SBML Model Report

Model name: "Fisher2006_Ca_Oscillation-_dpdnt_NFAT_dynamics"

May 6, 2016

1 General Overview

This is a document in SBML Level 2 Version 1 format. This model was created by Harish Dharuri[1] at June 26th 2007 at 3:45 p. m. and last time modified at February 14th 2014 at 4:52 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	2
species types	0	species	14
events	3	constraints	0
reactions	17	function definitions	0
global parameters	23	unit definitions	1
rules	0	initial assignments	0

Model Notes

The model reproduces the calcium oscillation dependent activation-deactivation kinetics of nuclear factor of activated T cells (NFAT) as depicted in Fig 4a of the paper. A simple algorithm in the events section takes care of the calcium oscillation. The model was successfully tested on MathSBML.

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2 Unit Definitions

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

2.1 Unit `substance`

Name micro mole

Definition µmol

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 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 Compartments

This model contains two compartments.

Table 2: Properties of all compartments.

Id	Name	SBO	Spatial Dimensions	Size	Unit	Constant	Outside
`cytosol`	cytosol		3	$2.69 \cdot 10^{-13}$	l	☑	
`nucleus`	nucleus		3	$1.13 \cdot 10^{-13}$	l	☑	`cytosol`

3.1 Compartment `cytosol`

This is a three dimensional compartment with a constant size of $2.69 \cdot 10^{-13}$ litre.

Name cytosol

3.2 Compartment `nucleus`

This is a three dimensional compartment with a constant size of $1.13 \cdot 10^{-13}$ litre, which is surrounded by `cytosol` (cytosol).

Name nucleus

4 Species

This model contains 14 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
`Ca_Nuc`	Calcium in Nucleus	`nucleus`	$\mu mol \cdot l^{-1}$	⊟	☑
`Ca_Cyt`	Calcium in Cytosol	`cytosol`	$\mu mol \cdot l^{-1}$	⊟	☑
`NFAT_Nuc`	NFAT_nuc	`nucleus`	$\mu mol \cdot l^{-1}$	⊟	⊟
`Act_C_Nuc`	Active Calcineurin in Nucleus	`nucleus`	$\mu mol \cdot l^{-1}$	⊟	⊟
`NFAT_Pi_Nuc`	Phosphorylated NFAT in nucleus	`nucleus`	$\mu mol \cdot l^{-1}$	⊟	⊟
`NFAT_Act_C_Nuc`	NFAT Calcineurin complex in nucleus	`nucleus`	$\mu mol \cdot l^{-1}$	⊟	⊟
`NFAT_Pi_Act_C_Nuc`	Phosphorylated NFAT Calcineurin complex in nucleus	`nucleus`	$\mu mol \cdot l^{-1}$	⊟	⊟
`Inact_C_Nuc`	Inactive Calcineurin in nucleus	`nucleus`	$\mu mol \cdot l^{-1}$	⊟	⊟
`NFAT_Cyt`	NFAT_Cyt	`cytosol`	$\mu mol \cdot l^{-1}$	⊟	⊟
`Act_C_Cyt`	Active Calcineurin in cytosol	`cytosol`	$\mu mol \cdot l^{-1}$	⊟	⊟
`NFAT_Pi_Cyt`	Phosphorylated NFAT in cytosol	`cytosol`	$\mu mol \cdot l^{-1}$	⊟	⊟
`NFAT_Act_C_Cyt`	NFAT Calcineurin complex in cytosol	`cytosol`	$\mu mol \cdot l^{-1}$	⊟	⊟
`NFAT_Pi_Act_C_Cyt`	Phosphorylated NFAT Calcineurin complex in cytosol	`cytosol`	$\mu mol \cdot l^{-1}$	⊟	⊟
`Inact_C_Cyt`	Inactive Calcineurin in cytosol	`cytosol`	$\mu mol \cdot l^{-1}$	⊟	⊟

5 Parameters

This model contains 23 global parameters.

Table 4: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
k1			$2.56 \cdot 10^{-5}$		☑
k2			0.003		☑
k16			6.630		☑
k15			0.002		☑
k18			$9.6 \cdot 10^{-4}$		☑
k17			0.002		☑
k6			$9.2 \cdot 10^{-4}$		☑
k5			0.002		☑
k14			0.003		☑
k13			0.500		☑
k12			0.002		☑
k11			6.630		☑
k10			0.005		☑
k9			0.500		☑
k3			0.005		☑
k4			0.500		☑
k7			0.005		☑
k8			0.500		☑
k19			1.000		☑
k20			1.000		☑
k21			0.210		☑
k22			0.500		☑
Time_in_Seconds	Time_in_Seconds		100.000		☐

6 Events

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

6.1 Event `event_0000001`

Trigger condition

$$(\text{Time\_in\_Seconds} - \text{t} \leq 0) \wedge (\text{t} < 1500) \tag{1}$$

Assignments

$$\text{Time\_in\_Seconds} = \text{Time\_in\_Seconds} + 100 \tag{2}$$
$$\text{Ca\_Cyt} = 1 \tag{3}$$
$$\text{Ca\_Nuc} = 1 \tag{4}$$

6.2 Event `event_0000002`

Trigger condition

$$(\text{Time\_in\_Seconds} - \text{t} \leq 90) \wedge (\text{t} < 1500) \tag{5}$$

Assignments

$$\text{Ca\_Cyt} = 0.1 \tag{6}$$
$$\text{Ca\_Nuc} = 0.1 \tag{7}$$

6.3 Event `event_0000003`

Trigger condition

$$\text{t} \geq 1500 \tag{8}$$

Assignments

$$\text{Ca\_Cyt} = 0.1 \tag{9}$$
$$\text{Ca\_Nuc} = 0.1 \tag{10}$$

7 Reactions

This model contains 17 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	Calcineurin dpdnt NFAT dephosphorylation	NFAT_Pi_Nuc + Act_C_Nuc $\rightleftharpoons$ Act_C_Nuc + NFAT_Nuc	
2	R2	NFAT Calcineurin complex formation	Act_C_Nuc + NFAT_Nuc $\rightleftharpoons$ NFAT_Act_C_Nuc	
3	R3	NFAT transport	NFAT_Nuc $\rightleftharpoons$ NFAT_Cyt	
4	R4	Active Calcineurin transport	Act_C_Nuc $\rightleftharpoons$ Act_C_Cyt	
5	R5	NFAT Calcineurin complex phosphorylation	NFAT_Act_C_Nuc $\rightleftharpoons$ NFAT_Pi_Act_C_Nuc	
6	R6	Phosphorylated NFAT Calcineurin complex disassembly	NFAT_Pi_Act_C_Nuc $\rightleftharpoons$ Act_C_Nuc + NFAT_Pi_Nuc	
7	R7	NFAT Calcineurin complex transport	NFAT_Act_C_Nuc $\rightleftharpoons$ NFAT_Act_C_Cyt	
8	R8	NFAT Calcineurin complex phosphorylation	NFAT_Act_C_Cyt $\rightleftharpoons$ NFAT_Pi_Act_C_Cyt	
9	R9	Phosphorylated NFAT Calcineurin complex disassembly	NFAT_Pi_Act_C_Cyt $\rightleftharpoons$ Act_C_Cyt + NFAT_Pi_Cyt	
10	R10	Phosphorylated NFAT transport	NFAT_Pi_Cyt $\rightleftharpoons$ NFAT_Pi_Nuc	
11	R11	NFAT Calcineurin complex disassembly	NFAT_Act_C_Cyt $\rightleftharpoons$ Act_C_Cyt + NFAT_Cyt	
12	R17	Phosphorylated NFAT Calcineurin complex transport	NFAT_Pi_Act_C_Cyt $\rightleftharpoons$ NFAT_Pi_Act_C_Nuc	
13	R12	Calcineurin dpdnt NFAT dephosphorylation	NFAT_Pi_Cyt + Act_C_Cyt $\rightleftharpoons$ Act_C_Cyt + NFAT_Cyt	
14	R13	Calcineurin activation	3 Ca_Cyt + Inact_C_Cyt $\rightleftharpoons$ Act_C_Cyt	
15	R14	Calcineurin activation	3 Ca_Nuc + Inact_C_Nuc $\rightleftharpoons$ Act_C_Nuc	
16	R15	Inactive Calcineurin transport	Inact_C_Cyt $\rightleftharpoons$ Inact_C_Nuc	
17	R16	Calcium transport	Ca_Cyt $\rightleftharpoons$ Ca_Nuc	

7.1 Reaction R1

This is a reversible reaction of two reactants forming two products.

Name Calcineurin dpdnt NFAT dephosphorylation

Reaction equation

$$\text{NFAT\_Pi\_Nuc} + \text{Act\_C\_Nuc} \rightleftharpoons \text{Act\_C\_Nuc} + \text{NFAT\_Nuc} \tag{11}$$

Reactants

Table 6: Properties of each reactant.

Id	Name	SBO
NFAT_Pi_Nuc	Phosphorylated NFAT in nucleus	
Act_C_Nuc	Active Calcineurin in Nucleus	

Products

Table 7: Properties of each product.

Id	Name	SBO
Act_C_Nuc	Active Calcineurin in Nucleus	
NFAT_Nuc	NFAT_nuc	

Kinetic Law

Derived unit contains undeclared units

$$v_1 = \text{vol}(\text{nucleus}) \cdot (\text{k1} \cdot [\text{NFAT\_Pi\_Nuc}] - \text{k2} \cdot [\text{NFAT\_Nuc}]) \tag{12}$$

7.2 Reaction R2

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

Name NFAT Calcineurin complex formation

Reaction equation

$$\text{Act\_C\_Nuc} + \text{NFAT\_Nuc} \rightleftharpoons \text{NFAT\_Act\_C\_Nuc} \tag{13}$$

Reactants

Table 8: Properties of each reactant.

Id	Name	SBO
Act_C_Nuc	Active Calcineurin in Nucleus	
NFAT_Nuc	NFAT_nuc	

Product

Table 9: Properties of each product.

Id	Name	SBO
NFAT_Act_C_Nuc	NFAT Calcineurin complex in nucleus	

Kinetic Law

Derived unit contains undeclared units

$$v_2 = \mathrm{vol}\,(\mathrm{nucleus}) \cdot (\mathrm{k16} \cdot [\mathrm{NFAT\_Nuc}] \cdot [\mathrm{Act\_C\_Nuc}] - \mathrm{k15} \cdot [\mathrm{NFAT\_Act\_C\_Nuc}]) \quad (14)$$

7.3 Reaction R3

This is a reversible reaction of one reactant forming one product.

Name NFAT transport

Reaction equation

$$\mathrm{NFAT\_Nuc} \rightleftharpoons \mathrm{NFAT\_Cyt} \quad (15)$$

Reactant

Table 10: Properties of each reactant.

Id	Name	SBO
NFAT_Nuc	NFAT_nuc	

Product

Table 11: Properties of each product.

Id	Name	SBO
NFAT_Cyt	NFAT_Cyt	

Id	Name	SBO

Kinetic Law

Derived unit contains undeclared units

$$v_3 = \mathrm{vol}\,(\mathrm{nucleus}) \cdot \mathrm{k18} \cdot [\mathrm{NFAT\_Nuc}] - \mathrm{vol}\,(\mathrm{cytosol}) \cdot \mathrm{k17} \cdot [\mathrm{NFAT\_Cyt}] \tag{16}$$

7.4 Reaction R4

This is a reversible reaction of one reactant forming one product.

Name Active Calcineurin transport

Reaction equation

$$\mathrm{Act\_C\_Nuc} \rightleftharpoons \mathrm{Act\_C\_Cyt} \tag{17}$$

Reactant

Table 12: Properties of each reactant.

Id	Name	SBO
Act_C_Nuc	Active Calcineurin in Nucleus	

Product

Table 13: Properties of each product.

Id	Name	SBO
Act_C_Cyt	Active Calcineurin in cytosol	

Kinetic Law

Derived unit contains undeclared units

$$v_4 = \mathrm{vol}\,(\mathrm{nucleus}) \cdot \mathrm{k6} \cdot [\mathrm{Act\_C\_Nuc}] - \mathrm{vol}\,(\mathrm{cytosol}) \cdot \mathrm{k5} \cdot [\mathrm{Act\_C\_Cyt}] \tag{18}$$

7.5 Reaction R5

This is a reversible reaction of one reactant forming one product.

Name NFAT Calcineurin complex phosphorylation

Reaction equation

$$\text{NFAT\_Act\_C\_Nuc} \rightleftharpoons \text{NFAT\_Pi\_Act\_C\_Nuc} \tag{19}$$

Reactant

Table 14: Properties of each reactant.

Id	Name	SBO
NFAT_Act_C_Nuc	NFAT Calcineurin complex in nucleus	

Product

Table 15: Properties of each product.

Id	Name	SBO
NFAT_Pi_Act_C_Nuc	Phosphorylated NFAT Calcineurin complex in nucleus	

Kinetic Law

Derived unit contains undeclared units

$$v_5 = \text{vol}(\text{nucleus}) \cdot (\text{k14} \cdot [\text{NFAT\_Act\_C\_Nuc}] - \text{k13} \cdot [\text{NFAT\_Pi\_Act\_C\_Nuc}]) \tag{20}$$

7.6 Reaction R6

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

Name Phosphorylated NFAT Calcineurin complex disassembly

Reaction equation

$$\text{NFAT\_Pi\_Act\_C\_Nuc} \rightleftharpoons \text{Act\_C\_Nuc} + \text{NFAT\_Pi\_Nuc} \tag{21}$$

Reactant

Table 16: Properties of each reactant.

Id	Name	SBO
NFAT_Pi_Act_C_Nuc	Phosphorylated NFAT Calcineurin complex in nucleus	

Products

Table 17: Properties of each product.

Id	Name	SBO
Act_C_Nuc	Active Calcineurin in Nucleus	
NFAT_Pi_Nuc	Phosphorylated NFAT in nucleus	

Kinetic Law

Derived unit contains undeclared units

$$v_6 = \mathrm{vol}\,(\mathrm{nucleus}) \cdot (\mathrm{k12} \cdot [\mathrm{NFAT\_Pi\_Act\_C\_Nuc}] - \mathrm{k11} \cdot [\mathrm{NFAT\_Pi\_Nuc}] \cdot [\mathrm{Act\_C\_Nuc}]) \quad (22)$$

7.7 Reaction R7

This is a reversible reaction of one reactant forming one product.

Name NFAT Calcineurin complex transport

Reaction equation

$$\mathrm{NFAT\_Act\_C\_Nuc} \rightleftharpoons \mathrm{NFAT\_Act\_C\_Cyt} \quad (23)$$

Reactant

Table 18: Properties of each reactant.

Id	Name	SBO
NFAT_Act_C_Nuc	NFAT Calcineurin complex in nucleus	

Product

Table 19: Properties of each product.

Id	Name	SBO
NFAT_Act_C_Cyt	NFAT Calcineurin complex in cytosol	

Kinetic Law

Derived unit contains undeclared units

$$v_7 = \mathrm{vol}\,(\mathrm{nucleus}) \cdot \mathrm{k10} \cdot [\mathrm{NFAT\_Act\_C\_Nuc}] - \mathrm{vol}\,(\mathrm{cytosol}) \cdot \mathrm{k9} \cdot [\mathrm{NFAT\_Act\_C\_Cyt}] \quad (24)$$

7.8 Reaction R8

This is a reversible reaction of one reactant forming one product.

Name NFAT Calcineurin complex phosphorylation

Reaction equation

$$\text{NFAT\_Act\_C\_Cyt} \rightleftharpoons \text{NFAT\_Pi\_Act\_C\_Cyt} \tag{25}$$

Reactant

Table 20: Properties of each reactant.

Id	Name	SBO
NFAT_Act_C_Cyt	NFAT Calcineurin complex in cytosol	

Product

Table 21: Properties of each product.

Id	Name	SBO
NFAT_Pi_Act_C_Cyt	Phosphorylated NFAT Calcineurin complex in cytosol	

Kinetic Law

Derived unit contains undeclared units

$$v_8 = \text{vol}(\text{cytosol}) \cdot (\text{k14} \cdot [\text{NFAT\_Act\_C\_Cyt}] - \text{k13} \cdot [\text{NFAT\_Pi\_Act\_C\_Cyt}]) \tag{26}$$

7.9 Reaction R9

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

Name Phosphorylated NFAT Calcineurin complex disassembly

Reaction equation

$$\text{NFAT\_Pi\_Act\_C\_Cyt} \rightleftharpoons \text{Act\_C\_Cyt} + \text{NFAT\_Pi\_Cyt} \tag{27}$$

Reactant

Table 22: Properties of each reactant.

Id	Name	SBO
NFAT_Pi_Act_C_Cyt	Phosphorylated NFAT Calcineurin complex in cytosol	

Products

Table 23: Properties of each product.

Id	Name	SBO
Act_C_Cyt	Active Calcineurin in cytosol	
NFAT_Pi_Cyt	Phosphorylated NFAT in cytosol	

Kinetic Law

Derived unit contains undeclared units

$$v_9 = \mathrm{vol}\,(\mathrm{cytosol}) \cdot (\mathrm{k12} \cdot [\mathrm{NFAT\_Pi\_Act\_C\_Cyt}] - \mathrm{k11} \cdot [\mathrm{NFAT\_Pi\_Cyt}] \cdot [\mathrm{Act\_C\_Cyt}]) \quad (28)$$

7.10 Reaction R10

This is a reversible reaction of one reactant forming one product.

Name Phosphorylated NFAT transport

Reaction equation

$$\mathrm{NFAT\_Pi\_Cyt} \rightleftharpoons \mathrm{NFAT\_Pi\_Nuc} \quad (29)$$

Reactant

Table 24: Properties of each reactant.

Id	Name	SBO
NFAT_Pi_Cyt	Phosphorylated NFAT in cytosol	

Product

Table 25: Properties of each product.

Id	Name	SBO
NFAT_Pi_Nuc	Phosphorylated NFAT in nucleus	

Id	Name	SBO

Kinetic Law

Derived unit contains undeclared units

$$v_{10} = \mathrm{vol}\,(\mathrm{cytosol}) \cdot \mathrm{k3} \cdot [\mathrm{NFAT\_Pi\_Cyt}] - \mathrm{vol}\,(\mathrm{nucleus}) \cdot \mathrm{k4} \cdot [\mathrm{NFAT\_Pi\_Nuc}] \tag{30}$$

7.11 Reaction R11

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

Name NFAT Calcineurin complex disassembly

Reaction equation

$$\mathrm{NFAT\_Act\_C\_Cyt} \rightleftharpoons \mathrm{Act\_C\_Cyt} + \mathrm{NFAT\_Cyt} \tag{31}$$

Reactant

Table 26: Properties of each reactant.

Id	Name	SBO
NFAT_Act_C_Cyt	NFAT Calcineurin complex in cytosol	

Products

Table 27: Properties of each product.

Id	Name	SBO
Act_C_Cyt	Active Calcineurin in cytosol	
NFAT_Cyt	NFAT_Cyt	

Kinetic Law

Derived unit contains undeclared units

$$v_{11} = \mathrm{vol}\,(\mathrm{cytosol}) \cdot (\mathrm{k15} \cdot [\mathrm{NFAT\_Act\_C\_Cyt}] - \mathrm{k16} \cdot [\mathrm{NFAT\_Cyt}] \cdot [\mathrm{Act\_C\_Cyt}]) \tag{32}$$

7.12 Reaction R17

This is a reversible reaction of one reactant forming one product.

Name Phosphorylated NFAT Calcineurin complex transport

Reaction equation

$$\text{NFAT\_Pi\_Act\_C\_Cyt} \rightleftharpoons \text{NFAT\_Pi\_Act\_C\_Nuc} \tag{33}$$

Reactant

Table 28: Properties of each reactant.

Id	Name	SBO
NFAT_Pi_Act_C_Cyt	Phosphorylated NFAT Calcineurin complex in cytosol	

Product

Table 29: Properties of each product.

Id	Name	SBO
NFAT_Pi_Act_C_Nuc	Phosphorylated NFAT Calcineurin complex in nucleus	

Kinetic Law

Derived unit contains undeclared units

$$v_{12} = \text{vol}(\text{cytosol}) \cdot \text{k7} \cdot [\text{NFAT\_Pi\_Act\_C\_Cyt}] - \text{vol}(\text{nucleus}) \cdot \text{k8} \cdot [\text{NFAT\_Pi\_Act\_C\_Nuc}] \tag{34}$$

7.13 Reaction R12

This is a reversible reaction of two reactants forming two products.

Name Calcineurin dpdnt NFAT dephosphorylation

Reaction equation

$$\text{NFAT\_Pi\_Cyt} + \text{Act\_C\_Cyt} \rightleftharpoons \text{Act\_C\_Cyt} + \text{NFAT\_Cyt} \tag{35}$$

Reactants

Table 30: Properties of each reactant.

Id	Name	SBO
NFAT_Pi_Cyt	Phosphorylated NFAT in cytosol	
Act_C_Cyt	Active Calcineurin in cytosol	

Products

Table 31: Properties of each product.

Id	Name	SBO
Act_C_Cyt	Active Calcineurin in cytosol	
NFAT_Cyt	NFAT_Cyt	

Kinetic Law

Derived unit contains undeclared units

$$v_{13} = \mathrm{vol}\,(\mathrm{cytosol}) \cdot (\mathrm{k1} \cdot [\mathrm{NFAT\_Pi\_Cyt}] - \mathrm{k2} \cdot [\mathrm{NFAT\_Cyt}]) \tag{36}$$

7.14 Reaction R13

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

Name Calcineurin activation

Reaction equation

$$3\,\mathrm{Ca\_Cyt} + \mathrm{Inact\_C\_Cyt} \rightleftharpoons \mathrm{Act\_C\_Cyt} \tag{37}$$

Reactants

Table 32: Properties of each reactant.

Id	Name	SBO
Ca_Cyt	Calcium in Cytosol	
Inact_C_Cyt	Inactive Calcineurin in cytosol	

Product

Table 33: Properties of each product.

Id	Name	SBO
Act_C_Cyt	Active Calcineurin in cytosol	

Kinetic Law

Derived unit contains undeclared units

$$v_{14} = \mathrm{vol}\,(\mathrm{cytosol}) \cdot \left(\mathrm{k19} \cdot [\mathrm{Inact\_C\_Cyt}] \cdot [\mathrm{Ca\_Cyt}]^3 - \mathrm{k20} \cdot [\mathrm{Act\_C\_Cyt}]\right) \tag{38}$$

7.15 Reaction R14

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

Name Calcineurin activation

Reaction equation

$$3\,\mathrm{Ca\_Nuc} + \mathrm{Inact\_C\_Nuc} \rightleftharpoons \mathrm{Act\_C\_Nuc} \tag{39}$$

Reactants

Table 34: Properties of each reactant.

Id	Name	SBO
Ca_Nuc	Calcium in Nucleus	
Inact_C_Nuc	Inactive Calcineurin in nucleus	

Product

Table 35: Properties of each product.

Id	Name	SBO
Act_C_Nuc	Active Calcineurin in Nucleus	

Kinetic Law

Derived unit contains undeclared units

$$v_{15} = \mathrm{vol}\,(\mathrm{nucleus}) \cdot \left(\mathrm{k19} \cdot [\mathrm{Inact\_C\_Nuc}] \cdot [\mathrm{Ca\_Nuc}]^3 - \mathrm{k20} \cdot [\mathrm{Act\_C\_Nuc}]\right) \tag{40}$$

7.16 Reaction R15

This is a reversible reaction of one reactant forming one product.

Name Inactive Calcineurin transport

Reaction equation

$$\mathrm{Inact\_C\_Cyt} \rightleftharpoons \mathrm{Inact\_C\_Nuc} \tag{41}$$

Reactant

Table 36: Properties of each reactant.

Id	Name	SBO
Inact_C_Cyt	Inactive Calcineurin in cytosol	

Product

Table 37: Properties of each product.

Id	Name	SBO
Inact_C_Nuc	Inactive Calcineurin in nucleus	

Kinetic Law

Derived unit contains undeclared units

$$v_{16} = \mathrm{vol}\,(\mathrm{cytosol}) \cdot \mathrm{k5} \cdot [\mathrm{Inact\_C\_Cyt}] - \mathrm{vol}\,(\mathrm{nucleus}) \cdot \mathrm{k6} \cdot [\mathrm{Inact\_C\_Nuc}] \tag{42}$$

7.17 Reaction R16

This is a reversible reaction of one reactant forming one product.

Name Calcium transport

Reaction equation

$$\mathrm{Ca\_Cyt} \rightleftharpoons \mathrm{Ca\_Nuc} \tag{43}$$

Reactant

Table 38: Properties of each reactant.

Id	Name	SBO
Ca_Cyt	Calcium in Cytosol	

Product

Table 39: Properties of each product.

Id	Name	SBO
Ca_Nuc	Calcium in Nucleus	

Kinetic Law

Derived unit contains undeclared units

$$v_{17} = \mathrm{vol}\,(\mathrm{cytosol}) \cdot \mathrm{k21} \cdot [\mathrm{Ca\_Cyt}] - \mathrm{vol}\,(\mathrm{nucleus}) \cdot \mathrm{k22} \cdot [\mathrm{Ca\_Nuc}] \tag{44}$$

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 Ca_Nuc

Name Calcium in Nucleus

Initial concentration $1\ \mu\mathrm{mol} \cdot \mathrm{l}^{-1}$

Involved in events event_0000001, event_0000002, event_0000003

This species takes part in two reactions (as a reactant in R14 and as a product in R16). Not these but three events influence the species' quantity because this species is on the boundary of the reaction system.

8.2 Species Ca_Cyt

Name Calcium in Cytosol

Initial concentration $1\ \mu\mathrm{mol} \cdot \mathrm{l}^{-1}$

Involved in events event_0000001, event_0000002, event_0000003

This species takes part in two reactions (as a reactant in R13, R16). Not these but three events influence the species' quantity because this species is on the boundary of the reaction system.

8.3 Species NFAT_Nuc

Name NFAT_nuc

Initial concentration $5.219 \cdot 10^{-4}$ µmol · l^{-1}

This species takes part in three reactions (as a reactant in R2, R3 and as a product in R1).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{NFAT\_Nuc} = v_1 - v_2 - v_3 \tag{45}$$

8.4 Species Act_C_Nuc

Name Active Calcineurin in Nucleus

Initial concentration $5.05 \cdot 10^{-5}$ µmol · l^{-1}

This species takes part in six reactions (as a reactant in R1, R2, R4 and as a product in R1, R6, R14).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{Act\_C\_Nuc} = v_1 + v_6 + v_{15} - v_1 - v_2 - v_4 \tag{46}$$

8.5 Species NFAT_Pi_Nuc

Name Phosphorylated NFAT in nucleus

Initial concentration $2.272 \cdot 10^{-4}$ µmol · l^{-1}

This species takes part in three reactions (as a reactant in R1 and as a product in R6, R10).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{NFAT\_Pi\_Nuc} = v_6 + v_{10} - v_1 \tag{47}$$

8.6 Species NFAT_Act_C_Nuc

Name NFAT Calcineurin complex in nucleus

Initial concentration $9.477 \cdot 10^{-4}$ µmol · l^{-1}

This species takes part in three reactions (as a reactant in R5, R7 and as a product in R2).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{NFAT\_Act\_C\_Nuc} = v_2 - v_5 - v_7 \tag{48}$$

8.7 Species NFAT_Pi_Act_C_Nuc

Name Phosphorylated NFAT Calcineurin complex in nucleus

Initial concentration $2.5 \cdot 10^{-6}$ µmol · l^{-1}

This species takes part in three reactions (as a reactant in R6 and as a product in R5, R17).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{NFAT\_Pi\_Act\_C\_Nuc} = v_5 + v_{12} - v_6 \tag{49}$$

8.8 Species Inact_C_Nuc

Name Inactive Calcineurin in nucleus

Initial concentration $0.049198\ \mu\text{mol}\cdot\text{l}^{-1}$

This species takes part in two reactions (as a reactant in R14 and as a product in R15).

$$\frac{\mathrm{d}}{\mathrm{d}t}\text{Inact\_C\_Nuc} = v_{16} - v_{15} \tag{50}$$

8.9 Species NFAT_Cyt

Name NFAT_Cyt

Initial concentration $1.101\cdot10^{-4}\ \mu\text{mol}\cdot\text{l}^{-1}$

This species takes part in three reactions (as a product in R3, R11, R12).

$$\frac{\mathrm{d}}{\mathrm{d}t}\text{NFAT\_Cyt} = v_3 + v_{11} + v_{13} \tag{51}$$

8.10 Species Act_C_Cyt

Name Active Calcineurin in cytosol

Initial concentration $9.1\cdot10^{-6}\ \mu\text{mol}\cdot\text{l}^{-1}$

This species takes part in six reactions (as a reactant in R12 and as a product in R4, R9, R11, R12, R13).

$$\frac{\mathrm{d}}{\mathrm{d}t}\text{Act\_C\_Cyt} = v_4 + v_9 + v_{11} + v_{13} + v_{14} - v_{13} \tag{52}$$

8.11 Species NFAT_Pi_Cyt

Name Phosphorylated NFAT in cytosol

Initial concentration $0.0094397\ \mu\text{mol}\cdot\text{l}^{-1}$

This species takes part in three reactions (as a reactant in R10, R12 and as a product in R9).

$$\frac{\mathrm{d}}{\mathrm{d}t}\text{NFAT\_Pi\_Cyt} = v_9 - v_{10} - v_{13} \tag{53}$$

8.12 Species NFAT_Act_C_Cyt

Name NFAT Calcineurin complex in cytosol

Initial concentration $6.1\cdot10^{-6}\ \mu\text{mol}\cdot\text{l}^{-1}$

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

$$\frac{\mathrm{d}}{\mathrm{d}t}\text{NFAT\_Act\_C\_Cyt} = v_7 - v_8 - v_{11} \tag{54}$$

8.13 Species NFAT_Pi_Act_C_Cyt

Name Phosphorylated NFAT Calcineurin complex in cytosol

Initial concentration $2.2 \cdot 10^{-6}$ µmol · l^{-1}

This species takes part in three reactions (as a reactant in R9, R17 and as a product in R8).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{NFAT\_Pi\_Act\_C\_Cyt} = v_8 - v_9 - v_{12} \tag{55}$$

8.14 Species Inact_C_Cyt

Name Inactive Calcineurin in cytosol

Initial concentration 0.0097108 µmol · l^{-1}

This species takes part in two reactions (as a reactant in R13, R15).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{Inact\_C\_Cyt} = -v_{14} - v_{16} \tag{56}$$

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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