SBML Model Report

Model name: “Noguchi2013 - Insulin dependent glucose metabolism”

May 6, 2016

1 General Overview

This is a document in SBML Level 2 Version 4 format.

Notes Created by The MathWorks, Inc. SimBiology tool, Version 4.0

Document Notes

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This model was created by the following two authors: Vijayalakshmi Chelliah[1] and Rei Noguchi[2] at September 23rd 2013 at 11:08 a. m. and last time modified at October tenth 2014 at 10:31 a. 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	3
species types	0	species	23
events	0	constraints	0
reactions	29	function definitions	0
global parameters	56	unit definitions	1
rules	0	initial assignments	0

[1]EMBL-EBI, viji@ebi.ac.uk

[2]Department of Computational Biology, Graduate School of Frontier Sciences, The University of Tokyo, Kashiwa, Chiba, Japan, noguchi@bi.s.u-tokyo.ac.jp

2 Unit Definitions

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

2.1 Unit MWDERIVEDUNIT_nanomole__litre

Name nanomole/litre

Definition $\mathrm{m}^{-3} \cdot \mathrm{mol} \cdot 10^{-6}$ dimensionless

2.2 Unit substance

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

Definition mol

2.3 Unit volume

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

Definition l

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

2.6 Unit time

Notes Second is the predefined SBML unit for `time`.

Definition s

3 Compartments

This model contains three compartments.

Table 2: Properties of all compartments.

Id	Name	SBO	Spatial Dimensions	Size	Unit	Constant	Outside
`default`	default		3	1	litre	☑	
`Vex`	Vex		3	0.0040		☑	`default`
`Vin`	Vin		3	$2.64 \cdot 10^{-5}$		☑	`default`

3.1 Compartment `default`

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

Name default

3.2 Compartment `Vex`

This is a three dimensional compartment with a constant size of 0.0040 litre, which is surrounded by `default` (default).

Name Vex

3.3 Compartment `Vin`

This is a three dimensional compartment with a constant size of $2.64 \cdot 10^{-5}$ litre, which is surrounded by `default` (default).

Name Vin

4 Species

This model contains 23 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
GP	GP	default	$\mathrm{mol} \cdot \mathrm{l}^{-1}$	⊟	⊟
pGP	pGP	default	$\mathrm{mol} \cdot \mathrm{l}^{-1}$	⊟	⊟
mRNA	mRNA	default	$\mathrm{mol} \cdot \mathrm{l}^{-1}$	⊟	⊟
PEPCK	PEPCK	default	$\mathrm{mol} \cdot \mathrm{l}^{-1}$	⊟	⊟
IRS	IRS	default	$\mathrm{mol} \cdot \mathrm{l}^{-1}$	⊟	⊟
p1IRS	p1IRS	default	$\mathrm{mol} \cdot \mathrm{l}^{-1}$	⊟	⊟
p2IRS	p2IRS	default	$\mathrm{mol} \cdot \mathrm{l}^{-1}$	⊟	⊟
p1p2IRS	p1p2IRS	default	$\mathrm{mol} \cdot \mathrm{l}^{-1}$	⊟	⊟
Akt	Akt	default	$\mathrm{mol} \cdot \mathrm{l}^{-1}$	⊟	⊟
pAkt	pAkt	default	$\mathrm{mol} \cdot \mathrm{l}^{-1}$	⊟	⊟
mTOR	mTOR	default	$\mathrm{mol} \cdot \mathrm{l}^{-1}$	⊟	⊟
pmTOR	pmTOR	default	$\mathrm{mol} \cdot \mathrm{l}^{-1}$	⊟	⊟
Foxo	Foxo	default	$\mathrm{mol} \cdot \mathrm{l}^{-1}$	⊟	⊟
pFoxo	pFoxo	default	$\mathrm{mol} \cdot \mathrm{l}^{-1}$	⊟	⊟
PYRout	PYRout	Vex	$\mathrm{mol} \cdot \mathrm{l}^{-1}$	⊟	⊟
GLCex	GLCex	Vex	$\mathrm{mol} \cdot \mathrm{l}^{-1}$	⊟	⊟
F16P	F16P	Vin	$\mathrm{mol} \cdot \mathrm{l}^{-1}$	⊟	⊟
PYRin	PYRin	Vin	$\mathrm{mol} \cdot \mathrm{l}^{-1}$	⊟	⊟
LAC	LAC	Vin	$\mathrm{mol} \cdot \mathrm{l}^{-1}$	⊟	⊟
OAA	OAA	Vin	$\mathrm{mol} \cdot \mathrm{l}^{-1}$	⊟	⊟
GLY	GLY	Vin	$\mathrm{mol} \cdot \mathrm{l}^{-1}$	⊟	⊟
G1P	G1P	Vin	$\mathrm{mol} \cdot \mathrm{l}^{-1}$	⊟	⊟

Id	Name	Compartment	Derived Unit	Constant	Boundary Condition
G6P	G6P	Vin	$\mathrm{mol} \cdot \mathrm{l}^{-1}$	⊟	⊟

5 Parameters

This model contains 56 global parameters.

Table 4: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
V1	V1		8.970		☑
K1	K1		0.045		☑
V2_G6P	V2_G6P		7.710		☑
K2_G6P	K2_G6P		925.000		☑
V2_F16P	V2_F16P		0.084		☑
K2_F16P	K2_F16P		0.597		☑
V3	V3		0.002		☑
K3	K3		2.920		☑
V6	V6		0.002		☑
K6	K6		0.996		☑
V7	V7		$2.84 \cdot 10^{-5}$		☑
K7	K7		8.430		☑
V4_PYR	V4_PYR		23.600		☑
K4_PYR	K4_PYR		56.400		☑
V4_LAC	V4_LAC		$1.2 \cdot 10^{-6}$		☑
K4_LAC	K4_LAC		0.015		☑
V8_G6P	V8_G6P		$2.02 \cdot 10^{-5}$		☑
K8_G6P	K8_G6P		0.791		☑
V8_G1P	V8_G1P		0.040		☑
K8_G1P	K8_G1P		69.800		☑
V5	V5		0.001		☑
K5	K5		0.228		☑
V9_G1P	V9_G1P		0.488		☑
K9_G1P	K9_G1P		2.690		☑
V9_GLY	V9_GLY		$1.02 \cdot 10^{-6}$		☑
K9_GLY	K9_GLY		$6.23 \cdot 10^{-4}$		☑
k3	k3		112.760		☑
k4	k4		1.945		☑
s1	s1		1.722		☑
s2	s4		214.700		☑
s3	s2		46.540		☑
s4	s3		1.190		☑
k1_PEPCK	k1_PEPCK		0.122		☑
k2_PEPCK	k2_PEPCK		0.005		☑
k3_PEPCK	k3_PEPCK		486.280		☑
k4_PEPCK	k4_PEPCK		0.005		☑
k5_PEPCK	k5_PEPCK		$1.0958 \cdot 10^{-4}$		☑

Id	Name	SBO	Value	Unit	Constant
k6_PEPCK	k6_PEPCK		0.002		☑
param1	param1		5.570		☑
param2	param2		2.397		☑
param3	param3		0.021		☑
param4	param4		$1.214 \cdot 10^{-5}$		☑
param5	param5		0.275		☑
param6	param6		0.007		☑
param7	param7		758.120		☑
param8	param8		0.918		☑
param9	param9		0.041		☑
param10	param10		$1.3032 \cdot 10^{-4}$		☑
param11	param11		$1.92 \cdot 10^{-4}$		☑
param12	param12		0.029		☑
param13	param13		$4.4307 \cdot 10^{-5}$		☑
param14	param14		0.352		☑
param15	param15		$3.1385 \cdot 10^{-5}$		☑
param16	param16		0.010		☑
proIRS	proIRS		888.770		☑
insulin	insulin		100.000	$m^{-3} \cdot mol \cdot 10^{-6}$ dimensionless	☑

6 Reactions

This model contains 29 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	$\mathrm{GLCex} \xrightleftharpoons{\mathrm{GLCex,\ G6P}} \mathrm{G6P}$	
2	v2	v2	$\mathrm{pAkt} + \mathrm{G6P} \xrightleftharpoons{\mathrm{pAkt,\ G6P,\ F16P}} \mathrm{pAkt} + \mathrm{F16P}$	
3	v3	v3	$\mathrm{F16P} \xrightarrow{\mathrm{F16P}} \mathrm{PYRin}$	
4	v4	v4	$\mathrm{PYRin} \xrightleftharpoons{\mathrm{PYRin,\ LAC}} \mathrm{LAC}$	
5	v5	v5	$\mathrm{PYRout} \xrightleftharpoons{\mathrm{PYRout,\ PYRin}} \mathrm{PYRin}$	
6	v6	v6	$\mathrm{PYRin} \xrightarrow{\mathrm{PYRin}} \mathrm{OAA}$	
7	v7	v7	$\mathrm{PEPCK} + \mathrm{OAA} \xrightarrow{\mathrm{PEPCK,\ OAA}} \mathrm{PEPCK} + \mathrm{F16P}$	
8	v8	v8	$\mathrm{pAkt} + \mathrm{G6P} \xrightleftharpoons{\mathrm{pAkt,\ G6P,\ G1P}} \mathrm{pAkt} + \mathrm{G1P}$	
9	v9	v9	$\mathrm{pGP} + \mathrm{G1P} \xrightleftharpoons{\mathrm{G1P,\ pGP,\ GLY}} \mathrm{pGP} + \mathrm{GLY}$	
10	metabolicENZ	metabolicENZ1	$\mathrm{pGP} + \mathrm{G6P} \xrightarrow{\mathrm{pGP,\ G6P}} \mathrm{GP} + \mathrm{G6P}$	
11	reaction1	reaction1	$\emptyset \xrightarrow{\mathrm{IRS}} \mathrm{IRS}$	
12	reaction2	reaction2	$\mathrm{IRS} \xrightleftharpoons{\mathrm{IRS,\ p1IRS}} \mathrm{p1IRS}$	
13	reaction3	reaction3	$\mathrm{p1IRS} \xrightarrow{\mathrm{p1IRS}} \emptyset$	
14	reaction4	reaction4	$\mathrm{p1IRS} + \mathrm{pmTOR} \xrightarrow{\mathrm{p1IRS,\ pmTOR}} \mathrm{p1p2IRS} + \mathrm{pmTOR}$	
15	reaction5	reaction5	$\mathrm{p1p2IRS} \xrightarrow{\mathrm{p1p2IRS}} \mathrm{p1IRS}$	

№	Id	Name	Reaction Equation	SBO
16	reaction6	reaction6	$\mathrm{IRS} + \mathrm{pmTOR} \xrightarrow{\mathrm{IRS,\ pmTOR}} \mathrm{p2IRS} + \mathrm{pmTOR}$	
17	reaction7	reaction7	$\mathrm{p2IRS} \xrightarrow{\mathrm{p2IRS}} \mathrm{IRS}$	
18	reaction8	reaction8	$\mathrm{p2IRS} \xrightarrow{\mathrm{p2IRS}} \emptyset$	
19	reaction9	reaction9	$\mathrm{p2IRS} \xrightleftharpoons{\mathrm{p2IRS,\ p1p2IRS}} \mathrm{p1p2IRS}$	
20	reaction10	reaction10	$\mathrm{p1p2IRS} \xrightarrow{\mathrm{p1p2IRS}} \emptyset$	
21	reaction11	reaction11	$\mathrm{Akt} + \mathrm{p1IRS} \xrightarrow{\mathrm{p1IRS,\ Akt}} \mathrm{pAkt} + \mathrm{p1IRS}$	
22	reaction12	reaction12	$\mathrm{pAkt} \xrightarrow{\mathrm{pAkt}} \mathrm{Akt}$	
23	reaction13	reaction13	$\mathrm{mTOR} + \mathrm{pAkt} \xrightarrow{\mathrm{mTOR,\ pAkt}} \mathrm{pmTOR} + \mathrm{pAkt}$	
24	reaction14	reaction14	$\mathrm{pmTOR} \xrightarrow{\mathrm{pmTOR}} \mathrm{mTOR}$	
25	reaction15	reaction15	$\mathrm{Foxo} + \mathrm{pAkt} \xrightarrow{\mathrm{pAkt,\ Foxo}} \mathrm{pFoxo} + \mathrm{pAkt}$	
26	reactionPEP1	reactionPEP1	$\mathrm{Foxo} \xrightarrow{\mathrm{Foxo,\ mRNA}} \mathrm{mRNA} + \mathrm{Foxo}$	
27	reactionPEP2	reactionPEP2	$\mathrm{mRNA} \xrightarrow{\mathrm{mRNA,\ PEPCK}} \mathrm{PEPCK} + \mathrm{mRNA}$	
28	mw7c079c91-_51e3-_4732_8dca-_23fb3cd716a7	reaction16	$\mathrm{pFoxo} \xrightarrow{\mathrm{pFoxo}} \mathrm{Foxo}$	
29	mwfc720c89-_b1b3-_416a_8958-_e9d0aff9f4a6	metabolicENZ2	$\mathrm{GP} \xrightarrow{\mathrm{GP}} \mathrm{pGP}$	

6.1 Reaction v1

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

Name v1

Reaction equation

$$\mathrm{GLCex} \xrightleftharpoons{\mathrm{GLCex,\ G6P}} \mathrm{G6P} \tag{1}$$

Reactant

Table 6: Properties of each reactant.

Id	Name	SBO
GLCex	GLCex	

Modifiers

Table 7: Properties of each modifier.

Id	Name	SBO
GLCex	GLCex	
G6P	G6P	

Product

Table 8: Properties of each product.

Id	Name	SBO
G6P	G6P	

Kinetic Law

Derived unit contains undeclared units

$$v_1 = \frac{\mathrm{V1} \cdot \frac{[\mathrm{GLCex}]}{\mathrm{K1}} - \mathrm{V1} \cdot \frac{[\mathrm{G6P}]}{\mathrm{K1}}}{1 + \frac{[\mathrm{GLCex}]}{\mathrm{K1}} + \frac{[\mathrm{G6P}]}{\mathrm{K1}}} \tag{2}$$

6.2 Reaction v2

This is a reversible reaction of two reactants forming two products influenced by three modifiers.

Name v2

Reaction equation

$$\mathrm{pAkt} + \mathrm{G6P} \overset{\mathrm{pAkt,\ G6P,\ F16P}}{\rightleftharpoons} \mathrm{pAkt} + \mathrm{F16P} \tag{3}$$

Reactants

Table 9: Properties of each reactant.

Id	Name	SBO
pAkt	pAkt	
G6P	G6P	

Modifiers

Table 10: Properties of each modifier.

Id	Name	SBO
pAkt	pAkt	
G6P	G6P	
F16P	F16P	

Products

Table 11: Properties of each product.

Id	Name	SBO
pAkt	pAkt	
F16P	F16P	

Kinetic Law

Derived unit contains undeclared units

$$v_2 = \frac{\frac{(1+\mathrm{s1}\cdot[\mathrm{pAkt}])\cdot \mathrm{V2\_G6P}\cdot[\mathrm{G6P}]}{\mathrm{K2\_G6P}} - \frac{\mathrm{V2\_F16P}\cdot[\mathrm{F16P}]}{\mathrm{K2\_F16P}}}{1 + \frac{[\mathrm{G6P}]}{\mathrm{K2\_G6P}} + \frac{[\mathrm{F16P}]}{\mathrm{K2\_F16P}}} \tag{4}$$

6.3 Reaction v3

This is an irreversible reaction of one reactant forming one product influenced by one modifier.

Name v3

Reaction equation

$$\mathrm{F16P} \xrightarrow{\mathrm{F16P}} \mathrm{PYRin} \tag{5}$$

Reactant

Table 12: Properties of each reactant.

Id	Name	SBO
F16P	F16P	

Modifier

Table 13: Properties of each modifier.

Id	Name	SBO
F16P	F16P	

Product

Table 14: Properties of each product.

Id	Name	SBO
PYRin	PYRin	

Kinetic Law

Derived unit contains undeclared units

$$v_3 = \frac{\mathrm{V3} \cdot [\mathrm{F16P}]}{\mathrm{K3} + [\mathrm{F16P}]} \tag{6}$$

6.4 Reaction v4

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

Name v4

Reaction equation

$$\mathrm{PYRin} \underset{}{\overset{\mathrm{PYRin,\ LAC}}{\rightleftharpoons}} \mathrm{LAC} \tag{7}$$

Reactant

Table 15: Properties of each reactant.

Id	Name	SBO
PYRin	PYRin	

Modifiers

Table 16: Properties of each modifier.

Id	Name	SBO
PYRin	PYRin	
LAC	LAC	

Product

Table 17: Properties of each product.

Id	Name	SBO
LAC	LAC	

Kinetic Law

Derived unit contains undeclared units

$$v_4 = \frac{\frac{\text{V4\_PYR}\cdot[\text{PYRin}]}{\text{K4\_PYR}} - \frac{\text{V4\_LAC}\cdot[\text{LAC}]}{\text{K4\_LAC}}}{1 + \frac{[\text{PYRin}]}{\text{K4\_PYR}} + \frac{[\text{LAC}]}{\text{K4\_LAC}}} \tag{8}$$

6.5 Reaction v5

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

Name v5

Reaction equation

$$\text{PYRout} \underset{\text{PYRout, PYRin}}{\rightleftharpoons} \text{PYRin} \tag{9}$$

Reactant

Table 18: Properties of each reactant.

Id	Name	SBO
PYRout	PYRout	

Modifiers

Table 19: Properties of each modifier.

Id	Name	SBO
PYRout	PYRout	
PYRin	PYRin	

Product

Table 20: Properties of each product.

Id	Name	SBO
PYRin	PYRin	

Kinetic Law

Derived unit contains undeclared units

$$v_5 = \frac{\frac{V5 \cdot [PYRout]}{K5} - \frac{V5 \cdot [PYRin]}{K5}}{1 + \frac{[PYRout]}{K5} + \frac{[PYRin]}{K5}} \tag{10}$$

6.6 Reaction v6

This is an irreversible reaction of one reactant forming one product influenced by one modifier.

Name v6

Reaction equation

$$\text{PYRin} \xrightarrow{\text{PYRin}} \text{OAA} \tag{11}$$

Reactant

Table 21: Properties of each reactant.

Id	Name	SBO
PYRin	PYRin	

Modifier

Table 22: Properties of each modifier.

Id	Name	SBO
PYRin	PYRin	

Product

Table 23: Properties of each product.

Id	Name	SBO
OAA	OAA	

Kinetic Law

Derived unit contains undeclared units

$$v_6 = \frac{\mathrm{V6} \cdot [\mathrm{PYRin}]}{\mathrm{K6} + [\mathrm{PYRin}]} \tag{12}$$

6.7 Reaction v7

This is an irreversible reaction of two reactants forming two products influenced by two modifiers.

Name v7

Reaction equation

$$\mathrm{PEPCK} + \mathrm{OAA} \xrightarrow{\text{PEPCK, OAA}} \mathrm{PEPCK} + \mathrm{F16P} \tag{13}$$

Reactants

Table 24: Properties of each reactant.

Id	Name	SBO
PEPCK	PEPCK	
OAA	OAA	

Modifiers

Table 25: Properties of each modifier.

Id	Name	SBO
PEPCK	PEPCK	
OAA	OAA	

Products

Table 26: Properties of each product.

Id	Name	SBO
PEPCK	PEPCK	
F16P	F16P	

Kinetic Law

Derived unit contains undeclared units

$$v_7 = \frac{(1 + \mathrm{s3} \cdot [\mathrm{PEPCK}]) \cdot \mathrm{V7} \cdot [\mathrm{OAA}]}{\mathrm{K7} + [\mathrm{OAA}]} \tag{14}$$

6.8 Reaction v8

This is a reversible reaction of two reactants forming two products influenced by three modifiers.

Name v8

Reaction equation

$$\mathrm{pAkt} + \mathrm{G6P} \xrightleftharpoons{\mathrm{pAkt,\ G6P,\ G1P}} \mathrm{pAkt} + \mathrm{G1P} \tag{15}$$

Reactants

Table 27: Properties of each reactant.

Id	Name	SBO
pAkt	pAkt	
G6P	G6P	

Modifiers

Table 28: Properties of each modifier.

Id	Name	SBO
pAkt	pAkt	
G6P	G6P	
G1P	G1P	

Products

Table 29: Properties of each product.

Id	Name	SBO
pAkt	pAkt	
G1P	G1P	

Kinetic Law

Derived unit contains undeclared units

$$v_8 = \frac{\frac{(1+s4\cdot[\mathrm{pAkt}])\cdot \mathrm{V8\_G6P}\cdot[\mathrm{G6P}]}{\mathrm{K8\_G6P}} - \frac{\mathrm{V8\_G1P}\cdot[\mathrm{G1P}]}{\mathrm{K8\_G1P}}}{1 + \frac{[\mathrm{G6P}]}{\mathrm{K8\_G6P}} + \frac{[\mathrm{G1P}]}{\mathrm{K8\_G1P}}} \tag{16}$$

6.9 Reaction v9

This is a reversible reaction of two reactants forming two products influenced by three modifiers.

Name v9

Reaction equation

$$\mathrm{pGP} + \mathrm{G1P} \xrightleftharpoons{\mathrm{G1P,\ pGP,\ GLY}} \mathrm{pGP} + \mathrm{GLY} \tag{17}$$

Reactants

Table 30: Properties of each reactant.

Id	Name	SBO
pGP	pGP	
G1P	G1P	

Modifiers

Table 31: Properties of each modifier.

Id	Name	SBO
G1P	G1P	
pGP	pGP	
GLY	GLY	

Products

Table 32: Properties of each product.

Id	Name	SBO
pGP	pGP	
GLY	GLY	

Kinetic Law

Derived unit contains undeclared units

$$v_9 = \frac{\frac{\text{V9\_G1P}\cdot[\text{G1P}]}{\text{K9\_G1P}} - \frac{(1+\text{s2}\cdot[\text{pGP}])\cdot\text{V9\_GLY}\cdot[\text{GLY}]}{\text{K9\_GLY}}}{1 + \frac{[\text{G1P}]}{\text{K9\_G1P}} + \frac{[\text{GLY}]}{\text{K9\_GLY}}} \tag{18}$$

6.10 Reaction metabolicENZ

This is an irreversible reaction of two reactants forming two products influenced by two modifiers.

Name metabolicENZ1

Reaction equation

$$\text{pGP} + \text{G6P} \xrightarrow{\text{pGP, G6P}} \text{GP} + \text{G6P} \tag{19}$$

Reactants

Table 33: Properties of each reactant.

Id	Name	SBO
pGP	pGP	
G6P	G6P	

Modifiers

Table 34: Properties of each modifier.

Id	Name	SBO
pGP	pGP	
G6P	G6P	

Products

Table 35: Properties of each product.

Id	Name	SBO
GP	GP	
G6P	G6P	

Kinetic Law

Derived unit contains undeclared units

$$v_{10} = [\mathrm{pGP}] \cdot [\mathrm{G6P}] \cdot \mathrm{k4} \tag{20}$$

6.11 Reaction `reaction1`

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

Name reaction1

Reaction equation

$$\emptyset \xrightarrow{\mathrm{IRS}} \mathrm{IRS} \tag{21}$$

Modifier

Table 36: Properties of each modifier.

Id	Name	SBO
IRS	IRS	

Product

Table 37: Properties of each product.

Id	Name	SBO
IRS	IRS	

Kinetic Law

Derived unit contains undeclared units

$$v_{11} = (\text{proIRS} - [\text{IRS}]) \cdot \text{param1} \tag{22}$$

6.12 Reaction `reaction2`

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

Name reaction2

Reaction equation

$$\text{IRS} \underset{}{\overset{\text{IRS, p1IRS}}{\rightleftharpoons}} \text{p1IRS} \tag{23}$$

Reactant

Table 38: Properties of each reactant.

Id	Name	SBO
IRS	IRS	

Modifiers

Table 39: Properties of each modifier.

Id	Name	SBO
IRS	IRS	

Id	Name	SBO
p1IRS	p1IRS	

Product

Table 40: Properties of each product.

Id	Name	SBO
p1IRS	p1IRS	

Kinetic Law

Derived unit contains undeclared units

$$v_{12} = [\text{IRS}] \cdot \text{insulin} \cdot \text{param2} - [\text{p1IRS}] \cdot \text{param3} \tag{24}$$

6.13 Reaction `reaction3`

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

Name reaction3

Reaction equation

$$\text{p1IRS} \xrightarrow{\text{p1IRS}} \emptyset \tag{25}$$

Reactant

Table 41: Properties of each reactant.

Id	Name	SBO
p1IRS	p1IRS	

Modifier

Table 42: Properties of each modifier.

Id	Name	SBO
p1IRS	p1IRS	

Kinetic Law

Derived unit contains undeclared units

$$v_{13} = [\text{p1IRS}] \cdot \text{param4} \tag{26}$$

6.14 Reaction `reaction4`

This is an irreversible reaction of two reactants forming two products influenced by two modifiers.

Name reaction4

Reaction equation

$$\text{p1IRS} + \text{pmTOR} \xrightarrow{\text{p1IRS, pmTOR}} \text{p1p2IRS} + \text{pmTOR} \tag{27}$$

Reactants

Table 43: Properties of each reactant.

Id	Name	SBO
`p1IRS`	p1IRS	
`pmTOR`	pmTOR	

Modifiers

Table 44: Properties of each modifier.

Id	Name	SBO
`p1IRS`	p1IRS	
`pmTOR`	pmTOR	

Products

Table 45: Properties of each product.

Id	Name	SBO
`p1p2IRS`	p1p2IRS	
`pmTOR`	pmTOR	

Kinetic Law

Derived unit contains undeclared units

$$v_{14} = [\text{p1IRS}] \cdot [\text{pmTOR}] \cdot \text{param5} \tag{28}$$

6.15 Reaction `reaction5`

This is an irreversible reaction of one reactant forming one product influenced by one modifier.

Name reaction5

Reaction equation

$$\text{p1p2IRS} \xrightarrow{\text{p1p2IRS}} \text{p1IRS} \tag{29}$$

Reactant

Table 46: Properties of each reactant.

Id	Name	SBO
p1p2IRS	p1p2IRS	

Modifier

Table 47: Properties of each modifier.

Id	Name	SBO
p1p2IRS	p1p2IRS	

Product

Table 48: Properties of each product.

Id	Name	SBO
p1IRS	p1IRS	

Kinetic Law

Derived unit contains undeclared units

$$v_{15} = [\text{p1p2IRS}] \cdot \text{param6} \tag{30}$$

6.16 Reaction reaction6

This is an irreversible reaction of two reactants forming two products influenced by two modifiers.

Name reaction6

Reaction equation

$$\mathrm{IRS} + \mathrm{pmTOR} \xrightarrow{\mathrm{IRS,\ pmTOR}} \mathrm{p2IRS} + \mathrm{pmTOR} \tag{31}$$

Reactants

Table 49: Properties of each reactant.

Id	Name	SBO
IRS	IRS	
pmTOR	pmTOR	

Modifiers

Table 50: Properties of each modifier.

Id	Name	SBO
IRS	IRS	
pmTOR	pmTOR	

Products

Table 51: Properties of each product.

Id	Name	SBO
p2IRS	p2IRS	
pmTOR	pmTOR	

Kinetic Law

Derived unit contains undeclared units

$$v_{16} = [\mathrm{IRS}] \cdot [\mathrm{pmTOR}] \cdot \mathrm{param7} \tag{32}$$

6.17 Reaction reaction7

This is an irreversible reaction of one reactant forming one product influenced by one modifier.

Name reaction7

Reaction equation

$$\text{p2IRS} \xrightarrow{\text{p2IRS}} \text{IRS} \tag{33}$$

Reactant

Table 52: Properties of each reactant.

Id	Name	SBO
p2IRS	p2IRS	

Modifier

Table 53: Properties of each modifier.

Id	Name	SBO
p2IRS	p2IRS	

Product

Table 54: Properties of each product.

Id	Name	SBO
IRS	IRS	

Kinetic Law

Derived unit contains undeclared units

$$v_{17} = [\text{p2IRS}] \cdot \text{param8} \tag{34}$$

6.18 Reaction reaction8

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

Name reaction8

Reaction equation

$$\text{p2IRS} \xrightarrow{\text{p2IRS}} \emptyset \tag{35}$$

Reactant

Table 55: Properties of each reactant.

Id	Name	SBO
p2IRS	p2IRS	

Modifier

Table 56: Properties of each modifier.

Id	Name	SBO
p2IRS	p2IRS	

Kinetic Law

Derived unit contains undeclared units

$$v_{18} = [\text{p2IRS}] \cdot \text{param9} \tag{36}$$

6.19 Reaction `reaction9`

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

Name reaction9

Reaction equation

$$\text{p2IRS} \underset{}{\overset{\text{p2IRS, p1p2IRS}}{\rightleftharpoons}} \text{p1p2IRS} \tag{37}$$

Reactant

Table 57: Properties of each reactant.

Id	Name	SBO
p2IRS	p2IRS	

Modifiers

Table 58: Properties of each modifier.

Id	Name	SBO
p2IRS	p2IRS	
p1p2IRS	p1p2IRS	

Product

Table 59: Properties of each product.

Id	Name	SBO
p1p2IRS	p1p2IRS	

Kinetic Law

Derived unit contains undeclared units

$$v_{19} = [\text{p2IRS}] \cdot \text{insulin} \cdot \text{param10} - [\text{p1p2IRS}] \cdot \text{param11} \tag{38}$$

6.20 Reaction `reaction10`

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

Name reaction10

Reaction equation

$$\text{p1p2IRS} \xrightarrow{\text{p1p2IRS}} \emptyset \tag{39}$$

Reactant

Table 60: Properties of each reactant.

Id	Name	SBO
p1p2IRS	p1p2IRS	

Modifier

Table 61: Properties of each modifier.

Id	Name	SBO
p1p2IRS	p1p2IRS	

Kinetic Law

Derived unit contains undeclared units

$$v_{20} = [\text{p1p2IRS}] \cdot \text{param12} \tag{40}$$

6.21 Reaction reaction11

This is an irreversible reaction of two reactants forming two products influenced by two modifiers.

Name reaction11

Reaction equation

$$\text{Akt} + \text{p1IRS} \xrightarrow{\text{p1IRS, Akt}} \text{pAkt} + \text{p1IRS} \tag{41}$$

Reactants

Table 62: Properties of each reactant.

Id	Name	SBO
Akt	Akt	
p1IRS	p1IRS	

Modifiers

Table 63: Properties of each modifier.

Id	Name	SBO
p1IRS	p1IRS	
Akt	Akt	

Products

Table 64: Properties of each product.

Id	Name	SBO
pAkt	pAkt	
p1IRS	p1IRS	

Kinetic Law

Derived unit contains undeclared units

$$v_{21} = [\text{p1IRS}] \cdot [\text{Akt}] \cdot \text{param13} \tag{42}$$

6.22 Reaction reaction12

This is an irreversible reaction of one reactant forming one product influenced by one modifier.

Name reaction12

Reaction equation

$$\text{pAkt} \xrightarrow{\text{pAkt}} \text{Akt} \tag{43}$$

Reactant

Table 65: Properties of each reactant.

Id	Name	SBO
pAkt	pAkt	

Modifier

Table 66: Properties of each modifier.

Id	Name	SBO
pAkt	pAkt	

Product

Table 67: Properties of each product.

Id	Name	SBO
Akt	Akt	

Kinetic Law

Derived unit contains undeclared units

$$v_{22} = [\text{pAkt}] \cdot \text{param14} \tag{44}$$

6.23 Reaction reaction13

This is an irreversible reaction of two reactants forming two products influenced by two modifiers.

Name reaction13

Reaction equation

$$\text{mTOR} + \text{pAkt} \xrightarrow{\text{mTOR, pAkt}} \text{pmTOR} + \text{pAkt} \tag{45}$$

Reactants

Table 68: Properties of each reactant.

Id	Name	SBO
mTOR	mTOR	
pAkt	pAkt	

Modifiers

Table 69: Properties of each modifier.

Id	Name	SBO
mTOR	mTOR	
pAkt	pAkt	

Products

Table 70: Properties of each product.

Id	Name	SBO
pmTOR	pmTOR	
pAkt	pAkt	

Kinetic Law

Derived unit contains undeclared units

$$v_{23} = [\text{mTOR}] \cdot [\text{pAkt}] \cdot \text{param15} \tag{46}$$

6.24 Reaction reaction14

This is an irreversible reaction of one reactant forming one product influenced by one modifier.

Name reaction14

Reaction equation

$$\text{pmTOR} \xrightarrow{\text{pmTOR}} \text{mTOR} \tag{47}$$

Reactant

Table 71: Properties of each reactant.

Id	Name	SBO
pmTOR	pmTOR	

Modifier

Table 72: Properties of each modifier.

Id	Name	SBO
pmTOR	pmTOR	

Product

Table 73: Properties of each product.

Id	Name	SBO
mTOR	mTOR	

Kinetic Law

Derived unit contains undeclared units

$$v_{24} = [\text{pmTOR}] \cdot \text{param16} \tag{48}$$

6.25 Reaction reaction15

This is an irreversible reaction of two reactants forming two products influenced by two modifiers.

Name reaction15

Reaction equation

$$\text{Foxo} + \text{pAkt} \xrightarrow{\text{pAkt, Foxo}} \text{pFoxo} + \text{pAkt} \tag{49}$$

Reactants

Table 74: Properties of each reactant.

Id	Name	SBO
Foxo	Foxo	
pAkt	pAkt	

Modifiers

Table 75: Properties of each modifier.

Id	Name	SBO
pAkt	pAkt	
Foxo	Foxo	

Products

Table 76: Properties of each product.

Id	Name	SBO
pFoxo	pFoxo	
pAkt	pAkt	

Kinetic Law

Derived unit contains undeclared units

$$v_{25} = [\text{pAkt}] \cdot [\text{Foxo}] \cdot \text{k1\_PEPCK} \tag{50}$$

6.26 Reaction reactionPEP1

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

Name reactionPEP1

Reaction equation

$$\text{Foxo} \xrightarrow{\text{Foxo, mRNA}} \text{mRNA} + \text{Foxo} \tag{51}$$

Reactant

Table 77: Properties of each reactant.

Id	Name	SBO
Foxo	Foxo	

Modifiers

Table 78: Properties of each modifier.

Id	Name	SBO
Foxo	Foxo	
mRNA	mRNA	

Products

Table 79: Properties of each product.

Id	Name	SBO
mRNA	mRNA	
Foxo	Foxo	

Kinetic Law

Derived unit contains undeclared units

$$v_{26} = [\text{Foxo}] \cdot \text{k3\_PEPCK} - [\text{mRNA}] \cdot \text{k4\_PEPCK} \tag{52}$$

6.27 Reaction reactionPEP2

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

Name reactionPEP2

Reaction equation

$$\text{mRNA} \xrightarrow{\text{mRNA, PEPCK}} \text{PEPCK} + \text{mRNA} \tag{53}$$

Reactant

Table 80: Properties of each reactant.

Id	Name	SBO
mRNA	mRNA	

Modifiers

Table 81: Properties of each modifier.

Id	Name	SBO
mRNA	mRNA	
PEPCK	PEPCK	

Products

Table 82: Properties of each product.

Id	Name	SBO
PEPCK	PEPCK	
mRNA	mRNA	

Kinetic Law

Derived unit contains undeclared units

$$v_{27} = \text{k5\_PEPCK} \cdot [\text{mRNA}] - \text{k6\_PEPCK} \cdot [\text{PEPCK}] \tag{54}$$

6.28 Reaction mw7c079c91_51e3_4732_8dca_23fb3cd716a7

This is an irreversible reaction of one reactant forming one product influenced by one modifier.

Name reaction16

Reaction equation

$$\text{pFoxo} \xrightarrow{\text{pFoxo}} \text{Foxo} \tag{55}$$

Reactant

Table 83: Properties of each reactant.

Id	Name	SBO
pFoxo	pFoxo	

Modifier

Table 84: Properties of each modifier.

Id	Name	SBO
pFoxo	pFoxo	

Product

Table 85: Properties of each product.

Id	Name	SBO
Foxo	Foxo	

Kinetic Law

Derived unit contains undeclared units

$$v_{28} = [\text{pFoxo}] \cdot \text{k2\_PEPCK} \tag{56}$$

6.29 Reaction mwfc720c89_b1b3_416a_8958_e9d0aff9f4a6

This is an irreversible reaction of one reactant forming one product influenced by one modifier.

Name metabolicENZ2

Reaction equation

$$\text{GP} \xrightarrow{\text{GP}} \text{pGP} \tag{57}$$

Reactant

Table 86: Properties of each reactant.

Id	Name	SBO
GP	GP	

Modifier

Table 87: Properties of each modifier.

Id	Name	SBO
GP	GP	

Product

Table 88: Properties of each product.

Id	Name	SBO
pGP	pGP	

Kinetic Law

Derived unit contains undeclared units

$$v_{29} = [\mathrm{GP}] \cdot \mathrm{k3} \tag{58}$$

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 GP

Name GP

Initial amount 0.4726 mol

This species takes part in three reactions (as a reactant in mwfc720c89_b1b3_416a_8958_e9d0aff9f4a6 and as a product in metabolicENZ and as a modifier in mwfc720c89_b1b3_416a_8958_e9d0aff9f4a6).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{GP} = v_{10} - v_{29} \tag{59}$$

7.2 Species pGP

Name pGP

Initial amount 0.1723 mol

This species takes part in six reactions (as a reactant in v9, metabolicENZ and as a product in v9, mwfc720c89_b1b3_416a_8958_e9d0aff9f4a6 and as a modifier in v9, metabolicENZ).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{pGP} = v_9 + v_{29} - v_9 - v_{10} \tag{60}$$

7.3 Species mRNA

Name mRNA

Initial amount 2.905 mol

This species takes part in five reactions (as a reactant in reactionPEP2 and as a product in reactionPEP1, reactionPEP2 and as a modifier in reactionPEP1, reactionPEP2).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{mRNA} = v_{26} + v_{27} - v_{27} \tag{61}$$

7.4 Species PEPCK

Name PEPCK

Initial amount 0.7686 mol

This species takes part in five reactions (as a reactant in v7 and as a product in v7, reactionPEP2 and as a modifier in v7, reactionPEP2).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{PEPCK} = v_{7} + v_{27} - v_{7} \tag{62}$$

7.5 Species IRS

Name IRS

Initial amount 888.77 mol

This species takes part in seven reactions (as a reactant in reaction2, reaction6 and as a product in reaction1, reaction7 and as a modifier in reaction1, reaction2, reaction6).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{IRS} = v_{11} + v_{17} - v_{12} - v_{16} \tag{63}$$

7.6 Species p1IRS

Name p1IRS

Initial amount 0 mol

This species takes part in ten reactions (as a reactant in reaction3, reaction4, reaction11 and as a product in reaction2, reaction5, reaction11 and as a modifier in reaction2, reaction3, reaction4, reaction11).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{p1IRS} = v_{12} + v_{15} + v_{21} - v_{13} - v_{14} - v_{21} \tag{64}$$

7.7 Species p2IRS

Name p2IRS

Initial amount 0 mol

This species takes part in seven reactions (as a reactant in reaction7, reaction8, reaction9 and as a product in reaction6 and as a modifier in reaction7, reaction8, reaction9).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{p2IRS} = v_{16} - v_{17} - v_{18} - v_{19} \tag{65}$$

7.8 Species p1p2IRS

Name p1p2IRS

Initial amount 0 mol

This species takes part in seven reactions (as a reactant in reaction5, reaction10 and as a product in reaction4, reaction9 and as a modifier in reaction5, reaction9, reaction10).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{p1p2IRS} = v_{14} + v_{19} - v_{15} - v_{20} \tag{66}$$

7.9 Species Akt

Name Akt

Initial amount 1.1182 mol

This species takes part in three reactions (as a reactant in reaction11 and as a product in reaction12 and as a modifier in reaction11).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{Akt} = v_{22} - v_{21} \tag{67}$$

7.10 Species pAkt

Name pAkt

Initial amount 0 mol

This species takes part in 15 reactions (as a reactant in v2, v8, reaction12, reaction13, reaction15 and as a product in v2, v8, reaction11, reaction13, reaction15 and as a modifier in v2, v8, reaction12, reaction13, reaction15).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{pAkt} = v_2 + v_8 + v_{21} + v_{23} + v_{25} - v_2 - v_8 - v_{22} - v_{23} - v_{25} \tag{68}$$

7.11 Species mTOR

Name mTOR

Initial amount 880.25 mol

This species takes part in three reactions (as a reactant in reaction13 and as a product in reaction14 and as a modifier in reaction13).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{mTOR} = v_{24} - v_{23} \tag{69}$$

7.12 Species pmTOR

Name pmTOR

Initial amount 0 mol

This species takes part in nine reactions (as a reactant in reaction4, reaction6, reaction14 and as a product in reaction4, reaction6, reaction13 and as a modifier in reaction4, reaction6, reaction14).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{pmTOR} = v_{14} + v_{16} + v_{23} - v_{14} - v_{16} - v_{24} \tag{70}$$

7.13 Species Foxo

Name Foxo

Initial amount $1.069 \cdot 10^{-5}$ mol

This species takes part in six reactions (as a reactant in reaction15, reactionPEP1 and as a product in reactionPEP1, mw7c079c91_51e3_4732_8dca_23fb3cd716a7 and as a modifier in reaction15, reactionPEP1).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{Foxo} = v_{26} + v_{28} - v_{25} - v_{26} \tag{71}$$

7.14 Species pFoxo

Name pFoxo

Initial amount 0 mol

This species takes part in three reactions (as a reactant in mw7c079c91_51e3_4732_8dca_23fb3cd716a7 and as a product in reaction15 and as a modifier in mw7c079c91_51e3_4732_8dca_23fb3cd716a7).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{pFoxo} = v_{25} - v_{28} \tag{72}$$

7.15 Species PYRout

Name PYRout

Initial amount 137.5 mol

This species takes part in two reactions (as a reactant in v5 and as a modifier in v5).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{PYRout} = -v_5 \tag{73}$$

7.16 Species GLCex

Name GLCex

Initial amount 114.9 mol

This species takes part in two reactions (as a reactant in v1 and as a modifier in v1).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{GLCex} = -v_1 \tag{74}$$

7.17 Species F16P

Name F16P

Initial amount 9.571 mol

This species takes part in five reactions (as a reactant in v3 and as a product in v2, v7 and as a modifier in v2, v3).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{F16P} = v_2 + v_7 - v_3 \tag{75}$$

7.18 Species PYRin

Name PYRin

Initial amount 0.9872 mol

This species takes part in seven reactions (as a reactant in v4, v6 and as a product in v3, v5 and as a modifier in v4, v5, v6).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{PYRin} = v_3 + v_5 - v_4 - v_6 \tag{76}$$

7.19 Species LAC

Name LAC

Initial amount 1001 mol

This species takes part in two reactions (as a product in v4 and as a modifier in v4).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{LAC} = v_4 \tag{77}$$

7.20 Species OAA

Name OAA

Initial amount 0.0022 mol

This species takes part in three reactions (as a reactant in v7 and as a product in v6 and as a modifier in v7).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{OAA} = v_6 - v_7 \tag{78}$$

7.21 Species GLY

Name GLY

Initial amount 4.8248 mol

This species takes part in two reactions (as a product in v9 and as a modifier in v9).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{GLY} = v_9 \tag{79}$$

7.22 Species G1P

Name G1P

Initial amount 5.303 mol

This species takes part in four reactions (as a reactant in v9 and as a product in v8 and as a modifier in v8, v9).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{G1P} = v_8 - v_9 \tag{80}$$

7.23 Species G6P

Name G6P

Initial amount 0.5188 mol

This species takes part in nine reactions (as a reactant in v2, v8, metabolicENZ and as a product in v1, metabolicENZ and as a modifier in v1, v2, v8, metabolicENZ).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{G6P} = v_1 + v_{10} - v_2 - v_8 - v_{10} \tag{81}$$

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