# SBML Model Report

# Model name: "Liebal2012 - B.subtilis sigB proteolysis model"

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 Ulf Liebal[2] at June sixth 2013 at 7:30 p. m. and last time modified at June tenth 2013 at 1:46 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 | 1 |
| species types | 0 | species | 4 |
| events | 0 | constraints | 0 |
| reactions | 3 | function definitions | 0 |
| global parameters | 7 | unit definitions | 0 |
| rules | 0 | initial assignments | 0 |

## Model Notes

Liebal2012 - B.subtilis sigB proteolysis model

An important transcription factor of B.subsilis is sigma $^B$ . Liebal et al. (2012) have performed experiments in B.subtilis wild type and mutant straits to test and validate a mathematical model of the dynamics of sigma $^B$ activity. The following three models were con-

---

[1]EMBL-EBI, `viji@ebi.ac.uk`
[2]The University of Rostock, `ulf.liebal@uni-rostock.de`

structed and their ability to fit the experimental data were tested. 1) Transcription inhibition model (MODEL1212180000), 2) sigma $^B$ proteolysis model (MODEL1302080000) and 3) Post-transcriptional instability model (MODEL1302080001). This model corresponds to the sigma $^B$ proteolysis model (MODEL1302080000).

This model is described in the article:Proteolysis of beta-galactosidase following SigmaB activation in Bacillus subtilis.Liebal UW, Sappa PK, Millat T, Steil L, Homuth G, Vlker U, Wolkenhauer O.2012 Jun;8(6):1806-14.

Abstract:

In Bacillus subtilis the (B) mediated general stress response provides protection against various environmental and energy related stress conditions. To better understand the general stress response, we need to explore the mechanism by which the components interact. Here, we performed experiments in B. subtilis wild type and mutant strains to test and validate a mathematical model of the dynamics of (B) activity. In the mutant strain BSA115, (B) transcription is inducible by the addition of IPTG and negative control of (B) activity by the anti-sigma factor RsbW is absent. In contrast to our expectations of a continuous -galactosidase activity from a ctc::lacZ fusion, we observed a transient activity in the mutant. To explain this experimental finding, we constructed mathematical models reflecting different hypotheses regarding the regulation of (B) and -galactosidase dynamics. Only the model assuming instability of either ctc::lacZ mRNA or -galactosidase protein is able to reproduce the experiments in silico. Subsequent Northern blot experiments revealed stable high-level ctc::lacZ mRNA concentrations after the induction of the (B) response. Therefore, we conclude that protein instability following (B) activation is the most likely explanation for the experimental observations. Our results thus support the idea that B. subtilis increases the cytoplasmic proteolytic degradation to adapt the proteome in face of environmental challenges following activation of the general stress response. The findings also have practical implications for the analysis of stress response dynamics using lacZ reporter gene fusions, a frequently used strategy for the (B) response.

Figure 3a of the reference article has been reproduced. beta-galactosidase (lacz in model) activity at different concentrations of IPTG (100M, 200M and 1000M) has been reproduced. SED-ML (Simulation Experiment Description Markup Language) file is available for this model (see curation tab).

This model is hosted on BioModels Database and identifiedby: MODEL1302080000 .

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 which are all predefined by SBML and not mentioned in the model.

Produced by SBML2LATEX

## 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 four species. The boundary condition of one of these species is set to `true` so that this species' amount cannot be changed by any reaction. 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 |
|----|------|-------------|--------------|----------|--------------------|
| IPTG | IPTG | compartment | $mol \cdot l^{-1}$ | ☑ | ☑ |
| sigb | sigb | compartment | $mol \cdot l^{-1}$ | ⊟ | ⊟ |
| lacz | lacz | compartment | $mol \cdot l^{-1}$ | ⊟ | ⊟ |
| x | x | compartment | $mol \cdot l^{-1}$ | ⊟ | ⊟ |

# 5 Parameters

This model contains seven global parameters.

Table 4: Properties of each parameter.

| Id | Name | SBO | Value | Unit | Constant |
|----|------|-----|-------|------|----------|
| kbd | kbd | | $5.8 \cdot 10^{-9}$ | | ☑ |
| kbs | kbs | | 100.000 | | ☑ |
| kbx | kbx | | $8.4 \cdot 10^{-5}$ | | ☑ |
| kxd | kxd | | $1.2 \cdot 10^{-13}$ | | ☑ |
| kxs | kxs | | $2 \cdot 10^{-6}$ | | ☑ |
| kzd | kzd | | 0.052 | | ☑ |
| kzs | kzs | | $1.7 \cdot 10^{-6}$ | | ☑ |

# 6 Reactions

This model contains three 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 | v1 | v1 | $\text{IPTG} \xrightleftharpoons{\text{x, IPTG, sigb, x}} \text{sigb}$ | |
| 2 | v2 | v2 | $\text{sigb} \xrightleftharpoons{\text{lacz, sigb}} \text{lacz}$ | |
| 3 | v3 | v3 | $\text{sigb} \xrightleftharpoons{\text{sigb, x}} \text{x}$ | |

## 6.1 Reaction v1

This is a reversible reaction of one reactant forming one product influenced by four modifiers.

**Name** v1

### Reaction equation

$$\text{IPTG} \xrightleftharpoons{\text{x, IPTG, sigb, x}} \text{sigb} \tag{1}$$

### Reactant

Table 6: Properties of each reactant.

| Id | Name | SBO |
|------|------|-----|
| IPTG | IPTG | |

### Modifiers

Table 7: Properties of each modifier.

| Id | Name | SBO |
|------|------|-----|
| x | x | |
| IPTG | IPTG | |
| sigb | sigb | |
| x | x | |

### Product

Table 8: Properties of each product.

| Id | Name | SBO |
|------|------|-----|
| sigb | sigb | |

### Kinetic Law

**Derived unit** contains undeclared units

$$v_1 = [\text{IPTG}] \cdot \text{kbs} - [\text{sigb}] \cdot (\text{kbd} + \text{kbx} \cdot [\text{x}]) \tag{2}$$

## 6.2 Reaction v2

This is a reversible reaction of one reactant forming one product influenced by two modifiers.

**Name** v2

<span style="color:#2e74b5">**Reaction equation**</span>

$$\text{sigb} \xrightleftharpoons{\text{lacz, sigb}} \text{lacz} \tag{3}$$

<span style="color:#2e74b5">**Reactant**</span>

Table 9: Properties of each reactant.

| Id | Name | SBO |
|----|------|-----|
| sigb | sigb | |

<span style="color:#2e74b5">**Modifiers**</span>

Table 10: Properties of each modifier.

| Id | Name | SBO |
|----|------|-----|
| lacz | lacz | |
| sigb | sigb | |

<span style="color:#2e74b5">**Product**</span>

Table 11: Properties of each product.

| Id | Name | SBO |
|----|------|-----|
| lacz | lacz | |

<span style="color:#2e74b5">**Kinetic Law**</span>

**Derived unit**  contains undeclared units

$$v_2 = (\text{kzd} \cdot [\text{lacz}]) + \text{kzs} \cdot [\text{sigb}] \tag{4}$$

## 6.3 Reaction v3

This is a reversible reaction of one reactant forming one product influenced by two modifiers.

**Name** v3

**Reaction equation**

$$\text{sigb} \xrightleftharpoons{\text{sigb, x}} \text{x} \tag{5}$$

**Reactant**

Table 12: Properties of each reactant.

| Id | Name | SBO |
|---|---|---|
| sigb | sigb | |

**Modifiers**

Table 13: Properties of each modifier.

| Id | Name | SBO |
|---|---|---|
| sigb | sigb | |
| x | x | |

**Product**

Table 14: Properties of each product.

| Id | Name | SBO |
|---|---|---|
| x | x | |

**Kinetic Law**

**Derived unit** contains undeclared units

$$v_3 = \text{kxs} \cdot [\text{sigb}] - \text{kxd} \cdot [\text{x}] \tag{6}$$

# 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 `IPTG`

**Name** IPTG

**Initial concentration** $100 \, \text{mol} \cdot \text{l}^{-1}$

This species takes part in two reactions (as a reactant in v1 and as a modifier in v1), which do not influence its rate of change because this constant species is on the boundary of the reaction system:

$$\frac{\text{d}}{\text{d}t}\text{IPTG} = 0 \tag{7}$$

## 7.2 Species `sigb`

**Name** sigb

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

This species takes part in six reactions (as a reactant in v2, v3 and as a product in v1 and as a modifier in v1, v2, v3).

$$\frac{\text{d}}{\text{d}t}\text{sigb} = v_1 - v_2 - v_3 \tag{8}$$

## 7.3 Species `lacz`

**Name** lacz

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

This species takes part in two reactions (as a product in v2 and as a modifier in v2).

$$\frac{\text{d}}{\text{d}t}\text{lacz} = v_2 \tag{9}$$

## 7.4 Species `x`

**Name** x

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

This species takes part in four reactions (as a product in v3 and as a modifier in v1, v1, v3).

$$\frac{\text{d}}{\text{d}t}\text{x} = v_3 \tag{10}$$