

SBML Model Report

Model name:
“Hoffmann2002_WT_IkBNFkB_Signaling”



May 6, 2016

1 General Overview

This is a document in SBML Level 2 Version 1 format. This model was created by Harish Dharuri¹ at May 16th 2007 at 1:37 p. m. and last time modified at July fifth 2012 at 2:50 p. m. Table 1 shows 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	24
events	1	constraints	0
reactions	45	function definitions	0
global parameters	45	unit definitions	2
rules	5	initial assignments	0

Model Notes

This model corresponds to the IkB-NFkB signaling in wild type cells and reproduces the dynamics of the species as depicted in Figure 2 F of the paper. The authors mention that the simulation is carried out in three phases, where the steady state values of the species in one phase are fed to the succeeding phase. This model captures the simulation dynamics of two phases and makes use of the event section to introduce the stimulus and thereby transition to the next phase. Accordingly, a few terms have been introduced that make this transition possible, this in no way

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compromises the original model. Also, the simulation plots are not an exact reproduction of the figures in the paper, they do however match the simulation results that the authors shared with us. Model was successfully tested on MathSBML.

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To cite BioModels Database, please use: [Li C, Donizelli M, Rodriguez N, Dharuri H, Endler L, Chelliah V, Li L, He E, Henry A, Stefan MI, Snoep JL, Hucka M, Le Novre N, Laibe C \(2010\) BioModels Database: An enhanced, curated and annotated resource for published quantitative kinetic models. BMC Syst Biol., 4:92.](#)

2 Unit Definitions

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

2.1 Unit substance

Name micro mole

Definition μmol

2.2 Unit time

Name minutes

Definition 60 s

2.3 Unit volume

Notes Litre is the predefined SBML unit for volume.

Definition 1

2.4 Unit area

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

Definition m^2

2.5 Unit `length`

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

Definition `m`

3 Compartments

This model contains two compartments.

Table 2: Properties of all compartments.

Id	Name	SBO	Spatial Dimensions	Size	Unit	Constant	Outside
<code>cytoplasm</code>			3	1	litre	<input checked="" type="checkbox"/>	
<code>nucleus</code>			3	1	litre	<input checked="" type="checkbox"/>	<code>cytoplasm</code>

3.1 Compartment `cytoplasm`

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

3.2 Compartment `nucleus`

This is a three dimensional compartment with a constant size of one litre, which is surrounded by `cytoplasm`.

4 Species

This model contains 24 species. 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
IkBalpha		cytoplasm	$\mu\text{mol} \cdot \text{l}^{-1}$	\boxplus	\boxplus
NFkB		cytoplasm	$\mu\text{mol} \cdot \text{l}^{-1}$	\boxplus	\boxplus
IkBalpha_NFkB		cytoplasm	$\mu\text{mol} \cdot \text{l}^{-1}$	\boxplus	\boxplus
IkBbeta		cytoplasm	$\mu\text{mol} \cdot \text{l}^{-1}$	\boxplus	\boxplus
IkBbeta_NFkB		cytoplasm	$\mu\text{mol} \cdot \text{l}^{-1}$	\boxplus	\boxplus
IkBeps		cytoplasm	$\mu\text{mol} \cdot \text{l}^{-1}$	\boxplus	\boxplus
IkBeps_NFkB		cytoplasm	$\mu\text{mol} \cdot \text{l}^{-1}$	\boxplus	\boxplus
IKK_IkBalpha		cytoplasm	$\mu\text{mol} \cdot \text{l}^{-1}$	\boxplus	\boxplus
IKK_IkBalpha_NFkB		cytoplasm	$\mu\text{mol} \cdot \text{l}^{-1}$	\boxplus	\boxplus
IKK		cytoplasm	$\mu\text{mol} \cdot \text{l}^{-1}$	\boxplus	\boxplus
IKK_IkBbeta		cytoplasm	$\mu\text{mol} \cdot \text{l}^{-1}$	\boxplus	\boxplus
IKK_IkBbeta_NFkB		cytoplasm	$\mu\text{mol} \cdot \text{l}^{-1}$	\boxplus	\boxplus
IKK_IkBeps		cytoplasm	$\mu\text{mol} \cdot \text{l}^{-1}$	\boxplus	\boxplus
IKK_IkBeps_NFkB		cytoplasm	$\mu\text{mol} \cdot \text{l}^{-1}$	\boxplus	\boxplus
NFkB_nuc		nucleus	$\mu\text{mol} \cdot \text{l}^{-1}$	\boxplus	\boxplus
IkBalpha_nuc		nucleus	$\mu\text{mol} \cdot \text{l}^{-1}$	\boxplus	\boxplus
IkBalpha_nuc- _NFkB_nuc		nucleus	$\mu\text{mol} \cdot \text{l}^{-1}$	\boxplus	\boxplus
IkBbeta_nuc		nucleus	$\mu\text{mol} \cdot \text{l}^{-1}$	\boxplus	\boxplus
IkBbeta_nuc_NFkB- _nuc		nucleus	$\mu\text{mol} \cdot \text{l}^{-1}$	\boxplus	\boxplus
IkBeps_nuc		nucleus	$\mu\text{mol} \cdot \text{l}^{-1}$	\boxplus	\boxplus

Id	Name	Compartment	Derived Unit	Constant	Boundary Condi- tion
IkBalpha- _transcript		nucleus	$\mu\text{mol} \cdot \text{l}^{-1}$	\boxplus	\boxplus
IkBbeta- _transcript		nucleus	$\mu\text{mol} \cdot \text{l}^{-1}$	\boxplus	\boxplus
IkBeps_transcript		nucleus	$\mu\text{mol} \cdot \text{l}^{-1}$	\boxplus	\boxplus
IkBeps_nuc_NFkB- _nuc		nucleus	$\mu\text{mol} \cdot \text{l}^{-1}$	\boxplus	\boxplus

5 Parameters

This model contains 45 global parameters.

Table 4: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
a4			30.000		<input checked="" type="checkbox"/>
d4			0.030		<input checked="" type="checkbox"/>
a5			30.000		<input checked="" type="checkbox"/>
d5			0.030		<input checked="" type="checkbox"/>
a6			30.000		<input checked="" type="checkbox"/>
d6			0.030		<input checked="" type="checkbox"/>
r4			1.224		<input checked="" type="checkbox"/>
r5			0.450		<input checked="" type="checkbox"/>
r6			0.660		<input checked="" type="checkbox"/>
deg4			0.001		<input checked="" type="checkbox"/>
k1			5.400		<input checked="" type="checkbox"/>
k01			0.005		<input checked="" type="checkbox"/>
tr2a			$9.25 \cdot 10^{-5}$		<input checked="" type="checkbox"/>
tr2			0.990		<input checked="" type="checkbox"/>
tr3			0.017		<input checked="" type="checkbox"/>
tr2b			$1.068 \cdot 10^{-5}$		<input checked="" type="checkbox"/>
tr2e			$7.62 \cdot 10^{-6}$		<input checked="" type="checkbox"/>
a1			1.350		<input checked="" type="checkbox"/>
d1			0.075		<input checked="" type="checkbox"/>
tr1			0.245		<input checked="" type="checkbox"/>
deg1			0.007		<input checked="" type="checkbox"/>
tp1			0.018		<input checked="" type="checkbox"/>
tp2			0.012		<input checked="" type="checkbox"/>
a2			0.360		<input checked="" type="checkbox"/>
d2			0.105		<input checked="" type="checkbox"/>
a3			0.540		<input checked="" type="checkbox"/>
d3			0.105		<input checked="" type="checkbox"/>
a7			11.100		<input checked="" type="checkbox"/>
k2			0.828		<input checked="" type="checkbox"/>
a8			2.880		<input checked="" type="checkbox"/>
k2.beta			0.624		<input checked="" type="checkbox"/>
a9			4.200		<input checked="" type="checkbox"/>
k2.eps			0.624		<input checked="" type="checkbox"/>
r1			0.244		<input checked="" type="checkbox"/>
r2			0.090		<input checked="" type="checkbox"/>
r3			0.132		<input checked="" type="checkbox"/>
k02			0.007		<input checked="" type="checkbox"/>

Id	Name	SBO	Value	Unit	Constant
trigger- _value			0.000		<input type="checkbox"/>
fr			1.000		<input type="checkbox"/>
fr_after- _trigger			0.500		<input type="checkbox"/>
Total- _IkBbeta			0.000		<input type="checkbox"/>
Total_IkBeps			0.000		<input type="checkbox"/>
Total- _IkBalpha			0.000		<input type="checkbox"/>
Total_NFkBn			0.000		<input type="checkbox"/>
flag_for- _after- _trigger			0.500		<input type="checkbox"/>

6 Rules

This is an overview of five rules.

6.1 Rule `Total_IkBbeta`

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

$$\text{Total_IkBbeta} = [\text{IkBbeta}] + [\text{IkBbeta_NFkB}] + [\text{IKK_IkBbeta}] + [\text{IKK_IkBbeta_NFkB}] \quad (1)$$

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

6.2 Rule `Total_IkBeps`

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

$$\text{Total_IkBeps} = [\text{IkBeps}] + [\text{IkBeps_NFkB}] + [\text{IKK_IkBeps}] + [\text{IKK_IkBeps_NFkB}] \quad (2)$$

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

6.3 Rule `Total_IkBalpha`

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

$$\text{Total_IkBalpha} = [\text{IkBalpha}] + [\text{IkBalpha_NFkB}] + [\text{IKK_IkBalpha}] + [\text{IKK_IkBalpha_NFkB}] \quad (3)$$

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

6.4 Rule `Total_NFkBn`

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

$$\text{Total_NFkBn} = [\text{IkBbeta_nuc_NFkB_nuc}] + [\text{NFkB_nuc}] \quad (4)$$

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

6.5 Rule `fr_after_trigger`

Rule `fr_after_trigger` is a rate rule for parameter `fr_after_trigger`:

$$\frac{d}{dt} \text{fr_after_trigger} = \text{trigger_value} \cdot \frac{-0.5}{(1 + (t - 2000))^2} \quad (5)$$

7 Event

This is an overview of one event. Each event is initiated whenever its trigger condition switches from `false` to `true`. A delay function postpones the effects of an event to a later time point. At the time of execution, an event can assign values to species, parameters or compartments if these are not set to constant.

7.1 Event `event_0000001`

Notes The events section is used to set the IKK signal, the system is allowed to equilibrate for 2000 minutes and IKK is increased to 0.1 μM . `trigger_value` is a parameter that is zero until equilibration and then is set to 1, this in turn is used in the rate rule section for `„fr_after_trigger„`. The latter term corresponds to `fr` in the paper.

Trigger condition

$$(t \geq 2000) \wedge (\text{trigger_value} = 0) \quad (6)$$

Assignments

$$\text{IKK} = 0.1 \quad (7)$$

$$\text{trigger_value} = 1 \quad (8)$$

$$\text{flag_for_after_trigger} = 0 \quad (9)$$

8 Reactions

This model contains 45 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	v1	NFkB-IkBalpha complex formation	$\text{NFkB} + \text{IkBalp} \rightleftharpoons \text{IkBalp_NFkB}$	
2	v2	NFkB-IkBbeta complex formation	$\text{NFkB} + \text{IkBbet} \rightleftharpoons \text{IkBbet_NFkB}$	
3	v3	NFkB-IkBeps complex formation	$\text{NFkB} + \text{IkBeps} \rightleftharpoons \text{IkBeps_NFkB}$	
4	v4	NFkB-binary IKK IkBalp complex formation	$\text{NFkB} + \text{IKK_IkBalp} \rightleftharpoons \text{IKK_IkBalp_NFkB}$	
5	v5	IkBalp degradation	$\text{IKK_IkBalp_NFkB} \longrightarrow \text{NFkB} + \text{IKK}$	
6	v6	NFkB binary IKK IkBbet complex formation	$\text{NFkB} + \text{IKK_IkBbet} \rightleftharpoons \text{IKK_IkBbet_NFkB}$	
7	v7	IkBbet degradation	$\text{IKK_IkBbet_NFkB} \longrightarrow \text{NFkB} + \text{IKK}$	
8	v8	NFkB binary IKK IkBeps complex formation	$\text{NFkB} + \text{IKK_IkBeps} \rightleftharpoons \text{IKK_IkBeps_NFkB}$	
9	v9	IkBeps degradation	$\text{IKK_IkBeps_NFkB} \longrightarrow \text{NFkB} + \text{IKK}$	
10	v10	IkBalp degradation	$\text{IkBalp_NFkB} \longrightarrow \text{NFkB}$	
11	v11	IkBbet degradation	$\text{IkBbet_NFkB} \longrightarrow \text{NFkB}$	
12	v12	IkBeps degradation	$\text{IkBeps_NFkB} \longrightarrow \text{NFkB}$	
13	v13	NFkB translocation	$\text{NFkB} \rightleftharpoons \text{NFkB_nuc}$	
14	v14	NFkB-IkBalpha complex formation	$\text{NFkB_nuc} + \text{IkBalp_nuc} \rightleftharpoons \text{IkBalp_nuc_NFkB_nuc}$	
15	v15	NFkB-IkBbeta complex formation	$\text{NFkB_nuc} + \text{IkBbet_nuc} \rightleftharpoons \text{IkBbet_nuc_NFkB_nuc}$	
16	v16	NFkB-IkBeps complex formation	$\text{NFkB_nuc} + \text{IkBeps_nuc} \rightleftharpoons \text{IkBeps_nuc_NFkB_nuc}$	
17	v17	IkBalp transcription	$\emptyset \longrightarrow \text{IkBalp_transcript}$	
18	v18	IkBalp inducible transcription	$\emptyset \xrightarrow{\text{NFkB_nuc}} \text{IkBalp_transcript}$	
19	v19	IkBalp transcript degradation	$\text{IkBalp_transcript} \longrightarrow \emptyset$	
20	v20	IkBbet transcription	$\emptyset \longrightarrow \text{IkBbet_transcript}$	

Nº	Id	Name	Reaction Equation	SBO
21	v21	IkBbeta transcript degradation	$\text{IkBbeta_transcript} \longrightarrow \emptyset$	
22	v22	IkBeps transcription	$\emptyset \longrightarrow \text{IkBeps_transcript}$	
23	v23	IkBeps transcript degradation	$\text{IkBeps_transcript} \longrightarrow \emptyset$	
24	v24	IKK-IkBalpha complex formation	$\text{IKK} + \text{IkBalpha} \rightleftharpoons \text{IKK_IkBalpha}$	
25	v25	IkBalpha synthesis	$\emptyset \xrightarrow{\text{IkBalpha_transcript}} \text{IkBalpha}$	
26	v26	IkBalpha degradation	$\text{IkBalpha} \longrightarrow \emptyset$	
27	v27	IkBalpha translocation	$\text{IkBalpha} \rightleftharpoons \text{IkBalpha_nuc}$	
28	v28	IKK-IkBbeta complex formation	$\text{IKK} + \text{IkBbeta} \rightleftharpoons \text{IKK_IkBbeta}$	
29	v29	IkBbeta synthesis	$\emptyset \xrightarrow{\text{IkBbeta_transcript}} \text{IkBbeta}$	
30	v30	IkBbeta degradation	$\text{IkBbeta} \longrightarrow \emptyset$	
31	v31	IkBbeta translocation	$\text{IkBbeta} \rightleftharpoons \text{IkBbeta_nuc}$	
32	v32	IKK-IkBeps complex formation	$\text{IKK} + \text{IkBeps} \rightleftharpoons \text{IKK_IkBeps}$	
33	v33	IkBeps synthesis	$\emptyset \xrightarrow{\text{IkBeps_transcript}} \text{IkBeps}$	
34	v34	IkBeps degradation	$\text{IkBeps} \longrightarrow \emptyset$	
35	v35	IkBeps translocation	$\text{IkBeps} \rightleftharpoons \text{IkBeps_nuc}$	
36	v36	IKK-binary IkBalpha NFkB complex formation	$\text{IKK} + \text{IkBalpha_NFkB} \rightleftharpoons \text{IKK_IkBalpha_NFkB}$	
37	v37	IkBalpha_NFkB translocation	$\text{IkBalpha_nuc_NFkB_nuc} \longrightarrow \text{IkBalpha_NFkB}$	
38	v38	IKK binary IkBbeta NFkB complex formation	$\text{IKK} + \text{IkBbeta_NFkB} \rightleftharpoons \text{IKK_IkBbeta_NFkB}$	
39	v39	IkBbeta_NFkB translocation	$\text{IkBbeta_nuc_NFkB_nuc} \longrightarrow \text{IkBbeta_NFkB}$	
40	v40	IKK binary IkBeps NFkB complex formation	$\text{IKK} + \text{IkBeps_NFkB} \rightleftharpoons \text{IKK_IkBeps_NFkB}$	
41	v41	IkBeps_NFkB translocation	$\text{IkBeps_nuc_NFkB_nuc} \longrightarrow \text{IkBeps_NFkB}$	
42	v42	IkBalpha degradation	$\text{IKK_IkBalpha} \longrightarrow \text{IKK}$	
43	v43	IkBbeta degradation	$\text{IKK_IkBbeta} \longrightarrow \text{IKK}$	
44	v44	IkBeps degradation	$\text{IKK_IkBeps} \longrightarrow \text{IKK}$	
45	v45	IKK consumption	$\text{IKK} \longrightarrow \emptyset$	

8.1 Reaction v1

This is a reversible reaction of two reactants forming one product.

Name NFkB-IkBalpha complex formation

Reaction equation



Reactants

Table 6: Properties of each reactant.

Id	Name	SBO
<hr/>		
NFkB		
IkBalpha		
<hr/>		

Product

Table 7: Properties of each product.

Id	Name	SBO
<hr/>		
IkBalpha_NFkB		
<hr/>		

Kinetic Law

Derived unit contains undeclared units

$$v_1 = \text{vol}(\text{cytoplasm}) \cdot (a_4 \cdot [\text{IkBalpha}] \cdot [\text{NFkB}] - d_4 \cdot [\text{IkBalpha_NFkB}]) \quad (11)$$

8.2 Reaction v2

This is a reversible reaction of two reactants forming one product.

Name NFkB-IkBbeta complex formation

Reaction equation



Reactants

Table 8: Properties of each reactant.

Id	Name	SBO
NFkB		
IkBbeta		

Product

Table 9: Properties of each product.

Id	Name	SBO
IkBbeta_NFkB		

Kinetic Law

Derived unit contains undeclared units

$$v_2 = \text{vol}(\text{cytoplasm}) \cdot (a_5 \cdot [\text{IkBbeta}] \cdot [\text{NFkB}] - d_5 \cdot [\text{IkBbeta_NFkB}]) \quad (13)$$

8.3 Reaction v3

This is a reversible reaction of two reactants forming one product.

Name NFkB-IkBeps complex formation

Reaction equation



Reactants

Table 10: Properties of each reactant.

Id	Name	SBO
NFkB		
IkBeps		

Product

Table 11: Properties of each product.

Id	Name	SBO
<hr/>		
IkBeps_NFkB		
<hr/>		

Kinetic Law**Derived unit** contains undeclared units

$$v_3 = \text{vol}(\text{cytoplasm}) \cdot (a_6 \cdot [\text{IkBeps}] \cdot [\text{NFkB}] - d_6 \cdot [\text{IkBeps_NFkB}]) \quad (15)$$

8.4 Reaction v4

This is a reversible reaction of two reactants forming one product.

Name NFkB-binary IKK IkBalpha complex formation**Reaction equation****Reactants**

Table 12: Properties of each reactant.

Id	Name	SBO
<hr/>		
NFkB		
IKK_IkBalpha		
<hr/>		

Product

Table 13: Properties of each product.

Id	Name	SBO
<hr/>		
IKK_IkBalpha_NFkB		
<hr/>		

Kinetic Law**Derived unit** contains undeclared units

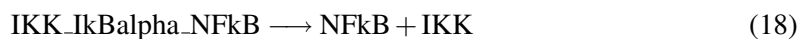
$$v_4 = \text{vol}(\text{cytoplasm}) \cdot (a_4 \cdot [\text{IKK_IkBalpha}] \cdot [\text{NFkB}] - d_4 \cdot [\text{IKK_IkBalpha_NFkB}]) \quad (17)$$

8.5 Reaction v5

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

Name IkBalpha degradation

Reaction equation



Reactant

Table 14: Properties of each reactant.

Id	Name	SBO
IKK_IkBalpha_NFkB		

Products

Table 15: Properties of each product.

Id	Name	SBO
NFkB		
IKK		

Kinetic Law

Derived unit contains undeclared units

$$v_5 = \text{vol}(\text{cytoplasm}) \cdot r_4 \cdot [\text{IKK_IkBalpha_NFkB}] \quad (19)$$

8.6 Reaction v6

This is a reversible reaction of two reactants forming one product.

Name NFkB binary IKK IkBbeta complex formation

Reaction equation



Reactants

Table 16: Properties of each reactant.

Id	Name	SBO
NFkB		
IKK_IkBbeta		

Product

Table 17: Properties of each product.

Id	Name	SBO
IKK_IkBbeta_NFkB		

Kinetic Law

Derived unit contains undeclared units

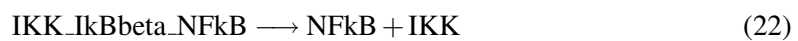
$$v_6 = \text{vol}(\text{cytoplasm}) \cdot (a_5 \cdot [\text{IKK_IkBbeta}] \cdot [\text{NFkB}] - d_5 \cdot [\text{IKK_IkBbeta_NFkB}]) \quad (21)$$

8.7 Reaction v7

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

Name IkBbeta degradation

Reaction equation



Reactant

Table 18: Properties of each reactant.

Id	Name	SBO
IKK_IkBbeta_NFkB		

Products

Table 19: Properties of each product.

Id	Name	SBO
NFkB		

Id	Name	SBO
IKK		

Kinetic Law

Derived unit contains undeclared units

$$v_7 = \text{vol}(\text{cytoplasm}) \cdot r_5 \cdot [\text{IKK_IkBbeta_NFkB}] \quad (23)$$

8.8 Reaction v8

This is a reversible reaction of two reactants forming one product.

Name NFkB binary IKK IkBeps complex formation

Reaction equation



Reactants

Table 20: Properties of each reactant.

Id	Name	SBO
NFkB		
IKK_IkBeps		

Product

Table 21: Properties of each product.

Id	Name	SBO
IKK_IkBeps_NFkB		

Kinetic Law

Derived unit contains undeclared units

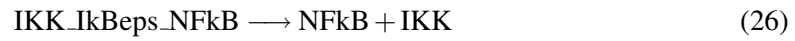
$$v_8 = \text{vol}(\text{cytoplasm}) \cdot (a_6 \cdot [\text{IKK_IkBeps}] \cdot [\text{NFkB}] - d_6 \cdot [\text{IKK_IkBeps_NFkB}]) \quad (25)$$

8.9 Reaction v9

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

Name IkBeps degradation

Reaction equation



Reactant

Table 22: Properties of each reactant.

Id	Name	SBO
IKK_IkBeps_NFkB		

Products

Table 23: Properties of each product.

Id	Name	SBO
NFkB		
IKK		

Kinetic Law

Derived unit contains undeclared units

$$v_9 = \text{vol}(\text{cytoplasm}) \cdot r_6 \cdot [\text{IKK_IkBeps_NFkB}] \quad (27)$$

8.10 Reaction v10

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

Name IkBalpha degradation

Reaction equation



Reactant

Table 24: Properties of each reactant.

Id	Name	SBO
IkBalpha_NFkB		

Product

Table 25: Properties of each product.

Id	Name	SBO
	NFkB	

Kinetic Law

Derived unit contains undeclared units

$$v_{10} = \text{vol}(\text{cytoplasm}) \cdot \text{deg4} \cdot [\text{IkBalpha_NFkB}] \quad (29)$$

8.11 Reaction v11

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

Name IkBbeta degradation

Reaction equation



Reactant

Table 26: Properties of each reactant.

Id	Name	SBO
	IkBbeta_NFkB	

Product

Table 27: Properties of each product.

Id	Name	SBO
	NFkB	

Kinetic Law

Derived unit contains undeclared units

$$v_{11} = \text{vol}(\text{cytoplasm}) \cdot \text{deg4} \cdot [\text{IkBbeta_NFkB}] \quad (31)$$

8.12 Reaction v12

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

Name IkBeps degradation

Reaction equation



Reactant

Table 28: Properties of each reactant.

Id	Name	SBO
IkBeps_NFkB		

Product

Table 29: Properties of each product.

Id	Name	SBO
NFkB		

Kinetic Law

Derived unit contains undeclared units

$$v_{12} = \text{vol}(\text{cytoplasm}) \cdot \text{deg4} \cdot [\text{IkBeps_NFkB}] \quad (33)$$

8.13 Reaction v13

This is a reversible reaction of one reactant forming one product.

Name NFkB translocation

Reaction equation



Reactant

Table 30: Properties of each reactant.

Id	Name	SBO
NFkB		

Product

Table 31: Properties of each product.

Id	Name	SBO
NFkB_nuc		

Kinetic Law

Derived unit contains undeclared units

$$v_{13} = \text{vol}(\text{cytoplasm}) \cdot k_1 \cdot [\text{NFkB}] - \text{vol}(\text{nucleus}) \cdot k_{01} \cdot [\text{NFkB_nuc}] \quad (35)$$

8.14 Reaction v14

This is a reversible reaction of two reactants forming one product.

Name NFkB-IkBAlpha complex formation

Reaction equation



Reactants

Table 32: Properties of each reactant.

Id	Name	SBO
NFkB_nuc		
IkBalpha_nuc		

Product

Table 33: Properties of each product.

Id	Name	SBO
IkBalpha_nuc_NFkB_nuc		

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

Kinetic Law

Derived unit contains undeclared units

$$v_{14} = \text{vol}(\text{nucleus}) \cdot (a4 \cdot [\text{IkBalp} \alpha_{\text{nuc}}] \cdot [\text{NFkB}_{\text{nuc}}] - d4 \cdot [\text{IkBalp} \alpha_{\text{nuc_NFkB_nuc}}]) \quad (37)$$

8.15 Reaction v15

This is a reversible reaction of two reactants forming one product.

Name NFkB-IkBbeta complex formation

Reaction equation



Reactants

Table 34: Properties of each reactant.

Id	Name	SBO
	NFkB_nuc	
	IkBbeta_nuc	

Product

Table 35: Properties of each product.

Id	Name	SBO
	IkBbeta_nuc_NFkB_nuc	

Kinetic Law

Derived unit contains undeclared units

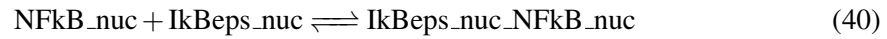
$$v_{15} = \text{vol}(\text{nucleus}) \cdot (a5 \cdot [\text{IkBbeta}_{\text{nuc}}] \cdot [\text{NFkB}_{\text{nuc}}] - d5 \cdot [\text{IkBbeta}_{\text{nuc_NFkB_nuc}}]) \quad (39)$$

8.16 Reaction v16

This is a reversible reaction of two reactants forming one product.

Name NFkB-IkBeps complex formation

Reaction equation



Reactants

Table 36: Properties of each reactant.

Id	Name	SBO
NFkB_nuc		
IkBeps_nuc		

Product

Table 37: Properties of each product.

Id	Name	SBO
IkBeps_nuc_NFkB_nuc		

Kinetic Law

Derived unit contains undeclared units

$$v_{16} = \text{vol}(\text{nucleus}) \cdot (a_6 \cdot [\text{IkBeps_nuc}] \cdot [\text{NFkB_nuc}] - d_6 \cdot [\text{IkBeps_nuc_NFkB_nuc}]) \quad (41)$$

8.17 Reaction v17

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

Name IkBalpa transcription

Reaction equation



Product

Table 38: Properties of each product.

Id	Name	SBO
IkBalpa_transcript		

Kinetic Law

Derived unit contains undeclared units

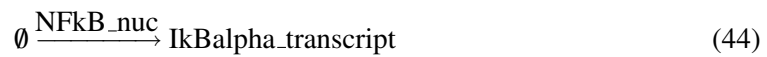
$$v_{17} = \text{vol}(\text{nucleus}) \cdot \text{tr2a} \quad (43)$$

8.18 Reaction v18

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

Name IkBalpha inducible transcription

Reaction equation



Modifier

Table 39: Properties of each modifier.

Id	Name	SBO
NFkB_nuc		

Product

Table 40: Properties of each product.

Id	Name	SBO
IkBalpha_transcript		

Kinetic Law

Derived unit contains undeclared units

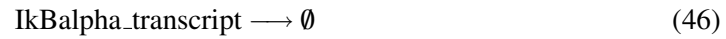
$$v_{18} = \text{vol}(\text{nucleus}) \cdot \text{tr2} \cdot [\text{NFkB_nuc}]^2 \quad (45)$$

8.19 Reaction v19

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

Name IkBalpha transcript degradation

Reaction equation



Reactant

Table 41: Properties of each reactant.

Id	Name	SBO
IkBalpha_transcript		

Kinetic Law

Derived unit contains undeclared units

$$v_{19} = \text{vol}(\text{nucleus}) \cdot \text{tr3} \cdot [\text{IkBalpha_transcript}] \quad (47)$$

8.20 Reaction v20

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

Name IkBbeta transcription

Reaction equation



Product

Table 42: Properties of each product.

Id	Name	SBO
IkBbeta_transcript		

Kinetic Law

Derived unit contains undeclared units

$$v_{20} = \text{vol}(\text{nucleus}) \cdot \text{tr2b} \quad (49)$$

8.21 Reaction v21

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

Name IkBbeta transcript degradation

Reaction equation



Reactant

Table 43: Properties of each reactant.

Id	Name	SBO
IkBbeta_transcript		

Kinetic Law

Derived unit contains undeclared units

$$v_{21} = \text{vol}(\text{nucleus}) \cdot \text{tr3} \cdot [\text{IkBbeta_transcript}] \quad (51)$$

8.22 Reaction v22

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

Name IkBeps transcription

Reaction equation



Product

Table 44: Properties of each product.

Id	Name	SBO
IkBeps_transcript		

Kinetic Law

Derived unit contains undeclared units

$$v_{22} = \text{vol}(\text{nucleus}) \cdot \text{tr2e} \quad (53)$$

8.23 Reaction v23

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

Name IkBeps transcript degradation

Reaction equation



Reactant

Table 45: Properties of each reactant.

Id	Name	SBO
IkBeps_transcript		

Kinetic Law

Derived unit contains undeclared units

$$v_{23} = \text{vol}(\text{nucleus}) \cdot \text{tr3} \cdot [\text{IkBeps_transcript}] \quad (55)$$

8.24 Reaction v24

This is a reversible reaction of two reactants forming one product.

Name IKK-IkBalpha complex formation

Reaction equation



Reactants

Table 46: Properties of each reactant.

Id	Name	SBO
IKK		
IkBalpha		

Product

Table 47: Properties of each product.

Id	Name	SBO
IKK_IkBalpha		

Kinetic Law

Derived unit contains undeclared units

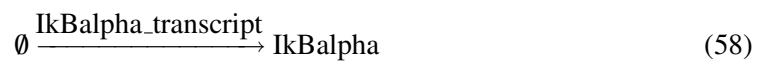
$$v_{24} = \text{vol}(\text{cytoplasm}) \cdot (a1 \cdot [\text{IkBalpha}] \cdot [\text{IKK}] - d1 \cdot [\text{IKK_IkBalpha}]) \quad (57)$$

8.25 Reaction v25

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

Name IkBalpha synthesis

Reaction equation



Modifier

Table 48: Properties of each modifier.

Id	Name	SBO
IkBalpha_transcript		

Product

Table 49: Properties of each product.

Id	Name	SBO
IkBalpha		

Kinetic Law

Derived unit contains undeclared units

$$v_{25} = \text{vol}(\text{nucleus}) \cdot \text{tr1} \cdot [\text{IkBalpha_transcript}] \quad (59)$$

8.26 Reaction v26

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

Name IkBalpha degradation

Reaction equation



Reactant

Table 50: Properties of each reactant.

Id	Name	SBO
<hr/>		
IkBalpha		
<hr/>		

Kinetic Law

Derived unit contains undeclared units

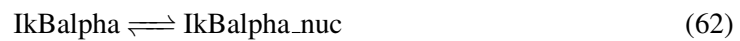
$$v_{26} = \text{vol}(\text{cytoplasm}) \cdot \text{deg1} \cdot [\text{IkBalpha}] \quad (61)$$

8.27 Reaction v27

This is a reversible reaction of one reactant forming one product.

Name IkBalpha translocation

Reaction equation



Reactant

Table 51: Properties of each reactant.

Id	Name	SBO
<hr/>		
IkBalpha		
<hr/>		

Product

Table 52: Properties of each product.

Id	Name	SBO
<hr/>		
IkBalpha_nuc		
<hr/>		

Kinetic Law

Derived unit contains undeclared units

$$v_{27} = \text{vol}(\text{cytoplasm}) \cdot \text{tp1} \cdot [\text{IkBalpha}] - \text{vol}(\text{nucleus}) \cdot \text{tp2} \cdot [\text{IkBalpha_nuc}] \quad (63)$$

8.28 Reaction v28

This is a reversible reaction of two reactants forming one product.

Name IKK-IkBbeta complex formation

Reaction equation



Reactants

Table 53: Properties of each reactant.

Id	Name	SBO
IKK		
IkBbeta		

Product

Table 54: Properties of each product.

Id	Name	SBO
IKK_IkBbeta		

Kinetic Law

Derived unit contains undeclared units

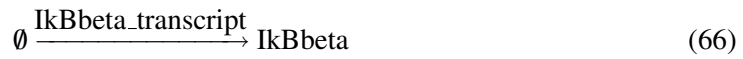
$$v_{28} = \text{vol}(\text{cytoplasm}) \cdot (a2 \cdot [\text{IkBbeta}] \cdot [\text{IKK}] - d2 \cdot [\text{IKK_IkBbeta}]) \quad (65)$$

8.29 Reaction v29

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

Name IkBbeta synthesis

Reaction equation



Modifier

Table 55: Properties of each modifier.

Id	Name	SBO
IkBbeta_transcript		

Product

Table 56: Properties of each product.

Id	Name	SBO
IkBbeta		

Kinetic Law

Derived unit contains undeclared units

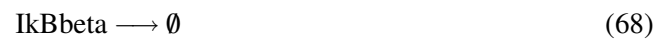
$$v_{29} = \text{vol}(\text{nucleus}) \cdot \text{tr1} \cdot [\text{IkBbeta_transcript}] \quad (67)$$

8.30 Reaction v30

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

Name IkBbeta degradation

Reaction equation



Reactant

Table 57: Properties of each reactant.

Id	Name	SBO
IkBbeta		

Kinetic Law

Derived unit contains undeclared units

$$v_{30} = \text{vol}(\text{cytoplasm}) \cdot \text{deg1} \cdot [\text{IkBbeta}] \quad (69)$$

8.31 Reaction v31

This is a reversible reaction of one reactant forming one product.

Name IkBbeta translocation

Reaction equation



Reactant

Table 58: Properties of each reactant.

Id	Name	SBO
IkBbeta		

Product

Table 59: Properties of each product.

Id	Name	SBO
IkBbeta_nuc		

Kinetic Law

Derived unit contains undeclared units

$$v_{31} = \text{vol}(\text{cytoplasm}) \cdot 0.5 \cdot \text{tp1} \cdot [\text{IkBbeta}] - \text{vol}(\text{nucleus}) \cdot 0.5 \cdot \text{tp2} \cdot [\text{IkBbeta_nuc}] \quad (71)$$

8.32 Reaction v32

This is a reversible reaction of two reactants forming one product.

Name IKK-IkBeps complex formation

Reaction equation



Reactants

Table 60: Properties of each reactant.

Id	Name	SBO
IKK		
IkBeps		

Product

Table 61: Properties of each product.

Id	Name	SBO
IKK_IkBeps		

Kinetic Law

Derived unit contains undeclared units

$$v_{32} = \text{vol}(\text{cytoplasm}) \cdot (a_3 \cdot [\text{IkBeps}] \cdot [\text{IKK}] - d_3 \cdot [\text{IKK_IkBeps}]) \quad (73)$$

8.33 Reaction v33

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

Name IkBeps synthesis

Reaction equation



Modifier

Table 62: Properties of each modifier.

Id	Name	SBO
IkBeps_transcript		

Product

Table 63: Properties of each product.

Id	Name	SBO
IkBeps		

Kinetic Law

Derived unit contains undeclared units

$$v_{33} = \text{vol}(\text{nucleus}) \cdot \text{tr1} \cdot [\text{IkBeps_transcript}] \quad (75)$$

8.34 Reaction v34

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

Name Ikbeps degradation

Reaction equation



Reactant

Table 64: Properties of each reactant.

Id	Name	SBO
IkBeps		

Kinetic Law

Derived unit contains undeclared units

$$v_{34} = \text{vol}(\text{cytoplasm}) \cdot \text{deg1} \cdot [\text{IkBeps}] \quad (77)$$

8.35 Reaction v35

This is a reversible reaction of one reactant forming one product.

Name Ikbeps translocation

Reaction equation



Reactant

Table 65: Properties of each reactant.

Id	Name	SBO
IkBeps		

Product

Table 66: Properties of each product.

Id	Name	SBO
IkBeps_nuc		

Kinetic Law

Derived unit contains undeclared units

$$v_{35} = \text{vol}(\text{cytoplasm}) \cdot 0.5 \cdot \text{tp1} \cdot [\text{IkBeps}] - \text{vol}(\text{nucleus}) \cdot 0.5 \cdot \text{tp2} \cdot [\text{IkBeps_nuc}] \quad (79)$$

8.36 Reaction v36

This is a reversible reaction of two reactants forming one product.

Name IKK-binary IkBalp ha NFkB complex formation

Reaction equation



Reactants

Table 67: Properties of each reactant.

Id	Name	SBO
IKK		
IkBalp ha_NFkB		

Product

Table 68: Properties of each product.

Id	Name	SBO
IKK_IkBalp ha_NFkB		

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

Kinetic Law

Derived unit contains undeclared units

$$v_{36} = \text{vol}(\text{cytoplasm}) \cdot (a7 \cdot [\text{IKK}] \cdot [\text{IkBalpha_NFkB}] - d1 \cdot [\text{IKK_IkBalpha_NFkB}]) \quad (81)$$

8.37 Reaction v37

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

Name IkBalpha_NFkB translocation

Reaction equation



Reactant

Table 69: Properties of each reactant.

Id	Name	SBO
	IkBalpha_nuc_NFkB_nuc	

Product

Table 70: Properties of each product.

Id	Name	SBO
	IkBalpha_NFkB	

Kinetic Law

Derived unit contains undeclared units

$$v_{37} = \text{vol}(\text{nucleus}) \cdot k2 \cdot [\text{IkBalpha_nuc_NFkB_nuc}] \quad (83)$$

8.38 Reaction v38

This is a reversible reaction of two reactants forming one product.

Name IKK binary IkBbeta NFkB complex formation

Reaction equation



Reactants

Table 71: Properties of each reactant.

Id	Name	SBO
IKK		
IkBbeta_NFkB		

Product

Table 72: Properties of each product.

Id	Name	SBO
IKK_IkBbeta_NFkB		

Kinetic Law

Derived unit contains undeclared units

$$v_{38} = \text{vol}(\text{cytoplasm}) \cdot (a8 \cdot [\text{IKK}] \cdot [\text{IkBbeta_NFkB}] - d2 \cdot [\text{IKK_IkBbeta_NFkB}]) \quad (85)$$

8.39 Reaction v39

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

Name IkBbeta_NFkB translocation

Reaction equation



Reactant

Table 73: Properties of each reactant.

Id	Name	SBO
IkBbeta_nuc_NFkB_nuc		

Product

Table 74: Properties of each product.

Id	Name	SBO
	IkBbeta_NFkB	

Kinetic Law

Notes The sum of „flag_for_after_signal,, and „fr_after_trigger,, insures that the value of the fraction of „IkBbeta_nuc_NFkB_nuc,, capable of nuclear export is equal to one before the signal is introduced and then follows the rate rule for „fr_after_trigger,, after the signal is introduced.

Derived unit contains undeclared units

$$v_{39} = \text{vol}(\text{nucleus}) \cdot k2_IkBbeta_nuc_NFkB_nuc \cdot (\text{fr_after_trigger} + \text{flag_for_after_trigger}) \cdot [IkBbeta_nuc_NFkB_nuc] \quad (87)$$

Table 75: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
	k2_IkBbeta-_nuc_NFkB_nuc		0.007		<input checked="" type="checkbox"/>

8.40 Reaction v40

This is a reversible reaction of two reactants forming one product.

Name IKK binary IkBeps NFkB complex formation

Reaction equation



Reactants

Table 76: Properties of each reactant.

Id	Name	SBO
	IKK	

Id	Name	SBO
	IkBeps_NFkB	

Product

Table 77: Properties of each product.

Id	Name	SBO
	IKK_IkBeps_NFkB	

Kinetic Law

Derived unit contains undeclared units

$$v_{40} = \text{vol}(\text{cytoplasm}) \cdot (a_9 \cdot [\text{IKK}] \cdot [\text{IkBeps_NFkB}] - d_3 \cdot [\text{IKK_IkBeps_NFkB}]) \quad (89)$$

8.41 Reaction v41

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

Name IkBeps_NFkB translocation

Reaction equation



Reactant

Table 78: Properties of each reactant.

Id	Name	SBO
	IkBeps_nuc_NFkB_nuc	

Product

Table 79: Properties of each product.

Id	Name	SBO
	IkBeps_NFkB	

Kinetic Law

Derived unit contains undeclared units

$$v_{41} = \text{vol}(\text{nucleus}) \cdot 0.5 \cdot k2_eps \cdot [\text{IkBeps_nuc_NFkB_nuc}] \quad (91)$$

8.42 Reaction v42

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

Name IkBalpha degradation

Reaction equation



Reactant

Table 80: Properties of each reactant.

Id	Name	SBO
IKK_IkBalpha		

Product

Table 81: Properties of each product.

Id	Name	SBO
IKK		

Kinetic Law

Derived unit contains undeclared units

$$v_{42} = \text{vol}(\text{cytoplasm}) \cdot r1 \cdot [\text{IKK_IkBalpha}] \quad (93)$$

8.43 Reaction v43

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

Name IkBbeta degradation

Reaction equation



Reactant

Table 82: Properties of each reactant.

Id	Name	SBO
IKK_IkBbeta		

Product

Table 83: Properties of each product.

Id	Name	SBO
IKK		

Kinetic Law

Derived unit contains undeclared units

$$v_{43} = \text{vol}(\text{cytoplasm}) \cdot r_2 \cdot [\text{IKK_IkBbeta}] \quad (95)$$

8.44 Reaction v_{44}

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

Name IkBeps degradation

Reaction equation



Reactant

Table 84: Properties of each reactant.

Id	Name	SBO
IKK_IkBeps		

Product

Table 85: Properties of each product.

Id	Name	SBO
IKK		

Kinetic Law

Derived unit contains undeclared units

$$v_{44} = \text{vol}(\text{cytoplasm}) \cdot r_3 \cdot [\text{IKK_IkBeps}] \quad (97)$$

8.45 Reaction v45

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

Name IKK consumption

Reaction equation



Reactant

Table 86: Properties of each reactant.

Id	Name	SBO
IKK		

Kinetic Law

Derived unit contains undeclared units

$$v_{45} = \text{vol}(\text{cytoplasm}) \cdot k_{02} \cdot [\text{IKK}] \quad (99)$$

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 IkBalpha

Initial concentration $0.1 \mu\text{mol} \cdot \text{l}^{-1}$

This species takes part in five reactions (as a reactant in [v1](#), [v24](#), [v26](#), [v27](#) and as a product in [v25](#)).

$$\frac{d}{dt} \text{IkBalpha} = v_{25} - v_1 - v_{24} - v_{26} - v_{27} \quad (100)$$

9.2 Species NFkB

Initial concentration $0.1 \mu\text{mol} \cdot \text{l}^{-1}$

This species takes part in 13 reactions (as a reactant in [v1](#), [v2](#), [v3](#), [v4](#), [v6](#), [v8](#), [v13](#) and as a product in [v5](#), [v7](#), [v9](#), [v10](#), [v11](#), [v12](#)).

$$\frac{d}{dt} \text{NFkB} = v_5 + v_7 + v_9 + v_{10} + v_{11} + v_{12} - v_1 - v_2 - v_3 - v_4 - v_6 - v_8 - v_{13} \quad (101)$$

9.3 Species IkBalpha_NFkB

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

This species takes part in four reactions (as a reactant in [v10](#), [v36](#) and as a product in [v1](#), [v37](#)).

$$\frac{d}{dt} \text{IkBalpha_NFkB} = v_1 + v_{37} - v_{10} - v_{36} \quad (102)$$

9.4 Species IkBbeta

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

This species takes part in five reactions (as a reactant in [v2](#), [v28](#), [v30](#), [v31](#) and as a product in [v29](#)).

$$\frac{d}{dt} \text{IkBbeta} = v_{29} - v_2 - v_{28} - v_{30} - v_{31} \quad (103)$$

9.5 Species IkBbeta_NFkB

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

This species takes part in four reactions (as a reactant in [v11](#), [v38](#) and as a product in [v2](#), [v39](#)).

$$\frac{d}{dt} \text{IkBbeta_NFkB} = v_2 + v_{39} - v_{11} - v_{38} \quad (104)$$

9.6 Species IkBeps

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

This species takes part in five reactions (as a reactant in [v3](#), [v32](#), [v34](#), [v35](#) and as a product in [v33](#)).

$$\frac{d}{dt}\text{IkBeps} = v_{33} - v_3 - v_{32} - v_{34} - v_{35} \quad (105)$$

9.7 Species IkBeps_NFkB

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

This species takes part in four reactions (as a reactant in [v12](#), [v40](#) and as a product in [v3](#), [v41](#)).

$$\frac{d}{dt}\text{IkBeps_NFkB} = v_3 + v_{41} - v_{12} - v_{40} \quad (106)$$

9.8 Species IKK_IkBalpha

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

This species takes part in three reactions (as a reactant in [v4](#), [v42](#) and as a product in [v24](#)).

$$\frac{d}{dt}\text{IKK_IkBalp} = v_{24} - v_4 - v_{42} \quad (107)$$

9.9 Species IKK_IkBalpha_NFkB

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

This species takes part in three reactions (as a reactant in [v5](#) and as a product in [v4](#), [v36](#)).

$$\frac{d}{dt}\text{IKK_IkBalp_NFkB} = v_4 + v_{36} - v_5 \quad (108)$$

9.10 Species IKK

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

Involved in event [event_0000001](#)

This species takes part in 13 reactions (as a reactant in [v24](#), [v28](#), [v32](#), [v36](#), [v38](#), [v40](#), [v45](#) and as a product in [v5](#), [v7](#), [v9](#), [v42](#), [v43](#), [v44](#)).

$$\begin{aligned} \frac{d}{dt}\text{IKK} = & v_5 + v_7 + v_9 + v_{42} + v_{43} + v_{44} - v_{24} \\ & - v_{28} - v_{32} - v_{36} - v_{38} - v_{40} - v_{45} \end{aligned} \quad (109)$$

Furthermore, one event influences this species' rate of change.

9.11 Species `IKK_IkBbeta`

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

This species takes part in three reactions (as a reactant in [v6](#), [v43](#) and as a product in [v28](#)).

$$\frac{d}{dt}\text{IKK_IkBbeta} = v_{28} - v_6 - v_{43} \quad (110)$$

9.12 Species `IKK_IkBbeta_NFkB`

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

This species takes part in three reactions (as a reactant in [v7](#) and as a product in [v6](#), [v38](#)).

$$\frac{d}{dt}\text{IKK_IkBbeta_NFkB} = v_6 + v_{38} - v_7 \quad (111)$$

9.13 Species `IKK_IkBeps`

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

This species takes part in three reactions (as a reactant in [v8](#), [v44](#) and as a product in [v32](#)).

$$\frac{d}{dt}\text{IKK_IkBeps} = v_{32} - v_8 - v_{44} \quad (112)$$

9.14 Species `IKK_IkBeps_NFkB`

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

This species takes part in three reactions (as a reactant in [v9](#) and as a product in [v8](#), [v40](#)).

$$\frac{d}{dt}\text{IKK_IkBeps_NFkB} = v_8 + v_{40} - v_9 \quad (113)$$

9.15 Species `NFkB_nuc`

Initial concentration $0.0010 \mu\text{mol} \cdot \text{l}^{-1}$

This species takes part in five reactions (as a reactant in [v14](#), [v15](#), [v16](#) and as a product in [v13](#) and as a modifier in [v18](#)).

$$\frac{d}{dt}\text{NFkB_nuc} = v_{13} - v_{14} - v_{15} - v_{16} \quad (114)$$

9.16 Species IkBalpha_nuc

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

This species takes part in two reactions (as a reactant in v14 and as a product in v27).

$$\frac{d}{dt}\text{IkBalpha_nuc} = v_{27} - v_{14} \quad (115)$$

9.17 Species IkBalpha_nuc_NFkB_nuc

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

This species takes part in two reactions (as a reactant in v37 and as a product in v14).

$$\frac{d}{dt}\text{IkBalpha_nuc_NFkB_nuc} = v_{14} - v_{37} \quad (116)$$

9.18 Species IkBbeta_nuc

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

This species takes part in two reactions (as a reactant in v15 and as a product in v31).

$$\frac{d}{dt}\text{IkBbeta_nuc} = v_{31} - v_{15} \quad (117)$$

9.19 Species IkBbeta_nuc_NFkB_nuc

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

This species takes part in two reactions (as a reactant in v39 and as a product in v15).

$$\frac{d}{dt}\text{IkBbeta_nuc_NFkB_nuc} = v_{15} - v_{39} \quad (118)$$

9.20 Species IkBeps_nuc

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

This species takes part in two reactions (as a reactant in v16 and as a product in v35).

$$\frac{d}{dt}\text{IkBeps_nuc} = v_{35} - v_{16} \quad (119)$$

9.21 Species IkBalpha_transcript

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

This species takes part in four reactions (as a reactant in v19 and as a product in v17, v18 and as a modifier in v25).

$$\frac{d}{dt}\text{IkBalpha_transcript} = v_{17} + v_{18} - v_{19} \quad (120)$$

9.22 Species IkBbeta_transcript

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

This species takes part in three reactions (as a reactant in v21 and as a product in v20 and as a modifier in v29).

$$\frac{d}{dt} \text{IkBbeta_transcript} = v_{20} - v_{21} \quad (121)$$

9.23 Species IkBeps_transcript

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

This species takes part in three reactions (as a reactant in v23 and as a product in v22 and as a modifier in v33).

$$\frac{d}{dt} \text{IkBeps_transcript} = v_{22} - v_{23} \quad (122)$$

9.24 Species IkBeps_nuc_NFkB_nuc

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

This species takes part in two reactions (as a reactant in v41 and as a product in v16).

$$\frac{d}{dt} \text{IkBeps_nuc_NFkB_nuc} = v_{16} - v_{41} \quad (123)$$

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