SBML Model Report

Model name: "Akman2008_Circadian_Clock_Model1"

May 6, 2016

1 General Overview

This is a document in SBML Level 2 Version 3 format. This model was created by the following two authors: Vijayalakshmi Chelliah[1] and Ozgur Akman[2] at December third 2008 at 12:40 a. m. and last time modified at February 25th 2015 at 1:50 p. 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	5
events	0	constraints	0
reactions	8	function definitions	0
global parameters	17	unit definitions	0
rules	1	initial assignments	0

Model Notes

This a model from the article:
Isoform switching facilitates period control in the Neurospora crassa circadian clock.
Akman OE, Locke JC, Tang S, Carr I, Millar AJ, Rand DA Mol. Syst. Biol. 2008;Vol 4: 164

[1]EMBL-EBI, viji@ebi.ac.uk
[2]Centre for Systems Biology at Edinburgh, The University of Edinburgh, Edinburgh, UK, oakman@staffmail.ed.ac.uk

18277380 ,

Abstract:
A striking and defining feature of circadian clocks is the small variation in period over a physiological range of temperatures. This is referred to as temperature compensation, although recent work has suggested that the variation observed is a specific, adaptive control of period. Moreover, given that many biological rate constants have a Q(10) of around 2, it is remarkable that such clocks remain rhythmic under significant temperature changes. We introduce a new mathematical model for the Neurospora crassa circadian network incorporating experimental work showing that temperature alters the balance of translation between a short and long form of the FREQUENCY (FRQ) protein. This is used to discuss period control and functionality for the Neurospora system. The model reproduces a broad range of key experimental data on temperature dependence and rhythmicity, both in wild-type and mutant strains. We present a simple mechanism utilising the presence of the FRQ isoforms (isoform switching) by which period control could have evolved, and argue that this regulatory structure may also increase the temperature range where the clock is robustly rhythmic.

2 Unit Definitions

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

2.1 Unit `substance`

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

Definition mol

2.2 Unit `volume`

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

Definition l

2.3 Unit `area`

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

Definition m^2

2.4 Unit length

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

Definition m

2.5 Unit time

Notes Second is the predefined SBML unit for time.

Definition s

3 Compartments

This model contains two compartments.

Table 2: Properties of all compartments.

Id	Name	SBO	Spatial Dimensions	Size	Unit	Constant	Outside
nucleus	nucleus	0000290	3	1	litre	☑	
cytoplasm	cytoplasm	0000290	3	1	litre	☑	

3.1 Compartment nucleus

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

Name nucleus

SBO:0000290 physical compartment

3.2 Compartment cytoplasm

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

Name cytoplasm

SBO:0000290 physical compartment

4 Species

This model contains five 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
FC	FC	cytoplasm	$\mathrm{mol} \cdot \mathrm{l}^{-1}$	⊟	⊟
FCp	FCp	cytoplasm	$\mathrm{mol} \cdot \mathrm{l}^{-1}$	⊟	⊟
FN	FN	nucleus	$\mathrm{mol} \cdot \mathrm{l}^{-1}$	⊟	⊟
FNp	FNp	nucleus	$\mathrm{mol} \cdot \mathrm{l}^{-1}$	⊟	⊟
MF	MF	nucleus	$\mathrm{mol} \cdot \mathrm{l}^{-1}$	⊟	⊟

5 Parameters

This model contains 17 global parameters.

Table 4: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
vs	vs	0000186	1.224		☑
ki	ki	0000009	5.045		☑
n	n	0000190	6.396		☑
vm	vm	0000186	0.885		☑
km	km	0000027	0.085		☑
ks	ks	0000009	0.314		☑
vd	vd	0000009	0.161		☑
k1n	k1n	0000027	0.223		☑
k2n	k2n	0000027	0.331		☑
ksp	ksp	0000009	0.295		☑
vdp	vdp	0000009	0.140		☑
k1np	k1np	0000009	0.272		☑
k2np	k2np	0000009	0.295		☑
amp	amp	0000492	0.000		☑
dawn	dawn	0000002	6.000		☑
dusk	dusk	0000002	18.000		☑
Tot_FRQ	Tot_FRQ		0.000		☐

6 Rule

This is an overview of one rule.

6.1 Rule Tot_FRQ

Rule Tot_FRQ is an assignment rule for parameter Tot_FRQ:

$$\text{Tot\_FRQ} = [\text{FC}] + [\text{FCp}] + [\text{FN}] + [\text{FNp}] \tag{1}$$

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

7 Reactions

This model contains eight 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	MFtrn	MFtrn	$\emptyset \xrightarrow{\text{FN, FNp}} \text{MF}$	0000183
2	MFdeg	MFdeg	$\text{MF} \longrightarrow \emptyset$	0000179
3	FCtrl	FCtrl	$\emptyset \xrightarrow{\text{MF}} \text{FC}$	0000184
4	FCdeg	FCdeg	$\text{FC} \longrightarrow \emptyset$	0000179
5	FCtrs	FCtrs	$\text{FC} \rightleftharpoons \text{FN}$	0000185
6	FCptrl	FCptrl	$\emptyset \xrightarrow{\text{MF}} \text{FCp}$	0000184
7	FCpdeg	FCpdeg	$\text{FCp} \longrightarrow \emptyset$	0000179
8	FCptrs	FCptrs	$\text{FCp} \rightleftharpoons \text{FNp}$	0000185

7.1 Reaction MFtrn

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

Name MFtrn

SBO:0000183 transcription

Reaction equation

$$\emptyset \xrightarrow{\text{FN, FNp}} \text{MF} \tag{2}$$

Modifiers

Table 6: Properties of each modifier.

Id	Name	SBO
FN	FN	
FNp	FNp	

Product

Table 7: Properties of each product.

Id	Name	SBO
MF	MF	

Kinetic Law

Derived unit contains undeclared units

$$v_1 = \frac{\left(\text{vs} + \text{amp} \cdot \frac{\left(1+\tanh\left(2\cdot\left(\text{time}-24\cdot\left\lfloor\frac{\text{time}}{24}\right\rfloor-\text{dawn}\right)\right)\right)\cdot\left(1-\tanh\left(2\cdot\left(\text{time}-24\cdot\left\lfloor\frac{\text{time}}{24}\right\rfloor-\text{dusk}\right)\right)\right)}{4}\right)\cdot \text{ki}^{\text{n}}}{\text{ki}^{\text{n}} + \left([\text{FN}] + [\text{FNp}]\right)^{\text{n}}} \tag{3}$$

7.2 Reaction MFdeg

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

Name MFdeg

SBO:0000179 degradation

Reaction equation

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

Reactant

Table 8: Properties of each reactant.

Id	Name	SBO
MF	MF	

Kinetic Law

Derived unit contains undeclared units

$$v_2 = \frac{\mathrm{vm} \cdot [\mathrm{MF}]}{\mathrm{km} + [\mathrm{MF}]} \tag{5}$$

7.3 Reaction FCtrl

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

Name FCtrl

SBO:0000184 translation

Reaction equation

$$\emptyset \xrightarrow{\mathrm{MF}} \mathrm{FC} \tag{6}$$

Modifier

Table 9: Properties of each modifier.

Id	Name	SBO
MF	MF	

Product

Table 10: Properties of each product.

Id	Name	SBO
FC	FC	

Id	Name	SBO

Kinetic Law

Derived unit contains undeclared units

$$v_3 = \mathrm{ks} \cdot [\mathrm{MF}] \tag{7}$$

7.4 Reaction FCdeg

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

Name FCdeg

SBO:0000179 degradation

Reaction equation

$$\mathrm{FC} \longrightarrow \emptyset \tag{8}$$

Reactant

Table 11: Properties of each reactant.

Id	Name	SBO
FC	FC	

Kinetic Law

Derived unit contains undeclared units

$$v_4 = \mathrm{vd} \cdot [\mathrm{FC}] \tag{9}$$

7.5 Reaction FCtrs

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

Name FCtrs

SBO:0000185 transport reaction

Reaction equation

$$\mathrm{FC} \rightleftharpoons \mathrm{FN} \tag{10}$$

Reactant

Table 12: Properties of each reactant.

Id	Name	SBO
FC	FC	

Product

Table 13: Properties of each product.

Id	Name	SBO
FN	FN	

Kinetic Law

Derived unit contains undeclared units

$$v_5 = \mathrm{k1n} \cdot [\mathrm{FC}] - \mathrm{k2n} \cdot [\mathrm{FN}] \tag{11}$$

7.6 Reaction FCptrl

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

Name FCptrl

SBO:0000184 translation

Reaction equation

$$\emptyset \xrightarrow{\mathrm{MF}} \mathrm{FCp} \tag{12}$$

Modifier

Table 14: Properties of each modifier.

Id	Name	SBO
MF	MF	

Product

Table 15: Properties of each product.

Id	Name	SBO
FCp	FCp	

Kinetic Law

Derived unit contains undeclared units

$$v_6 = \text{ksp} \cdot [\text{MF}] \tag{13}$$

7.7 Reaction FCpdeg

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

Name FCpdeg

SBO:0000179 degradation

Reaction equation

$$\text{FCp} \longrightarrow \emptyset \tag{14}$$

Reactant

Table 16: Properties of each reactant.

Id	Name	SBO
FCp	FCp	

Kinetic Law

Derived unit contains undeclared units

$$v_7 = \text{vdp} \cdot [\text{FCp}] \tag{15}$$

7.8 Reaction FCptrs

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

Name FCptrs

SBO:0000185 transport reaction

Reaction equation

$$\mathrm{FCp} \rightleftharpoons \mathrm{FNp} \tag{16}$$

Reactant

Table 17: Properties of each reactant.

Id	Name	SBO
FCp	FCp	

Product

Table 18: Properties of each product.

Id	Name	SBO
FNp	FNp	

Kinetic Law

Derived unit contains undeclared units

$$v_8 = \mathrm{k1np} \cdot [\mathrm{FCp}] - \mathrm{k2np} \cdot [\mathrm{FNp}] \tag{17}$$

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 FC

Name FC

SBO:0000245 macromolecule

Initial concentration $2.46246334204771\ \mathrm{mol} \cdot \mathrm{l}^{-1}$

This species takes part in three reactions (as a reactant in FCdeg, FCtrs and as a product in FCtrl).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{FC} = v_3 - v_4 - v_5 \tag{18}$$

8.2 Species FCp

Name FCp

SBO:0000245 macromolecule

Initial concentration $2.7123114824279\ \mathrm{mol}\cdot\mathrm{l}^{-1}$

This species takes part in three reactions (as a reactant in FCpdeg, FCptrs and as a product in FCptrl).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{FCp} = v_6 - v_7 - v_8 \tag{19}$$

8.3 Species FN

Name FN

SBO:0000245 macromolecule

Initial concentration $1.84400040515923\ \mathrm{mol}\cdot\mathrm{l}^{-1}$

This species takes part in two reactions (as a product in FCtrs and as a modifier in MFtrn).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{FN} = v_5 \tag{20}$$

8.4 Species FNp

Name FNp

SBO:0000245 macromolecule

Initial concentration $2.74224951500791\ \mathrm{mol}\cdot\mathrm{l}^{-1}$

This species takes part in two reactions (as a product in FCptrs and as a modifier in MFtrn).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{FNp} = v_8 \tag{21}$$

8.5 Species MF

Name MF

SBO:0000278 messenger RNA

Initial concentration $0.725579308537909\ \mathrm{mol}\cdot\mathrm{l}^{-1}$

This species takes part in four reactions (as a reactant in MFdeg and as a product in MFtrn and as a modifier in FCtrl, FCptrl).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{MF} = v_1 - v_2 \tag{22}$$

A Glossary of Systems Biology Ontology Terms

SBO:0000002 quantitative systems description parameter: A numerical value that defines certain characteristics of systems or system functions. It may be part of a calculation, but its value is not determined by the form of the equation itself, and may be arbitrarily assigned

SBO:0000009 kinetic constant: Numerical parameter that quantifies the velocity of a chemical reaction

SBO:0000027 Michaelis constant: Substrate concentration at which the velocity of reaction is half its maximum. Michaelis constant is an experimental parameter. According to the underlying molecular mechanism it can be interpreted differently in terms of microscopic constants

SBO:0000179 degradation: Complete disappearance of a physical entity

SBO:0000183 transcription: Process through which a DNA sequence is copied to produce a complementary RNA

SBO:0000184 translation: Process in which a polypeptide chain is produced from a messenger RNA

SBO:0000185 transport reaction: Movement of a physical entity without modification of the structure of the entity

SBO:0000186 maximal velocity: Limiting maximal velocity of an enzymatic reaction, reached when the substrate is in large excess and all the enzyme is complexed.

SBO:0000190 Hill coefficient: Empirical parameter created by Archibald Vivian Hill to describe the cooperative binding of oxygen on hemoglobine (Hill (1910). The possible effects of the aggregation of the molecules of haemoglobin on its dissociation curves. J Physiol 40: iv-vii)

SBO:0000245 macromolecule: Molecular entity mainly built-up by the repetition of pseudo-identical units. CHEBI:3383

SBO:0000278 messenger RNA: A messenger RNA is a ribonucleic acid synthesized during the transcription of a gene, and that carries the information to encode one or several proteins

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

SBO:0000492 amplitude: Amplitude is the magnitude of change in the oscillating variable, with each oscillation, within an oscillating system.

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.

[a]Center for Bioinformatics Tübingen (ZBIT), Germany
[b]California Institute of Technology, Beckman Institute BNMC, Pasadena, United States
[c]European Bioinformatics Institute, Wellcome Trust Genome Campus, Hinxton, United Kingdom
[d]EML Research gGmbH, Heidelberg, Germany