SBML Model Report

Model name: "Weimann2004_CircadianOscillator"

May 5, 2016

1 General Overview

This is a document in SBML Level 2 Version 1 format. This model was created by Harish Dharuri[1] at April 16th 2008 at 11:56 a. m. and last time modified at May 16th 2012 at 10:04 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	2
species types	0	species	7
events	0	constraints	0
reactions	17	function definitions	0
global parameters	27	unit definitions	6
rules	3	initial assignments	0

Model Notes

The model reproduces the time profile of the species as depicted in Fig 3A of the paper. Model successfully tested on MathSBML and Jarnac.

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2 Unit Definitions

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

2.1 Unit substance

Name nano mole

Definition nmol

2.2 Unit time

Name hour

Definition 3600 s

2.3 Unit nM

Name nM

Definition $\mathrm{nmol} \cdot \mathrm{l}^{-1}$

2.4 Unit nM_per_hour

Name nM_per_hour

Definition $\mathrm{nmol} \cdot \mathrm{l}^{-1} \cdot (3600\ \mathrm{s})^{-1}$

2.5 Unit time_inverse

Name hr_inv

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

2.6 Unit nM_inv_hr_inv

Name nM_inv_hr_inv

Definition $\mathrm{nmol}^{-1} \cdot \mathrm{l} \cdot (3600\ \mathrm{s})^{-1}$

2.7 Unit volume

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

Definition l

2.8 Unit area

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

Definition m^2

2.9 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
Nucleus	Nucleus		3	1	litre	☑	
Cytoplasm	Cytoplasm		3	1	litre	☑	

3.1 Compartment Nucleus

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

Name Nucleus

3.2 Compartment Cytoplasm

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

Name Cytoplasm

4 Species

This model contains seven 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
y1	Per2 or Cry mRNA	Cytoplasm	$\mathrm{nmol} \cdot \mathrm{l}^{-1}$	⊟	⊟
y2	PER2_CRY_complex_cytoplasm	Cytoplasm	$\mathrm{nmol} \cdot \mathrm{l}^{-1}$	⊟	⊟
y3	PER2_CRY_complex_nucleus	Nucleus	$\mathrm{nmol} \cdot \mathrm{l}^{-1}$	⊟	⊟
y4	Bmal1 mRNA	Cytoplasm	$\mathrm{nmol} \cdot \mathrm{l}^{-1}$	⊟	⊟
y5	BMAL1_cytoplasm	Cytoplasm	$\mathrm{nmol} \cdot \mathrm{l}^{-1}$	⊟	⊟
y6	BMAL1_nucleus	Nucleus	$\mathrm{nmol} \cdot \mathrm{l}^{-1}$	⊟	⊟
y7	Active BMAL1	Nucleus	$\mathrm{nmol} \cdot \mathrm{l}^{-1}$	⊟	⊟

5 Parameters

This model contains 27 global parameters.

Table 4: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
trans_per2_cry			0.000	nmol · l^{-1} · (3600 s)$^{-1}$	⊟
v1b			9.000	nmol · l^{-1} · (3600 s)$^{-1}$	☑
c			0.010	nmol · l^{-1}	☑
k1b			1.000	nmol · l^{-1}	☑
k1i			0.560	nmol · l^{-1}	☑
hill_coeff			8.000	dimensionless	☑
trans_Bmal1			0.000	nmol · l^{-1} · (3600 s)$^{-1}$	⊟
v4b			3.600	nmol · l^{-1} · (3600 s)$^{-1}$	☑
r			3.000	dimensionless	☑
k4b			2.160	nmol · l^{-1}	☑
y5_y6_y7			3.050	nmol · l^{-1}	⊟
k1d			0.120	(3600 s)$^{-1}$	☑
k2b			0.300	nmol^{-1} · l · (3600 s)$^{-1}$	☑
q			2.000	dimensionless	☑
k2d			0.050	(3600 s)$^{-1}$	☑
k2t			0.240	(3600 s)$^{-1}$	☑
k3t			0.020	(3600 s)$^{-1}$	☑
k3d			0.120	(3600 s)$^{-1}$	☑
k4d			0.750	(3600 s)$^{-1}$	☑
k5b			0.240	(3600 s)$^{-1}$	☑
k5d			0.060	(3600 s)$^{-1}$	☑
k5t			0.450	(3600 s)$^{-1}$	☑
k6t			0.060	(3600 s)$^{-1}$	☑
k6d			0.120	(3600 s)$^{-1}$	☑
k6a			0.090	(3600 s)$^{-1}$	☑
k7a			0.003	(3600 s)$^{-1}$	☑
k7d			0.090	(3600 s)$^{-1}$	☑

6 Rules

This is an overview of three rules.

6.1 Rule `trans_per2_cry`

Rule `trans_per2_cry` is an assignment rule for parameter `trans_per2_cry`:

$$\text{trans\_per2\_cry} = \frac{\text{v1b} \cdot (\text{[y7]} + \text{c})}{\text{k1b} \cdot \left(1 + \left(\frac{\text{[y3]}}{\text{k1i}}\right)^{\text{hill\_coeff}}\right) + \text{[y7]} + \text{c}} \tag{1}$$

6.2 Rule `trans_Bmal1`

Rule `trans_Bmal1` is an assignment rule for parameter `trans_Bmal1`:

$$\text{trans\_Bmal1} = \frac{\text{v4b} \cdot \text{[y3]}^{\text{r}}}{\text{k4b}^{\text{r}} + \text{[y3]}^{\text{r}}} \tag{2}$$

Derived unit $10^{-9}\ \text{mol} \cdot \text{l}^{-1} \cdot (3600\ \text{s})^{-1}$

6.3 Rule `y5_y6_y7`

Rule `y5_y6_y7` is an assignment rule for parameter `y5_y6_y7`:

$$\text{y5\_y6\_y7} = \text{[y5]} + \text{[y6]} + \text{[y7]} \tag{3}$$

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

7 Reactions

This model contains 17 reactions. All reactions are listed in the following table and are subsequently described in detail. If a reaction is affected by a modifier, the identifier of this species is written above the reaction arrow.

Table 5: Overview of all reactions

№	Id	Name	Reaction Equation	SBO
1	per2_cry_transcription	per2_cry_transcription	$\emptyset \longrightarrow y1$	
2	per2_cry_mRNA_degradation	per2_cry_mRNA_degradation	$y1 \longrightarrow \emptyset$	
3	per2_cry_complex_formation	per2_cry_complex_formation	$\emptyset \xrightarrow{y1} y2$	
4	cytoplasmic_per2_cry_complex_degradation	cytoplasmic_per2_cry_complex_degradation	$y2 \longrightarrow \emptyset$	
5	per2_cry_nuclear_import	per2_cry_nuclear_import	$y2 \longrightarrow y3$	
6	per2_cry_nuclear_export	per2_cry_nuclear_export	$y3 \longrightarrow y2$	
7	nuclear_per2_cry_complex_degradation	nuclear_per2_cry_complex_degradation	$y3 \longrightarrow \emptyset$	
8	Bmal1_transcription	Bmal1_transcription	$\emptyset \longrightarrow y4$	
9	Bmal1_mRNA_degradation	Bmal1_mRNA_degradation	$y4 \longrightarrow \emptyset$	

№	Id	Name	Reaction Equation	SBO
10	BMAL1_translation	BMAL1_translation	$\emptyset \xrightarrow{y4} y5$	
11	cytoplasmic_BMAL1_degradation	cytoplasmic_BMAL1_degradation	$y5 \longrightarrow \emptyset$	
12	BMAL1_nuclear_import	BMAL1_nuclear_import	$y5 \longrightarrow y6$	
13	BMAL1_nuclear_export	BMAL1_nuclear_export	$y6 \longrightarrow y5$	
14	nuclear_BMAL1_degradation	nuclear_BMAL1_degradation	$y6 \longrightarrow \emptyset$	
15	BMAL1_activation	BMAL1_activation	$y6 \longrightarrow y7$	
16	BMAL1_deactivation	BMAL1_deactivation	$y7 \longrightarrow y6$	
17	Active_BMAL1_degradation	Active_BMAL1_degradation	$y7 \longrightarrow \emptyset$	

7.1 Reaction per2_cry_transcription

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

Name per2_cry_transcription

Reaction equation

$$\emptyset \longrightarrow \mathrm{y1} \tag{4}$$

Product

Table 6: Properties of each product.

Id	Name	SBO
y1	Per2 or Cry mRNA	

Kinetic Law

Derived unit $\mathrm{nmol} \cdot (3600\ \mathrm{s})^{-1}$

$$v_1 = \mathrm{vol}\,(\mathrm{Cytoplasm}) \cdot \mathrm{trans\_per2\_cry} \tag{5}$$

7.2 Reaction per2_cry_mRNA_degradation

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

Name per2_cry_mRNA_degradation

Reaction equation

$$\mathrm{y1} \longrightarrow \emptyset \tag{6}$$

Reactant

Table 7: Properties of each reactant.

Id	Name	SBO
y1	Per2 or Cry mRNA	

Kinetic Law

Derived unit $(3600\ \mathrm{s})^{-1} \cdot \mathrm{nmol}$

$$v_2 = \mathrm{vol}\,(\mathrm{Cytoplasm}) \cdot \mathrm{k1d} \cdot [\mathrm{y1}] \tag{7}$$

7.3 Reaction per2_cry_complex_formation

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

Name per2_cry_complex_formation

Reaction equation

$$\emptyset \xrightarrow{\mathrm{y1}} \mathrm{y2} \tag{8}$$

Modifier

Table 8: Properties of each modifier.

Id	Name	SBO
y1	Per2 or Cry mRNA	

Product

Table 9: Properties of each product.

Id	Name	SBO
y2	PER2_CRY_complex_cytoplasm	

Kinetic Law

Derived unit $9.999999999999998 \cdot 10^{-10}\ \mathrm{mol} \cdot (3600\ \mathrm{s})^{-1}$

$$v_3 = \mathrm{vol}\,(\mathrm{Cytoplasm}) \cdot \mathrm{k2b} \cdot [\mathrm{y1}]^{\mathrm{q}} \tag{9}$$

7.4 Reaction cytoplasmic_per2_cry_complex_degradation

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

Name cytoplasmic_per2_cry_complex_degradation

Reaction equation

$$\mathrm{y2} \longrightarrow \emptyset \tag{10}$$

Reactant

Table 10: Properties of each reactant.

Id	Name	SBO
y2	PER2_CRY_complex_cytoplasm	

Kinetic Law

Derived unit $(3600\ \mathrm{s})^{-1} \cdot \mathrm{nmol}$

$$v_4 = \mathrm{vol}\,(\mathrm{Cytoplasm}) \cdot \mathrm{k2d} \cdot [\mathrm{y2}] \tag{11}$$

7.5 Reaction per2_cry_nuclear_import

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

Name per2_cry_nuclear_import

Reaction equation

$$\mathrm{y2} \longrightarrow \mathrm{y3} \tag{12}$$

Reactant

Table 11: Properties of each reactant.

Id	Name	SBO
y2	PER2_CRY_complex_cytoplasm	

Product

Table 12: Properties of each product.

Id	Name	SBO
y3	PER2_CRY_complex_nucleus	

Kinetic Law

Derived unit $(3600\ \mathrm{s})^{-1} \cdot \mathrm{nmol}$

$$v_5 = \mathrm{vol}\,(\mathrm{Cytoplasm}) \cdot \mathrm{k2t} \cdot [\mathrm{y2}] \tag{13}$$

7.6 Reaction per2_cry_nuclear_export

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

Name per2_cry_nuclear_export

Reaction equation

$$\mathrm{y3} \longrightarrow \mathrm{y2} \tag{14}$$

Reactant

Table 13: Properties of each reactant.

Id	Name	SBO
y3	PER2_CRY_complex_nucleus	

Product

Table 14: Properties of each product.

Id	Name	SBO
y2	PER2_CRY_complex_cytoplasm	

Kinetic Law

Derived unit $(3600\ \mathrm{s})^{-1} \cdot \mathrm{nmol}$

$$v_6 = \mathrm{vol}\,(\mathrm{Nucleus}) \cdot \mathrm{k3t} \cdot [\mathrm{y3}] \tag{15}$$

7.7 Reaction nuclear_per2_cry_complex_degradation

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

Name nuclear_per2_cry_complex_degradation

Reaction equation

$$\mathrm{y3} \longrightarrow \emptyset \tag{16}$$

Reactant

Table 15: Properties of each reactant.

Id	Name	SBO
y3	PER2_CRY_complex_nucleus	

Kinetic Law

Derived unit $(3600\ \mathrm{s})^{-1} \cdot \mathrm{nmol}$

$$v_7 = \mathrm{vol}\,(\mathrm{Nucleus}) \cdot \mathrm{k3d} \cdot [\mathrm{y3}] \tag{17}$$

7.8 Reaction Bmal1_transcription

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

Name Bmal1_transcription

Reaction equation

$$\emptyset \longrightarrow \mathrm{y4} \tag{18}$$

Product

Table 16: Properties of each product.

Id	Name	SBO
y4	Bmal1 mRNA	

Kinetic Law

Derived unit $\mathrm{nmol} \cdot (3600\ \mathrm{s})^{-1}$

$$v_8 = \mathrm{vol}\,(\mathrm{Cytoplasm}) \cdot \mathrm{trans\_Bmal1} \tag{19}$$

7.9 Reaction Bmal1_mRNA_degradation

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

Name Bmal1_mRNA_degradation

Reaction equation

$$\mathrm{y4} \longrightarrow \emptyset \tag{20}$$

Reactant

Table 17: Properties of each reactant.

Id	Name	SBO
y4	Bmal1 mRNA	

Kinetic Law

Derived unit $(3600\ \mathrm{s})^{-1} \cdot \mathrm{nmol}$

$$v_9 = \mathrm{vol}\,(\mathrm{Cytoplasm}) \cdot \mathrm{k4d} \cdot [\mathrm{y4}] \tag{21}$$

7.10 Reaction BMAL1_translation

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

Name BMAL1_translation

Reaction equation

$$\emptyset \xrightarrow{\mathrm{y4}} \mathrm{y5} \tag{22}$$

Modifier

Table 18: Properties of each modifier.

Id	Name	SBO
y4	Bmal1 mRNA	

Product

Table 19: Properties of each product.

Id	Name	SBO
y5	BMAL1_cytoplasm	

Kinetic Law

Derived unit $(3600\ \mathrm{s})^{-1} \cdot \mathrm{nmol}$

$$v_{10} = \mathrm{vol}\,(\mathrm{Cytoplasm}) \cdot \mathrm{k5b} \cdot [\mathrm{y4}] \tag{23}$$

7.11 Reaction cytoplasmic_BMAL1_degradation

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

Name cytoplasmic_BMAL1_degradation

Reaction equation

$$\mathrm{y5} \longrightarrow \emptyset \tag{24}$$

Reactant

Table 20: Properties of each reactant.

Id	Name	SBO
y5	BMAL1_cytoplasm	

Kinetic Law

Derived unit $(3600\ \mathrm{s})^{-1} \cdot \mathrm{nmol}$

$$v_{11} = \mathrm{vol}\,(\mathrm{Cytoplasm}) \cdot \mathrm{k5d} \cdot [\mathrm{y5}] \tag{25}$$

7.12 Reaction BMAL1_nuclear_import

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

Name BMAL1_nuclear_import

Reaction equation

$$\mathrm{y5} \longrightarrow \mathrm{y6} \tag{26}$$

Reactant

Table 21: Properties of each reactant.

Id	Name	SBO
y5	BMAL1_cytoplasm	

Product

Table 22: Properties of each product.

Id	Name	SBO
y6	BMAL1_nucleus	

Kinetic Law

Derived unit $(3600\ \mathrm{s})^{-1} \cdot \mathrm{nmol}$

$$v_{12} = \mathrm{vol}\,(\mathrm{Cytoplasm}) \cdot \mathrm{k5t} \cdot [\mathrm{y5}] \tag{27}$$

7.13 Reaction BMAL1_nuclear_export

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

Name BMAL1_nuclear_export

Reaction equation

$$\mathrm{y6} \longrightarrow \mathrm{y5} \tag{28}$$

Reactant

Table 23: Properties of each reactant.

Id	Name	SBO
y6	BMAL1_nucleus	

Product

Table 24: Properties of each product.

Id	Name	SBO
y5	BMAL1_cytoplasm	

Kinetic Law

Derived unit $(3600\ \mathrm{s})^{-1} \cdot \mathrm{nmol}$

$$v_{13} = \mathrm{vol}\,(\mathrm{Nucleus}) \cdot \mathrm{k6t} \cdot [\mathrm{y6}] \tag{29}$$

7.14 Reaction nuclear_BMAL1_degradation

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

Name nuclear_BMAL1_degradation

Reaction equation

$$\mathrm{y6} \longrightarrow \emptyset \tag{30}$$

Reactant

Table 25: Properties of each reactant.

Id	Name	SBO
y6	BMAL1_nucleus	

Kinetic Law

Derived unit $(3600\ \mathrm{s})^{-1} \cdot \mathrm{nmol}$

$$v_{14} = \mathrm{vol}(\mathrm{Nucleus}) \cdot \mathrm{k6d} \cdot [\mathrm{y6}] \tag{31}$$

7.15 Reaction BMAL1_activation

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

Name BMAL1_activation

Reaction equation

$$\mathrm{y6} \longrightarrow \mathrm{y7} \tag{32}$$

Reactant

Table 26: Properties of each reactant.

Id	Name	SBO
y6	BMAL1_nucleus	

Product

Table 27: Properties of each product.

Id	Name	SBO
y7	Active BMAL1	

Kinetic Law

Derived unit $(3600\ \mathrm{s})^{-1} \cdot \mathrm{nmol}$

$$v_{15} = \mathrm{vol}\,(\mathrm{Nucleus}) \cdot \mathrm{k6a} \cdot [\mathrm{y6}] \tag{33}$$

7.16 Reaction `BMAL1_deactivation`

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

Name BMAL1_deactivation

Reaction equation

$$\mathrm{y7} \longrightarrow \mathrm{y6} \tag{34}$$

Reactant

Table 28: Properties of each reactant.

Id	Name	SBO
y7	Active BMAL1	

Product

Table 29: Properties of each product.

Id	Name	SBO
y6	BMAL1_nucleus	

Kinetic Law

Derived unit $(3600\ \mathrm{s})^{-1} \cdot \mathrm{nmol}$

$$v_{16} = \mathrm{vol}\,(\mathrm{Nucleus}) \cdot \mathrm{k7a} \cdot [\mathrm{y7}] \tag{35}$$

7.17 Reaction Active_BMAL1_degradation

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

Name Active_BMAL1_degradation

Reaction equation

$$\mathrm{y7} \longrightarrow \emptyset \tag{36}$$

Reactant

Table 30: Properties of each reactant.

Id	Name	SBO
y7	Active BMAL1	

Kinetic Law

Derived unit $(3600\ \mathrm{s})^{-1} \cdot \mathrm{nmol}$

$$v_{17} = \mathrm{vol}\,(\mathrm{Nucleus}) \cdot \mathrm{k7d} \cdot [\mathrm{y7}] \tag{37}$$

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.

8.1 Species y1

Name Per2 or Cry mRNA

Initial concentration $0.2\ \mathrm{nmol} \cdot \mathrm{l}^{-1}$

This species takes part in three reactions (as a reactant in per2_cry_mRNA_degradation and as a product in per2_cry_transcription and as a modifier in per2_cry_complex_formation).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{y1} = v_1 - v_2 \tag{38}$$

8.2 Species y2

Name PER2_CRY_complex_cytoplasm

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

This species takes part in four reactions (as a reactant in cytoplasmic_per2_cry_complex_degradation, per2_cry_nuclear_import and as a product in per2_cry_complex_formation, per2_cry_nuclear_export).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{y2} = v_3 + v_6 - v_4 - v_5 \tag{39}$$

8.3 Species y3

Name PER2_CRY_complex_nucleus

Initial concentration $1.1\ \mathrm{nmol}\cdot\mathrm{l}^{-1}$

This species takes part in three reactions (as a reactant in per2_cry_nuclear_export, nuclear_per2_cry_complex_degradation and as a product in per2_cry_nuclear_import).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{y3} = v_5 - v_6 - v_7 \tag{40}$$

8.4 Species y4

Name Bmal1 mRNA

Initial concentration $0.8\ \mathrm{nmol}\cdot\mathrm{l}^{-1}$

This species takes part in three reactions (as a reactant in Bmal1_mRNA_degradation and as a product in Bmal1_transcription and as a modifier in BMAL1_translation).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{y4} = v_8 - v_9 \tag{41}$$

8.5 Species y5

Name BMAL1_cytoplasm

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

This species takes part in four reactions (as a reactant in cytoplasmic_BMAL1_degradation, BMAL1_nuclear_import and as a product in BMAL1_translation, BMAL1_nuclear_export).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{y5} = v_{10} + v_{13} - v_{11} - v_{12} \tag{42}$$

8.6 Species y6

Name BMAL1_nucleus

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

This species takes part in five reactions (as a reactant in BMAL1_nuclear_export, nuclear_BMAL1_degradation, BMAL1_activation and as a product in BMAL1_nuclear_import, BMAL1_deactivation).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{y6} = v_{12} + v_{16} - v_{13} - v_{14} - v_{15} \tag{43}$$

8.7 Species y7

Name Active BMAL1

Initial concentration $1.05\ \mathrm{nmol} \cdot \mathrm{l}^{-1}$

This species takes part in three reactions (as a reactant in BMAL1_deactivation, Active_BMAL1_degradation and as a product in BMAL1_activation).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{y7} = v_{15} - v_{16} - v_{17} \tag{44}$$

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

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