

## SBML Model Report

# Model name: “Dutta-Roy2015 - Opening of the multiple AMPA receptor conductance states”



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: Nicolas Le Novre<sup>1</sup> and Audald Lloret i Villas<sup>2</sup> at March 23<sup>rd</sup> 2015 at one o’ clock in the afternoon. and last time modified at April eighth 2016 at 5:53 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	21
events	0	constraints	0
reactions	62	function definitions	8
global parameters	42	unit definitions	0
rules	0	initial assignments	24

## Model Notes

Dutta-Roy2015 - Opening of the multiple AMPA receptor conductance states

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This model is described in the article: [Ligand-dependent opening of the multiple AMPA receptor conductance States: a concerted model](#). Dutta-Roy R, Rosenmund C, Edelstein SJ, Le Novre N. PLoS ONE 2015; 10(1): e0116616

Abstract:

Modulation of the properties of AMPA receptors at the post-synaptic membrane is one of the main suggested mechanisms underlying fast synaptic transmission in the central nervous system of vertebrates. Electrophysiological recordings of single channels stimulated with agonists showed that both recombinant and native AMPA receptors visit multiple conductance states in an agonist concentration dependent manner. We propose an allosteric model of the multiple conductance states based on concerted conformational transitions of the four subunits, as an iris diaphragm. Our model predicts that the thermodynamic behaviour of the conductance states upon full and partial agonist stimulations can be described with increased affinity of receptors as they progress to higher conductance states. The model also predicts the existence of AMPA receptors in non-liganded conductive substates. However, the probability of spontaneous openings decreases with increasing conductances. Finally, we predict that the large conductance states are stabilized within the rise phase of a whole-cell EPSC in glutamatergic hippocampal neurons. Our model provides a mechanistic link between ligand concentration and conductance states that can explain thermodynamic and kinetic features of AMPA receptor gating.

This model is hosted on [BioModels Database](#) and identified by: [BIOMD0000000569](#).

To cite BioModels Database, please use: [BioModels Database: An enhanced, curated and annotated resource for published quantitative kinetic models](#).

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## 2 Unit Definitions

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

### 2.1 Unit `substance`

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

**Definition** mol

### 2.2 Unit `volume`

**Notes** Litre is the predefined SBML unit for volume.

**Definition** l

### 2.3 Unit area

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

**Definition**  $\text{m}^2$

### 2.4 Unit length

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

**Definition**  $\text{m}$

### 2.5 Unit time

**Notes** Second is the predefined SBML unit for time.

**Definition**  $\text{s}$

## 3 Compartment

This model contains one compartment.

Table 2: Properties of all compartments.

Id	Name	SBO	Spatial Dimensions	Size	Unit	Constant	Outside
synapse	synapse		3	$10^{-16}$	l	<input checked="" type="checkbox"/>	

### 3.1 Compartment `synapse`

This is a three dimensional compartment with a constant size of  $10^{-16}$  litre.

**Name** `synapse`

**Notes** The volume must be divided by 50 (resulting in  $2\text{e-}18$  litre) to simulate a single receptor.

## 4 Species

This model contains 21 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
B0	B0	synapse	$\text{mol} \cdot \text{l}^{-1}$	$\square$	$\square$
S0	S0	synapse	$\text{mol} \cdot \text{l}^{-1}$	$\square$	$\square$
B1	B1	synapse	$\text{mol} \cdot \text{l}^{-1}$	$\square$	$\square$
S1	S1	synapse	$\text{mol} \cdot \text{l}^{-1}$	$\square$	$\square$
B2	B2	synapse	$\text{mol} \cdot \text{l}^{-1}$	$\square$	$\square$
S2	S2	synapse	$\text{mol} \cdot \text{l}^{-1}$	$\square$	$\square$
B3	B3	synapse	$\text{mol} \cdot \text{l}^{-1}$	$\square$	$\square$
S3	S3	synapse	$\text{mol} \cdot \text{l}^{-1}$	$\square$	$\square$
B4	B4	synapse	$\text{mol} \cdot \text{l}^{-1}$	$\square$	$\square$
S4	S4	synapse	$\text{mol} \cdot \text{l}^{-1}$	$\square$	$\square$
M0	M0	synapse	$\text{mol} \cdot \text{l}^{-1}$	$\square$	$\square$
M1	M1	synapse	$\text{mol} \cdot \text{l}^{-1}$	$\square$	$\square$
M2	M2	synapse	$\text{mol} \cdot \text{l}^{-1}$	$\square$	$\square$
M3	M3	synapse	$\text{mol} \cdot \text{l}^{-1}$	$\square$	$\square$
M4	M4	synapse	$\text{mol} \cdot \text{l}^{-1}$	$\square$	$\square$
L0	L0	synapse	$\text{mol} \cdot \text{l}^{-1}$	$\square$	$\square$
L1	L1	synapse	$\text{mol} \cdot \text{l}^{-1}$	$\square$	$\square$
L2	L2	synapse	$\text{mol} \cdot \text{l}^{-1}$	$\square$	$\square$
L3	L3	synapse	$\text{mol} \cdot \text{l}^{-1}$	$\square$	$\square$
L4	L4	synapse	$\text{mol} \cdot \text{l}^{-1}$	$\square$	$\square$
glu	glu	synapse	$\text{mol} \cdot \text{l}^{-1}$	$\square$	$\square$

## 5 Parameters

This model contains 42 global parameters.

Table 4: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
Bkon	Bkon		5000000.000		✓
Bkoff	Bkoff		4495.000		✓
Skon	Skon		5000000.000		✓
Skoff	Skoff		270.400		✓
Mkon	Mkon		5000000.000		✓
Mkoff	Mkoff		16.650		✓
Lkon	Lkon		5000000.000		✓
Lkoff	Lkoff		1.149		✓
BSk0	BSk0		1083.603		✓
SBk0	SBk0		238094.579		✓
BSk1	BSk1		4420.109		✓
SBk1	SBk1		58369.604		✓
BSk2	BSk2		18030.000		✓
SBk2	SBk2		14309.484		✓
BSk3	BSk3		73545.904		✓
SBk3	SBk3		3508.013		✓
BSk4	BSk4		300000.000		✓
SBk4	SBk4		860.000		✓
SMk0	SMk0		75.891		✓
MSk0	MSk0		38212.599		✓
SMk1	SMk1		305.774		✓
MSk1	MSk1		9484.118		✓
SMk2	SMk2		1232.000		✓
MSk2	MSk2		2353.896		✓
SMk3	SMk3		4963.869		✓
MSk3	MSk3		584.222		✓
SMk4	SMk4		20000.000		✓
MSk4	MSk4		145.000		✓
MLk0	MLk0		238.050		✓
LMk0	LMk0		145137.576		✓
MLk1	MLk1		906.241		✓
LMk1	LMk1		38124.522		✓
MLk2	MLk2		3450.000		✓
LMk2	LMk2		10014.493		✓
MLk3	MLk3		13133.926		✓
LMk3	LMk3		2630.592		✓
MLk4	MLk4		50000.000		✓

Id	Name	SBO	Value	Unit	Constant
LMk4	LMk4		691.000		✓
BSc	BSc		0.060		✓
SMc	SMc		0.062		✓
MLc	MLc		0.069		✓
p	p		0.500		✓

## 6 Initialassignments

This is an overview of 24 initialassignments.

### 6.1 Initialassignment BSk0

**Derived unit** contains undeclared units

**Math**  $\text{BSk1} \cdot \text{BSc}^p$

### 6.2 Initialassignment SBk0

**Derived unit** contains undeclared units

**Math**  $\frac{\text{SBk1}}{\text{BSc}^p}$

### 6.3 Initialassignment BSk1

**Derived unit** contains undeclared units

**Math**  $\text{BSk2} \cdot \text{BSc}^p$

### 6.4 Initialassignment SBk1

**Derived unit** contains undeclared units

**Math**  $\frac{\text{SBk2}}{\text{BSc}^p}$

### 6.5 Initialassignment BSk2

**Derived unit** contains undeclared units

**Math**  $\text{BSk3} \cdot \text{BSc}^p$

### 6.6 Initialassignment SBk2

**Derived unit** contains undeclared units

**Math**  $\frac{\text{SBk3}}{\text{BSc}^p}$

### 6.7 Initialassignment BSk3

**Derived unit** contains undeclared units

**Math**  $\text{BSk4} \cdot \text{BSc}^p$

### 6.8 Initialassignment SBk3

**Derived unit** contains undeclared units

**Math**  $\frac{\text{SBk4}}{\text{BSc}^p}$

### 6.9 Initialassignment SMk0

**Derived unit** contains undeclared units

**Math**  $\text{SMk1} \cdot \text{SMc}^p$

### 6.10 Initialassignment MSk0

**Derived unit** contains undeclared units

**Math**  $\frac{\text{MSk1}}{\text{SMc}^p}$

### 6.11 Initialassignment SMk1

**Derived unit** contains undeclared units

**Math**  $\text{SMk2} \cdot \text{SMc}^p$

### 6.12 Initialassignment MSk1

**Derived unit** contains undeclared units

**Math**  $\frac{\text{MSk2}}{\text{SMc}^p}$

### 6.13 Initialassignment SMk2

**Derived unit** contains undeclared units

**Math**  $\text{SMk3} \cdot \text{SMc}^p$

### 6.14 Initialassignment MSk2

**Derived unit** contains undeclared units

**Math**  $\frac{\text{MSk3}}{\text{SMc}^p}$

### 6.15 Initialassignment SMk3

**Derived unit** contains undeclared units

**Math**  $\text{SMk4} \cdot \text{SMc}^{\text{P}}$

### 6.16 Initialassignment MSk3

**Derived unit** contains undeclared units

**Math**  $\frac{\text{MSk4}}{\text{SMc}^{\text{P}}}$

### 6.17 Initialassignment MLk0

**Derived unit** contains undeclared units

**Math**  $\text{MLk1} \cdot \text{MLc}^{\text{P}}$

### 6.18 Initialassignment LMk0

**Derived unit** contains undeclared units

**Math**  $\frac{\text{LMk1}}{\text{MLc}^{\text{P}}}$

### 6.19 Initialassignment MLk1

**Derived unit** contains undeclared units

**Math**  $\text{MLk2} \cdot \text{MLc}^{\text{P}}$

### 6.20 Initialassignment LMk1

**Derived unit** contains undeclared units

**Math**  $\frac{\text{LMk2}}{\text{MLc}^{\text{P}}}$

### 6.21 Initialassignment MLk2

**Derived unit** contains undeclared units

**Math**  $\text{MLk3} \cdot \text{MLc}^{\text{P}}$

### 6.22 Initialassignment LMk2

**Derived unit** contains undeclared units

**Math**  $\frac{\text{LMk3}}{\text{MLc}^{\text{P}}}$



### 6.23 Initialassignment MLk3

**Derived unit** contains undeclared units

**Math**  $MLk4 \cdot MLc^p$

### 6.24 Initialassignment LMk3

**Derived unit** contains undeclared units

**Math**  $\frac{LMk4}{MLc^p}$

## 7 Function definitions

This is an overview of eight function definitions.

### 7.1 Function definition Ligand\_Binding\_1

**Name** Ligand Binding 1

**Arguments** k, R, L

**Mathematical Expression**

$$4 \cdot k \cdot R \cdot L \quad (1)$$

### 7.2 Function definition Ligand\_Binding\_2

**Name** Ligand Binding 2

**Arguments** k, R, L

**Mathematical Expression**

$$3 \cdot k \cdot R \cdot L \quad (2)$$

### 7.3 Function definition Ligand\_Binding\_3

**Name** Ligand Binding 3

**Arguments** k, R, L

**Mathematical Expression**

$$2 \cdot k \cdot R \cdot L \quad (3)$$

#### 7.4 Function definition [Ligand\\_Binding\\_4](#)

**Name** Ligand Binding 4

**Arguments** k, R, L

**Mathematical Expression**

$$k \cdot R \cdot L \quad (4)$$

#### 7.5 Function definition [Ligand\\_Unbinding\\_1](#)

**Name** Ligand Unbinding 1

**Arguments** k, R

**Mathematical Expression**

$$k \cdot R \quad (5)$$

#### 7.6 Function definition [Ligand\\_Unbinding\\_2](#)

**Name** Ligand Unbinding 2

**Arguments** k, R

**Mathematical Expression**

$$2 \cdot k \cdot R \quad (6)$$

#### 7.7 Function definition [Ligand\\_Unbinding\\_3](#)

**Name** Ligand Unbinding 3

**Arguments** k, R

**Mathematical Expression**

$$3 \cdot k \cdot R \quad (7)$$

#### 7.8 Function definition [Ligand\\_Unbinding\\_4](#)

**Name** Ligand Unbinding 4

**Arguments** k, R

**Mathematical Expression**

$$4 \cdot k \cdot R \quad (8)$$

## 8 Reactions

This model contains 62 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	B0____S0	B0 -> S0	$B0 \xrightarrow{B0} S0$	
2	S0____B0	S0 -> B0	$S0 \xrightarrow{S0} B0$	
3	B1____S1	B1 -> S1	$B1 \xrightarrow{B1} S1$	
4	S1____B1	S1 -> B1	$S1 \xrightarrow{S1} B1$	
5	B2____S2	B2 -> S2	$B2 \xrightarrow{B2} S2$	
6	S2____B2	S2 -> B2	$S2 \xrightarrow{S2} B2$	
7	B3____S3	B3 -> S3	$B3 \xrightarrow{B3} S3$	
8	S3____B3	S3 -> B3	$S3 \xrightarrow{S3} B3$	
9	B4____S4	B4 -> S4	$B4 \xrightarrow{B4} S4$	
10	S4____B4	S4 -> B4	$S4 \xrightarrow{S4} B4$	
11	S0____M0	S0 -> M0	$S0 \xrightarrow{S0} M0$	
12	M0____S0	M0 -> S0	$M0 \xrightarrow{M0} S0$	
13	S1____M1	S1 -> M1	$S1 \xrightarrow{S1} M1$	
14	M1____S1	M1 -> S1	$M1 \xrightarrow{M1} S1$	
15	S2____M2	S2 -> M2	$S2 \xrightarrow{S2} M2$	
16	M2____S2	M2 -> S2	$M2 \xrightarrow{M2} S2$	

Nº	Id	Name	Reaction Equation	SBO
17	S3____M3	S3 -> M3	$S3 \xrightarrow{S3} M3$	
18	M3____S3	M3 -> S3	$M3 \xrightarrow{M3} S3$	
19	S4____M4	S4 -> M4	$S4 \xrightarrow{S4} M4$	
20	M4____S4	M4 -> S4	$M4 \xrightarrow{M4} S4$	
21	M0____L0	M0 -> L0	$M0 \xrightarrow{M0} L0$	
22	L0____M0	L0 -> M0	$L0 \xrightarrow{L0} M0$	
23	M1____L1	M1 -> L1	$M1 \xrightarrow{M1} L1$	
24	L1____M1	L1 -> M1	$L1 \xrightarrow{L1} M1$	
25	M2____L2	M2 -> L2	$M2 \xrightarrow{M2} L2$	
26	L2____M2	L2 -> M2	$L2 \xrightarrow{L2} M2$	
27	M3____L3	M3 -> L3	$M3 \xrightarrow{M3} L3$	
28	L3____M3	L3 -> M3	$L3 \xrightarrow{L3} M3$	
29	M4____L4	M4 -> L4	$M4 \xrightarrow{M4} L4$	
30	L4____M4	L4 -> M4	$L4 \xrightarrow{L4} M4$	
31	B0____B1	B0 -> B1	$B0 + \text{glu} \xrightarrow{B0, \text{glu}} B1$	
32	B1____B0	B1 -> B0	$B1 \xrightarrow{B1} B0 + \text{glu}$	
33	B1____B2	B1 -> B2	$B1 + \text{glu} \xrightarrow{B1, \text{glu}} B2$	
34	B2____B1	B2 -> B1	$B2 \xrightarrow{B2} B1 + \text{glu}$	
35	B2____B3	B2 -> B3	$B2 + \text{glu} \xrightarrow{B2, \text{glu}} B3$	
36	B3____B2	B3 -> B2	$B3 \xrightarrow{B3} B2 + \text{glu}$	
37	B3____B4	B3 -> B4	$B3 + \text{glu} \xrightarrow{B3, \text{glu}} B4$	

Nº	Id	Name	Reaction Equation	SBO
38	B4____B3	B4 -> B3	$B4 \xrightarrow{B4} B3 + \text{glu}$	
39	S0____S1	S0 -> S1	$S0 + \text{glu} \xrightarrow{S0, \text{glu}} S1$	
40	S1____S0	S1 -> S0	$S1 \xrightarrow{S1} S0 + \text{glu}$	
41	S1____S2	S1 -> S2	$S1 + \text{glu} \xrightarrow{S1, \text{glu}} S2$	
42	S2____S1	S2 -> S1	$S2 \xrightarrow{S2} S1 + \text{glu}$	
43	S2____S3	S2 -> S3	$S2 + \text{glu} \xrightarrow{S2, \text{glu}} S3$	
44	S3____S2	S3 -> S2	$S3 \xrightarrow{S3} S2 + \text{glu}$	
45	S3____S4	S3 -> S4	$S3 + \text{glu} \xrightarrow{S3, \text{glu}} S4$	
46	S4____S3	S4 -> S3	$S4 \xrightarrow{S4} S3 + \text{glu}$	
47	M0____M1	M0 -> M1	$M0 + \text{glu} \xrightarrow{M0, \text{glu}} M1$	
48	M1____M0	M1 -> M0	$M1 \xrightarrow{M1} M0 + \text{glu}$	
49	M1____M2	M1 -> M2	$M1 + \text{glu} \xrightarrow{M1, \text{glu}} M2$	
50	M2____M1	M2 -> M1	$M2 \xrightarrow{M2} M1 + \text{glu}$	
51	M2____M3	M2 -> M3	$M2 + \text{glu} \xrightarrow{M2, \text{glu}} M3$	
52	M3____M2	M3 -> M2	$M3 \xrightarrow{M3} M2 + \text{glu}$	
53	M3____M4	M3 -> M4	$M3 + \text{glu} \xrightarrow{M3} M4$	
54	M4____M3	M4 -> M3	$M4 \xrightarrow{M4} M3 + \text{glu}$	
55	L0____L1	L0 -> L1	$L0 + \text{glu} \xrightarrow{L0, \text{glu}} L1$	
56	L1____L0	L1 -> L0	$L1 \xrightarrow{L1} L0 + \text{glu}$	
57	L1____L2	L1 -> L2	$L1 + \text{glu} \xrightarrow{L1, \text{glu}} L2$	

Nº	Id	Name	Reaction Equation	SBO
58	L2____L1	L2 -> L1	$L2 \xrightarrow{L2} L1 + \text{glu}$	
59	L2____L3	L2 -> L3	$L2 + \text{glu} \xrightarrow{L2, \text{glu}} L3$	
60	L3____L2	L3 -> L2	$L3 \xrightarrow{L3} L2 + \text{glu}$	
61	L3____L4	L3 -> L4	$L3 + \text{glu} \xrightarrow{L3, \text{glu}} L4$	
62	L4____L3	L4 -> L3	$L4 \xrightarrow{L4} L3 + \text{glu}$	

### 8.1 Reaction B0\_\_\_\_S0

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

**Name** B0 -> S0

#### Reaction equation



#### Reactant

Table 6: Properties of each reactant.

Id	Name	SBO
B0	B0	

#### Modifier

Table 7: Properties of each modifier.

Id	Name	SBO
B0	B0	

#### Product

Table 8: Properties of each product.

Id	Name	SBO
S0	S0	

#### Kinetic Law

**Derived unit** contains undeclared units

$$v_1 = \text{vol}(\text{synapse}) \cdot \text{BSk0} \cdot [B0] \quad (10)$$

### 8.2 Reaction S0\_\_\_\_B0

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

**Name** S0 -> B0

### Reaction equation



### Reactant

Table 9: Properties of each reactant.

Id	Name	SBO
S0	S0	

### Modifier

Table 10: Properties of each modifier.

Id	Name	SBO
S0	S0	

### Product

Table 11: Properties of each product.

Id	Name	SBO
B0	B0	

### Kinetic Law

**Derived unit** contains undeclared units

$$v_2 = \text{vol}(\text{synapse}) \cdot \text{SBk0} \cdot [S0] \quad (12)$$

### 8.3 Reaction B1\_\_\_\_S1

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

**Name** B1 -> S1

### Reaction equation



### Reactant



Table 12: Properties of each reactant.

Id	Name	SBO
B1	B1	

## Modifier

Table 13: Properties of each modifier.

Id	Name	SBO
B1	B1	

## Product

Table 14: Properties of each product.

Id	Name	SBO
S1	S1	

## Kinetic Law

**Derived unit** contains undeclared units

$$v_3 = \text{vol}(\text{synapse}) \cdot \text{BSk1} \cdot [\text{B1}] \quad (14)$$

## 8.4 Reaction S1\_\_\_\_B1

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

**Name** S1 -> B1

## Reaction equation



## Reactant

Table 15: Properties of each reactant.

Id	Name	SBO
S1	S1	

## Modifier

Table 16: Properties of each modifier.

Id	Name	SBO
S1	S1	

## Product

Table 17: Properties of each product.

Id	Name	SBO
B1	B1	

## Kinetic Law

**Derived unit** contains undeclared units

$$v_4 = \text{vol}(\text{synapse}) \cdot \text{SBk1} \cdot [\text{S1}] \quad (16)$$

### 8.5 Reaction B2\_\_\_\_S2

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

**Name** B2 -> S2

#### Reaction equation



## Reactant

Table 18: Properties of each reactant.

Id	Name	SBO
B2	B2	

## Modifier

Table 19: Properties of each modifier.

Id	Name	SBO
B2	B2	

## Product

Table 20: Properties of each product.

Id	Name	SBO
S2	S2	

## Kinetic Law

**Derived unit** contains undeclared units

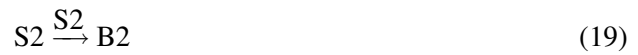
$$v_5 = \text{vol}(\text{synapse}) \cdot \text{BSk2} \cdot [\text{B2}] \quad (18)$$

## 8.6 Reaction S2\_\_\_\_B2

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

**Name** S2 -> B2

## Reaction equation



## Reactant

Table 21: Properties of each reactant.

Id	Name	SBO
S2	S2	

## Modifier

Table 22: Properties of each modifier.

Id	Name	SBO
S2	S2	

## Product

Table 23: Properties of each product.

Id	Name	SBO
B2	B2	

## Kinetic Law

**Derived unit** contains undeclared units

$$v_6 = \text{vol}(\text{synapse}) \cdot \text{SBk2} \cdot [\text{S2}] \quad (20)$$

## 8.7 Reaction B3\_\_\_\_S3

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

**Name** B3 -> S3

## Reaction equation



## Reactant

Table 24: Properties of each reactant.

Id	Name	SBO
B3	B3	

## Modifier

Table 25: Properties of each modifier.

Id	Name	SBO
B3	B3	

## Product

Table 26: Properties of each product.

Id	Name	SBO
S3	S3	

### Kinetic Law

**Derived unit** contains undeclared units

$$v_7 = \text{vol}(\text{synapse}) \cdot \text{BSk3} \cdot [\text{B3}] \quad (22)$$

### 8.8 Reaction S3\_\_\_\_B3

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

**Name** S3 -> B3

### Reaction equation



### Reactant

Table 27: Properties of each reactant.

Id	Name	SBO
S3	S3	

### Modifier

Table 28: Properties of each modifier.

Id	Name	SBO
S3	S3	

### Product

Table 29: Properties of each product.

Id	Name	SBO
B3	B3	

## Kinetic Law

**Derived unit** contains undeclared units

$$v_8 = \text{vol}(\text{synapse}) \cdot \text{SBk3} \cdot [\text{S3}] \quad (24)$$

## 8.9 Reaction B4\_\_\_\_S4

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

**Name** B4 -> S4

### Reaction equation



### Reactant

Table 30: Properties of each reactant.

Id	Name	SBO
B4	B4	

### Modifier

Table 31: Properties of each modifier.

Id	Name	SBO
B4	B4	

### Product

Table 32: Properties of each product.

Id	Name	SBO
S4	S4	

## Kinetic Law

**Derived unit** contains undeclared units

$$v_9 = \text{vol}(\text{synapse}) \cdot \text{BSk4} \cdot [\text{B4}] \quad (26)$$

### 8.10 Reaction S4\_\_\_\_B4

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

**Name** S4 -> B4

#### Reaction equation



#### Reactant

Table 33: Properties of each reactant.

Id	Name	SBO
S4	S4	

#### Modifier

Table 34: Properties of each modifier.

Id	Name	SBO
S4	S4	

#### Product

Table 35: Properties of each product.

Id	Name	SBO
B4	B4	

#### Kinetic Law

**Derived unit** contains undeclared units

$$v_{10} = \text{vol}(\text{synapse}) \cdot \text{SBk4} \cdot [S4] \quad (28)$$

### 8.11 Reaction S0\_\_\_\_M0

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

**Name** S0 -> M0

### Reaction equation



### Reactant

Table 36: Properties of each reactant.

Id	Name	SBO
S0	S0	

### Modifier

Table 37: Properties of each modifier.

Id	Name	SBO
S0	S0	

### Product

Table 38: Properties of each product.

Id	Name	SBO
M0	M0	

### Kinetic Law

**Derived unit** contains undeclared units

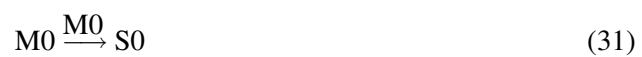
$$v_{11} = \text{vol}(\text{synapse}) \cdot \text{SMk0} \cdot [S0] \quad (30)$$

### 8.12 Reaction M0\_\_\_\_S0

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

**Name** M0 -> S0

### Reaction equation



### Reactant



Table 39: Properties of each reactant.

Id	Name	SBO
M0	M0	

## Modifier

Table 40: Properties of each modifier.

Id	Name	SBO
M0	M0	

## Product

Table 41: Properties of each product.

Id	Name	SBO
S0	S0	

## Kinetic Law

**Derived unit** contains undeclared units

$$v_{12} = \text{vol}(\text{synapse}) \cdot \text{MSk0} \cdot [\text{M0}] \quad (32)$$

### 8.13 Reaction S1\_\_\_M1

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

**Name** S1 -> M1

## Reaction equation



## Reactant

Table 42: Properties of each reactant.

Id	Name	SBO
S1	S1	

## Modifier

Table 43: Properties of each modifier.

Id	Name	SBO
S1	S1	

## Product

Table 44: Properties of each product.

Id	Name	SBO
M1	M1	

## Kinetic Law

**Derived unit** contains undeclared units

$$v_{13} = \text{vol}(\text{synapse}) \cdot \text{SMk1} \cdot [\text{S1}] \quad (34)$$

### 8.14 Reaction M1\_\_\_\_S1

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

**Name** M1 -> S1

## Reaction equation



## Reactant

Table 45: Properties of each reactant.

Id	Name	SBO
M1	M1	

## Modifier

Table 46: Properties of each modifier.

Id	Name	SBO
M1	M1	

## Product

Table 47: Properties of each product.

Id	Name	SBO
S1	S1	

## Kinetic Law

**Derived unit** contains undeclared units

$$v_{14} = \text{vol}(\text{synapse}) \cdot \text{MSk1} \cdot [\text{M1}] \quad (36)$$

## 8.15 Reaction S2→M2

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

**Name** S2 → M2

## Reaction equation



## Reactant

Table 48: Properties of each reactant.

Id	Name	SBO
S2	S2	

## Modifier

Table 49: Properties of each modifier.

Id	Name	SBO
S2	S2	

## Product

Table 50: Properties of each product.

Id	Name	SBO
M2	M2	

## Kinetic Law

**Derived unit** contains undeclared units

$$v_{15} = \text{vol}(\text{synapse}) \cdot \text{SMk2} \cdot [\text{S2}] \quad (38)$$

## 8.16 Reaction M2\_\_\_\_S2

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

**Name** M2 -> S2

## Reaction equation



## Reactant

Table 51: Properties of each reactant.

Id	Name	SBO
M2	M2	

## Modifier

Table 52: Properties of each modifier.

Id	Name	SBO
M2	M2	

## Product

Table 53: Properties of each product.

Id	Name	SBO
S2	S2	

### Kinetic Law

**Derived unit** contains undeclared units

$$v_{16} = \text{vol}(\text{synapse}) \cdot \text{MSk2} \cdot [\text{M2}] \quad (40)$$

### 8.17 Reaction S3\_\_\_\_M3

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

**Name** S3 -> M3

### Reaction equation



### Reactant

Table 54: Properties of each reactant.

Id	Name	SBO
S3	S3	

### Modifier

Table 55: Properties of each modifier.

Id	Name	SBO
S3	S3	

### Product

Table 56: Properties of each product.

Id	Name	SBO
M3	M3	

## Kinetic Law

**Derived unit** contains undeclared units

$$v_{17} = \text{vol}(\text{synapse}) \cdot \text{SMk3} \cdot [\text{S3}] \quad (42)$$

## 8.18 Reaction M3→S3

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

**Name** M3 -> S3

## Reaction equation



## Reactant

Table 57: Properties of each reactant.

Id	Name	SBO
M3	M3	

## Modifier

Table 58: Properties of each modifier.

Id	Name	SBO
M3	M3	

## Product

Table 59: Properties of each product.

Id	Name	SBO
S3	S3	

## Kinetic Law

**Derived unit** contains undeclared units

$$v_{18} = \text{vol}(\text{synapse}) \cdot \text{MSk3} \cdot [\text{M3}] \quad (44)$$

### 8.19 Reaction S4\_\_\_\_M4

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

**Name** S4 -> M4

#### Reaction equation



#### Reactant

Table 60: Properties of each reactant.

Id	Name	SBO
S4	S4	

#### Modifier

Table 61: Properties of each modifier.

Id	Name	SBO
S4	S4	

#### Product

Table 62: Properties of each product.

Id	Name	SBO
M4	M4	

#### Kinetic Law

**Derived unit** contains undeclared units

$$v_{19} = \text{vol}(\text{synapse}) \cdot \text{SMk4} \cdot [S4] \quad (46)$$

### 8.20 Reaction M4\_\_\_\_S4

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

**Name** M4 -> S4

## Reaction equation



## Reactant

Table 63: Properties of each reactant.

Id	Name	SBO
M4	M4	

## Modifier

Table 64: Properties of each modifier.

Id	Name	SBO
M4	M4	

## Product

Table 65: Properties of each product.

Id	Name	SBO
S4	S4	

## Kinetic Law

**Derived unit** contains undeclared units

$$v_{20} = \text{vol}(\text{synapse}) \cdot \text{MSk4} \cdot [M4] \quad (48)$$

## 8.21 Reaction M0\_\_\_L0

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

**Name** M0 -> L0

## Reaction equation



## Reactant



Table 66: Properties of each reactant.

Id	Name	SBO
M0	M0	

## Modifier

Table 67: Properties of each modifier.

Id	Name	SBO
M0	M0	

## Product

Table 68: Properties of each product.

Id	Name	SBO
L0	L0	

## Kinetic Law

**Derived unit** contains undeclared units

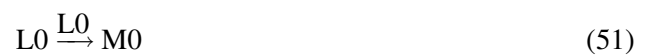
$$v_{21} = \text{vol}(\text{synapse}) \cdot \text{MLk0} \cdot [\text{M0}] \quad (50)$$

## 8.22 Reaction L0→M0

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

**Name** L0 → M0

## Reaction equation



## Reactant

Table 69: Properties of each reactant.

Id	Name	SBO
L0	L0	

## Modifier

Table 70: Properties of each modifier.

Id	Name	SBO
L0	L0	

## Product

Table 71: Properties of each product.

Id	Name	SBO
M0	M0	

## Kinetic Law

**Derived unit** contains undeclared units

$$v_{22} = \text{vol}(\text{synapse}) \cdot \text{LMk0} \cdot [\text{L0}] \quad (52)$$

### 8.23 Reaction M1\_\_\_\_L1

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

**Name** M1 -> L1

#### Reaction equation



## Reactant

Table 72: Properties of each reactant.

Id	Name	SBO
M1	M1	

## Modifier

Table 73: Properties of each modifier.

Id	Name	SBO
M1	M1	

## Product

Table 74: Properties of each product.

Id	Name	SBO
L1	L1	

## Kinetic Law

**Derived unit** contains undeclared units

$$v_{23} = \text{vol}(\text{synapse}) \cdot \text{MLk1} \cdot [\text{M1}] \quad (54)$$

## 8.24 Reaction L1→M1

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

**Name** L1 → M1

## Reaction equation



## Reactant

Table 75: Properties of each reactant.

Id	Name	SBO
L1	L1	

## Modifier

Table 76: Properties of each modifier.

Id	Name	SBO
L1	L1	

## Product

Table 77: Properties of each product.

Id	Name	SBO
M1	M1	

## Kinetic Law

**Derived unit** contains undeclared units

$$v_{24} = \text{vol}(\text{synapse}) \cdot \text{LMk1} \cdot [\text{L1}] \quad (56)$$

## 8.25 Reaction M2\_\_\_L2

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

**Name** M2 -> L2

## Reaction equation



## Reactant

Table 78: Properties of each reactant.

Id	Name	SBO
M2	M2	

## Modifier

Table 79: Properties of each modifier.

Id	Name	SBO
M2	M2	

## Product

Table 80: Properties of each product.

Id	Name	SBO
L2	L2	

**Kinetic Law**

**Derived unit** contains undeclared units

$$v_{25} = \text{vol}(\text{synapse}) \cdot \text{MLk2} \cdot [\text{M2}] \tag{58}$$

**8.26 Reaction L2\_\_\_\_M2**

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

**Name** L2 -> M2

**Reaction equation**



**Reactant**

Table 81: Properties of each reactant.

Id	Name	SBO
L2	L2	

**Modifier**

Table 82: Properties of each modifier.

Id	Name	SBO
L2	L2	

**Product**

Table 83: Properties of each product.

Id	Name	SBO
M2	M2	

## Kinetic Law

**Derived unit** contains undeclared units

$$v_{26} = \text{vol}(\text{synapse}) \cdot \text{LMk2} \cdot [\text{L2}] \quad (60)$$

## 8.27 Reaction M3→L3

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

**Name** M3 → L3

### Reaction equation



### Reactant

Table 84: Properties of each reactant.

Id	Name	SBO
M3	M3	

### Modifier

Table 85: Properties of each modifier.

Id	Name	SBO
M3	M3	

### Product

Table 86: Properties of each product.

Id	Name	SBO
L3	L3	

## Kinetic Law

**Derived unit** contains undeclared units

$$v_{27} = \text{vol}(\text{synapse}) \cdot \text{MLk3} \cdot [\text{M3}] \quad (62)$$

### 8.28 Reaction L3\_\_\_M3

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

**Name** L3 -> M3

#### Reaction equation



#### Reactant

Table 87: Properties of each reactant.

Id	Name	SBO
L3	L3	

#### Modifier

Table 88: Properties of each modifier.

Id	Name	SBO
L3	L3	

#### Product

Table 89: Properties of each product.

Id	Name	SBO
M3	M3	

#### Kinetic Law

**Derived unit** contains undeclared units

$$v_{28} = \text{vol}(\text{synapse}) \cdot \text{LMk3} \cdot [L3] \quad (64)$$

### 8.29 Reaction M4\_\_\_L4

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

**Name** M4 -> L4

### Reaction equation



### Reactant

Table 90: Properties of each reactant.

Id	Name	SBO
M4	M4	

### Modifier

Table 91: Properties of each modifier.

Id	Name	SBO
M4	M4	

### Product

Table 92: Properties of each product.

Id	Name	SBO
L4	L4	

### Kinetic Law

**Derived unit** contains undeclared units

$$v_{29} = \text{vol}(\text{synapse}) \cdot \text{MLk4} \cdot [\text{M4}] \quad (66)$$

### 8.30 Reaction L4\_\_\_\_M4

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

**Name** L4 -> M4

### Reaction equation



### Reactant



Table 93: Properties of each reactant.

Id	Name	SBO
L4	L4	

## Modifier

Table 94: Properties of each modifier.

Id	Name	SBO
L4	L4	

## Product

Table 95: Properties of each product.

Id	Name	SBO
M4	M4	

## Kinetic Law

**Derived unit** contains undeclared units

$$v_{30} = \text{vol}(\text{synapse}) \cdot \text{LMk4} \cdot [\text{L4}] \quad (68)$$

### 8.31 Reaction B0\_\_\_B1

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

**Name** B0 -> B1

## Reaction equation



## Reactants

Table 96: Properties of each reactant.

Id	Name	SBO
B0	B0	
glu	glu	

## Modifiers

Table 97: Properties of each modifier.

Id	Name	SBO
B0	B0	
glu	glu	

## Product

Table 98: Properties of each product.

Id	Name	SBO
B1	B1	

## Kinetic Law

**Derived unit** contains undeclared units

$$v_{31} = \text{vol}(\text{synapse}) \cdot \text{Ligand\_Binding\_1}(\text{Bkon}, [\text{B0}], [\text{glu}]) \quad (70)$$

$$\text{Ligand\_Binding\_1}(k, R, L) = 4 \cdot k \cdot R \cdot L \quad (71)$$

$$\text{Ligand\_Binding\_1}(k, R, L) = 4 \cdot k \cdot R \cdot L \quad (72)$$

### 8.32 Reaction B1\_\_\_\_B0

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

**Name** B1 -> B0

#### Reaction equation



## Reactant

Table 99: Properties of each reactant.

Id	Name	SBO
B1	B1	

## Modifier

Table 100: Properties of each modifier.

Id	Name	SBO
B1	B1	

## Products

Table 101: Properties of each product.

Id	Name	SBO
B0	B0	
glu	glu	

## Kinetic Law

**Derived unit** contains undeclared units

$$v_{32} = \text{vol}(\text{synapse}) \cdot \text{Ligand\_Unbinding\_1}(\text{Bkoff}, [\text{B1}]) \quad (74)$$

$$\text{Ligand\_Unbinding\_1}(k, R) = k \cdot R \quad (75)$$

$$\text{Ligand\_Unbinding\_1}(k, R) = k \cdot R \quad (76)$$

### 8.33 Reaction B1\_\_\_\_B2

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

**Name** B1 -> B2

#### Reaction equation



## Reactants

Table 102: Properties of each reactant.

Id	Name	SBO
B1	B1	
glu	glu	

## Modifiers

Table 103: Properties of each modifier.

Id	Name	SBO
B1	B1	
glu	glu	

## Product

Table 104: Properties of each product.

Id	Name	SBO
B2	B2	

## Kinetic Law

**Derived unit** contains undeclared units

$$v_{33} = \text{vol}(\text{synapse}) \cdot \text{Ligand\_Binding\_2}(\text{Bkon}, [\text{B1}], [\text{glu}]) \quad (78)$$

$$\text{Ligand\_Binding\_2}(k, R, L) = 3 \cdot k \cdot R \cdot L \quad (79)$$

$$\text{Ligand\_Binding\_2}(k, R, L) = 3 \cdot k \cdot R \cdot L \quad (80)$$

### 8.34 Reaction B2→B1

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

**Name** B2 -> B1

#### Reaction equation



## Reactant

Table 105: Properties of each reactant.

Id	Name	SBO
B2	B2	

## Modifier

Table 106: Properties of each modifier.

Id	Name	SBO
B2	B2	

## Products

Table 107: Properties of each product.

Id	Name	SBO
B1	B1	
glu	glu	

## Kinetic Law

**Derived unit** contains undeclared units

$$v_{34} = \text{vol}(\text{synapse}) \cdot \text{Ligand\_Unbinding\_2}(\text{Bkoff}, [\text{B2}]) \quad (82)$$

$$\text{Ligand\_Unbinding\_2}(k, R) = 2 \cdot k \cdot R \quad (83)$$

$$\text{Ligand\_Unbinding\_2}(k, R) = 2 \cdot k \cdot R \quad (84)$$

### 8.35 Reaction B2----B3

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

**Name** B2 -> B3

## Reaction equation



## Reactants

Table 108: Properties of each reactant.

Id	Name	SBO
B2	B2	
glu	glu	

## Modifiers

Table 109: Properties of each modifier.

Id	Name	SBO
B2	B2	
glu	glu	

## Product

Table 110: Properties of each product.

Id	Name	SBO
B3	B3	

## Kinetic Law

**Derived unit** contains undeclared units

$$v_{35} = \text{vol}(\text{synapse}) \cdot \text{Ligand\_Binding\_3}(\text{Bkon}, [\text{B2}], [\text{glu}]) \quad (86)$$

$$\text{Ligand\_Binding\_3}(k, R, L) = 2 \cdot k \cdot R \cdot L \quad (87)$$

$$\text{Ligand\_Binding\_3}(k, R, L) = 2 \cdot k \cdot R \cdot L \quad (88)$$

### 8.36 Reaction B3\_\_\_B2

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

**Name** B3 -> B2

#### Reaction equation



## Reactant

Table 111: Properties of each reactant.

Id	Name	SBO
B3	B3	

## Modifier

Table 112: Properties of each modifier.

Id	Name	SBO
B3	B3	

## Products

Table 113: Properties of each product.

Id	Name	SBO
B2	B2	
glu	glu	

## Kinetic Law

**Derived unit** contains undeclared units

$$v_{36} = \text{vol}(\text{synapse}) \cdot \text{Ligand\_Unbinding\_3}(\text{Bkoff}, [\text{B3}]) \quad (90)$$

$$\text{Ligand\_Unbinding\_3}(k, R) = 3 \cdot k \cdot R \quad (91)$$

$$\text{Ligand\_Unbinding\_3}(k, R) = 3 \cdot k \cdot R \quad (92)$$

### 8.37 Reaction B3\_\_\_\_B4

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

**Name** B3 -> B4

#### Reaction equation



## Reactants

Table 114: Properties of each reactant.

Id	Name	SBO
B3	B3	
glu	glu	

## Modifiers

Table 115: Properties of each modifier.

Id	Name	SBO
B3	B3	
glu	glu	

## Product

Table 116: Properties of each product.

Id	Name	SBO
B4	B4	

## Kinetic Law

**Derived unit** contains undeclared units

$$v_{37} = \text{vol}(\text{synapse}) \cdot \text{Ligand\_Binding\_4}(\text{Bkon}, [\text{B3}], [\text{glu}]) \quad (94)$$

$$\text{Ligand\_Binding\_4}(k, R, L) = k \cdot R \cdot L \quad (95)$$

$$\text{Ligand\_Binding\_4}(k, R, L) = k \cdot R \cdot L \quad (96)$$

### 8.38 Reaction B4→B3

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

**Name** B4 -> B3

#### Reaction equation



## Reactant

Table 117: Properties of each reactant.

Id	Name	SBO
B4	B4	



## Modifier

Table 118: Properties of each modifier.

Id	Name	SBO
B4	B4	

## Products

Table 119: Properties of each product.

Id	Name	SBO
B3	B3	
glu	glu	

## Kinetic Law

**Derived unit** contains undeclared units

$$v_{38} = \text{vol}(\text{synapse}) \cdot \text{Ligand\_Unbinding\_4}(\text{Bkoff}, [\text{B4}]) \quad (98)$$

$$\text{Ligand\_Unbinding\_4}(k, R) = 4 \cdot k \cdot R \quad (99)$$

$$\text{Ligand\_Unbinding\_4}(k, R) = 4 \cdot k \cdot R \quad (100)$$

### 8.39 Reaction S0\_\_\_\_S1

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

**Name** S0 -> S1

#### Reaction equation



## Reactants

Table 120: Properties of each reactant.

Id	Name	SBO
S0	S0	
glu	glu	

## Modifiers

Table 121: Properties of each modifier.

Id	Name	SBO
S0	S0	
glu	glu	

## Product

Table 122: Properties of each product.

Id	Name	SBO
S1	S1	

## Kinetic Law

**Derived unit** contains undeclared units

$$v_{39} = \text{vol}(\text{synapse}) \cdot \text{Ligand\_Binding\_1}(\text{Skon}, [\text{S0}], [\text{glu}]) \quad (102)$$

$$\text{Ligand\_Binding\_1}(k, R, L) = 4 \cdot k \cdot R \cdot L \quad (103)$$

$$\text{Ligand\_Binding\_1}(k, R, L) = 4 \cdot k \cdot R \cdot L \quad (104)$$

### 8.40 Reaction S1----S0

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

**Name** S1 -> S0

#### Reaction equation



## Reactant

Table 123: Properties of each reactant.

Id	Name	SBO
S1	S1	

## Modifier

Table 124: Properties of each modifier.

Id	Name	SBO
S1	S1	

## Products

Table 125: Properties of each product.

Id	Name	SBO
S0	S0	
glu	glu	

## Kinetic Law

**Derived unit** contains undeclared units

$$v_{40} = \text{vol}(\text{synapse}) \cdot \text{Ligand\_Unbinding\_1}(\text{Skoff}, [\text{S1}]) \quad (106)$$

$$\text{Ligand\_Unbinding\_1}(k, R) = k \cdot R \quad (107)$$

$$\text{Ligand\_Unbinding\_1}(k, R) = k \cdot R \quad (108)$$

### 8.41 Reaction S1----S2

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

**Name** S1 -> S2

#### Reaction equation



## Reactants

Table 126: Properties of each reactant.

Id	Name	SBO
S1	S1	
glu	glu	

## Modifiers

Table 127: Properties of each modifier.

Id	Name	SBO
S1	S1	
glu	glu	

## Product

Table 128: Properties of each product.

Id	Name	SBO
S2	S2	

## Kinetic Law

**Derived unit** contains undeclared units

$$v_{41} = \text{vol}(\text{synapse}) \cdot \text{Ligand\_Binding\_2}(\text{Skon}, [\text{S1}], [\text{glu}]) \quad (110)$$

$$\text{Ligand\_Binding\_2}(k, R, L) = 3 \cdot k \cdot R \cdot L \quad (111)$$

$$\text{Ligand\_Binding\_2}(k, R, L) = 3 \cdot k \cdot R \cdot L \quad (112)$$

### 8.42 Reaction S2→S1

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

**Name** S2 -> S1

#### Reaction equation



## Reactant

Table 129: Properties of each reactant.

Id	Name	SBO
S2	S2	

## Modifier

Table 130: Properties of each modifier.

Id	Name	SBO
S2	S2	

## Products

Table 131: Properties of each product.

Id	Name	SBO
S1	S1	
glu	glu	

## Kinetic Law

**Derived unit** contains undeclared units

$$v_{42} = \text{vol}(\text{synapse}) \cdot \text{Ligand\_Unbinding\_2}(\text{Skoff}, [\text{S2}]) \quad (114)$$

$$\text{Ligand\_Unbinding\_2}(k, R) = 2 \cdot k \cdot R \quad (115)$$

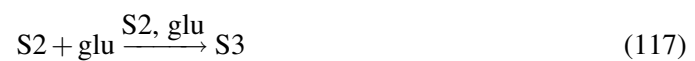
$$\text{Ligand\_Unbinding\_2}(k, R) = 2 \cdot k \cdot R \quad (116)$$

### 8.43 Reaction S2----S3

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

**Name** S2 -> S3

## Reaction equation



## Reactants

Table 132: Properties of each reactant.

Id	Name	SBO
S2	S2	
glu	glu	

## Modifiers

Table 133: Properties of each modifier.

Id	Name	SBO
S2	S2	
glu	glu	

## Product

Table 134: Properties of each product.

Id	Name	SBO
S3	S3	

## Kinetic Law

**Derived unit** contains undeclared units

$$v_{43} = \text{vol}(\text{synapse}) \cdot \text{Ligand\_Binding\_3}(\text{Skon}, [\text{S2}], [\text{glu}]) \quad (118)$$

$$\text{Ligand\_Binding\_3}(k, R, L) = 2 \cdot k \cdot R \cdot L \quad (119)$$

$$\text{Ligand\_Binding\_3}(k, R, L) = 2 \cdot k \cdot R \cdot L \quad (120)$$

### 8.44 Reaction S3\_\_\_\_S2

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

**Name** S3 -> S2

#### Reaction equation



## Reactant

Table 135: Properties of each reactant.

Id	Name	SBO
S3	S3	

## Modifier

Table 136: Properties of each modifier.

Id	Name	SBO
S3	S3	

## Products

Table 137: Properties of each product.

Id	Name	SBO
S2	S2	
glu	glu	

## Kinetic Law

**Derived unit** contains undeclared units

$$v_{44} = \text{vol}(\text{synapse}) \cdot \text{Ligand\_Unbinding\_3}(\text{Skoff}, [\text{S3}]) \quad (122)$$

$$\text{Ligand\_Unbinding\_3}(k, R) = 3 \cdot k \cdot R \quad (123)$$

$$\text{Ligand\_Unbinding\_3}(k, R) = 3 \cdot k \cdot R \quad (124)$$

### 8.45 Reaction S3\_\_\_\_S4

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

**Name** S3 -> S4

## Reaction equation



## Reactants

Table 138: Properties of each reactant.

Id	Name	SBO
S3	S3	
glu	glu	

## Modifiers

Table 139: Properties of each modifier.

Id	Name	SBO
S3	S3	
glu	glu	

## Product

Table 140: Properties of each product.

Id	Name	SBO
S4	S4	

## Kinetic Law

**Derived unit** contains undeclared units

$$v_{45} = \text{vol}(\text{synapse}) \cdot \text{Ligand\_Binding\_4}(\text{Skon}, [\text{S3}], [\text{glu}]) \quad (126)$$

$$\text{Ligand\_Binding\_4}(k, R, L) = k \cdot R \cdot L \quad (127)$$

$$\text{Ligand\_Binding\_4}(k, R, L) = k \cdot R \cdot L \quad (128)$$

### 8.46 Reaction S4→S3

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

**Name** S4 -> S3

#### Reaction equation



## Reactant

Table 141: Properties of each reactant.

Id	Name	SBO
S4	S4	



## Modifier

Table 142: Properties of each modifier.

Id	Name	SBO
S4	S4	

## Products

Table 143: Properties of each product.

Id	Name	SBO
S3	S3	
glu	glu	

## Kinetic Law

**Derived unit** contains undeclared units

$$v_{46} = \text{vol}(\text{synapse}) \cdot \text{Ligand\_Unbinding\_4}(\text{Skoff}, [\text{S4}]) \quad (130)$$

$$\text{Ligand\_Unbinding\_4}(k, R) = 4 \cdot k \cdot R \quad (131)$$

$$\text{Ligand\_Unbinding\_4}(k, R) = 4 \cdot k \cdot R \quad (132)$$

### 8.47 Reaction M0\_\_\_M1

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

**Name** M0 -> M1

#### Reaction equation



## Reactants

Table 144: Properties of each reactant.

Id	Name	SBO
M0	M0	
glu	glu	

## Modifiers

Table 145: Properties of each modifier.

Id	Name	SBO
M0	M0	
glu	glu	

## Product

Table 146: Properties of each product.

Id	Name	SBO
M1	M1	

## Kinetic Law

**Derived unit** contains undeclared units

$$v_{47} = \text{vol}(\text{synapse}) \cdot \text{Ligand\_Binding\_1}(\text{Mkon}, [\text{M0}], [\text{glu}]) \quad (134)$$

$$\text{Ligand\_Binding\_1}(k, R, L) = 4 \cdot k \cdot R \cdot L \quad (135)$$

$$\text{Ligand\_Binding\_1}(k, R, L) = 4 \cdot k \cdot R \cdot L \quad (136)$$

### 8.48 Reaction M1→M0

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

**Name** M1 -> M0

#### Reaction equation



## Reactant

Table 147: Properties of each reactant.

Id	Name	SBO
M1	M1	

## Modifier

Table 148: Properties of each modifier.

Id	Name	SBO
M1	M1	

## Products

Table 149: Properties of each product.

Id	Name	SBO
M0	M0	
glu	glu	

## Kinetic Law

**Derived unit** contains undeclared units

$$v_{48} = \text{vol}(\text{synapse}) \cdot \text{Ligand\_Unbinding\_1}(\text{Mkoff}, [\text{M1}]) \quad (138)$$

$$\text{Ligand\_Unbinding\_1}(k, R) = k \cdot R \quad (139)$$

$$\text{Ligand\_Unbinding\_1}(k, R) = k \cdot R \quad (140)$$

### 8.49 Reaction M1\_\_\_M2

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

**Name** M1 -> M2

#### Reaction equation



## Reactants

Table 150: Properties of each reactant.

Id	Name	SBO
M1	M1	
glu	glu	

## Modifiers

Table 151: Properties of each modifier.

Id	Name	SBO
M1	M1	
glu	glu	

## Product

Table 152: Properties of each product.

Id	Name	SBO
M2	M2	

## Kinetic Law

**Derived unit** contains undeclared units

$$v_{49} = \text{vol}(\text{synapse}) \cdot \text{Ligand\_Binding\_2}(\text{Mkon}, [\text{M1}], [\text{glu}]) \quad (142)$$

$$\text{Ligand\_Binding\_2}(k, R, L) = 3 \cdot k \cdot R \cdot L \quad (143)$$

$$\text{Ligand\_Binding\_2}(k, R, L) = 3 \cdot k \cdot R \cdot L \quad (144)$$

### 8.50 Reaction M2→M1

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

**Name** M2 -> M1

#### Reaction equation



## Reactant

Table 153: Properties of each reactant.

Id	Name	SBO
M2	M2	

## Modifier

Table 154: Properties of each modifier.

Id	Name	SBO
M2	M2	

## Products

Table 155: Properties of each product.

Id	Name	SBO
M1	M1	
glu	glu	

## Kinetic Law

**Derived unit** contains undeclared units

$$v_{50} = \text{vol}(\text{synapse}) \cdot \text{Ligand\_Unbinding\_2}(\text{Mkoff}, [\text{M2}]) \quad (146)$$

$$\text{Ligand\_Unbinding\_2}(k, R) = 2 \cdot k \cdot R \quad (147)$$

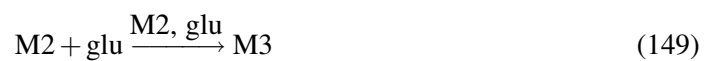
$$\text{Ligand\_Unbinding\_2}(k, R) = 2 \cdot k \cdot R \quad (148)$$

### 8.51 Reaction M2→M3

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

**Name** M2 -> M3

#### Reaction equation



## Reactants

Table 156: Properties of each reactant.

Id	Name	SBO
M2	M2	
glu	glu	

## Modifiers

Table 157: Properties of each modifier.

Id	Name	SBO
M2	M2	
glu	glu	

## Product

Table 158: Properties of each product.

Id	Name	SBO
M3	M3	

## Kinetic Law

**Derived unit** contains undeclared units

$$v_{51} = \text{vol}(\text{synapse}) \cdot \text{Ligand\_Binding\_3}(\text{Mkon}, [\text{M2}], [\text{glu}]) \quad (150)$$

$$\text{Ligand\_Binding\_3}(k, R, L) = 2 \cdot k \cdot R \cdot L \quad (151)$$

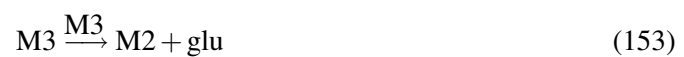
$$\text{Ligand\_Binding\_3}(k, R, L) = 2 \cdot k \cdot R \cdot L \quad (152)$$

### 8.52 Reaction M3\_\_\_M2

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

**Name** M3 -> M2

#### Reaction equation



## Reactant

Table 159: Properties of each reactant.

Id	Name	SBO
M3	M3	

## Modifier

Table 160: Properties of each modifier.

Id	Name	SBO
M3	M3	

## Products

Table 161: Properties of each product.

Id	Name	SBO
M2	M2	
glu	glu	

## Kinetic Law

**Derived unit** contains undeclared units

$$v_{52} = \text{vol}(\text{synapse}) \cdot \text{Ligand\_Unbinding\_3}(\text{Mkoff}, [\text{M3}]) \quad (154)$$

$$\text{Ligand\_Unbinding\_3}(k, R) = 3 \cdot k \cdot R \quad (155)$$

$$\text{Ligand\_Unbinding\_3}(k, R) = 3 \cdot k \cdot R \quad (156)$$

### 8.53 Reaction M3\_\_\_M4

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

**Name** M3 -> M4

#### Reaction equation



## Reactants

Table 162: Properties of each reactant.

Id	Name	SBO
M3	M3	
glu	glu	

## Modifier

Table 163: Properties of each modifier.

Id	Name	SBO
M3	M3	

## Product

Table 164: Properties of each product.

Id	Name	SBO
M4	M4	

## Kinetic Law

**Derived unit** contains undeclared units

$$v_{53} = \text{vol}(\text{synapse}) \cdot \text{Ligand\_Unbinding\_4}(\text{Mkon}, [\text{M3}]) \quad (158)$$

$$\text{Ligand\_Unbinding\_4}(k, R) = 4 \cdot k \cdot R \quad (159)$$

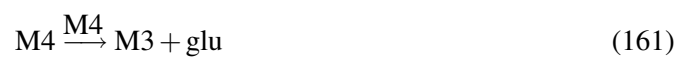
$$\text{Ligand\_Unbinding\_4}(k, R) = 4 \cdot k \cdot R \quad (160)$$

### 8.54 Reaction M4\_\_\_M3

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

**Name** M4 -> M3

## Reaction equation



## Reactant

Table 165: Properties of each reactant.

Id	Name	SBO
M4	M4	



## Modifier

Table 166: Properties of each modifier.

Id	Name	SBO
M4	M4	

## Products

Table 167: Properties of each product.

Id	Name	SBO
M3	M3	
glu	glu	

## Kinetic Law

**Derived unit** contains undeclared units

$$v_{54} = \text{vol}(\text{synapse}) \cdot \text{Ligand\_Unbinding\_4}(\text{Mkoff}, [\text{M4}]) \quad (162)$$

$$\text{Ligand\_Unbinding\_4}(k, R) = 4 \cdot k \cdot R \quad (163)$$

$$\text{Ligand\_Unbinding\_4}(k, R) = 4 \cdot k \cdot R \quad (164)$$

### 8.55 Reaction L0\_\_\_L1

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

**Name** L0 -> L1

#### Reaction equation



## Reactants

Table 168: Properties of each reactant.

Id	Name	SBO
L0	L0	
glu	glu	

## Modifiers

Table 169: Properties of each modifier.

Id	Name	SBO
L0	L0	
glu	glu	

## Product

Table 170: Properties of each product.

Id	Name	SBO
L1	L1	

## Kinetic Law

**Derived unit** contains undeclared units

$$v_{55} = \text{vol}(\text{synapse}) \cdot \text{Ligand\_Binding\_1}(\text{Lkon}, [\text{L0}], [\text{glu}]) \quad (166)$$

$$\text{Ligand\_Binding\_1}(k, R, L) = 4 \cdot k \cdot R \cdot L \quad (167)$$

$$\text{Ligand\_Binding\_1}(k, R, L) = 4 \cdot k \cdot R \cdot L \quad (168)$$

### 8.56 Reaction L1→L0

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

**Name** L1 -> L0

#### Reaction equation



## Reactant

Table 171: Properties of each reactant.

Id	Name	SBO
L1	L1	

## Modifier

Table 172: Properties of each modifier.

Id	Name	SBO
L1	L1	

## Products

Table 173: Properties of each product.

Id	Name	SBO
L0	L0	
glu	glu	

## Kinetic Law

**Derived unit** contains undeclared units

$$v_{56} = \text{vol}(\text{synapse}) \cdot \text{Ligand\_Unbinding\_1}(\text{Lkoff}, [\text{L1}]) \quad (170)$$

$$\text{Ligand\_Unbinding\_1}(k, R) = k \cdot R \quad (171)$$

$$\text{Ligand\_Unbinding\_1}(k, R) = k \cdot R \quad (172)$$

### 8.57 Reaction L1----L2

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

**Name** L1 -> L2

#### Reaction equation



## Reactants

Table 174: Properties of each reactant.

Id	Name	SBO
L1	L1	
glu	glu	

## Modifiers

Table 175: Properties of each modifier.

Id	Name	SBO
L1	L1	
glu	glu	

## Product

Table 176: Properties of each product.

Id	Name	SBO
L2	L2	

## Kinetic Law

**Derived unit** contains undeclared units

$$v_{57} = \text{vol}(\text{synapse}) \cdot \text{Ligand\_Binding\_2}(\text{Lkon}, [\text{L1}], [\text{glu}]) \quad (174)$$

$$\text{Ligand\_Binding\_2}(k, R, L) = 3 \cdot k \cdot R \cdot L \quad (175)$$

$$\text{Ligand\_Binding\_2}(k, R, L) = 3 \cdot k \cdot R \cdot L \quad (176)$$

### 8.58 Reaction L2→L1

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

**Name** L2 -> L1

#### Reaction equation



## Reactant

Table 177: Properties of each reactant.

Id	Name	SBO
L2	L2	

## Modifier

Table 178: Properties of each modifier.

Id	Name	SBO
L2	L2	

## Products

Table 179: Properties of each product.

Id	Name	SBO
L1	L1	
glu	glu	

## Kinetic Law

**Derived unit** contains undeclared units

$$v_{58} = \text{vol}(\text{synapse}) \cdot \text{Ligand\_Unbinding\_2}(\text{Lkoff}, [\text{L2}]) \quad (178)$$

$$\text{Ligand\_Unbinding\_2}(k, R) = 2 \cdot k \cdot R \quad (179)$$

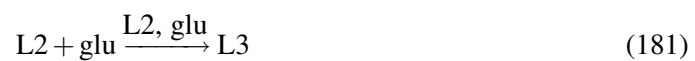
$$\text{Ligand\_Unbinding\_2}(k, R) = 2 \cdot k \cdot R \quad (180)$$

### 8.59 Reaction L2→L3

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

**Name** L2 -> L3

#### Reaction equation



## Reactants

Table 180: Properties of each reactant.

Id	Name	SBO
L2	L2	
glu	glu	

## Modifiers

Table 181: Properties of each modifier.

Id	Name	SBO
L2	L2	
glu	glu	

## Product

Table 182: Properties of each product.

Id	Name	SBO
L3	L3	

## Kinetic Law

**Derived unit** contains undeclared units

$$v_{59} = \text{vol}(\text{synapse}) \cdot \text{Ligand\_Binding\_3}(\text{Lkon}, [\text{L2}], [\text{glu}]) \quad (182)$$

$$\text{Ligand\_Binding\_3}(k, R, L) = 2 \cdot k \cdot R \cdot L \quad (183)$$

$$\text{Ligand\_Binding\_3}(k, R, L) = 2 \cdot k \cdot R \cdot L \quad (184)$$

### 8.60 Reaction L3→L2

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

**Name** L3 -> L2

#### Reaction equation



## Reactant

Table 183: Properties of each reactant.

Id	Name	SBO
L3	L3	

## Modifier

Table 184: Properties of each modifier.

Id	Name	SBO
L3	L3	

## Products

Table 185: Properties of each product.

Id	Name	SBO
L2	L2	
glu	glu	

## Kinetic Law

**Derived unit** contains undeclared units

$$v_{60} = \text{vol}(\text{synapse}) \cdot \text{Ligand\_Unbinding\_3}(\text{Lkoff}, [\text{L3}]) \quad (186)$$

$$\text{Ligand\_Unbinding\_3}(k, R) = 3 \cdot k \cdot R \quad (187)$$

$$\text{Ligand\_Unbinding\_3}(k, R) = 3 \cdot k \cdot R \quad (188)$$

### 8.61 Reaction L3\_\_\_L4

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

**Name** L3 -> L4

#### Reaction equation



## Reactants

Table 186: Properties of each reactant.

Id	Name	SBO
L3	L3	
glu	glu	

## Modifiers

Table 187: Properties of each modifier.

Id	Name	SBO
L3	L3	
glu	glu	

## Product

Table 188: Properties of each product.

Id	Name	SBO
L4	L4	

## Kinetic Law

**Derived unit** contains undeclared units

$$v_{61} = \text{vol}(\text{synapse}) \cdot \text{Ligand\_Binding\_4}(\text{Lkon}, [\text{L3}], [\text{glu}]) \quad (190)$$

$$\text{Ligand\_Binding\_4}(k, R, L) = k \cdot R \cdot L \quad (191)$$

$$\text{Ligand\_Binding\_4}(k, R, L) = k \cdot R \cdot L \quad (192)$$

### 8.62 Reaction L4→L3

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

**Name** L4 -> L3

#### Reaction equation



## Reactant

Table 189: Properties of each reactant.

Id	Name	SBO
L4	L4	



## Modifier

Table 190: Properties of each modifier.

Id	Name	SBO
L4	L4	

## Products

Table 191: Properties of each product.

Id	Name	SBO
L3	L3	
glu	glu	

## Kinetic Law

**Derived unit** contains undeclared units

$$v_{62} = \text{vol}(\text{synapse}) \cdot \text{Ligand\_Unbinding\_4}(\text{Lkoff}, [\text{L4}]) \quad (194)$$

$$\text{Ligand\_Unbinding\_4}(k, R) = 4 \cdot k \cdot R \quad (195)$$

$$\text{Ligand\_Unbinding\_4}(k, R) = 4 \cdot k \cdot R \quad (196)$$

## 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 B0

**Name** B0

**Notes** The amount must be divided by 50 to simulate a single receptor (scale down the vol

**Initial concentration**  $8.30269391581363 \cdot 10^{-7} \text{ mol} \cdot \text{l}^{-1}$

This species takes part in six reactions (as a reactant in B0\_\_\_\_S0, B0\_\_\_\_B1 and as a product in S0\_\_\_\_B0, B1\_\_\_\_B0 and as a modifier in B0\_\_\_\_S0, B0\_\_\_\_B1).

$$\frac{d}{dt}B0 = v_2 + v_{32} - v_1 - v_{31} \quad (197)$$

## 9.2 Species S0

**Name** S0

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

This species takes part in nine reactions (as a reactant in S0\_\_\_\_B0, S0\_\_\_\_M0, S0\_\_\_\_S1 and as a product in B0\_\_\_\_S0, M0\_\_\_\_S0, S1\_\_\_\_S0 and as a modifier in S0\_\_\_\_B0, S0\_\_\_\_M0, S0\_\_\_\_S1).

$$\frac{d}{dt}S0 = v_1 + v_{12} + v_{40} - v_2 - v_{11} - v_{39} \quad (198)$$

## 9.3 Species B1

**Name** B1

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

This species takes part in nine reactions (as a reactant in B1\_\_\_\_S1, B1\_\_\_\_B0, B1\_\_\_\_B2 and as a product in S1\_\_\_\_B1, B0\_\_\_\_B1, B2\_\_\_\_B1 and as a modifier in B1\_\_\_\_S1, B1\_\_\_\_B0, B1\_\_\_\_B2).

$$\frac{d}{dt}B1 = v_4 + v_{31} + v_{34} - v_3 - v_{32} - v_{33} \quad (199)$$

## 9.4 Species S1

**Name** S1

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

This species takes part in twelve reactions (as a reactant in S1\_\_\_\_B1, S1\_\_\_\_M1, S1\_\_\_\_S0, S1\_\_\_\_S2 and as a product in B1\_\_\_\_S1, M1\_\_\_\_S1, S0\_\_\_\_S1, S2\_\_\_\_S1 and as a modifier in S1\_\_\_\_B1, S1\_\_\_\_M1, S1\_\_\_\_S0, S1\_\_\_\_S2).

$$\frac{d}{dt}S1 = v_3 + v_{14} + v_{39} + v_{42} - v_4 - v_{13} - v_{40} - v_{41} \quad (200)$$

## 9.5 Species B2

**Name** B2

**Initial concentration** 0 mol · l<sup>-1</sup>

This species takes part in nine reactions (as a reactant in B2\_\_\_\_S2, B2\_\_\_\_B1, B2\_\_\_\_B3 and as a product in S2\_\_\_\_B2, B1\_\_\_\_B2, B3\_\_\_\_B2 and as a modifier in B2\_\_\_\_S2, B2\_\_\_\_B1, B2\_\_\_\_B3).

$$\frac{d}{dt}B2 = v_6 + v_{33} + v_{36} - v_5 - v_{34} - v_{35} \quad (201)$$

## 9.6 Species S2

**Name** S2

**Initial concentration** 0 mol · l<sup>-1</sup>

This species takes part in twelve reactions (as a reactant in S2\_\_\_\_B2, S2\_\_\_\_M2, S2\_\_\_\_S1, S2\_\_\_\_S3 and as a product in B2\_\_\_\_S2, M2\_\_\_\_S2, S1\_\_\_\_S2, S3\_\_\_\_S2 and as a modifier in S2\_\_\_\_B2, S2\_\_\_\_M2, S2\_\_\_\_S1, S2\_\_\_\_S3).

$$\frac{d}{dt}S2 = v_5 + v_{16} + v_{41} + v_{44} - v_6 - v_{15} - v_{42} - v_{43} \quad (202)$$

## 9.7 Species B3

**Name** B3

**Initial concentration** 0 mol · l<sup>-1</sup>

This species takes part in nine reactions (as a reactant in B3\_\_\_\_S3, B3\_\_\_\_B2, B3\_\_\_\_B4 and as a product in S3\_\_\_\_B3, B2\_\_\_\_B3, B4\_\_\_\_B3 and as a modifier in B3\_\_\_\_S3, B3\_\_\_\_B2, B3\_\_\_\_B4).

$$\frac{d}{dt}B3 = v_8 + v_{35} + v_{38} - v_7 - v_{36} - v_{37} \quad (203)$$

## 9.8 Species S3

**Name** S3

**Initial concentration** 0 mol · l<sup>-1</sup>

This species takes part in twelve reactions (as a reactant in S3\_\_\_\_B3, S3\_\_\_\_M3, S3\_\_\_\_S2, S3\_\_\_\_S4 and as a product in B3\_\_\_\_S3, M3\_\_\_\_S3, S2\_\_\_\_S3, S4\_\_\_\_S3 and as a modifier in S3\_\_\_\_B3, S3\_\_\_\_M3, S3\_\_\_\_S2, S3\_\_\_\_S4).

$$\frac{d}{dt}S3 = v_7 + v_{18} + v_{43} + v_{46} - v_8 - v_{17} - v_{44} - v_{45} \quad (204)$$

## 9.9 Species B4

**Name** B4

**Initial concentration** 0 mol · l<sup>-1</sup>

This species takes part in six reactions (as a reactant in B4\_\_\_\_S4, B4\_\_\_\_B3 and as a product in S4\_\_\_\_B4, B3\_\_\_\_B4 and as a modifier in B4\_\_\_\_S4, B4\_\_\_\_B3).

$$\frac{d}{dt}B4 = v_{10} + v_{37} - v_9 - v_{38} \quad (205)$$

## 9.10 Species S4

**Name** S4

**Initial concentration** 0 mol · l<sup>-1</sup>

This species takes part in nine reactions (as a reactant in S4\_\_\_\_B4, S4\_\_\_\_M4, S4\_\_\_\_S3 and as a product in B4\_\_\_\_S4, M4\_\_\_\_S4, S3\_\_\_\_S4 and as a modifier in S4\_\_\_\_B4, S4\_\_\_\_M4, S4\_\_\_\_S3).

$$\frac{d}{dt}S4 = v_9 + v_{20} + v_{45} - v_{10} - v_{19} - v_{46} \quad (206)$$

## 9.11 Species M0

**Name** M0

**Initial concentration** 0 mol · l<sup>-1</sup>

This species takes part in nine reactions (as a reactant in M0\_\_\_\_S0, M0\_\_\_\_L0, M0\_\_\_\_M1 and as a product in S0\_\_\_\_M0, L0\_\_\_\_M0, M1\_\_\_\_M0 and as a modifier in M0\_\_\_\_S0, M0\_\_\_\_L0, M0\_\_\_\_M1).

$$\frac{d}{dt}M0 = v_{11} + v_{22} + v_{48} - v_{12} - v_{21} - v_{47} \quad (207)$$

## 9.12 Species M1

**Name** M1

**Initial concentration** 0 mol · l<sup>-1</sup>

This species takes part in twelve reactions (as a reactant in M1\_\_\_\_S1, M1\_\_\_\_L1, M1\_\_\_\_M0, M1\_\_\_\_M2 and as a product in S1\_\_\_\_M1, L1\_\_\_\_M1, M0\_\_\_\_M1, M2\_\_\_\_M1 and as a modifier in M1\_\_\_\_S1, M1\_\_\_\_L1, M1\_\_\_\_M0, M1\_\_\_\_M2).

$$\frac{d}{dt}M1 = v_{13} + v_{24} + v_{47} + v_{50} - v_{14} - v_{23} - v_{48} - v_{49} \quad (208)$$

### 9.13 Species M2

**Name** M2

**Initial concentration** 0 mol · l<sup>-1</sup>

This species takes part in twelve reactions (as a reactant in M2\_\_\_\_S2, M2\_\_\_\_L2, M2\_\_\_\_M1, M2\_\_\_\_M3 and as a product in S2\_\_\_\_M2, L2\_\_\_\_M2, M1\_\_\_\_M2, M3\_\_\_\_M2 and as a modifier in M2\_\_\_\_S2, M2\_\_\_\_L2, M2\_\_\_\_M1, M2\_\_\_\_M3).

$$\frac{d}{dt}M2 = v_{15} + v_{26} + v_{49} + v_{52} - v_{16} - v_{25} - v_{50} - v_{51} \quad (209)$$

### 9.14 Species M3

**Name** M3

**Initial concentration** 0 mol · l<sup>-1</sup>

This species takes part in twelve reactions (as a reactant in M3\_\_\_\_S3, M3\_\_\_\_L3, M3\_\_\_\_M2, M3\_\_\_\_M4 and as a product in S3\_\_\_\_M3, L3\_\_\_\_M3, M2\_\_\_\_M3, M4\_\_\_\_M3 and as a modifier in M3\_\_\_\_S3, M3\_\_\_\_L3, M3\_\_\_\_M2, M3\_\_\_\_M4).

$$\frac{d}{dt}M3 = v_{17} + v_{28} + v_{51} + v_{54} - v_{18} - v_{27} - v_{52} - v_{53} \quad (210)$$

### 9.15 Species M4

**Name** M4

**Initial concentration** 0 mol · l<sup>-1</sup>

This species takes part in nine reactions (as a reactant in M4\_\_\_\_S4, M4\_\_\_\_L4, M4\_\_\_\_M3 and as a product in S4\_\_\_\_M4, L4\_\_\_\_M4, M3\_\_\_\_M4 and as a modifier in M4\_\_\_\_S4, M4\_\_\_\_L4, M4\_\_\_\_M3).

$$\frac{d}{dt}M4 = v_{19} + v_{30} + v_{53} - v_{20} - v_{29} - v_{54} \quad (211)$$

### 9.16 Species L0

**Name** L0

**Initial concentration** 0 mol · l<sup>-1</sup>

This species takes part in six reactions (as a reactant in L0\_\_\_\_M0, L0\_\_\_\_L1 and as a product in M0\_\_\_\_L0, L1\_\_\_\_L0 and as a modifier in L0\_\_\_\_M0, L0\_\_\_\_L1).

$$\frac{d}{dt}L0 = v_{21} + v_{56} - v_{22} - v_{55} \quad (212)$$

### 9.17 Species L1

**Name** L1

**Initial concentration** 0 mol · l<sup>-1</sup>

This species takes part in nine reactions (as a reactant in L1\_\_\_M1, L1\_\_\_L0, L1\_\_\_L2 and as a product in M1\_\_\_L1, L0\_\_\_L1, L2\_\_\_L1 and as a modifier in L1\_\_\_M1, L1\_\_\_L0, L1\_\_\_L2).

$$\frac{d}{dt}L1 = v_{23} + v_{55} + v_{58} - v_{24} - v_{56} - v_{57} \quad (213)$$

### 9.18 Species L2

**Name** L2

**Initial concentration** 0 mol · l<sup>-1</sup>

This species takes part in nine reactions (as a reactant in L2\_\_\_M2, L2\_\_\_L1, L2\_\_\_L3 and as a product in M2\_\_\_L2, L1\_\_\_L2, L3\_\_\_L2 and as a modifier in L2\_\_\_M2, L2\_\_\_L1, L2\_\_\_L3).

$$\frac{d}{dt}L2 = v_{25} + v_{57} + v_{60} - v_{26} - v_{58} - v_{59} \quad (214)$$

### 9.19 Species L3

**Name** L3

**Initial concentration** 0 mol · l<sup>-1</sup>

This species takes part in nine reactions (as a reactant in L3\_\_\_M3, L3\_\_\_L2, L3\_\_\_L4 and as a product in M3\_\_\_L3, L2\_\_\_L3, L4\_\_\_L3 and as a modifier in L3\_\_\_M3, L3\_\_\_L2, L3\_\_\_L4).

$$\frac{d}{dt}L3 = v_{27} + v_{59} + v_{62} - v_{28} - v_{60} - v_{61} \quad (215)$$

### 9.20 Species L4

**Name** L4

**Initial concentration** 0 mol · l<sup>-1</sup>

This species takes part in six reactions (as a reactant in L4\_\_\_M4, L4\_\_\_L3 and as a product in M4\_\_\_L4, L3\_\_\_L4 and as a modifier in L4\_\_\_M4, L4\_\_\_L3).

$$\frac{d}{dt}L4 = v_{29} + v_{61} - v_{30} - v_{62} \quad (216)$$

## 9.21 Species glu

**Name** glu

**Initial concentration**  $8.30269391581363 \cdot 10^{-4} \text{ mol} \cdot \text{l}^{-1}$

This species takes part in 47 reactions (as a reactant in B0\_\_\_B1, B1\_\_\_B2, B2\_\_\_B3, B3\_\_\_B4, S0\_\_\_S1, S1\_\_\_S2, S2\_\_\_S3, S3\_\_\_S4, M0\_\_\_M1, M1\_\_\_M2, M2\_\_\_M3, M3\_\_\_M4, L0\_\_\_L1, L1\_\_\_L2, L2\_\_\_L3, L3\_\_\_L4 and as a product in B1\_\_\_B0, B2\_\_\_B1, B3\_\_\_B2, B4\_\_\_B3, S1\_\_\_S0, S2\_\_\_S1, S3\_\_\_S2, S4\_\_\_S3, M1\_\_\_M0, M2\_\_\_M1, M3\_\_\_M2, M4\_\_\_M3, L1\_\_\_L0, L2\_\_\_L1, L3\_\_\_L2, L4\_\_\_L3 and as a modifier in B0\_\_\_B1, B1\_\_\_B2, B2\_\_\_B3, B3\_\_\_B4, S0\_\_\_S1, S1\_\_\_S2, S2\_\_\_S3, S3\_\_\_S4, M0\_\_\_M1, M1\_\_\_M2, M2\_\_\_M3, L0\_\_\_L1, L1\_\_\_L2, L2\_\_\_L3, L3\_\_\_L4).

$$\begin{aligned} \frac{d}{dt} \text{glu} = & v_{32} + v_{34} + v_{36} + v_{38} + v_{40} + v_{42} + v_{44} + v_{46} + v_{48} + v_{50} + v_{52} \\ & + v_{54} + v_{56} + v_{58} + v_{60} + v_{62} - v_{31} - v_{33} - v_{35} - v_{37} - v_{39} - v_{41} \\ & - v_{43} - v_{45} - v_{47} - v_{49} - v_{51} - v_{53} - v_{55} - v_{57} - v_{59} - v_{61} \end{aligned} \quad (217)$$

SBML2<sup>LaTeX</sup> was developed by Andreas Dräger<sup>a</sup>, Hannes Planatscher<sup>a</sup>, Dieudonné M Wouamba<sup>a</sup>, Adrian Schröder<sup>a</sup>, Michael Hucka<sup>b</sup>, Lukas Endler<sup>c</sup>, Martin Golebiewski<sup>d</sup> and Andreas Zell<sup>a</sup>. Please see <http://www.ra.cs.uni-tuebingen.de/software/SBML2LaTeX> for more information.

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