

SBML Model Report

Model name: “Ciliberto2003 - CyclinE / Cdk2 timer in the cell cycle of *Xenopus laevis* embryo”



May 17, 2018

1 General Overview

This is a document in SBML Level 2 Version 4 format. This model was created by the following two authors: Rahuman Sheriff¹ and Matthieu MAIRE² at April 23rd 2018 at 9:03 a. m. and last time modified at May first 2018 at 12:26 a. m. Table 1 provides an overview of the quantities of all components of this model.

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

Element	Quantity	Element	Quantity
compartment types	0	compartments	1
species types	0	species	16
events	0	constraints	0
reactions	30	function definitions	13
global parameters	25	unit definitions	5
rules	6	initial assignments	0

Model Notes

Ciliberto2003 - CyclinE / Cdk2 timer in the cell cycle of *Xenopus laevis* embryo

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This model is described in the article: [A kinetic model of the cyclin E/Cdk2 developmental timer in *Xenopus laevis* embryos](#). Ciliberto A, Petrus MJ, Tyson JJ, Sible JC. *Biophys. Chem.* 2003 Jul; 104(3): 573-589

Abstract:

Early cell cycles of *Xenopus laevis* embryos are characterized by rapid oscillations in the activity of two cyclin-dependent kinases. Cdk1 activity peaks at mitosis, driven by periodic degradation of cyclins A and B. In contrast, Cdk2 activity oscillates twice per cell cycle, despite a constant level of its partner, cyclin E. Cyclin E degrades at a fixed time after fertilization, normally corresponding to the midblastula transition. Based on published data and new experiments, we constructed a mathematical model in which: (1) oscillations in Cdk2 activity depend upon changes in phosphorylation, (2) Cdk2 participates in a negative feedback loop with the inhibitory kinase Wee1; (3) cyclin E is cooperatively removed from the oscillatory system; and (4) removed cyclin E is degraded by a pathway activated by cyclin E/Cdk2 itself. The model's predictions about embryos injected with Xic1, a stoichiometric inhibitor of cyclin E/Cdk2, were experimentally validated.

This model is hosted on [BioModels Database](#) and identified by: [BIOMD0000000697](#).

To cite BioModels Database, please use: [Chelliah V et al. BioModels: ten-year anniversary. Nucl. Acids Res. 2015, 43\(Database issue\):D542-8.](#)

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2 Unit Definitions

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

2.1 Unit `volume`

Name volume

Definition ml

2.2 Unit `time`

Name time

Definition 60 s

2.3 Unit `substance`

Name substance

Definition mmol

2.4 Unit `unit_0`

Name 1

Definition dimensionless⁰

2.5 Unit `unit_1`

Name 1/s

Definition s⁻¹

2.6 Unit `area`

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

Definition m²

2.7 Unit `length`

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

Definition m

3 Compartment

This model contains one compartment.

Table 2: Properties of all compartments.

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

3.1 Compartment `compartment`

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

Name embryo

4 Species

This model contains 16 species. The boundary condition of three of these species is set to `true` so that these species' amount cannot be changed by any reaction. 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
PCdk2_CycE	PCdk2_CycE	compartment	$\text{mmol} \cdot \text{ml}^{-1}$	<input type="checkbox"/>	<input type="checkbox"/>
Cdk2_CycE	Cdk2_CycE	compartment	$\text{mmol} \cdot \text{ml}^{-1}$	<input type="checkbox"/>	<input type="checkbox"/>
Wee1_a	Wee1_a	compartment	$\text{mmol} \cdot \text{ml}^{-1}$	<input type="checkbox"/>	<input type="checkbox"/>
Wee1_total	Wee1_total	compartment	$\text{mmol} \cdot \text{ml}^{-1}$	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Cdk2_CycErem	Cdk2_CycErem	compartment	$\text{mmol} \cdot \text{ml}^{-1}$	<input type="checkbox"/>	<input type="checkbox"/>
PCdk2_CycErem	PCdk2_CycErem	compartment	$\text{mmol} \cdot \text{ml}^{-1}$	<input type="checkbox"/>	<input type="checkbox"/>
Deg_a	Deg_CycE	compartment	$\text{mmol} \cdot \text{ml}^{-1}$	<input type="checkbox"/>	<input type="checkbox"/>
Xic	Xic	compartment	$\text{mmol} \cdot \text{ml}^{-1}$	<input type="checkbox"/>	<input type="checkbox"/>
Xic_Cdk2_CycE	Xic_Cdk2_CycE	compartment	$\text{mmol} \cdot \text{ml}^{-1}$	<input type="checkbox"/>	<input type="checkbox"/>
Xic_PCdk2_CycE	Xic_PCdk2_CycE	compartment	$\text{mmol} \cdot \text{ml}^{-1}$	<input type="checkbox"/>	<input type="checkbox"/>
Xic_Cdk2_CycErem	Xic_Cdk2_CycErem	compartment	$\text{mmol} \cdot \text{ml}^{-1}$	<input type="checkbox"/>	<input type="checkbox"/>
Xic_PCdk2_CycErem	Xic_PCdk2_CycErem	compartment	$\text{mmol} \cdot \text{ml}^{-1}$	<input type="checkbox"/>	<input type="checkbox"/>
Xicrem	Xicrem	compartment	$\text{mmol} \cdot \text{ml}^{-1}$	<input type="checkbox"/>	<input type="checkbox"/>
Cyc_total	Cyc_total	compartment	$\text{mmol} \cdot \text{ml}^{-1}$	<input type="checkbox"/>	<input checked="" type="checkbox"/>
Xic_total	Xic_total	compartment	$\text{mmol} \cdot \text{ml}^{-1}$	<input type="checkbox"/>	<input checked="" type="checkbox"/>
Kin_a	Kin_a	compartment	$\text{mmol} \cdot \text{ml}^{-1}$	<input type="checkbox"/>	<input type="checkbox"/>

5 Parameters

This model contains 25 global parameters.

Table 4: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
Jwact	Jwact		0.010		<input checked="" type="checkbox"/>
Jwinact	Jwinact		0.010	dimensionless ⁰	<input checked="" type="checkbox"/>
kwact	kwact		0.750	s ⁻¹	<input checked="" type="checkbox"/>
kwinact	kwinact		1.500	s ⁻¹	<input checked="" type="checkbox"/>
Jiact	Jiact		0.010		<input checked="" type="checkbox"/>
Jiinact	Jiinact		0.010		<input checked="" type="checkbox"/>
kiact	kiact		0.150	s ⁻¹	<input checked="" type="checkbox"/>
kiinact	kiinact		0.600	s ⁻¹	<input checked="" type="checkbox"/>
Heav	Heav		0.000	dimensionless ⁰	<input type="checkbox"/>
kdact	kdact		0.023	s ⁻¹	<input checked="" type="checkbox"/>
theta	theta		0.300		<input checked="" type="checkbox"/>
kwee	kwee		1.500	s ⁻¹	<input checked="" type="checkbox"/>
k25A	k25A		0.100	s ⁻¹	<input checked="" type="checkbox"/>
kon	kon		0.020	s ⁻¹	<input checked="" type="checkbox"/>
koff	koff		10 ⁻⁴	s ⁻¹	<input checked="" type="checkbox"/>
kassoc	kassoc		0.100	s ⁻¹	<input checked="" type="checkbox"/>
kdisso	kdisso		0.001	s ⁻¹	<input checked="" type="checkbox"/>
kedeg	kedeg		0.017	s ⁻¹	<input checked="" type="checkbox"/>
kxdeg	kxdeg		0.010	s ⁻¹	<input checked="" type="checkbox"/>
phi	phi		0.039	dimensionless ⁰	<input type="checkbox"/>
epsilon	epsilon		0.001		<input checked="" type="checkbox"/>
pool	pool		0.000	dimensionless ⁰	<input type="checkbox"/>
n	n		4.000		<input checked="" type="checkbox"/>
L	L		0.400		<input checked="" type="checkbox"/>
x	x		-0.300		<input type="checkbox"/>

6 Function definitions

This is an overview of 13 function definitions.

6.1 Function definition `function_removed_from_oscillatory_system_1`

Name `function_removed_from_oscillatory_system_1`

Arguments `[Cdk2_CycE], kon, phi`

Mathematical Expression

$$\text{kon} \cdot \text{phi} \cdot [\text{Cdk2_CycE}] \quad (1)$$

6.2 Function definition [function_removed_from_oscillatory_system_2](#)**Name** function removed from oscillatory system_2**Arguments** [PCdk2_CycE], kon, phi**Mathematical Expression**

$$\text{kon} \cdot \text{phi} \cdot [\text{PCdk2_CycE}] \quad (2)$$

6.3 Function definition [Function_for_degradation_of_Xic_Cyc_Cdk_1](#)**Name** Function for degradation of Xic_Cyc_Cdk_1**Arguments** [Deg_a], [Xic_PCdk2_CycErem], kedeg**Mathematical Expression**

$$\text{kedeg} \cdot [\text{Xic_PCdk2_CycErem}] \cdot [\text{Deg_a}] \quad (3)$$

6.4 Function definition [Function_for_degradation_of_Xic_Cyc_Cdk_2](#)**Name** Function for degradation of Xic_Cyc_Cdk_2**Arguments** [Deg_a], [Xic_Cdk2_CycErem], kedeg**Mathematical Expression**

$$\text{kedeg} \cdot [\text{Xic_Cdk2_CycErem}] \cdot [\text{Deg_a}] \quad (4)$$

6.5 Function definition [function_Hill_Cdk2_CycE_removal_1](#)**Name** function Hill_Cdk2_CycE_removal_1**Arguments** Heav, kdact**Mathematical Expression**

$$\text{kdact} \cdot \text{Heav} \quad (5)$$

6.6 Function definition [Function_phosphorylation_with_Wee1_1](#)**Name** Function phosphorylation with Wee1_1**Arguments** [Wee1_a], [Xic_Cdk2_CycE], kwee**Mathematical Expression**

$$\text{kwee} \cdot [\text{Wee1_a}] \cdot [\text{Xic_Cdk2_CycE}] \quad (6)$$

6.7 Function definition [Function_phosphorylation_with_Wee1_2](#)

Name Function phosphorylation with Wee1_2

Arguments [Cdk2_CycE], [Wee1_a], kwee

Mathematical Expression

$$kwee \cdot [Wee1_a] \cdot [Cdk2_CycE] \quad (7)$$

6.8 Function definition [Function_for_Kin_a_1](#)

Name Function for Kin_a_1

Arguments [Cdk2_CycE], Jiact, Jiinact, [Kin_a], kiact, kiinact

Mathematical Expression

$$\frac{kiact \cdot (1 - [Kin_a])}{Jiact + 1 - [Kin_a]} - \frac{kiinact \cdot [Cdk2_CycE] \cdot [Kin_a]}{Jiinact + [Kin_a]} \quad (8)$$

6.9 Function definition [Function_for_degradation_of_Xic_Cyc_Cdk_3](#)

Name Function for degradation of Xic_Cyc_Cdk_3

Arguments [Cdk2_CycErem], [Deg_a], kedeg

Mathematical Expression

$$kedeg \cdot [Cdk2_CycErem] \cdot [Deg_a] \quad (9)$$

6.10 Function definition [Function_for_degradation_of_Xic_Cyc_Cdk_4](#)

Name Function for degradation of Xic_Cyc_Cdk_4

Arguments [Deg_a], [PCdk2_CycErem], kedeg

Mathematical Expression

$$kedeg \cdot [PCdk2_CycErem] \cdot [Deg_a] \quad (10)$$

6.11 Function definition [function_removed_from_oscillatory_system_3](#)

Name function removed from oscillatory system_3

Arguments [Xic_PCdk2_CycE], kon, phi

Mathematical Expression

$$kon \cdot phi \cdot [Xic_PCdk2_CycE] \quad (11)$$

6.12 Function definition `function_removed_from_oscillatory_system_4`

Name `function_removed_from_oscillatory_system_4`

Arguments `[Xic_Cdk2_CycE]`, `kon`, `phi`

Mathematical Expression

$$\text{kon} \cdot \text{phi} \cdot [\text{Xic_Cdk2_CycE}] \quad (12)$$

6.13 Function definition `Function_for_Wee1_a_1`

Name `Function_for_Wee1_a_1`

Arguments `Jwact`, `Jwinact`, `[Kin_a]`, `[Wee1_a]`, `[Wee1_total]`, `kwact`, `kwinact`

Mathematical Expression

$$\frac{\text{kwact} \cdot ([\text{Wee1_total}] - [\text{Wee1_a}])}{\text{Jwact} + [\text{Wee1_total}] - [\text{Wee1_a}]} - \frac{\text{kwinact} \cdot [\text{Kin_a}] \cdot [\text{Wee1_a}]}{\text{Jwinact} + [\text{Wee1_a}]} \quad (13)$$

7 Rules

This is an overview of six rules.

7.1 Rule `Cyc_total`

Rule `Cyc_total` is an assignment rule for species `Cyc_total`:

$$\begin{aligned} \text{Cyc_total} = & [\text{Xic_PCdk2_CycE}] + [\text{Xic_Cdk2_CycE}] + [\text{Xic_PCdk2_CycErem}] \\ & + [\text{Xic_Cdk2_CycErem}] + [\text{PCdk2_CycErem}] \\ & + [\text{Cdk2_CycErem}] + [\text{Cdk2_CycE}] + [\text{PCdk2_CycE}] \end{aligned} \quad (14)$$

Derived unit $\text{mmol} \cdot \text{ml}^{-1}$

7.2 Rule `Xic_total`

Rule `Xic_total` is an assignment rule for species `Xic_total`:

$$\begin{aligned} \text{Xic_total} & \quad (15) \\ = & \frac{[\text{Xic}] + [\text{Xic_PCdk2_CycE}] + [\text{Xic_Cdk2_CycE}] + [\text{Xic_PCdk2_CycErem}] + [\text{Xic_Cdk2_CycErem}] + [\text{Xicrem}]}{3} \end{aligned}$$

7.3 Rule `pool`

Rule `pool` is an assignment rule for parameter `pool`:

$$\text{pool} = [\text{Cdk2_CycErem}] + [\text{PCdk2_CycErem}] + [\text{Xic_Cdk2_CycErem}] + [\text{Xic_PCdk2_CycErem}] \quad (16)$$

Derived unit $\text{mmol} \cdot \text{ml}^{-1}$

7.4 Rule ϕ

Rule ϕ is an assignment rule for parameter ϕ :

$$\phi = \frac{\text{epsilon} + \text{pool}^n}{L^n + \text{pool}^n} \quad (17)$$

7.5 Rule x

Rule x is an assignment rule for parameter x :

$$x = [\text{Cdk2.CycErem}] - \text{theta} \quad (18)$$

7.6 Rule Heav

Rule Heav is an assignment rule for parameter Heav :

$$\text{Heav} = \begin{cases} 0 & \text{if } x < 0 \\ 1 & \text{otherwise} \end{cases} \quad (19)$$

8 Reactions

This model contains 30 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	Xic_Cdk2_CycE- _association	Xic_Cdk2_CycE_association	$Xic + Cdk2_CycE \longrightarrow Xic_Cdk2_CycE$	
2	Xic_Cdk2- _CycErem- _association	Xic_Cdk2_CycErem_association	$Xic + Cdk2_CycErem \longrightarrow Xic_Cdk2_CycErem$	
3	Xic_Cdk2_CycE- _dissociation	Xic_Cdk2_CycE_dissociation	$Xic_Cdk2_CycE \longrightarrow Xic + Cdk2_CycE$	
4	Xic_Cdk2- _CycErem- _dissociation	Xic_Cdk2_CycErem_dissociation	$Xic_Cdk2_CycErem \longrightarrow Xic + Cdk2_CycErem$	
5	Cdk2_CycErem- _to_not_rem	Cdk2_CycErem_to_not_rem	$Cdk2_CycErem \longrightarrow Cdk2_CycE$	
6	PCdk2_CycE_to- _not_rem	PCdk2_CycE_to_not_rem	$PCdk2_CycErem \longrightarrow PCdk2_CycE$	
7	Cdk2_CycE_to- _rem	Cdk2_CycE_to_rem	$Cdk2_CycE \longrightarrow Cdk2_CycErem$	
8	PCdk2_CycE_to- _rem	PCdk2_CycE_to_rem	$PCdk2_CycE \longrightarrow PCdk2_CycErem$	
9	X_degradation	X_degradation	$Xic_Cdk2_CycErem \longrightarrow Cdk2_CycErem$	
10	X_degradation- _phosphorylated- _complex	X_degradation_phosphorylated_complex	$Xic_PCdk2_CycErem \longrightarrow PCdk2_CycErem$	

Nº	Id	Name	Reaction Equation	SBO
11	Degradation- _XicPCdk2- _CycErem	Degradation_XicPCdk2_CycErem	$\text{Xic_PCdk2_CycErem} \xrightarrow{\text{Deg_a}} \text{Xicrem}$	
12	Degradation- _XicCdk2- _CycErem	Degradation_XicCdk2_CycErem	$\text{Xic_Cdk2_CycErem} \xrightarrow{\text{Deg_a}} \text{Xicrem}$	
13	Dephos_Xic- _PCdk2_CycE	Dephos_Xic_PCdk2_CycE	$\text{Xic_PCdk2_CycE} \longrightarrow \text{Xic_Cdk2_CycE}$	
14	Dephos_PCdk2- _CycE	Dephos_PCdk2_CycE	$\text{PCdk2_CycE} \longrightarrow \text{Cdk2_CycE}$	
15	Degradation- _increase	Degradation_increase	$\emptyset \longrightarrow \text{Deg_a}$	
16	Phos_Xic_PCdk2- _CycE	Phos_Xic_PCdk2_CycE	$\text{Xic_Cdk2_CycE} \xrightarrow{\text{Wee1_a}} \text{Xic_PCdk2_CycE}$	
17	Phos_PCdk2_CycE	Phos_PCdk2_CycE	$\text{Cdk2_CycE} \xrightarrow{\text{Wee1_a}} \text{PCdk2_CycE}$	
18	Kinase_- _regulation	Kinase_regulation	$\text{Cdk2_CycE} \xrightarrow{\text{Cdk2_CycE}} \text{Kin_a} + \text{Cdk2_CycE}$	
19	Xic_PCdk2_CycE- _association	Xic_PCdk2_CycE_association	$\text{Xic} + \text{PCdk2_CycE} \longrightarrow \text{Xic_PCdk2_CycE}$	
20	Xic_PCdk2- _CycErem- _association	Xic_PCdk2_CycErem_association	$\text{Xic} + \text{PCdk2_CycErem} \longrightarrow \text{Xic_PCdk2_CycErem}$	
21	Xic_PCdk2_CycE- _dissociation	Xic_PCdk2_CycE_dissociation	$\text{Xic_PCdk2_CycE} \longrightarrow \text{Xic} + \text{PCdk2_CycE}$	
22	Xic_PCdk2- _CycErem- _dissociation	Xic_PCdk2_CycErem_dissociation	$\text{Xic_PCdk2_CycErem} \longrightarrow \text{Xic} + \text{PCdk2_CycErem}$	

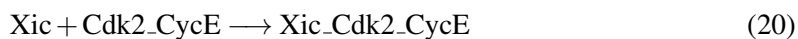
Nº	Id	Name	Reaction Equation	SBO
23	Degradation- _Cdk2_CycErem	Degradation_Cdk2_CycErem	$\text{Cdk2_CycErem} \xrightarrow{\text{Deg_a}} \emptyset$	
24	Degradation- _PCdk2_CycErem	Degradation_PCdk2_CycErem	$\text{PCdk2_CycErem} \xrightarrow{\text{Deg_a}} \emptyset$	
25	Xicrem- _degradation	Xicrem degradation	$\text{Xicrem} \longrightarrow \emptyset$	
26	Xic_PCdk2- _CycErem_to- _not_rem	Xic_PCdk2_CycErem_to_not_rem	$\text{Xic_PCdk2_CycErem} \longrightarrow \text{Xic_PCdk2_CycE}$	
27	Xic_Cdk2- _CycErem_to- _not_rem	Xic_Cdk2_CycErem_to_not_rem	$\text{Xic_Cdk2_CycErem} \longrightarrow \text{Xic_Cdk2_CycE}$	
28	Xic_PCdk2_CycE- _to_rem	Xic_PCdk2_CycE_to_rem	$\text{Xic_PCdk2_CycE} \longrightarrow \text{Xic_PCdk2_CycErem}$	
29	Xic_Cdk2_CycE- _to_rem	Xic_Cdk2_CycE_to_rem	$\text{Xic_Cdk2_CycE} \longrightarrow \text{Xic_Cdk2_CycErem}$	
30	Wee1_regulation	Wee1_regulation	$\emptyset \xrightarrow{\text{Kin_a, Wee1_total}} \text{Wee1_a}$	

8.1 Reaction `Xic_Cdk2_CycE_association`

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

Name `Xic_Cdk2_CycE_association`

Reaction equation



Reactants

Table 6: Properties of each reactant.

Id	Name	SBO
<code>Xic</code>	<code>Xic</code>	
<code>Cdk2_CycE</code>	<code>Cdk2_CycE</code>	

Product

Table 7: Properties of each product.

Id	Name	SBO
<code>Xic_Cdk2_CycE</code>	<code>Xic_Cdk2_CycE</code>	

Kinetic Law

Derived unit $\text{s}^{-1} \cdot (0.0010 \text{ mol})^2 \cdot \text{ml}^{-1}$

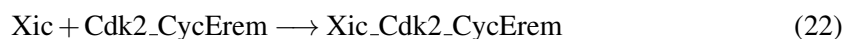
$$v_1 = \text{vol}(\text{compartment}) \cdot k_{\text{assoc}} \cdot [\text{Xic}] \cdot [\text{Cdk2_CycE}] \quad (21)$$

8.2 Reaction `Xic_Cdk2_CycErem_association`

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

Name `Xic_Cdk2_CycErem_association`

Reaction equation



Reactants

Table 8: Properties of each reactant.

Id	Name	SBO
Xic	Xic	
Cdk2_CycErem	Cdk2_CycErem	

Product

Table 9: Properties of each product.

Id	Name	SBO
Xic_Cdk2_CycErem	Xic_Cdk2_CycErem	

Kinetic Law

Derived unit $\text{s}^{-1} \cdot (0.0010 \text{ mol})^2 \cdot \text{ml}^{-1}$

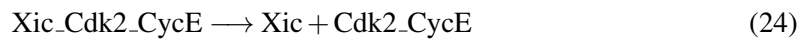
$$v_2 = \text{vol}(\text{compartment}) \cdot k_{\text{assoc}} \cdot [\text{Xic}] \cdot [\text{Cdk2_CycErem}] \quad (23)$$

8.3 Reaction Xic_Cdk2_CycE_dissociation

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

Name Xic_Cdk2_CycE_dissociation

Reaction equation



Reactant

Table 10: Properties of each reactant.

Id	Name	SBO
Xic_Cdk2_CycE	Xic_Cdk2_CycE	

Products

Table 11: Properties of each product.

Id	Name	SBO
Xic	Xic	
Cdk2_CycE	Cdk2_CycE	

Kinetic Law

Derived unit $\text{s}^{-1} \cdot \text{mmol}$

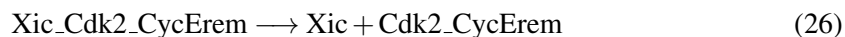
$$v_3 = \text{vol}(\text{compartment}) \cdot k_{\text{dissoc}} \cdot [\text{Xic_Cdk2_CycE}] \quad (25)$$

8.4 Reaction Xic_Cdk2_CycErem_dissociation

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

Name Xic_Cdk2_CycErem_dissociation

Reaction equation



Reactant

Table 12: Properties of each reactant.

Id	Name	SBO
Xic_Cdk2_CycErem	Xic_Cdk2_CycErem	

Products

Table 13: Properties of each product.

Id	Name	SBO
Xic	Xic	
Cdk2_CycErem	Cdk2_CycErem	

Kinetic Law

Derived unit $\text{s}^{-1} \cdot \text{mmol}$

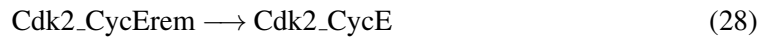
$$v_4 = \text{vol}(\text{compartment}) \cdot k_{\text{dissoc}} \cdot [\text{Xic_Cdk2_CycErem}] \quad (27)$$

8.5 Reaction Cdk2_CycErem_to_not_rem

This is an irreversible reaction of one reactant forming one product.

Name Cdk2_CycErem_to_not_rem

Reaction equation



Reactant

Table 14: Properties of each reactant.

Id	Name	SBO
Cdk2_CycErem	Cdk2_CycErem	

Product

Table 15: Properties of each product.

Id	Name	SBO
Cdk2_CycE	Cdk2_CycE	

Kinetic Law

Derived unit $\text{s}^{-1} \cdot \text{mmol}$

$$v_5 = \text{vol}(\text{compartment}) \cdot k_{\text{off}} \cdot [\text{Cdk2_CycErem}] \quad (29)$$

8.6 Reaction PCdk2_CycE_to_not_rem

This is an irreversible reaction of one reactant forming one product.

Name PCdk2_CycE_to_not_rem

Reaction equation



Reactant

Table 16: Properties of each reactant.

Id	Name	SBO
PCdk2_CycErem	PCdk2_CycErem	

Product

Table 17: Properties of each product.

Id	Name	SBO
PCdk2_CycE	PCdk2_CycE	

Kinetic Law

Derived unit $\text{s}^{-1} \cdot \text{mmol}$

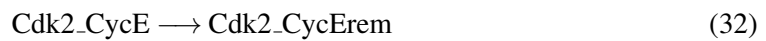
$$v_6 = \text{vol}(\text{compartment}) \cdot \text{koff} \cdot [\text{PCdk2_CycErem}] \quad (31)$$

8.7 Reaction Cdk2_CycE_to_rem

This is an irreversible reaction of one reactant forming one product.

Name Cdk2_CycE_to_rem

Reaction equation



Reactant

Table 18: Properties of each reactant.

Id	Name	SBO
Cdk2_CycE	Cdk2_CycE	

Product

Table 19: Properties of each product.

Id	Name	SBO
Cdk2_CycErem	Cdk2_CycErem	

Kinetic Law

Derived unit $\text{s}^{-1} \cdot \text{mmol}$

$$v_7 = \text{vol}(\text{compartment}) \cdot \text{function_removed_from_oscillatory_system_1}([Cdk2_CycE], \text{kon}, \text{phi}) \quad (33)$$

$$\text{function_removed_from_oscillatory_system_1}([Cdk2_CycE], \text{kon}, \text{phi}) = \text{kon} \cdot \text{phi} \cdot [Cdk2_CycE] \quad (34)$$

$$\text{function_removed_from_oscillatory_system_1}([Cdk2_CycE], \text{kon}, \text{phi}) = \text{kon} \cdot \text{phi} \cdot [Cdk2_CycE] \quad (35)$$

8.8 Reaction PCdk2_CycE_to_rem

This is an irreversible reaction of one reactant forming one product.

Name PCdk2_CycE_to_rem

Reaction equation



Reactant

Table 20: Properties of each reactant.

Id	Name	SBO
PCdk2_CycE	PCdk2_CycE	

Product

Table 21: Properties of each product.

Id	Name	SBO
PCdk2_CycErem	PCdk2_CycErem	

Kinetic Law

Derived unit $\text{s}^{-1} \cdot \text{mmol}$

$$v_8 = \text{vol}(\text{compartment}) \cdot \text{function_removed_from_oscillatory_system_2}([\text{PCdk2_CycE}], \text{kon}, \text{phi}) \quad (37)$$

$$\begin{aligned} &\text{function_removed_from_oscillatory_system_2}([\text{PCdk2_CycE}], \text{kon}, \text{phi}) \\ &= \text{kon} \cdot \text{phi} \cdot [\text{PCdk2_CycE}] \end{aligned} \quad (38)$$

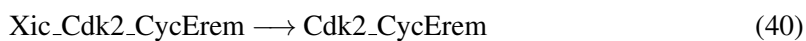
$$\begin{aligned} &\text{function_removed_from_oscillatory_system_2}([\text{PCdk2_CycE}], \text{kon}, \text{phi}) \\ &= \text{kon} \cdot \text{phi} \cdot [\text{PCdk2_CycE}] \end{aligned} \quad (39)$$

8.9 Reaction X_degradation

This is an irreversible reaction of one reactant forming one product.

Name X_degradation

Reaction equation



Reactant

Table 22: Properties of each reactant.

Id	Name	SBO
Xic_Cdk2_CycErem	Xic_Cdk2_CycErem	

Product

Table 23: Properties of each product.

Id	Name	SBO
Cdk2_CycErem	Cdk2_CycErem	

Kinetic Law

Derived unit $\text{s}^{-1} \cdot \text{mmol}$

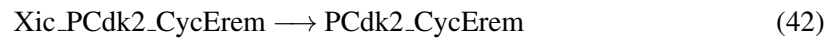
$$v_9 = \text{vol}(\text{compartment}) \cdot kxdeg \cdot [\text{Xic_Cdk2_CycErem}] \quad (41)$$

8.10 Reaction X_degradation_phosphorylated_complex

This is an irreversible reaction of one reactant forming one product.

Name X_degradation_phosphorylated_complex

Reaction equation



Reactant

Table 24: Properties of each reactant.

Id	Name	SBO
Xic_PCdk2_CycErem	Xic_PCdk2_CycErem	

Product

Table 25: Properties of each product.

Id	Name	SBO
PCdk2_CycErem	PCdk2_CycErem	

Kinetic Law

Derived unit $\text{s}^{-1} \cdot \text{mmol}$

$$v_{10} = \text{vol}(\text{compartment}) \cdot kxdeg \cdot [\text{Xic_PCdk2_CycErem}] \quad (43)$$

8.11 Reaction Degradation_XicPCdk2_CycErem

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

Name Degradation_XicPCdk2_CycErem

Reaction equation



Reactant

Table 26: Properties of each reactant.

Id	Name	SBO
Xic_PCdk2_CycErem	Xic_PCdk2_CycErem	

Modifier

Table 27: Properties of each modifier.

Id	Name	SBO
Deg_a	Deg_CycE	

Product

Table 28: Properties of each product.

Id	Name	SBO
Xicrem	Xicrem	

Kinetic Law

Derived unit $(0.0010\text{ l})^{-1} \cdot \text{s}^{-1} \cdot (0.0010\text{ mol})^2$

$$v_{11} = \text{vol}(\text{compartment}) \cdot \text{Function_for_degradation_of_Xic_Cyc_Cdk_1}([\text{Deg_a}], [\text{Xic_PCdk2_CycErem}], \text{kedeg}) \quad (45)$$

$$\begin{aligned} &\text{Function_for_degradation_of_Xic_Cyc_Cdk_1} ([\text{Deg_a}], [\text{Xic_PCdk2_CycErem}], \text{kedeg}) \\ &= \text{kedeg} \cdot [\text{Xic_PCdk2_CycErem}] \cdot [\text{Deg_a}] \end{aligned} \quad (46)$$

$$\begin{aligned} &\text{Function_for_degradation_of_Xic_Cyc_Cdk_1} ([\text{Deg_a}], [\text{Xic_PCdk2_CycErem}], \text{kedeg}) \\ &= \text{kedeg} \cdot [\text{Xic_PCdk2_CycErem}] \cdot [\text{Deg_a}] \end{aligned} \quad (47)$$

8.12 Reaction Degradation_XicCdk2_CycErem

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

Name Degradation_XicCdk2_CycErem

Reaction equation



Reactant

Table 29: Properties of each reactant.

Id	Name	SBO
Xic_Cdk2_CycErem	Xic_Cdk2_CycErem	

Modifier

Table 30: Properties of each modifier.

Id	Name	SBO
Deg_a	Deg_CycE	

Product

Table 31: Properties of each product.

Id	Name	SBO
Xicrem	Xicrem	

Kinetic Law

Derived unit $(0.0010\text{ l})^{-1} \cdot \text{s}^{-1} \cdot (0.0010\text{ mol})^2$

$$v_{12} = \text{vol}(\text{compartment}) \cdot \text{Function_for_degradation_of_Xic_Cyc_Cdk_2}([\text{Deg_a}], [\text{Xic_Cdk2_CycErem}], \text{kedeg}) \quad (49)$$

$$\begin{aligned} & \text{Function_for_degradation_of_Xic_Cyc_Cdk_2}([\text{Deg_a}], [\text{Xic_Cdk2_CycErem}], \text{kedeg}) \\ &= \text{kedeg} \cdot [\text{Xic_Cdk2_CycErem}] \cdot [\text{Deg_a}] \end{aligned} \quad (50)$$

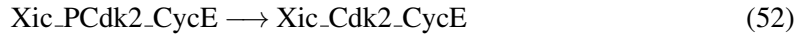
$$\begin{aligned} & \text{Function_for_degradation_of_Xic_Cyc_Cdk_2}([\text{Deg_a}], [\text{Xic_Cdk2_CycErem}], \text{kedeg}) \\ &= \text{kedeg} \cdot [\text{Xic_Cdk2_CycErem}] \cdot [\text{Deg_a}] \end{aligned} \quad (51)$$

8.13 Reaction Dephos_Xic_PCdk2_CycE

This is an irreversible reaction of one reactant forming one product.

Name Dephos_Xic_PCdk2_CycE

Reaction equation



Reactant

Table 32: Properties of each reactant.

Id	Name	SBO
Xic_PCdk2_CycE	Xic_PCdk2_CycE	

Product

Table 33: Properties of each product.

Id	Name	SBO
Xic_Cdk2_CycE	Xic_Cdk2_CycE	

Kinetic Law

Derived unit $\text{s}^{-1} \cdot \text{mmol}$

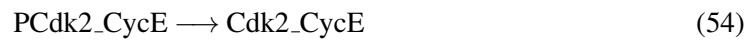
$$v_{13} = \text{vol}(\text{compartment}) \cdot k_{25A} \cdot [\text{Xic_PCdk2_CycE}] \quad (53)$$

8.14 Reaction Dephos_PCdk2_CycE

This is an irreversible reaction of one reactant forming one product.

Name Dephos_PCdk2_CycE

Reaction equation



Reactant

Table 34: Properties of each reactant.

Id	Name	SBO
PCdk2_CycE	PCdk2_CycE	

Product

Table 35: Properties of each product.

Id	Name	SBO
Cdk2_CycE	Cdk2_CycE	

Kinetic Law

Derived unit $\text{s}^{-1} \cdot \text{mmol}$

$$v_{14} = \text{vol}(\text{compartment}) \cdot k_{25A} \cdot [\text{PCdk2_CycE}] \quad (55)$$

8.15 Reaction Degradation_increase

This is an irreversible reaction of no reactant forming one product.

Name Degradation_increase

Reaction equation



Product

Table 36: Properties of each product.

Id	Name	SBO
Deg_a	Deg_CycE	

Kinetic Law

Derived unit $\text{ml} \cdot \text{s}^{-1}$

$$v_{15} = \text{vol}(\text{compartment}) \cdot \text{function_Hill_Cdk2_CycE_removal_1}(\text{Heav}, \text{kdact}) \quad (57)$$

$$\text{function_Hill_Cdk2_CycE_removal_1}(\text{Heav}, \text{kdact}) = \text{kdact} \cdot \text{Heav} \quad (58)$$

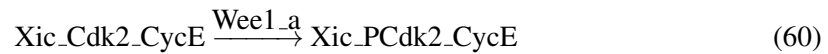
$$\text{function_Hill_Cdk2_CycE_removal_1}(\text{Heav}, \text{kdact}) = \text{kdact} \cdot \text{Heav} \quad (59)$$

8.16 Reaction Phos_Xic_PCdk2_CycE

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

Name Phos_Xic_PCdk2_CycE

Reaction equation



Reactant

Table 37: Properties of each reactant.

Id	Name	SBO
Xic_Cdk2_CycE	Xic_Cdk2_CycE	

Modifier

Table 38: Properties of each modifier.

Id	Name	SBO
Wee1_a	Wee1_a	

Product

Table 39: Properties of each product.

Id	Name	SBO
Xic_PCdk2_CycE	Xic_PCdk2_CycE	

Kinetic Law

Derived unit $(0.0010\text{ l})^{-1} \cdot \text{s}^{-1} \cdot (0.0010\text{ mol})^2$

$$v_{16} = \text{vol}(\text{compartment}) \cdot \text{Function_phosphorylation_with_Wee1_1}([Wee1_a], [Xic_Cdk2_CycE], k_{wee}) \quad (61)$$

$$\begin{aligned} &\text{Function_phosphorylation_with_Wee1_1}([Wee1_a], [Xic_Cdk2_CycE], k_{wee}) \\ &= k_{wee} \cdot [Wee1_a] \cdot [Xic_Cdk2_CycE] \end{aligned} \quad (62)$$

$$\begin{aligned} &\text{Function_phosphorylation_with_Wee1_1}([Wee1_a], [Xic_Cdk2_CycE], k_{wee}) \\ &= k_{wee} \cdot [Wee1_a] \cdot [Xic_Cdk2_CycE] \end{aligned} \quad (63)$$

8.17 Reaction Phos_PCdk2_CycE

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

Name Phos_PCdk2_CycE

Reaction equation



Reactant

Table 40: Properties of each reactant.

Id	Name	SBO
Cdk2_CycE	Cdk2_CycE	

Modifier

Table 41: Properties of each modifier.

Id	Name	SBO
Wee1_a	Wee1_a	

Product

Table 42: Properties of each product.

Id	Name	SBO
PCdk2_CycE	PCdk2_CycE	

Kinetic Law

Derived unit $(0.00101)^{-1} \cdot \text{s}^{-1} \cdot (0.0010 \text{ mol})^2$

$$v_{17} = \text{vol}(\text{compartment}) \cdot \text{Function_phosphorylation_with_Wee1_2}([\text{Cdk2_CycE}], [\text{Wee1_a}], k_{\text{wee}}) \quad (65)$$

$$\begin{aligned} &\text{Function_phosphorylation_with_Wee1_2}([\text{Cdk2_CycE}], [\text{Wee1_a}], k_{\text{wee}}) \\ &= k_{\text{wee}} \cdot [\text{Wee1_a}] \cdot [\text{Cdk2_CycE}] \end{aligned} \quad (66)$$

$$\begin{aligned} &\text{Function_phosphorylation_with_Wee1_2}([\text{Cdk2_CycE}], [\text{Wee1_a}], k_{\text{wee}}) \\ &= k_{\text{wee}} \cdot [\text{Wee1_a}] \cdot [\text{Cdk2_CycE}] \end{aligned} \quad (67)$$

8.18 Reaction Kinase__regulation

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

Name Kinase _regulation

Reaction equation



Reactant

Table 43: Properties of each reactant.

Id	Name	SBO
Cdk2_CycE	Cdk2_CycE	

Modifier

Table 44: Properties of each modifier.

Id	Name	SBO
Cdk2_CycE	Cdk2_CycE	

Products

Table 45: Properties of each product.

Id	Name	SBO
Kin_a	Kin_a	
Cdk2_CycE	Cdk2_CycE	

Kinetic Law

Derived unit contains undeclared units

$$v_{18} = \text{vol}(\text{compartment}) \cdot \text{Function_for_Kin_a_1}([Cdk2_CycE], J_{iact}, J_{iinact}, [Kin_a], k_{iact}, k_{iinact}) \quad (69)$$

$$\begin{aligned} & \text{Function_for_Kin_a_1}([Cdk2_CycE], J_{iact}, J_{iinact}, [Kin_a], k_{iact}, k_{iinact}) \\ &= \frac{k_{iact} \cdot (1 - [Kin_a])}{J_{iact} + 1 - [Kin_a]} - \frac{k_{iinact} \cdot [Cdk2_CycE] \cdot [Kin_a]}{J_{iinact} + [Kin_a]} \end{aligned} \quad (70)$$

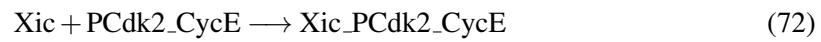
$$\begin{aligned} & \text{Function_for_Kin_a_1} ([\text{Cdk2_CycE}], J_{\text{iact}}, J_{\text{inact}}, [\text{Kin_a}], k_{\text{iact}}, k_{\text{inact}}) \\ &= \frac{k_{\text{iact}} \cdot (1 - [\text{Kin_a}])}{J_{\text{iact}} + 1 - [\text{Kin_a}]} - \frac{k_{\text{inact}} \cdot [\text{Cdk2_CycE}] \cdot [\text{Kin_a}]}{J_{\text{inact}} + [\text{Kin_a}]} \end{aligned} \quad (71)$$

8.19 Reaction `Xic_PCdk2_CycE_association`

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

Name `Xic_PCdk2_CycE_association`

Reaction equation



Reactants

Table 46: Properties of each reactant.

Id	Name	SBO
<code>Xic</code>	Xic	
<code>PCdk2_CycE</code>	PCdk2_CycE	

Product

Table 47: Properties of each product.

Id	Name	SBO
<code>Xic_PCdk2_CycE</code>	Xic_PCdk2_CycE	

Kinetic Law

Derived unit $\text{s}^{-1} \cdot (0.0010 \text{ mol})^2 \cdot \text{ml}^{-1}$

$$v_{19} = \text{vol}(\text{compartment}) \cdot k_{\text{assoc}} \cdot [\text{Xic}] \cdot [\text{PCdk2_CycE}] \quad (73)$$

8.20 Reaction `Xic_PCdk2_CycErem_association`

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

Name `Xic_PCdk2_CycErem_association`

Reaction equation



Reactants

Table 48: Properties of each reactant.

Id	Name	SBO
Xic	Xic	
PCdk2_CycErem	PCdk2_CycErem	

Product

Table 49: Properties of each product.

Id	Name	SBO
Xic_PCdk2_CycErem	Xic_PCdk2_CycErem	

Kinetic Law

Derived unit $\text{s}^{-1} \cdot (0.0010 \text{ mol})^2 \cdot \text{ml}^{-1}$

$$v_{20} = \text{vol}(\text{compartment}) \cdot k_{\text{assoc}} \cdot [\text{Xic}] \cdot [\text{PCdk2_CycErem}] \quad (75)$$

8.21 Reaction Xic_PCdk2_CycE_dissociation

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

Name Xic_PCdk2_CycE_dissociation

Reaction equation



Reactant

Table 50: Properties of each reactant.

Id	Name	SBO
Xic_PCdk2_CycE	Xic_PCdk2_CycE	

Products

Table 51: Properties of each product.

Id	Name	SBO
Xic PCdk2_CycE	Xic PCdk2_CycE	

Kinetic Law

Derived unit $\text{s}^{-1} \cdot \text{mmol}$

$$v_{21} = \text{vol}(\text{compartment}) \cdot k_{\text{dissoc}} \cdot [\text{Xic_PCdk2_CycE}] \quad (77)$$

8.22 Reaction Xic_PCdk2_CycErem_dissociation

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

Name Xic_PCdk2_CycErem_dissociation

Reaction equation



Reactant

Table 52: Properties of each reactant.

Id	Name	SBO
Xic_PCdk2_CycErem	Xic_PCdk2_CycErem	

Products

Table 53: Properties of each product.

Id	Name	SBO
Xic	Xic	
PCdk2_CycErem	PCdk2_CycErem	

Kinetic Law

Derived unit $\text{s}^{-1} \cdot \text{mmol}$

$$v_{22} = \text{vol}(\text{compartment}) \cdot \text{kdisso} \cdot [\text{Xic.PCdk2_CycErem}] \quad (79)$$

8.23 Reaction [Degradation_Cdk2_CycErem](#)

This is an irreversible reaction of one reactant forming no product influenced by one modifier.

Name [Degradation_Cdk2_CycErem](#)

Reaction equation



Reactant

Table 54: Properties of each reactant.

Id	Name	SBO
Cdk2_CycErem	Cdk2_CycErem	

Modifier

Table 55: Properties of each modifier.

Id	Name	SBO
Deg_a	Deg_CycE	

Kinetic Law

Derived unit $(0.00101)^{-1} \cdot \text{s}^{-1} \cdot (0.0010 \text{ mol})^2$

$$v_{23} = \text{vol}(\text{compartment}) \cdot \text{Function_for_degradation_of_Xic_Cyc_Cdk_3}([\text{Cdk2_CycErem}], [\text{Deg_a}], \text{kedeg}) \quad (81)$$

$$\begin{aligned} &\text{Function_for_degradation_of_Xic_Cyc_Cdk_3}([\text{Cdk2_CycErem}], [\text{Deg_a}], \text{kedeg}) \\ &= \text{kedeg} \cdot [\text{Cdk2_CycErem}] \cdot [\text{Deg_a}] \end{aligned} \quad (82)$$

$$\begin{aligned} &\text{Function_for_degradation_of_Xic_Cyc_Cdk_3}([\text{Cdk2_CycErem}], [\text{Deg_a}], \text{kedeg}) \\ &= \text{kedeg} \cdot [\text{Cdk2_CycErem}] \cdot [\text{Deg_a}] \end{aligned} \quad (83)$$

8.24 Reaction Degradation_PCdk2_CycErem

This is an irreversible reaction of one reactant forming no product influenced by one modifier.

Name Degradation_PCdk2_CycErem

Reaction equation



Reactant

Table 56: Properties of each reactant.

Id	Name	SBO
PCdk2_CycErem	PCdk2_CycErem	

Modifier

Table 57: Properties of each modifier.

Id	Name	SBO
Deg_a	Deg_CycE	

Kinetic Law

Derived unit $(0.00101)^{-1} \cdot \text{s}^{-1} \cdot (0.0010 \text{ mol})^2$

$$v_{24} = \text{vol}(\text{compartment}) \cdot \text{Function_for_degradation_of_Xic_Cyc_Cdk_4}([\text{Deg_a}], [\text{PCdk2_CycErem}], \text{kedeg}) \quad (85)$$

$$\begin{aligned} &\text{Function_for_degradation_of_Xic_Cyc_Cdk_4}([\text{Deg_a}], [\text{PCdk2_CycErem}], \text{kedeg}) \\ &= \text{kedeg} \cdot [\text{PCdk2_CycErem}] \cdot [\text{Deg_a}] \end{aligned} \quad (86)$$

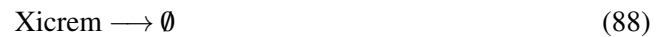
$$\begin{aligned} &\text{Function_for_degradation_of_Xic_Cyc_Cdk_4}([\text{Deg_a}], [\text{PCdk2_CycErem}], \text{kedeg}) \\ &= \text{kedeg} \cdot [\text{PCdk2_CycErem}] \cdot [\text{Deg_a}] \end{aligned} \quad (87)$$

8.25 Reaction Xicrem_degradation

This is an irreversible reaction of one reactant forming no product.

Name Xicrem degradation

Reaction equation



Reactant

Table 58: Properties of each reactant.

Id	Name	SBO
Xicrem	Xicrem	

Kinetic Law

Derived unit $\text{s}^{-1} \cdot \text{mmol}$

$$v_{25} = \text{vol}(\text{compartment}) \cdot \text{kxdeg} \cdot [\text{Xicrem}] \quad (89)$$

8.26 Reaction Xic_PCdk2_CycErem_to_not_rem

This is an irreversible reaction of one reactant forming one product.

Name Xic_PCdk2_CycErem_to_not_rem

Reaction equation



Reactant

Table 59: Properties of each reactant.

Id	Name	SBO
Xic_PCdk2_CycErem	Xic_PCdk2_CycErem	

Product

Table 60: Properties of each product.

Id	Name	SBO
Xic_PCdk2_CycE	Xic_PCdk2_CycE	

Kinetic Law

Derived unit $\text{s}^{-1} \cdot \text{mmol}$

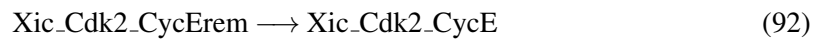
$$v_{26} = \text{vol}(\text{compartment}) \cdot \text{koff} \cdot [\text{Xic_PCdk2_CycErem}] \quad (91)$$

8.27 Reaction [Xic_Cdk2_CycErem_to_not_rem](#)

This is an irreversible reaction of one reactant forming one product.

Name Xic_Cdk2_CycErem_to_not_rem

Reaction equation



Reactant

Table 61: Properties of each reactant.

Id	Name	SBO
Xic_Cdk2_CycErem	Xic_Cdk2_CycErem	

Product

Table 62: Properties of each product.

Id	Name	SBO
Xic_Cdk2_CycE	Xic_Cdk2_CycE	

Kinetic Law**Derived unit** $\text{s}^{-1} \cdot \text{mmol}$

$$v_{27} = \text{vol}(\text{compartment}) \cdot \text{koff} \cdot [\text{Xic_Cdk2_CycErem}] \quad (93)$$

8.28 Reaction Xic_PCdk2_CycE_to_rem

This is an irreversible reaction of one reactant forming one product.

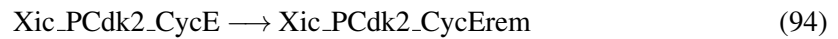
Name Xic_PCdk2_CycE_to_rem**Reaction equation****Reactant**

Table 63: Properties of each reactant.

Id	Name	SBO
Xic_PCdk2_CycE	Xic_PCdk2_CycE	

Product

Table 64: Properties of each product.

Id	Name	SBO
Xic_PCdk2_CycErem	Xic_PCdk2_CycErem	

Kinetic Law**Derived unit** $\text{s}^{-1} \cdot \text{mmol}$

$$v_{28} = \text{vol}(\text{compartment}) \cdot \text{function_removed_from_oscillatory_system_3}([Xic_PCdk2_CycE], \text{kon}, \text{phi}) \quad (95)$$

$$\begin{aligned} &\text{function_removed_from_oscillatory_system_3}([Xic_PCdk2_CycE], \text{kon}, \text{phi}) \\ &= \text{kon} \cdot \text{phi} \cdot [Xic_PCdk2_CycE] \end{aligned} \quad (96)$$

$$\begin{aligned} &\text{function_removed_from_oscillatory_system_3}([Xic_PCdk2_CycE], \text{kon}, \text{phi}) \\ &= \text{kon} \cdot \text{phi} \cdot [Xic_PCdk2_CycE] \end{aligned} \quad (97)$$

8.29 Reaction `Xic_Cdk2_CycE_to_rem`

This is an irreversible reaction of one reactant forming one product.

Name `Xic_Cdk2_CycE_to_rem`

Reaction equation



Reactant

Table 65: Properties of each reactant.

Id	Name	SBO
<code>Xic_Cdk2_CycE</code>	<code>Xic_Cdk2_CycE</code>	

Product

Table 66: Properties of each product.

Id	Name	SBO
<code>Xic_Cdk2_CycErem</code>	<code>Xic_Cdk2_CycErem</code>	

Kinetic Law

Derived unit $\text{s}^{-1} \cdot \text{mmol}$

$$v_{29} = \text{vol}(\text{compartment}) \cdot \text{function_removed_from_oscillatory_system_4}([\text{Xic_Cdk2_CycE}], \text{kon}, \text{phi}) \quad (99)$$

$$\begin{aligned} &\text{function_removed_from_oscillatory_system_4}([\text{Xic_Cdk2_CycE}], \text{kon}, \text{phi}) \\ &= \text{kon} \cdot \text{phi} \cdot [\text{Xic_Cdk2_CycE}] \end{aligned} \quad (100)$$

$$\begin{aligned} &\text{function_removed_from_oscillatory_system_4}([\text{Xic_Cdk2_CycE}], \text{kon}, \text{phi}) \\ &= \text{kon} \cdot \text{phi} \cdot [\text{Xic_Cdk2_CycE}] \end{aligned} \quad (101)$$

8.30 Reaction `Wee1_regulation`

This is an irreversible reaction of no reactant forming one product influenced by two modifiers.

Name `Wee1_regulation`

Reaction equation



Modifiers

Table 67: Properties of each modifier.

Id	Name	SBO
<code>Kin_a</code>	<code>Kin_a</code>	
<code>Wee1_total</code>	<code>Wee1_total</code>	

Product

Table 68: Properties of each product.

Id	Name	SBO
<code>Wee1_a</code>	<code>Wee1_a</code>	

Kinetic Law

Derived unit contains undeclared units

$$v_{30} = \text{vol}(\text{compartment}) \cdot \text{Function_for_Wee1_a_1}(\text{Jwact}, \text{Jwinact}, [\text{Kin_a}], [\text{Wee1_a}], [\text{Wee1_total}], \text{kwact}, \text{kwinact}) \quad (103)$$

$$\begin{aligned} & \text{Function_for_Wee1_a_1}(\text{Jwact}, \text{Jwinact}, [\text{Kin_a}], [\text{Wee1_a}], [\text{Wee1_total}], \text{kwact}, \text{kwinact}) \\ &= \frac{\text{kwact} \cdot ([\text{Wee1_total}] - [\text{Wee1_a}])}{\text{Jwact} + [\text{Wee1_total}] - [\text{Wee1_a}]} - \frac{\text{kwinact} \cdot [\text{Kin_a}] \cdot [\text{Wee1_a}]}{\text{Jwinact} + [\text{Wee1_a}]} \end{aligned} \quad (104)$$

$$\begin{aligned} & \text{Function_for_Wee1_a_1}(\text{Jwact}, \text{Jwinact}, [\text{Kin_a}], [\text{Wee1_a}], [\text{Wee1_total}], \text{kwact}, \text{kwinact}) \\ &= \frac{\text{kwact} \cdot ([\text{Wee1_total}] - [\text{Wee1_a}])}{\text{Jwact} + [\text{Wee1_total}] - [\text{Wee1_a}]} - \frac{\text{kwinact} \cdot [\text{Kin_a}] \cdot [\text{Wee1_a}]}{\text{Jwinact} + [\text{Wee1_a}]} \end{aligned} \quad (105)$$

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 `spatialDimensions` > 0 for certain species.

9.1 Species PCdk2_CycE

Name PCdk2_CycE

Initial concentration 0.94 mmol · ml⁻¹

This species takes part in six reactions (as a reactant in [PCdk2_CycE_to_rem](#), [Dephos_PCdk2_CycE](#), [Xic_PCdk2_CycE_association](#) and as a product in [PCdk2_CycE_to_not_rem](#), [Phos_PCdk2_CycE](#), [Xic_PCdk2_CycE_dissociation](#)).

$$\frac{d}{dt} \text{PCdk2_CycE} = v_6 + v_{17} + v_{21} - v_8 - v_{14} - v_{19} \quad (106)$$

9.2 Species Cdk2_CycE

Name Cdk2_CycE

Initial concentration 0.05999999999999999 mmol · ml⁻¹

This species takes part in nine reactions (as a reactant in [Xic_Cdk2_CycE_association](#), [Cdk2_CycE_to_rem](#), [Phos_PCdk2_CycE](#), [Kinase__regulation](#) and as a product in [Xic_Cdk2_CycE_dissociation](#), [Cdk2_CycErem_to_not_rem](#), [Dephos_PCdk2_CycE](#), [Kinase__regulation](#) and as a modifier in [Kinase__regulation](#)).

$$\frac{d}{dt}\text{Cdk2_CycE} = v_3 + v_5 + v_{14} + v_{18} - v_1 - v_7 - v_{17} - v_{18} \quad (107)$$

9.3 Species [Wee1_a](#)

Name Wee1_a

Initial concentration 1.02 mmol · ml⁻¹

This species takes part in three reactions (as a product in [Wee1_regulation](#) and as a modifier in [Phos_Xic_PCdk2_CycE](#), [Phos_PCdk2_CycE](#)).

$$\frac{d}{dt}\text{Wee1_a} = v_{30} \quad (108)$$

9.4 Species [Wee1_total](#)

Name Wee1_total

Initial concentration 7.99999999999998 mmol · ml⁻¹

This species takes part in one reaction (as a modifier in [Wee1_regulation](#)), which does not influence its rate of change because this constant species is on the boundary of the reaction system:

$$\frac{d}{dt}\text{Wee1_total} = 0 \quad (109)$$

9.5 Species [Cdk2_CycErem](#)

Name Cdk2_CycErem

Initial concentration 0 mmol · ml⁻¹

This species takes part in six reactions (as a reactant in [Xic_Cdk2_CycErem_association](#), [Cdk2_CycErem_to_not_rem](#), [Degradation_Cdk2_CycErem](#) and as a product in [Xic_Cdk2_CycErem_dissociation](#), [Cdk2_CycE_to_rem](#), [X_degradation](#)).

$$\frac{d}{dt}\text{Cdk2_CycErem} = v_4 + v_7 + v_9 - v_2 - v_5 - v_{23} \quad (110)$$

9.6 Species PCdk2_CycErem

Name PCdk2_CycErem

Initial concentration 0 mmol · ml⁻¹

This species takes part in six reactions (as a reactant in [PCdk2_CycE_to_not_rem](#), [Xic_PCdk2_CycErem_association](#), [Degradation_PCdk2_CycErem](#) and as a product in [PCdk2_CycE_to_rem](#), [X_degradation_phosphorylated_complex](#), [Xic_PCdk2_CycErem_dissociation](#)).

$$\frac{d}{dt} \text{PCdk2_CycErem} = v_8 + v_{10} + v_{22} - v_6 - v_{20} - v_{24} \quad (111)$$

9.7 Species Deg_a

Name Deg_CycE

Initial concentration 0 mmol · ml⁻¹

This species takes part in five reactions (as a product in [Degradation_increase](#) and as a modifier in [Degradation_XicPCdk2_CycErem](#), [Degradation_XicCdk2_CycErem](#), [Degradation_Cdk2_CycErem](#), [Degradation_PCdk2_CycErem](#)).

$$\frac{d}{dt} \text{Deg_a} = v_{15} \quad (112)$$

9.8 Species Xic

Name Xic

Initial concentration 2.99999999999998 mmol · ml⁻¹

This species takes part in eight reactions (as a reactant in [Xic_Cdk2_CycE_association](#), [Xic_Cdk2_CycErem_association](#), [Xic_PCdk2_CycE_association](#), [Xic_PCdk2_CycErem_association](#) and as a product in [Xic_Cdk2_CycE_dissociation](#), [Xic_Cdk2_CycErem_dissociation](#), [Xic_PCdk2_CycE_dissociation](#), [Xic_PCdk2_CycErem_dissociation](#)).

$$\frac{d}{dt} \text{Xic} = v_3 + v_4 + v_{21} + v_{22} - v_1 - v_2 - v_{19} - v_{20} \quad (113)$$

9.9 Species Xic_Cdk2_CycE

Name Xic_Cdk2_CycE

Initial concentration 0 mmol · ml⁻¹

This species takes part in six reactions (as a reactant in [Xic_Cdk2_CycE_dissociation](#), [Phos_Xic_PCdk2_CycE](#), [Xic_Cdk2_CycE_to_rem](#) and as a product in [Xic_Cdk2_CycE_association](#), [Dephos_Xic_PCdk2_CycE](#), [Xic_Cdk2_CycErem_to_not_rem](#)).

$$\frac{d}{dt} \text{Xic_Cdk2_CycE} = v_1 + v_{13} + v_{27} - v_3 - v_{16} - v_{29} \quad (114)$$

9.10 Species [Xic_PCdk2_CycE](#)

Name [Xic_PCdk2_CycE](#)

Initial concentration 0 mmol · ml⁻¹

This species takes part in six reactions (as a reactant in [Dephos_Xic_PCdk2_CycE](#), [Xic_PCdk2_CycE_dissociation](#), [Xic_PCdk2_CycE_to_rem](#) and as a product in [Phos_Xic_PCdk2_CycE](#), [Xic_PCdk2_CycE_association](#), [Xic_PCdk2_CycErem_to_not_rem](#)).

$$\frac{d}{dt}Xic_PCdk2_CycE = v_{16} + v_{19} + v_{26} - v_{13} - v_{21} - v_{28} \quad (115)$$

9.11 Species [Xic_Cdk2_CycErem](#)

Name [Xic_Cdk2_CycErem](#)

Initial concentration 0 mmol · ml⁻¹

This species takes part in six reactions (as a reactant in [Xic_Cdk2_CycErem_dissociation](#), [X_degradation](#), [Degradation_XicCdk2_CycErem](#), [Xic_Cdk2_CycErem_to_not_rem](#) and as a product in [Xic_Cdk2_CycErem_association](#), [Xic_Cdk2_CycE_to_rem](#)).

$$\frac{d}{dt}Xic_Cdk2_CycErem = v_2 + v_{29} - v_4 - v_9 - v_{12} - v_{27} \quad (116)$$

9.12 Species [Xic_PCdk2_CycErem](#)

Name [Xic_PCdk2_CycErem](#)

Initial concentration 0 mmol · ml⁻¹

This species takes part in six reactions (as a reactant in [X_degradation_phosphorylated_complex](#), [Degradation_XicPCdk2_CycErem](#), [Xic_PCdk2_CycErem_dissociation](#), [Xic_PCdk2_CycErem_to_not_rem](#) and as a product in [Xic_PCdk2_CycErem_association](#), [Xic_PCdk2_CycE_to_rem](#)).

$$\frac{d}{dt}Xic_PCdk2_CycErem = v_{20} + v_{28} - v_{10} - v_{11} - v_{22} - v_{26} \quad (117)$$

9.13 Species [Xicrem](#)

Name [Xicrem](#)

Initial concentration 0 mmol · ml⁻¹

This species takes part in three reactions (as a reactant in [Xicrem_degradation](#) and as a product in [Degradation_XicPCdk2_CycErem](#), [Degradation_XicCdk2_CycErem](#)).

$$\frac{d}{dt}Xicrem = v_{11} + v_{12} - v_{25} \quad (118)$$

9.14 Species `Cyc_total`

Name `Cyc_total`

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

Involved in rule `Cyc_total`

One rule determines the species' quantity.

9.15 Species `Xic_total`

Name `Xic_total`

Initial concentration $0.999999999999993 \text{ mmol} \cdot \text{ml}^{-1}$

Involved in rule `Xic_total`

One rule determines the species' quantity.

9.16 Species `Kin_a`

Name `Kin_a`

Initial concentration $0.6 \text{ mmol} \cdot \text{ml}^{-1}$

This species takes part in two reactions (as a product in `Kinase_regulation` and as a modifier in `Wee1_regulation`).

$$\frac{d}{dt} \text{Kin}_a = v_{18} \quad (119)$$

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