SBML Model Report

Model name: "Wodarz2007 - HIV/CD4 T-cell interaction"

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1 General Overview

This is a document in SBML Level 2 Version 4 format. This model was created by the following two authors: Matthew Roberts[1] and Rahuman Sheriff[2] at January 22nd 2018 at 4:17 p. m. and last time modified at January 22nd 2018 at 4:17 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	3
events	0	constraints	0
reactions	9	function definitions	6
global parameters	7	unit definitions	2
rules	0	initial assignments	0

Model Notes

Wodarz2007 - HIV/CD4 T-cell interactionA deterministic model illustrating howCD4 T-cells can influence HIV infection.

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This model is described in the article:Infection dynamics in HIV-specific CD4 T cells: does a CD4 T cell boost benefit the host or the virus?Wodarz D, Hamer DH.Math Biosci 2007 Sep; 209(1): 14-29

Abstract:

Recent experimental data have shown that HIV-specific CD4 T cells provide a very important target for HIV replication. We use mathematical models to explore the effect of specific CD4 T cell infection on the dynamics of virus spread and immune responses. Infected CD4 T cells can provide antigen for their own stimulation. We show that such autocatalytic cell division can significantly enhance virus spread, and can also provide an additional reservoir for virus persistence during anti-viral drug therapy. In addition, the initial number of HIV-specific CD4 T cells is an important determinant of acute infection dynamics. A high initial number of HIV-specific CD4 T cells can lead to a sudden and fast drop of the population of HIV-specific CD4 T cells which results quickly in their extinction. On the other hand, a low initial number of HIV-specific CD4 T cells can lead to a prolonged persistence of HIV-specific CD4 T cell help at higher levels. The model suggests that boosting the population of HIV-specific CD4 T cells can increase the amount of virus-induced immune impairment, lead to less efficient anti-viral effector responses, and thus speed up disease progression, especially if effector responses such as CTL have not been sufficiently boosted at the same time.

This model is hosted on BioModels Database and identified by: BIOMD0000000663.

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

2 Unit Definitions

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

2.1 Unit `volume`

Name volume

Definition ml

2.2 Unit `substance`

Name substance

Definition mmol

2.3 Unit `area`

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

Definition m^2

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`	compartment		3	1	litre	☑	

3.1 Compartment `compartment`

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

Name compartment

4 Species

This model contains three 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
`x`	x_Tcell_infected	`compartment`	$\mathrm{mmol} \cdot \mathrm{ml}^{-1}$	☐	☐
`y`	y_Tcell_uninfected	`compartment`	$\mathrm{mmol} \cdot \mathrm{ml}^{-1}$	☐	☐
`v`	v_free_virus	`compartment`	$\mathrm{mmol} \cdot \mathrm{ml}^{-1}$	☐	☐

5 Parameters

This model contains seven global parameters.

Table 4: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
r	r		1.0		☑
k	k		10.0		☑
d	d		0.1		☑
Beta	Beta		0.2		☑
a	a		0.2		☑
eta	eta		1.0		☑
u	u		0.5		☑

6 Function definitions

This is an overview of six function definitions.

6.1 Function definition generic_modifier_function_2_1

Name generic modifier function 2_1

Arguments r, [v], [x]

Mathematical Expression

$$r \cdot [v] \cdot [x] \tag{1}$$

6.2 Function definition function_for_x_degrad_2_1

Name function for x degrad 2_1

Arguments k, r, [v], [x], [y]

Mathematical Expression

$$\frac{r \cdot [x] \cdot [v] \cdot ([x] + [y])}{k} \tag{2}$$

6.3 Function definition generic_modifier_function_1

Name generic modifier function_1

Arguments Beta, [v], [x]

Mathematical Expression

$$\mathrm{Beta} \cdot [\mathrm{v}] \cdot [\mathrm{x}] \tag{3}$$

6.4 Function definition `generic_modifier_function_2_2`

Name generic modifier function 2_2

Arguments r, [v], [y]

Mathematical Expression

$$\mathrm{r} \cdot [\mathrm{v}] \cdot [\mathrm{y}] \tag{4}$$

6.5 Function definition `function_for_y_degrad_2_1`

Name function for y degrad 2_1

Arguments k, r, [v], [x], [y]

Mathematical Expression

$$\frac{\mathrm{r} \cdot [\mathrm{y}] \cdot [\mathrm{v}] \cdot ([\mathrm{x}] + [\mathrm{y}])}{\mathrm{k}} \tag{5}$$

6.6 Function definition `generic_function_3_1`

Name generic function 3_1

Arguments eta, [y]

Mathematical Expression

$$\mathrm{eta} \cdot [\mathrm{y}] \tag{6}$$

7 Reactions

This model contains nine 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	`reaction`	Uninfected Tcell proliferation	$\emptyset \xrightarrow{\mathrm{v}} \mathrm{x}$	
2	`reaction_1`	Reduction in x-proliferation due to carry capacity	$\mathrm{x} \xrightarrow{\mathrm{v},\,\mathrm{y}} \emptyset$	
3	`reaction_2`	Uninfected T cell death	$\mathrm{x} \longrightarrow \emptyset$	
4	`reaction_3`	Tcell Infection 1	$\mathrm{x} \xrightarrow{\mathrm{v}} \mathrm{y}$	
5	`reaction_4`	Tcell Infection 2	$\emptyset \xrightarrow{\mathrm{v}} \mathrm{y}$	
6	`reaction_5`	Reduction in y-proliferation due to carry capacity	$\mathrm{y} \xrightarrow{\mathrm{v},\,\mathrm{x}} \emptyset$	
7	`reaction_6`	Infected T cell death	$\mathrm{y} \longrightarrow \emptyset$	
8	`reaction_7`	HIV proliferation	$\emptyset \xrightarrow{\mathrm{y}} \mathrm{v}$	
9	`reaction_8`	HIV degradation	$\mathrm{v} \longrightarrow \emptyset$	

7.1 Reaction `reaction`

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

Name Uninfected Tcell proliferation

Reaction equation

$$\emptyset \xrightarrow{\mathrm{v}} \mathrm{x} \tag{7}$$

Modifier

Table 6: Properties of each modifier.

Id	Name	SBO
v	v_free_virus	

Product

Table 7: Properties of each product.

Id	Name	SBO
x	x_Tcell_infected	

Kinetic Law

Derived unit contains undeclared units

$$v_1 = \mathrm{vol}\left(\mathrm{compartment}\right) \cdot \mathrm{generic\_modifier\_function\_2\_1}\left(\mathrm{r}, [\mathrm{v}], [\mathrm{x}]\right) \tag{8}$$

$$\mathrm{generic\_modifier\_function\_2\_1}\left(\mathrm{r}, [\mathrm{v}], [\mathrm{x}]\right) = \mathrm{r} \cdot [\mathrm{v}] \cdot [\mathrm{x}] \tag{9}$$

$$\mathrm{generic\_modifier\_function\_2\_1}\left(\mathrm{r}, [\mathrm{v}], [\mathrm{x}]\right) = \mathrm{r} \cdot [\mathrm{v}] \cdot [\mathrm{x}] \tag{10}$$

7.2 Reaction `reaction_1`

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

Name Reduction in x-proliferation due to carry capacity

Reaction equation

$$x \xrightarrow{v,\, y} \emptyset \tag{11}$$

Reactant

Table 8: Properties of each reactant.

Id	Name	SBO
x	x_Tcell_infected	

Modifiers

Table 9: Properties of each modifier.

Id	Name	SBO
v	v_free_virus	
y	y_Tcell_uninfected	

Kinetic Law

Derived unit contains undeclared units

$$v_2 = \text{vol}\left(\text{compartment}\right) \cdot \text{function\_for\_x\_degrad\_2\_1}\left(\text{k}, \text{r}, [\text{v}], [\text{x}], [\text{y}]\right) \tag{12}$$

$$\text{function\_for\_x\_degrad\_2\_1}\left(\text{k}, \text{r}, [\text{v}], [\text{x}], [\text{y}]\right) = \frac{\text{r} \cdot [\text{x}] \cdot [\text{v}] \cdot ([\text{x}] + [\text{y}])}{\text{k}} \tag{13}$$

$$\text{function\_for\_x\_degrad\_2\_1}\left(\text{k}, \text{r}, [\text{v}], [\text{x}], [\text{y}]\right) = \frac{\text{r} \cdot [\text{x}] \cdot [\text{v}] \cdot ([\text{x}] + [\text{y}])}{\text{k}} \tag{14}$$

7.3 Reaction `reaction_2`

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

Name Uninfected T cell death

Reaction equation

$$x \longrightarrow \emptyset \tag{15}$$

Reactant

Table 10: Properties of each reactant.

Id	Name	SBO
x	x_Tcell_infected	

Kinetic Law

Derived unit contains undeclared units

$$v_3 = \mathrm{vol}\left(\mathrm{compartment}\right) \cdot \mathrm{d} \cdot [\mathrm{x}] \tag{16}$$

7.4 Reaction `reaction_3`

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

Name Tcell Infection 1

Reaction equation

$$\mathrm{x} \xrightarrow{\mathrm{v}} \mathrm{y} \tag{17}$$

Reactant

Table 11: Properties of each reactant.

Id	Name	SBO
x	x_Tcell_infected	

Modifier

Table 12: Properties of each modifier.

Id	Name	SBO
v	v_free_virus	

Product

Table 13: Properties of each product.

Id	Name	SBO
y	y_Tcell_uninfected	

Kinetic Law

Derived unit contains undeclared units

$$v_4 = \mathrm{vol}\left(\mathrm{compartment}\right) \cdot \mathrm{generic\_modifier\_function\_1}\left(\mathrm{Beta}, [\mathrm{v}], [\mathrm{x}]\right) \tag{18}$$

$$\mathrm{generic\_modifier\_function\_1}\left(\mathrm{Beta}, [\mathrm{v}], [\mathrm{x}]\right) = \mathrm{Beta} \cdot [\mathrm{v}] \cdot [\mathrm{x}] \tag{19}$$

$$\mathrm{generic\_modifier\_function\_1}\left(\mathrm{Beta}, [\mathrm{v}], [\mathrm{x}]\right) = \mathrm{Beta} \cdot [\mathrm{v}] \cdot [\mathrm{x}] \tag{20}$$

7.5 Reaction `reaction_4`

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

Name Tcell Infection 2

Reaction equation

$$\emptyset \xrightarrow{\mathrm{v}} \mathrm{y} \tag{21}$$

Modifier

Table 14: Properties of each modifier.

Id	Name	SBO
v	v_free_virus	

Product

Table 15: Properties of each product.

Id	Name	SBO
y	y_Tcell_uninfected	

Kinetic Law

Derived unit contains undeclared units

$$v_5 = \mathrm{vol}\left(\mathrm{compartment}\right) \cdot \mathrm{generic\_modifier\_function\_2\_2}\left(\mathrm{r}, [\mathrm{v}], [\mathrm{y}]\right) \tag{22}$$

$$\mathrm{generic\_modifier\_function\_2\_2}\left(\mathrm{r}, [\mathrm{v}], [\mathrm{y}]\right) = \mathrm{r} \cdot [\mathrm{v}] \cdot [\mathrm{y}] \tag{23}$$

$$\mathrm{generic\_modifier\_function\_2\_2}\left(\mathrm{r}, [\mathrm{v}], [\mathrm{y}]\right) = \mathrm{r} \cdot [\mathrm{v}] \cdot [\mathrm{y}] \tag{24}$$

7.6 Reaction `reaction_5`

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

Name Reduction in y-proliferation due to carry capacity

Reaction equation

$$\mathrm{y} \xrightarrow{\mathrm{v},\ \mathrm{x}} \emptyset \tag{25}$$

Reactant

Table 16: Properties of each reactant.

Id	Name	SBO
y	y_Tcell_uninfected	

Modifiers

Table 17: Properties of each modifier.

Id	Name	SBO
v	v_free_virus	
x	x_Tcell_infected	

Kinetic Law

Derived unit contains undeclared units

$$v_6 = \mathrm{vol}\left(\mathrm{compartment}\right) \cdot \mathrm{function\_for\_y\_degrad\_2\_1}\left(\mathrm{k}, \mathrm{r}, [\mathrm{v}], [\mathrm{x}], [\mathrm{y}]\right) \tag{26}$$

$$\mathrm{function\_for\_y\_degrad\_2\_1}\left(\mathrm{k},\mathrm{r},[\mathrm{v}],[\mathrm{x}],[\mathrm{y}]\right)=\frac{\mathrm{r}\cdot[\mathrm{y}]\cdot[\mathrm{v}]\cdot([\mathrm{x}]+[\mathrm{y}])}{\mathrm{k}} \quad (27)$$

$$\mathrm{function\_for\_y\_degrad\_2\_1}\left(\mathrm{k},\mathrm{r},[\mathrm{v}],[\mathrm{x}],[\mathrm{y}]\right)=\frac{\mathrm{r}\cdot[\mathrm{y}]\cdot[\mathrm{v}]\cdot([\mathrm{x}]+[\mathrm{y}])}{\mathrm{k}} \quad (28)$$

7.7 Reaction `reaction_6`

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

Name Infected T cell death

Reaction equation

$$\mathrm{y} \longrightarrow \emptyset \quad (29)$$

Reactant

Table 18: Properties of each reactant.

Id	Name	SBO
y	y_Tcell_uninfected	

Kinetic Law

Derived unit contains undeclared units

$$v_7 = \mathrm{vol}\left(\mathrm{compartment}\right)\cdot\mathrm{a}\cdot[\mathrm{y}] \quad (30)$$

7.8 Reaction `reaction_7`

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

Name HIV proliferation

Reaction equation

$$\emptyset \xrightarrow{\mathrm{y}} \mathrm{v} \quad (31)$$

Modifier

Table 19: Properties of each modifier.

Id	Name	SBO
y	y_Tcell_uninfected	

Product

Table 20: Properties of each product.

Id	Name	SBO
v	v_free_virus	

Kinetic Law

Derived unit contains undeclared units

$$v_8 = \mathrm{vol}\left(\mathrm{compartment}\right) \cdot \mathrm{generic\_function\_3\_1}\left(\mathrm{eta}, [\mathrm{y}]\right) \tag{32}$$

$$\mathrm{generic\_function\_3\_1}\left(\mathrm{eta}, [\mathrm{y}]\right) = \mathrm{eta} \cdot [\mathrm{y}] \tag{33}$$

$$\mathrm{generic\_function\_3\_1}\left(\mathrm{eta}, [\mathrm{y}]\right) = \mathrm{eta} \cdot [\mathrm{y}] \tag{34}$$

7.9 Reaction `reaction_8`

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

Name HIV degradation

Reaction equation

$$\mathrm{v} \longrightarrow \emptyset \tag{35}$$

Reactant

Table 21: Properties of each reactant.

Id	Name	SBO
v	v_free_virus	

Kinetic Law

Derived unit contains undeclared units

$$v_9 = \mathrm{vol}\left(\mathrm{compartment}\right) \cdot \mathrm{u} \cdot [\mathrm{v}] \tag{36}$$

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 x

Name x_Tcell_infected

Initial concentration $0.1\ \mathrm{mmol} \cdot \mathrm{ml}^{-1}$

This species takes part in five reactions (as a reactant in `reaction_1`, `reaction_2`, `reaction_3` and as a product in `reaction` and as a modifier in `reaction_5`).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{x} = v_1 - v_2 - v_3 - v_4 \tag{37}$$

8.2 Species y

Name y_Tcell_uninfected

Initial concentration $0\ \mathrm{mmol} \cdot \mathrm{ml}^{-1}$

This species takes part in six reactions (as a reactant in `reaction_5`, `reaction_6` and as a product in `reaction_3`, `reaction_4` and as a modifier in `reaction_1`, `reaction_7`).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{y} = v_4 + v_5 - v_6 - v_7 \tag{38}$$

8.3 Species v

Name v_free_virus

Initial concentration $1\ \mathrm{mmol} \cdot \mathrm{ml}^{-1}$

This species takes part in seven reactions (as a reactant in reaction_8 and as a product in reaction_7 and as a modifier in reaction, reaction_1, reaction_3, reaction_4, reaction_5).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{v} = v_8 - v_9 \tag{39}$$

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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