

## SBML Model Report

# Model name: “Croft2013 - GPCR-RGS interaction that compartmentalizes RGS activity”



May 6, 2016

## 1 General Overview

This is a document in SBML Level 2 Version 4 format. This model was created by the following three authors: Vijayalakshmi Chelliah<sup>1</sup>, Manuel Esparza-Franco<sup>2</sup> and Wayne Croft<sup>3</sup> at September thirteenth 2013 at 12:39 a. m. and last time modified at April 28<sup>th</sup> 2014 at 4:04 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	28
events	1	constraints	0
reactions	44	function definitions	0
global parameters	2	unit definitions	4
rules	0	initial assignments	0

## Model Notes

Croft2013 - GPCR-RGS interaction that compartmentalizes RGS activity

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Through modelling studies, the classic quaternary complex (ligand-GPCR-G-RGS) has been extended to include an additional layer of regulation through GPCR-RGS interactions, which facilitate the compartmentalization of RGS activity into the plasma membrane and non-plasma compartments.

This model is described in the article: [A physiologically required G protein-coupled receptor \(GPCR\)-regulator of G protein signaling \(RGS\) interaction that compartmentalizes RGS activity](#). Croft W, Hill C, McCann E, Bond M, Esparza-Franco M, Bennett J, Rand D, Davey J, Ladds G. *J Biol Chem*. 2013 Sep 20;288(38):27327-42.

#### Abstract:

G protein-coupled receptors (GPCRs) can interact with regulator of G protein signaling (RGS) proteins. However, the effects of such interactions on signal transduction and their physiological relevance have been largely undetermined. Ligand-bound GPCRs initiate by promoting exchange of GDP for GTP on the G subunit of heterotrimeric G proteins. Signaling is terminated by hydrolysis of GTP to GDP through intrinsic GTPase activity of the G subunit, a reaction catalyzed by RGS proteins. Using yeast as a tool to study GPCR signaling in isolation, we define an interaction between the cognate GPCR (Mam2) and RGS (Rgs1), mapping the interaction domains. This reaction tethers Rgs1 at the plasma membrane and is essential for physiological signaling response. In vivo quantitative data inform the development of a kinetic model of the GTPase cycle, which extends previous attempts by including GPCR-RGS interactions. In vivo and in silico data confirm that GPCR-RGS interactions can impose an additional layer of regulation through mediating RGS subcellular localization to compartmentalize RGS activity within a cell, thus highlighting their importance as potential targets to modulate GPCR signaling pathways.

#### Author's comment on reproducing the plots:

To reproduce dose-response plots in the publication, the model is simulated with 12 different ligand concentrations (see parameter `Ligand_conc`).

For each ligand concentration, a single value corresponding to total amount of output must be obtained, by calculating the area under the curve of the trajectory of species `z3`, from time=0 to time=30.

These total output values are then used to build a dose-response plot (authors used GraphPad Prism).

Mutant strains are simulated with alternative parameter values or initial conditions specified in the Supplementary Material.

This model is hosted on [BioModels Database](#) and identified by: [BIOMD0000000479](#).

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 nine unit definitions of which five are predefined by SBML and not mentioned in the model.

### 2.1 Unit nanoMolar

**Name** nM

**Definition**  $\text{nmol} \cdot \text{l}^{-1}$

### 2.2 Unit hour

**Name** hr

**Definition** 3600 s

### 2.3 Unit FirstOrder

**Name** 1/hr

**Definition**  $(3600 \text{ s})^{-1}$

### 2.4 Unit SecondOrder

**Name** 1/(nM\*hr)

**Definition**  $\text{nmol}^{-1} \cdot \text{l} \cdot (3600 \text{ s})^{-1}$

### 2.5 Unit substance

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

**Definition** mol

### 2.6 Unit volume

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

**Definition** l

### 2.7 Unit area

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

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

## 2.8 Unit length

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

**Definition** m

## 2.9 Unit time

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

**Definition** s

# 3 Compartment

This model contains one compartment.

Table 2: Properties of all compartments.

Id	Name	SBO	Spatial Dimensions	Size	Unit	Constant	Outside
compartment	cell	0000290	3	1	litre	<input checked="" type="checkbox"/>	

## 3.1 Compartment `compartment`

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

**Name** cell

**SBO:0000290** physical compartment

## 4 Species

This model contains 28 species. Section 8 provides further details and the derived rates of change of each species.

Table 3: Properties of each species.

Id	Name	Compartment	Derived Unit	Constant	Boundary Condition
L	L	compartment	$\text{nmol} \cdot \text{l}^{-1} \cdot \text{l}^{-1}$	$\square$	$\square$
R	R	compartment	$\text{nmol} \cdot \text{l}^{-1} \cdot \text{l}^{-1}$	$\square$	$\square$
LR	LR	compartment	$\text{nmol} \cdot \text{l}^{-1} \cdot \text{l}^{-1}$	$\square$	$\square$
Gabg	Gabg	compartment	$\text{nmol} \cdot \text{l}^{-1} \cdot \text{l}^{-1}$	$\square$	$\square$
RGabg	RGabg	compartment	$\text{nmol} \cdot \text{l}^{-1} \cdot \text{l}^{-1}$	$\square$	$\square$
LRGabg	LRGabg	compartment	$\text{nmol} \cdot \text{l}^{-1} \cdot \text{l}^{-1}$	$\square$	$\square$
RRGSm	RRGSm	compartment	$\text{nmol} \cdot \text{l}^{-1} \cdot \text{l}^{-1}$	$\square$	$\square$
LRRGSm	LRRGSm	compartment	$\text{nmol} \cdot \text{l}^{-1} \cdot \text{l}^{-1}$	$\square$	$\square$
RRGSmGabg	RRGSmGabg	compartment	$\text{nmol} \cdot \text{l}^{-1} \cdot \text{l}^{-1}$	$\square$	$\square$
LRRGSmGabg	LRRGSmGabg	compartment	$\text{nmol} \cdot \text{l}^{-1} \cdot \text{l}^{-1}$	$\square$	$\square$
GaGTP	GaGTP	compartment	$\text{nmol} \cdot \text{l}^{-1} \cdot \text{l}^{-1}$	$\square$	$\square$
Gbg	Gbg	compartment	$\text{nmol} \cdot \text{l}^{-1} \cdot \text{l}^{-1}$	$\square$	$\square$
Effector	Effector	compartment	$\text{nmol} \cdot \text{l}^{-1} \cdot \text{l}^{-1}$	$\square$	$\square$
GaGTPEffector	GaGTPEffector	compartment	$\text{nmol} \cdot \text{l}^{-1} \cdot \text{l}^{-1}$	$\square$	$\square$
RGS <sub>c</sub>	RGS <sub>c</sub>	compartment	$\text{nmol} \cdot \text{l}^{-1} \cdot \text{l}^{-1}$	$\square$	$\square$
RGS <sub>m</sub>	RGS <sub>m</sub>	compartment	$\text{nmol} \cdot \text{l}^{-1} \cdot \text{l}^{-1}$	$\square$	$\square$
RGS <sub>m</sub> GaGTP	RGS <sub>m</sub> GaGTP	compartment	$\text{nmol} \cdot \text{l}^{-1} \cdot \text{l}^{-1}$	$\square$	$\square$
GaGTPEffectorOFF	GaGTPEffectorOFF	compartment	$\text{nmol} \cdot \text{l}^{-1} \cdot \text{l}^{-1}$	$\square$	$\square$
RGS <sub>m</sub> GaGTPEffectorOFF	RGS <sub>m</sub> GaGTPEffectorOFF	compartment	$\text{nmol} \cdot \text{l}^{-1} \cdot \text{l}^{-1}$	$\square$	$\square$
GaGDPP	GaGDPP	compartment	$\text{nmol} \cdot \text{l}^{-1} \cdot \text{l}^{-1}$	$\square$	$\square$
LRRGSmGaGTP	LRRGSmGaGTP	compartment	$\text{nmol} \cdot \text{l}^{-1} \cdot \text{l}^{-1}$	$\square$	$\square$
RRGSmGaGTP	RRGSmGaGTP	compartment	$\text{nmol} \cdot \text{l}^{-1} \cdot \text{l}^{-1}$	$\square$	$\square$

Id	Name	Compartment	Derived Unit	Constant	Boundary Condi- tion
LRRGSmGaGTPEffectorOFF	LRRGSmGaGTPEffectorOFF	compartment	$\text{nmol} \cdot \text{l}^{-1} \cdot \text{l}^{-1}$	<input type="checkbox"/>	<input type="checkbox"/>
GaGDP	GaGDP	compartment	$\text{nmol} \cdot \text{l}^{-1} \cdot \text{l}^{-1}$	<input type="checkbox"/>	<input type="checkbox"/>
P	P	compartment	$\text{nmol} \cdot \text{l}^{-1} \cdot \text{l}^{-1}$	<input type="checkbox"/>	<input type="checkbox"/>
z1	z1	compartment	$\text{nmol} \cdot \text{l}^{-1} \cdot \text{l}^{-1}$	<input type="checkbox"/>	<input type="checkbox"/>
z2	z2	compartment	$\text{nmol} \cdot \text{l}^{-1} \cdot \text{l}^{-1}$	<input type="checkbox"/>	<input type="checkbox"/>
z3	z3	compartment	$\text{nmol} \cdot \text{l}^{-1} \cdot \text{l}^{-1}$	<input type="checkbox"/>	<input type="checkbox"/>

## 5 Parameters

This model contains two global parameters.

Table 4: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
ka	ka		1.5	$(3600\text{ s})^{-1}$	<input checked="" type="checkbox"/>
Ligand_conc	Ligand_conc		0.1	$\text{nmol} \cdot \text{l}^{-1}$	<input checked="" type="checkbox"/>

## 6 Event

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

### 6.1 Event `Ligand_addition`

**Name** `Ligand_addition`

**Trigger condition**  $\text{time} \geq 14$  (1)

**Assignment**  $L = [L] + \text{Ligand\_conc}$  (2)

## 7 Reactions

This model contains 44 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	R1	Receptor-Ligand association	$L + R \xrightarrow{L, R} LR$	
2	R2	Receptor-Gprotein association	$R + Gabg \xrightarrow{R, Gabg} RGabg$	
3	R3	LR-Gprotein association	$LR + Gabg \xrightarrow{LR, Gabg} LRGabg$	
4	R4	Ligand-RGabg association	$L + RGabg \xrightarrow{L, RGabg} LRGabg$	
5	R5	Ligand-RRGSm association	$L + RRGSm \xrightarrow{L, RRGSm} LRRGSm$	
6	R6	RRGSm-Gprotein association	$RRGSm + Gabg \xrightarrow{RRGSm, Gabg} RRGSmGabg$	
7	R7	LRRGSm-Gprotein association	$LRRGSm + Gabg \xrightarrow{LRRGSm, Gabg} LRRGSmGabg$	
8	R8	Ligand-RRGSmGabg association	$L + RRGSmGabg \xrightarrow{L, RRGSmGabg} LRRGSmGabg$	
9	R9	Gprotein activation by LR	$LRGabg \xrightarrow{LRGabg} LR + GaGTP + Gbg$	
10	R10	Gprotein spontaneous activation	$Gabg \xrightarrow{Gabg} GaGTP + Gbg$	
11	R11	Gprotein activation by LRRGSm	$LRRGSmGabg \xrightarrow{LRRGSmGabg} GaGTP + Gbg + LRRGSm$	
12	R12	Effector-GaGTP association	$Effector + GaGTP \xrightarrow{Effector, GaGTP} GaGTPEffector$	
13	R13	RGS in cytosol moves to membrane	$RGSc \xrightarrow{RGSc} RGSm$	
14	R14	RGS in membrane moves to cytosol	$RGSm \xrightarrow{RGSm} RGSc$	
15	R15	Receptor recruits RGSc to membrane	$R + RGSc \xrightarrow{R, RGSc} RRGSm$	



Nº	Id	Name	Reaction Equation	SBO
16	R16	R-RGSm dissociation	$\text{RRGSm} \xrightarrow{\text{RRGSm}} \text{R} + \text{RGSm}$	
17	R17	LR recruits RGSc to membrane	$\text{LR} + \text{RGSc} \xrightarrow{\text{LR}, \text{RGSc}} \text{LRRGSm}$	
18	R18	LR-RGSm dissociation	$\text{LRRGSm} \xrightarrow{\text{LRRGSm}} \text{LR} + \text{RGSm}$	
19	R19	RGabg recruits RGSc to membrane	$\text{RGabg} + \text{RGSc} \xrightarrow{\text{RGabg}, \text{RGSc}} \text{RRGSmGabg}$	
20	R20	RRGSmGabg dissociation	$\text{RRGSmGabg} \xrightarrow{\text{RRGSmGabg}} \text{RGabg} + \text{RGSm}$	
21	R21	LRGabg recruits RGSc to membrane	$\text{LRGabg} + \text{RGSc} \xrightarrow{\text{LRGabg}, \text{RGSc}} \text{LRRGSmGabg}$	
22	R22	GaGTP recruits RGSc to membrane	$\text{GaGTP} + \text{RGSc} \xrightarrow{\text{GaGTP}, \text{RGSc}} \text{RGSmGaGTP}$	
23	R23	RGSmGaGTP dissociation	$\text{RGSmGaGTP} \xrightarrow{\text{RGSmGaGTP}} \text{GaGTP} + \text{RGSc}$	
24	R24	GaGTPEffectorOFF recruits RGS from cytosol	$\text{GaGTPEffectorOFF} + \text{RGSc} \xrightarrow{\text{GaGTPEffectorOFF}, \text{RGSc}} \text{RGSmGaGTPEffectorOFF}$	
25	R25	Effector turns off	$\text{GaGTPEffector} \xrightarrow{\text{GaGTPEffector}} \text{GaGTPEffectorOFF}$	
26	R26	GaGTP hydrolyzes GTP	$\text{GaGTP} \xrightarrow{\text{GaGTP}} \text{GaGDPP}$	
27	R27	GaGTP-RGSm association	$\text{GaGTP} + \text{RGSm} \xrightarrow{\text{GaGTP}, \text{RGSm}} \text{RGSmGaGTP}$	
28	R28	RGSmGaGTP hydrolyzes GTP	$\text{RGSmGaGTP} \xrightarrow{\text{RGSmGaGTP}} \text{GaGDPP} + \text{RGSc}$	
29	R29	GaGTP-LRRGSm association	$\text{GaGTP} + \text{LRRGSm} \xrightarrow{\text{GaGTP}, \text{LRRGSm}} \text{LRRGSmGaGTP}$	
30	R30	LRRGSmGaGTP hydrolyzes GTP	$\text{LRRGSmGaGTP} \xrightarrow{\text{LRRGSmGaGTP}} \text{GaGDPP} + \text{LRRGSm}$	
31	R31	GaGTP-RRGSm association	$\text{GaGTP} + \text{RRGSm} \xrightarrow{\text{GaGTP}, \text{RRGSm}} \text{RRGSmGaGTP}$	
32	R32	RRGSmGaGTP hydrolyzes GTP	$\text{RRGSmGaGTP} \xrightarrow{\text{RRGSmGaGTP}} \text{GaGDPP} + \text{RRGSm}$	
33	R33	GaGTPEffectorOFF hydrolyzes GTP	$\text{GaGTPEffectorOFF} \xrightarrow{\text{GaGTPEffectorOFF}} \text{GaGDPP} + \text{Effector}$	

Nº	Id	Name	Reaction Equation	SBO
34	R34	GaGTPEffectorOFF-RGSm association	$\text{GaGTPEffectorOFF} + \text{RGSm} \xrightarrow{\text{GaGTPEffectorOFF, RGSm}} \text{RGSmGaGTPEffectorOFF}$	
35	R35	RGSmGaGTPEffectorOFF hydrolyzes GTP	$\text{RGSmGaGTPEffectorOFF} \xrightarrow{\text{RGSmGaGTPEffectorOFF}} \text{GaGDPP} + \text{RGSc} + \text{Effector}$	
36	R36	GaGTPEffectorOFF-LRRGSm association	$\text{GaGTPEffectorOFF} + \text{LRRGSm} \xrightarrow{\text{GaGTPEffectorOFF, LRRGSm}} \text{LRRGSmGaGTPEffectorOFF}$	
37	R37	LRRGSmGaGTPEffectorOFF hydrolyzes GTP	$\text{LRRGSmGaGTPEffectorOFF} \xrightarrow{\text{LRRGSmGaGTPEffectorOFF}} \text{GaGDPP} + \text{LRRGSm} + \text{Effector}$	
38	R38	Phosphate release	$\text{GaGDPP} \xrightarrow{\text{GaGDPP}} \text{GaGDP} + \text{P}$	
39	R39	Gprotein subunits association	$\text{GaGDP} + \text{Gbg} \xrightarrow{\text{GaGDP, Gbg}} \text{Gabg}$	
40	R40	Phosphate degradation	$\text{P} \xrightarrow{\text{P}} \emptyset$	
41	R41	Delay 1	$\emptyset \xrightarrow{\text{GaGTPEffector, GaGTPEffector}} z1$	
42	R42	Delay 2	$z1 \xrightarrow{z1} z2$	
43	R43	Delay 3	$z2 \xrightarrow{z2} z3$	
44	R44	Final output	$z3 \xrightarrow{z3} \emptyset$	

## 7.1 Reaction R1

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

**Name** Receptor-Ligand association

### Reaction equation



### Reactants

Table 6: Properties of each reactant.

Id	Name	SBO
L	L	
R	R	

### Modifiers

Table 7: Properties of each modifier.

Id	Name	SBO
L	L	
R	R	

### Product

Table 8: Properties of each product.

Id	Name	SBO
LR	LR	

### Kinetic Law

**Derived unit**  $1^{-2} \cdot 9.999999999999998 \cdot 10^{-10} \text{ mol} \cdot (3600 \text{ s})^{-1}$

$$v_1 = \text{vol}(\text{compartment}) \cdot [L] \cdot [R] \cdot k_1 \quad (4)$$

Table 9: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
k1	k1		0.003	$\text{nmol}^{-1} \cdot \text{l} \cdot (\text{3600 s})^{-1}$	<input checked="" type="checkbox"/>

## 7.2 Reaction R2

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

**Name** Receptor-Gprotein association

### Reaction equation



### Reactants

Table 10: Properties of each reactant.

Id	Name	SBO
R	R	
Gabg	Gabg	

### Modifiers

Table 11: Properties of each modifier.

Id	Name	SBO
R	R	
Gabg	Gabg	

### Product

Table 12: Properties of each product.

Id	Name	SBO
RGabg	RGabg	

## Kinetic Law

**Derived unit**  $1^{-2} \cdot 9.999999999999998 \cdot 10^{-10} \text{ mol} \cdot (3600 \text{ s})^{-1}$

$$v_2 = \text{vol}(\text{compartment}) \cdot [\text{R}] \cdot [\text{Gabg}] \cdot k_2 \quad (6)$$

Table 13: Properties of each parameter.

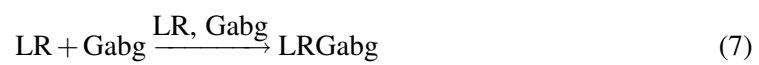
Id	Name	SBO	Value	Unit	Constant
k2	k2		0.005	$\text{nmol}^{-1} \cdot (3600 \text{ s})^{-1}$	<input checked="" type="checkbox"/>

## 7.3 Reaction R3

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

**Name** LR-Gprotein association

### Reaction equation



### Reactants

Table 14: Properties of each reactant.

Id	Name	SBO
LR	LR	
Gabg	Gabg	

### Modifiers

Table 15: Properties of each modifier.

Id	Name	SBO
LR	LR	
Gabg	Gabg	

### Product

Table 16: Properties of each product.

Id	Name	SBO
LRGabg	LRGabg	

### Kinetic Law

**Derived unit**  $1^{-2} \cdot 9.999999999999998 \cdot 10^{-10} \text{ mol} \cdot (3600 \text{ s})^{-1}$

$$v_3 = \text{vol}(\text{compartment}) \cdot [\text{LR}] \cdot [\text{Gabg}] \cdot k_3 \quad (8)$$

Table 17: Properties of each parameter.

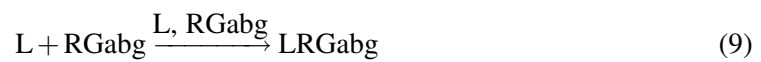
Id	Name	SBO	Value	Unit	Constant
k3	k3		0.02	$\text{nmol}^{-1} \cdot 1 \cdot (3600 \text{ s})^{-1}$	<input checked="" type="checkbox"/>

### 7.4 Reaction R4

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

**Name** Ligand-RGabg association

### Reaction equation



### Reactants

Table 18: Properties of each reactant.

Id	Name	SBO
L	L	
RGabg	RGabg	

### Modifiers

Table 19: Properties of each modifier.

Id	Name	SBO
L	L	

Id	Name	SBO
RGabg	RGabg	

## Product

Table 20: Properties of each product.

Id	Name	SBO
LRGabg	LRGabg	

## Kinetic Law

**Derived unit**  $l^{-2} \cdot 9.999999999999998 \cdot 10^{-10} \text{ mol} \cdot (3600 \text{ s})^{-1}$

$$v_4 = \text{vol}(\text{compartment}) \cdot [L] \cdot [RGabg] \cdot k_4 \quad (10)$$

Table 21: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
k4	k4		0.005	$\text{nmol}^{-1} \cdot 1 \cdot (3600 \text{ s})^{-1}$	<input checked="" type="checkbox"/>

## 7.5 Reaction R5

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

**Name** Ligand-RRGSm association

## Reaction equation



## Reactants

Table 22: Properties of each reactant.

Id	Name	SBO
L	L	
RRGSm	RRGSm	

## Modifiers

Table 23: Properties of each modifier.

Id	Name	SBO
L	L	
RRGSm	RRGSm	

## Product

Table 24: Properties of each product.

Id	Name	SBO
LRRGSm	LRRGSm	

## Kinetic Law

**Derived unit**  $1^{-2} \cdot 9.999999999999998 \cdot 10^{-10} \text{ mol} \cdot (3600 \text{ s})^{-1}$

$$v_5 = \text{vol}(\text{compartment}) \cdot [\text{L}] \cdot [\text{RRGSm}] \cdot k_5 \quad (12)$$

Table 25: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
k5	k5		0.005	$\text{nmol}^{-1} \cdot (3600 \text{ s})^{-1}$	<input checked="" type="checkbox"/>

## 7.6 Reaction R6

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

**Name** RRGSm-Gprotein association

### Reaction equation



## Reactants



Table 26: Properties of each reactant.

Id	Name	SBO
RRGSm	RRGSm	
Gabg	Gabg	

## Modifiers

Table 27: Properties of each modifier.

Id	Name	SBO
RRGSm	RRGSm	
Gabg	Gabg	

## Product

Table 28: Properties of each product.

Id	Name	SBO
RRGSmGabg	RRGSmGabg	

## Kinetic Law

**Derived unit**  $l^{-2} \cdot 9.999999999999998 \cdot 10^{-10} \text{ mol} \cdot (3600 \text{ s})^{-1}$

$$v_6 = \text{vol}(\text{compartment}) \cdot [\text{RRGSm}] \cdot [\text{Gabg}] \cdot k_6 \quad (14)$$

Table 29: Properties of each parameter.

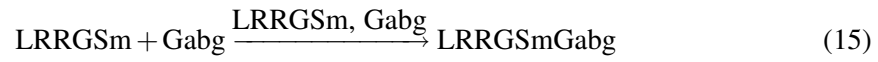
Id	Name	SBO	Value	Unit	Constant
k6	k6		0.005	$\text{nmol}^{-1} \cdot (3600 \text{ s})^{-1}$	<input checked="" type="checkbox"/>

## 7.7 Reaction R7

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

**Name** LRRGSm-Gprotein association

## Reaction equation



## Reactants

Table 30: Properties of each reactant.

Id	Name	SBO
LRRGSm	LRRGSm	
Gabg	Gabg	

## Modifiers

Table 31: Properties of each modifier.

Id	Name	SBO
LRRGSm	LRRGSm	
Gabg	Gabg	

## Product

Table 32: Properties of each product.

Id	Name	SBO
LRRGSmGabg	LRRGSmGabg	

## Kinetic Law

**Derived unit**  $1^{-2} \cdot 9.999999999999998 \cdot 10^{-10} \text{ mol} \cdot (3600 \text{ s})^{-1}$

$$v_7 = \text{vol}(\text{compartment}) \cdot [\text{LRRGSm}] \cdot [\text{Gabg}] \cdot k_7 \quad (16)$$

Table 33: Properties of each parameter.

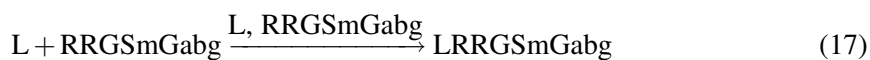
Id	Name	SBO	Value	Unit	Constant
k7	k7		0.02	$\text{nmol}^{-1} \cdot 1 \cdot (3600 \text{ s})^{-1}$	<input checked="" type="checkbox"/>

## 7.8 Reaction R8

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

**Name** Ligand-RRGSmGabg association

### Reaction equation



### Reactants

Table 34: Properties of each reactant.

Id	Name	SBO
L	L	
RRGSmGabg	RRGSmGabg	

### Modifiers

Table 35: Properties of each modifier.

Id	Name	SBO
L	L	
RRGSmGabg	RRGSmGabg	

### Product

Table 36: Properties of each product.

Id	Name	SBO
LRRGSmGabg	LRRGSmGabg	

### Kinetic Law

**Derived unit**  $1^{-2} \cdot 9.999999999999998 \cdot 10^{-10} \text{ mol} \cdot (3600 \text{ s})^{-1}$

$$v_8 = \text{vol}(\text{compartment}) \cdot [L] \cdot [\text{RRGSmGabg}] \cdot k_8 \quad (18)$$

Table 37: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
k8	k8		0.005	$\text{nmol}^{-1} \cdot 1 \cdot (\text{3600 s})^{-1}$	<input checked="" type="checkbox"/>

## 7.9 Reaction R9

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

**Name** Gprotein activation by LR

### Reaction equation



### Reactant

Table 38: Properties of each reactant.

Id	Name	SBO
LRGabg	LRGabg	

### Modifier

Table 39: Properties of each modifier.

Id	Name	SBO
LRGabg	LRGabg	

### Products

Table 40: Properties of each product.

Id	Name	SBO
LR	LR	
GaGTP	GaGTP	
Gbg	Gbg	

## Kinetic Law

**Derived unit**  $\text{l}^{-1} \cdot \text{nmol} \cdot (3600 \text{ s})^{-1}$

$$v_9 = \text{vol}(\text{compartment}) \cdot [\text{LRGabg}] \cdot k_9 \quad (20)$$

Table 41: Properties of each parameter.

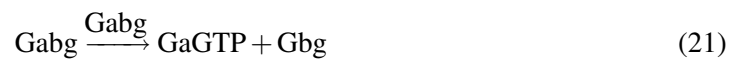
Id	Name	SBO	Value	Unit	Constant
k9	k9		50.0	$(3600 \text{ s})^{-1}$	<input checked="" type="checkbox"/>

## 7.10 Reaction R10

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

**Name** Gprotein spontaneous activation

### Reaction equation



### Reactant

Table 42: Properties of each reactant.

Id	Name	SBO
Gabg	Gabg	

### Modifier

Table 43: Properties of each modifier.

Id	Name	SBO
Gabg	Gabg	

### Products

Table 44: Properties of each product.

Id	Name	SBO
GaGTP	GaGTP	
Gbg	Gbg	

### Kinetic Law

**Derived unit**  $\text{l}^{-1} \cdot \text{nmol} \cdot (3600 \text{ s})^{-1}$

$$v_{10} = \text{vol}(\text{compartment}) \cdot [\text{Gabg}] \cdot k_{10} \quad (22)$$

Table 45: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
k10	k10		0.2	$(3600 \text{ s})^{-1}$	<input checked="" type="checkbox"/>

### 7.11 Reaction R11

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

**Name** Gprotein activation by LRRGSm

### Reaction equation



### Reactant

Table 46: Properties of each reactant.

Id	Name	SBO
LRRGSmGabg	LRRGSmGabg	

### Modifier

Table 47: Properties of each modifier.

Id	Name	SBO
LRRGSmGabg	LRRGSmGabg	

## Products

Table 48: Properties of each product.

Id	Name	SBO
GaGTP	GaGTP	
Gbg	Gbg	
LRRGSm	LRRGSm	

## Kinetic Law

**Derived unit**  $\text{l}^{-1} \cdot \text{nmol} \cdot (3600 \text{ s})^{-1}$

$$v_{11} = \text{vol}(\text{compartment}) \cdot [\text{LRRGSmGbg}] \cdot k_{11} \quad (24)$$

Table 49: Properties of each parameter.

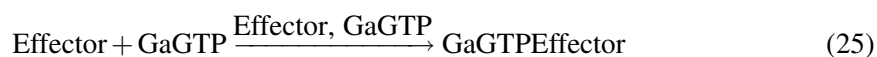
Id	Name	SBO	Value	Unit	Constant
k11	k11		40.0	$(3600 \text{ s})^{-1}$	<input checked="" type="checkbox"/>

### 7.12 Reaction R12

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

**Name** Effector-GaGTP association

#### Reaction equation



## Reactants

Table 50: Properties of each reactant.

Id	Name	SBO
Effector	Effector	
GaGTP	GaGTP	

## Modifiers

Table 51: Properties of each modifier.

Id	Name	SBO
Effector	Effector	
GaGTP	GaGTP	

## Product

Table 52: Properties of each product.

Id	Name	SBO
GaGTPEffector	GaGTPEffector	

## Kinetic Law

**Derived unit**  $1^{-2} \cdot 9.999999999999998 \cdot 10^{-10} \text{ mol} \cdot (3600 \text{ s})^{-1}$

$$v_{12} = \text{vol}(\text{compartment}) \cdot [\text{Effector}] \cdot [\text{GaGTP}] \cdot k_{12} \quad (26)$$

Table 53: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
k12	k12		10.0	$\text{nmol}^{-1} \cdot (3600 \text{ s})^{-1}$	<input checked="" type="checkbox"/>

## 7.13 Reaction R13

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

**Name** RGS in cytosol moves to membrane

## Reaction equation



## Reactant

Table 54: Properties of each reactant.

Id	Name	SBO
RGSc	RGSc	



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

## Modifier

Table 55: Properties of each modifier.

Id	Name	SBO
RGSc	RGSc	

## Product

Table 56: Properties of each product.

Id	Name	SBO
RGS <sub>m</sub>	RGS <sub>m</sub>	

## Kinetic Law

**Derived unit**  $\text{l}^{-1} \cdot \text{nmol} \cdot (3600 \text{ s})^{-1}$

$$v_{13} = \text{vol}(\text{compartment}) \cdot [\text{RGSc}] \cdot k_{13} \quad (28)$$

Table 57: Properties of each parameter.

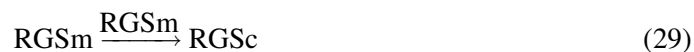
Id	Name	SBO	Value	Unit	Constant
k13	k13		$5 \cdot 10^{-4}$	$(3600 \text{ s})^{-1}$	<input checked="" type="checkbox"/>

### 7.14 Reaction R14

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

**Name** RGS in membrane moves to cytosol

#### Reaction equation



## Reactant

Table 58: Properties of each reactant.

Id	Name	SBO
RGSm	RGSm	

## Modifier

Table 59: Properties of each modifier.

Id	Name	SBO
RGSm	RGSm	

## Product

Table 60: Properties of each product.

Id	Name	SBO
RGSc	RGSc	

## Kinetic Law

**Derived unit**  $\text{l}^{-1} \cdot \text{nmol} \cdot (3600 \text{ s})^{-1}$

$$v_{14} = \text{vol}(\text{compartment}) \cdot [\text{RGSm}] \cdot k_{14} \quad (30)$$

Table 61: Properties of each parameter.

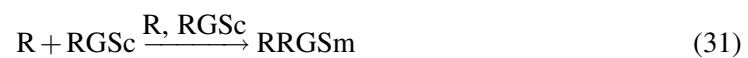
Id	Name	SBO	Value	Unit	Constant
k14	k14		0.005	$(3600 \text{ s})^{-1}$	<input checked="" type="checkbox"/>

### 7.15 Reaction R15

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

**Name** Receptor recruits RGSc to membrane

## Reaction equation



## Reactants

Table 62: Properties of each reactant.

Id	Name	SBO
R	R	
RGS <sub>c</sub>	RGS <sub>c</sub>	

## Modifiers

Table 63: Properties of each modifier.

Id	Name	SBO
R	R	
RGS <sub>c</sub>	RGS <sub>c</sub>	

## Product

Table 64: Properties of each product.

Id	Name	SBO
RRGS <sub>m</sub>	RRGS <sub>m</sub>	

## Kinetic Law

**Derived unit**  $l^{-2} \cdot 9.999999999999998 \cdot 10^{-10} \text{ mol} \cdot (3600 \text{ s})^{-1}$

$$v_{15} = \text{vol}(\text{compartment}) \cdot [R] \cdot [RGS_c] \cdot k_{15} \quad (32)$$

Table 65: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
k15	k15		0.1	$\text{nmol}^{-1} \cdot l \cdot (3600 \text{ s})^{-1}$	<input checked="" type="checkbox"/>

### 7.16 Reaction R16

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

**Name** R-RGS<sub>m</sub> dissociation

## Reaction equation



## Reactant

Table 66: Properties of each reactant.

Id	Name	SBO
RRGSm	RRGSm	

## Modifier

Table 67: Properties of each modifier.

Id	Name	SBO
RRGSm	RRGSm	

## Products

Table 68: Properties of each product.

Id	Name	SBO
R	R	
RGSm	RGSm	

## Kinetic Law

**Derived unit**  $\text{l}^{-1} \cdot \text{nmol} \cdot (3600 \text{ s})^{-1}$

$$v_{16} = \text{vol}(\text{compartment}) \cdot [\text{RRGSm}] \cdot k_{16} \quad (34)$$

Table 69: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
k16	k16		100.0	$(3600 \text{ s})^{-1}$	<input checked="" type="checkbox"/>

### 7.17 Reaction R17

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

**Name** LR recruits RGSc to membrane

#### Reaction equation



#### Reactants

Table 70: Properties of each reactant.

Id	Name	SBO
LR	LR	
RGSc	RGSc	

#### Modifiers

Table 71: Properties of each modifier.

Id	Name	SBO
LR	LR	
RGSc	RGSc	

#### Product

Table 72: Properties of each product.

Id	Name	SBO
LRRGSm	LRRGSm	

#### Kinetic Law

**Derived unit**  $1^{-2} \cdot 9.999999999999998 \cdot 10^{-10} \text{ mol} \cdot (3600 \text{ s})^{-1}$

$$v_{17} = \text{vol}(\text{compartment}) \cdot [\text{LR}] \cdot [\text{RGSc}] \cdot k_{17} \quad (36)$$

Table 73: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
k17	k17		0.1	$\text{nmol}^{-1} \cdot \text{l} \cdot (\text{3600 s})^{-1}$	<input checked="" type="checkbox"/>

### 7.18 Reaction R18

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

**Name** LR-RGS<sub>m</sub> dissociation

#### Reaction equation



#### Reactant

Table 74: Properties of each reactant.

Id	Name	SBO
LRRGS <sub>m</sub>	LRRGS <sub>m</sub>	

#### Modifier

Table 75: Properties of each modifier.

Id	Name	SBO
LRRGS <sub>m</sub>	LRRGS <sub>m</sub>	

#### Products

Table 76: Properties of each product.

Id	Name	SBO
LR	LR	
RGS <sub>m</sub>	RGS <sub>m</sub>	

#### Kinetic Law

**Derived unit**  $\text{l}^{-1} \cdot \text{nmol} \cdot (\text{3600 s})^{-1}$

$$v_{18} = \text{vol}(\text{compartment}) \cdot [\text{LRRGSm}] \cdot k18 \quad (38)$$

Table 77: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
k18	k18		100.0	$(3600 \text{ s})^{-1}$	<input checked="" type="checkbox"/>

### 7.19 Reaction R19

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

**Name** RGabg recruits RGSc to membrane

#### Reaction equation



#### Reactants

Table 78: Properties of each reactant.

Id	Name	SBO
RGabg	RGabg	
RGSc	RGSc	

#### Modifiers

Table 79: Properties of each modifier.

Id	Name	SBO
RGabg	RGabg	
RGSc	RGSc	

#### Product

Table 80: Properties of each product.

Id	Name	SBO
RRGSmGabg	RRGSmGabg	

## Kinetic Law

**Derived unit**  $1^{-2} \cdot 9.999999999999998 \cdot 10^{-10} \text{ mol} \cdot (3600 \text{ s})^{-1}$

$$v_{19} = \text{vol}(\text{compartment}) \cdot [\text{RGabg}] \cdot [\text{RGSc}] \cdot k_{19} \quad (40)$$

Table 81: Properties of each parameter.

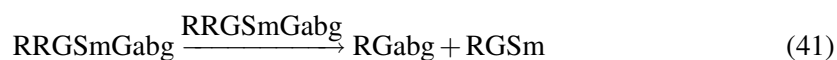
Id	Name	SBO	Value	Unit	Constant
k19	k19		0.1	$\text{nmol}^{-1} \cdot \text{l} \cdot (3600 \text{ s})^{-1}$	<input checked="" type="checkbox"/>

## 7.20 Reaction R20

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

**Name** RRGSmGabg dissociation

## Reaction equation



## Reactant

Table 82: Properties of each reactant.

Id	Name	SBO
RRGSmGabg	RRGSmGabg	

## Modifier

Table 83: Properties of each modifier.

Id	Name	SBO
RRGSmGabg	RRGSmGabg	

## Products



Table 84: Properties of each product.

Id	Name	SBO
RGabg	RGabg	
RGS <sub>m</sub>	RGS <sub>m</sub>	

### Kinetic Law

**Derived unit**  $\text{l}^{-1} \cdot \text{nmol} \cdot (3600 \text{ s})^{-1}$

$$v_{20} = \text{vol}(\text{compartment}) \cdot [\text{RRGS}_m\text{Gabg}] \cdot k_{20} \quad (42)$$

Table 85: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
k <sub>20</sub>	k <sub>20</sub>		0.1	$(3600 \text{ s})^{-1}$	<input checked="" type="checkbox"/>

### 7.21 Reaction R21

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

**Name** LRGabg recruits RGSc to membrane

### Reaction equation



### Reactants

Table 86: Properties of each reactant.

Id	Name	SBO
LRGabg	LRGabg	
RGSc	RGSc	

### Modifiers

Table 87: Properties of each modifier.

Id	Name	SBO
LRGabg	LRGabg	

Id	Name	SBO
RGSc	RGSc	

## Product

Table 88: Properties of each product.

Id	Name	SBO
LRRGSmGabg	LRRGSmGabg	

## Kinetic Law

**Derived unit**  $1^{-2} \cdot 9.999999999999998 \cdot 10^{-10} \text{ mol} \cdot (3600 \text{ s})^{-1}$

$$v_{21} = \text{vol}(\text{compartment}) \cdot [\text{LRGAbg}] \cdot [\text{RGSc}] \cdot k_{21} \quad (44)$$

Table 89: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
k21	k21		0.1	$\text{nmol}^{-1} \cdot (3600 \text{ s})^{-1}$	<input checked="" type="checkbox"/>

## 7.22 Reaction R22

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

**Name** GaGTP recruits RGSc to membrane

## Reaction equation



## Reactants

Table 90: Properties of each reactant.

Id	Name	SBO
GaGTP	GaGTP	
RGSc	RGSc	

## Modifiers

Table 91: Properties of each modifier.

Id	Name	SBO
GaGTP	GaGTP	
RGS <sub>c</sub>	RGS <sub>c</sub>	

## Product

Table 92: Properties of each product.

Id	Name	SBO
RGS <sub>m</sub> GaGTP	RGS <sub>m</sub> GaGTP	

## Kinetic Law

**Derived unit**  $1^{-2} \cdot 9.999999999999998 \cdot 10^{-10} \text{ mol} \cdot (3600 \text{ s})^{-1}$

$$v_{22} = \text{vol}(\text{compartment}) \cdot [\text{GaGTP}] \cdot [\text{RGS}_c] \cdot k_{22} \quad (46)$$

Table 93: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
k <sub>22</sub>	k <sub>22</sub>		60.0	$\text{nmol}^{-1} \cdot 1 \cdot (3600 \text{ s})^{-1}$	<input checked="" type="checkbox"/>

### 7.23 Reaction R<sub>23</sub>

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

**Name** RGS<sub>m</sub>GaGTP dissociation

#### Reaction equation



## Reactant

Table 94: Properties of each reactant.

Id	Name	SBO
RGSmGaGTP	RGSmGaGTP	

## Modifier

Table 95: Properties of each modifier.

Id	Name	SBO
RGSmGaGTP	RGSmGaGTP	

## Products

Table 96: Properties of each product.

Id	Name	SBO
GaGTP	GaGTP	
RGS <sub>c</sub>	RGS <sub>c</sub>	

## Kinetic Law

**Derived unit**  $\text{l}^{-1} \cdot \text{nmol} \cdot (3600 \text{ s})^{-1}$

$$v_{23} = \text{vol}(\text{compartment}) \cdot [\text{RGSmGaGTP}] \cdot k_{23} \quad (48)$$

Table 97: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
k <sub>23</sub>	k <sub>23</sub>		0.05	$(3600 \text{ s})^{-1}$	<input checked="" type="checkbox"/>

### 7.24 Reaction R<sub>24</sub>

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

**Name** GaGTPEffectorOFF recruits RGS from cytosol

#### Reaction equation



## Reactants

Table 98: Properties of each reactant.

Id	Name	SBO
GaGTPEffectorOFF RGSc	GaGTPEffectorOFF RGSc	

## Modifiers

Table 99: Properties of each modifier.

Id	Name	SBO
GaGTPEffectorOFF RGSc	GaGTPEffectorOFF RGSc	

## Product

Table 100: Properties of each product.

Id	Name	SBO
RGSmGaGTPEffectorOFF	RGSmGaGTPEffectorOFF	

## Kinetic Law

**Derived unit**  $1^{-2} \cdot 9.999999999999998 \cdot 10^{-10} \text{ mol} \cdot (3600 \text{ s})^{-1}$

$$v_{24} = \text{vol}(\text{compartment}) \cdot [\text{GaGTPEffectorOFF}] \cdot [\text{RGSc}] \cdot k_{24} \quad (50)$$

Table 101: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
k24	k24		$10^{-4}$	$\text{nmol}^{-1} \cdot (3600 \text{ s})^{-1}$	<input checked="" type="checkbox"/>

### 7.25 Reaction R25

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

**Name** Effector turns off

## Reaction equation



## Reactant

Table 102: Properties of each reactant.

Id	Name	SBO
GaGTPEffector	GaGTPEffector	

## Modifier

Table 103: Properties of each modifier.

Id	Name	SBO
GaGTPEffector	GaGTPEffector	

## Product

Table 104: Properties of each product.

Id	Name	SBO
GaGTPEffectorOFF	GaGTPEffectorOFF	

## Kinetic Law

**Derived unit**  $\text{l}^{-1} \cdot \text{nmol} \cdot (3600 \text{ s})^{-1}$

$$v_{25} = \text{vol}(\text{compartment}) \cdot [\text{GaGTPEffector}] \cdot k_{25} \quad (52)$$

Table 105: Properties of each parameter.

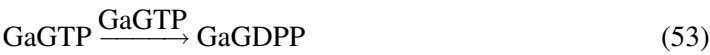
Id	Name	SBO	Value	Unit	Constant
k25	k25		1.0	$(3600 \text{ s})^{-1}$	<input checked="" type="checkbox"/>

## 7.26 Reaction R26

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

**Name** GaGTP hydrolyzes GTP

**Reaction equation**



**Reactant**

Table 106: Properties of each reactant.

Id	Name	SBO
GaGTP	GaGTP	

**Modifier**

Table 107: Properties of each modifier.

Id	Name	SBO
GaGTP	GaGTP	

**Product**

Table 108: Properties of each product.

Id	Name	SBO
GaGDPP	GaGDPP	

**Kinetic Law**

**Derived unit**  $\text{l}^{-1} \cdot \text{nmol} \cdot (3600 \text{ s})^{-1}$

$$v_{26} = \text{vol}(\text{compartment}) \cdot [\text{GaGTP}] \cdot k_{26}$$

(54)

Table 109: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
k26	k26		0.005	$(3600 \text{ s})^{-1}$	<input checked="" type="checkbox"/>

## 7.27 Reaction R27

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

**Name** GaGTP-RGS<sub>m</sub> association

### Reaction equation



### Reactants

Table 110: Properties of each reactant.

Id	Name	SBO
GaGTP	GaGTP	
RGS <sub>m</sub>	RGS <sub>m</sub>	

### Modifiers

Table 111: Properties of each modifier.

Id	Name	SBO
GaGTP	GaGTP	
RGS <sub>m</sub>	RGS <sub>m</sub>	

### Product

Table 112: Properties of each product.

Id	Name	SBO
RGS <sub>m</sub> GaGTP	RGS <sub>m</sub> GaGTP	

### Kinetic Law

**Derived unit**  $1^{-2} \cdot 9.999999999999998 \cdot 10^{-10} \text{ mol} \cdot (3600 \text{ s})^{-1}$

$$v_{27} = \text{vol}(\text{compartment}) \cdot [\text{GaGTP}] \cdot [\text{RGS}_m] \cdot k_{27} \quad (56)$$



Table 113: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
k27	k27		500.0	$\text{nmol}^{-1} \cdot \text{l} \cdot (\text{3600 s})^{-1}$	<input checked="" type="checkbox"/>

## 7.28 Reaction R28

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

**Name** RGSmGaGTP hydrolyzes GTP

### Reaction equation



### Reactant

Table 114: Properties of each reactant.

Id	Name	SBO
RGSmGaGTP	RGSmGaGTP	

### Modifier

Table 115: Properties of each modifier.

Id	Name	SBO
RGSmGaGTP	RGSmGaGTP	

### Products

Table 116: Properties of each product.

Id	Name	SBO
GaGDPP	GaGDPP	
RGSc	RGSc	

### Kinetic Law

**Derived unit**  $\text{l}^{-1} \cdot \text{nmol} \cdot (\text{3600 s})^{-1}$

$$v_{28} = \text{vol}(\text{compartment}) \cdot [\text{RGSmGaGTP}] \cdot k_{28} \quad (58)$$

Table 117: Properties of each parameter.

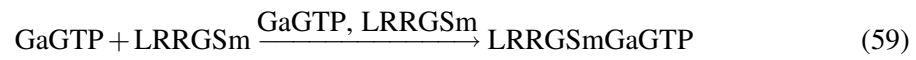
Id	Name	SBO	Value	Unit	Constant
k28	k28		2.5	$(3600 \text{ s})^{-1}$	<input checked="" type="checkbox"/>

## 7.29 Reaction R29

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

**Name** GaGTP-LRRGS<sub>m</sub> association

### Reaction equation



### Reactants

Table 118: Properties of each reactant.

Id	Name	SBO
GaGTP	GaGTP	
LRRGS <sub>m</sub>	LRRGS <sub>m</sub>	

### Modifiers

Table 119: Properties of each modifier.

Id	Name	SBO
GaGTP	GaGTP	
LRRGS <sub>m</sub>	LRRGS <sub>m</sub>	

### Product

Table 120: Properties of each product.

Id	Name	SBO
LRRGS <sub>m</sub> GaGTP	LRRGS <sub>m</sub> GaGTP	

### Kinetic Law

**Derived unit**  $1^{-2} \cdot 9.999999999999998 \cdot 10^{-10} \text{ mol} \cdot (3600 \text{ s})^{-1}$

$$v_{29} = \text{vol}(\text{compartment}) \cdot [\text{GaGTP}] \cdot [\text{LRRGSm}] \cdot k_{29} \quad (60)$$

Table 121: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
k29	k29		100.0	$\text{nmol}^{-1} \cdot \text{l} \cdot (3600 \text{ s})^{-1}$	<input checked="" type="checkbox"/>

### 7.30 Reaction R30

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

**Name** LRRGSmGaGTP hydrolyzes GTP

### Reaction equation



### Reactant

Table 122: Properties of each reactant.

Id	Name	SBO
LRRGSmGaGTP	LRRGSmGaGTP	

### Modifier

Table 123: Properties of each modifier.

Id	Name	SBO
LRRGSmGaGTP	LRRGSmGaGTP	

### Products

Table 124: Properties of each product.

Id	Name	SBO
GaGDPP	GaGDPP	
LRRGS <sub>m</sub>	LRRGS <sub>m</sub>	

### Kinetic Law

**Derived unit**  $\text{l}^{-1} \cdot \text{nmol} \cdot (3600 \text{ s})^{-1}$

$$v_{30} = \text{vol}(\text{compartment}) \cdot [\text{LRRGS}_m\text{GaGTP}] \cdot k_{30} \quad (62)$$

Table 125: Properties of each parameter.

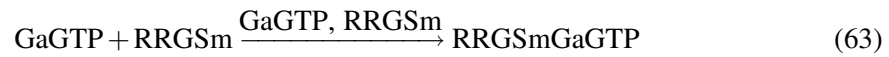
Id	Name	SBO	Value	Unit	Constant
k <sub>30</sub>	k <sub>30</sub>		2.5	$(3600 \text{ s})^{-1}$	<input checked="" type="checkbox"/>

### 7.31 Reaction R31

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

**Name** GaGTP-RRGS<sub>m</sub> association

### Reaction equation



### Reactants

Table 126: Properties of each reactant.

Id	Name	SBO
GaGTP	GaGTP	
RRGS <sub>m</sub>	RRGS <sub>m</sub>	

### Modifiers

Table 127: Properties of each modifier.

Id	Name	SBO
GaGTP	GaGTP	

Id	Name	SBO
RRGSm	RRGSm	

## Product

Table 128: Properties of each product.

Id	Name	SBO
RRGSmGaGTP	RRGSmGaGTP	

## Kinetic Law

**Derived unit**  $1^{-2} \cdot 9.999999999999998 \cdot 10^{-10} \text{ mol} \cdot (3600 \text{ s})^{-1}$

$$v_{31} = \text{vol}(\text{compartment}) \cdot [\text{GaGTP}] \cdot [\text{RRGSm}] \cdot k_{31} \quad (64)$$

Table 129: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
k31	k31		0.5	$\text{nmol}^{-1} \cdot (3600 \text{ s})^{-1}$	<input checked="" type="checkbox"/>

## 7.32 Reaction R32

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

**Name** RRGSmGaGTP hydrolyzes GTP

## Reaction equation



## Reactant

Table 130: Properties of each reactant.

Id	Name	SBO
RRGSmGaGTP	RRGSmGaGTP	

## Modifier

Table 131: Properties of each modifier.

Id	Name	SBO
RRGSmGaGTP	RRGSmGaGTP	

## Products

Table 132: Properties of each product.

Id	Name	SBO
GaGDPP	GaGDPP	
RRGSm	RRGSm	

## Kinetic Law

**Derived unit**  $\text{l}^{-1} \cdot \text{nmol} \cdot (3600 \text{ s})^{-1}$

$$v_{32} = \text{vol}(\text{compartment}) \cdot [\text{RRGSmGaGTP}] \cdot k_{32} \quad (66)$$

Table 133: Properties of each parameter.

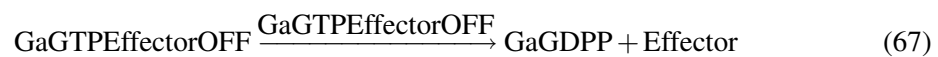
Id	Name	SBO	Value	Unit	Constant
k32	k32		0.5	$(3600 \text{ s})^{-1}$	<input checked="" type="checkbox"/>

### 7.33 Reaction R33

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

**Name** GaGTPEffectorOFF hydrolyzes GTP

#### Reaction equation



#### Reactant

Table 134: Properties of each reactant.

Id	Name	SBO
GaGTPEffectorOFF	GaGTPEffectorOFF	

## Modifier

Table 135: Properties of each modifier.

Id	Name	SBO
GaGTPEffectorOFF	GaGTPEffectorOFF	

## Products

Table 136: Properties of each product.

Id	Name	SBO
GaGDPP Effector	GaGDPP Effector	

## Kinetic Law

**Derived unit**  $\text{l}^{-1} \cdot \text{nmol} \cdot (3600 \text{ s})^{-1}$

$$v_{33} = \text{vol}(\text{compartment}) \cdot [\text{GaGTPEffectorOFF}] \cdot k_{33} \quad (68)$$

Table 137: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
k33	k33		0.005	$(3600 \text{ s})^{-1}$	<input checked="" type="checkbox"/>

### 7.34 Reaction R34

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

**Name** GaGTPEffectorOFF-RGS<sub>m</sub> association

## Reaction equation



## Reactants

Table 138: Properties of each reactant.

Id	Name	SBO
GaGTPEffectorOFF RGS <sub>m</sub>	GaGTPEffectorOFF RGS <sub>m</sub>	

## Modifiers

Table 139: Properties of each modifier.

Id	Name	SBO
GaGTPEffectorOFF RGS <sub>m</sub>	GaGTPEffectorOFF RGS <sub>m</sub>	

## Product

Table 140: Properties of each product.

Id	Name	SBO
RGS <sub>m</sub> GaGTPEffectorOFF	RGS <sub>m</sub> GaGTPEffectorOFF	

## Kinetic Law

**Derived unit**  $1^{-2} \cdot 9.999999999999998 \cdot 10^{-10} \text{ mol} \cdot (3600 \text{ s})^{-1}$

$$v_{34} = \text{vol}(\text{compartment}) \cdot [\text{GaGTPEffectorOFF}] \cdot [\text{RGS}_m] \cdot k_{34} \quad (70)$$

Table 141: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
k34	k34		50.0	$\text{nmol}^{-1} \cdot 1 \cdot (3600 \text{ s})^{-1}$	<input checked="" type="checkbox"/>

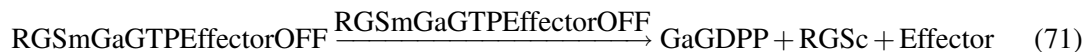
### 7.35 Reaction R35

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

**Name** RGS<sub>m</sub>GaGTPEffectorOFF hydrolyzes GTP



## Reaction equation



## Reactant

Table 142: Properties of each reactant.

Id	Name	SBO
RGSmGaGTPEffectorOFF	RGSmGaGTPEffectorOFF	

## Modifier

Table 143: Properties of each modifier.

Id	Name	SBO
RGSmGaGTPEffectorOFF	RGSmGaGTPEffectorOFF	

## Products

Table 144: Properties of each product.

Id	Name	SBO
GaGDPP	GaGDPP	
RGSc	RGSc	
Effector	Effector	

## Kinetic Law

**Derived unit**  $\text{l}^{-1} \cdot \text{nmol} \cdot (3600 \text{ s})^{-1}$

$$v_{35} = \text{vol}(\text{compartment}) \cdot [\text{RGSmGaGTPEffectorOFF}] \cdot k_{35} \quad (72)$$

Table 145: Properties of each parameter.

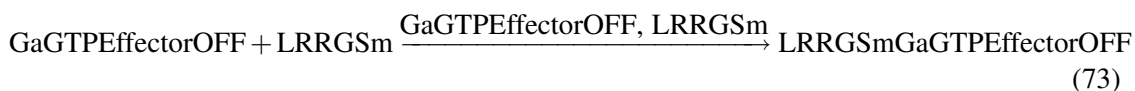
Id	Name	SBO	Value	Unit	Constant
k35	k35		0.3	$(3600 \text{ s})^{-1}$	<input checked="" type="checkbox"/>

### 7.36 Reaction R36

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

**Name** GaGTPEffectorOFF-LRRGSm association

#### Reaction equation



#### Reactants

Table 146: Properties of each reactant.

Id	Name	SBO
GaGTPEffectorOFF	GaGTPEffectorOFF	
LRRGSm	LRRGSm	

#### Modifiers

Table 147: Properties of each modifier.

Id	Name	SBO
GaGTPEffectorOFF	GaGTPEffectorOFF	
LRRGSm	LRRGSm	

#### Product

Table 148: Properties of each product.

Id	Name	SBO
LRRGSmGaGTPEffectorOFF	LRRGSmGaGTPEffectorOFF	

#### Kinetic Law

**Derived unit**  $\text{l}^{-2} \cdot 9.999999999999998 \cdot 10^{-10} \text{ mol} \cdot (3600 \text{ s})^{-1}$

$$v_{36} = \text{vol}(\text{compartment}) \cdot [\text{GaGTPEffectorOFF}] \cdot [\text{LRRGSm}] \cdot k_{36} \quad (74)$$

Table 149: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
k36	k36		50.0	$\text{nmol}^{-1} \cdot \text{s}^{-1}$ (3600 s) <sup>-1</sup>	<input checked="" type="checkbox"/>

### 7.37 Reaction R37

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

**Name** LRRGSmGaGTPEffectorOFF hydrolyzes GTP

#### Reaction equation



#### Reactant

Table 150: Properties of each reactant.

Id	Name	SBO
LRRGSmGaGTPEffectorOFF	LRRGSmGaGTPEffectorOFF	

#### Modifier

Table 151: Properties of each modifier.

Id	Name	SBO
LRRGSmGaGTPEffectorOFF	LRRGSmGaGTPEffectorOFF	

#### Products

Table 152: Properties of each product.

Id	Name	SBO
GaGDPP	GaGDPP	
LRRGSm	LRRGSm	
Effector	Effector	

## Kinetic Law

**Derived unit**  $\text{l}^{-1} \cdot \text{nmol} \cdot (3600 \text{ s})^{-1}$

$$v_{37} = \text{vol}(\text{compartment}) \cdot [\text{LRRGSmGaGTPEffectorOFF}] \cdot k_{37} \quad (76)$$

Table 153: Properties of each parameter.

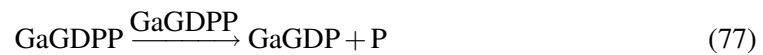
Id	Name	SBO	Value	Unit	Constant
k37	k37		0.3	$(3600 \text{ s})^{-1}$	<input checked="" type="checkbox"/>

## 7.38 Reaction R38

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

**Name** Phosphate release

## Reaction equation



## Reactant

Table 154: Properties of each reactant.

Id	Name	SBO
GaGDPP	GaGDPP	

## Modifier

Table 155: Properties of each modifier.

Id	Name	SBO
GaGDPP	GaGDPP	

## Products

Table 156: Properties of each product.

Id	Name	SBO
GaGDP	GaGDP	
P	P	

### Kinetic Law

**Derived unit**  $l^{-1} \cdot \text{nmol} \cdot (3600 \text{ s})^{-1}$

$$v_{38} = \text{vol}(\text{compartment}) \cdot [\text{GaGDPP}] \cdot k_{38} \quad (78)$$

Table 157: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
k38	k38		1000.0	$(3600 \text{ s})^{-1}$	<input checked="" type="checkbox"/>

### 7.39 Reaction R39

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

**Name** Gprotein subunits association

### Reaction equation



### Reactants

Table 158: Properties of each reactant.

Id	Name	SBO
GaGDP	GaGDP	
Gbg	Gbg	

### Modifiers

Table 159: Properties of each modifier.

Id	Name	SBO
GaGDP	GaGDP	

Id	Name	SBO
Gbg	Gbg	

## Product

Table 160: Properties of each product.

Id	Name	SBO
Gabg	Gabg	

## Kinetic Law

**Derived unit**  $l^{-2} \cdot 9.999999999999998 \cdot 10^{-10} \text{ mol} \cdot (3600 \text{ s})^{-1}$

$$v_{39} = \text{vol}(\text{compartment}) \cdot [\text{GaGDP}] \cdot [\text{Gbg}] \cdot k_{39} \quad (80)$$

Table 161: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
k39	k39		1000.0	$\text{nmol}^{-1} \cdot l \cdot (3600 \text{ s})^{-1}$	<input checked="" type="checkbox"/>

## 7.40 Reaction R40

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

**Name** Phosphate degradation

## Reaction equation



## Reactant

Table 162: Properties of each reactant.

Id	Name	SBO
P	P	

## Modifier

Table 163: Properties of each modifier.

Id	Name	SBO
P	P	

## Kinetic Law

**Derived unit**  $\text{l}^{-1} \cdot \text{nmol} \cdot (3600 \text{ s})^{-1}$

$$v_{40} = \text{vol}(\text{compartment}) \cdot [\text{P}] \cdot k_{40} \quad (82)$$

Table 164: Properties of each parameter.

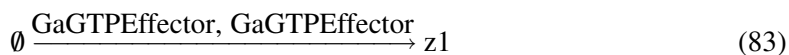
Id	Name	SBO	Value	Unit	Constant
k40	k40		10.0	$(3600 \text{ s})^{-1}$	<input checked="" type="checkbox"/>

### 7.41 Reaction R41

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

**Name** Delay 1

## Reaction equation



## Modifiers

Table 165: Properties of each modifier.

Id	Name	SBO
GaGTPEffector	GaGTPEffector	
GaGTPEffector	GaGTPEffector	

## Product

Table 166: Properties of each product.

Id	Name	SBO
z1	z1	

### Kinetic Law

**Derived unit**  $\text{l}^{-1} \cdot \text{nmol} \cdot (3600 \text{ s})^{-1}$

$$v_{41} = \text{vol}(\text{compartment}) \cdot [\text{GaGTPEffector}] \cdot k_a \quad (84)$$

### 7.42 Reaction R42

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

**Name** Delay 2

### Reaction equation



### Reactant

Table 167: Properties of each reactant.

Id	Name	SBO
z1	z1	

### Modifier

Table 168: Properties of each modifier.

Id	Name	SBO
z1	z1	

### Product

Table 169: Properties of each product.

Id	Name	SBO
z2	z2	



**Kinetic Law**

**Derived unit**  $l^{-1} \cdot \text{nmol} \cdot (3600 \text{ s})^{-1}$

$$v_{42} = \text{vol}(\text{compartment}) \cdot [z1] \cdot ka \tag{86}$$

**7.43 Reaction R43**

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

**Name** Delay 3

**Reaction equation**



**Reactant**

Table 170: Properties of each reactant.

Id	Name	SBO
z2	z2	

**Modifier**

Table 171: Properties of each modifier.

Id	Name	SBO
z2	z2	

**Product**

Table 172: Properties of each product.

Id	Name	SBO
z3	z3	

**Kinetic Law**

**Derived unit**  $l^{-1} \cdot \text{nmol} \cdot (3600 \text{ s})^{-1}$

$$v_{43} = \text{vol}(\text{compartment}) \cdot [z2] \cdot ka \tag{88}$$

## 7.44 Reaction R44

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

**Name** Final output

### Reaction equation



### Reactant

Table 173: Properties of each reactant.

Id	Name	SBO
z3	z3	

### Modifier

Table 174: Properties of each modifier.

Id	Name	SBO
z3	z3	

### Kinetic Law

**Derived unit**  $\text{l}^{-1} \cdot \text{nmol} \cdot (3600 \text{ s})^{-1}$

$$v_{44} = \text{vol}(\text{compartment}) \cdot [z3] \cdot k_a \quad (90)$$

## 8 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.

## 8.1 Species L

**Name** L

**SBO:0000280** ligand

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

**Involved in event** [Ligand\\_addition](#)

This species takes part in eight reactions (as a reactant in [R1](#), [R4](#), [R5](#), [R8](#) and as a modifier in [R1](#), [R4](#), [R5](#), [R8](#)).

$$\frac{d}{dt}L = -v_1 - v_4 - v_5 - v_8 \quad (91)$$

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

## 8.2 Species R

**Name** R

**SBO:0000244** receptor

**Initial concentration** 205 nmol · l<sup>-1</sup> · l<sup>-1</sup>

This species takes part in seven reactions (as a reactant in [R1](#), [R2](#), [R15](#) and as a product in [R16](#) and as a modifier in [R1](#), [R2](#), [R15](#)).

$$\frac{d}{dt}R = v_{16} - v_1 - v_2 - v_{15} \quad (92)$$

## 8.3 Species LR

**Name** LR

**SBO:0000296** macromolecular complex

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

This species takes part in seven reactions (as a reactant in [R3](#), [R17](#) and as a product in [R1](#), [R9](#), [R18](#) and as a modifier in [R3](#), [R17](#)).

$$\frac{d}{dt}LR = v_1 + v_9 + v_{18} - v_3 - v_{17} \quad (93)$$

## 8.4 Species Gabg

**Name** Gabg

**SBO:0000297** protein complex

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

This species takes part in eleven reactions (as a reactant in [R2](#), [R3](#), [R6](#), [R7](#), [R10](#) and as a product in [R39](#) and as a modifier in [R2](#), [R3](#), [R6](#), [R7](#), [R10](#)).

$$\frac{d}{dt}\text{Gabg} = v_{39} - v_2 - v_3 - v_6 - v_7 - v_{10} \quad (94)$$

## 8.5 Species RGabg

**Name** RGabg

**SBO:0000297** protein complex

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

This species takes part in six reactions (as a reactant in [R4](#), [R19](#) and as a product in [R2](#), [R20](#) and as a modifier in [R4](#), [R19](#)).

$$\frac{d}{dt}\text{RGabg} = v_2 + v_{20} - v_4 - v_{19} \quad (95)$$

## 8.6 Species LRGabg

**Name** LRGabg

**SBO:0000296** macromolecular complex

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

This species takes part in six reactions (as a reactant in [R9](#), [R21](#) and as a product in [R3](#), [R4](#) and as a modifier in [R9](#), [R21](#)).

$$\frac{d}{dt}\text{LRGabg} = v_3 + v_4 - v_9 - v_{21} \quad (96)$$

## 8.7 Species RRGSm

**Name** RRGSm

**SBO:0000297** protein complex

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

This species takes part in ten reactions (as a reactant in [R5](#), [R6](#), [R16](#), [R31](#) and as a product in [R15](#), [R32](#) and as a modifier in [R5](#), [R6](#), [R16](#), [R31](#)).

$$\frac{d}{dt}\text{RRGSm} = v_{15} + v_{32} - v_5 - v_6 - v_{16} - v_{31} \quad (97)$$

## 8.8 Species LRRGS<sub>m</sub>

**Name** LRRGS<sub>m</sub>

**SBO:0000296** macromolecular complex

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

This species takes part in 13 reactions (as a reactant in R7, R18, R29, R36 and as a product in R5, R11, R17, R30, R37 and as a modifier in R7, R18, R29, R36).

$$\frac{d}{dt} \text{LRRGS}_m = v_5 + v_{11} + v_{17} + v_{30} + v_{37} - v_7 - v_{18} - v_{29} - v_{36} \quad (98)$$

## 8.9 Species RRGSmGabg

**Name** RRGSmGabg

**SBO:0000297** protein complex

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

This species takes part in six reactions (as a reactant in R8, R20 and as a product in R6, R19 and as a modifier in R8, R20).

$$\frac{d}{dt} \text{RRGS}_m \text{Gabg} = v_6 + v_{19} - v_8 - v_{20} \quad (99)$$

## 8.10 Species LRRGS<sub>m</sub>Gabg

**Name** LRRGS<sub>m</sub>Gabg

**SBO:0000296** macromolecular complex

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

This species takes part in five reactions (as a reactant in R11 and as a product in R7, R8, R21 and as a modifier in R11).

$$\frac{d}{dt} \text{LRRGS}_m \text{Gabg} = v_7 + v_8 + v_{21} - v_{11} \quad (100)$$

## 8.11 Species GaGTP

**Name** GaGTP

**SBO:0000296** macromolecular complex

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

This species takes part in 16 reactions (as a reactant in R12, R22, R26, R27, R29, R31 and as a product in R9, R10, R11, R23 and as a modifier in R12, R22, R26, R27, R29, R31).

$$\frac{d}{dt} \text{GaGTP} = v_9 + v_{10} + v_{11} + v_{23} - v_{12} - v_{22} - v_{26} - v_{27} - v_{29} - v_{31} \quad (101)$$

## 8.12 Species Gbg

**Name** Gbg

**SBO:0000297** protein complex

**Initial concentration**  $205 \text{ nmol} \cdot \text{l}^{-1} \cdot \text{l}^{-1}$

This species takes part in five reactions (as a reactant in [R39](#) and as a product in [R9](#), [R10](#), [R11](#) and as a modifier in [R39](#)).

$$\frac{d}{dt}\text{Gbg} = v_9 + v_{10} + v_{11} - v_{39} \quad (102)$$

## 8.13 Species Effector

**Name** Effector

**Initial concentration**  $305 \text{ nmol} \cdot \text{l}^{-1} \cdot \text{l}^{-1}$

This species takes part in five reactions (as a reactant in [R12](#) and as a product in [R33](#), [R35](#), [R37](#) and as a modifier in [R12](#)).

$$\frac{d}{dt}\text{Effector} = v_{33} + v_{35} + v_{37} - v_{12} \quad (103)$$

## 8.14 Species GaGTPEffector

**Name** GaGTPEffector

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

This species takes part in five reactions (as a reactant in [R25](#) and as a product in [R12](#) and as a modifier in [R25](#), [R41](#), [R41](#)).

$$\frac{d}{dt}\text{GaGTPEffector} = v_{12} - v_{25} \quad (104)$$

## 8.15 Species RGSc

**Name** RGSc

**SBO:0000252** polypeptide chain

**Initial concentration**  $60 \text{ nmol} \cdot \text{l}^{-1} \cdot \text{l}^{-1}$

This species takes part in 18 reactions (as a reactant in [R13](#), [R15](#), [R17](#), [R19](#), [R21](#), [R22](#), [R24](#) and as a product in [R14](#), [R23](#), [R28](#), [R35](#) and as a modifier in [R13](#), [R15](#), [R17](#), [R19](#), [R21](#), [R22](#), [R24](#)).

$$\frac{d}{dt}\text{RGSc} = v_{14} + v_{23} + v_{28} + v_{35} - v_{13} - v_{15} - v_{17} - v_{19} - v_{21} - v_{22} - v_{24} \quad (105)$$

### 8.16 Species RGS<sub>m</sub>

**Name** RGS<sub>m</sub>

**SBO:0000252** polypeptide chain

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

This species takes part in ten reactions (as a reactant in [R14](#), [R27](#), [R34](#) and as a product in [R13](#), [R16](#), [R18](#), [R20](#) and as a modifier in [R14](#), [R27](#), [R34](#)).

$$\frac{d}{dt} \text{RGS}_m = v_{13} + v_{16} + v_{18} + v_{20} - v_{14} - v_{27} - v_{34} \quad (106)$$

### 8.17 Species RGS<sub>m</sub>GaGTP

**Name** RGS<sub>m</sub>GaGTP

**SBO:0000296** macromolecular complex

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

This species takes part in six reactions (as a reactant in [R23](#), [R28](#) and as a product in [R22](#), [R27](#) and as a modifier in [R23](#), [R28](#)).

$$\frac{d}{dt} \text{RGS}_m \text{GaGTP} = v_{22} + v_{27} - v_{23} - v_{28} \quad (107)$$

### 8.18 Species GaGTPEffectorOFF

**Name** GaGTPEffectorOFF

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

This species takes part in nine reactions (as a reactant in [R24](#), [R33](#), [R34](#), [R36](#) and as a product in [R25](#) and as a modifier in [R24](#), [R33](#), [R34](#), [R36](#)).

$$\frac{d}{dt} \text{GaGTPEffectorOFF} = v_{25} - v_{24} - v_{33} - v_{34} - v_{36} \quad (108)$$

### 8.19 Species RGS<sub>m</sub>GaGTPEffectorOFF

**Name** RGS<sub>m</sub>GaGTPEffectorOFF

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

This species takes part in four reactions (as a reactant in [R35](#) and as a product in [R24](#), [R34](#) and as a modifier in [R35](#)).

$$\frac{d}{dt} \text{RGS}_m \text{GaGTPEffectorOFF} = v_{24} + v_{34} - v_{35} \quad (109)$$

## 8.20 Species GaGDPP

**Name** GaGDPP

**SBO:0000296** macromolecular complex

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

This species takes part in nine reactions (as a reactant in [R38](#) and as a product in [R26](#), [R28](#), [R30](#), [R32](#), [R33](#), [R35](#), [R37](#) and as a modifier in [R38](#)).

$$\frac{d}{dt}\text{GaGDPP} = v_{26} + v_{28} + v_{30} + v_{32} + v_{33} + v_{35} + v_{37} - v_{38} \quad (110)$$

## 8.21 Species LRRGSmGaGTP

**Name** LRRGSmGaGTP

**SBO:0000296** macromolecular complex

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

This species takes part in three reactions (as a reactant in [R30](#) and as a product in [R29](#) and as a modifier in [R30](#)).

$$\frac{d}{dt}\text{LRRGSmGaGTP} = v_{29} - v_{30} \quad (111)$$

## 8.22 Species RRGSmGaGTP

**Name** RRGSmGaGTP

**SBO:0000296** macromolecular complex

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

This species takes part in three reactions (as a reactant in [R32](#) and as a product in [R31](#) and as a modifier in [R32](#)).

$$\frac{d}{dt}\text{RRGSmGaGTP} = v_{31} - v_{32} \quad (112)$$

## 8.23 Species LRRGSmGaGTPEffectorOFF

**Name** LRRGSmGaGTPEffectorOFF

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

This species takes part in three reactions (as a reactant in [R37](#) and as a product in [R36](#) and as a modifier in [R37](#)).

$$\frac{d}{dt}\text{LRRGSmGaGTPEffectorOFF} = v_{36} - v_{37} \quad (113)$$



## 8.24 Species GaGDP

**Name** GaGDP

**SBO:0000296** macromolecular complex

**Initial concentration**  $205 \text{ nmol} \cdot \text{l}^{-1} \cdot \text{l}^{-1}$

This species takes part in three reactions (as a reactant in [R39](#) and as a product in [R38](#) and as a modifier in [R39](#)).

$$\frac{d}{dt}\text{GaGDP} = v_{38} - v_{39} \quad (114)$$

## 8.25 Species P

**Name** P

**SBO:0000247** simple chemical

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

This species takes part in three reactions (as a reactant in [R40](#) and as a product in [R38](#) and as a modifier in [R40](#)).

$$\frac{d}{dt}\text{P} = v_{38} - v_{40} \quad (115)$$

## 8.26 Species z1

**Name** z1

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

This species takes part in three reactions (as a reactant in [R42](#) and as a product in [R41](#) and as a modifier in [R42](#)).

$$\frac{d}{dt}\text{z1} = v_{41} - v_{42} \quad (116)$$

## 8.27 Species z2

**Name** z2

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

This species takes part in three reactions (as a reactant in [R43](#) and as a product in [R42](#) and as a modifier in [R43](#)).

$$\frac{d}{dt}\text{z2} = v_{42} - v_{43} \quad (117)$$

## 8.28 Species $z3$

**Name**  $z3$

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

This species takes part in three reactions (as a reactant in [R44](#) and as a product in [R43](#) and as a modifier in [R44](#)).

$$\frac{d}{dt}z3 = v_{43} - v_{44} \quad (118)$$

## A Glossary of Systems Biology Ontology Terms

**SBO:0000244 receptor:** Participating entity that binds to a specific physical entity and initiates the response to that physical entity. The original concept of the receptor was introduced independently at the end of the 19th century by John Newport Langley (1852-1925) and Paul Ehrlich (1854-1915). Langley JN. On the reaction of cells and of nerve-endings to certain poisons, chiefly as regards the reaction of striated muscle to nicotine and to curari. J Physiol. 1905 Dec 30;33(4-5):374-413

**SBO:0000247 simple chemical:** Simple, non-repetitive chemical entity

**SBO:0000252 polypeptide chain:** Naturally occurring macromolecule formed by the repetition of amino-acid residues linked by peptidic bonds. A polypeptide chain is synthesized by the ribosome. CHEBI:1654

**SBO:0000280 ligand:** In biochemistry, a ligand is an effector, a physical entity that binds to a site on a receptor's surface by intermolecular forces

**SBO:0000290 physical compartment:** Specific location of space, that can be bounded or not. A physical compartment can have 1, 2 or 3 dimensions

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

**SBO:0000297 protein complex:** Macromolecular complex containing one or more polypeptide chains possibly associated with simple chemicals. CHEBI:3608

SBML<sup>2</sup>TeX 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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