Don’t reinvent the brain
Using ModelDB and other archives for your research

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What is ModelDB?
Amyloid beta (IA block) effects on a model CA1 pyramidal cell (Morse et al. 2010)

Model Information
Accession: 87284
The model simulations provide evidence oblique dendrites in CA1 pyramidal neurons are susceptible to hyper-excitability by amyloid beta block of the channel, IA. See paper for details.

Reference:

Model Information
Model Name: Amyloid beta (IA block) effects on a model CA1 pyramidal cell
Model Type: Neuron or other electrically excitable cell
Brain Region(s)/Organism: 
- Hippocampus CA1 pyramidal cell
- Channel(s): I Na, I L high threshold; I N; I T low threshold; I A; I K; I h;
- Gap Junctions:
- Receptor(s):
- Gene(s):
- Transmitter(s):

Morse et al. 2010

root: soma

ca_ion (calcium.mod)
cacm (caccum.mod)
cagk (cagk.mod)
ca_1 (cap1.mod)
cat (catmod)
ds (distmod)
h (hmod)
k (kdradial.mod)
gl (gl羯mod)
iso (isomod)
kr (krdrac.mod)
na (na3.mod)

Morse et al. 2010

References and models cited by this paper
- Roles of IA and morphology in AP prop. in CA1 pyramidal cell densities (Acker and White 2007) [Model]


References and models that cite this paper
- CA1 pyramidal neurons: effects of Alzheimer (Cuimone and Migliore 2012) [Model]

- ModelView: online structural analysis of computational models (McDougal et al. 2015) [Model]
Twenty years of ModelDB and beyond: building essential modeling tools for the future of neuroscience

Robert A. McDougal 1 · Thomas M. Morse 1 · Ted Carnevale 1 · Luis Marenco 1,2,3 · Rixin Wang 3,4 · Michele Migliore 1,5 · Perry L. Miller 2,3,4 · Gordon M. Shepherd 1 · Michael L. Hines 1

Abstract Neuron modeling may be said to have originated with the Hodgkin and Huxley action potential model in 1952 and Rall’s models of integrative activity of dendrites in 1964. Over the ensuing decades, these have led to a massive development of increasingly accurate and complex data-based models of neurons and neuronal circuits. Groups (Allen Brain Institute, EU Human Brain Project, etc.) are emerging that collect data across multiple scales and integrate that data into many complex models, presenting new challenges. Scientific computing and high performance computation, and increasingly in need of comprehensive tools. J Comput Neurosci
DOI 10.1007/s10827-016-0623-7
What is in ModelDB?

Models for:
- 178 cell types
- 16+ species
- 54 ion channels, pumps, etc
- 145 topics (Alzheimer’s, STDP, etc)
- 24+ mammalian brain regions

1211 published models from 76 simulators
- 575 NEURON models
- 340 “realistic” networks
- 48 connectionist networks

Numbers are as of May 20, 2017
Why use ModelDB?
“Non-reproducible single occurrences are of no significance to science.”

– Karl Popper in *The logic of scientific discovery*, 1959.

What is needed for a model to be reproducible?

**Model**
- an approximation of the system of interest
  e.g. a model organism or a complete statement of the properties of the model in mathematical or computable form

**Experimental protocol**
- what was done with the model to produce the data

Science builds upon previous work; in order to do that, the previous work needs to be reproducible.
38.5% of ModelDB models have **over 20 files**; 24.2% of files are **over 5K**.

It is often hard to fully describe this complexity in a paper.

Any bugs, typos, errors, or omissions might completely change the dynamics.

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Distributions from ModelDB, Fall 2013. A model was counted as having 0 files if it was not hosted on ModelDB.
The easiest way to replicate someone else’s results – a first step toward building on them – is to get their model code from a repository such as ModelDB.

But beware:
- They may be solving a different problem than you (with respect to species, temperature, age, etc).
- Their code may have bugs.

To reduce the risk of problems:
- **Read** the associated paper.
- **Compare** the model and results to other similar models.
- **Examine** the model with ModelView and/or psection.
- **Test** ion channels individually.
- **Collaborate** with an experimentalist.
Reproducibility in Computational Neuroscience Models and Simulations

Robert A. McDougal, Anna S. Bulanova, William W. Lytton

Abstract—Objective: Like all scientific research, computational neuroscience research must be reproducible. Big data science, including simulation research, cannot depend exclusively on journal articles as the method to provide the sharing and transparency required for reproducibility.

Simulators (NEURON, MCell, XPPAUT, NEST, etc)

Multi-simulator interoperability (NeuroML, SWC, PyNN, NeuroConstruct, etc)

Shared resources (Neuroscience Gateway, Simulation Platform)

Sharing resources (ModelDB, OpenSourceBrain, NeuroMorpho.Org, etc)

More: NSDF, NeuroLex, NIF, MIASE, licensing, etc
Neurobiological context

Morphology

Metadata: cell types, channels, receptors, genes, transmitters, model topics, publication

NeuronDB

Electrophysiology

Model Entry

Microconnectome
ModelDB is a place to see what has been modeled in a cell type. Not only can you get code, but by comparing models, you can see what mechanisms are considered critical by the community.
How to use ModelDB
Finding models

- **Search box** on the top-left of every page.
- Do **full text** or **attribute** searches.
- Word completions (based on ModelDB entries not English) and attribute results **updated as you type**.
- **Advanced search** and **browsing** are also available.
ShowModel features

(1) Search models.  (2) Browse models.  (3) Link to download the entire model code.
(4) Auto-launch a NEURON simulation (requires browser configuration).  (5) View model files.
(6) Find models and papers cited by this model’s paper, or that cite this model.  (7) ModelView: visualize model structure.  (8) Simulation platform (5 minutes of remote desktop access to experiment with the model).  (9) 3D printable versions of cells from the model (in 3DModelDB).
(10) Description of model.  (11) Paper(s) describing or using model.  (12) Searchable metadata.
(13) Links to NeuronDB (channel distributions etc within cell types).
(14) Download the currently selected file. (15) Directory browser, showing model files. (16) View pane for the currently selected file.
Identifying existing reuse

Amyloid beta (IA block) effects on a model CA1 pyramidal cell (Morse et al. 2010)

This is the readme for a model used in the paper Morse TM, Carnevale NT, Mutalik PG, Migliore M, Shepherd GM (2010) Abnormal excitability of oblique dendrites implicated in early Alzheimer's: a computational study Front. Neural Circuits 4:16

The model code was contributed by Tom Morse. It was created (see paper for details) from earlier models (especially Migliore et al. 2005 and calcium channels from Hemond et al. 2008) with modifications and additions by Tom Morse and Ted Carnevale with interaction with the other authors. It requires the NEURON simulator to be installed (available at http://www.neuron.yale.edu).

To recreate figures from the paper, start the simulator by auto-launching from ModelDB *OR*

Under unix systems:

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In the expanded archive's folder compile the mod files using the command “nrnivmodl” run the simulation with the command “nrngui mosinit.hoc”

Under Windows systems:

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Compile the mod files using the “mknrndll” program. A double click on the simulation file mosinit.hoc will open the simulation window.

Under MAC OS X:

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drag and drop the expanded archive's folder onto the mknrndll icon.

drag and drop the mosinit.hoc file onto the nrngui icon.

Once the simulation is started click on a button to recreate a figure from the paper, e.g.:

Figure 1, 2 generates Figure 1B and 2 simultaneously:

(the simulation part is Figure 1B right hand side traces):

Asterisks in the file browser indicate that the file is reused in other models; click the asterisk to see a list of the other models.
When viewing most mod files describing an ion channel, an ICGenealogy button appears. Clicking this button loads the corresponding page of the ICGenealogy database which shows curated information about the channel model (how it was derived, information about the underlying data, etc) and response curves.

Podlaski, Seeholzer, Vogels
Amyloid beta (IA block) effects on a model CA1 pyramidal cell (Morse et al. 2010)

The model simulations provide evidence oblique dendrites in CA1 pyramidal neurons are susceptible to hyper-excitability by amyloid beta block of the transient K+ channel, IA. See paper for details.

Reference:
Morse et al. 2010

- 194 sections; 974 segments
- 1 cell with morphology
- 0 artificial cells
- 0 NetCon objects
- 0 LinearMechanism objects
- Temperature: 35°C
- Density Mechanisms
- 1 point processes (0 can receive events) of 1 base classes
- 7 files shared with other ModelDB models
- References
**Morse et al. 2010**

- 18 inserted mechanisms
  - Ra
  - cm
  - pas
  - na_ion
  - k_ion
  - ca_ion
  - cacum (cacumm.mod)
  - cagk (cagk.mod)
  - cal (cal2.mod)
  - can (can2.mod)
  - cat (cat.mod)
  - ds (distr.mod)
  - hd (h.mod)
  - kad (kadist.mod)
  - kap (kapprox.mod)
  - kdr (kdrca1.mod)
  - na3 (na3n.mod)
  - nax (naxn.mod)

**root: soma**

- X-Y
- X-Z
- Y-Z

**Density Mechanisms**

- 18 mechanisms in use
  - Ra
  - cm
  - pas
  - na_ion
  - k_ion
  - ca_ion
  - cacum (cacumm.mod)

- READS: ica
- WRITEs: cai, Non specific Current
- Present in 193 sections

- cagk (cagk.mod)
- READS: cai, ek
- WRITEs: ik
- Present in 193 sections
- Possibly temperature dependent

- cal (cal2.mod)
What described where?
Beware: comments, if statements.

ModelView

Metadata from ModelDB

Static Analysis of Source Code

Simulator Introspection

Ask the simulator what it did.
What morphology?
What mechanisms?

Provides structured data from unstructured code.
How do people use ModelDB?

- Find a model described in a paper, download it, and experiment to understand the model’s predictions.
- Find a model described in a paper. Use ModelView to understand the model’s structure.
- Locate models and modeling papers on a given topic.
- Locate model components (e.g. L-type calcium channel) for potential reuse.
- Search for simulator keywords (e.g. FInitializeHandler) to find examples of how to use them.

You can help by sharing your model code on ModelDB after publication.
Sharing your models

ModelDB provides an accessible location for storing and efficiently retrieving computational neuroscience models. ModelDB is tightly coupled with NeuronDB. Models can be coded in any language for any environment. Model code can be viewed before downloading and browsers can be set to auto-launch the models. For further information, see model sharing in general and ModelDB in particular.

Browse or search through over 1000 models using the navigation on the left bar or in the menu button on a mobile device. To search papers instead of models, go here; this may be used to identify models whose paper cites or is cited by a given paper.

Tweets by @SenseLabProject

New in ModelDB: A Layer V CCS type pyramidal cell, inhibitory synapse current conductin (Kubota Y et al., 2015)
modeldb.yale.edu/183424

McDougal et al, submitted
Sharing your models

Submit New Model

Required information:

Your full name:

Modeler or Contributor name

Your email address:

Email

Zip file of model code:

Choose File

No file chosen

Read-Write access code (15 character max):

Access code

Used as a password to only access this model

PubMed ID(s) or citation(s) associated with the model:

Only required for publicly shared models.

Citation(s) can be in any bibliographic format.

You may Submit. With just the above information, but to make your model more discoverable, please fill out as much of the next section as you can. Note:

Your model will remain private until you request the ModelDB administrator make it public.

Let us find ModelDB keywords for you!

Click the button to automatically find, approve, and populate model entry keywords based on your paper abstract.

Additional information: More information will help your model more discoverable

McDougal et al, submitted
McDougal, Dalal, Shepherd in preparation; abstract from Morse et al, 2010.
### Sharing your models

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</table>

McDougal et al, submitted
@SenseLabProject: newly available models
Other resources
NeuroMorpho.Org is home to 70,025 reconstructed neurons (and glia) from 400 cell types and 41 species as of November 9, 2017.

Warning: not every morphology was reconstructed with the intent of being in a simulation. Before using: rotate to check for z-axis errors, check to make sure the diameters are not all equal.

Use the Import 3D tool to import morphologies into NEURON. For details, see: neuron.yale.edu/neuron/docs/import3d
Home to information about ion channels.

Many channels have one or more associated models (e.g. different species or cell types); all are downloadable as MOD files.

Shows gating variable and channel response to voltage clamp for each model.
Biomodels is a systems biology model repository.

Models are in SBML but can be converted to MOD files via e.g. jNeuroML (github.com/NeuroML/jNeuroML). Test converted models before using in a larger model. Edits will likely be necessary to get them to interoperate with other mechanisms.

A native SBML importer for NEURON’s rxd module is under development.
Open Source Brain (OpenSourceBrain.org)

- Open Source Brain promotes collaborative model development via github.
- Models are typically in NeuroML or neuroConstruct format; neuroConstruct (neuroConstruct.org) converts both formats to NEURON.
- The conversion process places different ion channels in different MOD files, which allows extracting model components.
NeuroElectro archives experimentally measured electrophysiology values for different cell types; it shows the spread and allows comparing values across different cell types.

Read the paper associated with a value to understand: species, experimental conditions, etc.
SenseLab is a suite of 10 interconnected databases (listed at left).

ModelDB and NeuronDB (at right) are the most useful for modeling.

NeuronDB shows what channels are present and the inputs and outputs by cell region (e.g. distal apical dendrite vs proximal apical dendrite).
Stay up to date

Twitter

Many groups announce new developments on Twitter, including:

- SenseLab (including ModelDB): @SenseLabProject
- Open Source Brain: @OSBTeam
- NeuroMorpho.Org: @NeuroMorphoOrg
- ICGenealogy Project: @ICGenealogy
- Int. Neuroinformatics Coordinating Facility (INCF): @INCForg