

SBML Model Report

Model name: “Schaber2012 - Hog pathway in yeast”



May 5, 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 Joerg Schaber² at November 22nd 2012 at 6:31 p. m. and last time modified at December 14th 2012 at 2:24 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	4
species types	0	species	15
events	0	constraints	0
reactions	16	function definitions	10
global parameters	88	unit definitions	1
rules	22	initial assignments	37

Model Notes

Schaber2012 - Hog pathway in yeast

The high osmolarity glycerol (HOG) pathway in the yeast *Saccharomyces cerevisiae* is one of the best-studied mitogen-activated protein kinase (MAPK) pathways and serves as a prototype

¹EMBL-EBI, viji@ebi.ac.uk

²OvGU, schaber@med.ovgu.de

signalling system for eukaryotes. This pathway is necessary and sufficient to adapt to high external osmolarity. A key component of this pathway is the stress-activated protein kinase (SAPK) Hog1, which is rapidly phosphorylated by the SAPK kinase Pbs2 upon hyper-osmotic shock, and which is the terminal kinase of two parallel signalling pathways, subsequently called the Sho1 branch and the Sln1 branch, respectively. Ensemble modelling (192 models) is used to study the yeast HOG pathway, a prototype for eukaryotic mitogen-activated kinase signalling systems. The best fit model (Model Nr.22: described here) provides new insights into the function of this system, some of which are then experimentally validated.

This model is described in the article: [Modelling reveals novel roles of two parallel signalling pathways and homeostatic feedbacks in yeast](#). Schaber J, Baltanas R, Bush A, Klipp E, Colman-Lerner A. Mol Syst Biol. 2012 Nov 13;8:622.

Abstract:

The high osmolarity glycerol (HOG) pathway in yeast serves as a prototype signalling system for eukaryotes. We used an unprecedented amount of data to parameterise 192 models capturing different hypotheses about molecular mechanisms underlying osmo-adaptation and selected a best approximating model. This model implied novel mechanisms regulating osmo-adaptation in yeast. The model suggested that (i) the main mechanism for osmo-adaptation is a fast and transient non-transcriptional Hog1-mediated activation of glycerol production, (ii) the transcriptional response serves to maintain an increased steady-state glycerol production with low steady-state Hog1 activity, and (iii) fast negative feedbacks of activated Hog1 on upstream signalling branches serves to stabilise adaptation response. The best approximating model also indicated that homeostatic adaptive systems with two parallel redundant signalling branches show a more robust and faster response than single-branch systems. We corroborated this notion to a large extent by dedicated measurements of volume recovery in single cells. Our study also demonstrates that systematically testing a model ensemble against data has the potential to achieve a better and unbiased understanding of molecular mechanisms.

This model is hosted on [BioModels Database](#) and identified by: [MODEL1209110001](#).

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

To the extent possible under law, all copyright and related or neighbouring rights to this encoded model have been dedicated to the public domain worldwide. Please refer to [CC0 Public Domain Dedication](#) for more information.

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

Name substance

Definition μmol

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 four compartments.

Table 2: Properties of all compartments.

Id	Name	SBO	Spatial Dimensions	Size	Unit	Constant	Outside
compartment_1	Vos		3	29.5	l	<input type="checkbox"/>	
compartment_2	Vex		3	50000	l	<input checked="" type="checkbox"/>	
compartment_3	V		3	50	l	<input type="checkbox"/>	
compartment_4	M		3	1	litre	<input checked="" type="checkbox"/>	

3.1 Compartment compartment_1

This is a three dimensional compartment with a not constant size of 29.5 litre.

Name Vos

Notes Osmolytically active volume, derived from a total cell volume of 50 fl and a solid

3.2 Compartment `compartment_2`

This is a three dimensional compartment with a constant size of 50000 litre.

Name `Vex`

3.3 Compartment `compartment_3`

This is a three dimensional compartment with a not constant size of 50 litre.

Name `V`

Notes `Total cell volume.`

3.4 Compartment `compartment_4`

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

Name `M`

4 Species

This model contains 15 species. The boundary condition of one of these species is set to `true` so that this species' amount cannot be changed by any reaction. Section 10 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
species_1	Glyin	compartment_1	μmol	<input type="checkbox"/>	<input type="checkbox"/>
species_2	Hog1	compartment_1	μmol	<input type="checkbox"/>	<input type="checkbox"/>
species_3	Hog1PP	compartment_1	μmol	<input type="checkbox"/>	<input type="checkbox"/>
species_4	Pbs2	compartment_1	μmol	<input type="checkbox"/>	<input type="checkbox"/>
species_5	Pbs2P	compartment_1	μmol	<input type="checkbox"/>	<input type="checkbox"/>
species_6	Phosphatase	compartment_1	μmol	<input type="checkbox"/>	<input type="checkbox"/>
species_7	Protein	compartment_1	μmol	<input type="checkbox"/>	<input type="checkbox"/>
species_8	RNA	compartment_1	μmol	<input type="checkbox"/>	<input type="checkbox"/>
species_9	Hog1P	compartment_1	μmol	<input type="checkbox"/>	<input type="checkbox"/>
species_10	Sho1	compartment_1	μmol	<input type="checkbox"/>	<input type="checkbox"/>
species_11	Sho1Pbs2P	compartment_1	μmol	<input type="checkbox"/>	<input type="checkbox"/>
species_12	Hog1PPActive	compartment_1	μmol	<input type="checkbox"/>	<input checked="" type="checkbox"/>
species_13	Glyex	compartment_2	μmol	<input type="checkbox"/>	<input type="checkbox"/>
species_14	Fps1	compartment_4	μmol	<input type="checkbox"/>	<input type="checkbox"/>
species_15	Fps1P	compartment_4	μmol	<input type="checkbox"/>	<input type="checkbox"/>

5 Parameters

This model contains 88 global parameters.

Table 4: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
parameter_1	R		8.314		<input checked="" type="checkbox"/>
parameter_2	T		303.150		<input checked="" type="checkbox"/>
parameter_3	mol		$6.022 \cdot 10^{23}$		<input checked="" type="checkbox"/>
parameter_4	phi		0.930		<input checked="" type="checkbox"/>
parameter_5	c2p			10^{-9}	<input checked="" type="checkbox"/>
parameter_6	tm		10.000		<input checked="" type="checkbox"/>
parameter_7	Lp		0.013		<input checked="" type="checkbox"/>
parameter_8	P0		0.610		<input checked="" type="checkbox"/>
parameter_9	eps		14.300		<input checked="" type="checkbox"/>
parameter_10	minf		0.410		<input checked="" type="checkbox"/>
parameter_11	ce_0		260000.000		<input checked="" type="checkbox"/>
parameter_12	V_0		50.000		<input checked="" type="checkbox"/>
parameter_13	Vb		20.500		<input checked="" type="checkbox"/>
parameter_14	maxHog1nucf		0.800		<input checked="" type="checkbox"/>
parameter_15	VP_0		47.912		<input checked="" type="checkbox"/>
parameter_16	Area		65.634		<input type="checkbox"/>
parameter_17	Hog1PPrelIniwt		2.230		<input checked="" type="checkbox"/>
parameter_18	N2uM		$5.62907756305974 \cdot 10^{-5}$		<input checked="" type="checkbox"/>
parameter_19	ci_0		502026.122		<input checked="" type="checkbox"/>
parameter_20	cin_0		322026.122		<input checked="" type="checkbox"/>
parameter_21	Turgor		0.610		<input type="checkbox"/>
parameter_22	ActivationSln1-nlfb		$7.10539561053171 \cdot 10^{-4}$		<input type="checkbox"/>
parameter_23	NaCl		0.400		<input checked="" type="checkbox"/>
parameter_24	ActivOffsetSln1-nlfb		$-7.10539561053171 \cdot 10^{-4}$		<input checked="" type="checkbox"/>
parameter_25	kHog1phos1		42.640		<input checked="" type="checkbox"/>
parameter_26	kHog1dephos		1.786		<input checked="" type="checkbox"/>
parameter_27	ks		$4.28194136809108 \cdot 10^{-4}$		<input type="checkbox"/>
parameter_28	Fps1TransportCapacitty		0.500		<input type="checkbox"/>
parameter_29	FitVrel		100.000		<input type="checkbox"/>
parameter_30	FitHog1PPrel		2.230		<input type="checkbox"/>
parameter_31	FitProteinrel		19.900		<input type="checkbox"/>
parameter_32	FitGlyinrel		17.000		<input type="checkbox"/>
parameter_33	Turgor2Osm		242026.122		<input type="checkbox"/>
parameter_34	Fps1ClosureRate		0.128		<input checked="" type="checkbox"/>
parameter_35	Protein_deg_k		$6.78688610600496 \cdot 10^{-5}$		<input checked="" type="checkbox"/>

Id	Name	SBO	Value	Unit	Constant
parameter_36	FitRNARel		3.400		<input type="checkbox"/>
parameter_37	Hog1Total		0.382		<input checked="" type="checkbox"/>
parameter_38	Pbs2Total		0.122		<input checked="" type="checkbox"/>
parameter_39	RNA_deg_k_MM		7.096		<input checked="" type="checkbox"/>
parameter_40	Sho1Total		0.131		<input checked="" type="checkbox"/>
parameter_41	kHog1phos2		48.000		<input checked="" type="checkbox"/>
parameter_42	Hog1PPrelIniSln1		2.230		<input checked="" type="checkbox"/>
parameter_43	Hog1PPrelIniSho1		2.230		<input checked="" type="checkbox"/>
parameter_44	Osmex		260000.000		<input type="checkbox"/>
parameter_45	Osmin		502026.122		<input type="checkbox"/>
parameter_46	Vos_0		29.500		<input checked="" type="checkbox"/>
parameter_47	A_0		65.634		<input checked="" type="checkbox"/>
parameter_48	ts		600.000		<input checked="" type="checkbox"/>
parameter_49	cen		258200.000		<input type="checkbox"/>
parameter_50	Glyex_0		1800.000		<input checked="" type="checkbox"/>
parameter_51	Protein_0		0.045		<input checked="" type="checkbox"/>
parameter_52	RNA_0		0.034		<input checked="" type="checkbox"/>
parameter_53	Glyin_0		180000.000		<input checked="" type="checkbox"/>
parameter_54	Hog1PP_0		0.007		<input checked="" type="checkbox"/>
parameter_55	ActivOffsetSho1- _nlfb		-0.004		<input checked="" type="checkbox"/>
parameter_56	ActivationSho1- _nlfb		0.004		<input type="checkbox"/>
parameter_57	Sho1BranchActive		1.000		<input checked="" type="checkbox"/>
parameter_58	Sln1BranchActive		1.000		<input checked="" type="checkbox"/>
parameter_59	Fps1TotalIni		0.051		<input checked="" type="checkbox"/>
parameter_60	Fps1TotalTrans		0.051		<input type="checkbox"/>
parameter_61	TurgorActiv_h		2.000		<input checked="" type="checkbox"/>
parameter_62	TurgorActivation		0.500		<input type="checkbox"/>
parameter_63	TurgorDeactivation		0.500		<input type="checkbox"/>
parameter_64	v16_5_k		0.003		<input checked="" type="checkbox"/>
parameter_65	v16_6_k		0.003		<input checked="" type="checkbox"/>
parameter_66	v16_7_k		0.005		<input checked="" type="checkbox"/>
parameter_67	Hog1Activity		0.001		<input checked="" type="checkbox"/>
parameter_68	tinh		600.000		<input checked="" type="checkbox"/>
parameter_69	Hog1Inhibition		1.000		<input type="checkbox"/>
parameter_70	Inhibition		0.000		<input checked="" type="checkbox"/>
parameter_71	Fps1Delta		1.000		<input checked="" type="checkbox"/>
parameter_72	v2_k		0.607		<input checked="" type="checkbox"/>
parameter_73	v1_fb_Ki		0.009		<input checked="" type="checkbox"/>
parameter_74	v1_fb_h		0.346		<input checked="" type="checkbox"/>
parameter_75	v1_fb_k		0.075		<input checked="" type="checkbox"/>

Id	Name	SBO	Value	Unit	Constant
parameter_76	v11_k		$9.06781 \cdot 10^{-5}$		<input checked="" type="checkbox"/>
parameter_77	v9_k		18.182		<input checked="" type="checkbox"/>
parameter_78	v9_Km		0.507		<input checked="" type="checkbox"/>
parameter_79	v4_k1		0.002		<input checked="" type="checkbox"/>
parameter_80	v3_fb_Ki		0.298		<input checked="" type="checkbox"/>
parameter_81	v3_fb_h		2.079		<input checked="" type="checkbox"/>
parameter_82	v3_fb_k		0.005		<input checked="" type="checkbox"/>
parameter_83	v15_5_k		0.005		<input checked="" type="checkbox"/>
parameter_84	v16_6_Ki		0.081		<input checked="" type="checkbox"/>
parameter_85	v16_6_h		0.629		<input checked="" type="checkbox"/>
parameter_86	v13_k1		680.818		<input checked="" type="checkbox"/>
parameter_87	v13_k2		46.836		<input checked="" type="checkbox"/>
parameter_88	v13_Km		0.421		<input checked="" type="checkbox"/>

6 Initialassignments

This is an overview of 37 initialassignments.

6.1 Initialassignment compartment_1

Derived unit contains undeclared units

Math parameter_46

6.2 Initialassignment compartment_2

Derived unit contains undeclared units

Math $1000 \cdot \text{vol}(\text{compartment}_3)$

6.3 Initialassignment species_1

Derived unit contains undeclared units

Math $\text{parameter}_{53} \cdot \text{vol}(\text{compartment}_1)$

6.4 Initialassignment species_2

Derived unit contains undeclared units

Math $\left(\text{parameter}_{37} - \frac{\text{species}_9}{\text{vol}(\text{compartment}_1)} - \frac{\text{species}_3}{\text{vol}(\text{compartment}_1)} \right) \cdot \text{vol}(\text{compartment}_1)$

6.5 Initialassignment species_3

Derived unit contains undeclared units

Math $\text{parameter_54} \cdot \text{vol}(\text{compartment_1})$

6.6 Initialassignment species_4

Derived unit contains undeclared units

Math $\left(\text{parameter_38} - \frac{\text{species_5}}{\text{vol}(\text{compartment_1})} - \frac{\text{species_11}}{\text{vol}(\text{compartment_1})} \right) \cdot \text{vol}(\text{compartment_1})$

6.7 Initialassignment species_5

Derived unit contains undeclared units

Math
$$\begin{cases} \left(\frac{\text{parameter_26} \cdot \frac{\text{species_6}}{\text{vol}(\text{compartment_1})} \cdot \left(\frac{\text{species_3}}{\text{vol}(\text{compartment_1})} + \sqrt{2} \right)}{4 \cdot \text{parameter_25} \cdot \left(\frac{\text{species_3}}{\text{vol}(\text{compartment_1})} - \text{parameter_37} \right)} \right) & \text{if } (\text{parameter_58} = 1) \wedge (\text{para} \\ \left(\frac{\text{parameter_25} \cdot \text{parameter_26} \cdot \frac{\text{species_6}}{\text{vol}(\text{compartment_1})} \cdot \frac{\text{species_3}}{\text{vol}(\text{compartment_1})} + \sqrt{2}}{2 \cdot \text{parameter_25}^2 \cdot \left(\frac{\text{species_3}}{\text{vol}(\text{compartment_1})} - \text{parameter_37} \right)} \right) & \\ 0 & \text{otherwise} \end{cases}$$

 $\text{vol}(\text{compartment_1})$

6.8 Initialassignment species_6

Derived unit contains undeclared units

Math $769 \cdot \text{parameter_18} \cdot \text{vol}(\text{compartment_1})$

6.9 Initialassignment species_7

Derived unit contains undeclared units

Math $\text{parameter_51} \cdot \text{vol}(\text{compartment_1})$

6.10 Initialassignment species_8

Derived unit contains undeclared units

Math $\text{parameter_52} \cdot \text{vol}(\text{compartment_1})$

6.11 Initialassignment species_9

Derived unit contains undeclared units

$$\text{Math} \left\{ \begin{array}{ll} \frac{1}{2} \cdot \left(\left(\frac{\text{species}_3}{\text{vol}(\text{compartment}_1)} \right) + \sqrt{2} \right) & \text{if } (\text{parameter}_{58} = 1) \wedge (\text{parameter}_{59} = 1) \\ \frac{\text{parameter}_{25} \cdot \text{parameter}_{26} \cdot \frac{\text{species}_6}{\text{vol}(\text{compartment}_1)} \cdot \frac{\text{species}_3}{\text{vol}(\text{compartment}_1)} + \sqrt{2}}{2 \cdot \text{parameter}_{25} \cdot \text{parameter}_{26} \cdot \frac{\text{species}_6}{\text{vol}(\text{compartment}_1)}} & \text{otherwise} \\ \frac{\text{parameter}_{41} \cdot \text{parameter}_{26} \cdot \frac{\text{species}_6}{\text{vol}(\text{compartment}_1)} \cdot \frac{\text{species}_3}{\text{vol}(\text{compartment}_1)} + \sqrt{2}}{2 \cdot \text{parameter}_{41} \cdot \text{parameter}_{26} \cdot \frac{\text{species}_6}{\text{vol}(\text{compartment}_1)}} & \text{otherwise} \end{array} \right.$$

6.12 Initialassignment species_10

Derived unit contains undeclared units

$$\text{Math} \left(\text{parameter}_{40} - \frac{\text{species}_{11}}{\text{vol}(\text{compartment}_1)} \right) \cdot \text{vol}(\text{compartment}_1)$$

6.13 Initialassignment species_11

Derived unit contains undeclared units

$$\text{Math} \left\{ \begin{array}{ll} \left(\frac{\text{parameter}_{26} \cdot \frac{\text{species}_6}{\text{vol}(\text{compartment}_1)} \cdot \left(\frac{\text{species}_3}{\text{vol}(\text{compartment}_1)} + \sqrt{2} \right)}{4 \cdot \text{parameter}_{41} \cdot \left(\frac{\text{species}_3}{\text{vol}(\text{compartment}_1)} - \text{parameter}_{37} \right)} \right) & \text{if } (\text{parameter}_{58} = 0) \wedge (\text{parameter}_{59} = 1) \\ \left(\frac{\text{parameter}_{41} \cdot \text{parameter}_{26} \cdot \frac{\text{species}_6}{\text{vol}(\text{compartment}_1)} \cdot \frac{\text{species}_3}{\text{vol}(\text{compartment}_1)} + \sqrt{2}}{2 \cdot \text{parameter}_{41}^2 \cdot \left(\frac{\text{species}_3}{\text{vol}(\text{compartment}_1)} - \text{parameter}_{37} \right)} \right) & \text{otherwise} \\ 0 & \text{otherwise} \end{array} \right.$$

6.14 Initialassignment species_13

Derived unit contains undeclared units

$$\text{Math} \frac{\frac{\text{species}_1}{\text{vol}(\text{compartment}_1)}}{100} \cdot \text{vol}(\text{compartment}_2)$$

6.15 Initialassignment species_14

Derived unit contains undeclared units

$$\text{Math} \frac{\text{parameter}_{59}}{2} \cdot \text{vol}(\text{compartment}_4)$$

6.16 Initialassignment species_15

Derived unit contains undeclared units

Math $\frac{\text{parameter_59}}{2} \cdot \text{vol}(\text{compartment_4})$

6.17 Initialassignment parameter_13

Derived unit contains undeclared units

Math $\text{parameter_12} \cdot \text{parameter_10}$

6.18 Initialassignment parameter_15

Derived unit contains undeclared units

Math $\text{parameter_12} \cdot \exp\left(\frac{\text{parameter_8}}{\text{parameter_9}}\right)$

6.19 Initialassignment parameter_18

Derived unit contains undeclared units

Math $\frac{1.0E21}{\text{parameter_3} \cdot \text{vol}(\text{compartment_1})}$

6.20 Initialassignment parameter_19

Derived unit contains undeclared units

Math $\text{parameter_11} + \frac{\text{parameter_8}}{\text{parameter_5} \cdot \text{parameter_1} \cdot \text{parameter_2}}$

6.21 Initialassignment parameter_20

Derived unit contains undeclared units

Math $\text{parameter_19} - \frac{\text{species_1}}{\text{vol}(\text{compartment_1})}$

6.22 Initialassignment parameter_24

Derived unit contains undeclared units

Math
$$\frac{\text{parameter_72} \cdot \frac{\text{species_6}}{\text{vol}(\text{compartment_1})} \cdot \frac{\text{species_5}}{\text{vol}(\text{compartment_1})} \cdot \left(1 + \left(\frac{\text{species_3}}{\frac{\text{vol}(\text{compartment_1})}{\text{parameter_73}}}\right)^{\text{parameter_74}}\right)}{\text{parameter_75} \cdot \frac{\text{species_4}}{\text{vol}(\text{compartment_1})}}$$

6.23 Initialassignment parameter_35

Derived unit contains undeclared units

Math
$$\frac{\text{parameter_76} \cdot \frac{\text{species_8}}{\text{vol}(\text{compartment_1})}}{\frac{\text{species_7}}{\text{vol}(\text{compartment_1})}}$$

6.24 Initialassignment parameter_37

Derived unit contains undeclared units

Math
$$6788 \cdot \text{parameter_18}$$

6.25 Initialassignment parameter_38

Derived unit contains undeclared units

Math
$$2160 \cdot \text{parameter_18}$$

6.26 Initialassignment parameter_39

Derived unit contains undeclared units

Math
$$\frac{\frac{\text{parameter_77} \cdot \frac{\text{species_3}}{\text{vol}(\text{compartment_1})}}{\text{parameter_78} + \frac{\text{species_3}}{\text{vol}(\text{compartment_1})}} \cdot \frac{\text{species_8}}{\text{vol}(\text{compartment_1})}}$$

6.27 Initialassignment parameter_40

Derived unit contains undeclared units

Math
$$2330 \cdot \text{parameter_18}$$

6.28 Initialassignment parameter_46

Derived unit contains undeclared units

Math
$$\text{parameter_12} \cdot (1 - \text{parameter_10})$$

6.29 Initialassignment parameter_47

Derived unit contains undeclared units

Math
$$(36 \cdot \pi)^{\frac{1}{3}} \cdot \text{parameter_12}^{\frac{2}{3}}$$

6.30 Initialassignment parameter_50

Derived unit contains undeclared units

Math
$$\frac{\text{parameter_53}}{100}$$

6.31 Initialassignment parameter_51

Derived unit contains undeclared units

Math $807 \cdot \text{parameter_18}$

6.32 Initialassignment parameter_54

Derived unit contains undeclared units

$$\text{Math} \begin{cases} \frac{\text{parameter_37} \cdot \text{parameter_17} \cdot \text{parameter_14}}{100} & \text{if } (\text{parameter_58} = 1) \wedge (\text{parameter_57} = 0) \\ \frac{\text{parameter_37} \cdot \text{parameter_42} \cdot \text{parameter_14}}{100} & \text{otherwise} \\ \frac{\text{parameter_37} \cdot \text{parameter_43} \cdot \text{parameter_14}}{100} & \text{otherwise} \end{cases}$$

6.33 Initialassignment parameter_55

Derived unit contains undeclared units

$$\text{Math} \frac{\text{parameter_79} \cdot \frac{\text{species_11}}{\text{vol}(\text{compartment_1})} \cdot \left(1 + \left(\frac{\text{species_3}}{\frac{\text{vol}(\text{compartment_1})}{\text{parameter_80}}} \right)^{\text{parameter_81}} \right)}{\text{parameter_82} \cdot \frac{\text{species_4}}{\text{vol}(\text{compartment_1})} \cdot \frac{\text{species_10}}{\text{vol}(\text{compartment_1})}}$$

6.34 Initialassignment parameter_59

Derived unit contains undeclared units

Math $907 \cdot \text{parameter_18}$

6.35 Initialassignment parameter_64

Derived unit contains undeclared units

$$\text{Math} \frac{\text{parameter_83} \cdot \frac{\text{species_14}}{\text{vol}(\text{compartment_4})} \cdot \text{parameter_63}}{\frac{\text{species_15}}{\text{vol}(\text{compartment_4})}}$$

6.36 Initialassignment parameter_65

Derived unit contains undeclared units

$$\text{Math} \frac{\text{parameter_83} \cdot \frac{\text{species_14}}{\text{vol}(\text{compartment_4})} \cdot \text{parameter_63} \cdot \left(1 + \left(\frac{\text{species_3}}{\frac{\text{vol}(\text{compartment_1})}{\text{parameter_84}}} \right)^{\text{parameter_85}} \right)}{\frac{\text{species_15}}{\text{vol}(\text{compartment_4})}}$$

6.37 Initialassignment parameter_66

Derived unit contains undeclared units

Math
$$\frac{\text{parameter_83} \cdot \frac{\text{species_14}}{\text{vol}(\text{compartment_4})} \cdot \text{parameter_63}}{\frac{\text{species_15}}{\text{vol}(\text{compartment_4})} \cdot \text{parameter_62}}$$

7 Function definitions

This is an overview of ten function definitions.

7.1 Function definition function_10

Name 1 para inh Mass action (rrev)

Arguments ko, k, S, M, Ki, h

Mathematical Expression

$$\frac{k_0 \cdot k \cdot S}{1 + \left(\frac{M}{K_i}\right)^h} \quad (1)$$

7.2 Function definition function_9

Name 3 param mass action (irrev)

Arguments ko, k, M, S

Mathematical Expression

$$k_0 \cdot k \cdot M \cdot S \quad (2)$$

7.3 Function definition function_8

Name 2 param 2 S MA with inhibition (irrev)

Arguments ko, k, M1, S1, S2, M2, Ki, h

Mathematical Expression

$$\frac{k_0 \cdot k \cdot M1 \cdot S1 \cdot S2}{1 + \left(\frac{M2}{K_i}\right)^h} \quad (3)$$

7.4 Function definition function_4

Name Modified constant flux (irrev)

Arguments k, M

Mathematical Expression

$$k \cdot M \quad (4)$$

7.5 Function definition [function_6](#)

Name transport (rev)

Arguments A, P, S, f, ks

Mathematical Expression

$$f \cdot ks \cdot A \cdot (S - P) \quad (5)$$

7.6 Function definition [function_2](#)

Name Modified mass action (irrev)

Arguments k, M, S

Mathematical Expression

$$k \cdot M \cdot S \quad (6)$$

7.7 Function definition [function_5](#)

Name 2 param mod. add. constant flux MM (irrev)

Arguments k1, M1, k2, M2, Km

Mathematical Expression

$$\frac{k1 \cdot M1 \cdot (1 + k2 \cdot M2)}{Km + M1 \cdot (1 + k2 \cdot M2)} \quad (7)$$

7.8 Function definition [function_7](#)

Name mod. constat flux (MM) (irrev)

Arguments k, M, Km

Mathematical Expression

$$\frac{k \cdot M}{Km + M} \quad (8)$$

7.9 Function definition [function_3](#)

Name mod. MA OR (irrev)

Arguments k1, M1, S, k2, M2

Mathematical Expression

$$k1 \cdot M1 \cdot S + k2 \cdot M2 \cdot S \quad (9)$$

7.10 Function definition `function_1`

Name 3 param activation with inhibition (iirev)

Arguments ko, k, M1, S, M2, h, Ki

Mathematical Expression

$$\frac{ko \cdot k \cdot M1 \cdot S}{1 + \left(\frac{M2}{Ki}\right)^h} \quad (10)$$

8 Rules

This is an overview of 22 rules.

8.1 Rule `compartment_3`

Rule `compartment_3` is an assignment rule for compartment `compartment_3`:

$$\text{vol}(\text{compartment}_3) = \text{parameter}_{13} + \text{vol}(\text{compartment}_1) \quad (11)$$

8.2 Rule `parameter_16`

Rule `parameter_16` is an assignment rule for parameter `parameter_16`:

$$\text{parameter}_{16} = (36 \cdot \pi)^{\frac{1}{3}} \cdot \text{vol}(\text{compartment}_3)^{\frac{2}{3}} \quad (12)$$

8.3 Rule `parameter_21`

Rule `parameter_21` is an assignment rule for parameter `parameter_21`:

$$\begin{aligned} &\text{parameter}_{21} \\ &= \begin{cases} \text{parameter}_9 \cdot \left(\frac{\text{vol}(\text{compartment}_3)}{\text{parameter}_{15}} \right) & \text{if } \text{vol}(\text{compartment}_3) > \text{parameter}_{15} \\ 0 & \text{otherwise} \end{cases} \end{aligned} \quad (13)$$

8.4 Rule `parameter_22`

Rule `parameter_22` is an assignment rule for parameter `parameter_22`:

$$\begin{aligned} &\text{parameter}_{22} \\ &= \begin{cases} \frac{\text{parameter}_{47} - \text{parameter}_{16}}{\text{parameter}_{47}} - \text{parameter}_{24} & \text{if } \frac{\text{parameter}_{47} - \text{parameter}_{16}}{\text{parameter}_{47}} > \text{parameter}_{24} \\ 0 & \text{otherwise} \end{cases} \end{aligned} \quad (14)$$

8.5 Rule parameter_27

Rule parameter_27 is an assignment rule for parameter parameter_27:

$$\text{parameter_27} = \frac{\frac{\text{parameter_86} \cdot \text{parameter_51} \cdot (1 + \text{parameter_87} \cdot \text{parameter_54})}{\text{parameter_88} + \text{parameter_51} \cdot (1 + \text{parameter_87} \cdot \text{parameter_54})} \cdot \text{parameter_46}}{0.5 \cdot \text{parameter_47} \cdot (\text{parameter_53} - \text{parameter_50})} \quad (15)$$

8.6 Rule parameter_28

Rule parameter_28 is an assignment rule for parameter parameter_28:

$$\text{parameter_28} = \frac{\frac{\text{species_14}}{\text{vol}(\text{compartment_4})}}{\text{parameter_59}} \quad (16)$$

8.7 Rule parameter_29

Rule parameter_29 is an assignment rule for parameter parameter_29:

$$\text{parameter_29} = \frac{100 \cdot \text{vol}(\text{compartment_3})}{\text{parameter_12}} \quad (17)$$

8.8 Rule parameter_30

Rule parameter_30 is an assignment rule for parameter parameter_30:

$$\text{parameter_30} = \frac{100 \cdot \frac{\text{species_3}}{\text{vol}(\text{compartment_1})} \cdot \text{vol}(\text{compartment_1})}{\text{parameter_14} \cdot \text{parameter_37} \cdot \text{parameter_46}} \quad (18)$$

8.9 Rule parameter_31

Rule parameter_31 is an assignment rule for parameter parameter_31:

$$\text{parameter_31} = \frac{19.9 \cdot \frac{\text{species_7}}{\text{vol}(\text{compartment_1})} \cdot \text{vol}(\text{compartment_1})}{\text{parameter_51} \cdot \text{parameter_46}} \quad (19)$$

8.10 Rule parameter_32

Rule parameter_32 is an assignment rule for parameter parameter_32:

$$\text{parameter_32} = \frac{17 \cdot \frac{\text{species_1}}{\text{vol}(\text{compartment_1})} \cdot \text{vol}(\text{compartment_1})}{\text{parameter_53} \cdot \text{parameter_46}} \quad (20)$$

8.11 Rule parameter_33

Rule parameter_33 is an assignment rule for parameter parameter_33:

$$\text{parameter_33} = \frac{\text{parameter_21}}{\text{parameter_1} \cdot \text{parameter_2} \cdot \text{parameter_5}} \quad (21)$$

8.12 Rule parameter_36

Rule parameter_36 is an assignment rule for parameter parameter_36:

$$\text{parameter_36} = \frac{3.4 \cdot \frac{\text{species_8}}{\text{vol}(\text{compartment_1})} \cdot \text{vol}(\text{compartment_1})}{\text{parameter_52} \cdot \text{parameter_46}} \quad (22)$$

8.13 Rule parameter_45

Rule parameter_45 is an assignment rule for parameter parameter_45:

$$\text{parameter_45} = \frac{\text{species_1}}{\text{vol}(\text{compartment_1})} + \frac{\text{parameter_20} \cdot \text{parameter_46}}{\text{vol}(\text{compartment_1})} \quad (23)$$

8.14 Rule parameter_49

Rule parameter_49 is an assignment rule for parameter parameter_49:

$$\begin{aligned} &\text{parameter_49} \quad (24) \\ &= \begin{cases} \text{parameter_11} - \text{parameter_50} + \left(1 - \exp\left(\frac{\text{parameter_48} - \text{time}}{\text{parameter_6}}\right)\right) \cdot 2 \cdot \text{parameter_4} \cdot \text{parameter_23} \cdot 10^6 & \text{if} \\ \text{parameter_11} - \text{parameter_50} & \text{otherwise} \end{cases} \end{aligned}$$

8.15 Rule parameter_44

Rule parameter_44 is an assignment rule for parameter parameter_44:

$$\text{parameter_44} = \text{parameter_49} + \frac{\text{species_13}}{\text{vol}(\text{compartment_2})} \quad (25)$$

8.16 Rule parameter_56

Rule parameter_56 is an assignment rule for parameter parameter_56:

$$\text{parameter_56} = \begin{cases} \frac{\text{parameter_47} - \text{parameter_16}}{\text{parameter_47}} - \text{parameter_55} & \text{if } \frac{\text{parameter_47} - \text{parameter_16}}{\text{parameter_47}} > \text{parameter_55} \\ 0 & \text{otherwise} \end{cases} \quad (26)$$

8.17 Rule parameter_60

Rule parameter_60 is an assignment rule for parameter parameter_60:

$$\text{parameter_60} = \frac{\text{species_14}}{\text{vol}(\text{compartment_4})} + \frac{\text{species_15}}{\text{vol}(\text{compartment_4})} \quad (27)$$

Derived unit $\mu\text{mol} \cdot \text{l}^{-1}$

8.18 Rule `parameter_62`

Rule `parameter_62` is an assignment rule for parameter `parameter_62`:

$$\text{parameter_62} = \frac{\text{parameter_21}^{\text{parameter_61}}}{\text{parameter_8}^{\text{parameter_61}} + \text{parameter_21}^{\text{parameter_61}}} \quad (28)$$

8.19 Rule `parameter_63`

Rule `parameter_63` is an assignment rule for parameter `parameter_63`:

$$\text{parameter_63} = 1 - \frac{\text{parameter_21}^{\text{parameter_61}}}{\text{parameter_8}^{\text{parameter_61}} + \text{parameter_21}^{\text{parameter_61}}} \quad (29)$$

8.20 Rule `parameter_69`

Rule `parameter_69` is an assignment rule for parameter `parameter_69`:

$$\text{parameter_69} = \begin{cases} \begin{cases} \text{parameter_67} & \text{if time} > \text{parameter_68} \\ 1 & \text{otherwise} \end{cases} & \text{if parameter_70} = 1 \\ 1 & \text{otherwise} \end{cases} \quad (30)$$

8.21 Rule `species_12`

Rule `species_12` is an assignment rule for species `species_12`:

$$[\text{species_12}] = \text{parameter_69} \cdot \frac{\text{species_3}}{\text{vol}(\text{compartment_1})} \cdot \text{vol}(\text{compartment_1}) \quad (31)$$

8.22 Rule `compartment_1`

Rule `compartment_1` is a rate rule for compartment `compartment_1`:

$$\frac{d}{dt} \text{vol}(\text{compartment_1}) = \text{parameter_7} \cdot \text{parameter_16} \cdot (\text{parameter_21} + \text{parameter_5} \cdot \text{parameter_1} \cdot \text{parameter_2} \cdot (\text{parameter_44} - \text{parameter_45})) \quad (32)$$

9 Reactions

This model contains 16 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	reaction_1	v1_fb	$\text{species_4} \xrightarrow{\text{species_12, species_4, species_12}} \text{species_5}$	
2	reaction_2	v2	$\text{species_5} \xrightarrow{\text{species_6, species_6, species_5}} \text{species_4}$	
3	reaction_3	v5	$\text{species_2} \xrightarrow{\text{species_5, species_11, species_5, species_2, species_11}} \text{species_9}$	
4	reaction_4	v6	$\text{species_9} \xrightarrow{\text{species_6, species_6, species_9}} \text{species_2}$	
5	reaction_5	v11	$\emptyset \xrightarrow{\text{species_8, species_8}} \text{species_7}$	
6	reaction_6	v12	$\text{species_7} \xrightarrow{\text{species_7}} \emptyset$	
7	reaction_7	v13	$\emptyset \xrightarrow{\text{species_7, species_12, species_7, species_12}} \text{species_1}$	
8	reaction_8	v14	$\text{species_1} \xrightleftharpoons{\text{species_13, species_1}} \text{species_13}$	
9	reaction_9	v9	$\emptyset \xrightarrow{\text{species_12, species_12}} \text{species_8}$	
10	reaction_10	v10	$\text{species_8} \xrightarrow{\text{species_8}} \emptyset$	
11	reaction_11	v7	$\text{species_9} \xrightarrow{\text{species_5, species_11, species_5, species_9, species_11}} \text{species_3}$	
12	reaction_12	v8	$\text{species_3} \xrightarrow{\text{species_6, species_6, species_3}} \text{species_9}$	
13	reaction_13	v4	$\text{species_11} \xrightarrow{\text{species_11}} \text{species_10} + \text{species_4}$	
14	reaction_14	v3_fb	$\text{species_4} + \text{species_10} \xrightarrow{\text{species_12, species_4, species_10, species_12}} \text{species_11}$	
15	reaction_15	v15_5	$\text{species_14} \xrightarrow{\text{species_14}} \text{species_15}$	

Nº	Id	Name	Reaction Equation	SBO
16	reaction_16	v16.6	species_15 $\xrightarrow{\text{species_12, species_15, species_12}}$ species_14	

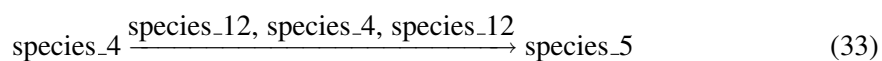
9.1 Reaction `reaction_1`

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

Name `v1_fb`

Notes Simple cell surface area dependent linear activation of Pbs2 through the Sln1 branch

Reaction equation



Reactant

Table 6: Properties of each reactant.

Id	Name	SBO
<code>species_4</code>	Pbs2	

Modifiers

Table 7: Properties of each modifier.

Id	Name	SBO
<code>species_12</code>	Hog1PPActive	
<code>species_4</code>	Pbs2	
<code>species_12</code>	Hog1PPActive	

Product

Table 8: Properties of each product.

Id	Name	SBO
<code>species_5</code>	Pbs2P	

Kinetic Law

Derived unit contains undeclared units

$$v_1 = \text{vol}(\text{compartment}_1) \cdot \text{function}_1 \left(\text{parameter}_{58}, \text{parameter}_{75}, \text{parameter}_{22}, \frac{\text{species}_4}{\text{vol}(\text{compartment}_1)}, \frac{\text{species}_{12}}{\text{vol}(\text{compartment}_1)}, \text{parameter}_{74}, \text{parameter}_{73} \right) \quad (34)$$

$$\text{function}_1(ko, k, M1, S, M2, h, Ki) = \frac{ko \cdot k \cdot M1 \cdot S}{1 + \left(\frac{M2}{Ki}\right)^h} \quad (35)$$

$$\text{function}_1(ko, k, M1, S, M2, h, Ki) = \frac{ko \cdot k \cdot M1 \cdot S}{1 + \left(\frac{M2}{Ki}\right)^h} \quad (36)$$

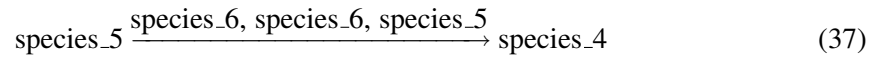
9.2 Reaction `reaction_2`

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

Name `v2`

Notes Constitutive phosphatase dependent deactivation.

Reaction equation



Reactant

Table 9: Properties of each reactant.

Id	Name	SBO
<code>species_5</code>	Pbs2P	

Modifiers

Table 10: Properties of each modifier.

Id	Name	SBO
<code>species_6</code>	Phosphatase	
<code>species_6</code>	Phosphatase	
<code>species_5</code>	Pbs2P	

Product

Table 11: Properties of each product.

Id	Name	SBO
species_4	Pbs2	

Kinetic Law

Derived unit contains undeclared units

$$v_2 = \text{vol}(\text{compartment}_1) \cdot \text{function}_2 \left(\text{parameter}_{72}, \frac{\text{species}_6}{\text{vol}(\text{compartment}_1)}, \frac{\text{species}_5}{\text{vol}(\text{compartment}_1)} \right) \quad (38)$$

$$\text{function}_2(k, M, S) = k \cdot M \cdot S \quad (39)$$

$$\text{function}_2(k, M, S) = k \cdot M \cdot S \quad (40)$$

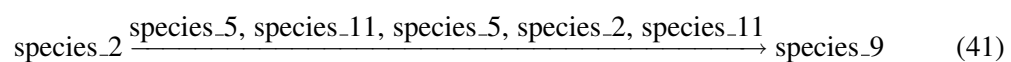
9.3 Reaction [reaction_3](#)

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

Name v5

Notes Linear phosphorylation of Hog1 by either the scaffold complex (Sho1-branch) or act.

Reaction equation



Reactant

Table 12: Properties of each reactant.

Id	Name	SBO
species_2	Hog1	

Modifiers

Table 13: Properties of each modifier.

Id	Name	SBO
species_5	Pbs2P	
species_11	Sho1Pbs2P	
species_5	Pbs2P	
species_2	Hog1	
species_11	Sho1Pbs2P	

Product

Table 14: Properties of each product.

Id	Name	SBO
species_9	Hog1P	

Kinetic Law

Derived unit contains undeclared units

$$v_3 = \text{vol}(\text{compartment}_1) \cdot \text{function}_3 \left(\text{parameter}_{25}, \frac{\text{species}_5}{\text{vol}(\text{compartment}_1)}, \frac{\text{species}_2}{\text{vol}(\text{compartment}_1)}, \text{parameter}_{41}, \frac{\text{species}_{11}}{\text{vol}(\text{compartment}_1)} \right) \quad (42)$$

$$\text{function}_3(k_1, M_1, S, k_2, M_2) = k_1 \cdot M_1 \cdot S + k_2 \cdot M_2 \cdot S \quad (43)$$

$$\text{function}_3(k_1, M_1, S, k_2, M_2) = k_1 \cdot M_1 \cdot S + k_2 \cdot M_2 \cdot S \quad (44)$$

9.4 Reaction [reaction_4](#)

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

Name v6

Notes Constitutive phosphatase dependent de-phosphorylation.

Reaction equation



Reactant

Table 15: Properties of each reactant.

Id	Name	SBO
species_9	Hog1P	

Modifiers

Table 16: Properties of each modifier.

Id	Name	SBO
species_6	Phosphatase	
species_6	Phosphatase	
species_9	Hog1P	

Product

Table 17: Properties of each product.

Id	Name	SBO
species_2	Hog1	

Kinetic Law

Derived unit contains undeclared units

$$v_4 = \text{vol}(\text{compartment}_1) \cdot \text{function}_2 \left(\text{parameter}_{26}, \frac{\text{species}_6}{\text{vol}(\text{compartment}_1)}, \frac{\text{species}_9}{\text{vol}(\text{compartment}_1)} \right) \quad (46)$$

$$\text{function}_2(k, M, S) = k \cdot M \cdot S \quad (47)$$

$$\text{function}_2(k, M, S) = k \cdot M \cdot S \quad (48)$$

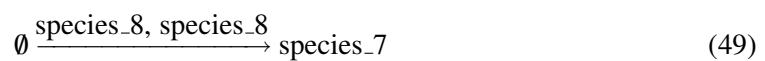
9.5 Reaction `reaction_5`

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

Name `v11`

Notes Protein/enzyme production/synthesis

Reaction equation



Modifiers

Table 18: Properties of each modifier.

Id	Name	SBO
species_8	RNA	
species_8	RNA	

Product

Table 19: Properties of each product.

Id	Name	SBO
species_7	Protein	

Kinetic Law

Derived unit contains undeclared units

$$v_5 = \text{vol}(\text{compartment}_1) \cdot \text{function}_4 \left(\text{parameter}_{76}, \frac{\text{species}_8}{\text{vol}(\text{compartment}_1)} \right) \quad (50)$$

$$\text{function}_4(k, M) = k \cdot M \quad (51)$$

$$\text{function}_4(k, M) = k \cdot M \quad (52)$$

9.6 Reaction [reaction_6](#)

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

Name v12

Notes Protein/enzyme degradation

Reaction equation



Reactant

Table 20: Properties of each reactant.

Id	Name	SBO
species_7	Protein	

Modifier

Table 21: Properties of each modifier.

Id	Name	SBO
species_7	Protein	

Kinetic Law

Derived unit contains undeclared units

$$v_6 = \text{parameter_35} \cdot \text{species_7} \quad (54)$$

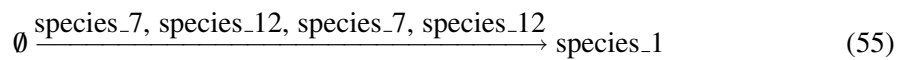
9.7 Reaction `reaction_7`

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

Name v13

Notes Glycerol production. As glycerol concentration also involves other proteins and co

Reaction equation



Modifiers

Table 22: Properties of each modifier.

Id	Name	SBO
species_7	Protein	
species_12	Hog1PPActive	
species_7	Protein	
species_12	Hog1PPActive	

Product

Table 23: Properties of each product.

Id	Name	SBO
species_1	Glyin	

Kinetic Law

Derived unit contains undeclared units

$$v_7 = \text{vol}(\text{compartment}_1) \cdot \text{function_5} \left(\text{parameter_86}, \frac{\text{species_7}}{\text{vol}(\text{compartment}_1)}, \text{parameter_87}, \frac{\text{species_12}}{\text{vol}(\text{compartment}_1)}, \text{parameter_88} \right) \quad (56)$$

$$\text{function_5}(k_1, M_1, k_2, M_2, K_m) = \frac{k_1 \cdot M_1 \cdot (1 + k_2 \cdot M_2)}{K_m + M_1 \cdot (1 + k_2 \cdot M_2)} \quad (57)$$

$$\text{function_5}(k_1, M_1, k_2, M_2, K_m) = \frac{k_1 \cdot M_1 \cdot (1 + k_2 \cdot M_2)}{K_m + M_1 \cdot (1 + k_2 \cdot M_2)} \quad (58)$$

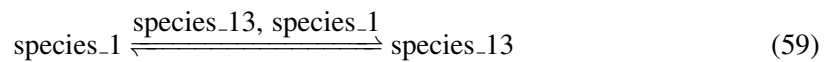
9.8 Reaction reaction_8

This is a reversible reaction of one reactant forming one product influenced by two modifiers.

Name v14

Notes Gradient driven glycerol flow out of the cell, where k_tr characterises the state of

Reaction equation



Reactant

Table 24: Properties of each reactant.

Id	Name	SBO
species_1	Glyin	

Modifiers

Table 25: Properties of each modifier.

Id	Name	SBO
species_13	Glyex	
species_1	Glyin	

Product

Table 26: Properties of each product.

Id	Name	SBO
species_13	Glyex	

Kinetic Law

Derived unit contains undeclared units

$$v_8 = \text{function_6} \left(\text{parameter_16}, \frac{\text{species_13}}{\text{vol}(\text{compartment_2})}, \frac{\text{species_1}}{\text{vol}(\text{compartment_1})}, \text{parameter_28}, \text{parameter_27} \right) \quad (60)$$

$$\text{function_6}(A, P, S, f, k_s) = f \cdot k_s \cdot A \cdot (S - P) \quad (61)$$

9.9 Reaction `reaction_9`

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

Name `v9`

Notes Gene transcription. Hog1 mediated transcription also involves other proteins that a

Reaction equation



Modifiers

Table 27: Properties of each modifier.

Id	Name	SBO
species_12	Hog1PPActive	
species_12	Hog1PPActive	

Product

Table 28: Properties of each product.

Id	Name	SBO
species_8	RNA	

Kinetic Law

Derived unit contains undeclared units

$$v_9 = \text{vol}(\text{compartment}_1) \cdot \text{function}_7 \left(\text{parameter}_{77}, \frac{\text{species}_{12}}{\text{vol}(\text{compartment}_1)}, \text{parameter}_{78} \right) \quad (63)$$

$$\text{function}_7(k, M, K_m) = \frac{k \cdot M}{K_m + M} \quad (64)$$

$$\text{function}_7(k, M, K_m) = \frac{k \cdot M}{K_m + M} \quad (65)$$

9.10 Reaction [reaction_10](#)

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

Name v10

Notes mRNA degradation

Reaction equation



Reactant

Table 29: Properties of each reactant.

Id	Name	SBO
species_8	RNA	

Modifier

Table 30: Properties of each modifier.

Id	Name	SBO
species_8	RNA	

Kinetic Law

Derived unit contains undeclared units

$$v_{10} = \text{parameter_39} \cdot \text{species_8} \quad (67)$$

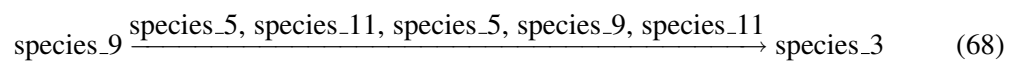
9.11 Reaction [reaction_11](#)

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

Name v7

Notes Linear phosphorylation of Hog1 by either the scaffold complex (Sho1-branch) or act.

Reaction equation



Reactant

Table 31: Properties of each reactant.

Id	Name	SBO
species_9	Hog1P	

Modifiers

Table 32: Properties of each modifier.

Id	Name	SBO
species_5	Pbs2P	
species_11	Sho1Pbs2P	
species_5	Pbs2P	
species_9	Hog1P	
species_11	Sho1Pbs2P	

Product

Table 33: Properties of each product.

Id	Name	SBO
species_3	Hog1PP	

Kinetic Law

Derived unit contains undeclared units

$$v_{11} = \text{vol}(\text{compartment}_1) \cdot \text{function}_3 \left(\text{parameter}_{25}, \frac{\text{species}_5}{\text{vol}(\text{compartment}_1)}, \frac{\text{species}_9}{\text{vol}(\text{compartment}_1)}, \text{parameter}_{41}, \frac{\text{species}_{11}}{\text{vol}(\text{compartment}_1)} \right) \quad (69)$$

$$\text{function}_3(k1, M1, S, k2, M2) = k1 \cdot M1 \cdot S + k2 \cdot M2 \cdot S \quad (70)$$

$$\text{function}_3(k1, M1, S, k2, M2) = k1 \cdot M1 \cdot S + k2 \cdot M2 \cdot S \quad (71)$$

9.12 Reaction `reaction_12`

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

Name v8

Notes Constitutive phosphatase dependent de-phosphorylation.

Reaction equation



Reactant

Table 34: Properties of each reactant.

Id	Name	SBO
species_3	Hog1PP	

Modifiers

Table 35: Properties of each modifier.

Id	Name	SBO
species_6	Phosphatase	
species_6	Phosphatase	
species_3	Hog1PP	

Product

Table 36: Properties of each product.

Id	Name	SBO
species_9	Hog1P	

Kinetic Law

Derived unit contains undeclared units

$$v_{12} = \text{vol}(\text{compartment_1}) \cdot \text{function_2} \left(\text{parameter_26}, \frac{\text{species_6}}{\text{vol}(\text{compartment_1})}, \frac{\text{species_3}}{\text{vol}(\text{compartment_1})} \right) \quad (73)$$

$$\text{function_2}(k, M, S) = k \cdot M \cdot S \quad (74)$$

$$\text{function_2}(k, M, S) = k \cdot M \cdot S \quad (75)$$

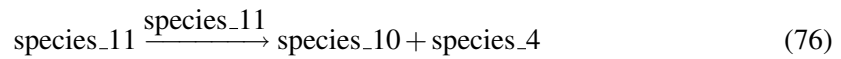
9.13 Reaction [reaction_13](#)

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

Name v4

Notes Constitutive dissociation of the scaffold complex.

Reaction equation



Reactant

Table 37: Properties of each reactant.

Id	Name	SBO
species_11	Sho1Pbs2P	

Modifier

Table 38: Properties of each modifier.

Id	Name	SBO
species_11	Sho1Pbs2P	

Products

Table 39: Properties of each product.

Id	Name	SBO
species_10	Sho1	
species_4	Pbs2	

Kinetic Law

Derived unit contains undeclared units

$$v_{13} = \text{parameter_79} \cdot \text{species_11} \quad (77)$$

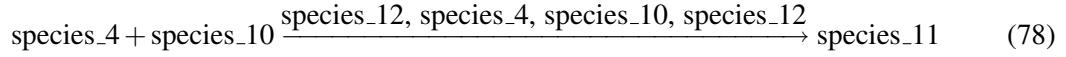
9.14 Reaction `reaction_14`

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

Name `v3_fb`

Notes Simple cell surface area dependent binding of Pbs2 to Sho1. The complex is supposed

Reaction equation



Reactants

Table 40: Properties of each reactant.

Id	Name	SBO
species_4	Pbs2	
species_10	Sho1	

Modifiers

Table 41: Properties of each modifier.

Id	Name	SBO
species_12	Hog1PPActive	
species_4	Pbs2	
species_10	Sho1	
species_12	Hog1PPActive	

Product

Table 42: Properties of each product.

Id	Name	SBO
species_11	Sho1Pbs2P	

Kinetic Law

Derived unit contains undeclared units

$$v_{14} = \text{vol}(\text{compartment_1}) \cdot \text{function_8} \left(\text{parameter_57}, \text{parameter_82}, \text{parameter_56}, \frac{\text{species_4}}{\text{vol}(\text{compartment_1})}, \frac{\text{species_10}}{\text{vol}(\text{compartment_1})}, \frac{\text{species_12}}{\text{vol}(\text{compartment_1})}, \text{parameter_80}, \text{parameter_81} \right) \quad (79)$$

$$\text{function_8}(\text{ko}, \text{k}, \text{M1}, \text{S1}, \text{S2}, \text{M2}, \text{Ki}, \text{h}) = \frac{\text{ko} \cdot \text{k} \cdot \text{M1} \cdot \text{S1} \cdot \text{S2}}{1 + \left(\frac{\text{M2}}{\text{Ki}} \right)^h} \quad (80)$$

$$\text{function_8}(k_o, k, M1, S1, S2, M2, K_i, h) = \frac{k_o \cdot k \cdot M1 \cdot S1 \cdot S2}{1 + \left(\frac{M2}{K_i}\right)^h} \quad (81)$$

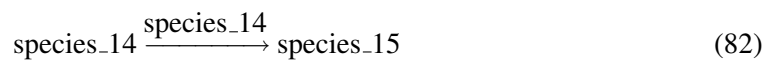
9.15 Reaction `reaction_15`

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

Name `v15_5`

Notes Turgor dependent closure of `Fps1`, in conjunction with `v16_5`, `v16_6`, `v16_7`, `v16_8`.

Reaction equation



Reactant

Table 43: Properties of each reactant.

Id	Name	SBO
<code>species_14</code>	<code>Fps1</code>	

Modifier

Table 44: Properties of each modifier.

Id	Name	SBO
<code>species_14</code>	<code>Fps1</code>	

Product

Table 45: Properties of each product.

Id	Name	SBO
<code>species_15</code>	<code>Fps1P</code>	

Kinetic Law

Derived unit contains undeclared units

$$v_{15} = \text{vol}(\text{compartment_4}) \cdot \text{function_9} \left(\text{parameter_71}, \text{parameter_83}, \text{parameter_63}, \frac{\text{species_14}}{\text{vol}(\text{compartment_4})} \right) \quad (83)$$

$$\text{function_9}(\text{ko}, \text{k}, \text{M}, \text{S}) = \text{ko} \cdot \text{k} \cdot \text{M} \cdot \text{S} \quad (84)$$

$$\text{function_9}(\text{ko}, \text{k}, \text{M}, \text{S}) = \text{ko} \cdot \text{k} \cdot \text{M} \cdot \text{S} \quad (85)$$

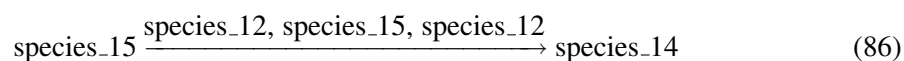
9.16 Reaction [reaction_16](#)

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

Name v16_6

Notes Activated Hog1 inhibited channel opening, in conjunction with v15_5.

Reaction equation



Reactant

Table 46: Properties of each reactant.

Id	Name	SBO
species_15	Fps1P	

Modifiers

Table 47: Properties of each modifier.

Id	Name	SBO
species_12	Hog1PPActive	
species_15	Fps1P	
species_12	Hog1PPActive	

Product

Table 48: Properties of each product.

Id	Name	SBO
species_14	Fps1	

Kinetic Law

Derived unit contains undeclared units

$$v_{16} = \text{vol}(\text{compartment_4}) \cdot \text{function_10} \left(\text{parameter_71}, \text{parameter_65}, \frac{\text{species_15}}{\text{vol}(\text{compartment_4})}, \frac{\text{species_12}}{\text{vol}(\text{compartment_1})}, \text{parameter_84}, \text{parameter_85} \right) \quad (87)$$

$$\text{function_10}(k_o, k, S, M, K_i, h) = \frac{k_o \cdot k \cdot S}{1 + \left(\frac{M}{K_i}\right)^h} \quad (88)$$

$$\text{function_10}(k_o, k, S, M, K_i, h) = \frac{k_o \cdot k \cdot S}{1 + \left(\frac{M}{K_i}\right)^h} \quad (89)$$

10 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.

10.1 Species `species_1`

Name Glyin

Notes Intracellular glycerol, approximated by assuming a measured value of 0.1 mM/OD in 18106 cells per ml sample culture and an average osmotic cell volume of 29.5 fl, i.e.

Initial amount 5310000 μmol

Initial assignment `species_1`

This species takes part in three reactions (as a reactant in [reaction_8](#) and as a product in [reaction_7](#) and as a modifier in [reaction_8](#)).

$$\frac{d}{dt}\text{species}_1 = v_7 - v_8 \quad (90)$$

10.2 Species [species_2](#)

Name Hog1

Notes MAP kinase

Initial amount 9.6760009944572 μmol

Initial assignment [species_2](#)

This species takes part in three reactions (as a reactant in [reaction_3](#) and as a product in [reaction_4](#) and as a modifier in [reaction_3](#)).

$$\frac{d}{dt}\text{species}_2 = v_4 - v_3 \quad (91)$$

10.3 Species [species_3](#)

Name Hog1PP

Notes Double phosphorylated, i.e. active, MAP kinase. It was derived from data that 2.23

Initial amount 0.201092527399535 μmol

Initial assignment [species_3](#)

This species takes part in three reactions (as a reactant in [reaction_12](#) and as a product in [reaction_11](#) and as a modifier in [reaction_12](#)).

$$\frac{d}{dt}\text{species}_3 = v_{11} - v_{12} \quad (92)$$

10.4 Species [species_4](#)

Name Pbs2

Notes MAP kinase kinase

Initial amount 3.57956846222666 μmol

Initial assignment [species_4](#)

This species takes part in six reactions (as a reactant in [reaction_1](#), [reaction_14](#) and as a product in [reaction_2](#), [reaction_13](#) and as a modifier in [reaction_1](#), [reaction_14](#)).

$$\frac{d}{dt}\text{species}_4 = v_2 + v_{13} - v_1 - v_{14} \quad (93)$$

10.5 Species `species_5`

Name Pbs2P

Notes Activated MAP kinase kinase (Sln1 branch). Initial condition set such that a steady

Initial amount 0.00385515442085361 μmol

Initial assignment `species_5`

This species takes part in seven reactions (as a reactant in [reaction_2](#) and as a product in [reaction_1](#) and as a modifier in [reaction_2](#), [reaction_3](#), [reaction_3](#), [reaction_11](#), [reaction_11](#)).

$$\frac{d}{dt}\text{species}_5 = v_1 - v_2 \quad (94)$$

10.6 Species `species_6`

Name Phosphatase

Notes Placeholder for phosphatases like Ppt1/2/3 and others. Initial value derived from m

Initial amount 1.27698439056792 μmol

Initial assignment `species_6`

This species takes part in six reactions (as a modifier in [reaction_2](#), [reaction_2](#), [reaction_4](#), [reaction_4](#), [reaction_12](#), [reaction_12](#)).

$$\frac{d}{dt}\text{species}_6 = 0 \quad (95)$$

10.7 Species `species_7`

Name Protein

Notes Placeholder for Hog1-dependent proteins, especially Gpd1. Initial value derived from

Initial amount 1.34008635004982 μmol

Initial assignment `species_7`

This species takes part in five reactions (as a reactant in [reaction_6](#) and as a product in [reaction_5](#) and as a modifier in [reaction_6](#), [reaction_7](#), [reaction_7](#)).

$$\frac{d}{dt}\text{species}_7 = v_5 - v_6 \quad (96)$$

10.8 Species `species_8`

Name RNA

Notes Placeholder for transcribed genes. Initial value derived from data, i.e. initial p

Initial amount 1.003 μmol

Initial assignment `species_8`

This species takes part in five reactions (as a reactant in [reaction_10](#) and as a product in [reaction_9](#) and as a modifier in [reaction_5](#), [reaction_5](#), [reaction_10](#)).

$$\frac{d}{dt}\text{species_8} = v_9 - v_{10} \quad (97)$$

10.9 Species `species_9`

Name Hog1P

Notes Single phosphorylated MAP kinase. Initial condition set such that a steady state o

Initial amount 1.39490913506788 μmol

Initial assignment `species_9`

This species takes part in six reactions (as a reactant in [reaction_4](#), [reaction_11](#) and as a product in [reaction_3](#), [reaction_12](#) and as a modifier in [reaction_4](#), [reaction_11](#)).

$$\frac{d}{dt}\text{species_9} = v_3 + v_{12} - v_4 - v_{11} \quad (98)$$

10.10 Species `species_10`

Name Sho1

Notes One of the putative upstream sensors

Initial amount 3.86572185643496 μmol

Initial assignment `species_10`

This species takes part in three reactions (as a reactant in [reaction_14](#) and as a product in [reaction_13](#) and as a modifier in [reaction_14](#)).

$$\frac{d}{dt}\text{species_10} = v_{13} - v_{14} \quad (99)$$

10.11 Species `species_11`

Name Sho1Pbs2P

Notes Active scaffold complex (Sho1 branch). Initial condition set such that a steady state is reached.

Initial amount 0.00342460653415448 μmol

Initial assignment `species_11`

This species takes part in seven reactions (as a reactant in [reaction_13](#) and as a product in [reaction_14](#) and as a modifier in [reaction_3](#), [reaction_3](#), [reaction_11](#), [reaction_11](#), [reaction_13](#)).

$$\frac{d}{dt}\text{species_11} = v_{14} - v_{13} \quad (100)$$

10.12 Species `species_12`

Name Hog1PPActive

Initial amount 0.201092527399535 μmol

Involved in rule `species_12`

This species takes part in ten reactions (as a modifier in [reaction_1](#), [reaction_1](#), [reaction_7](#), [reaction_7](#), [reaction_9](#), [reaction_9](#), [reaction_14](#), [reaction_14](#), [reaction_16](#), [reaction_16](#)). Not these but one rule determines the species' quantity because this species is on the boundary of the reaction system.

10.13 Species `species_13`

Name Glyex

Notes Extracellular glycerol, assumed to be 100 times lower than Gly_in.

Initial amount $9 \cdot 10^7$ μmol

Initial assignment `species_13`

This species takes part in two reactions (as a product in [reaction_8](#) and as a modifier in [reaction_8](#)).

$$\frac{d}{dt}\text{species_13} = v_8 \quad (101)$$

10.14 Species `species_14`

Name Fps1

Notes Membrane bound open form of aquaglyceroporin Fps1 (assumed to be independent from v

Initial amount 0.0255278667484759 μmol

Initial assignment `species_14`

This species takes part in three reactions (as a reactant in [reaction_15](#) and as a product in [reaction_16](#) and as a modifier in [reaction_15](#)).

$$\frac{d}{dt}\text{species_14} = v_{16} - v_{15} \quad (102)$$

10.15 Species `species_15`

Name Fps1P

Notes Membrane bound closed form of aquaglyceroporin Fps1 (assumed to be independent from

Initial amount 0.0255278667484759 μmol

Initial assignment `species_15`

This species takes part in three reactions (as a reactant in [reaction_16](#) and as a product in [reaction_15](#) and as a modifier in [reaction_16](#)).

$$\frac{d}{dt}\text{species_15} = v_{15} - v_{16} \quad (103)$$

SBML²TeX was developed by Andreas Dräger^a, Hannes Planatscher^a, Dieudonné M Wouamba^a, Adrian Schröder^a, Michael Hucka^b, Lukas Endler^c, Martin Golebiewski^d and Andreas Zell^a. Please see <http://www.ra.cs.uni-tuebingen.de/software/SBML2LaTeX> for more information.

^aCenter for Bioinformatics Tübingen (ZBIT), Germany

^bCalifornia Institute of Technology, Beckman Institute BNMC, Pasadena, United States

^cEuropean Bioinformatics Institute, Wellcome Trust Genome Campus, Hinxton, United Kingdom

^dEML Research gGmbH, Heidelberg, Germany