mdm2polyUbiquitination, p53Monoubiquitination, p53Polyubiquitination1, p53Polyubiquitination2, p53Polyubiquitination, Mdm2PUbiquitination, Mdm2PpolyUbiquitination1, Mdm2PpolyUbiquitination2, Mdm2PpolyUbiquitina and as a modifier in E2UbBinding).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{E2} = v_{17} + v_{18} + v_{19} + v_{20} + v_{28} + v_{29} + v_{30}$$
$$+ v_{31} + v_{73} + v_{74} + v_{75} + v_{76} - v_{16} \tag{240}$$

## 8.15 Species E1_Ub

**Initial amount** 0 item

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

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{E1\_Ub} = v_{15} - v_{16} \tag{241}$$

## 8.16 Species E2_Ub

**Initial amount** 0 item

This species takes part in 25 reactions (as a reactant in Mdm2Ubiquitination, Mdm2polyUbiquitination1, Mdm2polyUbiquitination2, Mdm2polyUbiquitination3, p53Monoubiquitination, p53Polyubiquitinati p53Polyubiquitination2, p53Polyubiquitination3, Mdm2PUbiquitination, Mdm2PpolyUbiquitination Mdm2PpolyUbiquitination2, Mdm2PpolyUbiquitination3 and as a product in E2UbBinding and as a modifier in Mdm2Ubiquitination, Mdm2polyUbiquitination1, Mdm2polyUbiquitination2, Mdm2polyUbiquitination3, p53Monoubiquitination, p53Polyubiquitination1, p53Polyubiquitinatio p53Polyubiquitination3, Mdm2PUbiquitination, Mdm2PpolyUbiquitination1, Mdm2PpolyUbiquitinati Mdm2PpolyUbiquitination3).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{E2\_Ub} = v_{16} - v_{17} - v_{18} - v_{19} - v_{20} - v_{28} - v_{29}$$
$$- v_{30} - v_{31} - v_{73} - v_{74} - v_{75} - v_{76} \tag{242}$$

## 8.17 Species Proteasome

**Initial amount** 500 item

This species takes part in 16 reactions (as a reactant in `Mdm2ProteasomeBinding1`, `p53ProteasomeBinding1`, `ProteasomeInhibitionAggTau`, `ProteasomeInhibitionAbeta`, `Mdm2PProteasomeBinding1`, `TauProteasomeBinding` and as a product in `Mdm2Degradation`, `Degradationp53_Ub4`, `Mdm2PDegradation`, `Tau20SProteasomeDegradation` and as a modifier in `Mdm2ProteasomeBinding1`, `p53ProteasomeBinding1`, `ProteasomeInhibitionAggTau`, `ProteasomeInhibitionAbeta`, `Mdm2PProteasomeBinding1`, `TauProteasomeBinding`).

$$\frac{d}{dt}\text{Proteasome} = v_{26} + v_{40} + v_{82} + v_{90} - v_{25} - v_{39} - v_{59} - v_{63} - v_{81} - v_{89} \quad (243)$$

## 8.18 Species `Ub`

**Initial amount**  4000 item

This species takes part in 17 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` and as a modifier in `E1UbBinding`).

$$\frac{d}{dt}\text{Ub} = v_{21} + v_{22} + v_{23} + v_{24} + 4\,v_{26} + v_{32} + v_{33} + v_{34}$$
$$+ v_{35} + 4\,v_{40} + v_{77} + v_{78} + v_{79} + v_{80} + 4\,v_{82} - v_{15} \quad (244)$$

## 8.19 Species `p53DUB`

**Initial amount**  200 item

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

$$\frac{d}{dt}\text{p53DUB} = v_{32} + v_{33} + v_{34} + v_{35} - v_{32} - v_{33} - v_{34} - v_{35} \quad (245)$$

## 8.20 Species `Mdm2DUB`

**Initial amount**  200 item

This species takes part in 24 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` and as

a modifier in `Mdm2Deubiquitination4`, `Mdm2Deubiquitination3`, `Mdm2Deubiquitination2`, `Mdm2Deubiquitination1`, `Mdm2PDeubiquitination4`, `Mdm2PDeubiquitination3`, `Mdm2PDeubiquitination` `Mdm2PDeubiquitination1`).

$$\frac{d}{dt}\text{Mdm2DUB} = v_{21} + v_{22} + v_{23} + v_{24} + v_{77} + v_{78} + v_{79} + v_{80} \tag{246}$$
$$- v_{21} - v_{22} - v_{23} - v_{24} - v_{77} - v_{78} - v_{79} - v_{80}$$

## 8.21 Species `DUB`

**Initial amount**  200 item

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

$$\frac{d}{dt}\text{DUB} = 0 \tag{247}$$

## 8.22 Species `Mdm2_p53_Ub`

**Initial amount**  0 item

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

$$\frac{d}{dt}\text{Mdm2\_p53\_Ub} = v_{28} + v_{34} - v_{29} - v_{35} \tag{248}$$

## 8.23 Species `Mdm2_p53_Ub2`

**Initial amount**  0 item

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

$$\frac{d}{dt}\text{Mdm2\_p53\_Ub2} = v_{29} + v_{33} - v_{30} - v_{34} \tag{249}$$

## 8.24 Species `Mdm2_p53_Ub3`

**Initial amount**  0 item

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

$$\frac{d}{dt}\text{Mdm2\_p53\_Ub3} = v_{30} + v_{32} - v_{31} - v_{33} \tag{250}$$

## 8.25 Species `Mdm2_p53_Ub4`

**Initial amount** 0 item

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

$$\frac{d}{dt}\text{Mdm2\_p53\_Ub4} = v_{31} - v_{32} - v_{36} - v_{37} - v_{38} \tag{251}$$

## 8.26 Species `Mdm2_P1_p53_Ub4`

**Initial amount** 0 item

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

$$\frac{d}{dt}\text{Mdm2\_P1\_p53\_Ub4} = v_{36} + v_{37} + v_{38} - v_{39} \tag{252}$$

## 8.27 Species `Mdm2_Ub`

**Initial amount** 0 item

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

$$\frac{d}{dt}\text{Mdm2\_Ub} = v_{17} + v_{23} - v_{18} - v_{24} \tag{253}$$

## 8.28 Species `Mdm2_Ub2`

**Initial amount** 0 item

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

$$\frac{d}{dt}\text{Mdm2\_Ub2} = v_{18} + v_{22} - v_{19} - v_{23} \tag{254}$$

## 8.29 Species `Mdm2_Ub3`

**Initial amount** 0 item

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

$$
\frac{d}{dt}\text{Mdm2\_Ub3} = v_{19} + v_{21} - v_{20} - v_{22} \tag{255}
$$

## 8.30 Species `Mdm2_Ub4`

**Initial amount** 0 item

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

$$
\frac{d}{dt}\text{Mdm2\_Ub4} = v_{20} - v_{21} - v_{25} \tag{256}
$$

## 8.31 Species `Mdm2_P_Ub`

**Initial amount** 0 item

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

$$
\frac{d}{dt}\text{Mdm2\_P\_Ub} = v_{73} + v_{79} - v_{74} - v_{80} \tag{257}
$$

## 8.32 Species `Mdm2_P_Ub2`

**Initial amount** 0 item

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

$$
\frac{d}{dt}\text{Mdm2\_P\_Ub2} = v_{74} + v_{78} - v_{75} - v_{79} \tag{258}
$$

## 8.33 Species `Mdm2_P_Ub3`

**Initial amount** 0 item

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

$$\frac{d}{dt}\text{Mdm2\_P\_Ub3} = v_{75} + v_{77} - v_{76} - v_{78} \tag{259}$$

## 8.34 Species `Mdm2_P_Ub4`

**Initial amount** 0 item

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

$$\frac{d}{dt}\text{Mdm2\_P\_Ub4} = v_{76} - v_{77} - v_{81} \tag{260}$$

## 8.35 Species `p53_Ub4_Proteasome`

**Initial amount** 0 item

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

$$\frac{d}{dt}\text{p53\_Ub4\_Proteasome} = v_{39} - v_{40} \tag{261}$$

## 8.36 Species `Mdm2_Ub4_Proteasome`

**Initial amount** 0 item

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

$$\frac{d}{dt}\text{Mdm2\_Ub4\_Proteasome} = v_{25} - v_{26} \tag{262}$$

## 8.37 Species `Mdm2_P_Ub4_Proteasome`

**Initial amount** 0 item

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

$$\frac{d}{dt}\text{Mdm2\_P\_Ub4\_Proteasome} = v_{81} - v_{82} \tag{263}$$

## 8.38 Species GSK3b

**Initial amount** 500 item

This species takes part in 15 reactions (as a reactant in GSK3p53Binding, GSK3p53PBinding, Mdm2GSK3phosphorylation1, Tauphosphorylation5, Tauphosphorylation6 and as a product in GSK3p53Release, GSK3_p53PRelease, Mdm2GSK3phosphorylation1, Tauphosphorylation5, Tauphosphorylation6 and as a modifier in GSK3p53Binding, GSK3p53PBinding, Mdm2GSK3phosphorylation1, Tauphosphorylation5, Tauphosphorylation6).

$$\frac{\mathrm{d}}{\mathrm{d}t}\text{GSK3b} = v_{12} + v_{14} + v_{36} + v_{47} + v_{48} - v_{11} - v_{13} - v_{36} - v_{47} - v_{48} \quad (264)$$

## 8.39 Species GSK3b_p53

**Initial amount** 0 item

This species takes part in 18 reactions (as a reactant in Mdm2mRNASynthesis3, GSK3p53Release, Mdm2GSK3phosphorylation2, Tauphosphorylation1, Tauphosphorylation2, Abetaproduction2 and as a product in Mdm2mRNASynthesis3, GSK3p53Binding, Mdm2GSK3phosphorylation2, Tauphosphorylation1, Tauphosphorylation2, Abetaproduction2 and as a modifier in Mdm2mRNASynthesis3, GSK3p53Release, Mdm2GSK3phosphorylation2, Tauphosphorylation1, Tauphosphorylation2, Abetaproduction2).

$$\frac{\mathrm{d}}{\mathrm{d}t}\text{GSK3b\_p53} = v_6 + v_{11} + v_{37} + v_{43} + v_{44} + v_{61}$$
$$- v_6 - v_{12} - v_{37} - v_{43} - v_{44} - v_{61} \quad (265)$$

## 8.40 Species GSK3b_p53_P

**Initial amount** 0 item

This species takes part in 18 reactions (as a reactant in Mdm2mRNASynthesis4, GSK3_p53PRelease, Mdm2GSK3phosphorylation3, Tauphosphorylation3, Tauphosphorylation4, Abetaproduction3 and as a product in Mdm2mRNASynthesis4, GSK3p53PBinding, Mdm2GSK3phosphorylation3, Tauphosphorylation3, Tauphosphorylation4, Abetaproduction3 and as a modifier in Mdm2mRNASynthesis4, GSK3_p53PRelease, Mdm2GSK3phosphorylation3, Tauphosphorylation3, Tauphosphorylation4, Abetaproduction3).

$$\frac{\mathrm{d}}{\mathrm{d}t}\text{GSK3b\_p53\_P} = v_7 + v_{13} + v_{38} + v_{45} + v_{46} + v_{62}$$
$$- v_7 - v_{14} - v_{38} - v_{45} - v_{46} - v_{62} \quad (266)$$

## 8.41 Species `Abeta`

**Initial amount** 0 item

This species takes part in 16 reactions (as a reactant in `AbetaDegradation`, `p53transcriptionViaAbeta`, `AbetaROSproduction1`, `AbetaAggregation1`, `Abeta_antiAbBinding` and as a product in `Abetaproduction1`, `Abetaproduction2`, `Abetaproduction3`, `p53transcriptionViaAbeta`, `AbetaROSproduction1`, `AbetaDisaggregation1` and as a modifier in `AbetaDegradation`, `p53transcriptionViaAbeta`, `AbetaROSproduction1`, `AbetaAggregation1`, `Abeta_antiAbBinding`).

$$\frac{d}{dt}\text{Abeta} = v_{60} + v_{61} + v_{62} + v_{65} + v_{84} + 2\,v_{94} - v_{64} - v_{65} - v_{84} - 2\,v_{91} - v_{97} \quad (267)$$

## 8.42 Species `AggAbeta_Proteasome`

**Initial amount** 0 item

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

$$\frac{d}{dt}\text{AggAbeta\_Proteasome} = v_{63} + v_{86} - v_{86} \quad (268)$$

## 8.43 Species `AbetaPlaque`

**Initial amount** 0 item

This species takes part in 20 reactions (as a reactant in `PlaqueROSproduction`, `AbetaPlaqueGrowth`, `AbetaDisaggregation3`, `AbetaDisaggregation4`, `GliaActivationStep1`, `GliaActivationStep2`, `AbetaBindingToGlia` and as a product in `PlaqueROSproduction`, `AbetaPlaqueFormation1`, `AbetaPlaqueGrowth`, `GliaActivationStep1`, `GliaActivationStep2`, `AbetaReleaseFromGlia` and as a modifier in `PlaqueROSproduction`, `AbetaPlaqueGrowth`, `AbetaDisaggregation3`, `AbetaDisaggregation4`, `GliaActivationStep1`, `GliaActivationStep2`, `AbetaBindingToGlia`).

$$\frac{d}{dt}\text{AbetaPlaque} = v_{85} + v_{92} + 2\,v_{93} + v_{101} + v_{102} + v_{108} - v_{85}$$
$$- v_{93} - v_{95} - v_{96} - v_{101} - v_{102} - v_{107} \quad (269)$$

## 8.44 Species `Tau`

**Initial amount** 0 item

This species takes part in 17 reactions (as a reactant in `TauMTbinding`, `Tauphosphorylation1`, `Tauphosphorylation3`, `Tauphosphorylation5`, `TauAggregation1`, `TauAggregation2`, `TauProteasomeBinding` and as a product in `TauMTrelease`, `Taudephosphorylation2`, `TauSynthesis` and as a modifier in `TauMTbinding`, `Tauphosphorylation1`, `Tauphosphorylation3`, `Tauphosphorylation5`, `TauAggregation1`, `TauAggregation2`, `TauProteasomeBinding`).

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$$\frac{d}{dt}\text{Tau} = v_{42} + v_{50} + v_{88} - v_{41} - v_{43} - v_{45} - v_{47} - 2\,v_{55} - v_{56} - v_{89} \quad (270)$$

## 8.45 Species `Tau_P1`

**Initial amount** 0 item

This species takes part in 16 reactions (as a reactant in `Tauphosphorylation2`, `Tauphosphorylation4`, `Tauphosphorylation6`, `Taudephosphorylation2`, `TauP1Aggregation1`, `TauP1Aggregation2` and as a product in `Tauphosphorylation1`, `Tauphosphorylation3`, `Tauphosphorylation5`, `Taudephosphorylation1` and as a modifier in `Tauphosphorylation2`, `Tauphosphorylation4`, `Tauphosphorylation6`, `Taudephosphorylation2`, `TauP1Aggregation1`, `TauP1Aggregation2`).

$$\frac{d}{dt}\text{Tau\_P1} = v_{43} + v_{45} + v_{47} + v_{49} - v_{44} - v_{46} - v_{48} - v_{50} - 2\,v_{51} - v_{52} \quad (271)$$

## 8.46 Species `Tau_P2`

**Initial amount** 0 item

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

$$\frac{d}{dt}\text{Tau\_P2} = v_{44} + v_{46} + v_{48} - v_{49} - 2\,v_{53} - v_{54} \quad (272)$$

## 8.47 Species `MT_Tau`

**Initial amount** 100 item

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

$$\frac{d}{dt}\text{MT\_Tau} = v_{41} - v_{42} \quad (273)$$

## 8.48 Species `AggTau`

**Initial amount** 0 item

This species takes part in 18 reactions (as a reactant in `TauP1Aggregation2`, `TauP2Aggregation2`, `TauAggregation2`, `TangleFormation1`, `TangleFormation2`, `ProteasomeInhibitionAggTau` and as a product in `TauP1Aggregation1`, `TauP1Aggregation2`, `TauP2Aggregation1`, `TauP2Aggregation2`, `TauAggregation1`, `TauAggregation2` and as a modifier in `TauP1Aggregation2`, `TauP2Aggregation2`, `TauAggregation2`, `TangleFormation1`, `TangleFormation2`, `ProteasomeInhibitionAggTau`).

$$\frac{d}{dt}\text{AggTau} = 2\,v_{51} + 2\,v_{52} + 2\,v_{53} + 2\,v_{54} + 2\,v_{55} + 2\,v_{56}$$
$$- v_{52} - v_{54} - v_{56} - 2\,v_{57} - v_{58} - v_{59} \quad (274)$$

## 8.49 Species `AggTau_Proteasome`

**Initial amount** 0 item

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

$$\frac{d}{dt}\text{AggTau\_Proteasome} = v_{59} \tag{275}$$

## 8.50 Species `Proteasome_Tau`

**Initial amount** 0 item

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

$$\frac{d}{dt}\text{Proteasome\_Tau} = v_{89} - v_{90} \tag{276}$$

## 8.51 Species `PP1`

**Initial amount** 50 item

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

$$\frac{d}{dt}\text{PP1} = v_{49} + v_{50} - v_{49} - v_{50} \tag{277}$$

## 8.52 Species `NFT`

**Initial amount** 0 item

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

$$\frac{d}{dt}\text{NFT} = 2\,v_{57} + 2\,v_{58} - v_{58} \tag{278}$$

## 8.53 Species `ATP`

**Initial amount** 10000 item

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

$$\frac{d}{dt}\text{ATP} = 0 \tag{279}$$

## 8.54 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:

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{ADP} = 0 \tag{280}$$

## 8.55 Species `AMP`

**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:

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{AMP} = 0 \tag{281}$$

## 8.56 Species `AbetaDimer`

**Initial amount** 0 item

This species takes part in 13 reactions (as a reactant in `ProteasomeInhibitionAbeta`, `AbetaPlaqueFormation1`, `AbetaPlaqueGrowth`, `AbetaDisaggregation1`, `AbetaDimer_antiAbBinding` and as a product in `AbetaAggregation1`, `AbetaDisaggregation3`, `AbetaDisaggregation4` and as a modifier in `ProteasomeInhibitionAbeta`, `AbetaPlaqueFormation1`, `AbetaPlaqueGrowth`, `AbetaDisaggregation1`, `AbetaDimer_antiAbBinding`).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{AbetaDimer} = v_{91} + v_{95} + v_{96} - v_{63} - 2\,v_{92} - v_{93} - v_{94} - v_{98} \tag{282}$$

## 8.57 Species `AbetaPlaque_GliaA`

**Initial amount** 0 item

This species takes part in eight reactions (as a reactant in `AbetaReleaseFromGlia`, `AbetaPlaqueClearanceByGli` `ROSgenerationByGlia` and as a product in `AbetaBindingToGlia`, `ROSgenerationByGlia` and as a modifier in `AbetaReleaseFromGlia`, `AbetaPlaqueClearanceByGlia`, `ROSgenerationByGlia`).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{AbetaPlaque\_GliaA} = v_{107} + v_{110} - v_{108} - v_{109} - v_{110} \tag{283}$$

## 8.58 Species `GliaI`

**Notes**  Inactive glia

**Initial amount**  100 item

This species takes part in three reactions (as a reactant in `GliaActivationStep1` and as a product in `GliaInactivationStep3` and as a modifier in `GliaActivationStep1`).

$$\frac{d}{dt}\text{GliaI} = v_{106} - v_{101} \tag{284}$$

## 8.59 Species `GliaM1`

**Notes**  Glia associated with plaques but not able to phagocytose

**Initial amount**  0 item

This species takes part in six reactions (as a reactant in `GliaActivationStep2`, `GliaInactivationStep3` and as a product in `GliaActivationStep1`, `GliaInactivationStep2` and as a modifier in `GliaActivationStep2`, `GliaInactivationStep3`).

$$\frac{d}{dt}\text{GliaM1} = v_{101} + v_{105} - v_{102} - v_{106} \tag{285}$$

## 8.60 Species `GliaM2`

**Notes**  Glia associated with plaques but not able to phagocytose

**Initial amount**  0 item

This species takes part in six reactions (as a reactant in `GliaActivationStep3`, `GliaInactivationStep2` and as a product in `GliaActivationStep2`, `GliaInactivationStep1` and as a modifier in `GliaActivationStep3`, `GliaInactivationStep2`).

$$\frac{d}{dt}\text{GliaM2} = v_{102} + v_{104} - v_{103} - v_{105} \tag{286}$$

## 8.61 Species `GliaA`

**Notes**  Active glia which can phagocytose

**Initial amount**  0 item

This species takes part in seven reactions (as a reactant in `GliaInactivationStep1`, `AbetaBindingToGlia` and as a product in `GliaActivationStep3`, `AbetaReleaseFromGlia`, `AbetaPlaqueClearanceByGlia` and as a modifier in `GliaInactivationStep1`, `AbetaBindingToGlia`).

$$\frac{d}{dt}\text{GliaA} = v_{103} + v_{108} + v_{109} - v_{104} - v_{107} \tag{287}$$

## 8.62 Species `antiAb`

**Notes** Antibody against amyloid-beta

**Initial amount** 0 item

**Involved in event** `ImmunizeCell`

This species takes part in 14 reactions (as a reactant in `AbetaDisaggregation4`, `Abeta_antiAbBinding`, `AbetaDimer_antiAbBinding`, `GliaActivationStep3`, `antiAbRemoval` and as a product in `AbetaDisaggregation4`, `Abeta_antiAbDegredation`, `AbetaDimer_antiAbDegredation`, `GliaActivationStep3` and as a modifier in `AbetaDisaggregation4`, `Abeta_antiAbBinding`, `AbetaDimer_antiAbBinding`, `GliaActivationStep3`, `antiAbRemoval`).

$$\frac{\mathrm{d}}{\mathrm{d}t}\text{antiAb} = v_{96} + v_{99} + v_{100} + v_{103} - v_{96} - v_{97} - v_{98} - v_{103} - v_{111} \quad (288)$$

Furthermore, one event influences this species' rate of change.

## 8.63 Species `Abeta_antiAb`

**Notes** Abeta monomer bound to antibody

**Initial amount** 0 item

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

$$\frac{\mathrm{d}}{\mathrm{d}t}\text{Abeta\_antiAb} = v_{97} - v_{99} \quad (289)$$

## 8.64 Species `AbetaDimer_antiAb`

**Notes** Abeta dimer bound to antibody

**Initial amount** 0 item

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

$$\frac{\mathrm{d}}{\mathrm{d}t}\text{AbetaDimer\_antiAb} = v_{98} - v_{100} \quad (290)$$

## 8.65 Species `degAbetaGlia`

**Initial amount** 0 item

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

$$\frac{\mathrm{d}}{\mathrm{d}t}\text{degAbetaGlia} = v_{109} \quad (291)$$

## 8.66 Species `disaggPlaque1`

**Initial amount**  0 item

This species takes part in one reaction (as a product in `AbetaDisaggregation3`).

$$\frac{d}{dt}\text{disaggPlaque1} = v_{95} \tag{292}$$

## 8.67 Species `disaggPlaque2`

**Initial amount**  0 item

This species takes part in one reaction (as a product in `AbetaDisaggregation4`).

$$\frac{d}{dt}\text{disaggPlaque2} = v_{96} \tag{293}$$

## 8.68 Species `Source`

**SBO:0000291**  empty set

**Initial amount**  1 item

This species takes part in six reactions (as a reactant in `p53mRNASynthesis`, `Abetaproduction1`, `TauSynthesis` and as a modifier in `p53mRNASynthesis`, `Abetaproduction1`, `TauSynthesis`), which do not influence its rate of change because this constant species is on the boundary of the reaction system:

$$\frac{d}{dt}\text{Source} = 0 \tag{294}$$

## 8.69 Species `Sink`

**SBO:0000291**  empty set

**Initial amount**  1 item

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

$$\frac{d}{dt}\text{Sink} = 0 \tag{295}$$

# A  Glossary of Systems Biology Ontology Terms

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