SBML Model Report

Model name: "Moore2004 - Chronic Myeloid Leukemic cells and T-lymphocyte interaction"

May 17, 2018

1 General Overview

This is a document in SBML Level 2 Version 4 format. This model was created by the following three authors: Matthew Grant Roberts[1], Rahuman Sheriff[2] and Catherine Lloyd[3] at June 25th 2010 at 1:18 p. m. and last time modified at June 25th 2010 at 1:18 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	5
events	0	constraints	0
reactions	10	function definitions	6
global parameters	12	unit definitions	7
rules	0	initial assignments	0

Model Notes

Moore2004 - Chronic Myeloid Leukemic cellsand T-lymphocytes interactionA mathematical model for theinteraction of between cancer cells and immune system, involvingCML cancer

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cells, naive and effector T-lymphocytes.

This model is described in the article:A mathematical model for chronic myelogenous leukemia (CML) and T cell interaction.Moore H, Li NK.J. Theor. Biol. 2004 Apr; 227(4): 513-523

Abstract:

In this paper, we propose and analyse a mathematical model for chronic myelogenous leukemia (CML), a cancer of the blood. We model the interaction between naive T cells, effector T cells, and CML cancer cells in the body, using a system of ordinary differential equations which gives rates of change of the three cell populations. One of the difficulties in modeling CML is the scarcity of experimental data which can be used to estimate parameters values. To compensate for the resulting uncertainties, we use Latin hypercube sampling (LHS) on large ranges of possible parameter values in our analysis. A major goal of this work is the determination of parameters which play a critical role in remission or clearance of the cancer in the model. Our analysis examines 12 parameters, and identifies two of these, the growth and death rates of CML, as critical to the outcome of the system. Our results indicate that the most promising research avenues for treatments of CML should be those that affect these two significant parameters (CML growth and death rates), while altering the other parameters should have little effect on the outcome.

This model is hosted on BioModels Database and identified by: BIOMD0000000662.

To cite BioModels Database, please use: Chelliah V et al. BioModels: ten-year anniversary. Nucl. Acids Res. 2015, 43(Database issue):D542-8.

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2 Unit Definitions

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

2.1 Unit `time`

Name time

Definition 86400 s

2.2 Unit `substance`

Name substance

Definition item

2.3 Unit unit_0

Name 1/(11.5741*l*s)

Definition $(11.5741\ \mathrm{l})^{-1} \cdot \mathrm{s}^{-1}$

2.4 Unit unit_1

Name 1/(0.0115741*ms)

Definition $(0.0115741\ \mathrm{ms})^{-1}$

2.5 Unit unit_2

Name 1

Definition $\mathrm{dimensionless}^{0}$

2.6 Unit unit_3

Name 0.0864*l/s

Definition $0.0864\ \mathrm{l} \cdot \mathrm{s}^{-1}$

2.7 Unit unit_4

Name 1/Ml

Definition Ml^{-1}

2.8 Unit volume

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

Definition l

2.9 Unit area

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

Definition m^{2}

2.10 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	Blood		3	1	litre	☑	

3.1 Compartment COMpartment

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

Name Blood

4 Species

This model contains five species. The boundary condition of two of these species is set to `true` so that these species' amount cannot be changed by any reaction. 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
`CML`	CML	`COMpartment`	$\text{item} \cdot \text{l}^{-1}$	⊟	⊟
`T_cell_naive`	T_cell_naive	`COMpartment`	$\text{item} \cdot \text{l}^{-1}$	⊟	⊟
`T_cell_effector`	T_cell_effector	`COMpartment`	$\text{item} \cdot \text{l}^{-1}$	⊟	⊟
`Source`	Source	`COMpartment`	$\text{item} \cdot \text{l}^{-1}$	☑	☑
`Sink`	Sink	`COMpartment`	$\text{item} \cdot \text{l}^{-1}$	☑	☑

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5 Parameters

This model contains twelve global parameters.

Table 4: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
sn	sn		0.071	$(11.5741\,\mathrm{l})^{-1} \cdot \mathrm{s}^{-1}$	☑
dn	dn		0.050	$(0.0115741\,\mathrm{ms})^{-1}$	☑
alpha_n	alpha_n		0.560	$\mathrm{dimensionless}^{0}$	☑
alpha_e	alpha_e		0.530	$(0.0115741\,\mathrm{ms})^{-1}$	☑
de	de		0.120	$(0.0115741\,\mathrm{ms})^{-1}$	☑
gamma_e	gamma_e		0.008	$0.0864\,\mathrm{l} \cdot \mathrm{s}^{-1}$	☑
Cmax	Cmax		190000.000	Ml^{-1}	☑
rc	rc		0.230	$(0.0115741\,\mathrm{ms})^{-1}$	☑
dc	dc		0.680	$(0.0115741\,\mathrm{ms})^{-1}$	☑
gamma_c	gamma_c		0.047	$0.0864\,\mathrm{l} \cdot \mathrm{s}^{-1}$	☑
kn	kn		0.063	$(0.0115741\,\mathrm{ms})^{-1}$	☑
eta	eta		43.000	Ml^{-1}	☑

6 Function definitions

This is an overview of six function definitions.

6.1 Function definition `function_for_naive_activation`

Name function for naive activation

Arguments naive, [CML], eta, k

Mathematical Expression

$$\mathrm{k} \cdot \mathrm{naive} \cdot \frac{[\mathrm{CML}]}{[\mathrm{CML}] + \mathrm{eta}} \tag{1}$$

6.2 Function definition `function_for_T_cell_effector_death_by_CML`

Name function for T_cell_effector death by CML

Arguments param, [CML], effector

Mathematical Expression

$$\mathrm{param} \cdot [\mathrm{CML}] \cdot \mathrm{effector} \tag{2}$$

6.3 Function definition function_for_CML_growth

Name function for CML growth

Arguments r, C, Cmax

Mathematical Expression

$$\mathrm{r} \cdot \mathrm{C} \cdot \left(\frac{\mathrm{Cmax}}{\mathrm{C}}\right) \tag{3}$$

6.4 Function definition function_for_CML_death_by_T_cell_effector

Name function for CML death by T_cell_effector

Arguments param, mod, substrate

Mathematical Expression

$$\mathrm{param} \cdot \mathrm{mod} \cdot \mathrm{substrate} \tag{4}$$

6.5 Function definition function_for_T_cell_effector_production_from_T-_cell_naive_activation

Name function for T_cell_effector production from T_cell_naive activation

Arguments alpha, k, naive, [CML], eta

Mathematical Expression

$$\mathrm{alpha} \cdot \mathrm{k} \cdot \mathrm{naive} \cdot \frac{[\mathrm{CML}]}{[\mathrm{CML}] + \mathrm{eta}} \tag{5}$$

6.6 Function definition function_for_T_cell_effector_recruitment

Name function for T_cell_effector_recruitment

Arguments alpha, effector, [CML], eta

Mathematical Expression

$$\mathrm{alpha} \cdot \mathrm{effector} \cdot \frac{[\mathrm{CML}]}{[\mathrm{CML}] + \mathrm{eta}} \tag{6}$$

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7 Reactions

This model contains ten 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	T_cell_naive_Source	T_cell_naive Source	Source $\longrightarrow$ T_cell_naive	
2	T_cell_naive_Natural_Death	T_cell_naive Natural Death	T_cell_naive $\longrightarrow$ Sink	
3	T_cell_naive_Activation	T_cell_naive Activation	T_cell_naive $\xrightarrow{\text{CML}}$ Sink	
4	T_cell_effector_Recruitment	T_cell_effector Recruitment	Source $\xrightarrow{\text{CML}}$ T_cell_effector	
5	T_cell_effector_Natural_Death	T_cell_effector Natural Death	T_cell_effector $\longrightarrow$ Sink	
6	T_cell_effector_Death_by_CML	T_cell_effector Death by CML	T_cell_effector $\xrightarrow{\text{CML}}$ Sink	
7	CML_Growth	CML Growth	Source $\longrightarrow$ CML	
8	CML_death_by_T_cell_effector	CML death by T_cell_effector	CML $\xrightarrow{\text{T\_cell\_effector}}$ Sink	
9	CML_natural_death	CML natural death	CML $\longrightarrow$ Sink	

№	Id	Name	Reaction Equation	SBO
10	T_cell-_effector-_Production-_from_T-_cell_Naive-_activation	T_cell_effector Production from T_cell_Naive activation	Source $\xrightarrow{\text{T\_cell\_naive, CML}}$ T_cell_effector	

Produced by SBML2LaTeX

7.1 Reaction T_cell_naive_Source

This is an irreversible reaction of one reactant forming one product.

Name T_cell_naive Source

Reaction equation

$$\text{Source} \longrightarrow \text{T\_cell\_naive} \tag{7}$$

Reactant

Table 6: Properties of each reactant.

Id	Name	SBO
Source	Source	

Product

Table 7: Properties of each product.

Id	Name	SBO
T_cell_naive	T_cell_naive	

Kinetic Law

Derived unit $\mathrm{s}^{-1} \cdot \mathrm{item} \cdot \mathrm{l}^{-1}$

$$v_1 = \mathrm{vol}\,(\mathrm{COMpartment}) \cdot \mathrm{sn} \cdot [\mathrm{Source}] \tag{8}$$

7.2 Reaction T_cell_naive_Natural_Death

This is an irreversible reaction of one reactant forming one product.

Name T_cell_naive Natural Death

Reaction equation

$$\text{T\_cell\_naive} \longrightarrow \text{Sink} \tag{9}$$

Reactant

Table 8: Properties of each reactant.

Id	Name	SBO
T_cell_naive	T_cell_naive	

Product

Table 9: Properties of each product.

Id	Name	SBO
Sink	Sink	

Kinetic Law

Derived unit $(0.0115741\ \text{ms})^{-1} \cdot \text{item}$

$$v_2 = \text{vol}\left(\text{COMpartment}\right) \cdot \text{dn} \cdot [\text{T\_cell\_naive}] \tag{10}$$

7.3 Reaction T_cell_naive_Activation

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

Name T_cell_naive Activation

Reaction equation

$$\text{T\_cell\_naive} \xrightarrow{\text{CML}} \text{Sink} \tag{11}$$

Reactant

Table 10: Properties of each reactant.

Id	Name	SBO
T_cell_naive	T_cell_naive	

Modifier

Table 11: Properties of each modifier.

Id	Name	SBO
CML	CML	

Product

Table 12: Properties of each product.

Id	Name	SBO
Sink	Sink	

Kinetic Law

Derived unit $(0.0115741\ \mathrm{ms})^{-1} \cdot \mathrm{item}$

$$v_3 = \mathrm{vol}(\mathrm{COMpartment}) \cdot \mathrm{function\_for\_naive\_activation}([\mathrm{T\_cell\_naive}], [\mathrm{CML}], \mathrm{eta}, \mathrm{kn}) \quad (12)$$

$$\mathrm{function\_for\_naive\_activation}(\mathrm{naive}, [\mathrm{CML}], \mathrm{eta}, \mathrm{k}) = \mathrm{k} \cdot \mathrm{naive} \cdot \frac{[\mathrm{CML}]}{[\mathrm{CML}] + \mathrm{eta}} \quad (13)$$

$$\mathrm{function\_for\_naive\_activation}(\mathrm{naive}, [\mathrm{CML}], \mathrm{eta}, \mathrm{k}) = \mathrm{k} \cdot \mathrm{naive} \cdot \frac{[\mathrm{CML}]}{[\mathrm{CML}] + \mathrm{eta}} \quad (14)$$

7.4 Reaction T_cell_effector_Recruitment

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

Name T_cell_effector Recruitment

Reaction equation

$$\mathrm{Source} \xrightarrow{\mathrm{CML}} \mathrm{T\_cell\_effector} \quad (15)$$

Reactant

Table 13: Properties of each reactant.

Id	Name	SBO
Source	Source	

Modifier

Table 14: Properties of each modifier.

Id	Name	SBO
CML	CML	

Product

Table 15: Properties of each product.

Id	Name	SBO
T_cell_effector	T_cell_effector	

Kinetic Law

Derived unit $(0.0115741\ \text{ms})^{-1} \cdot \text{item}$

$$v_4 = \text{vol}\left(\text{COMpartment}\right) \cdot \text{function\_for\_T\_cell\_effector\_recruitment}\left(\text{alpha\_e}, [\text{T\_cell\_effector}], [\text{CML}], \text{eta}\right) \tag{16}$$

$$\text{function\_for\_T\_cell\_effector\_recruitment}\left(\text{alpha}, \text{effector}, [\text{CML}], \text{eta}\right) = \text{alpha} \cdot \text{effector} \cdot \frac{[\text{CML}]}{[\text{CML}] + \text{eta}} \tag{17}$$

$$\text{function\_for\_T\_cell\_effector\_recruitment}\left(\text{alpha}, \text{effector}, [\text{CML}], \text{eta}\right) = \text{alpha} \cdot \text{effector} \cdot \frac{[\text{CML}]}{[\text{CML}] + \text{eta}} \tag{18}$$

7.5 Reaction T_cell_effector_Natural_Death

This is an irreversible reaction of one reactant forming one product.

Name T_cell_effector Natural Death

Reaction equation

$$\text{T\_cell\_effector} \longrightarrow \text{Sink} \tag{19}$$

Reactant

Table 16: Properties of each reactant.

Id	Name	SBO
T_cell_effector	T_cell_effector	

Product

Table 17: Properties of each product.

Id	Name	SBO
Sink	Sink	

Kinetic Law

Derived unit $(0.0115741\ \text{ms})^{-1} \cdot \text{item}$

$$v_5 = \text{vol}\left(\text{COMpartment}\right) \cdot \text{de} \cdot [\text{T\_cell\_effector}] \tag{20}$$

7.6 Reaction T_cell_effector_Death_by_CML

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

Name T_cell_effector Death by CML

Reaction equation

$$\text{T\_cell\_effector} \xrightarrow{\text{CML}} \text{Sink} \tag{21}$$

Reactant

Table 18: Properties of each reactant.

Id	Name	SBO
T_cell_effector	T_cell_effector	

Modifier

Table 19: Properties of each modifier.

Id	Name	SBO
CML	CML	

Product

Table 20: Properties of each product.

Id	Name	SBO
Sink	Sink	

Kinetic Law

Derived unit $\mathrm{s}^{-1} \cdot \mathrm{item}^{2}$

$$v_6 = \mathrm{vol}\left(\mathrm{COMpartment}\right) \cdot \mathrm{function\_for\_T\_cell\_effector\_death\_by\_CML}\left(\mathrm{gamma\_e}, [\mathrm{CML}], [\mathrm{T\_cell\_effector}]\right) \tag{22}$$

$$\mathrm{function\_for\_T\_cell\_effector\_death\_by\_CML}\left(\mathrm{param}, [\mathrm{CML}], \mathrm{effector}\right) = \mathrm{param} \cdot [\mathrm{CML}] \cdot \mathrm{effector} \tag{23}$$

$$\mathrm{function\_for\_T\_cell\_effector\_death\_by\_CML}\left(\mathrm{param}, [\mathrm{CML}], \mathrm{effector}\right) = \mathrm{param} \cdot [\mathrm{CML}] \cdot \mathrm{effector} \tag{24}$$

7.7 Reaction `CML_Growth`

This is an irreversible reaction of one reactant forming one product.

Name CML Growth

Reaction equation

$$\mathrm{Source} \longrightarrow \mathrm{CML} \tag{25}$$

Reactant

Table 21: Properties of each reactant.

Id	Name	SBO
Source	Source	

Product

Table 22: Properties of each product.

Id	Name	SBO
CML	CML	

Kinetic Law

Derived unit $(0.0115741\ \mathrm{ms})^{-1} \cdot \mathrm{item}$

$$v_7 = \mathrm{vol}\left(\mathrm{COMpartment}\right) \cdot \mathrm{function\_for\_CML\_growth}\left(\mathrm{rc}, [\mathrm{CML}], \mathrm{Cmax}\right) \tag{26}$$

$$\mathrm{function\_for\_CML\_growth}\left(\mathrm{r}, \mathrm{C}, \mathrm{Cmax}\right) = \mathrm{r} \cdot \mathrm{C} \cdot \left(\frac{\mathrm{Cmax}}{\mathrm{C}}\right) \tag{27}$$

$$\mathrm{function\_for\_CML\_growth}\left(\mathrm{r}, \mathrm{C}, \mathrm{Cmax}\right) = \mathrm{r} \cdot \mathrm{C} \cdot \left(\frac{\mathrm{Cmax}}{\mathrm{C}}\right) \tag{28}$$

7.8 Reaction `CML_death_by_T_cell_effector`

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

Name CML death by T_cell_effector

Reaction equation

$$\mathrm{CML} \xrightarrow{\mathrm{T\_cell\_effector}} \mathrm{Sink} \tag{29}$$

Reactant

Table 23: Properties of each reactant.

Id	Name	SBO
CML	CML	

Modifier

Table 24: Properties of each modifier.

Id	Name	SBO
T_cell_effector	T_cell_effector	

Product

Table 25: Properties of each product.

Id	Name	SBO
Sink	Sink	

Kinetic Law

Derived unit $\mathrm{s}^{-1} \cdot \mathrm{item}^2$

$$\begin{aligned} v_8 = & \operatorname{vol}(\mathrm{COMpartment}) \\ & \cdot \mathrm{function\_for\_CML\_death\_by\_T\_cell\_effector}(\mathrm{gamma\_c}, [\mathrm{T\_cell\_effector}], [\mathrm{CML}]) \end{aligned} \tag{30}$$

$$\mathrm{function\_for\_CML\_death\_by\_T\_cell\_effector}(\mathrm{param}, \mathrm{mod}, \mathrm{substrate}) = \mathrm{param} \cdot \mathrm{mod} \cdot \mathrm{substrate} \tag{31}$$

$$\mathrm{function\_for\_CML\_death\_by\_T\_cell\_effector}(\mathrm{param}, \mathrm{mod}, \mathrm{substrate}) = \mathrm{param} \cdot \mathrm{mod} \cdot \mathrm{substrate} \tag{32}$$

7.9 Reaction CML_natural_death

This is an irreversible reaction of one reactant forming one product.

Name CML natural death

Reaction equation

$$\mathrm{CML} \longrightarrow \mathrm{Sink} \tag{33}$$

Reactant

Table 26: Properties of each reactant.

Id	Name	SBO
CML	CML	

Product

Table 27: Properties of each product.

Id	Name	SBO
Sink	Sink	

Kinetic Law

Derived unit $(0.0115741\ \mathrm{ms})^{-1} \cdot \mathrm{item}$

$$v_9 = \mathrm{vol}\left(\mathrm{COMpartment}\right) \cdot \mathrm{dc} \cdot [\mathrm{CML}] \tag{34}$$

7.10 Reaction T_cell_effector_Production_from_T_cell_Naive_activation

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

Name T_cell_effector Production from T_cell_Naive activation

Reaction equation

$$\mathrm{Source} \xrightarrow{\mathrm{T\_cell\_naive,\ CML}} \mathrm{T\_cell\_effector} \tag{35}$$

Reactant

Table 28: Properties of each reactant.

Id	Name	SBO
Source	Source	

Modifiers

Table 29: Properties of each modifier.

Id	Name	SBO
T_cell_naive	T_cell_naive	
CML	CML	

Product

Table 30: Properties of each product.

Id	Name	SBO
T_cell_effector	T_cell_effector	

Kinetic Law

Derived unit $(0.0115741\ \mathrm{ms})^{-1} \cdot \mathrm{item}$

$$v_{10} = \mathrm{vol}(\mathrm{COMpartment}) \cdot \mathrm{function\_for\_T\_cell\_effector\_production\_from\_T\_cell\_naive\_activation}(\mathrm{alpha\_n}, \mathrm{kn}, [\mathrm{T\_cell\_naive}], [\mathrm{CML}], \mathrm{eta}) \tag{36}$$

$$\mathrm{function\_for\_T\_cell\_effector\_production\_from\_T\_cell\_naive\_activation}(\mathrm{alpha}, \mathrm{k}, \mathrm{naive}, [\mathrm{CML}], \mathrm{eta}) = \mathrm{alpha} \cdot \mathrm{k} \cdot \mathrm{naive} \cdot \frac{[\mathrm{CML}]}{[\mathrm{CML}] + \mathrm{eta}} \tag{37}$$

$$\mathrm{function\_for\_T\_cell\_effector\_production\_from\_T\_cell\_naive\_activation}(\mathrm{alpha}, \mathrm{k}, \mathrm{naive}, [\mathrm{CML}], \mathrm{eta}) = \mathrm{alpha} \cdot \mathrm{k} \cdot \mathrm{naive} \cdot \frac{[\mathrm{CML}]}{[\mathrm{CML}] + \mathrm{eta}} \tag{38}$$

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 CML

Name CML

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

This species takes part in seven reactions (as a reactant in CML_death_by_T_cell_effector, CML_natural_death and as a product in CML_Growth and as a modifier in T_cell_naive_Activation, T_cell_effector_Recruitment, T_cell_effector_Death_by_CML, T_cell_effector_Production_from_T_cell_Naive_activation).

$$\frac{\mathrm{d}}{\mathrm{d}t}\text{CML} = v_7 - v_8 - v_9 \tag{39}$$

8.2 Species T_cell_naive

Name T_cell_naive

Initial concentration $1510 \text{ item} \cdot \text{l}^{-1}$

This species takes part in four reactions (as a reactant in T_cell_naive_Natural_Death, T_cell_naive_Activation and as a product in T_cell_naive_Source and as a modifier in T_cell_effector_Production_from_T_cell_Naive_activation).

$$\frac{\mathrm{d}}{\mathrm{d}t}\text{T\_cell\_naive} = v_1 - v_2 - v_3 \tag{40}$$

8.3 Species T_cell_effector

Name T_cell_effector

Initial concentration $20 \text{ item} \cdot \text{l}^{-1}$

This species takes part in five reactions (as a reactant in T_cell_effector_Natural_Death, T_cell_effector_Death_by_CML and as a product in T_cell_effector_Recruitment, T_cell_effector_Production_from_T_cell_Naive_activation and as a modifier in CML_death_by_T_cell_effector).

$$\frac{\mathrm{d}}{\mathrm{d}t}\text{T\_cell\_effector} = v_4 + v_{10} - v_5 - v_6 \tag{41}$$

8.4 Species Source

Name Source

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

This species takes part in four reactions (as a reactant in T_cell_naive_Source, T_cell_effector_Recruitment, CML_Growth, T_cell_effector_Production_from_T_cell_Naive_activation), which do not influence its rate of change because this constant species is on the boundary of the reaction system:

$$\frac{\mathrm{d}}{\mathrm{d}t}\text{Source} = 0 \tag{42}$$

8.5 Species Sink

Name Sink

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

This species takes part in six reactions (as a product in T_cell_naive_Natural_Death, T_cell_naive_Activation, T_cell_effector_Natural_Death, T_cell_effector_Death_by_CML, CML_death_by_T_cell_effector, CML_natural_death), which do not influence its rate of change because this constant species is on the boundary of the reaction system:

$$\frac{\mathrm{d}}{\mathrm{d}t}\text{Sink} = 0 \tag{43}$$

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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