

## SBML Model Report

**Model name:**  
**“Conradie2010\_RPControl\_CellCycle”**



May 6, 2016

### 1 General Overview

This is a document in SBML Level 2 Version 4 format. This model was created by the following three authors: Jacky L Snoep<sup>1</sup>, Vijayalakshmi Chelliah<sup>2</sup> and Kieran Smallbone<sup>3</sup> at July 20<sup>th</sup> 2010 at 10:27 a. m. and last time modified at February 25<sup>th</sup> 2015 at 12:32 a. m. Table 1 shows an overview of the quantities of all components of this model.

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

Element	Quantity	Element	Quantity
compartment types	0	compartments	1
species types	0	species	23
events	4	constraints	0
reactions	52	function definitions	0
global parameters	50	unit definitions	3
rules	9	initial assignments	0

### Model Notes

This model is from the article:

**Restriction point control of the mammalian cell cycle via the cyclin E/Cdk2:p27 complex.**

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**Abstract:**

Numerous top-down kinetic models have been constructed to describe the cell cycle. These models have typically been constructed, validated and analyzed using model species (molecular intermediates and proteins) and phenotypic observations, and therefore do not focus on the individual model processes (reaction steps). We have developed a method to: (a) quantify the importance of each of the reaction steps in a kinetic model for the positioning of a switch point [i.e. the restriction point (RP)]; (b) relate this control of reaction steps to their effects on molecular species, using sensitivity and co-control analysis; and thereby (c) go beyond a correlation towards a causal relationship between molecular species and effects. The method is generic and can be applied to responses of any type, but is most useful for the analysis of dynamic and emergent responses such as switch points in the cell cycle. The strength of the analysis is illustrated for an existing mammalian cell cycle model focusing on the RP [Novak B, Tyson J (2004) J Theor Biol 230, 563-579]. The reactions in the model with the highest RP control were those involved in: (a) the interplay between retinoblastoma protein and E2F transcription factor; (b) those synthesizing the delayed response genes and cyclin D/Cdk4 in response to growth signals; (c) the E2F-dependent cyclin E/Cdk2 synthesis reaction; as well as (d) p27 formation reactions. Nine of the 23 intermediates were shown to have a good correlation between their concentration control and RP control. Sensitivity and co-control analysis indicated that the strongest control of the RP is mediated via the cyclin E/Cdk2:p27 complex concentration. Any perturbation of the RP could be related to a change in the concentration of this complex; apparent effects of other molecular species were indirect and always worked through cyclin E/Cdk2:p27, indicating a causal relationship between this complex and the positioning of the RP.

The rate constants presented in the paper have units [per tenth of an hour] and have been changed here to [per hour] (e.g.  $k_{16} = 0.25$  not 0.025); for further confirmation of the correctness of this change, see the original model (Novak, J Theor Biol 2004 230:563).

## 2 Unit Definitions

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

### 2.1 Unit substance

**Name** arbitrary units

**Definition** dimensionless

### 2.2 Unit time

**Name** hour

**Definition** 3600 s

## 2.3 Unit per\_hour

**Name** per hour

**Definition**  $(3600\text{ s})^{-1}$

## 2.4 Unit volume

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

**Definition** l

## 2.5 Unit area

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

**Definition** m<sup>2</sup>

## 2.6 Unit length

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

**Definition** m

# 3 Compartment

This model contains one compartment.

Table 2: Properties of all compartments.

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

## 3.1 Compartment cell

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

**Name** cell

## 4 Species

This model contains 23 species. Section 9 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
CDc20	Cdc20	cell	$\text{dimensionless} \cdot \text{l}^{-1}$	$\boxplus$	$\boxplus$
CDh1	Cdh1	cell	$\text{dimensionless} \cdot \text{l}^{-1}$	$\boxplus$	$\boxplus$
CYCA	cyclin A:Cdk2	cell	$\text{dimensionless} \cdot \text{l}^{-1}$	$\boxplus$	$\boxplus$
CYCB	cyclin B:Cdk2	cell	$\text{dimensionless} \cdot \text{l}^{-1}$	$\boxplus$	$\boxplus$
CYCD	cyclin D:Cdk2	cell	$\text{dimensionless} \cdot \text{l}^{-1}$	$\boxplus$	$\boxplus$
CYCE	cyclin E:Cdk2	cell	$\text{dimensionless} \cdot \text{l}^{-1}$	$\boxplus$	$\boxplus$
DRG	delayed-response genes	cell	$\text{dimensionless} \cdot \text{l}^{-1}$	$\boxplus$	$\boxplus$
var2	E2F	cell	$\text{dimensionless} \cdot \text{l}^{-1}$	$\boxplus$	$\boxplus$
var5	E2F:Rb	cell	$\text{dimensionless} \cdot \text{l}^{-1}$	$\boxplus$	$\boxplus$
ERG	early-response genes	cell	$\text{dimensionless} \cdot \text{l}^{-1}$	$\boxplus$	$\boxplus$
GM	general machinery for protein synthesis	cell	$\text{dimensionless} \cdot \text{l}^{-1}$	$\boxplus$	$\boxplus$
var1	hypophosphorylated Rb	cell	$\text{dimensionless} \cdot \text{l}^{-1}$	$\boxplus$	$\boxplus$
CDc20T	inactive Cdc20	cell	$\text{dimensionless} \cdot \text{l}^{-1}$	$\boxplus$	$\boxplus$
MASS	mass	cell	$\text{dimensionless} \cdot \text{l}^{-1}$	$\boxplus$	$\boxplus$
P27	P27	cell	$\text{dimensionless} \cdot \text{l}^{-1}$	$\boxplus$	$\boxplus$
CA	P27:cyclin A:Cdk2	cell	$\text{dimensionless} \cdot \text{l}^{-1}$	$\boxplus$	$\boxplus$
CD	P27:cyclin D:Cdk2	cell	$\text{dimensionless} \cdot \text{l}^{-1}$	$\boxplus$	$\boxplus$
CE	P27:cyclin E:Cdk2	cell	$\text{dimensionless} \cdot \text{l}^{-1}$	$\boxplus$	$\boxplus$
var3	phosphorylated E2F	cell	$\text{dimensionless} \cdot \text{l}^{-1}$	$\boxplus$	$\boxplus$
var6	phosphorylated E2F:Rb	cell	$\text{dimensionless} \cdot \text{l}^{-1}$	$\boxplus$	$\boxplus$
IEP	phosphorylated intermediary enzyme	cell	$\text{dimensionless} \cdot \text{l}^{-1}$	$\boxplus$	$\boxplus$
PPX	PPX	cell	$\text{dimensionless} \cdot \text{l}^{-1}$	$\boxplus$	$\boxplus$

Id	Name	Compartment	Derived Unit	Constant	Boundary Condi- tion
var4	retinoblastoma protein (Rb)	cell	dimensionless · l <sup>-1</sup>	⊞	⊞

## 5 Parameters

This model contains 50 global parameters.

Table 4: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
Flag			1.000	dimensionless	<input type="checkbox"/>
r31switch			1.000	dimensionless	<input type="checkbox"/>
PP1A			0.000	dimensionless	<input type="checkbox"/>
V2			0.000	dimensionless	<input type="checkbox"/>
V4			0.000	dimensionless	<input type="checkbox"/>
V6			0.000	dimensionless	<input type="checkbox"/>
V8			0.000	dimensionless	<input type="checkbox"/>
CYCET			0.000	dimensionless	<input type="checkbox"/>
CYCDT			0.000	dimensionless	<input type="checkbox"/>
CYCAT			0.000	dimensionless	<input type="checkbox"/>
P27T			0.000	dimensionless	<input type="checkbox"/>
K10			5.000	$(3600\text{ s})^{-1}$	<input checked="" type="checkbox"/>
K8a			0.100	$(3600\text{ s})^{-1}$	<input checked="" type="checkbox"/>
K8			2.000	$(3600\text{ s})^{-1}$	<input checked="" type="checkbox"/>
K25			1000.000	$(3600\text{ s})^{-1}$	<input checked="" type="checkbox"/>
K25R			10.000	$(3600\text{ s})^{-1}$	<input checked="" type="checkbox"/>
J8			0.100	dimensionless	<input checked="" type="checkbox"/>
YE			1.000	dimensionless	<input checked="" type="checkbox"/>
YB			0.050	dimensionless	<input checked="" type="checkbox"/>
K30			20.000	$(3600\text{ s})^{-1}$	<input checked="" type="checkbox"/>
K2a			0.050	$(3600\text{ s})^{-1}$	<input checked="" type="checkbox"/>
K2			20.000	$(3600\text{ s})^{-1}$	<input checked="" type="checkbox"/>
K2aa			1.000	$(3600\text{ s})^{-1}$	<input checked="" type="checkbox"/>
K6a			10.000	$(3600\text{ s})^{-1}$	<input checked="" type="checkbox"/>
K6			100.000	$(3600\text{ s})^{-1}$	<input checked="" type="checkbox"/>
HE			0.500	dimensionless	<input checked="" type="checkbox"/>
HB			1.000	dimensionless	<input checked="" type="checkbox"/>
HA			0.500	dimensionless	<input checked="" type="checkbox"/>
RBT			10.000	dimensionless	<input checked="" type="checkbox"/>
LD			3.300	dimensionless	<input checked="" type="checkbox"/>
LE			5.000	dimensionless	<input checked="" type="checkbox"/>
LB			5.000	dimensionless	<input checked="" type="checkbox"/>
LA			3.000	dimensionless	<input checked="" type="checkbox"/>
K20			10.000	$(3600\text{ s})^{-1}$	<input checked="" type="checkbox"/>
K21			1.000	dimensionless	<input checked="" type="checkbox"/>
PP1T			1.000	dimensionless	<input checked="" type="checkbox"/>

Id	Name	SBO	Value	Unit	Constant
FE			25.000	dimensionless	✓
FB			2.000	dimensionless	✓
K4			40.000	$(3600\text{ s})^{-1}$	✓
GE			0.000	dimensionless	✓
GB			1.000	dimensionless	✓
GA			0.300	dimensionless	✓
K12			1.500	$(3600\text{ s})^{-1}$	✓
E2FT			5.000	dimensionless	✓
K22			1.000	$(3600\text{ s})^{-1}$	✓
K23a			0.005	$(3600\text{ s})^{-1}$	✓
K23			1.000	$(3600\text{ s})^{-1}$	✓
K26			10000.000	$(3600\text{ s})^{-1}$	✓
K26R			200.000	$(3600\text{ s})^{-1}$	✓
eps			1.000	dimensionless	✓

## 6 Rules

This is an overview of nine rules.

### 6.1 Rule PP1A

Rule PP1A is an assignment rule for parameter PP1A:

$$PP1A = \frac{PP1T}{1 + K21 \cdot (FB \cdot [CYCB] + FE \cdot ([CYCA] + [CYCE]))} \quad (1)$$

### 6.2 Rule V2

Rule V2 is an assignment rule for parameter V2:

$$V2 = K2aa \cdot [CDc20] + K2a \cdot (1 - [CDh1]) + K2 \cdot [CDh1] \quad (2)$$

### 6.3 Rule V4

Rule V4 is an assignment rule for parameter V4:

$$V4 = K4 \cdot (GA \cdot [CYCA] + GB \cdot [CYCB] + GE \cdot [CYCE]) \quad (3)$$

**Derived unit**  $(3600\text{ s})^{-1} \cdot \text{l}^{-1}$

#### 6.4 Rule V6

Rule V6 is an assignment rule for parameter V6:

$$V6 = K6a + K6 \cdot (HA \cdot [CYCA] + HB \cdot [CYCB] + HE \cdot [CYCE]) \quad (4)$$

**Derived unit**  $(3600 \text{ s})^{-1}$

#### 6.5 Rule V8

Rule V8 is an assignment rule for parameter V8:

$$V8 = K8a + \frac{K8 \cdot (YB \cdot [CYCB] + YE \cdot ([CYCA] + [CYCE]))}{CYCET + J8} \quad (5)$$

**Derived unit**  $(3600 \text{ s})^{-1}$

#### 6.6 Rule CYCET

Rule CYCET is an assignment rule for parameter CYCET:

$$CYCET = [CE] + [CYCE] \quad (6)$$

**Derived unit**  $\text{l}^{-1}$

#### 6.7 Rule CYCDT

Rule CYCDT is an assignment rule for parameter CYCDT:

$$CYCDT = [CD] + [CYCD] \quad (7)$$

**Derived unit**  $\text{l}^{-1}$

#### 6.8 Rule CYCAT

Rule CYCAT is an assignment rule for parameter CYCAT:

$$CYCAT = [CA] + [CYCA] \quad (8)$$

**Derived unit**  $\text{l}^{-1}$

#### 6.9 Rule P27T

Rule P27T is an assignment rule for parameter P27T:

$$P27T = [CA] + [CD] + [CE] + [P27] \quad (9)$$

**Derived unit**  $\text{l}^{-1}$



## 7 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.

### 7.1 Event `r31Ifpart1`

**Name** `r31Ifpart1`

**Trigger condition**

$$([var4] + [var5] + [var6]) \cdot ([var1] + [var4] + [var5] + [var6])^{-1} > 0.8 \quad (10)$$

**Assignment**

$$r31switch = 0 \quad (11)$$

### 7.2 Event `r31Ifpart2`

**Name** `r31Ifpart2`

**Trigger condition**

$$([var4] + [var5] + [var6]) \cdot ([var1] + [var4] + [var5] + [var6])^{-1} < 0.8 \quad (12)$$

**Assignment**

$$r31switch = 1 \quad (13)$$

### 7.3 Event `divisionEvent`

**Name** `divisionEvent`

**Trigger condition**

$$([CDh1] > 0.2) \wedge (Flag = 1) \quad (14)$$

**Assignments**

$$GM = 0.5 \cdot [GM] \quad (15)$$

$$MASS = 0.5 \cdot [MASS] \quad (16)$$

$$Flag = 2 \quad (17)$$

### 7.4 Event `checkEvent`

**Name** `checkEvent`

**Trigger condition**

$$([CDh1] < 0.2) \wedge (Flag = 2) \quad (18)$$

**Assignment**

$$Flag = 1 \quad (19)$$

## 8 Reactions

This model contains 52 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	v1	v1	$\text{ERG} \rightleftharpoons \emptyset$	
2	v2	v2	$\text{DRG} \rightleftharpoons \emptyset$	
3	v3	v3	$\text{CD} \rightleftharpoons \text{P27}$	
4	v4	v4	$\text{CYCD} \rightleftharpoons \emptyset$	
5	v5	v5	$\text{CYCE} + \text{P27} \rightleftharpoons \text{CE}$	
6	v6	v6	$\text{CYCA} + \text{P27} \rightleftharpoons \text{CA}$	
7	v7	v7	$\text{CYCD} + \text{P27} \rightleftharpoons \text{CD}$	
8	v8	v8	$\text{CD} \rightleftharpoons \text{CYCD} + \text{P27}$	
9	v9	v9	$\text{CYCA} \xrightleftharpoons{\text{CDc20}} \emptyset$	
10	v10	v10	$\text{CA} \xrightleftharpoons{\text{CDc20}} \text{P27}$	
11	v11	v11	$\text{CE} \rightleftharpoons \text{CYCE} + \text{P27}$	
12	v12	v12	$\text{CA} \rightleftharpoons \text{CYCA} + \text{P27}$	
13	v13	v13	$\text{CE} \xrightleftharpoons{\text{CYCB, CYCA, CYCE}} \text{P27}$	
14	v14	v14	$\text{CYCE} \xrightleftharpoons{\text{CYCB, CYCA, CE}} \emptyset$	
15	v15	v15	$\text{P27} \xrightleftharpoons{\text{CYCA, CYCB, CYCE}} \emptyset$	
16	v16	v16	$\text{CE} \xrightleftharpoons{\text{CYCA, CYCB}} \text{CYCE}$	
17	v17	v17	$\text{CD} \xrightleftharpoons{\text{CYCA, CYCB, CYCE}} \text{CYCD}$	
18	v18	v18	$\text{CA} \xrightleftharpoons{\text{CYCB, CYCE}} \text{CYCA}$	

Nº	Id	Name	Reaction Equation	SBO
19	v19	v19	$\text{CYCB} \xrightleftharpoons{\text{CDc20, CDh1}} \emptyset$	
20	v20	v20	$\emptyset \xrightleftharpoons{\text{CDc20}} \text{CDh1}$	
21	v21	v21	$\text{CDh1} \xrightleftharpoons{\text{CYCA, CYCB, CYCE}} \emptyset$	
22	v22	v22	$\text{PPX} \rightleftharpoons \emptyset$	
23	v23	v23	$\emptyset \xrightleftharpoons{\text{CYCB}} \text{IEP}$	
24	v24	v24	$\text{IEP} \xrightleftharpoons{\text{PPX}} \emptyset$	
25	v25	v25	$\text{CDc20T} \rightleftharpoons \emptyset$	
26	v26	v26	$\emptyset \xrightleftharpoons{\text{CDc20T, IEP}} \text{CDc20}$	
27	v27	v27	$\text{CDc20} \rightleftharpoons \emptyset$	
28	v28	v28	$\text{CDc20} \rightleftharpoons \emptyset$	
29	v29	v29	$\text{var5} \xrightleftharpoons{\text{CYCA, CYCB, CD, CYCD, CYCE}} \text{var1} + \text{var2}$	
30	v30	v30	$\text{var6} \xrightleftharpoons{\text{CYCA, CYCB, CD, CYCD, CYCE}} \text{var1} + \text{var3}$	
31	v31	v31	$\emptyset \xrightleftharpoons{\text{MASS}} \text{GM}$	
32	v32	v32	$\text{GM} \rightleftharpoons \emptyset$	
33	v33	v33	$\emptyset \xrightleftharpoons{\text{GM}} \text{MASS}$	
34	v34	v34	$\emptyset \xrightleftharpoons{\text{DRG}} \text{ERG}$	
35	v35	v35	$\emptyset \xrightleftharpoons{\text{CYCB}} \text{CDc20T}$	
36	v36	v36	$\emptyset \xrightleftharpoons{\text{MASS, var2}} \text{CYCA}$	
37	v37	v37	$\emptyset \rightleftharpoons \text{PPX}$	
38	v38	v38	$\emptyset \xrightleftharpoons{\text{var2}} \text{CYCE}$	

Nº	Id	Name	Reaction Equation	SBO
39	v39	v39	$\emptyset \xrightarrow{\text{DRG}} \text{CYCD}$	
40	v40	v40	$\emptyset \rightleftharpoons \text{P27}$	
41	v41	v41	$\emptyset \xrightarrow{\text{ERG}} \text{DRG}$	
42	v42	v42	$\emptyset \rightleftharpoons \text{CYCB}$	
43	v43	v43	$\text{var4} \xrightarrow{\text{CYCA, CYCB, CD, CYCD, CYCE}} \text{var1}$	
44	v44	v44	$\text{var1} \xrightarrow{\text{CYCB, CYCA, CYCE}} \text{var4}$	
45	v45	v45	$\text{var5} \rightleftharpoons \text{var2} + \text{var4}$	
46	v46	v46	$\text{var2} \xrightarrow{\text{CYCA, CYCB}} \text{var3}$	
47	v47	v47	$\text{var3} \rightleftharpoons \text{var2}$	
48	v48	v48	$\text{var2} + \text{var4} \rightleftharpoons \text{var5}$	
49	v49	v49	$\text{var6} \rightleftharpoons \text{var3} + \text{var4}$	
50	v50	v50	$\text{var3} + \text{var4} \rightleftharpoons \text{var6}$	
51	v51	v51	$\text{var6} \rightleftharpoons \text{var5}$	
52	v52	v52	$\text{var5} \xrightarrow{\text{CYCA, CYCB}} \text{var6}$	

### 8.1 Reaction v1

This is a reversible reaction of one reactant forming no product.

**Name** v1

#### Reaction equation



#### Reactant

Table 6: Properties of each reactant.

Id	Name	SBO
ERG	early-response genes	

#### Kinetic Law

**Derived unit**  $(3600 \text{ s})^{-1} \cdot \text{l}^{-1}$

$$v_1 = k16 \cdot [\text{ERG}] \quad (21)$$

Table 7: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
k16			0.25	$(3600 \text{ s})^{-1}$	<input checked="" type="checkbox"/>

### 8.2 Reaction v2

This is a reversible reaction of one reactant forming no product.

**Name** v2

#### Reaction equation



#### Reactant

Table 8: Properties of each reactant.

Id	Name	SBO
DRG	delayed-response genes	

### Kinetic Law

**Derived unit**  $(3600\text{ s})^{-1} \cdot \text{l}^{-1}$

$$v_2 = k18 \cdot [\text{DRG}] \quad (23)$$

Table 9: Properties of each parameter.

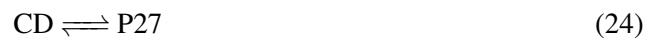
Id	Name	SBO	Value	Unit	Constant
k18			10.0	$(3600\text{ s})^{-1}$	<input checked="" type="checkbox"/>

### 8.3 Reaction v3

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

**Name** v3

### Reaction equation



### Reactant

Table 10: Properties of each reactant.

Id	Name	SBO
CD	P27:cyclin D:Cdk2	

### Product

Table 11: Properties of each product.

Id	Name	SBO
P27	P27	

### Kinetic Law

**Derived unit**  $(3600\text{ s})^{-1} \cdot \text{l}^{-1}$

$$v_3 = K10 \cdot [\text{CD}] \quad (25)$$

### 8.4 Reaction v4

This is a reversible reaction of one reactant forming no product.

**Name** v4

### Reaction equation



### Reactant

Table 12: Properties of each reactant.

Id	Name	SBO
CYCD	cyclin D:Cdk2	

### Kinetic Law

**Derived unit**  $(3600\text{ s})^{-1} \cdot \text{l}^{-1}$

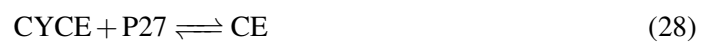
$$v_4 = K10 \cdot [\text{CYCD}] \quad (27)$$

### 8.5 Reaction v5

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

**Name** v5

### Reaction equation



### Reactants

Table 13: Properties of each reactant.

Id	Name	SBO
CYCE	cyclin E:Cdk2	
P27	P27	

## Product

Table 14: Properties of each product.

Id	Name	SBO
CE	P27:cyclin E:Cdk2	

## Kinetic Law

**Derived unit**  $(3600\text{ s})^{-1} \cdot \text{l}^{-2}$

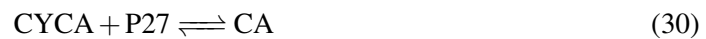
$$v_5 = K25 \cdot [\text{CYCE}] \cdot [\text{P27}] \quad (29)$$

## 8.6 Reaction $v_6$

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

**Name**  $v_6$

## Reaction equation



## Reactants

Table 15: Properties of each reactant.

Id	Name	SBO
CYCA	cyclin A:Cdk2	
P27	P27	

## Product



Table 16: Properties of each product.

Id	Name	SBO
CA	P27:cyclin A:Cdk2	

**Kinetic Law**

**Derived unit**  $(3600\text{ s})^{-1} \cdot \text{l}^{-2}$

$$v_6 = K25 \cdot [\text{CYCA}] \cdot [\text{P27}] \tag{31}$$

**8.7 Reaction  $v_7$**

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

**Name**  $v_7$

**Reaction equation**



**Reactants**

Table 17: Properties of each reactant.

Id	Name	SBO
CYCD	cyclin D:Cdk2	
P27	P27	

**Product**

Table 18: Properties of each product.

Id	Name	SBO
CD	P27:cyclin D:Cdk2	

**Kinetic Law**

**Derived unit**  $(3600\text{ s})^{-1} \cdot \text{l}^{-2}$

$$v_7 = k24 \cdot [\text{CYCD}] \cdot [\text{P27}] \tag{33}$$

Table 19: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
k24			1000.0	$(3600\text{ s})^{-1}$	<input checked="" type="checkbox"/>

## 8.8 Reaction v8

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

**Name** v8

### Reaction equation



### Reactant

Table 20: Properties of each reactant.

Id	Name	SBO
CD	P27:cyclin D:Cdk2	

### Products

Table 21: Properties of each product.

Id	Name	SBO
CYCD	cyclin D:Cdk2	
P27	P27	

### Kinetic Law

**Derived unit**  $(3600\text{ s})^{-1} \cdot \text{l}^{-1}$

$$v_8 = k24r \cdot [\text{CD}] \quad (35)$$

Table 22: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
k24r			10.0	$(3600\text{ s})^{-1}$	<input checked="" type="checkbox"/>

### 8.9 Reaction v9

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

**Name** v9

**Reaction equation**



**Reactant**

Table 23: Properties of each reactant.

Id	Name	SBO
CYCA	cyclin A:Cdk2	

**Modifier**

Table 24: Properties of each modifier.

Id	Name	SBO
CDc20	Cdc20	

**Kinetic Law**

**Derived unit**  $(3600 \text{ s})^{-1} \cdot \text{l}^{-2}$

$$v_9 = K30 \cdot [\text{CDc20}] \cdot [\text{CYCA}] \quad (37)$$

### 8.10 Reaction v10

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

**Name** v10

**Reaction equation**



**Reactant**

Table 25: Properties of each reactant.

Id	Name	SBO
CA	P27:cyclin A:Cdk2	

**Modifier**

Table 26: Properties of each modifier.

Id	Name	SBO
CDc20	Cdc20	

**Product**

Table 27: Properties of each product.

Id	Name	SBO
P27	P27	

**Kinetic Law****Derived unit**  $(3600\text{ s})^{-1} \cdot \text{l}^{-2}$ 

$$v_{10} = K30 \cdot [\text{CA}] \cdot [\text{CDc20}] \quad (39)$$

**8.11 Reaction v11**

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

**Name** v11**Reaction equation****Reactant**

Table 28: Properties of each reactant.

Id	Name	SBO
CE	P27:cyclin E:Cdk2	

## Products

Table 29: Properties of each product.

Id	Name	SBO
CYCE	cyclin E:Cdk2	
P27	P27	

## Kinetic Law

**Derived unit**  $(3600\text{ s})^{-1} \cdot \text{l}^{-1}$

$$v_{11} = K25R \cdot [\text{CE}] \quad (41)$$

## 8.12 Reaction v12

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

**Name** v12

## Reaction equation



## Reactant

Table 30: Properties of each reactant.

Id	Name	SBO
CA	P27:cyclin A:Cdk2	

## Products

Table 31: Properties of each product.

Id	Name	SBO
CYCA	cyclin A:Cdk2	
P27	P27	

## Kinetic Law

**Derived unit**  $(3600\text{ s})^{-1} \cdot \text{l}^{-1}$

$$v_{12} = K25R \cdot [CA] \quad (43)$$

### 8.13 Reaction v13

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

**Name** v13

#### Reaction equation



#### Reactant

Table 32: Properties of each reactant.

Id	Name	SBO
CE	P27:cyclin E:Cdk2	

#### Modifiers

Table 33: Properties of each modifier.

Id	Name	SBO
CYCB	cyclin B:Cdk2	
CYCA	cyclin A:Cdk2	
CYCE	cyclin E:Cdk2	

#### Product

Table 34: Properties of each product.

Id	Name	SBO
P27	P27	

#### Kinetic Law

**Derived unit**  $\text{l}^{-1}$

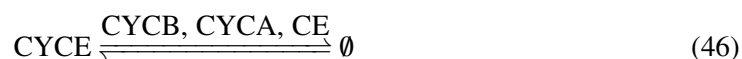
$$v_{13} = V8 \cdot [CE] \quad (45)$$

### 8.14 Reaction v14

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

**Name** v14

#### Reaction equation



#### Reactant

Table 35: Properties of each reactant.

Id	Name	SBO
CYCE	cyclin E:Cdk2	

#### Modifiers

Table 36: Properties of each modifier.

Id	Name	SBO
CYCB	cyclin B:Cdk2	
CYCA	cyclin A:Cdk2	
CE	P27:cyclin E:Cdk2	

#### Kinetic Law

**Derived unit**  $\text{l}^{-1}$

$$v_{14} = V8 \cdot [\text{CYCE}] \quad (47)$$

### 8.15 Reaction v15

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

**Name** v15

#### Reaction equation



#### Reactant

Table 37: Properties of each reactant.

Id	Name	SBO
P27	P27	

## Modifiers

Table 38: Properties of each modifier.

Id	Name	SBO
CYCA	cyclin A:Cdk2	
CYCB	cyclin B:Cdk2	
CYCE	cyclin E:Cdk2	

## Kinetic Law

**Derived unit**  $\text{l}^{-1}$

$$v_{15} = V6 \cdot [\text{P27}] \quad (49)$$

## 8.16 Reaction $v_{16}$

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

**Name**  $v_{16}$

## Reaction equation



## Reactant

Table 39: Properties of each reactant.

Id	Name	SBO
CE	P27:cyclin E:Cdk2	

## Modifiers



Table 40: Properties of each modifier.

Id	Name	SBO
CYCA	cyclin A:Cdk2	
CYCB	cyclin B:Cdk2	

## Product

Table 41: Properties of each product.

Id	Name	SBO
CYCE	cyclin E:Cdk2	

## Kinetic Law

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

$$v_{16} = V_6 \cdot [\text{CE}] \quad (51)$$

## 8.17 Reaction $v_{17}$

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

Name  $v_{17}$

## Reaction equation



## Reactant

Table 42: Properties of each reactant.

Id	Name	SBO
CD	P27:cyclin D:Cdk2	

## Modifiers

Table 43: Properties of each modifier.

Id	Name	SBO
CYCA	cyclin A:Cdk2	
CYCB	cyclin B:Cdk2	
CYCE	cyclin E:Cdk2	

## Product

Table 44: Properties of each product.

Id	Name	SBO
CYCD	cyclin D:Cdk2	

## Kinetic Law

**Derived unit**  $\text{l}^{-1}$

$$v_{17} = V_6 \cdot [\text{CD}] \quad (53)$$

## 8.18 Reaction $v_{18}$

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

**Name**  $v_{18}$

## Reaction equation



## Reactant

Table 45: Properties of each reactant.

Id	Name	SBO
CA	P27:cyclin A:Cdk2	

## Modifiers

Table 46: Properties of each modifier.

Id	Name	SBO
CYCB	cyclin B:Cdk2	
CYCE	cyclin E:Cdk2	

## Product

Table 47: Properties of each product.

Id	Name	SBO
CYCA	cyclin A:Cdk2	

## Kinetic Law

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

$$v_{18} = V_6 \cdot [\text{CA}] \quad (55)$$

## 8.19 Reaction $v_{19}$

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

**Name**  $v_{19}$

## Reaction equation



## Reactant

Table 48: Properties of each reactant.

Id	Name	SBO
CYCB	cyclin B:Cdk2	

## Modifiers

Table 49: Properties of each modifier.

Id	Name	SBO
CDc20	Cdc20	
CDh1	Cdh1	

**Kinetic Law****Derived unit**  $l^{-1}$ 

$$v_{19} = V2 \cdot [CYCB] \quad (57)$$

**8.20 Reaction v20**

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

**Name** v20**Reaction equation****Modifier**

Table 50: Properties of each modifier.

Id	Name	SBO
CDc20	Cdc20	

**Product**

Table 51: Properties of each product.

Id	Name	SBO
CDh1	Cdh1	

**Kinetic Law****Derived unit** contains undeclared units

$$v_{20} = \frac{(K3a + K3 \cdot [CDc20]) \cdot (1 - [CDh1])}{1 + J3 - [CDh1]} \quad (59)$$

Table 52: Properties of each parameter.

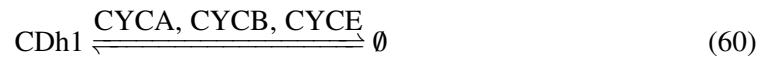
Id	Name	SBO	Value	Unit	Constant
J3			0.01	dimensionless	<input checked="" type="checkbox"/>
K3			140.00	$(3600\text{ s})^{-1}$	<input checked="" type="checkbox"/>
K3a			7.50	$(3600\text{ s})^{-1}$	<input checked="" type="checkbox"/>

## 8.21 Reaction v21

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

**Name** v21

### Reaction equation



### Reactant

Table 53: Properties of each reactant.

Id	Name	SBO
CDh1	Cdh1	

### Modifiers

Table 54: Properties of each modifier.

Id	Name	SBO
CYCA	cyclin A:Cdk2	
CYCB	cyclin B:Cdk2	
CYCE	cyclin E:Cdk2	

### Kinetic Law

**Derived unit**  $\text{l}^{-1}$

$$v_{21} = \frac{V4 \cdot [\text{CDh1}]}{J4 + [\text{CDh1}]} \quad (61)$$

Table 55: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
J4			0.01	dimensionless	<input checked="" type="checkbox"/>

### 8.22 Reaction v22

This is a reversible reaction of one reactant forming no product.

**Name** v22

#### Reaction equation



#### Reactant

Table 56: Properties of each reactant.

Id	Name	SBO
PPX	PPX	

#### Kinetic Law

**Derived unit**  $(3600 \text{ s})^{-1} \cdot \text{l}^{-1}$

$$v_{22} = K34 \cdot [\text{PPX}] \quad (63)$$

Table 57: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
K34			0.05	$(3600 \text{ s})^{-1}$	<input checked="" type="checkbox"/>

### 8.23 Reaction v23

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

**Name** v23

#### Reaction equation



## Modifier

Table 58: Properties of each modifier.

Id	Name	SBO
CYCB	cyclin B:Cdk2	

## Product

Table 59: Properties of each product.

Id	Name	SBO
IEP	phosphorylated intermediary enzyme	

## Kinetic Law

**Derived unit** contains undeclared units

$$v_{23} = \frac{K31 \cdot [\text{CYCB}] \cdot (1 - [\text{IEP}])}{1 + J31 - [\text{IEP}]} \quad (65)$$

Table 60: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
J31			0.01	dimensionless	✓
K31			0.70	(3600 s) <sup>-1</sup>	✓

### 8.24 Reaction v24

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

**Name** v24

#### Reaction equation



## Reactant

Table 61: Properties of each reactant.

Id	Name	SBO
IEP	phosphorylated intermediary enzyme	

## Modifier

Table 62: Properties of each modifier.

Id	Name	SBO
PPX	PPX	

## Kinetic Law

**Derived unit**  $(3600 \text{ s})^{-1} \cdot \text{l}^{-2}$

$$v_{24} = \frac{K32 \cdot [\text{IEP}] \cdot [\text{PPX}]}{J32 + [\text{IEP}]} \quad (67)$$

Table 63: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
J32			0.01	dimensionless	<input checked="" type="checkbox"/>
K32			1.80	$(3600 \text{ s})^{-1}$	<input checked="" type="checkbox"/>

## 8.25 Reaction v25

This is a reversible reaction of one reactant forming no product.

**Name** v25

## Reaction equation



## Reactant

Table 64: Properties of each reactant.

Id	Name	SBO
CDc20T	inactive Cdc20	



## Kinetic Law

**Derived unit**  $(3600\text{ s})^{-1} \cdot \text{l}^{-1}$

$$v_{25} = K_{12} \cdot [\text{CDc20T}] \quad (69)$$

## 8.26 Reaction v26

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

**Name** v26

## Reaction equation



## Modifiers

Table 65: Properties of each modifier.

Id	Name	SBO
CDc20T	inactive Cdc20	
IEP	phosphorylated intermediary enzyme	

## Product

Table 66: Properties of each product.

Id	Name	SBO
CDc20	Cdc20	

## Kinetic Law

**Derived unit**  $(3600\text{ s})^{-1} \cdot \text{l}^{-2}$

$$v_{26} = \frac{K_{13} \cdot ([\text{CDc20}] + [\text{CDc20T}]) \cdot [\text{IEP}]}{J_{13} - [\text{CDc20}] + [\text{CDc20T}]} \quad (71)$$

Table 67: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
J13			0.005	dimensionless	<input checked="" type="checkbox"/>
K13			5.000	$(3600\text{ s})^{-1}$	<input checked="" type="checkbox"/>

## 8.27 Reaction v27

This is a reversible reaction of one reactant forming no product.

**Name** v27

### Reaction equation



### Reactant

Table 68: Properties of each reactant.

Id	Name	SBO
CDc20	Cdc20	

### Kinetic Law

**Derived unit**  $(3600\text{ s})^{-1} \cdot \text{l}^{-1}$

$$v_{27} = \frac{K14 \cdot [\text{CDc20}]}{J14 + [\text{CDc20}]} \quad (73)$$

Table 69: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
J14			0.005	dimensionless	<input checked="" type="checkbox"/>
K14			2.500	$(3600\text{ s})^{-1}$	<input checked="" type="checkbox"/>

## 8.28 Reaction v28

This is a reversible reaction of one reactant forming no product.

**Name** v28

### Reaction equation



### Reactant

Table 70: Properties of each reactant.

Id	Name	SBO
CDc20	Cdc20	

### Kinetic Law

**Derived unit**  $(3600 \text{ s})^{-1} \cdot \text{l}^{-1}$

$$v_{28} = K12 \cdot [\text{CDc20}] \quad (75)$$

## 8.29 Reaction v29

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

**Name** v29

### Reaction equation



### Reactant

Table 71: Properties of each reactant.

Id	Name	SBO
var5	E2F:Rb	

### Modifiers

Table 72: Properties of each modifier.

Id	Name	SBO
CYCA	cyclin A:Cdk2	
CYCB	cyclin B:Cdk2	
CD	P27:cyclin D:Cdk2	

Id	Name	SBO
CYCD	cyclin D:Cdk2	
CYCE	cyclin E:Cdk2	

## Products

Table 73: Properties of each product.

Id	Name	SBO
var1	hypophosphorylated Rb	
var2	E2F	

## Kinetic Law

**Derived unit**  $(3600\text{ s})^{-1} \cdot \text{l}^{-2}$

$$v_{29} = K20 \cdot (LA \cdot [CYCA] + LB \cdot [CYCB] + LD \cdot ([CD] + [CYCD]) + LE \cdot [CYCE]) \cdot [\text{var5}] \quad (77)$$

## 8.30 Reaction v30

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

**Name** v30

## Reaction equation



## Reactant

Table 74: Properties of each reactant.

Id	Name	SBO
var6	phosphorylated E2F:Rb	

## Modifiers

Table 75: Properties of each modifier.

Id	Name	SBO
CYCA	cyclin A:Cdk2	

Id	Name	SBO
CYCB	cyclin B:Cdk2	
CD	P27:cyclin D:Cdk2	
CYCD	cyclin D:Cdk2	
CYCE	cyclin E:Cdk2	

## Products

Table 76: Properties of each product.

Id	Name	SBO
var1	hypophosphorylated Rb	
var3	phosphorylated E2F	

## Kinetic Law

**Derived unit**  $(3600\text{ s})^{-1} \cdot \text{l}^{-2}$

$$v_{30} = K20 \cdot (LA \cdot [CYCA] + LB \cdot [CYCB] + LD \cdot ([CD] + [CYCD]) + LE \cdot [CYCE]) \cdot [\text{var6}] \quad (79)$$

### 8.31 Reaction v31

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

**Name** v31

## Reaction equation



## Modifier

Table 77: Properties of each modifier.

Id	Name	SBO
MASS	mass	

## Product

Table 78: Properties of each product.

Id	Name	SBO
GM	general machinery for protein synthesis	

**Kinetic Law****Derived unit**  $(3600\text{ s})^{-1} \cdot \text{l}^{-1}$ 

$$v_{31} = K27 \cdot [\text{MASS}] \cdot r31\text{switch} \quad (81)$$

Table 79: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
K27			0.2	$(3600\text{ s})^{-1}$	<input checked="" type="checkbox"/>

**8.32 Reaction v32**

This is a reversible reaction of one reactant forming no product.

**Name** v32**Reaction equation****Reactant**

Table 80: Properties of each reactant.

Id	Name	SBO
GM	general machinery for protein synthesis	

**Kinetic Law****Derived unit**  $(3600\text{ s})^{-1} \cdot \text{l}^{-1}$ 

$$v_{32} = K28 \cdot [\text{GM}] \quad (83)$$

Table 81: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
K28			0.2	$(3600\text{ s})^{-1}$	<input checked="" type="checkbox"/>

### 8.33 Reaction v33

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

**Name** v33

#### Reaction equation



#### Modifier

Table 82: Properties of each modifier.

Id	Name	SBO
GM	general machinery for protein synthesis	

#### Product

Table 83: Properties of each product.

Id	Name	SBO
MASS	mass	

#### Kinetic Law

**Derived unit**  $(3600\text{ s})^{-1} \cdot \text{l}^{-1}$

$$v_{33} = \text{eps} \cdot \text{MU} \cdot [\text{GM}] \quad (85)$$

Table 84: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
MU			0.061	$(3600\text{ s})^{-1}$	<input checked="" type="checkbox"/>

### 8.34 Reaction v34

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

**Name** v34

#### Reaction equation



#### Modifier

Table 85: Properties of each modifier.

Id	Name	SBO
DRG	delayed-response genes	

#### Product

Table 86: Properties of each product.

Id	Name	SBO
ERG	early-response genes	

#### Kinetic Law

**Derived unit** contains undeclared units

$$v_{34} = \frac{\text{eps} \cdot k15}{1 + \frac{[\text{DRG}]^2}{J15^2}} \quad (87)$$

Table 87: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
J15			0.10	dimensionless	<input checked="" type="checkbox"/>
k15			0.25	(3600 s) <sup>-1</sup>	<input checked="" type="checkbox"/>

### 8.35 Reaction v35

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



**Name** v35

### Reaction equation



### Modifier

Table 88: Properties of each modifier.

Id	Name	SBO
CYCB	cyclin B:Cdk2	

### Product

Table 89: Properties of each product.

Id	Name	SBO
CDc20T	inactive Cdc20	

### Kinetic Law

**Derived unit**  $(3600 \text{ s})^{-1}$

$$v_{35} = \text{eps} \cdot (\text{K11a} + \text{K11} \cdot [\text{CYCB}]) \quad (89)$$

Table 90: Properties of each parameter.

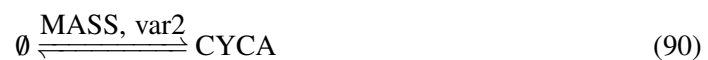
Id	Name	SBO	Value	Unit	Constant
K11			1.5	$(3600 \text{ s})^{-1}$	<input checked="" type="checkbox"/>
K11a			0.0	$(3600 \text{ s})^{-1}$	<input checked="" type="checkbox"/>

## 8.36 Reaction v36

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

**Name** v36

### Reaction equation



## Modifiers

Table 91: Properties of each modifier.

Id	Name	SBO
MASS	mass	
var2	E2F	

## Product

Table 92: Properties of each product.

Id	Name	SBO
CYCA	cyclin A:Cdk2	

## Kinetic Law

**Derived unit**  $(3600\text{ s})^{-1} \cdot 1^{-2}$

$$v_{36} = \text{eps} \cdot K29 \cdot [\text{MASS}] \cdot [\text{var2}] \quad (91)$$

Table 93: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
K29			0.05	$(3600\text{ s})^{-1}$	<input checked="" type="checkbox"/>

### 8.37 Reaction v37

This is a reversible reaction of no reactant forming one product.

**Name** v37

#### Reaction equation



## Product

Table 94: Properties of each product.

Id	Name	SBO
PPX	PPX	

### Kinetic Law

**Derived unit**  $(3600\text{ s})^{-1}$

$$v_{37} = \text{eps} \cdot \text{K33} \quad (93)$$

Table 95: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
K33			0.05	$(3600\text{ s})^{-1}$	<input checked="" type="checkbox"/>

### 8.38 Reaction v38

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

**Name** v38

### Reaction equation



### Modifier

Table 96: Properties of each modifier.

Id	Name	SBO
var2	E2F	

### Product

Table 97: Properties of each product.

Id	Name	SBO
CYCE	cyclin E:Cdk2	

### Kinetic Law

**Derived unit**  $(3600\text{ s})^{-1}$

$$v_{38} = \text{eps} \cdot (\text{K7a} + \text{K7} \cdot [\text{var2}]) \quad (95)$$

Table 98: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
K7			0.6	$(3600\text{ s})^{-1}$	<input checked="" type="checkbox"/>
K7a			0.0	$(3600\text{ s})^{-1}$	<input checked="" type="checkbox"/>

### 8.39 Reaction v39

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

**Name** v39

### Reaction equation



### Modifier

Table 99: Properties of each modifier.

Id	Name	SBO
DRG	delayed-response genes	

### Product

Table 100: Properties of each product.

Id	Name	SBO
CYCD	cyclin D:Cdk2	

### Kinetic Law

**Derived unit**  $(3600\text{ s})^{-1} \cdot \text{l}^{-1}$

$$v_{39} = \text{eps} \cdot \text{K9} \cdot [\text{DRG}] \quad (97)$$

Table 101: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
K9			2.5	$(3600\text{ s})^{-1}$	<input checked="" type="checkbox"/>

#### 8.40 Reaction v40

This is a reversible reaction of no reactant forming one product.

**Name** v40

#### Reaction equation



#### Product

Table 102: Properties of each product.

Id	Name	SBO
P27	P27	

#### Kinetic Law

**Derived unit**  $(3600\text{ s})^{-1}$

$$v_{40} = \text{eps} \cdot \text{K5} \quad (99)$$

Table 103: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
K5			20.0	$(3600\text{ s})^{-1}$	<input checked="" type="checkbox"/>

#### 8.41 Reaction v41

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

**Name** v41

#### Reaction equation



## Modifier

Table 104: Properties of each modifier.

Id	Name	SBO
ERG	early-response genes	

## Product

Table 105: Properties of each product.

Id	Name	SBO
DRG	delayed-response genes	

## Kinetic Law

**Derived unit** contains undeclared units

$$v_{41} = \text{eps} \cdot \left( \frac{k17 \cdot [\text{DRG}]^2}{J17^2 \cdot \left( 1 + \frac{[\text{DRG}]^2}{J17^2} \right)} + k17a \cdot [\text{ERG}] \right) \quad (101)$$

Table 106: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
J17			0.30	dimensionless	✓
k17			10.00	(3600 s) <sup>-1</sup>	✓
k17a			0.35	(3600 s) <sup>-1</sup>	✓

## 8.42 Reaction v42

This is a reversible reaction of no reactant forming one product.

**Name** v42

### Reaction equation



## Product

Table 107: Properties of each product.

Id	Name	SBO
CYCB	cyclin B:Cdk2	

### Kinetic Law

**Derived unit** contains undeclared units

$$v_{42} = \text{eps} \cdot \left( K1a + \frac{K1 \cdot [\text{CYCB}]^2}{J1^2 \cdot \left( 1 + \frac{[\text{CYCB}]^2}{J1^2} \right)} \right) \quad (103)$$

Table 108: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
J1			0.1	dimensionless	<input checked="" type="checkbox"/>
K1			0.6	$(3600 \text{ s})^{-1}$	<input checked="" type="checkbox"/>
K1a			0.1	$(3600 \text{ s})^{-1}$	<input checked="" type="checkbox"/>

### 8.43 Reaction v43

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

**Name** v43

### Reaction equation



### Reactant

Table 109: Properties of each reactant.

Id	Name	SBO
var4	retinoblastoma protein (Rb)	

### Modifiers

Table 110: Properties of each modifier.

Id	Name	SBO
CYCA	cyclin A:Cdk2	
CYCB	cyclin B:Cdk2	
CD	P27:cyclin D:Cdk2	
CYCD	cyclin D:Cdk2	
CYCE	cyclin E:Cdk2	

## Product

Table 111: Properties of each product.

Id	Name	SBO
var1	hypophosphorylated Rb	

## Kinetic Law

**Derived unit**  $(3600\text{ s})^{-1} \cdot \text{l}^{-2}$

$$v_{43} = K20 \cdot (LA \cdot [CYCA] + LB \cdot [CYCB] + LD \cdot ([CD] + [CYCD]) + LE \cdot [CYCE]) \cdot [\text{var4}] \quad (105)$$

## 8.44 Reaction v44

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

**Name** v44

## Reaction equation



## Reactant

Table 112: Properties of each reactant.

Id	Name	SBO
var1	hypophosphorylated Rb	

## Modifiers



Table 113: Properties of each modifier.

Id	Name	SBO
CYCB	cyclin B:Cdk2	
CYCA	cyclin A:Cdk2	
CYCE	cyclin E:Cdk2	

## Product

Table 114: Properties of each product.

Id	Name	SBO
var4	retinoblastoma protein (Rb)	

## Kinetic Law

**Derived unit**  $(3600\text{ s})^{-1} \cdot \text{l}^{-1}$

$$v_{44} = (K19 \cdot PP1A + K19a \cdot (PP1T - PP1A)) \cdot [\text{var1}] \quad (107)$$

Table 115: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
K19			20.0	$(3600\text{ s})^{-1}$	<input checked="" type="checkbox"/>
K19a			0.0	$(3600\text{ s})^{-1}$	<input checked="" type="checkbox"/>

## 8.45 Reaction v45

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

**Name** v45

## Reaction equation



## Reactant

Table 116: Properties of each reactant.

Id	Name	SBO
var5	E2F:Rb	

## Products

Table 117: Properties of each product.

Id	Name	SBO
var2	E2F	
var4	retinoblastoma protein (Rb)	

## Kinetic Law

**Derived unit**  $(3600\text{ s})^{-1} \cdot \text{l}^{-1}$

$$v_{45} = K_{26R} \cdot [\text{var5}] \quad (109)$$

## 8.46 Reaction v46

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

**Name** v46

## Reaction equation



## Reactant

Table 118: Properties of each reactant.

Id	Name	SBO
var2	E2F	

## Modifiers

Table 119: Properties of each modifier.

Id	Name	SBO
CYCA	cyclin A:Cdk2	
CYCB	cyclin B:Cdk2	

## Product

Table 120: Properties of each product.

Id	Name	SBO
var3	phosphorylated E2F	

## Kinetic Law

**Derived unit**  $(3600\text{ s})^{-1} \cdot \text{l}^{-1}$

$$v_{46} = (K23a + K23 \cdot ([CYCA] + [CYCB])) \cdot [\text{var2}] \quad (111)$$

## 8.47 Reaction v47

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

**Name** v47

## Reaction equation



## Reactant

Table 121: Properties of each reactant.

Id	Name	SBO
var3	phosphorylated E2F	

## Product

Table 122: Properties of each product.

Id	Name	SBO
var2	E2F	

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

### Kinetic Law

**Derived unit**  $(3600\text{ s})^{-1} \cdot \text{l}^{-1}$

$$v_{47} = K_{22} \cdot [\text{var3}] \quad (113)$$

### 8.48 Reaction v48

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

**Name** v48

### Reaction equation



### Reactants

Table 123: Properties of each reactant.

Id	Name	SBO
var2	E2F	
var4	retinoblastoma protein (Rb)	

### Product

Table 124: Properties of each product.

Id	Name	SBO
var5	E2F:Rb	

### Kinetic Law

**Derived unit**  $(3600\text{ s})^{-1} \cdot \text{l}^{-2}$

$$v_{48} = K_{26} \cdot [\text{var2}] \cdot [\text{var4}] \quad (115)$$

### 8.49 Reaction v49

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

**Name** v49

**Reaction equation**



**Reactant**

Table 125: Properties of each reactant.

Id	Name	SBO
var6	phosphorylated E2F:Rb	

**Products**

Table 126: Properties of each product.

Id	Name	SBO
var3	phosphorylated E2F	
var4	retinoblastoma protein (Rb)	

**Kinetic Law**

**Derived unit**  $(3600\text{ s})^{-1} \cdot \text{l}^{-1}$

$$v_{49} = K_{26R} \cdot [\text{var6}]$$

(117)

**8.50 Reaction v50**

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

**Name** v50

**Reaction equation**



**Reactants**

Table 127: Properties of each reactant.

Id	Name	SBO
var3	phosphorylated E2F	
var4	retinoblastoma protein (Rb)	

## Product

Table 128: Properties of each product.

Id	Name	SBO
var6	phosphorylated E2F:Rb	

## Kinetic Law

**Derived unit**  $(3600\text{ s})^{-1} \cdot \text{l}^{-2}$

$$v_{50} = K26 \cdot [\text{var3}] \cdot [\text{var4}] \quad (119)$$

## 8.51 Reaction v51

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

**Name** v51

## Reaction equation



## Reactant

Table 129: Properties of each reactant.

Id	Name	SBO
var6	phosphorylated E2F:Rb	

## Product

Table 130: Properties of each product.

Id	Name	SBO
var5	E2F:Rb	

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

### Kinetic Law

**Derived unit**  $(3600\text{ s})^{-1} \cdot \text{l}^{-1}$

$$v_{51} = K22 \cdot [\text{var6}] \quad (121)$$

### 8.52 Reaction v52

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

**Name** v52

### Reaction equation



### Reactant

Table 131: Properties of each reactant.

Id	Name	SBO
var5	E2F:Rb	

### Modifiers

Table 132: Properties of each modifier.

Id	Name	SBO
CYCA	cyclin A:Cdk2	
CYCB	cyclin B:Cdk2	

### Product

Table 133: Properties of each product.

Id	Name	SBO
var6	phosphorylated E2F:Rb	

## Kinetic Law

**Derived unit**  $(3600\text{ s})^{-1} \cdot \text{l}^{-1}$

$$v_{52} = (K23a + K23 \cdot ([\text{CYCA}] + [\text{CYCB}])) \cdot [\text{var5}] \quad (123)$$

## 9 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.

### 9.1 Species CDc20

**Name** Cdc20

**Initial concentration**  $0.00220177 \text{ dimensionless} \cdot \text{l}^{-1}$

This species takes part in seven reactions (as a reactant in [v27](#), [v28](#) and as a product in [v26](#) and as a modifier in [v9](#), [v10](#), [v19](#), [v20](#)).

$$\frac{d}{dt}\text{CDc20} = v_{26} - v_{27} - v_{28} \quad (124)$$

### 9.2 Species CDh1

**Name** Cdh1

**Initial concentration**  $6.53278 \cdot 10^{-4} \text{ dimensionless} \cdot \text{l}^{-1}$

This species takes part in three reactions (as a reactant in [v21](#) and as a product in [v20](#) and as a modifier in [v19](#)).

$$\frac{d}{dt}\text{CDh1} = v_{20} - v_{21} \quad (125)$$



### 9.3 Species CYCA

**Name** cyclin A:Cdk2

**Initial concentration** 1.4094 dimensionless · l<sup>-1</sup>

This species takes part in 17 reactions (as a reactant in v6, v9 and as a product in v12, v18, v36 and as a modifier in v13, v14, v15, v16, v17, v21, v29, v30, v43, v44, v46, v52).

$$\frac{d}{dt}CYCA = v_{12} + v_{18} + v_{36} - v_6 - v_9 \quad (126)$$

### 9.4 Species CYCB

**Name** cyclin B:Cdk2

**Initial concentration** 2.72898 dimensionless · l<sup>-1</sup>

This species takes part in 17 reactions (as a reactant in v19 and as a product in v42 and as a modifier in v13, v14, v15, v16, v17, v18, v21, v23, v29, v30, v35, v43, v44, v46, v52).

$$\frac{d}{dt}CYCB = v_{42} - v_{19} \quad (127)$$

### 9.5 Species CYCD

**Name** cyclin D:Cdk2

**Initial concentration** 0.43929 dimensionless · l<sup>-1</sup>

This species takes part in eight reactions (as a reactant in v4, v7 and as a product in v8, v17, v39 and as a modifier in v29, v30, v43).

$$\frac{d}{dt}CYCD = v_8 + v_{17} + v_{39} - v_4 - v_7 \quad (128)$$

### 9.6 Species CYCE

**Name** cyclin E:Cdk2

**Initial concentration** 0.0229112 dimensionless · l<sup>-1</sup>

This species takes part in 14 reactions (as a reactant in v5, v14 and as a product in v11, v16, v38 and as a modifier in v13, v15, v17, v18, v21, v29, v30, v43, v44).

$$\frac{d}{dt}CYCE = v_{11} + v_{16} + v_{38} - v_5 - v_{14} \quad (129)$$

## 9.7 Species DRG

**Name** delayed-response genes

**Initial concentration** 0.900533 dimensionless · l<sup>-1</sup>

This species takes part in four reactions (as a reactant in v2 and as a product in v41 and as a modifier in v34, v39).

$$\frac{d}{dt}\text{DRG} = v_{41} - v_2 \quad (130)$$

## 9.8 Species var2

**Name** E2F

**Initial concentration** 0.989986 dimensionless · l<sup>-1</sup>

This species takes part in seven reactions (as a reactant in v46, v48 and as a product in v29, v45, v47 and as a modifier in v36, v38).

$$\frac{d}{dt}\text{var2} = v_{29} + v_{45} + v_{47} - v_{46} - v_{48} \quad (131)$$

## 9.9 Species var5

**Name** E2F:Rb

**Initial concentration** 0.00478911 dimensionless · l<sup>-1</sup>

This species takes part in five reactions (as a reactant in v29, v45, v52 and as a product in v48, v51).

$$\frac{d}{dt}\text{var5} = v_{48} + v_{51} - v_{29} - v_{45} - v_{52} \quad (132)$$

## 9.10 Species ERG

**Name** early-response genes

**Initial concentration** 0.0121809 dimensionless · l<sup>-1</sup>

This species takes part in three reactions (as a reactant in v1 and as a product in v34 and as a modifier in v41).

$$\frac{d}{dt}\text{ERG} = v_{34} - v_1 \quad (133)$$

### 9.11 Species GM

**Name** general machinery for protein synthesis

**Initial concentration** 1.35565 dimensionless · l<sup>-1</sup>

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

This species takes part in three reactions (as a reactant in [v32](#) and as a product in [v31](#) and as a modifier in [v33](#)).

$$\frac{d}{dt}GM = v_{31} - v_{32} \quad (134)$$

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

### 9.12 Species var1

**Name** hypophosphorylated Rb

**Initial concentration** 9.97574 dimensionless · l<sup>-1</sup>

This species takes part in four reactions (as a reactant in [v44](#) and as a product in [v29](#), [v30](#), [v43](#)).

$$\frac{d}{dt}var1 = v_{29} + v_{30} + v_{43} - v_{44} \quad (135)$$

### 9.13 Species CDc20T

**Name** inactive Cdc20

**Initial concentration** 2.36733 dimensionless · l<sup>-1</sup>

This species takes part in three reactions (as a reactant in [v25](#) and as a product in [v35](#) and as a modifier in [v26](#)).

$$\frac{d}{dt}CDc20T = v_{35} - v_{25} \quad (136)$$

### 9.14 Species MASS

**Name** mass

**Initial concentration** 1.68776 dimensionless · l<sup>-1</sup>

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

This species takes part in three reactions (as a product in [v33](#) and as a modifier in [v31](#), [v36](#)).

$$\frac{d}{dt}MASS = v_{33} \quad (137)$$

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

### 9.15 Species P27

**Name** P27

**Initial concentration** 0.00922806 dimensionless · l<sup>-1</sup>

This species takes part in eleven reactions (as a reactant in v5, v6, v7, v15 and as a product in v3, v8, v10, v11, v12, v13, v40).

$$\frac{d}{dt}P27 = v_3 + v_8 + v_{10} + v_{11} + v_{12} + v_{13} + v_{40} - v_5 - v_6 - v_7 - v_{15} \quad (138)$$

### 9.16 Species CA

**Name** P27:cyclin A:Cdk2

**Initial concentration** 0.0356927 dimensionless · l<sup>-1</sup>

This species takes part in four reactions (as a reactant in v10, v12, v18 and as a product in v6).

$$\frac{d}{dt}CA = v_6 - v_{10} - v_{12} - v_{18} \quad (139)$$

### 9.17 Species CD

**Name** P27:cyclin D:Cdk2

**Initial concentration** 0.010976 dimensionless · l<sup>-1</sup>

This species takes part in seven reactions (as a reactant in v3, v8, v17 and as a product in v7 and as a modifier in v29, v30, v43).

$$\frac{d}{dt}CD = v_7 - v_3 - v_8 - v_{17} \quad (140)$$

### 9.18 Species CE

**Name** P27:cyclin E:Cdk2

**Initial concentration** 5.42587 · 10<sup>-4</sup> dimensionless · l<sup>-1</sup>

This species takes part in five reactions (as a reactant in v11, v13, v16 and as a product in v5 and as a modifier in v14).

$$\frac{d}{dt}CE = v_5 - v_{11} - v_{13} - v_{16} \quad (141)$$

### 9.19 Species `var3`

**Name** phosphorylated E2F

**Initial concentration** 3.98594 dimensionless · l<sup>-1</sup>

This species takes part in five reactions (as a reactant in [v47](#), [v50](#) and as a product in [v30](#), [v46](#), [v49](#)).

$$\frac{d}{dt}\text{var3} = v_{30} + v_{46} + v_{49} - v_{47} - v_{50} \quad (142)$$

### 9.20 Species `var6`

**Name** phosphorylated E2F:Rb

**Initial concentration** 0.0192822 dimensionless · l<sup>-1</sup>

This species takes part in five reactions (as a reactant in [v30](#), [v49](#), [v51](#) and as a product in [v50](#), [v52](#)).

$$\frac{d}{dt}\text{var6} = v_{50} + v_{52} - v_{30} - v_{49} - v_{51} \quad (143)$$

### 9.21 Species `IEP`

**Name** phosphorylated intermediary enzyme

**Initial concentration** 0.154655 dimensionless · l<sup>-1</sup>

This species takes part in three reactions (as a reactant in [v24](#) and as a product in [v23](#) and as a modifier in [v26](#)).

$$\frac{d}{dt}\text{IEP} = v_{23} - v_{24} \quad (144)$$

### 9.22 Species `PPX`

**Name** PPX

**Initial concentration** 1 dimensionless · l<sup>-1</sup>

This species takes part in three reactions (as a reactant in [v22](#) and as a product in [v37](#) and as a modifier in [v24](#)).

$$\frac{d}{dt}\text{PPX} = v_{37} - v_{22} \quad (145)$$

## 9.23 Species `var4`

**Name** retinoblastoma protein (Rb)

**Initial concentration**  $1.90871 \cdot 10^{-4}$  dimensionless  $\cdot l^{-1}$

This species takes part in six reactions (as a reactant in [v43](#), [v48](#), [v50](#) and as a product in [v44](#), [v45](#), [v49](#)).

$$\frac{d}{dt} \text{var4} = v_{44} + v_{45} + v_{49} - v_{43} - v_{48} - v_{50} \quad (146)$$

SBML2<sup>AT</sup>EX 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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