

SBML Model Report

Model name: “Singh2006_TCA_mtu_model2”



May 6, 2016

1 General Overview

This is a document in SBML Level 2 Version 4 format. This model was created by the following three authors: Lukas Endler¹, Vijayalakshmi Chelliah² and Vivek Kumar Singh³ at September 29th 2006 at 10:49 p. m. and last time modified at July fifth 2012 at 2:45 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	13
events	0	constraints	0
reactions	14	function definitions	0
global parameters	0	unit definitions	4
rules	0	initial assignments	0

Model Notes

This a model from the article:

Kinetic modeling of tricarboxylic acid cycle and glyoxylate bypass in Mycobacterium tuberculosis, and its application to assessment of drug targets.

Singh VK , Ghosh I Theor Biol Med Model 2006 Aug 3;3:27 [16887020](#) ,

Abstract:

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BACKGROUND: Targeting persistent tubercule bacilli has become an important challenge in the development of anti-tuberculous drugs. As the glyoxylate bypass is essential for persistent bacilli, interference with it holds the potential for designing new antibacterial drugs. We have developed kinetic models of the tricarboxylic acid cycle and glyoxylate bypass in *Escherichia coli* and *Mycobacterium tuberculosis*, and studied the effects of inhibition of various enzymes in the *M. tuberculosis* model. **RESULTS:** We used *E. coli* to validate the pathway-modeling protocol and showed that changes in metabolic flux can be estimated from gene expression data. The *M. tuberculosis* model reproduced the observation that deletion of one of the two isocitrate lyase genes has little effect on bacterial growth in macrophages, but deletion of both genes leads to the elimination of the bacilli from the lungs. It also substantiated the inhibition of isocitrate lyases by 3-nitropropionate. On the basis of our simulation studies, we propose that: (i) fractional inactivation of both isocitrate dehydrogenase 1 and isocitrate dehydrogenase 2 is required for a flux through the glyoxylate bypass in persistent mycobacteria; and (ii) increasing the amount of active isocitrate dehydrogenases can stop the flux through the glyoxylate bypass, so the kinase that inactivates isocitrate dehydrogenase 1 and/or the proposed inactivator of isocitrate dehydrogenase 2 is a potential target for drugs against persistent mycobacteria. In addition, competitive inhibition of isocitrate lyases along with a reduction in the inactivation of isocitrate dehydrogenases appears to be a feasible strategy for targeting persistent mycobacteria. **CONCLUSION:** We used kinetic modeling of biochemical pathways to assess various potential anti-tuberculous drug targets that interfere with the glyoxylate bypass flux, and indicated the type of inhibition needed to eliminate the pathogen. The advantage of such an approach to the assessment of drug targets is that it facilitates the study of systemic effect(s) of the modulation of the target enzyme(s) in the cellular environment.

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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 seven unit definitions of which three are predefined by SBML and not mentioned in the model.

2.1 Unit `time`

Name `min`

Definition `60 s`

2.2 Unit `substance`

Name `mmole`

Definition `mmol`

2.3 Unit `mmlmin`

Name `mM_per_min`

Definition $\text{mmol} \cdot \text{l}^{-1} \cdot (60 \text{ s})^{-1}$

2.4 Unit `mml`

Name `mM`

Definition $\text{mmol} \cdot \text{l}^{-1}$

2.5 Unit `volume`

Notes Litre is the predefined SBML unit for volume.

Definition `l`

2.6 Unit `area`

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

Definition m^2

2.7 Unit `length`

Notes Metre is the predefined SBML unit for length since SBML Level 2 Version 1.

Definition `m`

3 Compartment

This model contains one compartment.

Table 2: Properties of all compartments.

Id	Name	SBO	Spatial Dimensions	Size	Unit	Constant	Outside
cell		0000290	3	1	litre	<input checked="" type="checkbox"/>	

3.1 Compartment `cell`

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

SBO:0000290 physical compartment

4 Species

This model contains 13 species. The boundary condition of four of these species is set to `true` so that these species' amount cannot be changed by any reaction. Section 6 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 Condi- tion
aca		cell	$\text{mmol} \cdot \text{l}^{-1}$	<input type="checkbox"/>	<input checked="" type="checkbox"/>
oaa		cell	$\text{mmol} \cdot \text{l}^{-1}$	<input type="checkbox"/>	<input checked="" type="checkbox"/>
coa		cell	$\text{mmol} \cdot \text{l}^{-1}$	<input type="checkbox"/>	<input checked="" type="checkbox"/>
cit		cell	$\text{mmol} \cdot \text{l}^{-1}$	<input type="checkbox"/>	<input type="checkbox"/>
icit		cell	$\text{mmol} \cdot \text{l}^{-1}$	<input type="checkbox"/>	<input type="checkbox"/>
akg		cell	$\text{mmol} \cdot \text{l}^{-1}$	<input type="checkbox"/>	<input type="checkbox"/>
ssa		cell	$\text{mmol} \cdot \text{l}^{-1}$	<input type="checkbox"/>	<input type="checkbox"/>
suc		cell	$\text{mmol} \cdot \text{l}^{-1}$	<input type="checkbox"/>	<input type="checkbox"/>
sca		cell	$\text{mmol} \cdot \text{l}^{-1}$	<input type="checkbox"/>	<input type="checkbox"/>
fa		cell	$\text{mmol} \cdot \text{l}^{-1}$	<input type="checkbox"/>	<input type="checkbox"/>
mal		cell	$\text{mmol} \cdot \text{l}^{-1}$	<input type="checkbox"/>	<input type="checkbox"/>
gly		cell	$\text{mmol} \cdot \text{l}^{-1}$	<input type="checkbox"/>	<input type="checkbox"/>
biosyn		cell	$\text{mmol} \cdot \text{l}^{-1}$	<input type="checkbox"/>	<input checked="" type="checkbox"/>

5 Reactions

This model contains 14 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 4: Overview of all reactions

Nº	Id	Name	Reaction Equation	SBO
1	CS		$\text{aca} + \text{oaa} \rightleftharpoons \text{coa} + \text{cit}$	0000402
2	ACN		$\text{cit} \rightleftharpoons \text{icit}$	0000377
3	ICD1		$\text{icit} \rightleftharpoons \text{akg}$	0000399
4	ICD2		$\text{icit} \rightleftharpoons \text{akg}$	0000399
5	KGD		$\text{akg} \rightleftharpoons \text{ssa}$	0000399
6	SSADH		$\text{ssa} \rightleftharpoons \text{suc}$	
7	ScAS		$\text{sca} \rightleftharpoons \text{suc}$	
8	SDH		$\text{suc} \rightleftharpoons \text{fa}$	
9	FUM		$\text{fa} \rightleftharpoons \text{mal}$	
10	MDH		$\text{mal} \rightleftharpoons \text{oaa}$	
11	ICL1		$\text{icit} \rightleftharpoons \text{suc} + \text{gly}$	
12	ICL2		$\text{icit} \rightleftharpoons \text{suc} + \text{gly}$	
13	MS		$\text{gly} + \text{aca} \rightleftharpoons \text{mal} + \text{coa}$	
14	SYN		$\text{akg} \xrightleftharpoons{\text{icit}} \text{biosyn}$	

5.1 Reaction CS

This is a reversible reaction of two reactants forming two products.

SBO:0000402 transfer of a chemical group

Reaction equation



Reactants

Table 5: Properties of each reactant.

Id	Name	SBO
aca		
oaa		

Products

Table 6: Properties of each product.

Id	Name	SBO
coa		
cit		

Kinetic Law

Derived unit contains undeclared units

$$v_1 = \text{vol}(\text{cell}) \cdot \frac{Vf_cs \cdot \frac{[aca]}{Kaca_cs} \cdot \frac{[oaa]}{Koaa_cs} - Vr_cs \cdot \frac{[coa]}{Kcoa_cs} \cdot \frac{[cit]}{Kcit_cs}}{\left(1 + \frac{[aca]}{Kaca_cs} + \frac{[coa]}{Kcoa_cs}\right) \cdot \left(1 + \frac{[oaa]}{Koaa_cs} + \frac{[cit]}{Kcit_cs}\right)} \quad (2)$$

Table 7: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
Vf_cs		0000350	64.800	mmol · l ⁻¹ · (60 s) ⁻¹	<input checked="" type="checkbox"/>
Kaca_cs		0000322	0.050	mmol · l ⁻¹	<input checked="" type="checkbox"/>
Koaa_cs		0000322	0.012	mmol · l ⁻¹	<input checked="" type="checkbox"/>
Vr_cs		0000353	0.648	mmol · l ⁻¹ · (60 s) ⁻¹	<input checked="" type="checkbox"/>

Id	Name	SBO	Value	Unit	Constant
Kcoa_cs		0000323	0.500	mmol · l ⁻¹	<input checked="" type="checkbox"/>
Kcit_cs		0000323	0.120	mmol · l ⁻¹	<input checked="" type="checkbox"/>

5.2 Reaction ACN

This is a reversible reaction of one reactant forming one product.

SBO:0000377 isomerisation

Reaction equation



Reactant

Table 8: Properties of each reactant.

Id	Name	SBO
cit		

Product

Table 9: Properties of each product.

Id	Name	SBO
icit		

Kinetic Law

Derived unit contains undeclared units

$$v_2 = \text{vol}(\text{cell}) \cdot \frac{Vf_acn \cdot \frac{[\text{cit}]}{K_{cit_acn}} - Vr_acn \cdot \frac{[\text{icit}]}{K_{icit_acn}}}{1 + \frac{[\text{cit}]}{K_{cit_acn}} + \frac{[\text{icit}]}{K_{icit_acn}}} \quad (4)$$

Table 10: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
Vf_acn		0000350	31.200	mmol · l ⁻¹ · (60 s) ⁻¹	<input checked="" type="checkbox"/>

Id	Name	SBO	Value	Unit	Constant
Kcit_acn		0000322	1.700	mmol · l ⁻¹	<input checked="" type="checkbox"/>
Vr_acn		0000353	0.312	mmol · l ⁻¹ · (60 s) ⁻¹	<input checked="" type="checkbox"/>
Kicit_acn		0000323	0.700	mmol · l ⁻¹	<input checked="" type="checkbox"/>

5.3 Reaction ICD1

This is a reversible reaction of one reactant forming one product.

SBO:0000399 decarboxylation

Reaction equation



Reactant

Table 11: Properties of each reactant.

Id	Name	SBO
icit		

Product

Table 12: Properties of each product.

Id	Name	SBO
akg		

Kinetic Law

Derived unit contains undeclared units

$$v_3 = \text{vol}(\text{cell}) \cdot \frac{Vf_icd1 \cdot \frac{[icit]}{Kicit_icd1} - Vr_icd1 \cdot \frac{[akg]}{Kakg_icd1}}{1 + \frac{[icit]}{Kicit_icd1} + \frac{[akg]}{Kakg_icd1}} \quad (6)$$

Table 13: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
Vf_icd1		0000350	10.200	mmol · l ⁻¹ · (60 s) ⁻¹	<input checked="" type="checkbox"/>
Kicit_icd1		0000322	0.030	mmol · l ⁻¹	<input checked="" type="checkbox"/>
Vr_icd1		0000353	0.102	mmol · l ⁻¹ · (60 s) ⁻¹	<input checked="" type="checkbox"/>
Kakg_icd1		0000323	0.300	mmol · l ⁻¹	<input checked="" type="checkbox"/>

5.4 Reaction ICD2

This is a reversible reaction of one reactant forming one product.

SBO:0000399 decarboxylation

Reaction equation



Reactant

Table 14: Properties of each reactant.

Id	Name	SBO
	icit	

Product

Table 15: Properties of each product.

Id	Name	SBO
	akg	

Kinetic Law

Derived unit contains undeclared units

$$v_4 = \text{vol}(\text{cell}) \cdot \frac{Vf_icd2 \cdot \frac{[icit]}{Kicit_icd2} - Vr_icd2 \cdot \frac{[akg]}{Kakg_icd2}}{1 + \frac{[icit]}{Kicit_icd2} + \frac{[akg]}{Kakg_icd2}} \quad (8)$$

Table 16: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
Vf_icd2		0000350	9.965	mmol · l ⁻¹ · (60 s) ⁻¹	<input checked="" type="checkbox"/>
Kicit_icd2		0000322	0.060	mmol · l ⁻¹	<input checked="" type="checkbox"/>
Vr_icd2		0000353	0.100	mmol · l ⁻¹ · (60 s) ⁻¹	<input checked="" type="checkbox"/>
Kakg_icd2		0000323	0.600	mmol · l ⁻¹	<input checked="" type="checkbox"/>

5.5 Reaction KGD

This is a reversible reaction of one reactant forming one product.

SBO:0000399 decarboxylation

Reaction equation



Reactant

Table 17: Properties of each reactant.

Id	Name	SBO
	akg	

Product

Table 18: Properties of each product.

Id	Name	SBO
	ssa	

Kinetic Law

Derived unit contains undeclared units

$$v_5 = \text{vol}(\text{cell}) \cdot \frac{Vf_kgd \cdot \frac{[akg]}{Kakg_kgd} - Vr_kgd \cdot \frac{[ssa]}{Kssa_kgd}}{1 + \frac{[akg]}{Kakg_kgd} + \frac{[ssa]}{Kssa_kgd}} \quad (10)$$

Table 19: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
Vf_kgd		0000350	48.300	mmol · l ⁻¹ · (60 s) ⁻¹	<input checked="" type="checkbox"/>
Kakg_kgd		0000322	0.480	mmol · l ⁻¹	<input checked="" type="checkbox"/>
Vr_kgd		0000353	0.483	mmol · l ⁻¹ · (60 s) ⁻¹	<input checked="" type="checkbox"/>
Kssa_kgd		0000323	4.800	mmol · l ⁻¹	<input checked="" type="checkbox"/>

5.6 Reaction SSADH

This is a reversible reaction of one reactant forming one product.

Reaction equation



Reactant

Table 20: Properties of each reactant.

Id	Name	SBO
	ssa	

Product

Table 21: Properties of each product.

Id	Name	SBO
	suc	

Kinetic Law

Derived unit contains undeclared units

$$v_6 = \text{vol}(\text{cell}) \cdot \frac{Vf_ssadh \cdot \frac{[ssa]}{Kssa_ssadh} - Vr_ssadh \cdot \frac{[suc]}{Ksuc_ssadh}}{1 + \frac{[ssa]}{Kssa_ssadh} + \frac{[suc]}{Ksuc_ssadh}} \quad (12)$$

Table 22: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
Vf_ssadh		0000350	6.510	mmol · l ⁻¹ · (60 s) ⁻¹	<input checked="" type="checkbox"/>
Kssa_ssadh		0000322	0.015	mmol · l ⁻¹	<input checked="" type="checkbox"/>
Vr_ssadh		0000353	0.065	mmol · l ⁻¹ · (60 s) ⁻¹	<input checked="" type="checkbox"/>
Ksuc_ssadh		0000323	0.150	mmol · l ⁻¹	<input checked="" type="checkbox"/>

5.7 Reaction ScAS

This is a reversible reaction of one reactant forming one product.

Reaction equation



Reactant

Table 23: Properties of each reactant.

Id	Name	SBO
sca		

Product

Table 24: Properties of each product.

Id	Name	SBO
suc		

Kinetic Law

Derived unit contains undeclared units

$$v_7 = \text{vol}(\text{cell}) \cdot \frac{Vf_scas \cdot \frac{[sca]}{Ksca_scas} - Vr_scas \cdot \frac{[suc]}{Ksuc_scas}}{1 + \frac{[sca]}{Ksca_scas} + \frac{[suc]}{Ksuc_scas}} \quad (14)$$

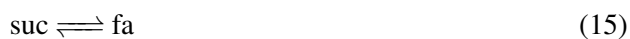
Table 25: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
Vf_scas		0000350	1.200	mmol · l ⁻¹ · (60 s) ⁻¹	<input checked="" type="checkbox"/>
Ksca_scas		0000322	0.020	mmol · l ⁻¹	<input checked="" type="checkbox"/>
Vr_scas		0000353	0.012	mmol · l ⁻¹ · (60 s) ⁻¹	<input checked="" type="checkbox"/>
Ksuc_scas		0000323	5.000	mmol · l ⁻¹	<input checked="" type="checkbox"/>

5.8 Reaction SDH

This is a reversible reaction of one reactant forming one product.

Reaction equation



Reactant

Table 26: Properties of each reactant.

Id	Name	SBO
	suc	

Product

Table 27: Properties of each product.

Id	Name	SBO
	fa	

Kinetic Law

Derived unit contains undeclared units

$$v_8 = \text{vol}(\text{cell}) \cdot \frac{Vf_sdh \cdot \frac{[\text{suc}]}{Ksuc_sdh} - Vr_sdh \cdot \frac{[\text{fa}]}{Kfa_sdh}}{1 + \frac{[\text{suc}]}{Ksuc_sdh} + \frac{[\text{fa}]}{Kfa_sdh}} \quad (16)$$

Table 28: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
Vf_sdh		0000350	1.02	mmol · l ⁻¹ · (60 s) ⁻¹	<input checked="" type="checkbox"/>
Ksuc_sdh		0000322	0.12	mmol · l ⁻¹	<input checked="" type="checkbox"/>
Vr_sdh		0000353	1.02	mmol · l ⁻¹ · (60 s) ⁻¹	<input checked="" type="checkbox"/>
Kfa_sdh		0000323	0.15	mmol · l ⁻¹	<input checked="" type="checkbox"/>

5.9 Reaction FUM

This is a reversible reaction of one reactant forming one product.

Reaction equation



Reactant

Table 29: Properties of each reactant.

Id	Name	SBO
fa		

Product

Table 30: Properties of each product.

Id	Name	SBO
mal		

Kinetic Law

Derived unit contains undeclared units

$$v_9 = \text{vol}(\text{cell}) \cdot \frac{Vf_fum \cdot \frac{[fa]}{Kfa_fum} - Vr_fum \cdot \frac{[mal]}{Kmal_fum}}{1 + \frac{[fa]}{Kfa_fum} + \frac{[mal]}{Kmal_fum}} \quad (18)$$

Table 31: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
Vf_fum		0000350	87.70	mmol · l ⁻¹ · (60 s) ⁻¹	<input checked="" type="checkbox"/>
Kfa_fum		0000322	0.25	mmol · l ⁻¹	<input checked="" type="checkbox"/>
Vr_fum		0000353	87.70	mmol · l ⁻¹ · (60 s) ⁻¹	<input checked="" type="checkbox"/>
Kmal_fum		0000323	2.38	mmol · l ⁻¹	<input checked="" type="checkbox"/>

5.10 Reaction MDH

This is a reversible reaction of one reactant forming one product.

Reaction equation



Reactant

Table 32: Properties of each reactant.

Id	Name	SBO
mal		

Product

Table 33: Properties of each product.

Id	Name	SBO
oaa		

Kinetic Law

Derived unit contains undeclared units

$$v_{10} = \text{vol}(\text{cell}) \cdot \frac{Vf_mdh \cdot \frac{[\text{mal}]}{Kmal_mdh} - Vr_mdh \cdot \frac{[\text{oaa}]}{Koaa_mdh}}{1 + \frac{[\text{mal}]}{Kmal_mdh} + \frac{[\text{oaa}]}{Koaa_mdh}} \quad (20)$$

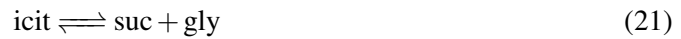
Table 34: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
Vf_mdh		0000350	184.000	mmol · l ⁻¹ · (60 s) ⁻¹	✓
Kmal_mdh		0000322	0.833	mmol · l ⁻¹	✓
Vr_mdh		0000353	184.000	mmol · l ⁻¹ · (60 s) ⁻¹	✓
Koaa_mdh		0000323	0.044	mmol · l ⁻¹	✓

5.11 Reaction ICL1

This is a reversible reaction of one reactant forming two products.

Reaction equation



Reactant

Table 35: Properties of each reactant.

Id	Name	SBO
	icit	

Products

Table 36: Properties of each product.

Id	Name	SBO
	suc	
	gly	

Kinetic Law

Derived unit contains undeclared units

$$v_{11} = \text{vol}(\text{cell}) \cdot \frac{Vf_icl1 \cdot \frac{[icit]}{K_{icit_icl1}} - Vr_icl1 \cdot \frac{[suc]}{K_{suc_icl1}} \cdot \frac{[gly]}{K_{gly_icl1}}}{1 + \frac{[icit]}{K_{icit_icl1}} + \frac{[suc]}{K_{suc_icl1}} + \frac{[gly]}{K_{gly_icl1}} + \frac{[icit]}{K_{icit_icl1}} \cdot \frac{[suc]}{K_{suc_icl1}} + \frac{[suc]}{K_{suc_icl1}} \cdot \frac{[gly]}{K_{gly_icl1}}} \quad (22)$$

Table 37: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
Vf_icl1		0000350	1.172	mmol · l ⁻¹ · (60 s) ⁻¹	✓
Kicit_icl1		0000322	0.145	mmol · l ⁻¹	✓
Vr_icl1		0000353	0.012	mmol · l ⁻¹ · (60 s) ⁻¹	✓
Ksuc_icl1		0000323	0.590	mmol · l ⁻¹	✓
Kgly_icl1		0000323	0.130	mmol · l ⁻¹	✓

5.12 Reaction ICL2

This is a reversible reaction of one reactant forming two products.

Reaction equation



Reactant

Table 38: Properties of each reactant.

Id	Name	SBO
	icit	

Products

Table 39: Properties of each product.

Id	Name	SBO
	suc	
	gly	

Kinetic Law

Derived unit contains undeclared units

$$v_{12} = \text{vol}(\text{cell}) \cdot \frac{Vf_icl2 \cdot \frac{[icit]}{Kicit_icl2} - Vr_icl2 \cdot \frac{[suc]}{Ksuc_icl2} \cdot \frac{[gly]}{Kgly_icl2}}{1 + \frac{[icit]}{Kicit_icl2} + \frac{[suc]}{Ksuc_icl2} + \frac{[gly]}{Kgly_icl2} + \frac{[icit]}{Kicit_icl2} \cdot \frac{[suc]}{Ksuc_icl2} + \frac{[suc]}{Ksuc_icl2} \cdot \frac{[gly]}{Kgly_icl2}} \quad (24)$$

Table 40: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
Vf_icl2		0000350	0.391	mmol · l ⁻¹ · (60 s) ⁻¹	✓
Kicit_icl2		0000322	1.300	mmol · l ⁻¹	✓
Vr_icl2		0000353	0.004	mmol · l ⁻¹ · (60 s) ⁻¹	✓
Ksuc_icl2		0000323	5.900	mmol · l ⁻¹	✓
Kgly_icl2		0000323	1.300	mmol · l ⁻¹	✓

5.13 Reaction MS

This is a reversible reaction of two reactants forming two products.

Reaction equation



Reactants

Table 41: Properties of each reactant.

Id	Name	SBO
	gly	
	aca	

Products

Table 42: Properties of each product.

Id	Name	SBO
	mal	
	coa	

Kinetic Law

Derived unit contains undeclared units

$$v_{13} = \text{vol}(\text{cell}) \cdot \frac{Vf_ms \cdot \frac{[\text{gly}]}{Kgly_ms} \cdot \frac{[\text{aca}]}{Kaca_ms} - Vr_ms \cdot \frac{[\text{mal}]}{Kmal_ms} \cdot \frac{[\text{coa}]}{Kcoa_ms}}{\left(1 + \frac{[\text{gly}]}{Kgly_ms} + \frac{[\text{mal}]}{Kmal_ms}\right) \cdot \left(1 + \frac{[\text{aca}]}{Kaca_ms} + \frac{[\text{coa}]}{Kcoa_ms}\right)} \quad (26)$$

Table 43: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
Vf_ms		0000350	20.000	mmol · l ⁻¹ · (60 s) ⁻¹	<input checked="" type="checkbox"/>
Kgly_ms		0000322	0.057	mmol · l ⁻¹	<input checked="" type="checkbox"/>
Kaca_ms		0000322	0.030	mmol · l ⁻¹	<input checked="" type="checkbox"/>
Vr_ms		0000353	0.200	mmol · l ⁻¹ · (60 s) ⁻¹	<input checked="" type="checkbox"/>
Kmal_ms		0000323	1.000	mmol · l ⁻¹	<input checked="" type="checkbox"/>
Kcoa_ms		0000323	0.100	mmol · l ⁻¹	<input checked="" type="checkbox"/>

5.14 Reaction SYN

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

Reaction equation



Reactant

Table 44: Properties of each reactant.

Id	Name	SBO
akg		

Modifier

Table 45: Properties of each modifier.

Id	Name	SBO
icit		

Product

Table 46: Properties of each product.

Id	Name	SBO
biosyn		

Kinetic Law

Derived unit contains undeclared units

$$v_{14} = \text{vol}(\text{cell}) \cdot 0.0341 \cdot \left(\frac{Vf_icd1 \cdot \frac{[icit]}{Kicit_icd1} - Vr_icd1 \cdot \frac{[akg]}{Kakg_icd1}}{1 + \frac{[icit]}{Kicit_icd1} + \frac{[akg]}{Kakg_icd1}} + \frac{Vf_icd2 \cdot \frac{[icit]}{Kicit_icd2} - Vr_icd2 \cdot \frac{[akg]}{Kakg_icd2}}{1 + \frac{[icit]}{Kicit_icd2} + \frac{[akg]}{Kakg_icd2}} \right) \quad (28)$$

Table 47: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
Vf_icd1		0000350	10.200	mmol · l ⁻¹ · (60 s) ⁻¹	✓
Kicit_icd1		0000322	0.030	mmol · l ⁻¹	✓
Vr_icd1		0000353	0.102	mmol · l ⁻¹ · (60 s) ⁻¹	✓
Kakg_icd1		0000323	0.300	mmol · l ⁻¹	✓
Vf_icd2		0000350	9.965	mmol · l ⁻¹ · (60 s) ⁻¹	✓
Kicit_icd2		0000322	0.060	mmol · l ⁻¹	✓
Vr_icd2		0000353	0.100	mmol · l ⁻¹ · (60 s) ⁻¹	✓
Kakg_icd2		0000323	0.600	mmol · l ⁻¹	✓

6 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.

6.1 Species *aca*

SBO:0000247 simple chemical

Initial concentration 0.5 mmol · l⁻¹

This species takes part in two reactions (as a reactant in [CS](#), [MS](#)), which do not influence its rate of change because this species is on the boundary of the reaction system:

$$\frac{d}{dt}aca = 0 \quad (29)$$

6.2 Species oaa

SBO:0000247 simple chemical

Initial concentration $3 \cdot 10^{-4} \text{ mmol} \cdot \text{l}^{-1}$

This species takes part in two reactions (as a reactant in [CS](#) and as a product in [MDH](#)), which do not influence its rate of change because this species is on the boundary of the reaction system:

$$\frac{d}{dt} \text{oaa} = 0 \quad (30)$$

6.3 Species coa

SBO:0000247 simple chemical

Initial concentration $10^{-4} \text{ mmol} \cdot \text{l}^{-1}$

This species takes part in two reactions (as a product in [CS](#), [MS](#)), which do not influence its rate of change because this species is on the boundary of the reaction system:

$$\frac{d}{dt} \text{coa} = 0 \quad (31)$$

6.4 Species cit

SBO:0000247 simple chemical

Initial concentration $3.4 \text{ mmol} \cdot \text{l}^{-1}$

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

$$\frac{d}{dt} \text{cit} = v_1 - v_2 \quad (32)$$

6.5 Species icit

SBO:0000247 simple chemical

Initial concentration $0.06 \text{ mmol} \cdot \text{l}^{-1}$

This species takes part in six reactions (as a reactant in [ICD1](#), [ICD2](#), [ICL1](#), [ICL2](#) and as a product in [ACN](#) and as a modifier in [SYN](#)).

$$\frac{d}{dt} \text{icit} = v_2 - v_3 - v_4 - v_{11} - v_{12} \quad (33)$$

6.6 Species `akg`

SBO:0000247 simple chemical

Initial concentration $0.96 \text{ mmol} \cdot \text{l}^{-1}$

This species takes part in four reactions (as a reactant in [KGD](#), [SYN](#) and as a product in [ICD1](#), [ICD2](#)).

$$\frac{d}{dt} \text{akg} = v_3 + v_4 - v_5 - v_{14} \quad (34)$$

6.7 Species `ssa`

SBO:0000247 simple chemical

Initial concentration $0.03 \text{ mmol} \cdot \text{l}^{-1}$

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

$$\frac{d}{dt} \text{ssa} = v_5 - v_6 \quad (35)$$

6.8 Species `suc`

SBO:0000247 simple chemical

Initial concentration $2.464 \text{ mmol} \cdot \text{l}^{-1}$

This species takes part in five reactions (as a reactant in [SDH](#) and as a product in [SSADH](#), [ScAS](#), [ICL1](#), [ICL2](#)).

$$\frac{d}{dt} \text{suc} = v_6 + v_7 + v_{11} + v_{12} - v_8 \quad (36)$$

6.9 Species `sca`

SBO:0000247 simple chemical

Initial concentration $0.04 \text{ mmol} \cdot \text{l}^{-1}$

This species takes part in one reaction (as a reactant in [ScAS](#)).

$$\frac{d}{dt} \text{sca} = -v_7 \quad (37)$$

6.10 Species `fa`

SBO:0000247 simple chemical

Initial concentration $0.08528 \text{ mmol} \cdot \text{l}^{-1}$

This species takes part in two reactions (as a reactant in `FUM` and as a product in `SDH`).

$$\frac{d}{dt}fa = v_8 - v_9 \quad (38)$$

6.11 Species `mal`

SBO:0000247 simple chemical

Initial concentration $0.408 \text{ mmol} \cdot \text{l}^{-1}$

This species takes part in three reactions (as a reactant in `MDH` and as a product in `FUM`, `MS`).

$$\frac{d}{dt}mal = v_9 + v_{13} - v_{10} \quad (39)$$

6.12 Species `gly`

SBO:0000247 simple chemical

Initial concentration $0.114 \text{ mmol} \cdot \text{l}^{-1}$

This species takes part in three reactions (as a reactant in `MS` and as a product in `ICL1`, `ICL2`).

$$\frac{d}{dt}gly = v_{11} + v_{12} - v_{13} \quad (40)$$

6.13 Species `biosyn`

Initial concentration $0.1 \text{ mmol} \cdot \text{l}^{-1}$

This species takes part in one reaction (as a product in `SYN`), which does not influence its rate of change because this species is on the boundary of the reaction system:

$$\frac{d}{dt}biosyn = 0 \quad (41)$$

A Glossary of Systems Biology Ontology Terms

SBO:0000247 simple chemical: Simple, non-repetitive chemical entity

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

SBO:0000322 Michaelis constant for substrate: Substrate concentration at which the velocity of product production by the forward activity of a reversible enzyme is half its maximum.

SBO:0000323 Michaelis constant for product: Product concentration at which the velocity of substrate production by the reverse activity of a reversible enzyme is half its maximum.

SBO:0000350 forward reaction velocity: The speed of an enzymatic reaction at a defined concentration of substrate(s) and enzyme

SBO:0000353 reverse reaction velocity: The speed of an enzymatic reaction at a defined concentration of substrate(s) and enzyme.

SBO:0000377 isomerisation: A reaction in which the principal reactant and principal product are isomers of each other

SBO:0000399 decarboxylation: A process in which a carboxyl group (COOH) is removed from a molecule as carbon dioxide

SBO:0000402 transfer of a chemical group: Covalent reaction that results in the transfer of a chemical group from one molecule to another

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