SBML Model Report

Model name: "Queralt2006_MitoticExit-_Cdc55DownregulationBySeparase"

May 6, 2016

1 General Overview

This is a document in SBML Level 2 Version 4 format. This model was created by the following two authors: Lukas Endler[1] and Vijayalakshmi Chelliah[2] at August 20th 2009 at 4:15 p. m. and last time modified at July 16th 2012 at 12:01 a. m. Table 1 gives an overview of the quantities of all components of this model.

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

Element	Quantity	Element	Quantity
compartment types	0	compartments	1
species types	0	species	24
events	0	constraints	0
reactions	31	function definitions	0
global parameters	54	unit definitions	0
rules	10	initial assignments	0

Model Notes

This model is from the article:
Downregulation of PP2A(Cdc55) phosphatase by separase initiates mitotic exit in budding yeast.
Queralt E, Lehane C, Novak B, Uhlmann F. Cell. 2006 May 19;125(4):719-32. 16713564 ,

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Abstract:
After anaphase, the high mitotic cyclin-dependent kinase (Cdk) activity is downregulated to promote exit from mitosis. To this end, in the budding yeast S. cerevisiae, the Cdk counteracting phosphatase Cdc14 is activated. In metaphase, Cdc14 is kept inactive in the nucleolus by its inhibitor Net1. During anaphase, Cdk- and Polo-dependent phosphorylation of Net1 is thought to release active Cdc14. How Net1 is phosphorylated specifically in anaphase, when mitotic kinase activity starts to decline, has remained unexplained. Here, we show that PP2A(Cdc55) phosphatase keeps Net1 underphosphorylated in metaphase. The sister chromatid-separating protease separase, activated at anaphase onset, interacts with and downregulates PP2A(Cdc55), thereby facilitating Cdk-dependent Net1 phosphorylation. PP2A(Cdc55) downregulation also promotes phosphorylation of Bfa1, contributing to activation of the „mitotic exit network„ that sustains Cdc14 as Cdk activity declines. These findings allow us to present a new quantitative model for mitotic exit in budding yeast.

2 Unit Definitions

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

2.1 Unit `substance`

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

Definition mol

2.2 Unit `volume`

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

Definition l

2.3 Unit `area`

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

Definition m^2

2.4 Unit `length`

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

Definition m

2.5 Unit `time`

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

Definition s

3 Compartment

This model contains one compartment.

Table 2: Properties of all compartments.

Id	Name	SBO	Spatial Dimensions	Size	Unit	Constant	Outside
`compartment`	compartment	0000290	3	1	litre	☑	

3.1 Compartment `compartment`

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

Name compartment

SBO:0000290 physical compartment

4 Species

This model contains 24 species. The boundary condition of eleven 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 Condition
AA	AA	compartment	$\mathrm{mol} \cdot \mathrm{l}^{-1}$	☑	☑
Clb2	Clb2	compartment	$\mathrm{mol} \cdot \mathrm{l}^{-1}$	☐	☐
degr	degr	compartment	$\mathrm{mol} \cdot \mathrm{l}^{-1}$	☑	☑
Cdc20	Cdc20	compartment	$\mathrm{mol} \cdot \mathrm{l}^{-1}$	☐	☐
Cdh1	Cdh1	compartment	$\mathrm{mol} \cdot \mathrm{l}^{-1}$	☐	☐
Cdh1_i	inactive Cdh1	compartment	$\mathrm{mol} \cdot \mathrm{l}^{-1}$	☐	☑
securinT	securinT	compartment	$\mathrm{mol} \cdot \mathrm{l}^{-1}$	☐	☐
securin	securin	compartment	$\mathrm{mol} \cdot \mathrm{l}^{-1}$	☐	☑
separaseT	separaseT	compartment	$\mathrm{mol} \cdot \mathrm{l}^{-1}$	☐	☐
separase	separase	compartment	$\mathrm{mol} \cdot \mathrm{l}^{-1}$	☐	☑
securinseparase	securin:separase	compartment	$\mathrm{mol} \cdot \mathrm{l}^{-1}$	☐	☐
Net1	Net1	compartment	$\mathrm{mol} \cdot \mathrm{l}^{-1}$	☐	☐
Net1Cdc14	Net1Cdc14	compartment	$\mathrm{mol} \cdot \mathrm{l}^{-1}$	☐	☐
PoloT	PoloT	compartment	$\mathrm{mol} \cdot \mathrm{l}^{-1}$	☐	☐
Polo	Polo	compartment	$\mathrm{mol} \cdot \mathrm{l}^{-1}$	☐	☐
Polo_i	inactive Polo	compartment	$\mathrm{mol} \cdot \mathrm{l}^{-1}$	☐	☑
Tem1	Tem1	compartment	$\mathrm{mol} \cdot \mathrm{l}^{-1}$	☐	☐
Tem1_i	inactive Tem1	compartment	$\mathrm{mol} \cdot \mathrm{l}^{-1}$	☐	☑
Cdc15	Cdc15	compartment	$\mathrm{mol} \cdot \mathrm{l}^{-1}$	☐	☐
Cdc15_i	inactive Cdc15	compartment	$\mathrm{mol} \cdot \mathrm{l}^{-1}$	☐	☑
MEN	MEN	compartment	$\mathrm{mol} \cdot \mathrm{l}^{-1}$	☐	☐

Id	Name	Compartment	Derived Unit	Constant	Boundary Condition
PP2A	PP2A	compartment	$\mathrm{mol} \cdot \mathrm{l}^{-1}$	⊟	☑
Net1P	Net1P	compartment	$\mathrm{mol} \cdot \mathrm{l}^{-1}$	⊟	☑
Cdc14	Cdc14	compartment	$\mathrm{mol} \cdot \mathrm{l}^{-1}$	⊟	☑

5 Parameters

This model contains 54 global parameters.

Table 4: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
Cdk	Cdk activity		0.000		☐
ksclb2	ksclb2		0.030		☑
kdclb2	kdclb2		0.030		☑
kadclb2	kadclb2		0.200		☑
kaadclb2	kaadclb2		2.000		☑
kscdc20	kscdc20		0.015		☑
kdcdc20	kdcdc20		0.050		☑
kadcdc20	kadcdc20		2.000		☑
kdcdh	kdcdh		0.010		☑
kadcdh	kadcdh		1.000		☑
kapcdh	kapcdh		1.000		☑
Jcdh	Jcdh		0.002		☑
Cdh1T	Cdh1T		1.000		☑
kssecurin	kssecurin		0.030		☑
kdsecurin	kdsecurin		0.050		☑
kadsecurin	kadsecurin		2.000		☑
ksseparase	ksseparase		0.001		☑
kdseparase	kdseparase		0.004		☑
lasecurin	lasecurin		500.000		☑
ldsecurin	ldsecurin		1.000		☑
kad	kad		0.100		☑
kd	kd		0.450		☑
kp	kp		0.400		☑
kap	kap		2.000		☑
Jnet	Jnet		0.200		☑
lanet	lanet		500.000		☑
ldnet	ldnet		1.000		☑
Net1T	Net1T		1.000		☑
Cdc14T	Cdc14T		0.500		☑
kspolo	kspolo		0.010		☑
kdpolo	kdpolo		0.010		☑
kadpolo	kadpolo		0.250		☑
kapolo	kapolo		0.000		☑
kaapolo	kaapolo		0.500		☑
kipolo	kipolo		0.100		☑
Jpolo	Jpolo		0.250		☑
katem	katem		0.000		☑

Id	Name	SBO	Value	Unit	Constant
kaatem	kaatem		0.500		☑
kitem	kitem		0.100		☑
kaitem	kaitem		1.000		☑
Jtem1	Jtem1		0.005		☑
Tem1T	Tem1T		1.000		☑
kacdc15	kacdc15		0.020		☑
kaacdc15	kaacdc15		0.500		☑
kicdc15	kicdc15		0.000		☑
kaicdc15	kaicdc15		0.200		☑
Jcdc15	Jcdc15		0.200		☑
lamen	lamen		10.000		☑
ldmen	ldmen		0.100		☑
Cdc15T	Cdc15T		1.000		☑
kpp	kpp		0.100		☑
ki	ki		20.000		☑
PP2AT	PP2AT		1.000		☑
Inh	Inh		0.000		☑

6 Rules

This is an overview of ten rules.

6.1 Rule separase

Rule separase is an assignment rule for species separase:

$$\text{separase} = [\text{separaseT}] - [\text{securinseparase}] \tag{1}$$

Derived unit $\text{mol} \cdot \text{l}^{-1}$

6.2 Rule Cdh1_i

Rule Cdh1_i is an assignment rule for species Cdh1_i:

$$\text{Cdh1\_i} = \text{Cdh1T} - [\text{Cdh1}] \tag{2}$$

6.3 Rule Tem1_i

Rule Tem1_i is an assignment rule for species Tem1_i:

$$\text{Tem1\_i} = \text{Tem1T} - [\text{Tem1}] \tag{3}$$

6.4 Rule securin

Rule securin is an assignment rule for species securin:

$$\text{securin} = [\text{securinT}] - [\text{securinseparase}] \tag{4}$$

Derived unit $\text{mol} \cdot \text{l}^{-1}$

6.5 Rule Polo_i

Rule Polo_i is an assignment rule for species Polo_i:

$$\text{Polo\_i} = [\text{PoloT}] - [\text{Polo}] \tag{5}$$

Derived unit $\text{mol} \cdot \text{l}^{-1}$

6.6 Rule Cdk

Rule Cdk is an assignment rule for parameter Cdk:

$$\text{Cdk} = \frac{[\text{Clb2}]}{1 + \text{Inh}} \tag{6}$$

6.7 Rule Net1P

Rule Net1P is an assignment rule for species Net1P:

$$\text{Net1P} = \text{Net1T} - [\text{Net1}] - [\text{Net1Cdc14}] \tag{7}$$

6.8 Rule Cdc14

Rule Cdc14 is an assignment rule for species Cdc14:

$$\text{Cdc14} = \text{Cdc14T} - [\text{Net1Cdc14}] \tag{8}$$

6.9 Rule Cdc15_i

Rule Cdc15_i is an assignment rule for species Cdc15_i:

$$\text{Cdc15\_i} = \text{Cdc15T} - [\text{Cdc15}] \tag{9}$$

6.10 Rule PP2A

Rule PP2A is an assignment rule for species PP2A:

$$\text{PP2A} = \frac{1 + \text{kpp} \cdot \text{ki} \cdot [\text{separase}]}{1 + \text{ki} \cdot [\text{separase}]} \cdot \text{PP2AT} \tag{10}$$

7 Reactions

This model contains 31 reactions. All reactions are listed in the following table and are subsequently described in detail. If a reaction is affected by a modifier, the identifier of this species is written above the reaction arrow.

Table 5: Overview of all reactions

№	Id	Name	Reaction Equation	SBO
1	v1	v1	$\mathrm{AA} \rightleftharpoons \mathrm{Clb2}$	0000393
2	v2	v2	$\mathrm{Clb2} \overset{\mathrm{Cdc20,\ Cdh1}}{\rightleftharpoons} \mathrm{degr}$	0000179
3	v3	v3	$\mathrm{AA} \rightleftharpoons \mathrm{Cdc20}$	0000393
4	v4	v4	$\mathrm{Cdc20} \overset{\mathrm{Cdh1}}{\rightleftharpoons} \mathrm{degr}$	0000179
5	v5	v5	$\mathrm{Cdh1\_i} \overset{\mathrm{Cdc14}}{\rightleftharpoons} \mathrm{Cdh1}$	0000181
6	v6	v6	$\mathrm{Cdh1} \rightleftharpoons \mathrm{Cdh1\_i}$	0000181
7	v7	v7	$\mathrm{AA} \rightleftharpoons \mathrm{securinT} + \mathrm{securin}$	0000393
8	v8	v8	$\mathrm{securinT} + \mathrm{securin} \overset{\mathrm{Cdc20}}{\rightleftharpoons} \mathrm{degr}$	0000179
9	v9	v9	$\mathrm{AA} \rightleftharpoons \mathrm{separaseT} + \mathrm{separase}$	0000393
10	v10	v10	$\mathrm{separaseT} + \mathrm{separase} \rightleftharpoons \mathrm{degr}$	0000179
11	v11	v11	$\mathrm{securin} + \mathrm{separase} \rightleftharpoons \mathrm{securinseparase}$	0000526
12	securinseparase_securindegradation	securinseparase securindegradation	$\mathrm{securinseparase} \overset{\mathrm{Cdc20}}{\rightleftharpoons} \mathrm{separase}$	0000179
13	securinseparase_separase_degradation	securin:separase separase degradation	$\mathrm{securinseparase} \rightleftharpoons \mathrm{securin}$	0000179
14	v13	Net1P dephosphorylation	$\mathrm{Net1P} \overset{\mathrm{Cdc14,\ Clb2,\ PP2A}}{\rightleftharpoons} \mathrm{Net1}$	0000330
15	v14	Net1 phosphorylation	$\mathrm{Net1} \overset{\mathrm{MEN,\ Net1Cdc14,\ Clb2}}{\rightleftharpoons} \mathrm{Net1P}$	0000216
16	v15	v15	$\mathrm{Net1} \overset{\mathrm{Cdc14}}{\rightleftharpoons} \mathrm{Net1Cdc14}$	0000526

№	Id	Name	Reaction Equation	SBO
17	v16	v16	$\text{Net1Cdc14} \rightleftharpoons \text{Net1}$	0000180
18	v17	Net1Cdc14 phosphorylation	$\text{Net1Cdc14} \overset{\text{MEN, Net1, Clb2}}{\rightleftharpoons} \text{Net1P}$	0000216
19	v18	v18	$\text{AA} \rightleftharpoons \text{PoloT} + \text{Polo\_i}$	0000393
20	v19	v19	$\text{PoloT} + \text{Polo\_i} \overset{\text{Cdh1}}{\rightleftharpoons} \text{degr}$	0000179
21	v20	v20	$\text{Polo\_i} \overset{\text{PoloT}}{\rightleftharpoons} \text{Polo}$	0000181
22	v21	v21	$\text{Polo} \rightleftharpoons \text{Polo\_i}$	0000181
23	v22	v22	$\text{Polo} \overset{\text{Cdh1}}{\rightleftharpoons} \text{degr}$	0000179
24	v23	v23	$\text{Tem1\_i} \overset{\text{Polo}}{\rightleftharpoons} \text{Tem1}$	0000181
25	v24	v24	$\text{Tem1} \overset{\text{PP2A}}{\rightleftharpoons} \text{Tem1\_i}$	0000181
26	v25	v25	$\text{Cdc15\_i} \overset{\text{Cdc14}}{\rightleftharpoons} \text{Cdc15}$	0000181
27	v26	v26	$\text{Cdc15} \rightleftharpoons \text{Cdc15\_i}$	0000181
28	v27	v27	$\text{AA} \overset{\text{Tem1, Cdc15}}{\rightleftharpoons} \text{MEN}$	0000393
29	v28	v28	$\text{MEN} \rightleftharpoons \text{degr}$	0000179
30	v29	Tem1 degradation in MEN	$\text{MEN} \overset{\text{Tem1, PP2A}}{\rightleftharpoons} \emptyset$	0000179
31	v30	Cdc15 degradation in MEN	$\text{MEN} \overset{\text{Cdc15, Clb2}}{\rightleftharpoons} \emptyset$	0000179

7.1 Reaction v1

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

Name v1

SBO:0000393 production

Reaction equation

$$\mathrm{AA} \rightleftharpoons \mathrm{Clb2} \tag{11}$$

Reactant

Table 6: Properties of each reactant.

Id	Name	SBO
AA	AA	

Product

Table 7: Properties of each product.

Id	Name	SBO
Clb2	Clb2	

Kinetic Law

Derived unit not available

$$v_1 = \mathrm{ksclb2} \tag{12}$$

7.2 Reaction v2

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

Name v2

SBO:0000179 degradation

Reaction equation

$$\mathrm{Clb2} \overset{\mathrm{Cdc20,\ Cdh1}}{\rightleftharpoons} \mathrm{degr} \tag{13}$$

Reactant

Table 8: Properties of each reactant.

Id	Name	SBO
Clb2	Clb2	

Modifiers

Table 9: Properties of each modifier.

Id	Name	SBO
Cdc20	Cdc20	
Cdh1	Cdh1	

Product

Table 10: Properties of each product.

Id	Name	SBO
degr	degr	

Kinetic Law

Derived unit contains undeclared units

$$v_2 = (\text{kdclb2} + \text{kadclb2} \cdot [\text{Cdc20}] + \text{kaadclb2} \cdot [\text{Cdh1}]) \cdot [\text{Clb2}] \tag{14}$$

7.3 Reaction v3

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

Name v3

SBO:0000393 production

Reaction equation

$$\text{AA} \rightleftharpoons \text{Cdc20} \tag{15}$$

Reactant

Table 11: Properties of each reactant.

Id	Name	SBO
AA	AA	

Product

Table 12: Properties of each product.

Id	Name	SBO
Cdc20	Cdc20	

Kinetic Law

Derived unit not available

$$v_3 = \text{kscdc20} \tag{16}$$

7.4 Reaction v4

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

Name v4

SBO:0000179 degradation

Reaction equation

$$\text{Cdc20} \overset{\text{Cdh1}}{\rightleftharpoons} \text{degr} \tag{17}$$

Reactant

Table 13: Properties of each reactant.

Id	Name	SBO
Cdc20	Cdc20	

Modifier

Table 14: Properties of each modifier.

Id	Name	SBO
Cdh1	Cdh1	

Product

Table 15: Properties of each product.

Id	Name	SBO
degr	degr	

Kinetic Law

Derived unit contains undeclared units

$$v_4 = (\text{kdcdc20} + \text{kadcdc20} \cdot [\text{Cdh1}]) \cdot [\text{Cdc20}] \tag{18}$$

7.5 Reaction v5

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

Name v5

SBO:0000181 conformational transition

Reaction equation

$$\text{Cdh1\_i} \xrightleftharpoons{\text{Cdc14}} \text{Cdh1} \tag{19}$$

Reactant

Table 16: Properties of each reactant.

Id	Name	SBO
Cdh1_i	inactive Cdh1	

Modifier

Table 17: Properties of each modifier.

Id	Name	SBO
Cdc14	Cdc14	

Product

Table 18: Properties of each product.

Id	Name	SBO
Cdh1	Cdh1	

Kinetic Law

Derived unit contains undeclared units

$$v_5 = (\mathrm{kdcdh} + \mathrm{kadcdh} \cdot [\mathrm{Cdc14}]) \cdot \frac{\mathrm{Cdh1T} - [\mathrm{Cdh1}]}{\mathrm{Jcdh} + \mathrm{Cdh1T} - [\mathrm{Cdh1}]} \tag{20}$$

7.6 Reaction v6

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

Name v6

SBO:0000181 conformational transition

Reaction equation

$$\mathrm{Cdh1} \rightleftharpoons \mathrm{Cdh1\_i} \tag{21}$$

Reactant

Table 19: Properties of each reactant.

Id	Name	SBO
Cdh1	Cdh1	

Product

Table 20: Properties of each product.

Id	Name	SBO
Cdh1_i	inactive Cdh1	

Kinetic Law

Derived unit contains undeclared units

$$v_6 = \text{kapcdh} \cdot \text{Cdk} \cdot \frac{[\text{Cdh1}]}{\text{Jcdh} + [\text{Cdh1}]} \tag{22}$$

7.7 Reaction v7

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

Name v7

SBO:0000393 production

Reaction equation

$$\text{AA} \rightleftharpoons \text{securinT} + \text{securin} \tag{23}$$

Reactant

Table 21: Properties of each reactant.

Id	Name	SBO
AA	AA	

Products

Table 22: Properties of each product.

Id	Name	SBO
securinT	securinT	
securin	securin	

Kinetic Law

Derived unit not available

$$v_7 = \text{kssecurin} \tag{24}$$

7.8 Reaction v8

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

Name v8

SBO:0000179 degradation

Reaction equation

$$\text{securinT} + \text{securin} \overset{\text{Cdc20}}{\rightleftharpoons} \text{degr} \tag{25}$$

Reactants

Table 23: Properties of each reactant.

Id	Name	SBO
securinT	securinT	
securin	securin	

Modifier

Table 24: Properties of each modifier.

Id	Name	SBO
Cdc20	Cdc20	

Product

Table 25: Properties of each product.

Id	Name	SBO
degr	degr	

Kinetic Law

Derived unit contains undeclared units

$$v_8 = (\text{kdsecurin} + \text{kadsecurin} \cdot [\text{Cdc20}]) \cdot [\text{securinT}] \tag{26}$$

7.9 Reaction v9

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

Name v9

SBO:0000393 production

Reaction equation

$$\mathrm{AA} \rightleftharpoons \mathrm{separaseT} + \mathrm{separase} \tag{27}$$

Reactant

Table 26: Properties of each reactant.

Id	Name	SBO
AA	AA	

Products

Table 27: Properties of each product.

Id	Name	SBO
separaseT	separaseT	
separase	separase	

Kinetic Law

Derived unit not available

$$v_9 = \mathrm{ksseparase} \tag{28}$$

7.10 Reaction v10

This is a reversible reaction of two reactants forming one product.

Name v10

SBO:0000179 degradation

Reaction equation

$$\mathrm{separaseT} + \mathrm{separase} \rightleftharpoons \mathrm{degr} \tag{29}$$

Reactants

Table 28: Properties of each reactant.

Id	Name	SBO
separaseT	separaseT	
separase	separase	

Product

Table 29: Properties of each product.

Id	Name	SBO
degr	degr	

Kinetic Law

Derived unit contains undeclared units

$$v_{10} = \text{kdseparase} \cdot [\text{separaseT}] \tag{30}$$

7.11 Reaction v11

This is a reversible reaction of two reactants forming one product.

Name v11

SBO:0000526 protein complex formation

Reaction equation

$$\text{securin} + \text{separase} \rightleftharpoons \text{securinseparase} \tag{31}$$

Reactants

Table 30: Properties of each reactant.

Id	Name	SBO
securin	securin	
separase	separase	

Product

Table 31: Properties of each product.

Id	Name	SBO
securinseparase	securin:separase	

Kinetic Law

Derived unit contains undeclared units

$$v_{11} = \text{lasecurin} \cdot [\text{securin}] \cdot [\text{separase}] - \text{ldsecurin} \cdot [\text{securinseparase}] \tag{32}$$

7.12 Reaction securinseparase_securindegradation

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

Name securinseparase securindegradation

SBO:0000179 degradation

Reaction equation

$$\text{securinseparase} \overset{\text{Cdc20}}{\rightleftharpoons} \text{separase} \tag{33}$$

Reactant

Table 32: Properties of each reactant.

Id	Name	SBO
securinseparase	securin:separase	

Modifier

Table 33: Properties of each modifier.

Id	Name	SBO
Cdc20	Cdc20	

Product

Table 34: Properties of each product.

Id	Name	SBO
separase	separase	

Kinetic Law

Derived unit contains undeclared units

$$v_{12} = (\text{kdsecurin} + \text{kadsecurin} \cdot [\text{Cdc20}]) \cdot [\text{securinseparase}] \tag{34}$$

7.13 Reaction securinseparase_separase_degradation

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

Name securin:separase separase degradation

SBO:0000179 degradation

Reaction equation

$$\text{securinseparase} \rightleftharpoons \text{securin} \tag{35}$$

Reactant

Table 35: Properties of each reactant.

Id	Name	SBO
securinseparase	securin:separase	

Product

Table 36: Properties of each product.

Id	Name	SBO
securin	securin	

Kinetic Law

Derived unit contains undeclared units

$$v_{13} = \text{kdseparase} \cdot [\text{securinseparase}] \tag{36}$$

7.14 Reaction v13

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

Name Net1P dephosphorylation

SBO:0000330 dephosphorylation

Reaction equation

$$\text{Net1P} \underset{\leftarrow}{\overset{\text{Cdc14, Clb2, PP2A}}{\rightleftharpoons}} \text{Net1} \tag{37}$$

Reactant

Table 37: Properties of each reactant.

Id	Name	SBO
Net1P	Net1P	

Modifiers

Table 38: Properties of each modifier.

Id	Name	SBO
Cdc14	Cdc14	
Clb2	Clb2	
PP2A	PP2A	

Product

Table 39: Properties of each product.

Id	Name	SBO
Net1	Net1	

Kinetic Law

Derived unit contains undeclared units

$$v_{14} = (\text{kad} \cdot [\text{Cdc14}] + \text{kd} \cdot [\text{PP2A}]) \cdot \frac{[\text{Net1P}]}{\text{Jnet} + [\text{Net1P}]} \tag{38}$$

7.15 Reaction v14

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

Name Net1 phosphorylation

SBO:0000216 phosphorylation

Reaction equation

$$\text{Net1} \xrightleftharpoons{\text{MEN, Net1Cdc14, Clb2}} \text{Net1P} \tag{39}$$

Reactant

Table 40: Properties of each reactant.

Id	Name	SBO
Net1	Net1	

Modifiers

Table 41: Properties of each modifier.

Id	Name	SBO
MEN	MEN	
Net1Cdc14	Net1Cdc14	
Clb2	Clb2	

Product

Table 42: Properties of each product.

Id	Name	SBO
Net1P	Net1P	

Kinetic Law

Derived unit contains undeclared units

$$v_{15} = (\text{kp} \cdot \text{Cdk} + \text{kap} \cdot [\text{MEN}]) \cdot \frac{[\text{Net1}]}{\text{Jnet} + [\text{Net1}] + [\text{Net1Cdc14}]} \tag{40}$$

7.16 Reaction v15

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

Name v15

SBO:0000526 protein complex formation

Reaction equation

$$\text{Net1} \overset{\text{Cdc14}}{\rightleftharpoons} \text{Net1Cdc14} \tag{41}$$

Reactant

Table 43: Properties of each reactant.

Id	Name	SBO
Net1	Net1	

Modifier

Table 44: Properties of each modifier.

Id	Name	SBO
Cdc14	Cdc14	

Product

Table 45: Properties of each product.

Id	Name	SBO
Net1Cdc14	Net1Cdc14	

Kinetic Law

Derived unit contains undeclared units

$$v_{16} = \text{lanet} \cdot [\text{Net1}] \cdot [\text{Cdc14}] \tag{42}$$

7.17 Reaction v16

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

Name v16

SBO:0000180 dissociation

Reaction equation

$$\text{Net1Cdc14} \rightleftharpoons \text{Net1} \tag{43}$$

Reactant

Table 46: Properties of each reactant.

Id	Name	SBO
Net1Cdc14	Net1Cdc14	

Product

Table 47: Properties of each product.

Id	Name	SBO
Net1	Net1	

Kinetic Law

Derived unit contains undeclared units

$$v_{17} = \text{ldnet} \cdot [\text{Net1Cdc14}] \tag{44}$$

7.18 Reaction v17

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

Name Net1Cdc14 phosphorylation

SBO:0000216 phosphorylation

Reaction equation

$$\text{Net1Cdc14} \xrightleftharpoons{\text{MEN, Net1, Clb2}} \text{Net1P} \tag{45}$$

Reactant

Table 48: Properties of each reactant.

Id	Name	SBO
Net1Cdc14	Net1Cdc14	

Modifiers

Table 49: Properties of each modifier.

Id	Name	SBO
MEN	MEN	
Net1	Net1	
Clb2	Clb2	

Product

Table 50: Properties of each product.

Id	Name	SBO
Net1P	Net1P	

Kinetic Law

Derived unit contains undeclared units

$$v_{18} = (\mathrm{kp} \cdot \mathrm{Cdk} + \mathrm{kap} \cdot [\mathrm{MEN}]) \cdot \frac{[\mathrm{Net1Cdc14}]}{\mathrm{Jnet} + [\mathrm{Net1}] + [\mathrm{Net1Cdc14}]} \tag{46}$$

7.19 Reaction v18

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

Name v18

SBO:0000393 production

Reaction equation

$$\mathrm{AA} \rightleftharpoons \mathrm{PoloT} + \mathrm{Polo\_i} \tag{47}$$

Reactant

Table 51: Properties of each reactant.

Id	Name	SBO
AA	AA	

Products

Table 52: Properties of each product.

Id	Name	SBO
PoloT	PoloT	
Polo_i	inactive Polo	

Kinetic Law

Derived unit not available

$$v_{19} = \text{kspolo} \tag{48}$$

7.20 Reaction v19

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

Name v19

SBO:0000179 degradation

Reaction equation

$$\text{PoloT} + \text{Polo\_i} \overset{\text{Cdh1}}{\rightleftharpoons} \text{degr} \tag{49}$$

Reactants

Table 53: Properties of each reactant.

Id	Name	SBO
PoloT	PoloT	
Polo_i	inactive Polo	

Modifier

Table 54: Properties of each modifier.

Id	Name	SBO
Cdh1	Cdh1	

Product

Table 55: Properties of each product.

Id	Name	SBO
degr	degr	

Kinetic Law

Derived unit contains undeclared units

$$v_{20} = (\text{kdpolo} + \text{kadpolo} \cdot [\text{Cdh1}]) \cdot [\text{PoloT}] \tag{50}$$

7.21 Reaction v20

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

Name v20

SBO:0000181 conformational transition

Reaction equation

$$\text{Polo\_i} \underset{\longleftarrow}{\overset{\text{PoloT}}{\rightleftharpoons}} \text{Polo} \tag{51}$$

Reactant

Table 56: Properties of each reactant.

Id	Name	SBO
Polo_i	inactive Polo	

Modifier

Table 57: Properties of each modifier.

Id	Name	SBO
PoloT	PoloT	

Product

Table 58: Properties of each product.

Id	Name	SBO
Polo	Polo	

Kinetic Law

Derived unit contains undeclared units

$$v_{21} = (\text{kapolo} + \text{kaapolo} \cdot \text{Cdk}) \cdot \frac{[\text{PoloT}] - [\text{Polo}]}{\text{Jpolo} + [\text{PoloT}] - [\text{Polo}]} \tag{52}$$

7.22 Reaction v21

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

Name v21

SBO:0000181 conformational transition

Reaction equation

$$\text{Polo} \rightleftharpoons \text{Polo\_i} \tag{53}$$

Reactant

Table 59: Properties of each reactant.

Id	Name	SBO
Polo	Polo	

Product

Table 60: Properties of each product.

Id	Name	SBO
`Polo_i`	inactive Polo	

Kinetic Law

Derived unit contains undeclared units

$$v_{22} = \text{kipolo} \cdot \frac{[\text{Polo}]}{\text{Jpolo} + [\text{Polo}]} \tag{54}$$

7.23 Reaction v22

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

Name v22

SBO:0000179 degradation

Reaction equation

$$\text{Polo} \overset{\text{Cdh1}}{\rightleftharpoons} \text{degr} \tag{55}$$

Reactant

Table 61: Properties of each reactant.

Id	Name	SBO
`Polo`	Polo	

Modifier

Table 62: Properties of each modifier.

Id	Name	SBO
`Cdh1`	Cdh1	

Product

Table 63: Properties of each product.

Id	Name	SBO
degr	degr	

Kinetic Law

Derived unit contains undeclared units

$$v_{23} = (\text{kdpolo} + \text{kadpolo} \cdot [\text{Cdh1}]) \cdot [\text{Polo}] \tag{56}$$

7.24 Reaction v23

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

Name v23

SBO:0000181 conformational transition

Reaction equation

$$\text{Tem1\_i} \overset{\text{Polo}}{\rightleftharpoons} \text{Tem1} \tag{57}$$

Reactant

Table 64: Properties of each reactant.

Id	Name	SBO
Tem1_i	inactive Tem1	

Modifier

Table 65: Properties of each modifier.

Id	Name	SBO
Polo	Polo	

Product

Table 66: Properties of each product.

Id	Name	SBO
Tem1	Tem1	

Kinetic Law

Derived unit contains undeclared units

$$v_{24} = (\text{katem} + \text{kaatem} \cdot [\text{Polo}]) \cdot \frac{\text{Tem1T} - [\text{Tem1}]}{\text{Jtem1} + \text{Tem1T} - [\text{Tem1}]} \tag{58}$$

7.25 Reaction v24

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

Name v24

SBO:0000181 conformational transition

Reaction equation

$$\text{Tem1} \underset{}{\overset{\text{PP2A}}{\rightleftharpoons}} \text{Tem1\_i} \tag{59}$$

Reactant

Table 67: Properties of each reactant.

Id	Name	SBO
Tem1	Tem1	

Modifier

Table 68: Properties of each modifier.

Id	Name	SBO
PP2A	PP2A	

Product

Table 69: Properties of each product.

Id	Name	SBO
Tem1_i	inactive Tem1	

Kinetic Law

Derived unit contains undeclared units

$$v_{25} = (\text{kitem} + \text{kaitem} \cdot [\text{PP2A}]) \cdot \frac{[\text{Tem1}]}{\text{Jtem1} + [\text{Tem1}]} \tag{60}$$

7.26 Reaction v25

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

Name v25

SBO:0000181 conformational transition

Reaction equation

$$\text{Cdc15\_i} \overset{\text{Cdc14}}{\rightleftharpoons} \text{Cdc15} \tag{61}$$

Reactant

Table 70: Properties of each reactant.

Id	Name	SBO
Cdc15_i	inactive Cdc15	

Modifier

Table 71: Properties of each modifier.

Id	Name	SBO
Cdc14	Cdc14	

Product

Table 72: Properties of each product.

Id	Name	SBO
Cdc15	Cdc15	

Kinetic Law

Derived unit contains undeclared units

$$v_{26} = (\text{kacdc15} + \text{kaacdc15} \cdot [\text{Cdc14}]) \cdot \frac{\text{Cdc15T} - [\text{Cdc15}]}{\text{Jcdc15} + \text{Cdc15T} - [\text{Cdc15}]} \tag{62}$$

7.27 Reaction v26

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

Name v26

SBO:0000181 conformational transition

Reaction equation

$$\text{Cdc15} \rightleftharpoons \text{Cdc15\_i} \tag{63}$$

Reactant

Table 73: Properties of each reactant.

Id	Name	SBO
Cdc15	Cdc15	

Product

Table 74: Properties of each product.

Id	Name	SBO
Cdc15_i	inactive Cdc15	

Kinetic Law

Derived unit contains undeclared units

$$v_{27} = (\text{kicdc15} + \text{kaicdc15} \cdot \text{Cdk}) \cdot \frac{[\text{Cdc15}]}{\text{Jcdc15} + [\text{Cdc15}]} \tag{64}$$

7.28 Reaction v27

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

Name v27

SBO:0000393 production

Reaction equation

$$\mathrm{AA} \xrightleftharpoons{\text{Tem1, Cdc15}} \mathrm{MEN} \tag{65}$$

Reactant

Table 75: Properties of each reactant.

Id	Name	SBO
AA	AA	

Modifiers

Table 76: Properties of each modifier.

Id	Name	SBO
Tem1	Tem1	
Cdc15	Cdc15	

Product

Table 77: Properties of each product.

Id	Name	SBO
MEN	MEN	

Kinetic Law

Derived unit contains undeclared units

$$v_{28} = \mathrm{lamen} \cdot ([\mathrm{Tem1}] - [\mathrm{MEN}]) \cdot ([\mathrm{Cdc15}] - [\mathrm{MEN}]) \tag{66}$$

7.29 Reaction v28

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

Name v28

SBO:0000179 degradation

Reaction equation

$$\mathrm{MEN} \rightleftharpoons \mathrm{degr} \tag{67}$$

Reactant

Table 78: Properties of each reactant.

Id	Name	SBO
MEN	MEN	

Product

Table 79: Properties of each product.

Id	Name	SBO
degr	degr	

Kinetic Law

Derived unit contains undeclared units

$$v_{29} = \mathrm{ldmen} \cdot [\mathrm{MEN}] \tag{68}$$

7.30 Reaction v29

This is a reversible reaction of one reactant forming no product influenced by two modifiers.

Name Tem1 degradation in MEN

SBO:0000179 degradation

Reaction equation

$$\mathrm{MEN} \overset{\mathrm{Tem1,\ PP2A}}{\rightleftharpoons} \emptyset \tag{69}$$

Reactant

Table 80: Properties of each reactant.

Id	Name	SBO
MEN	MEN	

Modifiers

Table 81: Properties of each modifier.

Id	Name	SBO
Tem1	Tem1	
PP2A	PP2A	

Kinetic Law

Derived unit contains undeclared units

$$v_{30} = (\text{kitem} + \text{kaitem} \cdot [\text{PP2A}]) \cdot \frac{[\text{MEN}]}{\text{Jtem1} + [\text{Tem1}]} \tag{70}$$

7.31 Reaction v30

This is a reversible reaction of one reactant forming no product influenced by two modifiers.

Name Cdc15 degradation in MEN

SBO:0000179 degradation

Reaction equation

$$\text{MEN} \xrightleftharpoons{\text{Cdc15, Clb2}} \emptyset \tag{71}$$

Reactant

Table 82: Properties of each reactant.

Id	Name	SBO
MEN	MEN	

Modifiers

Table 83: Properties of each modifier.

Id	Name	SBO
Cdc15	Cdc15	
Clb2	Clb2	

Kinetic Law

Derived unit contains undeclared units

$$v_{31} = (\text{kicdc15} + \text{kaicdc15} \cdot \text{Cdk}) \cdot \frac{[\text{MEN}]}{\text{Jcdc15} + [\text{Cdc15}]} \tag{72}$$

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 AA

Name AA

SBO:0000291 empty set

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

This species takes part in six reactions (as a reactant in v1, v3, v7, v9, v18, v27), which do not influence its rate of change because this constant species is on the boundary of the reaction system:

$$\frac{\text{d}}{\text{d}t}\text{AA} = 0 \tag{73}$$

8.2 Species Clb2

Name Clb2

SBO:0000252 polypeptide chain

Initial concentration $0.997\ \mathrm{mol}\cdot\mathrm{l}^{-1}$

This species takes part in six reactions (as a reactant in v2 and as a product in v1 and as a modifier in v13, v14, v17, v30).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{Clb2} = v_1 - v_2 \tag{74}$$

8.3 Species degr

Name degr

SBO:0000291 empty set

Initial concentration $1\ \mathrm{mol}\cdot\mathrm{l}^{-1}$

This species takes part in seven reactions (as a product in v2, v4, v8, v10, v19, v22, v28), which do not influence its rate of change because this constant species is on the boundary of the reaction system:

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{degr} = 0 \tag{75}$$

8.4 Species Cdc20

Name Cdc20

SBO:0000252 polypeptide chain

Initial concentration $0\ \mathrm{mol}\cdot\mathrm{l}^{-1}$

This species takes part in five reactions (as a reactant in v4 and as a product in v3 and as a modifier in v2, v8, securinseparase_securindegradation).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{Cdc20} = v_3 - v_4 \tag{76}$$

8.5 Species Cdh1

Name Cdh1

SBO:0000252 polypeptide chain

Initial concentration $3.8\cdot 10^{-5}\ \mathrm{mol}\cdot\mathrm{l}^{-1}$

This species takes part in six reactions (as a reactant in v6 and as a product in v5 and as a modifier in v2, v4, v19, v22).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{Cdh1} = v_5 - v_6 \tag{77}$$

8.6 Species Cdh1_i

Name inactive Cdh1

SBO:0000252 polypeptide chain

Involved in rule Cdh1_i

This species takes part in two reactions (as a reactant in v5 and as a product in v6). Not these but one rule determines the species' quantity because this species is on the boundary of the reaction system.

8.7 Species securinT

Name securinT

SBO:0000252 polypeptide chain

Initial concentration $0.6\ \mathrm{mol}\cdot\mathrm{l}^{-1}$

This species takes part in two reactions (as a reactant in v8 and as a product in v7).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{securinT} = v_7 - v_8 \tag{78}$$

8.8 Species securin

Name securin

SBO:0000252 polypeptide chain

Involved in rule securin

This species takes part in four reactions (as a reactant in v8, v11 and as a product in v7, securinseparase_separase_degradation). Not these but one rule determines the species' quantity because this species is on the boundary of the reaction system.

8.9 Species separaseT

Name separaseT

SBO:0000252 polypeptide chain

Initial concentration $0.25\ \mathrm{mol}\cdot\mathrm{l}^{-1}$

This species takes part in two reactions (as a reactant in v10 and as a product in v9).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{separaseT} = v_9 - v_{10} \tag{79}$$

8.10 Species separase

Name separase

SBO:0000252 polypeptide chain

Involved in rule separase

This species takes part in four reactions (as a reactant in v10, v11 and as a product in v9, securinseparase_securindegradation). Not these but one rule determines the species' quantity because this species is on the boundary of the reaction system.

8.11 Species securinseparase

Name securin:separase

SBO:0000297 protein complex

Initial concentration $0.248\ \mathrm{mol}\cdot\mathrm{l}^{-1}$

This species takes part in three reactions (as a reactant in securinseparase_securindegradation, securinseparase_separase_degradation and as a product in v11).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{securinseparase} = v_{11} - v_{12} - v_{13} \tag{80}$$

8.12 Species Net1

Name Net1

SBO:0000252 polypeptide chain

Initial concentration $0.098\ \mathrm{mol}\cdot\mathrm{l}^{-1}$

This species takes part in five reactions (as a reactant in v14, v15 and as a product in v13, v16 and as a modifier in v17).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{Net1} = v_{14} + v_{17} - v_{15} - v_{16} \tag{81}$$

8.13 Species Net1Cdc14

Name Net1Cdc14

SBO:0000297 protein complex

Initial concentration $0.485\ \mathrm{mol}\cdot\mathrm{l}^{-1}$

This species takes part in four reactions (as a reactant in v16, v17 and as a product in v15 and as a modifier in v14).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{Net1Cdc14} = v_{16} - v_{17} - v_{18} \tag{82}$$

8.14 Species PoloT

Name PoloT

SBO:0000252 polypeptide chain

Initial concentration $0.99\ \mathrm{mol}\cdot\mathrm{l}^{-1}$

This species takes part in three reactions (as a reactant in v19 and as a product in v18 and as a modifier in v20).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{PoloT} = v_{19} - v_{20} \tag{83}$$

8.15 Species Polo

Name Polo

SBO:0000252 polypeptide chain

Initial concentration $0.945\ \mathrm{mol}\cdot\mathrm{l}^{-1}$

This species takes part in four reactions (as a reactant in v21, v22 and as a product in v20 and as a modifier in v23).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{Polo} = v_{21} - v_{22} - v_{23} \tag{84}$$

8.16 Species Polo_i

Name inactive Polo

SBO:0000252 polypeptide chain

Involved in rule Polo_i

This species takes part in four reactions (as a reactant in v19, v20 and as a product in v18, v21). Not these but one rule determines the species' quantity because this species is on the boundary of the reaction system.

8.17 Species Tem1

Name Tem1

SBO:0000252 polypeptide chain

Initial concentration $0.00389\ \mathrm{mol}\cdot\mathrm{l}^{-1}$

This species takes part in four reactions (as a reactant in v24 and as a product in v23 and as a modifier in v27, v29).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{Tem1} = v_{24} - v_{25} \tag{85}$$

8.18 Species Tem1_i

Name inactive Tem1

SBO:0000252 polypeptide chain

Involved in rule Tem1_i

This species takes part in two reactions (as a reactant in v23 and as a product in v24). Not these but one rule determines the species' quantity because this species is on the boundary of the reaction system.

8.19 Species Cdc15

Name Cdc15

SBO:0000252 polypeptide chain

Initial concentration $0.0257\ \mathrm{mol}\cdot\mathrm{l}^{-1}$

This species takes part in four reactions (as a reactant in v26 and as a product in v25 and as a modifier in v27, v30).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{Cdc15} = v_{26} - v_{27} \tag{86}$$

8.20 Species Cdc15_i

Name inactive Cdc15

SBO:0000252 polypeptide chain

Involved in rule Cdc15_i

This species takes part in two reactions (as a reactant in v25 and as a product in v26). Not these but one rule determines the species' quantity because this species is on the boundary of the reaction system.

8.21 Species MEN

Name MEN

SBO:0000297 protein complex

Initial concentration $8\cdot10^{-6}\ \mathrm{mol}\cdot\mathrm{l}^{-1}$

This species takes part in six reactions (as a reactant in v28, v29, v30 and as a product in v27 and as a modifier in v14, v17).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{MEN} = v_{28} - v_{29} - v_{30} - v_{31} \tag{87}$$

8.22 Species PP2A

Name PP2A

SBO:0000252 polypeptide chain

Involved in rule PP2A

This species takes part in three reactions (as a modifier in v13, v24, v29). Not these but one rule determines the species' quantity because this species is on the boundary of the reaction system.

8.23 Species Net1P

Name Net1P

SBO:0000297 protein complex

Involved in rule Net1P

This species takes part in three reactions (as a reactant in v13 and as a product in v14, v17). Not these but one rule determines the species' quantity because this species is on the boundary of the reaction system.

8.24 Species Cdc14

Name Cdc14

SBO:0000252 polypeptide chain

Involved in rule Cdc14

This species takes part in four reactions (as a modifier in v5, v13, v15, v25). Not these but one rule determines the species' quantity because this species is on the boundary of the reaction system.

A Glossary of Systems Biology Ontology Terms

SBO:0000179 degradation: Complete disappearance of a physical entity

SBO:0000180 dissociation: Transformation of a non-covalent complex that results in the formation of several independent biochemical entitie

SBO:0000181 conformational transition: Biochemical reaction that does not result in the modification of covalent bonds of reactants, but rather modifies the conformation of some reactants, that is the relative position of their atoms in space

SBO:0000216 phosphorylation: Addition of a phosphate group (-H2PO4) to a chemical entity

SBO:0000252 polypeptide chain: Naturally occurring macromolecule formed by the repetition of amino-acid residues linked by peptidic bonds. A polypeptide chain is synthesized by the ribosome. CHEBI:1654

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

SBO: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.

SBO:0000297 protein complex: Macromolecular complex containing one or more polypeptide chains possibly associated with simple chemicals. CHEBI:3608

SBO:0000330 dephosphorylation: Removal of a phosphate group (-H2PO4) from a chemical entity.

SBO:0000393 production: Generation of a material or conceptual entity.

SBO:0000526 protein complex formation: The process by which two or more proteins interact non-covalently to form a protein complex (SBO:0000297)

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