

SBML Model Report

Model name: “Leloup1999_CircClock”



August 10, 2016

1 General Overview

This is a document in SBML Level 2 Version 1 format. This model was created by the following two authors: Nicolas Le Novre¹ and Bruce Shapiro² at June 29th 2005 at 10:27 a. m. and last time modified at February 25th 2015 at 1:16 p. 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 | 2 |
| species types | 0 | species | 10 |
| events | 0 | constraints | 0 |
| reactions | 24 | function definitions | 0 |
| global parameters | 4 | unit definitions | 2 |
| rules | 2 | initial assignments | 0 |

Model Notes

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To cite BioModels Database, please use [Le Novre N., Bornstein B., Broicher A., Courtot M., Donizelli M., Dharuri H., Li L., Sauro H., Schilstra M., Shapiro B., Snoep J.L., Hucka M. \(2006\)](#)

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BioModels Database: A Free, Centralized Database of Curated, Published, Quantitative Kinetic Models of Biochemical and Cellular Systems *Nucleic Acids Res.*, 34: D689-D691.

2 Unit Definitions

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

2.1 Unit `substance`

Name nanomole (default)

Definition nmol

2.2 Unit `time`

Name hour (default)

Definition 3600 s

2.3 Unit `volume`

Notes Litre is the predefined SBML unit for volume.

Definition l

2.4 Unit `area`

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

Definition m²

2.5 Unit `length`

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

Definition m

3 Compartments

This model contains two compartments.

Table 2: Properties of all compartments.

| Id | Name | SBO | Spatial Dimensions | Size | Unit | Constant | Outside |
|---------------------|-----------|-----|-----------------------|------|-------|-------------------------------------|---------|
| Cell | cytoplasm | | 3 | 1 | litre | <input checked="" type="checkbox"/> | |
| compartment_0000002 | nucleus | | 3 | 1 | litre | <input checked="" type="checkbox"/> | Cell |

3.1 Compartment [Cell](#)

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

Name cytoplasm

3.2 Compartment [compartment_0000002](#)

This is a three dimensional compartment with a constant size of one litre, which is surrounded by [Cell](#) (cytoplasm).

Name nucleus

4 Species

This model contains ten species. Section 8 provides further details and the derived rates of change of each species.

Table 3: Properties of each species.

| Id | Name | Compartment | Derived Unit | Constant | Boundary Condition |
|----|-----------------------------------|---------------------|-----------------------------------|-----------|--------------------|
| P0 | PER Protein (unphosphorylated) | Cell | $\text{nmol} \cdot \text{l}^{-1}$ | \square | \square |
| T0 | TIM Protein (unphosphorylated) | Cell | $\text{nmol} \cdot \text{l}^{-1}$ | \square | \square |
| P1 | PER Protein (mono-phosphorylated) | Cell | $\text{nmol} \cdot \text{l}^{-1}$ | \square | \square |
| T1 | TIM Protein (mono-phosphorylated) | Cell | $\text{nmol} \cdot \text{l}^{-1}$ | \square | \square |
| P2 | PER Protein (bi-phosphorylated) | Cell | $\text{nmol} \cdot \text{l}^{-1}$ | \square | \square |
| T2 | TIM Protein (bi-phosphorylated) | Cell | $\text{nmol} \cdot \text{l}^{-1}$ | \square | \square |
| CC | Cytosolic PER-TIM Complex | Cell | $\text{nmol} \cdot \text{l}^{-1}$ | \square | \square |
| Cn | Nuclear PER-TIM Complex | compartment_0000002 | $\text{nmol} \cdot \text{l}^{-1}$ | \square | \square |
| Mp | PER mRNA | Cell | $\text{nmol} \cdot \text{l}^{-1}$ | \square | \square |
| Mt | TIM mRNA | Cell | $\text{nmol} \cdot \text{l}^{-1}$ | \square | \square |

5 Parameters

This model contains four global parameters.

Table 4: Properties of each parameter.

| Id | Name | SBO | Value | Unit | Constant |
|------|-----------|-----|-------|------|-------------------------------------|
| Pt | Total Per | | 0.0 | | <input type="checkbox"/> |
| Tt | Total Tim | | 0.0 | | <input type="checkbox"/> |
| V_mT | | | 0.7 | | <input checked="" type="checkbox"/> |
| V_dT | | | 2.0 | | <input checked="" type="checkbox"/> |

6 Rules

This is an overview of two rules.

6.1 Rule Pt

Rule Pt is an assignment rule for parameter Pt:

$$Pt = [CC] + [Cn] + [P0] + [P1] + [P2] \quad (1)$$

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

6.2 Rule Tt

Rule Tt is an assignment rule for parameter Tt:

$$Tt = [CC] + [Cn] + [T0] + [T1] + [T2] \quad (2)$$

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

7 Reactions

This model contains 24 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 | P0.to_P1 | First Phosphorylation of PER | $P0 \longrightarrow P1$ | |
| 2 | T0.to_T1 | First Phosphorylation of TIM | $T0 \longrightarrow T1$ | |
| 3 | P1.to_P0 | Dephosphorylation of PER (1st P) | $P1 \longrightarrow P0$ | |
| 4 | T1.to_T0 | Dephosphorylation of TIM (1st P) | $T1 \longrightarrow T0$ | |
| 5 | P1.to_P2 | Second Phosphorylation of PER | $P1 \longrightarrow P2$ | |
| 6 | T1.to_T2 | Second Phosphorylation of TIM | $T1 \longrightarrow T2$ | |
| 7 | P2.to_P1 | Dephosphorylation of PER (2nd P) | $P2 \longrightarrow P1$ | |
| 8 | T2.to_T1 | Dephosphorylation of TIM (2nd P) | $T2 \longrightarrow T1$ | |
| 9 | P0.degradation | PER degradation | $P0 \longrightarrow \emptyset$ | |
| 10 | T0.degradation | TIM degradation | $T0 \longrightarrow \emptyset$ | |
| 11 | P1.degradation | PER-1 degradation | $P1 \longrightarrow \emptyset$ | |
| 12 | T1.degradation | TIM-1 degradation | $T1 \longrightarrow \emptyset$ | |
| 13 | P2.degradation | PER-2 degradation | $P2 \longrightarrow \emptyset$ | |
| 14 | T2.degradation | TIM-2 degradation | $T2 \longrightarrow \emptyset$ | |
| 15 | PT.complex- _formation | PER-TIM complex formation | $P2 + T2 \rightleftharpoons CC$ | |
| 16 | PT.complex- _nucleation | PER-TIM complex nucleation | $CC \rightleftharpoons Cn$ | |
| 17 | PT.complex- _degradation | PER-TIM complex degradation (cytosol) | $CC \longrightarrow \emptyset$ | |
| 18 | PTnucl.complex- _degradation | PER-TIM complex degradation (nuclear) | $Cn \longrightarrow \emptyset$ | |

| Nº | Id | Name | Reaction Equation | SBO |
|----|----------------|----------------------|---|-----|
| 19 | Mp_production | PER mRNA production | $\emptyset \xrightarrow{\text{Cn}} \text{Mp}$ | |
| 20 | Mt_production | TIM mRNA production | $\emptyset \xrightarrow{\text{Cn}} \text{Mt}$ | |
| 21 | P0_production | PER production | $\emptyset \xrightarrow{\text{Mp}} \text{P0}$ | |
| 22 | T0_production | TIM production | $\emptyset \xrightarrow{\text{Mt}} \text{T0}$ | |
| 23 | Mp_degradation | PER mRNA degradation | $\text{Mp} \longrightarrow \emptyset$ | |
| 24 | Mt_degradation | TIM mRNA degradation | $\text{Mt} \longrightarrow \emptyset$ | |

7.1 Reaction P0_to_P1

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

Name First Phosphorylation of PER

Notes This phosphorylation is triggered by the protein product of the gene double-time (DBT, [DCO_DROME](#)). Not explicitly represented in the model.

Reaction equation



Reactant

Table 6: Properties of each reactant.

| Id | Name | SBO |
|----|--------------------------------|-----|
| P0 | PER Protein (unphosphorylated) | |

Product

Table 7: Properties of each product.

| Id | Name | SBO |
|----|-----------------------------------|-----|
| P1 | PER Protein (mono-phosphorylated) | |

Kinetic Law

Derived unit contains undeclared units

$$v_1 = \frac{\text{vol}(\text{Cell}) \cdot V_{1P} \cdot [P0]}{K1_P + [P0]} \quad (4)$$

Table 8: Properties of each parameter.

| Id | Name | SBO | Value | Unit | Constant |
|------|------|-----|-------|------|-------------------------------------|
| K1_P | | | 2.0 | | <input checked="" type="checkbox"/> |
| V_1P | | | 8.0 | | <input checked="" type="checkbox"/> |

7.2 Reaction T0_to_T1

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

Name First Phosphorylation of TIM

Reaction equation



Reactant

Table 9: Properties of each reactant.

| Id | Name | SBO |
|----|--------------------------------|-----|
| T0 | TIM Protein (unphosphorylated) | |

Product

Table 10: Properties of each product.

| Id | Name | SBO |
|----|-----------------------------------|-----|
| T1 | TIM Protein (mono-phosphorylated) | |

Kinetic Law

Derived unit contains undeclared units

$$v_2 = \frac{\text{vol}(\text{Cell}) \cdot V_{1T} \cdot [T0]}{K_{1T} + [T0]} \quad (6)$$

Table 11: Properties of each parameter.

| Id | Name | SBO | Value | Unit | Constant |
|------|------|-----|-------|------|-------------------------------------|
| K_1T | | | 2.0 | | <input checked="" type="checkbox"/> |
| V_1T | | | 8.0 | | <input checked="" type="checkbox"/> |

7.3 Reaction P1_to_P0

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

Name Dephosphorylation of PER (1st P)

Reaction equation



Reactant

Table 12: Properties of each reactant.

| Id | Name | SBO |
|----|-----------------------------------|-----|
| P1 | PER Protein (mono-phosphorylated) | |

Product

Table 13: Properties of each product.

| Id | Name | SBO |
|----|--------------------------------|-----|
| P0 | PER Protein (unphosphorylated) | |

Kinetic Law

Derived unit contains undeclared units

$$v_3 = \frac{\text{vol}(\text{Cell}) \cdot V_2P \cdot [P1]}{K_2P + [P1]} \quad (8)$$

Table 14: Properties of each parameter.

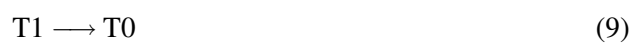
| Id | Name | SBO | Value | Unit | Constant |
|------|------|-----|-------|------|-------------------------------------|
| K_2P | | | 2.0 | | <input checked="" type="checkbox"/> |
| V_2P | | | 1.0 | | <input checked="" type="checkbox"/> |

7.4 Reaction T1_to_T0

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

Name Dephosphorylation of TIM (1st P)

Reaction equation



Reactant

Table 15: Properties of each reactant.

| Id | Name | SBO |
|----|-----------------------------------|-----|
| T1 | TIM Protein (mono-phosphorylated) | |

Product

Table 16: Properties of each product.

| Id | Name | SBO |
|----|--------------------------------|-----|
| T0 | TIM Protein (unphosphorylated) | |

Kinetic Law

Derived unit contains undeclared units

$$v_4 = \frac{\text{vol}(\text{Cell}) \cdot V_{2T} \cdot [T1]}{K_{2T} + [T1]} \quad (10)$$

Table 17: Properties of each parameter.

| Id | Name | SBO | Value | Unit | Constant |
|------|------|-----|-------|------|-------------------------------------|
| K_2T | | | 2.0 | | <input checked="" type="checkbox"/> |
| V_2T | | | 1.0 | | <input checked="" type="checkbox"/> |

7.5 Reaction P1_to_P2

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

Name Second Phosphorylation of PER

Notes This phosphorylation is triggered by the protein product of the gene double-time (DBT, [DCO_DROME](#)). Not explicitly represented in the model.

Reaction equation



Reactant

Table 18: Properties of each reactant.

| Id | Name | SBO |
|----|-----------------------------------|-----|
| P1 | PER Protein (mono-phosphorylated) | |

Product

Table 19: Properties of each product.

| Id | Name | SBO |
|----|---------------------------------|-----|
| P2 | PER Protein (bi-phosphorylated) | |

Kinetic Law

Derived unit contains undeclared units

$$v_5 = \frac{\text{vol}(\text{Cell}) \cdot V_3P \cdot [P1]}{K_3P + [P1]} \quad (12)$$

Table 20: Properties of each parameter.

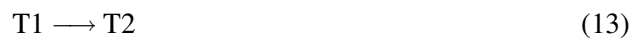
| Id | Name | SBO | Value | Unit | Constant |
|------|------|-----|-------|------|-------------------------------------|
| K_3P | | | 2.0 | | <input checked="" type="checkbox"/> |
| V_3P | | | 8.0 | | <input checked="" type="checkbox"/> |

7.6 Reaction T1_to_T2

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

Name Second Phosphorylation of TIM

Reaction equation



Reactant

Table 21: Properties of each reactant.

| Id | Name | SBO |
|----|-----------------------------------|-----|
| T1 | TIM Protein (mono-phosphorylated) | |

Product

Table 22: Properties of each product.

| Id | Name | SBO |
|----|---------------------------------|-----|
| T2 | TIM Protein (bi-phosphorylated) | |

Kinetic Law

Derived unit contains undeclared units

$$v_6 = \frac{\text{vol}(\text{Cell}) \cdot V_{3T} \cdot [T1]}{K_{3T} + [T1]} \quad (14)$$

Table 23: Properties of each parameter.

| Id | Name | SBO | Value | Unit | Constant |
|------|------|-----|-------|------|-------------------------------------|
| K_3T | | | 2.0 | | <input checked="" type="checkbox"/> |
| V_3T | | | 8.0 | | <input checked="" type="checkbox"/> |

7.7 Reaction P2_to_P1

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

Name Dephosphorylation of PER (2nd P)

Reaction equation



Reactant

Table 24: Properties of each reactant.

| Id | Name | SBO |
|----|---------------------------------|-----|
| P2 | PER Protein (bi-phosphorylated) | |

Product

Table 25: Properties of each product.

| Id | Name | SBO |
|----|-----------------------------------|-----|
| P1 | PER Protein (mono-phosphorylated) | |

Kinetic Law

Derived unit contains undeclared units

$$v_7 = \frac{\text{vol}(\text{Cell}) \cdot V_{4P} \cdot [P2]}{K_{4P} + [P2]} \quad (16)$$

Table 26: Properties of each parameter.

| Id | Name | SBO | Value | Unit | Constant |
|------|------|-----|-------|------|-------------------------------------|
| K_4P | | | 2.0 | | <input checked="" type="checkbox"/> |
| V_4P | | | 1.0 | | <input checked="" type="checkbox"/> |

7.8 Reaction T2_to_T1

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

Name Dephosphorylation of TIM (2nd P)

Reaction equation



Reactant

Table 27: Properties of each reactant.

| Id | Name | SBO |
|----|---------------------------------|-----|
| T2 | TIM Protein (bi-phosphorylated) | |

Product

Table 28: Properties of each product.

| Id | Name | SBO |
|----|-----------------------------------|-----|
| T1 | TIM Protein (mono-phosphorylated) | |

Kinetic Law

Derived unit contains undeclared units

$$v_8 = \frac{\text{vol}(\text{Cell}) \cdot V_{4T} \cdot [T2]}{K_{4T} + [T2]} \quad (18)$$

Table 29: Properties of each parameter.

| Id | Name | SBO | Value | Unit | Constant |
|------|------|-----|-------|------|-------------------------------------|
| K_4T | | | 2.0 | | <input checked="" type="checkbox"/> |
| V_4T | | | 1.0 | | <input checked="" type="checkbox"/> |

7.9 Reaction P0_degradation

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

Name PER degradation

Reaction equation



Reactant

Table 30: Properties of each reactant.

| Id | Name | SBO |
|----|--------------------------------|-----|
| P0 | PER Protein (unphosphorylated) | |

Kinetic Law

Derived unit contains undeclared units

$$v_9 = \text{vol}(\text{Cell}) \cdot k_d \cdot [P0] \quad (20)$$

Table 31: Properties of each parameter.

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

7.10 Reaction T0_degradation

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

Name TIM degradation

Reaction equation



Reactant

Table 32: Properties of each reactant.

| Id | Name | SBO |
|----|--------------------------------|-----|
| T0 | TIM Protein (unphosphorylated) | |

Kinetic Law

Derived unit contains undeclared units

$$v_{10} = \text{vol}(\text{Cell}) \cdot k_d \cdot [T0] \quad (22)$$

Table 33: Properties of each parameter.

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

7.11 Reaction P1_degradation

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

Name PER-1 degradation

Reaction equation



Reactant

Table 34: Properties of each reactant.

| Id | Name | SBO |
|----|-----------------------------------|-----|
| P1 | PER Protein (mono-phosphorylated) | |

Kinetic Law**Derived unit** contains undeclared units

$$v_{11} = \text{vol}(\text{Cell}) \cdot k_d \cdot [\text{P1}] \quad (24)$$

Table 35: Properties of each parameter.

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

7.12 Reaction T1_degradation

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

Name TIM-1 degradation**Reaction equation****Reactant**

Table 36: Properties of each reactant.

| Id | Name | SBO |
|----|-----------------------------------|-----|
| T1 | TIM Protein (mono-phosphorylated) | |

Kinetic Law**Derived unit** contains undeclared units

$$v_{12} = \text{vol}(\text{Cell}) \cdot k_d \cdot [\text{T1}] \quad (26)$$

Table 37: Properties of each parameter.

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

7.13 Reaction P2_degradation

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

Name PER-2 degradation

Reaction equation



Reactant

Table 38: Properties of each reactant.

| Id | Name | SBO |
|----|---------------------------------|-----|
| P2 | PER Protein (bi-phosphorylated) | |

Kinetic Law

Derived unit contains undeclared units

$$v_{13} = \text{vol}(\text{Cell}) \cdot k_d \cdot [P2] + \frac{\text{vol}(\text{Cell}) \cdot V_{dP} \cdot [P2]}{K_{dP} + [P2]} \quad (28)$$

Table 39: Properties of each parameter.

| Id | Name | SBO | Value | Unit | Constant |
|------|------|-----|-------|------|-------------------------------------|
| k_d | | | 0.01 | | <input checked="" type="checkbox"/> |
| V_dP | | | 2.00 | | <input checked="" type="checkbox"/> |
| K_dP | | | 0.20 | | <input checked="" type="checkbox"/> |

7.14 Reaction T2_degradation

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

Name TIM-2 degradation

Reaction equation



Reactant

Table 40: Properties of each reactant.

| Id | Name | SBO |
|----|---------------------------------|-----|
| T2 | TIM Protein (bi-phosphorylated) | |

Kinetic Law

Derived unit contains undeclared units

$$v_{14} = \text{vol}(\text{Cell}) \cdot k_d \cdot [T2] + \frac{\text{vol}(\text{Cell}) \cdot V_{dT} \cdot [T2]}{K_{dT} + [T2]} \quad (30)$$

Table 41: Properties of each parameter.

| Id | Name | SBO | Value | Unit | Constant |
|------|------|-----|-------|------|-------------------------------------|
| k_d | | | 0.01 | | <input checked="" type="checkbox"/> |
| K_dT | | | 0.20 | | <input checked="" type="checkbox"/> |

7.15 Reaction `PT_complex_formation`

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

Name PER-TIM complex formation

Reaction equation



Reactants

Table 42: Properties of each reactant.

| Id | Name | SBO |
|----|---------------------------------|-----|
| P2 | PER Protein (bi-phosphorylated) | |
| T2 | TIM Protein (bi-phosphorylated) | |

Product

Table 43: Properties of each product.

| Id | Name | SBO |
|----|---------------------------|-----|
| CC | Cytosolic PER-TIM Complex | |

Kinetic Law

Derived unit contains undeclared units

$$v_{15} = \text{vol}(\text{Cell}) \cdot k3 \cdot [\text{P2}] \cdot [\text{T2}] - \text{vol}(\text{Cell}) \cdot k4 \cdot [\text{CC}] \quad (32)$$

Table 44: Properties of each parameter.

| Id | Name | SBO | Value | Unit | Constant |
|----|------|-----|-------|------|-------------------------------------|
| k3 | | | 1.2 | | <input checked="" type="checkbox"/> |
| k4 | | | 0.6 | | <input checked="" type="checkbox"/> |

7.16 Reaction `PT_complex_nucleation`

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

Name PER-TIM complex nucleation

Reaction equation



Reactant

Table 45: Properties of each reactant.

| Id | Name | SBO |
|----|---------------------------|-----|
| CC | Cytosolic PER-TIM Complex | |

Product

Table 46: Properties of each product.

| Id | Name | SBO |
|----|-------------------------|-----|
| Cn | Nuclear PER-TIM Complex | |

Kinetic Law

Derived unit contains undeclared units

$$v_{16} = \text{vol}(\text{Cell}) \cdot k1 \cdot [\text{CC}] - \text{vol}(\text{compartment_0000002}) \cdot k2 \cdot [\text{Cn}] \quad (34)$$

Table 47: Properties of each parameter.

| Id | Name | SBO | Value | Unit | Constant |
|----|------|-----|-------|------|-------------------------------------|
| k1 | | | 0.6 | | <input checked="" type="checkbox"/> |
| k2 | | | 0.2 | | <input checked="" type="checkbox"/> |

7.17 Reaction `PT_complex_degradation`

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

Name PER-TIM complex degradation (cytosol)

Reaction equation



Reactant

Table 48: Properties of each reactant.

| Id | Name | SBO |
|----|---------------------------|-----|
| CC | Cytosolic PER-TIM Complex | |

Kinetic Law

Derived unit contains undeclared units

$$v_{17} = \text{vol}(\text{Cell}) \cdot k_dC \cdot [\text{CC}] \quad (36)$$

Table 49: Properties of each parameter.

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

7.18 Reaction PTnucl_complex_degradation

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

Name PER-TIM complex degradation (nuclear)

Reaction equation



Reactant

Table 50: Properties of each reactant.

| Id | Name | SBO |
|----|-------------------------|-----|
| Cn | Nuclear PER-TIM Complex | |

Kinetic Law

Derived unit contains undeclared units

$$v_{18} = \text{vol}(\text{compartment_0000002}) \cdot k_{dN} \cdot [Cn] \quad (38)$$

Table 51: Properties of each parameter.

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

7.19 Reaction Mp_production

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

Name PER mRNA production

Reaction equation



Modifier

Table 52: Properties of each modifier.

| Id | Name | SBO |
|----|-------------------------|-----|
| Cn | Nuclear PER-TIM Complex | |

Product

Table 53: Properties of each product.

| Id | Name | SBO |
|----|----------|-----|
| Mp | PER mRNA | |

Kinetic Law

Derived unit contains undeclared units

$$v_{19} = \frac{\text{vol}(\text{Cell}) \cdot v_{\text{sP}} \cdot K_{\text{IP}}^n}{K_{\text{IP}}^n + [\text{Cn}]^n} \quad (40)$$

Table 54: Properties of each parameter.

| Id | Name | SBO | Value | Unit | Constant |
|------|------|-----|-------|------|----------|
| v_sP | | | 1.0 | | ✓ |
| K_IP | | | 1.0 | | ✓ |
| n | | | 4.0 | | ✓ |

7.20 Reaction Mt_production

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

Name TIM mRNA production

Reaction equation



Modifier

Table 55: Properties of each modifier.

| Id | Name | SBO |
|----|-------------------------|-----|
| Cn | Nuclear PER-TIM Complex | |

Product

Table 56: Properties of each product.

| Id | Name | SBO |
|----|----------|-----|
| Mt | TIM mRNA | |

Kinetic Law

Derived unit contains undeclared units

$$v_{20} = \frac{\text{vol}(\text{Cell}) \cdot V_{sT} \cdot K_{IT}^n}{K_{IT}^n + [Cn]^n} \quad (42)$$

Table 57: Properties of each parameter.

| Id | Name | SBO | Value | Unit | Constant |
|------|------|-----|-------|------|-------------------------------------|
| V_sT | | | 1.0 | | <input checked="" type="checkbox"/> |
| K_IT | | | 1.0 | | <input checked="" type="checkbox"/> |
| n | | | 4.0 | | <input checked="" type="checkbox"/> |

7.21 Reaction P0_production

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

Name PER production

Reaction equation



Modifier

Table 58: Properties of each modifier.

| Id | Name | SBO |
|----|----------|-----|
| Mp | PER mRNA | |

Product

Table 59: Properties of each product.

| Id | Name | SBO |
|----|--------------------------------|-----|
| P0 | PER Protein (unphosphorylated) | |

Kinetic Law

Derived unit contains undeclared units

$$v_{21} = \text{vol}(\text{Cell}) \cdot k_{\text{sP}} \cdot [\text{Mp}] \quad (44)$$

Table 60: Properties of each parameter.

| Id | Name | SBO | Value | Unit | Constant |
|------|------|-----|-------|------|-------------------------------------|
| k_sP | | | 0.9 | | <input checked="" type="checkbox"/> |

7.22 Reaction T0_production

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

Name TIM production

Reaction equation



Modifier

Table 61: Properties of each modifier.

| Id | Name | SBO |
|----|----------|-----|
| Mt | TIM mRNA | |

Product

Table 62: Properties of each product.

| Id | Name | SBO |
|----|--------------------------------|-----|
| T0 | TIM Protein (unphosphorylated) | |

Kinetic Law

Derived unit contains undeclared units

$$v_{22} = \text{vol}(\text{Cell}) \cdot k_{sT} \cdot [\text{Mt}] \quad (46)$$

Table 63: Properties of each parameter.

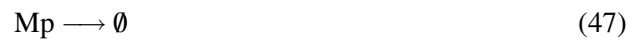
| Id | Name | SBO | Value | Unit | Constant |
|------|------|-----|-------|------|-------------------------------------|
| k_sT | | | 0.9 | | <input checked="" type="checkbox"/> |

7.23 Reaction Mp_degradation

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

Name PER mRNA degradation

Reaction equation



Reactant

Table 64: Properties of each reactant.

| Id | Name | SBO |
|----|----------|-----|
| Mp | PER mRNA | |

Kinetic Law

Derived unit contains undeclared units

$$v_{23} = \text{vol}(\text{Cell}) \cdot k_{d} \cdot [\text{Mp}] + \frac{\text{vol}(\text{Cell}) \cdot V_{mP} \cdot [\text{Mp}]}{K_{mP} + [\text{Mp}]} \quad (48)$$

Table 65: Properties of each parameter.

| Id | Name | SBO | Value | Unit | Constant |
|------|------|-----|-------|------|-------------------------------------|
| k_d | | | 0.01 | | <input checked="" type="checkbox"/> |
| V_mP | | | 0.70 | | <input checked="" type="checkbox"/> |
| K_mP | | | 0.20 | | <input checked="" type="checkbox"/> |

7.24 Reaction Mt_degradation

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

Name TIM mRNA degradation

Reaction equation



Reactant

Table 66: Properties of each reactant.

| Id | Name | SBO |
|----|----------|-----|
| Mt | TIM mRNA | |

Kinetic Law

Derived unit contains undeclared units

$$v_{24} = \text{vol}(\text{Cell}) \cdot k_d \cdot [\text{Mt}] + \frac{\text{vol}(\text{Cell}) \cdot V_{mT} \cdot [\text{Mt}]}{K_{mT} + [\text{Mt}]} \quad (50)$$

Table 67: Properties of each parameter.

| Id | Name | SBO | Value | Unit | Constant |
|------|------|-----|-------|------|-------------------------------------|
| k_d | | | 0.01 | | <input checked="" type="checkbox"/> |
| K_mT | | | 0.20 | | <input checked="" type="checkbox"/> |

8 Derived Rate Equations

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

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

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

8.1 Species P0

Name PER Protein (unphosphorylated)

Initial concentration $0 \text{ nmol} \cdot \text{l}^{-1}$

This species takes part in four reactions (as a reactant in [P0_to_P1](#), [P0_degradation](#) and as a product in [P1_to_P0](#), [P0_production](#)).

$$\frac{d}{dt}P0 = v_3 + v_{21} - v_1 - v_9 \quad (51)$$

8.2 Species T0

Name TIM Protein (unphosphorylated)

Initial concentration $0 \text{ nmol} \cdot \text{l}^{-1}$

This species takes part in four reactions (as a reactant in [T0_to_T1](#), [T0_degradation](#) and as a product in [T1_to_T0](#), [T0_production](#)).

$$\frac{d}{dt}T0 = v_4 + v_{22} - v_2 - v_{10} \quad (52)$$

8.3 Species P1

Name PER Protein (mono-phosphorylated)

Initial concentration $0 \text{ nmol} \cdot \text{l}^{-1}$

This species takes part in five reactions (as a reactant in [P1_to_P0](#), [P1_to_P2](#), [P1_degradation](#) and as a product in [P0_to_P1](#), [P2_to_P1](#)).

$$\frac{d}{dt}P1 = v_1 + v_7 - v_3 - v_5 - v_{11} \quad (53)$$

8.4 Species T1

Name TIM Protein (mono-phosphorylated)

Initial concentration 0 nmol · l⁻¹

This species takes part in five reactions (as a reactant in [T1_to_T0](#), [T1_to_T2](#), [T1_degradation](#) and as a product in [T0_to_T1](#), [T2_to_T1](#)).

$$\frac{d}{dt}T1 = v_2 + v_8 - v_4 - v_6 - v_{12} \quad (54)$$

8.5 Species P2

Name PER Protein (bi-phosphorylated)

Initial concentration 0 nmol · l⁻¹

This species takes part in four reactions (as a reactant in [P2_to_P1](#), [P2_degradation](#), [PT_complex_formation](#) and as a product in [P1_to_P2](#)).

$$\frac{d}{dt}P2 = v_5 - v_7 - v_{13} - v_{15} \quad (55)$$

8.6 Species T2

Name TIM Protein (bi-phosphorylated)

Initial concentration 0 nmol · l⁻¹

This species takes part in four reactions (as a reactant in [T2_to_T1](#), [T2_degradation](#), [PT_complex_formation](#) and as a product in [T1_to_T2](#)).

$$\frac{d}{dt}T2 = v_6 - v_8 - v_{14} - v_{15} \quad (56)$$

8.7 Species CC

Name Cytosolic PER-TIM Complex

Initial concentration 0 nmol · l⁻¹

This species takes part in three reactions (as a reactant in [PT_complex_nucleation](#), [PT_complex_degradation](#) and as a product in [PT_complex_formation](#)).

$$\frac{d}{dt}CC = v_{15} - v_{16} - v_{17} \quad (57)$$

8.8 Species Cn

Name Nuclear PER-TIM Complex

Initial concentration $0 \text{ nmol} \cdot \text{l}^{-1}$

This species takes part in four reactions (as a reactant in [PTnucl_complex_degradation](#) and as a product in [PT_complex_nucleation](#) and as a modifier in [Mp_production](#), [Mt_production](#)).

$$\frac{d}{dt}Cn = v_{16} - v_{18} \quad (58)$$

8.9 Species Mp

Name PER mRNA

Initial concentration $0 \text{ nmol} \cdot \text{l}^{-1}$

This species takes part in three reactions (as a reactant in [Mp_degradation](#) and as a product in [Mp_production](#) and as a modifier in [PO_production](#)).

$$\frac{d}{dt}Mp = v_{19} - v_{23} \quad (59)$$

8.10 Species Mt

Name TIM mRNA

Initial concentration $0 \text{ nmol} \cdot \text{l}^{-1}$

This species takes part in three reactions (as a reactant in [Mt_degradation](#) and as a product in [Mt_production](#) and as a modifier in [TO_production](#)).

$$\frac{d}{dt}Mt = v_{20} - v_{24} \quad (60)$$

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