

SBML Model Report

Model identifier: “Goldbeter2008_Somite-Segmentation_Clock_Notch_Wnt_FGF”



September 28, 2010

1. General Overview

This is a document in SBML Level 2 Version 3 format. This model was created by the following two authors: Catherine Lloyd¹ and Lukas Endler² at November seventh 2008 at 3:03 p. m. and last modified at June 24th 2009 at one o’ clock in the afternoon. Table 1 provides an overview of the quantities of all components of this model.

Table 1: The SBML components in this model.
All components are described in more detail in the following sections.

Element	Quantity	Element	Quantity
compartment types	0	compartments	1
species types	0	species	26
events	0	constraints	0
reactions	33	function definitions	0
global parameters	71	unit definitions	6
rules	5	initial assignments	0

Model Notes

This is a model of the coupled Natch, Wnt and FGF modules as described in:

A. Goldbeter and O. Pourqui, Modeling the segmentation clock as a network of coupled

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oscillations in the Notch, Wnt and FGF signaling pathways. *J Theor Biol.* 2008 Jun 7;252(3):574-85, pubmed ID: [18308339](#)

To uncouple the modules remove the reaction `MAX_trans_Xa` and set `vsFK=vsF`.

The SBML version of the model was converted from the CellML [version](#) by Catherine Lloyd for the [CellML repository](#).

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Model Annotation

The following resources provide further information about this model:

This model is [urn:miriam:biomodels.db:BIOMD0000000201](#).

This model is [urn:miriam:biomodels.db:MODEL6415057828](#).

This model is described by [urn:miriam:pubmed:18308339](#).

This biological entity is [urn:miriam:taxonomy:32524](#).

This biological entity has the version:

- [urn:miriam:reactome:REACT_11045.1](#).
- [urn:miriam:reactome:REACT_299.2](#).
- [urn:miriam:reactome:REACT_9470.2](#).

This biological entity is a part of [urn:miriam:obo.go:GO%3A0001756](#).

This biological entity has the version:

- [urn:miriam:kegg.pathway:ko04310](#).
- [urn:miriam:kegg.pathway:ko04330](#).
- [urn:miriam:kegg.pathway:ko04010](#).

This biological entity has the version:

- [urn:miriam:obo.go:GO%3A0007219](#).
- [urn:miriam:obo.go:GO%3A0008543](#).
- [urn:miriam:obo.go:GO%3A0016055](#).

2. Unit Definitions

This is an overview of nine unit definitions. The units volume, area, and length are predefined by SBML and not mentioned in the model.

2.1. Unit `substance`

Name nanomole

Definition nmol

2.2. Unit `time`

Name minute

Definition 60 s

2.3. Unit `first_order_rate_constant`

Name first_order_rate_constant

Definition $(60\text{ s})^{-1}$

2.4. Unit `second_order_rate_constant`

Name second_order_rate_constant

Definition $\text{nmol}^{-1} \cdot \text{l} \cdot (60\text{ s})^{-1}$

2.5. Unit `flux`

Name flux

Definition $\text{nmol} \cdot \text{l}^{-1} \cdot (60\text{ s})^{-1}$

2.6. Unit `nanomolar`

Name nanomolar

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

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. Compartment

This model contains one compartment.

Table 2: Properties of all compartments.

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

3.1. Compartment `cytosol`

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

MIRIAM Annotation This biological entity is [urn:miriam:obo.go:GO:3A0005829](http://miriam.org/obo/go/GO:3A0005829).

4. Species

This model contains 26 species. The boundary condition of four of these species is set to `true` so that these species' amount cannot be changed by any reaction. 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
N	Notch protein	cytosol	$\text{nmol} \cdot \text{l}^{-1}$	<input type="checkbox"/>	<input type="checkbox"/>
Na	cytosolic NicD	cytosol	$\text{nmol} \cdot \text{l}^{-1}$	<input type="checkbox"/>	<input type="checkbox"/>
Nan	nuclear NicD	cytosol	$\text{nmol} \cdot \text{l}^{-1}$	<input type="checkbox"/>	<input type="checkbox"/>
MF	Lunatic fringe mRNA	cytosol	$\text{nmol} \cdot \text{l}^{-1}$	<input type="checkbox"/>	<input type="checkbox"/>
F	Lunatic Fringe protein	cytosol	$\text{nmol} \cdot \text{l}^{-1}$	<input type="checkbox"/>	<input type="checkbox"/>
Bp	phosph. beta-catenin	cytosol	$\text{nmol} \cdot \text{l}^{-1}$	<input type="checkbox"/>	<input type="checkbox"/>
BN	nuclear beta-catenin	cytosol	$\text{nmol} \cdot \text{l}^{-1}$	<input type="checkbox"/>	<input type="checkbox"/>
A	Axin2 protein	cytosol	$\text{nmol} \cdot \text{l}^{-1}$	<input type="checkbox"/>	<input type="checkbox"/>
K	Gsk3	cytosol	$\text{nmol} \cdot \text{l}^{-1}$	<input type="checkbox"/>	<input type="checkbox"/>
B	beta-catenin	cytosol	$\text{nmol} \cdot \text{l}^{-1}$	<input type="checkbox"/>	<input type="checkbox"/>
MAx	Axin2 mRNA	cytosol	$\text{nmol} \cdot \text{l}^{-1}$	<input type="checkbox"/>	<input type="checkbox"/>
Rasa	active Ras	cytosol	$\text{nmol} \cdot \text{l}^{-1}$	<input type="checkbox"/>	<input type="checkbox"/>
ERKa	active ERK	cytosol	$\text{nmol} \cdot \text{l}^{-1}$	<input type="checkbox"/>	<input type="checkbox"/>
Xa	active TF X	cytosol	$\text{nmol} \cdot \text{l}^{-1}$	<input type="checkbox"/>	<input type="checkbox"/>
MDusp	Dusp6 mRNA	cytosol	$\text{nmol} \cdot \text{l}^{-1}$	<input type="checkbox"/>	<input type="checkbox"/>
Dusp	Dusp6 protein	cytosol	$\text{nmol} \cdot \text{l}^{-1}$	<input type="checkbox"/>	<input type="checkbox"/>
Rasi	inactive Ras	cytosol	$\text{nmol} \cdot \text{l}^{-1}$	<input type="checkbox"/>	<input checked="" type="checkbox"/>
ERKi	inactive ERK	cytosol	$\text{nmol} \cdot \text{l}^{-1}$	<input type="checkbox"/>	<input checked="" type="checkbox"/>
Xi	inactive TF X	cytosol	$\text{nmol} \cdot \text{l}^{-1}$	<input type="checkbox"/>	<input checked="" type="checkbox"/>
Rast	Ras total	cytosol	$\text{nmol} \cdot \text{l}^{-1}$	<input type="checkbox"/>	<input type="checkbox"/>
ERKt	ERK total	cytosol	$\text{nmol} \cdot \text{l}^{-1}$	<input type="checkbox"/>	<input type="checkbox"/>

Id	Name	Compartment	Derived Unit	Constant	Boundary Condition
Xt	X total	cytosol	$\text{nmol} \cdot \text{l}^{-1}$	<input type="checkbox"/>	<input type="checkbox"/>
D	Dsh protein	cytosol	$\text{nmol} \cdot \text{l}^{-1}$	<input type="checkbox"/>	<input type="checkbox"/>
AK	Axin2/Gsk3 destruction complex	cytosol	$\text{nmol} \cdot \text{l}^{-1}$	<input type="checkbox"/>	<input checked="" type="checkbox"/>
Kt	Kt	cytosol	$\text{nmol} \cdot \text{l}^{-1}$	<input checked="" type="checkbox"/>	<input type="checkbox"/>
Fgf	Fgf	cytosol	$\text{nmol} \cdot \text{l}^{-1}$	<input checked="" type="checkbox"/>	<input type="checkbox"/>

5. Parameters

This model contains 71 global parameters.

Table 4: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
KdN	KdN	0000027	1.400	$\text{nmol} \cdot \text{l}^{-1}$	<input checked="" type="checkbox"/>
vsN	vsN	0000048	0.230	$\text{nmol} \cdot \text{l}^{-1} \cdot (60 \text{ s})^{-1}$	<input checked="" type="checkbox"/>
vdN	vdN	0000324	2.820	$\text{nmol} \cdot \text{l}^{-1} \cdot (60 \text{ s})^{-1}$	<input checked="" type="checkbox"/>
KdNa	KdNa	0000027	0.001	$\text{nmol} \cdot \text{l}^{-1}$	<input checked="" type="checkbox"/>
VdNa	VdNa	0000186	0.010	$\text{nmol} \cdot \text{l}^{-1} \cdot (60 \text{ s})^{-1}$	<input checked="" type="checkbox"/>
kt1	kt1	0000022	0.100	$(60 \text{ s})^{-1}$	<input checked="" type="checkbox"/>
kt2	kt2	0000032	0.100	$(60 \text{ s})^{-1}$	<input checked="" type="checkbox"/>
KdNan	KdNan	0000027	0.001	$\text{nmol} \cdot \text{l}^{-1}$	<input checked="" type="checkbox"/>
VdNan	VdNan	0000186	0.100	$\text{nmol} \cdot \text{l}^{-1} \cdot (60 \text{ s})^{-1}$	<input checked="" type="checkbox"/>
KdMF	KdMF	0000027	0.768	$\text{nmol} \cdot \text{l}^{-1}$	<input checked="" type="checkbox"/>
KIG1	KIG1		2.500	$\text{nmol} \cdot \text{l}^{-1}$	<input checked="" type="checkbox"/>
vsFK	vsFK	0000186	0.000	$\text{nmol} \cdot \text{l}^{-1} \cdot (60 \text{ s})^{-1}$	<input type="checkbox"/>
vsF	vsF	0000186	3.000	$\text{nmol} \cdot \text{l}^{-1} \cdot (60 \text{ s})^{-1}$	<input checked="" type="checkbox"/>
vmF	vmF	0000186	1.920	$\text{nmol} \cdot \text{l}^{-1} \cdot (60 \text{ s})^{-1}$	<input checked="" type="checkbox"/>
KA	KA		0.050	$\text{nmol} \cdot \text{l}^{-1}$	<input checked="" type="checkbox"/>
KdF	KdF	0000027	0.370	$\text{nmol} \cdot \text{l}^{-1}$	<input checked="" type="checkbox"/>
vdF	vdF	0000186	0.390	$\text{nmol} \cdot \text{l}^{-1} \cdot (60 \text{ s})^{-1}$	<input checked="" type="checkbox"/>
ksF	ksF	0000022	0.300	$(60 \text{ s})^{-1}$	<input checked="" type="checkbox"/>
kd1	kd1	0000022	0.000	$(60 \text{ s})^{-1}$	<input checked="" type="checkbox"/>
vsB	vsB	0000186	0.087	$\text{nmol} \cdot \text{l}^{-1} \cdot (60 \text{ s})^{-1}$	<input checked="" type="checkbox"/>
kd2	kd2	0000022	7.062	$(60 \text{ s})^{-1}$	<input checked="" type="checkbox"/>
v0	v0	0000186	0.060	$\text{nmol} \cdot \text{l}^{-1} \cdot (60 \text{ s})^{-1}$	<input checked="" type="checkbox"/>
vMB	vMB	0000186	1.640	$\text{nmol} \cdot \text{l}^{-1} \cdot (60 \text{ s})^{-1}$	<input checked="" type="checkbox"/>
vmd	vmd	0000186	0.800	$\text{nmol} \cdot \text{l}^{-1} \cdot (60 \text{ s})^{-1}$	<input checked="" type="checkbox"/>
KaB	KaB		0.700	$\text{nmol} \cdot \text{l}^{-1}$	<input checked="" type="checkbox"/>
KaXa	KaXa	0000027	0.050	$\text{nmol} \cdot \text{l}^{-1}$	<input checked="" type="checkbox"/>
Kmd	Kmd		0.480	$\text{nmol} \cdot \text{l}^{-1}$	<input checked="" type="checkbox"/>
n	n	0000190	2.000	dimensionless	<input checked="" type="checkbox"/>
m	m	0000190	2.000	dimensionless	<input checked="" type="checkbox"/>
vMXa	vMXa	0000186	0.500	$\text{nmol} \cdot \text{l}^{-1} \cdot (60 \text{ s})^{-1}$	<input checked="" type="checkbox"/>
ksAx	ksAx	0000022	0.020	$(60 \text{ s})^{-1}$	<input checked="" type="checkbox"/>
vdAx	vdAx	0000186	0.600	$\text{nmol} \cdot \text{l}^{-1} \cdot (60 \text{ s})^{-1}$	<input checked="" type="checkbox"/>
KdAx	KdAx	0000027	0.630	$\text{nmol} \cdot \text{l}^{-1}$	<input checked="" type="checkbox"/>
d1	d1	0000338	0.100	$(60 \text{ s})^{-1}$	<input checked="" type="checkbox"/>
a1	a1	0000023	1.800	$\text{nmol}^{-1} \cdot \text{l} \cdot (60 \text{ s})^{-1}$	<input checked="" type="checkbox"/>

Id	Name	SBO	Value	Unit	Constant
K1	K1	0000027	0.280	$\text{nmol} \cdot \text{l}^{-1}$	<input checked="" type="checkbox"/>
K2	K2	0000027	0.030	$\text{nmol} \cdot \text{l}^{-1}$	<input checked="" type="checkbox"/>
kt3	kt3	0000022	0.700	$(60 \text{ s})^{-1}$	<input checked="" type="checkbox"/>
kt4	kt4	0000032	1.500	$(60 \text{ s})^{-1}$	<input checked="" type="checkbox"/>
ksDusp	ksDusp	0000022	0.500	$(60 \text{ s})^{-1}$	<input checked="" type="checkbox"/>
vdDusp	vdDusp	0000186	2.000	$\text{nmol} \cdot \text{l}^{-1} \cdot (60 \text{ s})^{-1}$	<input checked="" type="checkbox"/>
KdDusp	KdDusp	0000027	0.500	$\text{nmol} \cdot \text{l}^{-1}$	<input checked="" type="checkbox"/>
kcDusp	kcDusp	0000022	1.350	$(60 \text{ s})^{-1}$	<input checked="" type="checkbox"/>
KaFgf	KaFgf	0000191	0.500	$\text{nmol} \cdot \text{l}^{-1}$	<input checked="" type="checkbox"/>
KaRas	KaRas	0000027	0.103	$\text{nmol} \cdot \text{l}^{-1}$	<input checked="" type="checkbox"/>
KdRas	KdRas	0000027	0.100	$\text{nmol} \cdot \text{l}^{-1}$	<input checked="" type="checkbox"/>
KdErk	KdErk	0000027	0.050	$\text{nmol} \cdot \text{l}^{-1}$	<input checked="" type="checkbox"/>
KaErk	KaErk	0000027	0.050	$\text{nmol} \cdot \text{l}^{-1}$	<input checked="" type="checkbox"/>
KaX	KaX	0000027	0.050	$\text{nmol} \cdot \text{l}^{-1}$	<input checked="" type="checkbox"/>
KIF	KIF	0000191	0.500	$\text{nmol} \cdot \text{l}^{-1}$	<input checked="" type="checkbox"/>
KID	KID	0000027	0.500	$\text{nmol} \cdot \text{l}^{-1}$	<input checked="" type="checkbox"/>
KdX	KdX	0000027	0.050	$\text{nmol} \cdot \text{l}^{-1}$	<input checked="" type="checkbox"/>
KaMDusp	KaMDusp	0000191	0.500	$\text{nmol} \cdot \text{l}^{-1}$	<input checked="" type="checkbox"/>
KdMDusp	KdMDusp	0000027	0.500	$\text{nmol} \cdot \text{l}^{-1}$	<input checked="" type="checkbox"/>
q	q	0000190	2.000	dimensionless	<input checked="" type="checkbox"/>
r	r	0000191	2.000	dimensionless	<input checked="" type="checkbox"/>
kc	kc	0000022	3.450	$(60 \text{ s})^{-1}$	<input checked="" type="checkbox"/>
j	j	0000191	2.000	dimensionless	<input checked="" type="checkbox"/>
p	p	0000191	2.000	dimensionless	<input checked="" type="checkbox"/>
epsilon	epsilon	0000381	0.300	dimensionless	<input checked="" type="checkbox"/>
theta	theta	0000381	1.500	dimensionless	<input checked="" type="checkbox"/>
eta	eta	0000381	0.300	dimensionless	<input checked="" type="checkbox"/>
VMsMDusp	VMsMDusp	0000186	0.900	$\text{nmol} \cdot \text{l}^{-1} \cdot (60 \text{ s})^{-1}$	<input checked="" type="checkbox"/>
VMdMDusp	VMdMDusp	0000186	0.500	$\text{nmol} \cdot \text{l}^{-1} \cdot (60 \text{ s})^{-1}$	<input checked="" type="checkbox"/>
VMK	VMK	0000186	5.080	$\text{nmol} \cdot \text{l}^{-1} \cdot (60 \text{ s})^{-1}$	<input checked="" type="checkbox"/>
VMP	VMP	0000186	1.000	$\text{nmol} \cdot \text{l}^{-1} \cdot (60 \text{ s})^{-1}$	<input checked="" type="checkbox"/>
VMaRas	VMaRas	0000186	4.968	$\text{nmol} \cdot \text{l}^{-1} \cdot (60 \text{ s})^{-1}$	<input checked="" type="checkbox"/>
VMdRas	VMdRas	0000186	0.410	$\text{nmol} \cdot \text{l}^{-1} \cdot (60 \text{ s})^{-1}$	<input checked="" type="checkbox"/>
VMaErk	VMaErk	0000186	3.300	$\text{nmol} \cdot \text{l}^{-1} \cdot (60 \text{ s})^{-1}$	<input checked="" type="checkbox"/>
VMaX	VMaX	0000186	1.600	$\text{nmol} \cdot \text{l}^{-1} \cdot (60 \text{ s})^{-1}$	<input checked="" type="checkbox"/>
VMdX	VMdX	0000186	0.500	$\text{nmol} \cdot \text{l}^{-1} \cdot (60 \text{ s})^{-1}$	<input checked="" type="checkbox"/>

6. Rules

This is an overview of five rules.

6.1. Rule vsFK

Rule vsFK is an assignment rule for parameter vsFK:

$$vsFK = vsF \cdot \frac{KIG1}{KIG1 + [K]} \quad (1)$$

Derived unit $\text{nmol} \cdot \text{l}^{-1} \cdot (60 \text{ s})^{-1}$

6.2. Rule AK

Rule AK is an assignment rule for species AK:

$$AK = [Kt] - [K] \quad (2)$$

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

6.3. Rule Rasi

Rule Rasi is an assignment rule for species Rasi:

$$Rasi = [Rast] - [Rasa] \quad (3)$$

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

6.4. Rule ERKi

Rule ERKi is an assignment rule for species ERKi:

$$ERKi = [ERKt] - [ERKa] \quad (4)$$

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

6.5. Rule Xi

Rule Xi is an assignment rule for species Xi:

$$Xi = [Xt] - [Xa] \quad (5)$$

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

7. Reactions

This model contains 33 reactions. All reactions are listed in the following table and are subsequently described in detail. If a reaction is affected by one or more modifiers, the identifiers of the modifier species are written above the reaction arrow.

Table 5: Overview of all reactions

Nº	Id	Name	Reaction Equation	SBO
1	n_synth	Notch_synthesis	$\emptyset \longrightarrow N$	
2	N_degradation	N_degradation	$N \longrightarrow \emptyset$	0000179
3	N_activation	Notch_activation	$N \xrightarrow{F} Na$	0000178
4	Na_degradation	Na_degradation	$Na \longrightarrow \emptyset$	0000179
5	Na_transport		$Na \rightleftharpoons Nan$	0000185
6	Nan_degradation		$Nan \longrightarrow \emptyset$	0000179
7	MF- _transkription		$\emptyset \xrightarrow{Nan} MF$	0000183
8	MF_degradation		$MF \longrightarrow \emptyset$	0000179
9	F_translation		$\emptyset \xrightarrow{MF} F$	0000184
10	F_degradation		$F \longrightarrow \emptyset$	0000179
11	AK_dissoc		$AK \rightleftharpoons A + K$	0000180
12	B_synth		$\emptyset \longrightarrow B$	
13	B_degradation		$B \longrightarrow \emptyset$	0000179
14	B- _phosphorylation		$B \xrightarrow{AK, D, Kt} Bp$	0000216
15	BP- _dephosphorylation		$Bp \longrightarrow B$	0000330
16	B_shuttling		$BN \rightleftharpoons B$	0000185
17	Bp_degradation		$Bp \longrightarrow \emptyset$	0000179
18	MAx_trans_basal		$\emptyset \xrightarrow{BN} MAx$	0000183

Nº	Id	Name	Reaction Equation	SBO
19	MAx.trans_BN		$\emptyset \xrightarrow{BN} MAx$	0000183
20	MAx.trans_Xa		$\emptyset \xrightarrow{Xa} MAx$	0000183
21	MAx.degradation		$MAx \longrightarrow \emptyset$	0000179
22	A.translation		$\emptyset \xrightarrow{MAx} A$	0000184
23	A.degradation		$A \longrightarrow \emptyset$	0000179
24	Ras.activation		$\emptyset \xrightarrow{Rasi, Fgf} Rasa$	
25	Ras- _inactivation		$Rasa \longrightarrow \emptyset$	
26	Erk.activation		$\emptyset \xrightarrow{ERKi, Rasa, Rast} ERKa$	
27	Erk- _inactivation		$ERKa \xrightarrow{Dusp} \emptyset$	
28	X.activation		$\emptyset \xrightarrow{ERKa, ERKt, Xi} Xa$	
29	X.inactivation		$Xa \longrightarrow \emptyset$	
30	MDusp- _transkription		$\emptyset \xrightarrow{Xa} MDusp$	0000183
31	MDusp- _degradation		$MDusp \longrightarrow \emptyset$	0000179
32	Dusp- _translation		$\emptyset \xrightarrow{MDusp} Dusp$	0000184
33	Dusp- _degradation		$Dusp \longrightarrow \emptyset$	0000179

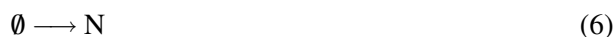
7.1. Reaction `n_synth`

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

Name `Notch_synthesis`

MIRIAM Annotation This biological entity is a version of [urn:miriam:obo:go:G0%3A0010467](http://miriam.org/obo/go/G0%3A0010467).

Reaction equation



Product

Table 6: Properties of each product.

Id	Name	SBO
N	Notch protein	

Kinetic Law

Derived unit $\text{nmol} \cdot (60 \text{ s})^{-1}$

$$v_1 = \text{vol}(\text{cytosol}) \cdot \text{epsilon} \cdot \text{vsN} \quad (7)$$

7.2. Reaction `N_degradation`

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

Name `N_degradation`

SBO:0000179 degradation

MIRIAM Annotation This biological entity is a version of [urn:miriam:obo:go:G0%3A0030163](http://miriam.org/obo/go/G0%3A0030163).

Reaction equation



Reactant

Table 7: Properties of each reactant.

Id	Name	SBO
N	Notch protein	

Kinetic Law

Derived unit $9.999999999999998 \cdot 10^{-10} \text{ mol} \cdot (60 \text{ s})^{-1}$

$$v_2 = \frac{\text{epsilon} \cdot \text{vol}(\text{cytosol}) \cdot \text{vdN} \cdot [\text{N}]}{\text{KdN} + [\text{N}]} \quad (9)$$

7.3. Reaction `N_activation`

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

Name `Notch_activation`

SBO:0000178 cleavage

MIRIAM Annotation This biological entity is a version of:

- [urn:miriam:reactome:REACT_691.2](http://miriam.org/uri/urn:miriam:reactome:REACT_691.2).
- [urn:miriam:obo.go:GO%3A0007220](http://miriam.org/uri/urn:miriam:obo.go:GO%3A0007220).

Reaction equation



Reactant

Table 8: Properties of each reactant.

Id	Name	SBO
N	Notch protein	

Modifier

Table 9: Properties of each modifier.

Id	Name	SBO
F	Lunatic Fringe protein	

Product

Table 10: Properties of each product.

Id	Name	SBO
Na	cytosolic NicD	

Kinetic Law

Derived unit $(60 \text{ s})^{-1} \cdot 1.0000000000000038 \cdot 10^{-9} \text{ mol}$

$$v_3 = \frac{\text{epsilon} \cdot \text{vol}(\text{cytosol}) \cdot \text{kc} \cdot [\text{N}] \cdot \text{KIF}^j}{\text{KIF}^j + [\text{F}]^j} \quad (11)$$

7.4. Reaction Na_degradation

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

Name Na_degradation

SBO:0000179 degradation

MIRIAM Annotation This biological entity is a version of [urn:miriam:obo:GO%3A0030163](http://miriam.org/obo/go/G0%3A0030163).

Reaction equation



Reactant

Table 11: Properties of each reactant.

Id	Name	SBO
Na	cytosolic NicD	

Kinetic Law

Derived unit $9.99999999999998 \cdot 10^{-10} \text{ mol} \cdot (60 \text{ s})^{-1}$

$$v_4 = \frac{\text{epsilon} \cdot \text{vol}(\text{cytosol}) \cdot \text{VdNa} \cdot [\text{Na}]}{\text{KdNa} + [\text{Na}]} \quad (13)$$

7.5. Reaction Na_transport

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

SBO:0000185 transport

MIRIAM Annotation This biological entity is a version of:

- [urn:miriam:reactome:REACT_2155.3](http://miriam.org/uri/urn:miriam:reactome:REACT_2155.3).
- [urn:miriam:obo.go:GO%3A0006913](http://miriam.org/uri/urn:miriam:obo.go:GO%3A0006913).

Reaction equation



Reactant

Table 12: Properties of each reactant.

Id	Name	SBO
Na	cytosolic NicD	

Product

Table 13: Properties of each product.

Id	Name	SBO
Nan	nuclear NicD	

Kinetic Law

Derived unit $(60 \text{ s})^{-1} \cdot \text{nmol}$

$$v_5 = \text{epsilon} \cdot \text{vol}(\text{cytosol}) \cdot (\text{kt1} \cdot [\text{Na}] - \text{kt2} \cdot [\text{Nan}]) \quad (15)$$

7.6. Reaction [Nan_degradation](#)

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

SBO:0000179 degradation

MIRIAM Annotation This biological entity is a version of [urn:miriam:obo.go:GO%3A0030163](http://miriam.org/uri/urn:miriam:obo.go:GO%3A0030163).

Reaction equation



Reactant

Table 14: Properties of each reactant.

Id	Name	SBO
Nan	nuclear NicD	

Kinetic Law

Derived unit $9.999999999999998 \cdot 10^{-10} \text{ mol} \cdot (60 \text{ s})^{-1}$

$$v_6 = \frac{\text{epsilon} \cdot \text{vol}(\text{cytosol}) \cdot \text{VdNan} \cdot [\text{Nan}]}{\text{KdNan} + [\text{Nan}]} \quad (17)$$

7.7. Reaction MF_transkription

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

SBO:0000183 transcription

MIRIAM Annotation This biological entity is a version of [urn:miriam:obo:go:G0%3A0009299](http://miriam.org/obo/go/G0%3A0009299).

Reaction equation



Modifier

Table 15: Properties of each modifier.

Id	Name	SBO
Nan	nuclear NicD	

Product

Table 16: Properties of each product.

Id	Name	SBO
MF	Lunatic fringe mRNA	

Kinetic Law

Derived unit $1.0000000000000038 \cdot 10^{-9} \text{ mol} \cdot (60 \text{ s})^{-1}$

$$v_7 = \frac{\text{epsilon} \cdot \text{vol}(\text{cytosol}) \cdot \text{vsFK} \cdot [\text{Nan}]^p}{K_A^p + [\text{Nan}]^p} \quad (19)$$

7.8. Reaction MF_degradation

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

SBO:0000179 degradation

MIRIAM Annotation This biological entity is a version of [urn:miriam:obo:go:G0%3A0006402](http://miriam.org/obo/go/G0%3A0006402).

Reaction equation



Reactant

Table 17: Properties of each reactant.

Id	Name	SBO
MF	Lunatic fringe mRNA	

Kinetic Law

Derived unit $9.999999999999998 \cdot 10^{-10} \text{ mol} \cdot (60 \text{ s})^{-1}$

$$v_8 = \frac{\text{epsilon} \cdot \text{vol}(\text{cytosol}) \cdot \text{vmF} \cdot [\text{MF}]}{K_{\text{dMF}} + [\text{MF}]} \quad (21)$$

7.9. Reaction F_translation

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

SBO:0000184 translation

MIRIAM Annotation This biological entity is a version of [urn:miriam:obo:go:G0%3A0006412](http://miriam.org/obo/go/G0%3A0006412).

Reaction equation



Modifier

Table 18: Properties of each modifier.

Id	Name	SBO
MF	Lunatic fringe mRNA	

Product

Table 19: Properties of each product.

Id	Name	SBO
F	Lunatic Fringe protein	

Kinetic Law

Derived unit $(60 \text{ s})^{-1} \cdot \text{nmol}$

$$v_9 = \text{epsilon} \cdot \text{vol}(\text{cytosol}) \cdot \text{ksF} \cdot [\text{MF}] \quad (23)$$

7.10. Reaction `F_degradation`

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

SBO:0000179 degradation

MIRIAM Annotation This biological entity is a version of [urn:miriam:obo.go:G0%3A0030163](http://miriam.org/obo/go/G0%3A0030163).

Reaction equation



Reactant

Table 20: Properties of each reactant.

Id	Name	SBO
F	Lunatic Fringe protein	

Kinetic Law

Derived unit $9.999999999999998 \cdot 10^{-10} \text{ mol} \cdot (60 \text{ s})^{-1}$

$$v_{10} = \frac{\text{epsilon} \cdot \text{vol}(\text{cytosol}) \cdot \text{vdF} \cdot [\text{F}]}{\text{KdF} + [\text{F}]} \quad (25)$$

7.11. Reaction `AK_dissoc`

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

SBO:0000180 dissociation

MIRIAM Annotation This biological entity is a version of [urn:miriam:obo.go:G0%3A0043241](http://miriam.org/obo/go/G0%3A0043241).

Reaction equation



Reactant

Table 21: Properties of each reactant.

Id	Name	SBO
AK	Axin2/Gsk3 destruction complex	

Products

Table 22: Properties of each product.

Id	Name	SBO
A	Axin2 protein	
K	Gsk3	

Kinetic Law

Derived unit $(60 \text{ s})^{-1} \cdot \text{nmol}$

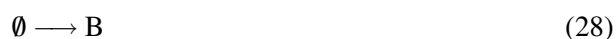
$$v_{11} = \text{theta} \cdot \text{vol}(\text{cytosol}) \cdot (d1 \cdot [AK] - a1 \cdot [A] \cdot [K]) \quad (27)$$

7.12. Reaction `B_synth`

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

MIRIAM Annotation This biological entity is a version of [urn:miriam:obo.go:G0%3A0010467](http://miriam.org/obo/go/G0%3A0010467).

Reaction equation



Product

Table 23: Properties of each product.

Id	Name	SBO
B	beta-catenin	

Kinetic Law

Derived unit $\text{nmol} \cdot (60 \text{ s})^{-1}$

$$v_{12} = \text{theta} \cdot \text{vol}(\text{cytosol}) \cdot \text{vsB} \quad (29)$$

7.13. Reaction B_degradation

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

SBO:0000179 degradation

MIRIAM Annotation This biological entity is a version of [urn:miriam:obo.go:G0%3A0030163](http://miriam.org/obo/go/G0%3A0030163).

Reaction equation



Reactant

Table 24: Properties of each reactant.

Id	Name	SBO
B	beta-catenin	

Kinetic Law

Derived unit $(60 \text{ s})^{-1} \cdot \text{nmol}$

$$v_{13} = \text{theta} \cdot \text{vol}(\text{cytosol}) \cdot \text{kd1} \cdot [\text{B}] \quad (31)$$

7.14. Reaction B_phosphorylation

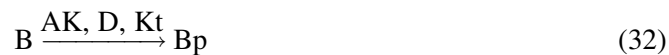
This is an irreversible reaction of one reactant forming one product influenced by three modifiers.

SBO:0000216 phosphorylation

MIRIAM Annotation This biological entity is a version of:

- [urn:miriam:reactome:REACT_11065.1](http://miriam.org/reactome/REACT_11065.1).
- [urn:miriam:obo.go:G0%3A0006468](http://miriam.org/obo/go/G0%3A0006468).

Reaction equation



Reactant

Table 25: Properties of each reactant.

Id	Name	SBO
B	beta-catenin	

Modifiers

Table 26: Properties of each modifier.

Id	Name	SBO
AK	Axin2/Gsk3 destruction complex	
D	Dsh protein	
Kt	Kt	

Product

Table 27: Properties of each product.

Id	Name	SBO
Bp	phosph. beta-catenin	

Kinetic Law

Derived unit $9.999999999999996 \cdot 10^{-10} \text{ mol} \cdot (60 \text{ s})^{-1}$

$$v_{14} = \frac{\frac{\text{theta} \cdot \text{vol}(\text{cytosol}) \cdot \text{VMK} \cdot \text{KID} \cdot [\text{B}]}{\text{KID} + [\text{D}]}}{\text{K1} + [\text{B}]} \cdot [\text{AK}] \quad (33)$$

7.15. Reaction BP_dephosphorylation

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

SBO:0000330 dephosphorylation

MIRIAM Annotation This biological entity is a version of [urn:miriam:obo.go:G0%3A0006470](http://miriam.org/obo/go/G0%3A0006470).

Reaction equation



Reactant

Table 28: Properties of each reactant.

Id	Name	SBO
Bp	phosph. beta-catenin	

Product

Table 29: Properties of each product.

Id	Name	SBO
B	beta-catenin	

Kinetic Law

Derived unit $9.999999999999998 \cdot 10^{-10} \text{ mol} \cdot (60 \text{ s})^{-1}$

$$v_{15} = \frac{\text{theta} \cdot \text{vol}(\text{cytosol}) \cdot \text{VMP} \cdot [\text{Bp}]}{\text{K2} + [\text{Bp}]} \quad (35)$$

7.16. Reaction B_shuttling

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

SBO:0000185 transport

MIRIAM Annotation This biological entity is a version of [urn:miriam:obo.go:G0%3A0006913](http://miriam.obo.go.org/G0%3A0006913).

Reaction equation



Reactant

Table 30: Properties of each reactant.

Id	Name	SBO
BN	nuclear beta-catenin	

Product

Table 31: Properties of each product.

Id	Name	SBO
B	beta-catenin	

Kinetic Law

Derived unit $(60 \text{ s})^{-1} \cdot \text{nmol}$

$$v_{16} = \text{theta} \cdot \text{vol}(\text{cytosol}) \cdot (\text{kt4} \cdot [\text{BN}] - \text{kt3} \cdot [\text{B}]) \quad (37)$$

7.17. Reaction `Bp_degradation`

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

SBO:0000179 degradation

MIRIAM Annotation This biological entity is a version of:

- [urn:miriam:reactome:REACT_11063.1](http://miriam.org/urn:miriam:reactome:REACT_11063.1).
- [urn:miriam:obo.go:GO%3A0030163](http://miriam.org/urn:miriam:obo.go:GO%3A0030163).

Reaction equation



Reactant

Table 32: Properties of each reactant.

Id	Name	SBO
Bp	phosph. beta-catenin	

Kinetic Law

Derived unit $(60 \text{ s})^{-1} \cdot \text{nmol}$

$$v_{17} = \text{theta} \cdot \text{vol}(\text{cytosol}) \cdot \text{kd2} \cdot [\text{Bp}] \quad (39)$$

7.18. Reaction `MAx_trans_basal`

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

SBO:0000183 transcription

MIRIAM Annotation This biological entity is a version of [urn:miriam:obo.go:G0%3A0009299](http://miriam.org/obo/go/G0%3A0009299).

Reaction equation



Modifier

Table 33: Properties of each modifier.

Id	Name	SBO
BN	nuclear beta-catenin	

Product

Table 34: Properties of each product.

Id	Name	SBO
MAx	Axin2 mRNA	

Kinetic Law

Derived unit $\text{nmol} \cdot (60 \text{ s})^{-1}$

$$v_{18} = \text{theta} \cdot \text{vol}(\text{cytosol}) \cdot v_0 \quad (41)$$

7.19. Reaction `MAx.trans.BN`

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

SBO:0000183 transcription

MIRIAM Annotation This biological entity is a version of [urn:miriam:obo.go:G0%3A0009299](http://miriam.org/obo/go/G0%3A0009299).

Reaction equation



Modifier

Table 35: Properties of each modifier.

Id	Name	SBO
BN	nuclear beta-catenin	

Product

Table 36: Properties of each product.

Id	Name	SBO
MAx	Axin2 mRNA	

Kinetic Law

Derived unit $1.0000000000000038 \cdot 10^{-9} \text{ mol} \cdot (60 \text{ s})^{-1}$

$$v_{19} = \text{theta} \cdot \text{vol}(\text{cytosol}) \cdot \frac{v_{\text{MB}} \cdot [\text{BN}]^n}{K_{\text{aB}}^n + [\text{BN}]^n} \quad (43)$$

7.20. Reaction MAx_trans_Xa

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

SBO:0000183 transcription

MIRIAM Annotation This biological entity is a version of [urn:miriam:obo.go:G0%3A0009299](http://miriam.org/obo/go/G0%3A0009299).

Reaction equation



Modifier

Table 37: Properties of each modifier.

Id	Name	SBO
Xa	active TF X	

Product

Table 38: Properties of each product.

Id	Name	SBO
MAx	Axin2 mRNA	

Kinetic Law

Derived unit $1.0000000000000038 \cdot 10^{-9} \text{ mol} \cdot (60 \text{ s})^{-1}$

$$v_{20} = \text{theta} \cdot \text{vol}(\text{cytosol}) \cdot \frac{v\text{MXa} \cdot [\text{Xa}]^m}{K\text{aXa}^m + [\text{Xa}]^m} \quad (45)$$

7.21. Reaction MAx_degradation

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

SBO:0000179 degradation

MIRIAM Annotation This biological entity is a version of [urn:miriam:obo:go:G0%3A0006402](http://miriam.org/obo/go/G0%3A0006402).

Reaction equation



Reactant

Table 39: Properties of each reactant.

Id	Name	SBO
MAx	Axin2 mRNA	

Kinetic Law

Derived unit $9.999999999999998 \cdot 10^{-10} \text{ mol} \cdot (60 \text{ s})^{-1}$

$$v_{21} = \frac{\text{theta} \cdot \text{vol}(\text{cytosol}) \cdot v\text{md} \cdot [\text{MAx}]}{K\text{md} + [\text{MAx}]} \quad (47)$$

7.22. Reaction A_translation

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

SBO:0000184 translation

MIRIAM Annotation This biological entity is a version of [urn:miriam:obo:go:G0%3A0006412](http://miriam.org/obo/go/G0%3A0006412).

Reaction equation



Modifier

Table 40: Properties of each modifier.

Id	Name	SBO
MAx	Axin2 mRNA	

Product

Table 41: Properties of each product.

Id	Name	SBO
A	Axin2 protein	

Kinetic Law

Derived unit $(60 \text{ s})^{-1} \cdot \text{nmol}$

$$v_{22} = \text{theta} \cdot \text{vol}(\text{cytosol}) \cdot \text{ksAx} \cdot [\text{MAx}] \quad (49)$$

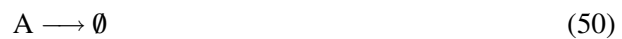
7.23. Reaction A_degradation

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

SBO:0000179 degradation

MIRIAM Annotation This biological entity is a version of [urn:miriam:obo:go:G0%3A0030163](http://miriam.org/obo/go/G0%3A0030163).

Reaction equation



Reactant

Table 42: Properties of each reactant.

Id	Name	SBO
A	Axin2 protein	

Kinetic Law

Derived unit $9.999999999999998 \cdot 10^{-10} \text{ mol} \cdot (60 \text{ s})^{-1}$

$$v_{23} = \frac{\text{theta} \cdot \text{vol}(\text{cytosol}) \cdot \text{vdAx} \cdot [\text{A}]}{\text{KdAx} + [\text{A}]} \quad (51)$$

7.24. Reaction Ras_activation

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

MIRIAM Annotation This biological entity is a version of:

- [urn:miriam:reactome:REACT_2010.5](http://miriam.org/uri/urn:miriam:reactome:REACT_2010.5).
- [urn:miriam:obo.go:GO%3A0032856](http://miriam.org/uri/urn:miriam:obo.go:GO%3A0032856).

Reaction equation



Modifiers

Table 43: Properties of each modifier.

Id	Name	SBO
Rasi	inactive Ras	
Fgf	Fgf	

Product

Table 44: Properties of each product.

Id	Name	SBO
Rasa	active Ras	

Kinetic Law

Derived unit $1.00000000000000038 \cdot 10^{-9} \text{ mol} \cdot (60 \text{ s})^{-1}$

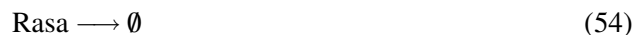
$$v_{24} = \frac{\frac{\text{eta} \cdot \text{vol}(\text{cytosol}) \cdot \text{VMaRas} \cdot [\text{Fgf}]^r}{\text{KaFgf}^r + [\text{Fgf}]^r} \cdot [\text{Rasi}]}{\text{KaRas} + [\text{Rasi}]} \quad (53)$$

7.25. Reaction `Ras_inactivation`

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

MIRIAM Annotation This biological entity is a version of [urn:miriam:obo:go:G0%3A0034261](http://miriam.org/obo/go/G0%3A0034261).

Reaction equation



Reactant

Table 45: Properties of each reactant.

Id	Name	SBO
Rasa	active Ras	

Kinetic Law

Derived unit $9.999999999999998 \cdot 10^{-10} \text{ mol} \cdot (60 \text{ s})^{-1}$

$$v_{25} = \frac{\text{eta} \cdot \text{vol}(\text{cytosol}) \cdot \text{VMdRas} \cdot [\text{Rasa}]}{\text{KdRas} + [\text{Rasa}]} \quad (55)$$

7.26. Reaction `Erk_activation`

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

MIRIAM Annotation This biological entity is a version of [urn:miriam:reactome:REACT_1482.4](http://miriam.org/reactome/REACT_1482.4).

Reaction equation



Modifiers

Table 46: Properties of each modifier.

Id	Name	SBO
ERKi	inactive ERK	
Rasa	active Ras	
Rast	Ras total	

Product

Table 47: Properties of each product.

Id	Name	SBO
ERKa	active ERK	

Kinetic Law

Derived unit $9.999999999999996 \cdot 10^{-10} \text{ mol} \cdot (60 \text{ s})^{-1}$

$$v_{26} = \frac{\frac{\text{eta} \cdot \text{vol}(\text{cytosol}) \cdot V_{\text{MaErk}} \cdot [\text{Rasa}]}{[\text{Rast}]} \cdot [\text{ERKi}]}{K_{\text{aErk}} + [\text{ERKi}]} \quad (57)$$

7.27. Reaction Erk_inactivation

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

MIRIAM Annotation This biological entity is a version of [urn:miriam:reactome:REACT_12436.1](http://miriam.org/uri/reactome/REACT_12436.1).

Reaction equation



Reactant

Table 48: Properties of each reactant.

Id	Name	SBO
ERKa	active ERK	

Modifier

Table 49: Properties of each modifier.

Id	Name	SBO
Dusp	Dusp6 protein	

Kinetic Law

Derived unit $(60 \text{ s})^{-1} \cdot 9.999999999999998 \cdot 10^{-10} \text{ mol}$

$$v_{27} = \frac{\text{eta} \cdot \text{vol}(\text{cytosol}) \cdot \text{kcDusp} \cdot [\text{Dusp}] \cdot [\text{ERKa}]}{\text{KdErk} + [\text{ERKa}]} \quad (59)$$

7.28. Reaction $X_{\text{activation}}$

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

MIRIAM Annotation This biological entity is a version of [urn:miriam:obo:go:G0%3A0051091](http://miriam.org/obo/go/G0%3A0051091).

Reaction equation



Modifiers

Table 50: Properties of each modifier.

Id	Name	SBO
ERKa	active ERK	
ERKt	ERK total	
Xi	inactive TF X	

Product

Table 51: Properties of each product.

Id	Name	SBO
Xa	active TF X	

Kinetic Law

Derived unit $9.999999999999996 \cdot 10^{-10} \text{ mol} \cdot (60 \text{ s})^{-1}$

$$v_{28} = \frac{\frac{\text{eta} \cdot \text{vol}(\text{cytosol}) \cdot \text{VMaX} \cdot [\text{ERKa}]}{[\text{ERKt}]} \cdot [\text{Xi}]}{\text{KaX} + [\text{Xi}]} \quad (61)$$

7.29. Reaction $X_{\text{inactivation}}$

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

MIRIAM Annotation This biological entity is a version of [urn:miriam:obo:go:G0%3A0043433](http://miriam.org/obo/go/G0%3A0043433).

Reaction equation



Reactant

Table 52: Properties of each reactant.

Id	Name	SBO
Xa	active TF X	

Kinetic Law

Derived unit $9.999999999999998 \cdot 10^{-10} \text{ mol} \cdot (60 \text{ s})^{-1}$

$$v_{29} = \frac{\text{eta} \cdot \text{vol}(\text{cytosol}) \cdot \text{VMdX} \cdot [Xa]}{\text{KdX} + [Xa]} \quad (63)$$

7.30. Reaction MDusp_transkription

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

SBO:0000183 transcription

MIRIAM Annotation This biological entity is a version of [urn:miriam:obo.go:GO:3A0009299](http://miriam.org/obo/go/GO:3A0009299).

Reaction equation



Modifier

Table 53: Properties of each modifier.

Id	Name	SBO
Xa	active TF X	

Product

Table 54: Properties of each product.

Id	Name	SBO
MDusp	Dusp6 mRNA	

Id	Name	SBO
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Kinetic Law

Derived unit $1.0000000000000038 \cdot 10^{-9} \text{ mol} \cdot (60 \text{ s})^{-1}$

$$v_{30} = \frac{\text{eta} \cdot \text{vol}(\text{cytosol}) \cdot \text{VMsMDusp} \cdot [\text{Xa}]^q}{\text{KaMDusp}^q + [\text{Xa}]^q} \quad (65)$$

7.31. Reaction MDusp_degradation

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

SBO:0000179 degradation

MIRIAM Annotation This biological entity is a version of [urn:miriam:obo:go:G0%3A0006402](http://miriam.org/obo/go/G0%3A0006402).

Reaction equation



Reactant

Table 55: Properties of each reactant.

Id	Name	SBO
MDusp	Dusp6 mRNA	

Kinetic Law

Derived unit $9.99999999999998 \cdot 10^{-10} \text{ mol} \cdot (60 \text{ s})^{-1}$

$$v_{31} = \frac{\text{eta} \cdot \text{vol}(\text{cytosol}) \cdot \text{VMdMDusp} \cdot [\text{MDusp}]}{\text{KdMDusp} + [\text{MDusp}]} \quad (67)$$

7.32. Reaction Dusp_translation

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

SBO:0000184 translation

MIRIAM Annotation This biological entity is a version of [urn:miriam:obo:go:G0%3A0006412](http://miriam.org/obo/go/G0%3A0006412).

Reaction equation



Modifier

Table 56: Properties of each modifier.

Id	Name	SBO
MDusp	Dusp6 mRNA	

Product

Table 57: Properties of each product.

Id	Name	SBO
Dusp	Dusp6 protein	

Kinetic Law

Derived unit $(60 \text{ s})^{-1} \cdot \text{nmol}$

$$v_{32} = \text{eta} \cdot \text{vol}(\text{cytosol}) \cdot \text{ksDusp} \cdot [\text{MDusp}] \quad (69)$$

7.33. Reaction `Dusp_degradation`

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

SBO:0000179 degradation

MIRIAM Annotation This biological entity is a version of [urn:miriam:obo.go:G0%3A0030163](http://miriam.org/obo/go/G0%3A0030163).

Reaction equation



Reactant

Table 58: Properties of each reactant.

Id	Name	SBO
Dusp	Dusp6 protein	

Kinetic Law

Derived unit $9.999999999999998 \cdot 10^{-10} \text{ mol} \cdot (60 \text{ s})^{-1}$

$$v_{33} = \frac{\text{eta} \cdot \text{vol}(\text{cytosol}) \cdot \text{vdDusp} \cdot [\text{Dusp}]}{\text{KdDusp} + [\text{Dusp}]} \quad (71)$$

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 N

Name Notch protein

SBO:0000252 polypeptide chain

MIRIAM Annotation This biological entity is a version of [urn:miriam:interpro:IPR008297](http://miriam.org/interpro/IPR008297).

This biological entity is described by [urn:miriam:uniprot:P46531](http://miriam.org/uniprot/P46531).

Initial concentration $0.5 \text{ nmol} \cdot \text{l}^{-1}$

This species takes part in three reactions (as a reactant in [N_degradation](#), [N_activation](#) and as a product in [n_synth](#)).

$$\frac{d}{dt}N = v_1 - v_2 - v_3 \quad (72)$$

8.2. Species Na

Name cytosolic NicD

SBO:0000252 polypeptide chain

MIRIAM Annotation This biological entity is a part of [urn:miriam:interpro:IPR008297](http://miriam.org/interpro/IPR008297).

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

This species takes part in three reactions (as a reactant in [Na_degradation](#), [Na_transport](#) and as a product in [N_activation](#)).

$$\frac{d}{dt}Na = v_3 - v_4 - v_5 \quad (73)$$

8.3. Species Nan

Name nuclear NicD

SBO:0000252 polypeptide chain

MIRIAM Annotation This biological entity is a part of [urn:miriam:interpro:IPR008297](http://miriam.org/interpro/IPR008297).

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

This species takes part in three reactions (as a reactant in [Nan_degradation](#) and as a product in [Na_transport](#) and as a modifier in [MF_transkription](#)).

$$\frac{d}{dt}\text{Nan} = v_5 - v_6 \quad (74)$$

8.4. Species MF

Name Lunatic fringe mRNA

SBO:0000250 ribonucleic acid

MIRIAM Annotation This biological entity has something to do with:

- [urn:miriam:uniprot:Q8NES3](http://miriam.org/uniprot/Q8NES3).
- [urn:miriam:interpro:IPR017374](http://miriam.org/interpro/IPR017374).

This biological entity is a version of [urn:miriam:obo.chebi:CHEBI%3A33699](http://miriam.org/obo/chebi/CHEBI%3A33699).

Initial concentration $0.1 \text{ nmol} \cdot \text{l}^{-1}$

This species takes part in three reactions (as a reactant in [MF_degradation](#) and as a product in [MF_transkription](#) and as a modifier in [F_translation](#)).

$$\frac{d}{dt}\text{MF} = v_7 - v_8 \quad (75)$$

8.5. Species F

Name Lunatic Fringe protein

SBO:0000252 polypeptide chain

MIRIAM Annotation This biological entity is described by [urn:miriam:uniprot:Q8NES3](http://miriam.org/uniprot/Q8NES3).

This biological entity is a version of [urn:miriam:interpro:IPR017374](http://miriam.org/interpro/IPR017374).

Initial concentration $0.0010 \text{ nmol} \cdot \text{l}^{-1}$

This species takes part in three reactions (as a reactant in [F_degradation](#) and as a product in [F_translation](#) and as a modifier in [N_activation](#)).

$$\frac{d}{dt}\text{F} = v_9 - v_{10} \quad (76)$$

8.6. Species Bp

Name phosph. beta-catenin

SBO:0000252 polypeptide chain

MIRIAM Annotation This biological entity is a version of:

- [urn:miriam:interpro:IPR013284](http://miriam.org/interpro/IPR013284).
- [urn:miriam:kegg.compound:C00562](http://miriam.org/kegg/compound/C00562).

This biological entity is described by [urn:miriam:uniprot:P35222](http://miriam.org/uniprot/P35222).

Initial concentration $0.1 \text{ nmol} \cdot \text{l}^{-1}$

This species takes part in three reactions (as a reactant in [BP_dephosphorylation](#), [Bp_degradation](#) and as a product in [B_phosphorylation](#)).

$$\frac{d}{dt}\text{Bp} = v_{14} - v_{15} - v_{17} \quad (77)$$

8.7. Species BN

Name nuclear beta-catenin

SBO:0000252 polypeptide chain

MIRIAM Annotation This biological entity is a version of [urn:miriam:interpro:IPR013284](http://miriam.org/interpro/IPR013284).

This biological entity is described by [urn:miriam:uniprot:P35222](http://miriam.org/uniprot/P35222).

Initial concentration $0.0010 \text{ nmol} \cdot \text{l}^{-1}$

This species takes part in three reactions (as a reactant in [B_shuttling](#) and as a modifier in [MAx_trans_basal](#), [MAx_trans_BN](#)).

$$\frac{d}{dt}\text{BN} = -v_{16} \quad (78)$$

8.8. Species A

Name Axin2 protein

SBO:0000252 polypeptide chain

MIRIAM Annotation This biological entity is described by [urn:miriam:uniprot:Q9Y2T1](http://miriam.org/uniprot/Q9Y2T1).

Initial concentration $0.1 \text{ nmol} \cdot \text{l}^{-1}$

This species takes part in three reactions (as a reactant in [A_degradation](#) and as a product in [AK_dissoc](#), [A_translation](#)).

$$\frac{d}{dt}\text{A} = v_{11} + v_{22} - v_{23} \quad (79)$$

8.9. Species K

Name Gsk3

SBO:0000252 polypeptide chain

MIRIAM Annotation This biological entity is described by [urn:miriam:uniprot:P49841](http://miriam.org/urn:miriam:uniprot:P49841).

Initial concentration $3 \text{ nmol} \cdot \text{l}^{-1}$

This species takes part in one reaction (as a product in [AK_dissoc](#)).

$$\frac{d}{dt}K = v_{11} \quad (80)$$

8.10. Species B

Name beta-catenin

SBO:0000252 polypeptide chain

MIRIAM Annotation This biological entity is a version of [urn:miriam:interpro:IPR013284](http://miriam.org/urn:miriam:interpro:IPR013284).

Initial concentration $0.1 \text{ nmol} \cdot \text{l}^{-1}$

This species takes part in five reactions (as a reactant in [B_degradation](#), [B_phosphorylation](#) and as a product in [B_synth](#), [BP_dephosphorylation](#), [B_shuttling](#)).

$$\frac{d}{dt}B = v_{12} + v_{15} + v_{16} - v_{13} - v_{14} \quad (81)$$

8.11. Species M_{Ax}

Name Axin2 mRNA

SBO:0000250 ribonucleic acid

MIRIAM Annotation This biological entity has something to do with [urn:miriam:uniprot:Q9Y2T1](http://miriam.org/urn:miriam:uniprot:Q9Y2T1).

This biological entity is described by [urn:miriam:ensembl:ENSG00000168646](http://miriam.org/urn:miriam:ensembl:ENSG00000168646).

This biological entity is a version of [urn:miriam:obo.chebi:CHEBI%3A33699](http://miriam.org/urn:miriam:obo.chebi:CHEBI%3A33699).

Initial concentration $0.1 \text{ nmol} \cdot \text{l}^{-1}$

This species takes part in five reactions (as a reactant in [M_{Ax}_degradation](#) and as a product in [M_{Ax}_trans_basal](#), [M_{Ax}_trans_BN](#), [M_{Ax}_trans_Xa](#) and as a modifier in [A_translation](#)).

$$\frac{d}{dt}M_{Ax} = v_{18} + v_{19} + v_{20} - v_{21} \quad (82)$$

8.12. Species *Rasa*

Name active Ras

SBO:0000252 polypeptide chain

MIRIAM Annotation This biological entity has the version:

- [urn:miriam:obo.chebi:CHEBI%3A15996](http://miriam.org/obo/chebi/CHEBI%3A15996).
- [urn:miriam:interpro:IPR001806](http://miriam.org/interpro/IPR001806).

Initial concentration $0.5 \text{ nmol} \cdot \text{l}^{-1}$

This species takes part in three reactions (as a reactant in [Ras_inactivation](#) and as a product in [Ras_activation](#) and as a modifier in [Erk_activation](#)).

$$\frac{d}{dt} \text{Rasa} = v_{24} - v_{25} \quad (83)$$

8.13. Species *ERKa*

Name active ERK

SBO:0000252 polypeptide chain

MIRIAM Annotation This biological entity is a version of [urn:miriam:interpro:IPR008349](http://miriam.org/interpro/IPR008349).

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

This species takes part in three reactions (as a reactant in [Erk_inactivation](#) and as a product in [Erk_activation](#) and as a modifier in [X_activation](#)).

$$\frac{d}{dt} \text{ERKa} = v_{26} - v_{27} \quad (84)$$

8.14. Species *Xa*

Name active TF X

SBO:0000252 polypeptide chain

MIRIAM Annotation This biological entity is a version of [urn:miriam:interpro:IPR006715](http://miriam.org/interpro/IPR006715).

Initial concentration $0.1 \text{ nmol} \cdot \text{l}^{-1}$

This species takes part in four reactions (as a reactant in [X_inactivation](#) and as a product in [X_activation](#) and as a modifier in [MAX_trans_Xa](#), [MDusp_transkription](#)).

$$\frac{d}{dt} \text{Xa} = v_{28} - v_{29} \quad (85)$$

8.15. Species MDusp

Name Dusp6 mRNA

SBO:0000250 ribonucleic acid

MIRIAM Annotation This biological entity is described by <urn:miriam:ensembl:ENSG00000139318>.

This biological entity has something to do with <urn:miriam:uniprot:Q16828>.

Initial concentration $0.1 \text{ nmol} \cdot \text{l}^{-1}$

This species takes part in three reactions (as a reactant in [MDusp_degradation](#) and as a product in [MDusp_transkription](#) and as a modifier in [Dusp_translation](#)).

$$\frac{d}{dt} \text{MDusp} = v_{30} - v_{31} \quad (86)$$

8.16. Species Dusp

Name Dusp6 protein

SBO:0000252 polypeptide chain

MIRIAM Annotation This biological entity is described by <urn:miriam:uniprot:Q16828>.

Initial concentration $0.1 \text{ nmol} \cdot \text{l}^{-1}$

This species takes part in three reactions (as a reactant in [Dusp_degradation](#) and as a product in [Dusp_translation](#) and as a modifier in [Erk_inactivation](#)).

$$\frac{d}{dt} \text{Dusp} = v_{32} - v_{33} \quad (87)$$

8.17. Species Rasi

Name inactive Ras

SBO:0000252 polypeptide chain

MIRIAM Annotation This biological entity has the version:

- <urn:miriam:obo.chebi:CHEBI%3A17552>.
- <urn:miriam:interpro:IPR001806>.

Involved in rule [Rasi](#)

This species takes part in one reaction (as a modifier in [Ras_activation](#)). Not this but one rule determines the species' quantity because this species is on the boundary of the reaction system.

8.18. Species [ERKi](#)

Name inactive ERK

SBO:0000252 polypeptide chain

MIRIAM Annotation This biological entity is a version of [urn:miriam:interpro:IPR008349](http://miriam.org/urn:miriam:interpro:IPR008349).

Involved in rule [ERKi](#)

This species takes part in one reaction (as a modifier in [Erk_activation](#)). Not this but one rule determines the species' quantity because this species is on the boundary of the reaction system.

8.19. Species [Xi](#)

Name inactive TF X

SBO:0000252 polypeptide chain

MIRIAM Annotation This biological entity is a version of [urn:miriam:interpro:IPR006715](http://miriam.org/urn:miriam:interpro:IPR006715).

Involved in rule [Xi](#)

This species takes part in one reaction (as a modifier in [X_activation](#)). Not this but one rule determines the species' quantity because this species is on the boundary of the reaction system.

8.20. Species [Rast](#)

Name Ras total

SBO:0000252 polypeptide chain

MIRIAM Annotation This biological entity is a version of [urn:miriam:interpro:IPR001806](http://miriam.org/urn:miriam:interpro:IPR001806).

Initial concentration $2 \text{ nmol} \cdot \text{l}^{-1}$

This species takes part in one reaction (as a modifier in [Erk_activation](#)).

$$\frac{d}{dt} \text{Rast} = 0 \quad (88)$$

8.21. Species [ERKt](#)

Name ERK total

SBO:0000252 polypeptide chain

MIRIAM Annotation This biological entity is a version of [urn:miriam:interpro:IPR008349](http://miriam.org/urn:miriam:interpro:IPR008349).

Initial concentration $2 \text{ nmol} \cdot \text{l}^{-1}$

This species takes part in one reaction (as a modifier in [X_activation](#)).

$$\frac{d}{dt} \text{ERKt} = 0 \quad (89)$$

8.22. Species X_t

Name X total

SBO:0000252 polypeptide chain

MIRIAM Annotation This biological entity is a version of [urn:miriam:interpro:IPR006715](http://miriam.org/urn:miriam:interpro:IPR006715).

Initial concentration $2 \text{ nmol} \cdot \text{l}^{-1}$

This species does not take part in any reactions. Its quantity does hence not change over time:

$$\frac{d}{dt}X_t = 0 \quad (90)$$

8.23. Species D

Name Dsh protein

SBO:0000252 polypeptide chain

MIRIAM Annotation This biological entity is described by [urn:miriam:uniprot:014640](http://miriam.org/urn:miriam:uniprot:014640).

This biological entity is a version of [urn:miriam:interpro:IPR003351](http://miriam.org/urn:miriam:interpro:IPR003351).

Initial concentration $2 \text{ nmol} \cdot \text{l}^{-1}$

This species takes part in one reaction (as a modifier in [B_phosphorylation](#)).

$$\frac{d}{dt}D = 0 \quad (91)$$

8.24. Species AK

Name Axin2/Gsk3 destruction complex

SBO:0000297 protein

MIRIAM Annotation This biological entity has parts:

- [urn:miriam:uniprot:P49841](http://miriam.org/urn:miriam:uniprot:P49841).
- [urn:miriam:uniprot:Q9Y2T1](http://miriam.org/urn:miriam:uniprot:Q9Y2T1).

Involved in rule [AK](#)

This species takes part in two reactions (as a reactant in [AK_dissoc](#) and as a modifier in [B_phosphorylation](#)). Not these but one rule determines the species' quantity because this species is on the boundary of the reaction system.

8.25. Species Kt

Name Kt

SBO:0000252 polypeptide chain

MIRIAM Annotation This biological entity is described by [urn:miriam:uniprot:P49841](http://miriam.org/urn:miriam:uniprot:P49841).

Initial concentration $3 \text{ nmol} \cdot \text{l}^{-1}$

This species takes part in one reaction (as a modifier in [B_phosphorylation](#)).

$$\frac{d}{dt}Kt = 0 \quad (92)$$

8.26. Species Fgf

Name Fgf

SBO:0000252 polypeptide chain

MIRIAM Annotation This biological entity is a version of [urn:miriam:interpro:IPR017338](http://miriam.org/urn:miriam:interpro:IPR017338).

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

This species takes part in one reaction (as a modifier in [Ras_activation](#)).

$$\frac{d}{dt}Fgf = 0 \quad (93)$$

A. Glossary of Systems Biology Ontology Terms

SBO:0000022 forward unimolecular rate constant: Numerical parameter that quantifies the forward velocity of a chemical reaction involving only one reactant. This parameter encompasses all the contributions to the velocity except the quantity of the reactant

SBO:0000023 forward bimolecular rate constant: Numerical parameter that quantifies the forward velocity of a chemical reaction involving two reactants. This parameter encompasses all the contributions to the velocity except the quantity of the reactants.

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:0000032 reverse unimolecular rate constant: Numerical parameter that quantifies the reverse velocity of a chemical reaction involving only one product. This parameter encompasses all the contributions to the velocity except the quantity of the product

SBO:000048 forward zeroth order rate constant

, **continuous case:** Numerical parameter that quantifies the forward velocity of a chemical reaction independent of the reactant quantities. This parameter encompasses all the contributions to the velocity. It is to be used in a reaction modelled using a continuous framework.

SBO:000178 cleavage: Rupture of a covalent bond resulting in the conversion of one physical entity into several physical entities

SBO:000179 degradation: Complete disappearance of a physical entity

SBO:000180 dissociation: Transformation of a non-covalent complex that results in the formation of several independent biochemical entities

SBO:000183 transcription: Process through which a DNA sequence is copied to produce a complementary RNA

SBO:000184 translation: Process in which a polypeptide chain is produced from a messenger RNA

SBO:000185 transport: Movement of a physical entity without modification of the structure of the entity

SBO:000186 maximal velocity: Limiting maximal velocity of an enzymatic reaction, reached when the substrate is in large excess and all the enzyme is complexed.

SBO:000190 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). Determined from a "Hill plot", it is sometimes assumed to be the number of binding or catalytic sites in a polymer, but it is incorrect. In some mechanistic model, the Hill coefficient gives a lower limit for the number of sites.

SBO:000191 Hill constant: Empirical constant 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). Different from a microscopic dissociation constant, it has the dimension of concentration to the power of the Hill coefficient

SBO:000216 phosphorylation: Addition of a phosphate group ($-H_2PO_4$) to a chemical entity

SBO:000250 ribonucleic acid: Macromolecule formed by a repetition of ribonucleosides linked by phosphodiester bonds. CHEBI:3369

SBO:000252 polypeptide chain: Naturally occurring macromolecule formed by the repetition of amino-acid residues linked by peptidic bonds. A polypeptide chain is synthesized by the ribosome. CHEBI:1654

SBO:0000297 protein: Macromolecular complex containing one or more polypeptide chains possibly associated with simple chemicals. CHEBI:3608

SBO:0000324 forward maximal velocity: Limiting maximal velocity of the forward reaction of a reversible enzyme, reached when the substrate is in large excess and all the enzyme is complexed.

SBO:0000330 dephosphorylation: Removal of a phosphate group (-H₂PO₄) from a chemical entity.

SBO:0000338 dissociation rate constant: Rate with which a complex dissociates into its components

SBO:0000381 Unknown SBO id 381: Unknown SBO id 381

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