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 Chelliah[1] and Carole J Proctor[2] 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 ONE2011; 6(7): e22038. doi: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 m^2

2.4 Unit length

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

Definition m

2.5 Unit time

Notes Second is the predefined SBML unit for time.

Definition s

3 Compartments

This model contains 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 Condition
NatP		cytosol	item	⊟	⊟
MisP		cytosol	item	⊟	⊟
Hsp70		cytosol	item	⊟	⊟
Hsp90		cytosol	item	⊟	⊟
Hsp70_dam		cytosol	item	⊟	⊟
Hsp90_dam		cytosol	item	⊟	⊟
Hsp90_Proteasome		cytosol	item	⊟	⊟
Hsp70_Proteasome		cytosol	item	⊟	⊟
Hsp70Client		cytosol	item	⊟	⊟
Hsp90Client		cytosol	item	⊟	⊟
Hsp70_Hsp70Client		cytosol	item	⊟	⊟
Hsp90_Hsp90Client		cytosol	item	⊟	⊟
Akt		cytosol	item	⊟	⊟
Akt_Hsp90		cytosol	item	⊟	⊟
CHIP		cytosol	item	⊟	⊟
Akt_CHIP_Hsp90		cytosol	item	⊟	⊟
Akt_Proteasome		cytosol	item	⊟	⊟
Hsf1		cytosol	item	⊟	⊟
Hsf1_Hsp90		cytosol	item	⊟	⊟
Hsp90_MisP		cytosol	item	⊟	⊟
Hsp70_MisP		cytosol	item	⊟	⊟

Id	Name	Compartment	Derived Unit	Constant	Boundary Condition
Hsf1_Hsf1_Hsf1		nucleus	item	⊟	⊟
Hsf1_Hsf1_Hsf1_P		nucleus	item	⊟	⊟
Hsf1_Hsf1		cytosol	item	⊟	⊟
HSEHsp70		nucleus	item	⊟	⊟
HSEHsp90		nucleus	item	⊟	⊟
HSEHsp70_Hsf1-_Hsf1_Hsf1		nucleus	item	⊟	⊟
HSEHsp70_Hsf1-_Hsf1_Hsf1_P		nucleus	item	⊟	⊟
HSEHsp90_Hsf1-_Hsf1_Hsf1		nucleus	item	⊟	⊟
HSEHsp90_Hsf1-_Hsf1_Hsf1_P		nucleus	item	⊟	⊟
Jnk		cytosol	item	⊟	⊟
Jnk_P		cytosol	item	⊟	⊟
Ppx		cytosol	item	⊟	⊟
Mkp1		cytosol	item	⊟	⊟
Mkp1_P		cytosol	item	⊟	⊟
Mkp1_Proteasome		cytosol	item	⊟	⊟
Hsp70_Ppx		cytosol	item	⊟	⊟
Pkc		cytosol	item	⊟	⊟
p38		cytosol	item	⊟	⊟
p38_P		cytosol	item	⊟	⊟
Proteasome		cytosol	item	⊟	⊟
MisP_Proteasome		cytosol	item	⊟	⊟
AggP		cytosol	item	⊟	⊟
SeqAggP		cytosol	item	⊟	⊟

Id	Name	Compartment	Derived Unit	Constant	Boundary Condition
AggP_Proteasome		cytosol	item	☐	☐
ROS		cytosol	item	☐	☐
ATP		cytosol	item	☐	☑
ADP		cytosol	item	☐	☑
Source		cytosol	item	☐	☑
Sink		cytosol	item	☐	☑
p38Death		cytosol	item	☐	☐
JNKDeath		cytosol	item	☐	☐
PIDeath		cytosol	item	☐	☐
CellDeath		cytosol	item	☐	☐

5 Parameters

This model contains 65 global parameters.

Table 4: Properties of each parameter.

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

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

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:

$$\begin{aligned} \text{tot\_Hsp90} = {} & \text{Hsp90} + \text{Hsp90\_dam} + \text{Hsp90\_Proteasome} + \text{Hsp90\_Hsp90Client} \\ & + \text{Akt\_Hsp90} + \text{Akt\_CHIP\_Hsp90} + \text{Hsf1\_Hsp90} + \text{Hsp90\_MisP} \end{aligned} \tag{1}$$

Derived unit item

6.2 Rule tot_Hsp70

Rule tot_Hsp70 is an assignment rule for parameter tot_Hsp70:

$$\begin{aligned}\text{tot\_Hsp70} = {} & \text{Hsp70} + \text{Hsp70\_dam} + \text{Hsp70\_Proteasome} \\ & + \text{Hsp70\_Hsp70Client} + \text{Hsp70\_MisP} + \text{Hsp70\_Ppx}\end{aligned} \tag{2}$$

Derived unit item

6.3 Rule tot_MisP

Rule tot_MisP is an assignment rule for parameter tot_MisP:

$$\text{tot\_MisP} = \text{MisP} + \text{Hsp70\_MisP} + \text{Hsp90\_MisP} \tag{3}$$

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

$$\text{CellDeath} \geq 1 \tag{4}$$

Assignment

$$\text{kalive} = 0 \tag{5}$$

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

№	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

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

№	Id	Name	Reaction Equation	SBO
40	radicalFormation	radicalFormation	Source ⟶ ROS	0000393
41	radicalScavenging	radicalScavenging	ROS ⟶ Sink	0000179
42	Hsp70-_PpxBinding		Hsp70 + Ppx ⟶ Hsp70_Ppx	0000526
43	Hsp70-_PPXRelease		Hsp70_Ppx ⟶ Hsp70 + Ppx	0000180
44	JnkPhosphorylation		ROS + Jnk ⟶ ROS + Jnk_P	0000216
45	JNKDephosphorylatioByMkp1		Jnk_P + Mkp1_P ⟶ Jnk + Mkp1_P	0000330
46	p38Phosphorylation		ROS + p38 ⟶ ROS + p38_P	0000216
47	p38DePhosphorylationByMkp1		p38_P + Mkp1_P ⟶ p38 + Mkp1_P	0000330
48	Aggregation1		2 MisP ⟶ AggP	0000177
49	SequesteringOfAggregate		MisP + AggP ⟶ SeqAggP	0000177
50	InclusionGrowth		SeqAggP + MisP ⟶ 2 SeqAggP	0000177
51	ProteasomeInhibtion		AggP + Proteasome ⟶ AggP_Proteasome	0000177
52	ROSgenerationSmallAggP		AggP ⟶ AggP + ROS	0000393
53	ROSgenerationAggPProteasome		AggP_Proteasome ⟶ AggP_Proteasome + ROS	0000393
54	AktSynthesis		Source ⟶ Akt	0000184
55	Hsp90AktBinding		Hsp90 + Akt ⟶ Akt_Hsp90	0000526
56	Hsp90AktRelease		Akt_Hsp90 ⟶ Akt + Hsp90	0000180
57	CHIPbinding		CHIP + Akt_Hsp90 ⟶ Akt_CHIP_Hsp90	0000526
58	CHIPrelease		Akt_CHIP_Hsp90 ⟶ CHIP + Akt_Hsp90	0000526
59	AktProteasomeBinding		Akt_CHIP_Hsp90 + Proteasome ⟶ Akt_Proteasome + CHIP + Hsp90	0000177
60	AktProteasomeRelease		Akt_Proteasome ⟶ Akt + Proteasome	0000180
61	AktDegradation		Akt_Proteasome + ATP ⟶ Proteasome + ADP	0000179
62	Mkp1Synthesis		Source ⟶ Mkp1	0000184
63	Mkp1ProteasomeBinding		Mkp1 + Proteasome ⟶ Mkp1_Proteasome	0000177
64	Mkp1Degradation		Mkp1_Proteasome + ATP ⟶ Proteasome + ADP	0000179
65	Mkp1Phosphorylation		Mkp1 + Hsp70 ⟶ Mkp1_P + Hsp70	0000216

№	Id	Name	Reaction Equation	SBO
66	Mkp1Dephosphorylation		Mkp1_P + ROS ⟶ Mkp1 + ROS	0000330
67	p38ROSproduction		p38_P ⟶ p38_P + ROS	0000393
68	Hsp70Damage		Hsp70 + ROS ⟶ Hsp70_dam + ROS	0000177
69	Hsp90Damage		Hsp90 + ROS ⟶ Hsp90_dam + ROS	0000177
70	Hsp70DamProteasomeBinding		Hsp70_dam + Proteasome ⟶ Hsp70_Proteasome	0000177
71	Hsp90DamProteasomeBinding		Hsp90_dam + Proteasome ⟶ Hsp90_Proteasome	0000177
72	Hsp70DamAggregation1		2 Hsp70_dam ⟶ AggP	0000177
73	Hsp70DamInclusionFormation		Hsp70_dam + AggP ⟶ SeqAggP	0000177
74	Hsp90DamAggregation		2 Hsp90_dam ⟶ AggP	0000177
75	Hsp90DamInclusionFormation		Hsp90_dam + AggP ⟶ SeqAggP	0000177
76	Hsp70DamSequestering		Hsp70_dam + SeqAggP ⟶ 2 SeqAggP	0000177
77	Hsp90DamSequestering		Hsp90_dam + SeqAggP ⟶ 2 SeqAggP	0000177
78	p38CellDeath		p38_P ⟶ p38_P + p38Death + CellDeath	0000179
79	JnkCellDeath		Jnk_P ⟶ Jnk_P + JNKDeath + CellDeath	0000179
80	PICellDeath		AggP_Proteasome ⟶ AggP_Proteasome + PIDeath + CellDeath	0000179

8.1 Reaction `ProteinSynthesis`

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

SBO:0000284 transporter

Reaction equation

$$\text{Source} \longrightarrow \text{NatP} \tag{6}$$

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

$$v_1 = \text{ksynNatP} \cdot \text{Source} \cdot \text{kalive} \tag{7}$$

8.2 Reaction `Misfolding`

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

SBO:0000344 molecular interaction

Reaction equation

$$\text{NatP} + \text{ROS} \longrightarrow \text{MisP} + \text{ROS} \tag{8}$$

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

$$v_2 = \text{kmisfold} \cdot \text{NatP} \cdot \text{ROS} \cdot \text{kalive} \tag{9}$$

8.3 Reaction Hsp90MisPBinding

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

SBO:0000526 protein complex formation

Reaction equation

$$\text{MisP} + \text{Hsp90} \longrightarrow \text{Hsp90\_MisP} \tag{10}$$

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

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

8.4 Reaction Hsp90unsuccessulRefolding

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

SBO:0000180 dissociation

Reaction equation

$$\text{Hsp90\_MisP} \longrightarrow \text{MisP} + \text{Hsp90} \tag{12}$$

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

$$v_4 = \text{krelHspMisp} \cdot \text{Hsp90\_MisP} \cdot \text{kalive} \tag{13}$$

8.5 Reaction Hsp90refolding

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

SBO:0000344 molecular interaction

Reaction equation

$$\text{Hsp90\_MisP} + \text{ATP} \longrightarrow \text{Hsp90} + \text{NatP} + \text{ADP} \tag{14}$$

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

$$v_5 = \frac{\text{krefold} \cdot \text{Hsp90\_MisP} \cdot \text{kalive} \cdot \text{ATP}}{5000 + \text{ATP}} \tag{15}$$

8.6 Reaction Hsp70MisPBinding

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

SBO:0000526 protein complex formation

Reaction equation

$$\text{MisP} + \text{Hsp70} \longrightarrow \text{Hsp70\_MisP} \tag{16}$$

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

$$v_6 = \text{kbinHspMisp} \cdot \text{MisP} \cdot \text{Hsp70} \cdot \text{kalive} \tag{17}$$

8.7 Reaction Hsp70unsuccessulRefolding

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

SBO:0000180 dissociation

Reaction equation

$$\text{Hsp70\_MisP} \longrightarrow \text{MisP} + \text{Hsp70} \tag{18}$$

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

$$v_7 = \text{krelHspMisp} \cdot \text{Hsp70\_MisP} \cdot \text{kalive} \tag{19}$$

8.8 Reaction Hsp70refolding

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

SBO:0000344 molecular interaction

Reaction equation

$$\text{Hsp70\_MisP} + \text{ATP} \longrightarrow \text{Hsp70} + \text{NatP} + \text{ADP} \tag{20}$$

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

$$v_8 = \frac{\text{krefold} \cdot \text{Hsp70\_MisP} \cdot \text{kalive} \cdot \text{ATP}}{5000 + \text{ATP}} \tag{21}$$

8.9 Reaction Hsp70ClientBinding

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

SBO:0000526 protein complex formation

Reaction equation

$$\text{Hsp70} + \text{Hsp70Client} \longrightarrow \text{Hsp70\_Hsp70Client} \tag{22}$$

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

$$v_9 = \text{kbinHsp70client} \cdot \text{Hsp70} \cdot \text{Hsp70Client} \cdot \text{kalive} \tag{23}$$

8.10 Reaction Hsp70ClientRelease

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

SBO:0000180 dissociation

Reaction equation

$$\text{Hsp70\_Hsp70Client} \longrightarrow \text{Hsp70} + \text{Hsp70Client} \tag{24}$$

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

$$v_{10} = \text{krelHsp70client} \cdot \text{Hsp70\_Hsp70Client} \cdot \text{kalive} \tag{25}$$

8.11 Reaction Hsp90ClientBinding

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

SBO:0000526 protein complex formation

Reaction equation

$$\text{Hsp90} + \text{Hsp90Client} \longrightarrow \text{Hsp90\_Hsp90Client} \tag{26}$$

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

$$v_{11} = \text{kbinHsp90client} \cdot \text{Hsp90} \cdot \text{Hsp90Client} \cdot \text{kalive} \tag{27}$$

8.12 Reaction Hsp90ClientRelease

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

SBO:0000180 dissociation

Reaction equation

$$\text{Hsp90\_Hsp90Client} \longrightarrow \text{Hsp90} + \text{Hsp90Client} \tag{28}$$

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

$$v_{12} = \text{krelHsp90client} \cdot \text{Hsp90\_Hsp90Client} \cdot \text{kalive} \tag{29}$$

8.13 Reaction Hsp90HSF1Binding

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

SBO:0000526 protein complex formation

Reaction equation

$$\text{Hsp90} + \text{Hsf1} \longrightarrow \text{Hsf1\_Hsp90} \tag{30}$$

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

$$v_{13} = \text{kbinHsf1Hsp90} \cdot \text{Hsp90} \cdot \text{Hsf1} \cdot \text{kalive} \tag{31}$$

8.14 Reaction Hsp90HSF1Release

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

SBO:0000180 dissociation

Reaction equation

$$\text{Hsf1\_Hsp90} \longrightarrow \text{Hsp90} + \text{Hsf1} \tag{32}$$

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

$$v_{14} = \text{krelHsf1Hsp90} \cdot \text{Hsf1\_Hsp90} \cdot \text{kalive} \tag{33}$$

8.15 Reaction dimerisation

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

SBO:0000526 protein complex formation

Reaction equation

$$2\,\text{Hsf1} \longrightarrow \text{Hsf1\_Hsf1} \tag{34}$$

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

Kinetic Law

Derived unit contains undeclared units

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

8.16 Reaction `trimerisation`

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

SBO:0000526 protein complex formation

Reaction equation

$$\mathrm{Hsf1} + \mathrm{Hsf1\_Hsf1} \longrightarrow \mathrm{Hsf1\_Hsf1\_Hsf1} \tag{36}$$

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

$$v_{16} = \mathrm{ktrimerHsf1} \cdot \mathrm{Hsf1} \cdot \mathrm{Hsf1\_Hsf1} \cdot \mathrm{kalive} \tag{37}$$

8.17 Reaction `deTrimerisation`

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

SBO:0000180 dissociation

Reaction equation

$$\mathrm{Hsf1\_Hsf1\_Hsf1} \longrightarrow \mathrm{Hsf1} + \mathrm{Hsf1\_Hsf1} \tag{38}$$

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

$$v_{17} = \mathrm{kdetrimerHsf1} \cdot \mathrm{Hsf1\_Hsf1\_Hsf1} \cdot \mathrm{kalive} \tag{39}$$

8.18 Reaction deDimerisation

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

SBO:0000180 dissociation

Reaction equation

$$\mathrm{Hsf1\_Hsf1} \longrightarrow 2\,\mathrm{Hsf1} \tag{40}$$

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

$$v_{18} = \text{kdedimerHsf1} \cdot \text{Hsf1\_Hsf1} \cdot \text{kalive} \tag{41}$$

8.19 Reaction HSE70TriHBinding

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

SBO:0000526 protein complex formation

Reaction equation

$$\text{Hsf1\_Hsf1\_Hsf1} + \text{HSEHsp70} \longrightarrow \text{HSEHsp70\_Hsf1\_Hsf1\_Hsf1} \tag{42}$$

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

$$v_{19} = \text{kbinHSEHsf1} \cdot \text{HSEHsp70} \cdot \text{Hsf1\_Hsf1\_Hsf1} \cdot \text{kalive} \tag{43}$$

8.20 Reaction HSE70TriHRelease

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

SBO:0000180 dissociation

Reaction equation

$$\text{HSEHsp70\_Hsf1\_Hsf1\_Hsf1} \longrightarrow \text{HSEHsp70} + \text{Hsf1\_Hsf1\_Hsf1} \tag{44}$$

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

$$v_{20} = \text{krelHSEHsf1} \cdot \text{HSEHsp70\_Hsf1\_Hsf1\_Hsf1} \cdot \text{kalive} \tag{45}$$

8.21 Reaction HSE90TriHBinding

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

SBO:0000526 protein complex formation

Reaction equation

$$\text{Hsf1\_Hsf1\_Hsf1} + \text{HSEHsp90} \longrightarrow \text{HSEHsp90\_Hsf1\_Hsf1\_Hsf1} \tag{46}$$

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

$$v_{21} = \text{kbinHSEHsf1} \cdot \text{HSEHsp90} \cdot \text{Hsf1\_Hsf1\_Hsf1} \cdot \text{kalive} \tag{47}$$

8.22 Reaction HSE90TriHRelease

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

SBO:0000180 dissociation

Reaction equation

$$\text{HSEHsp90\_Hsf1\_Hsf1\_Hsf1} \longrightarrow \text{HSEHsp90} + \text{Hsf1\_Hsf1\_Hsf1} \tag{48}$$

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

$$v_{22} = \text{krelHSEHsf1} \cdot \text{HSEHsp90\_Hsf1\_Hsf1\_Hsf1} \cdot \text{kalive} \tag{49}$$

8.23 Reaction Hsf1_Hsf1_Hsf1Phosphorylation

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

SBO:0000216 phosphorylation

Reaction equation

$$\text{Hsf1\_Hsf1\_Hsf1} + \text{Pkc} \longrightarrow \text{Hsf1\_Hsf1\_Hsf1\_P} + \text{Pkc} \tag{50}$$

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

$$v_{23} = \text{kphosHsf1} \cdot \text{Hsf1\_Hsf1\_Hsf1} \cdot \text{Pkc} \cdot \text{kalive} \tag{51}$$

8.24 Reaction Hsf1_Hsf1_Hsf1DePhosphorylation

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

SBO:0000330 dephosphorylation

Reaction equation

$$\text{Hsf1\_Hsf1\_Hsf1\_P} + \text{Hsp70\_Ppx} \longrightarrow \text{Hsf1\_Hsf1\_Hsf1} + \text{Hsp70\_Ppx} \tag{52}$$

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

$$v_{24} = \text{kdephosHsf1} \cdot \text{Hsf1\_Hsf1\_Hsf1\_P} \cdot \text{Hsp70\_Ppx} \cdot \text{kalive} \tag{53}$$

8.25 Reaction HSE70PhosTriHBinding

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

SBO:0000526 protein complex formation

Reaction equation

$$\text{Hsf1\_Hsf1\_Hsf1\_P} + \text{HSEHsp70} \longrightarrow \text{HSEHsp70\_Hsf1\_Hsf1\_Hsf1\_P} \tag{54}$$

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

$$v_{25} = \text{kbinHSEPhosTriH} \cdot \text{HSEHsp70} \cdot \text{Hsf1\_Hsf1\_Hsf1\_P} \cdot \text{kalive} \tag{55}$$

8.26 Reaction HSE70PhosTriHRelease

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

SBO:0000180 dissociation

Reaction equation

$$\text{HSEHsp70\_Hsf1\_Hsf1\_Hsf1\_P} \longrightarrow \text{Hsf1\_Hsf1\_Hsf1\_P} + \text{HSEHsp70} \tag{56}$$

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

$$v_{26} = \text{krelHSEPhosTriH} \cdot \text{HSEHsp70\_Hsf1\_Hsf1\_Hsf1\_P} \cdot \text{kalive} \tag{57}$$

8.27 Reaction HSE90PhosTriHBinding

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

SBO:0000526 protein complex formation

Reaction equation

$$\text{Hsf1\_Hsf1\_Hsf1\_P} + \text{HSEHsp90} \longrightarrow \text{HSEHsp90\_Hsf1\_Hsf1\_Hsf1\_P} \tag{58}$$

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

$$v_{27} = \text{kbinHSEPhosTriH} \cdot \text{HSEHsp90} \cdot \text{Hsf1\_Hsf1\_Hsf1\_P} \cdot \text{kalive} \tag{59}$$

8.28 Reaction HSE90PhosTriHRelease

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

SBO:0000180 dissociation

Reaction equation

$$\text{HSEHsp90\_Hsf1\_Hsf1\_Hsf1\_P} \longrightarrow \text{Hsf1\_Hsf1\_Hsf1\_P} + \text{HSEHsp90} \tag{60}$$

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

$$\text{Source} \longrightarrow \text{Hsp90} \tag{62}$$

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

$$v_{29} = \text{kbasalsynHsp90} \cdot \text{kalive} \tag{63}$$

8.30 Reaction Hsp90Upregulation

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

SBO:0000177 non-covalent binding

Reaction equation

$$\text{HSEHsp90\_Hsf1\_Hsf1\_Hsf1\_P} \longrightarrow \text{HSEHsp90\_Hsf1\_Hsf1\_Hsf1\_P} + \text{Hsp90} \tag{64}$$

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

$$v_{30} = \text{kupregHsp} \cdot \text{HSEHsp90\_Hsf1\_Hsf1\_Hsf1\_P} \cdot \text{kalive} \tag{65}$$

8.31 Reaction Hsp90ProteasomeBinding

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

SBO:0000526 protein complex formation

Reaction equation

$$\text{Hsp90} + \text{Proteasome} \longrightarrow \text{Hsp90\_Proteasome} \tag{66}$$

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

$$v_{31} = \text{kbinHsp90Prot} \cdot \text{Hsp90} \cdot \text{Proteasome} \cdot \text{kalive} \tag{67}$$

8.32 Reaction Hsp90Degradation

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

SBO:0000179 degradation

Reaction equation

$$\text{Hsp90\_Proteasome} + \text{ATP} \longrightarrow \text{Proteasome} + \text{ADP} \tag{68}$$

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

$$v_{32} = \frac{\text{kdegHsp90} \cdot \text{Hsp90\_Proteasome} \cdot \text{kalive} \cdot \text{ATP}}{5000 + \text{ATP}} \tag{69}$$

8.33 Reaction Hsp70BasalSynthesis

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

SBO:0000184 translation

Reaction equation

$$\text{Source} \longrightarrow \text{Hsp70} \tag{70}$$

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

$$v_{33} = \text{kbasalsynHsp70} \cdot \text{kalive} \tag{71}$$

8.34 Reaction Hsp70Upregulation

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

SBO:0000177 non-covalent binding

Reaction equation

$$\text{HSEHsp70\_Hsf1\_Hsf1\_Hsf1\_P} \longrightarrow \text{HSEHsp70\_Hsf1\_Hsf1\_Hsf1\_P} + \text{Hsp70} \tag{72}$$

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

$$v_{34} = \text{kupregHsp} \cdot \text{HSEHsp70\_Hsf1\_Hsf1\_Hsf1\_P} \cdot \text{kalive} \tag{73}$$

8.35 Reaction Hsp70ProteasomeBinding

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

SBO:0000526 protein complex formation

Reaction equation

$$\text{Hsp70} + \text{Proteasome} \longrightarrow \text{Hsp70\_Proteasome} \tag{74}$$

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

$$v_{35} = \text{kbinHsp70Prot} \cdot \text{Hsp70} \cdot \text{Proteasome} \cdot \text{kalive} \tag{75}$$

8.36 Reaction Hsp70Degradation

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

SBO:0000179 degradation

Reaction equation

$$\text{Hsp70\_Proteasome} + \text{ATP} \longrightarrow \text{Proteasome} + \text{ADP} \tag{76}$$

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

$$v_{36} = \frac{\text{kdegHsp70} \cdot \text{Hsp70\_Proteasome} \cdot \text{kalive} \cdot \text{ATP}}{5000 + \text{ATP}} \tag{77}$$

8.37 Reaction MisPProteasomeBinding1

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

SBO:0000177 non-covalent binding

Reaction equation

$$\text{Hsp70\_MisP} + \text{Proteasome} \longrightarrow \text{MisP\_Proteasome} + \text{Hsp70} \tag{78}$$

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

$$v_{37} = \text{kbinMisPProt} \cdot \text{Hsp70\_MisP} \cdot \text{Proteasome} \cdot \text{kalive} \tag{79}$$

8.38 Reaction MisPProteasomeBinding2

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

SBO:0000177 non-covalent binding

Reaction equation

$$\text{Hsp90\_MisP} + \text{Proteasome} \longrightarrow \text{MisP\_Proteasome} + \text{Hsp90} \tag{80}$$

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

$$v_{38} = \text{kbinMisPProt} \cdot \text{Hsp90\_MisP} \cdot \text{Proteasome} \cdot \text{kalive} \tag{81}$$

8.39 Reaction MisPDegradation

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

SBO:0000179 degradation

Reaction equation

$$\text{MisP\_Proteasome} + \text{ATP} \longrightarrow \text{Proteasome} + \text{ADP} \tag{82}$$

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

$$v_{39} = \frac{\text{kdegMisP} \cdot \text{MisP\_Proteasome} \cdot \text{kalive} \cdot \text{ATP}}{5000 + \text{ATP}} \tag{83}$$

8.40 Reaction radicalFormation

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

Name radicalFormation

SBO:0000393 production

Reaction equation

$$\text{Source} \longrightarrow \text{ROS} \tag{84}$$

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

$$v_{40} = \text{kgenROS} \cdot \text{Source} \cdot \text{kalive} \tag{85}$$

8.41 Reaction radicalScavenging

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

Name radicalScavenging

SBO:0000179 degradation

Reaction equation

$$\text{ROS} \longrightarrow \text{Sink} \tag{86}$$

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

$$v_{41} = \text{kremROS} \cdot \text{ROS} \cdot \text{kalive} \tag{87}$$

8.42 Reaction Hsp70_PpxBinding

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

SBO:0000526 protein complex formation

Reaction equation

$$\text{Hsp70} + \text{Ppx} \longrightarrow \text{Hsp70\_Ppx} \tag{88}$$

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

$$v_{42} = \text{kbinHsp70Ppx} \cdot \text{Hsp70} \cdot \text{Ppx} \cdot \text{kalive} \tag{89}$$

8.43 Reaction Hsp70_PPXRelease

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

SBO:0000180 dissociation

Reaction equation

$$\text{Hsp70\_Ppx} \longrightarrow \text{Hsp70} + \text{Ppx} \tag{90}$$

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

$$v_{43} = \text{krelHsp70Ppx} \cdot \text{Hsp70\_Ppx} \cdot \text{kalive} \tag{91}$$

8.44 Reaction JnkPhosphorylation

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

SBO:0000216 phosphorylation

Reaction equation

$$\text{ROS} + \text{Jnk} \longrightarrow \text{ROS} + \text{Jnk\_P} \tag{92}$$

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

$$v_{44} = \text{kphosJnk} \cdot \text{Jnk} \cdot \text{ROS} \cdot \text{kalive} \tag{93}$$

8.45 Reaction JNKDephosphorylatioByMkp1

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

SBO:0000330 dephosphorylation

Reaction equation

$$\text{Jnk\_P} + \text{Mkp1\_P} \longrightarrow \text{Jnk} + \text{Mkp1\_P} \tag{94}$$

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

$$v_{45} = \text{kdephosJnkMkp1} \cdot \text{Jnk\_P} \cdot \text{Mkp1\_P} \cdot \text{kalive} \tag{95}$$

8.46 Reaction p38Phosphorylation

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

SBO:0000216 phosphorylation

Reaction equation

$$\text{ROS} + \text{p38} \longrightarrow \text{ROS} + \text{p38\_P} \tag{96}$$

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

$$v_{46} = \text{kphosp38} \cdot \text{ROS} \cdot \text{p38} \cdot \text{kalive} \tag{97}$$

8.47 Reaction p38DePhosphorylationByMkp1

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

SBO:0000330 dephosphorylation

Reaction equation

$$\text{p38\_P} + \text{Mkp1\_P} \longrightarrow \text{p38} + \text{Mkp1\_P} \tag{98}$$

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

$$v_{47} = \text{kdephosp38Mkp1} \cdot \text{p38\_P} \cdot \text{Mkp1\_P} \cdot \text{kalive} \tag{99}$$

8.48 Reaction Aggregation1

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

SBO:0000177 non-covalent binding

Reaction equation

$$2\,\text{MisP} \longrightarrow \text{AggP} \tag{100}$$

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

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

8.49 Reaction SequesteringOfAggregate

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

SBO:0000177 non-covalent binding

Reaction equation

$$\text{MisP} + \text{AggP} \longrightarrow \text{SeqAggP} \tag{102}$$

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

$$v_{49} = \text{kagg} \cdot \text{MisP} \cdot \text{AggP} \cdot \text{kalive} \tag{103}$$

8.50 Reaction `InclusionGrowth`

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

SBO:0000177 non-covalent binding

Reaction equation

$$\text{SeqAggP} + \text{MisP} \longrightarrow 2\,\text{SeqAggP} \tag{104}$$

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

$$v_{50} = \text{kseqagg} \cdot \text{SeqAggP} \cdot \text{MisP} \cdot \text{kalive} \tag{105}$$

8.51 Reaction `ProteasomeInhibtion`

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

SBO:0000177 non-covalent binding

Reaction equation

$$\text{AggP} + \text{Proteasome} \longrightarrow \text{AggP\_Proteasome} \tag{106}$$

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

$$v_{51} = \text{kbinAggPProt} \cdot \text{AggP} \cdot \text{Proteasome} \cdot \text{kalive} \tag{107}$$

8.52 Reaction ROSgenerationSmallAggP

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

SBO:0000393 production

Reaction equation

$$\text{AggP} \longrightarrow \text{AggP} + \text{ROS} \tag{108}$$

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

$$v_{52} = \text{kgenROSAggP} \cdot \text{AggP} \cdot \text{kalive} \tag{109}$$

8.53 Reaction ROSgenerationAggPProteasome

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

SBO:0000393 production

Reaction equation

$$\text{AggP\_Proteasome} \longrightarrow \text{AggP\_Proteasome} + \text{ROS} \tag{110}$$

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

$$v_{53} = \text{kgenROSAggP} \cdot \text{AggP\_Proteasome} \cdot \text{kalive} \tag{111}$$

8.54 Reaction `AktSynthesis`

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

SBO:0000184 translation

Reaction equation

$$\text{Source} \longrightarrow \text{Akt} \tag{112}$$

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

$$v_{54} = \text{ksynAkt} \cdot \text{Source} \cdot \text{kalive} \tag{113}$$

8.55 Reaction `Hsp90AktBinding`

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

SBO:0000526 protein complex formation

Reaction equation

$$\text{Hsp90} + \text{Akt} \longrightarrow \text{Akt\_Hsp90} \tag{114}$$

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

$$v_{55} = \text{kbinAktHsp90} \cdot \text{Hsp90} \cdot \text{Akt} \cdot \text{kalive} \tag{115}$$

8.56 Reaction Hsp90AktRelease

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

SBO:0000180 dissociation

Reaction equation

$$\text{Akt\_Hsp90} \longrightarrow \text{Akt} + \text{Hsp90} \tag{116}$$

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

$$v_{56} = \text{krelAktHsp90} \cdot \text{Akt\_Hsp90} \cdot \text{kalive} \tag{117}$$

8.57 Reaction CHIPbinding

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

SBO:0000526 protein complex formation

Reaction equation

$$\text{CHIP} + \text{Akt\_Hsp90} \longrightarrow \text{Akt\_CHIP\_Hsp90} \tag{118}$$

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

$$v_{57} = \text{kbinCHIP} \cdot \text{CHIP} \cdot \text{Akt\_Hsp90} \cdot \text{kalive} \tag{119}$$

8.58 Reaction CHIPrelease

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

SBO:0000526 protein complex formation

Reaction equation

$$\text{Akt\_CHIP\_Hsp90} \longrightarrow \text{CHIP} + \text{Akt\_Hsp90} \tag{120}$$

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

$$v_{58} = \text{krelCHIP} \cdot \text{Akt\_CHIP\_Hsp90} \cdot \text{kalive} \tag{121}$$

8.59 Reaction AktProteasomeBinding

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

SBO:0000177 non-covalent binding

Reaction equation

$$\text{Akt\_CHIP\_Hsp90} + \text{Proteasome} \longrightarrow \text{Akt\_Proteasome} + \text{CHIP} + \text{Hsp90} \tag{122}$$

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

$$v_{59} = \text{kbinAktProt} \cdot \text{Akt\_CHIP\_Hsp90} \cdot \text{Proteasome} \cdot \text{kalive} \tag{123}$$

8.60 Reaction AktProteasomeRelease

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

SBO:0000180 dissociation

Reaction equation

$$\text{Akt\_Proteasome} \longrightarrow \text{Akt} + \text{Proteasome} \tag{124}$$

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

$$v_{60} = \text{krelAktProt} \cdot \text{Akt\_Proteasome} \cdot \text{kalive} \tag{125}$$

8.61 Reaction `AktDegradation`

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

SBO:0000179 degradation

Reaction equation

$$\text{Akt\_Proteasome} + \text{ATP} \longrightarrow \text{Proteasome} + \text{ADP} \tag{126}$$

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

$$v_{61} = \frac{\text{kdegAkt} \cdot \text{Akt\_Proteasome} \cdot \text{kalive} \cdot \text{ATP}}{5000 + \text{ATP}} \tag{127}$$

8.62 Reaction `Mkp1Synthesis`

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

SBO:0000184 translation

Reaction equation

$$\text{Source} \longrightarrow \text{Mkp1} \tag{128}$$

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

$$v_{62} = \text{ksynMkp1} \cdot \text{Source} \cdot \text{kalive} \tag{129}$$

8.63 Reaction Mkp1ProteasomeBinding

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

SBO:0000177 non-covalent binding

Reaction equation

$$\text{Mkp1} + \text{Proteasome} \longrightarrow \text{Mkp1\_Proteasome} \tag{130}$$

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

$$v_{63} = \text{kbinMkp1Prot} \cdot \text{Mkp1} \cdot \text{Proteasome} \cdot \text{kalive} \tag{131}$$

8.64 Reaction Mkp1Degradation

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

SBO:0000179 degradation

Reaction equation

$$\text{Mkp1\_Proteasome} + \text{ATP} \longrightarrow \text{Proteasome} + \text{ADP} \tag{132}$$

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

$$v_{64} = \frac{\text{kdegMkp1} \cdot \text{Mkp1\_Proteasome} \cdot \text{kalive} \cdot \text{ATP}}{5000 + \text{ATP}} \tag{133}$$

8.65 Reaction `Mkp1Phosphorylation`

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

SBO:0000216 phosphorylation

Reaction equation

$$\text{Mkp1} + \text{Hsp70} \longrightarrow \text{Mkp1\_P} + \text{Hsp70} \tag{134}$$

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

$$v_{65} = \text{kphosMkp1} \cdot \text{Mkp1} \cdot \text{Hsp70} \cdot \text{kalive} \tag{135}$$

8.66 Reaction `Mkp1Dephosphorylation`

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

SBO:0000330 dephosphorylation

Reaction equation

$$\text{Mkp1\_P} + \text{ROS} \longrightarrow \text{Mkp1} + \text{ROS} \tag{136}$$

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

$$v_{66} = \text{kdephosMkp1} \cdot \text{Mkp1\_P} \cdot \text{ROS} \cdot \text{kalive} \tag{137}$$

8.67 Reaction p38ROSproduction

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

SBO:0000393 production

Reaction equation

$$\text{p38\_P} \longrightarrow \text{p38\_P} + \text{ROS} \tag{138}$$

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

$$v_{67} = \text{kgenROSp38} \cdot \text{p38\_P} \cdot \text{kalive} \cdot \text{kp38act} \tag{139}$$

8.68 Reaction Hsp70Damage

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

SBO:0000177 non-covalent binding

Reaction equation

$$\text{Hsp70} + \text{ROS} \longrightarrow \text{Hsp70\_dam} + \text{ROS} \tag{140}$$

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

$$v_{68} = \text{kdamHsp} \cdot \text{Hsp70} \cdot \text{ROS} \cdot \text{kalive} \tag{141}$$

8.69 Reaction Hsp90Damage

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

SBO:0000177 non-covalent binding

Reaction equation

$$\text{Hsp90} + \text{ROS} \longrightarrow \text{Hsp90\_dam} + \text{ROS} \tag{142}$$

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

$$v_{69} = \text{kdamHsp} \cdot \text{Hsp90} \cdot \text{ROS} \cdot \text{kalive} \tag{143}$$

8.70 Reaction Hsp70DamProteasomeBinding

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

SBO:0000177 non-covalent binding

Reaction equation

$$\text{Hsp70\_dam} + \text{Proteasome} \longrightarrow \text{Hsp70\_Proteasome} \tag{144}$$

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

$$v_{70} = \text{kbinHsp70Prot} \cdot \text{Hsp70\_dam} \cdot \text{Proteasome} \cdot \text{kalive} \tag{145}$$

8.71 Reaction Hsp90DamProteasomeBinding

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

SBO:0000177 non-covalent binding

Reaction equation

$$\text{Hsp90\_dam} + \text{Proteasome} \longrightarrow \text{Hsp90\_Proteasome} \tag{146}$$

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

$$v_{71} = \text{kbinHsp90Prot} \cdot \text{Hsp90\_dam} \cdot \text{Proteasome} \cdot \text{kalive} \tag{147}$$

8.72 Reaction Hsp70DamAggregation1

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

SBO:0000177 non-covalent binding

Reaction equation

$$2\,\text{Hsp70\_dam} \longrightarrow \text{AggP} \tag{148}$$

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

$$v_{72} = \text{kagg} \cdot \text{Hsp70\_dam} \cdot (\text{Hsp70\_dam} - 1) \cdot 0.5 \cdot \text{kalive} \tag{149}$$

8.73 Reaction Hsp70DamInclusionFormation

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

SBO:0000177 non-covalent binding

Reaction equation

$$\text{Hsp70\_dam} + \text{AggP} \longrightarrow \text{SeqAggP} \tag{150}$$

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

$$v_{73} = \text{kagg} \cdot \text{Hsp70\_dam} \cdot \text{AggP} \cdot \text{kalive} \tag{151}$$

8.74 Reaction Hsp90DamAggregation

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

SBO:0000177 non-covalent binding

Reaction equation

$$2\,\text{Hsp90\_dam} \longrightarrow \text{AggP} \tag{152}$$

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

$$v_{74} = \text{kagg} \cdot \text{Hsp90\_dam} \cdot (\text{Hsp90\_dam} - 1) \cdot 0.5 \cdot \text{kalive} \tag{153}$$

8.75 Reaction Hsp90DamInclusionFormation

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

SBO:0000177 non-covalent binding

Reaction equation

$$\text{Hsp90\_dam} + \text{AggP} \longrightarrow \text{SeqAggP} \tag{154}$$

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

Kinetic Law

Derived unit contains undeclared units

$$v_{75} = \text{kagg} \cdot \text{Hsp90\_dam} \cdot \text{AggP} \cdot \text{kalive} \tag{155}$$

8.76 Reaction `Hsp70DamSequestering`

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

SBO:0000177 non-covalent binding

Reaction equation

$$\text{Hsp70\_dam} + \text{SeqAggP} \longrightarrow 2\,\text{SeqAggP} \tag{156}$$

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

$$v_{76} = \text{kseqagg} \cdot \text{Hsp70\_dam} \cdot \text{SeqAggP} \cdot \text{kalive} \tag{157}$$

8.77 Reaction `Hsp90DamSequestering`

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

SBO:0000177 non-covalent binding

Reaction equation

$$\text{Hsp90\_dam} + \text{SeqAggP} \longrightarrow 2\,\text{SeqAggP} \tag{158}$$

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

$$v_{77} = \text{kseqagg} \cdot \text{Hsp90\_dam} \cdot \text{SeqAggP} \cdot \text{kalive} \tag{159}$$

8.78 Reaction p38CellDeath

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

SBO:0000179 degradation

Reaction equation

$$\text{p38\_P} \longrightarrow \text{p38\_P} + \text{p38Death} + \text{CellDeath} \tag{160}$$

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

$$v_{78} = \text{kp38death} \cdot \text{p38\_P} \cdot \text{kalive} \cdot \text{kp38act} \tag{161}$$

8.79 Reaction JnkCellDeath

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

SBO:0000179 degradation

Reaction equation

$$\text{Jnk\_P} \longrightarrow \text{Jnk\_P} + \text{JNKDeath} + \text{CellDeath} \tag{162}$$

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

$$v_{79} = \text{kJnkdeath} \cdot \text{Jnk\_P} \cdot \text{kalive} \tag{163}$$

8.80 Reaction PICellDeath

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

SBO:0000179 degradation

Reaction equation

$$\text{AggP\_Proteasome} \longrightarrow \text{AggP\_Proteasome} + \text{PIDeath} + \text{CellDeath} \tag{164}$$

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

$$v_{80} = \text{kPIdeath} \cdot \text{AggP\_Proteasome} \cdot \text{kalive} \tag{165}$$

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).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{NatP} = v_1 + v_5 + v_8 - v_2 \tag{166}$$

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, Hsp90unsuccessulRefolding, Hsp70unsuccessulRefolding).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{MisP} = v_2 + v_4 + v_7 - v_3 - v_6 - 2\,v_{48} - v_{49} - v_{50} \tag{167}$$

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 Hsp70unsuccessulRefolding, Hsp70refolding, Hsp70ClientRelease, Hsp70BasalSynthesis, Hsp70Upregulation, MisPProteasomeBinding1, Hsp70_PPXRelease, Mkp1Phosphorylation).

$$\begin{aligned}\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{Hsp70} = {} & v_7 + v_8 + v_{10} + v_{33} + v_{34} + v_{37} + v_{43} \\ & + v_{65} - v_6 - v_9 - v_{35} - v_{42} - v_{65} - v_{68}\end{aligned} \tag{168}$$

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 Hsp90unsuccessulRefolding, Hsp90refolding, Hsp90ClientRelease, Hsp90HSF1Release, Hsp90BasalSynthesis, Hsp90Upregulation, MisPProteasomeBinding2, Hsp90AktRelease, AktProteasomeBinding).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{Hsp90} = v_4 + v_5 + v_{12} + v_{14} + v_{29} + v_{30} + v_{38} + v_{56} + v_{59} - v_3 - v_{11} - v_{13} - v_{31} - v_{55} - v_{69} \tag{169}$$

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).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{Hsp70\_dam} = v_{68} - v_{70} - 2\,v_{72} - v_{73} - v_{76} \tag{170}$$

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).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{Hsp90\_dam} = v_{69} - v_{71} - 2\,v_{74} - v_{75} - v_{77} \tag{171}$$

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).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{Hsp90\_Proteasome} = v_{31} + v_{71} - v_{32} \tag{172}$$

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).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{Hsp70\_Proteasome} = v_{35} + v_{70} - v_{36} \tag{173}$$

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).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{Hsp70Client} = v_{10} - v_{9} \tag{174}$$

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).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{Hsp90Client} = v_{12} - v_{11} \tag{175}$$

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).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{Hsp70\_Hsp70Client} = v_{9} - v_{10} \tag{176}$$

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).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{Hsp90\_Hsp90Client} = v_{11} - v_{12} \tag{177}$$

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).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{Akt} = v_{54} + v_{56} + v_{60} - v_{55} \tag{178}$$

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).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{Akt\_Hsp90} = v_{55} + v_{58} - v_{56} - v_{57} \tag{179}$$

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).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{CHIP} = v_{58} + v_{59} - v_{57} \tag{180}$$

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).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{Akt\_CHIP\_Hsp90} = v_{57} - v_{58} - v_{59} \tag{181}$$

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).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{Akt\_Proteasome} = v_{59} - v_{60} - v_{61} \tag{182}$$

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).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{Hsf1} = v_{14} + v_{17} + 2\,v_{18} - v_{13} - 2\,v_{15} - v_{16} \tag{183}$$

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).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{Hsf1\_Hsp90} = v_{13} - v_{14} \tag{184}$$

9.20 Species Hsp90_MisP

SBO:0000297 protein complex

Initial amount 470 item

This species takes part in four reactions (as a reactant in Hsp90unsuccessulRefolding, Hsp90refolding, MisPProteasomeBinding2 and as a product in Hsp90MisPBinding).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{Hsp90\_MisP} = v_3 - v_4 - v_5 - v_{38} \tag{185}$$

9.21 Species Hsp70_MisP

SBO:0000297 protein complex

Initial amount 410 item

This species takes part in four reactions (as a reactant in Hsp70unsuccessulRefolding, Hsp70refolding, MisPProteasomeBinding1 and as a product in Hsp70MisPBinding).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{Hsp70\_MisP} = v_6 - v_7 - v_8 - v_{37} \tag{186}$$

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).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{Hsf1\_Hsf1\_Hsf1} = v_{16} + v_{20} + v_{22} + v_{24} - v_{17} - v_{19} - v_{21} - v_{23} \tag{187}$$

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).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{Hsf1\_Hsf1\_Hsf1\_P} = v_{23} + v_{26} + v_{28} - v_{24} - v_{25} - v_{27} \tag{188}$$

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).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{Hsf1\_Hsf1} = v_{15} + v_{17} - v_{16} - v_{18} \tag{189}$$

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).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{HSEHsp70} = v_{20} + v_{26} - v_{19} - v_{25} \tag{190}$$

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).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{HSEHsp90} = v_{22} + v_{28} - v_{21} - v_{27} \tag{191}$$

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).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{HSEHsp70\_Hsf1\_Hsf1\_Hsf1} = v_{19} - v_{20} \tag{192}$$

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).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{HSEHsp70\_Hsf1\_Hsf1\_Hsf1\_P} = v_{25} + v_{34} - v_{26} - v_{34} \tag{193}$$

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).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{HSEHsp90\_Hsf1\_Hsf1\_Hsf1} = v_{21} - v_{22} \tag{194}$$

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).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{HSEHsp90\_Hsf1\_Hsf1\_Hsf1\_P} = v_{27} + v_{30} - v_{28} - v_{30} \tag{195}$$

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 JNKDephosphorylatioByMkp1).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{Jnk} = v_{45} - v_{44} \tag{196}$$

9.32 Species Jnk_P

SBO:0000252 polypeptide chain

Initial amount 0 item

This species takes part in four reactions (as a reactant in JNKDephosphorylatioByMkp1, JnkCellDeath and as a product in JnkPhosphorylation, JnkCellDeath).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{Jnk\_P} = v_{44} + v_{79} - v_{45} - v_{79} \tag{197}$$

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).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{Ppx} = v_{43} - v_{42} \tag{198}$$

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).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{Mkp1} = v_{62} + v_{66} - v_{63} - v_{65} \tag{199}$$

9.35 Species Mkp1_P

SBO:0000252 polypeptide chain

Initial amount 100 item

This species takes part in six reactions (as a reactant in JNKDephosphorylatioByMkp1, p38DePhosphorylationBy Mkp1Dephosphorylation and as a product in JNKDephosphorylatioByMkp1, p38DePhosphorylationByMkp1, Mkp1Phosphorylation).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{Mkp1\_P} = v_{45} + v_{47} + v_{65} - v_{45} - v_{47} - v_{66} \tag{200}$$

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).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{Mkp1\_Proteasome} = v_{63} - v_{64} \tag{201}$$

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).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{Hsp70\_Ppx} = v_{24} + v_{42} - v_{24} - v_{43} \tag{202}$$

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).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{Pkc} = v_{23} - v_{23} \tag{203}$$

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).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{p38} = v_{47} - v_{46} \tag{204}$$

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, p38ROSproduction, p38CellDeath and as a product in p38Phosphorylation, p38ROSproduction, p38CellDeath).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{p38\_P} = v_{46} + v_{67} + v_{78} - v_{47} - v_{67} - v_{78} \tag{205}$$

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, ProteasomeInhibtion, AktProteasomeBinding, Mkp1ProteasomeBinding, Hsp70DamProteasomeBinding, Hsp90DamProteasomeBinding and as a product in Hsp90Degradation, Hsp70Degradation, MisPDegradation, AktProteasomeRelease, AktDegradation, Mkp1Degradation).

$$\begin{aligned}\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{Proteasome} = {} & v_{32} + v_{36} + v_{39} + v_{60} + v_{61} + v_{64} - v_{31} - v_{35} \\ & - v_{37} - v_{38} - v_{51} - v_{59} - v_{63} - v_{70} - v_{71}\end{aligned} \tag{206}$$

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).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{MisP\_Proteasome} = v_{37} + v_{38} - v_{39} \tag{207}$$

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).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{AggP} = v_{48} + v_{52} + v_{72} + v_{74} - v_{49} - v_{51} - v_{52} - v_{73} - v_{75} \tag{208}$$

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).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{SeqAggP} = v_{49} + 2\,v_{50} + v_{73} + v_{75} + 2\,v_{76} + 2\,v_{77} - v_{50} - v_{76} - v_{77} \tag{209}$$

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).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{AggP\_Proteasome} = v_{51} + v_{53} + v_{80} - v_{53} - v_{80} \tag{210}$$

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).

$$\begin{aligned}\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{ROS} = {} & v_2 + v_{40} + v_{44} + v_{46} + v_{52} + v_{53} + v_{66} + v_{67} + v_{68} \\ & + v_{69} - v_2 - v_{41} - v_{44} - v_{46} - v_{66} - v_{68} - v_{69}\end{aligned} \tag{211}$$

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:

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{ATP} = 0 \tag{212}$$

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:

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{ADP} = 0 \tag{213}$$

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:

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{Source} = 0 \tag{214}$$

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:

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{Sink} = 0 \tag{215}$$

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).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{p38Death} = v_{78} \tag{216}$$

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).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{JNKDeath} = v_{79} \tag{217}$$

9.53 Species PIDeath

SBO:0000236 physical entity representation

Initial amount 0 item

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

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{PIDeath} = v_{80} \tag{218}$$

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).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{CellDeath} = v_{78} + v_{79} + v_{80} \tag{219}$$

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 comple

SBO:0000179 degradation: Complete disappearance of a physical entity

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

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

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