

SBML Model Report

Model name: “Schmitz2014 - RNA triplex formation”



March 3, 2017

1 General Overview

This is a document in SBML Level 2 Version 4 format. This model was created by Felix Winter¹ at October 23rd 2013 at 8:46 p. m. and last time modified at July 28th 2014 at 1:23 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	1
species types	0	species	10
events	0	constraints	0
reactions	17	function definitions	4
global parameters	0	unit definitions	1
rules	0	initial assignments	0

Model Notes

Schmitz2014 - RNA triplex formationThe model is parameterized using the parameters for gene CCDC3 from Supplementary Table S1. The two miRNAs which form the triplex together with CCDC3 are miR-551b and miR-138.

This model is described in the article:[Cooperative gene regulation by microRNA pairs and their identification using a computational workflow](#). Schmitz U, Lai X, Winter F, Wolkenhauer O, Vera J, Gupta SK. Nucleic Acids Res. 2014 Jul; 42(12): 7539-7552

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Abstract:

MicroRNAs (miRNAs) are an integral part of gene regulation at the post-transcriptional level. Recently, it has been shown that pairs of miRNAs can repress the translation of a target mRNA in a cooperative manner, which leads to an enhanced effectiveness and specificity in target repression. However, it remains unclear which miRNA pairs can synergize and which genes are target of cooperative miRNA regulation. In this paper, we present a computational workflow for the prediction and analysis of cooperating miRNAs and their mutual target genes, which we refer to as RNA triplexes. The workflow integrates methods of miRNA target prediction; triplex structure analysis; molecular dynamics simulations and mathematical modeling for a reliable prediction of functional RNA triplexes and target repression efficiency. In a case study we analyzed the human genome and identified several thousand targets of cooperative gene regulation. Our results suggest that miRNA cooperativity is a frequent mechanism for an enhanced target repression by pairs of miRNAs facilitating distinctive and fine-tuned target gene expression patterns. Human RNA triplexes predicted and characterized in this study are organized in a web resource at www.sbi.uni-rostock.de/triplexrna/.

This model is hosted on [BioModels Database](#) and identified by: [BIOMD0000000530](#).

To cite BioModels Database, please use: [BioModels Database: An enhanced, curated and annotated resource for published quantitative kinetic models](#).

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2 Unit Definitions

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

2.1 Unit `substance`

Name substance

Definition mmol

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 m²

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 Compartment

This model contains one compartment.

Table 2: Properties of all compartments.

Id	Name	SBO	Spatial Dimensions	Size	Unit	Constant	Outside
<code>compartment_1</code>	<code>compartment</code>		3	1	litre	<input checked="" type="checkbox"/>	

3.1 Compartment `compartment_1`

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

Name `compartment`

4 Species

This model contains ten species. Section 7 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
species_1	mRNA	compartment_1	$\text{mmol} \cdot \text{l}^{-1}$	\square	\square
species_2	miRNA_1	compartment_1	$\text{mmol} \cdot \text{l}^{-1}$	\square	\square
species_3	miRNA_2	compartment_1	$\text{mmol} \cdot \text{l}^{-1}$	\square	\square
species_4	duplex_1	compartment_1	$\text{mmol} \cdot \text{l}^{-1}$	\square	\square
species_5	duplex_2	compartment_1	$\text{mmol} \cdot \text{l}^{-1}$	\square	\square
species_6	triplex	compartment_1	$\text{mmol} \cdot \text{l}^{-1}$	\square	\square
species_7	TF_mRNA	compartment_1	$\text{mmol} \cdot \text{l}^{-1}$	\square	\square
species_8	TF_miRNA_1	compartment_1	$\text{mmol} \cdot \text{l}^{-1}$	\square	\square
species_9	TF_miRNA_2	compartment_1	$\text{mmol} \cdot \text{l}^{-1}$	\square	\square
species_10	protein	compartment_1	$\text{mmol} \cdot \text{l}^{-1}$	\square	\square

5 Function definitions

This is an overview of four function definitions.

5.1 Function definition [function_1](#)

Name mRNA synthesis_1

Arguments k_syn_mRNA, [species_7]

Mathematical Expression

$$k_syn_mRNA \cdot [species_7] \quad (1)$$

5.2 Function definition [function_3](#)

Name miRNA_2 synthesis_1

Arguments k_syn_miRNA_2, [species_9]

Mathematical Expression

$$k_syn_miRNA_2 \cdot [species_9] \quad (2)$$

5.3 Function definition [function_4](#)

Name protein synthesis_1

Arguments k_syn_prot, [species_1]

Mathematical Expression

$$k_syn_prot \cdot [species_1] \quad (3)$$

5.4 Function definition [function_2](#)

Name miRNA_1 synthesis_1

Arguments k_syn_miRNA_1, [species_8]

Mathematical Expression

$$k_syn_miRNA_1 \cdot [species_8] \quad (4)$$

6 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 4: Overview of all reactions

Nº	Id	Name	Reaction Equation	SBO
1	reaction_1	duplex 1 association	$\text{species_1} + \text{species_2} \xrightarrow{\text{species_1, species_2}} \text{species_4}$	
2	reaction_2	duplex 2 association	$\text{species_1} + \text{species_3} \xrightarrow{\text{species_1, species_3}} \text{species_5}$	
3	reaction_3	triplex association	$\text{species_1} + \text{species_2} + \text{species_3} \xrightarrow{\text{species_1, species_2, species_3}} \text{species_6}$	
4	reaction_4	mRNA synthesis	$\emptyset \xrightarrow{\text{species_7, species_7}} \text{species_1}$	
5	reaction_5	miRNA_1 synthesis	$\emptyset \xrightarrow{\text{species_8, species_8}} \text{species_2}$	
6	reaction_6	miRNA_2 synthesis	$\emptyset \xrightarrow{\text{species_9, species_9}} \text{species_3}$	
7	reaction_7	mRNA degradation	$\text{species_1} \xrightarrow{\text{species_1}} \emptyset$	
8	reaction_8	miRNA_1 degradation	$\text{species_2} \xrightarrow{\text{species_2}} \emptyset$	
9	reaction_9	miRNA_2 degradation	$\text{species_3} \xrightarrow{\text{species_3}} \emptyset$	
10	reaction_10	duplex 1 dissociation	$\text{species_4} \xrightarrow{\text{species_4}} \text{species_2} + \text{species_1}$	
11	reaction_11	duplex 2 dissociation	$\text{species_5} \xrightarrow{\text{species_5}} \text{species_3} + \text{species_1}$	
12	reaction_12	triplex dissociation	$\text{species_6} \xrightarrow{\text{species_6}} \text{species_2} + \text{species_3} + \text{species_1}$	
13	reaction_13	duplex 1 degradation	$\text{species_4} \xrightarrow{\text{species_4}} \emptyset$	
14	reaction_14	duplex 2 degradation	$\text{species_5} \xrightarrow{\text{species_5}} \emptyset$	

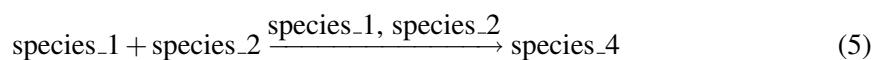
Nº	Id	Name	Reaction Equation	SBO
15	reaction_15	triplex degradation	$\text{species_6} \xrightarrow{\text{species_6}} \emptyset$	
16	reaction_16	protein synthesis	$\emptyset \xrightarrow{\text{species_1}, \text{species_1}} \text{species_10}$	
17	reaction_17	protein degradation	$\text{species_10} \xrightarrow{\text{species_10}} \emptyset$	

6.1 Reaction `reaction_1`

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

Name duplex 1 association

Reaction equation



Reactants

Table 5: Properties of each reactant.

Id	Name	SBO
<code>species_1</code>	mRNA	
<code>species_2</code>	miRNA_1	

Modifiers

Table 6: Properties of each modifier.

Id	Name	SBO
<code>species_1</code>	mRNA	
<code>species_2</code>	miRNA_1	

Product

Table 7: Properties of each product.

Id	Name	SBO
<code>species_4</code>	duplex_1	

Kinetic Law

Derived unit contains undeclared units

$$v_1 = \text{vol}(\text{compartment_1}) \cdot k_1 \cdot [\text{species_1}] \cdot [\text{species_2}] \quad (6)$$

Table 8: Properties of each parameter.

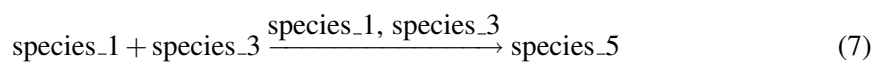
Id	Name	SBO	Value	Unit	Constant
k1	k1		$4.5298 \cdot 10^{-4}$		<input checked="" type="checkbox"/>

6.2 Reaction `reaction_2`

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

Name duplex 2 association

Reaction equation



Reactants

Table 9: Properties of each reactant.

Id	Name	SBO
species_1	mRNA	
species_3	miRNA_2	

Modifiers

Table 10: Properties of each modifier.

Id	Name	SBO
species_1	mRNA	
species_3	miRNA_2	

Product

Table 11: Properties of each product.

Id	Name	SBO
species_5	duplex_2	

Kinetic Law

Derived unit contains undeclared units

$$v_2 = \text{vol}(\text{compartment}_1) \cdot k_1 \cdot [\text{species}_1] \cdot [\text{species}_3] \quad (8)$$

Table 12: Properties of each parameter.

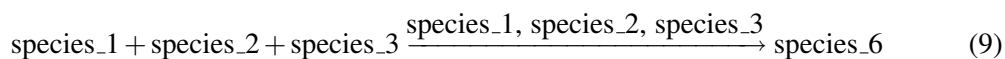
Id	Name	SBO	Value	Unit	Constant
k1	k1		$1.30837 \cdot 10^{-5}$		<input checked="" type="checkbox"/>

6.3 Reaction `reaction_3`

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

Name triplex association

Reaction equation



Reactants

Table 13: Properties of each reactant.

Id	Name	SBO
species_1	mRNA	
species_2	miRNA_1	
species_3	miRNA_2	

Modifiers

Table 14: Properties of each modifier.

Id	Name	SBO
species_1	mRNA	
species_2	miRNA_1	
species_3	miRNA_2	

Product

Table 15: Properties of each product.

Id	Name	SBO
species_6	triplex	

Kinetic Law

Derived unit contains undeclared units

$$v_3 = \text{vol}(\text{compartment}_1) \cdot k1 \cdot [\text{species}_1] \cdot [\text{species}_2] \cdot [\text{species}_3] \quad (10)$$

Table 16: Properties of each parameter.

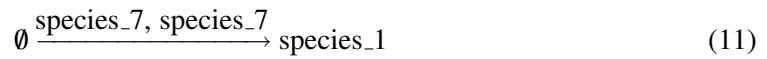
Id	Name	SBO	Value	Unit	Constant
k1	k1		1.000		<input checked="" type="checkbox"/>

6.4 Reaction [reaction_4](#)

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

Name mRNA synthesis

Reaction equation



Modifiers

Table 17: Properties of each modifier.

Id	Name	SBO
species_7	TF_mRNA	
species_7	TF_mRNA	

Product

Table 18: Properties of each product.

Id	Name	SBO
species_1	mRNA	

Kinetic Law

Derived unit contains undeclared units

$$v_4 = \text{vol}(\text{compartment_1}) \cdot \text{function_1}(\text{k_syn_mRNA}, [\text{species_7}]) \quad (12)$$

$$\text{function_1}(\text{k_syn_mRNA}, [\text{species_7}]) = \text{k_syn_mRNA} \cdot [\text{species_7}] \quad (13)$$

$$\text{function_1}(\text{k_syn_mRNA}, [\text{species_7}]) = \text{k_syn_mRNA} \cdot [\text{species_7}] \quad (14)$$

Table 19: Properties of each parameter.

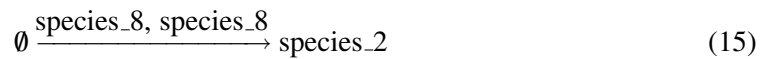
Id	Name	SBO	Value	Unit	Constant
k_syn_mRNA	k_syn_mRNA		1.0		<input checked="" type="checkbox"/>

6.5 Reaction `reaction_5`

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

Name miRNA_1 synthesis

Reaction equation



Modifiers

Table 20: Properties of each modifier.

Id	Name	SBO
species_8	TF_miRNA_1	
species_8	TF_miRNA_1	

Product

Table 21: Properties of each product.

Id	Name	SBO
species_2	miRNA_1	

Kinetic Law

Derived unit contains undeclared units

$$v_5 = \text{vol}(\text{compartment_1}) \cdot \text{function_2}(\text{k_syn_miRNA_1}, [\text{species_8}]) \quad (16)$$

$$\text{function_2}(\text{k_syn_miRNA_1}, [\text{species_8}]) = \text{k_syn_miRNA_1} \cdot [\text{species_8}] \quad (17)$$

$$\text{function_2}(\text{k_syn_miRNA_1}, [\text{species_8}]) = \text{k_syn_miRNA_1} \cdot [\text{species_8}] \quad (18)$$

Table 22: Properties of each parameter.

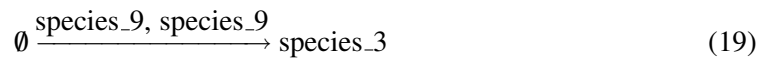
Id	Name	SBO	Value	Unit	Constant
k_syn_miRNA_1	k_syn_miRNA_1		1.0		<input checked="" type="checkbox"/>

6.6 Reaction `reaction_6`

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

Name miRNA_2 synthesis

Reaction equation



Modifiers

Table 23: Properties of each modifier.

Id	Name	SBO
species_9	TF_miRNA_2	
species_9	TF_miRNA_2	

Product

Table 24: Properties of each product.

Id	Name	SBO
species_3	miRNA_2	

Kinetic Law

Derived unit contains undeclared units

$$v_6 = \text{vol}(\text{compartment_1}) \cdot \text{function_3}(\text{k_syn_miRNA_2}, [\text{species_9}]) \quad (20)$$

$$\text{function_3}(\text{k_syn_miRNA_2}, [\text{species_9}]) = \text{k_syn_miRNA_2} \cdot [\text{species_9}] \quad (21)$$

$$\text{function_3}(\text{k_syn_miRNA_2}, [\text{species_9}]) = \text{k_syn_miRNA_2} \cdot [\text{species_9}] \quad (22)$$

Table 25: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
k_syn_miRNA_2	k_syn_miRNA_2		1.0		<input checked="" type="checkbox"/>

6.7 Reaction `reaction_7`

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

Name mRNA degradation

Reaction equation



Reactant

Table 26: Properties of each reactant.

Id	Name	SBO
species_1	mRNA	

Modifier

Table 27: Properties of each modifier.

Id	Name	SBO
species_1	mRNA	

Kinetic Law

Derived unit contains undeclared units

$$v_7 = \text{vol}(\text{compartment_1}) \cdot k1 \cdot [\text{species_1}] \quad (24)$$

Table 28: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
k1	k1		1.0		<input checked="" type="checkbox"/>

6.8 Reaction `reaction_8`

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

Name miRNA_1 degradation

Reaction equation



Reactant

Table 29: Properties of each reactant.

Id	Name	SBO
species_2	miRNA_1	

Modifier

Table 30: Properties of each modifier.

Id	Name	SBO
species_2	miRNA_1	

Kinetic Law

Derived unit contains undeclared units

$$v_8 = \text{vol}(\text{compartment_1}) \cdot k1 \cdot [\text{species_2}] \quad (26)$$

Table 31: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
k1	k1		1.0		<input checked="" type="checkbox"/>

6.9 Reaction `reaction_9`

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

Name miRNA_2 degradation

Reaction equation



Reactant

Table 32: Properties of each reactant.

Id	Name	SBO
species_3	miRNA_2	

Modifier

Table 33: Properties of each modifier.

Id	Name	SBO
species_3	miRNA_2	

Kinetic Law

Derived unit contains undeclared units

$$v_9 = \text{vol}(\text{compartment_1}) \cdot k1 \cdot [\text{species_3}] \quad (28)$$

Table 34: Properties of each parameter.

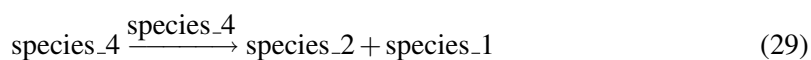
Id	Name	SBO	Value	Unit	Constant
k1	k1		1.0		<input checked="" type="checkbox"/>

6.10 Reaction `reaction_10`

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

Name duplex 1 dissociation

Reaction equation



Reactant

Table 35: Properties of each reactant.

Id	Name	SBO
species_4	duplex_1	

Modifier

Table 36: Properties of each modifier.

Id	Name	SBO
species_4	duplex_1	

Products

Table 37: Properties of each product.

Id	Name	SBO
species_2	miRNA_1	
species_1	mRNA	

Kinetic Law

Derived unit contains undeclared units

$$v_{10} = \text{vol}(\text{compartment_1}) \cdot k_1 \cdot [\text{species_4}] \quad (30)$$

Table 38: Properties of each parameter.

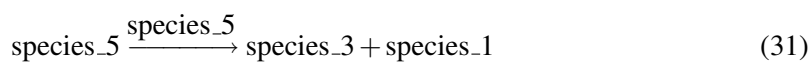
Id	Name	SBO	Value	Unit	Constant
k1	k1		0.250		<input checked="" type="checkbox"/>

6.11 Reaction [reaction_11](#)

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

Name duplex 2 dissociation

Reaction equation



Reactant

Table 39: Properties of each reactant.

Id	Name	SBO
species_5	duplex_2	

Modifier

Table 40: Properties of each modifier.

Id	Name	SBO
species_5	duplex_2	

Products

Table 41: Properties of each product.

Id	Name	SBO
species_3	miRNA_2	
species_1	mRNA	

Kinetic Law

Derived unit contains undeclared units

$$v_{11} = \text{vol}(\text{compartment_1}) \cdot k1 \cdot [\text{species_5}] \quad (32)$$

Table 42: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
k1	k1		0.241		<input checked="" type="checkbox"/>

6.12 Reaction [reaction_12](#)

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

Name triplex dissociation

Reaction equation



Reactant

Table 43: Properties of each reactant.

Id	Name	SBO
species_6	triplex	

Modifier

Table 44: Properties of each modifier.

Id	Name	SBO
species_6	triplex	

Products

Table 45: Properties of each product.

Id	Name	SBO
species_2	miRNA_1	
species_3	miRNA_2	
species_1	mRNA	

Kinetic Law

Derived unit contains undeclared units

$$v_{12} = \text{vol}(\text{compartment_1}) \cdot k1 \cdot [\text{species_6}] \quad (34)$$

Table 46: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
k1	k1		0.188		<input checked="" type="checkbox"/>

6.13 Reaction `reaction_13`

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

Name duplex 1 degradation

Reaction equation



Reactant

Table 47: Properties of each reactant.

Id	Name	SBO
species_4	duplex_1	

Modifier

Table 48: Properties of each modifier.

Id	Name	SBO
species_4	duplex_1	

Kinetic Law

Derived unit contains undeclared units

$$v_{13} = \text{vol}(\text{compartment_1}) \cdot k1 \cdot [\text{species_4}] \quad (36)$$

Table 49: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
k1	k1		1.0		<input checked="" type="checkbox"/>

6.14 Reaction [reaction_14](#)

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

Name duplex 2 degradation

Reaction equation



Reactant

Table 50: Properties of each reactant.

Id	Name	SBO
species_5	duplex_2	

Modifier

Table 51: Properties of each modifier.

Id	Name	SBO
species_5	duplex_2	

Kinetic Law

Derived unit contains undeclared units

$$v_{14} = \text{vol}(\text{compartment_1}) \cdot k1 \cdot [\text{species_5}] \quad (38)$$

Table 52: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
k1	k1		1.0		<input checked="" type="checkbox"/>

6.15 Reaction `reaction_15`

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

Name triplex degradation

Reaction equation



Reactant

Table 53: Properties of each reactant.

Id	Name	SBO
<code>species_6</code>	triplex	

Modifier

Table 54: Properties of each modifier.

Id	Name	SBO
<code>species_6</code>	triplex	

Kinetic Law

Derived unit contains undeclared units

$$v_{15} = \text{vol}(\text{compartment_1}) \cdot k1 \cdot [\text{species_6}] \quad (40)$$

Table 55: Properties of each parameter.

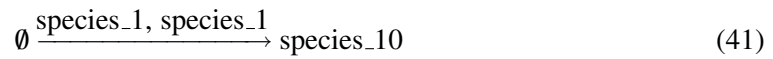
Id	Name	SBO	Value	Unit	Constant
<code>k1</code>	<code>k1</code>		1.0		<input checked="" type="checkbox"/>

6.16 Reaction `reaction_16`

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

Name protein synthesis

Reaction equation



Modifiers

Table 56: Properties of each modifier.

Id	Name	SBO
species_1	mRNA	
species_1	mRNA	

Product

Table 57: Properties of each product.

Id	Name	SBO
species_10	protein	

Kinetic Law

Derived unit contains undeclared units

$$v_{16} = \text{vol}(\text{compartment_1}) \cdot \text{function_4}(\text{k_syn_prot}, [\text{species_1}]) \quad (42)$$

$$\text{function_4}(\text{k_syn_prot}, [\text{species_1}]) = \text{k_syn_prot} \cdot [\text{species_1}] \quad (43)$$

$$\text{function_4}(\text{k_syn_prot}, [\text{species_1}]) = \text{k_syn_prot} \cdot [\text{species_1}] \quad (44)$$

Table 58: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
k_syn_prot	k_syn_prot		1.0		<input checked="" type="checkbox"/>

6.17 Reaction [reaction_17](#)

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

Name protein degradation

Reaction equation



Reactant

Table 59: Properties of each reactant.

Id	Name	SBO
species_10	protein	

Modifier

Table 60: Properties of each modifier.

Id	Name	SBO
species_10	protein	

Kinetic Law

Derived unit contains undeclared units

$$v_{17} = \text{vol}(\text{compartment_1}) \cdot k1 \cdot [\text{species_10}] \quad (46)$$

Table 61: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
k1	k1		1.0		<input checked="" type="checkbox"/>

7 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.

7.1 Species `species_1`

Name mRNA

Initial concentration 1 mmol · l⁻¹

This species takes part in 14 reactions (as a reactant in [reaction_1](#), [reaction_2](#), [reaction_3](#), [reaction_7](#) and as a product in [reaction_4](#), [reaction_10](#), [reaction_11](#), [reaction_12](#) and as a modifier in [reaction_1](#), [reaction_2](#), [reaction_3](#), [reaction_7](#), [reaction_16](#), [reaction_16](#)).

$$\frac{d}{dt}\text{species}_1 = v_4 + v_{10} + v_{11} + v_{12} - v_1 - v_2 - v_3 - v_7 \quad (47)$$

7.2 Species `species_2`

Name miRNA_1

Initial concentration 0 mmol · l⁻¹

This species takes part in nine reactions (as a reactant in [reaction_1](#), [reaction_3](#), [reaction_8](#) and as a product in [reaction_5](#), [reaction_10](#), [reaction_12](#) and as a modifier in [reaction_1](#), [reaction_3](#), [reaction_8](#)).

$$\frac{d}{dt}\text{species}_2 = v_5 + v_{10} + v_{12} - v_1 - v_3 - v_8 \quad (48)$$

7.3 Species `species_3`

Name miRNA_2

Initial concentration 0 mmol · l⁻¹

This species takes part in nine reactions (as a reactant in [reaction_2](#), [reaction_3](#), [reaction_9](#) and as a product in [reaction_6](#), [reaction_11](#), [reaction_12](#) and as a modifier in [reaction_2](#), [reaction_3](#), [reaction_9](#)).

$$\frac{d}{dt}\text{species}_3 = v_6 + v_{11} + v_{12} - v_2 - v_3 - v_9 \quad (49)$$

7.4 Species `species_4`

Name duplex_1

Initial concentration 0 mmol · l⁻¹

This species takes part in five reactions (as a reactant in [reaction_10](#), [reaction_13](#) and as a product in [reaction_1](#) and as a modifier in [reaction_10](#), [reaction_13](#)).

$$\frac{d}{dt}\text{species}_4 = v_1 - v_{10} - v_{13} \quad (50)$$

7.5 Species `species_5`

Name duplex_2

Initial concentration 0 mmol · l⁻¹

This species takes part in five reactions (as a reactant in [reaction_11](#), [reaction_14](#) and as a product in [reaction_2](#) and as a modifier in [reaction_11](#), [reaction_14](#)).

$$\frac{d}{dt}\text{species}_5 = v_2 - v_{11} - v_{14} \quad (51)$$

7.6 Species `species_6`

Name triplex

Initial concentration 0 mmol · l⁻¹

This species takes part in five reactions (as a reactant in [reaction_12](#), [reaction_15](#) and as a product in [reaction_3](#) and as a modifier in [reaction_12](#), [reaction_15](#)).

$$\frac{d}{dt}\text{species}_6 = v_3 - v_{12} - v_{15} \quad (52)$$

7.7 Species `species_7`

Name TF_mRNA

Initial concentration 1 mmol · l⁻¹

This species takes part in two reactions (as a modifier in [reaction_4](#), [reaction_4](#)).

$$\frac{d}{dt}\text{species}_7 = 0 \quad (53)$$

7.8 Species `species_8`

Name TF_miRNA_1

Initial concentration 1 mmol · l⁻¹

This species takes part in two reactions (as a modifier in [reaction_5](#), [reaction_5](#)).

$$\frac{d}{dt}\text{species}_8 = 0 \quad (54)$$

7.9 Species `species_9`

Name `TF_miRNA_2`

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

This species takes part in two reactions (as a modifier in [reaction_6](#), [reaction_6](#)).

$$\frac{d}{dt} \text{species}_9 = 0 \quad (55)$$

7.10 Species `species_10`

Name `protein`

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

This species takes part in three reactions (as a reactant in [reaction_17](#) and as a product in [reaction_16](#) and as a modifier in [reaction_17](#)).

$$\frac{d}{dt} \text{species}_{10} = v_{16} - v_{17} \quad (56)$$

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