

# A quick summary of the state of SBML

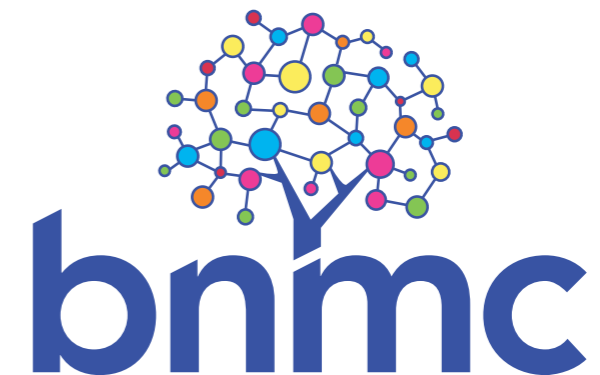
## Michael Hucka

*Senior Research Fellow—Control and Dynamical Systems*

*Co-director—Biological Network Modeling Center (BNMC), Beckman Institute*

*California Institute of Technology*

*Pasadena, California, USA*



# Software support



SBML.org - The home site for the Systems Biology Markup Language

http://sbml.org/index.psp

## SBML Systems Biology Markup Language

home • contacts • documents • downloads • FAQs • forums • Level 3 • models

The Systems Biology Markup Language (SBML) is a computer-readable format for representing **models of biochemical reaction networks**. SBML is applicable to metabolic networks, cell signaling pathways, regulatory networks, and many others.


### Internationally Supported and Widely Used

SBML has been evolving since mid-2000 through the efforts of an international group of software developers and users. Today, SBML is **supported by over 100 software systems**, including the following (where "\*" indicates SBML support in development):

BALSA	DBsolve	MMT2	SBMLmerge
BASIS	Dizzy	Modesto	SBMLR
BIOCHAM	E-CELL	Moleculizer	SBMLSim
BioCharon	ecellJ	Monod	SBMLToolbox
ByoDyn	ESS	Narrator	SBlID
BioCyc	FluxAnalyzer	NetBuilder	SBToolbox
BioGrid	Fluxor	Oscill8	SBW
BioModels	Gepasi	PANTHER Pathway	SClpath
BioNetGen	Gillespie2	PathArt	Sigmoid*
BioPathway Explorer	HSMB	PathScout	SigPath
Bio Sketch Pad	HybridSBML	PathwayLab	SigTran
BioSnp	INSULICO discovery	Pathway Tools	SIMBA

- ▶ In 2005: 90
- ▶ In 2006: 109
- ▶ A rate >1/month

# Support by journals

- ▶ Nature
    - ▶ Nature/EMBO Molecular Systems Biology offers SBML uploads
  - ▶ *PLoS Computational Biology*
  - ▶ *BMC*
- 
- BioModels Database**

# Support by educators

- ▶ Books
  - ▶ Stochastic Modelling for Systems Biology (D. Wilkinson, 2006)
- ▶ Courses
  - ▶ University of Newcastle (Darren Wilkinson)
  - ▶ KGI (Herbert Sauro)
  - ▶ Case Western Reserve University
  - ▶ Rostock
  - ▶ Indiana University
  - ▶ USB
  - ▶ Johns Hopkins
  - ▶ Rutgers University

# Current publications about SBML

- ▶ SBML specifications are online at <http://sbml.org>
  - ▶ Also have FAQ, community wiki, discussion forums
- ▶ Papers:
  - ▶ Hucka et al., *Bioinformatics* 19(4): 524-531, 2003
  - ▶ Finney & Hucka, *Biochem. Soc. Trans.* 31, 2003
  - ▶ Hucka et al., *Systems Biology* 1(1): 41-53, 2004
  - ▶ Finney, *Lecture Notes in Comp. Sci.*, 3082, 2005
  - ▶ Hucka & Finney, *Molecular Systems Biology* 1(1), 2005
  - ▶ Finney et al., *Sys. Modelling in Cellular Bio.*, ed. Szallasi, et al., 2006
- ▶ Other:
  - ▶ MIME type for SBML (RFC 3823) `application/sbml+x`

# Citations

- ▶ 2003 paper: 147

# Current versions

- ▶ SBML Level 1 Version 2
  - ▶ Released 28 Aug. 2003
- ▶ SBML Level 2 Version 2
  - ▶ Released 26 Sep. 2006

---

## Systems Biology Markup Language (SBML) Level 2: Structures and Facilities for Model Definitions

---

Andrew Finney  
[afinney@sbml.org](mailto:afinney@sbml.org)  
Physiomics PLC  
Magdalen Centre  
Oxford Science Park  
Oxford, OX4 4GA, UK

Michael Hucka  
[mhucka@sbml.org](mailto:mhucka@sbml.org)  
Biological Network Modeling Center  
Beckman Institute, Mail Code 139-74  
California Institute of Technology  
Pasadena, CA 91125, USA

Nicolas Le Novère  
[lenov@ebi.ac.uk](mailto:lenov@ebi.ac.uk)  
European Bioinformatics Institute  
Wellcome Trust Genome Campus, Hinxton  
Cambridge, CB10 1SD, UK

SBML Level 2, Version 2, Revision 1  
26 September 2006

Corrections and other revisions of this SBML language specification may appear over time.  
Notifications of revisions are broadcast on the mailing list [sbml-announce@caltech.edu](mailto:sbml-announce@caltech.edu)

The latest revision of the SBML Level 2 Version 2 specification is available at  
<http://sbml.org/specifications/sbml-level-2/version-2/>

*This revision of the SBML Level 2 Version 2 specification is available at*  
<http://sbml.org/specifications/sbml-level-2/version-2/revision-1/>

# The SBML Team people

- ▶ Hamid Bolouri
- ▶ Herbert Sauro
- ▶ Andrew Finney
- ▶ Maria Schilstra
- ▶ Jo Matthews
- ▶ Akira Funahashi
- ▶ Ben Bornstein
- ▶ Ben Kovitz
- ▶ Bruce Shapiro
- ▶ Sarah Keating
- ▶ Michael Hucka

# The funding

- ▶ JST ERATO Kitano Symbiotic Systems Project (Japan) (to 2003)
- ▶ National Institute of General Medical Sciences (USA)
- ▶ National Science Foundation (USA)
- ▶ International Joint Research Program of NEDO (Japan)
- ▶ JST ERATO-SORST Program (Japan)
- ▶ Japanese Ministry of Agriculture
- ▶ Japanese Ministry of Educ., Culture, Sports, Science and Tech.
- ▶ BBSRC e-Science Initiative (UK)
- ▶ DARPA IPTO Bio-SPIICE Bio-Computation Program (USA)
- ▶ Air Force Office of Scientific Research (USA)
- ▶ STRI, University of Hertfordshire (UK)
- ▶ Beckman Institute, Caltech (USA)
- ▶ Molecular Sciences Institute (USA)

# Specific current grants

- ▶ NIH/NIGMS R01 GM 070923
  - ▶ Subportion for BioModels Database
- ▶ NIH/NIGMS R01 GM GM077671
  - ▶ SBML Test Suite development (just received!)
- ▶ NSF
  - ▶ Computable Plant, but side-effect is work on MathSBML
- ▶ Beckman Institute, Caltech

# Waiting on

- ▶ NIH renewal proposal for 3 more years



What lies ahead?

# Full SBML Test Suite

- ▶ Allows developers to test implementation of SBML support
- ▶ Critical for improving software interoperability
- ▶ Currently have a partial “SBML semantic test suite”
- ▶ Needs further work to—
  - ▶ Complete coverage of SBML features
  - ▶ Improve ease of use
  - ▶ Update for Level 2 Version 2 and Level 3
  - ▶ Add web system for reporting results, comparisons, etc.

# SBML Level 3

# SBML Level 3

- ▶ Modular language extensions
  - ▶ Core expected to be based “mostly” on Level 2 Version 2

# SBML Level 3

- ▶ Modular language extensions
  - ▶ Core expected to be based “mostly” on Level 2 Version 2
- ▶ Layered on top of core: feature sets for—
  - ▶ Diagram storage
  - ▶ Multicomponent species
  - ▶ Models composed of submodels
  - ▶ Arrays and/or sets of components
  - ▶ Spatial geometry
  - ▶ *Other capabilities*

# Modular extensions support in libSBML & SBML Test Suite

- ▶ Goal: enable libSBML to be extended through plug-ins
  - ▶ Proposals for SBML extensions can come with libSBML add-on
  - ▶ Developers can pick & choose which ones are compiled in
- ▶ Goal: enable Test Suite to be similarly extended
  - ▶ Proposals for SBML extensions can come with Test Suite add-ons

# Collateral standardization efforts

- ▶ **Systems Biology Ontology (SBO)**
  - ▶ For computational models
  - ▶ Add annotations about roles & meanings of the math
- ▶ **“Parameter sets”**
  - ▶ Single model, multiple sets of numerical values

# Revised SBML governance & development process

- ▶ Borrow ideas from W3C & other organizations
- ▶ Implement a better-defined, **regimented process**
  - ▶ Calls for proposals, etc.
  - ▶ Voting, etc.
  - ▶ Issue tracking system
- ▶ Have an **architectural board** to steer development
- ▶ Have **more SBML Editors**
  - ▶ Elect SBML Editors for **limited terms**

# Standards body recognition

- ▶ Currently not recognized by a standards-making body
  - ▶ At some point in the future, it probably should be
    - ▶ Of special interest to commercial efforts
- ▶ Questions remain
  - ▶ **When** to seek standardization
  - ▶ **Which agency?** ISO? OMG? W3C?