

SBML Model Report

Model name: “McAuley2012 - Whole-body Cholesterol Metabolism”



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: Vijayalakshmi Chelliah¹ and Mark Mc Auley² at November 27th 2012 at 4:32 p. m. and last time modified at October ninth 2014 at 3:44 p. m. Table 1 shows 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	6
species types	0	species	34
events	0	constraints	0
reactions	35	function definitions	23
global parameters	0	unit definitions	3
rules	0	initial assignments	0

Model Notes

McAuley2012 - Whole-body Cholesterol Metabolism

Lipid metabolism has a key role to play in human longevity and healthy aging. A whole-body mathematical model of cholesterol metabolism that explores the changes in both the rate of intestinal cholesterol absorption and the hepatic rate of clearance of LDL-C from the plasma,

¹EMBL-EBI, viji@ebi.ac.uk

²Liverpool Hope University, mcaulem@hope.ac.uk

has been presented here. The model showed that of these two mechanisms, changes to the rate of LDL-C removal from the plasma with age had the most significant effect on cholesterol metabolism.

The original SBML model file was generated using MathSBML 2.5.1.

This model is described in the article: [A whole-body mathematical model of cholesterol metabolism and its age-associated dysregulation](#). McAuley MM, Wilkinson DJ, Jones JJ, Kirkwood TT. BMC Syst Biol. 2012 Oct 10;6(1):130.

Abstract:

BACKGROUND: Global demographic changes have stimulated marked interest in the process of ageing. There has been, and will continue to be, an unrelenting rise in the number of the oldest old (>85 years of age). Together with an ageing population there comes an increase in the prevalence of age related disease. Of the diseases of ageing, cardiovascular disease (CVD) has by far the highest prevalence. It is regarded that a finely tuned lipid profile may help to prevent CVD as there is a long established relationship between alterations to lipid metabolism and CVD risk. In fact elevated plasma cholesterol, particularly Low Density Lipoprotein Cholesterol (LDL-C) has consistently stood out as a risk factor for having a cardiovascular event. Moreover it is widely acknowledged that LDL-C may rise with age in both sexes in a wide variety of groups. The aim of this work was to use a whole-body mathematical model to investigate why LDL-C rises with age, and to test the hypothesis that mechanistic changes to cholesterol absorption and LDL-C removal from the plasma are responsible for the rise. The whole-body mechanistic nature of the model differs from previous models of cholesterol metabolism which have either focused on intracellular cholesterol homeostasis or have concentrated on an isolated area of lipoprotein dynamics. The model integrates both current and previously published data relating to molecular biology, physiology, ageing and nutrition in an integrated fashion.

RESULTS: The model was used to test the hypothesis that alterations to the rate of cholesterol absorption and changes to the rate of removal of LDL-C from the plasma are integral to understanding why LDL-C rises with age. The model demonstrates that increasing the rate of intestinal cholesterol absorption from 50% to 80% by age 65 years can result in an increase of LDL-C by as much as 34mg/dL in a hypothetical male subject. The model also shows that decreasing the rate of hepatic clearance of LDL-C gradually to 50% by age 65 years can result in an increase of LDL-C by as much as 116mg/dL.

CONCLUSIONS: Our model clearly demonstrates that of the two putative mechanisms that have been implicated in the dysregulation of cholesterol metabolism with age, alterations to the removal rate of plasma LDL-C has the most significant impact on cholesterol metabolism and small changes to the number of hepatic LDL receptors can result in a significant rise in LDL-C. This first whole-body systems based model of cholesterol balance could potentially be used as a tool to further improve our understanding of whole-body cholesterol metabolism and its dysregulation with age. Furthermore, given further fine tuning the model may help to investigate potential dietary and lifestyle regimes that have the potential to mitigate the effects aging has on cholesterol metabolism.

This model is hosted on [BioModels Database](#) and identified by: [MODEL1206010000](#).

To cite BioModels Database, please use: [BioModels Database: An enhanced, curated and annotated resource for published quantitative kinetic models](#).

To the extent possible under law, all copyright and related or neighbouring rights to this encoded model have been dedicated to the public domain worldwide. Please refer to [CC0 Public Domain Dedication](#) for more information.

2 Unit Definitions

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

2.1 Unit volume

Name volume

Definition dimensionless

2.2 Unit time

Name time

Definition 86400 s

2.3 Unit substance

Name substance

Definition dimensionless

2.4 Unit area

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

Definition m²

2.5 Unit length

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

Definition m

3 Compartments

This model contains six compartments.

Table 2: Properties of all compartments.

Id	Name	SBO	Spatial Dimensions	Size	Unit	Constant	Outside
Intake	Intake		3	1	dimensionless	<input checked="" type="checkbox"/>	
Intestine	Intestine		3	1	dimensionless	<input checked="" type="checkbox"/>	
HepaticTissue	HepaticTissue		3	1	dimensionless	<input checked="" type="checkbox"/>	
PeripheralTissue	PeripheralTissue		3	1	dimensionless	<input checked="" type="checkbox"/>	
Plasma	Plasma		3	1	dimensionless	<input checked="" type="checkbox"/>	
Excreted	Excreted		3	1	dimensionless	<input checked="" type="checkbox"/>	

3.1 Compartment `Intake`

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

Name `Intake`

3.2 Compartment `Intestine`

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

Name `Intestine`

3.3 Compartment `HepaticTissue`

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

Name `HepaticTissue`

3.4 Compartment `PeripheralTissue`

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

Name `PeripheralTissue`

3.5 Compartment `Plasma`

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

Name `Plasma`

3.6 Compartment `Excreted`

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

Name `Excreted`

4 Species

This model contains 34 species. The boundary condition of eight of these species is set to `true` so that these species' amount cannot be changed by any reaction. 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
species_1	DC	Intake	dimensionless · dimensionless ⁻¹	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
species_2	IC	Intestine	dimensionless · dimensionless ⁻¹	<input type="checkbox"/>	<input type="checkbox"/>
species_3	ICS	Intestine	dimensionless · dimensionless ⁻¹	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
species_4	HBS	HepaticTissue	dimensionless · dimensionless ⁻¹	<input type="checkbox"/>	<input type="checkbox"/>
species_5	IBS	Intestine	dimensionless · dimensionless ⁻¹	<input type="checkbox"/>	<input type="checkbox"/>
species_6	EBS	Excreted	dimensionless · dimensionless ⁻¹	<input type="checkbox"/>	<input type="checkbox"/>
species_7	HFC	HepaticTissue	dimensionless · dimensionless ⁻¹	<input type="checkbox"/>	<input type="checkbox"/>
species_8	EC	Excreted	dimensionless · dimensionless ⁻¹	<input type="checkbox"/>	<input type="checkbox"/>
species_9	INHDLS	Plasma	dimensionless · dimensionless ⁻¹	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
species_10	NHDL	Plasma	dimensionless · dimensionless ⁻¹	<input type="checkbox"/>	<input type="checkbox"/>

Id	Name	Compartment	Derived Unit	Constant	Boundary Condition
species_11	PFC	PeripheralTissue	dimensionless dimensionless ⁻¹	· <input type="checkbox"/>	<input type="checkbox"/>
species_12	HCS	HepaticTissue	dimensionless dimensionless ⁻¹	· <input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
species_13	HCE	HepaticTissue	dimensionless dimensionless ⁻¹	· <input type="checkbox"/>	<input type="checkbox"/>
species_14	ACAT	HepaticTissue	dimensionless dimensionless ⁻¹	· <input type="checkbox"/>	<input type="checkbox"/>
species_15	CEH	HepaticTissue	dimensionless dimensionless ⁻¹	· <input type="checkbox"/>	<input type="checkbox"/>
species_16	HNHDLS	HepaticTissue	dimensionless dimensionless ⁻¹	· <input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
species_17	VLDLC	Plasma	dimensionless dimensionless ⁻¹	· <input type="checkbox"/>	<input type="checkbox"/>
species_18	LDLRs	HepaticTissue	dimensionless dimensionless ⁻¹	· <input type="checkbox"/>	<input type="checkbox"/>
species_19	LDLRsS	HepaticTissue	dimensionless dimensionless ⁻¹	· <input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
species_20	LDLRD	HepaticTissue	dimensionless dimensionless ⁻¹	· <input type="checkbox"/>	<input type="checkbox"/>
species_21	IDLC	Plasma	dimensionless dimensionless ⁻¹	· <input type="checkbox"/>	<input type="checkbox"/>
species_22	LPL	Plasma	dimensionless dimensionless ⁻¹	· <input type="checkbox"/>	<input type="checkbox"/>
species_23	LDLC	Plasma	dimensionless dimensionless ⁻¹	· <input type="checkbox"/>	<input type="checkbox"/>

Id	Name	Compartment	Derived Unit	Constant	Boundary Condition
species_24	HSL	Plasma	dimensionless dimensionless ⁻¹	· <input type="checkbox"/>	<input type="checkbox"/>
species_25	PLDLRs	PeripheralTissue	dimensionless dimensionless ⁻¹	· <input type="checkbox"/>	<input type="checkbox"/>
species_26	PLDLRsS	PeripheralTissue	dimensionless dimensionless ⁻¹	· <input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
species_27	PLDLRD	PeripheralTissue	dimensionless dimensionless ⁻¹	· <input type="checkbox"/>	<input type="checkbox"/>
species_28	PCE	PeripheralTissue	dimensionless dimensionless ⁻¹	· <input type="checkbox"/>	<input type="checkbox"/>
species_29	PSS	PeripheralTissue	dimensionless dimensionless ⁻¹	· <input type="checkbox"/>	<input type="checkbox"/>
species_30	HDLC	Plasma	dimensionless dimensionless ⁻¹	· <input type="checkbox"/>	<input type="checkbox"/>
species_31	LCAT	Plasma	dimensionless dimensionless ⁻¹	· <input type="checkbox"/>	<input type="checkbox"/>
species_32	PCS	PeripheralTissue	dimensionless dimensionless ⁻¹	· <input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
species_33	CETP	Plasma	dimensionless dimensionless ⁻¹	· <input type="checkbox"/>	<input type="checkbox"/>
species_34	SRB1	HepaticTissue	dimensionless dimensionless ⁻¹	· <input type="checkbox"/>	<input type="checkbox"/>

5 Function definitions

This is an overview of 23 function definitions.

5.1 Function definition `function_1`

Name Rate Law for Intestinal Cholesterol Synthesis

Arguments ICSmax, IC, ICt, IS

Mathematical Expression

$$\frac{\text{ICSmax}}{1 + \left(\frac{\text{IC}}{\text{ICt}}\right)^{\text{IS}}} \quad (1)$$

5.2 Function definition `function_2`

Name Rate Law for Bile Salt Synthesis

Arguments k5, HFC, HBS

Mathematical Expression

$$\frac{k5 \cdot \text{HFC}}{\text{HBS}} \quad (2)$$

5.3 Function definition `function_3`

Name Rate Law for Cholesterol Absorption

Arguments k6, IC, IBS

Mathematical Expression

$$k6 \cdot \text{IC} \cdot \text{IBS} \quad (3)$$

5.4 Function definition `function_4`

Name Rate Law for Cholesterol Excretion

Arguments k7, IC, IBS

Mathematical Expression

$$k7 \cdot \text{IC} \cdot \text{IBS} \quad (4)$$

5.5 Function definition `function_5`

Name Rate Law for Intestinal Nascent HDL Synthesis

Arguments k8, PFC

Mathematical Expression

$$k8 \cdot \text{PFC} \quad (5)$$

5.6 Function definition [function_6](#)

Name Rate Law for Biliary Cholesterol Release

Arguments BCRmax, BCRt, HFC, BS

Mathematical Expression

$$\frac{\text{BCRmax}}{1 + \left(\frac{\text{BCRt}}{\text{HFC}}\right)^{\text{BS}}} \quad (6)$$

5.7 Function definition [function_7](#)

Name Rate Law for Hepatic Cholesterol Synthesis

Arguments HCSmax, HFC, HCSt, HS

Mathematical Expression

$$\frac{\text{HCSmax}}{1 + \left(\frac{\text{HFC}}{\text{HCSt}}\right)^{\text{HS}}} \quad (7)$$

5.8 Function definition [function_8](#)

Name Rate Law for Hepatic Cholesterol Storage_1

Arguments k9, ACAT, HFC

Mathematical Expression

$$\text{k9} \cdot \text{ACAT} \cdot \text{HFC} \quad (8)$$

5.9 Function definition [function_9](#)

Name Rate Law for Release of Stored Cholesterol

Arguments k10, CEH, HCE

Mathematical Expression

$$\text{k10} \cdot \text{CEH} \cdot \text{HCE} \quad (9)$$

5.10 Function definition [function_10](#)

Name Rate Law for Hepatic Nascent HDL Synthesis

Arguments k11, PFC

Mathematical Expression

$$\text{k11} \cdot \text{PFC} \quad (10)$$

5.11 Function definition [function_11](#)

Name Rate Law for Hepatic LDLR Synthesis

Arguments khrs, HLDLRsS, HFC

Mathematical Expression

$$\frac{khrs \cdot HLDLRsS}{HFC} \quad (11)$$

5.12 Function definition [function_12](#)

Name Rate Law for IDL Cholesterol Formation

Arguments k15, VLDLC, LPL

Mathematical Expression

$$k15 \cdot VLDLC \cdot LPL \quad (12)$$

5.13 Function definition [function_13](#)

Name Rate Law for LDL Cholesterol Formation

Arguments k17, IDLC, HSL

Mathematical Expression

$$k17 \cdot IDLC \cdot HSL \quad (13)$$

5.14 Function definition [function_14](#)

Name Rate Law for Receptor Dependent Hepatic Uptake

Arguments k18, LDLC, HLDLRs

Mathematical Expression

$$k18 \cdot LDLC \cdot HLDLRs \quad (14)$$

5.15 Function definition [function_15](#)

Name Rate Law for Receptor Dependent Peripheral Uptake

Arguments k20, PLDLRs, LDLC

Mathematical Expression

$$k20 \cdot PLDLRs \cdot LDLC \quad (15)$$

5.16 Function definition [function_16](#)

Name Rate Law for Peripheral LDLR Synthesis

Arguments kprs, PLDLRsS, PFC

Mathematical Expression

$$\frac{kprs \cdot PLDLRsS}{PFC} \quad (16)$$

5.17 Function definition [function_17](#)

Name Rate Law for Peripheral Cholesterol Storage

Arguments k23, ACAT, PFC

Mathematical Expression

$$k23 \cdot ACAT \cdot PFC \quad (17)$$

5.18 Function definition [function_18](#)

Name Rate Law for Release of Stored Peripheral Cholesterol

Arguments k24, CEH, PCE

Mathematical Expression

$$k24 \cdot CEH \cdot PCE \quad (18)$$

5.19 Function definition [function_19](#)

Name Rate Law for HDL Cholesterol Formation

Arguments k26, PFC, NHDL, LCAT

Mathematical Expression

$$k26 \cdot PFC \cdot NHDL \cdot LCAT \quad (19)$$

5.20 Function definition [function_20](#)

Name Rate Law for Peripheral Cholesterol Synthesis

Arguments PCSmax, PFC, PPCt, PCSS

Mathematical Expression

$$\frac{PCSmax}{1 + \left(\frac{PFC}{PPCt}\right)^{PCSS}} \quad (20)$$

5.21 Function definition [function_21](#)

Name Rate Law for CETP Mediated Transfer To VLDL

Arguments k27, HDLC, CETP

Mathematical Expression

$$k27 \cdot HDLC \cdot CETP \quad (21)$$

5.22 Function definition [function_22](#)

Name Rate Law for CETP Mediated TransferTo LDL

Arguments k28, HDLC, CETP

Mathematical Expression

$$k28 \cdot HDLC \cdot CETP \quad (22)$$

5.23 Function definition [function_23](#)

Name Rate Law for Reverse Cholesterol Transport

Arguments k29, HDLC, SRB1

Mathematical Expression

$$k29 \cdot HDLC \cdot SRB1 \quad (23)$$

6 Reactions

This model contains 35 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	reaction_1	Ingestion	species_1 $\xrightarrow{\text{species}_1}$ species_2	
2	reaction_2	Intestinal Cholesterol Synthesis	species_3 $\xrightarrow{\text{species}_2, \text{species}_2}$ species_2	
3	reaction_3	Bile Salt Release	species_4 $\xrightarrow{\text{species}_4}$ species_5	
4	reaction_4	Bile Salt Return	species_5 $\xrightarrow{\text{species}_5}$ species_4	
5	reaction_5	Bile Salt Excretion	species_5 $\xrightarrow{\text{species}_5}$ species_6	
6	reaction_6	Bile Salt Synthesis	species_7 $\xrightarrow{\text{species}_4, \text{species}_7, \text{species}_4}$ species_4	
7	reaction_7	Cholesterol Absorption	species_2 $\xrightarrow{\text{species}_5, \text{species}_2, \text{species}_5}$ species_7	
8	reaction_8	Cholesterol Excretion	species_2 $\xrightarrow{\text{species}_5, \text{species}_2, \text{species}_5}$ species_8	
9	reaction_9	Intestinal Nascent HDL Synthesis	species_9 $\xrightarrow{\text{species}_{11}, \text{species}_{11}}$ species_{10}	
10	reaction_{10}	Billary Cholesterol Release	species_7 $\xrightarrow{\text{species}_7, \text{species}_7}$ species_2	
11	reaction_{11}	Hepatic Cholesterol Synthesis	species_{12} $\xrightarrow{\text{species}_7, \text{species}_7}$ species_7	
12	reaction_{12}	Hepatic Cholesterol Storage	species_7 $\xrightarrow{\text{species}_{14}, \text{species}_7, \text{species}_{14}, \text{species}_7}$ species_{13}	
13	reaction_{13}	Release of Stored Cholesterol	species_{13} $\xrightarrow{\text{species}_{15}, \text{species}_{13}, \text{species}_{15}, \text{species}_{13}}$ species_7	
14	reaction_{14}	Hepatic Nascent HDL Synthesis	species_{16} $\xrightarrow{\text{species}_{11}, \text{species}_{11}}$ species_{10}	
15	reaction_{15}	VLDL Cholesterol Formation	species_7 $\xrightarrow{\text{species}_7}$ species_{17}	

Nº	Id	Name	Reaction Equation	SBO
16	reaction_16	Hepatic LDLR Synthesis	species_19 $\xrightarrow{\text{species}_19, \text{species}_7, \text{species}_19, \text{species}_7}$ species_18	
17	reaction_17	Hepatic LDL Receptor Degradation	species_18 $\xrightarrow{\text{species}_18}$ species_20	
18	reaction_18	VLDL Cholesterol ReUptake	species_17 $\xrightarrow{\text{species}_17}$ species_7	
19	reaction_19	IDL Cholesterol Formation	species_17 $\xrightarrow{\text{species}_17, \text{species}_22, \text{species}_17, \text{species}_22}$ species_21	
20	reaction_20	IDL Cholesterol ReUptake	species_21 $\xrightarrow{\text{species}_21}$ species_7	
21	reaction_21	LDL Cholesterol Formation	species_21 $\xrightarrow{\text{species}_24, \text{species}_21, \text{species}_24}$ species_23	
22	reaction_22	Receptor Dependent Hepatic Uptake	species_23 $\xrightarrow{\text{species}_18, \text{species}_23, \text{species}_18}$ species_7	
23	reaction_23	Receptor Independent Hepatic Uptake	species_23 $\xrightarrow{\text{species}_23}$ species_7	
24	reaction_24	Receptor Dependent Peripheral Uptake	species_23 $\xrightarrow{\text{species}_25, \text{species}_25, \text{species}_23}$ species_11	
25	reaction_25	Receptor Independent Peripheral Uptake	species_23 $\xrightarrow{\text{species}_23}$ species_11	
26	reaction_26	Peripheral LDLR Synthesis	species_26 $\xrightarrow{\text{species}_11, \text{species}_26, \text{species}_11}$ species_25	
27	reaction_27	Peripheral LDL Receptor Degradation	species_25 $\xrightarrow{\text{species}_25}$ species_27	
28	reaction_28	Peripheral Cholesterol Storage	species_11 $\xrightarrow{\text{species}_14, \text{species}_14, \text{species}_11}$ species_28	
29	reaction_29	Release of Stored Peripheral Cholesterol	species_28 $\xrightarrow{\text{species}_15, \text{species}_15, \text{species}_28}$ species_11	
30	reaction_30	Peripheral Steroid Production	species_11 $\xrightarrow{\text{species}_11}$ species_29	
31	reaction_31	HDL Cholesterol Formation	species_11 + species_10 $\xrightarrow{\text{species}_31, \text{species}_11, \text{species}_10, \text{species}_31}$ species_30	
32	reaction_32	Peripheral Cholesterol Synthesis	species_32 $\xrightarrow{\text{species}_11}$ species_11	
33	reaction_33	CETP Mediated Transfer To VLDL	species_30 $\xrightarrow{\text{species}_33, \text{species}_30, \text{species}_33}$ species_17	
34	reaction_34	CETP Mediated TransferTo LDL	species_30 $\xrightarrow{\text{species}_33, \text{species}_30, \text{species}_33}$ species_23	

Nº	Id	Name	Reaction Equation	SBO
35	reaction_35	Reverse Cholesterol Transport	species_30 $\xrightarrow{\text{species_34, species_30, species_34}}$ species_7	

6.1 Reaction `reaction_1`

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

Name Ingestion

Reaction equation



Reactant

Table 5: Properties of each reactant.

Id	Name	SBO
species_1	DC	

Modifier

Table 6: Properties of each modifier.

Id	Name	SBO
species_1	DC	

Product

Table 7: Properties of each product.

Id	Name	SBO
species_2	IC	

Kinetic Law

Derived unit contains undeclared units

$$v_1 = k_1 \cdot [\text{species_1}] \quad (25)$$

Table 8: Properties of each parameter.

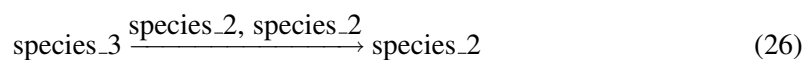
Id	Name	SBO	Value	Unit	Constant
k1	k1		1.0		<input checked="" type="checkbox"/>

6.2 Reaction `reaction_2`

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

Name Intestinal Cholesterol Synthesis

Reaction equation



Reactant

Table 9: Properties of each reactant.

Id	Name	SBO
species_3	ICS	

Modifiers

Table 10: Properties of each modifier.

Id	Name	SBO
species_2	IC	
species_2	IC	

Product

Table 11: Properties of each product.

Id	Name	SBO
species_2	IC	

Kinetic Law

Derived unit contains undeclared units

$$v_2 = \text{function_1}(\text{ICSmax}, [\text{species_2}], \text{ICt}, \text{IS}) \quad (27)$$

$$\text{function_1}(\text{ICSmax}, \text{IC}, \text{ICt}, \text{IS}) = \frac{\text{ICSmax}}{1 + \left(\frac{\text{IC}}{\text{ICt}}\right)^{\text{IS}}} \quad (28)$$

Table 12: Properties of each parameter.

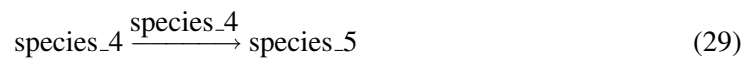
Id	Name	SBO	Value	Unit	Constant
ICSmax	ICSmax		100.0		<input checked="" type="checkbox"/>
ICt	ICt		3120.0		<input checked="" type="checkbox"/>
IS	IS		5.0		<input checked="" type="checkbox"/>

6.3 Reaction *reaction_3*

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

Name Bile Salt Release

Reaction equation



Reactant

Table 13: Properties of each reactant.

Id	Name	SBO
species_4	HBS	

Modifier

Table 14: Properties of each modifier.

Id	Name	SBO
species_4	HBS	

Product

Table 15: Properties of each product.

Id	Name	SBO
species_5	IBS	

Kinetic Law

Derived unit contains undeclared units

$$v_3 = k1 \cdot [\text{species_4}] \quad (30)$$

Table 16: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
k1	k1		6.0		<input checked="" type="checkbox"/>

6.4 Reaction `reaction_4`

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

Name Bile Salt Return

Reaction equation



Reactant

Table 17: Properties of each reactant.

Id	Name	SBO
species_5	IBS	

Modifier

Table 18: Properties of each modifier.

Id	Name	SBO
species_5	IBS	

Product

Table 19: Properties of each product.

Id	Name	SBO
species_4	HBS	

Kinetic Law

Derived unit contains undeclared units

$$v_4 = k1 \cdot [\text{species_5}] \quad (32)$$

Table 20: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
k1	k1		4.29		<input checked="" type="checkbox"/>

6.5 Reaction `reaction_5`

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

Name Bile Salt Excretion

Reaction equation



Reactant

Table 21: Properties of each reactant.

Id	Name	SBO
species_5	IBS	

Modifier

Table 22: Properties of each modifier.

Id	Name	SBO
species_5	IBS	

Product

Table 23: Properties of each product.

Id	Name	SBO
species_6	EBS	

Id	Name	SBO
----	------	-----

Kinetic Law

Derived unit contains undeclared units

$$v_5 = k1 \cdot [\text{species}_5] \quad (34)$$

Table 24: Properties of each parameter.

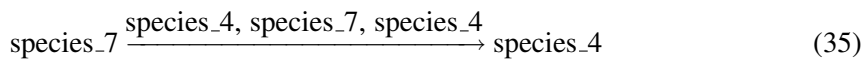
Id	Name	SBO	Value	Unit	Constant
k1	k1		0.856		<input checked="" type="checkbox"/>

6.6 Reaction `reaction_6`

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

Name Bile Salt Synthesis

Reaction equation



Reactant

Table 25: Properties of each reactant.

Id	Name	SBO
species_7	HFC	

Modifiers

Table 26: Properties of each modifier.

Id	Name	SBO
species_4	HBS	
species_7	HFC	
species_4	HBS	

Product

Table 27: Properties of each product.

Id	Name	SBO
species_4	HBS	

Kinetic Law

Derived unit contains undeclared units

$$v_6 = \text{function_2}(k5, [\text{species_7}], [\text{species_4}]) \quad (36)$$

$$\text{function_2}(k5, \text{HFC}, \text{HBS}) = \frac{k5 \cdot \text{HFC}}{\text{HBS}} \quad (37)$$

Table 28: Properties of each parameter.

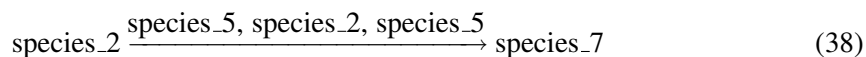
Id	Name	SBO	Value	Unit	Constant
k5	k5		2.66		<input checked="" type="checkbox"/>

6.7 Reaction `reaction_7`

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

Name Cholesterol Absorption

Reaction equation



Reactant

Table 29: Properties of each reactant.

Id	Name	SBO
species_2	IC	

Modifiers

Table 30: Properties of each modifier.

Id	Name	SBO
species_5	IBS	
species_2	IC	
species_5	IBS	

Product

Table 31: Properties of each product.

Id	Name	SBO
species_7	HFC	

Kinetic Law

Derived unit contains undeclared units

$$v_7 = \text{function_3}(k_6, [\text{species_2}], [\text{species_5}]) \quad (39)$$

$$\text{function_3}(k_6, \text{IC}, \text{IBS}) = k_6 \cdot \text{IC} \cdot \text{IBS} \quad (40)$$

Table 32: Properties of each parameter.

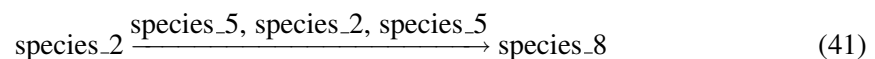
Id	Name	SBO	Value	Unit	Constant
k6	k6		$5.286 \cdot 10^{-4}$		<input checked="" type="checkbox"/>

6.8 Reaction [reaction_8](#)

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

Name Cholesterol Excretion

Reaction equation



Reactant

Table 33: Properties of each reactant.

Id	Name	SBO
species_2	IC	

Modifiers

Table 34: Properties of each modifier.

Id	Name	SBO
species_5	IBS	
species_2	IC	
species_5	IBS	

Product

Table 35: Properties of each product.

Id	Name	SBO
species_8	EC	

Kinetic Law

Derived unit contains undeclared units

$$v_8 = \text{function_4}(k7, [\text{species_2}], [\text{species_5}]) \quad (42)$$

$$\text{function_4}(k7, \text{IC}, \text{IBS}) = k7 \cdot \text{IC} \cdot \text{IBS} \quad (43)$$

Table 36: Properties of each parameter.

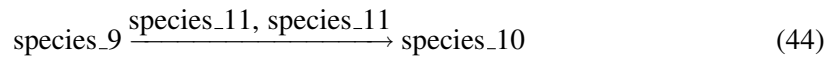
Id	Name	SBO	Value	Unit	Constant
k7	k7		$5.286 \cdot 10^{-4}$		<input checked="" type="checkbox"/>

6.9 Reaction `reaction_9`

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

Name Intestinal Nascent HDL Synthesis

Reaction equation



Reactant

Table 37: Properties of each reactant.

Id	Name	SBO
species_9	INHDL	

Modifiers

Table 38: Properties of each modifier.

Id	Name	SBO
species_11	PFC	
species_11	PFC	

Product

Table 39: Properties of each product.

Id	Name	SBO
species_10	NHDL	

Kinetic Law

Derived unit contains undeclared units

$$v_9 = \text{function_5}(k_8, [\text{species_11}]) \quad (45)$$

$$\text{function_5}(k_8, \text{PFC}) = k_8 \cdot \text{PFC} \quad (46)$$

Table 40: Properties of each parameter.

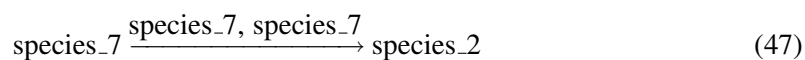
Id	Name	SBO	Value	Unit	Constant
k8	k8		$5 \cdot 10^{-4}$		<input checked="" type="checkbox"/>

6.10 Reaction `reaction_10`

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

Name Biliary Cholesterol Release

Reaction equation



Reactant

Table 41: Properties of each reactant.

Id	Name	SBO
<code>species_7</code>	HFC	

Modifiers

Table 42: Properties of each modifier.

Id	Name	SBO
<code>species_7</code>	HFC	
<code>species_7</code>	HFC	

Product

Table 43: Properties of each product.

Id	Name	SBO
<code>species_2</code>	IC	

Kinetic Law

Derived unit contains undeclared units

$$v_{10} = \text{function_6}(\text{BCRmax}, \text{BCRt}, [\text{species_7}], \text{BS}) \quad (48)$$

$$\text{function_6}(\text{BCRmax}, \text{BCRt}, \text{HFC}, \text{BS}) = \frac{\text{BCRmax}}{1 + \left(\frac{\text{BCRt}}{\text{HFC}}\right)^{\text{BS}}} \quad (49)$$

Table 44: Properties of each parameter.

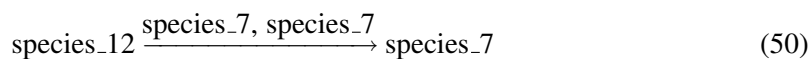
Id	Name	SBO	Value	Unit	Constant
BCRmax	BCRmax		2000.0		<input checked="" type="checkbox"/>
BCRt	BCRt		55326.0		<input checked="" type="checkbox"/>
BS	BS		5.0		<input checked="" type="checkbox"/>

6.11 Reaction `reaction_11`

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

Name Hepatic Cholesterol Synthesis

Reaction equation



Reactant

Table 45: Properties of each reactant.

Id	Name	SBO
<code>species_12</code>	HCS	

Modifiers

Table 46: Properties of each modifier.

Id	Name	SBO
<code>species_7</code>	HFC	
<code>species_7</code>	HFC	

Product

Table 47: Properties of each product.

Id	Name	SBO
<code>species_7</code>	HFC	

Kinetic Law

Derived unit contains undeclared units

$$v_{11} = \text{function_7}(\text{HCSmax}, [\text{species_7}], \text{HCSt}, \text{HS}) \quad (51)$$

$$\text{function_7}(\text{HCSmax}, \text{HFC}, \text{HCSt}, \text{HS}) = \frac{\text{HCSmax}}{1 + \left(\frac{\text{HFC}}{\text{HCSt}}\right)^{\text{HS}}} \quad (52)$$

Table 48: Properties of each parameter.

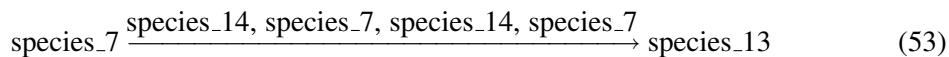
Id	Name	SBO	Value	Unit	Constant
HCSmax	HCSmax		500.0		<input checked="" type="checkbox"/>
HCSt	HCSt		93925.0		<input checked="" type="checkbox"/>
HS	HS		5.0		<input checked="" type="checkbox"/>

6.12 Reaction [reaction_12](#)

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

Name Hepatic Cholesterol Storage

Reaction equation



Reactant

Table 49: Properties of each reactant.

Id	Name	SBO
species_7	HFC	

Modifiers

Table 50: Properties of each modifier.

Id	Name	SBO
species_14	ACAT	
species_7	HFC	

Id	Name	SBO
species_14	ACAT	
species_7	HFC	

Product

Table 51: Properties of each product.

Id	Name	SBO
species_13	HCE	

Kinetic Law

Derived unit contains undeclared units

$$v_{12} = \text{function_8}(k9, [\text{species_14}], [\text{species_7}]) \quad (54)$$

$$\text{function_8}(k9, \text{ACAT}, \text{HFC}) = k9 \cdot \text{ACAT} \cdot \text{HFC} \quad (55)$$

Table 52: Properties of each parameter.

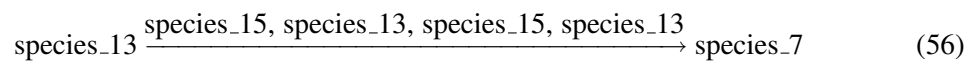
Id	Name	SBO	Value	Unit	Constant
k9	k9		1.0		<input checked="" type="checkbox"/>

6.13 Reaction [reaction_13](#)

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

Name Release of Stored Cholesterol

Reaction equation



Reactant

Table 53: Properties of each reactant.

Id	Name	SBO
species_13	HCE	

Modifiers

Table 54: Properties of each modifier.

Id	Name	SBO
species_15	CEH	
species_13	HCE	
species_15	CEH	
species_13	HCE	

Product

Table 55: Properties of each product.

Id	Name	SBO
species_7	HFC	

Kinetic Law

Derived unit contains undeclared units

$$v_{13} = \text{function_9}(k10, [\text{species_15}], [\text{species_13}]) \quad (57)$$

$$\text{function_9}(k10, \text{CEH}, \text{HCE}) = k10 \cdot \text{CEH} \cdot \text{HCE} \quad (58)$$

Table 56: Properties of each parameter.

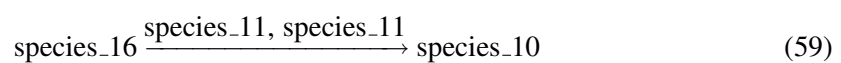
Id	Name	SBO	Value	Unit	Constant
k10	k10		5.998		<input checked="" type="checkbox"/>

6.14 Reaction [reaction_14](#)

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

Name Hepatic Nascent HDL Synthesis

Reaction equation



Reactant

Table 57: Properties of each reactant.

Id	Name	SBO
species_16	HNHDL	

Modifiers

Table 58: Properties of each modifier.

Id	Name	SBO
species_11	PFC	
species_11	PFC	

Product

Table 59: Properties of each product.

Id	Name	SBO
species_10	NHDL	

Kinetic Law

Derived unit contains undeclared units

$$v_{14} = \text{function_10}(k_{11}, [\text{species_11}]) \quad (60)$$

$$\text{function_10}(k_{11}, \text{PFC}) = k_{11} \cdot \text{PFC} \quad (61)$$

Table 60: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
k11	k11		0.005		<input checked="" type="checkbox"/>

6.15 Reaction `reaction_15`

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

Name VLDL Cholesterol Formation

Reaction equation



Reactant

Table 61: Properties of each reactant.

Id	Name	SBO
species_7	HFC	

Modifier

Table 62: Properties of each modifier.

Id	Name	SBO
species_7	HFC	

Product

Table 63: Properties of each product.

Id	Name	SBO
species_17	VLDLC	

Kinetic Law

Derived unit contains undeclared units

$$v_{15} = k1 \cdot [\text{species_7}] \quad (63)$$

Table 64: Properties of each parameter.

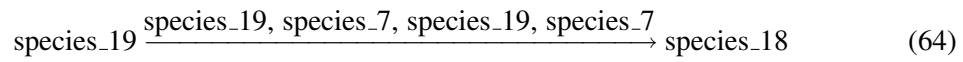
Id	Name	SBO	Value	Unit	Constant
k1	k1		0.016		<input checked="" type="checkbox"/>

6.16 Reaction `reaction_16`

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

Name Hepatic LDLR Synthesis

Reaction equation



Reactant

Table 65: Properties of each reactant.

Id	Name	SBO
species_19	HLDLRsS	

Modifiers

Table 66: Properties of each modifier.

Id	Name	SBO
species_19	HLDLRsS	
species_7	HFC	
species_19	HLDLRsS	
species_7	HFC	

Product

Table 67: Properties of each product.

Id	Name	SBO
species_18	HLDLRs	

Kinetic Law

Derived unit contains undeclared units

$$v_{16} = \text{function_11}(\text{khrrs}, [\text{species_19}], [\text{species_7}]) \quad (65)$$

$$\text{function_11}(\text{khrrs}, \text{HLDLRsS}, \text{HFC}) = \frac{\text{khrrs} \cdot \text{HLDLRsS}}{\text{HFC}} \quad (66)$$

Table 68: Properties of each parameter.

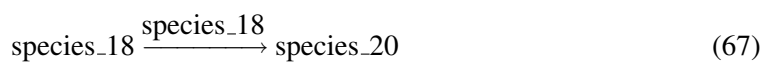
Id	Name	SBO	Value	Unit	Constant
khrrs	khrrs		100.0		<input checked="" type="checkbox"/>

6.17 Reaction [reaction_17](#)

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

Name Hepatic LDL Receptor Degradation

Reaction equation



Reactant

Table 69: Properties of each reactant.

Id	Name	SBO
species_18	HLDLRs	

Modifier

Table 70: Properties of each modifier.

Id	Name	SBO
species_18	HLDLRs	

Product

Table 71: Properties of each product.

Id	Name	SBO
species_20	HLDLRD	

Kinetic Law

Derived unit contains undeclared units

$$v_{17} = k1 \cdot [\text{species_18}] \quad (68)$$

Table 72: Properties of each parameter.

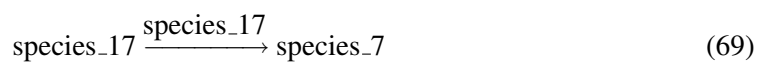
Id	Name	SBO	Value	Unit	Constant
k1	k1		0.01		<input checked="" type="checkbox"/>

6.18 Reaction [reaction_18](#)

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

Name VLDL Cholesterol ReUptake

Reaction equation



Reactant

Table 73: Properties of each reactant.

Id	Name	SBO
species_17	VLDLC	

Modifier

Table 74: Properties of each modifier.

Id	Name	SBO
species_17	VLDLC	

Product

Table 75: Properties of each product.

Id	Name	SBO
species_7	HFC	

Kinetic Law

Derived unit contains undeclared units

$$v_{18} = k1 \cdot [\text{species_17}] \quad (70)$$

Table 76: Properties of each parameter.

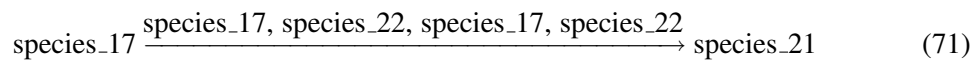
Id	Name	SBO	Value	Unit	Constant
k1	k1		0.050		<input checked="" type="checkbox"/>

6.19 Reaction [reaction_19](#)

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

Name IDL Cholesterol Formation

Reaction equation



Reactant

Table 77: Properties of each reactant.

Id	Name	SBO
species_17	VLDLC	

Modifiers

Table 78: Properties of each modifier.

Id	Name	SBO
species_17	VLDLC	
species_22	LPL	
species_17	VLDLC	
species_22	LPL	

Product

Table 79: Properties of each product.

Id	Name	SBO
species_21	IDLC	

Kinetic Law

Derived unit contains undeclared units

$$v_{19} = \text{function_12}(k15, [\text{species_17}], [\text{species_22}]) \quad (72)$$

$$\text{function_12}(k15, \text{VLDLC}, \text{LPL}) = k15 \cdot \text{VLDLC} \cdot \text{LPL} \quad (73)$$

Table 80: Properties of each parameter.

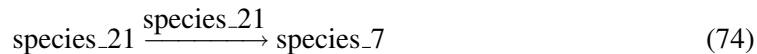
Id	Name	SBO	Value	Unit	Constant
k15	k15		0.43		<input checked="" type="checkbox"/>

6.20 Reaction `reaction_20`

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

Name IDL Cholesterol ReUptake

Reaction equation



Reactant

Table 81: Properties of each reactant.

Id	Name	SBO
species_21	IDLC	

Modifier

Table 82: Properties of each modifier.

Id	Name	SBO
species_21	IDLC	

Product

Table 83: Properties of each product.

Id	Name	SBO
species_7	HFC	

Kinetic Law

Derived unit contains undeclared units

$$v_{20} = k1 \cdot [\text{species_21}] \quad (75)$$

Table 84: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
k1	k1		0.054		<input checked="" type="checkbox"/>

6.21 Reaction [reaction_21](#)

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

Name LDL Cholesterol Formation

Reaction equation



Reactant

Table 85: Properties of each reactant.

Id	Name	SBO
species_21	IDLC	

Modifiers

Table 86: Properties of each modifier.

Id	Name	SBO
species_24	HSL	
species_21	IDLC	
species_24	HSL	

Id	Name	SBO
----	------	-----

Product

Table 87: Properties of each product.

Id	Name	SBO
species_23	LDLC	

Kinetic Law

Derived unit contains undeclared units

$$v_{21} = \text{function_13}(k17, [\text{species_21}], [\text{species_24}]) \quad (77)$$

$$\text{function_13}(k17, \text{IDLC}, \text{HSL}) = k17 \cdot \text{IDLC} \cdot \text{HSL} \quad (78)$$

Table 88: Properties of each parameter.

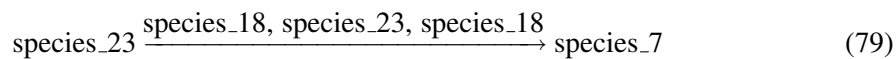
Id	Name	SBO	Value	Unit	Constant
k17	k17		0.38		<input checked="" type="checkbox"/>

6.22 Reaction [reaction_22](#)

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

Name Receptor Dependent Hepatic Uptake

Reaction equation



Reactant

Table 89: Properties of each reactant.

Id	Name	SBO
species_23	LDLC	

Modifiers

Table 90: Properties of each modifier.

Id	Name	SBO
species_18	HLDLRs	
species_23	LDLC	
species_18	HLDLRs	

Product

Table 91: Properties of each product.

Id	Name	SBO
species_7	HFC	

Kinetic Law

Derived unit contains undeclared units

$$v_{22} = \text{function_14}(k18, [\text{species_23}], [\text{species_18}]) \quad (80)$$

$$\text{function_14}(k18, \text{LDLC}, \text{HLDLRs}) = k18 \cdot \text{LDLC} \cdot \text{HLDLRs} \quad (81)$$

Table 92: Properties of each parameter.

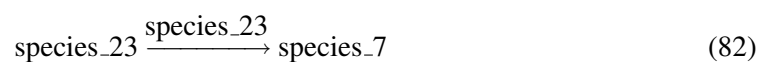
Id	Name	SBO	Value	Unit	Constant
k18	k18		0.068		<input checked="" type="checkbox"/>

6.23 Reaction [reaction_23](#)

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

Name Receptor Independent Hepatic Uptake

Reaction equation



Reactant

Table 93: Properties of each reactant.

Id	Name	SBO
species_23	LDLC	

Modifier

Table 94: Properties of each modifier.

Id	Name	SBO
species_23	LDLC	

Product

Table 95: Properties of each product.

Id	Name	SBO
species_7	HFC	

Kinetic Law

Derived unit contains undeclared units

$$v_{23} = k1 \cdot [\text{species_23}] \quad (83)$$

Table 96: Properties of each parameter.

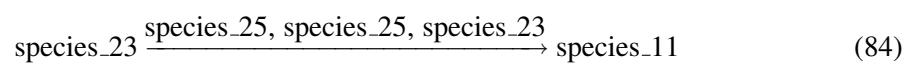
Id	Name	SBO	Value	Unit	Constant
k1	k1		0.005		<input checked="" type="checkbox"/>

6.24 Reaction [reaction_24](#)

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

Name Receptor Dependent Peripheral Uptake

Reaction equation



Reactant

Table 97: Properties of each reactant.

Id	Name	SBO
species_23	LDLC	

Modifiers

Table 98: Properties of each modifier.

Id	Name	SBO
species_25	PLDLRs	
species_25	PLDLRs	
species_23	LDLC	

Product

Table 99: Properties of each product.

Id	Name	SBO
species_11	PFC	

Kinetic Law

Derived unit contains undeclared units

$$v_{24} = \text{function_15}(k20, [\text{species_25}], [\text{species_23}]) \quad (85)$$

$$\text{function_15}(k20, \text{PLDLRs}, \text{LDLC}) = k20 \cdot \text{PLDLRs} \cdot \text{LDLC} \quad (86)$$

Table 100: Properties of each parameter.

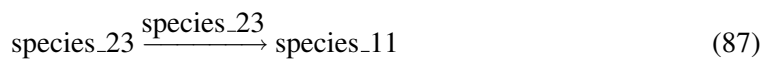
Id	Name	SBO	Value	Unit	Constant
k20	k20		0.007		<input checked="" type="checkbox"/>

6.25 Reaction [reaction_25](#)

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

Name Receptor Independent Peripheral Uptake

Reaction equation



Reactant

Table 101: Properties of each reactant.

Id	Name	SBO
species_23	LDLC	

Modifier

Table 102: Properties of each modifier.

Id	Name	SBO
species_23	LDLC	

Product

Table 103: Properties of each product.

Id	Name	SBO
species_11	PFC	

Kinetic Law

Derived unit contains undeclared units

$$v_{25} = k1 \cdot [\text{species_23}] \quad (88)$$

Table 104: Properties of each parameter.

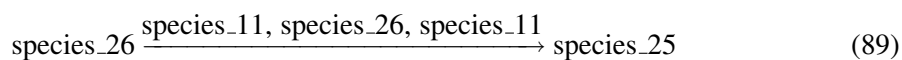
Id	Name	SBO	Value	Unit	Constant
k1	k1		$5 \cdot 10^{-6}$		<input checked="" type="checkbox"/>

6.26 Reaction `reaction_26`

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

Name Peripheral LDLR Synthesis

Reaction equation



Reactant

Table 105: Properties of each reactant.

Id	Name	SBO
<code>species_26</code>	PLDLRsS	

Modifiers

Table 106: Properties of each modifier.

Id	Name	SBO
<code>species_11</code>	PFC	
<code>species_26</code>	PLDLRsS	
<code>species_11</code>	PFC	

Product

Table 107: Properties of each product.

Id	Name	SBO
<code>species_25</code>	PLDLRs	

Kinetic Law

Derived unit contains undeclared units

$$v_{26} = \text{function_16}(\text{kprs}, [\text{species_26}], [\text{species_11}]) \quad (90)$$

$$\text{function_16}(\text{kprs}, \text{PLDLRsS}, \text{PFC}) = \frac{\text{kprs} \cdot \text{PLDLRsS}}{\text{PFC}} \quad (91)$$

Table 108: Properties of each parameter.

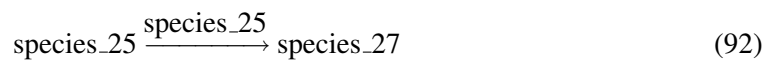
Id	Name	SBO	Value	Unit	Constant
kprs	kprs		100.0		<input checked="" type="checkbox"/>

6.27 Reaction [reaction_27](#)

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

Name Peripheral LDL Receptor Degradation

Reaction equation



Reactant

Table 109: Properties of each reactant.

Id	Name	SBO
species_25	PLDLRs	

Modifier

Table 110: Properties of each modifier.

Id	Name	SBO
species_25	PLDLRs	

Product

Table 111: Properties of each product.

Id	Name	SBO
species_27	PLDLRD	

Kinetic Law

Derived unit contains undeclared units

$$v_{27} = k1 \cdot [\text{species_25}] \quad (93)$$

Table 112: Properties of each parameter.

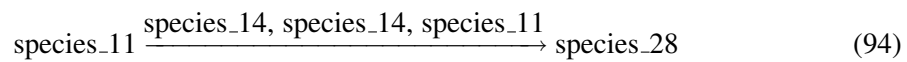
Id	Name	SBO	Value	Unit	Constant
k1	k1		0.01		<input checked="" type="checkbox"/>

6.28 Reaction [reaction_28](#)

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

Name Peripheral Cholesterol Storage

Reaction equation



Reactant

Table 113: Properties of each reactant.

Id	Name	SBO
species_11	PFC	

Modifiers

Table 114: Properties of each modifier.

Id	Name	SBO
species_14	ACAT	
species_14	ACAT	
species_11	PFC	

Product

Table 115: Properties of each product.

Id	Name	SBO
species_28	PCE	

Kinetic Law

Derived unit contains undeclared units

$$v_{28} = \text{function_17}(k23, [\text{species_14}], [\text{species_11}]) \quad (95)$$

$$\text{function_17}(k23, \text{ACAT}, \text{PFC}) = k23 \cdot \text{ACAT} \cdot \text{PFC} \quad (96)$$

Table 116: Properties of each parameter.

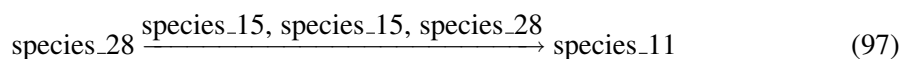
Id	Name	SBO	Value	Unit	Constant
k23	k23		0.017		<input checked="" type="checkbox"/>

6.29 Reaction [reaction_29](#)

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

Name Release of Stored Peripheral Cholesterol

Reaction equation



Reactant

Table 117: Properties of each reactant.

Id	Name	SBO
species_28	PCE	

Modifiers

Table 118: Properties of each modifier.

Id	Name	SBO
species_15	CEH	
species_15	CEH	
species_28	PCE	

Product

Table 119: Properties of each product.

Id	Name	SBO
species_11	PFC	

Kinetic Law

Derived unit contains undeclared units

$$v_{29} = \text{function_18}(k24, [\text{species_15}], [\text{species_28}]) \quad (98)$$

$$\text{function_18}(k24, \text{CEH}, \text{PCE}) = k24 \cdot \text{CEH} \cdot \text{PCE} \quad (99)$$

Table 120: Properties of each parameter.

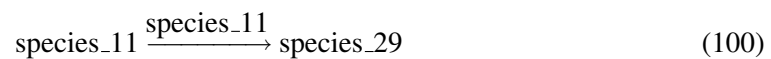
Id	Name	SBO	Value	Unit	Constant
k24	k24		0.107		<input checked="" type="checkbox"/>

6.30 Reaction [reaction_30](#)

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

Name Peripheral Steroid Production

Reaction equation



Reactant

Table 121: Properties of each reactant.

Id	Name	SBO
species_11	PFC	

Modifier

Table 122: Properties of each modifier.

Id	Name	SBO
species_11	PFC	

Product

Table 123: Properties of each product.

Id	Name	SBO
species_29	PSS	

Kinetic Law

Derived unit contains undeclared units

$$v_{30} = k1 \cdot [\text{species_11}] \quad (101)$$

Table 124: Properties of each parameter.

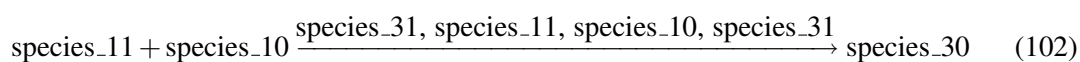
Id	Name	SBO	Value	Unit	Constant
k1	k1		$5 \cdot 10^{-4}$		<input checked="" type="checkbox"/>

6.31 Reaction [reaction_31](#)

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

Name HDL Cholesterol Formation

Reaction equation



Reactants

Table 125: Properties of each reactant.

Id	Name	SBO
species_11	PFC	
species_10	NHDL	

Modifiers

Table 126: Properties of each modifier.

Id	Name	SBO
species_31	LCAT	
species_11	PFC	
species_10	NHDL	
species_31	LCAT	

Product

Table 127: Properties of each product.

Id	Name	SBO
species_30	HDLC	

Kinetic Law

Derived unit contains undeclared units

$$v_{31} = \text{function_19}(k26, [\text{species_11}], [\text{species_10}], [\text{species_31}]) \quad (103)$$

$$\text{function_19}(k26, \text{PFC}, \text{NHDL}, \text{LCAT}) = k26 \cdot \text{PFC} \cdot \text{NHDL} \cdot \text{LCAT} \quad (104)$$

Table 128: Properties of each parameter.

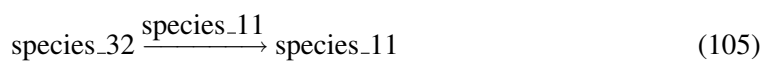
Id	Name	SBO	Value	Unit	Constant
k26	k26		$1.5 \cdot 10^{-5}$		<input checked="" type="checkbox"/>

6.32 Reaction `reaction_32`

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

Name Peripheral Cholesterol Synthesis

Reaction equation



Reactant

Table 129: Properties of each reactant.

Id	Name	SBO
species_32	PCS	

Modifier

Table 130: Properties of each modifier.

Id	Name	SBO
species_11	PFC	

Product

Table 131: Properties of each product.

Id	Name	SBO
species_11	PFC	

Kinetic Law

Derived unit contains undeclared units

$$v_{32} = \text{function_20}(\text{PCSmax}, [\text{species_11}], \text{PPCt}, \text{PCSS}) \quad (106)$$

$$\text{function_20}(\text{PCSmax}, \text{PFC}, \text{PPCt}, \text{PCSS}) = \frac{\text{PCSmax}}{1 + \left(\frac{\text{PFC}}{\text{PPCt}}\right)^{\text{PCSS}}} \quad (107)$$

Table 132: Properties of each parameter.

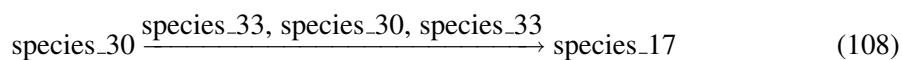
Id	Name	SBO	Value	Unit	Constant
PCSmax	PCSmax		500.0		✓
PPCt	PPCt		80342.0		✓
PCSS	PCSS		5.0		✓

6.33 Reaction `reaction_33`

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

Name CETP Mediated Transfer To VLDL

Reaction equation



Reactant

Table 133: Properties of each reactant.

Id	Name	SBO
species_30	HDLC	

Modifiers

Table 134: Properties of each modifier.

Id	Name	SBO
species_33	CETP	
species_30	HDLC	
species_33	CETP	

Product

Table 135: Properties of each product.

Id	Name	SBO
species_17	VLDLC	

Kinetic Law

Derived unit contains undeclared units

$$v_{33} = \text{function_21} (k27, [\text{species_30}], [\text{species_33}]) \quad (109)$$

$$\text{function_21} (k27, \text{HDLC}, \text{CETP}) = k27 \cdot \text{HDLC} \cdot \text{CETP} \quad (110)$$

Table 136: Properties of each parameter.

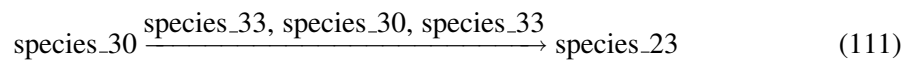
Id	Name	SBO	Value	Unit	Constant
k27	k27		0.01		<input checked="" type="checkbox"/>

6.34 Reaction [reaction_34](#)

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

Name CETP Mediated TransferTo LDL

Reaction equation



Reactant

Table 137: Properties of each reactant.

Id	Name	SBO
species_30	HDLC	

Modifiers

Table 138: Properties of each modifier.

Id	Name	SBO
species_33	CETP	
species_30	HDLC	
species_33	CETP	

Product

Table 139: Properties of each product.

Id	Name	SBO
species_23	LDLC	

Kinetic Law

Derived unit contains undeclared units

$$v_{34} = \text{function_22} (k28, [\text{species_30}], [\text{species_33}]) \quad (112)$$

$$\text{function_22} (k28, \text{HDLC}, \text{CETP}) = k28 \cdot \text{HDLC} \cdot \text{CETP} \quad (113)$$

Table 140: Properties of each parameter.

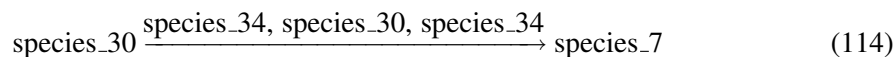
Id	Name	SBO	Value	Unit	Constant
k28	k28		0.001		<input checked="" type="checkbox"/>

6.35 Reaction `reaction_35`

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

Name Reverse Cholesterol Transport

Reaction equation



Reactant

Table 141: Properties of each reactant.

Id	Name	SBO
species_30	HDLC	

Modifiers

Table 142: Properties of each modifier.

Id	Name	SBO
species_34	SRB1	
species_30	HDLC	
species_34	SRB1	

Product

Table 143: Properties of each product.

Id	Name	SBO
species_7	HFC	

Kinetic Law

Derived unit contains undeclared units

$$v_{35} = \text{function_23}(k29, [\text{species_30}], [\text{species_34}]) \quad (115)$$

$$\text{function_23}(k29, \text{HDLC}, \text{SRB1}) = k29 \cdot \text{HDLC} \cdot \text{SRB1} \quad (116)$$

Table 144: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
k29	k29		0.05		<input checked="" type="checkbox"/>

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 `species_1`

Name DC

Initial concentration 304 dimensionless · dimensionless⁻¹

This species takes part in two reactions (as a reactant in `reaction_1` and as a modifier in `reaction_1`), which do not influence its rate of change because this constant species is on the boundary of the reaction system:

$$\frac{d}{dt} \text{species_1} = 0 \quad (117)$$

7.2 Species `species_2`

Name IC

Initial concentration 3150 dimensionless · dimensionless⁻¹

This species takes part in nine reactions (as a reactant in [reaction_7](#), [reaction_8](#) and as a product in [reaction_1](#), [reaction_2](#), [reaction_10](#) and as a modifier in [reaction_2](#), [reaction_7](#), [reaction_8](#)).

$$\frac{d}{dt}\text{species_2} = v_1 + v_2 + v_{10} - v_7 - v_8 \quad (118)$$

7.3 Species `species_3`

Name ICS

SBO:0000291 empty set

Initial concentration 0 dimensionless · dimensionless⁻¹

This species takes part in one reaction (as a reactant in [reaction_2](#)), which does not influence its rate of change because this constant species is on the boundary of the reaction system:

$$\frac{d}{dt}\text{species_3} = 0 \quad (119)$$

7.4 Species `species_4`

Name HBS

Initial concentration 400 dimensionless · dimensionless⁻¹

This species takes part in six reactions (as a reactant in [reaction_3](#) and as a product in [reaction_4](#), [reaction_6](#) and as a modifier in [reaction_3](#), [reaction_6](#), [reaction_6](#)).

$$\frac{d}{dt}\text{species_4} = v_4 + v_6 - v_3 \quad (120)$$

7.5 Species `species_5`

Name IBS

Initial concentration 467 dimensionless · dimensionless⁻¹

This species takes part in nine reactions (as a reactant in [reaction_4](#), [reaction_5](#) and as a product in [reaction_3](#) and as a modifier in [reaction_4](#), [reaction_5](#), [reaction_7](#), [reaction_7](#), [reaction_8](#), [reaction_8](#)).

$$\frac{d}{dt}\text{species_5} = v_3 - v_4 - v_5 \quad (121)$$

7.6 Species `species_6`

Name EBS

Initial concentration 0 dimensionless · dimensionless⁻¹

This species takes part in one reaction (as a product in [reaction_5](#)).

$$\frac{d}{dt}\text{species_6} = v_5 \quad (122)$$

7.7 Species `species_7`

Name HFC

Initial concentration 60000 dimensionless · dimensionless⁻¹

This species takes part in 22 reactions (as a reactant in [reaction_6](#), [reaction_10](#), [reaction_12](#), [reaction_15](#) and as a product in [reaction_7](#), [reaction_11](#), [reaction_13](#), [reaction_18](#), [reaction_20](#), [reaction_22](#), [reaction_23](#), [reaction_35](#) and as a modifier in [reaction_6](#), [reaction_10](#), [reaction_10](#), [reaction_11](#), [reaction_11](#), [reaction_12](#), [reaction_12](#), [reaction_15](#), [reaction_16](#), [reaction_16](#)).

$$\frac{d}{dt}\text{species_7} = v_7 + v_{11} + v_{13} + v_{18} + v_{20} + v_{22} + v_{23} + v_{35} - v_6 - v_{10} - v_{12} - v_{15} \quad (123)$$

7.8 Species `species_8`

Name EC

Initial concentration 0 dimensionless · dimensionless⁻¹

This species takes part in one reaction (as a product in [reaction_8](#)).

$$\frac{d}{dt}\text{species_8} = v_8 \quad (124)$$

7.9 Species `species_9`

Name INHDLS

Initial concentration 0 dimensionless · dimensionless⁻¹

This species takes part in one reaction (as a reactant in [reaction_9](#)), which does not influence its rate of change because this constant species is on the boundary of the reaction system:

$$\frac{d}{dt}\text{species_9} = 0 \quad (125)$$

7.10 Species `species_10`

Name NHDL

Initial concentration 100 dimensionless · dimensionless⁻¹

This species takes part in four reactions (as a reactant in [reaction_31](#) and as a product in [reaction_9](#), [reaction_14](#) and as a modifier in [reaction_31](#)).

$$\frac{d}{dt}\text{species_10} = v_9 + v_{14} - v_{31} \quad (126)$$

7.11 Species `species_11`

Name PFC

Initial concentration 57516 dimensionless · dimensionless⁻¹

This species takes part in 17 reactions (as a reactant in [reaction_28](#), [reaction_30](#), [reaction_31](#) and as a product in [reaction_24](#), [reaction_25](#), [reaction_29](#), [reaction_32](#) and as a modifier in [reaction_9](#), [reaction_9](#), [reaction_14](#), [reaction_14](#), [reaction_26](#), [reaction_26](#), [reaction_28](#), [reaction_30](#), [reaction_31](#), [reaction_32](#)).

$$\frac{d}{dt}\text{species_11} = v_{24} + v_{25} + v_{29} + v_{32} - v_{28} - v_{30} - v_{31} \quad (127)$$

7.12 Species `species_12`

Name HCS

SBO:0000291 empty set

Initial concentration 0 dimensionless · dimensionless⁻¹

This species takes part in one reaction (as a reactant in [reaction_11](#)), which does not influence its rate of change because this constant species is on the boundary of the reaction system:

$$\frac{d}{dt}\text{species_12} = 0 \quad (128)$$

7.13 Species `species_13`

Name HCE

Initial concentration 10000 dimensionless · dimensionless⁻¹

This species takes part in four reactions (as a reactant in [reaction_13](#) and as a product in [reaction_12](#) and as a modifier in [reaction_13](#), [reaction_13](#)).

$$\frac{d}{dt}\text{species_13} = v_{12} - v_{13} \quad (129)$$

7.14 Species `species_14`

Name ACAT

Initial concentration 100 dimensionless · dimensionless⁻¹

This species takes part in four reactions (as a modifier in [reaction_12](#), [reaction_12](#), [reaction_28](#), [reaction_28](#)).

$$\frac{d}{dt}\text{species_14} = 0 \quad (130)$$

7.15 Species `species_15`

Name CEH

Initial concentration 100 dimensionless · dimensionless⁻¹

This species takes part in four reactions (as a modifier in [reaction_13](#), [reaction_13](#), [reaction_29](#), [reaction_29](#)).

$$\frac{d}{dt}\text{species_15} = 0 \quad (131)$$

7.16 Species `species_16`

Name HNHDLS

SBO:0000291 empty set

Initial concentration 0 dimensionless · dimensionless⁻¹

This species takes part in one reaction (as a reactant in [reaction_14](#)), which does not influence its rate of change because this constant species is on the boundary of the reaction system:

$$\frac{d}{dt}\text{species_16} = 0 \quad (132)$$

7.17 Species `species_17`

Name VLDLC

Initial concentration 20 dimensionless · dimensionless⁻¹

This species takes part in seven reactions (as a reactant in [reaction_18](#), [reaction_19](#) and as a product in [reaction_15](#), [reaction_33](#) and as a modifier in [reaction_18](#), [reaction_19](#), [reaction_19](#)).

$$\frac{d}{dt}\text{species_17} = v_{15} + v_{33} - v_{18} - v_{19} \quad (133)$$

7.18 Species `species_18`

Name HLDLRs

Initial concentration 100 dimensionless · dimensionless⁻¹

This species takes part in five reactions (as a reactant in [reaction_17](#) and as a product in [reaction_16](#) and as a modifier in [reaction_17](#), [reaction_22](#), [reaction_22](#)).

$$\frac{d}{dt}\text{species_18} = v_{16} - v_{17} \quad (134)$$

7.19 Species `species_19`

Name HLDLRsS

SBO:0000291 empty set

Initial concentration 600 dimensionless · dimensionless⁻¹

This species takes part in three reactions (as a reactant in [reaction_16](#) and as a modifier in [reaction_16](#), [reaction_16](#)), which do not influence its rate of change because this constant species is on the boundary of the reaction system:

$$\frac{d}{dt}\text{species_19} = 0 \quad (135)$$

7.20 Species `species_20`

Name HLDLRD

SBO:0000291 empty set

Initial concentration 0 dimensionless · dimensionless⁻¹

This species takes part in one reaction (as a product in [reaction_17](#)).

$$\frac{d}{dt}\text{species_20} = v_{17} \quad (136)$$

7.21 Species `species_21`

Name IDLC

Initial concentration 20 dimensionless · dimensionless⁻¹

This species takes part in five reactions (as a reactant in [reaction_20](#), [reaction_21](#) and as a product in [reaction_19](#) and as a modifier in [reaction_20](#), [reaction_21](#)).

$$\frac{d}{dt}\text{species_21} = v_{19} - v_{20} - v_{21} \quad (137)$$

7.22 Species `species_22`

Name LPL

Initial concentration 100 dimensionless · dimensionless⁻¹

This species takes part in two reactions (as a modifier in [reaction_19](#), [reaction_19](#)).

$$\frac{d}{dt}\text{species_22} = 0 \quad (138)$$

7.23 Species `species_23`

Name LDLC

Initial concentration 100 dimensionless · dimensionless⁻¹

This species takes part in ten reactions (as a reactant in [reaction_22](#), [reaction_23](#), [reaction_24](#), [reaction_25](#) and as a product in [reaction_21](#), [reaction_34](#) and as a modifier in [reaction_22](#), [reaction_23](#), [reaction_24](#), [reaction_25](#)).

$$\frac{d}{dt}\text{species_23} = v_{21} + v_{34} - v_{22} - v_{23} - v_{24} - v_{25} \quad (139)$$

7.24 Species `species_24`

Name HSL

Initial concentration 100 dimensionless · dimensionless⁻¹

This species takes part in two reactions (as a modifier in [reaction_21](#), [reaction_21](#)).

$$\frac{d}{dt}\text{species_24} = 0 \quad (140)$$

7.25 Species `species_25`

Name PLDLRs

Initial concentration 100 dimensionless · dimensionless⁻¹

This species takes part in five reactions (as a reactant in [reaction_27](#) and as a product in [reaction_26](#) and as a modifier in [reaction_24](#), [reaction_24](#), [reaction_27](#)).

$$\frac{d}{dt}\text{species_25} = v_{26} - v_{27} \quad (141)$$

7.26 Species `species_26`

Name PLDLRsS

SBO:0000291 empty set

Initial concentration 575.16 dimensionless · dimensionless⁻¹

This species takes part in two reactions (as a reactant in [reaction_26](#) and as a modifier in [reaction_26](#)), which do not influence its rate of change because this constant species is on the boundary of the reaction system:

$$\frac{d}{dt}\text{species_26} = 0 \quad (142)$$

7.27 Species `species_27`

Name PLDLRD

SBO:0000291 empty set

Initial concentration 0 dimensionless · dimensionless⁻¹

This species takes part in one reaction (as a product in [reaction_27](#)).

$$\frac{d}{dt}\text{species_27} = v_{27} \quad (143)$$

7.28 Species `species_28`

Name PCE

Initial concentration 9363 dimensionless · dimensionless⁻¹

This species takes part in three reactions (as a reactant in [reaction_29](#) and as a product in [reaction_28](#) and as a modifier in [reaction_29](#)).

$$\frac{d}{dt}\text{species_28} = v_{28} - v_{29} \quad (144)$$

7.29 Species `species_29`

Name PSS

SBO:0000291 empty set

Initial concentration 0 dimensionless · dimensionless⁻¹

This species takes part in one reaction (as a product in [reaction_30](#)).

$$\frac{d}{dt}\text{species_29} = v_{30} \quad (145)$$

7.30 Species `species_30`

Name HDLC

Initial concentration 45 dimensionless · dimensionless⁻¹

This species takes part in seven reactions (as a reactant in [reaction_33](#), [reaction_34](#), [reaction_35](#) and as a product in [reaction_31](#) and as a modifier in [reaction_33](#), [reaction_34](#), [reaction_35](#)).

$$\frac{d}{dt}\text{species_30} = v_{31} - v_{33} - v_{34} - v_{35} \quad (146)$$

7.31 Species `species_31`

Name LCAT

Initial concentration 100 dimensionless · dimensionless⁻¹

This species takes part in two reactions (as a modifier in [reaction_31](#), [reaction_31](#)).

$$\frac{d}{dt}\text{species_31} = 0 \quad (147)$$

7.32 Species `species_32`

Name PCS

SBO:0000291 empty set

Initial concentration 0 dimensionless · dimensionless⁻¹

This species takes part in one reaction (as a reactant in [reaction_32](#)), which does not influence its rate of change because this constant species is on the boundary of the reaction system:

$$\frac{d}{dt}\text{species_32} = 0 \quad (148)$$

7.33 Species `species_33`

Name CETP

Initial concentration 100 dimensionless · dimensionless⁻¹

This species takes part in four reactions (as a modifier in [reaction_33](#), [reaction_33](#), [reaction_34](#), [reaction_34](#)).

$$\frac{d}{dt}\text{species_33} = 0 \quad (149)$$

7.34 Species `species_34`

Name SRB1

Initial concentration 100 dimensionless · dimensionless⁻¹

This species takes part in two reactions (as a modifier in [reaction_35](#), [reaction_35](#)).

$$\frac{d}{dt}\text{species_34} = 0 \quad (150)$$

A Glossary of Systems Biology Ontology Terms

SBO:0000291 empty set: Entity defined by the absence of any actual object. An empty set is often used to represent the source of a creation process or the result of a degradation process.

SBML2^ATeX 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.

^aCenter for Bioinformatics Tübingen (ZBIT), Germany

^bCalifornia Institute of Technology, Beckman Institute BNMC, Pasadena, United States

^cEuropean Bioinformatics Institute, Wellcome Trust Genome Campus, Hinxton, United Kingdom

^dEML Research gGmbH, Heidelberg, Germany