SBML Model Report

Model name: "Hoffmann2002_KnockOut-_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 Dharuri[1] at May 16th 2007 at 1:37 p. m. and last time modified at July fifth 2012 at 2:45 p. m. Table 1 provides an overview of the quantities of all components of this model.

Table 1: Number of components in this model, which are described in the following sections.

Element	Quantity	Element	Quantity
compartment types	0	compartments	2
species types	0	species	24
events	1	constraints	0
reactions	45	function definitions	0
global parameters	45	unit definitions	2
rules	5	initial assignments	0

Model Notes

The model corresponds to the knock out model of beta-/-, epsilon -/- and reproduces the upper panel in Fig 2C. In order to reproduce the other knock out models the transcription rate of the species that are not present must be set to zero and the rate of the one that is present must be set as seven times its corresponding value for the wild type model. This is done so as to compensate for the loss of other isoforms. 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 l

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
`cytoplasm`			3	1	litre	☑	
`nucleus`			3	1	litre	☑	`cytoplasm`

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	$\mu mol \cdot l^{-1}$	⊟	⊟
NFkB		cytoplasm	$\mu mol \cdot l^{-1}$	⊟	⊟
IkBalpha_NFkB		cytoplasm	$\mu mol \cdot l^{-1}$	⊟	⊟
IkBbeta		cytoplasm	$\mu mol \cdot l^{-1}$	⊟	⊟
IkBbeta_NFkB		cytoplasm	$\mu mol \cdot l^{-1}$	⊟	⊟
IkBeps		cytoplasm	$\mu mol \cdot l^{-1}$	⊟	⊟
IkBeps_NFkB		cytoplasm	$\mu mol \cdot l^{-1}$	⊟	⊟
IKK_IkBalpha		cytoplasm	$\mu mol \cdot l^{-1}$	⊟	⊟
IKK_IkBalpha_NFkB		cytoplasm	$\mu mol \cdot l^{-1}$	⊟	⊟
IKK		cytoplasm	$\mu mol \cdot l^{-1}$	⊟	⊟
IKK_IkBbeta		cytoplasm	$\mu mol \cdot l^{-1}$	⊟	⊟
IKK_IkBbeta_NFkB		cytoplasm	$\mu mol \cdot l^{-1}$	⊟	⊟
IKK_IkBeps		cytoplasm	$\mu mol \cdot l^{-1}$	⊟	⊟
IKK_IkBeps_NFkB		cytoplasm	$\mu mol \cdot l^{-1}$	⊟	⊟
NFkB_nuc		nucleus	$\mu mol \cdot l^{-1}$	⊟	⊟
IkBalpha_nuc		nucleus	$\mu mol \cdot l^{-1}$	⊟	⊟
IkBalpha_nuc-_NFkB_nuc		nucleus	$\mu mol \cdot l^{-1}$	⊟	⊟
IkBbeta_nuc		nucleus	$\mu mol \cdot l^{-1}$	⊟	⊟
IkBbeta_nuc_NFkB-_nuc		nucleus	$\mu mol \cdot l^{-1}$	⊟	⊟
IkBeps_nuc		nucleus	$\mu mol \cdot l^{-1}$	⊟	⊟

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Id	Name	Compartment	Derived Unit	Constant	Boundary Condition
IkBalpha_transcript		nucleus	$\mu mol \cdot l^{-1}$	⊟	⊟
IkBbeta_transcript		nucleus	$\mu mol \cdot l^{-1}$	⊟	⊟
IkBeps_transcript		nucleus	$\mu mol \cdot l^{-1}$	⊟	⊟
IkBeps_nuc_NFkB_nuc		nucleus	$\mu mol \cdot l^{-1}$	⊟	⊟

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5 Parameters

This model contains 45 global parameters.

Table 4: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
a4			30.000		☑
d4			0.030		☑
a5			30.000		☑
d5			0.030		☑
a6			30.000		☑
d6			0.030		☑
r4			1.224		☑
r5			0.450		☑
r6			0.660		☑
deg4			0.001		☑
k1			5.400		☑
k01			0.005		☑
tr2a			$9.25 \cdot 10^{-5}$		☑
tr2			0.990		☑
tr3			0.017		☑
tr2b			0.000		☑
tr2e			0.000		☑
a1			1.350		☑
d1			0.075		☑
tr1			0.245		☑
deg1			0.007		☑
tp1			0.018		☑
tp2			0.012		☑
a2			0.360		☑
d2			0.105		☑
a3			0.540		☑
d3			0.105		☑
a7			11.100		☑
k2			0.828		☑
a8			2.880		☑
k2_beta			0.624		☑
a9			4.200		☑
k2_eps			0.624		☑
r1			0.244		☑
r2			0.090		☑
r3			0.132		☑
k02			0.007		☑

Id	Name	SBO	Value	Unit	Constant
trigger_value			0.000		⊟
fr			1.000		⊟
fr_after_trigger			0.500		⊟
Total_IkBbeta			0.000		⊟
Total_IkBeps			0.000		⊟
Total_IkBalpha			0.000		⊟
Total_NFkBn			0.000		⊟
flag_for_after_trigger			0.500		⊟

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:

$$\text{Total\_NFkBn} = [\text{IkBbeta\_nuc\_NFkB\_nuc}] + [\text{NFkB\_nuc}] \tag{4}$$

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:

$$\frac{\text{d}}{\text{d}t}\text{fr\_after\_trigger} = \text{trigger\_value} \cdot \frac{-0.5}{(1 + (\text{t} - 2000))^2} \tag{5}$$

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 uM. 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

$$(\text{t} \geq 2000) \wedge (\text{trigger\_value} = 0) \tag{6}$$

Assignments

$$\text{IKK} = 0.1 \tag{7}$$

$$\text{trigger\_value} = 1 \tag{8}$$

$$\text{flag\_for\_after\_trigger} = 0 \tag{9}$$

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

№	Id	Name	Reaction Equation	SBO
1	v1	NFkB-IkBalpha complex formation	NFkB + IkBalpha $\rightleftharpoons$ IkBalpha_NFkB	
2	v2	NFkB-IkBbeta complex formation	NFkB + IkBbeta $\rightleftharpoons$ IkBbeta_NFkB	
3	v3	NFkB-IkBeps complex formation	NFkB + IkBeps $\rightleftharpoons$ IkBeps_NFkB	
4	v4	NFkB-binary IKK IkBalpha complex formation	NFkB + IKK_IkBalpha $\rightleftharpoons$ IKK_IkBalpha_NFkB	
5	v5	IkBalpha degradation	IKK_IkBalpha_NFkB $\longrightarrow$ NFkB + IKK	
6	v6	NFkB binary IKK IkBbeta complex formation	NFkB + IKK_IkBbeta $\rightleftharpoons$ IKK_IkBbeta_NFkB	
7	v7	IkBbeta degradation	IKK_IkBbeta_NFkB $\longrightarrow$ NFkB + IKK	
8	v8	NFkB binary IKK IkBeps complex formation	NFkB + IKK_IkBeps $\rightleftharpoons$ IKK_IkBeps_NFkB	
9	v9	IkBeps degradation	IKK_IkBeps_NFkB $\longrightarrow$ NFkB + IKK	
10	v10	IkBalpha degradation	IkBalpha_NFkB $\longrightarrow$ NFkB	
11	v11	IkBbeta degradation	IkBbeta_NFkB $\longrightarrow$ NFkB	
12	v12	IkBeps degradation	IkBeps_NFkB $\longrightarrow$ NFkB	
13	v13	NFkB translocation	NFkB $\rightleftharpoons$ NFkB_nuc	
14	v14	NFkB-IkBalpha complex formation	NFkB_nuc + IkBalpha_nuc $\rightleftharpoons$ IkBalpha_nuc_NFkB_nuc	
15	v15	NFkB-IkBbeta complex formation	NFkB_nuc + IkBbeta_nuc $\rightleftharpoons$ IkBbeta_nuc_NFkB_nuc	
16	v16	NFkB-IkBeps complex formation	NFkB_nuc + IkBeps_nuc $\rightleftharpoons$ IkBeps_nuc_NFkB_nuc	
17	v17	IkBalpha transcription	$\emptyset \longrightarrow$ IkBalpha_transcript	
18	v18	IkBalpha inducible transcription	$\emptyset \xrightarrow{\text{NFkB\_nuc}}$ IkBalpha_transcript	
19	v19	IkBalpha transcript degradation	IkBalpha_transcript $\longrightarrow \emptyset$	
20	v20	IkBbeta transcription	$\emptyset \longrightarrow$ IkBbeta_transcript	

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№	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	$\text{IKK} \longrightarrow \emptyset$	

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8.1 Reaction v1

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

Name NFkB-IkBalpha complex formation

Reaction equation

$$\mathrm{NFkB} + \mathrm{IkBalpha} \rightleftharpoons \mathrm{IkBalpha\_NFkB} \tag{10}$$

Reactants

Table 6: Properties of each reactant.

Id	Name	SBO
NFkB		
IkBalpha		

Product

Table 7: Properties of each product.

Id	Name	SBO
IkBalpha_NFkB		

Kinetic Law

Derived unit contains undeclared units

$$v_1 = \mathrm{vol}\,(\mathrm{cytoplasm}) \cdot (\mathrm{a4} \cdot [\mathrm{IkBalpha}] \cdot [\mathrm{NFkB}] - \mathrm{d4} \cdot [\mathrm{IkBalpha\_NFkB}]) \tag{11}$$

8.2 Reaction v2

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

Name NFkB-IkBbeta complex formation

Reaction equation

$$\mathrm{NFkB} + \mathrm{IkBbeta} \rightleftharpoons \mathrm{IkBbeta\_NFkB} \tag{12}$$

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

$$v_2 = \mathrm{vol}\,(\mathrm{cytoplasm}) \cdot (\mathrm{a5} \cdot [\mathrm{IkBbeta}] \cdot [\mathrm{NFkB}] - \mathrm{d5} \cdot [\mathrm{IkBbeta\_NFkB}]) \tag{13}$$

8.3 Reaction v3

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

Name NFkB-IkBeps complex formation

Reaction equation

$$\mathrm{NFkB} + \mathrm{IkBeps} \rightleftharpoons \mathrm{IkBeps\_NFkB} \tag{14}$$

Reactants

Table 10: Properties of each reactant.

Id	Name	SBO
NFkB		
IkBeps		

Product

Table 11: Properties of each product.

Id	Name	SBO
IkBeps_NFkB		

Kinetic Law

Derived unit contains undeclared units

$$v_3 = \mathrm{vol}\,(\mathrm{cytoplasm}) \cdot (\mathrm{a6} \cdot [\mathrm{IkBeps}] \cdot [\mathrm{NFkB}] - \mathrm{d6} \cdot [\mathrm{IkBeps\_NFkB}]) \tag{15}$$

8.4 Reaction v4

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

Name NFkB-binary IKK IkBalpha complex formation

Reaction equation

$$\mathrm{NFkB} + \mathrm{IKK\_IkBalpha} \rightleftharpoons \mathrm{IKK\_IkBalpha\_NFkB} \tag{16}$$

Reactants

Table 12: Properties of each reactant.

Id	Name	SBO
NFkB		
IKK_IkBalpha		

Product

Table 13: Properties of each product.

Id	Name	SBO
IKK_IkBalpha_NFkB		

Kinetic Law

Derived unit contains undeclared units

$$v_4 = \mathrm{vol}\,(\mathrm{cytoplasm}) \cdot (\mathrm{a4} \cdot [\mathrm{IKK\_IkBalpha}] \cdot [\mathrm{NFkB}] - \mathrm{d4} \cdot [\mathrm{IKK\_IkBalpha\_NFkB}]) \tag{17}$$

8.5 Reaction v5

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

Name IkBalpha degradation

Reaction equation

$$\text{IKK\_IkBalpha\_NFkB} \longrightarrow \text{NFkB} + \text{IKK} \tag{18}$$

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

$$v_5 = \text{vol}\,(\text{cytoplasm}) \cdot \text{r4} \cdot [\text{IKK\_IkBalpha\_NFkB}] \tag{19}$$

8.6 Reaction v6

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

Name NFkB binary IKK IkBbeta complex formation

Reaction equation

$$\text{NFkB} + \text{IKK\_IkBbeta} \rightleftharpoons \text{IKK\_IkBbeta\_NFkB} \tag{20}$$

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

$$v_6 = \mathrm{vol}\,(\mathrm{cytoplasm}) \cdot (\mathrm{a5} \cdot [\mathrm{IKK\_IkBbeta}] \cdot [\mathrm{NFkB}] - \mathrm{d5} \cdot [\mathrm{IKK\_IkBbeta\_NFkB}]) \quad (21)$$

8.7 Reaction v7

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

Name IkBbeta degradation

Reaction equation

$$\mathrm{IKK\_IkBbeta\_NFkB} \longrightarrow \mathrm{NFkB} + \mathrm{IKK} \quad (22)$$

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

$$v_7 = \mathrm{vol}\,(\mathrm{cytoplasm}) \cdot \mathrm{r5} \cdot [\mathrm{IKK\_IkBbeta\_NFkB}] \tag{23}$$

8.8 Reaction v8

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

Name NFkB binary IKK IkBeps complex formation

Reaction equation

$$\mathrm{NFkB} + \mathrm{IKK\_IkBeps} \rightleftharpoons \mathrm{IKK\_IkBeps\_NFkB} \tag{24}$$

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

$$v_8 = \mathrm{vol}\,(\mathrm{cytoplasm}) \cdot (\mathrm{a6} \cdot [\mathrm{IKK\_IkBeps}] \cdot [\mathrm{NFkB}] - \mathrm{d6} \cdot [\mathrm{IKK\_IkBeps\_NFkB}]) \tag{25}$$

8.9 Reaction v9

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

Name IkBeps degradation

Reaction equation

$$\text{IKK\_IkBeps\_NFkB} \longrightarrow \text{NFkB} + \text{IKK} \tag{26}$$

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

$$v_9 = \text{vol}\,(\text{cytoplasm}) \cdot \text{r6} \cdot [\text{IKK\_IkBeps\_NFkB}] \tag{27}$$

8.10 Reaction v10

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

Name IkBalpha degradation

Reaction equation

$$\text{IkBalpha\_NFkB} \longrightarrow \text{NFkB} \tag{28}$$

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

$$v_{10} = \mathrm{vol}\,(\mathrm{cytoplasm}) \cdot \mathrm{deg4} \cdot [\mathrm{IkBalpha\_NFkB}] \tag{29}$$

8.11 Reaction v11

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

Name IkBbeta degradation

Reaction equation

$$\mathrm{IkBbeta\_NFkB} \longrightarrow \mathrm{NFkB} \tag{30}$$

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

$$v_{11} = \mathrm{vol}\,(\mathrm{cytoplasm}) \cdot \mathrm{deg4} \cdot [\mathrm{IkBbeta\_NFkB}] \tag{31}$$

8.12 Reaction v12

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

Name IkBeps degradation

Reaction equation

$$\text{IkBeps\_NFkB} \longrightarrow \text{NFkB} \tag{32}$$

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

$$v_{12} = \text{vol}\,(\text{cytoplasm}) \cdot \text{deg4} \cdot [\text{IkBeps\_NFkB}] \tag{33}$$

8.13 Reaction v13

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

Name NFkB translocation

Reaction equation

$$\text{NFkB} \rightleftharpoons \text{NFkB\_nuc} \tag{34}$$

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

$$v_{13} = \mathrm{vol}\,(\mathrm{cytoplasm}) \cdot \mathrm{k1} \cdot [\mathrm{NFkB}] - \mathrm{vol}\,(\mathrm{nucleus}) \cdot \mathrm{k01} \cdot [\mathrm{NFkB\_nuc}] \tag{35}$$

8.14 Reaction v14

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

Name NFkB-IkBalpha complex formation

Reaction equation

$$\mathrm{NFkB\_nuc} + \mathrm{IkBalpha\_nuc} \rightleftharpoons \mathrm{IkBalpha\_nuc\_NFkB\_nuc} \tag{36}$$

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

$$v_{14} = \mathrm{vol}\,(\mathrm{nucleus}) \cdot (\mathrm{a4} \cdot [\mathrm{IkBalpha\_nuc}] \cdot [\mathrm{NFkB\_nuc}] - \mathrm{d4} \cdot [\mathrm{IkBalpha\_nuc\_NFkB\_nuc}]) \quad (37)$$

8.15 Reaction v15

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

Name NFkB-IkBbeta complex formation

Reaction equation

$$\mathrm{NFkB\_nuc} + \mathrm{IkBbeta\_nuc} \rightleftharpoons \mathrm{IkBbeta\_nuc\_NFkB\_nuc} \quad (38)$$

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

$$v_{15} = \mathrm{vol}\,(\mathrm{nucleus}) \cdot (\mathrm{a5} \cdot [\mathrm{IkBbeta\_nuc}] \cdot [\mathrm{NFkB\_nuc}] - \mathrm{d5} \cdot [\mathrm{IkBbeta\_nuc\_NFkB\_nuc}]) \quad (39)$$

8.16 Reaction v16

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

Name NFkB-IkBeps complex formation

Reaction equation

$$\mathrm{NFkB\_nuc} + \mathrm{IkBeps\_nuc} \rightleftharpoons \mathrm{IkBeps\_nuc\_NFkB\_nuc} \tag{40}$$

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

$$v_{16} = \mathrm{vol}\,(\mathrm{nucleus}) \cdot (\mathrm{a6} \cdot [\mathrm{IkBeps\_nuc}] \cdot [\mathrm{NFkB\_nuc}] - \mathrm{d6} \cdot [\mathrm{IkBeps\_nuc\_NFkB\_nuc}]) \tag{41}$$

8.17 Reaction v17

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

Name IkBalpha transcription

Reaction equation

$$\emptyset \longrightarrow \mathrm{IkBalpha\_transcript} \tag{42}$$

Product

Table 38: Properties of each product.

Id	Name	SBO
IkBalpha_transcript		

Kinetic Law

Derived unit contains undeclared units

$$v_{17} = \mathrm{vol}\,(\mathrm{nucleus}) \cdot \mathrm{tr2a} \tag{43}$$

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

$$\emptyset \xrightarrow{\mathrm{NFkB\_nuc}} \mathrm{IkBalpha\_transcript} \tag{44}$$

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

$$v_{18} = \mathrm{vol}\,(\mathrm{nucleus}) \cdot \mathrm{tr2} \cdot [\mathrm{NFkB\_nuc}]^2 \tag{45}$$

8.19 Reaction v19

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

Name IkBalpha transcript degradation

Reaction equation

$$\text{IkBalpha\_transcript} \longrightarrow \emptyset \tag{46}$$

Reactant

Table 41: Properties of each reactant.

Id	Name	SBO
IkBalpha_transcript		

Kinetic Law

Derived unit contains undeclared units

$$v_{19} = \text{vol}(\text{nucleus}) \cdot \text{tr3} \cdot [\text{IkBalpha\_transcript}] \tag{47}$$

8.20 Reaction v20

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

Name IkBbeta transcription

Reaction equation

$$\emptyset \longrightarrow \text{IkBbeta\_transcript} \tag{48}$$

Product

Table 42: Properties of each product.

Id	Name	SBO
IkBbeta_transcript		

Kinetic Law

Derived unit contains undeclared units

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

8.21 Reaction v21

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

Name IkBbeta transcript degradation

Reaction equation

$$\text{IkBbeta\_transcript} \longrightarrow \emptyset \tag{50}$$

Reactant

Table 43: Properties of each reactant.

Id	Name	SBO
IkBbeta_transcript		

Kinetic Law

Derived unit contains undeclared units

$$v_{21} = \text{vol}(\text{nucleus}) \cdot \text{tr3} \cdot [\text{IkBbeta\_transcript}] \tag{51}$$

8.22 Reaction v22

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

Name IkBeps transcription

Reaction equation

$$\emptyset \longrightarrow \text{IkBeps\_transcript} \tag{52}$$

Product

Table 44: Properties of each product.

Id	Name	SBO
IkBeps_transcript		

Kinetic Law

Derived unit contains undeclared units

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

8.23 Reaction v23

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

Name IkBeps transcript degradation

Reaction equation

$$\text{IkBeps\_transcript} \longrightarrow \emptyset \tag{54}$$

Reactant

Table 45: Properties of each reactant.

Id	Name	SBO
IkBeps_transcript		

Kinetic Law

Derived unit contains undeclared units

$$v_{23} = \text{vol}\,(\text{nucleus}) \cdot \text{tr3} \cdot [\text{IkBeps\_transcript}] \tag{55}$$

8.24 Reaction v24

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

Name IKK-IkBalpha complex formation

Reaction equation

$$\text{IKK} + \text{IkBalpha} \rightleftharpoons \text{IKK\_IkBalpha} \tag{56}$$

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

$$v_{24} = \mathrm{vol}\,(\mathrm{cytoplasm}) \cdot (\mathrm{a1} \cdot [\mathrm{IkBalpha}] \cdot [\mathrm{IKK}] - \mathrm{d1} \cdot [\mathrm{IKK\_IkBalpha}]) \tag{57}$$

8.25 Reaction v25

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

Name IkBalpha synthesis

Reaction equation

$$\emptyset \xrightarrow{\text{IkBalpha\_transcript}} \text{IkBalpha} \tag{58}$$

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

$$v_{25} = \mathrm{vol}\,(\mathrm{nucleus}) \cdot \mathrm{tr1} \cdot [\mathrm{IkBalpha\_transcript}] \tag{59}$$

8.26 Reaction v26

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

Name IkBalpha degradation

Reaction equation

$$\text{IkBalpha} \longrightarrow \emptyset \tag{60}$$

Reactant

Table 50: Properties of each reactant.

Id	Name	SBO
IkBalpha		

Kinetic Law

Derived unit contains undeclared units

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

8.27 Reaction v27

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

Name IkBalpha translocation

Reaction equation

$$\text{IkBalpha} \rightleftharpoons \text{IkBalpha\_nuc} \tag{62}$$

Reactant

Table 51: Properties of each reactant.

Id	Name	SBO
IkBalpha		

Product

Table 52: Properties of each product.

Id	Name	SBO
IkBalpha_nuc		

Kinetic Law

Derived unit contains undeclared units

$$v_{27} = \mathrm{vol}\,(\mathrm{cytoplasm}) \cdot \mathrm{tp1} \cdot [\mathrm{IkBalpha}] - \mathrm{vol}\,(\mathrm{nucleus}) \cdot \mathrm{tp2} \cdot [\mathrm{IkBalpha\_nuc}] \tag{63}$$

8.28 Reaction v28

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

Name IKK-IkBbeta complex formation

Reaction equation

$$\mathrm{IKK} + \mathrm{IkBbeta} \rightleftharpoons \mathrm{IKK\_IkBbeta} \tag{64}$$

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

$$v_{28} = \mathrm{vol}\,(\mathrm{cytoplasm}) \cdot (\mathrm{a2} \cdot [\mathrm{IkBbeta}] \cdot [\mathrm{IKK}] - \mathrm{d2} \cdot [\mathrm{IKK\_IkBbeta}]) \tag{65}$$

8.29 Reaction v29

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

Name IkBbeta synthesis

Reaction equation

$$\emptyset \xrightarrow{\text{IkBbeta\_transcript}} \text{IkBbeta} \tag{66}$$

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

$$v_{29} = \text{vol}(\text{nucleus}) \cdot \text{tr1} \cdot [\text{IkBbeta\_transcript}] \tag{67}$$

8.30 Reaction v30

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

Name IkBbeta degradation

Reaction equation

$$\text{IkBbeta} \longrightarrow \emptyset \tag{68}$$

Reactant

Table 57: Properties of each reactant.

Id	Name	SBO
IkBbeta		

Kinetic Law

Derived unit contains undeclared units

$$v_{30} = \mathrm{vol}\,(\mathrm{cytoplasm}) \cdot \mathrm{deg1} \cdot [\mathrm{IkBbeta}] \tag{69}$$

8.31 Reaction v31

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

Name IkBbeta translocation

Reaction equation

$$\mathrm{IkBbeta} \rightleftharpoons \mathrm{IkBbeta\_nuc} \tag{70}$$

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

$$v_{31} = \mathrm{vol}\,(\mathrm{cytoplasm}) \cdot 0.5 \cdot \mathrm{tp1} \cdot [\mathrm{IkBbeta}] - \mathrm{vol}\,(\mathrm{nucleus}) \cdot 0.5 \cdot \mathrm{tp2} \cdot [\mathrm{IkBbeta\_nuc}] \tag{71}$$

8.32 Reaction v32

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

Name IKK-IkBeps complex formation

Reaction equation

$$\mathrm{IKK} + \mathrm{IkBeps} \rightleftharpoons \mathrm{IKK\_IkBeps} \tag{72}$$

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

$$v_{32} = \mathrm{vol}\,(\mathrm{cytoplasm}) \cdot (\mathrm{a3} \cdot [\mathrm{IkBeps}] \cdot [\mathrm{IKK}] - \mathrm{d3} \cdot [\mathrm{IKK\_IkBeps}]) \tag{73}$$

8.33 Reaction v33

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

Name IkBeps synthesis

Reaction equation

$$\emptyset \xrightarrow{\mathrm{IkBeps\_transcript}} \mathrm{IkBeps} \tag{74}$$

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

$$v_{33} = \mathrm{vol}\,(\mathrm{nucleus}) \cdot \mathrm{tr1} \cdot [\mathrm{IkBeps\_transcript}] \tag{75}$$

8.34 Reaction v34

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

Name IkBeps degradation

Reaction equation

$$\mathrm{IkBeps} \longrightarrow \emptyset \tag{76}$$

Reactant

Table 64: Properties of each reactant.

Id	Name	SBO
IkBeps		

Kinetic Law

Derived unit contains undeclared units

$$v_{34} = \mathrm{vol}\,(\mathrm{cytoplasm}) \cdot \mathrm{deg1} \cdot [\mathrm{IkBeps}] \tag{77}$$

8.35 Reaction v35

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

Name IkBeps translocation

Reaction equation

$$\mathrm{IkBeps} \rightleftharpoons \mathrm{IkBeps\_nuc} \tag{78}$$

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

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

8.36 Reaction v36

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

Name IKK-binary IkBalpha NFkB complex formation

Reaction equation

$$\mathrm{IKK} + \mathrm{IkBalpha\_NFkB} \rightleftharpoons \mathrm{IKK\_IkBalpha\_NFkB} \quad (80)$$

Reactants

Table 67: Properties of each reactant.

Id	Name	SBO
IKK		
IkBalpha_NFkB		

Product

Table 68: Properties of each product.

Id	Name	SBO
IKK_IkBalpha_NFkB		

Id	Name	SBO

Kinetic Law

Derived unit contains undeclared units

$$v_{36} = \mathrm{vol}(\mathrm{cytoplasm}) \cdot (\mathrm{a7} \cdot [\mathrm{IKK}] \cdot [\mathrm{IkBalpha\_NFkB}] - \mathrm{d1} \cdot [\mathrm{IKK\_IkBalpha\_NFkB}]) \quad (81)$$

8.37 Reaction v37

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

Name IkBalpha_NFkB translocation

Reaction equation

$$\mathrm{IkBalpha\_nuc\_NFkB\_nuc} \longrightarrow \mathrm{IkBalpha\_NFkB} \quad (82)$$

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

$$v_{37} = \mathrm{vol}(\mathrm{nucleus}) \cdot \mathrm{k2} \cdot [\mathrm{IkBalpha\_nuc\_NFkB\_nuc}] \quad (83)$$

8.38 Reaction v38

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

Name IKK binary IkBbeta NFkB complex formation

Reaction equation

$$\mathrm{IKK} + \mathrm{IkBbeta\_NFkB} \rightleftharpoons \mathrm{IKK\_IkBbeta\_NFkB} \tag{84}$$

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

$$v_{38} = \mathrm{vol}\,(\mathrm{cytoplasm}) \cdot (\mathrm{a8} \cdot [\mathrm{IKK}] \cdot [\mathrm{IkBbeta\_NFkB}] - \mathrm{d2} \cdot [\mathrm{IKK\_IkBbeta\_NFkB}]) \tag{85}$$

8.39 Reaction v39

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

Name IkBbeta_NFkB translocation

Reaction equation

$$\mathrm{IkBbeta\_nuc\_NFkB\_nuc} \longrightarrow \mathrm{IkBbeta\_NFkB} \tag{86}$$

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

$$v_{39} = \mathrm{vol}\,(\mathrm{nucleus}) \cdot \mathrm{k2\_IkBbeta\_nuc\_NFkB\_nuc} \cdot (\mathrm{fr\_after\_trigger} + \mathrm{flag\_for\_after\_trigger}) \cdot [\mathrm{IkBbeta\_nuc\_NFkB\_nuc}] \tag{87}$$

Table 75: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
k2_IkBbeta-_nuc_NFkB_nuc			0.007		☑

8.40 Reaction v40

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

Name IKK binary IkBeps NFkB complex formation

Reaction equation

$$\mathrm{IKK} + \mathrm{IkBeps\_NFkB} \rightleftharpoons \mathrm{IKK\_IkBeps\_NFkB} \tag{88}$$

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

$$v_{40} = \mathrm{vol}\,(\mathrm{cytoplasm}) \cdot (\mathrm{a9} \cdot [\mathrm{IKK}] \cdot [\mathrm{IkBeps\_NFkB}] - \mathrm{d3} \cdot [\mathrm{IKK\_IkBeps\_NFkB}]) \quad (89)$$

8.41 Reaction v41

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

Name IkBeps_NFkB translocation

Reaction equation

$$\mathrm{IkBeps\_nuc\_NFkB\_nuc} \longrightarrow \mathrm{IkBeps\_NFkB} \quad (90)$$

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

$$v_{41} = \mathrm{vol}(\mathrm{nucleus}) \cdot 0.5 \cdot \mathrm{k2\_eps} \cdot [\mathrm{IkBeps\_nuc\_NFkB\_nuc}] \tag{91}$$

8.42 Reaction v42

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

Name IkBalpha degradation

Reaction equation

$$\mathrm{IKK\_IkBalpha} \longrightarrow \mathrm{IKK} \tag{92}$$

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

$$v_{42} = \mathrm{vol}(\mathrm{cytoplasm}) \cdot \mathrm{r1} \cdot [\mathrm{IKK\_IkBalpha}] \tag{93}$$

8.43 Reaction v43

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

Name IkBbeta degradation

Reaction equation

$$\mathrm{IKK\_IkBbeta} \longrightarrow \mathrm{IKK} \tag{94}$$

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

$$v_{43} = \mathrm{vol}\,(\mathrm{cytoplasm}) \cdot \mathrm{r2} \cdot [\mathrm{IKK\_IkBbeta}] \tag{95}$$

8.44 Reaction v44

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

Name IkBeps degradation

Reaction equation

$$\mathrm{IKK\_IkBeps} \longrightarrow \mathrm{IKK} \tag{96}$$

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

$$v_{44} = \mathrm{vol}\,(\mathrm{cytoplasm}) \cdot \mathrm{r3} \cdot [\mathrm{IKK\_IkBeps}] \tag{97}$$

8.45 Reaction v45

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

Name IKK consumption

Reaction equation

$$\mathrm{IKK} \longrightarrow \emptyset \tag{98}$$

Reactant

Table 86: Properties of each reactant.

Id	Name	SBO
IKK		

Kinetic Law

Derived unit contains undeclared units

$$v_{45} = \mathrm{vol}\,(\mathrm{cytoplasm}) \cdot \mathrm{k02} \cdot [\mathrm{IKK}] \tag{99}$$

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`).

$$\frac{\text{d}}{\text{d}t}\text{IkBalpha} = v_{25} - v_1 - v_{24} - v_{26} - v_{27} \tag{100}$$

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`).

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

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`).

$$\frac{\text{d}}{\text{d}t}\text{IkBalpha\_NFkB} = v_1 + v_{37} - v_{10} - v_{36} \tag{102}$$

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`).

$$\frac{\text{d}}{\text{d}t}\text{IkBbeta} = v_{29} - v_2 - v_{28} - v_{30} - v_{31} \tag{103}$$

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`).

$$\frac{\text{d}}{\text{d}t}\text{IkBbeta\_NFkB} = v_2 + v_{39} - v_{11} - v_{38} \tag{104}$$

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).

$$\frac{\mathrm{d}}{\mathrm{d}t}\text{IkBeps} = v_{33} - v_3 - v_{32} - v_{34} - v_{35} \tag{105}$$

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).

$$\frac{\mathrm{d}}{\mathrm{d}t}\text{IkBeps\_NFkB} = v_3 + v_{41} - v_{12} - v_{40} \tag{106}$$

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).

$$\frac{\mathrm{d}}{\mathrm{d}t}\text{IKK\_IkBalpha} = v_{24} - v_4 - v_{42} \tag{107}$$

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).

$$\frac{\mathrm{d}}{\mathrm{d}t}\text{IKK\_IkBalpha\_NFkB} = v_4 + v_{36} - v_5 \tag{108}$$

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).

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

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).

$$\frac{\mathrm{d}}{\mathrm{d}t}\text{IKK\_IkBbeta} = v_{28} - v_6 - v_{43} \tag{110}$$

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).

$$\frac{\mathrm{d}}{\mathrm{d}t}\text{IKK\_IkBbeta\_NFkB} = v_6 + v_{38} - v_7 \tag{111}$$

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).

$$\frac{\mathrm{d}}{\mathrm{d}t}\text{IKK\_IkBeps} = v_{32} - v_8 - v_{44} \tag{112}$$

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).

$$\frac{\mathrm{d}}{\mathrm{d}t}\text{IKK\_IkBeps\_NFkB} = v_8 + v_{40} - v_9 \tag{113}$$

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).

$$\frac{\mathrm{d}}{\mathrm{d}t}\text{NFkB\_nuc} = v_{13} - v_{14} - v_{15} - v_{16} \tag{114}$$

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).

$$\frac{\text{d}}{\text{d}t}\text{IkBalpha\_nuc} = v_{27} - v_{14} \tag{115}$$

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).

$$\frac{\text{d}}{\text{d}t}\text{IkBalpha\_nuc\_NFkB\_nuc} = v_{14} - v_{37} \tag{116}$$

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).

$$\frac{\text{d}}{\text{d}t}\text{IkBbeta\_nuc} = v_{31} - v_{15} \tag{117}$$

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).

$$\frac{\text{d}}{\text{d}t}\text{IkBbeta\_nuc\_NFkB\_nuc} = v_{15} - v_{39} \tag{118}$$

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).

$$\frac{\text{d}}{\text{d}t}\text{IkBeps\_nuc} = v_{35} - v_{16} \tag{119}$$

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).

$$\frac{\text{d}}{\text{d}t}\text{IkBalpha\_transcript} = v_{17} + v_{18} - v_{19} \tag{120}$$

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).

$$\frac{\text{d}}{\text{d}t}\text{IkBbeta\_transcript} = v_{20} - v_{21} \tag{121}$$

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).

$$\frac{\text{d}}{\text{d}t}\text{IkBeps\_transcript} = v_{22} - v_{23} \tag{122}$$

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).

$$\frac{\text{d}}{\text{d}t}\text{IkBeps\_nuc\_NFkB\_nuc} = v_{16} - v_{41} \tag{123}$$

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