

## SBML Model Report

# Model name: “Proctor2016 - Circadian rhythm of PTH and the dynamics of signaling molecules on bone remodeling”



August 25, 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 Chelliah<sup>1</sup> and Carole Proctor<sup>2</sup> at May 26<sup>th</sup> 2016 at 4:04 p. m. and last time modified at June ninth 2016 at 10:37 a. m. Table 1 provides an overview of the quantities of all components of this model.

Table 1: Number of components in this model, which are described in the following sections.

Element	Quantity	Element	Quantity
compartment types	0	compartments	3
species types	0	species	37
events	4	constraints	0
reactions	76	function definitions	0
global parameters	72	unit definitions	1
rules	0	initial assignments	0

## Model Notes

Proctor2016 - Circadian rhythm of PTH and the dynamics of signaling molecules on bone remodeling

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This model is described in the article: [Simulated Interventions to Ameliorate Age-Related Bone Loss Indicate the Importance of Timing](#). Proctor CJ, Gartland A. Front Endocrinol (Lausanne) 2016; 7: 61

Abstract:

Bone remodeling is the continuous process of bone resorption by osteoclasts and bone formation by osteoblasts, in order to maintain homeostasis. The activity of osteoclasts and osteoblasts is regulated by a network of signaling pathways, including Wnt, parathyroid hormone (PTH), RANK ligand/osteoprotegerin, and TGF- $\beta$ , in response to stimuli, such as mechanical loading. During aging there is a gradual loss of bone mass due to dysregulation of signaling pathways. This may be due to a decline in physical activity with age and/or changes in hormones and other signaling molecules. In particular, hormones, such as PTH, have a circadian rhythm, which may be disrupted in aging. Due to the complexity of the molecular and cellular networks involved in bone remodeling, several mathematical models have been proposed to aid understanding of the processes involved. However, to date, there are no models, which explicitly consider the effects of mechanical loading, the circadian rhythm of PTH, and the dynamics of signaling molecules on bone remodeling. Therefore, we have constructed a network model of the system using a modular approach, which will allow further modifications as required in future research. The model was used to simulate the effects of mechanical loading and also the effects of different interventions, such as continuous or intermittent administration of PTH. Our model predicts that the absence of regular mechanical loading and/or an impaired PTH circadian rhythm leads to a gradual decrease in bone mass over time, which can be restored by simulated interventions and that the effectiveness of some interventions may depend on their timing.

This model is hosted on [BioModels Database](#) and identified by: [BIOMD0000000612](#).

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

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## 2 Unit Definitions

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

### 2.1 Unit substance

**Definition** item

### 2.2 Unit volume

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

**Definition** 1

### 2.3 Unit area

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

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

### 2.4 Unit length

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

**Definition** m

### 2.5 Unit time

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

**Definition** s

## 3 Compartments

This model contains three compartments.

Table 2: Properties of all compartments.

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

#### 3.1 Compartment bone

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

#### 3.2 Compartment ecm

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

#### 3.3 Compartment osteoblast

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

## 4 Species

This model contains 37 species. The boundary condition of two of these species is set to true so that these species' amount cannot be changed by any reaction. Section 8 provides further details and the derived rates of change of each species.

Table 3: Properties of each species.

Id	Name	Compartment	Derived Unit	Constant	Boundary Condi- tion
Bone		bone	item	<input type="checkbox"/>	<input type="checkbox"/>
HSC		bone	item	<input type="checkbox"/>	<input type="checkbox"/>
Ob_m		bone	item	<input type="checkbox"/>	<input type="checkbox"/>
Ob_p		bone	item	<input type="checkbox"/>	<input type="checkbox"/>
Ob_p_Tgfb_A		bone	item	<input type="checkbox"/>	<input type="checkbox"/>
Ob_pro		bone	item	<input type="checkbox"/>	<input type="checkbox"/>
Ocl_m		bone	item	<input type="checkbox"/>	<input type="checkbox"/>
Ocl_p		bone	item	<input type="checkbox"/>	<input type="checkbox"/>
Ocl_p_RANKL		bone	item	<input type="checkbox"/>	<input type="checkbox"/>
Ocy_A		bone	item	<input type="checkbox"/>	<input type="checkbox"/>
Ocy_I		bone	item	<input type="checkbox"/>	<input type="checkbox"/>
Ocy_I_PTH		bone	item	<input type="checkbox"/>	<input type="checkbox"/>
MSC		bone	item	<input type="checkbox"/>	<input type="checkbox"/>
LOAD		ecm	item	<input type="checkbox"/>	<input type="checkbox"/>
MCSF		ecm	item	<input type="checkbox"/>	<input type="checkbox"/>
Ob_m_PTH		ecm	item	<input type="checkbox"/>	<input type="checkbox"/>
Ob_p_PTH		ecm	item	<input type="checkbox"/>	<input type="checkbox"/>
OPG		ecm	item	<input type="checkbox"/>	<input type="checkbox"/>
OPG_RANKL		ecm	item	<input type="checkbox"/>	<input type="checkbox"/>
PTH		ecm	item	<input type="checkbox"/>	<input type="checkbox"/>
RANKL		ecm	item	<input type="checkbox"/>	<input type="checkbox"/>

Id	Name	Compartment	Derived Unit	Constant	Boundary Condi- tion
Sost		ecm	item	<input type="checkbox"/>	<input type="checkbox"/>
Tgfb_A		ecm	item	<input type="checkbox"/>	<input type="checkbox"/>
Tgfb_I		ecm	item	<input type="checkbox"/>	<input type="checkbox"/>
Wnt_A		ecm	item	<input type="checkbox"/>	<input type="checkbox"/>
Wnt_I		ecm	item	<input type="checkbox"/>	<input type="checkbox"/>
Source		ecm	item	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Sink		ecm	item	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
X		ecm	item	<input type="checkbox"/>	<input type="checkbox"/>
newbone		ecm	item	<input type="checkbox"/>	<input type="checkbox"/>
Bax		osteoblast	item	<input type="checkbox"/>	<input type="checkbox"/>
Bax_Bcl2		osteoblast	item	<input type="checkbox"/>	<input type="checkbox"/>
Bcl2		osteoblast	item	<input type="checkbox"/>	<input type="checkbox"/>
CREB		osteoblast	item	<input type="checkbox"/>	<input type="checkbox"/>
CREB_P		osteoblast	item	<input type="checkbox"/>	<input type="checkbox"/>
CREB_Runx2		osteoblast	item	<input type="checkbox"/>	<input type="checkbox"/>
Runx2		osteoblast	item	<input type="checkbox"/>	<input type="checkbox"/>

## 5 Parameters

This model contains 72 global parameters.

Table 4: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
kactCreb			0.009		✓
kactOcy			0.004		✓
kactOcyPth			0.080		✓
kactTgfb			$2 \cdot 10^{-7}$		✓
kactWnt			0.030		✓
kactWntPth			0.001		✓
kbinBaxBcl2			0.010		✓
kbinCrebRunx2			0.010		✓
kbinObmPTH			0.020		✓
kbinObpPTH			$3 \cdot 10^{-4}$		✓
kbinObpTgfb			$2 \cdot 10^{-4}$		✓
kbinOclpRANKL			0.001		✓
kbinOcyPTH			0.008		✓
kdeathOb			$2.4 \cdot 10^{-4}$		✓
kdeathOcl			$6.5 \cdot 10^{-5}$		✓
kdeathOclp			$10^{-5}$		✓
kdeathOcy			$10^{-8}$		✓
kdegBcl2			0.003		✓
kdegBone			$6.5 \cdot 10^{-9}$		✓
kdegMCSF			$10^{-4}$		✓
kdegOPG			$4 \cdot 10^{-6}$		✓
kdegOPGRANKL			$10^{-5}$		✓
kdegPTH			0.002		✓
kdegRANKL			$3 \cdot 10^{-5}$		✓
kdegRunx2			$10^{-4}$		✓
kdegRunx2PTH			0.003		✓
kdegSost			0.004		✓
kdegTgfb			$5 \cdot 10^{-5}$		✓
kdegTgfbPTH			$1.7 \cdot 10^{-5}$		✓
kdiffHSC			$5.5 \cdot 10^{-5}$		✓
kdiffMSC			$6.5 \cdot 10^{-4}$		✓
kdiffObP			$10^{-4}$		✓
kdiffObproTgfb			0.050		✓
kdiffOclP			$8 \cdot 10^{-5}$		✓
kformBone			$3.07 \cdot 10^{-6}$		✓
kinactCreb			$10^{-4}$		✓
kinactOcy			$2 \cdot 10^{-5}$		✓

Id	Name	SBO	Value	Unit	Constant
kinactWnt			0.800		<input checked="" type="checkbox"/>
kinhibRANKL			0.001		<input checked="" type="checkbox"/>
kmatOb			$2 \cdot 10^{-9}$		<input checked="" type="checkbox"/>
kmatObTgfb			$10^{-8}$		<input checked="" type="checkbox"/>
krelBaxBcl2			0.500		<input checked="" type="checkbox"/>
krelCrebRunx2			0.010		<input checked="" type="checkbox"/>
krelObmPTH			0.005		<input checked="" type="checkbox"/>
krelObpPTH			0.005		<input checked="" type="checkbox"/>
krelObpTgfb			0.010		<input checked="" type="checkbox"/>
krelOclpRANKL			0.001		<input checked="" type="checkbox"/>
krelOcyPTH			0.005		<input checked="" type="checkbox"/>
krelRANKL			0.001		<input checked="" type="checkbox"/>
ksecMCSFbyMSC			$10^{-5}$		<input checked="" type="checkbox"/>
ksecMCSFbyObm			$10^{-5}$		<input checked="" type="checkbox"/>
ksecMCSFbyObp			$10^{-5}$		<input checked="" type="checkbox"/>
ksecMCSFbyObpro			$10^{-5}$		<input checked="" type="checkbox"/>
ksecOPGbyObm			$10^{-5}$		<input checked="" type="checkbox"/>
ksecOPGbyObp			$2 \cdot 10^{-6}$		<input checked="" type="checkbox"/>
ksecOPGbyObpPTH			$10^{-6}$		<input checked="" type="checkbox"/>
ksecRANKLbyMSC			$10^{-6}$		<input checked="" type="checkbox"/>
ksecRANKLbyObm			$10^{-7}$		<input checked="" type="checkbox"/>
ksecRANKLbyObmPTH			$10^{-6}$		<input checked="" type="checkbox"/>
ksecRANKLbyObp			$3 \cdot 10^{-6}$		<input checked="" type="checkbox"/>
ksecRANKLbyObpPTH			$2 \cdot 10^{-5}$		<input checked="" type="checkbox"/>
ksecRANKLbyObpro			$7 \cdot 10^{-6}$		<input checked="" type="checkbox"/>
ksecRANKLbyObpTgfb			$4 \cdot 10^{-6}$		<input checked="" type="checkbox"/>
ksecRANKLbyOcy			$10^{-6}$		<input checked="" type="checkbox"/>
ksecRANKLbyOcyI			$10^{-7}$		<input checked="" type="checkbox"/>
ksecSost			$7.5 \cdot 10^{-4}$		<input checked="" type="checkbox"/>
ksecTgfb			$5 \cdot 10^{-5}$		<input checked="" type="checkbox"/>
ksynBcl2			0.005		<input checked="" type="checkbox"/>
ksynPTH			0.020		<input checked="" type="checkbox"/>
ksynRunx2			0.005		<input checked="" type="checkbox"/>
ksynX			0.012		<input checked="" type="checkbox"/>
kunload			$3.5 \cdot 10^{-4}$		<input checked="" type="checkbox"/>

## 6 Events

This is an overview of four events. Each event is initiated whenever its trigger condition switches from false to true. A delay function postpones the effects of an event to a later time point. At the time of execution, an event can assign values to species, parameters or compartments if

these are not set to constant.

### 6.1 Event `AddLOAD1`

**Trigger condition**  $X > 300$  (1)

**Assignment**  $[LOAD] = 1$  (2)

### 6.2 Event `AddLOAD2`

**Trigger condition**  $X > 600$  (3)

**Assignment**  $[LOAD] = 1$  (4)

### 6.3 Event `AddPTH1`

**Trigger condition**  $X > 625$  (5)

**Assignment**  $[PTH] = 150$  (6)

### 6.4 Event `AddPTH2`

**Trigger condition**  $X > 1000$  (7)

**Assignments**  
 $[PTH] = 170$  (8)  
 $[X] = 0$  (9)



## 7 Reactions

This model contains 76 reactions. All reactions are listed in the following table and are subsequently described in detail. If a reaction is affected by a modifier, the identifier of this species is written above the reaction arrow.

Table 5: Overview of all reactions

Nº	Id	Name	Reaction Equation	SBO
1	Unloading		$\text{LOAD} \xrightarrow{\text{LOAD}} \text{Sink}$	
2	Osteocyte- _activation		$\text{Ocy\_I} + \text{LOAD} \xrightarrow{\text{Ocy\_I, LOAD}} \text{Ocy\_A} + \text{LOAD}$	
3	Osteocyte- _activation.by- _PTH		$\text{Ocy\_I\_PTH} \xrightarrow{\text{Ocy\_I\_PTH}} \text{Ocy\_A} + \text{PTH}$	
4	Osteocyte- _inactivation		$\text{Ocy\_A} \xrightarrow{\text{Ocy\_A}} \text{Ocy\_I}$	
5	Ocy\_I\_bound.by- _PTH		$\text{Ocy\_I} + \text{PTH} \xrightarrow{\text{Ocy\_I, PTH}} \text{Ocy\_I\_PTH}$	
6	Ocy\_I\_PTH- _release		$\text{Ocy\_I\_PTH} \xrightarrow{\text{Ocy\_I\_PTH}} \text{Ocy\_I} + \text{PTH}$	
7	Ocy\_apoptosis		$\text{Ocy\_I} \xrightarrow{\text{Ocy\_I}} \text{Sink}$	
8	Sost\_secretion		$\text{Ocy\_I} \xrightarrow{\text{Ocy\_I}} \text{Ocy\_I} + \text{Sost}$	
9	Sost- _degradation		$\text{Sost} \xrightarrow{\text{Sost}} \text{Sink}$	
10	Wnt\_activation		$\text{Wnt\_I} \xrightarrow{\text{Wnt\_I}} \text{Wnt\_A}$	

Nº	Id	Name	Reaction Equation	SBO
11	Wnt_activation- _by_PTH		$\text{Wnt\_I} + \text{Ob\_m\_PTH} \xrightarrow{\text{Wnt\_I, Ob\_m\_PTH}} \text{Wnt\_A} + \text{Ob\_m\_PTH}$	
12	Inactivation- _of_Wnt_by_Sost		$\text{Wnt\_A} + \text{Sost} \xrightarrow{\text{Wnt\_A, Sost}} \text{Wnt\_I} + \text{Sost}$	
13	MSC- _differentiation- _to_Ob_pro		$\text{MSC} + \text{Wnt\_A} \xrightarrow{\text{MSC, Wnt\_A}} \text{MSC} + \text{Wnt\_A} + \text{Ob\_pro}$	
14	Osteoblast- _progenitor- _differentiation- _by_Tgfb		$\text{Ob\_pro} + \text{Tgfb\_A} \xrightarrow{\text{Ob\_pro, Tgfb\_A}} \text{Ob\_p} + \text{Tgfb\_A}$	
15	Ob_precursor- _differentiation		$\text{Ob\_p} \xrightarrow{\text{Ob\_p}} \text{Ob\_m}$	
16	Ob_p_binding- _by_PTH		$\text{Ob\_p} + \text{PTH} \xrightarrow{\text{Ob\_p, PTH}} \text{Ob\_p\_PTH}$	
17	Ob_p_PTH- _release		$\text{Ob\_p\_PTH} \xrightarrow{\text{Ob\_p\_PTH}} \text{Ob\_p} + \text{PTH}$	
18	Ob_p_Tgfb- _binding		$\text{Ob\_p} + \text{Tgfb\_A} \xrightarrow{\text{Ob\_p, Tgfb\_A}} \text{Ob\_p\_Tgfb\_A}$	
19	Ob_p_Tgfb- _release		$\text{Ob\_p\_Tgfb\_A} \xrightarrow{\text{Ob\_p\_Tgfb\_A}} \text{Ob\_p} + \text{Tgfb\_A}$	
20	Ob_maturation- _to_Ocy		$\text{Ob\_m} \xrightarrow{\text{Ob\_m}} \text{Ocy\_I}$	

Nº	Id	Name	Reaction Equation	SBO
21	Ob_maturation- _to_Ocy_by_Tgfb		$\text{Ob\_m} + \text{Tgfb\_A} \xrightarrow{\text{Ob\_m, Tgfb\_A}} \text{Ocy\_I} + \text{Tgfb\_A}$	
22	Ob_m_bound_by- _PTH		$\text{Ob\_m} + \text{PTH} \xrightarrow{\text{Ob\_m, PTH}} \text{Ob\_m\_PTH}$	
23	Ob_m_PTH- _release		$\text{Ob\_m\_PTH} \xrightarrow{\text{Ob\_m\_PTH}} \text{Ob\_m} + \text{PTH}$	
24	Ob_m_apoptosis		$\text{Ob\_m} + \text{Bax} \xrightarrow{\text{Ob\_m, Bax}} \text{Bax}$	
25	Ob_m_PTH- _apoptosis		$\text{Ob\_m\_PTH} + \text{Bax} \xrightarrow{\text{Ob\_m\_PTH, Bax}} \text{Bax} + \text{PTH}$	
26	HSC- _differentiation- _to_Ocl_p		$\text{HSC} + \text{MCSF} \xrightarrow{\text{HSC, MCSF}} \text{HSC} + \text{MCSF} + \text{Ocl\_p}$	
27	Ocl_p_apoptosis		$\text{Ocl\_p} \xrightarrow{\text{Ocl\_p}} \text{Sink}$	
28	Ocl_p_RANKL- _binding		$\text{RANKL} + \text{Ocl\_p} \xrightarrow{\text{Ocl\_p, RANKL}} \text{Ocl\_p\_RANKL}$	
29	Ocl_p_RANKL- _release		$\text{Ocl\_p\_RANKL} \xrightarrow{\text{Ocl\_p\_RANKL}} \text{Ocl\_p} + \text{RANKL}$	
30	Osteoclast- _precursor- _differentiation		$\text{Ocl\_p\_RANKL} \xrightarrow{\text{Ocl\_p\_RANKL}} \text{Ocl\_m}$	
31	RANKL- _inhibition		$\text{OPG} + \text{RANKL} \xrightarrow{\text{OPG, RANKL}} \text{OPG\_RANKL}$	
32	OPG_RANKL- _dissociation		$\text{OPG\_RANKL} \xrightarrow{\text{OPG\_RANKL}} \text{OPG} + \text{RANKL}$	

Nº	Id	Name	Reaction Equation	SBO
33	OPG_RANKL- _degradation		$\text{OPG\_RANKL} \xrightarrow{\text{OPG\_RANKL}} \text{Sink}$	
34	Osteoclast- _apoptosis		$\text{Ocl\_m} \xrightarrow{\text{Ocl\_m}} \text{Sink}$	
35	RANKL- _degradation		$\text{RANKL} \xrightarrow{\text{RANKL}} \text{Sink}$	
36	OPG_degradation		$\text{OPG} \xrightarrow{\text{OPG}} \text{Sink}$	
37	MCSF_secretion- _by_MSC		$\text{MSC} \xrightarrow{\text{MSC}} \text{MSC} + \text{MCSF}$	
38	MCSF_secretion- _by_Ob_pro		$\text{Ob\_pro} \xrightarrow{\text{Ob\_pro}} \text{Ob\_pro} + \text{MCSF}$	
39	MCSF_secretion- _by_Ob_p		$\text{Ob\_p} \xrightarrow{\text{Ob\_p}} \text{Ob\_p} + \text{MCSF}$	
40	MCSF_secretion- _by_Ob_p_PTH		$\text{Ob\_p\_PTH} \xrightarrow{\text{Ob\_p\_PTH}} \text{Ob\_p\_PTH} + \text{MCSF}$	
41	MCSF_secretion- _by_Ob_m		$\text{Ob\_m} \xrightarrow{\text{Ob\_m}} \text{Ob\_m} + \text{MCSF}$	
42	MCSF_secretion- _by_Ob_m_PTH		$\text{Ob\_m\_PTH} \xrightarrow{\text{Ob\_m\_PTH}} \text{Ob\_m\_PTH} + \text{MCSF}$	
43	MCSF- _degradation		$\text{MCSF} \xrightarrow{\text{MCSF}} \text{Sink}$	
44	OPG_secretion- _by_Ob_p		$\text{Ob\_p} \xrightarrow{\text{Ob\_p}} \text{Ob\_p} + \text{OPG}$	

Nº	Id	Name	Reaction Equation	SBO
45	OPG_secretion- _by_Ob_p_PTH		$\text{Ob\_p\_PTH} \xrightarrow{\text{Ob\_p\_PTH}} \text{Ob\_p\_PTH} + \text{OPG}$	
46	OPG_secretion- _by_Ob_m		$\text{Ob\_m} \xrightarrow{\text{Ob\_m}} \text{Ob\_m} + \text{OPG}$	
47	RANKL- _secretion- _by_Ocy_A		$\text{Ocy\_A} \xrightarrow{\text{Ocy\_A}} \text{Ocy\_A} + \text{RANKL}$	
48	RANKL- _secretion- _by_Ocy_I		$\text{Ocy\_I} \xrightarrow{\text{Ocy\_I}} \text{Ocy\_I} + \text{RANKL}$	
49	RANKL- _secretion- _by_MSCs		$\text{MSC} \xrightarrow{\text{MSC}} \text{MSC} + \text{RANKL}$	
50	RANKL- _secretion- _by_Ob_p		$\text{Ob\_p} \xrightarrow{\text{Ob\_p}} \text{Ob\_p} + \text{RANKL}$	
51	RANKL- _secretion- _by_Ob_p_Tgfb_A		$\text{Ob\_p\_Tgfb\_A} \xrightarrow{\text{Ob\_p\_Tgfb\_A}} \text{Ob\_p\_Tgfb\_A} + \text{RANKL}$	
52	RANKL- _secretion- _by_Ob_p_PTH		$\text{Ob\_p\_PTH} \xrightarrow{\text{Ob\_p\_PTH}} \text{Ob\_p\_PTH} + \text{RANKL}$	
53	RANKL- _secretion- _by_Ob_pro		$\text{Ob\_pro} \xrightarrow{\text{Ob\_pro}} \text{Ob\_pro} + \text{RANKL}$	

Nº	Id	Name	Reaction Equation	SBO
54	RANKL- _secretion- _by_Ob_m		$Ob\_m \xrightarrow{Ob\_m} Ob\_m + RANKL$	
55	RANKL- _secretion- _by_Ob_m_PTH- _enhanced		$Ob\_m\_PTH \xrightarrow{Ob\_m\_PTH} Ob\_m\_PTH + RANKL$	
56	Tgfb_secretion- _by_Obm		$Ob\_m \xrightarrow{Ob\_m} Ob\_m + Tgfb\_I$	
57	Tgfb_activation		$Tgfb\_I + Ocl\_m \xrightarrow{Tgfb\_I, Ocl\_m} Tgfb\_A + Ocl\_m$	
58	Tgfb- _degradation		$Tgfb\_A \xrightarrow{Tgfb\_A} Sink$	
59	Tgfb- _degradation- _by_PTH		$Tgfb\_A + Ob\_m\_PTH \xrightarrow{Tgfb\_A, Ob\_m\_PTH} Ob\_m\_PTH$	
60	PTH_production		$Source \xrightarrow{Source} PTH$	
61	PTH_degradation		$PTH \xrightarrow{PTH} Sink$	
62	CREB_activation		$Ob\_m\_PTH + CREB \xrightarrow{CREB, Ob\_m\_PTH} Ob\_m\_PTH + CREB\_P$	
63	CREB- _inactivation		$CREB\_P \xrightarrow{CREB\_P} CREB$	
64	CREB_Runx2- _binding		$CREB\_P + Runx2 \xrightarrow{CREB\_P, Runx2} CREB\_Runx2$	

Nº	Id	Name	Reaction Equation	SBO
65	CREB_Runx2- _release		$\text{CREB\_Runx2} \xrightarrow{\text{CREB\_Runx2}} \text{CREB\_P} + \text{Runx2}$	
66	Bcl2_synthesis		$\text{CREB\_Runx2} \xrightarrow{\text{CREB\_Runx2}} \text{CREB\_Runx2} + \text{Bcl2}$	
67	Bcl2- _degradation		$\text{Bcl2} \xrightarrow{\text{Bcl2}} \text{Sink}$	
68	Bax_Bcl2- _binding		$\text{Bax} + \text{Bcl2} \xrightarrow{\text{Bax, Bcl2}} \text{Bax\_Bcl2}$	
69	Bax_Bcl2- _release		$\text{Bax\_Bcl2} \xrightarrow{\text{Bax\_Bcl2}} \text{Bax} + \text{Bcl2}$	
70	Runx2_synthesis		$\text{Source} \xrightarrow{\text{Source}} \text{Runx2}$	
71	Runx2- _degradation- _via_PTH		$\text{Ob\_m\_PTH} + \text{Runx2} \xrightarrow{\text{Runx2, Ob\_m\_PTH}} \text{Ob\_m\_PTH}$	
72	Runx2- _degradation		$\text{Runx2} \xrightarrow{\text{Runx2}} \text{Sink}$	
73	Bone_formation		$\text{Ob\_m} \xrightarrow{\text{Ob\_m}} \text{Ob\_m} + \text{Bone} + \text{newbone}$	
74	Bone_formation- _Obm_PTH		$\text{Ob\_m\_PTH} \xrightarrow{\text{Ob\_m\_PTH}} \text{Ob\_m\_PTH} + \text{Bone} + \text{newbone}$	
75	Bone- _degradation		$\text{Ocl\_m} + \text{Bone} \xrightarrow{\text{Ocl\_m, Bone}} \text{Ocl\_m}$	
76	Xsynthesis		$\text{Source} \xrightarrow{\text{Source}} \text{X}$	

## 7.1 Reaction Unloading

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

### Reaction equation



### Reactant

Table 6: Properties of each reactant.

Id	Name	SBO
LOAD		

### Modifier

Table 7: Properties of each modifier.

Id	Name	SBO
LOAD		

### Product

Table 8: Properties of each product.

Id	Name	SBO
Sink		

### Kinetic Law

**Derived unit** contains undeclared units

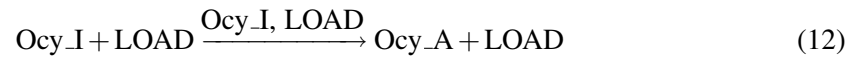
$$v_1 = k_{\text{unload}} \cdot \text{LOAD} \quad (11)$$

## 7.2 Reaction Osteocyte\_activation

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



## Reaction equation



## Reactants

Table 9: Properties of each reactant.

Id	Name	SBO
Ocy_I		
LOAD		

## Modifiers

Table 10: Properties of each modifier.

Id	Name	SBO
Ocy_I		
LOAD		

## Products

Table 11: Properties of each product.

Id	Name	SBO
Ocy_A		
LOAD		

## Kinetic Law

**Derived unit** contains undeclared units

$$v_2 = k_{actOcy} \cdot \text{Ocy\_I} \cdot \text{LOAD} \quad (13)$$

### 7.3 Reaction `Osteocyte_activation_by_PTH`

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

## Reaction equation



## Reactant

Table 12: Properties of each reactant.

Id	Name	SBO
Ocy_I_PTH		

## Modifier

Table 13: Properties of each modifier.

Id	Name	SBO
Ocy_I_PTH		

## Products

Table 14: Properties of each product.

Id	Name	SBO
Ocy_A		
PTH		

## Kinetic Law

**Derived unit** contains undeclared units

$$v_3 = kactOcyPth \cdot Ocy\_I\_PTH \quad (15)$$

### 7.4 Reaction `Osteocyte_inactivation`

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

#### Reaction equation



## Reactant

Table 15: Properties of each reactant.

Id	Name	SBO
Ocy_A		

## Modifier

Table 16: Properties of each modifier.

Id	Name	SBO
Ocy_A		

## Product

Table 17: Properties of each product.

Id	Name	SBO
Ocy_I		

## Kinetic Law

**Derived unit** contains undeclared units

$$v_4 = \text{kinactOcy} \cdot \text{Ocy\_A} \quad (17)$$

## 7.5 Reaction Ocy\_I\_bound\_by\_PTH

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

### Reaction equation



## Reactants

Table 18: Properties of each reactant.

Id	Name	SBO
Ocy_I		
PTH		

## Modifiers

Table 19: Properties of each modifier.

Id	Name	SBO
Ocy_I		
PTH		

## Product

Table 20: Properties of each product.

Id	Name	SBO
Ocy_I_PTH		

## Kinetic Law

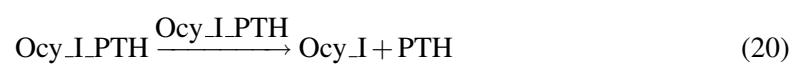
**Derived unit** contains undeclared units

$$v_5 = k_{\text{binOcyPTH}} \cdot \text{Ocy\_I} \cdot \frac{\text{PTH}^2}{100^2 + \text{PTH}^2} \quad (19)$$

### 7.6 Reaction `Ocy_I_PTH_release`

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

#### Reaction equation



## Reactant

Table 21: Properties of each reactant.

Id	Name	SBO
Ocy_I_PTH		

## Modifier

Table 22: Properties of each modifier.

Id	Name	SBO
Ocy_I_PTH		

## Products

Table 23: Properties of each product.

Id	Name	SBO
Ocy_I_PTH		

## Kinetic Law

**Derived unit** contains undeclared units

$$v_6 = krelOcyPTH \cdot Ocy\_I\_PTH \quad (21)$$

## 7.7 Reaction Ocy\_apoptosis

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

### Reaction equation



## Reactant

Table 24: Properties of each reactant.

Id	Name	SBO
Ocy_I		

## Modifier

Table 25: Properties of each modifier.

Id	Name	SBO
Ocy_I		

## Product

Table 26: Properties of each product.

Id	Name	SBO
Sink		

## Kinetic Law

**Derived unit** contains undeclared units

$$v_7 = k_{\text{deathOcy}} \cdot \text{Ocy\_I} \quad (23)$$

## 7.8 Reaction `Sost_secretion`

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

### Reaction equation



## Reactant

Table 27: Properties of each reactant.

Id	Name	SBO
Ocy_I		

## Modifier

Table 28: Properties of each modifier.

Id	Name	SBO
Ocy_I		

## Products

Table 29: Properties of each product.

Id	Name	SBO
Ocy_I		

Id	Name	SBO
Sost		

### Kinetic Law

**Derived unit** contains undeclared units

$$v_8 = ksecSost \cdot Ocy.I \quad (25)$$

## 7.9 Reaction Sost\_degradation

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

### Reaction equation



### Reactant

Table 30: Properties of each reactant.

Id	Name	SBO
Sost		

### Modifier

Table 31: Properties of each modifier.

Id	Name	SBO
Sost		

### Product

Table 32: Properties of each product.

Id	Name	SBO
Sink		

### Kinetic Law

**Derived unit** contains undeclared units

$$v_9 = kdegSost \cdot Sost \quad (27)$$

### 7.10 Reaction `Wnt_activation`

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

#### Reaction equation



#### Reactant

Table 33: Properties of each reactant.

Id	Name	SBO
<code>Wnt_I</code>		

#### Modifier

Table 34: Properties of each modifier.

Id	Name	SBO
<code>Wnt_I</code>		

#### Product

Table 35: Properties of each product.

Id	Name	SBO
<code>Wnt_A</code>		

#### Kinetic Law

**Derived unit** contains undeclared units

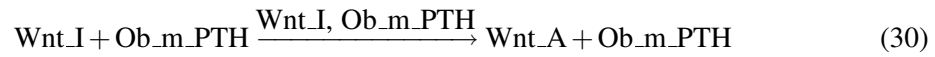
$$v_{10} = kactWnt \cdot Wnt\_I \quad (29)$$

### 7.11 Reaction `Wnt_activation_by_PTH`

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



### Reaction equation



### Reactants

Table 36: Properties of each reactant.

Id	Name	SBO
Wnt_I		
Ob_m_PTH		

### Modifiers

Table 37: Properties of each modifier.

Id	Name	SBO
Wnt_I		
Ob_m_PTH		

### Products

Table 38: Properties of each product.

Id	Name	SBO
Wnt_A		
Ob_m_PTH		

### Kinetic Law

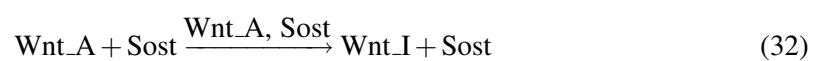
**Derived unit** contains undeclared units

$$v_{11} = k_{act} \text{WntPth} \cdot \text{Wnt\_I} \cdot \text{Ob\_m\_PTH} \quad (31)$$

## 7.12 Reaction *Inactivation\_of\_Wnt\_by\_Sost*

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

### Reaction equation



## Reactants

Table 39: Properties of each reactant.

Id	Name	SBO
Wnt_A		
Sost		

## Modifiers

Table 40: Properties of each modifier.

Id	Name	SBO
Wnt_A		
Sost		

## Products

Table 41: Properties of each product.

Id	Name	SBO
Wnt_I		
Sost		

## Kinetic Law

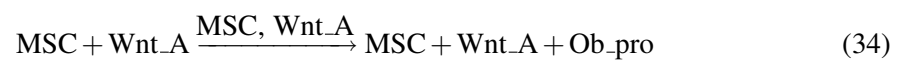
**Derived unit** contains undeclared units

$$v_{12} = \frac{\text{kinactWnt} \cdot \text{Wnt\_A} \cdot \text{Sost}^2}{50^2 + \text{Sost}^2} \quad (33)$$

### 7.13 Reaction `MSC_differentiation_to_Ob_pro`

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

#### Reaction equation



## Reactants

Table 42: Properties of each reactant.

Id	Name	SBO
MSC		
Wnt_A		

## Modifiers

Table 43: Properties of each modifier.

Id	Name	SBO
MSC		
Wnt_A		

## Products

Table 44: Properties of each product.

Id	Name	SBO
MSC		
Wnt_A		
Ob_pro		

## Kinetic Law

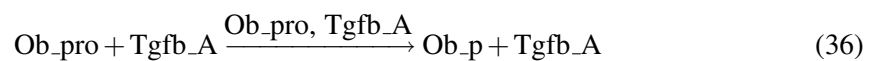
**Derived unit** contains undeclared units

$$v_{13} = \frac{\text{kdiffMSC} \cdot \text{MSC} \cdot \text{Wnt\_A}^2}{50^2 + \text{Wnt\_A}^2} \quad (35)$$

### 7.14 Reaction *Osteoblast progenitor differentiation by Tgfb*

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

#### Reaction equation



## Reactants

Table 45: Properties of each reactant.

Id	Name	SBO
Ob_pro		
Tgfb_A		

## Modifiers

Table 46: Properties of each modifier.

Id	Name	SBO
Ob_pro		
Tgfb_A		

## Products

Table 47: Properties of each product.

Id	Name	SBO
Ob_p		
Tgfb_A		

## Kinetic Law

**Derived unit** contains undeclared units

$$v_{14} = \frac{k_{\text{diffObproTgfb}} \cdot \text{Ob\_pro} \cdot \text{Tgfb\_A}^2}{50^2 + \text{Tgfb\_A}^2} \quad (37)$$

### 7.15 Reaction Ob\_precursor\_differentiation

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

#### Reaction equation



## Reactant

Table 48: Properties of each reactant.

Id	Name	SBO
Ob_p		

## Modifier

Table 49: Properties of each modifier.

Id	Name	SBO
Ob_p		

## Product

Table 50: Properties of each product.

Id	Name	SBO
Ob_m		

## Kinetic Law

**Derived unit** contains undeclared units

$$v_{15} = k_{\text{diffObP}} \cdot \text{Ob\_p} \quad (39)$$

### 7.16 Reaction Ob\_p\_binding\_by\_PTH

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

#### Reaction equation



## Reactants

Table 51: Properties of each reactant.

Id	Name	SBO
Ob_p		
PTH		

## Modifiers

Table 52: Properties of each modifier.

Id	Name	SBO
Ob_p		
PTH		

## Product

Table 53: Properties of each product.

Id	Name	SBO
Ob_p_PTH		

## Kinetic Law

**Derived unit** contains undeclared units

$$v_{16} = k_{\text{binObpPTH}} \cdot \text{Ob\_p} \cdot \frac{\text{PTH}^2}{100^2 + \text{PTH}^2} \quad (41)$$

### 7.17 Reaction Ob\_p\_PTH\_release

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

#### Reaction equation



## Reactant

Table 54: Properties of each reactant.

Id	Name	SBO
Ob_p_PTH		

## Modifier

Table 55: Properties of each modifier.

Id	Name	SBO
Ob_p_PTH		

## Products

Table 56: Properties of each product.

Id	Name	SBO
Ob_p_PTH		

## Kinetic Law

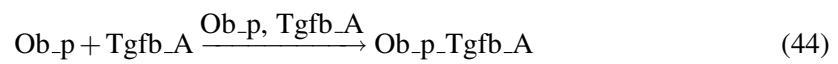
**Derived unit** contains undeclared units

$$v_{17} = k_{relObpPTH} \cdot Ob\_p\_PTH \quad (43)$$

### 7.18 Reaction Ob\_p\_Tgfb\_binding

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

#### Reaction equation



## Reactants

Table 57: Properties of each reactant.

Id	Name	SBO
Ob_p		
Tgfb_A		

## Modifiers

Table 58: Properties of each modifier.

Id	Name	SBO
Ob_p		

Id	Name	SBO
Tgfb_A		

## Product

Table 59: Properties of each product.

Id	Name	SBO
Ob_p_Tgfb_A		

## Kinetic Law

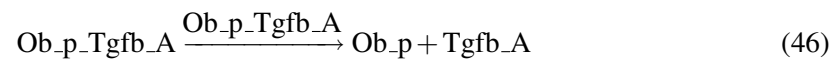
**Derived unit** contains undeclared units

$$v_{18} = k_{\text{binObpTgfb}} \cdot \text{Ob\_p} \cdot \text{Tgfb\_A} \quad (45)$$

## 7.19 Reaction Ob\_p\_Tgfb\_release

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

## Reaction equation



## Reactant

Table 60: Properties of each reactant.

Id	Name	SBO
Ob_p_Tgfb_A		

## Modifier

Table 61: Properties of each modifier.

Id	Name	SBO
Ob_p_Tgfb_A		

## Products



Table 62: Properties of each product.

Id	Name	SBO
Ob_p		
Tgfb_A		

### Kinetic Law

**Derived unit** contains undeclared units

$$v_{19} = k_{relObpTgfb} \cdot Ob\_p\_Tgfb\_A \quad (47)$$

## 7.20 Reaction Ob\_maturation\_to\_Ocy

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

### Reaction equation



### Reactant

Table 63: Properties of each reactant.

Id	Name	SBO
Ob_m		

### Modifier

Table 64: Properties of each modifier.

Id	Name	SBO
Ob_m		

### Product

Table 65: Properties of each product.

Id	Name	SBO
Ocy_I		

## Kinetic Law

**Derived unit** contains undeclared units

$$v_{20} = kmatOb \cdot Ob\_m \quad (49)$$

### 7.21 Reaction `Ob_maturation_to_Ocy_by_Tgfb`

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

#### Reaction equation



#### Reactants

Table 66: Properties of each reactant.

Id	Name	SBO
Ob_m		
Tgfb_A		

#### Modifiers

Table 67: Properties of each modifier.

Id	Name	SBO
Ob_m		
Tgfb_A		

#### Products

Table 68: Properties of each product.

Id	Name	SBO
Ocy_I		
Tgfb_A		

## Kinetic Law

**Derived unit** contains undeclared units

$$v_{21} = \frac{k_{\text{matObTgfb}} \cdot \text{Ob\_m} \cdot \text{Tgfb\_A}^2}{50^2 + \text{Tgfb\_A}^2} \quad (51)$$

## 7.22 Reaction Ob\_m\_bound\_by\_PTH

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

### Reaction equation



### Reactants

Table 69: Properties of each reactant.

Id	Name	SBO
Ob_m		
PTH		

### Modifiers

Table 70: Properties of each modifier.

Id	Name	SBO
Ob_m		
PTH		

### Product

Table 71: Properties of each product.

Id	Name	SBO
Ob_m_PTH		

## Kinetic Law

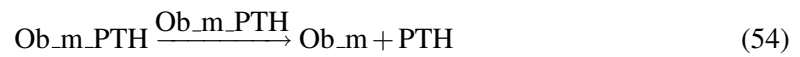
**Derived unit** contains undeclared units

$$v_{22} = k_{binObmPTH} \cdot Ob\_m \cdot \frac{PTH^2}{100^2 + PTH^2} \quad (53)$$

### 7.23 Reaction `Ob_m_PTH_release`

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

#### Reaction equation



#### Reactant

Table 72: Properties of each reactant.

Id	Name	SBO
<code>Ob_m_PTH</code>		

#### Modifier

Table 73: Properties of each modifier.

Id	Name	SBO
<code>Ob_m_PTH</code>		

#### Products

Table 74: Properties of each product.

Id	Name	SBO
<code>Ob_m</code>		
<code>PTH</code>		

#### Kinetic Law

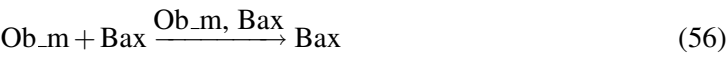
**Derived unit** contains undeclared units

$$v_{23} = k_{relObmPTH} \cdot Ob\_m\_PTH \quad (55)$$

### 7.24 Reaction `Ob_m_apoptosis`

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

Reaction equation



Reactants

Table 75: Properties of each reactant.

Id	Name	SBO
Ob_m		
Bax		

Modifiers

Table 76: Properties of each modifier.

Id	Name	SBO
Ob_m		
Bax		

Product

Table 77: Properties of each product.

Id	Name	SBO
Bax		

Kinetic Law

**Derived unit** contains undeclared units

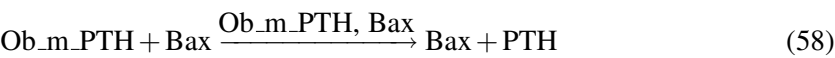
$$v_{24} = \frac{k_{deathOb} \cdot \text{Ob\_m} \cdot \text{Bax}^2}{50^2 + \text{Bax}^2}$$

(57)

7.25 Reaction Ob\_m\_PTH\_apoptosis

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

Reaction equation



## Reactants

Table 78: Properties of each reactant.

Id	Name	SBO
Ob_m_PTH		
Bax		

## Modifiers

Table 79: Properties of each modifier.

Id	Name	SBO
Ob_m_PTH		
Bax		

## Products

Table 80: Properties of each product.

Id	Name	SBO
Bax		
PTH		

## Kinetic Law

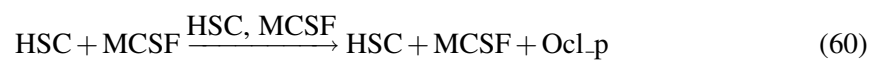
**Derived unit** contains undeclared units

$$v_{25} = \frac{k_{\text{deathOb}} \cdot \text{Ob\_m\_PTH} \cdot \text{Bax}^2}{50^2 + \text{Bax}^2} \quad (59)$$

### 7.26 Reaction [HSC\\_differentiation\\_to\\_Ocl\\_p](#)

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

#### Reaction equation



## Reactants

Table 81: Properties of each reactant.

Id	Name	SBO
HSC		
MCSF		

## Modifiers

Table 82: Properties of each modifier.

Id	Name	SBO
HSC		
MCSF		

## Products

Table 83: Properties of each product.

Id	Name	SBO
HSC		
MCSF		
Ocl_p		

## Kinetic Law

**Derived unit** contains undeclared units

$$v_{26} = \frac{k_{\text{diffHSC}} \cdot \text{HSC} \cdot \text{MCSF}^2}{50^2 + \text{MCSF}^2} \quad (61)$$

### 7.27 Reaction Ocl\_p\_apoptosis

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

#### Reaction equation



## Reactant

Table 84: Properties of each reactant.

Id	Name	SBO
Ocl_p		

## Modifier

Table 85: Properties of each modifier.

Id	Name	SBO
Ocl_p		

## Product

Table 86: Properties of each product.

Id	Name	SBO
Sink		

## Kinetic Law

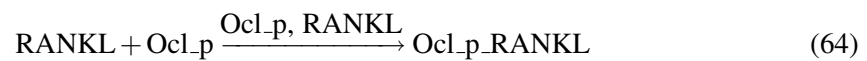
**Derived unit** contains undeclared units

$$v_{27} = k_{\text{deathOclp}} \cdot \text{Ocl\_p} \quad (63)$$

## 7.28 Reaction Ocl\_p\_RANKL\_binding

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

### Reaction equation



## Reactants

Table 87: Properties of each reactant.

Id	Name	SBO
RANKL		
Ocl_p		



## Modifiers

Table 88: Properties of each modifier.

Id	Name	SBO
Ocl_p		
RANKL		

## Product

Table 89: Properties of each product.

Id	Name	SBO
Ocl_p_RANKL		

## Kinetic Law

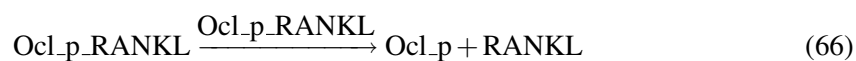
**Derived unit** contains undeclared units

$$v_{28} = k_{binOclpRANKL} \cdot Ocl\_p \cdot RANKL \quad (65)$$

### 7.29 Reaction Ocl\_p\_RANKL\_release

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

#### Reaction equation



## Reactant

Table 90: Properties of each reactant.

Id	Name	SBO
Ocl_p_RANKL		

## Modifier

Table 91: Properties of each modifier.

Id	Name	SBO
Ocl_p_RANKL		

## Products

Table 92: Properties of each product.

Id	Name	SBO
Ocl_p_RANKL		

## Kinetic Law

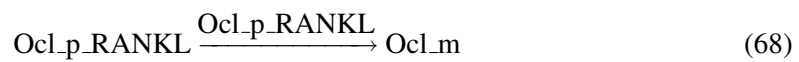
**Derived unit** contains undeclared units

$$v_{29} = k_{relOclpRANKL} \cdot Ocl\_p\_RANKL \quad (67)$$

### 7.30 Reaction `Osteoclast_precursor_differentiation`

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

## Reaction equation



## Reactant

Table 93: Properties of each reactant.

Id	Name	SBO
Ocl_p_RANKL		

## Modifier

Table 94: Properties of each modifier.

Id	Name	SBO
Ocl_p_RANKL		

## Product

Table 95: Properties of each product.

Id	Name	SBO
Ocl_m		

## Kinetic Law

**Derived unit** contains undeclared units

$$v_{30} = \text{kdiffOclP} \cdot \text{Ocl\_p\_RANKL} \quad (69)$$

### 7.31 Reaction RANKL\_inhibition

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

## Reaction equation



## Reactants

Table 96: Properties of each reactant.

Id	Name	SBO
OPG		
RANKL		

## Modifiers

Table 97: Properties of each modifier.

Id	Name	SBO
OPG		
RANKL		

## Product

Table 98: Properties of each product.

Id	Name	SBO
OPG_RANKL		

### Kinetic Law

**Derived unit** contains undeclared units

$$v_{31} = \text{kinhibRANKL} \cdot \text{OPG} \cdot \text{RANKL} \quad (71)$$

### 7.32 Reaction OPG\_RANKL\_dissociation

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

### Reaction equation



### Reactant

Table 99: Properties of each reactant.

Id	Name	SBO
OPG_RANKL		

### Modifier

Table 100: Properties of each modifier.

Id	Name	SBO
OPG_RANKL		

### Products

Table 101: Properties of each product.

Id	Name	SBO
OPG		
RANKL		

## Kinetic Law

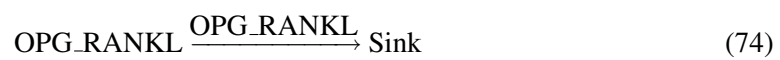
**Derived unit** contains undeclared units

$$v_{32} = k_{\text{reIRANKL}} \cdot \text{OPG\_RANKL} \quad (73)$$

### 7.33 Reaction OPG\_RANKL\_degradation

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

## Reaction equation



## Reactant

Table 102: Properties of each reactant.

Id	Name	SBO
OPG_RANKL		

## Modifier

Table 103: Properties of each modifier.

Id	Name	SBO
OPG_RANKL		

## Product

Table 104: Properties of each product.

Id	Name	SBO
Sink		

## Kinetic Law

**Derived unit** contains undeclared units

$$v_{33} = k_{\text{degOPGRANKL}} \cdot \text{OPG\_RANKL} \quad (75)$$

### 7.34 Reaction `Osteoclast_apoptosis`

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

#### Reaction equation



#### Reactant

Table 105: Properties of each reactant.

Id	Name	SBO
Ocl_m		

#### Modifier

Table 106: Properties of each modifier.

Id	Name	SBO
Ocl_m		

#### Product

Table 107: Properties of each product.

Id	Name	SBO
Sink		

#### Kinetic Law

**Derived unit** contains undeclared units

$$v_{34} = k_{\text{deathOcl}} \cdot \text{Ocl\_m} \quad (77)$$

### 7.35 Reaction `RANKL_degradation`

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

#### Reaction equation



## Reactant

Table 108: Properties of each reactant.

Id	Name	SBO
RANKL		

## Modifier

Table 109: Properties of each modifier.

Id	Name	SBO
RANKL		

## Product

Table 110: Properties of each product.

Id	Name	SBO
Sink		

## Kinetic Law

**Derived unit** contains undeclared units

$$v_{35} = k_{\text{degRANKL}} \cdot \text{RANKL} \quad (79)$$

### 7.36 Reaction `OPG_degradation`

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

#### Reaction equation



## Reactant

Table 111: Properties of each reactant.

Id	Name	SBO
OPG		

## Modifier

Table 112: Properties of each modifier.

Id	Name	SBO
OPG		

## Product

Table 113: Properties of each product.

Id	Name	SBO
Sink		

## Kinetic Law

**Derived unit** contains undeclared units

$$v_{36} = kdegOPG \cdot OPG \quad (81)$$

### 7.37 Reaction MCSF\_secretion\_by\_MSC

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

#### Reaction equation



## Reactant

Table 114: Properties of each reactant.

Id	Name	SBO
MSC		

## Modifier

Table 115: Properties of each modifier.

Id	Name	SBO
MSC		



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

## Products

Table 116: Properties of each product.

Id	Name	SBO
MSC		
MCSF		

## Kinetic Law

**Derived unit** contains undeclared units

$$v_{37} = k_{\text{secMCSFbyMSC}} \cdot \text{MSC} \quad (83)$$

### 7.38 Reaction MCSF\_secretion\_by\_Ob\_pro

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

## Reaction equation



## Reactant

Table 117: Properties of each reactant.

Id	Name	SBO
Ob_pro		

## Modifier

Table 118: Properties of each modifier.

Id	Name	SBO
Ob_pro		

## Products

Table 119: Properties of each product.

Id	Name	SBO
Ob_pro		
MCSF		

### Kinetic Law

**Derived unit** contains undeclared units

$$v_{38} = k_{\text{secMCSFbyObpro}} \cdot \text{Ob\_pro} \quad (85)$$

### 7.39 Reaction MCSF\_secretion\_by\_Ob\_p

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

### Reaction equation



### Reactant

Table 120: Properties of each reactant.

Id	Name	SBO
Ob_p		

### Modifier

Table 121: Properties of each modifier.

Id	Name	SBO
Ob_p		

### Products

Table 122: Properties of each product.

Id	Name	SBO
Ob_p		
MCSF		

## Kinetic Law

**Derived unit** contains undeclared units

$$v_{39} = k_{\text{secMCSFbyObp}} \cdot \text{Ob\_p} \quad (87)$$

## 7.40 Reaction MCSF\_secretion\_by\_Ob\_p\_PTH

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

### Reaction equation



### Reactant

Table 123: Properties of each reactant.

Id	Name	SBO
Ob_p_PTH		

### Modifier

Table 124: Properties of each modifier.

Id	Name	SBO
Ob_p_PTH		

### Products

Table 125: Properties of each product.

Id	Name	SBO
Ob_p_PTH		
MCSF		

## Kinetic Law

**Derived unit** contains undeclared units

$$v_{40} = k_{\text{secMCSFbyObp}} \cdot \text{Ob\_p\_PTH} \quad (89)$$

### 7.41 Reaction MCSF\_secretion\_by\_Ob\_m

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

#### Reaction equation



#### Reactant

Table 126: Properties of each reactant.

Id	Name	SBO
Ob_m		

#### Modifier

Table 127: Properties of each modifier.

Id	Name	SBO
Ob_m		

#### Products

Table 128: Properties of each product.

Id	Name	SBO
Ob_m		
MCSF		

#### Kinetic Law

**Derived unit** contains undeclared units

$$v_{41} = k_{\text{secMCSFbyObm}} \cdot \text{Ob\_m} \quad (91)$$

### 7.42 Reaction MCSF\_secretion\_by\_Ob\_m\_PTH

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

#### Reaction equation



## Reactant

Table 129: Properties of each reactant.

Id	Name	SBO
Ob_m_PTH		

## Modifier

Table 130: Properties of each modifier.

Id	Name	SBO
Ob_m_PTH		

## Products

Table 131: Properties of each product.

Id	Name	SBO
Ob_m_PTH		
MCSF		

## Kinetic Law

**Derived unit** contains undeclared units

$$v_{42} = k_{\text{secMCSFbyObm}} \cdot \text{Ob\_m\_PTH} \quad (93)$$

### 7.43 Reaction MCSF\_degradation

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

#### Reaction equation



## Reactant

Table 132: Properties of each reactant.

Id	Name	SBO
MCSF		

## Modifier

Table 133: Properties of each modifier.

Id	Name	SBO
MCSF		

## Product

Table 134: Properties of each product.

Id	Name	SBO
Sink		

## Kinetic Law

**Derived unit** contains undeclared units

$$v_{43} = kdegMCSF \cdot MCSF \quad (95)$$

## 7.44 Reaction [OPG\\_secretion\\_by\\_Ob\\_p](#)

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

### Reaction equation



## Reactant

Table 135: Properties of each reactant.

Id	Name	SBO
Ob_p		

## Modifier

Table 136: Properties of each modifier.

Id	Name	SBO
Ob_p		

## Products

Table 137: Properties of each product.

Id	Name	SBO
Ob_p		
OPG		

## Kinetic Law

**Derived unit** contains undeclared units

$$v_{44} = ksecOPGbyObp \cdot Ob\_p \quad (97)$$

### 7.45 Reaction OPG\_secretion\_by\_Ob\_p\_PTH

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

#### Reaction equation



## Reactant

Table 138: Properties of each reactant.

Id	Name	SBO
Ob_p_PTH		

## Modifier

Table 139: Properties of each modifier.

Id	Name	SBO
Ob_p_PTH		

## Products

Table 140: Properties of each product.

Id	Name	SBO
Ob_p_PTH		
OPG		

## Kinetic Law

**Derived unit** contains undeclared units

$$v_{45} = k_{\text{secOPGbyObpPTH}} \cdot \text{Ob\_p\_PTH} \quad (99)$$

## 7.46 Reaction OPG\_secretion\_by\_Ob\_m

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

### Reaction equation



## Reactant

Table 141: Properties of each reactant.

Id	Name	SBO
Ob_m		

## Modifier

Table 142: Properties of each modifier.

Id	Name	SBO
Ob_m		



## Products

Table 143: Properties of each product.

Id	Name	SBO
Ob_m		
OPG		

## Kinetic Law

**Derived unit** contains undeclared units

$$v_{46} = k_{\text{secOPGbyObm}} \cdot \text{Ob\_m} \quad (101)$$

## 7.47 Reaction RANKL\_secretion\_by\_Ocy\_A

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

### Reaction equation



## Reactant

Table 144: Properties of each reactant.

Id	Name	SBO
Ocy_A		

## Modifier

Table 145: Properties of each modifier.

Id	Name	SBO
Ocy_A		

## Products

Table 146: Properties of each product.

Id	Name	SBO
Ocy_A		
RANKL		

### Kinetic Law

**Derived unit** contains undeclared units

$$v_{47} = ksecRANKLbyOcy \cdot Ocy\_A \quad (103)$$

### 7.48 Reaction RANKL\_secretion\_by\_Ocy\_I

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

### Reaction equation



### Reactant

Table 147: Properties of each reactant.

Id	Name	SBO
Ocy_I		

### Modifier

Table 148: Properties of each modifier.

Id	Name	SBO
Ocy_I		

### Products

Table 149: Properties of each product.

Id	Name	SBO
Ocy_I		
RANKL		

## Kinetic Law

**Derived unit** contains undeclared units

$$v_{48} = k_{\text{secRANKLbyOcyI}} \cdot \text{OcyI} \quad (105)$$

## 7.49 Reaction RANKL\_secretion\_by\_MSCs

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

### Reaction equation



### Reactant

Table 150: Properties of each reactant.

Id	Name	SBO
MSC		

### Modifier

Table 151: Properties of each modifier.

Id	Name	SBO
MSC		

### Products

Table 152: Properties of each product.

Id	Name	SBO
MSC		
RANKL		

## Kinetic Law

**Derived unit** contains undeclared units

$$v_{49} = k_{\text{secRANKLbyMSC}} \cdot \text{MSC} \quad (107)$$

7.50 Reaction RANKL\_secretion\_by\_Ob\_p

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

Reaction equation



Reactant

Table 153: Properties of each reactant.

Id	Name	SBO
Ob_p		

Modifier

Table 154: Properties of each modifier.

Id	Name	SBO
Ob_p		

Products

Table 155: Properties of each product.

Id	Name	SBO
Ob_p		
RANKL		

Kinetic Law

Derived unit contains undeclared units

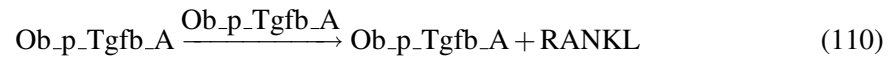
$$v_{50} = k_{\text{secRANKLbyObp}} \cdot \text{Ob\_p}$$

(109)

7.51 Reaction RANKL\_secretion\_by\_Ob\_p\_Tgfb\_A

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

### Reaction equation



### Reactant

Table 156: Properties of each reactant.

Id	Name	SBO
Ob_p_Tgfb_A		

### Modifier

Table 157: Properties of each modifier.

Id	Name	SBO
Ob_p_Tgfb_A		

### Products

Table 158: Properties of each product.

Id	Name	SBO
Ob_p_Tgfb_A		
RANKL		

### Kinetic Law

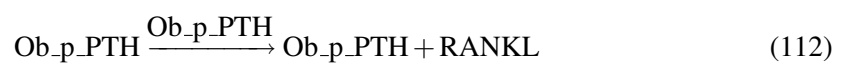
**Derived unit** contains undeclared units

$$v_{51} = k_{\text{secRANKLbyObpTgfb}} \cdot \text{Ob\_p\_Tgfb\_A} \quad (111)$$

## 7.52 Reaction RANKL\_secretion\_by\_Ob\_p\_PTH

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

### Reaction equation



### Reactant

Table 159: Properties of each reactant.

Id	Name	SBO
Ob_p_PTH		

## Modifier

Table 160: Properties of each modifier.

Id	Name	SBO
Ob_p_PTH		

## Products

Table 161: Properties of each product.

Id	Name	SBO
Ob_p_PTH		
RANKL		

## Kinetic Law

**Derived unit** contains undeclared units

$$v_{52} = k_{\text{secRANKLbyObpPTH}} \cdot \text{Ob\_p\_PTH} \quad (113)$$

### 7.53 Reaction `RANKL_secretion_by_Ob_pro`

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

## Reaction equation



## Reactant

Table 162: Properties of each reactant.

Id	Name	SBO
Ob_pro		

## Modifier

Table 163: Properties of each modifier.

Id	Name	SBO
Ob_pro		

## Products

Table 164: Properties of each product.

Id	Name	SBO
Ob_pro		
RANKL		

## Kinetic Law

**Derived unit** contains undeclared units

$$v_{53} = k_{\text{secRANKLbyObpro}} \cdot \text{Ob\_pro} \quad (115)$$

### 7.54 Reaction `RANKL_secretion_by_Ob_m`

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

#### Reaction equation



## Reactant

Table 165: Properties of each reactant.

Id	Name	SBO
Ob_m		

## Modifier

Table 166: Properties of each modifier.

Id	Name	SBO
Ob_m		

## Products

Table 167: Properties of each product.

Id	Name	SBO
Ob_m		
RANKL		

## Kinetic Law

**Derived unit** contains undeclared units

$$v_{54} = k_{\text{secRANKLbyObm}} \cdot \text{Ob\_m} \quad (117)$$

## 7.55 Reaction RANKL\_secretion\_by\_Ob\_m\_PTH\_enhanced

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

## Reaction equation



## Reactant

Table 168: Properties of each reactant.

Id	Name	SBO
Ob_m_PTH		

## Modifier

Table 169: Properties of each modifier.

Id	Name	SBO
Ob_m_PTH		



## Products

Table 170: Properties of each product.

Id	Name	SBO
Ob_m_PTH		
RANKL		

## Kinetic Law

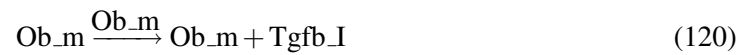
**Derived unit** contains undeclared units

$$v_{55} = k_{\text{secRANKLbyObmPTH}} \cdot \text{Ob\_m\_PTH} \quad (119)$$

## 7.56 Reaction [Tgfb\\_secretion\\_by\\_Obm](#)

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

## Reaction equation



## Reactant

Table 171: Properties of each reactant.

Id	Name	SBO
Ob_m		

## Modifier

Table 172: Properties of each modifier.

Id	Name	SBO
Ob_m		

## Products

Table 173: Properties of each product.

Id	Name	SBO
Ob_m		
Tgfb_I		

## Kinetic Law

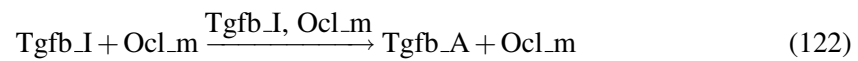
**Derived unit** contains undeclared units

$$v_{56} = k_{\text{secTgfb}} \cdot \text{Ob\_m} \quad (121)$$

## 7.57 Reaction Tgfb\_activation

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

## Reaction equation



## Reactants

Table 174: Properties of each reactant.

Id	Name	SBO
Tgfb_I		
Ocl_m		

## Modifiers

Table 175: Properties of each modifier.

Id	Name	SBO
Tgfb_I		
Ocl_m		

## Products

Table 176: Properties of each product.

Id	Name	SBO
Tgfb_A		
Ocl_m		

### Kinetic Law

**Derived unit** contains undeclared units

$$v_{57} = kactTgfb \cdot Tgfb\_I \cdot Ocl\_m \quad (123)$$

### 7.58 Reaction Tgfb\_degradation

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

### Reaction equation



### Reactant

Table 177: Properties of each reactant.

Id	Name	SBO
Tgfb_A		

### Modifier

Table 178: Properties of each modifier.

Id	Name	SBO
Tgfb_A		

### Product

Table 179: Properties of each product.

Id	Name	SBO
Sink		

## Kinetic Law

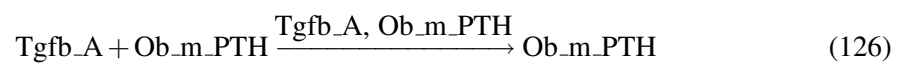
**Derived unit** contains undeclared units

$$v_{58} = kdegTgfb \cdot Tgfb\_A \quad (125)$$

## 7.59 Reaction `Tgfb_degradation_by_PTH`

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

### Reaction equation



### Reactants

Table 180: Properties of each reactant.

Id	Name	SBO
Tgfb_A		
Ob_m_PTH		

### Modifiers

Table 181: Properties of each modifier.

Id	Name	SBO
Tgfb_A		
Ob_m_PTH		

### Product

Table 182: Properties of each product.

Id	Name	SBO
Ob_m_PTH		

## Kinetic Law

**Derived unit** contains undeclared units

$$v_{59} = kdegTgfbPTH \cdot Tgfb\_A \cdot Ob\_m\_PTH \quad (127)$$

## 7.60 Reaction PTH<sub>production</sub>

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

### Reaction equation



### Reactant

Table 183: Properties of each reactant.

Id	Name	SBO
Source		

### Modifier

Table 184: Properties of each modifier.

Id	Name	SBO
Source		

### Product

Table 185: Properties of each product.

Id	Name	SBO
PTH		

### Kinetic Law

**Derived unit** contains undeclared units

$$v_{60} = k_{\text{synPTH}} \cdot \text{Source} \quad (129)$$

## 7.61 Reaction PTH<sub>degradation</sub>

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

### Reaction equation



## Reactant

Table 186: Properties of each reactant.

Id	Name	SBO
PTH		

## Modifier

Table 187: Properties of each modifier.

Id	Name	SBO
PTH		

## Product

Table 188: Properties of each product.

Id	Name	SBO
Sink		

## Kinetic Law

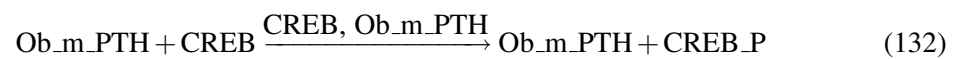
**Derived unit** contains undeclared units

$$v_{61} = k_{degPTH} \cdot PTH \quad (131)$$

### 7.62 Reaction CREB\_activation

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

#### Reaction equation



## Reactants

Table 189: Properties of each reactant.

Id	Name	SBO
Ob_m_PTH		
CREB		

## Modifiers

Table 190: Properties of each modifier.

Id	Name	SBO
CREB		
Ob_m_PTH		

## Products

Table 191: Properties of each product.

Id	Name	SBO
Ob_m_PTH		
CREB_P		

## Kinetic Law

**Derived unit** contains undeclared units

$$v_{62} = \frac{k_{actCreb} \cdot CREB \cdot Ob\_m\_PTH^2}{100^2 + Ob\_m\_PTH^2} \quad (133)$$

### 7.63 Reaction CREB\_inactivation

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

#### Reaction equation



#### Reactant

Table 192: Properties of each reactant.

Id	Name	SBO
CREB_P		

## Modifier

Table 193: Properties of each modifier.

Id	Name	SBO
CREB_P		

## Product

Table 194: Properties of each product.

Id	Name	SBO
CREB		

## Kinetic Law

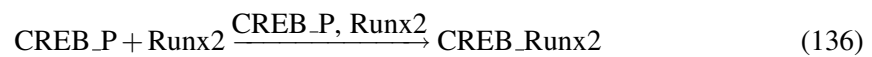
**Derived unit** contains undeclared units

$$v_{63} = \text{kinactCreb} \cdot \text{CREB\_P} \quad (135)$$

## 7.64 Reaction CREB\_Runx2\_binding

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

### Reaction equation



## Reactants

Table 195: Properties of each reactant.

Id	Name	SBO
CREB_P		
Runx2		



## Modifiers

Table 196: Properties of each modifier.

Id	Name	SBO
CREB_P		
Runx2		

## Product

Table 197: Properties of each product.

Id	Name	SBO
CREB_Runx2		

## Kinetic Law

**Derived unit** contains undeclared units

$$v_{64} = k_{\text{binCrebRunx2}} \cdot \text{CREB\_P} \cdot \text{Runx2} \quad (137)$$

### 7.65 Reaction CREB\_Runx2\_release

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

#### Reaction equation



## Reactant

Table 198: Properties of each reactant.

Id	Name	SBO
CREB_Runx2		

## Modifier

Table 199: Properties of each modifier.

Id	Name	SBO
CREB_Runx2		

## Products

Table 200: Properties of each product.

Id	Name	SBO
CREB_P Runx2		

## Kinetic Law

**Derived unit** contains undeclared units

$$v_{65} = krelCrebRunx2 \cdot CREB\_Runx2 \quad (139)$$

## 7.66 Reaction Bcl2\_synthesis

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

### Reaction equation



## Reactant

Table 201: Properties of each reactant.

Id	Name	SBO
CREB_Runx2		

## Modifier

Table 202: Properties of each modifier.

Id	Name	SBO
CREB_Runx2		

## Products

Table 203: Properties of each product.

Id	Name	SBO
CREB_Runx2		
Bcl2		

## Kinetic Law

**Derived unit** contains undeclared units

$$v_{66} = k_{\text{synBcl2}} \cdot \text{CREB\_Runx2} \quad (141)$$

### 7.67 Reaction Bcl2\_degradation

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

## Reaction equation



## Reactant

Table 204: Properties of each reactant.

Id	Name	SBO
Bcl2		

## Modifier

Table 205: Properties of each modifier.

Id	Name	SBO
Bcl2		

## Product

Table 206: Properties of each product.

Id	Name	SBO
Sink		

## Kinetic Law

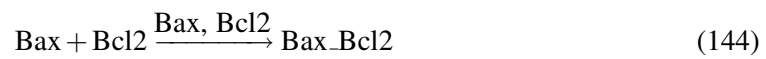
**Derived unit** contains undeclared units

$$v_{67} = kdegBcl2 \cdot Bcl2 \quad (143)$$

## 7.68 Reaction `Bax_Bcl2_binding`

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

## Reaction equation



## Reactants

Table 207: Properties of each reactant.

Id	Name	SBO
Bax		
Bcl2		

## Modifiers

Table 208: Properties of each modifier.

Id	Name	SBO
Bax		
Bcl2		

## Product

Table 209: Properties of each product.

Id	Name	SBO
Bax_Bcl2		

## Kinetic Law

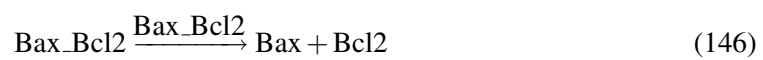
**Derived unit** contains undeclared units

$$v_{68} = k_{\text{binBaxBcl2}} \cdot \text{Bax} \cdot \text{Bcl2} \quad (145)$$

## 7.69 Reaction `Bax_Bcl2_release`

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

### Reaction equation



### Reactant

Table 210: Properties of each reactant.

Id	Name	SBO
<hr/>		
Bax_Bcl2		
<hr/>		

### Modifier

Table 211: Properties of each modifier.

Id	Name	SBO
<hr/>		
Bax_Bcl2		
<hr/>		

### Products

Table 212: Properties of each product.

Id	Name	SBO
<hr/>		
Bax		
Bcl2		
<hr/>		

## Kinetic Law

**Derived unit** contains undeclared units

$$v_{69} = k_{\text{relBaxBcl2}} \cdot \text{Bax\_Bcl2} \quad (147)$$

### 7.70 Reaction `Runx2_synthesis`

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

#### Reaction equation



#### Reactant

Table 213: Properties of each reactant.

Id	Name	SBO
Source		

#### Modifier

Table 214: Properties of each modifier.

Id	Name	SBO
Source		

#### Product

Table 215: Properties of each product.

Id	Name	SBO
Runx2		

#### Kinetic Law

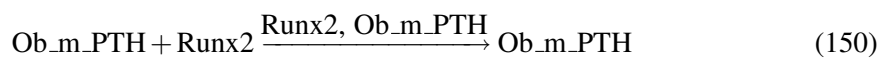
**Derived unit** contains undeclared units

$$v_{70} = \text{ksynRunx2} \cdot \text{Source} \quad (149)$$

### 7.71 Reaction `Runx2_degradation_via_PTH`

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

#### Reaction equation



## Reactants

Table 216: Properties of each reactant.

Id	Name	SBO
Ob_m_PTH		
Runx2		

## Modifiers

Table 217: Properties of each modifier.

Id	Name	SBO
Runx2		
Ob_m_PTH		

## Product

Table 218: Properties of each product.

Id	Name	SBO
Ob_m_PTH		

## Kinetic Law

**Derived unit** contains undeclared units

$$v_{71} = kdegRunx2PTH \cdot Runx2 \cdot Ob\_m\_PTH \quad (151)$$

### 7.72 Reaction `Runx2_degradation`

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

#### Reaction equation



## Reactant

Table 219: Properties of each reactant.

Id	Name	SBO
Runx2		

## Modifier

Table 220: Properties of each modifier.

Id	Name	SBO
Runx2		

## Product

Table 221: Properties of each product.

Id	Name	SBO
Sink		

## Kinetic Law

**Derived unit** contains undeclared units

$$v_{72} = kdegRunx2 \cdot Runx2 \quad (153)$$

### 7.73 Reaction Bone\_formation

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

#### Reaction equation



## Reactant

Table 222: Properties of each reactant.

Id	Name	SBO
Ob_m		



## Modifier

Table 223: Properties of each modifier.

Id	Name	SBO
Ob_m		

## Products

Table 224: Properties of each product.

Id	Name	SBO
Ob_m		
Bone		
newbone		

## Kinetic Law

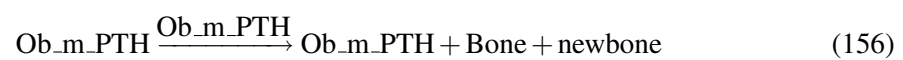
**Derived unit** contains undeclared units

$$v_{73} = k_{\text{formBone}} \cdot \text{Ob\_m} \quad (155)$$

### 7.74 Reaction `Bone_formation_Obm_PTH`

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

#### Reaction equation



## Reactant

Table 225: Properties of each reactant.

Id	Name	SBO
Ob_m_PTH		

## Modifier

Table 226: Properties of each modifier.

Id	Name	SBO
Ob_m_PTH		

## Products

Table 227: Properties of each product.

Id	Name	SBO
Ob_m_PTH		
Bone		
newbone		

## Kinetic Law

**Derived unit** contains undeclared units

$$v_{74} = k_{\text{formBone}} \cdot \text{Ob\_m\_PTH} \quad (157)$$

## 7.75 Reaction Bone\_degradation

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

### Reaction equation



## Reactants

Table 228: Properties of each reactant.

Id	Name	SBO
Ocl_m		
Bone		

## Modifiers

Table 229: Properties of each modifier.

Id	Name	SBO
Ocl_m		
Bone		

## Product

Table 230: Properties of each product.

Id	Name	SBO
Ocl_m		

## Kinetic Law

**Derived unit** contains undeclared units

$$v_{75} = kdegBone \cdot Ocl\_m \cdot Bone \quad (159)$$

## 7.76 Reaction X<sub>synthesis</sub>

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

## Reaction equation



## Reactant

Table 231: Properties of each reactant.

Id	Name	SBO
Source		

## Modifier

Table 232: Properties of each modifier.

Id	Name	SBO
Source		

## Product

Table 233: Properties of each product.

Id	Name	SBO
X		

## Kinetic Law

**Derived unit** contains undeclared units

$$v_{76} = k_{\text{synX}} \cdot \text{Source} \quad (161)$$

## 8 Derived Rate Equations

When interpreted as an ordinary differential equation framework, this model implies the following set of equations for the rates of change of each species.

Identifiers for kinetic laws highlighted in gray cannot be verified to evaluate to units of SBML substance per time. As a result, some SBML interpreters may not be able to verify the consistency of the units on quantities in the model. Please check if

- parameters without an unit definition are involved or
- volume correction is necessary because the `hasOnlySubstanceUnits` flag may be set to `false` and `spacialDimensions` > 0 for certain species.

### 8.1 Species Bone

**Initial amount** 2000 item

This species takes part in four reactions (as a reactant in [Bone\\_degradation](#) and as a product in [Bone\\_formation](#), [Bone\\_formation\\_Obm\\_PTH](#) and as a modifier in [Bone\\_degradation](#)).

$$\frac{d}{dt}\text{Bone} = v_{73} + v_{74} - v_{75} \quad (162)$$

### 8.2 Species HSC

**Initial amount** 100 item

This species takes part in three reactions (as a reactant in [HSC\\_differentiation\\_to\\_Ocl\\_p](#) and as a product in [HSC\\_differentiation\\_to\\_Ocl\\_p](#) and as a modifier in [HSC\\_differentiation\\_to\\_Ocl\\_p](#)).

$$\frac{d}{dt}\text{HSC} = v_{26} - v_{26} \quad (163)$$

### 8.3 Species Ob\_m

**Initial amount** 0 item

This species takes part in 25 reactions (as a reactant in [Ob\\_maturation\\_to\\_Ocy](#), [Ob\\_maturation\\_to\\_Ocy\\_by\\_Tgfb](#), [Ob\\_m\\_bound\\_by\\_PTH](#), [Ob\\_m\\_apoptosis](#), [MCSF\\_secretion\\_by\\_Ob\\_m](#), [OPG\\_secretion\\_by\\_Ob\\_m](#), [RANKL\\_secretion\\_by\\_Ob\\_m](#), [Tgfb\\_secretion\\_by\\_Obm](#), [Bone\\_formation](#) and as a product in [Ob\\_precursor\\_differentiation](#), [Ob\\_m\\_PTH\\_release](#), [MCSF\\_secretion\\_by\\_Ob\\_m](#), [OPG\\_secretion\\_by\\_Ob\\_m](#), [RANKL\\_secretion\\_by\\_Ob\\_m](#), [Tgfb\\_secretion\\_by\\_Obm](#), [Bone\\_formation](#) and as a modifier in [Ob\\_maturation\\_to\\_Ocy](#), [Ob\\_maturation\\_to\\_Ocy\\_by\\_Tgfb](#), [Ob\\_m\\_bound\\_by\\_PTH](#), [Ob\\_m\\_apoptosis](#), [MCSF\\_secretion\\_by\\_Ob\\_m](#), [OPG\\_secretion\\_by\\_Ob\\_m](#), [RANKL\\_secretion\\_by\\_Ob\\_m](#), [Tgfb\\_secretion\\_by\\_Obm](#), [Bone\\_formation](#)).

$$\frac{d}{dt}Ob\_m = v_{15} + v_{23} + v_{41} + v_{46} + v_{54} + v_{56} + v_{73} - v_{20} - v_{21} - v_{22} - v_{24} - v_{41} - v_{46} - v_{54} - v_{56} - v_{73} \quad (164)$$

### 8.4 Species Ob\_p

**Initial amount** 0 item

This species takes part in 18 reactions (as a reactant in [Ob\\_precursor\\_differentiation](#), [Ob\\_p\\_binding\\_by\\_PTH](#), [Ob\\_p\\_Tgfb\\_binding](#), [MCSF\\_secretion\\_by\\_Ob\\_p](#), [OPG\\_secretion\\_by\\_Ob\\_p](#), [RANKL\\_secretion\\_by\\_Ob\\_p](#) and as a product in [Osteoblast\\_progenitor\\_differentiation\\_by\\_Tgfb](#), [Ob\\_p\\_PTH\\_release](#), [Ob\\_p\\_Tgfb\\_release](#), [MCSF\\_secretion\\_by\\_Ob\\_p](#), [OPG\\_secretion\\_by\\_Ob\\_p](#), [RANKL\\_secretion\\_by\\_Ob\\_p](#) and as a modifier in [Ob\\_precursor\\_differentiation](#), [Ob\\_p\\_binding\\_by\\_PTH](#), [Ob\\_p\\_Tgfb\\_binding](#), [MCSF\\_secretion\\_by\\_Ob\\_p](#), [OPG\\_secretion\\_by\\_Ob\\_p](#), [RANKL\\_secretion\\_by\\_Ob\\_p](#)).

$$\frac{d}{dt}Ob\_p = v_{14} + v_{17} + v_{19} + v_{39} + v_{44} + v_{50} - v_{15} - v_{16} - v_{18} - v_{39} - v_{44} - v_{50} \quad (165)$$

### 8.5 Species Ob\_p\_Tgfb\_A

**Initial amount** 0 item

This species takes part in six reactions (as a reactant in [Ob\\_p\\_Tgfb\\_release](#), [RANKL\\_secretion\\_by\\_Ob\\_p\\_Tgfb\\_A](#) and as a product in [Ob\\_p\\_Tgfb\\_binding](#), [RANKL\\_secretion\\_by\\_Ob\\_p\\_Tgfb\\_A](#) and as a modifier in [Ob\\_p\\_Tgfb\\_release](#), [RANKL\\_secretion\\_by\\_Ob\\_p\\_Tgfb\\_A](#)).

$$\frac{d}{dt}Ob\_p\_Tgfb\_A = v_{18} + v_{51} - v_{19} - v_{51} \quad (166)$$

## 8.6 Species Ob\_pro

**Initial amount** 0 item

This species takes part in nine reactions (as a reactant in [Osteoblast\\_progenitor\\_differentiation\\_by\\_Tgfb](#), [MCSF\\_secretion\\_by\\_Ob\\_pro](#), [RANKL\\_secretion\\_by\\_Ob\\_pro](#) and as a product in [MSC\\_differentiation\\_to\\_Ob\\_pro](#), [MCSF\\_secretion\\_by\\_Ob\\_pro](#), [RANKL\\_secretion\\_by\\_Ob\\_pro](#) and as a modifier in [Osteoblast\\_progenitor\\_differentiation\\_by\\_Tgfb](#), [MCSF\\_secretion\\_by\\_Ob\\_pro](#), [RANKL\\_secretion\\_by\\_Ob\\_pro](#)).

$$\frac{d}{dt}\text{Ob\_pro} = v_{13} + v_{38} + v_{53} - v_{14} - v_{38} - v_{53} \quad (167)$$

## 8.7 Species Ocl\_m

**Initial amount** 0 item

This species takes part in nine reactions (as a reactant in [Osteoclast\\_apoptosis](#), [Tgfb\\_activation](#), [Bone\\_degradation](#) and as a product in [Osteoclast\\_precursor\\_differentiation](#), [Tgfb\\_activation](#), [Bone\\_degradation](#) and as a modifier in [Osteoclast\\_apoptosis](#), [Tgfb\\_activation](#), [Bone\\_degradation](#)).

$$\frac{d}{dt}\text{Ocl\_m} = v_{30} + v_{57} + v_{75} - v_{34} - v_{57} - v_{75} \quad (168)$$

## 8.8 Species Ocl\_p

**Initial amount** 0 item

This species takes part in six reactions (as a reactant in [Ocl\\_p\\_apoptosis](#), [Ocl\\_p\\_RANKL\\_binding](#) and as a product in [HSC\\_differentiation\\_to\\_Ocl\\_p](#), [Ocl\\_p\\_RANKL\\_release](#) and as a modifier in [Ocl\\_p\\_apoptosis](#), [Ocl\\_p\\_RANKL\\_binding](#)).

$$\frac{d}{dt}\text{Ocl\_p} = v_{26} + v_{29} - v_{27} - v_{28} \quad (169)$$

## 8.9 Species Ocl\_p\_RANKL

**Initial amount** 0 item

This species takes part in five reactions (as a reactant in [Ocl\\_p\\_RANKL\\_release](#), [Osteoclast\\_precursor\\_differentiation](#) and as a product in [Ocl\\_p\\_RANKL\\_binding](#) and as a modifier in [Ocl\\_p\\_RANKL\\_release](#), [Osteoclast\\_precursor\\_differentiation](#)).

$$\frac{d}{dt}\text{Ocl\_p\_RANKL} = v_{28} - v_{29} - v_{30} \quad (170)$$

### 8.10 Species `Ocy_A`

**Initial amount** 0 item

This species takes part in seven reactions (as a reactant in `Osteocyte_inactivation`, `RANKL_secretion_by_Ocy_A` and as a product in `Osteocyte_activation`, `Osteocyte_activation_by_PTH`, `RANKL_secretion_by_Ocy_A` and as a modifier in `Osteocyte_inactivation`, `RANKL_secretion_by_Ocy_A`).

$$\frac{d}{dt}\text{Ocy\_A} = v_2 + v_3 + v_{47} - v_4 - v_{47} \quad (171)$$

### 8.11 Species `Ocy_I`

**Initial amount** 1800 item

This species takes part in 16 reactions (as a reactant in `Osteocyte_activation`, `Ocy_I_bound_by_PTH`, `Ocy_apoptosis`, `Sost_secretion`, `RANKL_secretion_by_Ocy_I` and as a product in `Osteocyte_inactivation`, `Ocy_I_PTH_release`, `Sost_secretion`, `Ob_maturation_to_Ocy`, `Ob_maturation_to_Ocy_by_Tgfb`, `RANKL_secretion_by_Ocy_I` and as a modifier in `Osteocyte_activation`, `Ocy_I_bound_by_PTH`, `Ocy_apoptosis`, `Sost_secretion`, `RANKL_secretion_by_Ocy_I`).

$$\frac{d}{dt}\text{Ocy\_I} = v_4 + v_6 + v_8 + v_{20} + v_{21} + v_{48} - v_2 - v_5 - v_7 - v_8 - v_{48} \quad (172)$$

### 8.12 Species `Ocy_I_PTH`

**Initial amount** 0 item

This species takes part in five reactions (as a reactant in `Osteocyte_activation_by_PTH`, `Ocy_I_PTH_release` and as a product in `Ocy_I_bound_by_PTH` and as a modifier in `Osteocyte_activation_by_PTH`, `Ocy_I_PTH_release`).

$$\frac{d}{dt}\text{Ocy\_I\_PTH} = v_5 - v_3 - v_6 \quad (173)$$

### 8.13 Species `MSC`

**Initial amount** 100 item

This species takes part in nine reactions (as a reactant in `MSC_differentiation_to_Ob_pro`, `MCSF_secretion_by_MSC`, `RANKL_secretion_by_MSCs` and as a product in `MSC_differentiation_to_Ob_pro`, `MCSF_secretion_by_MSC`, `RANKL_secretion_by_MSCs` and as a modifier in `MSC_differentiation_to_Ob_pro`, `MCSF_secretion_by_MSC`, `RANKL_secretion_by_MSCs`).

$$\frac{d}{dt}\text{MSC} = v_{13} + v_{37} + v_{49} - v_{13} - v_{37} - v_{49} \quad (174)$$

## 8.14 Species LOAD

**Initial amount** 0 item

**Involved in events** AddLOAD1, AddLOAD2

This species takes part in five reactions (as a reactant in Unloading, Osteocyte\_activation and as a product in Osteocyte\_activation and as a modifier in Unloading, Osteocyte\_activation).

$$\frac{d}{dt}\text{LOAD} = v_2 - v_1 - v_2 \quad (175)$$

Furthermore, two events influence this species' rate of change.

## 8.15 Species MCSF

**Initial amount** 5 item

This species takes part in eleven reactions (as a reactant in HSC\_differentiation\_to\_Ocl\_p, MCSF\_degradation and as a product in HSC\_differentiation\_to\_Ocl\_p, MCSF\_secretion\_by\_MSC, MCSF\_secretion\_by\_Ob\_pro, MCSF\_secretion\_by\_Ob\_p, MCSF\_secretion\_by\_Ob\_p\_PTH, MCSF\_secretion\_by\_Ob\_m, MCSF\_secretion\_by\_Ob\_m\_PTH and as a modifier in HSC\_differentiation\_to\_Ocl\_p, MCSF\_degradation).

$$\frac{d}{dt}\text{MCSF} = v_{26} + v_{37} + v_{38} + v_{39} + v_{40} + v_{41} + v_{42} - v_{26} - v_{43} \quad (176)$$

## 8.16 Species Ob\_m\_PTH

**Initial amount** 0 item

This species takes part in 26 reactions (as a reactant in Wnt\_activation\_by\_PTH, Ob\_m\_PTH\_release, Ob\_m\_PTH\_apoptosis, MCSF\_secretion\_by\_Ob\_m\_PTH, RANKL\_secretion\_by\_Ob\_m\_PTH\_enhanced, Tgfb\_degradation\_by\_PTH, CREB\_activation, Runx2\_degradation\_via\_PTH, Bone\_formation\_Obm\_PTH and as a product in Wnt\_activation\_by\_PTH, Ob\_m\_bound\_by\_PTH, MCSF\_secretion\_by\_Ob\_m\_PTH, RANKL\_secretion\_by\_Ob\_m\_PTH\_enhanced, Tgfb\_degradation\_by\_PTH, CREB\_activation, Runx2\_degradation\_via\_PTH, Bone\_formation\_Obm\_PTH and as a modifier in Wnt\_activation\_by\_PTH, Ob\_m\_PTH\_release, Ob\_m\_PTH\_apoptosis, MCSF\_secretion\_by\_Ob\_m\_PTH, RANKL\_secretion\_by\_Ob\_m\_PTH\_enhanced, Tgfb\_degradation\_by\_PTH, CREB\_activation, Runx2\_degradation\_via\_PTH, Bone\_formation\_Obm\_PTH).

$$\begin{aligned} \frac{d}{dt}\text{Ob.m.PTH} = & v_{11} + v_{22} + v_{42} + v_{55} + v_{59} + v_{62} + v_{71} + v_{74} - v_{11} \\ & - v_{23} - v_{25} - v_{42} - v_{55} - v_{59} - v_{62} - v_{71} - v_{74} \end{aligned} \quad (177)$$



### 8.17 Species Ob\_p\_PTH

**Initial amount** 0 item

This species takes part in twelve reactions (as a reactant in [Ob\\_p\\_PTH\\_release](#), [MCSF\\_secretion\\_by\\_Ob\\_p\\_PTH](#), [OPG\\_secretion\\_by\\_Ob\\_p\\_PTH](#), [RANKL\\_secretion\\_by\\_Ob\\_p\\_PTH](#) and as a product in [Ob\\_p\\_binding\\_by\\_PTH](#), [MCSF\\_secretion\\_by\\_Ob\\_p\\_PTH](#), [OPG\\_secretion\\_by\\_Ob\\_p\\_PTH](#), [RANKL\\_secretion\\_by\\_Ob\\_p\\_PTH](#) and as a modifier in [Ob\\_p\\_PTH\\_release](#), [MCSF\\_secretion\\_by\\_Ob\\_p\\_PTH](#), [OPG\\_secretion\\_by\\_Ob\\_p\\_PTH](#), [RANKL\\_secretion\\_by\\_Ob\\_p\\_PTH](#)).

$$\frac{d}{dt}\text{Ob\_p\_PTH} = v_{16} + v_{40} + v_{45} + v_{52} - v_{17} - v_{40} - v_{45} - v_{52} \quad (178)$$

### 8.18 Species OPG

**Initial amount** 0 item

This species takes part in eight reactions (as a reactant in [RANKL\\_inhibition](#), [OPG\\_degradation](#) and as a product in [OPG\\_RANKL\\_dissociation](#), [OPG\\_secretion\\_by\\_Ob\\_p](#), [OPG\\_secretion\\_by\\_Ob\\_p\\_PTH](#), [OPG\\_secretion\\_by\\_Ob\\_m](#) and as a modifier in [RANKL\\_inhibition](#), [OPG\\_degradation](#)).

$$\frac{d}{dt}\text{OPG} = v_{32} + v_{44} + v_{45} + v_{46} - v_{31} - v_{36} \quad (179)$$

### 8.19 Species OPG\_RANKL

**Initial amount** 0 item

This species takes part in five reactions (as a reactant in [OPG\\_RANKL\\_dissociation](#), [OPG\\_RANKL\\_degradation](#) and as a product in [RANKL\\_inhibition](#) and as a modifier in [OPG\\_RANKL\\_dissociation](#), [OPG\\_RANKL\\_degradation](#)).

$$\frac{d}{dt}\text{OPG\_RANKL} = v_{31} - v_{32} - v_{33} \quad (180)$$

### 8.20 Species PTH

**Initial amount** 170 item

**Involved in events** [AddPTH1](#), [AddPTH2](#)

This species takes part in 14 reactions (as a reactant in [Ocy\\_I\\_bound\\_by\\_PTH](#), [Ob\\_p\\_binding\\_by\\_PTH](#), [Ob\\_m\\_bound\\_by\\_PTH](#), [PTH\\_degradation](#) and as a product in [Osteocyte\\_activation\\_by\\_PTH](#), [Ocy\\_I\\_PTH\\_release](#), [Ob\\_p\\_PTH\\_release](#), [Ob\\_m\\_PTH\\_release](#), [Ob\\_m\\_PTH\\_apoptosis](#), [PTH\\_production](#) and as a modifier in [Ocy\\_I\\_bound\\_by\\_PTH](#), [Ob\\_p\\_binding\\_by\\_PTH](#), [Ob\\_m\\_bound\\_by\\_PTH](#), [PTH\\_degradation](#)).

$$\frac{d}{dt}\text{PTH} = v_3 + v_6 + v_{17} + v_{23} + v_{25} + v_{60} - v_5 - v_{16} - v_{22} - v_{61} \quad (181)$$

Furthermore, two events influence this species' rate of change.

## 8.21 Species RANKL

**Initial amount** 0 item

This species takes part in 17 reactions (as a reactant in [Ocl\\_p\\_RANKL\\_binding](#), [RANKL\\_inhibition](#), [RANKL\\_degradation](#) and as a product in [Ocl\\_p\\_RANKL\\_release](#), [OPG\\_RANKL\\_dissociation](#), [RANKL\\_secretion\\_by\\_Ocy\\_A](#), [RANKL\\_secretion\\_by\\_Ocy\\_I](#), [RANKL\\_secretion\\_by\\_MSCs](#), [RANKL\\_secretion\\_by\\_Ob\\_p](#), [RANKL\\_secretion\\_by\\_Ob\\_p\\_Tgfb\\_A](#), [RANKL\\_secretion\\_by\\_Ob\\_p\\_PTH](#), [RANKL\\_secretion\\_by\\_Ob\\_pro](#), [RANKL\\_secretion\\_by\\_Ob\\_m](#), [RANKL\\_secretion\\_by\\_Ob\\_m\\_PTH-enhanced](#) and as a modifier in [Ocl\\_p\\_RANKL\\_binding](#), [RANKL\\_inhibition](#), [RANKL\\_degradation](#)).

$$\frac{d}{dt} \text{RANKL} = v_{29} + v_{32} + v_{47} + v_{48} + v_{49} + v_{50} + v_{51} + v_{52} + v_{53} + v_{54} + v_{55} - v_{28} - v_{31} - v_{35} \quad (182)$$

## 8.22 Species Sost

**Initial amount** 0 item

This species takes part in six reactions (as a reactant in [Sost\\_degradation](#), [Inactivation\\_of\\_Wnt\\_by\\_Sost](#) and as a product in [Sost\\_secretion](#), [Inactivation\\_of\\_Wnt\\_by\\_Sost](#) and as a modifier in [Sost\\_degradation](#), [Inactivation\\_of\\_Wnt\\_by\\_Sost](#)).

$$\frac{d}{dt} \text{Sost} = v_8 + v_{12} - v_9 - v_{12} \quad (183)$$

## 8.23 Species Tgfb\_A

**Initial amount** 5 item

This species takes part in 14 reactions (as a reactant in [Osteoblast\\_progenitor\\_differentiation\\_by\\_Tgfb](#), [Ob\\_p\\_Tgfb\\_binding](#), [Ob\\_maturation\\_to\\_Ocy\\_by\\_Tgfb](#), [Tgfb\\_degradation](#), [Tgfb\\_degradation\\_by\\_PTH](#) and as a product in [Osteoblast\\_progenitor\\_differentiation\\_by\\_Tgfb](#), [Ob\\_p\\_Tgfb\\_release](#), [Ob\\_maturation\\_to\\_Ocy\\_by\\_Tgfb](#), [Tgfb\\_activation](#) and as a modifier in [Osteoblast\\_progenitor\\_differentiation\\_by\\_Tgfb](#), [Ob\\_p\\_Tgfb\\_binding](#), [Ob\\_maturation\\_to\\_Ocy\\_by\\_Tgfb](#), [Tgfb\\_degradation](#), [Tgfb\\_degradation\\_by\\_PTH](#)).

$$\frac{d}{dt} \text{Tgfb\_A} = v_{14} + v_{19} + v_{21} + v_{57} - v_{14} - v_{18} - v_{21} - v_{58} - v_{59} \quad (184)$$

## 8.24 Species Tgfb\_I

**Initial amount** 500 item

This species takes part in three reactions (as a reactant in [Tgfb\\_activation](#) and as a product in [Tgfb\\_secretion\\_by\\_Obm](#) and as a modifier in [Tgfb\\_activation](#)).

$$\frac{d}{dt} \text{Tgfb\_I} = v_{56} - v_{57} \quad (185)$$

### 8.25 Species Wnt\_A

**Initial amount** 0 item

This species takes part in seven reactions (as a reactant in [Inactivation\\_of\\_Wnt\\_by\\_Sost](#), [MSC\\_differentiation\\_to\\_Ob\\_pro](#) and as a product in [Wnt\\_activation](#), [Wnt\\_activation\\_by\\_PTH](#), [MSC\\_differentiation\\_to\\_Ob\\_pro](#) and as a modifier in [Inactivation\\_of\\_Wnt\\_by\\_Sost](#), [MSC\\_differentiation\\_to\\_Ob\\_pro](#)).

$$\frac{d}{dt}Wnt\_A = v_{10} + v_{11} + v_{13} - v_{12} - v_{13} \quad (186)$$

### 8.26 Species Wnt\_I

**Initial amount** 200 item

This species takes part in five reactions (as a reactant in [Wnt\\_activation](#), [Wnt\\_activation\\_by\\_PTH](#) and as a product in [Inactivation\\_of\\_Wnt\\_by\\_Sost](#) and as a modifier in [Wnt\\_activation](#), [Wnt\\_activation\\_by\\_PTH](#)).

$$\frac{d}{dt}Wnt\_I = v_{12} - v_{10} - v_{11} \quad (187)$$

### 8.27 Species Source

**Initial amount** 1 item

This species takes part in six reactions (as a reactant in [PTH\\_production](#), [Runx2\\_synthesis](#), [Xsynthesis](#) and as a modifier in [PTH\\_production](#), [Runx2\\_synthesis](#), [Xsynthesis](#)), which do not influence its rate of change because this constant species is on the boundary of the reaction system:

$$\frac{d}{dt}Source = 0 \quad (188)$$

### 8.28 Species Sink

**Initial amount** 1 item

This species takes part in 13 reactions (as a product in [Unloading](#), [Ocy\\_apoptosis](#), [Sost\\_degradation](#), [Ocl\\_p\\_apoptosis](#), [OPG\\_RANKL\\_degradation](#), [Osteoclast\\_apoptosis](#), [RANKL\\_degradation](#), [OPG\\_degradation](#), [MCSF\\_degradation](#), [Tgfb\\_degradation](#), [PTH\\_degradation](#), [Bcl2\\_degradation](#), [Runx2\\_degradation](#)), which do not influence its rate of change because this constant species is on the boundary of the reaction system:

$$\frac{d}{dt}Sink = 0 \quad (189)$$

### 8.29 Species X

**Initial amount** 0 item

**Involved in event** [AddPTH2](#)

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

$$\frac{d}{dt}X = v_{76} \quad (190)$$

Furthermore, one event influences this species' rate of change.

### 8.30 Species [newbone](#)

**Initial amount** 0 item

This species takes part in two reactions (as a product in [Bone\\_formation](#), [Bone\\_formation-Obm\\_PTH](#)).

$$\frac{d}{dt}\text{newbone} = v_{73} + v_{74} \quad (191)$$

### 8.31 Species [Bax](#)

**Initial amount** 100 item

This species takes part in nine reactions (as a reactant in [Ob\\_m\\_apoptosis](#), [Ob\\_m\\_PTH\\_apoptosis](#), [Bax\\_Bcl2\\_binding](#) and as a product in [Ob\\_m\\_apoptosis](#), [Ob\\_m\\_PTH\\_apoptosis](#), [Bax\\_Bcl2\\_release](#) and as a modifier in [Ob\\_m\\_apoptosis](#), [Ob\\_m\\_PTH\\_apoptosis](#), [Bax\\_Bcl2\\_binding](#)).

$$\frac{d}{dt}Bax = v_{24} + v_{25} + v_{69} - v_{24} - v_{25} - v_{68} \quad (192)$$

### 8.32 Species [Bax\\_Bcl2](#)

**Initial amount** 0 item

This species takes part in three reactions (as a reactant in [Bax\\_Bcl2\\_release](#) and as a product in [Bax\\_Bcl2\\_binding](#) and as a modifier in [Bax\\_Bcl2\\_release](#)).

$$\frac{d}{dt}Bax\_Bcl2 = v_{68} - v_{69} \quad (193)$$

### 8.33 Species [Bcl2](#)

**Initial amount** 0 item

This species takes part in six reactions (as a reactant in [Bcl2\\_degradation](#), [Bax\\_Bcl2\\_binding](#) and as a product in [Bcl2\\_synthesis](#), [Bax\\_Bcl2\\_release](#) and as a modifier in [Bcl2\\_degradation](#), [Bax\\_Bcl2\\_binding](#)).

$$\frac{d}{dt}Bcl2 = v_{66} + v_{69} - v_{67} - v_{68} \quad (194)$$

### 8.34 Species CREB

**Initial amount** 100 item

This species takes part in three reactions (as a reactant in [CREB\\_activation](#) and as a product in [CREB\\_inactivation](#) and as a modifier in [CREB\\_activation](#)).

$$\frac{d}{dt}\text{CREB} = v_{63} - v_{62} \quad (195)$$

### 8.35 Species CREB\_P

**Initial amount** 0 item

This species takes part in six reactions (as a reactant in [CREB\\_inactivation](#), [CREB\\_Runx2\\_binding](#) and as a product in [CREB\\_activation](#), [CREB\\_Runx2\\_release](#) and as a modifier in [CREB\\_inactivation](#), [CREB\\_Runx2\\_binding](#)).

$$\frac{d}{dt}\text{CREB\_P} = v_{62} + v_{65} - v_{63} - v_{64} \quad (196)$$

### 8.36 Species CREB\_Runx2

**Initial amount** 0 item

This species takes part in six reactions (as a reactant in [CREB\\_Runx2\\_release](#), [Bcl2\\_synthesis](#) and as a product in [CREB\\_Runx2\\_binding](#), [Bcl2\\_synthesis](#) and as a modifier in [CREB\\_Runx2\\_release](#), [Bcl2\\_synthesis](#)).

$$\frac{d}{dt}\text{CREB\_Runx2} = v_{64} + v_{66} - v_{65} - v_{66} \quad (197)$$

### 8.37 Species Runx2

**Initial amount** 10 item

This species takes part in eight reactions (as a reactant in [CREB\\_Runx2\\_binding](#), [Runx2\\_degradation\\_via\\_PTH](#), [Runx2\\_degradation](#) and as a product in [CREB\\_Runx2\\_release](#), [Runx2\\_synthesis](#) and as a modifier in [CREB\\_Runx2\\_binding](#), [Runx2\\_degradation\\_via\\_PTH](#), [Runx2\\_degradation](#)).

$$\frac{d}{dt}\text{Runx2} = v_{65} + v_{70} - v_{64} - v_{71} - v_{72} \quad (198)$$

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

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