SBML Model Report

Model name: "Santolini2001_nNOS-_Mechanism_Regulation"

May 6, 2016

1 General Overview

This is a document in SBML Level 2 Version 3 format. This model was created by the following three authors: Lukas Endler[1], Vijayalakshmi Chelliah[2] and Jrme Santolini[3] at October 14th 2008 at 4:56 p. m. and last time modified at April eighth 2016 at 3:56 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	15
events	0	constraints	0
reactions	10	function definitions	0
global parameters	10	unit definitions	4
rules	1	initial assignments	0

Model Notes

This is a model of neuronal Nitric Oxide Synthase expressed in Escherichia coli based on Santolini J. et al. J Biol Chem. (2001) 276(2):1233-43.
Differing from the article, oxygen explicitly included in the reaction 2, 5 and 10 (numbers as

[1]EMBL-EBI, lukas@ebi.ac.uk
[2]EMBL-EBI, viji@ebi.ac.uk
[3]CEA IBITEC-S, Jerome.SANTOLINI@cea.fr

in scheme 1 in the article). In the article the assumed oxygen concentration of 140 uM was included in the pseudo first order rate constant.
Fig 2E in the article shows different time courses for citrulline and NO than the ones produced by this model. Dr. Santolini, one of the authors of the article, wrote that the legends in fig. 2E might be mixed up and should rather denote NO and NO3 instead of citrulline and NO.

2 Unit Definitions

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

2.1 Unit `substance`

Name micromole

Definition $\mu\mathrm{mol}$

2.2 Unit `peruMpersec`

Definition $1 \cdot \mu\mathrm{mol}^{-1} \cdot \mathrm{s}^{-1}$

2.3 Unit `uM`

Definition $\mu\mathrm{mol} \cdot 1^{-1}$

2.4 Unit `persec`

Definition s^{-1}

2.5 Unit `volume`

Notes Litre is the predefined SBML unit for `volume`.

Definition 1

2.6 Unit area

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

Definition m^2

2.7 Unit length

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

Definition m

2.8 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
cytosol			3	1	litre	☑	

3.1 Compartment cytosol

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

4 Species

This model contains 15 species. The boundary condition of six 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
FeIII	FeIII	cytosol	$\mu mol \cdot l^{-1}$	⊟	⊟
FeII	FeII	cytosol	$\mu mol \cdot l^{-1}$	⊟	⊟
FeII_O2	FeII_O2	cytosol	$\mu mol \cdot l^{-1}$	⊟	⊟
FeIII_star	FeIII_star	cytosol	$\mu mol \cdot l^{-1}$	⊟	⊟
FeII_star	FeII_star	cytosol	$\mu mol \cdot l^{-1}$	⊟	⊟
FeII_star_O2	FeII_star_O2	cytosol	$\mu mol \cdot l^{-1}$	⊟	⊟
FeIII_NO	FeIII_NO	cytosol	$\mu mol \cdot l^{-1}$	⊟	⊟
FeII_NO	FeII_NO	cytosol	$\mu mol \cdot l^{-1}$	⊟	⊟
NADPH	NADPH	cytosol	$\mu mol \cdot l^{-1}$	⊟	☑
O2	O2	cytosol	$\mu mol \cdot l^{-1}$	⊟	☑
citrulline	citruline	cytosol	$\mu mol \cdot l^{-1}$	⊟	☑
NO3	NO3	cytosol	$\mu mol \cdot l^{-1}$	⊟	☑
NO	NO	cytosol	$\mu mol \cdot l^{-1}$	⊟	☑
NADPplus	NADPplus	cytosol	$\mu mol \cdot l^{-1}$	⊟	☑
FeIII_t	FeIII_t	cytosol	$\mu mol \cdot l^{-1}$	⊟	⊟

5 Parameters

This model contains ten global parameters.

Table 4: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
k1	k1	0000035	2.600	s^{-1}	☑
k2	k2	0000339	0.900	$l \cdot \mu mol^{-1} \cdot s^{-1}$	☑
k3	k3	0000035	26.000	s^{-1}	☑
k4	k4	0000035	2.600	s^{-1}	☑
k5	k5	0000339	0.900	$l \cdot \mu mol^{-1} \cdot s^{-1}$	☑
k6	k6	0000035	26.000	s^{-1}	☑
k7	k7	0000035	5.000	s^{-1}	☑
k8	k8	0000035	2.600	s^{-1}	☑
k9	k9	0000035	10^{-4}	s^{-1}	☑
k10	k10	0000339	0.001	$l \cdot \mu mol^{-1} \cdot s^{-1}$	☑

6 Rule

This is an overview of one rule.

6.1 Rule FeIII_t

Rule FeIII_t is an assignment rule for species FeIII_t:

$$\text{FeIII\_t} = [\text{FeIII}] + [\text{FeIII\_star}] \tag{1}$$

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

7 Reactions

This model contains ten 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		FeIII + NADPH ⟶ FeII + NADPplus	0000200
2	r2		FeII + O2 ⟶ FeII_O2	0000177
3	r3		FeII_O2 ⟶ FeIII_star	0000201
4	r4		FeIII_star + 0 · 5 NADPH ⟶ FeII_star + 0 · 5 NADPplus	0000200
5	r5		FeII_star + O2 ⟶ FeII_star_O2	0000177
6	r6		FeII_star_O2 ⟶ FeIII_NO + citrulline	0000182
7	rF		FeIII_NO ⟶ FeIII + NO	0000180
8	rG		FeIII_NO + 0 · 5 NADPH ⟶ FeII_NO + 0 · 5 NADPplus	0000200
9	r9		FeII_NO ⟶ FeII + NO	0000180
10	r10		FeII_NO + O2 ⟶ FeIII + NO3	0000200

7.1 Reaction r1

This is an irreversible reaction of two reactants forming two products.

SBO:0000200 redox reaction

Reaction equation

$$\mathrm{FeIII} + \mathrm{NADPH} \longrightarrow \mathrm{FeII} + \mathrm{NADPplus} \tag{2}$$

Reactants

Table 6: Properties of each reactant.

Id	Name	SBO
FeIII	FeIII	
NADPH	NADPH	

Products

Table 7: Properties of each product.

Id	Name	SBO
FeII	FeII	
NADPplus	NADPplus	

Kinetic Law

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

$$v_1 = \mathrm{vol}\,(\mathrm{cytosol}) \cdot \mathrm{k1} \cdot [\mathrm{FeIII}] \tag{3}$$

7.2 Reaction r2

This is an irreversible reaction of two reactants forming one product.

SBO:0000177 non-covalent binding

Reaction equation

$$\mathrm{FeII} + \mathrm{O2} \longrightarrow \mathrm{FeII\_O2} \tag{4}$$

Reactants

Table 8: Properties of each reactant.

Id	Name	SBO
FeII	FeII	
O2	O2	

Product

Table 9: Properties of each product.

Id	Name	SBO
FeII_O2	FeII_O2	

Kinetic Law

Derived unit $s^{-1} \cdot \mu mol$

$$v_2 = \mathrm{vol}\,(\mathrm{cytosol}) \cdot \mathrm{k2} \cdot [\mathrm{FeII}] \cdot [\mathrm{O2}] \tag{5}$$

7.3 Reaction r3

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

SBO:0000201 oxidation

Reaction equation

$$\mathrm{FeII\_O2} \longrightarrow \mathrm{FeIII\_star} \tag{6}$$

Reactant

Table 10: Properties of each reactant.

Id	Name	SBO
FeII_O2	FeII_O2	

Product

Table 11: Properties of each product.

Id	Name	SBO
FeIII_star	FeIII_star	

Id	Name	SBO

Kinetic Law

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

$$v_3 = \mathrm{vol}\,(\mathrm{cytosol}) \cdot \mathrm{k3} \cdot [\mathrm{FeII\_O2}] \tag{7}$$

7.4 Reaction r4

This is an irreversible reaction of two reactants forming two products.

SBO:0000200 redox reaction

Reaction equation

$$\mathrm{FeIII\_star} + 0{\cdot}5\,\mathrm{NADPH} \longrightarrow \mathrm{FeII\_star} + 0{\cdot}5\,\mathrm{NADPplus} \tag{8}$$

Reactants

Table 12: Properties of each reactant.

Id	Name	SBO
FeIII_star	FeIII_star	
NADPH	NADPH	

Products

Table 13: Properties of each product.

Id	Name	SBO
FeII_star	FeII_star	
NADPplus	NADPplus	

Kinetic Law

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

$$v_4 = \mathrm{vol}\,(\mathrm{cytosol}) \cdot \mathrm{k4} \cdot [\mathrm{FeIII\_star}] \tag{9}$$

7.5 Reaction r5

This is an irreversible reaction of two reactants forming one product.

SBO:0000177 non-covalent binding

Reaction equation

$$\text{FeII\_star} + \text{O2} \longrightarrow \text{FeII\_star\_O2} \tag{10}$$

Reactants

Table 14: Properties of each reactant.

Id	Name	SBO
`FeII_star`	FeII_star	
`O2`	O2	

Product

Table 15: Properties of each product.

Id	Name	SBO
`FeII_star_O2`	FeII_star_O2	

Kinetic Law

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

$$v_5 = \mathrm{vol}\,(\text{cytosol}) \cdot \text{k5} \cdot [\text{FeII\_star}] \cdot [\text{O2}] \tag{11}$$

7.6 Reaction `r6`

This is an irreversible reaction of one reactant forming two products.

SBO:0000182 conversion

Reaction equation

$$\text{FeII\_star\_O2} \longrightarrow \text{FeIII\_NO} + \text{citrulline} \tag{12}$$

Reactant

Table 16: Properties of each reactant.

Id	Name	SBO
FeII_star_O2	FeII_star_O2	

Products

Table 17: Properties of each product.

Id	Name	SBO
FeIII_NO	FeIII_NO	
citrulline	citruline	

Kinetic Law

Derived unit $s^{-1} \cdot \mu mol$

$$v_6 = \mathrm{vol}\,(\mathrm{cytosol}) \cdot \mathrm{k6} \cdot [\mathrm{FeII\_star\_O2}] \tag{13}$$

7.7 Reaction rF

This is an irreversible reaction of one reactant forming two products.

SBO:0000180 dissociation

Reaction equation

$$\mathrm{FeIII\_NO} \longrightarrow \mathrm{FeIII} + \mathrm{NO} \tag{14}$$

Reactant

Table 18: Properties of each reactant.

Id	Name	SBO
FeIII_NO	FeIII_NO	

Products

Table 19: Properties of each product.

Id	Name	SBO
FeIII	FeIII	

Id	Name	SBO
NO	NO	

Kinetic Law

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

$$v_7 = \mathrm{vol}\,(\mathrm{cytosol}) \cdot \mathrm{k7} \cdot [\mathrm{FeIII\_NO}] \tag{15}$$

7.8 Reaction rG

This is an irreversible reaction of two reactants forming two products.

SBO:0000200 redox reaction

Reaction equation

$$\mathrm{FeIII\_NO} + 0{\cdot}5\,\mathrm{NADPH} \longrightarrow \mathrm{FeII\_NO} + 0{\cdot}5\,\mathrm{NADPplus} \tag{16}$$

Reactants

Table 20: Properties of each reactant.

Id	Name	SBO
FeIII_NO	FeIII_NO	
NADPH	NADPH	

Products

Table 21: Properties of each product.

Id	Name	SBO
FeII_NO	FeII_NO	
NADPplus	NADPplus	

Kinetic Law

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

$$v_8 = \mathrm{vol}\,(\mathrm{cytosol}) \cdot \mathrm{k8} \cdot [\mathrm{FeIII\_NO}] \tag{17}$$

7.9 Reaction r9

This is an irreversible reaction of one reactant forming two products.

SBO:0000180 dissociation

Reaction equation

$$\mathrm{FeII\_NO} \longrightarrow \mathrm{FeII} + \mathrm{NO} \tag{18}$$

Reactant

Table 22: Properties of each reactant.

Id	Name	SBO
FeII_NO	FeII_NO	

Products

Table 23: Properties of each product.

Id	Name	SBO
FeII	FeII	
NO	NO	

Kinetic Law

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

$$v_9 = \mathrm{vol}\,(\mathrm{cytosol}) \cdot \mathrm{k9} \cdot [\mathrm{FeII\_NO}] \tag{19}$$

7.10 Reaction r10

This is an irreversible reaction of two reactants forming two products.

SBO:0000200 redox reaction

Reaction equation

$$\mathrm{FeII\_NO} + \mathrm{O2} \longrightarrow \mathrm{FeIII} + \mathrm{NO3} \tag{20}$$

Reactants

Table 24: Properties of each reactant.

Id	Name	SBO
FeII_NO	FeII_NO	
O2	O2	

Products

Table 25: Properties of each product.

Id	Name	SBO
FeIII	FeIII	
NO3	NO3	

Kinetic Law

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

$$v_{10} = \mathrm{vol}\,(\mathrm{cytosol}) \cdot \mathrm{k10} \cdot [\mathrm{FeII\_NO}] \cdot [\mathrm{O2}] \tag{21}$$

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.

8.1 Species FeIII

Name FeIII

SBO:0000297 protein complex

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

This species takes part in three reactions (as a reactant in r1 and as a product in rF, r10).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{FeIII} = v_7 + v_{10} - v_1 \tag{22}$$

8.2 Species FeII

Name FeII

SBO:0000297 protein complex

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

This species takes part in three reactions (as a reactant in r2 and as a product in r1, r9).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{FeII} = v_1 + v_9 - v_2 \tag{23}$$

8.3 Species FeII_O2

Name FeII_O2

SBO:0000297 protein complex

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

This species takes part in two reactions (as a reactant in r3 and as a product in r2).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{FeII\_O2} = v_2 - v_3 \tag{24}$$

8.4 Species FeIII_star

Name FeIII_star

SBO:0000297 protein complex

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

This species takes part in two reactions (as a reactant in r4 and as a product in r3).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{FeIII\_star} = v_3 - v_4 \tag{25}$$

8.5 Species FeII_star

Name FeII_star

SBO:0000297 protein complex

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

This species takes part in two reactions (as a reactant in r5 and as a product in r4).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{FeII\_star} = v_4 - v_5 \tag{26}$$

8.6 Species FeII_star_O2

Name FeII_star_O2

SBO:0000297 protein complex

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

This species takes part in two reactions (as a reactant in r6 and as a product in r5).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{FeII\_star\_O2} = v_5 - v_6 \tag{27}$$

8.7 Species FeIII_NO

Name FeIII_NO

SBO:0000297 protein complex

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

This species takes part in three reactions (as a reactant in rF, rG and as a product in r6).

$$\frac{\mathrm{d}}{\mathrm{d}t}\text{FeIII\_NO} = v_6 - v_7 - v_8 \tag{28}$$

8.8 Species FeII_NO

Name FeII_NO

SBO:0000297 protein complex

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

This species takes part in three reactions (as a reactant in r9, r10 and as a product in rG).

$$\frac{\mathrm{d}}{\mathrm{d}t}\text{FeII\_NO} = v_8 - v_9 - v_{10} \tag{29}$$

8.9 Species NADPH

Name NADPH

SBO:0000247 simple chemical

Initial concentration $40\ \mu\text{mol}\cdot\text{l}^{-1}$

This species takes part in three reactions (as a reactant in r1, r4, rG), which do not influence its rate of change because this species is on the boundary of the reaction system:

$$\frac{\mathrm{d}}{\mathrm{d}t}\text{NADPH} = 0 \tag{30}$$

8.10 Species O2

Name O2

SBO:0000247 simple chemical

Initial concentration $140\ \mu\text{mol}\cdot\text{l}^{-1}$

This species takes part in three reactions (as a reactant in r2, r5, r10), which do not influence its rate of change because this species is on the boundary of the reaction system:

$$\frac{\mathrm{d}}{\mathrm{d}t}\text{O2} = 0 \tag{31}$$

8.11 Species citrulline

Name citruline

SBO:0000247 simple chemical

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

This species takes part in one reaction (as a product in r6), which does not influence its rate of change because this species is on the boundary of the reaction system:

$$\frac{\mathrm{d}}{\mathrm{d}t}\text{citrulline} = 0 \tag{32}$$

8.12 Species NO3

Name NO3

SBO:0000247 simple chemical

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

This species takes part in one reaction (as a product in r10), which does not influence its rate of change because this species is on the boundary of the reaction system:

$$\frac{\mathrm{d}}{\mathrm{d}t}\text{NO3} = 0 \tag{33}$$

8.13 Species NO

Name NO

SBO:0000247 simple chemical

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

This species takes part in two reactions (as a product in rF, r9), which do not influence its rate of change because this species is on the boundary of the reaction system:

$$\frac{\mathrm{d}}{\mathrm{d}t}\text{NO} = 0 \tag{34}$$

8.14 Species NADPplus

Name NADPplus

SBO:0000327 non-macromolecular ion

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

This species takes part in three reactions (as a product in r1, r4, rG), which do not influence its rate of change because this species is on the boundary of the reaction system:

$$\frac{\mathrm{d}}{\mathrm{d}t}\text{NADPplus} = 0 \tag{35}$$

8.15 Species FeIII_t

Name FeIII_t

SBO:0000297 protein complex

Involved in rule FeIII_t

One rule which determines this species' quantity.

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:0000177 non-covalent binding: Interaction between several biochemical entities that results in the formation of a non-covalent comple

SBO:0000180 dissociation: Transformation of a non-covalent complex that results in the formation of several independent biochemical entitie

SBO:0000182 conversion: Biochemical reaction that results in the modification of some covalent bonds

SBO:0000200 redox reaction: Chemical process in which atoms have their oxidation number (oxidation state) changed

SBO:0000201 oxidation: Chemical process during which a molecular entity loses electrons

SBO:0000247 simple chemical: Simple, non-repetitive chemical entity

SBO:0000297 protein complex: Macromolecular complex containing one or more polypeptide chains possibly associated with simple chemicals. CHEBI:3608

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

SBO:0000339 bimolecular association rate constant: Rate with which two components associate into a complex

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.

[a]Center for Bioinformatics Tübingen (ZBIT), Germany
[b]California Institute of Technology, Beckman Institute BNMC, Pasadena, United States
[c]European Bioinformatics Institute, Wellcome Trust Genome Campus, Hinxton, United Kingdom
[d]EML Research gGmbH, Heidelberg, Germany