SBML Model Report

Model name: “Brown2004 - NGF and EGF signaling”

May 6, 2016

1 General Overview

This is a document in SBML Level 2 Version 1 format. This model was created by the following two authors: Nicolas Le Novre[1] and Ryan Gutenkunst[2] at June tenth 2005 at 2:09 p. m. and last time modified at May 18th 2015 at 10:58 a. m. Table 1 provides an overview of the quantities of all components of this model.

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

Element	Quantity	Element	Quantity
compartment types	0	compartments	1
species types	0	species	32
events	0	constraints	0
reactions	26	function definitions	0
global parameters	48	unit definitions	2
rules	0	initial assignments	0

Model Notes

Brown2004 - NGF and EGF signaling

This model is described in the article:The statistical mechanics of complex signaling networks: nerve growth factor signaling.Brown KS, Hill CC, Calero GA, Myers CR, Lee KH, Sethna JP, Cerione RA.Phys Biol 2004 Dec; 1(3-4): 184-195

[1]EMBL-EBI, lenov@ebi.ac.uk
[2]Cornell University, rng7@cornell.edu

Abstract:

The inherent complexity of cellular signaling networks and their importance to a wide range of cellular functions necessitates the development of modeling methods that can be applied toward making predictions and highlighting the appropriate experiments to test our understanding of how these systems are designed and function. We use methods of statistical mechanics to extract useful predictions for complex cellular signaling networks. A key difficulty with signaling models is that, while significant effort is being made to experimentally measure the rate constants for individual steps in these networks, many of the parameters required to describe their behavior remain unknown or at best represent estimates. To establish the usefulness of our approach, we have applied our methods toward modeling the nerve growth factor (NGF)-induced differentiation of neuronal cells. In particular, we study the actions of NGF and mitogenic epidermal growth factor (EGF) in rat pheochromocytoma (PC12) cells. Through a network of intermediate signaling proteins, each of these growth factors stimulates extracellular regulated kinase (Erk) phosphorylation with distinct dynamical profiles. Using our modeling approach, we are able to predict the influence of specific signaling modules in determining the integrated cellular response to the two growth factors. Our methods also raise some interesting insights into the design and possible evolution of cellular systems, highlighting an inherent property of these systems that we call 'sloppiness.'
The figures in the paper show results from computationsperformed over an ensemble of all parameter sets that fit theavailable data. This file contains only the best fit parameters.The full ensemble of parameters is available athttp://www.lassp.cornell.edu/sethna/GeneDynamics/PC12DataFiles/(Also, the best-fit parameter set produces a curve for DN Rap1 thatis less „peakish„ than the ensemble average.)

The conversion factors for EGF and NGF concentrations accountfor their molecular weights and the density of cells in the culturedish. These concentrations are saturating, so the exact values arenot critical.

Because the Erk data fit to measure only fold changes inactivity, there is no absolute scale for the y-axes. Thus thecurves from this file have different magnitudes than thosepublished.

To reproduce the figures from the paper:
2a) For EGF stimulation, set the initial concentration of EGFto 100 ng/ml * 100020 (molecule/cell)/(ng/ml) = 10002000.
For NGF stimulation, set the initial concentration of NGF to50 ng/ml * 4560 (molecule/cell)/(ng/ml) = 456000
5a) To simulate LY294002 addition, set kPI3KRas and kPI3K to0.
5b) To simulate a dominant negative Rap1, set kRap1ToBRaf to0.
To simulate a dominant negative Ras, set kRasToRaf1 andkPI3KRas to 0.

Almost all the data fit with this model by the authors arefrom Western blots. Given the uncertainties in antibodyeffectiveness and other factors, one can't a priori derive aconversion between the arbitrary units for a given set of data andmolecules per cell. So the authors used an adjustable

„scalefactor„ that converts between molecules per cell and Western blotunits.

For the EGF stimulation data in figure 2a) the scale factorconversion is 1.414e-05 (U/mg)/(molecule/cell). For the NGFstimulation data in figure 2a) it is 7.135e-06(U/mg)/(molecule/cell).

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 item (default)

Definition item

2.2 Unit `time`

Name minute (default)

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 Compartment

This model contains one compartment.

Table 2: Properties of all compartments.

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

3.1 Compartment `cell`

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

4 Species

This model contains 32 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
EGF		cell	item · l^{-1}	☐	☐
NGF		cell	item · l^{-1}	☐	☐
freeEGFReceptor		cell	item · l^{-1}	☐	☐
boundEGFReceptor		cell	item · l^{-1}	☐	☐
freeNGFReceptor		cell	item · l^{-1}	☐	☐
boundNGFReceptor		cell	item · l^{-1}	☐	☐
SosInactive		cell	item · l^{-1}	☐	☐
SosActive		cell	item · l^{-1}	☐	☐
P90RskInactive		cell	item · l^{-1}	☐	☐
P90RskActive		cell	item · l^{-1}	☐	☐
RasInactive		cell	item · l^{-1}	☐	☐
RasActive		cell	item · l^{-1}	☐	☐
RasGapActive		cell	item · l^{-1}	☑	☐
Raf1Inactive		cell	item · l^{-1}	☐	☐
Raf1Active		cell	item · l^{-1}	☐	☐
BRafInactive		cell	item · l^{-1}	☐	☐
BRafActive		cell	item · l^{-1}	☐	☐
MekInactive		cell	item · l^{-1}	☐	☐
MekActive		cell	item · l^{-1}	☐	☐
ErkInactive		cell	item · l^{-1}	☐	☐
ErkActive		cell	item · l^{-1}	☐	☐
PI3KInactive		cell	item · l^{-1}	☐	☐

Id	Name	Compartment	Derived Unit	Constant	Boundary Condition
PI3KActive		cell	$\mathrm{item} \cdot \mathrm{l}^{-1}$	☐	☐
AktInactive		cell	$\mathrm{item} \cdot \mathrm{l}^{-1}$	☐	☐
AktActive		cell	$\mathrm{item} \cdot \mathrm{l}^{-1}$	☐	☐
C3GInactive		cell	$\mathrm{item} \cdot \mathrm{l}^{-1}$	☐	☐
C3GActive		cell	$\mathrm{item} \cdot \mathrm{l}^{-1}$	☐	☐
Rap1Inactive		cell	$\mathrm{item} \cdot \mathrm{l}^{-1}$	☐	☐
Rap1Active		cell	$\mathrm{item} \cdot \mathrm{l}^{-1}$	☐	☐
RapGapActive		cell	$\mathrm{item} \cdot \mathrm{l}^{-1}$	☑	☐
PP2AActive		cell	$\mathrm{item} \cdot \mathrm{l}^{-1}$	☑	☐
Raf1PPtase		cell	$\mathrm{item} \cdot \mathrm{l}^{-1}$	☑	☐

5 Parameters

This model contains 48 global parameters.

Table 4: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
krbEGF			$2.18503 \cdot 10^{-5}$		☑
kruEGF			0.012		☑
krbNGF			$1.38209 \cdot 10^{-7}$		☑
kruNGF			0.007		☑
kEGF			694.731		☑
KmEGF			6086070.000		☑
kNGF			389.428		☑
KmNGF			2112.660		☑
kdSos			1611.970		☑
KmdSos			896896.000		☑
kSos			32.344		☑
KmSos			35954.300		☑
kRasGap			1509.360		☑
KmRasGap			1432410.000		☑
kRasToRaf1			0.884		☑
KmRasToRaf1			62464.600		☑
kpRaf1			185.759		☑
KmpRaf1			4768350.000		☑
kpBRaf			125.089		☑
KmpBRaf			157948.000		☑
kdMek			2.832		☑
KmdMek			518753.000		☑
kpMekCytoplasmic			9.854		☑
KmpMekCytoplasmic			1007340.000		☑
kdErk			8.891		☑
KmdErk			3496490.000		☑
kpP90Rsk			0.021		☑
KmpP90Rsk			763523.000		☑
kPI3K			10.674		☑
KmPI3K			184912.000		☑
kPI3KRas			0.077		☑
KmPI3KRas			272056.000		☑
kAkt			0.057		☑
KmAkt			653951.000		☑
kdRaf1ByAkt			15.121		☑
KmRaf1ByAkt			119355.000		☑
kC3GNGF			146.912		☑

Id	Name	SBO	Value	Unit	Constant
KmC3GNGF			12876.200		☑
kC3G			1.401		☑
KmC3G			10965.600		☑
kRapGap			27.265		☑
KmRapGap			295990.000		☑
kRap1ToBRaf			2.210		☑
KmRap1ToBRaf			1025460.000		☑
kdRaf1			0.126		☑
KmdRaf1			1061.710		☑
kdBRaf			441.287		☑
KmdBRaf			$1.08795 \cdot 10^{7}$		☑

6 Reactions

This model contains 26 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	EGFBindingReaction	EGF binding	$EGF + freeEGFReceptor \longrightarrow boundEGFReceptor$	
2	EGFUnbindingReaction	EGF unbinding	$boundEGFReceptor \longrightarrow EGF + freeEGFReceptor$	
3	NGFBindingReaction	NGF binding	$NGF + freeNGFReceptor \longrightarrow boundNGFReceptor$	
4	NGFUnbindingReaction	NGF unbinding	$boundNGFReceptor \longrightarrow NGF + freeNGFReceptor$	
5	SosActivationByEGFReaction	SOS activation by EGF	$SosInactive \xrightleftharpoons{boundEGFReceptor} SosActive$	
6	SosActivationByNGFReaction	SOS activation by NGF	$SosInactive \xrightleftharpoons{boundNGFReceptor} SosActive$	
7	SosDeactivationReaction	SOS deactivation	$SosActive \xrightleftharpoons{P90RskActive} SosInactive$	
8	RasActivationReaction	Ras activation	$RasInactive \xrightleftharpoons{SosActive} RasActive$	
9	RasDeactivationReaction	Ras deactivation	$RasActive \xrightleftharpoons{RasGapActive} RasInactive$	
10	Raf1ByRasActivationReaction	Raf1 activation by Ras	$Raf1Inactive \xrightleftharpoons{RasActive} Raf1Active$	
11	MekbyRaf1ActivationReaction	Mek activation by Raf1	$MekInactive \xrightleftharpoons{Raf1Active} MekActive$	
12	MekbyBRafActivationReaction	Mek activation by B-Raf	$MekInactive \xrightleftharpoons{BRafActive} MekActive$	
13	ErkActivationReaction	Erk activation	$ErkInactive \xrightleftharpoons{MekActive} ErkActive$	
14	MekDeactivationReaction	Mek deactivation	$MekActive \xrightleftharpoons{PP2AActive} MekInactive$	
15	ErkDeactivationReaction	Erk deactivation	$ErkActive \xrightleftharpoons{PP2AActive} ErkInactive$	
16	Raf1byPPtaseDeactivationReaction	Raf1 deactivation by PPase	$Raf1Active \xrightleftharpoons{Raf1PPtase} Raf1Inactive$	

№	Id	Name	Reaction Equation	SBO
17	P90RskActivationReaction	P90Rsk activation	P90RskInactive $\xrightleftharpoons{\text{ErkActive}}$ P90RskActive	
18	PI3KbyEGFRActivationReaction	PI3K activation by EGFR	PI3KInactive $\xrightleftharpoons{\text{boundEGFReceptor}}$ PI3KActive	
19	PI3KbyRasActivationReaction	PI3K activation by Ras	PI3KInactive $\xrightleftharpoons{\text{RasActive}}$ PI3KActive	
20	AktActivationReaction	Akt activation	AktInactive $\xrightleftharpoons{\text{PI3KActive}}$ AktActive	
21	Raf1ByAktDeactivationReaction	Raf1 deactivation by Akt	Raf1Active $\xrightleftharpoons{\text{AktActive}}$ Raf1Inactive	
22	C3GActivationReaction	C3G activation	C3GInactive $\xrightleftharpoons{\text{boundNGFReceptor}}$ C3GActive	
23	Rap1ActivationReaction	Rap1 activation	Rap1Inactive $\xrightleftharpoons{\text{C3GActive}}$ Rap1Active	
24	Rap1DeactivationReaction	Rap1 deactivation	Rap1Active $\xrightleftharpoons{\text{RapGapActive}}$ Rap1Inactive	
25	BRafByRap1ActivationReaction	BRaf activation by Rap1	BRafInactive $\xrightleftharpoons{\text{Rap1Active}}$ BRafActive	
26	BRafbyPPtaseDeactivationReaction	BRaf deactivation by PPase	BRafActive $\xrightleftharpoons{\text{Raf1PPtase}}$ BRafInactive	

6.1 Reaction EGFBindingReaction

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

Name EGF binding

Reaction equation

$$\mathrm{EGF} + \mathrm{freeEGFReceptor} \longrightarrow \mathrm{boundEGFReceptor} \tag{1}$$

Reactants

Table 6: Properties of each reactant.

Id	Name	SBO
EGF		
freeEGFReceptor		

Product

Table 7: Properties of each product.

Id	Name	SBO
boundEGFReceptor		

Kinetic Law

Derived unit contains undeclared units

$$v_1 = \mathrm{vol}\,(\mathrm{cell}) \cdot \mathrm{krbEGF} \cdot [\mathrm{EGF}] \cdot [\mathrm{freeEGFReceptor}] \tag{2}$$

6.2 Reaction EGFUnbindingReaction

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

Name EFG unbinding

Reaction equation

$$\mathrm{boundEGFReceptor} \longrightarrow \mathrm{EGF} + \mathrm{freeEGFReceptor} \tag{3}$$

Reactant

Table 8: Properties of each reactant.

Id	Name	SBO
boundEGFReceptor		

Products

Table 9: Properties of each product.

Id	Name	SBO
EGF		
freeEGFReceptor		

Kinetic Law

Derived unit contains undeclared units

$$v_2 = \mathrm{vol}\,(\mathrm{cell}) \cdot \mathrm{kruEGF} \cdot [\mathrm{boundEGFReceptor}] \tag{4}$$

6.3 Reaction NGFBindingReaction

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

Name NGF binding

Reaction equation

$$\mathrm{NGF} + \mathrm{freeNGFReceptor} \longrightarrow \mathrm{boundNGFReceptor} \tag{5}$$

Reactants

Table 10: Properties of each reactant.

Id	Name	SBO
NGF		
freeNGFReceptor		

Product

Table 11: Properties of each product.

Id	Name	SBO
boundNGFReceptor		

Kinetic Law

Derived unit contains undeclared units

$$v_3 = \text{krbNGF} \cdot [\text{NGF}] \cdot [\text{freeNGFReceptor}] \cdot \text{vol}(\text{cell}) \tag{6}$$

6.4 Reaction NGFUnbindingReaction

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

Name NGF unbinding

Reaction equation

$$\text{boundNGFReceptor} \longrightarrow \text{NGF} + \text{freeNGFReceptor} \tag{7}$$

Reactant

Table 12: Properties of each reactant.

Id	Name	SBO
boundNGFReceptor		

Products

Table 13: Properties of each product.

Id	Name	SBO
NGF		
freeNGFReceptor		

Kinetic Law

Derived unit contains undeclared units

$$v_4 = \text{kruNGF} \cdot [\text{boundNGFReceptor}] \cdot \text{vol}(\text{cell}) \tag{8}$$

6.5 Reaction SosActivationByEGFReaction

This is a reversible reaction of one reactant forming one product influenced by one modifier.

Name SOS activation by EGF

Reaction equation

$$\text{SosInactive} \overset{\text{boundEGFReceptor}}{\rightleftharpoons} \text{SosActive} \tag{9}$$

Reactant

Table 14: Properties of each reactant.

Id	Name	SBO
SosInactive		

Modifier

Table 15: Properties of each modifier.

Id	Name	SBO
boundEGFReceptor		

Product

Table 16: Properties of each product.

Id	Name	SBO
SosActive		

Kinetic Law

Derived unit contains undeclared units

$$v_5 = \text{vol}\,(\text{cell}) \cdot \frac{\text{kEGF} \cdot [\text{boundEGFReceptor}] \cdot [\text{SosInactive}]}{[\text{SosInactive}] + \text{KmEGF}} \tag{10}$$

6.6 Reaction SosActivationByNGFReaction

This is a reversible reaction of one reactant forming one product influenced by one modifier.

Name SOS activation by NGF

Reaction equation

$$\text{SosInactive} \xrightleftharpoons{\text{boundNGFReceptor}} \text{SosActive} \tag{11}$$

Reactant

Table 17: Properties of each reactant.

Id	Name	SBO
SosInactive		

Modifier

Table 18: Properties of each modifier.

Id	Name	SBO
boundNGFReceptor		

Product

Table 19: Properties of each product.

Id	Name	SBO
SosActive		

Kinetic Law

Derived unit contains undeclared units

$$v_6 = \text{vol}\,(\text{cell}) \cdot \frac{\text{kNGF} \cdot [\text{boundNGFReceptor}] \cdot [\text{SosInactive}]}{[\text{SosInactive}] + \text{KmNGF}} \tag{12}$$

6.7 Reaction SosDeactivationReaction

This is a reversible reaction of one reactant forming one product influenced by one modifier.

Name SOS deactivation

Reaction equation

$$\text{SosActive} \xrightleftharpoons{\text{P90RskActive}} \text{SosInactive} \tag{13}$$

Reactant

Table 20: Properties of each reactant.

Id	Name	SBO
SosActive		

Modifier

Table 21: Properties of each modifier.

Id	Name	SBO
P90RskActive		

Product

Table 22: Properties of each product.

Id	Name	SBO
SosInactive		

Kinetic Law

Derived unit contains undeclared units

$$v_7 = \mathrm{vol}\,(\mathrm{cell}) \cdot \frac{\mathrm{kdSos} \cdot [\mathrm{P90RskActive}] \cdot [\mathrm{SosActive}]}{[\mathrm{SosActive}] + \mathrm{KmdSos}} \tag{14}$$

6.8 Reaction RasActivationReaction

This is a reversible reaction of one reactant forming one product influenced by one modifier.

Name Ras activation

Reaction equation

$$\mathrm{RasInactive} \underset{}{\overset{\mathrm{SosActive}}{\rightleftharpoons}} \mathrm{RasActive} \tag{15}$$

Reactant

Table 23: Properties of each reactant.

Id	Name	SBO
RasInactive		

Modifier

Table 24: Properties of each modifier.

Id	Name	SBO
SosActive		

Product

Table 25: Properties of each product.

Id	Name	SBO
RasActive		

Kinetic Law

Derived unit contains undeclared units

$$v_8 = \mathrm{vol}\,(\mathrm{cell}) \cdot \frac{\mathrm{kSos} \cdot [\mathrm{SosActive}] \cdot [\mathrm{RasInactive}]}{[\mathrm{RasInactive}] + \mathrm{KmSos}} \tag{16}$$

6.9 Reaction RasDeactivationReaction

This is a reversible reaction of one reactant forming one product influenced by one modifier.

Name Ras deactivation

Reaction equation

$$\mathrm{RasActive} \underset{}{\overset{\mathrm{RasGapActive}}{\rightleftharpoons}} \mathrm{RasInactive} \tag{17}$$

Reactant

Table 26: Properties of each reactant.

Id	Name	SBO
RasActive		

Modifier

Table 27: Properties of each modifier.

Id	Name	SBO
RasGapActive		

Product

Table 28: Properties of each product.

Id	Name	SBO
RasInactive		

Kinetic Law

Derived unit contains undeclared units

$$v_9 = \mathrm{vol}\,(\mathrm{cell}) \cdot \frac{\mathrm{kRasGap} \cdot [\mathrm{RasGapActive}] \cdot [\mathrm{RasActive}]}{[\mathrm{RasActive}] + \mathrm{KmRasGap}} \tag{18}$$

6.10 Reaction Raf1ByRasActivationReaction

This is a reversible reaction of one reactant forming one product influenced by one modifier.

Name Raf1 activation by Ras

Reaction equation

$$\mathrm{Raf1Inactive} \xrightleftharpoons{\mathrm{RasActive}} \mathrm{Raf1Active} \tag{19}$$

Reactant

Table 29: Properties of each reactant.

Id	Name	SBO
Raf1Inactive		

Modifier

Table 30: Properties of each modifier.

Id	Name	SBO
RasActive		

Product

Table 31: Properties of each product.

Id	Name	SBO
Raf1Active		

Kinetic Law

Derived unit contains undeclared units

$$v_{10} = \mathrm{vol}\,(\mathrm{cell}) \cdot \frac{\mathrm{kRasToRaf1} \cdot [\mathrm{RasActive}] \cdot [\mathrm{Raf1Inactive}]}{[\mathrm{Raf1Inactive}] + \mathrm{KmRasToRaf1}} \tag{20}$$

6.11 Reaction MekbyRaf1ActivationReaction

This is a reversible reaction of one reactant forming one product influenced by one modifier.

Name Mek activation by Raf1

Reaction equation

$$\mathrm{MekInactive} \xrightleftharpoons{\mathrm{Raf1Active}} \mathrm{MekActive} \tag{21}$$

Reactant

Table 32: Properties of each reactant.

Id	Name	SBO
MekInactive		

Modifier

Table 33: Properties of each modifier.

Id	Name	SBO
Raf1Active		

Product

Table 34: Properties of each product.

Id	Name	SBO
MekActive		

Kinetic Law

Derived unit contains undeclared units

$$v_{11} = \mathrm{vol}\,(\mathrm{cell}) \cdot \frac{\mathrm{kpRaf1} \cdot [\mathrm{Raf1Active}] \cdot [\mathrm{MekInactive}]}{[\mathrm{MekInactive}] + \mathrm{KmpRaf1}} \tag{22}$$

6.12 Reaction MekbyBRafActivationReaction

This is a reversible reaction of one reactant forming one product influenced by one modifier.

Name Mek activation by B-Raf

Reaction equation

$$\mathrm{MekInactive} \xrightleftharpoons{\mathrm{BRafActive}} \mathrm{MekActive} \tag{23}$$

Reactant

Table 35: Properties of each reactant.

Id	Name	SBO
MekInactive		

Modifier

Table 36: Properties of each modifier.

Id	Name	SBO
BRafActive		

Product

Table 37: Properties of each product.

Id	Name	SBO
MekActive		

Kinetic Law

Derived unit contains undeclared units

$$v_{12} = \mathrm{vol}\,(\mathrm{cell}) \cdot \frac{\mathrm{kpBRaf} \cdot [\mathrm{BRafActive}] \cdot [\mathrm{MekInactive}]}{[\mathrm{MekInactive}] + \mathrm{KmpBRaf}} \tag{24}$$

6.13 Reaction ErkActivationReaction

This is a reversible reaction of one reactant forming one product influenced by one modifier.

Name Erk activation

Reaction equation

$$\mathrm{ErkInactive} \xrightleftharpoons{\mathrm{MekActive}} \mathrm{ErkActive} \tag{25}$$

Reactant

Table 38: Properties of each reactant.

Id	Name	SBO
ErkInactive		

Modifier

Table 39: Properties of each modifier.

Id	Name	SBO
MekActive		

Product

Table 40: Properties of each product.

Id	Name	SBO
ErkActive		

Kinetic Law

Derived unit contains undeclared units

$$v_{13} = \mathrm{vol}\,(\mathrm{cell}) \cdot \frac{\mathrm{kpMekCytoplasmic} \cdot [\mathrm{MekActive}] \cdot [\mathrm{ErkInactive}]}{[\mathrm{ErkInactive}] + \mathrm{KmpMekCytoplasmic}} \tag{26}$$

6.14 Reaction MekDeactivationReaction

This is a reversible reaction of one reactant forming one product influenced by one modifier.

Name Mek deactivation

Reaction equation

$$\mathrm{MekActive} \xrightleftharpoons{\mathrm{PP2AActive}} \mathrm{MekInactive} \tag{27}$$

Reactant

Table 41: Properties of each reactant.

Id	Name	SBO
MekActive		

Modifier

Table 42: Properties of each modifier.

Id	Name	SBO
PP2AActive		

Product

Table 43: Properties of each product.

Id	Name	SBO
MekInactive		

Kinetic Law

Derived unit contains undeclared units

$$v_{14} = \mathrm{vol}\,(\mathrm{cell}) \cdot \frac{\mathrm{kdMek} \cdot [\mathrm{PP2AActive}] \cdot [\mathrm{MekActive}]}{[\mathrm{MekActive}] + \mathrm{KmdMek}} \tag{28}$$

6.15 Reaction ErkDeactivationReaction

This is a reversible reaction of one reactant forming one product influenced by one modifier.

Name Erk deactivation

Reaction equation

$$\mathrm{ErkActive} \overset{\mathrm{PP2AActive}}{\rightleftharpoons} \mathrm{ErkInactive} \tag{29}$$

Reactant

Table 44: Properties of each reactant.

Id	Name	SBO
ErkActive		

Modifier

Table 45: Properties of each modifier.

Id	Name	SBO
PP2AActive		

Product

Table 46: Properties of each product.

Id	Name	SBO
ErkInactive		

Kinetic Law

Derived unit contains undeclared units

$$v_{15} = \mathrm{vol}\,(\mathrm{cell}) \cdot \frac{\mathrm{kdErk} \cdot [\mathrm{PP2AActive}] \cdot [\mathrm{ErkActive}]}{[\mathrm{ErkActive}] + \mathrm{KmdErk}} \tag{30}$$

6.16 Reaction Raf1byPPtaseDeactivationReaction

This is a reversible reaction of one reactant forming one product influenced by one modifier.

Name Raf1 deactivation by PPase

Reaction equation

$$\mathrm{Raf1Active} \underset{}{\overset{\mathrm{Raf1PPtase}}{\rightleftharpoons}} \mathrm{Raf1Inactive} \tag{31}$$

Reactant

Table 47: Properties of each reactant.

Id	Name	SBO
Raf1Active		

Modifier

Table 48: Properties of each modifier.

Id	Name	SBO
Raf1PPtase		

Product

Table 49: Properties of each product.

Id	Name	SBO
Raf1Inactive		

Kinetic Law

Derived unit contains undeclared units

$$v_{16} = \mathrm{vol}(\mathrm{cell}) \cdot \frac{\mathrm{kdRaf1} \cdot [\mathrm{Raf1PPtase}] \cdot [\mathrm{Raf1Active}]}{[\mathrm{Raf1Active}] + \mathrm{KmdRaf1}} \tag{32}$$

6.17 Reaction P90RskActivationReaction

This is a reversible reaction of one reactant forming one product influenced by one modifier.

Name P90Rsk activation

Reaction equation

$$\mathrm{P90RskInactive} \xrightleftharpoons{\mathrm{ErkActive}} \mathrm{P90RskActive} \tag{33}$$

Reactant

Table 50: Properties of each reactant.

Id	Name	SBO
P90RskInactive		

Modifier

Table 51: Properties of each modifier.

Id	Name	SBO
ErkActive		

Product

Table 52: Properties of each product.

Id	Name	SBO
P90RskActive		

Kinetic Law

Derived unit contains undeclared units

$$v_{17} = \mathrm{vol}\,(\mathrm{cell}) \cdot \frac{\mathrm{kpP90Rsk} \cdot [\mathrm{ErkActive}] \cdot [\mathrm{P90RskInactive}]}{[\mathrm{P90RskInactive}] + \mathrm{KmpP90Rsk}} \tag{34}$$

6.18 Reaction PI3KbyEGFRActivationReaction

This is a reversible reaction of one reactant forming one product influenced by one modifier.

Name PI3K activation by EGFR

Reaction equation

$$\mathrm{PI3KInactive} \underset{}{\overset{\mathrm{boundEGFReceptor}}{\rightleftharpoons}} \mathrm{PI3KActive} \tag{35}$$

Reactant

Table 53: Properties of each reactant.

Id	Name	SBO
PI3KInactive		

Modifier

Table 54: Properties of each modifier.

Id	Name	SBO
boundEGFReceptor		

Product

Table 55: Properties of each product.

Id	Name	SBO
PI3KActive		

Kinetic Law

Derived unit contains undeclared units

$$v_{18} = \mathrm{vol}\,(\mathrm{cell}) \cdot \frac{\mathrm{kPI3K} \cdot [\mathrm{boundEGFReceptor}] \cdot [\mathrm{PI3KInactive}]}{[\mathrm{PI3KInactive}] + \mathrm{KmPI3K}} \tag{36}$$

6.19 Reaction PI3KbyRasActivationReaction

This is a reversible reaction of one reactant forming one product influenced by one modifier.

Name PI3K activation by Ras

Reaction equation

$$\mathrm{PI3KInactive} \overset{\mathrm{RasActive}}{\rightleftharpoons} \mathrm{PI3KActive} \tag{37}$$

Reactant

Table 56: Properties of each reactant.

Id	Name	SBO
PI3KInactive		

Modifier

Table 57: Properties of each modifier.

Id	Name	SBO
RasActive		

Product

Table 58: Properties of each product.

Id	Name	SBO
PI3KActive		

Kinetic Law

Derived unit contains undeclared units

$$v_{19} = \mathrm{vol}\,(\mathrm{cell}) \cdot \frac{\mathrm{kPI3KRas} \cdot [\mathrm{RasActive}] \cdot [\mathrm{PI3KInactive}]}{[\mathrm{PI3KInactive}] + \mathrm{KmPI3KRas}} \tag{38}$$

6.20 Reaction AktActivationReaction

This is a reversible reaction of one reactant forming one product influenced by one modifier.

Name Akt activation

Reaction equation

$$\mathrm{AktInactive} \xrightleftharpoons{\mathrm{PI3KActive}} \mathrm{AktActive} \tag{39}$$

Reactant

Table 59: Properties of each reactant.

Id	Name	SBO
AktInactive		

Modifier

Table 60: Properties of each modifier.

Id	Name	SBO
PI3KActive		

Product

Table 61: Properties of each product.

Id	Name	SBO
AktActive		

Kinetic Law

Derived unit contains undeclared units

$$v_{20} = \mathrm{vol}\,(\mathrm{cell}) \cdot \frac{\mathrm{kAkt} \cdot [\mathrm{PI3KActive}] \cdot [\mathrm{AktInactive}]}{[\mathrm{AktInactive}] + \mathrm{KmAkt}} \tag{40}$$

6.21 Reaction Raf1ByAktDeactivationReaction

This is a reversible reaction of one reactant forming one product influenced by one modifier.

Name Raf1 deactivation by Akt

Reaction equation

$$\mathrm{Raf1Active} \overset{\mathrm{AktActive}}{\rightleftharpoons} \mathrm{Raf1Inactive} \tag{41}$$

Reactant

Table 62: Properties of each reactant.

Id	Name	SBO
Raf1Active		

Modifier

Table 63: Properties of each modifier.

Id	Name	SBO
AktActive		

Product

Table 64: Properties of each product.

Id	Name	SBO
Raf1Inactive		

Kinetic Law

Derived unit contains undeclared units

$$v_{21} = \mathrm{vol}\,(\mathrm{cell}) \cdot \frac{\mathrm{kdRaf1ByAkt} \cdot [\mathrm{AktActive}] \cdot [\mathrm{Raf1Active}]}{[\mathrm{Raf1Active}] + \mathrm{KmRaf1ByAkt}} \tag{42}$$

6.22 Reaction C3GActivationReaction

This is a reversible reaction of one reactant forming one product influenced by one modifier.

Name C3G activation

Reaction equation

$$\mathrm{C3GInactive} \underset{}{\overset{\mathrm{boundNGFReceptor}}{\rightleftharpoons}} \mathrm{C3GActive} \tag{43}$$

Reactant

Table 65: Properties of each reactant.

Id	Name	SBO
C3GInactive		

Modifier

Table 66: Properties of each modifier.

Id	Name	SBO
boundNGFReceptor		

Product

Table 67: Properties of each product.

Id	Name	SBO
C3GActive		

Kinetic Law

Derived unit contains undeclared units

$$v_{22} = \mathrm{vol}\,(\mathrm{cell}) \cdot \frac{\mathrm{kC3GNGF} \cdot [\mathrm{boundNGFReceptor}] \cdot [\mathrm{C3GInactive}]}{[\mathrm{C3GInactive}] + \mathrm{KmC3GNGF}} \tag{44}$$

6.23 Reaction Rap1ActivationReaction

This is a reversible reaction of one reactant forming one product influenced by one modifier.

Name Rap1 activation

Reaction equation

$$\mathrm{Rap1Inactive} \xrightleftharpoons{\mathrm{C3GActive}} \mathrm{Rap1Active} \tag{45}$$

Reactant

Table 68: Properties of each reactant.

Id	Name	SBO
Rap1Inactive		

Modifier

Table 69: Properties of each modifier.

Id	Name	SBO
C3GActive		

Product

Table 70: Properties of each product.

Id	Name	SBO
Rap1Active		

Kinetic Law

Derived unit contains undeclared units

$$v_{23} = \mathrm{vol}\,(\mathrm{cell}) \cdot \frac{\mathrm{kC3G} \cdot [\mathrm{C3GActive}] \cdot [\mathrm{Rap1Inactive}]}{[\mathrm{Rap1Inactive}] + \mathrm{KmC3G}} \tag{46}$$

6.24 Reaction Rap1DeactivationReaction

This is a reversible reaction of one reactant forming one product influenced by one modifier.

Name Rap1 deactivation

Reaction equation

$$\mathrm{Rap1Active} \overset{\mathrm{RapGapActive}}{\rightleftharpoons} \mathrm{Rap1Inactive} \tag{47}$$

Reactant

Table 71: Properties of each reactant.

Id	Name	SBO
Rap1Active		

Modifier

Table 72: Properties of each modifier.

Id	Name	SBO
RapGapActive		

Product

Table 73: Properties of each product.

Id	Name	SBO
Rap1Inactive		

Kinetic Law

Derived unit contains undeclared units

$$v_{24} = \mathrm{vol}\,(\mathrm{cell}) \cdot \frac{\mathrm{kRapGap} \cdot [\mathrm{RapGapActive}] \cdot [\mathrm{Rap1Active}]}{[\mathrm{Rap1Active}] + \mathrm{KmRapGap}} \tag{48}$$

6.25 Reaction BRafByRap1ActivationReaction

This is a reversible reaction of one reactant forming one product influenced by one modifier.

Name BRaf activation by Rap1

Reaction equation

$$\mathrm{BRafInactive} \underset{}{\overset{\mathrm{Rap1Active}}{\rightleftharpoons}} \mathrm{BRafActive} \tag{49}$$

Reactant

Table 74: Properties of each reactant.

Id	Name	SBO
BRafInactive		

Modifier

Table 75: Properties of each modifier.

Id	Name	SBO
Rap1Active		

Product

Table 76: Properties of each product.

Id	Name	SBO
BRafActive		

Kinetic Law

Derived unit contains undeclared units

$$v_{25} = \mathrm{vol}\,(\mathrm{cell}) \cdot \frac{\mathrm{kRap1ToBRaf} \cdot [\mathrm{Rap1Active}] \cdot [\mathrm{BRafInactive}]}{[\mathrm{BRafInactive}] + \mathrm{KmRap1ToBRaf}} \tag{50}$$

6.26 Reaction BRafbyPPtaseDeactivationReaction

This is a reversible reaction of one reactant forming one product influenced by one modifier.

Name BRaf deactivation by PPase

Reaction equation

$$\mathrm{BRafActive} \underset{}{\overset{\mathrm{Raf1PPtase}}{\rightleftharpoons}} \mathrm{BRafInactive} \tag{51}$$

Reactant

Table 77: Properties of each reactant.

Id	Name	SBO
BRafActive		

Modifier

Table 78: Properties of each modifier.

Id	Name	SBO
Raf1PPtase		

Product

Table 79: Properties of each product.

Id	Name	SBO
BRafInactive		

Kinetic Law

Derived unit contains undeclared units

$$v_{26} = \mathrm{vol}\,(\mathrm{cell}) \cdot \frac{\mathrm{kdBRaf} \cdot [\mathrm{Raf1PPtase}] \cdot [\mathrm{BRafActive}]}{[\mathrm{BRafActive}] + \mathrm{KmdBRaf}} \tag{52}$$

7 Derived Rate Equations

When interpreted as an ordinary differential equation framework, this model implies the following set of equations for the rates of change of each species.

Identifiers for kinetic laws highlighted in gray cannot be verified to evaluate to units of SBML `substance` per `time`. As a result, some SBML interpreters may not be able to verify the consistency of the units on quantities in the model. Please check if

- parameters without an unit definition are involved or
- volume correction is necessary because the `hasOnlySubstanceUnits` flag may be set to `false` and `spacialDimensions`> 0 for certain species.

7.1 Species EGF

Initial concentration $1.0002 \cdot 10^{7}\ \mathrm{item} \cdot \mathrm{l}^{-1}$

This species takes part in two reactions (as a reactant in EGFBindingReaction and as a product in EGFUnbindingReaction).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{EGF} = v_2 - v_1 \tag{53}$$

7.2 Species NGF

Initial concentration $456000\ \mathrm{item}\cdot\mathrm{l}^{-1}$

This species takes part in two reactions (as a reactant in NGFBindingReaction and as a product in NGFUnbindingReaction).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{NGF} = v_4 - v_3 \tag{54}$$

7.3 Species freeEGFReceptor

Initial concentration $80000\ \mathrm{item}\cdot\mathrm{l}^{-1}$

This species takes part in two reactions (as a reactant in EGFBindingReaction and as a product in EGFUnbindingReaction).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{freeEGFReceptor} = v_2 - v_1 \tag{55}$$

7.4 Species boundEGFReceptor

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

This species takes part in four reactions (as a reactant in EGFUnbindingReaction and as a product in EGFBindingReaction and as a modifier in SosActivationByEGFReaction, PI3KbyEGFRActivationReaction).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{boundEGFReceptor} = v_1 - v_2 \tag{56}$$

7.5 Species freeNGFReceptor

Initial concentration $10000\ \mathrm{item}\cdot\mathrm{l}^{-1}$

This species takes part in two reactions (as a reactant in NGFBindingReaction and as a product in NGFUnbindingReaction).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{freeNGFReceptor} = v_4 - v_3 \tag{57}$$

7.6 Species boundNGFReceptor

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

This species takes part in four reactions (as a reactant in NGFUnbindingReaction and as a product in NGFBindingReaction and as a modifier in SosActivationByNGFReaction, C3GActivationReaction).

$$\frac{\text{d}}{\text{d}t}\text{boundNGFReceptor} = v_3 - v_4 \tag{58}$$

7.7 Species SosInactive

Initial concentration $120000\ \text{item} \cdot \text{l}^{-1}$

This species takes part in three reactions (as a reactant in SosActivationByEGFReaction, SosActivationByNGFReaction and as a product in SosDeactivationReaction).

$$\frac{\text{d}}{\text{d}t}\text{SosInactive} = v_7 - v_5 - v_6 \tag{59}$$

7.8 Species SosActive

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

This species takes part in four reactions (as a reactant in SosDeactivationReaction and as a product in SosActivationByEGFReaction, SosActivationByNGFReaction and as a modifier in RasActivationReaction).

$$\frac{\text{d}}{\text{d}t}\text{SosActive} = v_5 + v_6 - v_7 \tag{60}$$

7.9 Species P90RskInactive

Initial concentration $120000\ \text{item} \cdot \text{l}^{-1}$

This species takes part in one reaction (as a reactant in P90RskActivationReaction).

$$\frac{\text{d}}{\text{d}t}\text{P90RskInactive} = -v_{17} \tag{61}$$

7.10 Species P90RskActive

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

This species takes part in two reactions (as a product in P90RskActivationReaction and as a modifier in SosDeactivationReaction).

$$\frac{\text{d}}{\text{d}t}\text{P90RskActive} = v_{17} \tag{62}$$

7.11 Species RasInactive

Initial concentration $120000\ \text{item} \cdot \text{l}^{-1}$

This species takes part in two reactions (as a reactant in RasActivationReaction and as a product in RasDeactivationReaction).

$$\frac{\text{d}}{\text{d}t}\text{RasInactive} = v_9 - v_8 \tag{63}$$

7.12 Species RasActive

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

This species takes part in four reactions (as a reactant in RasDeactivationReaction and as a product in RasActivationReaction and as a modifier in Raf1ByRasActivationReaction, PI3KbyRasActivationReaction).

$$\frac{\text{d}}{\text{d}t}\text{RasActive} = v_8 - v_9 \tag{64}$$

7.13 Species RasGapActive

Initial concentration $120000\ \text{item} \cdot \text{l}^{-1}$

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

$$\frac{\text{d}}{\text{d}t}\text{RasGapActive} = 0 \tag{65}$$

7.14 Species Raf1Inactive

Initial concentration $120000\ \text{item} \cdot \text{l}^{-1}$

This species takes part in three reactions (as a reactant in Raf1ByRasActivationReaction and as a product in Raf1byPPtaseDeactivationReaction, Raf1ByAktDeactivationReaction).

$$\frac{\text{d}}{\text{d}t}\text{Raf1Inactive} = v_{16} + v_{21} - v_{10} \tag{66}$$

7.15 Species Raf1Active

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

This species takes part in four reactions (as a reactant in Raf1byPPtaseDeactivationReaction, Raf1ByAktDeactivationReaction and as a product in Raf1ByRasActivationReaction and as a modifier in MekbyRaf1ActivationReaction).

$$\frac{\text{d}}{\text{d}t}\text{Raf1Active} = v_{10} - v_{16} - v_{21} \tag{67}$$

7.16 Species BRafInactive

Initial concentration $120000\ \text{item} \cdot \text{l}^{-1}$

This species takes part in two reactions (as a reactant in BRafByRap1ActivationReaction and as a product in BRafbyPPtaseDeactivationReaction).

$$\frac{\text{d}}{\text{d}t}\text{BRafInactive} = v_{26} - v_{25} \tag{68}$$

7.17 Species BRafActive

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

This species takes part in three reactions (as a reactant in BRafbyPPtaseDeactivationReaction and as a product in BRafByRap1ActivationReaction and as a modifier in MekbyBRafActivationReaction).

$$\frac{\text{d}}{\text{d}t}\text{BRafActive} = v_{25} - v_{26} \tag{69}$$

7.18 Species MekInactive

Initial concentration $600000\ \text{item} \cdot \text{l}^{-1}$

This species takes part in three reactions (as a reactant in MekbyRaf1ActivationReaction, MekbyBRafActivationReaction and as a product in MekDeactivationReaction).

$$\frac{\text{d}}{\text{d}t}\text{MekInactive} = v_{14} - v_{11} - v_{12} \tag{70}$$

7.19 Species MekActive

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

This species takes part in four reactions (as a reactant in MekDeactivationReaction and as a product in MekbyRaf1ActivationReaction, MekbyBRafActivationReaction and as a modifier in ErkActivationReaction).

$$\frac{\text{d}}{\text{d}t}\text{MekActive} = v_{11} + v_{12} - v_{14} \tag{71}$$

7.20 Species ErkInactive

Initial concentration $600000\ \text{item} \cdot \text{l}^{-1}$

This species takes part in two reactions (as a reactant in ErkActivationReaction and as a product in ErkDeactivationReaction).

$$\frac{\text{d}}{\text{d}t}\text{ErkInactive} = v_{15} - v_{13} \tag{72}$$

7.21 Species ErkActive

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

This species takes part in three reactions (as a reactant in ErkDeactivationReaction and as a product in ErkActivationReaction and as a modifier in P90RskActivationReaction).

$$\frac{\text{d}}{\text{d}t}\text{ErkActive} = v_{13} - v_{15} \tag{73}$$

7.22 Species PI3KInactive

Initial concentration $120000\ \text{item} \cdot \text{l}^{-1}$

This species takes part in two reactions (as a reactant in PI3KbyEGFRActivationReaction, PI3KbyRasActivationReaction).

$$\frac{\text{d}}{\text{d}t}\text{PI3KInactive} = -v_{18} - v_{19} \tag{74}$$

7.23 Species PI3KActive

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

This species takes part in three reactions (as a product in PI3KbyEGFRActivationReaction, PI3KbyRasActivationReaction and as a modifier in AktActivationReaction).

$$\frac{\text{d}}{\text{d}t}\text{PI3KActive} = v_{18} + v_{19} \tag{75}$$

7.24 Species AktInactive

Initial concentration $120000\ \text{item} \cdot \text{l}^{-1}$

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

$$\frac{\text{d}}{\text{d}t}\text{AktInactive} = -v_{20} \tag{76}$$

7.25 Species AktActive

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

This species takes part in two reactions (as a product in AktActivationReaction and as a modifier in Raf1ByAktDeactivationReaction).

$$\frac{\text{d}}{\text{d}t}\text{AktActive} = v_{20} \tag{77}$$

7.26 Species C3GInactive

Initial concentration $120000\ \text{item} \cdot \text{l}^{-1}$

This species takes part in one reaction (as a reactant in C3GActivationReaction).

$$\frac{\text{d}}{\text{d}t}\text{C3GInactive} = -\ v_{22} \tag{78}$$

7.27 Species C3GActive

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

This species takes part in two reactions (as a product in C3GActivationReaction and as a modifier in Rap1ActivationReaction).

$$\frac{\text{d}}{\text{d}t}\text{C3GActive} = v_{22} \tag{79}$$

7.28 Species Rap1Inactive

Initial concentration $120000\ \text{item} \cdot \text{l}^{-1}$

This species takes part in two reactions (as a reactant in Rap1ActivationReaction and as a product in Rap1DeactivationReaction).

$$\frac{\text{d}}{\text{d}t}\text{Rap1Inactive} = v_{24} - v_{23} \tag{80}$$

7.29 Species Rap1Active

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

This species takes part in three reactions (as a reactant in Rap1DeactivationReaction and as a product in Rap1ActivationReaction and as a modifier in BRafByRap1ActivationReaction).

$$\frac{\text{d}}{\text{d}t}\text{Rap1Active} = v_{23} - v_{24} \tag{81}$$

7.30 Species RapGapActive

Initial concentration $120000\ \text{item} \cdot \text{l}^{-1}$

This species takes part in one reaction (as a modifier in Rap1DeactivationReaction).

$$\frac{\text{d}}{\text{d}t}\text{RapGapActive} = 0 \tag{82}$$

7.31 Species PP2AActive

Initial concentration $120000\ \text{item} \cdot \text{l}^{-1}$

This species takes part in two reactions (as a modifier in MekDeactivationReaction, ErkDeactivationReactior

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{PP2AActive} = 0 \tag{83}$$

7.32 Species Raf1PPtase

Initial concentration $120000\ \text{item} \cdot \text{l}^{-1}$

This species takes part in two reactions (as a modifier in Raf1byPPtaseDeactivationReaction, BRafbyPPtaseDeactivationReaction).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{Raf1PPtase} = 0 \tag{84}$$

SBML2LaTeX was developed by Andreas Dräger[a], Hannes Planatscher[a], Dieudonné M Wouamba[a], Adrian Schröder[a], Michael Hucka[b], Lukas Endler[c], Martin Golebiewski[d] and Andreas Zell[a]. Please see http://www.ra.cs.uni-tuebingen.de/software/SBML2LaTeX for more information.

[a]Center for Bioinformatics Tübingen (ZBIT), Germany
[b]California Institute of Technology, Beckman Institute BNMC, Pasadena, United States
[c]European Bioinformatics Institute, Wellcome Trust Genome Campus, Hinxton, United Kingdom
[d]EML Research gGmbH, Heidelberg, Germany