

SBML Model Report

Model name: “Neumann2010- _CD95Stimulation_NFkB_Apoptosis”



May 6, 2016

1 General Overview

This is a document in SBML Level 2 Version 4 format. This model was created by the following two authors: Vijayalakshmi Chelliah¹ and Leo Neumann² at March twelveth 2010 at 12:09 a. m. and last time modified at April eighth 2016 at 4:08 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	1
species types	0	species	23
events	0	constraints	0
reactions	23	function definitions	0
global parameters	17	unit definitions	2
rules	0	initial assignments	0

Model Notes

This is the reduced model (model 8) described in: **Dynamics within the CD95 death-inducing signaling complex decide life and death of cells.**

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Lavrik and Roland Eils (German Cancer Research Center (DKFZ), <http://www.dkfz.de>); *Mol Sys Biol* 2010;6:352. doi:[10.1038/msb.2010.6](https://doi.org/10.1038/msb.2010.6);

Abstract:

This study explores the dilemma in cellular signaling that triggering of CD95 (Fas/APO-1) in some situations results in cell death and in others leads to the activation of NF-B. We established an integrated kinetic mathematical model for CD95-mediated apoptotic and NF-B signaling. Systematic model reduction resulted in a surprisingly simple model well approximating experimentally observed dynamics. The model postulates a new link between c-FLIP_L cleavage in the death-inducing signaling complex (DISC) and the NF-B pathway. We validated experimentally that CD95 stimulation resulted in an interaction of p43-FLIP with the IKK complex followed by its activation. Furthermore, we showed that the apoptotic and NF-B pathways diverge already at the DISC. Model and experimental analysis of DISC formation showed that a subtle balance of c-FLIP_L and procaspase-8 determines life/death decisions in a nonlinear manner. We present an integrated model describing the complex dynamics of CD95-mediated apoptosis and NF-B signaling.

The original was taken from the MSB article supplementary material site msb20106-s2.xml. All the species ids were changed since the model was not a valid SBML with its original ids - Lukas.

Notes added to the species [L] (the initial concentration of Anti-CD95), regarding changes to be made in the initial concentration of [L], to obtain figure 5D.

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To cite BioModels Database, please use Le Novre N., Bornstein B., Broicher A., Courtot M., Donizelli M., Dharuri H., Li L., Sauro H., Schilstra M., Shapiro B., Snoep J.L., Hucka M. (2006) BioModels Database: A Free, Centralized Database of Curated, Published, Quantitative Kinetic Models of Biochemical and Cellular Systems *Nucleic Acids Res.*, 34: D689-D691.

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 time

Definition 60 s

2.2 Unit substance

Definition nmol

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 m²

2.5 Unit length

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

Definition m

3 Compartment

This model contains one compartment.

Table 2: Properties of all compartments.

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

3.1 Compartment default

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

Name default

4 Species

This model contains 23 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
L	L	default	$\text{nmol} \cdot \text{l}^{-1}$	\square	\square
L_RF	L:RF	default	$\text{nmol} \cdot \text{l}^{-1}$	\square	\square
L_RF_C8	L:RF:C8	default	$\text{nmol} \cdot \text{l}^{-1}$	\square	\square
L_RF_FL	L:RF:FL	default	$\text{nmol} \cdot \text{l}^{-1}$	\square	\square
L_RF_FS	L:RF:FS	default	$\text{nmol} \cdot \text{l}^{-1}$	\square	\square
p43_p41	p43/p41	default	$\text{nmol} \cdot \text{l}^{-1}$	\square	\square
C3	C3	default	$\text{nmol} \cdot \text{l}^{-1}$	\square	\square
C8	C8	default	$\text{nmol} \cdot \text{l}^{-1}$	\square	\square
C8_star	C8*	default	$\text{nmol} \cdot \text{l}^{-1}$	\square	\square
C3_star	C3*	default	$\text{nmol} \cdot \text{l}^{-1}$	\square	\square
p43_FLIP	p43-FLIP	default	$\text{nmol} \cdot \text{l}^{-1}$	\square	\square
NF_kB_IkB	NF-kB:IkB	default	$\text{nmol} \cdot \text{l}^{-1}$	\square	\square
NF_kB_IkB_P	NF-kB:IkB:P	default	$\text{nmol} \cdot \text{l}^{-1}$	\square	\square
p43_FLIP_IKK_star	p43-FLIP:IKK*	default	$\text{nmol} \cdot \text{l}^{-1}$	\square	\square
NF_kB_star	NF-kB*	default	$\text{nmol} \cdot \text{l}^{-1}$	\square	\square
RF	RF	default	$\text{nmol} \cdot \text{l}^{-1}$	\square	\square
FL	FL	default	$\text{nmol} \cdot \text{l}^{-1}$	\square	\square
FS	FS	default	$\text{nmol} \cdot \text{l}^{-1}$	\square	\square
IKK	IKK	default	$\text{nmol} \cdot \text{l}^{-1}$	\square	\square
L_RF_C8_FS	L:RF:C8:FS	default	$\text{nmol} \cdot \text{l}^{-1}$	\square	\square
L_RF_FL_FL	L:RF:FL:FL	default	$\text{nmol} \cdot \text{l}^{-1}$	\square	\square
L_RF_FL_FS	L:RF:FL:FS	default	$\text{nmol} \cdot \text{l}^{-1}$	\square	\square

Id	Name	Compartment	Derived Unit	Constant	Boundary Condi- tion
L_RF_FS_FS	L:RF:FS:FS	default	$\text{nmol} \cdot \text{l}^{-1}$	<input type="checkbox"/>	<input type="checkbox"/>

5 Parameters

This model contains 17 global parameters.

Table 4: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
k1	k1		1.000		✓
k2	k2		$1.277248 \cdot 10^{-4}$		✓
k3	k3		0.669		✓
k4	k4		10^{-5}		✓
k5	k5		$5.946569 \cdot 10^{-4}$		✓
k6	k6		1.000		✓
k7	k7		0.888		✓
k8	k8		$8.044378 \cdot 10^{-4}$		✓
k9	k9		0.002		✓
k10	k10		0.121		✓
k11	k11		0.029		✓
k12	k12		0.150		✓
k13	k13		$7.204261 \cdot 10^{-4}$		✓
k14	k14		0.359		✓
k15	k15		3.684		✓
k16	k16		0.022		✓
k17	k17		0.006		✓

6 Reactions

This model contains 23 reactions. All reactions are listed in the following table and are subsequently described in detail. If a reaction is affected by a modifier, the identifier of this species is written above the reaction arrow.

Table 5: Overview of all reactions

Nº	Id	Name	Reaction Equation	SBO
1	reaction_1	reaction_1	$L + RF \longrightarrow L_RF$	0000526
2	reaction_2	reaction_2	$L_RF + C8 \longrightarrow L_RF_C8$	0000526
3	reaction_3	reaction_3	$L_RF + FL \longrightarrow L_RF_FL$	0000526
4	reaction_4	reaction_4	$L_RF + FS \longrightarrow L_RF_FS$	0000526
5	reaction_5	reaction_5	$L_RF_C8 + C8 \longrightarrow p43_p41 + p43_p41$	
6	reaction_6	reaction_6	$L_RF_C8 + FL \longrightarrow p43_FLIP$	
7	reaction_7	reaction_7	$L_RF_C8 + FS \longrightarrow L_RF_C8_FS$	0000526
8	reaction_8	reaction_8	$L_RF_FL + C8 \longrightarrow p43_FLIP$	
9	reaction_9	reaction_9	$L_RF_FL + FL \longrightarrow L_RF_FL_FL$	0000526
10	reaction_10	reaction_10	$L_RF_FL + FS \longrightarrow L_RF_FL_FS$	0000526
11	reaction_11	reaction_11	$L_RF_FS + C8 \longrightarrow L_RF_C8_FS$	0000526
12	reaction_12	reaction_12	$L_RF_FS + FL \longrightarrow L_RF_FL_FS$	0000526
13	reaction_13	reaction_13	$L_RF_FS + FS \longrightarrow L_RF_FS_FS$	0000526
14	reaction_14	reaction_14	$p43_p41 + p43_p41 \longrightarrow C8_star$	
15	reaction_15	reaction_15	$C3 + C8_star \longrightarrow C3_star + C8_star$	
16	reaction_16	reaction_16	$C8 + C3_star \longrightarrow p43_p41 + C3_star$	
17	reaction_17	reaction_17	$C8_star \longrightarrow \emptyset$	
18	reaction_18	reaction_18	$C3_star \longrightarrow \emptyset$	
19	reaction_19	reaction_19	$p43_FLIP + IKK \longrightarrow p43_FLIP_IKK_star$	0000526
20	reaction_20	reaction_20	$NF_kB_Ikb + p43_FLIP_IKK_star \longrightarrow NF_kB_Ikb_P + p43_FLIP_IKK_star$	
21	reaction_21	reaction_21	$NF_kB_Ikb_P \longrightarrow NF_kB_star$	
22	reaction_22	reaction_22	$p43_FLIP_IKK_star \longrightarrow \emptyset$	

Nº	Id	Name	Reaction Equation	SBO
23	reaction_23	reaction_23	$\text{NF_kB_star} \longrightarrow \emptyset$	

6.1 Reaction `reaction_1`

This is an irreversible reaction of two reactants forming one product.

Name `reaction_1`

SBO:0000526 protein complex formation

Reaction equation



Reactants

Table 6: Properties of each reactant.

Id	Name	SBO
L	L	
RF	RF	

Product

Table 7: Properties of each product.

Id	Name	SBO
L_RF	L:RF	

Kinetic Law

Derived unit contains undeclared units

$$v_1 = \text{vol}(\text{default}) \cdot k_1 \cdot [L] \cdot [RF] \quad (2)$$

6.2 Reaction `reaction_2`

This is an irreversible reaction of two reactants forming one product.

Name `reaction_2`

SBO:0000526 protein complex formation

Reaction equation



Reactants

Table 8: Properties of each reactant.

Id	Name	SBO
L_RF	L:RF	
C8	C8	

Product

Table 9: Properties of each product.

Id	Name	SBO
L_RF_C8	L:RF:C8	

Kinetic Law

Derived unit contains undeclared units

$$v_2 = \text{vol}(\text{default}) \cdot k_2 \cdot [\text{L_RF}] \cdot [\text{C8}] \quad (4)$$

6.3 Reaction `reaction_3`

This is an irreversible reaction of two reactants forming one product.

Name `reaction_3`

SBO:0000526 protein complex formation

Reaction equation



Reactants

Table 10: Properties of each reactant.

Id	Name	SBO
L_RF	L:RF	
FL	FL	

Product

Table 11: Properties of each product.

Id	Name	SBO
L_RF_FL	L:RF:FL	

Kinetic Law

Derived unit contains undeclared units

$$v_3 = \text{vol}(\text{default}) \cdot k_3 \cdot [\text{L_RF}] \cdot [\text{FL}] \quad (6)$$

6.4 Reaction `reaction_4`

This is an irreversible reaction of two reactants forming one product.

Name `reaction_4`

SBO:0000526 protein complex formation

Reaction equation



Reactants

Table 12: Properties of each reactant.

Id	Name	SBO
L_RF	L:RF	
FS	FS	

Product

Table 13: Properties of each product.

Id	Name	SBO
L_RF_FS	L:RF:FS	

Kinetic Law

Derived unit contains undeclared units

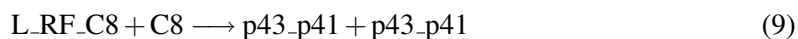
$$v_4 = \text{vol}(\text{default}) \cdot k_4 \cdot [\text{L_RF}] \cdot [\text{FS}] \quad (8)$$

6.5 Reaction `reaction_5`

This is an irreversible reaction of two reactants forming two products.

Name `reaction_5`

Reaction equation



Reactants

Table 14: Properties of each reactant.

Id	Name	SBO
L_RF_C8	L:RF:C8	
C8	C8	

Products

Table 15: Properties of each product.

Id	Name	SBO
p43_p41	p43/p41	
p43_p41	p43/p41	

Kinetic Law

Derived unit contains undeclared units

$$v_5 = \text{vol}(\text{default}) \cdot k_5 \cdot [\text{L_RF_C8}] \cdot [\text{C8}] \quad (10)$$

6.6 Reaction `reaction_6`

This is an irreversible reaction of two reactants forming one product.

Name `reaction_6`

Reaction equation



Reactants

Table 16: Properties of each reactant.

Id	Name	SBO
L_RF_C8	L:RF:C8	
FL	FL	

Product

Table 17: Properties of each product.

Id	Name	SBO
p43_FLIP	p43-FLIP	

Kinetic Law

Derived unit contains undeclared units

$$v_6 = \text{vol}(\text{default}) \cdot k_6 \cdot [\text{L_RF_C8}] \cdot [\text{FL}] \quad (12)$$

6.7 Reaction `reaction_7`

This is an irreversible reaction of two reactants forming one product.

Name `reaction_7`

SBO:0000526 protein complex formation

Reaction equation



Reactants

Table 18: Properties of each reactant.

Id	Name	SBO
L_RF_C8	L:RF:C8	
FS	FS	

Product

Table 19: Properties of each product.

Id	Name	SBO
L_RF_C8_FS	L:RF:C8:FS	

Kinetic Law

Derived unit contains undeclared units

$$v_7 = \text{vol}(\text{default}) \cdot k_7 \cdot [\text{L_RF_C8}] \cdot [\text{FS}] \quad (14)$$

6.8 Reaction `reaction_8`

This is an irreversible reaction of two reactants forming one product.

Name `reaction_8`

Reaction equation



Reactants

Table 20: Properties of each reactant.

Id	Name	SBO
L_RF_FL	L:RF:FL	
C8	C8	

Product

Table 21: Properties of each product.

Id	Name	SBO
p43_FLIP	p43-FLIP	

Kinetic Law

Derived unit contains undeclared units

$$v_8 = \text{vol}(\text{default}) \cdot k_5 \cdot [\text{L_RF_FL}] \cdot [\text{C8}] \quad (16)$$

6.9 Reaction `reaction_9`

This is an irreversible reaction of two reactants forming one product.

Name `reaction_9`

SBO:0000526 protein complex formation

Reaction equation



Reactants

Table 22: Properties of each reactant.

Id	Name	SBO
L_RF_FL	L:RF:FL	
FL	FL	

Product

Table 23: Properties of each product.

Id	Name	SBO
L_RF_FL_FL	L:RF:FL:FL	

Kinetic Law

Derived unit contains undeclared units

$$v_9 = \text{vol}(\text{default}) \cdot k_6 \cdot [\text{L_RF_FL}] \cdot [\text{FL}] \quad (18)$$

6.10 Reaction `reaction_10`

This is an irreversible reaction of two reactants forming one product.

Name `reaction_10`

SBO:0000526 protein complex formation

Reaction equation



Reactants

Table 24: Properties of each reactant.

Id	Name	SBO
L_RF_FL	L:RF:FL	
FS	FS	

Product

Table 25: Properties of each product.

Id	Name	SBO
L_RF_FL_FS	L:RF:FL:FS	

Kinetic Law

Derived unit contains undeclared units

$$v_{10} = \text{vol}(\text{default}) \cdot k_7 \cdot [\text{L_RF_FL}] \cdot [\text{FS}] \quad (20)$$

6.11 Reaction `reaction_11`

This is an irreversible reaction of two reactants forming one product.

Name `reaction_11`

SBO:0000526 protein complex formation

Reaction equation



Reactants

Table 26: Properties of each reactant.

Id	Name	SBO
L_RF_FS	L:RF:FS	
C8	C8	

Product

Table 27: Properties of each product.

Id	Name	SBO
L_RF_C8_FS	L:RF:C8:FS	

Kinetic Law

Derived unit contains undeclared units

$$v_{11} = \text{vol}(\text{default}) \cdot k_5 \cdot [\text{L_RF_FS}] \cdot [\text{C8}] \quad (22)$$

6.12 Reaction `reaction_12`

This is an irreversible reaction of two reactants forming one product.

Name `reaction_12`

SBO:0000526 protein complex formation

Reaction equation



Reactants

Table 28: Properties of each reactant.

Id	Name	SBO
L_RF_FS	L:RF:FS	
FL	FL	

Product

Table 29: Properties of each product.

Id	Name	SBO
L_RF_FL_FS	L:RF:FL:FS	

Kinetic Law

Derived unit contains undeclared units

$$v_{12} = \text{vol}(\text{default}) \cdot k_6 \cdot [\text{L_RF_FS}] \cdot [\text{FL}] \quad (24)$$

6.13 Reaction `reaction_13`

This is an irreversible reaction of two reactants forming one product.

Name `reaction_13`

SBO:0000526 protein complex formation

Reaction equation



Reactants

Table 30: Properties of each reactant.

Id	Name	SBO
L_RF_FS	L:RF:FS	
FS	FS	

Product

Table 31: Properties of each product.

Id	Name	SBO
L_RF_FS_FS	L:RF:FS:FS	

Kinetic Law

Derived unit contains undeclared units

$$v_{13} = \text{vol}(\text{default}) \cdot k_7 \cdot [\text{L_RF_FS}] \cdot [\text{FS}] \quad (26)$$

6.14 Reaction `reaction_14`

This is an irreversible reaction of two reactants forming one product.

Name `reaction_14`

Reaction equation



Reactants

Table 32: Properties of each reactant.

Id	Name	SBO
p43_p41	p43/p41	
p43_p41	p43/p41	

Product

Table 33: Properties of each product.

Id	Name	SBO
C8_star	C8*	

Kinetic Law

Derived unit contains undeclared units

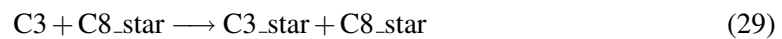
$$v_{14} = \text{vol}(\text{default}) \cdot k_8 \cdot [\text{p43_p41}] \cdot [\text{p43_p41}] \quad (28)$$

6.15 Reaction `reaction_15`

This is an irreversible reaction of two reactants forming two products.

Name `reaction_15`

Reaction equation



Reactants

Table 34: Properties of each reactant.

Id	Name	SBO
C3	C3	
C8_star	C8*	

Products

Table 35: Properties of each product.

Id	Name	SBO
C3_star	C3*	
C8_star	C8*	

Kinetic Law

Derived unit contains undeclared units

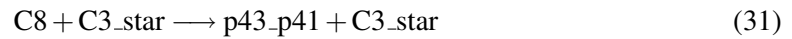
$$v_{15} = \text{vol}(\text{default}) \cdot k_9 \cdot [\text{C3}] \cdot [\text{C8_star}] \quad (30)$$

6.16 Reaction `reaction_16`

This is an irreversible reaction of two reactants forming two products.

Name `reaction_16`

Reaction equation



Reactants

Table 36: Properties of each reactant.

Id	Name	SBO
C8	C8	
C3_star	C3*	

Products

Table 37: Properties of each product.

Id	Name	SBO
p43_p41	p43/p41	
C3_star	C3*	

Kinetic Law

Derived unit contains undeclared units

$$v_{16} = \text{vol}(\text{default}) \cdot k_{10} \cdot [\text{C8}] \cdot [\text{C3_star}] \quad (32)$$

6.17 Reaction `reaction_17`

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

Name `reaction_17`

Reaction equation



Reactant

Table 38: Properties of each reactant.

Id	Name	SBO
<code>C8_star</code>	<code>C8*</code>	

Kinetic Law

Derived unit contains undeclared units

$$v_{17} = \text{vol}(\text{default}) \cdot k_{11} \cdot [\text{C8_star}] \quad (34)$$

6.18 Reaction `reaction_18`

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

Name `reaction_18`

Reaction equation



Reactant

Table 39: Properties of each reactant.

Id	Name	SBO
<code>C3_star</code>	<code>C3*</code>	

Kinetic Law

Derived unit contains undeclared units

$$v_{18} = \text{vol}(\text{default}) \cdot k_{12} \cdot [\text{C3_star}] \quad (36)$$

6.19 Reaction `reaction_19`

This is an irreversible reaction of two reactants forming one product.

Name `reaction_19`

SBO:0000526 protein complex formation

Reaction equation



Reactants

Table 40: Properties of each reactant.

Id	Name	SBO
p43_FLIP IKK	p43-FLIP IKK	

Product

Table 41: Properties of each product.

Id	Name	SBO
p43_FLIP_IKK_star	p43-FLIP:IKK*	

Kinetic Law

Derived unit contains undeclared units

$$v_{19} = \text{vol}(\text{default}) \cdot k_{13} \cdot [\text{p43_FLIP}] \cdot [\text{IKK}] \quad (38)$$

6.20 Reaction `reaction_20`

This is an irreversible reaction of two reactants forming two products.

Name `reaction_20`

Reaction equation



Reactants

Table 42: Properties of each reactant.

Id	Name	SBO
NF_kB_IkB	NF-kB:IkB	
p43_FLIP_IKK_star	p43-FLIP:IKK*	

Products

Table 43: Properties of each product.

Id	Name	SBO
NF_kB_IkB_P	NF-kB:IkB:P	
p43_FLIP_IKK_star	p43-FLIP:IKK*	

Kinetic Law

Derived unit contains undeclared units

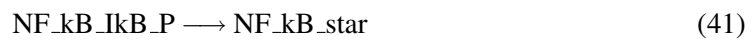
$$v_{20} = \text{vol}(\text{default}) \cdot k_{14} \cdot [\text{NF_kB_IkB}] \cdot [\text{p43_FLIP_IKK_star}] \quad (40)$$

6.21 Reaction `reaction_21`

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

Name `reaction_21`

Reaction equation



Reactant

Table 44: Properties of each reactant.

Id	Name	SBO
NF_kB_IkB_P	NF-kB:IkB:P	

Product

Table 45: Properties of each product.

Id	Name	SBO
NF_kB_star	NF-kB*	

Kinetic Law

Derived unit contains undeclared units

$$v_{21} = \text{vol}(\text{default}) \cdot k_{15} \cdot [\text{NF_kB_IkB_P}] \quad (42)$$

6.22 Reaction `reaction_22`

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

Name `reaction_22`

Reaction equation



Reactant

Table 46: Properties of each reactant.

Id	Name	SBO
p43_FLIP_IKK_star	p43-FLIP:IKK*	

Kinetic Law

Derived unit contains undeclared units

$$v_{22} = \text{vol}(\text{default}) \cdot k_{16} \cdot [\text{p43_FLIP_IKK_star}] \quad (44)$$

6.23 Reaction `reaction_23`

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

Name `reaction_23`

Reaction equation



Reactant

Table 47: Properties of each reactant.

Id	Name	SBO
NF_kB_star	NF-kB*	

Kinetic Law

Derived unit contains undeclared units

$$v_{23} = \text{vol}(\text{default}) \cdot k_{17} \cdot [\text{NF_kB_star}] \quad (46)$$

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 `spatialDimensions` > 0 for certain species.

7.1 Species L

Name L

SBO:0000245 macromolecule

Notes Initial concentration of anti-CD95 = 113.22nM is equivalent to 1500ng/ml. The model as such reproduces the figure 5D (black plot: i.e. anti-CD95=1500ng/ml).

To obtain the blue (anti-CD95=500ng/ml) and red (250ng/ml) plot of figure 5D, the model parameter [L] (initial concentration of anti-CD95 [L]) should be set as 37.74nM and 18.87nM respectively.

Initial concentration 113.22 nmol · l⁻¹

This species takes part in one reaction (as a reactant in [reaction_1](#)).

$$\frac{d}{dt}L = -v_1 \quad (47)$$

7.2 Species L_RF

Name L:RF

SBO:0000296 macromolecular complex

Initial concentration 0 nmol · l⁻¹

This species takes part in four reactions (as a reactant in [reaction_2](#), [reaction_3](#), [reaction_4](#) and as a product in [reaction_1](#)).

$$\frac{d}{dt}L_RF = v_1 - v_2 - v_3 - v_4 \quad (48)$$

7.3 Species L_RF_C8

Name L:RF:C8

SBO:0000296 macromolecular complex

Initial concentration 0 nmol · l⁻¹

This species takes part in four reactions (as a reactant in [reaction_5](#), [reaction_6](#), [reaction_7](#) and as a product in [reaction_2](#)).

$$\frac{d}{dt}L_RF_C8 = v_2 - v_5 - v_6 - v_7 \quad (49)$$

7.4 Species L_RF_FL

Name L:RF:FL

SBO:0000296 macromolecular complex

Initial concentration 0 nmol · l⁻¹

This species takes part in four reactions (as a reactant in [reaction_8](#), [reaction_9](#), [reaction_10](#) and as a product in [reaction_3](#)).

$$\frac{d}{dt}L_RF_FL = v_3 - v_8 - v_9 - v_{10} \quad (50)$$

7.5 Species L_RF_FS

Name L:RF:FS

SBO:0000296 macromolecular complex

Initial concentration 0 nmol · l⁻¹

This species takes part in four reactions (as a reactant in [reaction_11](#), [reaction_12](#), [reaction_13](#) and as a product in [reaction_4](#)).

$$\frac{d}{dt}L_RF_FS = v_4 - v_{11} - v_{12} - v_{13} \quad (51)$$

7.6 Species p43_p41

Name p43/p41

SBO:0000245 macromolecule

Initial concentration 0 nmol · l⁻¹

This species takes part in five reactions (as a reactant in [reaction_14](#), [reaction_14](#) and as a product in [reaction_5](#), [reaction_5](#), [reaction_16](#)).

$$\frac{d}{dt}p43_p41 = v_5 + v_5 + v_{16} - v_{14} - v_{14} \quad (52)$$

7.7 Species C3

Name C3

SBO:0000245 macromolecule

Initial concentration 1.443404 nmol · l⁻¹

This species takes part in one reaction (as a reactant in [reaction_15](#)).

$$\frac{d}{dt}C3 = -v_{15} \quad (53)$$

7.8 Species C8

Name C8

SBO:0000245 macromolecule

Initial concentration 64.47652 nmol · l⁻¹

This species takes part in five reactions (as a reactant in [reaction_2](#), [reaction_5](#), [reaction_8](#), [reaction_11](#), [reaction_16](#)).

$$\frac{d}{dt}C8 = -v_2 - v_5 - v_8 - v_{11} - v_{16} \quad (54)$$

7.9 Species C8_star

Name C8*

SBO:0000245 macromolecule

Initial concentration 0 nmol · l⁻¹

This species takes part in four reactions (as a reactant in [reaction_15](#), [reaction_17](#) and as a product in [reaction_14](#), [reaction_15](#)).

$$\frac{d}{dt}C8_star = v_{14} + v_{15} - v_{15} - v_{17} \quad (55)$$

7.10 Species C3_star

Name C3*

SBO:0000245 macromolecule

Initial concentration 0 nmol · l⁻¹

This species takes part in four reactions (as a reactant in [reaction_16](#), [reaction_18](#) and as a product in [reaction_15](#), [reaction_16](#)).

$$\frac{d}{dt}C3_star = v_{15} + v_{16} - v_{16} - v_{18} \quad (56)$$

7.11 Species p43_FLIP

Name p43-FLIP

SBO:0000245 macromolecule

Initial concentration 0 nmol · l⁻¹

This species takes part in three reactions (as a reactant in [reaction_19](#) and as a product in [reaction_6](#), [reaction_8](#)).

$$\frac{d}{dt}p43_FLIP = v_6 + v_8 - v_{19} \quad (57)$$

7.12 Species NF_kB_IkB

Name NF-kB:IkB

SBO:0000296 macromolecular complex

Initial concentration 4.739546 nmol · l⁻¹

This species takes part in one reaction (as a reactant in [reaction_20](#)).

$$\frac{d}{dt}NF_kB_IkB = -v_{20} \quad (58)$$

7.13 Species NF_kB_IkB_P

Name NF-kB:IkB:P

SBO:0000296 macromolecular complex

Initial concentration 0 nmol · l⁻¹

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

$$\frac{d}{dt}NF_kB_IkB_P = v_{20} - v_{21} \quad (59)$$

7.14 Species `p43_FLIP_IKK_star`

Name `p43-FLIP:IKK*`

SBO:0000296 macromolecular complex

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

This species takes part in four reactions (as a reactant in [reaction_20](#), [reaction_22](#) and as a product in [reaction_19](#), [reaction_20](#)).

$$\frac{d}{dt} \text{p43_FLIP_IKK_star} = v_{19} + v_{20} - v_{20} - v_{22} \quad (60)$$

7.15 Species `NF_kB_star`

Name `NF-kB*`

SBO:0000245 macromolecule

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

This species takes part in two reactions (as a reactant in [reaction_23](#) and as a product in [reaction_21](#)).

$$\frac{d}{dt} \text{NF_kB_star} = v_{21} - v_{23} \quad (61)$$

7.16 Species `RF`

Name `RF`

SBO:0000296 macromolecular complex

Initial concentration $91.26592 \text{ nmol} \cdot \text{l}^{-1}$

This species takes part in one reaction (as a reactant in [reaction_1](#)).

$$\frac{d}{dt} \text{RF} = -v_1 \quad (62)$$

7.17 Species `FL`

Name `FL`

SBO:0000245 macromolecule

Initial concentration $7.398562 \text{ nmol} \cdot \text{l}^{-1}$

This species takes part in four reactions (as a reactant in [reaction_3](#), [reaction_6](#), [reaction_9](#), [reaction_12](#)).

$$\frac{d}{dt} \text{FL} = -v_3 - v_6 - v_9 - v_{12} \quad (63)$$

7.18 Species FS

Name FS

SBO:0000245 macromolecule

Initial concentration 5.083923 nmol · l⁻¹

This species takes part in four reactions (as a reactant in [reaction_4](#), [reaction_7](#), [reaction_10](#), [reaction_13](#)).

$$\frac{d}{dt}FS = -v_4 - v_7 - v_{10} - v_{13} \quad (64)$$

7.19 Species IKK

Name IKK

SBO:0000245 macromolecule

Initial concentration 5.772825 nmol · l⁻¹

This species takes part in one reaction (as a reactant in [reaction_19](#)).

$$\frac{d}{dt}IKK = -v_{19} \quad (65)$$

7.20 Species L_RF_C8_FS

Name L:RF:C8:FS

SBO:0000296 macromolecular complex

Initial concentration 0 nmol · l⁻¹

This species takes part in two reactions (as a product in [reaction_7](#), [reaction_11](#)).

$$\frac{d}{dt}L_RF_C8_FS = v_7 + v_{11} \quad (66)$$

7.21 Species L_RF_FL_FL

Name L:RF:FL:FL

SBO:0000296 macromolecular complex

Initial concentration 0 nmol · l⁻¹

This species takes part in one reaction (as a product in [reaction_9](#)).

$$\frac{d}{dt}L_RF_FL_FL = v_9 \quad (67)$$

7.22 Species L_RF_FL_FS

Name L:RF:FL:FS

SBO:0000296 macromolecular complex

Initial concentration 0 nmol · l⁻¹

This species takes part in two reactions (as a product in [reaction_10](#), [reaction_12](#)).

$$\frac{d}{dt}L_RF_FL_FS = v_{10} + v_{12} \quad (68)$$

7.23 Species L_RF_FS_FS

Name L:RF:FS:FS

SBO:0000296 macromolecular complex

Initial concentration 0 nmol · l⁻¹

This species takes part in one reaction (as a product in [reaction_13](#)).

$$\frac{d}{dt}L_RF_FS_FS = v_{13} \quad (69)$$

A Glossary of Systems Biology Ontology Terms

SBO:0000245 macromolecule: Molecular entity mainly built-up by the repetition of pseudo-identical units. CHEBI:3383

SBO:0000296 macromolecular complex: Non-covalent complex of one or more macromolecules and zero or more simple chemicals

SBO:0000526 protein complex formation: The process by which two or more proteins interact non-covalently to form a protein complex (SBO:0000297)

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