SBML Model Report

Model name: “Borghans1997 - Calcium Oscillation - Model 2”

May 6, 2016

1 General Overview

This is a document in SBML Level 2 Version 4 format. This model was created by Harish Dharuri[1] at July eighth 2005 at 1:06 p. m. and last time modified at June third 2013 at 4:03 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	3
species types	0	species	4
events	0	constraints	0
reactions	8	function definitions	0
global parameters	1	unit definitions	2
rules	0	initial assignments	0

Model Notes

Borghans1997 - Calcium Oscillation - Model 2

A theoretical expoloration of possible mechanisms of intracellular calcium oscillations has been studied, considering three hypothesis (see below). This model corresponds to the second hypothesis.

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This model is described in the article:Complex intracellular calcium oscillations. A theoretical exploration of possible mechanisms.Borghans JM, Dupont G, Goldbeter A.Biophys. Chem. 1997 May; 66(1): 25-41

Abstract:

Intracellular Ca(2+) oscillations are commonly observed in a large number of cell types in response to stimulation by an extracellular agonist. In most cell types the mechanism of regular spiking is well understood and models based on Ca(2+)-induced Ca(2+) release (CICR) can account for many experimental observations. However, cells do not always exhibit simple Ca(2+) oscillations. In response to given agonists, some cells show more complex behaviour in the form of bursting, i.e. trains of Ca(2+) spikes separated by silent phases. Here we develop several theoretical models, based on physiologically plausible assumptions, that could account for complex intracellular Ca(2+) oscillations. The models are all based on one- or two-pool models based on CICR. We extend these models by (i) considering the inhibition of the Ca(2+)-release channel on a unique intracellular store at high cytosolic Ca(2+) concentrations, (ii) taking into account the Ca(2+)-activated degradation of inositol 1,4,5-trisphosphate (IP(3)), or (iii) considering explicity the evolution of the Ca(2+) concentration in two different pools, one sensitive and the other one insensitive to IP(3). Besides simple periodic oscillations, these three models can all account for more complex oscillatory behaviour in the form of bursting. Moreover, the model that takes the kinetics of IP(3) into account shows chaotic behaviour.

This model is hosted on BioModels Database and identifiedby: MODEL6622948601 .

To cite BioModels Database, please use: BioModels Database: An enhanced, curated and annotated resourcefor published quantitative kinetic models .

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 `substance`

Name micromole (default)

Definition µmol

2.2 Unit `time`

Name minute (default)

Definition 60 s

2.3 Unit volume

Notes Litre is the predefined SBML unit for volume.

Definition l

2.4 Unit area

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

Definition m^2

2.5 Unit length

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

Definition m

3 Compartments

This model contains three compartments.

Table 2: Properties of all compartments.

Id	Name	SBO	Spatial Dimensions	Size	Unit	Constant	Outside
extracellular		0000290	3	1	litre	☑	
cytosol		0000290	3	1	litre	☑	extracellular
intravesicular		0000290	3	1	litre	☑	cytosol

3.1 Compartment extracellular

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

SBO:0000290 physical compartment

3.2 Compartment cytosol

This is a three dimensional compartment with a constant size of one litre, which is surrounded by extracellular.

SBO:0000290 physical compartment

3.3 Compartment intravesicular

This is a three dimensional compartment with a constant size of one litre, which is surrounded by cytosol.

SBO:0000290 physical compartment

4 Species

This model contains four species. Section 7 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
EC		extracellular	$\mu mol \cdot l^{-1}$	⊟	⊟
Z		cytosol	$\mu mol \cdot l^{-1}$	⊟	⊟
A		cytosol	$\mu mol \cdot l^{-1}$	⊟	⊟
Y		intravesicular	$\mu mol \cdot l^{-1}$	⊟	⊟

5 Parameter

This model contains one global parameter.

Table 4: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
`beta`		0000498	0.5		☑

6 Reactions

This model contains eight 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	`vin`		$EC \longrightarrow Z$	0000185
2	`v2`		$Z \longrightarrow Y$	0000185
3	`v3`		$Y \xrightarrow{A} Z$	0000185
4	`v4`		$Y \longrightarrow Z$	0000185
5	`v5`		$Z \longrightarrow EC$	0000185
6	`v6`	Agonist stimulated production of IP3	$\emptyset \longrightarrow A$	0000393
7	`v7`	Ca dependent IP3 degradation	$A \xrightarrow{Z} \emptyset$	0000179
8	`v8`	Ca independent IP3 degradation	$A \longrightarrow \emptyset$	0000179

6.1 Reaction vin

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

SBO:0000185 transport reaction

Reaction equation

$$\mathrm{EC} \longrightarrow \mathrm{Z} \tag{1}$$

Reactant

Table 6: Properties of each reactant.

Id	Name	SBO
EC		

Product

Table 7: Properties of each product.

Id	Name	SBO
Z		

Kinetic Law

Derived unit contains undeclared units

$$v_1 = \mathrm{vol}\,(\mathrm{cytosol}) \cdot (\mathrm{v0} + \mathrm{v1} \cdot \mathrm{beta}) \tag{2}$$

Table 8: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
v0		0000485	2.0		☑
v1		0000162	1.0		☑

6.2 Reaction v2

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

SBO:0000185 transport reaction

Reaction equation

$$\mathrm{Z} \longrightarrow \mathrm{Y} \tag{3}$$

Reactant

Table 9: Properties of each reactant.

Id	Name	SBO
Z		

Product

Table 10: Properties of each product.

Id	Name	SBO
Y		

Kinetic Law

Derived unit contains undeclared units

$$v_2 = \mathrm{vol}\,(\mathrm{intravesicular}) \cdot \frac{\mathrm{Vm2} \cdot [\mathrm{Z}]^2}{\mathrm{K2}^2 + [\mathrm{Z}]^2} \tag{4}$$

Table 11: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
Vm2		0000186	6.5		☑
K2		0000424	0.1		☑

6.3 Reaction v3

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

SBO:0000185 transport reaction

Reaction equation

$$\mathrm{Y} \xrightarrow{\mathrm{A}} \mathrm{Z} \tag{5}$$

Reactant

Table 12: Properties of each reactant.

Id	Name	SBO
Y		

Modifier

Table 13: Properties of each modifier.

Id	Name	SBO
A		

Product

Table 14: Properties of each product.

Id	Name	SBO
Z		

Kinetic Law

Derived unit contains undeclared units

$$v_3 = \frac{\mathrm{vol}\,(\mathrm{cytosol}) \cdot \mathrm{Vm3} \cdot [\mathrm{A}]^4 \cdot [\mathrm{Y}]^2 \cdot [\mathrm{Z}]^4}{\left(\mathrm{Ka}^4 + [\mathrm{A}]^4\right) \cdot \left(\mathrm{Ky}^2 + [\mathrm{Y}]^2\right) \cdot \left(\mathrm{Kz}^4 + [\mathrm{Z}]^4\right)} \tag{6}$$

Table 15: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
Vm3		0000186	19.5		☑
Ka		0000194	0.2		☑
Ky		0000424	0.2		☑
Kz		0000423	0.3		☑

6.4 Reaction v4

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

SBO:0000185 transport reaction

Reaction equation

$$\mathrm{Y} \longrightarrow \mathrm{Z} \tag{7}$$

Reactant

Table 16: Properties of each reactant.

Id	Name	SBO
Y		

Product

Table 17: Properties of each product.

Id	Name	SBO
Z		

Kinetic Law

Derived unit contains undeclared units

$$v_4 = \mathrm{vol}\,(\mathrm{cytosol}) \cdot \mathrm{Kf} \cdot [\mathrm{Y}] \tag{8}$$

Table 18: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
Kf		0000035	1.0		☑

6.5 Reaction v5

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

SBO:0000185 transport reaction

Reaction equation

$$\mathrm{Z} \longrightarrow \mathrm{EC} \tag{9}$$

Reactant

Table 19: Properties of each reactant.

Id	Name	SBO
Z		

Product

Table 20: Properties of each product.

Id	Name	SBO
EC		

Kinetic Law

Derived unit contains undeclared units

$$v_5 = \mathrm{vol}\,(\mathrm{extracellular}) \cdot \mathrm{K} \cdot [\mathrm{Z}] \tag{10}$$

Table 21: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
K		0000035	10.0		☑

6.6 Reaction v6

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

Name Agonist stimulated production of IP3

SBO:0000393 production

Reaction equation

$$\emptyset \longrightarrow \mathrm{A} \tag{11}$$

Product

Table 22: Properties of each product.

Id	Name	SBO
A		

Kinetic Law

Derived unit contains undeclared units

$$v_6 = \mathrm{vol}\,(\mathrm{cytosol}) \cdot \mathrm{beta} \cdot \mathrm{Vp} \tag{12}$$

Table 23: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
Vp		0000048	2.5		☑

6.7 Reaction v7

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

Name Ca dependent IP3 degradation

SBO:0000179 degradation

Reaction equation

$$\mathrm{A} \xrightarrow{\mathrm{Z}} \emptyset \tag{13}$$

Reactant

Table 24: Properties of each reactant.

Id	Name	SBO
A		

Modifier

Table 25: Properties of each modifier.

Id	Name	SBO
Z		

Kinetic Law

Derived unit contains undeclared units

$$v_7 = \frac{\mathrm{vol}\,(\mathrm{cytosol}) \cdot \mathrm{Vd} \cdot [\mathrm{A}]^2 \cdot [\mathrm{Z}]^{\mathrm{n}}}{\left(\mathrm{Kp}^2 + [\mathrm{A}]^2\right) \cdot \left(\mathrm{Kd}^{\mathrm{n}} + [\mathrm{Z}]^{\mathrm{n}}\right)} \tag{14}$$

Table 26: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
Vd		0000324	80.0		☑
Kp		0000424	1.0		☑
Kd		0000194	0.4		☑
n		0000190	4.0		☑

6.8 Reaction v8

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

Name Ca independent IP3 degradation

SBO:0000179 degradation

Reaction equation

$$\mathrm{A} \longrightarrow \emptyset \tag{15}$$

Reactant

Table 27: Properties of each reactant.

Id	Name	SBO
A		

Kinetic Law

Derived unit contains undeclared units

$$v_8 = \mathrm{vol}\,(\mathrm{cytosol}) \cdot \mathrm{epsilon} \cdot [\mathrm{A}] \tag{16}$$

Table 28: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
epsilon		0000498	0.1		☑

7 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.

7.1 Species EC

SBO:0000327 non-macromolecular ion

Initial concentration $1000\ \mu\text{mol} \cdot \text{l}^{-1}$

This species takes part in two reactions (as a reactant in vin and as a product in v5).

$$\frac{\text{d}}{\text{d}t}\text{EC} = v_5 - v_1 \tag{17}$$

7.2 Species Z

SBO:0000327 non-macromolecular ion

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

This species takes part in six reactions (as a reactant in v2, v5 and as a product in vin, v3, v4 and as a modifier in v7).

$$\frac{\text{d}}{\text{d}t}\text{Z} = v_1 + v_3 + v_4 - v_2 - v_5 \tag{18}$$

7.3 Species A

SBO:0000327 non-macromolecular ion

Initial concentration $0.45\ \mu\text{mol}\cdot\text{l}^{-1}$

This species takes part in four reactions (as a reactant in v7, v8 and as a product in v6 and as a modifier in v3).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{A} = v_6 - v_7 - v_8 \tag{19}$$

7.4 Species Y

SBO:0000327 non-macromolecular ion

Initial concentration $0.36\ \mu\text{mol}\cdot\text{l}^{-1}$

This species takes part in three reactions (as a reactant in v3, v4 and as a product in v2).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{Y} = v_2 - v_3 - v_4 \tag{20}$$

A Glossary of Systems Biology Ontology Terms

SBO:0000035 **forward unimolecular rate constant, continuous case:** Numerical parameter that quantifies the forward velocity of a chemical reaction involving only one reactant. This parameter encompasses all the contributions to the velocity except the quantity of the reactant. It is to be used in a reaction modelled using a continuous framework

SBO:0000048 **forward zeroth order rate constant, continuous case:** Numerical parameter that quantifies the forward velocity of a chemical reaction independant of the reactant quantities. This parameter encompasses all the contributions to the velocity. It is to be used in a reaction modelled using a continuous framework.

SBO:0000162 **forward zeroth order rate constant:** Numerical parameter that quantifies the forward velocity of a chemical reaction independant of the reactant quantities. This parameter encompasses all the contributions to the velocity

SBO:0000179 **degradation:** Complete disappearance of a physical entity

SBO:0000185 **transport reaction:** Movement of a physical entity without modification of the structure of the entity

SBO:0000186 **maximal velocity:** Limiting maximal velocity of an enzymatic reaction, reached when the substrate is in large excess and all the enzyme is complexed.

SBO:0000190 Hill coefficient: Empirical parameter created by Archibald Vivian Hill to describe the cooperative binding of oxygen on hemoglobine (Hill (1910). The possible effects of the aggregation of the molecules of haemoglobin on its dissociation curves. J Physiol 40: iv-vii)

SBO:0000194 pseudo-dissociation constant: Dissociation constant equivalent to an intrinsic microscopic dissociation constant, but obtained from an averaging process, for instance by extracting the root of a Hill constant.

SBO:0000290 physical compartment: Specific location of space, that can be bounded or not. A physical compartment can have 1, 2 or 3 dimensions

SBO:0000324 forward maximal velocity: Limiting maximal velocity of the forward reaction of a reversible enzyme, reached when the substrate is in large excess and all the enzyme is complexed.

SBO:0000327 non-macromolecular ion: Chemical entity having a net electric charge

SBO:0000393 production: Generation of a material or conceptual entity.

SBO:0000423 pseudo-dissociation constant for product: In reversible reactions this is the concentration of product that is required to achieve half activation or inhibition in Hill-type kinetics, in the absence of the substrate.

SBO:0000424 pseudo-dissociation constant for substrate: In reversible reactions this is the concentration of substrate that is required to achieve half activation or inhibition in Hill-type kinetics, in the absence of the product.

SBO:0000485 basal rate constant: The minimal velocity observed under defined conditions, which may or may not include the presence of an effector. For example in an inhibitory system, this would be the residual velocity observed under full inhibition. In non-essential activation, this would be the velocity in the absence of any activator

SBO:0000498 relative activity: Value which ranges from 0 to 1, to describe the relative activity of a process or reaction.

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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