SBML Model Report

Model name: "Bertram1995_PancreaticBetaCell_CRAC"

May 6, 2016

1 General Overview

This is a document in SBML Level 2 Version 4 format. This model was created by the following two authors: Ishan Ajmera[1] and Catherine Lloyd[2] at September 29th 2011 at 10:07 p. m. and last time modified at April eighth 2016 at 5:07 p. m. Table 1 provides 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	0	function definitions	0
global parameters	50	unit definitions	0
rules	30	initial assignments	0

Model Notes

This a model from the article:
A role for calcium release-activated current (CRAC) in cholinergic modulation ofelectrical activity in pancreatic beta-cells.
Bertram R, Smolen P, Sherman A, Mears D, Atwater I, Martin F, Soria B. Biophys J1995

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Jun;68(6):2323-32 7647236,

Abstract:
S. Bordin and colleagues have proposed that the depolarizing effects ofacetylcholine and other muscarinic agonists on pancreatic beta-cells aremediated by a calcium release-activated current (CRAC). We support thishypothesis with additional data, and present a theoretical model which accountsfor most known data on muscarinic effects. Additional phenomena, such as thebiphasic responses of beta-cells to changes in glucose concentration and thedepolarizing effects of the sarco-endoplasmic reticulum calcium ATPase pumppoison thapsigargin, are also accounted for by our model. The ability of thissingle hypothesis, that CRAC is present in beta-cells, to explain so manyphenomena motivates a more complete characterization of this current.

This model was taken from the CellML repository and automatically converted to SBML.
The original model was:**Bertram R, Smolen P, Sherman A, Mears D, Atwater I, Martin F, Soria B. (1995) - version=1.0**
The original CellML model was created by:
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2 Unit Definitions

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

2.1 Unit `substance`

Notes Mole is the predefined SBML unit for `substance`.

Definition mol

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 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 litre.

Name COMpartment

4 Species

This model contains five 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
V_membrane	V_membrane	COMpartment	$\mathrm{mol} \cdot \mathrm{l}^{-1}$	$\boxminus$	$\boxminus$
n	n	COMpartment	$\mathrm{mol} \cdot \mathrm{l}^{-1}$	$\boxminus$	$\boxminus$
jm	jm	COMpartment	$\mathrm{mol} \cdot \mathrm{l}^{-1}$	$\boxminus$	$\boxminus$
Ca_er_Ca_equations	ca_er_ca_equations	COMpartment	$\mathrm{mol} \cdot \mathrm{l}^{-1}$	$\boxminus$	$\boxminus$
Ca_i	Ca_i	COMpartment	$\mathrm{mol} \cdot \mathrm{l}^{-1}$	$\boxminus$	$\boxminus$

5 Parameters

This model contains 50 global parameters.

Table 4: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
Cm	Cm	0000258	6158.000		☑
i_K	i_K		17.550		☐
g_K	g_K	0000009	3900.000		☑
n_infinity	n_infinity		$4.67956725632935 \cdot 10^{-4}$		☐
tau_n	tau_n		9.086		☐
lambda_n	lambda_n	0000009	1.850		☑
i_K_ATP	i_K_ATP		1350.000		☐
g_K_ATP	g_K_ATP		150.000		☑
i_Ca_f	i_Ca_f		−548.702		☐
V_Ca	V_Ca	0000009	100.000		☑
g_Ca_f	g_Ca_f	0000009	810.000		☑
m_f_infinity	m_f_infinity		0.004		☐
i_Ca_s	i_Ca_s		−793.881		☐
g_Ca_s	g_Ca_s	0000009	510.000		☑
m_s_infinity	m_s_infinity		0.011		☐
j	j		0.880		☐
jm_infinity	jm_infinity		0.018		☐
tau_j	tau_j		8145.056		☐
i_Ca	i_Ca		−1342.583		☐
i_K_Ca	i_K_Ca		3.455		☐
g_K_Ca	g_K_Ca	0000009	1200.000		☑
kdkca	kdkca	0000009	0.550		☑
i_CRAC	i_CRAC		−11.312		☐
g_CRAC	g_CRAC	0000009	75.000		☑
V_CRAC	V_CRAC	0000009	0.000		☑
r_infinity	r_infinity		0.002		☐
Ca_er_bar	Ca_er_bar	0000009	3.000		☑
i_leak	i_leak		0.000		☐
g_leak	g_leak	0000009	0.000		☑
J_er_p	J_er_p		0.131		☐
IP3	IP3	0000196	0.000		☑
kerp	kerp	0000009	0.100		☑
verp	verp	0000009	0.240		☑
dact	dact	0000009	0.100		☑
dinh	dinh	0000009	0.400		☑
dip3	dip3	0000009	0.200		☑
a_infinity	a_infinity		0.524		☐

Id	Name	SBO	Value	Unit	Constant
b_infinity	b_infinity		0.000		☐
h_infinity	h_infinity		0.784		☐
O	O		0.000		☐
J_er_tot	J_er_tot		0.046		☐
J_er_IP3	J_er_IP3		0.000		☐
J_er_leak	J_er_leak		0.178		☐
perl	perl	0000009	0.020		☑
lambda_er	lambda_er	0000009	250.000		☑
sigma_er	sigma_er	0000009	5.000		☑
k_Ca	k_Ca	0000009	0.070		☑
gamma	gamma	0000009	$3.607 \cdot 10^{-6}$		☑
J_mem_tot	J_mem_tot		$-2.8573018487523 \cdot 10^{-5}$		☐
f	f	0000009	0.010		☑

6 Rules

This is an overview of 30 rules.

6.1 Rule i_K

Rule i_K is an assignment rule for parameter i_K:

$$\mathrm{i\_K} = \mathrm{g\_K} \cdot [\mathrm{n}] \cdot ([\mathrm{V\_membrane}] + 70) \tag{1}$$

6.2 Rule n_infinity

Rule n_infinity is an assignment rule for parameter n_infinity:

$$\mathrm{n\_infinity} = \frac{1}{1 + \exp\left(\frac{15 - [\mathrm{V\_membrane}]}{6}\right)} \tag{2}$$

6.3 Rule tau_n

Rule tau_n is an assignment rule for parameter tau_n:

$$\mathrm{tau\_n} = \frac{9.09}{1 + \exp\left(\frac{15 + [\mathrm{V\_membrane}]}{6}\right)} \tag{3}$$

6.4 Rule i_K_ATP

Rule i_K_ATP is an assignment rule for parameter i_K_ATP:

$$\mathrm{i\_K\_ATP} = \mathrm{g\_K\_ATP} \cdot ([\mathrm{V\_membrane}] + 70) \tag{4}$$

6.5 Rule m_f_infinity

Rule m_f_infinity is an assignment rule for parameter m_f_infinity:

$$\mathrm{m\_f\_infinity} = \frac{1}{1 + \exp\left(\frac{20 - [\mathrm{V\_membrane}]}{7.5}\right)} \tag{5}$$

6.6 Rule i_Ca_f

Rule i_Ca_f is an assignment rule for parameter i_Ca_f:

$$\mathrm{i\_Ca\_f} = \mathrm{g\_Ca\_f} \cdot \mathrm{m\_f\_infinity} \cdot ([\mathrm{V\_membrane}] - \mathrm{V\_Ca}) \tag{6}$$

6.7 Rule m_s_infinity

Rule m_s_infinity is an assignment rule for parameter m_s_infinity:

$$\mathrm{m\_s\_infinity} = \frac{1}{1 + \exp\left(\frac{16 - [\mathrm{V\_membrane}]}{10}\right)} \tag{7}$$

6.8 Rule i_Ca_s

Rule i_Ca_s is an assignment rule for parameter i_Ca_s:

$$\mathrm{i\_Ca\_s} = \mathrm{g\_Ca\_s} \cdot \mathrm{m\_s\_infinity} \cdot (1 - [\mathrm{jm}]) \cdot ([\mathrm{V\_membrane}] - \mathrm{V\_Ca}) \tag{8}$$

6.9 Rule i_Ca

Rule i_Ca is an assignment rule for parameter i_Ca:

$$\mathrm{i\_Ca} = \mathrm{i\_Ca\_f} + \mathrm{i\_Ca\_s} \tag{9}$$

6.10 Rule j

Rule j is an assignment rule for parameter j:

$$\mathrm{j} = 1 - [\mathrm{jm}] \tag{10}$$

6.11 Rule jm_infinity

Rule jm_infinity is an assignment rule for parameter jm_infinity:

$$\mathrm{jm\_infinity} = 1 - \frac{1}{1 + \exp\left(\frac{53 + [\mathrm{V\_membrane}]}{2}\right)} \tag{11}$$

6.12 Rule tau_j

Rule tau_j is an assignment rule for parameter tau_j:

$$\text{tau\_j} = \frac{50000}{\exp\left(\frac{53+[\text{V\_membrane}]}{4}\right)+\exp\left(\frac{53-[\text{V\_membrane}]}{4}\right)} + 1500 \tag{12}$$

6.13 Rule i_K_Ca

Rule i_K_Ca is an assignment rule for parameter i_K_Ca:

$$\text{i\_K\_Ca} = \frac{\text{g\_K\_Ca} \cdot [\text{Ca\_i}]^5}{[\text{Ca\_i}]^5 + \text{kdkca}^5} \cdot ([\text{V\_membrane}] + 70) \tag{13}$$

6.14 Rule r_infinity

Rule r_infinity is an assignment rule for parameter r_infinity:

$$\text{r\_infinity} = \frac{1}{1+\exp\left(1 \cdot ([\text{Ca\_er\_Ca\_equations}] - \text{Ca\_er\_bar})\right)} \tag{14}$$

6.15 Rule i_CRAC

Rule i_CRAC is an assignment rule for parameter i_CRAC:

$$\text{i\_CRAC} = \text{g\_CRAC} \cdot \text{r\_infinity} \cdot ([\text{V\_membrane}] - \text{V\_CRAC}) \tag{15}$$

6.16 Rule i_leak

Rule i_leak is an assignment rule for parameter i_leak:

$$\text{i\_leak} = \text{g\_leak} \cdot ([\text{V\_membrane}] - \text{V\_CRAC}) \tag{16}$$

6.17 Rule J_er_p

Rule J_er_p is an assignment rule for parameter J_er_p:

$$\text{J\_er\_p} = \frac{\text{verp} \cdot [\text{Ca\_i}]^2}{[\text{Ca\_i}]^2 + \text{kerp}^2} \tag{17}$$

6.18 Rule a_infinity

Rule a_infinity is an assignment rule for parameter a_infinity:

$$\text{a\_infinity} = \frac{1}{1+\frac{\text{dact}}{[\text{Ca\_i}]}} \tag{18}$$

6.19 Rule b_infinity

Rule b_infinity is an assignment rule for parameter b_infinity:

$$\text{b\_infinity} = \frac{\text{IP3}}{\text{IP3} + \text{dip3}} \tag{19}$$

6.20 Rule h_infinity

Rule h_infinity is an assignment rule for parameter h_infinity:

$$\text{h\_infinity} = \frac{1}{1 + \frac{[\text{Ca\_i}]}{\text{dinh}}} \tag{20}$$

6.21 Rule O

Rule O is an assignment rule for parameter O:

$$\text{O} = \text{a\_infinity}^3 \cdot \text{b\_infinity}^3 \cdot \text{h\_infinity}^3 \cdot 1 \tag{21}$$

6.22 Rule J_er_IP3

Rule J_er_IP3 is an assignment rule for parameter J_er_IP3:

$$\text{J\_er\_IP3} = \text{O} \cdot ([\text{Ca\_er\_Ca\_equations}] - [\text{Ca\_i}]) \tag{22}$$

6.23 Rule J_er_leak

Rule J_er_leak is an assignment rule for parameter J_er_leak:

$$\text{J\_er\_leak} = \text{perl} \cdot ([\text{Ca\_er\_Ca\_equations}] - [\text{Ca\_i}]) \tag{23}$$

6.24 Rule J_er_tot

Rule J_er_tot is an assignment rule for parameter J_er_tot:

$$\text{J\_er\_tot} = \text{J\_er\_leak} + \text{J\_er\_IP3} - \text{J\_er\_p} \tag{24}$$

6.25 Rule J_mem_tot

Rule J_mem_tot is an assignment rule for parameter J_mem_tot:

$$\text{J\_mem\_tot} = \text{f} \cdot (\text{gamma} \cdot \text{i\_Ca} + \text{k\_Ca} \cdot [\text{Ca\_i}]) \tag{25}$$

6.26 Rule V_membrane

Rule V_membrane is a rate rule for species V_membrane:

$$\frac{\mathrm{d}}{\mathrm{d}t}\text{V\_membrane} = \frac{(\text{i\_Ca} + \text{i\_K} + \text{i\_K\_ATP} + \text{i\_K\_Ca} + \text{i\_CRAC} + \text{i\_leak})}{\text{Cm}} \tag{26}$$

6.27 Rule n

Rule n is a rate rule for species n:

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{n} = \frac{\mathrm{lambda\_n} \cdot (\mathrm{n\_infinity} - [\mathrm{n}])}{\mathrm{tau\_n}} \tag{27}$$

6.28 Rule jm

Rule jm is a rate rule for species jm:

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{jm} = \frac{\mathrm{jm\_infinity} - [\mathrm{jm}]}{\mathrm{tau\_j}} \tag{28}$$

6.29 Rule Ca_er_Ca_equations

Rule Ca_er_Ca_equations is a rate rule for species Ca_er_Ca_equations:

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{Ca\_er\_Ca\_equations} = \frac{\mathrm{J\_er\_tot}}{\mathrm{lambda\_er} \cdot \mathrm{sigma\_er}} \tag{29}$$

6.30 Rule Ca_i

Rule Ca_i is a rate rule for species Ca_i:

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{Ca\_i} = \frac{\mathrm{J\_er\_tot}}{\mathrm{lambda\_er}} + \mathrm{J\_mem\_tot} \tag{30}$$

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.

7.1 Species V_membrane

Name V_membrane

SBO:0000259 voltage

Initial amount -61 mol

Involved in rule V_membrane

One rule which determines this species' quantity.

7.2 Species n

Name n

Initial amount $5 \cdot 10^{-4}$ mol

Involved in rule n

One rule which determines this species' quantity.

7.3 Species jm

Name jm

SBO:0000412 biological activity

Initial amount 0.25 mol

Involved in rule jm

One rule which determines this species' quantity.

7.4 Species Ca_er_Ca_equations

Name ca_er_ca_equations

Initial amount 9 mol

Involved in rule Ca_er_Ca_equations

One rule which determines this species' quantity.

7.5 Species Ca_i

Name Ca_i

Initial amount 0.11 mol

Involved in rule Ca_i

One rule which determines this species' quantity.

A Glossary of Systems Biology Ontology Terms

SBO:0000009 **kinetic constant:** Numerical parameter that quantifies the velocity of a chemical reaction

SBO:0000196 **concentration of an entity pool:** The amount of an entity per unit of volume.

SBO:0000258 **capacitance:** Measure of the amount of electric charge stored (or separated) for a given electric potential. The unit of capacitance id the Farad

SBO:0000259 **voltage:** Difference of electrical potential between two points of an electrical network, expressed in volts

SBO:0000412 **biological activity:** The potential action that a biological entity has on other entities. Example are enzymatic activity, binding activity etc

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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