SBML Model Report

Model name: "Yugi2014 - Insulin induced signalling (PFKL phosphorylation) - model 1"

May 5, 2016

1 General Overview

This is a document in SBML Level 2 Version 4 format. This model was created by the following three authors: Vijayalakshmi Chelliah[1], Katsuyuki Yugi[2] and Audald Lloret i Villas[3] at August 14th 2014 at 12:58 a. m. and last time modified at September eighth 2014 at 2:05 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	1
species types	0	species	22
events	7	constraints	0
reactions	11	function definitions	0
global parameters	22	unit definitions	5
rules	1	initial assignments	0

Model Notes

Yugi2014 - Insulin induced signalling (PFKLphosphorylation) - model 1

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Insulin induces phosphorylation and activation of liver-type phosphofructokinase 1, which thereby controls a key reaction in glycolysis. This mechanism is revealed using the mathematical model. In this model, the PFKL phosphorylation time courses are obtained from experimental data.

Author's Note: Katsuyuki Yugi thank Akira Funahashi (Keio University, Japan) for his kind advice in converting the model from MATLAB to SBML.

This model is described in the article:Reconstruction of insulin signal flow from phosphoproteome and metabolome data.Yugi K, Kubota H, Toyoshima Y, Noguchi R, Kawata K, Komori Y, Uda S, Kunida K, Tomizawa Y, Funato Y, Miki H, Matsumoto M, Nakayama KI, Kashikura K, Endo K, Ikeda K, Soga T, Kuroda S.Cell Rep 2014 Aug; 8(4): 1171-1183

Abstract:

Cellular homeostasis is regulated by signals through multiple molecular networks that include protein phosphorylation and metabolites. However, where and when the signal flows through a network and regulates homeostasis has not been explored. We have developed a reconstruction method for the signal flow based on time-course phosphoproteome and metabolome data, using multiple databases, and have applied it to acute action of insulin, an important hormone for metabolic homeostasis. An insulin signal flows through a network, through signaling pathways that involve 13 protein kinases, 26 phosphorylated metabolic enzymes, and 35 allosteric effectors, resulting in quantitative changes in 44 metabolites. Analysis of the network reveals that insulin induces phosphorylation and activation of liver-type phosphofructokinase 1, thereby controlling a key reaction in glycolysis. We thus provide a versatile method of reconstruction of signal flow through the network using phosphoproteome and metabolome data.

This model is hosted on BioModels Database and identified by: BIOMD0000000540.

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

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2 Unit Definitions

This is an overview of five unit definitions.

2.1 Unit `substance`

Name substance

Definition mol

2.2 Unit `volume`

Name volume

Definition l

2.3 Unit `area`

Name area

Definition m^2

2.4 Unit `length`

Name length

Definition m

2.5 Unit `time`

Name time

Definition s

3 Compartment

This model contains one compartment.

Table 2: Properties of all compartments.

Id	Name	SBO	Spatial Dimensions	Size	Unit	Constant	Outside
`default`			3	1	litre	☑	

3.1 Compartment `default`

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

4 Species

This model contains 22 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 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
s1	PFKL	default	mol	⊟	⊟
s2	FBPase	default	mol	⊟	⊟
s3	F6P	default	mol	⊟	⊟
s4	F1,6BP	default	mol	⊟	⊟
s5	PEP	default	mol	⊟	⊟
s6	Isocitrate	default	mol	⊟	⊟
s7	2-oxoglutarate	default	mol	⊟	⊟
s8	Malate	default	mol	⊟	⊟
s9	F2,6BP	default	mol	⊟	⊟
s10	Citrate	default	mol	⊟	⊟
s11	sa4_degraded	default	$\mathrm{mol} \cdot \mathrm{l}^{-1}$	⊟	⊟
s12	ALDO	default	mol	⊟	⊟
s13	pPFKL	default	mol	⊟	⊟
s14	sa8_degraded	default	$\mathrm{mol} \cdot \mathrm{l}^{-1}$	⊟	⊟
s15	sa7_degraded	default	$\mathrm{mol} \cdot \mathrm{l}^{-1}$	⊟	⊟
s16	sa5_degraded	default	$\mathrm{mol} \cdot \mathrm{l}^{-1}$	⊟	⊟
s17	sa6_degraded	default	$\mathrm{mol} \cdot \mathrm{l}^{-1}$	⊟	⊟
s18	sa9_degraded	default	$\mathrm{mol} \cdot \mathrm{l}^{-1}$	⊟	⊟
s20	sa13_degraded	default	$\mathrm{mol} \cdot \mathrm{l}^{-1}$	⊟	⊟
s21	sa3_degraded	default	$\mathrm{mol} \cdot \mathrm{l}^{-1}$	⊟	⊟
s19	sa10_degraded	default	$\mathrm{mol} \cdot \mathrm{l}^{-1}$	⊟	⊟

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Id	Name	Compartment	Derived Unit	Constant	Boundary Condition
s22	F6P_proxy	default	mol	⊟	☑

5 Parameters

This model contains 22 global parameters.

Table 4: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
K_FBPase_cit	K_FBPase_cit		0.021	dimensionless	☑
K_FBPase_f16bp	K_FBPase_f16bp		0.104	dimensionless	☑
K_FBPase_f26bp	K_FBPase_f26bp		17.517	dimensionless	☑
K_PFKL_PHOS_S775	K_PFKL_PHOS_S775		6.284	dimensionless	☑
K_PFKL_akg	K_PFKL_akg		24661.012	dimensionless	☑
K_PFKL_cit	K_PFKL_cit		41.304	dimensionless	☑
K_PFKL_f26bp	K_PFKL_f26bp		1.282	dimensionless	☑
K_PFKL_f6p	K_PFKL_f6p		0.014	dimensionless	☑
K_PFKL_icit	K_PFKL_icit		1784.508	dimensionless	☑
K_PFKL_mal	K_PFKL_mal		9.545	dimensionless	☑
K_PFKL_pep	K_PFKL_pep		0.634	dimensionless	☑
Vf_FBPase	Vf_FBPase		9.933	dimensionless	☑
Vf_PFKL	Vf_PFKL		695063.719	dimensionless	☑
k_ALDO	k_ALDO		0.008	dimensionless	☑
k_mal	k_mal		1.006	mol	⊟
k_akg	k_akg		−3.544	mol	⊟
k_pep	k_pep		43.992	mol	⊟
k_icit	k_icit		−0.038	mol	⊟
k_f26bp	k_f26bp		−0.083	mol	⊟
k_cit	k_cit		−0.352	mol	⊟
k_pfkl_s775	k_pfkl_s775		−0.011	mol	⊟
k_f6p	k_f6p		−0.930	dimensionless	⊟

6 Rule

This is an overview of one rule.

6.1 Rule s22

Rule s22 is an assignment rule for species s22:

$$[\mathrm{s22}] = \mathrm{s3} \tag{1}$$

Derived unit mol

7 Events

This is an overview of seven events. 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 `ev2min`

Name ev2min

Trigger condition

$$t > 2 \tag{2}$$

Assignments

$$k\_akg = -1.357466063 \tag{3}$$
$$k\_cit = 0.351935646 \tag{4}$$
$$k\_f6p = 1.357466063 \tag{5}$$
$$k\_icit = -0.038210156 \tag{6}$$
$$k\_f26bp = 0.028924455 \tag{7}$$
$$k\_mal = -1.508295626 \tag{8}$$
$$k\_pep = 7.54147813 \tag{9}$$
$$k\_pfkl\_s775 = -0.011384308 \tag{10}$$

7.2 Event `ev5min`

Name ev5min

Trigger condition

$$t > 5 \tag{11}$$

Assignments

$$k\_akg = 0 \tag{12}$$
$$k\_cit = -0.211161388 \tag{13}$$
$$k\_f6p = 0.271493213 \tag{14}$$
$$k\_icit = -0.038210156 \tag{15}$$
$$k\_f26bp = 0.119075279 \tag{16}$$
$$k\_mal = -0.904977376 \tag{17}$$
$$k\_pep = -6.334841629 \tag{18}$$
$$k\_pfkl\_s775 = 0.057596439 \tag{19}$$

7.3 Event ev10min

Name ev10min

Trigger condition

$$t > 10 \tag{20}$$

Assignments

$$k\_akg = 0.36199095 \tag{21}$$
$$k\_cit = 1.085972851 \tag{22}$$
$$k\_f6p = -1.055806938 \tag{23}$$
$$k\_icit = -0.038210156 \tag{24}$$
$$k\_f26bp = -0.050207413 \tag{25}$$
$$k\_mal = 3.921568627 \tag{26}$$
$$k\_pep = 9.049773756 \tag{27}$$
$$k\_pfkl\_s775 = 0.006730598 \tag{28}$$

7.4 Event ev15min

Name ev15min

Trigger condition

$$t > 15 \tag{29}$$

Assignments

$$k\_akg = 1.085972851 \tag{30}$$
$$k\_cit = 0.452488688 \tag{31}$$
$$k\_f6p = -0.12066365 \tag{32}$$
$$k\_icit = -0.018099548 \tag{33}$$
$$k\_f26bp = 0.100115778 \tag{34}$$
$$k\_mal = 1.809954751 \tag{35}$$
$$k\_pep = -4.826546003 \tag{36}$$
$$k\_pfkl\_s775 = 0.006730598 \tag{37}$$

7.5 Event ev20min

Name ev20min

Trigger condition

$$t > 20 \tag{38}$$

Assignments

$$\text{k\_akg} = 0.226244344 \tag{39}$$
$$\text{k\_cit} = 0.377073906 \tag{40}$$
$$\text{k\_f6p} = -0.165912519 \tag{41}$$
$$\text{k\_icit} = 0.031674208 \tag{42}$$
$$\text{k\_f26bp} = -0.032601514 \tag{43}$$
$$\text{k\_mal} = 1.206636501 \tag{44}$$
$$\text{k\_pep} = -3.619909502 \tag{45}$$
$$\text{k\_pfkl\_s775} = 0.006730598 \tag{46}$$

7.6 Event `ev30min`

Name ev30min

Trigger condition

$$t > 30 \tag{47}$$

Assignments

$$\text{k\_akg} = 0.369532428 \tag{48}$$
$$\text{k\_cit} = 0.306686777 \tag{49}$$
$$\text{k\_f6p} = 0.070387129 \tag{50}$$
$$\text{k\_icit} = 0.031674208 \tag{51}$$
$$\text{k\_f26bp} = -0.003055632 \tag{52}$$
$$\text{k\_mal} = 0.502765209 \tag{53}$$
$$\text{k\_pep} = -0.301659125 \tag{54}$$
$$\text{k\_pfkl\_s775} = 0.006730598 \tag{55}$$

7.7 Event `ev45min`

Name ev45min

Trigger condition

$$t > 45 \tag{56}$$

Assignments

$$\text{k\_akg} = 0.369532428 \tag{57}$$

$$\text{k\_cit} = 0.306686777 \tag{58}$$

$$\text{k\_f6p} = 0.070387129 \tag{59}$$

$$\text{k\_icit} = 0.031674208 \tag{60}$$

$$\text{k\_f26bp} = -0.003055632 \tag{61}$$

$$\text{k\_mal} = 0.502765209 \tag{62}$$

$$\text{k\_pep} = -0.301659125 \tag{63}$$

$$\text{k\_pfkl\_s775} = 0.00673059831429 \tag{64}$$

8 Reactions

This model contains eleven 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	re1		$s22 \xrightarrow{s1,\ s5,\ s6,\ s7,\ s8,\ s9,\ s10,\ s13,\ s9,\ s7,\ s5,\ s10,\ s6,\ s8,\ s13,\ s22} s4$	
2	re2		$s4 \xrightarrow{s2,\ s9,\ s10,\ s9,\ s10,\ s4} s22$	
3	re3		$s4 \xrightarrow{s12,\ s4} s11$	
4	re4		$s8 \longrightarrow s14$	
5	re5		$s7 \longrightarrow s15$	
6	re6		$s5 \longrightarrow s16$	
7	re7		$s6 \longrightarrow s17$	
8	re8		$s9 \longrightarrow s18$	
9	re9		$s10 \longrightarrow s19$	
10	re10		$s13 \longrightarrow s20$	
11	re11		$s3 \longrightarrow s21$	

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8.1 Reaction re1

This is an irreversible reaction of one reactant forming one product influenced by 16 modifiers.

Reaction equation

$$\text{s22} \xrightarrow{\text{s1, s5, s6, s7, s8, s9, s10, s13, s9, s7, s5, s10, s6, s8, s13, s22}} \text{s4} \tag{65}$$

Reactant

Table 6: Properties of each reactant.

Id	Name	SBO
s22	F6P_proxy	

Modifiers

Table 7: Properties of each modifier.

Id	Name	SBO
s1	PFKL	
s5	PEP	
s6	Isocitrate	
s7	2-oxoglutarate	
s8	Malate	
s9	F2,6BP	
s10	Citrate	
s13	pPFKL	
s9	F2,6BP	
s7	2-oxoglutarate	
s5	PEP	
s10	Citrate	
s6	Isocitrate	
s8	Malate	
s13	pPFKL	
s22	F6P_proxy	

Product

Table 8: Properties of each product.

Id	Name	SBO
s4	F1,6BP	

Kinetic Law

Derived unit mol^3

$$v_1 = \frac{\text{s9}}{\text{K\_PFKL\_f26bp} + \text{s9}} \cdot \frac{\text{K\_PFKL\_akg}}{\text{K\_PFKL\_akg} + \text{s7}} \cdot \frac{\text{K\_PFKL\_pep}}{\text{K\_PFKL\_pep} + \text{s5}} \cdot \frac{\text{K\_PFKL\_cit}}{\text{K\_PFKL\_cit} + \text{s10}} \cdot \frac{\text{K\_PFKL\_icit}}{\text{K\_PFKL\_icit} + \text{s6}} \cdot \frac{\text{K\_PFKL\_mal}}{\text{K\_PFKL\_mal} + \text{s8}} \cdot \frac{\text{s13}}{\text{K\_PFKL\_PHOS\_S775} + \text{s13}} \cdot \frac{\text{Vf\_PFKL} \cdot \text{s22}}{\text{K\_PFKL\_f6p} + \text{s22}} \tag{66}$$

8.2 Reaction re2

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

Reaction equation

$$\text{s4} \xrightarrow{\text{s2, s9, s10, s9, s10, s4}} \text{s22} \tag{67}$$

Reactant

Table 9: Properties of each reactant.

Id	Name	SBO
s4	F1,6BP	

Modifiers

Table 10: Properties of each modifier.

Id	Name	SBO
s2	FBPase	
s9	F2,6BP	
s10	Citrate	
s9	F2,6BP	
s10	Citrate	

Id	Name	SBO
s4	F1,6BP	

Product

Table 11: Properties of each product.

Id	Name	SBO
s22	F6P_proxy	

Kinetic Law

Derived unit mol^2

$$v_2 = \frac{\text{K\_FBPase\_f26bp}}{\text{K\_FBPase\_f26bp} + \text{s9}} \cdot \frac{\text{s10}}{\text{K\_FBPase\_cit} + \text{s10}} \cdot \frac{\text{Vf\_FBPase} \cdot \text{s4}}{\text{K\_FBPase\_f16bp} + \text{s4}} \tag{68}$$

8.3 Reaction re3

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

Reaction equation

$$\text{s4} \xrightarrow{\text{s12, s4}} \text{s11} \tag{69}$$

Reactant

Table 12: Properties of each reactant.

Id	Name	SBO
s4	F1,6BP	

Modifiers

Table 13: Properties of each modifier.

Id	Name	SBO
s12	ALDO	
s4	F1,6BP	

Product

Table 14: Properties of each product.

Id	Name	SBO
s11	sa4_degraded	

Kinetic Law

Derived unit mol

$$v_3 = \text{k\_ALDO} \cdot \text{s4} \tag{70}$$

8.4 Reaction re4

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

Reaction equation

$$\text{s8} \longrightarrow \text{s14} \tag{71}$$

Reactant

Table 15: Properties of each reactant.

Id	Name	SBO
s8	Malate	

Product

Table 16: Properties of each product.

Id	Name	SBO
s14	sa8_degraded	

Kinetic Law

Derived unit mol

$$v_4 = \text{k\_mal} \tag{72}$$

8.5 Reaction re5

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

Reaction equation

$$\text{s7} \longrightarrow \text{s15} \tag{73}$$

Reactant

Table 17: Properties of each reactant.

Id	Name	SBO
s7	2-oxoglutarate	

Product

Table 18: Properties of each product.

Id	Name	SBO
s15	sa7_degraded	

Kinetic Law

Derived unit mol

$$v_5 = \text{k\_akg} \tag{74}$$

8.6 Reaction re6

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

Reaction equation

$$\text{s5} \longrightarrow \text{s16} \tag{75}$$

Reactant

Table 19: Properties of each reactant.

Id	Name	SBO
s5	PEP	

Product

Table 20: Properties of each product.

Id	Name	SBO
s16	sa5_degraded	

Kinetic Law

Derived unit mol

$$v_6 = \text{k\_pep} \tag{76}$$

8.7 Reaction re7

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

Reaction equation

$$\text{s6} \longrightarrow \text{s17} \tag{77}$$

Reactant

Table 21: Properties of each reactant.

Id	Name	SBO
s6	Isocitrate	

Product

Table 22: Properties of each product.

Id	Name	SBO
s17	sa6_degraded	

Kinetic Law

Derived unit mol

$$v_7 = \text{k\_icit} \tag{78}$$

8.8 Reaction re8

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

Reaction equation

$$\text{s9} \longrightarrow \text{s18} \tag{79}$$

Reactant

Table 23: Properties of each reactant.

Id	Name	SBO
s9	F2,6BP	

Product

Table 24: Properties of each product.

Id	Name	SBO
s18	sa9_degraded	

Kinetic Law

Derived unit mol

$$v_8 = \text{k\_f26bp} \tag{80}$$

8.9 Reaction re9

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

Reaction equation

$$\text{s10} \longrightarrow \text{s19} \tag{81}$$

Reactant

Table 25: Properties of each reactant.

Id	Name	SBO
s10	Citrate	

Product

Table 26: Properties of each product.

Id	Name	SBO
s19	sa10_degraded	

Kinetic Law

Derived unit mol

$$v_9 = \text{k\_cit} \tag{82}$$

8.10 Reaction re10

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

Reaction equation

$$\text{s13} \longrightarrow \text{s20} \tag{83}$$

Reactant

Table 27: Properties of each reactant.

Id	Name	SBO
s13	pPFKL	

Product

Table 28: Properties of each product.

Id	Name	SBO
s20	sa13_degraded	

Kinetic Law

Derived unit mol

$$v_{10} = \text{k\_pfkl\_s775} \tag{84}$$

8.11 Reaction re11

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

Reaction equation

$$\text{s3} \longrightarrow \text{s21} \tag{85}$$

Reactant

Table 29: Properties of each reactant.

Id	Name	SBO
s3	F6P	

Product

Table 30: Properties of each product.

Id	Name	SBO
s21	sa3_degraded	

Kinetic Law

Derived unit dimensionless

$$v_{11} = \text{k\_f6p} \tag{86}$$

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 s1

Name PFKL

Initial amount 1 mol

Charge 0

This species takes part in one reaction (as a modifier in re1).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{s1} = 0 \tag{87}$$

9.2 Species s2

Name FBPase

Initial amount 1 mol

Charge 0

This species takes part in one reaction (as a modifier in re2).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{s2} = 0 \tag{88}$$

9.3 Species s3

Name F6P

Initial amount 14.0774258421 mol

Charge 0

This species takes part in one reaction (as a reactant in re11).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{s3} = -v_{11} \tag{89}$$

9.4 Species s4

Name F1,6BP

Initial amount 104.07239819 mol

Charge 0

This species takes part in five reactions (as a reactant in re2, re3 and as a product in re1 and as a modifier in re2, re3).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{s4} = v_1 - v_2 - v_3 \tag{90}$$

9.5 Species s5

Name PEP

Initial amount 108.094519859 mol

Charge 0

This species takes part in three reactions (as a reactant in re6 and as a modifier in re1, re1).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{s5} = -v_6 \tag{91}$$

9.6 Species s6

Name Isocitrate

Initial amount 1.79487179487 mol

Charge 0

This species takes part in three reactions (as a reactant in re7 and as a modifier in re1, re1).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{s6} = -v_7 \tag{92}$$

9.7 Species s7

Name 2-oxoglutarate

Initial amount 25.1885369533 mol

Charge 0

This species takes part in three reactions (as a reactant in re5 and as a modifier in re1, re1).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{s7} = -v_5 \tag{93}$$

9.8 Species s8

Name Malate

Initial amount 68.8788335846 mol

Charge 0

This species takes part in three reactions (as a reactant in re4 and as a modifier in re1, re1).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{s8} = -v_4 \tag{94}$$

9.9 Species s9

Name F2,6BP

Initial amount 1 mol

Charge 0

This species takes part in five reactions (as a reactant in re8 and as a modifier in re1, re1, re2, re2).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{s9} = -v_8 \tag{95}$$

9.10 Species s10

Name Citrate

Initial amount 17.7476118652 mol

Charge 0

This species takes part in five reactions (as a reactant in re9 and as a modifier in re1, re1, re2, re2).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{s10} = -v_9 \tag{96}$$

9.11 Species s11

Name sa4_degraded

SBO:0000291 empty set

Initial amount 0 mol

This species takes part in one reaction (as a product in re3).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{s11} = v_3 \tag{97}$$

9.12 Species s12

Name ALDO

Initial amount 1 mol

Charge 0

This species takes part in one reaction (as a modifier in re3).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{s12} = 0 \tag{98}$$

9.13 Species s13

Name pPFKL

Initial amount 0.768939345 mol

Charge 0

This species takes part in three reactions (as a reactant in re10 and as a modifier in re1, re1).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{s13} = -\,v_{10} \tag{99}$$

9.14 Species s14

Name sa8_degraded

SBO:0000291 empty set

Initial amount 0 mol

This species takes part in one reaction (as a product in re4).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{s14} = v_4 \tag{100}$$

9.15 Species s15

Name sa7_degraded

SBO:0000291 empty set

Initial amount 0 mol

This species takes part in one reaction (as a product in re5).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{s15} = v_5 \tag{101}$$

9.16 Species s16

Name sa5_degraded

SBO:0000291 empty set

Initial amount 0 mol

This species takes part in one reaction (as a product in re6).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{s16} = v_6 \tag{102}$$

9.17 Species s17

Name sa6_degraded

SBO:0000291 empty set

Initial amount 0 mol

This species takes part in one reaction (as a product in re7).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{s17} = v_7 \tag{103}$$

9.18 Species s18

Name sa9_degraded

SBO:0000291 empty set

Initial amount 0 mol

This species takes part in one reaction (as a product in re8).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{s18} = v_8 \tag{104}$$

9.19 Species s20

Name sa13_degraded

SBO:0000291 empty set

Initial amount 0 mol

This species takes part in one reaction (as a product in re10).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{s20} = v_{10} \tag{105}$$

9.20 Species s21

Name sa3_degraded

SBO:0000291 empty set

Initial amount 0 mol

This species takes part in one reaction (as a product in re11).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{s21} = v_{11} \tag{106}$$

9.21 Species s19

Name sa10_degraded

SBO:0000291 empty set

Initial amount 0 mol

This species takes part in one reaction (as a product in re9).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{s19} = \nu_9 \tag{107}$$

9.22 Species s22

Name F6P_proxy

Initial amount 14.0774258421

Charge 0

Involved in rule s22

This species takes part in three reactions (as a reactant in re1 and as a product in re2 and as a modifier in re1). Not these but one rule determines the species' quantity because this species is on the boundary of the reaction system.

A Glossary of Systems Biology Ontology Terms

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

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