SBML Model Report

Model name: “deBack2012 - Lineage Specification in Pancreas Development”

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: Vijayalakshmi Chelliah[1] and Lutz Brusch[2] at November 28th 2012 at 1:53 p. m. and last time modified at February twelveth 2013 at 3:33 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	4
events	0	constraints	0
reactions	8	function definitions	2
global parameters	0	unit definitions	3
rules	0	initial assignments	0

Model Notes

deBack2012 - Lineage Specification in Pancreas Development

This model of two neighbouring pancreas precursor cells, describes the exocrine versus endocrine lineage specification process. To account for the tissue scale patterns, this couplet model has been extended to hundreds of coupled cells.

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This model is described in the article: On the role of lateral stabilization during early patterning in the pancreas de Back W., Zhou JX, Brusch LJ. R. Soc. Interface 6 February 2013 vol. 10 no. 79 20120766

Abstract:

The cell fate decision of multi-potent pancreatic progenitor cells between the exocrine and endocrine lineages is regulated by Notch signalling, mediated by cellcell interactions. However, canonical models of Notch-mediated lateral inhibition cannot explain the scattered spatial distribution of endocrine cells and the cell-type ratio in the developing pancreas. Based on evidence from acinar-to-islet cell transdifferentiation in vitro, we propose that lateral stabilization, i.e. positive feedback between adjacent progenitor cells, acts in parallel with lateral inhibition to regulate pattern formation in the pancreas. A simple mathematical model of transcriptional regulation and cellcell interaction reveals the existence of multi-stability of spatial patterns whose simultaneous occurrence causes scattering of endocrine cells in the presence of noise. The scattering pattern allows for control of the endocrine-to-exocrine cell-type ratio by modulation of lateral stabilization strength. These theoretical results suggest a previously unrecognized role for lateral stabilization in lineage specification, spatial patterning and cell-type ratio control in organ development.

This model is hosted on BioModels Database and identified by: MODEL1211010000 .

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

2 Unit Definitions

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

2.1 Unit volume

Name volume

Definition ml

2.2 Unit time

Name time

Definition 60 s

2.3 Unit substance

Name substance

Definition mmol

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_1`	compartment		3	1	litre	☑	

3.1 Compartment `compartment_1`

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

Name 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
`species_1`	Xi	`compartment_1`	$\mathrm{mmol} \cdot \mathrm{ml}^{-1}$	⊟	⊟
`species_2`	Yi	`compartment_1`	$\mathrm{mmol} \cdot \mathrm{ml}^{-1}$	⊟	⊟
`species_3`	Xj	`compartment_1`	$\mathrm{mmol} \cdot \mathrm{ml}^{-1}$	⊟	⊟
`species_4`	Yj	`compartment_1`	$\mathrm{mmol} \cdot \mathrm{ml}^{-1}$	⊟	⊟

5 Function definitions

This is an overview of two function definitions.

5.1 Function definition `function_1`

Name Lateral inhibition [1]

Arguments theta, a, Xj, n

Mathematical Expression

$$\frac{\mathrm{theta}}{\mathrm{theta} + \mathrm{a} \cdot \mathrm{Xj}^{\mathrm{n}}} \tag{1}$$

5.2 Function definition `function_2`

Name Lateral stabilisation [1]

Arguments theta, b, Yi, Yj, n, c, Xi

Mathematical Expression

$$\frac{\mathrm{theta} + \mathrm{b} \cdot (\mathrm{Yi} \cdot \mathrm{Yj})^{\mathrm{n}}}{\mathrm{theta} + \mathrm{c} \cdot \mathrm{Xi}^{\mathrm{n}} + \mathrm{b} \cdot (\mathrm{Yi} \cdot \mathrm{Yj})^{\mathrm{n}}} \tag{2}$$

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 4: Overview of all reactions

№	Id	Name	Reaction Equation	SBO
1	`reaction_1`	Xi expr	$\emptyset \xrightarrow{\text{species\_3, species\_3}} \text{species\_1}$	
2	`reaction_2`	Xi degr	$\text{species\_1} \xrightarrow{\text{species\_1}} \emptyset$	
3	`reaction_3`	Yi expr	$\emptyset \xrightarrow{\text{species\_2, species\_4, species\_1, species\_2, species\_4, species\_1}} \text{species\_2}$	
4	`reaction_4`	Yi degr	$\text{species\_2} \xrightarrow{\text{species\_2}} \emptyset$	
5	`reaction_5`	Xj expr	$\emptyset \xrightarrow{\text{species\_1, species\_1}} \text{species\_3}$	
6	`reaction_6`	Xj degr	$\text{species\_3} \xrightarrow{\text{species\_3}} \emptyset$	
7	`reaction_7`	Yj expr	$\emptyset \xrightarrow{\text{species\_2, species\_4, species\_3, species\_2, species\_4, species\_3}} \text{species\_4}$	
8	`reaction_8`	Yj degr	$\text{species\_4} \xrightarrow{\text{species\_4}} \emptyset$	

6.1 Reaction `reaction_1`

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

Name Xi expr

Reaction equation

$$\emptyset \xrightarrow{\text{species\_3, species\_3}} \text{species\_1} \tag{3}$$

Modifiers

Table 5: Properties of each modifier.

Id	Name	SBO
`species_3`	Xj	
`species_3`	Xj	

Product

Table 6: Properties of each product.

Id	Name	SBO
`species_1`	Xi	

Kinetic Law

Derived unit contains undeclared units

$$v_1 = \mathrm{vol}\left(\mathrm{compartment\_1}\right) \cdot \mathrm{function\_1}\left(\mathrm{theta}, \mathrm{a}, [\mathrm{species\_3}], \mathrm{n}\right) \tag{4}$$

$$\mathrm{function\_1}\left(\mathrm{theta}, \mathrm{a}, \mathrm{Xj}, \mathrm{n}\right) = \frac{\mathrm{theta}}{\mathrm{theta} + \mathrm{a} \cdot \mathrm{Xj}^{\mathrm{n}}} \tag{5}$$

$$\mathrm{function\_1}\left(\mathrm{theta}, \mathrm{a}, \mathrm{Xj}, \mathrm{n}\right) = \frac{\mathrm{theta}}{\mathrm{theta} + \mathrm{a} \cdot \mathrm{Xj}^{\mathrm{n}}} \tag{6}$$

Table 7: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
`theta`	theta		10^{-4}		☑
`a`	a		1.000		☑
`n`	n		4.000		☑

6.2 Reaction `reaction_2`

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

Name Xi degr

Reaction equation

$$\text{species\_1} \xrightarrow{\text{species\_1}} \emptyset \tag{7}$$

Reactant

Table 8: Properties of each reactant.

Id	Name	SBO
`species_1`	Xi	

Modifier

Table 9: Properties of each modifier.

Id	Name	SBO
`species_1`	Xi	

Kinetic Law

Derived unit contains undeclared units

$$v_2 = \mathrm{vol}\left(\mathrm{compartment\_1}\right) \cdot \mathrm{k1} \cdot [\mathrm{species\_1}] \tag{8}$$

Table 10: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
`k1`	k1		1.0		☑

6.3 Reaction `reaction_3`

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

Name Yi expr

Reaction equation

$$\emptyset \xrightarrow{\text{species\_2, species\_4, species\_1, species\_2, species\_4, species\_1}} \text{species\_2} \tag{9}$$

Modifiers

Table 11: Properties of each modifier.

Id	Name	SBO
species_2	Yi	
species_4	Yj	
species_1	Xi	
species_2	Yi	
species_4	Yj	
species_1	Xi	

Product

Table 12: Properties of each product.

Id	Name	SBO
species_2	Yi	

Kinetic Law

Derived unit contains undeclared units

$$v_3 = \mathrm{vol}\left(\mathrm{compartment\_1}\right) \cdot \mathrm{function\_2}\left(\mathrm{theta}, \mathrm{b}, [\mathrm{species\_2}], [\mathrm{species\_4}], \mathrm{n}, \mathrm{c}, [\mathrm{species\_1}]\right) \tag{10}$$

$$\mathrm{function\_2}\left(\mathrm{theta}, \mathrm{b}, \mathrm{Yi}, \mathrm{Yj}, \mathrm{n}, \mathrm{c}, \mathrm{Xi}\right) = \frac{\mathrm{theta} + \mathrm{b} \cdot \left(\mathrm{Yi} \cdot \mathrm{Yj}\right)^{\mathrm{n}}}{\mathrm{theta} + \mathrm{c} \cdot \mathrm{Xi}^{\mathrm{n}} + \mathrm{b} \cdot \left(\mathrm{Yi} \cdot \mathrm{Yj}\right)^{\mathrm{n}}} \tag{11}$$

$$\mathrm{function\_2}\left(\mathrm{theta}, \mathrm{b}, \mathrm{Yi}, \mathrm{Yj}, \mathrm{n}, \mathrm{c}, \mathrm{Xi}\right) = \frac{\mathrm{theta} + \mathrm{b} \cdot \left(\mathrm{Yi} \cdot \mathrm{Yj}\right)^{\mathrm{n}}}{\mathrm{theta} + \mathrm{c} \cdot \mathrm{Xi}^{\mathrm{n}} + \mathrm{b} \cdot \left(\mathrm{Yi} \cdot \mathrm{Yj}\right)^{\mathrm{n}}} \tag{12}$$

Table 13: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
theta	theta		10^{-4}		☑
b	b		21.000		☑
n	n		4.000		☑
c	c		1.000		☑

6.4 Reaction `reaction_4`

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

Name Yi degr

Reaction equation

$$\text{species\_2} \xrightarrow{\text{species\_2}} \emptyset \tag{13}$$

Reactant

Table 14: Properties of each reactant.

Id	Name	SBO
`species_2`	Yi	

Modifier

Table 15: Properties of each modifier.

Id	Name	SBO
`species_2`	Yi	

Kinetic Law

Derived unit contains undeclared units

$$v_4 = \text{vol}\left(\text{compartment\_1}\right) \cdot \text{k1} \cdot [\text{species\_2}] \tag{14}$$

Table 16: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
`k1`	k1		1.0		☑

6.5 Reaction `reaction_5`

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

Name Xj expr

Reaction equation

$$\emptyset \xrightarrow{\text{species\_1, species\_1}} \text{species\_3} \tag{15}$$

Modifiers

Table 17: Properties of each modifier.

Id	Name	SBO
species_1	Xi	
species_1	Xi	

Product

Table 18: Properties of each product.

Id	Name	SBO
species_3	Xj	

Kinetic Law

Derived unit contains undeclared units

$$v_5 = \mathrm{vol}\left(\mathrm{compartment\_1}\right) \cdot \mathrm{function\_1}\left(\mathrm{theta}, \mathrm{a}, [\mathrm{species\_1}], \mathrm{n}\right) \tag{16}$$

$$\mathrm{function\_1}\left(\mathrm{theta}, \mathrm{a}, \mathrm{Xj}, \mathrm{n}\right) = \frac{\mathrm{theta}}{\mathrm{theta} + \mathrm{a} \cdot \mathrm{Xj}^{\mathrm{n}}} \tag{17}$$

$$\mathrm{function\_1}\left(\mathrm{theta}, \mathrm{a}, \mathrm{Xj}, \mathrm{n}\right) = \frac{\mathrm{theta}}{\mathrm{theta} + \mathrm{a} \cdot \mathrm{Xj}^{\mathrm{n}}} \tag{18}$$

Table 19: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
theta	theta		10^{-4}		☑
a	a		1.000		☑
n	n		4.000		☑

6.6 Reaction reaction_6

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

Name Xj degr

Reaction equation

$$\text{species\_3} \xrightarrow{\text{species\_3}} \emptyset \tag{19}$$

Reactant

Table 20: Properties of each reactant.

Id	Name	SBO
species_3	Xj	

Modifier

Table 21: Properties of each modifier.

Id	Name	SBO
species_3	Xj	

Kinetic Law

Derived unit contains undeclared units

$$v_6 = \text{vol}(\text{compartment\_1}) \cdot \text{k1} \cdot [\text{species\_3}] \tag{20}$$

Table 22: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
k1	k1		1.0		☑

6.7 Reaction reaction_7

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

Name Yj expr

Reaction equation

$$\emptyset \xrightarrow{\text{species\_2, species\_4, species\_3, species\_2, species\_4, species\_3}} \text{species\_4} \quad (21)$$

Modifiers

Table 23: Properties of each modifier.

Id	Name	SBO
species_2	Yi	
species_4	Yj	
species_3	Xj	
species_2	Yi	
species_4	Yj	
species_3	Xj	

Product

Table 24: Properties of each product.

Id	Name	SBO
species_4	Yj	

Kinetic Law

Derived unit contains undeclared units

$$v_7 = \mathrm{vol}\left(\mathrm{compartment\_1}\right) \cdot \mathrm{function\_2}\left(\mathrm{theta}, \mathrm{b}, [\mathrm{species\_2}], [\mathrm{species\_4}], \mathrm{n}, \mathrm{c}, [\mathrm{species\_3}]\right) \quad (22)$$

$$\mathrm{function\_2}\left(\mathrm{theta}, \mathrm{b}, \mathrm{Yi}, \mathrm{Yj}, \mathrm{n}, \mathrm{c}, \mathrm{Xi}\right) = \frac{\mathrm{theta} + \mathrm{b} \cdot \left(\mathrm{Yi} \cdot \mathrm{Yj}\right)^{\mathrm{n}}}{\mathrm{theta} + \mathrm{c} \cdot \mathrm{Xi}^{\mathrm{n}} + \mathrm{b} \cdot \left(\mathrm{Yi} \cdot \mathrm{Yj}\right)^{\mathrm{n}}} \quad (23)$$

$$\mathrm{function\_2}\left(\mathrm{theta}, \mathrm{b}, \mathrm{Yi}, \mathrm{Yj}, \mathrm{n}, \mathrm{c}, \mathrm{Xi}\right) = \frac{\mathrm{theta} + \mathrm{b} \cdot \left(\mathrm{Yi} \cdot \mathrm{Yj}\right)^{\mathrm{n}}}{\mathrm{theta} + \mathrm{c} \cdot \mathrm{Xi}^{\mathrm{n}} + \mathrm{b} \cdot \left(\mathrm{Yi} \cdot \mathrm{Yj}\right)^{\mathrm{n}}} \quad (24)$$

Table 25: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
theta	theta		10^{-4}		☑
b	b		21.000		☑
n	n		4.000		☑
c	c		1.000		☑

6.8 Reaction `reaction_8`

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

Name Yj degr

Reaction equation

$$\text{species\_4} \xrightarrow{\text{species\_4}} \emptyset \tag{25}$$

Reactant

Table 26: Properties of each reactant.

Id	Name	SBO
`species_4`	Yj	

Modifier

Table 27: Properties of each modifier.

Id	Name	SBO
`species_4`	Yj	

Kinetic Law

Derived unit contains undeclared units

$$v_8 = \text{vol}\left(\text{compartment\_1}\right) \cdot \text{k1} \cdot [\text{species\_4}] \tag{26}$$

Table 28: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
`k1`	k1		1.0		☑

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 species_1

Name Xi

Initial concentration $0 \text{ mmol} \cdot \text{ml}^{-1}$

This species takes part in seven reactions (as a reactant in reaction_2 and as a product in reaction_1 and as a modifier in reaction_2, reaction_3, reaction_3, reaction_5, reaction_5).

$$\frac{\mathrm{d}}{\mathrm{d}t}\text{species\_1} = v_1 - v_2 \tag{27}$$

7.2 Species species_2

Name Yi

Initial concentration $0 \text{ mmol} \cdot \text{ml}^{-1}$

This species takes part in seven reactions (as a reactant in reaction_4 and as a product in reaction_3 and as a modifier in reaction_3, reaction_3, reaction_4, reaction_7, reaction_7).

$$\frac{\mathrm{d}}{\mathrm{d}t}\text{species\_2} = v_3 - v_4 \tag{28}$$

7.3 Species species_3

Name Xj

Initial concentration $0 \text{ mmol} \cdot \text{ml}^{-1}$

This species takes part in seven reactions (as a reactant in reaction_6 and as a product in reaction_5 and as a modifier in reaction_1, reaction_1, reaction_6, reaction_7, reaction_7).

$$\frac{\mathrm{d}}{\mathrm{d}t}\text{species\_3} = v_5 - v_6 \tag{29}$$

7.4 Species species_4

Name Yj

Initial concentration $0\ \mathrm{mmol} \cdot \mathrm{ml}^{-1}$

This species takes part in seven reactions (as a reactant in reaction_8 and as a product in reaction_7 and as a modifier in reaction_3, reaction_3, reaction_7, reaction_7, reaction_8).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{species\_4} = v_7 - v_8 \tag{30}$$

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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