

SBML Model Report

Model name: “Proctor2011- _ProteinHomeostasis_NormalCondition”



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 Chelliah¹ and Carole J Proctor² at July 21st 2011 at 4:40 p.m. and last time modified at April eighth 2016 at 5:01 p.m. Table 1 provides 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	2
species types	0	species	54
events	1	constraints	0
reactions	80	function definitions	0
global parameters	65	unit definitions	1
rules	3	initial assignments	0

Model Notes

This model is from the article:

Modelling the Role of the Hsp70/Hsp90 System in the Maintenance of Protein Homeostasis
Proctor CJ, Lorimer IAJ *PLoS ONE*2011; 6(7): e22038. [doi:10.1371/journal.pone.0022038](https://doi.org/10.1371/journal.pone.0022038),

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Abstract:

Neurodegeneration is an age-related disorder which is characterised by the accumulation of aggregated protein and neuronal cell death. There are many different neurodegenerative diseases which are classified according to the specific proteins involved and the regions of the brain which are affected. Despite individual differences, there are common mechanisms at the sub-cellular level leading to loss of protein homeostasis. The two central systems in protein homeostasis are the chaperone system, which promotes correct protein folding, and the cellular proteolytic system, which degrades misfolded or damaged proteins. Since these systems and their interactions are very complex, we use mathematical modelling to aid understanding of the processes involved. The model developed in this study focuses on the role of Hsp70 (IPR00103) and Hsp90 (IPR001404) chaperones in preventing both protein aggregation and cell death. Simulations were performed under three different conditions: no stress; transient stress due to an increase in reactive oxygen species; and high stress due to sustained increases in reactive oxygen species. The model predicts that protein homeostasis can be maintained during short periods of stress. However, under long periods of stress, the chaperone system becomes overwhelmed and the probability of cell death pathways being activated increases. Simulations were also run in which cell death mediated by the JNK (P45983) and p38 (Q16539) pathways was inhibited. The model predicts that inhibiting either or both of these pathways may delay cell death but does not stop the aggregation process and that eventually cells die due to aggregated protein inhibiting proteasomal function. This problem can be overcome if the sequestration of aggregated protein into inclusion bodies is enhanced. This model predicts responses to reactive oxygen species-mediated stress that are consistent with currently available experimental data. The model can be used to assess specific interventions to reduce cell death due to impaired protein homeostasis.

Note:

Simulations were performed under three different conditions: 1) normal condition (no stress), 2) moderate stress due to an increase in reactive oxygen species (ROS) i.e. ROS levels were increased by a factor of 4 at time=4hours for a period of 1 hour (not 2 hours as mentioned in the figure 5 legend of the reference publication. This is a typo in the paper and is clarified by the author) and 3) high stress due to sustained increase in reactive oxygen species (ROS) (here ROS increases with time).

The model that corresponds to the normal condition is submitted as a main model in the BioModels Database. The other two models, that corresponds to the moderate stress conditions and high stress conditions are available in SBML format as supporting files [go to Curation tab].

Supplementary figures S3 (normal condition), S4 (moderate stress condition) and S6 (high stress condition) are reproduced here.

2 Unit Definitions

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

2.1 Unit substance

Definition item

2.2 Unit volume

Notes Litre is the predefined SBML unit for volume.

Definition l

2.3 Unit area

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

Definition m²

2.4 Unit length

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

Definition m

2.5 Unit time

Notes Second is the predefined SBML unit for time.

Definition s

3 Compartments

This model contains two compartments.

Table 2: Properties of all compartments.

Id	Name	SBO	Spatial Dimensions	Size	Unit	Constant	Outside
cytosol		0000290	3	1	litre	✓	
nucleus		0000290	3	1	litre	✓	

3.1 Compartment cytosol

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

SBO:0000290 physical compartment

3.2 Compartment `nucleus`

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

SBO:0000290 physical compartment

4 Species

This model contains 54 species. The boundary condition of four of these species is set to `true` so that these species' amount cannot be changed by any reaction. Section 9 provides further details and the derived rates of change of each species.

Table 3: Properties of each species.

Id	Name	Compartment	Derived Unit	Constant	Boundary Condi- tion
	NatP	cytosol	item	<input type="checkbox"/>	<input type="checkbox"/>
	MisP	cytosol	item	<input type="checkbox"/>	<input type="checkbox"/>
	Hsp70	cytosol	item	<input type="checkbox"/>	<input type="checkbox"/>
	Hsp90	cytosol	item	<input type="checkbox"/>	<input type="checkbox"/>
	Hsp70_dam	cytosol	item	<input type="checkbox"/>	<input type="checkbox"/>
	Hsp90_dam	cytosol	item	<input type="checkbox"/>	<input type="checkbox"/>
	Hsp90_Proteasome	cytosol	item	<input type="checkbox"/>	<input type="checkbox"/>
	Hsp70_Proteasome	cytosol	item	<input type="checkbox"/>	<input type="checkbox"/>
	Hsp70Client	cytosol	item	<input type="checkbox"/>	<input type="checkbox"/>
	Hsp90Client	cytosol	item	<input type="checkbox"/>	<input type="checkbox"/>
	Hsp70_Hsp70Client	cytosol	item	<input type="checkbox"/>	<input type="checkbox"/>
	Hsp90_Hsp90Client	cytosol	item	<input type="checkbox"/>	<input type="checkbox"/>
	Akt	cytosol	item	<input type="checkbox"/>	<input type="checkbox"/>
	Akt_Hsp90	cytosol	item	<input type="checkbox"/>	<input type="checkbox"/>
	CHIP	cytosol	item	<input type="checkbox"/>	<input type="checkbox"/>
	Akt_CHIP_Hsp90	cytosol	item	<input type="checkbox"/>	<input type="checkbox"/>
	Akt_Proteasome	cytosol	item	<input type="checkbox"/>	<input type="checkbox"/>
	Hsf1	cytosol	item	<input type="checkbox"/>	<input type="checkbox"/>
	Hsf1_Hsp90	cytosol	item	<input type="checkbox"/>	<input type="checkbox"/>
	Hsp90_MisP	cytosol	item	<input type="checkbox"/>	<input type="checkbox"/>
	Hsp70_MisP	cytosol	item	<input type="checkbox"/>	<input type="checkbox"/>

Id	Name	Compartment	Derived Unit	Constant	Boundary Condi- tion
Hsf1_Hsf1_Hsf1		nucleus	item	<input type="checkbox"/>	<input type="checkbox"/>
Hsf1_Hsf1_Hsf1_P		nucleus	item	<input type="checkbox"/>	<input type="checkbox"/>
Hsf1_Hsf1		cytosol	item	<input type="checkbox"/>	<input type="checkbox"/>
HSEHsp70		nucleus	item	<input type="checkbox"/>	<input type="checkbox"/>
HSEHsp90		nucleus	item	<input type="checkbox"/>	<input type="checkbox"/>
HSEHsp70_Hsf1- _Hsf1_Hsf1		nucleus	item	<input type="checkbox"/>	<input type="checkbox"/>
HSEHsp70_Hsf1- _Hsf1_Hsf1_P		nucleus	item	<input type="checkbox"/>	<input type="checkbox"/>
HSEHsp90_Hsf1- _Hsf1_Hsf1		nucleus	item	<input type="checkbox"/>	<input type="checkbox"/>
HSEHsp90_Hsf1- _Hsf1_Hsf1_P		nucleus	item	<input type="checkbox"/>	<input type="checkbox"/>
Jnk		cytosol	item	<input type="checkbox"/>	<input type="checkbox"/>
Jnk_P		cytosol	item	<input type="checkbox"/>	<input type="checkbox"/>
Ppx		cytosol	item	<input type="checkbox"/>	<input type="checkbox"/>
Mkp1		cytosol	item	<input type="checkbox"/>	<input type="checkbox"/>
Mkp1_P		cytosol	item	<input type="checkbox"/>	<input type="checkbox"/>
Mkp1_Proteasome		cytosol	item	<input type="checkbox"/>	<input type="checkbox"/>
Hsp70_Ppx		cytosol	item	<input type="checkbox"/>	<input type="checkbox"/>
Pkc		cytosol	item	<input type="checkbox"/>	<input type="checkbox"/>
p38		cytosol	item	<input type="checkbox"/>	<input type="checkbox"/>
p38_P		cytosol	item	<input type="checkbox"/>	<input type="checkbox"/>
Proteasome		cytosol	item	<input type="checkbox"/>	<input type="checkbox"/>
MisP_Proteasome		cytosol	item	<input type="checkbox"/>	<input type="checkbox"/>
AggP		cytosol	item	<input type="checkbox"/>	<input type="checkbox"/>
SeqAggP		cytosol	item	<input type="checkbox"/>	<input type="checkbox"/>

Id	Name	Compartment	Derived Unit	Constant	Boundary Condi- tion
AggP_Proteasome		cytosol	item	<input type="checkbox"/>	<input type="checkbox"/>
ROS		cytosol	item	<input type="checkbox"/>	<input type="checkbox"/>
ATP		cytosol	item	<input type="checkbox"/>	<input checked="" type="checkbox"/>
ADP		cytosol	item	<input type="checkbox"/>	<input checked="" type="checkbox"/>
Source		cytosol	item	<input type="checkbox"/>	<input checked="" type="checkbox"/>
Sink		cytosol	item	<input type="checkbox"/>	<input checked="" type="checkbox"/>
p38Death		cytosol	item	<input type="checkbox"/>	<input type="checkbox"/>
JNKDeath		cytosol	item	<input type="checkbox"/>	<input type="checkbox"/>
PIDeath		cytosol	item	<input type="checkbox"/>	<input type="checkbox"/>
CellDeath		cytosol	item	<input type="checkbox"/>	<input type="checkbox"/>

5 Parameters

This model contains 65 global parameters.

Table 4: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
ksynNatP		0000009	0.042		<input checked="" type="checkbox"/>
kmisfold		0000009	$2 \cdot 10^{-6}$		<input checked="" type="checkbox"/>
kbinMisPProt		0000009	10^{-7}		<input checked="" type="checkbox"/>
kdegMisP		0000009	0.010		<input checked="" type="checkbox"/>
kagg		0000009	10^{-8}		<input checked="" type="checkbox"/>
kseqagg		0000009	$7 \cdot 10^{-7}$		<input checked="" type="checkbox"/>
kbinAggPProt		0000009	10^{-5}		<input checked="" type="checkbox"/>
kbinHspMisp		0000009	$8 \cdot 10^{-6}$		<input checked="" type="checkbox"/>
krelHspMisp		0000009	$8 \cdot 10^{-5}$		<input checked="" type="checkbox"/>
krefold		0000009	$5.5 \cdot 10^{-4}$		<input checked="" type="checkbox"/>
kbinHsf1Hsp90		0000009	0.020		<input type="checkbox"/>
krelHsf1Hsp90		0000009	0.500		<input checked="" type="checkbox"/>
kdimerHsf1		0000009	$8 \cdot 10^{-5}$		<input checked="" type="checkbox"/>
ktrimerHsf1		0000009	0.010		<input checked="" type="checkbox"/>
kdetrimerHsf1		0000009	0.500		<input checked="" type="checkbox"/>
kdedimerHsf1		0000009	0.500		<input checked="" type="checkbox"/>
kbinHSEHsf1		0000009	0.050		<input checked="" type="checkbox"/>
krelHSEHsf1		0000009	0.080		<input checked="" type="checkbox"/>
kupregHsp		0000009	0.200		<input checked="" type="checkbox"/>
kbasalsynHsp70		0000009	0.008		<input checked="" type="checkbox"/>
kbasalsynHsp90		0000009	0.008		<input checked="" type="checkbox"/>
kbinHsp70Prot		0000009	$1.2 \cdot 10^{-8}$		<input checked="" type="checkbox"/>
kbinHsp90Prot		0000009	10^{-8}		<input checked="" type="checkbox"/>
kdegHsp70		0000009	0.010		<input checked="" type="checkbox"/>
kdegHsp90		0000009	0.010		<input checked="" type="checkbox"/>
kgenROS		0000009	0.010		<input type="checkbox"/>
kremROS		0000009	0.001		<input checked="" type="checkbox"/>
kbinHsp70client		0000009	$2 \cdot 10^{-4}$		<input checked="" type="checkbox"/>
krelHsp70client		0000009	5.000		<input checked="" type="checkbox"/>
kbinHsp90client		0000009	$2 \cdot 10^{-4}$		<input checked="" type="checkbox"/>
krelHsp90client		0000009	5.000		<input type="checkbox"/>
kphosJnk		0000009	0.020		<input checked="" type="checkbox"/>
kdephosJnkMkp1		0000009	0.050		<input checked="" type="checkbox"/>
kbinHsp70Ppx		0000009	0.200		<input checked="" type="checkbox"/>
krelHsp70Ppx		0000009	5.000		<input checked="" type="checkbox"/>
kphosHsf1		0000009	0.030		<input checked="" type="checkbox"/>
kdephosHsf1		0000009	0.010		<input checked="" type="checkbox"/>

Id	Name	SBO	Value	Unit	Constant
kbinHSEPhosTriH		0000009	0.100		<input checked="" type="checkbox"/>
krelHSEPhosTriH		0000009	0.080		<input checked="" type="checkbox"/>
kphosp38		0000009	0.020		<input checked="" type="checkbox"/>
kdephosp38Mkp1		0000009	0.050		<input checked="" type="checkbox"/>
kgenROSAggP		0000009	10^{-6}		<input checked="" type="checkbox"/>
ksynAkt		0000009	0.002		<input checked="" type="checkbox"/>
kbinAktHsp90		0000009	$3.7 \cdot 10^{-4}$		<input checked="" type="checkbox"/>
krelAktHsp90		0000009	7.000		<input type="checkbox"/>
kbinAktProt		0000009	$6 \cdot 10^{-8}$		<input checked="" type="checkbox"/>
krelAktProt		0000009	10^{-8}		<input checked="" type="checkbox"/>
kdegAkt		0000009	0.010		<input checked="" type="checkbox"/>
kbinCHIP		0000009	$2 \cdot 10^{-7}$		<input checked="" type="checkbox"/>
krelCHIP		0000009	10^{-8}		<input checked="" type="checkbox"/>
ksynMkp1		0000009	10^{-5}		<input checked="" type="checkbox"/>
kbinMkp1Prot		0000009	$9.6 \cdot 10^{-9}$		<input checked="" type="checkbox"/>
kdegMkp1		0000009	0.010		<input checked="" type="checkbox"/>
kphosMkp1		0000009	0.020		<input checked="" type="checkbox"/>
kdephosMkp1		0000009	0.001		<input checked="" type="checkbox"/>
kgenROSp38		0000009	10^{-4}		<input checked="" type="checkbox"/>
kdamHsp		0000009	10^{-8}		<input checked="" type="checkbox"/>
kp38death		0000009	$1.5 \cdot 10^{-7}$		<input checked="" type="checkbox"/>
kJnkdeath		0000009	$1.5 \cdot 10^{-7}$		<input checked="" type="checkbox"/>
kPIdeath		0000009	$2 \cdot 10^{-8}$		<input checked="" type="checkbox"/>
kp38act		0000009	1.000		<input type="checkbox"/>
kalive		0000009	1.000		<input type="checkbox"/>
tot_Hsp90			0.000		<input type="checkbox"/>
tot_Hsp70			0.000		<input type="checkbox"/>
tot_MisP			0.000		<input type="checkbox"/>

6 Rules

This is an overview of three rules.

6.1 Rule tot_Hsp90

Rule tot_Hsp90 is an assignment rule for parameter tot_Hsp90:

$$\begin{aligned} \text{tot_Hsp90} = & \text{Hsp90} + \text{Hsp90_dam} + \text{Hsp90_Proteasome} + \text{Hsp90_Hsp90Client} \\ & + \text{Akt_Hsp90} + \text{Akt_CHIP_Hsp90} + \text{Hsf1_Hsp90} + \text{Hsp90_MisP} \end{aligned} \quad (1)$$

Derived unit item

6.2 Rule `tot_Hsp70`

Rule `tot_Hsp70` is an assignment rule for parameter `tot_Hsp70`:

$$\begin{aligned} \text{tot_Hsp70} = & \text{Hsp70} + \text{Hsp70_dam} + \text{Hsp70_Proteasome} \\ & + \text{Hsp70_Hsp70Client} + \text{Hsp70_MisP} + \text{Hsp70_Ppx} \end{aligned} \quad (2)$$

Derived unit item

6.3 Rule `tot_MisP`

Rule `tot_MisP` is an assignment rule for parameter `tot_MisP`:

$$\text{tot_MisP} = \text{MisP} + \text{Hsp70_MisP} + \text{Hsp90_MisP} \quad (3)$$

Derived unit item

7 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.

7.1 Event `DeathOfCell`

Trigger condition

$$\text{CellDeath} \geq 1 \quad (4)$$

Assignment

$$\text{kalive} = 0 \quad (5)$$

8 Reactions

This model contains 80 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

Nº	Id	Name	Reaction Equation	SBO
1	ProteinSynthesis		Source \longrightarrow NatP	0000284
2	Misfolding		NatP + ROS \longrightarrow MisP + ROS	0000344
3	Hsp90MisPBinding		MisP + Hsp90 \longrightarrow Hsp90_MisP	0000526
4	Hsp90unsuccessulRefolding		Hsp90_MisP \longrightarrow MisP + Hsp90	0000180
5	Hsp90refolding		Hsp90_MisP + ATP \longrightarrow Hsp90 + NatP + ADP	0000344
6	Hsp70MisPBinding		MisP + Hsp70 \longrightarrow Hsp70_MisP	0000526
7	Hsp70unsuccessulRefolding		Hsp70_MisP \longrightarrow MisP + Hsp70	0000180
8	Hsp70refolding		Hsp70_MisP + ATP \longrightarrow Hsp70 + NatP + ADP	0000344
9	Hsp70ClientBinding		Hsp70 + Hsp70Client \longrightarrow Hsp70_Hsp70Client	0000526
10	Hsp70ClientRelease		Hsp70_Hsp70Client \longrightarrow Hsp70 + Hsp70Client	0000180
11	Hsp90ClientBinding		Hsp90 + Hsp90Client \longrightarrow Hsp90_Hsp90Client	0000526
12	Hsp90ClientRelease		Hsp90_Hsp90Client \longrightarrow Hsp90 + Hsp90Client	0000180
13	Hsp90HSF1Binding		Hsp90 + Hsf1 \longrightarrow Hsf1_Hsp90	0000526
14	Hsp90HSF1Release		Hsf1_Hsp90 \longrightarrow Hsp90 + Hsf1	0000180
15	dimerisation		2 Hsf1 \longrightarrow Hsf1_Hsf1	0000526
16	trimerisation		Hsf1 + Hsf1_Hsf1 \longrightarrow Hsf1_Hsf1_Hsf1	0000526
17	deTrimerisation		Hsf1_Hsf1_Hsf1 \longrightarrow Hsf1 + Hsf1_Hsf1	0000180
18	deDimerisation		Hsf1_Hsf1 \longrightarrow 2 Hsf1	0000180
19	HSE70TriHBinding		Hsf1_Hsf1_Hsf1 + HSEHsp70 \longrightarrow HSEHsp70_Hsf1_Hsf1_Hsf1	0000526
20	HSE70TriHRelease		HSEHsp70_Hsf1_Hsf1_Hsf1 \longrightarrow HSEHsp70 + Hsf1_Hsf1_Hsf1	0000180
21	HSE90TriHBinding		Hsf1_Hsf1_Hsf1 + HSEHsp90 \longrightarrow HSEHsp90_Hsf1_Hsf1_Hsf1	0000526

Nº	Id	Name	Reaction Equation	SBO
22	HSE90TriHRelease		$\text{HSEHsp90_Hsf1_Hsf1_Hsf1} \longrightarrow \text{HSEHsp90_Hsf1_Hsf1_Hsf1}$	+ 0000180
23	Hsf1_Hsf1- _Hsf1Phosphorylation		$\text{Hsf1_Hsf1_Hsf1} + \text{Pkc} \longrightarrow \text{Hsf1_Hsf1_Hsf1_P} + \text{Pkc}$	+ 0000216
24	Hsf1_Hsf1- _Hsf1DePhosphorylation		$\text{Hsf1_Hsf1_Hsf1_P} \longrightarrow \text{Hsf1_Hsf1_Hsf1} + \text{Hsp70_Ppx}$	+ 0000330
25	HSE70PhosTriHBinding		$\text{Hsf1_Hsf1_Hsf1_P} \longrightarrow \text{HSEHsp70_Hsf1_Hsf1_Hsf1_P}$	+ 0000526
26	HSE70PhosTriHRelease		$\text{HSEHsp70_Hsf1_Hsf1_Hsf1_P} \longrightarrow \text{Hsf1_Hsf1_Hsf1_P} + \text{HSEHsp70}$	+ 0000180
27	HSE90PhosTriHBinding		$\text{Hsf1_Hsf1_Hsf1_P} \longrightarrow \text{HSEHsp90_Hsf1_Hsf1_Hsf1_P}$	+ 0000526
28	HSE90PhosTriHRelease		$\text{HSEHsp90_Hsf1_Hsf1_Hsf1_P} \longrightarrow \text{Hsf1_Hsf1_Hsf1_P} + \text{HSEHsp90}$	+ 0000180
29	Hsp90BasalSynthesis		$\text{Source} \longrightarrow \text{Hsp90}$	0000184
30	Hsp90Upregulation		$\text{HSEHsp90_Hsf1_Hsf1_Hsf1_P} \longrightarrow \text{HSEHsp90_Hsf1_Hsf1_Hsf1_P} + \text{Hsp90}$	+ 0000184
31	Hsp90ProteasomeBinding		$\text{Hsp90} + \text{Proteasome} \longrightarrow \text{Hsp90_Proteasome}$	0000526
32	Hsp90Degradation		$\text{Hsp90_Proteasome} + \text{ATP} \longrightarrow \text{Proteasome} + \text{ADP}$	0000179
33	Hsp70BasalSynthesis		$\text{Source} \longrightarrow \text{Hsp70}$	0000184
34	Hsp70Upregulation		$\text{HSEHsp70_Hsf1_Hsf1_Hsf1_P} \longrightarrow \text{HSEHsp70_Hsf1_Hsf1_Hsf1_P} + \text{Hsp70}$	+ 0000184
35	Hsp70ProteasomeBinding		$\text{Hsp70} + \text{Proteasome} \longrightarrow \text{Hsp70_Proteasome}$	0000526
36	Hsp70Degradation		$\text{Hsp70_Proteasome} + \text{ATP} \longrightarrow \text{Proteasome} + \text{ADP}$	0000179
37	MisPProteasomeBinding1		$\text{Hsp70_MisP} + \text{Proteasome} \longrightarrow \text{MisP_Proteasome} + \text{Hsp70}$	+ 0000177
38	MisPProteasomeBinding2		$\text{Hsp90_MisP} + \text{Proteasome} \longrightarrow \text{MisP_Proteasome} + \text{Hsp90}$	+ 0000177
39	MisPDegradation		$\text{MisP_Proteasome} + \text{ATP} \longrightarrow \text{Proteasome} + \text{ADP}$	0000179

Nº	Id	Name	Reaction Equation	SBO
40	radicalFormation	radicalFormation	Source \longrightarrow ROS	0000393
41	radicalScavenging	radicalScavenging	ROS \longrightarrow Sink	0000179
42	Hsp70- _PpxBinding		Hsp70 + Ppx \longrightarrow Hsp70_Ppx	0000526
43	Hsp70- _PPXRelease		Hsp70_Ppx \longrightarrow Hsp70 + Ppx	0000180
44	JnkPhosphorylation		ROS + Jnk \longrightarrow ROS + Jnk_P	0000216
45	JNKDephosphorylationByMkp1		Jnk_P + Mkp1_P \longrightarrow Jnk + Mkp1_P	0000330
46	p38Phosphorylation		ROS + p38 \longrightarrow ROS + p38_P	0000216
47	p38DePhosphorylationByMkp1		p38_P + Mkp1_P \longrightarrow p38 + Mkp1_P	0000330
48	Aggregation1		2 MisP \longrightarrow AggP	0000177
49	SequesteringOfAggregate		MisP + AggP \longrightarrow SeqAggP	0000177
50	InclusionGrowth		SeqAggP + MisP \longrightarrow 2 SeqAggP	0000177
51	ProteasomeInhibition		AggP + Proteasome \longrightarrow AggP_Proteasome	0000177
52	ROSgenerationSmallAggP		AggP \longrightarrow AggP + ROS	0000393
53	ROSgenerationAggPProteasome		AggP_Proteasome \longrightarrow AggP_Proteasome + ROS	0000393
54	AktSynthesis		Source \longrightarrow Akt	0000184
55	Hsp90AktBinding		Hsp90 + Akt \longrightarrow Akt_Hsp90	0000526
56	Hsp90AktRelease		Akt_Hsp90 \longrightarrow Akt + Hsp90	0000180
57	CHIPbinding		CHIP + Akt_Hsp90 \longrightarrow Akt_CHIP_Hsp90	0000526
58	CHIPrelease		Akt_CHIP_Hsp90 \longrightarrow CHIP + Akt_Hsp90	0000526
59	AktProteasomeBinding		Akt_CHIP_Hsp90 + Proteasome \longrightarrow Akt_Proteasome + CHIP + Hsp90	0000177
60	AktProteasomeRelease		Akt_Proteasome \longrightarrow Akt + Proteasome	0000180
61	AktDegradation		Akt_Proteasome + ATP \longrightarrow Proteasome + ADP	0000179
62	Mkp1Synthesis		Source \longrightarrow Mkp1	0000184
63	Mkp1ProteasomeBinding		Mkp1 + Proteasome \longrightarrow Mkp1_Proteasome	0000177
64	Mkp1Degradation		Mkp1_Proteasome + ATP \longrightarrow Proteasome + ADP	0000179
65	Mkp1Phosphorylation		Mkp1 + Hsp70 \longrightarrow Mkp1_P + Hsp70	0000216

Nº	Id	Name	Reaction Equation	SBO
66	Mkp1Dephosphorylation		$\text{Mkp1_P} + \text{ROS} \longrightarrow \text{Mkp1} + \text{ROS}$	0000330
67	p38ROSProduction		$\text{p38_P} \longrightarrow \text{p38_P} + \text{ROS}$	0000393
68	Hsp70Damage		$\text{Hsp70} + \text{ROS} \longrightarrow \text{Hsp70_dam} + \text{ROS}$	0000177
69	Hsp90Damage		$\text{Hsp90} + \text{ROS} \longrightarrow \text{Hsp90_dam} + \text{ROS}$	0000177
70	Hsp70DamProteasomeBinding		$\text{Hsp70_dam} + \text{Proteasome} \longrightarrow \text{Hsp70_Proteasome}$	0000177
71	Hsp90DamProteasomeBinding		$\text{Hsp90_dam} + \text{Proteasome} \longrightarrow \text{Hsp90_Proteasome}$	0000177
72	Hsp70DamAggregation1		$2 \text{Hsp70_dam} \longrightarrow \text{AggP}$	0000177
73	Hsp70DamInclusionFormation		$\text{Hsp70_dam} + \text{AggP} \longrightarrow \text{SeqAggP}$	0000177
74	Hsp90DamAggregation		$2 \text{Hsp90_dam} \longrightarrow \text{AggP}$	0000177
75	Hsp90DamInclusionFormation		$\text{Hsp90_dam} + \text{AggP} \longrightarrow \text{SeqAggP}$	0000177
76	Hsp70DamSequestering		$\text{Hsp70_dam} + \text{SeqAggP} \longrightarrow 2 \text{SeqAggP}$	0000177
77	Hsp90DamSequestering		$\text{Hsp90_dam} + \text{SeqAggP} \longrightarrow 2 \text{SeqAggP}$	0000177
78	p38CellDeath		$\text{p38_P} \longrightarrow \text{p38_P} + \text{p38Death} + \text{CellDeath}$	0000179
79	JnkCellDeath		$\text{Jnk_P} \longrightarrow \text{Jnk_P} + \text{JNKDeath} + \text{CellDeath}$	0000179
80	PICellDeath		$\text{AggP_Proteasome} \longrightarrow \text{AggP_Proteasome} + \text{PIDeath} + \text{CellDeath}$	0000179

8.1 Reaction ProteinSynthesis

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

SBO:0000284 transporter

Reaction equation



Reactant

Table 6: Properties of each reactant.

Id	Name	SBO
Source		

Product

Table 7: Properties of each product.

Id	Name	SBO
NatP		

Kinetic Law

Derived unit contains undeclared units

v1 = ksynNatP · Source · kalive (7)

8.2 Reaction Misfolding

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

SBO:0000344 molecular interaction

Reaction equation



Reactants

Table 8: Properties of each reactant.

Id	Name	SBO
	NatP	
	ROS	

Products

Table 9: Properties of each product.

Id	Name	SBO
	MisP	
	ROS	

Kinetic Law

Derived unit contains undeclared units

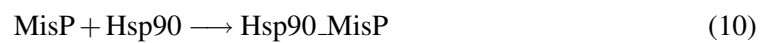
$$v_2 = k_{\text{misfold}} \cdot \text{NatP} \cdot \text{ROS} \cdot \text{kalive} \quad (9)$$

8.3 Reaction [Hsp90MisPBinding](#)

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

SBO:0000526 protein complex formation

Reaction equation



Reactants

Table 10: Properties of each reactant.

Id	Name	SBO
	MisP	
	Hsp90	

Product

Table 11: Properties of each product.

Id	Name	SBO
Hsp90_MisP		

Kinetic Law

Derived unit contains undeclared units

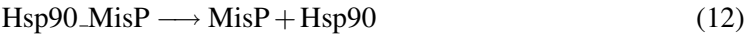
$$v_3 = kbinHspMisp \cdot MisP \cdot Hsp90 \cdot kalive \tag{11}$$

8.4 Reaction Hsp90unsuccessfulRefolding

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

SBO:0000180 dissociation

Reaction equation



Reactant

Table 12: Properties of each reactant.

Id	Name	SBO
Hsp90_MisP		

Products

Table 13: Properties of each product.

Id	Name	SBO
MisP		
Hsp90		

Kinetic Law

Derived unit contains undeclared units

$$v_4 = krelHspMisp \cdot Hsp90_MisP \cdot kalive \tag{13}$$

8.5 Reaction Hsp90refolding

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

SBO:0000344 molecular interaction

Reaction equation



Reactants

Table 14: Properties of each reactant.

Id	Name	SBO
Hsp90_MisP		
ATP		

Products

Table 15: Properties of each product.

Id	Name	SBO
Hsp90		
NatP		
ADP		

Kinetic Law

Derived unit contains undeclared units

$$v_5 = \frac{\text{krefold} \cdot \text{Hsp90_MisP} \cdot \text{kalive} \cdot \text{ATP}}{5000 + \text{ATP}} \quad (15)$$

8.6 Reaction Hsp70MisPBinding

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

SBO:0000526 protein complex formation

Reaction equation



Reactants

Table 16: Properties of each reactant.

Id	Name	SBO
MisP		
Hsp70		

Product

Table 17: Properties of each product.

Id	Name	SBO
Hsp70_MisP		

Kinetic Law

Derived unit contains undeclared units

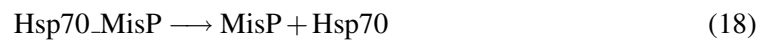
$$v_6 = k_{\text{binHspMisP}} \cdot \text{MisP} \cdot \text{Hsp70} \cdot k_{\text{alive}} \quad (17)$$

8.7 Reaction Hsp70unsuccessfulRefolding

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

SBO:0000180 dissociation

Reaction equation



Reactant

Table 18: Properties of each reactant.

Id	Name	SBO
Hsp70_MisP		

Products

Table 19: Properties of each product.

Id	Name	SBO
MisP		

Id	Name	SBO
Hsp70		

Kinetic Law

Derived unit contains undeclared units

$$v_7 = k_{relHspMisp} \cdot Hsp70_MisP \cdot kalive \quad (19)$$

8.8 Reaction Hsp70refolding

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

SBO:0000344 molecular interaction

Reaction equation



Reactants

Table 20: Properties of each reactant.

Id	Name	SBO
Hsp70_MisP		
ATP		

Products

Table 21: Properties of each product.

Id	Name	SBO
Hsp70		
NatP		
ADP		

Kinetic Law

Derived unit contains undeclared units

$$v_8 = \frac{k_{refold} \cdot Hsp70_MisP \cdot kalive \cdot ATP}{5000 + ATP} \quad (21)$$

8.9 Reaction Hsp70ClientBinding

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

SBO:0000526 protein complex formation

Reaction equation



Reactants

Table 22: Properties of each reactant.

Id	Name	SBO
Hsp70		
Hsp70Client		

Product

Table 23: Properties of each product.

Id	Name	SBO
Hsp70_Hsp70Client		

Kinetic Law

Derived unit contains undeclared units

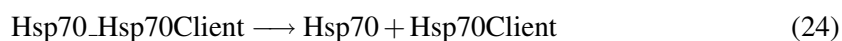
$$v_9 = k_{\text{binHsp70client}} \cdot \text{Hsp70} \cdot \text{Hsp70Client} \cdot k_{\text{alive}} \quad (23)$$

8.10 Reaction Hsp70ClientRelease

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

SBO:0000180 dissociation

Reaction equation



Reactant

Table 24: Properties of each reactant.

Id	Name	SBO
Hsp70_Hsp70Client		

Products

Table 25: Properties of each product.

Id	Name	SBO
Hsp70		
Hsp70Client		

Kinetic Law

Derived unit contains undeclared units

$$v_{10} = k_{relHsp70client} \cdot Hsp70_Hsp70Client \cdot k_{alive} \quad (25)$$

8.11 Reaction [Hsp90ClientBinding](#)

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

SBO:0000526 protein complex formation

Reaction equation



Reactants

Table 26: Properties of each reactant.

Id	Name	SBO
Hsp90		
Hsp90Client		

Product

Table 27: Properties of each product.

Id	Name	SBO
Hsp90_Hsp90Client		

Kinetic Law

Derived unit contains undeclared units

$$v_{11} = k_{\text{binHsp90client}} \cdot \text{Hsp90} \cdot \text{Hsp90Client} \cdot k_{\text{alive}} \quad (27)$$

8.12 Reaction Hsp90ClientRelease

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

SBO:0000180 dissociation

Reaction equation



Reactant

Table 28: Properties of each reactant.

Id	Name	SBO
Hsp90_Hsp90Client		

Products

Table 29: Properties of each product.

Id	Name	SBO
Hsp90		
Hsp90Client		

Kinetic Law

Derived unit contains undeclared units

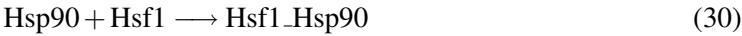
$$v_{12} = k_{\text{relHsp90client}} \cdot \text{Hsp90_Hsp90Client} \cdot k_{\text{alive}} \quad (29)$$

8.13 Reaction Hsp90HSF1Binding

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

SBO:0000526 protein complex formation

Reaction equation



Reactants

Table 30: Properties of each reactant.

Id	Name	SBO
Hsp90		
Hsf1		

Product

Table 31: Properties of each product.

Id	Name	SBO
Hsf1_Hsp90		

Kinetic Law

Derived unit contains undeclared units

$$v_{13} = k_{\text{binHsf1Hsp90}} \cdot \text{Hsp90} \cdot \text{Hsf1} \cdot k_{\text{alive}}$$

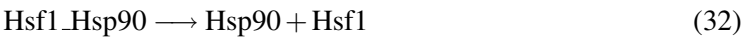
(31)

8.14 Reaction Hsp90HSF1Release

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

SBO:0000180 dissociation

Reaction equation



Reactant

Table 32: Properties of each reactant.

Id	Name	SBO
Hsf1_Hsp90		

Products

Table 33: Properties of each product.

Id	Name	SBO
Hsp90		
Hsf1		

Kinetic Law

Derived unit contains undeclared units

$$v_{14} = k_{rel}Hsf1Hsp90 \cdot Hsf1_Hsp90 \cdot k_{alive} \quad (33)$$

8.15 Reaction dimerisation

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

SBO:0000526 protein complex formation

Reaction equation



Reactant

Table 34: Properties of each reactant.

Id	Name	SBO
Hsf1		

Product

Table 35: Properties of each product.

Id	Name	SBO
Hsf1_Hsf1		

Id	Name	SBO
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Kinetic Law

Derived unit contains undeclared units

$$v_{15} = \frac{(\text{Hsf1} - 1) \cdot \text{kdimerHsf1} \cdot \text{kalive} \cdot \text{Hsf1}}{2} \quad (35)$$

8.16 Reaction trimerisation

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

SBO:0000526 protein complex formation

Reaction equation



Reactants

Table 36: Properties of each reactant.

Id	Name	SBO
Hsf1		
Hsf1_Hsf1		

Product

Table 37: Properties of each product.

Id	Name	SBO
Hsf1_Hsf1_Hsf1		

Kinetic Law

Derived unit contains undeclared units

$$v_{16} = \text{ktrimerHsf1} \cdot \text{Hsf1} \cdot \text{Hsf1_Hsf1} \cdot \text{kalive} \quad (37)$$

8.17 Reaction deTrimerisation

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

SBO:0000180 dissociation

Reaction equation



Reactant

Table 38: Properties of each reactant.

Id	Name	SBO
Hsf1_Hsf1_Hsf1		

Products

Table 39: Properties of each product.

Id	Name	SBO
Hsf1		
Hsf1_Hsf1		

Kinetic Law

Derived unit contains undeclared units

$$v_{17} = k_{\text{detrimerHsf1}} \cdot \text{Hsf1_Hsf1_Hsf1} \cdot \text{kalive}$$

(39)

8.18 Reaction deDimerisation

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

SBO:0000180 dissociation

Reaction equation



Reactant

Table 40: Properties of each reactant.

Id	Name	SBO
Hsf1_Hsf1		

Product

Table 41: Properties of each product.

Id	Name	SBO
Hsf1		

Kinetic Law

Derived unit contains undeclared units

$$v_{18} = k_{\text{dedimerHsf1}} \cdot \text{Hsf1_Hsf1} \cdot k_{\text{alive}} \quad (41)$$

8.19 Reaction HSE70TriHBinding

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

SBO:0000526 protein complex formation

Reaction equation



Reactants

Table 42: Properties of each reactant.

Id	Name	SBO
Hsf1_Hsf1_Hsf1		
HSEHsp70		

Product

Table 43: Properties of each product.

Id	Name	SBO
HSEHsp70_Hsf1_Hsf1_Hsf1		

Kinetic Law

Derived unit contains undeclared units

$$v_{19} = k_{\text{binHSEHsf1}} \cdot \text{HSEHsp70} \cdot \text{Hsf1_Hsf1_Hsf1} \cdot k_{\text{alive}} \quad (43)$$

8.20 Reaction HSE70TriHRelease

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

SBO:0000180 dissociation

Reaction equation



Reactant

Table 44: Properties of each reactant.

Id	Name	SBO
HSEHsp70_Hsf1_Hsf1_Hsf1		

Products

Table 45: Properties of each product.

Id	Name	SBO
HSEHsp70		
Hsf1_Hsf1_Hsf1		

Kinetic Law

Derived unit contains undeclared units

$$v_{20} = k_{\text{rel}} \text{HSEHsf1} \cdot \text{HSEHsp70_Hsf1_Hsf1_Hsf1} \cdot k_{\text{alive}} \quad (45)$$

8.21 Reaction HSE90TriHBinding

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

SBO:0000526 protein complex formation

Reaction equation



Reactants

Table 46: Properties of each reactant.

Id	Name	SBO
Hsf1_Hsf1_Hsf1		
HSEHsp90		

Product

Table 47: Properties of each product.

Id	Name	SBO
HSEHsp90_Hsf1_Hsf1_Hsf1		

Kinetic Law

Derived unit contains undeclared units

$$v_{21} = k_{\text{binHSEHsf1}} \cdot \text{HSEHsp90} \cdot \text{Hsf1_Hsf1_Hsf1} \cdot k_{\text{alive}} \quad (47)$$

8.22 Reaction HSE90TriHRelease

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

SBO:0000180 dissociation

Reaction equation



Reactant

Table 48: Properties of each reactant.

Id	Name	SBO
HSEHsp90_Hsf1_Hsf1_Hsf1		

Products

Table 49: Properties of each product.

Id	Name	SBO
HSEHsp90		

Id	Name	SBO
Hsf1_Hsf1_Hsf1		

Kinetic Law

Derived unit contains undeclared units

$$v_{22} = k_{relHSEHsf1} \cdot HSEHsp90_Hsf1_Hsf1_Hsf1 \cdot kalive \quad (49)$$

8.23 Reaction Hsf1_Hsf1_Hsf1Phosphorylation

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

SBO:0000216 phosphorylation

Reaction equation



Reactants

Table 50: Properties of each reactant.

Id	Name	SBO
Hsf1_Hsf1_Hsf1		
Pkc		

Products

Table 51: Properties of each product.

Id	Name	SBO
Hsf1_Hsf1_Hsf1_P		
Pkc		

Kinetic Law

Derived unit contains undeclared units

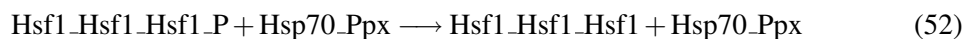
$$v_{23} = k_{phosHsf1} \cdot Hsf1_Hsf1_Hsf1 \cdot Pkc \cdot kalive \quad (51)$$

8.24 Reaction Hsf1_Hsf1_Hsf1DePhosphorylation

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

SBO:0000330 dephosphorylation

Reaction equation



Reactants

Table 52: Properties of each reactant.

Id	Name	SBO
Hsf1_Hsf1_Hsf1_P		
Hsp70_Ppx		

Products

Table 53: Properties of each product.

Id	Name	SBO
Hsf1_Hsf1_Hsf1		
Hsp70_Ppx		

Kinetic Law

Derived unit contains undeclared units

$$v_{24} = k_{\text{dephosHsf1}} \cdot \text{Hsf1_Hsf1_Hsf1_P} \cdot \text{Hsp70_Ppx} \cdot k_{\text{alive}} \quad (53)$$

8.25 Reaction HSE70PhosTriHBinding

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

SBO:0000526 protein complex formation

Reaction equation



Reactants

Table 54: Properties of each reactant.

Id	Name	SBO
Hsf1_Hsf1_Hsf1_P		
HSEHsp70		

Product

Table 55: Properties of each product.

Id	Name	SBO
HSEHsp70_Hsf1_Hsf1_Hsf1_P		

Kinetic Law

Derived unit contains undeclared units

$$v_{25} = k_{\text{binHSEPhosTriH}} \cdot \text{HSEHsp70} \cdot \text{Hsf1_Hsf1_Hsf1_P} \cdot k_{\text{alive}} \quad (55)$$

8.26 Reaction HSE70PhosTriHRelease

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

SBO:0000180 dissociation

Reaction equation



Reactant

Table 56: Properties of each reactant.

Id	Name	SBO
HSEHsp70_Hsf1_Hsf1_Hsf1_P		

Products

Table 57: Properties of each product.

Id	Name	SBO
Hsf1_Hsf1_Hsf1_P		

Id	Name	SBO
HSEHsp70		

Kinetic Law

Derived unit contains undeclared units

$$v_{26} = k_{relHSEPhosTriH} \cdot HSEHsp70_Hsf1_Hsf1_Hsf1_P \cdot kalive \quad (57)$$

8.27 Reaction HSE90PhosTriHBinding

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

SBO:0000526 protein complex formation

Reaction equation



Reactants

Table 58: Properties of each reactant.

Id	Name	SBO
Hsf1_Hsf1_Hsf1_P		
HSEHsp90		

Product

Table 59: Properties of each product.

Id	Name	SBO
HSEHsp90_Hsf1_Hsf1_Hsf1_P		

Kinetic Law

Derived unit contains undeclared units

$$v_{27} = k_{binHSEPhosTriH} \cdot HSEHsp90 \cdot Hsf1_Hsf1_Hsf1_P \cdot kalive \quad (59)$$

8.28 Reaction HSE90PhosTriHRelease

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

SBO:0000180 dissociation

Reaction equation



Reactant

Table 60: Properties of each reactant.

Id	Name	SBO
HSEHsp90_Hsf1_Hsf1_Hsf1_P		

Products

Table 61: Properties of each product.

Id	Name	SBO
Hsf1_Hsf1_Hsf1_P		
HSEHsp90		

Kinetic Law

Derived unit contains undeclared units

$$v_{28} = \text{krelHSEPhosTriH} \cdot \text{HSEHsp90_Hsf1_Hsf1_Hsf1_P} \cdot \text{kalive} \tag{61}$$

8.29 Reaction Hsp90BasalSynthesis

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

SBO:0000184 translation

Reaction equation



Reactant

Table 62: Properties of each reactant.

Id	Name	SBO
Source		

Product

Table 63: Properties of each product.

Id	Name	SBO
Hsp90		

Kinetic Law

Derived unit not available

$$v_{29} = k_{basalsynHsp90} \cdot kalive \quad (63)$$

8.30 Reaction Hsp90Upregulation

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

SBO:0000177 non-covalent binding

Reaction equation



Reactant

Table 64: Properties of each reactant.

Id	Name	SBO
HSEHsp90_Hsf1_Hsf1_Hsf1_P		

Products

Table 65: Properties of each product.

Id	Name	SBO
HSEHsp90_Hsf1_Hsf1_Hsf1_P		
Hsp90		

Kinetic Law

Derived unit contains undeclared units

$$v_{30} = k_{upregHsp} \cdot HSEHsp90_Hsf1_Hsf1_Hsf1_P \cdot kalive \quad (65)$$

8.31 Reaction [Hsp90ProteasomeBinding](#)

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

SBO:0000526 protein complex formation

Reaction equation



Reactants

Table 66: Properties of each reactant.

Id	Name	SBO
Hsp90		
Proteasome		

Product

Table 67: Properties of each product.

Id	Name	SBO
Hsp90_Proteasome		

Kinetic Law

Derived unit contains undeclared units

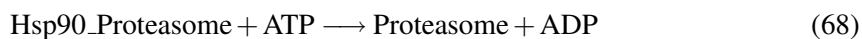
$$v_{31} = k_{\text{binHsp90Prot}} \cdot \text{Hsp90} \cdot \text{Proteasome} \cdot k_{\text{alive}} \quad (67)$$

8.32 Reaction [Hsp90Degradation](#)

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

SBO:0000179 degradation

Reaction equation



Reactants

Table 68: Properties of each reactant.

Id	Name	SBO
Hsp90_Proteasome		
ATP		

Products

Table 69: Properties of each product.

Id	Name	SBO
Proteasome		
ADP		

Kinetic Law

Derived unit contains undeclared units

$$v_{32} = \frac{k_{degHsp90} \cdot Hsp90_Proteasome \cdot k_{alive} \cdot ATP}{5000 + ATP} \quad (69)$$

8.33 Reaction Hsp70BasalSynthesis

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

SBO:0000184 translation

Reaction equation



Reactant

Table 70: Properties of each reactant.

Id	Name	SBO
Source		

Product

Table 71: Properties of each product.

Id	Name	SBO
Hsp70		

Kinetic Law

Derived unit not available

$$v_{33} = k_{\text{basalsynHsp70}} \cdot \text{kalive} \quad (71)$$

8.34 Reaction Hsp70Upregulation

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

SBO:0000177 non-covalent binding

Reaction equation



Reactant

Table 72: Properties of each reactant.

Id	Name	SBO
HSEHsp70_Hsf1_Hsf1_Hsf1_P		

Products

Table 73: Properties of each product.

Id	Name	SBO
HSEHsp70_Hsf1_Hsf1_Hsf1_P		
Hsp70		

Kinetic Law

Derived unit contains undeclared units

$$v_{34} = k_{\text{upregHsp}} \cdot \text{HSEHsp70_Hsf1_Hsf1_Hsf1_P} \cdot \text{kalive} \quad (73)$$

8.35 Reaction [Hsp70ProteasomeBinding](#)

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

SBO:0000526 protein complex formation

Reaction equation



Reactants

Table 74: Properties of each reactant.

Id	Name	SBO
Hsp70		
Proteasome		

Product

Table 75: Properties of each product.

Id	Name	SBO
Hsp70_Proteasome		

Kinetic Law

Derived unit contains undeclared units

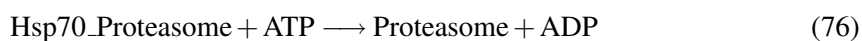
$$v_{35} = k_{\text{binHsp70Prot}} \cdot \text{Hsp70} \cdot \text{Proteasome} \cdot k_{\text{alive}} \quad (75)$$

8.36 Reaction [Hsp70Degradation](#)

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

SBO:0000179 degradation

Reaction equation



Reactants

Table 76: Properties of each reactant.

Id	Name	SBO
Hsp70_Proteasome		
ATP		

Products

Table 77: Properties of each product.

Id	Name	SBO
Proteasome		
ADP		

Kinetic Law

Derived unit contains undeclared units

$$v_{36} = \frac{kdegHsp70 \cdot Hsp70_Proteasome \cdot kalive \cdot ATP}{5000 + ATP} \quad (77)$$

8.37 Reaction MisPProteasomeBinding1

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

SBO:0000177 non-covalent binding

Reaction equation



Reactants

Table 78: Properties of each reactant.

Id	Name	SBO
Hsp70_MisP		
Proteasome		

Products

Table 79: Properties of each product.

Id	Name	SBO
	MisP_Proteasome	
	Hsp70	

Kinetic Law

Derived unit contains undeclared units

$$v_{37} = k_{\text{binMisPProt}} \cdot \text{Hsp70_MisP} \cdot \text{Proteasome} \cdot \text{kalive} \quad (79)$$

8.38 Reaction *MisPProteasomeBinding2*

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

SBO:0000177 non-covalent binding

Reaction equation



Reactants

Table 80: Properties of each reactant.

Id	Name	SBO
	Hsp90_MisP	
	Proteasome	

Products

Table 81: Properties of each product.

Id	Name	SBO
	MisP_Proteasome	
	Hsp90	

Kinetic Law

Derived unit contains undeclared units

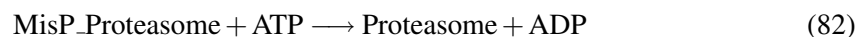
$$v_{38} = k_{\text{binMisPProt}} \cdot \text{Hsp90_MisP} \cdot \text{Proteasome} \cdot \text{kalive} \quad (81)$$

8.39 Reaction MisPDegradation

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

SBO:0000179 degradation

Reaction equation



Reactants

Table 82: Properties of each reactant.

Id	Name	SBO
MisP_Proteasome		
ATP		

Products

Table 83: Properties of each product.

Id	Name	SBO
Proteasome		
ADP		

Kinetic Law

Derived unit contains undeclared units

$$v_{39} = \frac{k_{\text{degMisP}} \cdot \text{MisP_Proteasome} \cdot k_{\text{alive}} \cdot \text{ATP}}{5000 + \text{ATP}} \quad (83)$$

8.40 Reaction radicalFormation

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

Name radicalFormation

SBO:0000393 production

Reaction equation



Reactant

Table 84: Properties of each reactant.

Id	Name	SBO
Source		

Product

Table 85: Properties of each product.

Id	Name	SBO
ROS		

Kinetic Law

Derived unit contains undeclared units

$$v_{40} = k_{genROS} \cdot Source \cdot kalive \tag{85}$$

8.41 Reaction radicalScavenging

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

Name radicalScavenging

SBO:0000179 degradation

Reaction equation



Reactant

Table 86: Properties of each reactant.

Id	Name	SBO
ROS		

Product

Table 87: Properties of each product.

Id	Name	SBO
Sink		

Kinetic Law

Derived unit contains undeclared units

$$v_{41} = \text{kremROS} \cdot \text{ROS} \cdot \text{kalive} \quad (87)$$

8.42 Reaction Hsp70_PpxBinding

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

SBO:0000526 protein complex formation

Reaction equation



Reactants

Table 88: Properties of each reactant.

Id	Name	SBO
Hsp70		
Ppx		

Product

Table 89: Properties of each product.

Id	Name	SBO
Hsp70_Ppx		

Kinetic Law

Derived unit contains undeclared units

$$v_{42} = \text{kbinHsp70Ppx} \cdot \text{Hsp70} \cdot \text{Ppx} \cdot \text{kalive} \quad (89)$$

8.43 Reaction Hsp70_PPXRelease

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

SBO:0000180 dissociation

Reaction equation



Reactant

Table 90: Properties of each reactant.

Id	Name	SBO
Hsp70_Ppx		

Products

Table 91: Properties of each product.

Id	Name	SBO
Hsp70		
Ppx		

Kinetic Law

Derived unit contains undeclared units

$$v_{43} = k_{relHsp70Ppx} \cdot \text{Hsp70_Ppx} \cdot k_{alive}$$

(91)

8.44 Reaction JnkPhosphorylation

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

SBO:0000216 phosphorylation

Reaction equation



Reactants

Table 92: Properties of each reactant.

Id	Name	SBO
ROS		
Jnk		

Products

Table 93: Properties of each product.

Id	Name	SBO
ROS		
Jnk_P		

Kinetic Law

Derived unit contains undeclared units

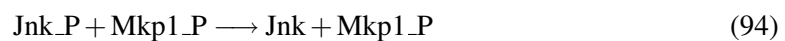
$$v_{44} = k_{\text{phosJnk}} \cdot \text{Jnk} \cdot \text{ROS} \cdot \text{kalive} \quad (93)$$

8.45 Reaction JNKDephosphorylationByMkp1

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

SBO:0000330 dephosphorylation

Reaction equation



Reactants

Table 94: Properties of each reactant.

Id	Name	SBO
Jnk_P		
Mkp1_P		

Products

Table 95: Properties of each product.

Id	Name	SBO
Jnk		
Mkp1_P		

Kinetic Law

Derived unit contains undeclared units

$$v_{45} = k_{\text{dephosJnkMkp1}} \cdot \text{Jnk_P} \cdot \text{Mkp1_P} \cdot \text{kalive} \quad (95)$$

8.46 Reaction p38Phosphorylation

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

SBO:0000216 phosphorylation

Reaction equation



Reactants

Table 96: Properties of each reactant.

Id	Name	SBO
ROS		
p38		

Products

Table 97: Properties of each product.

Id	Name	SBO
ROS		
p38_P		

Kinetic Law

Derived unit contains undeclared units

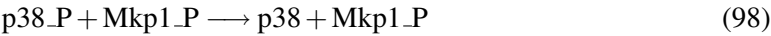
$$v_{46} = k_{\text{phosp38}} \cdot \text{ROS} \cdot \text{p38} \cdot \text{kalive} \quad (97)$$

8.47 Reaction p38DePhosphorylationByMkp1

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

SBO:0000330 dephosphorylation

Reaction equation



Reactants

Table 98: Properties of each reactant.

Id	Name	SBO
p38_P		
Mkp1_P		

Products

Table 99: Properties of each product.

Id	Name	SBO
p38		
Mkp1_P		

Kinetic Law

Derived unit contains undeclared units

$$v_{47} = k_{dephosp38Mkp1} \cdot p38_P \cdot Mkp1_P \cdot k_{alive} \tag{99}$$

8.48 Reaction Aggregation1

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

SBO:0000177 non-covalent binding

Reaction equation



Reactant

Table 100: Properties of each reactant.

Id	Name	SBO
MisP		

Product

Table 101: Properties of each product.

Id	Name	SBO
AggP		

Kinetic Law

Derived unit contains undeclared units

$$v_{48} = kagg \cdot MisP \cdot (MisP - 1) \cdot 0.5 \cdot kalive \quad (101)$$

8.49 Reaction SequesteringOfAggregate

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

SBO:0000177 non-covalent binding

Reaction equation



Reactants

Table 102: Properties of each reactant.

Id	Name	SBO
MisP		
AggP		

Product

Table 103: Properties of each product.

Id	Name	SBO
SeqAggP		

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

Kinetic Law

Derived unit contains undeclared units

$$v_{49} = k_{agg} \cdot \text{MisP} \cdot \text{AggP} \cdot \text{kalive} \quad (103)$$

8.50 Reaction *InclusionGrowth*

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

SBO:0000177 non-covalent binding

Reaction equation



Reactants

Table 104: Properties of each reactant.

Id	Name	SBO
	SeqAggP	
	MisP	

Product

Table 105: Properties of each product.

Id	Name	SBO
	SeqAggP	

Kinetic Law

Derived unit contains undeclared units

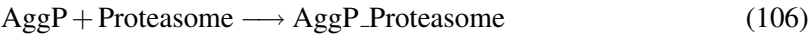
$$v_{50} = k_{seqagg} \cdot \text{SeqAggP} \cdot \text{MisP} \cdot \text{kalive} \quad (105)$$

8.51 Reaction *ProteasomeInhibtion*

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

SBO:0000177 non-covalent binding

Reaction equation



Reactants

Table 106: Properties of each reactant.

Id	Name	SBO
AggP		
Proteasome		

Product

Table 107: Properties of each product.

Id	Name	SBO
AggP_Proteasome		

Kinetic Law

Derived unit contains undeclared units

$$v_{51} = k_{\text{binAggPProt}} \cdot \text{AggP} \cdot \text{Proteasome} \cdot k_{\text{alive}}$$

(107)

8.52 Reaction ROSgenerationSmallAggP

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

SBO:0000393 production

Reaction equation



Reactant

Table 108: Properties of each reactant.

Id	Name	SBO
AggP		

Products

Table 109: Properties of each product.

Id	Name	SBO
AggP		
ROS		

Kinetic Law

Derived unit contains undeclared units

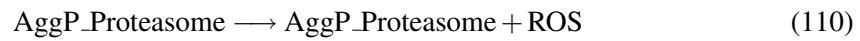
$$v_{52} = k_{\text{genROS}} \text{AggP} \cdot \text{AggP} \cdot \text{kalive} \quad (109)$$

8.53 Reaction ROSgenerationAggPProteasome

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

SBO:0000393 production

Reaction equation



Reactant

Table 110: Properties of each reactant.

Id	Name	SBO
AggP_Proteasome		

Products

Table 111: Properties of each product.

Id	Name	SBO
AggP_Proteasome		
ROS		

Kinetic Law

Derived unit contains undeclared units

$$v_{53} = k_{\text{genROSAggP}} \cdot \text{AggP_Proteasome} \cdot k_{\text{alive}} \quad (111)$$

8.54 Reaction AktSynthesis

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

SBO:0000184 translation

Reaction equation



Reactant

Table 112: Properties of each reactant.

Id	Name	SBO
Source		

Product

Table 113: Properties of each product.

Id	Name	SBO
Akt		

Kinetic Law

Derived unit contains undeclared units

$$v_{54} = k_{\text{synAkt}} \cdot \text{Source} \cdot k_{\text{alive}} \quad (113)$$

8.55 Reaction Hsp90AktBinding

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

SBO:0000526 protein complex formation

Reaction equation



Reactants

Table 114: Properties of each reactant.

Id	Name	SBO
Hsp90		
Akt		

Product

Table 115: Properties of each product.

Id	Name	SBO
Akt_Hsp90		

Kinetic Law

Derived unit contains undeclared units

$$v_{55} = k_{\text{binAktHsp90}} \cdot \text{Hsp90} \cdot \text{Akt} \cdot \text{kalive} \quad (115)$$

8.56 Reaction Hsp90AktRelease

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

SBO:0000180 dissociation

Reaction equation



Reactant

Table 116: Properties of each reactant.

Id	Name	SBO
Akt_Hsp90		

Products

Table 117: Properties of each product.

Id	Name	SBO
Akt		

Id	Name	SBO
Hsp90		

Kinetic Law

Derived unit contains undeclared units

$$v_{56} = k_{relAktHsp90} \cdot Akt_Hsp90 \cdot k_{alive} \quad (117)$$

8.57 Reaction [CHIPbinding](#)

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

SBO:0000526 protein complex formation

Reaction equation



Reactants

Table 118: Properties of each reactant.

Id	Name	SBO
CHIP		
Akt_Hsp90		

Product

Table 119: Properties of each product.

Id	Name	SBO
Akt_CHIP_Hsp90		

Kinetic Law

Derived unit contains undeclared units

$$v_{57} = k_{binCHIP} \cdot CHIP \cdot Akt_Hsp90 \cdot k_{alive} \quad (119)$$

8.58 Reaction [CHIPrelease](#)

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

SBO:0000526 protein complex formation

Reaction equation



Reactant

Table 120: Properties of each reactant.

Id	Name	SBO
Akt_CHIP_Hsp90		

Products

Table 121: Properties of each product.

Id	Name	SBO
CHIP		
Akt_Hsp90		

Kinetic Law

Derived unit contains undeclared units

$$v_{58} = \text{krelCHIP} \cdot \text{Akt_CHIP_Hsp90} \cdot \text{kalive} \quad (121)$$

8.59 Reaction AktProteasomeBinding

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

SBO:0000177 non-covalent binding

Reaction equation



Reactants

Table 122: Properties of each reactant.

Id	Name	SBO
Akt_CHIP_Hsp90		
Proteasome		

Products

Table 123: Properties of each product.

Id	Name	SBO
Akt_Proteasome		
CHIP		
Hsp90		

Kinetic Law

Derived unit contains undeclared units

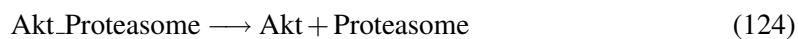
$$v_{59} = k_{\text{binAktProt}} \cdot \text{Akt_CHIP_Hsp90} \cdot \text{Proteasome} \cdot \text{kalive} \quad (123)$$

8.60 Reaction AktProteasomeRelease

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

SBO:0000180 dissociation

Reaction equation



Reactant

Table 124: Properties of each reactant.

Id	Name	SBO
Akt_Proteasome		

Products

Table 125: Properties of each product.

Id	Name	SBO
Akt		
Proteasome		

Kinetic Law

Derived unit contains undeclared units

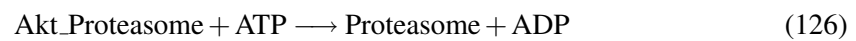
$$v_{60} = k_{\text{relAktProt}} \cdot \text{Akt_Proteasome} \cdot k_{\text{alive}} \quad (125)$$

8.61 Reaction AktDegradation

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

SBO:0000179 degradation

Reaction equation



Reactants

Table 126: Properties of each reactant.

Id	Name	SBO
Akt_Proteasome		
ATP		

Products

Table 127: Properties of each product.

Id	Name	SBO
Proteasome		
ADP		

Kinetic Law

Derived unit contains undeclared units

$$v_{61} = \frac{k_{\text{degAkt}} \cdot \text{Akt_Proteasome} \cdot k_{\text{alive}} \cdot \text{ATP}}{5000 + \text{ATP}} \quad (127)$$

8.62 Reaction Mkp1Synthesis

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

SBO:0000184 translation

Reaction equation



Reactant

Table 128: Properties of each reactant.

Id	Name	SBO
Source		

Product

Table 129: Properties of each product.

Id	Name	SBO
Mkp1		

Kinetic Law

Derived unit contains undeclared units

$$v_{62} = k_{\text{synMkp1}} \cdot \text{Source} \cdot k_{\text{alive}} \quad (129)$$

8.63 Reaction [Mkp1ProteasomeBinding](#)

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

SBO:0000177 non-covalent binding

Reaction equation



Reactants

Table 130: Properties of each reactant.

Id	Name	SBO
Mkp1		
Proteasome		

Product

Table 131: Properties of each product.

Id	Name	SBO
Mkp1_Proteasome		

Kinetic Law

Derived unit contains undeclared units

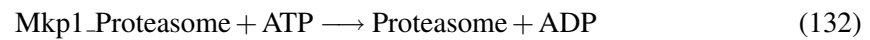
$$v_{63} = k_{\text{binMkp1Prot}} \cdot \text{Mkp1} \cdot \text{Proteasome} \cdot \text{kalive} \quad (131)$$

8.64 Reaction Mkp1Degradation

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

SBO:0000179 degradation

Reaction equation



Reactants

Table 132: Properties of each reactant.

Id	Name	SBO
Mkp1_Proteasome		
ATP		

Products

Table 133: Properties of each product.

Id	Name	SBO
Proteasome		
ADP		

Kinetic Law

Derived unit contains undeclared units

$$v_{64} = \frac{k_{degMkp1} \cdot Mkp1_Proteasome \cdot k_{alive} \cdot ATP}{5000 + ATP} \quad (133)$$

8.65 Reaction Mkp1Phosphorylation

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

SBO:0000216 phosphorylation

Reaction equation



Reactants

Table 134: Properties of each reactant.

Id	Name	SBO
Mkp1		
Hsp70		

Products

Table 135: Properties of each product.

Id	Name	SBO
Mkp1_P		
Hsp70		

Kinetic Law

Derived unit contains undeclared units

$$v_{65} = k_{phosMkp1} \cdot Mkp1 \cdot Hsp70 \cdot k_{alive} \quad (135)$$

8.66 Reaction Mkp1Dephosphorylation

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

SBO:0000330 dephosphorylation

Reaction equation



Reactants

Table 136: Properties of each reactant.

Id	Name	SBO
Mkp1_P		
ROS		

Products

Table 137: Properties of each product.

Id	Name	SBO
Mkp1		
ROS		

Kinetic Law

Derived unit contains undeclared units

$$v_{66} = k_{\text{dephosMkp1}} \cdot \text{Mkp1_P} \cdot \text{ROS} \cdot \text{kalive} \quad (137)$$

8.67 Reaction `p38ROSproduction`

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

SBO:0000393 production

Reaction equation



Reactant

Table 138: Properties of each reactant.

Id	Name	SBO
p38_P		

Products

Table 139: Properties of each product.

Id	Name	SBO
p38_P		
ROS		

Kinetic Law

Derived unit contains undeclared units

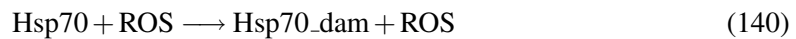
$$v_{67} = k_{\text{genROSp38}} \cdot \text{p38_P} \cdot k_{\text{alive}} \cdot \text{kp38act} \quad (139)$$

8.68 Reaction Hsp70Damage

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

SBO:0000177 non-covalent binding

Reaction equation



Reactants

Table 140: Properties of each reactant.

Id	Name	SBO
Hsp70		
ROS		

Products

Table 141: Properties of each product.

Id	Name	SBO
Hsp70_dam		
ROS		

Kinetic Law

Derived unit contains undeclared units

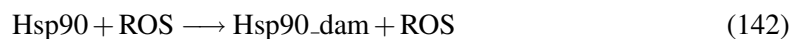
$$v_{68} = k_{\text{damHsp}} \cdot \text{Hsp70} \cdot \text{ROS} \cdot k_{\text{alive}} \quad (141)$$

8.69 Reaction Hsp90Damage

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

SBO:0000177 non-covalent binding

Reaction equation



Reactants

Table 142: Properties of each reactant.

Id	Name	SBO
Hsp90		
ROS		

Products

Table 143: Properties of each product.

Id	Name	SBO
Hsp90_dam		
ROS		

Kinetic Law

Derived unit contains undeclared units

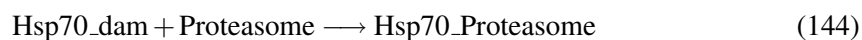
$$v_{69} = k_{\text{damHsp}} \cdot \text{Hsp90} \cdot \text{ROS} \cdot k_{\text{alive}} \quad (143)$$

8.70 Reaction Hsp70DamProteasomeBinding

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

SBO:0000177 non-covalent binding

Reaction equation



Reactants

Table 144: Properties of each reactant.

Id	Name	SBO
Hsp70_dam		
Proteasome		

Product

Table 145: Properties of each product.

Id	Name	SBO
Hsp70_Proteasome		

Kinetic Law

Derived unit contains undeclared units

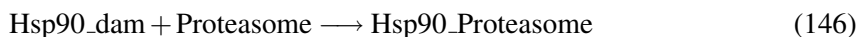
$$v_{70} = k_{\text{binHsp70Prot}} \cdot \text{Hsp70_dam} \cdot \text{Proteasome} \cdot \text{kalive} \quad (145)$$

8.71 Reaction Hsp90DamProteasomeBinding

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

SBO:0000177 non-covalent binding

Reaction equation



Reactants

Table 146: Properties of each reactant.

Id	Name	SBO
Hsp90_dam		
Proteasome		

Product

Table 147: Properties of each product.

Id	Name	SBO
Hsp90_Proteasome		

Kinetic Law

Derived unit contains undeclared units

$$v_{71} = k_{\text{binHsp90Prot}} \cdot \text{Hsp90_dam} \cdot \text{Proteasome} \cdot \text{kalive} \quad (147)$$

8.72 Reaction [Hsp70DamAggregation1](#)

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

SBO:0000177 non-covalent binding

Reaction equation



Reactant

Table 148: Properties of each reactant.

Id	Name	SBO
Hsp70_dam		

Product

Table 149: Properties of each product.

Id	Name	SBO
AggP		

Kinetic Law

Derived unit contains undeclared units

$$v_{72} = k_{\text{agg}} \cdot \text{Hsp70_dam} \cdot (\text{Hsp70_dam} - 1) \cdot 0.5 \cdot \text{kalive} \quad (149)$$

8.73 Reaction Hsp70DamInclusionFormation

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

SBO:0000177 non-covalent binding

Reaction equation



Reactants

Table 150: Properties of each reactant.

Id	Name	SBO
Hsp70_dam		
AggP		

Product

Table 151: Properties of each product.

Id	Name	SBO
SeqAggP		

Kinetic Law

Derived unit contains undeclared units

$$v_{73} = k_{agg} \cdot \text{Hsp70_dam} \cdot \text{AggP} \cdot k_{alive}$$

(151)

8.74 Reaction Hsp90DamAggregation

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

SBO:0000177 non-covalent binding

Reaction equation



Reactant

Table 152: Properties of each reactant.

Id	Name	SBO
Hsp90_dam		

Product

Table 153: Properties of each product.

Id	Name	SBO
AggP		

Kinetic Law

Derived unit contains undeclared units

$$v_{74} = kagg \cdot Hsp90_dam \cdot (Hsp90_dam - 1) \cdot 0.5 \cdot kalive \quad (153)$$

8.75 Reaction Hsp90DamInclusionFormation

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

SBO:0000177 non-covalent binding

Reaction equation



Reactants

Table 154: Properties of each reactant.

Id	Name	SBO
Hsp90_dam		
AggP		

Product

Table 155: Properties of each product.

Id	Name	SBO
SeqAggP		

Id	Name	SBO
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Kinetic Law

Derived unit contains undeclared units

$$v_{75} = k_{agg} \cdot \text{Hsp90_dam} \cdot \text{AggP} \cdot \text{kalive} \quad (155)$$

8.76 Reaction [Hsp70DamSequestering](#)

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

SBO:0000177 non-covalent binding

Reaction equation



Reactants

Table 156: Properties of each reactant.

Id	Name	SBO
	Hsp70_dam	
	SeqAggP	

Product

Table 157: Properties of each product.

Id	Name	SBO
	SeqAggP	

Kinetic Law

Derived unit contains undeclared units

$$v_{76} = k_{seqagg} \cdot \text{Hsp70_dam} \cdot \text{SeqAggP} \cdot \text{kalive} \quad (157)$$

8.77 Reaction [Hsp90DamSequestering](#)

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

SBO:0000177 non-covalent binding

Reaction equation



Reactants

Table 158: Properties of each reactant.

Id	Name	SBO
	Hsp90_dam	
	SeqAggP	

Product

Table 159: Properties of each product.

Id	Name	SBO
	SeqAggP	

Kinetic Law

Derived unit contains undeclared units

$$v_{77} = k_{\text{seqagg}} \cdot \text{Hsp90_dam} \cdot \text{SeqAggP} \cdot k_{\text{alive}} \quad (159)$$

8.78 Reaction `p38CellDeath`

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

SBO:0000179 degradation

Reaction equation



Reactant

Table 160: Properties of each reactant.

Id	Name	SBO
	p38_P	

Products

Table 161: Properties of each product.

Id	Name	SBO
p38_P		
p38Death		
CellDeath		

Kinetic Law

Derived unit contains undeclared units

$$v_{78} = \text{kp38death} \cdot \text{p38_P} \cdot \text{kalive} \cdot \text{kp38act} \quad (161)$$

8.79 Reaction JnkCellDeath

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

SBO:0000179 degradation

Reaction equation



Reactant

Table 162: Properties of each reactant.

Id	Name	SBO
Jnk_P		

Products

Table 163: Properties of each product.

Id	Name	SBO
Jnk_P		
JNKDeath		
CellDeath		

Kinetic Law

Derived unit contains undeclared units

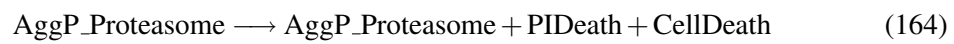
$$v_{79} = k_{\text{Jnkdeath}} \cdot \text{Jnk_P} \cdot \text{kalive} \quad (163)$$

8.80 Reaction `PICellDeath`

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

SBO:0000179 degradation

Reaction equation



Reactant

Table 164: Properties of each reactant.

Id	Name	SBO
	AggP_Proteasome	

Products

Table 165: Properties of each product.

Id	Name	SBO
	AggP_Proteasome	
	PIDeath	
	CellDeath	

Kinetic Law

Derived unit contains undeclared units

$$v_{80} = k_{\text{PIdeath}} \cdot \text{AggP_Proteasome} \cdot \text{kalive} \quad (165)$$

9 Derived Rate Equations

When interpreted as an ordinary differential equation framework, this model implies the following set of equations for the rates of change of each species.

Identifiers for kinetic laws highlighted in gray cannot be verified to evaluate to units of SBML substance per time. As a result, some SBML interpreters may not be able to verify the consistency of the units on quantities in the model. Please check if

- parameters without an unit definition are involved or
- volume correction is necessary because the `hasOnlySubstanceUnits` flag may be set to `false` and `spacialDimensions` > 0 for certain species.

9.1 Species NatP

SBO:0000252 polypeptide chain

Initial amount 17600 item

This species takes part in four reactions (as a reactant in [Misfolding](#) and as a product in [ProteinSynthesis](#), [Hsp90refolding](#), [Hsp70refolding](#)).

$$\frac{d}{dt}\text{NatP} = v_1 + v_5 + v_8 - v_2 \quad (166)$$

9.2 Species MisP

SBO:0000252 polypeptide chain

Initial amount 0 item

This species takes part in eight reactions (as a reactant in [Hsp90MisPBinding](#), [Hsp70MisPBinding](#), [Aggregation1](#), [SequesteringOfAggregate](#), [InclusionGrowth](#) and as a product in [Misfolding](#), [Hsp90unsuccessfulRefolding](#), [Hsp70unsuccessfulRefolding](#)).

$$\frac{d}{dt}\text{MisP} = v_2 + v_4 + v_7 - v_3 - v_6 - 2v_{48} - v_{49} - v_{50} \quad (167)$$

9.3 Species Hsp70

SBO:0000252 polypeptide chain

Initial amount 1400 item

This species takes part in 14 reactions (as a reactant in [Hsp70MisPBinding](#), [Hsp70ClientBinding](#), [Hsp70ProteasomeBinding](#), [Hsp70_PpxBinding](#), [Mkp1Phosphorylation](#), [Hsp70Damage](#) and as a product in [Hsp70unsuccessfulRefolding](#), [Hsp70refolding](#), [Hsp70ClientRelease](#), [Hsp70BasalSynthesis](#), [Hsp70Upregulation](#), [MisPProteasomeBinding1](#), [Hsp70_PPXRelease](#), [Mkp1Phosphorylation](#)).

$$\begin{aligned} \frac{d}{dt}\text{Hsp70} = & v_7 + v_8 + v_{10} + v_{33} + v_{34} + v_{37} + v_{43} \\ & + v_{65} - v_6 - v_9 - v_{35} - v_{42} - v_{65} - v_{68} \end{aligned} \quad (168)$$

9.4 Species Hsp90

SBO:0000252 polypeptide chain

Initial amount 1850 item

This species takes part in 15 reactions (as a reactant in [Hsp90MisPBinding](#), [Hsp90ClientBinding](#), [Hsp90HSF1Binding](#), [Hsp90ProteasomeBinding](#), [Hsp90AktBinding](#), [Hsp90Damage](#) and as a product in [Hsp90UnsuccessfulRefolding](#), [Hsp90Refolding](#), [Hsp90ClientRelease](#), [Hsp90HSF1Release](#), [Hsp90BasalSynthesis](#), [Hsp90Upregulation](#), [MisPProteasomeBinding2](#), [Hsp90AktRelease](#), [AktProteasomeBinding](#)).

$$\begin{aligned} \frac{d}{dt} \text{Hsp90} = & v_4 + v_5 + v_{12} + v_{14} + v_{29} + v_{30} + v_{38} + v_{56} \\ & + v_{59} - v_3 - v_{11} - v_{13} - v_{31} - v_{55} - v_{69} \end{aligned} \quad (169)$$

9.5 Species Hsp70_dam

SBO:0000252 polypeptide chain

Initial amount 0 item

This species takes part in five reactions (as a reactant in [Hsp70DamProteasomeBinding](#), [Hsp70DamAggregation1](#), [Hsp70DamInclusionFormation](#), [Hsp70DamSequestering](#) and as a product in [Hsp70Damage](#)).

$$\frac{d}{dt} \text{Hsp70_dam} = v_{68} - v_{70} - 2 v_{72} - v_{73} - v_{76} \quad (170)$$

9.6 Species Hsp90_dam

SBO:0000252 polypeptide chain

Initial amount 0 item

This species takes part in five reactions (as a reactant in [Hsp90DamProteasomeBinding](#), [Hsp90DamAggregation](#), [Hsp90DamInclusionFormation](#), [Hsp90DamSequestering](#) and as a product in [Hsp90Damage](#)).

$$\frac{d}{dt} \text{Hsp90_dam} = v_{69} - v_{71} - 2 v_{74} - v_{75} - v_{77} \quad (171)$$

9.7 Species Hsp90_Proteasome

Initial amount 0 item

This species takes part in three reactions (as a reactant in [Hsp90Degradation](#) and as a product in [Hsp90ProteasomeBinding](#), [Hsp90DamProteasomeBinding](#)).

$$\frac{d}{dt} \text{Hsp90_Proteasome} = v_{31} + v_{71} - v_{32} \quad (172)$$

9.8 Species [Hsp70_Proteasome](#)

SBO:0000297 protein complex

Initial amount 0 item

This species takes part in three reactions (as a reactant in [Hsp70Degradation](#) and as a product in [Hsp70ProteasomeBinding](#), [Hsp70DamProteasomeBinding](#)).

$$\frac{d}{dt}\text{Hsp70_Proteasome} = v_{35} + v_{70} - v_{36} \quad (173)$$

9.9 Species [Hsp70Client](#)

SBO:0000252 polypeptide chain

Initial amount 490 item

This species takes part in two reactions (as a reactant in [Hsp70ClientBinding](#) and as a product in [Hsp70ClientRelease](#)).

$$\frac{d}{dt}\text{Hsp70Client} = v_{10} - v_9 \quad (174)$$

9.10 Species [Hsp90Client](#)

SBO:0000252 polypeptide chain

Initial amount 590 item

This species takes part in two reactions (as a reactant in [Hsp90ClientBinding](#) and as a product in [Hsp90ClientRelease](#)).

$$\frac{d}{dt}\text{Hsp90Client} = v_{12} - v_{11} \quad (175)$$

9.11 Species [Hsp70_Hsp70Client](#)

SBO:0000297 protein complex

Initial amount 10 item

This species takes part in two reactions (as a reactant in [Hsp70ClientRelease](#) and as a product in [Hsp70ClientBinding](#)).

$$\frac{d}{dt}\text{Hsp70_Hsp70Client} = v_9 - v_{10} \quad (176)$$

9.12 Species Hsp90_Hsp90Client

SBO:0000297 protein complex

Initial amount 10 item

This species takes part in two reactions (as a reactant in [Hsp90ClientRelease](#) and as a product in [Hsp90ClientBinding](#)).

$$\frac{d}{dt}\text{Hsp90_Hsp90Client} = v_{11} - v_{12} \quad (177)$$

9.13 Species Akt

SBO:0000252 polypeptide chain

Initial amount 340 item

This species takes part in four reactions (as a reactant in [Hsp90AktBinding](#) and as a product in [AktSynthesis](#), [Hsp90AktRelease](#), [AktProteasomeRelease](#)).

$$\frac{d}{dt}\text{Akt} = v_{54} + v_{56} + v_{60} - v_{55} \quad (178)$$

9.14 Species Akt_Hsp90

SBO:0000297 protein complex

Initial amount 30 item

This species takes part in four reactions (as a reactant in [Hsp90AktRelease](#), [CHIPbinding](#) and as a product in [Hsp90AktBinding](#), [CHIPrelease](#)).

$$\frac{d}{dt}\text{Akt_Hsp90} = v_{55} + v_{58} - v_{56} - v_{57} \quad (179)$$

9.15 Species CHIP

SBO:0000252 polypeptide chain

Initial amount 255 item

This species takes part in three reactions (as a reactant in [CHIPbinding](#) and as a product in [CHIPrelease](#), [AktProteasomeBinding](#)).

$$\frac{d}{dt}\text{CHIP} = v_{58} + v_{59} - v_{57} \quad (180)$$

9.16 Species Akt_CHIP_Hsp90

SBO:0000297 protein complex

Initial amount 80 item

This species takes part in three reactions (as a reactant in [CHIPrelease](#), [AktProteasomeBinding](#) and as a product in [CHIPbinding](#)).

$$\frac{d}{dt}\text{Akt_CHIP_Hsp90} = v_{57} - v_{58} - v_{59} \quad (181)$$

9.17 Species Akt_Proteasome

SBO:0000297 protein complex

Initial amount 0 item

This species takes part in three reactions (as a reactant in [AktProteasomeRelease](#), [AktDegradation](#) and as a product in [AktProteasomeBinding](#)).

$$\frac{d}{dt}\text{Akt_Proteasome} = v_{59} - v_{60} - v_{61} \quad (182)$$

9.18 Species Hsf1

SBO:0000252 polypeptide chain

Initial amount 5 item

This species takes part in six reactions (as a reactant in [Hsp90HSF1Binding](#), [dimerisation](#), [trimerisation](#) and as a product in [Hsp90HSF1Release](#), [deTrimerisation](#), [deDimerisation](#)).

$$\frac{d}{dt}\text{Hsf1} = v_{14} + v_{17} + 2v_{18} - v_{13} - 2v_{15} - v_{16} \quad (183)$$

9.19 Species Hsf1_Hsp90

SBO:0000297 protein complex

Initial amount 95 item

This species takes part in two reactions (as a reactant in [Hsp90HSF1Release](#) and as a product in [Hsp90HSF1Binding](#)).

$$\frac{d}{dt}\text{Hsf1_Hsp90} = v_{13} - v_{14} \quad (184)$$

9.20 Species Hsp90_MisP

SBO:0000297 protein complex

Initial amount 470 item

This species takes part in four reactions (as a reactant in [Hsp90unsuccessfulRefolding](#), [Hsp90refolding](#), [MisPProteasomeBinding2](#) and as a product in [Hsp90MisPBinding](#)).

$$\frac{d}{dt}\text{Hsp90_MisP} = v_3 - v_4 - v_5 - v_{38} \quad (185)$$

9.21 Species Hsp70_MisP

SBO:0000297 protein complex

Initial amount 410 item

This species takes part in four reactions (as a reactant in [Hsp70unsuccessfulRefolding](#), [Hsp70refolding](#), [MisPProteasomeBinding1](#) and as a product in [Hsp70MisPBinding](#)).

$$\frac{d}{dt}\text{Hsp70_MisP} = v_6 - v_7 - v_8 - v_{37} \quad (186)$$

9.22 Species Hsf1_Hsf1_Hsf1

SBO:0000297 protein complex

Initial amount 0 item

This species takes part in eight reactions (as a reactant in [deTrimerisation](#), [HSE70TriHBinding](#), [HSE90TriHBinding](#), [Hsf1_Hsf1_Hsf1Phosphorylation](#) and as a product in [trimerisation](#), [HSE70TriHRelease](#), [HSE90TriHRelease](#), [Hsf1_Hsf1_Hsf1DePhosphorylation](#)).

$$\frac{d}{dt}\text{Hsf1_Hsf1_Hsf1} = v_{16} + v_{20} + v_{22} + v_{24} - v_{17} - v_{19} - v_{21} - v_{23} \quad (187)$$

9.23 Species Hsf1_Hsf1_Hsf1_P

SBO:0000297 protein complex

Initial amount 0 item

This species takes part in six reactions (as a reactant in [Hsf1_Hsf1_Hsf1DePhosphorylation](#), [HSE70PhosTriHBinding](#), [HSE90PhosTriHBinding](#) and as a product in [Hsf1_Hsf1_Hsf1Phosphorylation](#), [HSE70PhosTriHRelease](#), [HSE90PhosTriHRelease](#)).

$$\frac{d}{dt}\text{Hsf1_Hsf1_Hsf1_P} = v_{23} + v_{26} + v_{28} - v_{24} - v_{25} - v_{27} \quad (188)$$

9.24 Species Hsf1_Hsf1

SBO:0000297 protein complex

Initial amount 0 item

This species takes part in four reactions (as a reactant in [trimerisation](#), [deDimerisation](#) and as a product in [dimerisation](#), [deTrimerisation](#)).

$$\frac{d}{dt} \text{Hsf1_Hsf1} = v_{15} + v_{17} - v_{16} - v_{18} \quad (189)$$

9.25 Species HSEHsp70

SBO:0000369 gene regulatory region

Initial amount 2 item

This species takes part in four reactions (as a reactant in [HSE70TriHBinding](#), [HSE70PhosTriHBinding](#) and as a product in [HSE70TriHRelease](#), [HSE70PhosTriHRelease](#)).

$$\frac{d}{dt} \text{HSEHsp70} = v_{20} + v_{26} - v_{19} - v_{25} \quad (190)$$

9.26 Species HSEHsp90

SBO:0000369 gene regulatory region

Initial amount 2 item

This species takes part in four reactions (as a reactant in [HSE90TriHBinding](#), [HSE90PhosTriHBinding](#) and as a product in [HSE90TriHRelease](#), [HSE90PhosTriHRelease](#)).

$$\frac{d}{dt} \text{HSEHsp90} = v_{22} + v_{28} - v_{21} - v_{27} \quad (191)$$

9.27 Species HSEHsp70_Hsf1_Hsf1_Hsf1

SBO:0000297 protein complex

Initial amount 0 item

This species takes part in two reactions (as a reactant in [HSE70TriHRelease](#) and as a product in [HSE70TriHBinding](#)).

$$\frac{d}{dt} \text{HSEHsp70_Hsf1_Hsf1_Hsf1} = v_{19} - v_{20} \quad (192)$$

9.28 Species [HSEHsp70_Hsf1_Hsf1_Hsf1_P](#)

SBO:0000297 protein complex

Initial amount 0 item

This species takes part in four reactions (as a reactant in [HSE70PhosTriHRelease](#), [Hsp70Upregulation](#) and as a product in [HSE70PhosTriHBinding](#), [Hsp70Upregulation](#)).

$$\frac{d}{dt}\text{HSEHsp70_Hsf1_Hsf1_Hsf1_P} = v_{25} + v_{34} - v_{26} - v_{34} \quad (193)$$

9.29 Species [HSEHsp90_Hsf1_Hsf1_Hsf1](#)

SBO:0000297 protein complex

Initial amount 0 item

This species takes part in two reactions (as a reactant in [HSE90TriHRelease](#) and as a product in [HSE90TriHBinding](#)).

$$\frac{d}{dt}\text{HSEHsp90_Hsf1_Hsf1_Hsf1} = v_{21} - v_{22} \quad (194)$$

9.30 Species [HSEHsp90_Hsf1_Hsf1_Hsf1_P](#)

SBO:0000297 protein complex

Initial amount 0 item

This species takes part in four reactions (as a reactant in [HSE90PhosTriHRelease](#), [Hsp90Upregulation](#) and as a product in [HSE90PhosTriHBinding](#), [Hsp90Upregulation](#)).

$$\frac{d}{dt}\text{HSEHsp90_Hsf1_Hsf1_Hsf1_P} = v_{27} + v_{30} - v_{28} - v_{30} \quad (195)$$

9.31 Species [Jnk](#)

SBO:0000252 polypeptide chain

Initial amount 100 item

This species takes part in two reactions (as a reactant in [JnkPhosphorylation](#) and as a product in [JNKDephosphorylationByMkp1](#)).

$$\frac{d}{dt}\text{Jnk} = v_{45} - v_{44} \quad (196)$$

9.32 Species Jnk_P

SBO:0000252 polypeptide chain

Initial amount 0 item

This species takes part in four reactions (as a reactant in [JNKDephosphorylationByMkp1](#), [JnkCellDeath](#) and as a product in [JnkPhosphorylation](#), [JnkCellDeath](#)).

$$\frac{d}{dt} \text{Jnk_P} = v_{44} + v_{79} - v_{45} - v_{79} \quad (197)$$

9.33 Species Ppx

SBO:0000252 polypeptide chain

Initial amount 0 item

This species takes part in two reactions (as a reactant in [Hsp70_PpxBinding](#) and as a product in [Hsp70_PPXRelease](#)).

$$\frac{d}{dt} \text{Ppx} = v_{43} - v_{42} \quad (198)$$

9.34 Species Mkp1

SBO:0000252 polypeptide chain

Initial amount 0 item

This species takes part in four reactions (as a reactant in [Mkp1ProteasomeBinding](#), [Mkp1Phosphorylation](#) and as a product in [Mkp1Synthesis](#), [Mkp1Dephosphorylation](#)).

$$\frac{d}{dt} \text{Mkp1} = v_{62} + v_{66} - v_{63} - v_{65} \quad (199)$$

9.35 Species Mkp1_P

SBO:0000252 polypeptide chain

Initial amount 100 item

This species takes part in six reactions (as a reactant in [JNKDephosphorylationByMkp1](#), [p38DePhosphorylationByMkp1Dephosphorylation](#) and as a product in [JNKDephosphorylationByMkp1](#), [p38DePhosphorylationByMkp1](#), [Mkp1Phosphorylation](#)).

$$\frac{d}{dt} \text{Mkp1_P} = v_{45} + v_{47} + v_{65} - v_{45} - v_{47} - v_{66} \quad (200)$$

9.36 Species Mkp1_Proteasome

SBO:0000297 protein complex

Initial amount 0 item

This species takes part in two reactions (as a reactant in [Mkp1Degradation](#) and as a product in [Mkp1ProteasomeBinding](#)).

$$\frac{d}{dt}\text{Mkp1_Proteasome} = v_{63} - v_{64} \quad (201)$$

9.37 Species Hsp70_Ppx

SBO:0000297 protein complex

Initial amount 100 item

This species takes part in four reactions (as a reactant in [Hsf1_Hsf1_Hsf1DePhosphorylation](#), [Hsp70_PPXRelease](#) and as a product in [Hsf1_Hsf1_Hsf1DePhosphorylation](#), [Hsp70_PpxBinding](#)).

$$\frac{d}{dt}\text{Hsp70_Ppx} = v_{24} + v_{42} - v_{24} - v_{43} \quad (202)$$

9.38 Species Pkc

SBO:0000252 polypeptide chain

Initial amount 100 item

This species takes part in two reactions (as a reactant in [Hsf1_Hsf1_Hsf1Phosphorylation](#) and as a product in [Hsf1_Hsf1_Hsf1Phosphorylation](#)).

$$\frac{d}{dt}\text{Pkc} = v_{23} - v_{23} \quad (203)$$

9.39 Species p38

SBO:0000252 polypeptide chain

Initial amount 100 item

This species takes part in two reactions (as a reactant in [p38Phosphorylation](#) and as a product in [p38DePhosphorylationByMkp1](#)).

$$\frac{d}{dt}\text{p38} = v_{47} - v_{46} \quad (204)$$

9.40 Species p38_P

SBO:0000252 polypeptide chain

Initial amount 0 item

This species takes part in six reactions (as a reactant in [p38DePhosphorylationByMkp1](#), [p38R0Sproduction](#), [p38CellDeath](#) and as a product in [p38Phosphorylation](#), [p38R0Sproduction](#), [p38CellDeath](#)).

$$\frac{d}{dt}p38_P = v_{46} + v_{67} + v_{78} - v_{47} - v_{67} - v_{78} \quad (205)$$

9.41 Species Proteasome

SBO:0000297 protein complex

Initial amount 500 item

This species takes part in 15 reactions (as a reactant in [Hsp90ProteasomeBinding](#), [Hsp70ProteasomeBinding](#), [MisPProteasomeBinding1](#), [MisPProteasomeBinding2](#), [ProteasomeInhibition](#), [AktProteasomeBinding](#), [Mkp1ProteasomeBinding](#), [Hsp70DamProteasomeBinding](#), [Hsp90DamProteasomeBinding](#) and as a product in [Hsp90Degradation](#), [Hsp70Degradation](#), [MisPDegradation](#), [AktProteasomeRelease](#), [AktDegradation](#), [Mkp1Degradation](#)).

$$\begin{aligned} \frac{d}{dt}\text{Proteasome} = & v_{32} + v_{36} + v_{39} + v_{60} + v_{61} + v_{64} - v_{31} - v_{35} \\ & - v_{37} - v_{38} - v_{51} - v_{59} - v_{63} - v_{70} - v_{71} \end{aligned} \quad (206)$$

9.42 Species MisP_Proteasome

SBO:0000297 protein complex

Initial amount 0 item

This species takes part in three reactions (as a reactant in [MisPDegradation](#) and as a product in [MisPProteasomeBinding1](#), [MisPProteasomeBinding2](#)).

$$\frac{d}{dt}\text{MisP_Proteasome} = v_{37} + v_{38} - v_{39} \quad (207)$$

9.43 Species AggP

SBO:0000252 polypeptide chain

Initial amount 0 item

This species takes part in nine reactions (as a reactant in [SequesteringOfAggregate](#), [ProteasomeInhibtion](#), [ROSGenerationSmallAggP](#), [Hsp70DamInclusionFormation](#), [Hsp90DamInclusionFormation](#) and as a product in [Aggregation1](#), [ROSGenerationSmallAggP](#), [Hsp70DamAggregation1](#), [Hsp90DamAggregation](#)).

$$\frac{d}{dt}\text{AggP} = v_{48} + v_{52} + v_{72} + v_{74} - v_{49} - v_{51} - v_{52} - v_{73} - v_{75} \quad (208)$$

9.44 Species SeqAggP

SBO:0000252 polypeptide chain

Initial amount 0 item

This species takes part in nine reactions (as a reactant in [InclusionGrowth](#), [Hsp70DamSequestering](#), [Hsp90DamSequestering](#) and as a product in [SequesteringOfAggregate](#), [InclusionGrowth](#), [Hsp70DamInclusionFormation](#), [Hsp90DamInclusionFormation](#), [Hsp70DamSequestering](#), [Hsp90DamSequestering](#)).

$$\frac{d}{dt}\text{SeqAggP} = v_{49} + 2 v_{50} + v_{73} + v_{75} + 2 v_{76} + 2 v_{77} - v_{50} - v_{76} - v_{77} \quad (209)$$

9.45 Species AggP-Proteasome

SBO:0000297 protein complex

Initial amount 0 item

This species takes part in five reactions (as a reactant in [ROSGenerationAggPProteasome](#), [PICellDeath](#) and as a product in [ProteasomeInhibtion](#), [ROSGenerationAggPProteasome](#), [PICellDeath](#)).

$$\frac{d}{dt}\text{AggP-Proteasome} = v_{51} + v_{53} + v_{80} - v_{53} - v_{80} \quad (210)$$

9.46 Species ROS

SBO:0000247 simple chemical

Initial amount 10 item

This species takes part in 17 reactions (as a reactant in [Misfolding](#), [radicalScavenging](#), [JnkPhosphorylation](#), [p38Phosphorylation](#), [Mkp1Dephosphorylation](#), [Hsp70Damage](#), [Hsp90Damage](#) and as a product in [Misfolding](#), [radicalFormation](#), [JnkPhosphorylation](#), [p38Phosphorylation](#), [ROSGenerationSmallAggP](#), [ROSGenerationAggPProteasome](#), [Mkp1Dephosphorylation](#), [p38ROSproduction](#), [Hsp70Damage](#), [Hsp90Damage](#)).

$$\begin{aligned} \frac{d}{dt}\text{ROS} = & v_2 + v_{40} + v_{44} + v_{46} + v_{52} + v_{53} + v_{66} + v_{67} + v_{68} \\ & + v_{69} - v_2 - v_{41} - v_{44} - v_{46} - v_{66} - v_{68} - v_{69} \end{aligned} \quad (211)$$

9.47 Species ATP

SBO:0000247 simple chemical

Initial amount 10000 item

This species takes part in seven reactions (as a reactant in [Hsp90refolding](#), [Hsp70refolding](#), [Hsp90Degradation](#), [Hsp70Degradation](#), [MisPDegradation](#), [AktDegradation](#), [Mkp1Degradation](#)), which do not influence its rate of change because this species is on the boundary of the reaction system:

$$\frac{d}{dt} \text{ATP} = 0 \quad (212)$$

9.48 Species ADP

SBO:0000247 simple chemical

Initial amount 1000 item

This species takes part in seven reactions (as a product in [Hsp90refolding](#), [Hsp70refolding](#), [Hsp90Degradation](#), [Hsp70Degradation](#), [MisPDegradation](#), [AktDegradation](#), [Mkp1Degradation](#)), which do not influence its rate of change because this species is on the boundary of the reaction system:

$$\frac{d}{dt} \text{ADP} = 0 \quad (213)$$

9.49 Species Source

SBO:0000291 empty set

Initial amount 1 item

This species takes part in six reactions (as a reactant in [ProteinSynthesis](#), [Hsp90BasalSynthesis](#), [Hsp70BasalSynthesis](#), [radicalFormation](#), [AktSynthesis](#), [Mkp1Synthesis](#)), which do not influence its rate of change because this species is on the boundary of the reaction system:

$$\frac{d}{dt} \text{Source} = 0 \quad (214)$$

9.50 Species Sink

SBO:0000291 empty set

Initial amount 1 item

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

$$\frac{d}{dt} \text{Sink} = 0 \quad (215)$$

9.51 Species p38Death

SBO:0000236 physical entity representation

Initial amount 0 item

This species takes part in one reaction (as a product in [p38CellDeath](#)).

$$\frac{d}{dt}p38Death = v_{78} \quad (216)$$

9.52 Species JNKDeath

SBO:0000236 physical entity representation

Initial amount 0 item

This species takes part in one reaction (as a product in [JnkCellDeath](#)).

$$\frac{d}{dt}JNKDeath = v_{79} \quad (217)$$

9.53 Species PDeath

SBO:0000236 physical entity representation

Initial amount 0 item

This species takes part in one reaction (as a product in [PICellDeath](#)).

$$\frac{d}{dt}PDeath = v_{80} \quad (218)$$

9.54 Species CellDeath

SBO:0000236 physical entity representation

Initial amount 0 item

This species takes part in three reactions (as a product in [p38CellDeath](#), [JnkCellDeath](#), [PICellDeath](#)).

$$\frac{d}{dt}CellDeath = v_{78} + v_{79} + v_{80} \quad (219)$$

A Glossary of Systems Biology Ontology Terms

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

SBO:0000177 non-covalent binding: Interaction between several biochemical entities that results in the formation of a non-covalent complex

SBO:0000179 degradation: Complete disappearance of a physical entity

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

SBO:0000184 translation: Process in which a polypeptide chain is produced from a messenger RNA

SBO:0000216 phosphorylation: Addition of a phosphate group ($\text{-H}_2\text{PO}_4$) to a chemical entity

SBO:0000236 physical entity representation: Representation of an entity that may participate in an interaction, a process or relationship of significance.

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

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

SBO:0000284 transporter: Participating entity that facilitates the movement of another physical entity from a defined subset of the physical environment (for instance a cellular compartment) to another.

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

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

SBO:0000297 protein complex: Macromolecular complex containing one or more polypeptide chains possibly associated with simple chemicals. CHEBI:3608

SBO:0000330 dephosphorylation: Removal of a phosphate group ($\text{-H}_2\text{PO}_4$) from a chemical entity.

SBO:0000344 molecular interaction: Relationship between molecular entities, based on contacts, direct or indirect.

SBO:0000369 gene regulatory region: Region of a gene that is involved in the modulation of the expression of the gene.

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

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

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