SBML Model Report

Model name: “DallaMan2007_MealModel-_GlucoseInsulinSystem”

May 5, 2016

1 General Overview

This is a document in SBML Level 2 Version 4 format. This model was created by Ishan Ajmera[1] at October third 2011 at 3:39 p. m. and last time modified at April eighth 2016 at 5:09 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	12
events	0	constraints	0
reactions	0	function definitions	0
global parameters	57	unit definitions	0
rules	29	initial assignments	0

Model Notes

This a model from the article:
Meal simulation model of the glucose-insulin system.
Dalla Man C, Rizza RA, Cobelli C.IEEE Trans Biomed Eng.2007 Oct;54(10):1740-9. 17926672,
Abstract:
A simulation model of the glucose-insulin system in the postprandial state can be useful in several circumstances, including testing of glucose sensors, insulin infusion algorithms and decision

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support systems for diabetes. Here, we present a new simulation model in normal humans that describes the physiological events that occur after a meal, by employing the quantitative knowledge that has become available in recent years. Model parameters were set to fit the mean data of a large normal subject database that underwent a triple tracer meal protocol which provided quasi-model-independent estimates of major glucose and insulin fluxes, e.g., meal rate of appearance, endogenous glucose production, utilization of glucose, insulin secretion. By decomposing the system into subsystems, we have developed parametric models of each subsystem by using a forcing function strategy. Model results are shown in describing both a single meal and normal daily life (breakfast, lunch, dinner) in normal. The same strategy is also applied on a smaller database for extending the model to type 2 diabetes

2 Unit Definitions

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

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
`Compartment1`	default		3	1	litre	☑	

3.1 Compartment `Compartment1`

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

Name default

4 Species

This model contains twelve 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
G_p	G_p	Compartment1	$\mathrm{mol} \cdot \mathrm{l}^{-1}$	☐	☐
G_t	G_t	Compartment1	$\mathrm{mol} \cdot \mathrm{l}^{-1}$	☐	☐
I_l	I_l	Compartment1	$\mathrm{mol} \cdot \mathrm{l}^{-1}$	☐	☐
I_p	I_p	Compartment1	$\mathrm{mol} \cdot \mathrm{l}^{-1}$	☐	☐
Q_sto1	Q_sto1	Compartment1	$\mathrm{mol} \cdot \mathrm{l}^{-1}$	☐	☐
Q_gut	Q_gut	Compartment1	$\mathrm{mol} \cdot \mathrm{l}^{-1}$	☐	☐
I_1	I_1	Compartment1	$\mathrm{mol} \cdot \mathrm{l}^{-1}$	☐	☐
I_d	I_d	Compartment1	$\mathrm{mol} \cdot \mathrm{l}^{-1}$	☐	☐
X	X	Compartment1	$\mathrm{mol} \cdot \mathrm{l}^{-1}$	☐	☐
I_po	I_po	Compartment1	$\mathrm{mol} \cdot \mathrm{l}^{-1}$	☐	☐
Y	Y	Compartment1	$\mathrm{mol} \cdot \mathrm{l}^{-1}$	☐	☐
Q_sto2	Q_sto2	Compartment1	$\mathrm{mol} \cdot \mathrm{l}^{-1}$	☐	☐

5 Parameters

This model contains 57 global parameters.

Table 4: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
V_G	V_G	0000468	1.880		☑
k_1	k_1	0000009	0.065		☑
k_2	k_2	0000009	0.079		☑
G_b	G_b	0000009	95.000		☑
V_I	V_I	0000468	0.050		☑
m_1	m_1	0000009	0.190		☑
m_2	m_2	0000009	0.484		☑
m_4	m_4	0000009	0.194		☑
m_5	m_5	0000009	0.030		☑
m_6	m_6	0000009	0.647		☑
HE_b	HE_b	0000009	0.600		☑
I_b	I_b	0000009	25.000		☑
S_b	S_b	0000009	1.800		☑
S_b_minus	S_b_minus	0000009	−1.800		☑
k_max	k_max	0000009	0.056		☑
k_min	k_min	0000009	0.008		☑
k_abs	k_abs	0000009	0.057		☑
k_gri	k_gri	0000009	0.056		☑
f	f	0000540	0.900		☑
b	b	0000009	0.820		☑
d	d	0000009	0.010		☑
BW	BW	0000002	78.000		☑
k_p1	k_p1	0000009	2.700		☑
k_p2	k_p2	0000009	0.002		☑
k_p3	k_p3	0000009	0.009		☑
k_p4	k_p4	0000009	0.062		☑
k_i	k_i	0000009	0.008		☑
U_ii	U_ii	0000375	1.000		☑
V_m0	V_m0	0000009	2.500		☑
V_mX	V_mX	0000009	0.047		☑
K_m0	K_m0	0000009	225.590		☑
p_2U	p_2U	0000009	0.033		☑
part	part	0000009	0.200		☑
K	K	0000009	2.300		☑
alpha	alpha	0000009	0.050		☑
beta	beta	0000009	0.110		☑
gamma	gamma	0000009	0.500		☑

Id	Name	SBO	Value	Unit	Constant
k_e1	k_e1	0000009	$5 \cdot 10^{-4}$		☑
k_e2	k_e2	0000009	339.000		☑
D	D	0000361	78000.000		☑
aa	aa	0000009	$1.78062678062678 \cdot 10^{-4}$		☐
cc	cc	0000009	0.003		☐
EGP	EGP	0000393	1.879		☐
V_mmax	V_mmax	0000009	2.000		☐
E	E	0000375	0.000		☐
S	S	0000375	1.800		☐
I	I	0000361	25.000		☐
G	G	0000361	94.681		☐
HE	HE	0000375	0.592		☐
m_3	m_3	0000009	0.276		☐
Q_sto	Q_sto	0000361	78000.000		☐
Ra	Ra	0000009	0.000		☐
k_empt	k_empt	0000009	0.055		☐
U_idm	U_idm	0000009	0.749		☐
U_id	U_id	0000009	0.749		☐
U	U	0000375	1.749		☐
S_po	S_po	0000375	1.768		☐

6 Rules

This is an overview of 29 rules.

6.1 Rule aa

Rule aa is an assignment rule for parameter aa:

$$\mathrm{aa} = \frac{\frac{\frac{5}{2}}{1-\mathrm{b}}}{\mathrm{D}} \tag{1}$$

6.2 Rule cc

Rule cc is an assignment rule for parameter cc:

$$\mathrm{cc} = \frac{\frac{\frac{5}{2}}{\mathrm{d}}}{\mathrm{D}} \tag{2}$$

6.3 Rule EGP

Rule EGP is an assignment rule for parameter EGP:

$$\mathrm{EGP} = \mathrm{k\_p1} - \mathrm{k\_p2} \cdot [\mathrm{G\_p}] - \mathrm{k\_p3} \cdot [\mathrm{I\_d}] - \mathrm{k\_p4} \cdot [\mathrm{I\_po}] \tag{3}$$

6.4 Rule V_mmax

Rule V_mmax is an assignment rule for parameter V_mmax:

$$\text{V\_mmax} = (1 - \text{part}) \cdot (\text{V\_m0} + \text{V\_mX} \cdot [\text{X}]) \tag{4}$$

6.5 Rule U_idm

Rule U_idm is an assignment rule for parameter U_idm:

$$\text{U\_idm} = \frac{\text{V\_mmax} \cdot [\text{G\_t}]}{\text{K\_m0} + [\text{G\_t}]} \tag{5}$$

6.6 Rule E

Rule E is an assignment rule for parameter E:

$$\text{E} = 0 \tag{6}$$

6.7 Rule S

Rule S is an assignment rule for parameter S:

$$\text{S} = \text{gamma} \cdot [\text{I\_po}] \tag{7}$$

6.8 Rule I

Rule I is an assignment rule for parameter I:

$$\text{I} = \frac{[\text{I\_p}]}{\text{V\_I}} \tag{8}$$

6.9 Rule G

Rule G is an assignment rule for parameter G:

$$\text{G} = \frac{[\text{G\_p}]}{\text{V\_G}} \tag{9}$$

6.10 Rule HE

Rule HE is an assignment rule for parameter HE:

$$\text{HE} = \text{m\_5} \cdot \text{S} + \text{m\_6} \tag{10}$$

6.11 Rule m_3

Rule m_3 is an assignment rule for parameter m_3:

$$\text{m\_3} = \frac{\text{HE} \cdot \text{m\_1}}{1 - \text{HE}} \tag{11}$$

6.12 Rule Q_sto

Rule Q_sto is an assignment rule for parameter Q_sto:

$$\mathrm{Q\_sto} = [\mathrm{Q\_sto1}] + [\mathrm{Q\_sto2}] \tag{12}$$

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

6.13 Rule Ra

Rule Ra is an assignment rule for parameter Ra:

$$\mathrm{Ra} = \frac{\mathrm{f} \cdot \mathrm{k\_abs} \cdot [\mathrm{Q\_gut}]}{\mathrm{BW}} \tag{13}$$

6.14 Rule k_empt

Rule k_empt is an assignment rule for parameter k_empt:

$$\mathrm{k\_empt} = \mathrm{k\_min} + \frac{\mathrm{k\_max} - \mathrm{k\_min}}{2} \cdot (\tanh(\mathrm{aa} \cdot (\mathrm{Q\_sto} - \mathrm{b} \cdot \mathrm{D})) - \tanh(\mathrm{cc} \cdot (\mathrm{Q\_sto} - \mathrm{d} \cdot \mathrm{D})) + 2) \tag{14}$$

6.15 Rule U_id

Rule U_id is an assignment rule for parameter U_id:

$$\mathrm{U\_id} = \mathrm{U\_idm} \tag{15}$$

6.16 Rule U

Rule U is an assignment rule for parameter U:

$$\mathrm{U} = \mathrm{U\_ii} + \mathrm{U\_id} \tag{16}$$

6.17 Rule S_po

Rule S_po is an assignment rule for parameter S_po:

$$\mathrm{S\_po} = [\mathrm{Y}] + \frac{\mathrm{K} \cdot (\mathrm{EGP} + \mathrm{Ra} - \mathrm{E} - \mathrm{U\_ii} - \mathrm{k\_1} \cdot [\mathrm{G\_p}] + \mathrm{k\_2} \cdot [\mathrm{G\_t}])}{\mathrm{V\_G}} + \mathrm{S\_b} \tag{17}$$

6.18 Rule G_p

Rule G_p is a rate rule for species G_p:

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{G\_p} = \mathrm{EGP} + \mathrm{Ra} - \mathrm{E} - \mathrm{U\_ii} - \mathrm{k\_1} \cdot [\mathrm{G\_p}] + \mathrm{k\_2} \cdot [\mathrm{G\_t}] \tag{18}$$

6.19 Rule G_t

Rule G_t is a rate rule for species G_t:

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{G\_t} = \mathrm{U\_id} + \mathrm{k\_1} \cdot [\mathrm{G\_p}] - \mathrm{k\_2} \cdot [\mathrm{G\_t}] \tag{19}$$

6.20 Rule I_l

Rule I_l is a rate rule for species I_l:

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{I\_l} = \mathrm{m\_1} \cdot [\mathrm{I\_l}] - \mathrm{m\_3} \cdot [\mathrm{I\_l}] + \mathrm{m\_2} \cdot [\mathrm{I\_p}] + \mathrm{S} \tag{20}$$

6.21 Rule I_p

Rule I_p is a rate rule for species I_p:

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{I\_p} = \mathrm{m\_2} \cdot [\mathrm{I\_p}] - \mathrm{m\_4} \cdot [\mathrm{I\_p}] + \mathrm{m\_1} \cdot [\mathrm{I\_l}] \tag{21}$$

6.22 Rule Q_sto1

Rule Q_sto1 is a rate rule for species Q_sto1:

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{Q\_sto1} = \mathrm{k\_gri} \cdot [\mathrm{Q\_sto1}] \tag{22}$$

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

6.23 Rule Q_sto2

Rule Q_sto2 is a rate rule for species Q_sto2:

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{Q\_sto2} = \mathrm{k\_empt} \cdot [\mathrm{Q\_sto2}] + \mathrm{k\_gri} \cdot [\mathrm{Q\_sto1}] \tag{23}$$

6.24 Rule Q_gut

Rule Q_gut is a rate rule for species Q_gut:

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{Q\_gut} = \mathrm{k\_abs} \cdot [\mathrm{Q\_gut}] + \mathrm{k\_empt} \cdot [\mathrm{Q\_sto2}] \tag{24}$$

6.25 Rule I_1

Rule I_1 is a rate rule for species I_1:

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{I\_1} = \mathrm{k\_i} \cdot ([\mathrm{I\_1}] - \mathrm{I}) \tag{25}$$

6.26 Rule I_d

Rule I_d is a rate rule for species I_d:

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{I\_d} = \mathrm{k\_i} \cdot ([\mathrm{I\_d}] - [\mathrm{I\_1}]) \quad (26)$$

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

6.27 Rule X

Rule X is a rate rule for species X:

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{X} = \mathrm{p\_2U} \cdot [\mathrm{X}] + \mathrm{p\_2U} \cdot (\mathrm{I} - \mathrm{I\_b}) \quad (27)$$

6.28 Rule I_po

Rule I_po is a rate rule for species I_po:

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{I\_po} = \mathrm{gamma} \cdot [\mathrm{I\_po}] + \mathrm{S\_po} \quad (28)$$

6.29 Rule Y

Rule Y is a rate rule for species Y:

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{Y} = \mathrm{alpha} \cdot ([\mathrm{Y}] - \mathrm{beta} \cdot (\mathrm{G} - \mathrm{G\_b})) \quad (29)$$

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 G_p

Name G_p

Initial amount 178 mol

Involved in rule G_p

One rule which determines this species' quantity.

7.2 Species G_t

Name G_t

Initial amount 135 mol

Involved in rule G_t

One rule which determines this species' quantity.

7.3 Species I_l

Name I_l

Initial amount 4.5 mol

Involved in rule I_l

One rule which determines this species' quantity.

7.4 Species I_p

Name I_p

Initial amount 1.25 mol

Involved in rule I_p

One rule which determines this species' quantity.

7.5 Species Q_sto1

Name Q_sto1

Initial amount 78000 mol

Involved in rule Q_sto1

One rule which determines this species' quantity.

7.6 Species Q_gut

Name Q_gut

Initial amount 0 mol

Involved in rule Q_gut

One rule which determines this species' quantity.

7.7 Species I_1

Name I_1

Initial amount 25 mol

Involved in rule I_1

One rule which determines this species' quantity.

7.8 Species I_d

Name I_d

SBO:0000375 process

Initial amount 25 mol

Involved in rule I_d

One rule which determines this species' quantity.

7.9 Species X

Name X

Initial amount 0 mol

Involved in rule X

One rule which determines this species' quantity.

7.10 Species I_po

Name I_po

Initial amount 3.6 mol

Involved in rule I_po

One rule which determines this species' quantity.

7.11 Species Y

Name Y

SBO:0000236 physical entity representation

Initial amount 0 mol

Involved in rule Y

One rule which determines this species' quantity.

7.12 Species `Q_sto2`

Name Q_sto2

Initial amount 0 mol

Involved in rule `Q_sto2`

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:0000361 **amount of an entity pool:** A numerical measure of the quantity, or of some property, of the entities that constitute the entity pool.

SBO:0000375 **process:** A sequential series of actions, motions, or occurrences, such as chemical reactions, that affect one or more entities in a phenomenologically characteristic manner

SBO:0000393 **production:** Generation of a material or conceptual entity.

SBO:0000468 **volume:** A quantity representing the three-dimensional space occupied by all or part of an object

SBO:0000540 **fraction of an entity pool:** A ratio that represents the quantity of a defined constituent entity over the total number of all constituent entities present.

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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