SBML Model Report

Model name: "Locke2008_Circadian_Clock"

May 6, 2016

1 General Overview

This is a document in SBML Level 2 Version 3 format. This model was created by Harish Dharuri[1] at August 20th 2008 at 8:10 a. m. and last time modified at July eleventh 2012 at 5:47 p. m. Table 1 shows 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	8
events	0	constraints	0
reactions	20	function definitions	0
global parameters	19	unit definitions	5
rules	1	initial assignments	0

Model Notes

The model reproduces Fig 2A of the paper. Model successfully reproduced using Jarnac and MathSBML.

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commercially or not, in a restricted way or not.

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2 Unit Definitions

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

2.1 Unit `substance`

Name nano mole

Definition nmol

2.2 Unit `time`

Name hour

Definition 3600 s

2.3 Unit `nM`

Name nM

Definition $\mathrm{nmol} \cdot \mathrm{l}^{-1}$

2.4 Unit `nM_hr_1`

Name nM_hr_1

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

2.5 Unit `hr_1`

Name hr_1

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

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 m^2

2.8 Unit `length`

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

Definition m

3 Compartment

This model contains one compartment.

Table 2: Properties of all compartments.

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

3.1 Compartment `compartment`

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

Name Cell

4 Species

This model contains eight 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
X1	clock gene mRNA	compartment	$\mathrm{nmol} \cdot \mathrm{l}^{-1}$	⊟	⊟
Y1	clock protein	compartment	$\mathrm{nmol} \cdot \mathrm{l}^{-1}$	⊟	⊟
Z1	Transcriptional repressor	compartment	$\mathrm{nmol} \cdot \mathrm{l}^{-1}$	⊟	⊟
V1	Neuropeptide	compartment	$\mathrm{nmol} \cdot \mathrm{l}^{-1}$	⊟	⊟
X2	clock gene mRNA	compartment	$\mathrm{nmol} \cdot \mathrm{l}^{-1}$	⊟	⊟
Y2	clock protein	compartment	$\mathrm{nmol} \cdot \mathrm{l}^{-1}$	⊟	⊟
Z2	Transcriptional repressor	compartment	$\mathrm{nmol} \cdot \mathrm{l}^{-1}$	⊟	⊟
V2	Neuropeptide	compartment	$\mathrm{nmol} \cdot \mathrm{l}^{-1}$	⊟	⊟

5 Parameters

This model contains 19 global parameters.

Table 4: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
F			0.000	$\mathrm{nmol} \cdot \mathrm{l}^{-1}$	⊟
v_1			6.836	$\mathrm{nmol} \cdot \mathrm{l}^{-1} \cdot (3600\ \mathrm{s})^{-1}$	☑
K1			2.727	$\mathrm{nmol} \cdot \mathrm{l}^{-1}$	☑
n			5.665	dimensionless	☑
v_2			8.430	$\mathrm{nmol} \cdot \mathrm{l}^{-1} \cdot (3600\ \mathrm{s})^{-1}$	☑
K2			0.291	$\mathrm{nmol} \cdot \mathrm{l}^{-1}$	☑
vc			6.792	$\mathrm{nmol} \cdot \mathrm{l}^{-1} \cdot (3600\ \mathrm{s})^{-1}$	☑
K			1.000	dimensionless	☑
Kc			4.828	$\mathrm{nmol} \cdot \mathrm{l}^{-1}$	☑
L			0.000	$\mathrm{nmol} \cdot \mathrm{l}^{-1} \cdot (3600\ \mathrm{s})^{-1}$	☑
k3			0.118	$(3600\ \mathrm{s})^{-1}$	☑
v_4			1.084	$\mathrm{nmol} \cdot \mathrm{l}^{-1} \cdot (3600\ \mathrm{s})^{-1}$	☑
K4			8.134	$\mathrm{nmol} \cdot \mathrm{l}^{-1}$	☑
k5			0.335	$(3600\ \mathrm{s})^{-1}$	☑
v_6			4.665	$\mathrm{nmol} \cdot \mathrm{l}^{-1} \cdot (3600\ \mathrm{s})^{-1}$	☑
K6			9.985	$\mathrm{nmol} \cdot \mathrm{l}^{-1}$	☑
k7			0.228	$(3600\ \mathrm{s})^{-1}$	☑
v_8			3.522	$\mathrm{nmol} \cdot \mathrm{l}^{-1} \cdot (3600\ \mathrm{s})^{-1}$	☑
K8			7.452	$\mathrm{nmol} \cdot \mathrm{l}^{-1}$	☑

6 Rule

This is an overview of one rule.

6.1 Rule F

Rule F is an assignment rule for parameter F:

$$\mathrm{F} = \frac{1}{2} \cdot ([\mathrm{V1}] + [\mathrm{V2}]) \tag{1}$$

7 Reactions

This model contains 20 reactions. All reactions are listed in the following table and are subsequently described in detail. If a reaction is affected by a modifier, the identifier of this species is written above the reaction arrow.

Table 5: Overview of all reactions

№	Id	Name	Reaction Equation	SBO
1	R1	Transcription	$\emptyset \xrightarrow{Z1} X1$	
2	R2	mRNA degradation	$X1 \longrightarrow \emptyset$	
3	R3	Neuropeptide dependent transcription activation	$\emptyset \longrightarrow X1$	
4	R4	Light dependent transcription activation	$\emptyset \longrightarrow X1$	
5	R5	Translation	$\emptyset \xrightarrow{X1} Y1$	
6	R6	Protein degradation	$Y1 \longrightarrow \emptyset$	
7	R7	Transcriptional repressor synthesis	$\emptyset \xrightarrow{Y1} Z1$	
8	R8	Transcriptional repressor degradation	$Z1 \longrightarrow \emptyset$	
9	R9	Neuropeptide synthesis	$\emptyset \xrightarrow{X1} V1$	
10	R10	Neuropeptide degradation	$V1 \longrightarrow \emptyset$	
11	R11	Transcription	$\emptyset \xrightarrow{Z2} X2$	
12	R12	mRNA degradation	$X2 \longrightarrow \emptyset$	
13	R13	Neuropeptide dependent transcription activation	$\emptyset \longrightarrow X2$	
14	R14	Light dependent transcription activation	$\emptyset \longrightarrow X2$	
15	R15	Translation	$\emptyset \xrightarrow{X2} Y2$	
16	R16	Protein degradation	$Y2 \longrightarrow \emptyset$	
17	R17	Transcriptional repressor synthesis	$\emptyset \xrightarrow{Y2} Z2$	
18	R18	Transcriptional repressor degradation	$Z2 \longrightarrow \emptyset$	

№	Id	Name	Reaction Equation	SBO
19	R19	Neuropeptide synthesis	$\emptyset \xrightarrow{\text{X2}} \text{V2}$	
20	R20	Neuropeptide degradation	$\text{V2} \longrightarrow \emptyset$	

7.1 Reaction R1

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

Name Transcription

Reaction equation

$$\emptyset \xrightarrow{\text{Z1}} \text{X1} \tag{2}$$

Modifier

Table 6: Properties of each modifier.

Id	Name	SBO
Z1	Transcriptional repressor	

Product

Table 7: Properties of each product.

Id	Name	SBO
X1	clock gene mRNA	

Kinetic Law

Derived unit contains undeclared units

$$v_1 = \frac{\text{vol}\,(\text{compartment}) \cdot \text{v\_1} \cdot \text{K1}^{\text{n}}}{\text{K1}^{\text{n}} + [\text{Z1}]^{\text{n}}} \tag{3}$$

7.2 Reaction R2

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

Name mRNA degradation

Reaction equation

$$\text{X1} \longrightarrow \emptyset \tag{4}$$

Reactant

Table 8: Properties of each reactant.

Id	Name	SBO
X1	clock gene mRNA	

Kinetic Law

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

$$v_2 = \frac{\mathrm{vol}\,(\mathrm{compartment}) \cdot \mathrm{v\_2} \cdot [\mathrm{X1}]}{\mathrm{K2} + [\mathrm{X1}]} \tag{5}$$

7.3 Reaction R3

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

Name Neuropeptide dependent transcription activation

Reaction equation

$$\emptyset \longrightarrow \mathrm{X1} \tag{6}$$

Product

Table 9: Properties of each product.

Id	Name	SBO
X1	clock gene mRNA	

Kinetic Law

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

$$v_3 = \frac{\mathrm{vol}\,(\mathrm{compartment}) \cdot \mathrm{vc} \cdot \mathrm{K} \cdot \mathrm{F}}{\mathrm{Kc} + \mathrm{K} \cdot \mathrm{F}} \tag{7}$$

7.4 Reaction R4

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

Name Light dependent transcription activation

Reaction equation

$$\emptyset \longrightarrow \mathrm{X1} \tag{8}$$

Product

Table 10: Properties of each product.

Id	Name	SBO
X1	clock gene mRNA	

Kinetic Law

Derived unit $\mathrm{nmol} \cdot (3600\ \mathrm{s})^{-1}$

$$v_4 = \mathrm{vol}\,(\mathrm{compartment}) \cdot \mathrm{L} \tag{9}$$

7.5 Reaction R5

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

Name Translation

Reaction equation

$$\emptyset \xrightarrow{\mathrm{X1}} \mathrm{Y1} \tag{10}$$

Modifier

Table 11: Properties of each modifier.

Id	Name	SBO
X1	clock gene mRNA	

Product

Table 12: Properties of each product.

Id	Name	SBO
Y1	clock protein	

Kinetic Law

Derived unit $(3600\ \mathrm{s})^{-1} \cdot \mathrm{nmol}$

$$v_5 = \mathrm{vol}\,(\mathrm{compartment}) \cdot \mathrm{k3} \cdot [\mathrm{X1}] \tag{11}$$

7.6 Reaction R6

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

Name Protein degradation

Reaction equation

$$\mathrm{Y1} \longrightarrow \emptyset \tag{12}$$

Reactant

Table 13: Properties of each reactant.

Id	Name	SBO
Y1	clock protein	

Kinetic Law

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

$$v_6 = \frac{\mathrm{vol}\,(\mathrm{compartment}) \cdot \mathrm{v\_4} \cdot [\mathrm{Y1}]}{\mathrm{K4} + [\mathrm{Y1}]} \tag{13}$$

7.7 Reaction R7

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

Name Transcriptional repressor synthesis

Reaction equation

$$\emptyset \xrightarrow{\mathrm{Y1}} \mathrm{Z1} \tag{14}$$

Modifier

Table 14: Properties of each modifier.

Id	Name	SBO
Y1	clock protein	

Product

Table 15: Properties of each product.

Id	Name	SBO
Z1	Transcriptional repressor	

Kinetic Law

Derived unit $(3600\ \mathrm{s})^{-1} \cdot \mathrm{nmol}$

$$v_7 = \mathrm{vol}\,(\mathrm{compartment}) \cdot \mathrm{k5} \cdot [\mathrm{Y1}] \tag{15}$$

7.8 Reaction R8

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

Name Transcriptional repressor degradation

Reaction equation

$$\mathrm{Z1} \longrightarrow \emptyset \tag{16}$$

Reactant

Table 16: Properties of each reactant.

Id	Name	SBO
Z1	Transcriptional repressor	

Kinetic Law

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

$$v_8 = \frac{\mathrm{vol}\,(\mathrm{compartment}) \cdot \mathrm{v\_6} \cdot [\mathrm{Z1}]}{\mathrm{K6} + [\mathrm{Z1}]} \tag{17}$$

7.9 Reaction R9

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

Name Neuropeptide synthesis

Reaction equation

$$\emptyset \xrightarrow{\mathrm{X1}} \mathrm{V1} \tag{18}$$

Modifier

Table 17: Properties of each modifier.

Id	Name	SBO
X1	clock gene mRNA	

Product

Table 18: Properties of each product.

Id	Name	SBO
V1	Neuropeptide	

Kinetic Law

Derived unit $(3600\ \mathrm{s})^{-1} \cdot \mathrm{nmol}$

$$v_9 = \mathrm{vol}\,(\mathrm{compartment}) \cdot \mathrm{k7} \cdot [\mathrm{X1}] \tag{19}$$

7.10 Reaction R10

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

Name Neuropeptide degradation

Reaction equation

$$\mathrm{V1} \longrightarrow \emptyset \tag{20}$$

Reactant

Table 19: Properties of each reactant.

Id	Name	SBO
V1	Neuropeptide	

Kinetic Law

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

$$v_{10} = \frac{\mathrm{vol}\,(\mathrm{compartment}) \cdot \mathrm{v\_8} \cdot [\mathrm{V1}]}{\mathrm{K8} + [\mathrm{V1}]} \tag{21}$$

7.11 Reaction R11

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

Name Transcription

Reaction equation

$$\emptyset \xrightarrow{\mathrm{Z2}} \mathrm{X2} \tag{22}$$

Modifier

Table 20: Properties of each modifier.

Id	Name	SBO
Z2	Transcriptional repressor	

Product

Table 21: Properties of each product.

Id	Name	SBO
X2	clock gene mRNA	

Kinetic Law

Derived unit contains undeclared units

$$v_{11} = \frac{\mathrm{vol}\,(\mathrm{compartment}) \cdot \mathrm{v\_1} \cdot \mathrm{K1}^{\mathrm{n}}}{\mathrm{K1}^{\mathrm{n}} + [\mathrm{Z2}]^{\mathrm{n}}} \tag{23}$$

7.12 Reaction R12

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

Name mRNA degradation

Reaction equation

$$\mathrm{X2} \longrightarrow \emptyset \tag{24}$$

Reactant

Table 22: Properties of each reactant.

Id	Name	SBO
X2	clock gene mRNA	

Kinetic Law

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

$$v_{12} = \frac{\mathrm{vol}\,(\mathrm{compartment}) \cdot \mathrm{v\_2} \cdot [\mathrm{X2}]}{\mathrm{K2} + [\mathrm{X2}]} \tag{25}$$

7.13 Reaction R13

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

Name Neuropeptide dependent transcription activation

Reaction equation

$$\emptyset \longrightarrow \mathrm{X2} \tag{26}$$

Product

Table 23: Properties of each product.

Id	Name	SBO
X2	clock gene mRNA	

Kinetic Law

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

$$v_{13} = \frac{\mathrm{vol}\,(\mathrm{compartment}) \cdot \mathrm{vc} \cdot \mathrm{K} \cdot \mathrm{F}}{\mathrm{Kc} + \mathrm{K} \cdot \mathrm{F}} \tag{27}$$

7.14 Reaction R14

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

Name Light dependent transcription activation

Reaction equation

$$\emptyset \longrightarrow \mathrm{X2} \tag{28}$$

Product

Table 24: Properties of each product.

Id	Name	SBO
X2	clock gene mRNA	

Kinetic Law

Derived unit $\mathrm{nmol} \cdot (3600\ \mathrm{s})^{-1}$

$$v_{14} = \mathrm{vol}\,(\mathrm{compartment}) \cdot \mathrm{L} \tag{29}$$

7.15 Reaction R15

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

Name Translation

Reaction equation

$$\emptyset \xrightarrow{\mathrm{X2}} \mathrm{Y2} \tag{30}$$

Modifier

Table 25: Properties of each modifier.

Id	Name	SBO
X2	clock gene mRNA	

Product

Table 26: Properties of each product.

Id	Name	SBO
Y2	clock protein	

Kinetic Law

Derived unit $(3600\ \mathrm{s})^{-1} \cdot \mathrm{nmol}$

$$v_{15} = \mathrm{vol}\,(\mathrm{compartment}) \cdot \mathrm{k3} \cdot [\mathrm{X2}] \tag{31}$$

7.16 Reaction R16

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

Name Protein degradation

Reaction equation

$$\mathrm{Y2} \longrightarrow \emptyset \tag{32}$$

Reactant

Table 27: Properties of each reactant.

Id	Name	SBO
Y2	clock protein	

Kinetic Law

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

$$v_{16} = \frac{\mathrm{vol}\,(\mathrm{compartment}) \cdot \mathrm{v\_4} \cdot [\mathrm{Y2}]}{\mathrm{K4} + [\mathrm{Y2}]} \tag{33}$$

7.17 Reaction R17

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

Name Transcriptional repressor synthesis

Reaction equation

$$\emptyset \xrightarrow{\mathrm{Y2}} \mathrm{Z2} \tag{34}$$

Modifier

Table 28: Properties of each modifier.

Id	Name	SBO
Y2	clock protein	

Product

Table 29: Properties of each product.

Id	Name	SBO
Z2	Transcriptional repressor	

Kinetic Law

Derived unit $(3600\ \mathrm{s})^{-1} \cdot \mathrm{nmol}$

$$v_{17} = \mathrm{vol}\,(\mathrm{compartment}) \cdot \mathrm{k5} \cdot [\mathrm{Y2}] \tag{35}$$

7.18 Reaction R18

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

Name Transcriptional repressor degradation

Reaction equation

$$\mathrm{Z2} \longrightarrow \emptyset \tag{36}$$

Reactant

Table 30: Properties of each reactant.

Id	Name	SBO
Z2	Transcriptional repressor	

Kinetic Law

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

$$v_{18} = \frac{\mathrm{vol}\,(\mathrm{compartment}) \cdot \mathrm{v\_6} \cdot [\mathrm{Z2}]}{\mathrm{K6} + [\mathrm{Z2}]} \tag{37}$$

7.19 Reaction R19

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

Name Neuropeptide synthesis

Reaction equation

$$\emptyset \xrightarrow{\text{X2}} \text{V2} \tag{38}$$

Modifier

Table 31: Properties of each modifier.

Id	Name	SBO
X2	clock gene mRNA	

Product

Table 32: Properties of each product.

Id	Name	SBO
V2	Neuropeptide	

Kinetic Law

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

$$v_{19} = \text{vol}(\text{compartment}) \cdot \text{k7} \cdot [\text{X2}] \tag{39}$$

7.20 Reaction R20

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

Name Neuropeptide degradation

Reaction equation

$$\text{V2} \longrightarrow \emptyset \tag{40}$$

Reactant

Table 33: Properties of each reactant.

Id	Name	SBO
V2	Neuropeptide	

Kinetic Law

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

$$v_{20} = \frac{\mathrm{vol}\,(\mathrm{compartment}) \cdot \mathrm{v\_8} \cdot [\mathrm{V2}]}{\mathrm{K8} + [\mathrm{V2}]} \tag{41}$$

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.

8.1 Species X1

Name clock gene mRNA

Initial concentration $4.25\ \mathrm{nmol} \cdot \mathrm{l}^{-1}$

This species takes part in six reactions (as a reactant in R2 and as a product in R1, R3, R4 and as a modifier in R5, R9).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{X1} = v_1 + v_3 + v_4 - v_2 \tag{42}$$

8.2 Species Y1

Name clock protein

Initial concentration $3.25\ \mathrm{nmol} \cdot \mathrm{l}^{-1}$

This species takes part in three reactions (as a reactant in R6 and as a product in R5 and as a modifier in R7).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{Y1} = v_5 - v_6 \tag{43}$$

8.3 Species Z1

Name Transcriptional repressor

Initial concentration $2.25\ \mathrm{nmol}\cdot\mathrm{l}^{-1}$

This species takes part in three reactions (as a reactant in R8 and as a product in R7 and as a modifier in R1).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{Z1} = v_7 - v_8 \tag{44}$$

8.4 Species V1

Name Neuropeptide

Initial concentration $2.5\ \mathrm{nmol}\cdot\mathrm{l}^{-1}$

This species takes part in two reactions (as a reactant in R10 and as a product in R9).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{V1} = v_9 - v_{10} \tag{45}$$

8.5 Species X2

Name clock gene mRNA

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

This species takes part in six reactions (as a reactant in R12 and as a product in R11, R13, R14 and as a modifier in R15, R19).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{X2} = v_{11} + v_{13} + v_{14} - v_{12} \tag{46}$$

8.6 Species Y2

Name clock protein

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

This species takes part in three reactions (as a reactant in R16 and as a product in R15 and as a modifier in R17).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{Y2} = v_{15} - v_{16} \tag{47}$$

8.7 Species Z2

Name Transcriptional repressor

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

This species takes part in three reactions (as a reactant in R18 and as a product in R17 and as a modifier in R11).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{Z2} = v_{17} - v_{18} \tag{48}$$

8.8 Species V2

Name Neuropeptide

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

This species takes part in two reactions (as a reactant in R20 and as a product in R19).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{V2} = v_{19} - v_{20} \tag{49}$$

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

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