

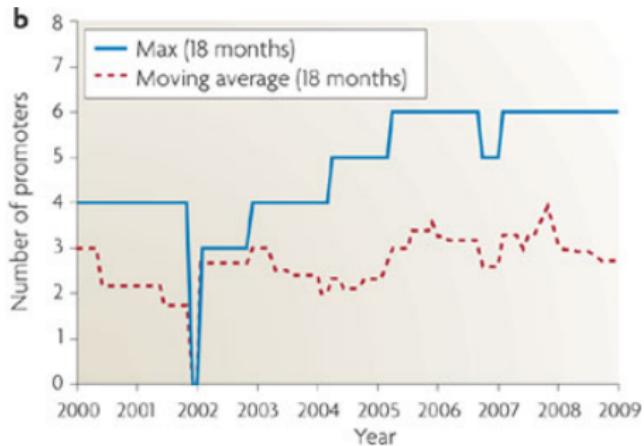
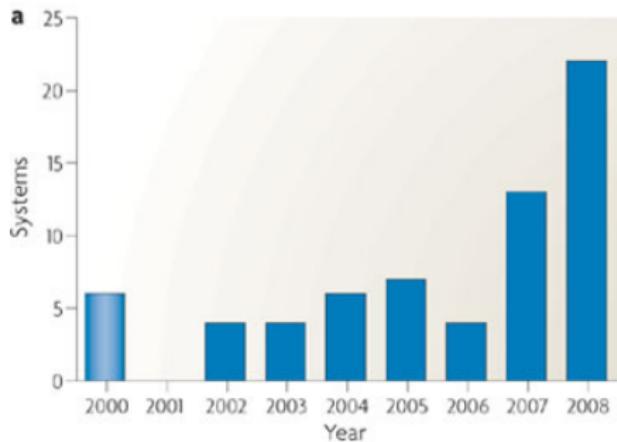
# A Methodology to Annotate Systems Biology Markup Language (SBML) Models with the Synthetic Biology Open Language (SBOL)

Nicholas Roehner, Chris Myers

University of Utah

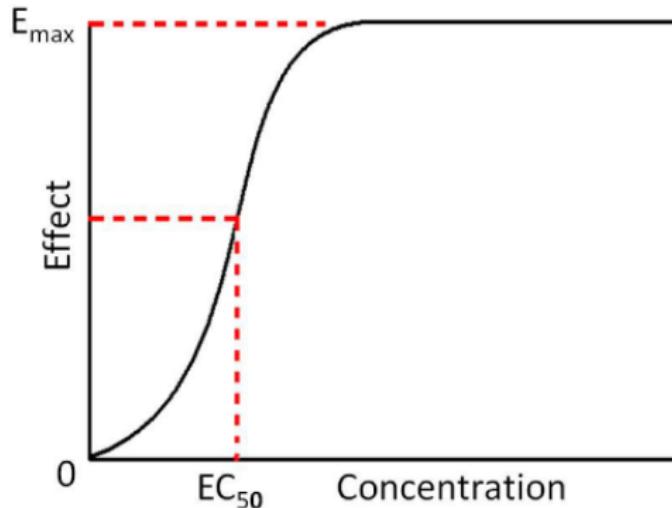
November 7, 2012

# Progress in Synthetic Biology

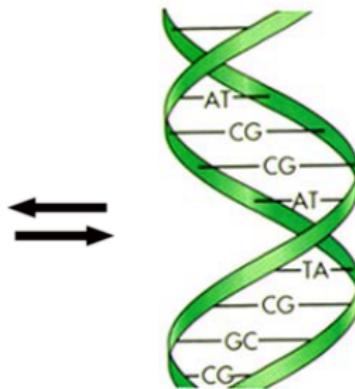


Nature Reviews | Molecular Cell Biology

# Coupling Models and DNA

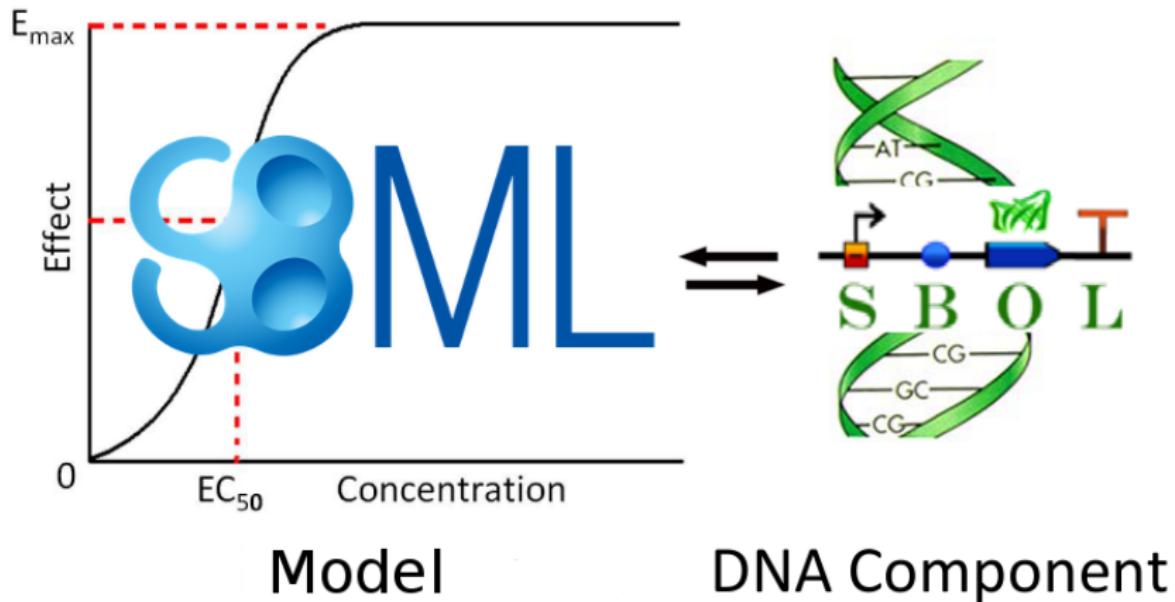


Model

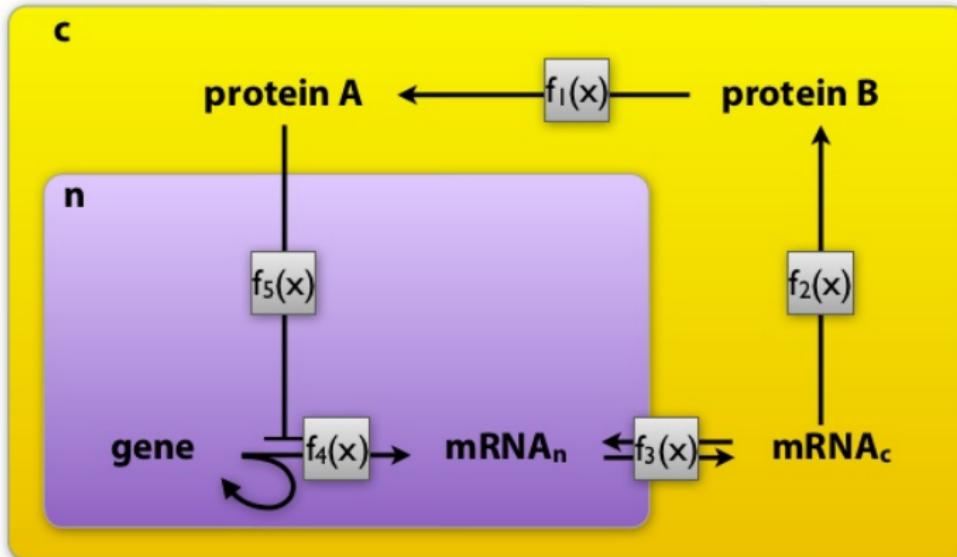


DNA Component

# Coupling Models and DNA

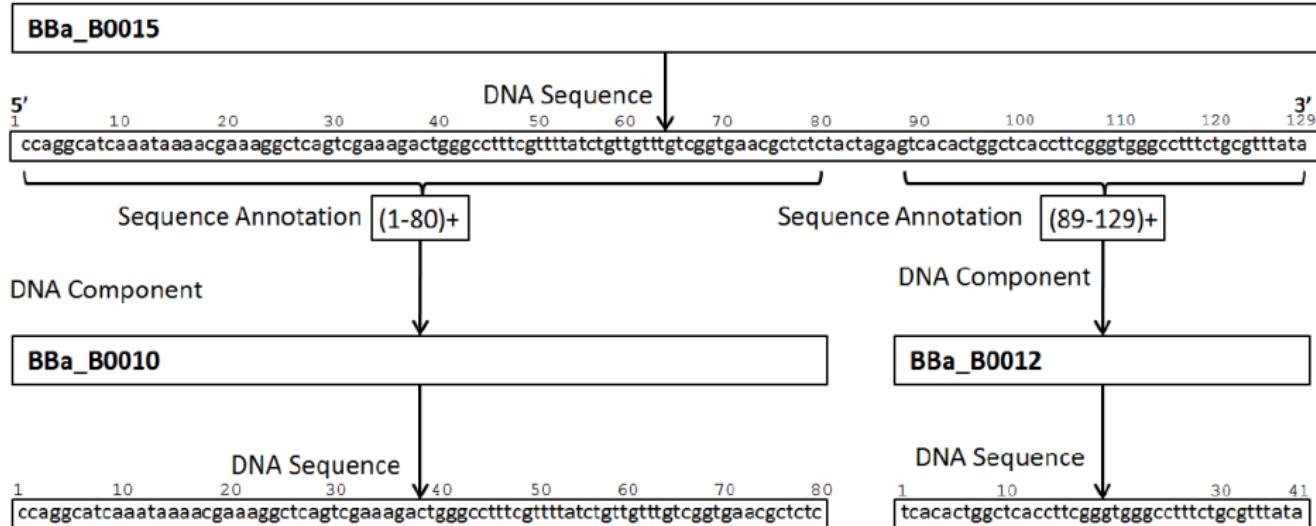


# Systems Biology Markup Language (SBML)



# Synthetic Biology Open Language (SBOL)

## DNA Component



# RDF/XML SBML-to-SBOL Annotation

**SBML**

Model

RDF/XML  
Annotation



DNA Component

# Model to Sequence Conversion (MoSeC)

Bioinformatics Advance Access published February 4, 2011

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## Model Annotation for Synthetic Biology: Automating Model to Nucleotide Sequence Conversion

Goksel Misirlı<sup>1</sup>, Jennifer S. Hallinan<sup>1</sup>, Tommy Yu<sup>2</sup>, James R. Lawson<sup>2</sup>, Sarala M. Wimalaratne<sup>3</sup>, Michael T. Cooling<sup>2</sup> and Anil Wipat<sup>1\*</sup>

<sup>1</sup>School of Computing Science, Newcastle University, Newcastle upon Tyne, UK

<sup>2</sup>Auckland Bioengineering Institute, The University of Auckland, New Zealand

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Associate Editor: Dr. Jonathan Wren

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### ABSTRACT

**Motivation:** The need for the automated computational design of genetic circuits is becoming increasingly apparent with the advent of ever more complex and ambitious synthetic biology projects. Cur-

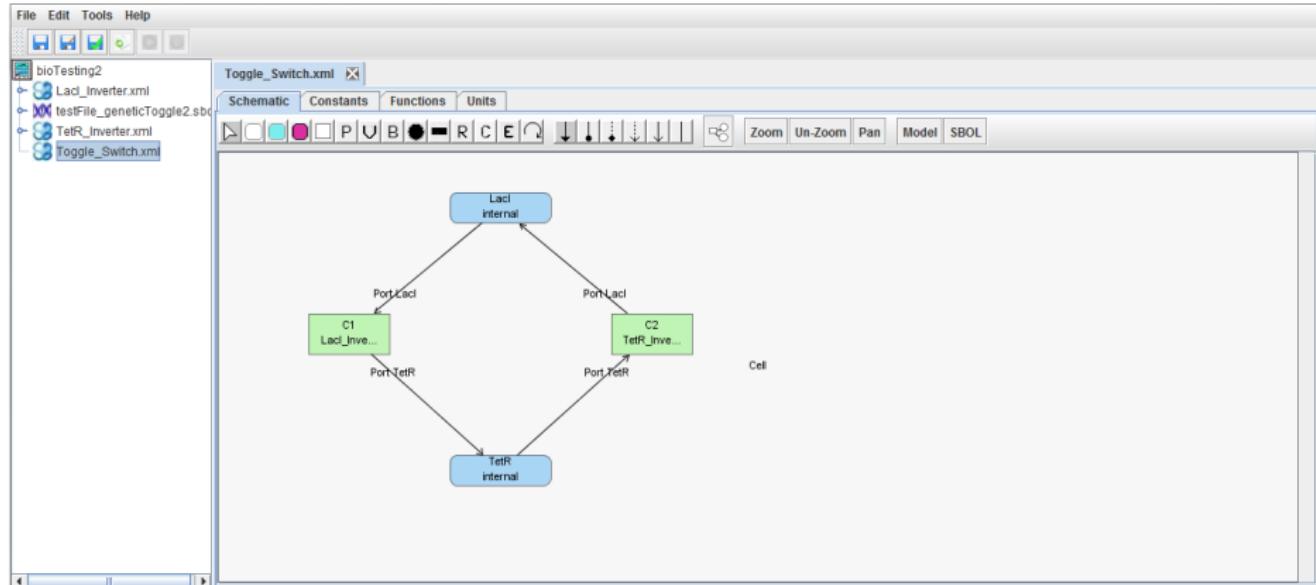
cuits has grown rapidly over the last few years (Bolouri and Davidson, 2002; Goldbeter, 2002; Hasty *et al.*, 2002; Weiss *et al.*, 2003; Andrianantoandro *et al.*, 2006; Endler *et al.*, 2009).

Genetic circuits are usually designed and simulated *in silico* as

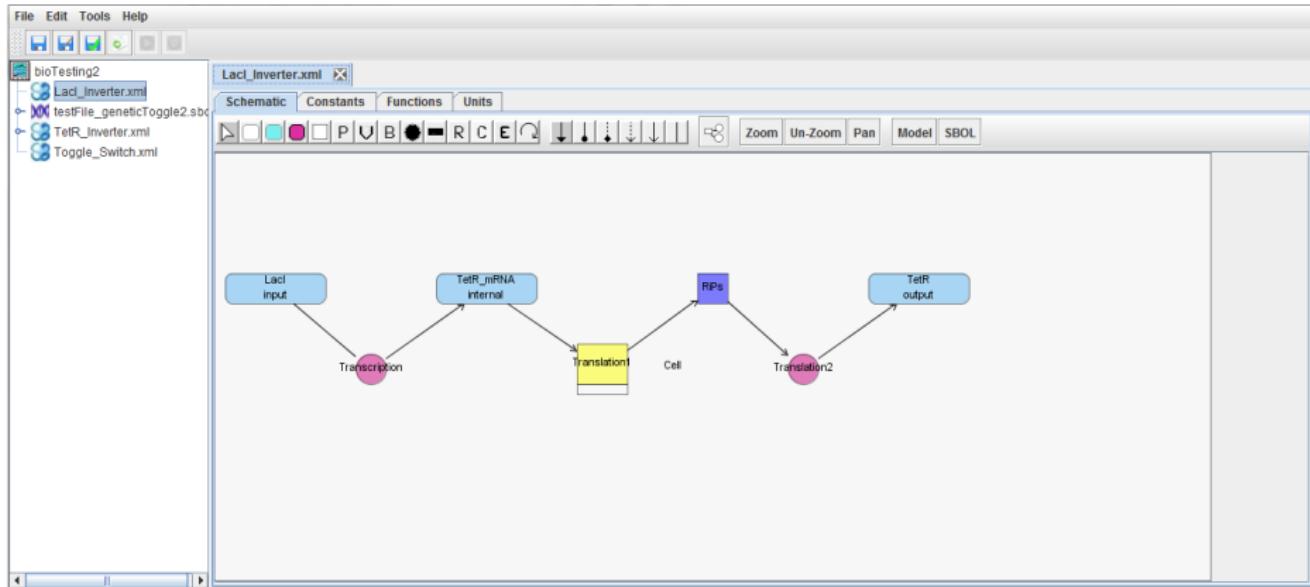
# RDF/XML SBML-to-SBOL Annotation

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                xmlns:mts="http://sbolstandard.org/modeltosbol/1.0#">
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            <rdf:Seq>
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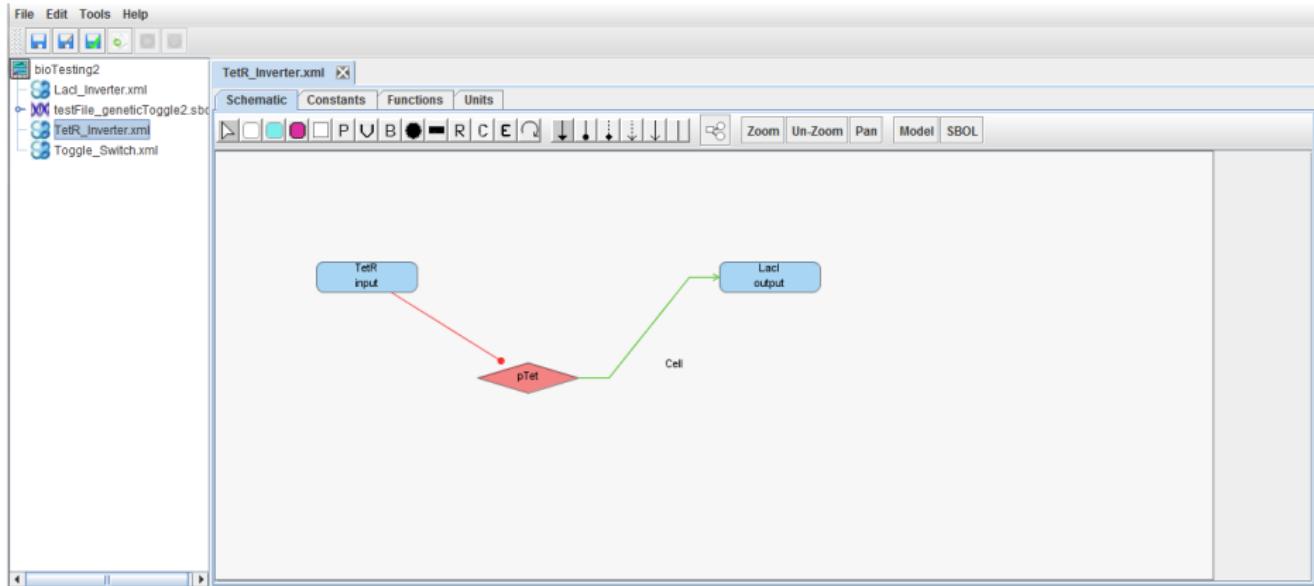
# iBioSim 2.0: Genetic Circuit Model Creation and Analysis



# iBioSim 2.0: Genetic Circuit Model Creation and Analysis

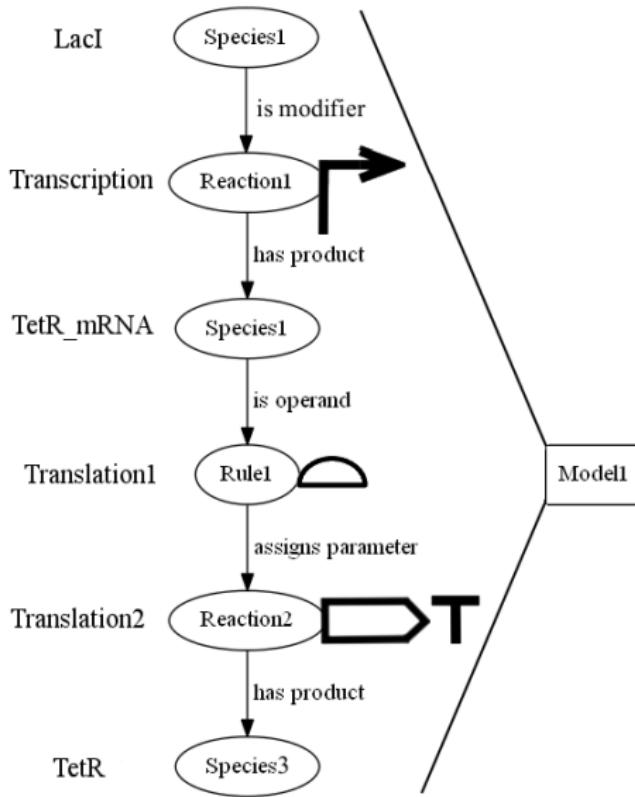


# iBioSim 2.0: Genetic Circuit Model Creation and Analysis

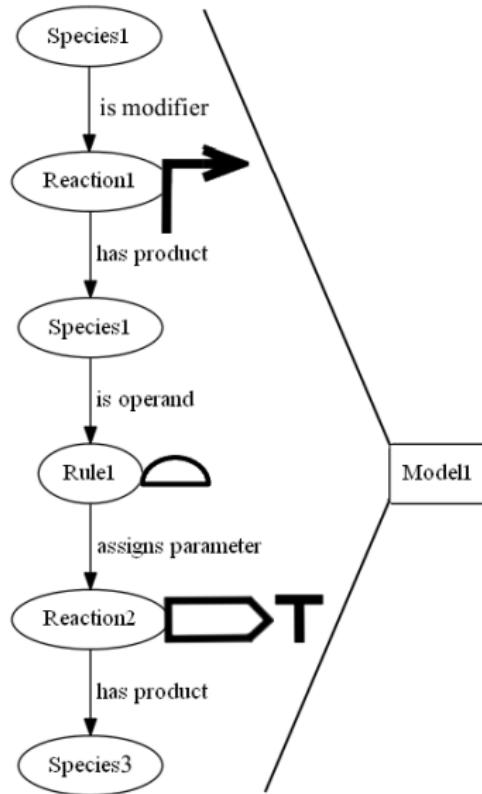


# iBioSim 2.0: SBML-to-SBOL Annotation

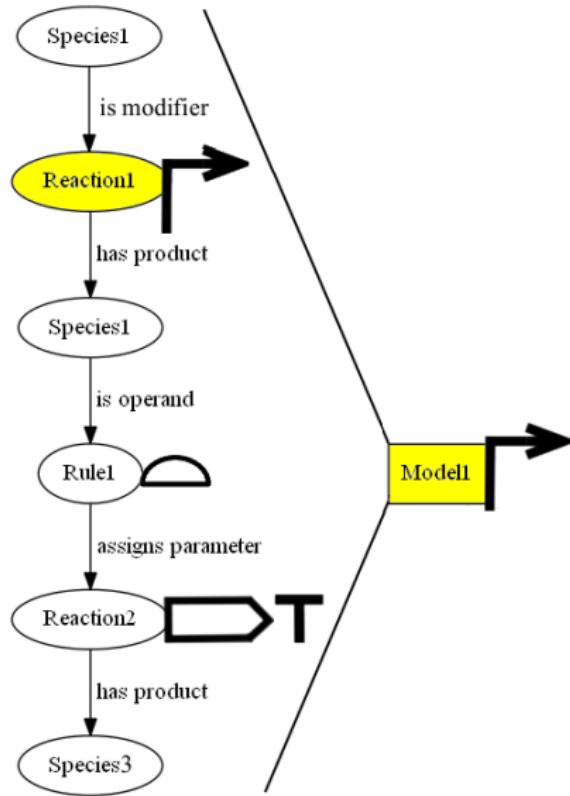
# Graph Representation - LacI Inverter



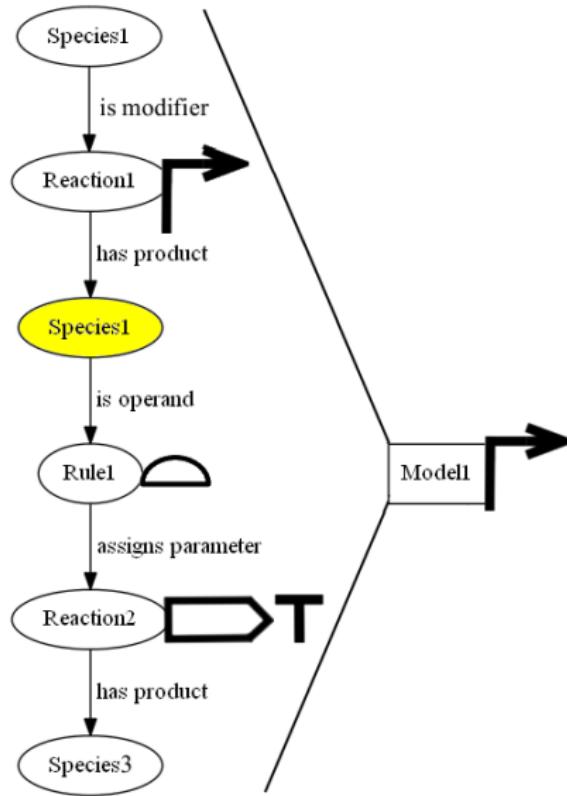
# Annotation Propagation - LacI Inverter



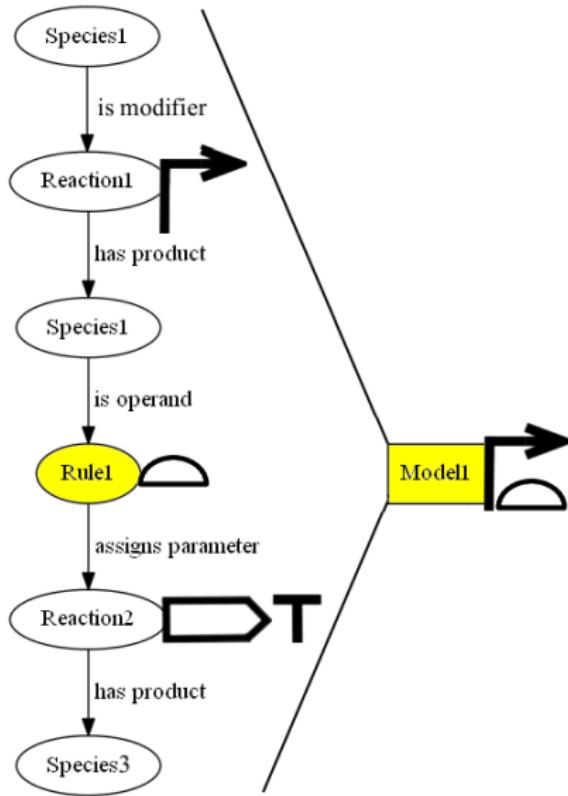
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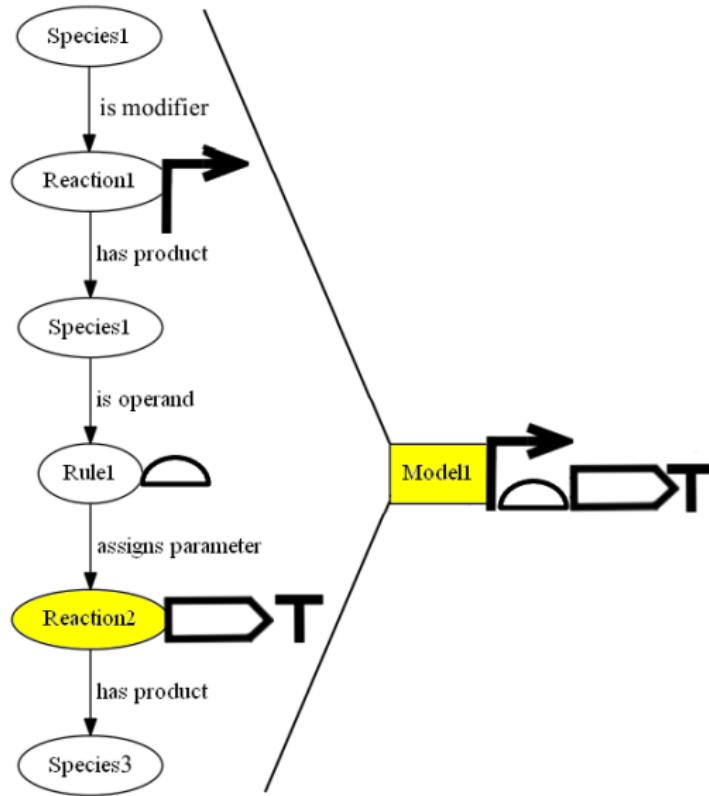
# Annotation Propagation - LacI Inverter



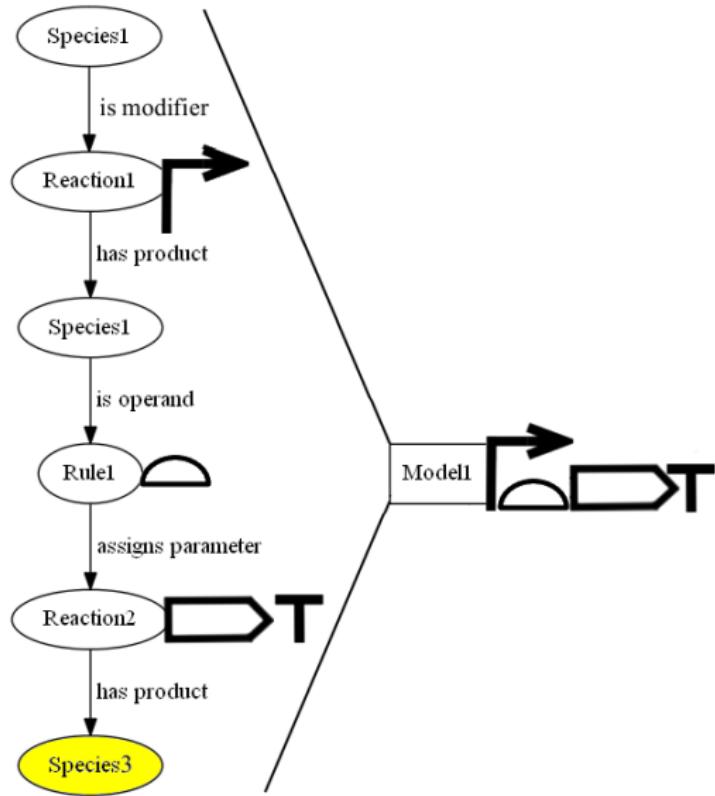
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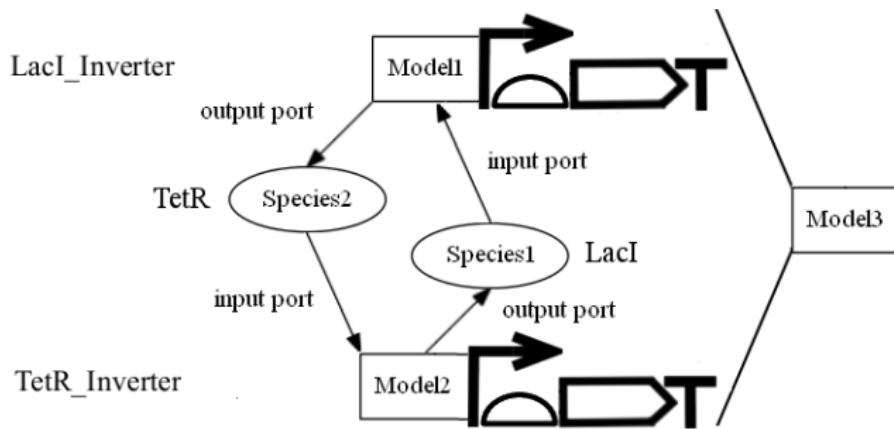
# Annotation Propagation - LacI Inverter



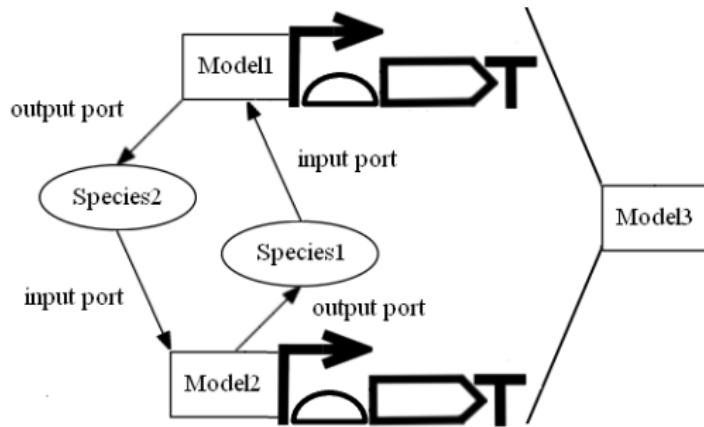
# Annotation Propagation - LacI Inverter



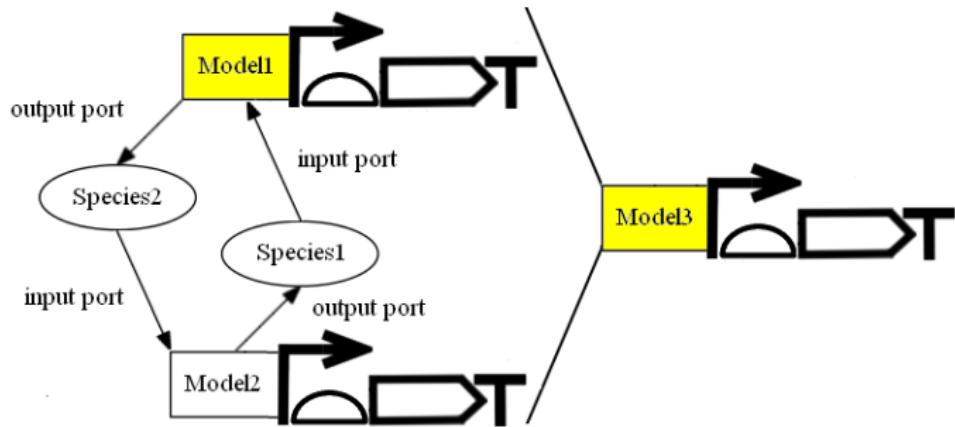
# Graph Representation - Toggle Switch



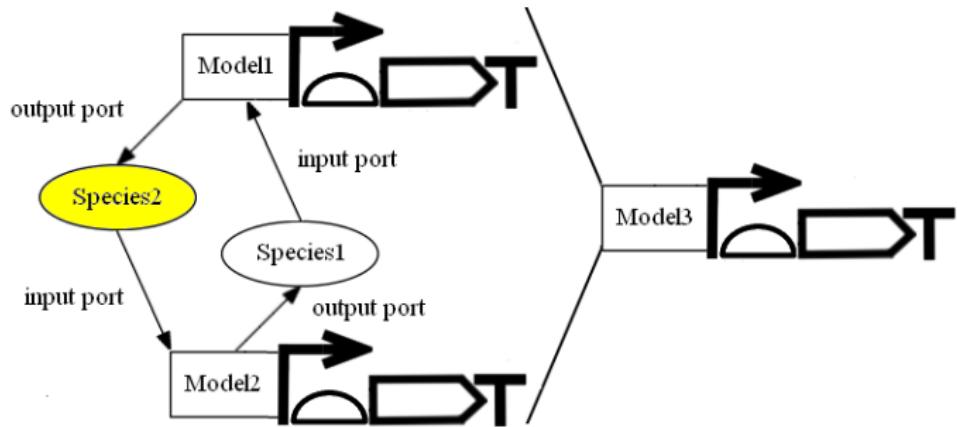
# Annotation Propagation - Toggle Switch



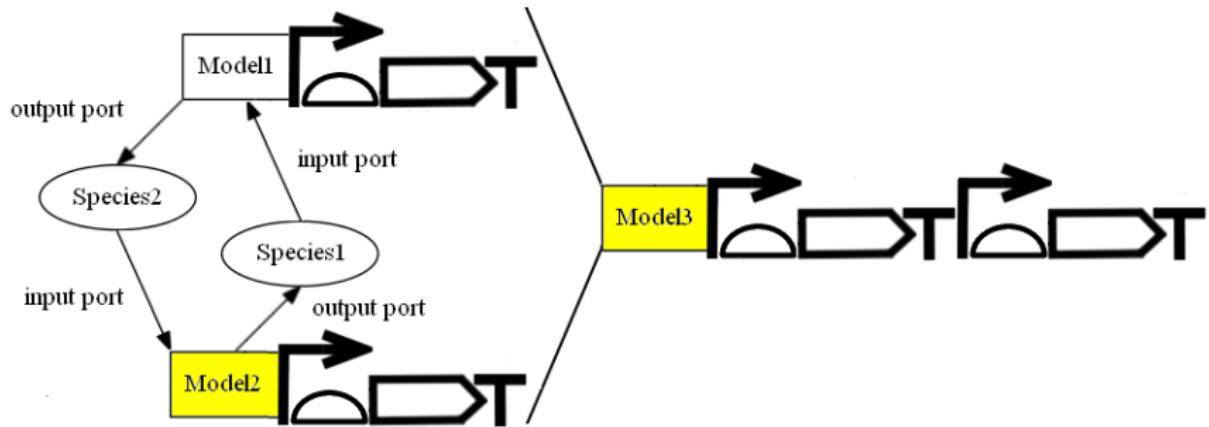
# Annotation Propagation - Toggle Switch



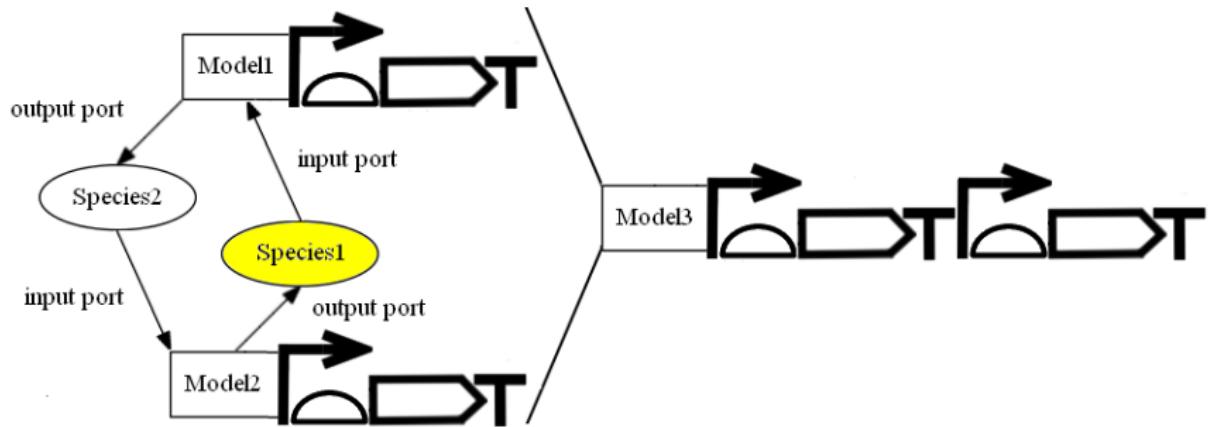
# Annotation Propagation - Toggle Switch



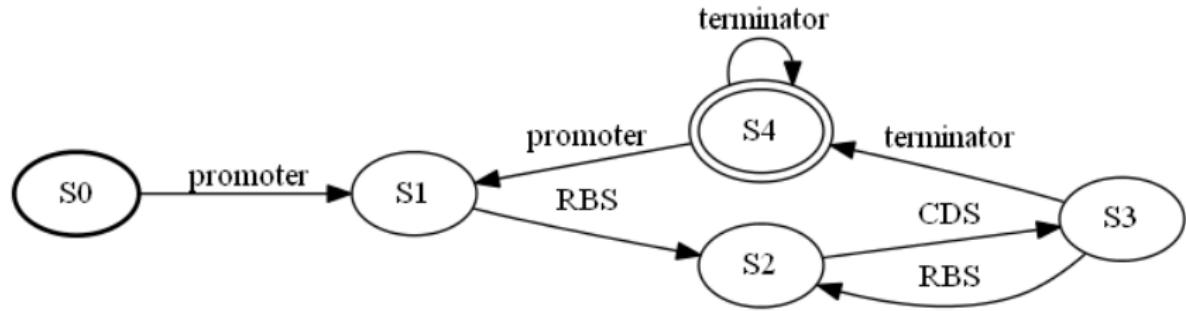
# Annotation Propagation - Toggle Switch



# Annotation Propagation - Toggle Switch

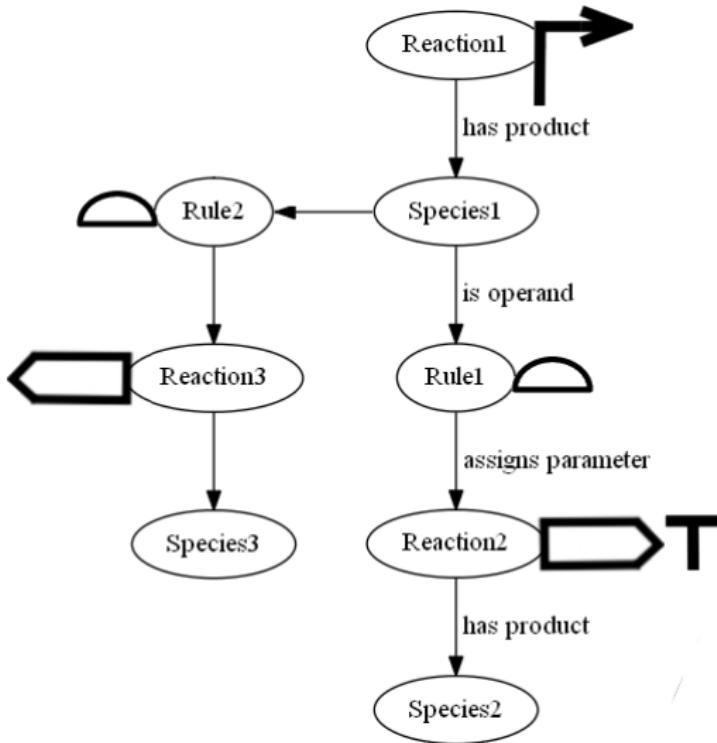


# Annotation Verification



Discrete finite automata for the regular expression  
 $(\text{promoter}(\text{RBS}, \text{CDS})^+ \text{terminator}^+)^+$

# Extending Annotation Propagation

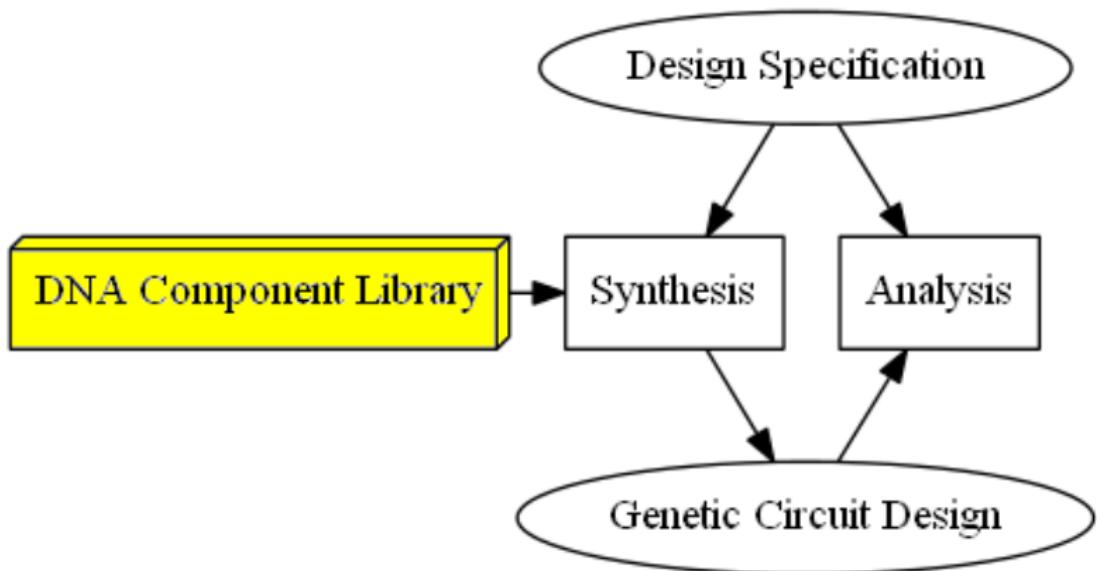


# Feature Summary

Using iBioSim, we can now

- Annotate SBML model elements such as reactions, rules, and species with SBOL DNA components.
- Assemble composite DNA components from these intra-model annotations and annotate the SBML models themselves.
- Propagate SBOL annotations up through a hierarchy of SBML models and compose DNA components to match this hierarchy.

# Genetic Design Automation (GDA)



# Acknowledgments



Dr. Chris Myers



Curtis Madsen



Jason Stevens



Tyler Patterson



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iBioSim is freely available for Windows, MacOS, and Fedora at <http://www.async.ece.utah.edu/>