SBML Model Report

Model name: "Bachmann2011_JAK2-STAT5-_FeedbackControl"

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 Chelliah[1] and Andreas Raue[2] at August nineth 2011 at 4:20 p.m. and last time modified at January 31st 2012 at 1:56 p.m. Table 1 gives 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	26
events	0	constraints	0
reactions	36	function definitions	0
global parameters	32	unit definitions	0
rules	0	initial assignments	0

Model Notes

This model is from the article:

Division of labor by dual feedback regulators controls JAK2/STAT5 signaling over broad ligand range.

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Abstract:
Cellular signal transduction is governed by multiple feedback mechanisms to elicit robust cellular decisions. The specific contributions of individual feedback regulators, however, remain unclear. Based on extensive time-resolved data sets in primary erythroid progenitor cells, we established a dynamic pathway model to dissect the roles of the two transcriptional negative feedback regulators of the suppressor of cytokine signaling (SOCS) family, CIS and SOCS3, in JAK2/STAT5 signaling. Facilitated by the model, we calculated the STAT5 response for experimentally unobservable Epo concentrations and provide a quantitative link between cell survival and the integrated response of STAT5 in the nucleus. Model predictions show that the two feedbacks CIS and SOCS3 are most effective at different ligand concentration ranges due to their distinct inhibitory mechanisms. This divided function of dual feedback regulation enables control of STAT5 responses for Epo concentrations that can vary 1000-fold in vivo. Our modeling approach reveals dose-dependent feedback control as key property to regulate STAT5-mediated survival decisions over a broad range of ligand concentrations.

2 Unit Definitions

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

2.1 Unit `substance`

Notes Mole is the predefined SBML unit for `substance`.

Definition mol

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
cyt	cyt	0000290	3	0.4	l	☑	
nuc	nuc	0000290	3	0.275	l	☑	

3.1 Compartment `cyt`

This is a three dimensional compartment with a constant size of 0.4 litre.

Name cyt

SBO:0000290 physical compartment

3.2 Compartment `nuc`

This is a three dimensional compartment with a constant size of 0.275 litre.

Name nuc

SBO:0000290 physical compartment

4 Species

This model contains 26 species. Section 7 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
EpoRJAK2	EpoRJAK2	cyt	$mol \cdot l^{-1}$	⊟	⊟
EpoRpJAK2	EpoRpJAK2	cyt	$mol \cdot l^{-1}$	⊟	⊟
p1EpoRpJAK2	p1EpoRpJAK2	cyt	$mol \cdot l^{-1}$	⊟	⊟
p2EpoRpJAK2	p2EpoRpJAK2	cyt	$mol \cdot l^{-1}$	⊟	⊟
p12EpoRpJAK2	p12EpoRpJAK2	cyt	$mol \cdot l^{-1}$	⊟	⊟
EpoRJAK2_CIS	EpoRJAK2_CIS	cyt	$mol \cdot l^{-1}$	⊟	⊟
SHP1	SHP1	cyt	$mol \cdot l^{-1}$	⊟	⊟
SHP1Act	SHP1Act	cyt	$mol \cdot l^{-1}$	⊟	⊟
STAT5	STAT5	cyt	$mol \cdot l^{-1}$	⊟	⊟
pSTAT5	pSTAT5	cyt	$mol \cdot l^{-1}$	⊟	⊟
npSTAT5	npSTAT5	nuc	$mol \cdot l^{-1}$	⊟	⊟
CISnRNA1	CISnRNA1	nuc	$mol \cdot l^{-1}$	⊟	⊟
CISnRNA2	CISnRNA2	nuc	$mol \cdot l^{-1}$	⊟	⊟
CISnRNA3	CISnRNA3	nuc	$mol \cdot l^{-1}$	⊟	⊟
CISnRNA4	CISnRNA4	nuc	$mol \cdot l^{-1}$	⊟	⊟
CISnRNA5	CISnRNA5	nuc	$mol \cdot l^{-1}$	⊟	⊟
CISRNA	CISRNA	cyt	$mol \cdot l^{-1}$	⊟	⊟
CIS	CIS	cyt	$mol \cdot l^{-1}$	⊟	⊟
SOCS3nRNA1	SOCS3nRNA1	nuc	$mol \cdot l^{-1}$	⊟	⊟
SOCS3nRNA2	SOCS3nRNA2	nuc	$mol \cdot l^{-1}$	⊟	⊟
SOCS3nRNA3	SOCS3nRNA3	nuc	$mol \cdot l^{-1}$	⊟	⊟
SOCS3nRNA4	SOCS3nRNA4	nuc	$mol \cdot l^{-1}$	⊟	⊟

Id	Name	Compartment	Derived Unit	Constant	Boundary Condi-tion
SOCS3nRNA5	SOCS3nRNA5	nuc	$\text{mol} \cdot \text{l}^{-1}$	⊟	⊟
SOCS3RNA	SOCS3RNA	cyt	$\text{mol} \cdot \text{l}^{-1}$	⊟	⊟
SOCS3	SOCS3	cyt	$\text{mol} \cdot \text{l}^{-1}$	⊟	⊟
Epo	Epo	cyt	$\text{mol} \cdot \text{l}^{-1}$	⊟	⊟

5 Parameters

This model contains 32 global parameters.

Table 4: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
ActD		0000363	0.000		☑
CISEqc		0000281	432.871		☑
CISEqcOE		0000281	0.530		☑
CISInh		0000261	$7.84653 \cdot 10^8$		☑
CISRNADelay		0000225	0.145		☑
CISRNAEqc		0000281	1.000		☑
CISRNATurn		0000009	1000.000		☑
CISTurn		0000009	0.008		☑
CISoe		0000009	0.000		☑
EpoRActJAK2		0000363	0.267		☑
EpoRCISInh		0000261	1000000.000		☑
EpoRCISRemove		0000009	5.429		☑
JAK2ActEpo		0000363	633253.000		☑
JAK2EpoRDeaSHP1		0000009	142.722		☑
SHP1ActEpoR		0000363	0.001		☑
SHP1Dea		0000009	0.008		☑
SOCS3Eqc		0000281	173.653		☑
SOCS3EqcOE		0000281	0.679		☑
SOCS3Inh		0000261	10.408		☑
SOCS3RNADelay		0000225	1.065		☑
SOCS3RNAEqc		0000281	1.000		☑
SOCS3RNATurn		0000009	0.008		☑
SOCS3Turn		0000009	10000.000		☑
SOCS3oe		0000009	0.000		☑
STAT5ActEpoR			38.976		☑
STAT5ActJAK2		0000363	0.078		☑
STAT5Exp		0000009	0.075		☑
STAT5Imp		0000009	0.027		☑
epo_level		0000009	$1.24997 \cdot 10^{-7}$		☑
init_EpoRJAK2		0000009	3.976		☑
init_SHP1		0000009	26.725		☑
init_STAT5		0000009	79.754		☑

6 Reactions

This model contains 36 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	reaction_1		$\text{EpoRJAK2} \xrightarrow{\text{Epo, SOCS3}} \text{EpoRpJAK2}$	0000216
2	reaction_2		$\text{EpoRpJAK2} \xrightarrow{\text{SHP1Act}} \text{EpoRJAK2}$	0000330
3	reaction_3		$\text{EpoRpJAK2} \xrightarrow{\text{SOCS3}} \text{p1EpoRpJAK2}$	0000216
4	reaction_4		$\text{EpoRpJAK2} \xrightarrow{\text{EpoRJAK2\_CIS, SOCS3}} \text{p2EpoRpJAK2}$	0000330
5	reaction_5		$\text{p1EpoRpJAK2} \xrightarrow{\text{EpoRJAK2\_CIS, SOCS3}} \text{p12EpoRpJAK2}$	0000216
6	reaction_6		$\text{p2EpoRpJAK2} \xrightarrow{\text{SOCS3}} \text{p12EpoRpJAK2}$	0000216
7	reaction_7		$\text{p1EpoRpJAK2} \xrightarrow{\text{SHP1Act}} \text{EpoRJAK2}$	0000330
8	reaction_8		$\text{p2EpoRpJAK2} \xrightarrow{\text{SHP1Act}} \text{EpoRJAK2}$	0000330
9	reaction_9		$\text{p12EpoRpJAK2} \xrightarrow{\text{SHP1Act}} \text{EpoRJAK2}$	0000330
10	reaction_10		$\text{EpoRJAK2\_CIS} \xrightarrow{\text{p12EpoRpJAK2, p1EpoRpJAK2}} \emptyset$	0000179
11	reaction_11		$\text{SHP1} \xrightarrow{\text{EpoRpJAK2, p12EpoRpJAK2, p1EpoRpJAK2, p2EpoRpJAK2}} \text{SHP1Act}$	0000181
12	reaction_12		$\text{SHP1Act} \longrightarrow \text{SHP1}$	0000181
13	reaction_13		$\text{STAT5} \xrightarrow{\text{EpoRpJAK2, SOCS3, p12EpoRpJAK2, p1EpoRpJAK2, p2EpoRpJAK2}} \text{pSTAT5}$	0000216
14	reaction_14		$\text{STAT5} \xrightarrow{\text{CIS, SOCS3, p12EpoRpJAK2, p1EpoRpJAK2}} \text{pSTAT5}$	0000216
15	reaction_15		$\text{pSTAT5} \longrightarrow \text{npSTAT5}$	0000185
16	reaction_16		$\text{npSTAT5} \longrightarrow \text{STAT5}$	0000330
17	reaction_17		$\emptyset \xrightleftharpoons{\text{npSTAT5}} \text{CISnRNA1}$	0000393

№	Id	Name	Reaction Equation	SBO
18	reaction_18		CISnRNA1 $\longrightarrow$ CISnRNA2	0000182
19	reaction_19		CISnRNA2 $\longrightarrow$ CISnRNA3	0000182
20	reaction_20		CISnRNA3 $\longrightarrow$ CISnRNA4	0000182
21	reaction_21		CISnRNA4 $\longrightarrow$ CISnRNA5	0000182
22	reaction_22		CISnRNA5 $\longrightarrow$ CISRNA	0000182
23	reaction_23		CISRNA $\longrightarrow \emptyset$	0000179
24	reaction_24		$\emptyset \xrightarrow{\text{CISRNA}}$ CIS	0000393
25	reaction_25		CIS $\longrightarrow \emptyset$	0000179
26	reaction_26		$\emptyset \longrightarrow$ CIS	0000393
27	reaction_27		$\emptyset \xrightleftharpoons{\text{npSTAT5}}$ SOCS3nRNA1	0000393
28	reaction_28		SOCS3nRNA1 $\longrightarrow$ SOCS3nRNA2	0000182
29	reaction_29		SOCS3nRNA2 $\longrightarrow$ SOCS3nRNA3	0000182
30	reaction_30		SOCS3nRNA3 $\longrightarrow$ SOCS3nRNA4	0000182
31	reaction_31		SOCS3nRNA4 $\longrightarrow$ SOCS3nRNA5	0000182
32	reaction_32		SOCS3nRNA5 $\longrightarrow$ SOCS3RNA	0000182
33	reaction_33		SOCS3RNA $\longrightarrow \emptyset$	0000179
34	reaction_34		$\emptyset \xrightarrow{\text{SOCS3RNA}}$ SOCS3	0000393
35	reaction_35		SOCS3 $\longrightarrow \emptyset$	0000179
36	reaction_36		$\emptyset \longrightarrow$ SOCS3	0000393

6.1 Reaction `reaction_1`

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

SBO:0000216 phosphorylation

Reaction equation

$$\text{EpoRJAK2} \xrightarrow{\text{Epo, SOCS3}} \text{EpoRpJAK2} \tag{1}$$

Reactant

Table 6: Properties of each reactant.

Id	Name	SBO
EpoRJAK2	EpoRJAK2	

Modifiers

Table 7: Properties of each modifier.

Id	Name	SBO
Epo	Epo	
SOCS3	SOCS3	

Product

Table 8: Properties of each product.

Id	Name	SBO
EpoRpJAK2	EpoRpJAK2	

Kinetic Law

Derived unit contains undeclared units

$$v_1 = \frac{\text{JAK2ActEpo} \cdot [\text{Epo}] \cdot [\text{EpoRJAK2}]}{\frac{\text{SOCS3Inh} \cdot [\text{SOCS3}]}{\text{SOCS3Eqc}} + 1} \cdot \text{vol}\,(\text{cyt}) \tag{2}$$

6.2 Reaction `reaction_2`

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

SBO:0000330 dephosphorylation

Reaction equation

$$\text{EpoRpJAK2} \xrightarrow{\text{SHP1Act}} \text{EpoRJAK2} \tag{3}$$

Reactant

Table 9: Properties of each reactant.

Id	Name	SBO
EpoRpJAK2	EpoRpJAK2	

Modifier

Table 10: Properties of each modifier.

Id	Name	SBO
SHP1Act	SHP1Act	

Product

Table 11: Properties of each product.

Id	Name	SBO
EpoRJAK2	EpoRJAK2	

Kinetic Law

Derived unit contains undeclared units

$$v_2 = \frac{\text{JAK2EpoRDeaSHP1} \cdot [\text{SHP1Act}] \cdot [\text{EpoRpJAK2}]}{\text{init\_SHP1}} \cdot \text{vol}\,(\text{cyt}) \tag{4}$$

6.3 Reaction `reaction_3`

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

SBO:0000216 phosphorylation

Reaction equation

$$\text{EpoRpJAK2} \xrightarrow{\text{SOCS3}} \text{p1EpoRpJAK2} \tag{5}$$

Reactant

Table 12: Properties of each reactant.

Id	Name	SBO
EpoRpJAK2	EpoRpJAK2	

Modifier

Table 13: Properties of each modifier.

Id	Name	SBO
SOCS3	SOCS3	

Product

Table 14: Properties of each product.

Id	Name	SBO
p1EpoRpJAK2	p1EpoRpJAK2	

Kinetic Law

Derived unit contains undeclared units

$$v_3 = \frac{\text{EpoRActJAK2} \cdot [\text{EpoRpJAK2}]}{\frac{\text{SOCS3Inh} \cdot [\text{SOCS3}]}{\text{SOCS3Eqc}} + 1} \cdot \text{vol}\,(\text{cyt}) \tag{6}$$

6.4 Reaction `reaction_4`

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

SBO:0000330 dephosphorylation

Reaction equation

$$\text{EpoRpJAK2} \xrightarrow{\text{EpoRJAK2\_CIS, SOCS3}} \text{p2EpoRpJAK2} \tag{7}$$

Reactant

Table 15: Properties of each reactant.

Id	Name	SBO
EpoRpJAK2	EpoRpJAK2	

Modifiers

Table 16: Properties of each modifier.

Id	Name	SBO
EpoRJAK2_CIS	EpoRJAK2_CIS	
SOCS3	SOCS3	

Product

Table 17: Properties of each product.

Id	Name	SBO
p2EpoRpJAK2	p2EpoRpJAK2	

Kinetic Law
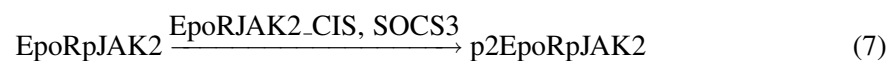
Derived unit contains undeclared units

$$v_4 = \frac{3 \cdot \text{EpoRActJAK2} \cdot [\text{EpoRpJAK2}]}{\left(\frac{\text{SOCS3Inh} \cdot [\text{SOCS3}]}{\text{SOCS3Eqc}} + 1 \right) \cdot (\text{EpoRCISInh} \cdot [\text{EpoRJAK2\_CIS}] + 1)} \cdot \text{vol}(\text{cyt}) \qquad (8)$$

6.5 Reaction reaction_5

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

SBO:0000216 phosphorylation

Reaction equation

$$\text{p1EpoRpJAK2} \xrightarrow{\text{EpoRJAK2\_CIS, SOCS3}} \text{p12EpoRpJAK2} \qquad (9)$$

Reactant

Produced by SBML2LATEX

Table 18: Properties of each reactant.

Id	Name	SBO
p1EpoRpJAK2	p1EpoRpJAK2	

Modifiers

Table 19: Properties of each modifier.

Id	Name	SBO
EpoRJAK2_CIS	EpoRJAK2_CIS	
SOCS3	SOCS3	

Product

Table 20: Properties of each product.

Id	Name	SBO
p12EpoRpJAK2	p12EpoRpJAK2	

Kinetic Law

Derived unit contains undeclared units

$$v_5 = \frac{3 \cdot \text{EpoRActJAK2} \cdot [\text{p1EpoRpJAK2}]}{\left(\frac{\text{SOCS3Inh} \cdot [\text{SOCS3}]}{\text{SOCS3Eqc}} + 1 \right) \cdot (\text{EpoRCISInh} \cdot [\text{EpoRJAK2\_CIS}] + 1)} \cdot \text{vol}\,(\text{cyt}) \qquad (10)$$

6.6 Reaction reaction_6

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

SBO:0000216 phosphorylation

Reaction equation

$$\text{p2EpoRpJAK2} \xrightarrow{\text{SOCS3}} \text{p12EpoRpJAK2} \qquad (11)$$

Reactant

Table 21: Properties of each reactant.

Id	Name	SBO
p2EpoRpJAK2	p2EpoRpJAK2	

Modifier

Table 22: Properties of each modifier.

Id	Name	SBO
SOCS3	SOCS3	

Product

Table 23: Properties of each product.

Id	Name	SBO
p12EpoRpJAK2	p12EpoRpJAK2	

Kinetic Law

Derived unit contains undeclared units

$$v_6 = \frac{\text{EpoRActJAK2} \cdot [\text{p2EpoRpJAK2}]}{\frac{\text{SOCS3Inh} \cdot [\text{SOCS3}]}{\text{SOCS3Eqc}} + 1} \cdot \text{vol}\,(\text{cyt}) \tag{12}$$

6.7 Reaction `reaction_7`

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

SBO:0000330 dephosphorylation

Reaction equation

$$\text{p1EpoRpJAK2} \xrightarrow{\text{SHP1Act}} \text{EpoRJAK2} \tag{13}$$

Reactant

Table 24: Properties of each reactant.

Id	Name	SBO
p1EpoRpJAK2	p1EpoRpJAK2	

Modifier

Table 25: Properties of each modifier.

Id	Name	SBO
SHP1Act	SHP1Act	

Product

Table 26: Properties of each product.

Id	Name	SBO
EpoRJAK2	EpoRJAK2	

Kinetic Law

Derived unit contains undeclared units

$$v_7 = \frac{\mathrm{JAK2EpoRDeaSHP1} \cdot [\mathrm{SHP1Act}] \cdot [\mathrm{p1EpoRpJAK2}]}{\mathrm{init\_SHP1}} \cdot \mathrm{vol\,(cyt)} \tag{14}$$

6.8 Reaction `reaction_8`

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

SBO:0000330 dephosphorylation

Reaction equation

$$\mathrm{p2EpoRpJAK2} \xrightarrow{\mathrm{SHP1Act}} \mathrm{EpoRJAK2} \tag{15}$$

Reactant

Table 27: Properties of each reactant.

Id	Name	SBO
p2EpoRpJAK2	p2EpoRpJAK2	

Modifier

Table 28: Properties of each modifier.

Id	Name	SBO
SHP1Act	SHP1Act	

Product

Table 29: Properties of each product.

Id	Name	SBO
EpoRJAK2	EpoRJAK2	

Kinetic Law

Derived unit contains undeclared units

$$v_8 = \frac{\text{JAK2EpoRDeaSHP1} \cdot [\text{SHP1Act}] \cdot [\text{p2EpoRpJAK2}]}{\text{init\_SHP1}} \cdot \text{vol}\,(\text{cyt}) \tag{16}$$

6.9 Reaction `reaction_9`

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

SBO:0000330 dephosphorylation

Reaction equation

$$\text{p12EpoRpJAK2} \xrightarrow{\text{SHP1Act}} \text{EpoRJAK2} \tag{17}$$

Reactant

Table 30: Properties of each reactant.

Id	Name	SBO
p12EpoRpJAK2	p12EpoRpJAK2	

Modifier

Produced by SBML2LATEX

Table 31: Properties of each modifier.

Id	Name	SBO
SHP1Act	SHP1Act	

Product

Table 32: Properties of each product.

Id	Name	SBO
EpoRJAK2	EpoRJAK2	

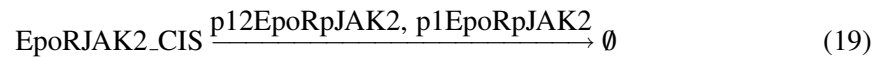**Kinetic Law**

Derived unit contains undeclared units

$$v_9 = \frac{\text{JAK2EpoRDeaSHP1} \cdot [\text{SHP1Act}] \cdot [\text{p12EpoRpJAK2}]}{\text{init\_SHP1}} \cdot \text{vol}(\text{cyt}) \tag{18}$$

6.10 Reaction `reaction_10`

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

SBO:0000179 degradation

Reaction equation

$$\text{EpoRJAK2\_CIS} \xrightarrow{\text{p12EpoRpJAK2, p1EpoRpJAK2}} \emptyset \tag{19}$$

Reactant

Table 33: Properties of each reactant.

Id	Name	SBO
EpoRJAK2_CIS	EpoRJAK2_CIS	

Modifiers

Table 34: Properties of each modifier.

Id	Name	SBO
p12EpoRpJAK2	p12EpoRpJAK2	

Id	Name	SBO
p1EpoRpJAK2	p1EpoRpJAK2	

Kinetic Law

Derived unit contains undeclared units

$$v_{10} = \frac{\text{EpoRCISRemove} \cdot [\text{EpoRJAK2\_CIS}] \cdot ([\text{p12EpoRpJAK2}] + [\text{p1EpoRpJAK2}])}{\text{init\_EpoRJAK2}} \cdot \text{vol (cyt)}$$

(20)

6.11 Reaction `reaction_11`

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

SBO:0000181 conformational transition

Reaction equation

$$\text{SHP1} \xrightarrow{\text{EpoRpJAK2, p12EpoRpJAK2, p1EpoRpJAK2, p2EpoRpJAK2}} \text{SHP1Act}$$

(21)

Reactant

Table 35: Properties of each reactant.

Id	Name	SBO
SHP1	SHP1	

Modifiers

Table 36: Properties of each modifier.

Id	Name	SBO
EpoRpJAK2	EpoRpJAK2	
p12EpoRpJAK2	p12EpoRpJAK2	
p1EpoRpJAK2	p1EpoRpJAK2	
p2EpoRpJAK2	p2EpoRpJAK2	

Product

Table 37: Properties of each product.

Id	Name	SBO
SHP1Act	SHP1Act	

Kinetic Law

Derived unit contains undeclared units

$$v_{11}$$
$$= \frac{\mathrm{SHP1ActEpoR} \cdot [\mathrm{SHP1}] \cdot ([\mathrm{EpoRpJAK2}] + [\mathrm{p12EpoRpJAK2}] + [\mathrm{p1EpoRpJAK2}] + [\mathrm{p2EpoRpJAK2}])}{\mathrm{init\_EpoRJAK2}}$$
$$\cdot \mathrm{vol}\,(\mathrm{cyt}) \tag{22}$$

6.12 Reaction `reaction_12`

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

SBO:0000181 conformational transition

Reaction equation

$$\mathrm{SHP1Act} \longrightarrow \mathrm{SHP1} \tag{23}$$

Reactant

Table 38: Properties of each reactant.

Id	Name	SBO
SHP1Act	SHP1Act	

Product

Table 39: Properties of each product.

Id	Name	SBO
SHP1	SHP1	

Kinetic Law

Derived unit contains undeclared units

$$v_{12} = \mathrm{SHP1Dea} \cdot [\mathrm{SHP1Act}] \cdot \mathrm{vol}\,(\mathrm{cyt}) \tag{24}$$

6.13 Reaction `reaction_13`

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

SBO:0000216 phosphorylation

Reaction equation

$$\text{STAT5} \xrightarrow{\text{EpoRpJAK2, SOCS3, p12EpoRpJAK2, p1EpoRpJAK2, p2EpoRpJAK2}} \text{pSTAT5} \quad (25)$$
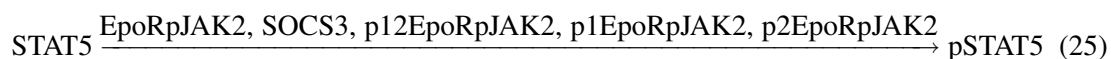
Reactant

Table 40: Properties of each reactant.

Id	Name	SBO
STAT5	STAT5	

Modifiers

Table 41: Properties of each modifier.

Id	Name	SBO
EpoRpJAK2	EpoRpJAK2	
SOCS3	SOCS3	
p12EpoRpJAK2	p12EpoRpJAK2	
p1EpoRpJAK2	p1EpoRpJAK2	
p2EpoRpJAK2	p2EpoRpJAK2	

Product

Table 42: Properties of each product.

Id	Name	SBO
pSTAT5	pSTAT5	

Kinetic Law

Derived unit contains undeclared units

$$v_{13}$$
(26)
$$= \frac{\text{STAT5ActJAK2} \cdot [\text{STAT5}] \cdot ([\text{EpoRpJAK2}] + [\text{p12EpoRpJAK2}] + [\text{p1EpoRpJAK2}] + [\text{p2EpoRpJAK2}])}{\text{init\_EpoRJAK2} \cdot \left(\frac{\text{SOCS3Inh} \cdot [\text{SOCS3}]}{\text{SOCS3Eqc}} + 1 \right)}$$
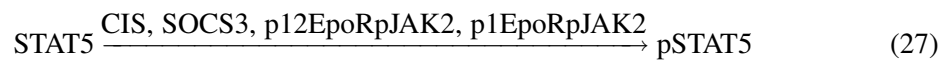$$\cdot \text{vol}\,(\text{cyt})$$

6.14 Reaction `reaction_14`

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

SBO:0000216 phosphorylation

Reaction equation

$$\text{STAT5} \xrightarrow{\text{CIS, SOCS3, p12EpoRpJAK2, p1EpoRpJAK2}} \text{pSTAT5} \qquad (27)$$

Reactant

Table 43: Properties of each reactant.

Id	Name	SBO
STAT5	STAT5	

Modifiers

Table 44: Properties of each modifier.

Id	Name	SBO
CIS	CIS	
SOCS3	SOCS3	
p12EpoRpJAK2	p12EpoRpJAK2	
p1EpoRpJAK2	p1EpoRpJAK2	

Product

Table 45: Properties of each product.

Id	Name	SBO
pSTAT5	pSTAT5	

Kinetic Law

Derived unit contains undeclared units

$$v_{14} = \frac{\text{STAT5ActEpoR} \cdot [\text{STAT5}] \cdot ([\text{p12EpoRpJAK2}] + [\text{p1EpoRpJAK2}])^2}{\text{init\_EpoRJAK2}^2 \cdot \left(\frac{\text{CISInh} \cdot [\text{CIS}]}{\text{CISEqc}} + 1 \right) \cdot \left(\frac{\text{SOCS3Inh} \cdot [\text{SOCS3}]}{\text{SOCS3Eqc}} + 1 \right)} \cdot \text{vol} \, (\text{cyt}) \quad (28)$$

6.15 Reaction `reaction_15`

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

SBO:0000185 transport reaction

Reaction equation

$$\text{pSTAT5} \longrightarrow \text{npSTAT5} \quad (29)$$

Reactant

Table 46: Properties of each reactant.

Id	Name	SBO
pSTAT5	pSTAT5	

Product

Table 47: Properties of each product.

Id	Name	SBO
npSTAT5	npSTAT5	

Kinetic Law

Derived unit contains undeclared units

$$v_{15} = \text{STAT5Imp} \cdot [\text{pSTAT5}] \cdot \text{vol} \, (\text{cyt}) \quad (30)$$

6.16 Reaction `reaction_16`

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

SBO:0000330 dephosphorylation

Reaction equation

$$npSTAT5 \longrightarrow STAT5 \tag{31}$$

Reactant

Table 48: Properties of each reactant.

Id	Name	SBO
npSTAT5	npSTAT5	

Product

Table 49: Properties of each product.

Id	Name	SBO
STAT5	STAT5	

Kinetic Law

Derived unit contains undeclared units

$$v_{16} = STAT5Exp \cdot [npSTAT5] \cdot vol\,(nuc) \tag{32}$$

6.17 Reaction `reaction_17`

This is a reversible reaction of no reactant forming one product influenced by one modifier.

SBO:0000393 production

Reaction equation

$$\emptyset \underset{\overset{npSTAT5}{\rightleftharpoons}}{} CISnRNA1 \tag{33}$$

Modifier

Table 50: Properties of each modifier.

Id	Name	SBO
npSTAT5	npSTAT5	

Product

Table 51: Properties of each product.

Id	Name	SBO
CISnRNA1	CISnRNA1	

Kinetic Law

Derived unit mol

$$v_{17} = \left(\frac{\text{CISRNAEqc} \cdot \text{CISRNATurn} \cdot [\text{npSTAT5}] \cdot (\text{ActD} - 1)}{\text{init\_STAT5}} \cdot \text{vol}\,(\text{nuc}) \right) \quad (34)$$

6.18 Reaction `reaction_18`

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

SBO:0000182 conversion

Reaction equation

$$\text{CISnRNA1} \longrightarrow \text{CISnRNA2} \quad (35)$$

Reactant

Table 52: Properties of each reactant.

Id	Name	SBO
CISnRNA1	CISnRNA1	

Product

Table 53: Properties of each product.

Id	Name	SBO
CISnRNA2	CISnRNA2	

Kinetic Law

Derived unit contains undeclared units

$$v_{18} = \text{CISRNADelay} \cdot [\text{CISnRNA1}] \cdot \text{vol}\,(\text{nuc}) \quad (36)$$

6.19 Reaction `reaction_19`

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

SBO:0000182 conversion

Reaction equation

$$CISnRNA2 \longrightarrow CISnRNA3 \tag{37}$$

Reactant

Table 54: Properties of each reactant.

Id	Name	SBO
CISnRNA2	CISnRNA2	

Product

Table 55: Properties of each product.

Id	Name	SBO
CISnRNA3	CISnRNA3	

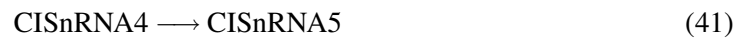**Kinetic Law**

Derived unit contains undeclared units

$$v_{19} = \text{CISRNADelay} \cdot [\text{CISnRNA2}] \cdot \text{vol}\,(\text{nuc}) \tag{38}$$

6.20 Reaction `reaction_20`

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

SBO:0000182 conversion

Reaction equation

$$CISnRNA3 \longrightarrow CISnRNA4 \tag{39}$$

Reactant

Table 56: Properties of each reactant.

Id	Name	SBO
CISnRNA3	CISnRNA3	

Product

Table 57: Properties of each product.

Id	Name	SBO
CISnRNA4	CISnRNA4	

Kinetic Law

Derived unit contains undeclared units

$$v_{20} = \mathrm{CISRNADelay} \cdot [\mathrm{CISnRNA3}] \cdot \mathrm{vol}\,(\mathrm{nuc}) \tag{40}$$

6.21 Reaction `reaction_21`

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

SBO:0000182 conversion

Reaction equation

$$\mathrm{CISnRNA4} \longrightarrow \mathrm{CISnRNA5} \tag{41}$$

Reactant

Table 58: Properties of each reactant.

Id	Name	SBO
CISnRNA4	CISnRNA4	

Product

Table 59: Properties of each product.

Id	Name	SBO
CISnRNA5	CISnRNA5	

Kinetic Law

Derived unit contains undeclared units

$$v_{21} = \text{CISRNADelay} \cdot [\text{CISnRNA4}] \cdot \text{vol}\,(\text{nuc}) \tag{42}$$

6.22 Reaction `reaction_22`

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

SBO:0000182 conversion

Reaction equation

$$\text{CISnRNA5} \longrightarrow \text{CISRNA} \tag{43}$$

Reactant

Table 60: Properties of each reactant.

Id	Name	SBO
CISnRNA5	CISnRNA5	

Product

Table 61: Properties of each product.

Id	Name	SBO
CISRNA	CISRNA	

Kinetic Law

Derived unit contains undeclared units

$$v_{22} = \text{CISRNADelay} \cdot [\text{CISnRNA5}] \cdot \text{vol}\,(\text{nuc}) \tag{44}$$

6.23 Reaction `reaction_23`

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

SBO:0000179 degradation

Reaction equation

$$\text{CISRNA} \longrightarrow \emptyset \tag{45}$$

Reactant

Table 62: Properties of each reactant.

Id	Name	SBO
CISRNA	CISRNA	

Kinetic Law

Derived unit contains undeclared units

$$v_{23} = \text{CISRNATurn} \cdot [\text{CISRNA}] \cdot \text{vol}\,(\text{cyt}) \tag{46}$$

6.24 Reaction `reaction_24`

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

SBO:0000393 production

Reaction equation

$$\emptyset \xrightarrow{\text{CISRNA}} \text{CIS} \tag{47}$$

Modifier

Table 63: Properties of each modifier.

Id	Name	SBO
CISRNA	CISRNA	

Product

Table 64: Properties of each product.

Id	Name	SBO
CIS	CIS	

Kinetic Law

Derived unit contains undeclared units

$$v_{24} = \frac{\text{CISEqc} \cdot \text{CISTurn} \cdot [\text{CISRNA}]}{\text{CISRNAEqc}} \cdot \text{vol}\,(\text{cyt}) \tag{48}$$

6.25 Reaction `reaction_25`

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

SBO:0000179 degradation

Reaction equation

$$CIS \longrightarrow \emptyset \tag{49}$$

Reactant

Table 65: Properties of each reactant.

Id	Name	SBO
CIS	CIS	

Kinetic Law

Derived unit contains undeclared units

$$v_{25} = CISTurn \cdot [CIS] \cdot vol\,(cyt) \tag{50}$$

6.26 Reaction `reaction_26`

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

SBO:0000393 production

Reaction equation

$$\emptyset \longrightarrow CIS \tag{51}$$

Product

Table 66: Properties of each product.

Id	Name	SBO
CIS	CIS	

Kinetic Law

Derived unit not available

$$v_{26} = CISoe \cdot CISEqc \cdot CISTurn \cdot CISEqcOE \tag{52}$$

6.27 Reaction `reaction_27`

This is a reversible reaction of no reactant forming one product influenced by one modifier.

SBO:0000393 production

Reaction equation

$$\emptyset \xrightleftharpoons{\text{npSTAT5}} \text{SOCS3nRNA1} \tag{53}$$

Modifier

<div align="center">

Table 67: Properties of each modifier.

Id	Name	SBO
npSTAT5	npSTAT5	

</div>

Product

<div align="center">

Table 68: Properties of each product.

Id	Name	SBO
SOCS3nRNA1	SOCS3nRNA1	

</div>

Kinetic Law

Derived unit mol

$$v_{27} = \left(\frac{\text{SOCS3RNAEqc} \cdot \text{SOCS3RNATurn} \cdot [\text{npSTAT5}] \cdot (\text{ActD} - 1)}{\text{init\_STAT5}} \cdot \text{vol}(\text{nuc}) \right) \tag{54}$$

6.28 Reaction `reaction_28`

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

SBO:0000182 conversion

Reaction equation

$$\text{SOCS3nRNA1} \longrightarrow \text{SOCS3nRNA2} \tag{55}$$

Reactant

Table 69: Properties of each reactant.

Id	Name	SBO
SOCS3nRNA1	SOCS3nRNA1	

Product

Table 70: Properties of each product.

Id	Name	SBO
SOCS3nRNA2	SOCS3nRNA2	

Kinetic Law

Derived unit contains undeclared units

$$v_{28} = \text{SOCS3RNADelay} \cdot [\text{SOCS3nRNA1}] \cdot \text{vol}\,(\text{nuc}) \tag{56}$$

6.29 Reaction `reaction_29`

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

SBO:0000182 conversion

Reaction equation

$$\text{SOCS3nRNA2} \longrightarrow \text{SOCS3nRNA3} \tag{57}$$

Reactant

Table 71: Properties of each reactant.

Id	Name	SBO
SOCS3nRNA2	SOCS3nRNA2	

Product

Table 72: Properties of each product.

Id	Name	SBO
SOCS3nRNA3	SOCS3nRNA3	

Kinetic Law

Derived unit contains undeclared units

$$v_{29} = \text{SOCS3RNADelay} \cdot [\text{SOCS3nRNA2}] \cdot \text{vol}\,(\text{nuc}) \tag{58}$$

6.30 Reaction `reaction_30`

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

SBO:0000182 conversion

Reaction equation

$$\text{SOCS3nRNA3} \longrightarrow \text{SOCS3nRNA4} \tag{59}$$

Reactant

Table 73: Properties of each reactant.

Id	Name	SBO
SOCS3nRNA3	SOCS3nRNA3	

Product

Table 74: Properties of each product.

Id	Name	SBO
SOCS3nRNA4	SOCS3nRNA4	

Kinetic Law

Derived unit contains undeclared units

$$v_{30} = \text{SOCS3RNADelay} \cdot [\text{SOCS3nRNA3}] \cdot \text{vol}\,(\text{nuc}) \tag{60}$$

6.31 Reaction `reaction_31`

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

SBO:0000182 conversion

Reaction equation

$$\text{SOCS3nRNA4} \longrightarrow \text{SOCS3nRNA5} \tag{61}$$

Reactant

Table 75: Properties of each reactant.

Id	Name	SBO
SOCS3nRNA4	SOCS3nRNA4	

Product

Table 76: Properties of each product.

Id	Name	SBO
SOCS3nRNA5	SOCS3nRNA5	

Kinetic Law

Derived unit contains undeclared units

$$v_{31} = \text{SOCS3RNADelay} \cdot [\text{SOCS3nRNA4}] \cdot \text{vol}\,(\text{nuc}) \tag{62}$$

6.32 Reaction `reaction_32`

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

SBO:0000182 conversion

Reaction equation

$$\text{SOCS3nRNA5} \longrightarrow \text{SOCS3RNA} \tag{63}$$

Reactant

Table 77: Properties of each reactant.

Id	Name	SBO
SOCS3nRNA5	SOCS3nRNA5	

Product

Table 78: Properties of each product.

Id	Name	SBO
SOCS3RNA	SOCS3RNA	

Kinetic Law

Derived unit contains undeclared units

$$v_{32} = \text{SOCS3RNADelay} \cdot [\text{SOCS3nRNA5}] \cdot \text{vol}\,(\text{nuc}) \tag{64}$$

6.33 Reaction `reaction_33`

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

SBO:0000179 degradation

Reaction equation

$$\text{SOCS3RNA} \longrightarrow \emptyset \tag{65}$$

Reactant

Table 79: Properties of each reactant.

Id	Name	SBO
SOCS3RNA	SOCS3RNA	

Kinetic Law

Derived unit contains undeclared units

$$v_{33} = \text{SOCS3RNATurn} \cdot [\text{SOCS3RNA}] \cdot \text{vol}\,(\text{cyt}) \tag{66}$$

6.34 Reaction `reaction_34`

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

SBO:0000393 production

Reaction equation

$$\emptyset \xrightarrow{\text{SOCS3RNA}} \text{SOCS3} \tag{67}$$

Modifier

Table 80: Properties of each modifier.

Id	Name	SBO
SOCS3RNA	SOCS3RNA	

Product

Table 81: Properties of each product.

Id	Name	SBO
SOCS3	SOCS3	

Kinetic Law

Derived unit contains undeclared units

$$v_{34} = \frac{\text{SOCS3Eqc} \cdot \text{SOCS3Turn} \cdot [\text{SOCS3RNA}]}{\text{SOCS3RNAEqc}} \cdot \text{vol}\,(\text{cyt}) \tag{68}$$

6.35 Reaction `reaction_35`

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

SBO:0000179 degradation

Reaction equation

$$\text{SOCS3} \longrightarrow \emptyset \tag{69}$$

Reactant

Table 82: Properties of each reactant.

Id	Name	SBO
SOCS3	SOCS3	

Kinetic Law

Derived unit contains undeclared units

$$v_{35} = \text{SOCS3Turn} \cdot [\text{SOCS3}] \cdot \text{vol}\,(\text{cyt}) \tag{70}$$

6.36 Reaction `reaction_36`

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

SBO:0000393 production

Reaction equation

$$\emptyset \longrightarrow \text{SOCS3} \tag{71}$$

Product

Table 83: Properties of each product.

Id	Name	SBO
SOCS3	SOCS3	

Kinetic Law

Derived unit not available

$$v_{36} = \text{SOCS3oe} \cdot \text{SOCS3Eqc} \cdot \text{SOCS3Turn} \cdot \text{SOCS3EqcOE} \tag{72}$$

7 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.

7.1 Species `EpoRJAK2`

Name EpoRJAK2

SBO:0000297 protein complex

Initial concentration $3.97622 \, \text{mol} \cdot \text{l}^{-1}$

This species takes part in five reactions (as a reactant in `reaction_1` and as a product in `reaction_2`, `reaction_7`, `reaction_8`, `reaction_9`).

$$\frac{\mathrm{d}}{\mathrm{d}t}\text{EpoRJAK2} = v_2 + v_7 + v_8 + v_9 - v_1 \tag{73}$$

7.2 Species `EpoRpJAK2`

Name EpoRpJAK2

SBO:0000297 protein complex

Initial concentration $0 \, \mathrm{mol} \cdot \mathrm{l}^{-1}$

This species takes part in six reactions (as a reactant in `reaction_2`, `reaction_3`, `reaction_4` and as a product in `reaction_1` and as a modifier in `reaction_11`, `reaction_13`).

$$\frac{\mathrm{d}}{\mathrm{d}t}\text{EpoRpJAK2} = v_1 - v_2 - v_3 - v_4 \tag{74}$$

7.3 Species `p1EpoRpJAK2`

Name p1EpoRpJAK2

SBO:0000297 protein complex

Initial concentration $0 \, \mathrm{mol} \cdot \mathrm{l}^{-1}$

This species takes part in seven reactions (as a reactant in `reaction_5`, `reaction_7` and as a product in `reaction_3` and as a modifier in `reaction_10`, `reaction_11`, `reaction_13`, `reaction_14`).

$$\frac{\mathrm{d}}{\mathrm{d}t}\text{p1EpoRpJAK2} = v_3 - v_5 - v_7 \tag{75}$$

7.4 Species `p2EpoRpJAK2`

Name p2EpoRpJAK2

SBO:0000297 protein complex

Initial concentration $0 \, \mathrm{mol} \cdot \mathrm{l}^{-1}$

This species takes part in five reactions (as a reactant in `reaction_6`, `reaction_8` and as a product in `reaction_4` and as a modifier in `reaction_11`, `reaction_13`).

$$\frac{\mathrm{d}}{\mathrm{d}t}\text{p2EpoRpJAK2} = v_4 - v_6 - v_8 \tag{76}$$

7.5 Species `p12EpoRpJAK2`

Name p12EpoRpJAK2

SBO:0000297 protein complex

Initial concentration $0 \, \text{mol} \cdot 1^{-1}$

This species takes part in seven reactions (as a reactant in `reaction_9` and as a product in `reaction_5`, `reaction_6` and as a modifier in `reaction_10`, `reaction_11`, `reaction_13`, `reaction_14`).

$$\frac{\mathrm{d}}{\mathrm{d}t}\text{p12EpoRpJAK2} = v_5 + v_6 - v_9 \tag{77}$$

7.6 Species `EpoRJAK2_CIS`

Name EpoRJAK2_CIS

SBO:0000297 protein complex

Initial concentration $0 \, \text{mol} \cdot 1^{-1}$

This species takes part in three reactions (as a reactant in `reaction_10` and as a modifier in `reaction_4`, `reaction_5`).

$$\frac{\mathrm{d}}{\mathrm{d}t}\text{EpoRJAK2\_CIS} = - v_{10} \tag{78}$$

7.7 Species `SHP1`

Name SHP1

SBO:0000252 polypeptide chain

Initial concentration $26.7251 \, \text{mol} \cdot 1^{-1}$

This species takes part in two reactions (as a reactant in `reaction_11` and as a product in `reaction_12`).

$$\frac{\mathrm{d}}{\mathrm{d}t}\text{SHP1} = v_{12} - v_{11} \tag{79}$$

7.8 Species `SHP1Act`

Name SHP1Act

SBO:0000252 polypeptide chain

Initial concentration $0 \, \text{mol} \cdot \text{l}^{-1}$

This species takes part in six reactions (as a reactant in `reaction_12` and as a product in `reaction_11` and as a modifier in `reaction_2`, `reaction_7`, `reaction_8`, `reaction_9`).

$$\frac{\text{d}}{\text{d}t}\text{SHP1Act} = v_{11} - v_{12} \tag{80}$$

7.9 Species `STAT5`

Name STAT5

SBO:0000252 polypeptide chain

Initial concentration $79.7535 \, \text{mol} \cdot \text{l}^{-1}$

This species takes part in three reactions (as a reactant in `reaction_13`, `reaction_14` and as a product in `reaction_16`).

$$\frac{\text{d}}{\text{d}t}\text{STAT5} = v_{16} - v_{13} - v_{14} \tag{81}$$

7.10 Species `pSTAT5`

Name pSTAT5

SBO:0000252 polypeptide chain

Initial concentration $0 \, \text{mol} \cdot \text{l}^{-1}$

This species takes part in three reactions (as a reactant in `reaction_15` and as a product in `reaction_13`, `reaction_14`).

$$\frac{\text{d}}{\text{d}t}\text{pSTAT5} = v_{13} + v_{14} - v_{15} \tag{82}$$

7.11 Species `npSTAT5`

Name npSTAT5

SBO:0000252 polypeptide chain

Initial concentration $0 \, \text{mol} \cdot \text{l}^{-1}$

This species takes part in four reactions (as a reactant in `reaction_16` and as a product in `reaction_15` and as a modifier in `reaction_17`, `reaction_27`).

$$\frac{\text{d}}{\text{d}t}\text{npSTAT5} = v_{15} - v_{16} \tag{83}$$

7.12 Species `CISnRNA1`

Name CISnRNA1

SBO:0000278 messenger RNA

Initial concentration $0 \, \text{mol} \cdot \text{l}^{-1}$

This species takes part in two reactions (as a reactant in `reaction_18` and as a product in `reaction_17`).

$$\frac{\mathrm{d}}{\mathrm{d}t}\text{CISnRNA1} = v_{17} - v_{18} \tag{84}$$

7.13 Species `CISnRNA2`

Name CISnRNA2

SBO:0000278 messenger RNA

Initial concentration $0 \, \text{mol} \cdot \text{l}^{-1}$

This species takes part in two reactions (as a reactant in `reaction_19` and as a product in `reaction_18`).

$$\frac{\mathrm{d}}{\mathrm{d}t}\text{CISnRNA2} = v_{18} - v_{19} \tag{85}$$

7.14 Species `CISnRNA3`

Name CISnRNA3

SBO:0000278 messenger RNA

Initial concentration $0 \, \text{mol} \cdot \text{l}^{-1}$

This species takes part in two reactions (as a reactant in `reaction_20` and as a product in `reaction_19`).

$$\frac{\mathrm{d}}{\mathrm{d}t}\text{CISnRNA3} = v_{19} - v_{20} \tag{86}$$

7.15 Species `CISnRNA4`

Name CISnRNA4

SBO:0000278 messenger RNA

Initial concentration $0 \, \text{mol} \cdot \text{l}^{-1}$

This species takes part in two reactions (as a reactant in `reaction_21` and as a product in `reaction_20`).

$$\frac{\mathrm{d}}{\mathrm{d}t}\text{CISnRNA4} = v_{20} - v_{21} \tag{87}$$

7.16 Species `CISnRNA5`

Name CISnRNA5

SBO:0000278 messenger RNA

Initial concentration $0 \, \text{mol} \cdot 1^{-1}$

This species takes part in two reactions (as a reactant in `reaction_22` and as a product in `reaction_21`).

$$\frac{d}{dt}\text{CISnRNA5} = v_{21} - v_{22} \tag{88}$$

7.17 Species `CISRNA`

Name CISRNA

SBO:0000278 messenger RNA

Initial concentration $0 \, \text{mol} \cdot 1^{-1}$

This species takes part in three reactions (as a reactant in `reaction_23` and as a product in `reaction_22` and as a modifier in `reaction_24`).

$$\frac{d}{dt}\text{CISRNA} = v_{22} - v_{23} \tag{89}$$

7.18 Species `CIS`

Name CIS

SBO:0000252 polypeptide chain

Initial concentration $0 \, \text{mol} \cdot 1^{-1}$

This species takes part in four reactions (as a reactant in `reaction_25` and as a product in `reaction_24`, `reaction_26` and as a modifier in `reaction_14`).

$$\frac{d}{dt}\text{CIS} = v_{24} + v_{26} - v_{25} \tag{90}$$

7.19 Species `SOCS3nRNA1`

Name SOCS3nRNA1

SBO:0000278 messenger RNA

Initial concentration $0 \, \text{mol} \cdot 1^{-1}$

This species takes part in two reactions (as a reactant in `reaction_28` and as a product in `reaction_27`).

$$\frac{d}{dt}\text{SOCS3nRNA1} = v_{27} - v_{28} \tag{91}$$

7.20 Species `SOCS3nRNA2`

Name SOCS3nRNA2

SBO:0000278 messenger RNA

Initial concentration $0 \, \text{mol} \cdot l^{-1}$

This species takes part in two reactions (as a reactant in `reaction_29` and as a product in `reaction_28`).

$$\frac{\mathrm{d}}{\mathrm{d}t}\text{SOCS3nRNA2} = v_{28} - v_{29} \tag{92}$$

7.21 Species `SOCS3nRNA3`

Name SOCS3nRNA3

SBO:0000278 messenger RNA

Initial concentration $0 \, \text{mol} \cdot l^{-1}$

This species takes part in two reactions (as a reactant in `reaction_30` and as a product in `reaction_29`).

$$\frac{\mathrm{d}}{\mathrm{d}t}\text{SOCS3nRNA3} = v_{29} - v_{30} \tag{93}$$

7.22 Species `SOCS3nRNA4`

Name SOCS3nRNA4

SBO:0000278 messenger RNA

Initial concentration $0 \, \text{mol} \cdot l^{-1}$

This species takes part in two reactions (as a reactant in `reaction_31` and as a product in `reaction_30`).

$$\frac{\mathrm{d}}{\mathrm{d}t}\text{SOCS3nRNA4} = v_{30} - v_{31} \tag{94}$$

7.23 Species `SOCS3nRNA5`

Name SOCS3nRNA5

SBO:0000278 messenger RNA

Initial concentration $0 \, \text{mol} \cdot l^{-1}$

This species takes part in two reactions (as a reactant in `reaction_32` and as a product in `reaction_31`).

$$\frac{\mathrm{d}}{\mathrm{d}t}\text{SOCS3nRNA5} = v_{31} - v_{32} \tag{95}$$

7.24 Species SOCS3RNA

Name SOCS3RNA

SBO:0000278 messenger RNA

Initial concentration $0 \, \text{mol} \cdot \text{l}^{-1}$

This species takes part in three reactions (as a reactant in reaction_33 and as a product in reaction_32 and as a modifier in reaction_34).

$$\frac{\mathrm{d}}{\mathrm{d}t}\text{SOCS3RNA} = v_{32} - v_{33} \tag{96}$$

7.25 Species SOCS3

Name SOCS3

SBO:0000252 polypeptide chain

Initial concentration $0 \, \text{mol} \cdot \text{l}^{-1}$

This species takes part in ten reactions (as a reactant in reaction_35 and as a product in reaction_34, reaction_36 and as a modifier in reaction_1, reaction_3, reaction_4, reaction_5, reaction_6, reaction_13, reaction_14).

$$\frac{\mathrm{d}}{\mathrm{d}t}\text{SOCS3} = v_{34} + v_{36} - v_{35} \tag{97}$$

7.26 Species Epo

Name Epo

SBO:0000252 polypeptide chain

Initial concentration $1.24997 \cdot 10^{-7} \, \text{mol} \cdot \text{l}^{-1}$

This species takes part in one reaction (as a modifier in reaction_1).

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

A Glossary of Systems Biology Ontology Terms

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

SBO:0000179 degradation: Complete disappearance of a physical entity

SBO:0000181 conformational transition: Biochemical reaction that does not result in the modification of covalent bonds of reactants, but rather modifies the conformation of some reactants, that is the relative position of their atoms in space

SBO:0000182 conversion: Biochemical reaction that results in the modification of some covalent bonds

SBO:0000185 transport reaction: Movement of a physical entity without modification of the structure of the entity

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

SBO:0000225 delay: Time during which some action is awaited

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:0000261 inhibitory constant: Dissociation constant of a compound from a target of which it inhibits the function.

SBO:0000278 messenger RNA: A messenger RNA is a ribonucleic acid synthesized during the transcription of a gene, and that carries the information to encode one or several proteins

SBO:0000281 equilibrium constant: Quantity characterizing a chemical equilibrium in a chemical reaction, which is a useful tool to determine the concentration of various reactants or products in a system where chemical equilibrium occurs

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: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:0000363 activation constant: Dissociation constant of a potentiator (activator) from a target (e.g. an enzyme) of which it activates the function

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