SBML Model Report

Model name: "FitzHugh1961_NerveMembrane"

May 6, 2016

1 General Overview

This is a document in SBML Level 2 Version 4 format. This model was created by Nicolas Le Novre[1] at April 28th 2009 at 1:20 p. m. and last time modified at April 20th 2012 at 9:37 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	2
events	0	constraints	0
reactions	0	function definitions	0
global parameters	4	unit definitions	1
rules	2	initial assignments	0

Model Notes

This is the original model from Richard FitzHugh, which led the famous FitzHughNagumo model, still used for instance in computational neurosciences.

Impulses and Physiological States in Theoretical Models of Nerve Membrane

FitzHugh R Biophysical Journal, 1961 July:1(6):445-466 doi:10.1016/S0006-3495(61)86902-6

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Abstract:
Van der Pol's equation for a relaxation oscillator is generalized by the addition of terms to produce a pair of non-linear differential equations with either a stable singular point or a limit cycle. The resulting BVP model has two variables of state, representing excitability and refractoriness, and qualitatively resembles Bonhoeffer's theoretical model for the iron wire model of nerve. This BVP model serves as a simple representative of a class of excitable-oscillatory systems including the Hodgkin-Huxley (HH) model of the squid giant axon. The BVP phase plane can be divided into regions corresponding to the physiological states of nerve fiber (resting, active, refractory, enhanced, depressed, etc.) to form a physiological state diagram, with the help of which many physiological phenomena can be summarized. A properly chosen projection from the 4-dimensional HH phase space onto a plane produces a similar diagram which shows the underlying relationship between the two models. Impulse trains occur in the BVP and HH models for a range of constant applied currents which make the singular point representing the resting state unstable.

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 `time`

Name time

Definition ms

2.2 Unit `substance`

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

Definition mol

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 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 two 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
`x`	x	`compartment`	$\mathrm{mol} \cdot \mathrm{l}^{-1}$	⊟	⊟
`y`	y	`compartment`	$\mathrm{mol} \cdot \mathrm{l}^{-1}$	⊟	⊟

5 Parameters

This model contains four global parameters.

Table 4: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
a	a	0000009	0.7	dimensionless	☑
b	b	0000009	0.8	dimensionless	☑
c	c	0000009	3.0	dimensionless	☑
z	z	0000009	−0.4	dimensionless	☐

6 Rules

This is an overview of two rules.

6.1 Rule x

Rule x is a rate rule for species x:

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{x} = \mathrm{c} \cdot \left([\mathrm{x}] + \left(\left(\frac{[\mathrm{x}]^3}{3}\right)\right) + [\mathrm{y}] + \mathrm{z}\right) \tag{1}$$

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

6.2 Rule y

Rule y is a rate rule for species y:

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{y} = \left(\frac{1}{\mathrm{c}}\right) \cdot ([\mathrm{x}] + (\mathrm{a}) + \mathrm{b} \cdot [\mathrm{y}]) \tag{2}$$

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

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.

7.1 Species x

Name x

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

Involved in rule x

One rule which determines this species' quantity.

7.2 Species y

Name y

Initial concentration $0.5\,\mathrm{mol}\cdot\mathrm{l}^{-1}$

Involved in rule y

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