

## SBML Model Report

# Model name: “Nyman2011\_M3Hierararchical- \_InsulinGlucosedynamics”



May 5, 2016

## 1 General Overview

This is a document in SBML Level 2 Version 4 format. This model was created by the following two authors: Ishan Ajmera<sup>1</sup> and Elin Nyman<sup>2</sup> at August 19<sup>th</sup> 2011 at 12:51 a. m. and last time modified at April eighth 2016 at 5:04 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	32
events	0	constraints	0
reactions	64	function definitions	0
global parameters	114	unit definitions	0
rules	35	initial assignments	0

## Model Notes

This a model from the article:

**A Hierarchical Whole-body Modeling Approach Elucidates the Link between in Vitro Insulin Signaling and in Vivo Glucose Homeostasis.**

Nyman E, Brannmark C, Palmer R, Brugard J, Nystrom FH, Stralfors P, Cedersund G.J Biol

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Chem.2011 Jul 22;286(29):26028-41. [21572040](#),

**Abstract:**

Type 2 diabetes is a metabolic disease that profoundly affects energy homeostasis. The disease involves failure at several levels and subsystems and is characterized by insulin resistance in target cells and tissues (i.e. by impaired intracellular insulin signaling). We have previously used an iterative experimental-theoretical approach to unravel the early insulin signaling events in primary human adipocytes. That study, like most insulin signaling studies, is based on in vitro experimental examination of cells, and the in vivo relevance of such studies for human beings has not been systematically examined. Herein, we develop a hierarchical model of the adipose tissue, which links intracellular insulin control of glucose transport in human primary adipocytes with whole-body glucose homeostasis. An iterative approach between experiments and minimal modeling allowed us to conclude that it is not possible to scale up the experimentally determined glucose uptake by the isolated adipocytes to match the glucose uptake profile of the adipose tissue in vivo. However, a model that additionally includes insulin effects on blood flow in the adipose tissue and GLUT4 translocation due to cell handling can explain all data, but neither of these additions is sufficient independently. We also extend the minimal model to include hierarchical dynamic links to more detailed models (both to our own models and to those by others), which act as submodules that can be turned on or off. The resulting multilevel hierarchical model can merge detailed results on different subsystems into a coherent understanding of whole-body glucose homeostasis. This hierarchical modeling can potentially create bridges between other experimental model systems and the in vivo human situation and offers a framework for systematic evaluation of the physiological relevance of in vitro obtained molecular/cellular experimental data.

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To cite BioModels Database, please use: [Li C, Donizelli M, Rodriguez N, Dharuri H, Endler L, Chelliah V, Li L, He E, Henry A, Stefan MI, Snoep JL, Hucka M, Le Novre N, Laibe C \(2010\) BioModels Database: An enhanced, curated and annotated resource for published quantitative kinetic models. BMC Syst Biol., 4:92.](#)

## 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** 1

## 2.3 Unit area

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

**Definition**  $\text{m}^2$

## 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
default	default		3	1	litre	<input checked="" type="checkbox"/>	

### 3.1 Compartment default

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

**Name** default

## 4 Species

This model contains 32 species. Section 8 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
r0	r0	default	$\text{mol} \cdot \text{l}^{-1}$	$\square$	$\square$
r1	r1	default	$\text{mol} \cdot \text{l}^{-1}$	$\square$	$\square$
r2	r2	default	$\text{mol} \cdot \text{l}^{-1}$	$\square$	$\square$
r11	r11	default	$\text{mol} \cdot \text{l}^{-1}$	$\square$	$\square$
r12	r12	default	$\text{mol} \cdot \text{l}^{-1}$	$\square$	$\square$
r22	r22	default	$\text{mol} \cdot \text{l}^{-1}$	$\square$	$\square$
r1x2	r1x2	default	$\text{mol} \cdot \text{l}^{-1}$	$\square$	$\square$
r11x2	r11x2	default	$\text{mol} \cdot \text{l}^{-1}$	$\square$	$\square$
r1x22	r1x22	default	$\text{mol} \cdot \text{l}^{-1}$	$\square$	$\square$
r1x22d	r1x22d	default	$\text{mol} \cdot \text{l}^{-1}$	$\square$	$\square$
r11x22	r11x22	default	$\text{mol} \cdot \text{l}^{-1}$	$\square$	$\square$
rend	rend	default	$\text{mol} \cdot \text{l}^{-1}$	$\square$	$\square$
rendP	rendP	default	$\text{mol} \cdot \text{l}^{-1}$	$\square$	$\square$
iendIR	iendIR	default	$\text{mol} \cdot \text{l}^{-1}$	$\square$	$\square$
iend	iend	default	$\text{mol} \cdot \text{l}^{-1}$	$\square$	$\square$
rPbasal	rPbasal	default	$\text{mol} \cdot \text{l}^{-1}$	$\square$	$\square$
IRS	IRS	default	$\text{mol} \cdot \text{l}^{-1}$	$\square$	$\square$
IRSiP	IRSiP	default	$\text{mol} \cdot \text{l}^{-1}$	$\square$	$\square$
X	X	default	$\text{mol} \cdot \text{l}^{-1}$	$\square$	$\square$
X_P	X_P	default	$\text{mol} \cdot \text{l}^{-1}$	$\square$	$\square$
PI3K	PI3K	default	$\text{mol} \cdot \text{l}^{-1}$	$\square$	$\square$
PI3K_	PI3K_	default	$\text{mol} \cdot \text{l}^{-1}$	$\square$	$\square$

Id	Name	Compartment	Derived Unit	Constant	Boundary Condi- tion
PDK1	PDK1	default	$\text{mol} \cdot \text{l}^{-1}$	<input type="checkbox"/>	<input type="checkbox"/>
PDK1_	PDK1_	default	$\text{mol} \cdot \text{l}^{-1}$	<input type="checkbox"/>	<input type="checkbox"/>
PKC	PKC	default	$\text{mol} \cdot \text{l}^{-1}$	<input type="checkbox"/>	<input type="checkbox"/>
PKC_P	PKC_P	default	$\text{mol} \cdot \text{l}^{-1}$	<input type="checkbox"/>	<input type="checkbox"/>
PKB	PKB	default	$\text{mol} \cdot \text{l}^{-1}$	<input type="checkbox"/>	<input type="checkbox"/>
PKB_P	PKB_P	default	$\text{mol} \cdot \text{l}^{-1}$	<input type="checkbox"/>	<input type="checkbox"/>
mTOR	mTOR	default	$\text{mol} \cdot \text{l}^{-1}$	<input type="checkbox"/>	<input type="checkbox"/>
mTOR_	mTOR_	default	$\text{mol} \cdot \text{l}^{-1}$	<input type="checkbox"/>	<input type="checkbox"/>
GLUT4_C	GLUT4_C	default	$\text{mol} \cdot \text{l}^{-1}$	<input type="checkbox"/>	<input type="checkbox"/>
GLUT4_M	GLUT4_M	default	$\text{mol} \cdot \text{l}^{-1}$	<input type="checkbox"/>	<input type="checkbox"/>

## 5 Parameters

This model contains 114 global parameters.

Table 4: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
a1	a1	0000009	$4.4825146271204 \cdot 10^8$		✓
a2	a2	0000009	4321891.903		✓
d1	d1	0000009	0.772		✓
d2	d2	0000009	0.012		✓
Kcr	Kcr	0000009	0.001		✓
Kex	Kex	0000009	37.082		✓
Kend	Kend	0000009	30.683		✓
Kdp	Kdp	0000009	$9.500831 \cdot 10^{-4}$		✓
Kcat	Kcat	0000009	237.519		✓
Km	Km	0000009	3.018		✓
kfbasal	kfbasal	0000009	0.498		✓
krbasal	krbasal	0000009	128042.884		✓
k21	k21	0000009	0.010		✓
k22	k22	0000009	2374.977		✓
k23	k23	0000009	0.120		✓
k24	k24	0000009	0.943		✓
k2b	k2b	0000009	608.584		✓
k3f	k3f	0000009	8.112		✓
k3b	k3b	0000009	0.190		✓
k4f	k4f	0000009	384885.688		✓
k4b	k4b	0000009	28137.070		✓
k5f	k5f	0000009	64300.071		✓
k5b	k5b	0000009	10052.508		✓
k6f	k6f	0000009	$1.60942017926563 \cdot 10^7$		✓
k6b	k6b	0000009	77.771		✓
k7f	k7f	0000009	4174.630		✓
k7b	k7b	0000009	565342.162		✓
k8f	k8f	0000009	1515762.419		✓
k8b	k8b	0000009	300.751		✓
k91	k91	0000009	$8.14 \cdot 10^{-8}$		✓
k92	k92	0000009	0.028		✓
k9b	k9b	0000009	4.030		✓
k5Basic	k5Basic	0000009	0.204		✓
k5BasicWb	k5BasicWb	0000009	$2.34 \cdot 10^{-8}$		✓
k_glut4	k_glut4	0000009	31.421		✓
k_glut1	k_glut1	0000009	0.297		✓
KmG1	KmG1	0000009	132.770		✓

Id	Name	SBO	Value	Unit	Constant
KmG4	KmG4	0000009	70.403		✓
kbf	kbf	0000009	0.003		✓
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	0000196	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	0000196	0.600		✓
I_b	I_b	0000196	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		0.820		✓
d	d		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	0000009	1.000		✓
V_m0	V_m0		2.500		✓
V_mX	V_mX		0.047		✓
K_m0	K_m0		225.590		✓
p_2U	p_2U	0000009	0.033		✓
part	part		0.200		✓
K	K		2.300		✓
alpha	alpha	0000009	0.050		✓
beta	beta	0000009	0.110		✓
gamma	gamma	0000009	0.500		✓
k_e1	k_e1	0000009	$5 \cdot 10^{-4}$		✓
k_e2	k_e2	0000009	339.000		✓
D	D		78000.000		✓

Id	Name	SBO	Value	Unit	Constant
vglucoseuptake	vglucoseuptake		0.000		<input type="checkbox"/>
KD	KD		0.000		<input type="checkbox"/>
S2	S2		0.000		<input type="checkbox"/>
S1	S1		0.000		<input type="checkbox"/>
K4	K4		0.000		<input type="checkbox"/>
K8	K8		0.000		<input type="checkbox"/>
aa	aa		0.000		<input type="checkbox"/>
cc	cc		0.000		<input type="checkbox"/>
EGP	EGP		0.000		<input type="checkbox"/>
V_mmax	V_mmax		0.000		<input type="checkbox"/>
E	E		0.000		<input type="checkbox"/>
S	S		0.000		<input type="checkbox"/>
I	I		0.000		<input type="checkbox"/>
G	G		0.000		<input type="checkbox"/>
HE	HE		0.000		<input type="checkbox"/>
m_3	m_3		0.000		<input type="checkbox"/>
Q_sto	Q_sto		0.000		<input type="checkbox"/>
Ra	Ra		0.000		<input type="checkbox"/>
k_empty	k_empty		0.000		<input type="checkbox"/>
U_idm	U_idm		0.000		<input type="checkbox"/>
U_id	U_id		0.000		<input type="checkbox"/>
U	U		0.000		<input type="checkbox"/>
S_po	S_po		0.000		<input type="checkbox"/>
G_p	G_p	0000196	178.000		<input type="checkbox"/>
G_t	G_t	0000196	135.000		<input type="checkbox"/>
I_l	I_l	0000196	4.500		<input type="checkbox"/>
I_p	I_p	0000196	1.250		<input type="checkbox"/>
Q_sto1	Q_sto1		78000.000		<input type="checkbox"/>
Q_sto2	Q_sto2		0.000		<input type="checkbox"/>
Q_gut	Q_gut		0.000		<input type="checkbox"/>
I_1	I_1		25.000		<input type="checkbox"/>
I_d	I_d		25.000		<input type="checkbox"/>
INS	INS	0000361	0.000		<input type="checkbox"/>
I_po	I_po	0000361	3.600		<input type="checkbox"/>
Y	Y		0.000		<input type="checkbox"/>

## 6 Rules

This is an overview of 35 rules.



### 6.1 Rule `vglucoseuptake`

Rule `vglucoseuptake` is an assignment rule for parameter `vglucoseuptake`:

$$\text{vglucoseuptake} = \frac{k\_glut1 \cdot G\_t}{K_{mG1} + G\_t} + \frac{k\_glut4 \cdot [GLUT4\_M] \cdot G\_t}{K_{mG4} + G\_t} + kbf \cdot (INS + 5) \quad (1)$$

### 6.2 Rule `KD`

Rule `KD` is an assignment rule for parameter `KD`:

$$KD = 7.0E - 6 \quad (2)$$

### 6.3 Rule `S2`

Rule `S2` is an assignment rule for parameter `S2`:

$$S2 = 0 \quad (3)$$

### 6.4 Rule `S1`

Rule `S1` is an assignment rule for parameter `S1`:

$$S1 = (INS + 5) \cdot 1.0E - 12 \quad (4)$$

### 6.5 Rule `K4`

Rule `K4` is an assignment rule for parameter `K4`:

$$K4 = 1400 \quad (5)$$

### 6.6 Rule `K8`

Rule `K8` is an assignment rule for parameter `K8`:

$$K8 = 0.01 \quad (6)$$

### 6.7 Rule `aa`

Rule `aa` is an assignment rule for parameter `aa`:

$$aa = \frac{\frac{5}{2}}{1-b} \cdot D \quad (7)$$

### 6.8 Rule `cc`

Rule `cc` is an assignment rule for parameter `cc`:

$$cc = \frac{\frac{5}{2}}{D} \quad (8)$$

### 6.9 Rule $\text{EGP}$

Rule  $\text{EGP}$  is an assignment rule for parameter  $\text{EGP}$ :

$$\text{EGP} = k_{\text{p1}} - k_{\text{p2}} \cdot G_{\text{p}} - k_{\text{p3}} \cdot I_{\text{d}} - k_{\text{p4}} \cdot I_{\text{po}} \quad (9)$$

### 6.10 Rule $V_{\text{mmax}}$

Rule  $V_{\text{mmax}}$  is an assignment rule for parameter  $V_{\text{mmax}}$ :

$$V_{\text{mmax}} = (1 - \text{part}) \cdot (V_{\text{m0}} + V_{\text{mX}} \cdot \text{INS}) \quad (10)$$

### 6.11 Rule $E$

Rule  $E$  is an assignment rule for parameter  $E$ :

$$E = 0 \quad (11)$$

### 6.12 Rule $S$

Rule  $S$  is an assignment rule for parameter  $S$ :

$$S = \text{gamma} \cdot I_{\text{po}} \quad (12)$$

### 6.13 Rule $I$

Rule  $I$  is an assignment rule for parameter  $I$ :

$$I = \frac{I_{\text{p}}}{V_{\text{I}}} \quad (13)$$

### 6.14 Rule $G$

Rule  $G$  is an assignment rule for parameter  $G$ :

$$G = \frac{G_{\text{p}}}{V_{\text{G}}} \quad (14)$$

### 6.15 Rule $\text{HE}$

Rule  $\text{HE}$  is an assignment rule for parameter  $\text{HE}$ :

$$\text{HE} = m_{\text{5}} \cdot S + m_{\text{6}} \quad (15)$$

### 6.16 Rule $m_{\text{3}}$

Rule  $m_{\text{3}}$  is an assignment rule for parameter  $m_{\text{3}}$ :

$$m_{\text{3}} = \frac{\text{HE} \cdot m_{\text{1}}}{1 - \text{HE}} \quad (16)$$

### 6.17 Rule $Q\_sto$

Rule  $Q\_sto$  is an assignment rule for parameter  $Q\_sto$ :

$$Q\_sto = Q\_sto1 + Q\_sto2 \quad (17)$$

### 6.18 Rule $Ra$

Rule  $Ra$  is an assignment rule for parameter  $Ra$ :

$$Ra = \frac{f \cdot k\_abs \cdot Q\_gut}{BW} \quad (18)$$

### 6.19 Rule $k\_empt$

Rule  $k\_empt$  is an assignment rule for parameter  $k\_empt$ :

$$k\_empt = k\_min + \frac{k\_max - k\_min}{2} \cdot (\tanh(aa \cdot (Q\_sto - b \cdot D)) - \tanh(cc \cdot (Q\_sto - d \cdot D)) + 2) \quad (19)$$

### 6.20 Rule $U\_idm$

Rule  $U\_idm$  is an assignment rule for parameter  $U\_idm$ :

$$U\_idm = \frac{V\_mmax \cdot G\_t}{K\_m0 + G\_t} \quad (20)$$

### 6.21 Rule $U\_id$

Rule  $U\_id$  is an assignment rule for parameter  $U\_id$ :

$$U\_id = U\_idm + vglucoseuptake \quad (21)$$

### 6.22 Rule $U$

Rule  $U$  is an assignment rule for parameter  $U$ :

$$U = U\_ii + U\_id \quad (22)$$

### 6.23 Rule $S\_po$

Rule  $S\_po$  is an assignment rule for parameter  $S\_po$ :

$$S\_po = Y + \frac{K \cdot (EGP + Ra - E - U\_ii - k\_1 \cdot G\_p + k\_2 \cdot G\_t)}{V\_G} + S\_b \quad (23)$$

### 6.24 Rule $G_p$

Rule  $G_p$  is a rate rule for parameter  $G_p$ :

$$\frac{d}{dt}G_p = EGP + Ra - E - U_{ii} - k_{-1} \cdot G_p + k_{-2} \cdot G_t \quad (24)$$

### 6.25 Rule $G_t$

Rule  $G_t$  is a rate rule for parameter  $G_t$ :

$$\frac{d}{dt}G_t = U_{id} + k_{-1} \cdot G_p - k_{-2} \cdot G_t \quad (25)$$

### 6.26 Rule $I_l$

Rule  $I_l$  is a rate rule for parameter  $I_l$ :

$$\frac{d}{dt}I_l = m_{-1} \cdot I_l - m_{-3} \cdot I_l + m_{-2} \cdot I_p + S \quad (26)$$

### 6.27 Rule $I_p$

Rule  $I_p$  is a rate rule for parameter  $I_p$ :

$$\frac{d}{dt}I_p = m_{-2} \cdot I_p - m_{-4} \cdot I_p + m_{-1} \cdot I_l \quad (27)$$

### 6.28 Rule $Q_{sto1}$

Rule  $Q_{sto1}$  is a rate rule for parameter  $Q_{sto1}$ :

$$\frac{d}{dt}Q_{sto1} = k_{gri} \cdot Q_{sto1} \quad (28)$$

### 6.29 Rule $Q_{sto2}$

Rule  $Q_{sto2}$  is a rate rule for parameter  $Q_{sto2}$ :

$$\frac{d}{dt}Q_{sto2} = k_{empt} \cdot Q_{sto2} + k_{gri} \cdot Q_{sto1} \quad (29)$$

### 6.30 Rule $Q_{gut}$

Rule  $Q_{gut}$  is a rate rule for parameter  $Q_{gut}$ :

$$\frac{d}{dt}Q_{gut} = k_{abs} \cdot Q_{gut} + k_{empt} \cdot Q_{sto2} \quad (30)$$

### 6.31 Rule I<sub>1</sub>

Rule I<sub>1</sub> is a rate rule for parameter I<sub>1</sub>:

$$\frac{d}{dt}I_1 = k_i \cdot (I_1 - I) \quad (31)$$

### 6.32 Rule I<sub>d</sub>

Rule I<sub>d</sub> is a rate rule for parameter I<sub>d</sub>:

$$\frac{d}{dt}I_d = k_i \cdot (I_d - I_1) \quad (32)$$

### 6.33 Rule INS

Rule INS is a rate rule for parameter INS:

$$\frac{d}{dt}INS = p_{2U} \cdot INS + p_{2U} \cdot (I - I_b) \quad (33)$$

### 6.34 Rule I<sub>po</sub>

Rule I<sub>po</sub> is a rate rule for parameter I<sub>po</sub>:

$$\frac{d}{dt}I_{po} = \text{gamma} \cdot I_{po} + S_{po} \quad (34)$$

### 6.35 Rule Y

Rule Y is a rate rule for parameter Y:

$$\frac{d}{dt}Y = \text{alpha} \cdot (Y - \text{beta} \cdot (G - G_b)) \quad (35)$$

## 7 Reactions

This model contains 64 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

Nº	Id	Name	Reaction Equation	SBO
1	R1	R1	$r0 \longrightarrow r1$	0000344
2	R2	R2	$r0 \longrightarrow r2$	0000344
3	R3	R3	$r1 \longrightarrow r11$	0000344
4	R4	R4	$r2 \longrightarrow r12$	0000344
5	R5	R5	$r1 \longrightarrow r0$	0000180
6	R6	R6	$r1 \longrightarrow r12$	0000344
7	R7	R7	$r2 \longrightarrow r22$	0000344
8	R8	R8	$r2 \longrightarrow r0$	0000180
9	R9	R9	$r1 \longrightarrow r1x2$	0000344
10	R10	R10	$r2 \longrightarrow r1x2$	0000344
11	R11	R11	$r1x2 \longrightarrow r11x2$	0000344
12	R12	R12	$r11 \longrightarrow r1$	0000344
13	R13	R13	$r12 \longrightarrow r2$	0000344
14	R14	R14	$r1x2 \longrightarrow r1x22$	0000344
15	R15	R15	$r12 \longrightarrow r1$	0000344
16	R16	R16	$r22 \longrightarrow r2$	0000344
17	R17	R17	$r11 \longrightarrow r11x2$	0000344
18	R18	R18	$r12 \longrightarrow r1x22$	0000344
19	R19	R19	$r1x2 \longrightarrow r1$	0000344
20	R20	R20	$r12 \longrightarrow r11x2$	0000344
21	R21	R21	$r22 \longrightarrow r1x22$	0000344
22	R22	R22	$r1x2 \longrightarrow r2$	0000344
23	R23	R23	$r1x2 \longrightarrow r1x22d$	0000344

Nº	Id	Name	Reaction Equation	SBO
24	R24	R24	$r1l x2 \longrightarrow r1x2$	0000344
25	R25	R25	$r1x22 \longrightarrow r1x2$	0000344
26	R26	R26	$r1l x2 \longrightarrow r1l$	0000344
27	R27	R27	$r1x22 \longrightarrow r12$	0000344
28	R28	R28	$r1l x2 \longrightarrow r12$	0000344
29	R29	R29	$r1x22 \longrightarrow r22$	0000344
30	R30	R30	$r1x22 \longrightarrow r1l x22$	0000344
31	R31	R31	$r1l x2 \longrightarrow r1l x22$	0000344
32	R32	R32	$r1x22 \longrightarrow r1x22d$	0000344
33	R33	R33	$r1x22d \longrightarrow r1x22$	0000344
34	R34	R34	$r1x22d \longrightarrow r1x2$	0000344
35	R35	R35	$r1l x22 \longrightarrow r1x22$	0000344
36	R36	R36	$r1l x22 \longrightarrow r1l x2$	0000344
37	R37	R37	$rend \longrightarrow r0$	0000185
38	R38	R38	$iend \longrightarrow \emptyset$	0000185
39	R39	R39	$r1x2 \longrightarrow rendP + iendIR$	0000185
40	R40	R40	$r1l x2 \longrightarrow rendP + 2 iendIR$	0000185
41	R41	R41	$r1x22 \longrightarrow rendP + 2 iendIR$	0000185
42	R42	R42	$r1x22d \longrightarrow rendP + 3 iendIR$	0000185
43	R43	R43	$r1l x22 \longrightarrow rendP + 3 iendIR$	0000185
44	R44	R44	$rendP \xrightarrow{X_P} rend$	0000330
45	R45	R45	$iendIR \xrightarrow{X_P} iend$	
46	R46	R46	$r0 \longrightarrow rPbasal$	0000216
47	R47	R47	$rPbasal \longrightarrow r0$	0000330
48	R48	R48	$rPbasal \longrightarrow rendP$	0000185
49	v2f	v2f	$IRS \xrightarrow{PKC_P, mTOR, r1l x2, r1l x22, r1x2, r1x22, r1x22d, rPbasal, rendP} IRSiP$	0000216
50	v2b	v2b	$IRSiP \longrightarrow IRS$	0000330

Nº	Id	Name	Reaction Equation	SBO
51	v3f	v3f	$X \xrightarrow{\text{IRSiP}} X\_P$	0000216
52	v3b	v3b	$X\_P \longrightarrow X$	0000330
53	v4f	v4f	$PI3K \xrightarrow{\text{IRSiP}} PI3K\_$	0000216
54	v4b	v4b	$PI3K\_ \longrightarrow PI3K$	0000330
55	v5f	v5f	$PDK1 \xrightarrow{PI3K\_} PDK1\_$	0000216
56	v5b	v5b	$PDK1\_ \longrightarrow PDK1$	0000330
57	v6f	v6f	$PKC \xrightarrow{PDK1\_} PKC\_P$	0000216
58	v6b	v6b	$PKC\_P \longrightarrow PKC$	0000330
59	v7f	v7f	$PKB \xrightarrow{PDK1\_} PKB\_P$	0000216
60	v7b	v7b	$PKB\_P \longrightarrow PKB$	0000330
61	v8f	v8f	$mTOR \xrightarrow{PKB\_P} mTOR\_$	0000216
62	v8b	v8b	$mTOR\_ \longrightarrow mTOR$	0000330
63	v9f	v9f	$GLUT4\_C \xrightarrow{PKB\_P, PKC\_P} GLUT4\_M$	0000344
64	v9b	v9b	$GLUT4\_M \longrightarrow GLUT4\_C$	0000344



## 7.1 Reaction R1

This is an irreversible reaction of one reactant forming one product.

**Name** R1

**SBO:0000344** molecular interaction

### Reaction equation



### Reactant

Table 6: Properties of each reactant.

Id	Name	SBO
r0	r0	

### Product

Table 7: Properties of each product.

Id	Name	SBO
r1	r1	

### Kinetic Law

**Derived unit** contains undeclared units

$$v_1 = 2 \cdot a_1 \cdot S_1 \cdot [r0] \quad (37)$$

## 7.2 Reaction R2

This is an irreversible reaction of one reactant forming one product.

**Name** R2

**SBO:0000344** molecular interaction

### Reaction equation



### Reactant

Table 8: Properties of each reactant.

Id	Name	SBO
r0	r0	

## Product

Table 9: Properties of each product.

Id	Name	SBO
r2	r2	

## Kinetic Law

**Derived unit** contains undeclared units

$$v_2 = 2 \cdot a_2 \cdot S1 \cdot [r0] \quad (39)$$

## 7.3 Reaction R3

This is an irreversible reaction of one reactant forming one product.

**Name** R3

**SBO:0000344** molecular interaction

## Reaction equation



## Reactant

Table 10: Properties of each reactant.

Id	Name	SBO
r1	r1	

## Product

Table 11: Properties of each product.

Id	Name	SBO
r11	r11	

### Kinetic Law

**Derived unit** contains undeclared units

$$v_3 = a1 \cdot S1 \cdot [r1] \quad (41)$$

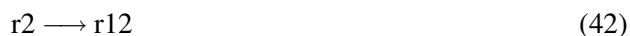
## 7.4 Reaction R4

This is an irreversible reaction of one reactant forming one product.

**Name** R4

**SBO:0000344** molecular interaction

### Reaction equation



### Reactant

Table 12: Properties of each reactant.

Id	Name	SBO
r2	r2	

### Product

Table 13: Properties of each product.

Id	Name	SBO
r12	r12	

### Kinetic Law

**Derived unit** contains undeclared units

$$v_4 = a1 \cdot S1 \cdot [r2] \quad (43)$$

## 7.5 Reaction R5

This is an irreversible reaction of one reactant forming one product.

**Name** R5

**SBO:0000180** dissociation

### Reaction equation



### Reactant

Table 14: Properties of each reactant.

Id	Name	SBO
r1	r1	

### Product

Table 15: Properties of each product.

Id	Name	SBO
r0	r0	

### Kinetic Law

**Derived unit** contains undeclared units

$$v_5 = d1 \cdot [r1] \quad (45)$$

## 7.6 Reaction R6

This is an irreversible reaction of one reactant forming one product.

**Name** R6

**SBO:0000344** molecular interaction

### Reaction equation



### Reactant

Table 16: Properties of each reactant.

Id	Name	SBO
r1	r1	

## Product

Table 17: Properties of each product.

Id	Name	SBO
r12	r12	

## Kinetic Law

**Derived unit** contains undeclared units

$$v_6 = a_2 \cdot S_1 \cdot [r_1] \quad (47)$$

## 7.7 Reaction R7

This is an irreversible reaction of one reactant forming one product.

**Name** R7

**SBO:0000344** molecular interaction

## Reaction equation



## Reactant

Table 18: Properties of each reactant.

Id	Name	SBO
r2	r2	

## Product

Table 19: Properties of each product.

Id	Name	SBO
r22	r22	

### Kinetic Law

**Derived unit** contains undeclared units

$$v_7 = a_2 \cdot S_1 \cdot [r_2] \quad (49)$$

## 7.8 Reaction R8

This is an irreversible reaction of one reactant forming one product.

**Name** R8

**SBO:0000180** dissociation

### Reaction equation



### Reactant

Table 20: Properties of each reactant.

Id	Name	SBO
r2	r2	

### Product

Table 21: Properties of each product.

Id	Name	SBO
r0	r0	

### Kinetic Law

**Derived unit** contains undeclared units

$$v_8 = d_2 \cdot [r_2] \quad (51)$$

## 7.9 Reaction R9

This is an irreversible reaction of one reactant forming one product.

**Name** R9

**SBO:0000344** molecular interaction

### Reaction equation



### Reactant

Table 22: Properties of each reactant.

Id	Name	SBO
r1	r1	

### Product

Table 23: Properties of each product.

Id	Name	SBO
r1x2	r1x2	

### Kinetic Law

**Derived unit** contains undeclared units

$$v_9 = K_{cr} \cdot [r1] \quad (53)$$

## 7.10 Reaction R10

This is an irreversible reaction of one reactant forming one product.

**Name** R10

**SBO:0000344** molecular interaction

### Reaction equation



### Reactant

Table 24: Properties of each reactant.

Id	Name	SBO
r2	r2	

Product

Table 25: Properties of each product.

Id	Name	SBO
r1x2	r1x2	

Kinetic Law

**Derived unit** contains undeclared units

$$v_{10} = Kcr \cdot [r2]$$

(55)

7.11 Reaction R11

This is an irreversible reaction of one reactant forming one product.

**Name** R11

**SBO:0000344** molecular interaction

Reaction equation



Reactant

Table 26: Properties of each reactant.

Id	Name	SBO
r1x2	r1x2	

Product



Table 27: Properties of each product.

Id	Name	SBO
r11x2	r11x2	

### Kinetic Law

**Derived unit** contains undeclared units

$$v_{11} = a_1 \cdot S_1 \cdot [r1x2] \quad (57)$$

## 7.12 Reaction R12

This is an irreversible reaction of one reactant forming one product.

**Name** R12

**SBO:0000344** molecular interaction

### Reaction equation



### Reactant

Table 28: Properties of each reactant.

Id	Name	SBO
r11	r11	

### Product

Table 29: Properties of each product.

Id	Name	SBO
r1	r1	

### Kinetic Law

**Derived unit** contains undeclared units

$$v_{12} = 2 \cdot d_1 \cdot [r11] \quad (59)$$

### 7.13 Reaction R13

This is an irreversible reaction of one reactant forming one product.

**Name** R13

**SBO:0000344** molecular interaction

#### Reaction equation



#### Reactant

Table 30: Properties of each reactant.

Id	Name	SBO
r12	r12	

#### Product

Table 31: Properties of each product.

Id	Name	SBO
r2	r2	

#### Kinetic Law

**Derived unit** contains undeclared units

$$v_{13} = d1 \cdot [r12] \quad (61)$$

### 7.14 Reaction R14

This is an irreversible reaction of one reactant forming one product.

**Name** R14

**SBO:0000344** molecular interaction

#### Reaction equation



#### Reactant

Table 32: Properties of each reactant.

Id	Name	SBO
r1x2	r1x2	

Product

Table 33: Properties of each product.

Id	Name	SBO
r1x22	r1x22	

Kinetic Law

**Derived unit** contains undeclared units

$$v_{14} = a2 \cdot S1 \cdot [r1x2]$$

(63)

7.15 Reaction R15

This is an irreversible reaction of one reactant forming one product.

**Name** R15

**SBO:0000344** molecular interaction

Reaction equation



Reactant

Table 34: Properties of each reactant.

Id	Name	SBO
r12	r12	

Product

Table 35: Properties of each product.

Id	Name	SBO
r1	r1	

### Kinetic Law

**Derived unit** contains undeclared units

$$v_{15} = d2 \cdot [r12] \quad (65)$$

### 7.16 Reaction R16

This is an irreversible reaction of one reactant forming one product.

**Name** R16

**SBO:0000344** molecular interaction

### Reaction equation



### Reactant

Table 36: Properties of each reactant.

Id	Name	SBO
r22	r22	

### Product

Table 37: Properties of each product.

Id	Name	SBO
r2	r2	

### Kinetic Law

**Derived unit** contains undeclared units

$$v_{16} = 2 \cdot d2 \cdot [r22] \quad (67)$$

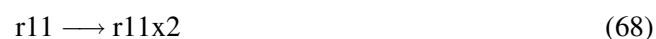
### 7.17 Reaction R17

This is an irreversible reaction of one reactant forming one product.

**Name** R17

**SBO:0000344** molecular interaction

#### Reaction equation



#### Reactant

Table 38: Properties of each reactant.

Id	Name	SBO
r11	r11	

#### Product

Table 39: Properties of each product.

Id	Name	SBO
r11x2	r11x2	

#### Kinetic Law

**Derived unit** contains undeclared units

$$v_{17} = 2 \cdot K_{cr} \cdot [r11] \quad (69)$$

### 7.18 Reaction R18

This is an irreversible reaction of one reactant forming one product.

**Name** R18

**SBO:0000344** molecular interaction

#### Reaction equation



#### Reactant

Table 40: Properties of each reactant.

Id	Name	SBO
r12	r12	

## Product

Table 41: Properties of each product.

Id	Name	SBO
r1x22	r1x22	

## Kinetic Law

**Derived unit** contains undeclared units

$$v_{18} = K_{cr} \cdot [r12] \quad (71)$$

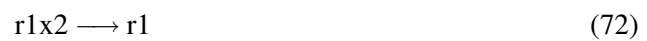
## 7.19 Reaction R19

This is an irreversible reaction of one reactant forming one product.

**Name** R19

**SBO:0000344** molecular interaction

## Reaction equation



## Reactant

Table 42: Properties of each reactant.

Id	Name	SBO
r1x2	r1x2	

## Product

Table 43: Properties of each product.

Id	Name	SBO
r1	r1	

**Kinetic Law**

**Derived unit** contains undeclared units

$$v_{19} = d2 \cdot [r1x2] \tag{73}$$

**7.20 Reaction R20**

This is an irreversible reaction of one reactant forming one product.

**Name** R20

**SBO:0000344** molecular interaction

**Reaction equation**



**Reactant**

Table 44: Properties of each reactant.

Id	Name	SBO
r12	r12	

**Product**

Table 45: Properties of each product.

Id	Name	SBO
r11x2	r11x2	

**Kinetic Law**

**Derived unit** contains undeclared units

$$v_{20} = Kcr \cdot [r12] \tag{75}$$

### 7.21 Reaction R21

This is an irreversible reaction of one reactant forming one product.

**Name** R21

**SBO:0000344** molecular interaction

#### Reaction equation



#### Reactant

Table 46: Properties of each reactant.

Id	Name	SBO
r22	r22	

#### Product

Table 47: Properties of each product.

Id	Name	SBO
r1x22	r1x22	

#### Kinetic Law

**Derived unit** contains undeclared units

$$v_{21} = 2 \cdot K_{cr} \cdot [r22] \quad (77)$$

### 7.22 Reaction R22

This is an irreversible reaction of one reactant forming one product.

**Name** R22

**SBO:0000344** molecular interaction

#### Reaction equation



#### Reactant



Table 48: Properties of each reactant.

Id	Name	SBO
r1x2	r1x2	

Product

Table 49: Properties of each product.

Id	Name	SBO
r2	r2	

Kinetic Law

**Derived unit** contains undeclared units

$$v_{22} = d1 \cdot [r1x2]$$

(79)

7.23 Reaction R23

This is an irreversible reaction of one reactant forming one product.

**Name** R23

**SBO:0000344** molecular interaction

Reaction equation



Reactant

Table 50: Properties of each reactant.

Id	Name	SBO
r1x2	r1x2	

Product

Table 51: Properties of each product.

Id	Name	SBO
r1x22d	r1x22d	

### Kinetic Law

**Derived unit** contains undeclared units

$$v_{23} = a_2 \cdot S_2 \cdot [r1x2] \quad (81)$$

## 7.24 Reaction R24

This is an irreversible reaction of one reactant forming one product.

**Name** R24

**SBO:0000344** molecular interaction

### Reaction equation



### Reactant

Table 52: Properties of each reactant.

Id	Name	SBO
r11x2	r11x2	

### Product

Table 53: Properties of each product.

Id	Name	SBO
r1x2	r1x2	

### Kinetic Law

**Derived unit** contains undeclared units

$$v_{24} = d_1 \cdot [r11x2] \quad (83)$$

7.25 Reaction R25

This is an irreversible reaction of one reactant forming one product.

Name R25

SBO:0000344 molecular interaction

Reaction equation



Reactant

Table 54: Properties of each reactant.

Id	Name	SBO
r1x22	r1x22	

Product

Table 55: Properties of each product.

Id	Name	SBO
r1x2	r1x2	

Kinetic Law

Derived unit contains undeclared units

$$v_{25} = d2 \cdot [r1x22]$$

(85)

7.26 Reaction R26

This is an irreversible reaction of one reactant forming one product.

Name R26

SBO:0000344 molecular interaction

Reaction equation



Reactant

Table 56: Properties of each reactant.

Id	Name	SBO
r11x2	r11x2	

Product

Table 57: Properties of each product.

Id	Name	SBO
r11	r11	

Kinetic Law

Derived unit contains undeclared units

$$v_{26} = d2 \cdot [r11x2]$$

(87)

7.27 Reaction R27

This is an irreversible reaction of one reactant forming one product.

Name R27

SBO:0000344 molecular interaction

Reaction equation



Reactant

Table 58: Properties of each reactant.

Id	Name	SBO
r1x22	r1x22	

Product

Table 59: Properties of each product.

Id	Name	SBO
r12	r12	

**Kinetic Law**

**Derived unit** contains undeclared units

$$v_{27} = d2 \cdot [r1x22] \tag{89}$$

**7.28 Reaction R28**

This is an irreversible reaction of one reactant forming one product.

**Name** R28

**SBO:0000344** molecular interaction

**Reaction equation**



**Reactant**

Table 60: Properties of each reactant.

Id	Name	SBO
r11x2	r11x2	

**Product**

Table 61: Properties of each product.

Id	Name	SBO
r12	r12	

**Kinetic Law**

**Derived unit** contains undeclared units

$$v_{28} = d1 \cdot [r11x2] \tag{91}$$

### 7.29 Reaction R29

This is an irreversible reaction of one reactant forming one product.

**Name** R29

**SBO:0000344** molecular interaction

#### Reaction equation



#### Reactant

Table 62: Properties of each reactant.

Id	Name	SBO
r1x22	r1x22	

#### Product

Table 63: Properties of each product.

Id	Name	SBO
r22	r22	

#### Kinetic Law

**Derived unit** contains undeclared units

$$v_{29} = d1 \cdot [r1x22] \quad (93)$$

### 7.30 Reaction R30

This is an irreversible reaction of one reactant forming one product.

**Name** R30

**SBO:0000344** molecular interaction

#### Reaction equation



#### Reactant

Table 64: Properties of each reactant.

Id	Name	SBO
r1x22	r1x22	

Product

Table 65: Properties of each product.

Id	Name	SBO
r11x22	r11x22	

Kinetic Law

**Derived unit** contains undeclared units

$$v_{30} = a1 \cdot S1 \cdot [r1x22] \tag{95}$$

7.31 Reaction R31

This is an irreversible reaction of one reactant forming one product.

**Name** R31

**SBO:0000344** molecular interaction

Reaction equation



Reactant

Table 66: Properties of each reactant.

Id	Name	SBO
r11x2	r11x2	

Product

Table 67: Properties of each product.

Id	Name	SBO
r11x22	r11x22	

**Kinetic Law**

**Derived unit** contains undeclared units

$$v_{31} = a2 \cdot S1 \cdot [r11x22] \tag{97}$$

**7.32 Reaction R32**

This is an irreversible reaction of one reactant forming one product.

**Name** R32

**SBO:0000344** molecular interaction

**Reaction equation**



**Reactant**

Table 68: Properties of each reactant.

Id	Name	SBO
r1x22	r1x22	

**Product**

Table 69: Properties of each product.

Id	Name	SBO
r1x22d	r1x22d	

**Kinetic Law**

**Derived unit** contains undeclared units

$$v_{32} = K4 \cdot S1 \cdot [r1x22] \tag{99}$$



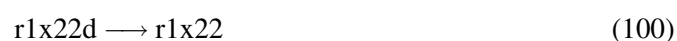
### 7.33 Reaction R33

This is an irreversible reaction of one reactant forming one product.

**Name** R33

**SBO:0000344** molecular interaction

#### Reaction equation



#### Reactant

Table 70: Properties of each reactant.

Id	Name	SBO
r1x22d	r1x22d	

#### Product

Table 71: Properties of each product.

Id	Name	SBO
r1x22	r1x22	

#### Kinetic Law

**Derived unit** contains undeclared units

$$v_{33} = K8 \cdot [\text{r1x22d}] \quad (101)$$

### 7.34 Reaction R34

This is an irreversible reaction of one reactant forming one product.

**Name** R34

**SBO:0000344** molecular interaction

#### Reaction equation



#### Reactant

Table 72: Properties of each reactant.

Id	Name	SBO
r1x22d	r1x22d	

Product

Table 73: Properties of each product.

Id	Name	SBO
r1x2	r1x2	

Kinetic Law

Derived unit contains undeclared units

$$v_{34} = d2 \cdot [r1x22d]$$

(103)

7.35 Reaction R35

This is an irreversible reaction of one reactant forming one product.

Name R35

SBO:0000344 molecular interaction

Reaction equation



Reactant

Table 74: Properties of each reactant.

Id	Name	SBO
r11x22	r11x22	

Product

Table 75: Properties of each product.

Id	Name	SBO
r1x22	r1x22	

### Kinetic Law

**Derived unit** contains undeclared units

$$v_{35} = d1 \cdot [r11x22] \quad (105)$$

### 7.36 Reaction R36

This is an irreversible reaction of one reactant forming one product.

**Name** R36

**SBO:0000344** molecular interaction

### Reaction equation



### Reactant

Table 76: Properties of each reactant.

Id	Name	SBO
r11x22	r11x22	

### Product

Table 77: Properties of each product.

Id	Name	SBO
r11x2	r11x2	

### Kinetic Law

**Derived unit** contains undeclared units

$$v_{36} = d2 \cdot [r11x22] \quad (107)$$

### 7.37 Reaction R37

This is an irreversible reaction of one reactant forming one product.

**Name** R37

**SBO:0000185** transport reaction

#### Reaction equation



#### Reactant

Table 78: Properties of each reactant.

Id	Name	SBO
rend	rend	

#### Product

Table 79: Properties of each product.

Id	Name	SBO
r0	r0	

#### Kinetic Law

**Derived unit** contains undeclared units

$$v_{37} = K_{ex} \cdot [\text{rend}] \quad (109)$$

### 7.38 Reaction R38

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

**Name** R38

**SBO:0000185** transport reaction

#### Reaction equation



#### Reactant

Table 80: Properties of each reactant.

Id	Name	SBO
iend	iend	

**Kinetic Law**

**Derived unit** contains undeclared units

$$v_{38} = K_{ex} \cdot [iend] \tag{111}$$

**7.39 Reaction R39**

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

**Name** R39

**SBO:0000185** transport reaction

**Reaction equation**



**Reactant**

Table 81: Properties of each reactant.

Id	Name	SBO
r1x2	r1x2	

**Products**

Table 82: Properties of each product.

Id	Name	SBO
rendP	rendP	
iendIR	iendIR	

**Kinetic Law**

**Derived unit** contains undeclared units

$$v_{39} = K_{end} \cdot [r1x2] \tag{113}$$

#### 7.40 Reaction R40

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

**Name** R40

**SBO:0000185** transport reaction

#### Reaction equation



#### Reactant

Table 83: Properties of each reactant.

Id	Name	SBO
r11x2	r11x2	

#### Products

Table 84: Properties of each product.

Id	Name	SBO
rendP	rendP	
iendIR	iendIR	

#### Kinetic Law

**Derived unit** contains undeclared units

$$v_{40} = K_{end} \cdot [r11x2] \quad (115)$$

#### 7.41 Reaction R41

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

**Name** R41

**SBO:0000185** transport reaction

#### Reaction equation



## Reactant

Table 85: Properties of each reactant.

Id	Name	SBO
r1x22	r1x22	

## Products

Table 86: Properties of each product.

Id	Name	SBO
rendP	rendP	
iendIR	iendIR	

## Kinetic Law

**Derived unit** contains undeclared units

$$v_{41} = K_{\text{end}} \cdot [\text{r1x22}] \quad (117)$$

## 7.42 Reaction R42

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

**Name** R42

**SBO:0000185** transport reaction

## Reaction equation



## Reactant

Table 87: Properties of each reactant.

Id	Name	SBO
r1x22d	r1x22d	

## Products

Table 88: Properties of each product.

Id	Name	SBO
rendP	rendP	
iendIR	iendIR	

### Kinetic Law

**Derived unit** contains undeclared units

$$v_{42} = K_{\text{end}} \cdot [r1x22d] \quad (119)$$

### 7.43 Reaction R43

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

**Name** R43

**SBO:0000185** transport reaction

### Reaction equation



### Reactant

Table 89: Properties of each reactant.

Id	Name	SBO
r11x22	r11x22	

### Products

Table 90: Properties of each product.

Id	Name	SBO
rendP	rendP	
iendIR	iendIR	

### Kinetic Law

**Derived unit** contains undeclared units



$$v_{43} = K_{\text{end}} \cdot [\text{r11x22}] \quad (121)$$

#### 7.44 Reaction R44

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

**Name** R44

**SBO:0000330** dephosphorylation

#### Reaction equation



#### Reactant

Table 91: Properties of each reactant.

Id	Name	SBO
rendP	rendP	

#### Modifier

Table 92: Properties of each modifier.

Id	Name	SBO
X_P	X_P	

#### Product

Table 93: Properties of each product.

Id	Name	SBO
rend	rend	

#### Kinetic Law

**Derived unit** contains undeclared units

$$v_{44} = \left( K_{\text{dp}} + \frac{K_{\text{cat}} \cdot [\text{X\_P}]}{K_{\text{m}} + [\text{X\_P}]} \right) \cdot [\text{rendP}] \quad (123)$$

### 7.45 Reaction R45

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

**Name** R45

#### Reaction equation



#### Reactant

Table 94: Properties of each reactant.

Id	Name	SBO
iendIR	iendIR	

#### Modifier

Table 95: Properties of each modifier.

Id	Name	SBO
X_P	X_P	

#### Product

Table 96: Properties of each product.

Id	Name	SBO
iend	iend	

#### Kinetic Law

**Derived unit** contains undeclared units

$$v_{45} = \left( K_{dp} + \frac{K_{cat} \cdot [\text{X\_P}]}{K_m + [\text{X\_P}]} \right) \cdot [\text{iendIR}] \quad (125)$$

### 7.46 Reaction R46

This is an irreversible reaction of one reactant forming one product.

**Name** R46

**SBO:0000216** phosphorylation

**Reaction equation**



**Reactant**

Table 97: Properties of each reactant.

Id	Name	SBO
r0	r0	

**Product**

Table 98: Properties of each product.

Id	Name	SBO
rPbasal	rPbasal	

**Kinetic Law**

**Derived unit** contains undeclared units

$$v_{46} = kf_{basal} \cdot [r0]$$

(127)

**7.47 Reaction R47**

This is an irreversible reaction of one reactant forming one product.

**Name** R47

**SBO:0000330** dephosphorylation

**Reaction equation**



**Reactant**

Table 99: Properties of each reactant.

Id	Name	SBO
rPbasal	rPbasal	

**Product**

Table 100: Properties of each product.

Id	Name	SBO
r0	r0	

**Kinetic Law**

**Derived unit** contains undeclared units

$$v_{47} = k_{rbasal} \cdot [rPbasal] \tag{129}$$

**7.48 Reaction R48**

This is an irreversible reaction of one reactant forming one product.

**Name** R48

**SBO:0000185** transport reaction

**Reaction equation**



**Reactant**

Table 101: Properties of each reactant.

Id	Name	SBO
rPbasal	rPbasal	

**Product**

Table 102: Properties of each product.

Id	Name	SBO
rendP	rendP	

### Kinetic Law

**Derived unit** contains undeclared units

$$v_{48} = K_{\text{end}} \cdot [\text{rPbasal}] \quad (131)$$

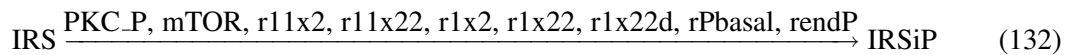
### 7.49 Reaction v2f

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

**Name** v2f

**SBO:0000216** phosphorylation

### Reaction equation



### Reactant

Table 103: Properties of each reactant.

Id	Name	SBO
IRS	IRS	

### Modifiers

Table 104: Properties of each modifier.

Id	Name	SBO
PKC_P	PKC_P	
mTOR	mTOR	
r11x2	r11x2	
r11x22	r11x22	
r1x2	r1x2	
r1x22	r1x22	
r1x22d	r1x22d	

Id	Name	SBO
rPbasal	rPbasal	
rendP	rendP	

## Product

Table 105: Properties of each product.

Id	Name	SBO
IRSiP	IRSiP	

## Kinetic Law

**Derived unit** contains undeclared units

$$v_{49} = k_{21} \cdot [\text{IRS}] \cdot ([r_{1x2}] + [r_{11x2}] + [r_{1x22}] + [r_{1x22d}] + [r_{11x22}] + [r_{\text{Pbasal}}] + k_{22} \cdot [r_{\text{endP}}]) \cdot (1 + k_{23} \cdot [\text{PKC\_P}] + k_{24} \cdot [\text{mTOR}]) \quad (133)$$

## 7.50 Reaction v2b

This is an irreversible reaction of one reactant forming one product.

**Name** v2b

**SBO:0000330** dephosphorylation

## Reaction equation



## Reactant

Table 106: Properties of each reactant.

Id	Name	SBO
IRSiP	IRSiP	

## Product

Table 107: Properties of each product.

Id	Name	SBO
IRS	IRS	

### Kinetic Law

**Derived unit** contains undeclared units

$$v_{50} = k_{2b} \cdot [\text{IRSiP}] \quad (135)$$

### 7.51 Reaction v3f

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

**Name** v3f

**SBO:0000216** phosphorylation

### Reaction equation



### Reactant

Table 108: Properties of each reactant.

Id	Name	SBO
X	X	

### Modifier

Table 109: Properties of each modifier.

Id	Name	SBO
IRSiP	IRSiP	

### Product

Table 110: Properties of each product.

Id	Name	SBO
X_P	X_P	

### Kinetic Law

**Derived unit** contains undeclared units

$$v_{51} = k_{3f} \cdot [X] \cdot [IRSiP] \quad (137)$$

### 7.52 Reaction v3b

This is an irreversible reaction of one reactant forming one product.

**Name** v3b

**SBO:0000330** dephosphorylation

### Reaction equation



### Reactant

Table 111: Properties of each reactant.

Id	Name	SBO
X_P	X_P	

### Product

Table 112: Properties of each product.

Id	Name	SBO
X	X	

### Kinetic Law

**Derived unit** contains undeclared units

$$v_{52} = k_{3b} \cdot [X_P] \quad (139)$$



7.53 Reaction v4f

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

Name v4f

SBO:0000216 phosphorylation

Reaction equation



Reactant

Table 113: Properties of each reactant.

Id	Name	SBO
PI3K	PI3K	

Modifier

Table 114: Properties of each modifier.

Id	Name	SBO
IRSiP	IRSiP	

Product

Table 115: Properties of each product.

Id	Name	SBO
PI3K_-	PI3K_-	

Kinetic Law

Derived unit contains undeclared units

$$v_{53} = k_{4f} \cdot [\text{PI3K}] \cdot [\text{IRSiP}]$$

(141)

7.54 Reaction v4b

This is an irreversible reaction of one reactant forming one product.

**Name** v4b

**SBO:0000330** dephosphorylation

**Reaction equation**



**Reactant**

Table 116: Properties of each reactant.

Id	Name	SBO
PI3K_	PI3K_	

**Product**

Table 117: Properties of each product.

Id	Name	SBO
PI3K	PI3K	

**Kinetic Law**

**Derived unit** contains undeclared units

$$v_{54} = k_{4b} \cdot [\text{PI3K}_-] \tag{143}$$

**7.55 Reaction v5f**

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

**Name** v5f

**SBO:0000216** phosphorylation

**Reaction equation**



**Reactant**

Table 118: Properties of each reactant.

Id	Name	SBO
PDK1	PDK1	

## Modifier

Table 119: Properties of each modifier.

Id	Name	SBO
PI3K_	PI3K_	

## Product

Table 120: Properties of each product.

Id	Name	SBO
PDK1_	PDK1_	

## Kinetic Law

**Derived unit** contains undeclared units

$$v_{55} = k_{5f} \cdot [\text{PDK1}] \cdot [\text{PI3K}_-] \quad (145)$$

## 7.56 Reaction v5b

This is an irreversible reaction of one reactant forming one product.

**Name** v5b

**SBO:0000330** dephosphorylation

## Reaction equation



## Reactant

Table 121: Properties of each reactant.

Id	Name	SBO
PDK1_	PDK1_	

## Product

Table 122: Properties of each product.

Id	Name	SBO
PDK1	PDK1	

## Kinetic Law

**Derived unit** contains undeclared units

$$v_{56} = k_{5b} \cdot [\text{PDK1}_-] \quad (147)$$

## 7.57 Reaction v6f

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

**Name** v6f

**SBO:0000216** phosphorylation

## Reaction equation



## Reactant

Table 123: Properties of each reactant.

Id	Name	SBO
PKC	PKC	

## Modifier

Table 124: Properties of each modifier.

Id	Name	SBO
PDK1_	PDK1_	

## Product

Table 125: Properties of each product.

Id	Name	SBO
PKC_P	PKC_P	

## Kinetic Law

**Derived unit** contains undeclared units

$$v_{57} = k_{6f} \cdot [\text{PKC}] \cdot [\text{PDK1}_-] \quad (149)$$

## 7.58 Reaction v6b

This is an irreversible reaction of one reactant forming one product.

**Name** v6b

**SBO:0000330** dephosphorylation

## Reaction equation



## Reactant

Table 126: Properties of each reactant.

Id	Name	SBO
PKC_P	PKC_P	

## Product

Table 127: Properties of each product.

Id	Name	SBO
PKC	PKC	

### Kinetic Law

**Derived unit** contains undeclared units

$$v_{58} = k_{6b} \cdot [\text{PKC\_P}] \quad (151)$$

### 7.59 Reaction $v_{7f}$

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

**Name**  $v_{7f}$

**SBO:0000216** phosphorylation

### Reaction equation



### Reactant

Table 128: Properties of each reactant.

Id	Name	SBO
PKB	PKB	

### Modifier

Table 129: Properties of each modifier.

Id	Name	SBO
PDK1_	PDK1_	

### Product

Table 130: Properties of each product.

Id	Name	SBO
PKB_P	PKB_P	

#### Kinetic Law

**Derived unit** contains undeclared units

$$v_{59} = k_{7f} \cdot [\text{PKB}] \cdot [\text{PDK1}_-] \quad (153)$$

#### 7.60 Reaction v7b

This is an irreversible reaction of one reactant forming one product.

**Name** v7b

**SBO:0000330** dephosphorylation

#### Reaction equation



#### Reactant

Table 131: Properties of each reactant.

Id	Name	SBO
PKB_P	PKB_P	

#### Product

Table 132: Properties of each product.

Id	Name	SBO
PKB	PKB	

#### Kinetic Law

**Derived unit** contains undeclared units

$$v_{60} = k_{7b} \cdot [\text{PKB\_P}] \quad (155)$$

### 7.61 Reaction v8f

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

**Name** v8f

**SBO:0000216** phosphorylation

#### Reaction equation



#### Reactant

Table 133: Properties of each reactant.

Id	Name	SBO
mTOR	mTOR	

#### Modifier

Table 134: Properties of each modifier.

Id	Name	SBO
PKB_P	PKB_P	

#### Product

Table 135: Properties of each product.

Id	Name	SBO
mTOR_	mTOR_	

#### Kinetic Law

**Derived unit** contains undeclared units

$$v_{61} = k_{8f} \cdot [\text{mTOR}] \cdot [\text{PKB\_P}] \quad (157)$$

### 7.62 Reaction v8b

This is an irreversible reaction of one reactant forming one product.



**Name** v8b

**SBO:0000330** dephosphorylation

### Reaction equation



### Reactant

Table 136: Properties of each reactant.

Id	Name	SBO
mTOR_	mTOR_	

### Product

Table 137: Properties of each product.

Id	Name	SBO
mTOR	mTOR	

### Kinetic Law

**Derived unit** contains undeclared units

$$v_{62} = k_{8b} \cdot [\text{mTOR\_}] \quad (159)$$

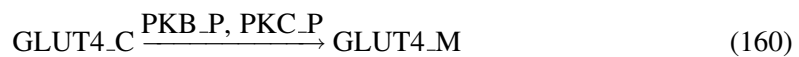
## 7.63 Reaction v9f

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

**Name** v9f

**SBO:0000344** molecular interaction

### Reaction equation



### Reactant

Table 138: Properties of each reactant.

Id	Name	SBO
GLUT4_C	GLUT4_C	

## Modifiers

Table 139: Properties of each modifier.

Id	Name	SBO
PKB_P	PKB_P	
PKC_P	PKC_P	

## Product

Table 140: Properties of each product.

Id	Name	SBO
GLUT4_M	GLUT4_M	

## Kinetic Law

**Derived unit** contains undeclared units

$$v_{63} = k_{91} \cdot [\text{GLUT4\_C}] \cdot [\text{PKC\_P}] + k_{92} \cdot [\text{GLUT4\_C}] \cdot [\text{PKB\_P}] + k_{5\text{BasicWb}} \cdot [\text{GLUT4\_C}] \quad (161)$$

## 7.64 Reaction v9b

This is an irreversible reaction of one reactant forming one product.

**Name** v9b

**SBO:0000344** molecular interaction

## Reaction equation



## Reactant

Table 141: Properties of each reactant.

Id	Name	SBO
GLUT4_M	GLUT4_M	

## Product

Table 142: Properties of each product.

Id	Name	SBO
GLUT4_C	GLUT4_C	

## Kinetic Law

**Derived unit** contains undeclared units

$$v_{64} = k_{9b} \cdot [\text{GLUT4\_M}] \quad (163)$$

## 8 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.

### 8.1 Species `r0`

**Name** `r0`

**SBO:0000244** receptor

**Initial amount** 9.96820379306998 mol

This species takes part in seven reactions (as a reactant in [R1](#), [R2](#), [R46](#) and as a product in [R5](#), [R8](#), [R37](#), [R47](#)).

$$\frac{d}{dt}r0 = v_5 + v_8 + v_{37} + v_{47} - v_1 - v_2 - v_{46} \quad (164)$$

## 8.2 Species r1

**Name** r1

**SBO:0000244** receptor

**Initial amount** 0.0221366043399864 mol

This species takes part in eight reactions (as a reactant in R3, R5, R6, R9 and as a product in R1, R12, R15, R19).

$$\frac{d}{dt}r1 = v_1 + v_{12} + v_{15} + v_{19} - v_3 - v_5 - v_6 - v_9 \quad (165)$$

## 8.3 Species r2

**Name** r2

**SBO:0000244** receptor

**Initial amount** 0.00934921094738169 mol

This species takes part in eight reactions (as a reactant in R4, R7, R8, R10 and as a product in R2, R13, R16, R22).

$$\frac{d}{dt}r2 = v_2 + v_{13} + v_{16} + v_{22} - v_4 - v_7 - v_8 - v_{10} \quad (166)$$

## 8.4 Species r11

**Name** r11

**SBO:0000244** receptor

**Initial amount**  $1.22886711962222 \cdot 10^{-5}$  mol

This species takes part in four reactions (as a reactant in R12, R17 and as a product in R3, R26).

$$\frac{d}{dt}r11 = v_3 + v_{26} - v_{12} - v_{17} \quad (167)$$

## 8.5 Species r12

**Name** r12

**SBO:0000244** receptor

**Initial amount**  $1.0376421415741 \cdot 10^{-5}$  mol

This species takes part in eight reactions (as a reactant in R13, R15, R18, R20 and as a product in R4, R6, R27, R28).

$$\frac{d}{dt}r12 = v_4 + v_6 + v_{27} + v_{28} - v_{13} - v_{15} - v_{18} - v_{20} \quad (168)$$

## 8.6 Species $r_{22}$

**Name**  $r_{22}$

**SBO:0000244** receptor

**Initial amount**  $2.18683301945588 \cdot 10^{-6}$  mol

This species takes part in four reactions (as a reactant in [R16](#), [R21](#) and as a product in [R7](#), [R29](#)).

$$\frac{d}{dt}r_{22} = v_7 + v_{29} - v_{16} - v_{21} \quad (169)$$

## 8.7 Species $r_{1x2}$

**Name**  $r_{1x2}$

**SBO:0000244** receptor

**Initial amount**  $1.36475817837692 \cdot 10^{-6}$  mol

This species takes part in twelve reactions (as a reactant in [R11](#), [R14](#), [R19](#), [R22](#), [R23](#), [R39](#) and as a product in [R9](#), [R10](#), [R24](#), [R25](#), [R34](#) and as a modifier in [v2f](#)).

$$\frac{d}{dt}r_{1x2} = v_9 + v_{10} + v_{24} + v_{25} + v_{34} - v_{11} - v_{14} - v_{19} - v_{22} - v_{23} - v_{39} \quad (170)$$

## 8.8 Species $r_{11x2}$

**Name**  $r_{11x2}$

**SBO:0000244** receptor

**Initial amount**  $1.51513915390766 \cdot 10^{-9}$  mol

This species takes part in ten reactions (as a reactant in [R24](#), [R26](#), [R28](#), [R31](#), [R40](#) and as a product in [R11](#), [R17](#), [R20](#), [R36](#) and as a modifier in [v2f](#)).

$$\frac{d}{dt}r_{11x2} = v_{11} + v_{17} + v_{20} + v_{36} - v_{24} - v_{26} - v_{28} - v_{31} - v_{40} \quad (171)$$

## 8.9 Species $r_{1x22}$

**Name**  $r_{1x22}$

**SBO:0000244** receptor

**Initial amount**  $6.39351849488596 \cdot 10^{-10}$  mol

This species takes part in twelve reactions (as a reactant in [R25](#), [R27](#), [R29](#), [R30](#), [R32](#), [R41](#) and as a product in [R14](#), [R18](#), [R21](#), [R33](#), [R35](#) and as a modifier in [v2f](#)).

$$\frac{d}{dt}r_{1x22} = v_{14} + v_{18} + v_{21} + v_{33} + v_{35} - v_{25} - v_{27} - v_{29} - v_{30} - v_{32} - v_{41} \quad (172)$$

### 8.10 Species `r1x22d`

**Name** `r1x22d`

**SBO:0000244** receptor

**Initial amount**  $5.59231079319369 \cdot 10^{-20}$  mol

This species takes part in six reactions (as a reactant in [R33](#), [R34](#), [R42](#) and as a product in [R23](#), [R32](#) and as a modifier in [v2f](#)).

$$\frac{d}{dt}r1x22d = v_{23} + v_{32} - v_{33} - v_{34} - v_{42} \quad (173)$$

### 8.11 Species `r11x22`

**Name** `r11x22`

**SBO:0000244** receptor

**Initial amount**  $1.78725515332219 \cdot 10^{-14}$  mol

This species takes part in six reactions (as a reactant in [R35](#), [R36](#), [R43](#) and as a product in [R30](#), [R31](#) and as a modifier in [v2f](#)).

$$\frac{d}{dt}r11x22 = v_{30} + v_{31} - v_{35} - v_{36} - v_{43} \quad (174)$$

### 8.12 Species `rend`

**Name** `rend`

**SBO:0000240** material entity

**Initial amount**  $3.31711803810961 \cdot 10^{-5}$  mol

This species takes part in two reactions (as a reactant in [R37](#) and as a product in [R44](#)).

$$\frac{d}{dt}rend = v_{44} - v_{37} \quad (175)$$

### 8.13 Species `rendP`

**Name** `rendP`

**SBO:0000240** material entity

**Initial amount**  $2.12533941418487 \cdot 10^{-4}$  mol

This species takes part in eight reactions (as a reactant in [R44](#) and as a product in [R39](#), [R40](#), [R41](#), [R42](#), [R43](#), [R48](#) and as a modifier in [v2f](#)).

$$\frac{d}{dt}rendP = v_{39} + v_{40} + v_{41} + v_{42} + v_{43} + v_{48} - v_{44} \quad (176)$$

### 8.14 Species `iendIR`

**Name** `iendIR`

**SBO:0000240** material entity

**Initial amount**  $7.25519178924707 \cdot 10^{-6}$  mol

This species takes part in six reactions (as a reactant in [R45](#) and as a product in [R39](#), [R40](#), [R41](#), [R42](#), [R43](#)).

$$\frac{d}{dt}iendIR = v_{39} + 2 v_{40} + 2 v_{41} + 3 v_{42} + 3 v_{43} - v_{45} \quad (177)$$

### 8.15 Species `iend`

**Name** `iend`

**SBO:0000240** material entity

**Initial amount**  $1.13228497567934 \cdot 10^{-6}$  mol

This species takes part in two reactions (as a reactant in [R38](#) and as a product in [R45](#)).

$$\frac{d}{dt}iend = v_{45} - v_{38} \quad (178)$$

### 8.16 Species `rPbasal`

**Name** `rPbasal`

**SBO:0000240** material entity

**Initial amount**  $3.87230309356247 \cdot 10^{-5}$  mol

This species takes part in four reactions (as a reactant in [R47](#), [R48](#) and as a product in [R46](#) and as a modifier in [v2f](#)).

$$\frac{d}{dt}rPbasal = v_{46} - v_{47} - v_{48} \quad (179)$$

### 8.17 Species `IRS`

**Name** `IRS`

**SBO:0000240** material entity

**Initial amount**  $9.99982253600007$  mol

This species takes part in two reactions (as a reactant in [v2f](#) and as a product in [v2b](#)).

$$\frac{d}{dt}IRS = v_{50} - v_{49} \quad (180)$$

### 8.18 Species IRSiP

**Name** IRSiP

**SBO:0000240** material entity

**Initial amount**  $1.77463999892648 \cdot 10^{-4}$  mol

This species takes part in four reactions (as a reactant in v2b and as a product in v2f and as a modifier in v3f, v4f).

$$\frac{d}{dt} \text{IRSiP} = v_{49} - v_{50} \quad (181)$$

### 8.19 Species X

**Name** X

**SBO:0000240** material entity

**Initial amount** 9.92463241634744 mol

This species takes part in two reactions (as a reactant in v3f and as a product in v3b).

$$\frac{d}{dt} X = v_{52} - v_{51} \quad (182)$$

### 8.20 Species X\_P

**Name** X\_P

**SBO:0000240** material entity

**Initial amount** 0.0753675836525682 mol

This species takes part in four reactions (as a reactant in v3b and as a product in v3f and as a modifier in R44, R45).

$$\frac{d}{dt} X_P = v_{51} - v_{52} \quad (183)$$

### 8.21 Species PI3K

**Name** PI3K

**SBO:0000240** material entity

**Initial amount** 9.97578356966623 mol

This species takes part in two reactions (as a reactant in v4f and as a product in v4b).

$$\frac{d}{dt} \text{PI3K} = v_{54} - v_{53} \quad (184)$$



## 8.22 Species PI3K<sub>-</sub>

**Name** PI3K<sub>-</sub>

**SBO:0000240** material entity

**Initial amount** 0.0242164303337614 mol

This species takes part in three reactions (as a reactant in [v4b](#) and as a product in [v4f](#) and as a modifier in [v5f](#)).

$$\frac{d}{dt}\text{PI3K}_{-} = v_{53} - v_{54} \quad (185)$$

## 8.23 Species PDK1

**Name** PDK1

**SBO:0000240** material entity

**Initial amount** 8.65876984730663 mol

This species takes part in two reactions (as a reactant in [v5f](#) and as a product in [v5b](#)).

$$\frac{d}{dt}\text{PDK1} = v_{56} - v_{55} \quad (186)$$

## 8.24 Species PDK1<sub>-</sub>

**Name** PDK1<sub>-</sub>

**SBO:0000240** material entity

**Initial amount** 1.34123015269338 mol

This species takes part in four reactions (as a reactant in [v5b](#) and as a product in [v5f](#) and as a modifier in [v6f](#), [v7f](#)).

$$\frac{d}{dt}\text{PDK1}_{-} = v_{55} - v_{56} \quad (187)$$

## 8.25 Species PKC

**Name** PKC

**SBO:0000240** material entity

**Initial amount**  $3.60283594102724 \cdot 10^{-5}$  mol

This species takes part in two reactions (as a reactant in [v6f](#) and as a product in [v6b](#)).

$$\frac{d}{dt}\text{PKC} = v_{58} - v_{57} \quad (188)$$

### 8.26 Species PKC\_P

**Name** PKC\_P

**SBO:0000240** material entity

**Initial amount** 9.99996397164059 mol

This species takes part in four reactions (as a reactant in v6b and as a product in v6f and as a modifier in v2f, v9f).

$$\frac{d}{dt}PKC\_P = v_{57} - v_{58} \quad (189)$$

### 8.27 Species PKB

**Name** PKB

**SBO:0000240** material entity

**Initial amount** 9.90193143617302 mol

This species takes part in two reactions (as a reactant in v7f and as a product in v7b).

$$\frac{d}{dt}PKB = v_{60} - v_{59} \quad (190)$$

### 8.28 Species PKB\_P

**Name** PKB\_P

**SBO:0000240** material entity

**Initial amount** 0.0980685638269942 mol

This species takes part in four reactions (as a reactant in v7b and as a product in v7f and as a modifier in v8f, v9f).

$$\frac{d}{dt}PKB\_P = v_{59} - v_{60} \quad (191)$$

### 8.29 Species mTOR

**Name** mTOR

**SBO:0000244** receptor

**Initial amount** 0.0201915011292933 mol

This species takes part in three reactions (as a reactant in v8f and as a product in v8b and as a modifier in v2f).

$$\frac{d}{dt}mTOR = v_{62} - v_{61} \quad (192)$$

### 8.30 Species `mTOR_`

**Name** `mTOR_`

**SBO:0000244** receptor

**Initial amount** 9.97980849887072 mol

This species takes part in two reactions (as a reactant in [v8b](#) and as a product in [v8f](#)).

$$\frac{d}{dt}mTOR_ = v_{61} - v_{62} \quad (193)$$

### 8.31 Species `GLUT4_C`

**Name** `GLUT4_C`

**SBO:0000284** transporter

**Initial amount** 9.99316830771855 mol

This species takes part in two reactions (as a reactant in [v9f](#) and as a product in [v9b](#)).

$$\frac{d}{dt}GLUT4_C = v_{64} - v_{63} \quad (194)$$

### 8.32 Species `GLUT4_M`

**Name** `GLUT4_M`

**SBO:0000284** transporter

**Initial amount** 0.00683169228144988 mol

This species takes part in two reactions (as a reactant in [v9b](#) and as a product in [v9f](#)).

$$\frac{d}{dt}GLUT4_M = v_{63} - v_{64} \quad (195)$$

## 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:0000180 dissociation:** Transformation of a non-covalent complex that results in the formation of several independent biochemical entities
- SBO:0000185 transport reaction:** Movement of a physical entity without modification of the structure of the entity
- SBO:0000196 concentration of an entity pool:** The amount of an entity per unit of volume.
- SBO:0000216 phosphorylation:** Addition of a phosphate group ( $\text{-H}_2\text{PO}_4$ ) to a chemical entity
- SBO:0000240 material entity:** A real thing that is defined by its physico-chemical structure.
- SBO:0000244 receptor:** Participating entity that binds to a specific physical entity and initiates the response to that physical entity. The original concept of the receptor was introduced independently at the end of the 19th century by John Newport Langley (1852-1925) and Paul Ehrlich (1854-1915). Langley JN. On the reaction of cells and of nerve-endings to certain poisons, chiefly as regards the reaction of striated muscle to nicotine and to curari. J Physiol. 1905 Dec 30;33(4-5):374-413
- SBO:0000284 transporter:** Participating entity that facilitates the movement of another physical entity from a defined subset of the physical environment (for instance a cellular compartment) to another.
- SBO:0000330 dephosphorylation:** Removal of a phosphate group ( $\text{-H}_2\text{PO}_4$ ) from a chemical entity.
- SBO:0000344 molecular interaction:** Relationship between molecular entities, based on contacts, direct or indirect.
- 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: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.

SBML<sup>2</sup>TeX was developed by Andreas Dräger<sup>a</sup>, Hannes Planatscher<sup>a</sup>, Dieudonné M Wouamba<sup>a</sup>, Adrian Schröder<sup>a</sup>, Michael Hucka<sup>b</sup>, Lukas Endler<sup>c</sup>, Martin Golebiewski<sup>d</sup> and Andreas Zell<sup>a</sup>. Please see <http://www.ra.cs.uni-tuebingen.de/software/SBML2LaTeX> for more information.

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