

SBML Model Report

Model name:
“Bornheimer2004_GTPaseCycle”



May 6, 2016

1 General Overview

This is a document in SBML Level 2 Version 1 format. This model was created by Enuo He¹ at November 29th 2006 at 5:40 p. m. and last time modified at July fifth 2012 at 2:49 p. m. Table 1 provides an overview of the quantities of all components of this model.

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

Element	Quantity	Element	Quantity
compartment types	0	compartments	1
species types	0	species	17
events	0	constraints	0
reactions	24	function definitions	0
global parameters	2	unit definitions	0
rules	2	initial assignments	0

Model Notes

This model is according to the paper *Computational modeling reveals how interplay between components of a GTPase-cycle module regulates signal transduction* by Bornheimer et al 2004. The figure 3 is reproduced by Copasi 4.0.19 (development). It is three-dimensional logarithmic plots show the output of simulations of Z and v at various concentrations of R and GAP.

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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 m²

2.4 Unit length

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

Definition m

2.5 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_0	cell		3	1	litre	<input checked="" type="checkbox"/>	

3.1 Compartment `compartment_0`

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

Name cell

4 Species

This model contains 17 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 Condi- tion
species_0	A	compartment_0	$\text{mol} \cdot \text{l}^{-1}$	\square	\square
species_1	G	compartment_0	$\text{mol} \cdot \text{l}^{-1}$	\square	\square
species_2	GA	compartment_0	$\text{mol} \cdot \text{l}^{-1}$	\square	\square
species_3	T	compartment_0	$\text{mol} \cdot \text{l}^{-1}$	\square	\square
species_4	R	compartment_0	$\text{mol} \cdot \text{l}^{-1}$	\square	\square
species_5	G*T	compartment_0	$\text{mol} \cdot \text{l}^{-1}$	\square	\square
species_6	GD	compartment_0	$\text{mol} \cdot \text{l}^{-1}$	\square	\square
species_7	Pi	compartment_0	$\text{mol} \cdot \text{l}^{-1}$	\square	\square
species_8	D	compartment_0	$\text{mol} \cdot \text{l}^{-1}$	\square	\square
species_9	RG	compartment_0	$\text{mol} \cdot \text{l}^{-1}$	\square	\square
species_10	RG*T	compartment_0	$\text{mol} \cdot \text{l}^{-1}$	\square	\square
species_11	G*AT	compartment_0	$\text{mol} \cdot \text{l}^{-1}$	\square	\square
species_12	GAD	compartment_0	$\text{mol} \cdot \text{l}^{-1}$	\square	\square
species_13	RGD	compartment_0	$\text{mol} \cdot \text{l}^{-1}$	\square	\square
species_14	RGA	compartment_0	$\text{mol} \cdot \text{l}^{-1}$	\square	\square
species_15	RG*AT	compartment_0	$\text{mol} \cdot \text{l}^{-1}$	\square	\square
species_16	RGAD	compartment_0	$\text{mol} \cdot \text{l}^{-1}$	\square	\square

5 Parameters

This model contains two global parameters.

Table 4: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
parameter_0	Z		0.0		<input type="checkbox"/>
parameter_1	v		0.0		<input type="checkbox"/>

6 Rules

This is an overview of two rules.

6.1 Rule parameter_0

Rule parameter_0 is an assignment rule for parameter parameter_0:

$$\text{parameter_0} = \frac{[\text{species_5}] + [\text{species_10}] + [\text{species_15}] + [\text{species_11}]}{1.0E - 8} \quad (1)$$

Notes The [Gtot]=the initial value of [G]=10e-9 M

6.2 Rule parameter_1

Rule parameter_1 is an assignment rule for parameter parameter_1:

$$\text{parameter_1} = \frac{25 \cdot [\text{species_15}] + 25 \cdot [\text{species_11}] + 0.013 \cdot [\text{species_10}] + 0.013 \cdot [\text{species_5}]}{1.0E - 8} \quad (2)$$

Notes The [Gtot]=the initial value of [G]=10e-9 M

7 Reactions

This model contains 24 reactions. All reactions are listed in the following table and are subsequently described in detail. If a reaction is affected by a modifier, the identifier of this species is written above the reaction arrow.

Table 5: Overview of all reactions

Nº	Id	Name	Reaction Equation	SBO
1	reaction_0	G protein binding GAP	$\text{species_1} + \text{species_0} \rightleftharpoons \text{species_2}$	
2	reaction_1	G protein binding GTP	$\text{species_1} + \text{species_3} \rightleftharpoons \text{species_5}$	
3	reaction_2	G binding Receptor	$\text{species_1} + \text{species_4} \rightleftharpoons \text{species_9}$	
4	reaction_3	G*T hydrolysis	$\text{species_5} \rightleftharpoons \text{species_6} + \text{species_7}$	
5	reaction_4	GD dissociation	$\text{species_6} \rightleftharpoons \text{species_1} + \text{species_8}$	
6	reaction_5	RG binding GTP	$\text{species_9} + \text{species_3} \rightleftharpoons \text{species_10}$	
7	reaction_6	G*T binding Receptor	$\text{species_5} + \text{species_4} \rightleftharpoons \text{species_10}$	
8	reaction_7	G*T binding GAP	$\text{species_5} + \text{species_0} \rightleftharpoons \text{species_11}$	
9	reaction_8	GD binding GAP	$\text{species_6} + \text{species_0} \rightleftharpoons \text{species_12}$	
10	reaction_9	GD binding Receptor	$\text{species_6} + \text{species_4} \rightleftharpoons \text{species_13}$	
11	reaction_10	RG*T hydrolysis	$\text{species_10} \rightleftharpoons \text{species_13} + \text{species_7}$	
12	reaction_11	RGD dissociation	$\text{species_13} \rightleftharpoons \text{species_9} + \text{species_8}$	
13	reaction_12	GA binding GTP	$\text{species_2} + \text{species_3} \rightleftharpoons \text{species_11}$	
14	reaction_13	G*AT hydrolysis	$\text{species_11} \rightleftharpoons \text{species_12} + \text{species_7}$	
15	reaction_14	GAD dissociation	$\text{species_12} \rightleftharpoons \text{species_2} + \text{species_8}$	
16	reaction_15	RG binding GAP	$\text{species_9} + \text{species_0} \rightleftharpoons \text{species_14}$	
17	reaction_16	GA binding Receptor	$\text{species_2} + \text{species_4} \rightleftharpoons \text{species_14}$	
18	reaction_17	RGA binding GTP	$\text{species_14} + \text{species_3} \rightleftharpoons \text{species_15}$	
19	reaction_18	G*AT binding Receptor	$\text{species_11} + \text{species_4} \rightleftharpoons \text{species_15}$	
20	reaction_19	RG*T binding GAP	$\text{species_10} + \text{species_0} \rightleftharpoons \text{species_15}$	
21	reaction_20	RG*AT hydrolysis	$\text{species_15} \rightleftharpoons \text{species_16} + \text{species_7}$	
22	reaction_21	RGD binding GAP	$\text{species_13} + \text{species_0} \rightleftharpoons \text{species_16}$	
23	reaction_22	GAD binding Receptor	$\text{species_12} + \text{species_4} \rightleftharpoons \text{species_16}$	

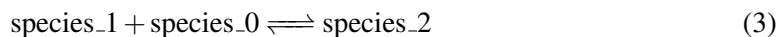
Nº	Id	Name	Reaction Equation	SBO
24	reaction_23	RGAD dissociation	$\text{species_16} \rightleftharpoons \text{species_14} + \text{species_8}$	

7.1 Reaction `reaction_0`

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

Name G protein binding GAP

Reaction equation



Reactants

Table 6: Properties of each reactant.

Id	Name	SBO
species_1	G	
species_0	A	

Product

Table 7: Properties of each product.

Id	Name	SBO
species_2	GA	

Kinetic Law

Derived unit contains undeclared units

$$v_1 = \text{vol}(\text{compartment_0}) \cdot (k_1 \cdot [\text{species_1}] \cdot [\text{species_0}] - k_2 \cdot [\text{species_2}]) \quad (4)$$

Table 8: Properties of each parameter.

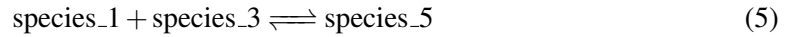
Id	Name	SBO	Value	Unit	Constant
k1			8780000.0		<input checked="" type="checkbox"/>
k2			8.0		<input checked="" type="checkbox"/>

7.2 Reaction `reaction_1`

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

Name G protein binding GTP

Reaction equation



Reactants

Table 9: Properties of each reactant.

Id	Name	SBO
species_1	G	
species_3	T	

Product

Table 10: Properties of each product.

Id	Name	SBO
species_5	G*T	

Kinetic Law

Derived unit contains undeclared units

$$v_2 = \text{vol}(\text{compartment_0}) \cdot (k_1 \cdot [\text{species_1}] \cdot [\text{species_3}] - k_2 \cdot [\text{species_5}]) \quad (6)$$

Table 11: Properties of each parameter.

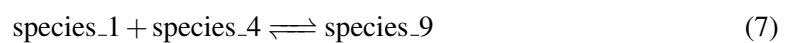
Id	Name	SBO	Value	Unit	Constant
k1			529000.000		<input checked="" type="checkbox"/>
k2			$8.38 \cdot 10^{-6}$		<input checked="" type="checkbox"/>

7.3 Reaction `reaction_2`

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

Name G binding Receptor

Reaction equation



Reactants

Table 12: Properties of each reactant.

Id	Name	SBO
species_1	G	
species_4	R	

Product

Table 13: Properties of each product.

Id	Name	SBO
species_9	RG	

Kinetic Law

Derived unit contains undeclared units

$$v_3 = \text{vol}(\text{compartment}_0) \cdot (k_1 \cdot [\text{species}_1] \cdot [\text{species}_4] - k_2 \cdot [\text{species}_9]) \quad (8)$$

Table 14: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
k1			$6.36 \cdot 10^8$		<input checked="" type="checkbox"/>
k2			0.018		<input checked="" type="checkbox"/>

7.4 Reaction `reaction_3`

This is a reversible reaction of one reactant forming two products.

Name G*T hydrolysis

Reaction equation



Reactant

Table 15: Properties of each reactant.

Id	Name	SBO
species_5	G*T	

Products

Table 16: Properties of each product.

Id	Name	SBO
species_6	GD	
species_7	Pi	

Kinetic Law

Derived unit contains undeclared units

$$v_4 = \text{vol}(\text{compartment}_0) \cdot (k_1 \cdot [\text{species}_5] - k_2 \cdot [\text{species}_6] \cdot [\text{species}_7]) \quad (10)$$

Table 17: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
k1			0.013		<input checked="" type="checkbox"/>
k2			$9.03 \cdot 10^{-7}$		<input checked="" type="checkbox"/>

7.5 Reaction `reaction_4`

This is a reversible reaction of one reactant forming two products.

Name GD dissociation

Reaction equation



Reactant

Table 18: Properties of each reactant.

Id	Name	SBO
species_6	GD	

Products

Table 19: Properties of each product.

Id	Name	SBO
species_1	G	
species_8	D	

Kinetic Law

Derived unit contains undeclared units

$$v_5 = \text{vol}(\text{compartment}_0) \cdot (k_1 \cdot [\text{species}_6] - k_2 \cdot [\text{species}_1] \cdot [\text{species}_8]) \quad (12)$$

Table 20: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
k1			10^{-4}		<input checked="" type="checkbox"/>
k2			62.300		<input checked="" type="checkbox"/>

7.6 Reaction `reaction_5`

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

Name RG binding GTP

Reaction equation



Reactants

Table 21: Properties of each reactant.

Id	Name	SBO
species_9	RG	
species_3	T	

Product

Table 22: Properties of each product.

Id	Name	SBO
species_10	RG*T	

Kinetic Law

Derived unit contains undeclared units

$$v_6 = \text{vol}(\text{compartment}_0) \cdot (k_1 \cdot [\text{species}_9] \cdot [\text{species}_3] - k_2 \cdot [\text{species}_{10}]) \quad (14)$$

Table 23: Properties of each parameter.

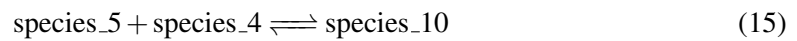
Id	Name	SBO	Value	Unit	Constant
k1			853000.000		<input checked="" type="checkbox"/>
k2			0.005		<input checked="" type="checkbox"/>

7.7 Reaction `reaction_6`

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

Name G*T binding Receptor

Reaction equation



Reactants

Table 24: Properties of each reactant.

Id	Name	SBO
species_5	G*T	
species_4	R	

Product

Table 25: Properties of each product.

Id	Name	SBO
species_10	RG*T	

Kinetic Law

Derived unit contains undeclared units

$$v_7 = \text{vol}(\text{compartment}_0) \cdot (k_1 \cdot [\text{species}_5] \cdot [\text{species}_4] - k_2 \cdot [\text{species}_{10}]) \quad (16)$$

Table 26: Properties of each parameter.

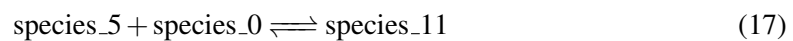
Id	Name	SBO	Value	Unit	Constant
k1			$1.32 \cdot 10^8$		<input checked="" type="checkbox"/>
k2			1.280		<input checked="" type="checkbox"/>

7.8 Reaction `reaction_7`

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

Name G*T binding GAP

Reaction equation



Reactants

Table 27: Properties of each reactant.

Id	Name	SBO
species_5	G*T	
species_0	A	

Product

Table 28: Properties of each product.

Id	Name	SBO
species_11	G*AT	

Kinetic Law

Derived unit contains undeclared units

$$v_8 = \text{vol}(\text{compartment}_0) \cdot (k_1 \cdot [\text{species}_5] \cdot [\text{species}_0] - k_2 \cdot [\text{species}_{11}]) \quad (18)$$

Table 29: Properties of each parameter.

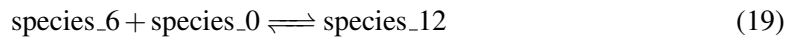
Id	Name	SBO	Value	Unit	Constant
k1			386000.000		<input checked="" type="checkbox"/>
k2			0.041		<input checked="" type="checkbox"/>

7.9 Reaction `reaction_8`

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

Name GD binding GAP

Reaction equation



Reactants

Table 30: Properties of each reactant.

Id	Name	SBO
species_6	GD	
species_0	A	

Product

Table 31: Properties of each product.

Id	Name	SBO
species_12	GAD	

Kinetic Law

Derived unit contains undeclared units

$$v_9 = \text{vol}(\text{compartment}_0) \cdot (k1 \cdot [\text{species_6}] \cdot [\text{species_0}] - k2 \cdot [\text{species_12}]) \quad (20)$$

Table 32: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
k1			64100.00		<input checked="" type="checkbox"/>
k2			0.95		<input checked="" type="checkbox"/>

7.10 Reaction `reaction_9`

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

Name GD binding Receptor

Reaction equation



Reactants

Table 33: Properties of each reactant.

Id	Name	SBO
species_6	GD	
species_4	R	

Product

Table 34: Properties of each product.

Id	Name	SBO
species_13	RGD	

Kinetic Law

Derived unit contains undeclared units

$$v_{10} = \text{vol}(\text{compartment_0}) \cdot (k1 \cdot [\text{species_6}] \cdot [\text{species_4}] - k2 \cdot [\text{species_13}]) \quad (22)$$

Table 35: Properties of each parameter.

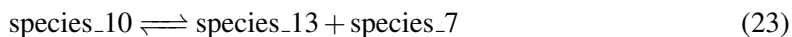
Id	Name	SBO	Value	Unit	Constant
k1			$9.47 \cdot 10^7$		<input checked="" type="checkbox"/>
k2			0.002		<input checked="" type="checkbox"/>

7.11 Reaction `reaction_10`

This is a reversible reaction of one reactant forming two products.

Name RG*T hydrolysis

Reaction equation



Reactant

Table 36: Properties of each reactant.

Id	Name	SBO
species_10	RG*T	

Products

Table 37: Properties of each product.

Id	Name	SBO
species_13	RGD	
species_7	Pi	

Kinetic Law

Derived unit contains undeclared units

$$v_{11} = \text{vol}(\text{compartment}_0) \cdot (k_1 \cdot [\text{species_10}] - k_2 \cdot [\text{species_13}] \cdot [\text{species_7}]) \quad (24)$$

Table 38: Properties of each parameter.

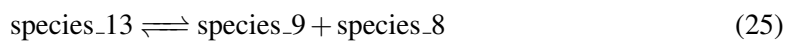
Id	Name	SBO	Value	Unit	Constant
k1			0.013		<input checked="" type="checkbox"/>
k2			$2.22 \cdot 10^{-9}$		<input checked="" type="checkbox"/>

7.12 Reaction [reaction_11](#)

This is a reversible reaction of one reactant forming two products.

Name RGD dissociation

Reaction equation



Reactant

Table 39: Properties of each reactant.

Id	Name	SBO
species_13	RGD	

Products

Table 40: Properties of each product.

Id	Name	SBO
species_9	RG	
species_8	D	

Kinetic Law

Derived unit contains undeclared units

$$v_{12} = \text{vol}(\text{compartment}_0) \cdot (k1 \cdot [\text{species}_{13}] - k2 \cdot [\text{species}_9] \cdot [\text{species}_8]) \quad (26)$$

Table 41: Properties of each parameter.

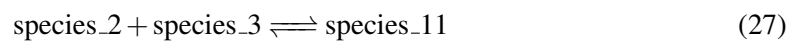
Id	Name	SBO	Value	Unit	Constant
k1			2.0		<input checked="" type="checkbox"/>
k2			1470000.0		<input checked="" type="checkbox"/>

7.13 Reaction [reaction_12](#)

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

Name GA binding GTP

Reaction equation



Reactants

Table 42: Properties of each reactant.

Id	Name	SBO
species_2	GA	
species_3	T	

Product

Table 43: Properties of each product.

Id	Name	SBO
species_11	G*AT	

Kinetic Law

Derived unit contains undeclared units

$$v_{13} = \text{vol}(\text{compartment}_0) \cdot (k_1 \cdot [\text{species}_2] \cdot [\text{species}_3] - k_2 \cdot [\text{species}_{11}]) \quad (28)$$

Table 44: Properties of each parameter.

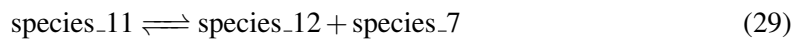
Id	Name	SBO	Value	Unit	Constant
k1			44700.000		<input checked="" type="checkbox"/>
k2			$8.32 \cdot 10^{-8}$		<input checked="" type="checkbox"/>

7.14 Reaction `reaction_13`

This is a reversible reaction of one reactant forming two products.

Name G*AT hydrolysis

Reaction equation



Reactant

Table 45: Properties of each reactant.

Id	Name	SBO
species_11	G*AT	

Products

Table 46: Properties of each product.

Id	Name	SBO
species_12	GAD	
species_7	Pi	

Kinetic Law

Derived unit contains undeclared units

$$v_{14} = \text{vol}(\text{compartment}_0) \cdot (k1 \cdot [\text{species}_{11}] - k2 \cdot [\text{species}_{12}] \cdot [\text{species}_7]) \quad (30)$$

Table 47: Properties of each parameter.

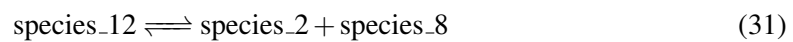
Id	Name	SBO	Value	Unit	Constant
k1			25.000		<input checked="" type="checkbox"/>
k2			0.244		<input checked="" type="checkbox"/>

7.15 Reaction [reaction_14](#)

This is a reversible reaction of one reactant forming two products.

Name GAD dissociation

Reaction equation



Reactant

Table 48: Properties of each reactant.

Id	Name	SBO
species_12	GAD	

Products

Table 49: Properties of each product.

Id	Name	SBO
species_2	GA	
species_8	D	

Kinetic Law

Derived unit contains undeclared units

$$v_{15} = \text{vol}(\text{compartment}_0) \cdot (k_1 \cdot [\text{species}_{12}] - k_2 \cdot [\text{species}_2] \cdot [\text{species}_8]) \quad (32)$$

Table 50: Properties of each parameter.

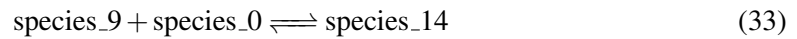
Id	Name	SBO	Value	Unit	Constant
k1			10^{-4}		<input checked="" type="checkbox"/>
k2			3.830		<input checked="" type="checkbox"/>

7.16 Reaction [reaction_15](#)

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

Name RG binding GAP

Reaction equation



Reactants

Table 51: Properties of each reactant.

Id	Name	SBO
species_9	RG	
species_0	A	

Product

Table 52: Properties of each product.

Id	Name	SBO
species_14	RGA	

Kinetic Law

Derived unit contains undeclared units

$$v_{16} = \text{vol}(\text{compartment}_0) \cdot (k_1 \cdot [\text{species}_9] \cdot [\text{species}_0] - k_2 \cdot [\text{species}_{14}]) \quad (34)$$

Table 53: Properties of each parameter.

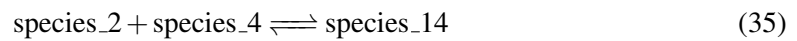
Id	Name	SBO	Value	Unit	Constant
k1			74300.000		<input checked="" type="checkbox"/>
k2			0.006		<input checked="" type="checkbox"/>

7.17 Reaction [reaction_16](#)

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

Name GA binding Receptor

Reaction equation



Reactants

Table 54: Properties of each reactant.

Id	Name	SBO
species_2	GA	
species_4	R	

Product

Table 55: Properties of each product.

Id	Name	SBO
species_14	RGA	

Kinetic Law

Derived unit contains undeclared units

$$v_{17} = \text{vol}(\text{compartment}_0) \cdot (k_1 \cdot [\text{species}_2] \cdot [\text{species}_4] - k_2 \cdot [\text{species}_{14}]) \quad (36)$$

Table 56: Properties of each parameter.

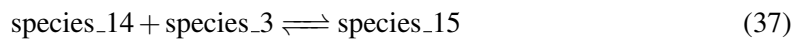
Id	Name	SBO	Value	Unit	Constant
k1			$2.28 \cdot 10^7$		<input checked="" type="checkbox"/>
k2			$5.43 \cdot 10^{-5}$		<input checked="" type="checkbox"/>

7.18 Reaction `reaction_17`

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

Name RGA binding GTP

Reaction equation



Reactants

Table 57: Properties of each reactant.

Id	Name	SBO
species ₁₄	RGA	
species ₃	T	

Product

Table 58: Properties of each product.

Id	Name	SBO
species ₁₅	RG*AT	

Kinetic Law

Derived unit contains undeclared units

$$v_{18} = \text{vol}(\text{compartment}_0) \cdot (k_1 \cdot [\text{species}_{14}] \cdot [\text{species}_3] - k_2 \cdot [\text{species}_{15}]) \quad (38)$$

Table 59: Properties of each parameter.

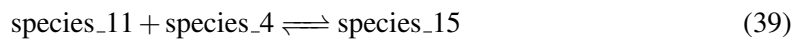
Id	Name	SBO	Value	Unit	Constant
k1			1620000.000		<input checked="" type="checkbox"/>
k2			0.009		<input checked="" type="checkbox"/>

7.19 Reaction [reaction_18](#)

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

Name G*AT binding Receptor

Reaction equation



Reactants

Table 60: Properties of each reactant.

Id	Name	SBO
species_11	G*AT	
species_4	R	

Product

Table 61: Properties of each product.

Id	Name	SBO
species_15	RG*AT	

Kinetic Law

Derived unit contains undeclared units

$$v_{19} = \text{vol}(\text{compartment_0}) \cdot (k1 \cdot [\text{species_11}] \cdot [\text{species_4}] - k2 \cdot [\text{species_15}]) \quad (40)$$

Table 62: Properties of each parameter.

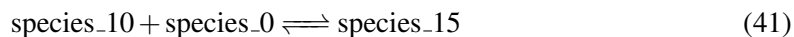
Id	Name	SBO	Value	Unit	Constant
k1			6200000.000		<input checked="" type="checkbox"/>
k2			0.043		<input checked="" type="checkbox"/>

7.20 Reaction `reaction_19`

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

Name RG*T binding GAP

Reaction equation



Reactants

Table 63: Properties of each reactant.

Id	Name	SBO
species_10	RG*T	
species_0	A	

Product

Table 64: Properties of each product.

Id	Name	SBO
species_15	RG*AT	

Kinetic Law

Derived unit contains undeclared units

$$v_{20} = \text{vol}(\text{compartment_0}) \cdot (k1 \cdot [\text{species_10}] \cdot [\text{species_0}] - k2 \cdot [\text{species_15}]) \quad (42)$$

Table 65: Properties of each parameter.

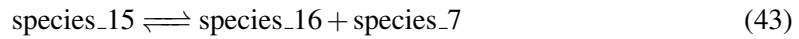
Id	Name	SBO	Value	Unit	Constant
k1			6300000.000		<input checked="" type="checkbox"/>
k2			0.478		<input checked="" type="checkbox"/>

7.21 Reaction `reaction_20`

This is a reversible reaction of one reactant forming two products.

Name RG*AT hydrolysis

Reaction equation



Reactant

Table 66: Properties of each reactant.

Id	Name	SBO
species_15	RG*AT	

Products

Table 67: Properties of each product.

Id	Name	SBO
species_16	RGAD	
species_7	Pi	

Kinetic Law

Derived unit contains undeclared units

$$v_{21} = \text{vol}(\text{compartment}_0) \cdot (k1 \cdot [\text{species_15}] - k2 \cdot [\text{species_16}] \cdot [\text{species_7}]) \quad (44)$$

Table 68: Properties of each parameter.

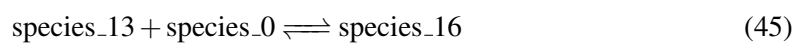
Id	Name	SBO	Value	Unit	Constant
k1			25.000		<input checked="" type="checkbox"/>
k2			0.003		<input checked="" type="checkbox"/>

7.22 Reaction [reaction_21](#)

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

Name RGD binding GAP

Reaction equation



Reactants

Table 69: Properties of each reactant.

Id	Name	SBO
species_13	RGD	
species_0	A	

Product

Table 70: Properties of each product.

Id	Name	SBO
species_16	RGAD	

Kinetic Law

Derived unit contains undeclared units

$$v_{22} = \text{vol}(\text{compartment}_0) \cdot (k_1 \cdot [\text{species}_13] \cdot [\text{species}_0] - k_2 \cdot [\text{species}_16]) \quad (46)$$

Table 71: Properties of each parameter.

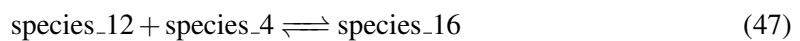
Id	Name	SBO	Value	Unit	Constant
k1			13000.000		<input checked="" type="checkbox"/>
k2			0.685		<input checked="" type="checkbox"/>

7.23 Reaction [reaction_22](#)

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

Name GAD binding Receptor

Reaction equation



Reactants

Table 72: Properties of each reactant.

Id	Name	SBO
species_12	GAD	
species_4	R	

Product

Table 73: Properties of each product.

Id	Name	SBO
species_16	RGAD	

Kinetic Law

Derived unit contains undeclared units

$$v_{23} = \text{vol}(\text{compartment}_0) \cdot (k_1 \cdot [\text{species}_12] \cdot [\text{species}_4] - k_2 \cdot [\text{species}_16]) \quad (48)$$

Table 74: Properties of each parameter.

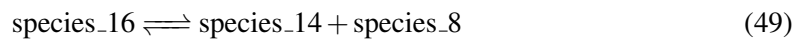
Id	Name	SBO	Value	Unit	Constant
k1			$4.94 \cdot 10^7$		<input checked="" type="checkbox"/>
k2			0.004		<input checked="" type="checkbox"/>

7.24 Reaction `reaction_23`

This is a reversible reaction of one reactant forming two products.

Name RGAD dissociation

Reaction equation



Reactant

Table 75: Properties of each reactant.

Id	Name	SBO
species_16	RGAD	

Products

Table 76: Properties of each product.

Id	Name	SBO
species_14	RGA	
species_8	D	

Kinetic Law

Derived unit contains undeclared units

$$v_{24} = \text{vol}(\text{compartment}_0) \cdot (k1 \cdot [\text{species}_{16}] - k2 \cdot [\text{species}_{14}] \cdot [\text{species}_8]) \quad (50)$$

Table 77: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
k1			2.75		<input checked="" type="checkbox"/>
k2			2940.00		<input checked="" type="checkbox"/>

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 `species_0`

Name A

Notes GAP

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

This species takes part in six reactions (as a reactant in [reaction_0](#), [reaction_7](#), [reaction_8](#), [reaction_15](#), [reaction_19](#), [reaction_21](#)).

$$\frac{d}{dt}\text{species}_0 = -v_1 - v_8 - v_9 - v_{16} - v_{20} - v_{22} \quad (51)$$

8.2 Species `species_1`

Name G

Notes inactive G protein

Initial concentration $10^{-8} \text{ mol} \cdot \text{l}^{-1}$

This species takes part in four reactions (as a reactant in [reaction_0](#), [reaction_1](#), [reaction_2](#) and as a product in [reaction_4](#)).

$$\frac{d}{dt}\text{species}_1 = v_5 - v_1 - v_2 - v_3 \quad (52)$$

8.3 Species `species_2`

Name GA

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

This species takes part in four reactions (as a reactant in [reaction_12](#), [reaction_16](#) and as a product in [reaction_0](#), [reaction_14](#)).

$$\frac{d}{dt}\text{species}_2 = v_1 + v_{15} - v_{13} - v_{17} \quad (53)$$

8.4 Species `species_3`

Name T

Notes GTP

Initial concentration $4.68 \cdot 10^{-4} \text{ mol} \cdot \text{l}^{-1}$

This species takes part in four reactions (as a reactant in [reaction_1](#), [reaction_5](#), [reaction_12](#), [reaction_17](#)).

$$\frac{d}{dt}\text{species}_3 = -v_2 - v_6 - v_{13} - v_{18} \quad (54)$$

8.5 Species `species_4`

Name R

Notes Receptor

Initial concentration $10^{-6} \text{ mol} \cdot \text{l}^{-1}$

This species takes part in six reactions (as a reactant in [reaction_2](#), [reaction_6](#), [reaction_9](#), [reaction_16](#), [reaction_18](#), [reaction_22](#)).

$$\frac{d}{dt}\text{species_4} = -v_3 - v_7 - v_{10} - v_{17} - v_{19} - v_{23} \quad (55)$$

8.6 Species `species_5`

Name G*T

Notes active G protein

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

This species takes part in four reactions (as a reactant in [reaction_3](#), [reaction_6](#), [reaction_7](#) and as a product in [reaction_1](#)).

$$\frac{d}{dt}\text{species_5} = v_2 - v_4 - v_7 - v_8 \quad (56)$$

8.7 Species `species_6`

Name GD

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

This species takes part in four reactions (as a reactant in [reaction_4](#), [reaction_8](#), [reaction_9](#) and as a product in [reaction_3](#)).

$$\frac{d}{dt}\text{species_6} = v_4 - v_5 - v_9 - v_{10} \quad (57)$$

8.8 Species `species_7`

Name Pi

Initial concentration $0.0044 \text{ mol} \cdot \text{l}^{-1}$

This species takes part in four reactions (as a product in [reaction_3](#), [reaction_10](#), [reaction_13](#), [reaction_20](#)).

$$\frac{d}{dt}\text{species_7} = v_4 + v_{11} + v_{14} + v_{21} \quad (58)$$

8.9 Species `species_8`

Name D

Notes GDP

Initial concentration $1.49 \cdot 10^{-4} \text{ mol} \cdot \text{l}^{-1}$

This species takes part in four reactions (as a product in [reaction_4](#), [reaction_11](#), [reaction_14](#), [reaction_23](#)).

$$\frac{d}{dt}\text{species_8} = v_5 + v_{12} + v_{15} + v_{24} \quad (59)$$

8.10 Species `species_9`

Name RG

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

This species takes part in four reactions (as a reactant in [reaction_5](#), [reaction_15](#) and as a product in [reaction_2](#), [reaction_11](#)).

$$\frac{d}{dt}\text{species_9} = v_3 + v_{12} - v_6 - v_{16} \quad (60)$$

8.11 Species `species_10`

Name RG*T

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

This species takes part in four reactions (as a reactant in [reaction_10](#), [reaction_19](#) and as a product in [reaction_5](#), [reaction_6](#)).

$$\frac{d}{dt}\text{species_10} = v_6 + v_7 - v_{11} - v_{20} \quad (61)$$

8.12 Species `species_11`

Name G*AT

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

This species takes part in four reactions (as a reactant in [reaction_13](#), [reaction_18](#) and as a product in [reaction_7](#), [reaction_12](#)).

$$\frac{d}{dt}\text{species_11} = v_8 + v_{13} - v_{14} - v_{19} \quad (62)$$

8.13 Species `species_12`

Name GAD

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

This species takes part in four reactions (as a reactant in [reaction_14](#), [reaction_22](#) and as a product in [reaction_8](#), [reaction_13](#)).

$$\frac{d}{dt}\text{species_12} = v_9 + v_{14} - v_{15} - v_{23} \quad (63)$$

8.14 Species `species_13`

Name RGD

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

This species takes part in four reactions (as a reactant in [reaction_11](#), [reaction_21](#) and as a product in [reaction_9](#), [reaction_10](#)).

$$\frac{d}{dt}\text{species_13} = v_{10} + v_{11} - v_{12} - v_{22} \quad (64)$$

8.15 Species `species_14`

Name RGA

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

This species takes part in four reactions (as a reactant in [reaction_17](#) and as a product in [reaction_15](#), [reaction_16](#), [reaction_23](#)).

$$\frac{d}{dt}\text{species_14} = v_{16} + v_{17} + v_{24} - v_{18} \quad (65)$$

8.16 Species `species_15`

Name RG*AT

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

This species takes part in four reactions (as a reactant in [reaction_20](#) and as a product in [reaction_17](#), [reaction_18](#), [reaction_19](#)).

$$\frac{d}{dt}\text{species_15} = v_{18} + v_{19} + v_{20} - v_{21} \quad (66)$$

8.17 Species `species_16`

Name RGAD

Initial concentration 0 mol · l⁻¹

This species takes part in four reactions (as a reactant in [reaction_23](#) and as a product in [reaction_20](#), [reaction_21](#), [reaction_22](#)).

$$\frac{d}{dt}\text{species_16} = v_{21} + v_{22} + v_{23} - v_{24} \quad (67)$$

SBML²TeX was developed by Andreas Dräger^a, Hannes Planatscher^a, Dieudonné M Wouamba^a, Adrian Schröder^a, Michael Hucka^b, Lukas Endler^c, Martin Golebiewski^d and Andreas Zell^a. Please see <http://www.ra.cs.uni-tuebingen.de/software/SBML2LaTeX> for more information.

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