SBML Model Report

Model name: "Rattanakul2003_BoneFormationModel"

May 6, 2016

1 General Overview

This is a document in SBML Level 2 Version 3 format. This model was created by the following four authors: Catherine Lloyd[1], Vijayalakshmi Chelliah[2], Chontita Rattanakul[3] and Yongwimon Lenbury[4] at March 25th 2009 at 12:01 a. m. and last time modified at June eighth 2014 at 6:07 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	3
events	0	constraints	0
reactions	0	function definitions	0
global parameters	13	unit definitions	2
rules	3	initial assignments	0

Model Notes

This a model from the article:
Modeling of bone formation and resorption mediated by parathyroid hormone: response

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to estrogen/PTH therapy.
Rattanakul C, Lenbury Y, Krishnamara N, Wollkind DJ. Biosystems 2003:70(1):55-72. 12753937,
Abstract:
Bone, a major reservoir of body calcium, is under the hormonal control of the parathyroid hormone (PTH). Several aspects of its growth, turnover, and mechanism, occur in the absence of gonadal hormones. Sex steroids such as estrogen, nonetheless, play an important role in bone physiology, and are extremely essential to maintain bone balance in adults. In order to provide a basis for understanding the underlying mechanisms of bone remodeling as it is mediated by PTH, we propose here a mathematical model of the process. The nonlinear system model is then utilized to study the temporal effect of PTH as well as the action of estrogen replacement therapy on bone turnover. Analysis of the model is done on the assumption, supported by reported clinical evidence, that the process is characterized by highly diversified dynamics, which warrants the use of singular perturbation arguments. The model is shown to exhibit limit cycle behavior, which can develop into chaotic dynamics for certain ranges of the system's parametric values. Effects of estrogen and PTH administrations are then investigated by extending on the core model. Analysis of the model seems to indicate that the paradoxical observation that intermittent PTH administration causes net bone deposition while continuous administration causes net bone loss, and certain other reported phenomena may be attributed to the highly diversified dynamics which characterizes this nonlinear remodeling process.

This model was taken from the CellML repository and automatically converted to SBML.
The original model was: **rattananakul, lenbury, krishnamara, wollkind. (2003) - version01**
The original CellML model was created by:
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2 Unit Definitions

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

2.1 Unit `minute`

Name minute

Definition 60 s

2.2 Unit `time`

Name time

Definition 60 s

2.3 Unit `substance`

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

Definition mol

2.4 Unit `volume`

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

Definition l

2.5 Unit `area`

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

Definition m^2

2.6 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`		0000290	3	1		☑	

3.1 Compartment `Compartment`

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

SBO:0000290 physical compartment

4 Species

This model contains three 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	PTH	Compartment	$\mathrm{mol} \cdot \mathrm{l}^{-1}$	⊟	⊟
y	active osteoclasts	Compartment	$\mathrm{mol} \cdot \mathrm{l}^{-1}$	⊟	⊟
z	active osteoblasts	Compartment	$\mathrm{mol} \cdot \mathrm{l}^{-1}$	⊟	⊟

5 Parameters

This model contains 13 global parameters.

Table 4: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
epsilon	epsilon	0000002	0.100		☑
delta	delta	0000002	0.900		☑
a1	a1	0000002	0.050		☑
a2	a2	0000002	0.009		☑
a3	a3	0000002	0.675		☑
a4	a4	0000002	0.010		☑
a5	a5	0000002	0.005		☑
b1	b1	0000002	0.100		☑
b2	b2	0000002	0.300		☑
b3	b3	0000002	0.010		☑
k1	k1	0000009	0.100		☑
k2	k2	0000009	0.500		☑
k3	k3	0000009	0.025		☑

6 Rules

This is an overview of three rules.

6.1 Rule x

Rule x is a rate rule for species x:

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{x} = \frac{\mathrm{a1}}{\mathrm{k1} + [\mathrm{y}]} - \mathrm{b1} \cdot [\mathrm{x}] \tag{1}$$

6.2 Rule y

Rule y is a rate rule for species y:

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{y} = \mathrm{epsilon} \cdot \left(\frac{(\mathrm{a2} + \mathrm{a3} \cdot [\mathrm{x}]) \cdot [\mathrm{y}] \cdot [\mathrm{z}]}{\mathrm{k2} + [\mathrm{x}]^2} - \mathrm{b2} \cdot [\mathrm{y}] \right) \tag{2}$$

6.3 Rule z

Rule z is a rate rule for species z:

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{z} = \mathrm{epsilon} \cdot \mathrm{delta} \cdot \left(\mathrm{a4} \cdot [\mathrm{x}] - \left(\mathrm{b3} \cdot [\mathrm{z}] + \frac{\mathrm{a5} \cdot [\mathrm{x}] \cdot [\mathrm{z}]}{\mathrm{k3} + [\mathrm{x}]} \right) \right) \tag{3}$$

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 PTH

SBO:0000245 macromolecule

Initial concentration $2\ \mathrm{mol} \cdot \mathrm{l}^{-1}$

Involved in rule x

One rule which determines this species' quantity.

7.2 Species y

Name active osteoclasts

SBO:0000236 physical entity representation

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

Involved in rule y

One rule which determines this species' quantity.

7.3 Species z

Name active osteoblasts

SBO:0000236 physical entity representation

Initial concentration $0.15\ \mathrm{mol} \cdot \mathrm{l}^{-1}$

Involved in rule z

One rule which determines this species' quantity.

A Glossary of Systems Biology Ontology Terms

SBO:0000002 quantitative systems description parameter: A numerical value that defines certain characteristics of systems or system functions. It may be part of a calculation, but its value is not determined by the form of the equation itself, and may be arbitrarily assigned

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

SBO:0000236 physical entity representation: Representation of an entity that may participate in an interaction, a process or relationship of significance.

SBO:0000245 macromolecule: Molecular entity mainly built-up by the repetition of pseudo-identical units. CHEBI:3383

SBO:0000290 physical compartment: Specific location of space, that can be bounded or not. A physical compartment can have 1, 2 or 3 dimensions

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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