ModelDB:
a Resource for Reproducibility in Computational Neuroscience

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The problem: reproducibility

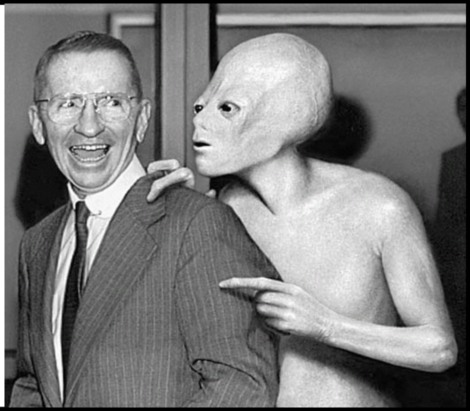
The solution: sharing models

ModelDB: a tool for sharing models

Status and future plans

THE SCIENTIFIC

ENQUIRER



Does computational modeling have a role in neuroscience research?

Scientific Method

Observation

Hypothesis

Prediction

Verification

Evaluation

Scientific Method

Observation

Hypothesis

Prediction

Verification

Reproducibility

Evaluation

Reproducibility in Computational Neuroscience

The ideal:

"Reproducibility is the cornerstone of scientific method."

"Experiments should be fully described
so that anyone can reproduce them."

Reproducibility in Computational Neuroscience

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"Reproducibility is the cornerstone of scientific method."

"Experiments should be fully described
so that anyone can reproduce them."

The harsh reality: "Velilind's Laws of Experimentation"

"If a straight line is required,
obtain only two data points."

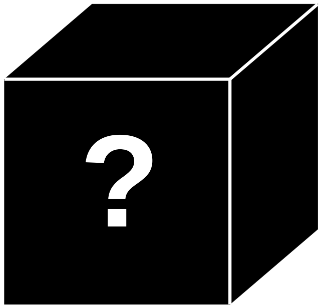
"If reproducibility may be a problem,
conduct the test only once."

Reproducibility: a special problem for computational neuroscience

What's the difference between

. . . a mouse

. . . and a model?



Reproducibility: a special problem for computational neuroscience

Does computational modeling have a role in neuroscience research?

Reproducibility: a special problem for computational neuroscience

Does computational modeling have a role in neuroscience research?

The solution: data (model) sharing

U.S. Funding Agency Policies on Data Sharing in Scientific Research

National Science Foundation

Article 36 of "Grant General Conditions"

http://www.nsf.gov/pubs/2001/gc101/gc101rev1.pdf

National Institutes of Health

Final NIH Statement on Sharing Research Data

http://grants2.nih.gov/grants/guide/notice-files/NOT-OD-03-032.html

NIH Data Sharing Policy and Implementation Guidance

http://grants1.nih.gov/grants/policy/data_sharing/data_sharing_guidance.htm

The Human Brain Project's Data Sharing Policy

http://www.nimh.nih.gov/neuroinformatics/guidelines.cfm

Data sharing summary

Timeliness

Attribution

Ownership

Privacy

Support

Reward

http://senselab.med.yale.edu/senselab/

SenseLab

Login

The SenseLab Project is a long term effort to build integrated, multidisciplinary models of neurons and neural systems, using the olfactory pathway as a model. This is one of a number of projects funded as part of the Human Brain Project whose aim is to develop neuroinformatics tools in support of neuroscience research. The project involves novel informatics approaches to constructing databases and database tools for collecting and analyzing neuroscience information, and providing for efficient interoperability with other neuroscience databases.

- Overview
- Membrane Properties Resource

Brain Database Research

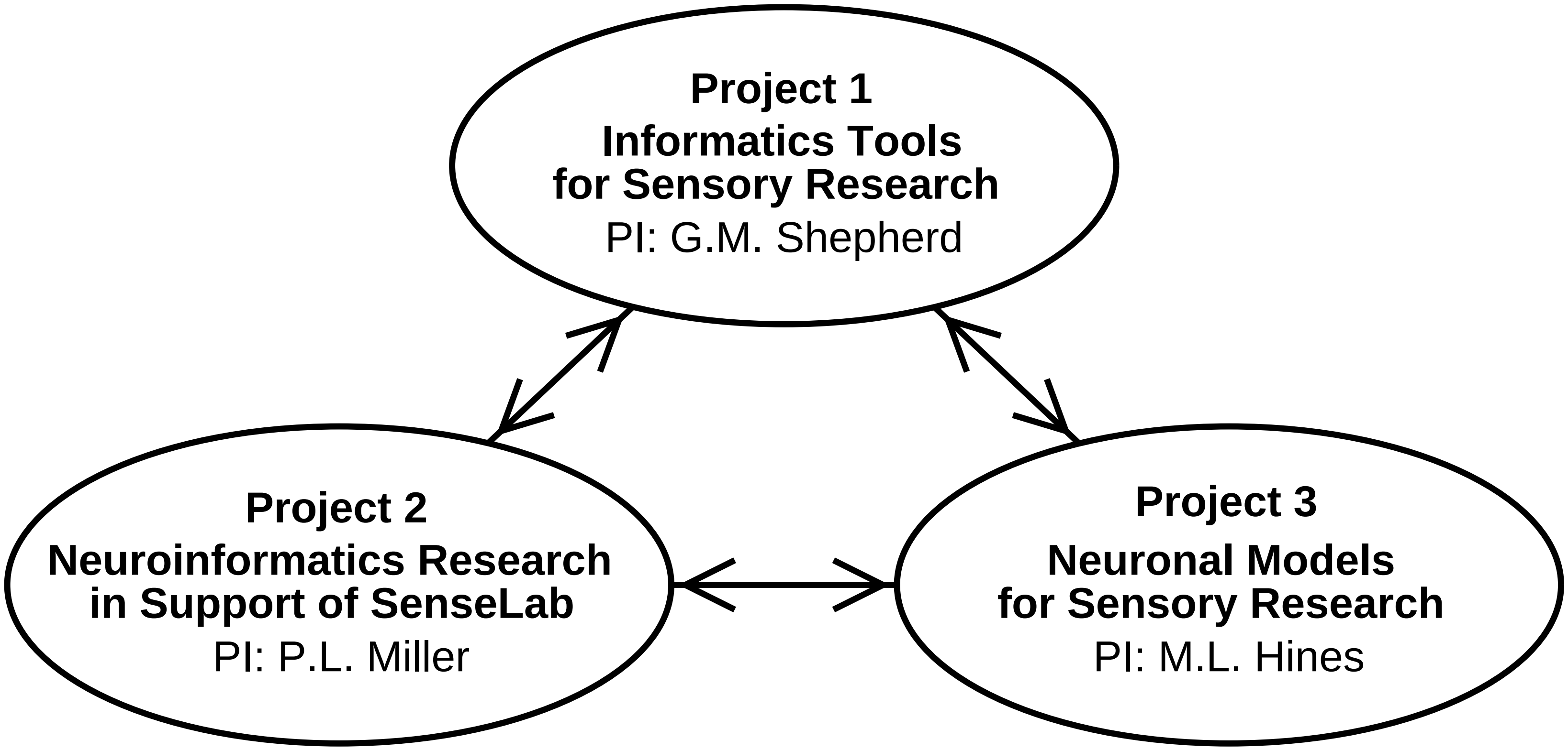
Neuronal Databases	CellPropDB	NeuronDB	ModelDB
Olfactory Databases	ORDB	OdorDB	OdorMapDB

Human Brain Project Database

Help & Introduction | Labs & People | Links | Publications | Architecture | Teaching

Total site hits since January 1, 2002: 890257

Overview of SenseLab



ModelDB Design Goals

Models:
- easy to deposit and find
- work and are reusable

Interface:
- simple and intuitive

ModelDB

- A curated database of models
  - More than 120 models as of 4/2004

ModelDB

- A curated database of models
  - More than 120 models as of 4/2004
- Searchable bibliography
  - More than 8000 papers

http://senselab.med.yale.edu/senselab/modeldb/

ModelDB provides an accessible location for storing and efficiently retrieving compartmental neuron models. ModelDB is tightly coupled with NeuronDB. Models can be coded in any language for any environment, though ModelDB has been initially constructed for use with NEURON and GENESIS. Model code can be viewed before downloading and browsers can be set to auto-launch the models. Help

- Search for models by author name [ ] Search
- List models sorted by first author, by each author or by model name
- Find models of a particular Neuron type
- Find models containing a particular Property: Currents, Receptors, or Transmitters
- Find models that relate to a Concept, e.g. synaptic plasticity, pattern recognition, etc.
- Find models that run in a particular Simulation environment
- List models of: Networks, Neurons, Synapses (and ligand-gated ion channels), Neuromuscular Junctions, Axons, voltage-gated Ion Channels
- Find models containing the following words [ ] Search ☐ Case Sensitive
- Search for publications in ModelDB or in PubMed

Models list

Select name to get detailed information

	Name
1	Active dendrites and spike propagation in a hippocampal interneuron by Saraga et al 2003
2	Activity dependent regulation of pacemaker channels by cAMP from Wang et al 2002
3	Application of a common kinetic formalism for synaptic models from Destexhe et al 1994

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104	Visual Cortex Neurons: Dendritic computations from Archie and Mel 2000
105	Visual Cortex Neurons: Dendritic study from Anderson et al 1999
106	Xenopus Myelinated Neuron: Frankenhaeuser and Huxley 1964

Find Models by Concept

Click on a Concept to show a list of models that incorporate or demonstrate that Concept.

Action Potentials	Action Potential Initiation	
	Axonal Action Potentials	
	Dendritic Action Potentials	
Active Dendrites		
Activity Patterns	Bursting	
	Oscillations	
	Spatio-temporal Activity Patterns	
	Synchronization	
	Temporal Pattern Generation	
Coincidence Detection		
Detailed Neuronal Models		
Influence of Dendritic Geometry		
Ion Channel Kinetics		
Parameter Fitting		
Pattern Recognition		
Simplified Models		
Synaptic Plasticity	Long-term Synaptic Plasticity	
	Short-term Synaptic Plasticity	Depression
		Facilitation
		Post-Tetanic Potentiation
Therapeutics		
Tutorial/Teaching		

Models that contain the Model Concept : Synchronization

(The model is used to investigate the mechanisms and/or effects of synchronization in neuronal networks.)

Models	Description
CA1 pyramidal neuron: effects of Ih on distal inputs from Migliore et al 2004	NEURON mod files from the paper: M. Migliore, L. Messineo, M. Ferrante Dendritic Ih selectively blocks temporal summation of unsynchronized distal inputs in CA1 pyramidal neurons, J.Comput. Neurosci. 16:5-13 (2004). The model demonstrates how the dendritic Ih in pyramidal neurons could selectively suppress AP generation for a volley of excitatory afferents when they are asynchronously and distally activated.
Gamma oscillations in hippocampal interneuron networks by Bartos et al 2002	To examine whether an interneuron network with fast inhibitory synapses can act as a gamma frequency oscillator, we developed an interneuron network model based on experimentally determined properties. In comparison to previous interneuron network models, our model was able to generate oscillatory activity with higher coherence over a broad range of frequencies (20-110 Hz). In this model, high coherence and flexibility in frequency control emerge from the combination of synaptic properties, network structure, and electrical coupling.
Gamma oscillations in hippocampal interneuron networks by Wang and Buzsaki 1996	The authors investigated the hypothesis that 20-80Hz neuronal (gamma) oscillations can emerge in sparsely connected network models of GABAergic fast-spiking interneurons. They explore model NN synchronization and compare their results to anatomical and electrophysiological data from hippocampal fast spiking interneurons.
Hopfield and Brody model (2000)	NEURON implementation of the Hopfield and Brody model from the papers: JJ Hopfield and CD Brody (2000) JJ Hopfield and CD Brody (2001). Instructions are provided in the below readme.txt file.
Olfactory Bulb Network: Davison et al 2003	A biologically-detailed model of the mammalian olfactory bulb, incorporating the mitral and granule cells and the dendrodendritic synapses between them. The results of simulation experiments with electrical stimulation agree closely in most details with published experimental data. The model predicts that the time course of dendrodendritic inhibition is dependent on the network connectivity as well as on the intrinsic parameters of the synapses. In response to simulated odor stimulation, strongly activated mitral cells tend to suppress neighboring cells, the mitral cells readily synchronize their firing, and increasing the stimulus intensity increases the degree of synchronization. For more details, see the reference below.
Sleep-wake transitions in corticothalamic system by Bazhenov et al 2002	The authors investigate the transition between sleep and awake states with intracellular recordings in cats and computational models. The model describes many essential features of slow wave sleep and activated states as well as the transition between them.
Thalamocortical and Thalamic Reticular Network: Destexhe et al 1996	NEURON model of oscillations in networks of thalamocortical and thalamic reticular neurons.

Find Models That Contain a Particular Ionic Current

Click on an Ionic Current to show a list of models that contain or implement that Current.

I Calcium	I L high threshold
	I N
	I T low threshold
	I p,q
I Chloride	I Cl,Ca
I Mixed	I CAN
	I CNG
	I IR,Q,h
	I K,Ca
I Potassium	I A
	I A, slow
	I K
	I K,leak
	I M
I Sodium	I Na,p
	I Na,t

Models that contain the Current : I p,q

(Includes both p-type and q-type currents)

Models	Description
Cerebellar purkinje cell: De Schutter and Bower 1994	Tutorial simulation of a cerebellar Purkinje cell. This tutorial is based upon a GENESIS simulation of a cerebellar Purkinje cell, modeled and fine-tuned by Erik de Schutter. The tutorial assumes that you have a basic knowledge of the Purkinje cell and its synaptic inputs. It gives visual insight in how different properties as concentrations and channel conductances vary and interact within a real Purkinje cell.
Dendritica by Vetter, Roth, and Hausser (2001)	Dendritica is a collection of programs for relating dendritic geometry and signal propagation. The programs are based on those used for the simulations described in: Vetter, P., Roth, A. & Hausser, M. (2001) For reprint requests and additional information please contact Dr. M. Hausser, email address: m.hausser@ucl.ac.uk

Finding models by a particular author

Search Results

The following author names match 'Johnston': Johnston D, Johnston P

Models by Johnston

1. CA1 pyramidal neuron: effects of Lamotrigine on dendritic excitability from Poolos et al 2002
   Poolos NP, Migliore M, Johnston D (2002) Pharmacological upregulation of h-channels reduces the excitability of pyramidal neuron dendrites. Nat Neurosci **5**:767-774 [PubMed]
2. CA1 pyramidal neuron: conditional boosting of dendritic APs from Watanabe et al 2002
   Watanabe S, Hoffman DA, Migliore M, Johnston D (2002) Dendritic K+ channels contribute to spike-timing dependent long-term potentiation in hippocampal pyramidal neurons. Proc Natl Acad Sci U S A 99:8366-8371 [PubMed]
3. CA1 pyramidal neuron: Migliore et al 1999
   Migliore M, Hoffman DA, Magee JC, Johnston D (1999) Role of an A-type K+ conductance in the back-propagation of action potentials in the dendrites of hippocampal pyramidal neurons. J Comput Neurosci 7:5-15 [PubMed]
4. CA3 Pyramidal Neuron: Migliore et al 1995
   Migliore M, Cook EP, Jaffe DB, Turner DA, Johnston D (1995) Computer simulations of morphologically reconstructed CA3 hippocampal neurons. J Neurophysiol 73:1157-68 [PubMed]

(Show all publications of Johnston D, Johnston P)

Find Models of a Particular Neuron

Click on a Neuron to show a list of models of that Neuron type.

Subdivision	General Region	Specific Region	Neurons
Forebrain	Archicortex	Dentate	Dentate granule Cell
		Hippocampus	CA1 pyramidal neuron
			CA3 pyramidal neuron
	Basal Ganglia	Neostriatum	Neostriatal spiny neuron
			Neostriatal cholinergic interneuron
		Substantia Nigra	Nigral dopaminergic cell
	Diencephalon	Thalamus	Thalamic relay neuron
			Thalamic reticular neuron
	Neocortex	Visual & Motor	Neocortical pyramidal neuron: deep
			Neocortical pyramidal neuron: superficial
			Neocortical basket cell
	Olfactory Bulb	Olfactory Bulb	Olfactory bulb mitral cell
			Olfactory bulb periglomerular cell
			Olfactory bulb granule cell
	Olfactory Epithelium	Olfactory Epithelium	Olfactory receptor neuron
	Paleocortex	Olfactory Cortex	Olfactory cortex pyramidal neuron
			Olfactory cortex interneuron: superficial
			Olfactory cortex interneuron:deep
Mesencephalon	Retina	Retina	Retinal ganglion cell
			Retinal photoreceptor
			Retinal bipolar cell
Metencephalon	Cerebellum	Cerebellum	Cerebellar Purkinje Cell
			Cerebellar granule cell
	Cochlear Nucleus	Ventral Cochlear Nucleus	CN bushy cell
			CN octopus cell
		Dorsal Cochlear Nucleus	CN pyramidal (fusiform) Cell
	Inner Ear	Vestibular Organ	Hair cell (vestibular)
		cochlea	Hair cell (auditory)
Myelencephalon			
Spinal Cord	Segment	Ventral Horn	Spinal Ia interneuron
			Spinal motor neuron

Models that contain the Neuron : Olfactory bulb mitral cell

Models	Description
Olfactory Bulb Network: Davison et al 2003	A biologically-detailed model of the mammalian olfactory bulb, incorporating the mitral and granule cells and the dendrodendritic synapses between them. The results of simulation experiments with electrical stimulation agree closely in most details with published experimental data. The model predicts that the time course of dendrodendritic inhibition is dependent on the network connectivity as well as on the intrinsic parameters of the synapses. In response to simulated odor stimulation, strongly activated mitral cells tend to suppress neighboring cells, the mitral cells readily synchronize their firing, and increasing the stimulus intensity increases the degree of synchronization. For more details, see the reference below.
Olfactory Mitral Cell: Bhalla and Bower 1993	This is a conversion to NEURON of the mitral cell model described in Bhalla and Bower (1993). The original model was written in GENESIS and is available by joining BABEL, the GENESIS users' group.
Olfactory Mitral Cell: Davison et al 2000	A four-compartment model of a mammalian olfactory bulb mitral cell, reduced from the complex 286-compartment model described by Bhalla and Bower (1993). The compartments are soma/axon, secondary dendrites, primary dendrite shaft and primary dendrite tuft. The reduced model runs 75 or more times faster than the full model, making its use in large, realistic network models of the olfactory bulb practical.
Olfactory Mitral Cell: I-A and I-K currents from Wang et al 1996	NEURON mod files for the I-A and I-K currents from the paper: X.Y. Wang, J.S. McKenzie and R.E. Kemm, Whole-cell K+ currents in identified olfactory bulb output neurones of rats. J Physiol. 1996 490.1:63-77. Please see the readme.txt included in the model file for more information.
Olfactory Mitral Cell: Shen et al 1999	Mitral cell model with standard parameters for the paper: Shen, G.Y., Chen, W. R., Midtgaard, J., Shepherd, G.M., and Hines, M.L. (1999) Computational Analysis of Action Potential Initiation in Mitral Cell Soma and Dendrites Based on Dual Patch Recordings. Journal of Neurophysiology 82:3006. Contact Michael.Hines@yale.edu if you have any questions about the implementation of the model.
Olfactory Mitral cell: AP initiation modes: Chen et al 2002	The mitral cell primary dendrite plays an important role in transmitting distal olfactory nerve input from olfactory glomerulus to the soma-axon initial segment. To understand how dendritic active properties are involved in this transmission, we have combined dual soma and dendritic patch recordings with computational modeling to analyze action-potential initiation and propagation in the primary dendrite.

Olfactory Mitral Cell: Shen et al 1999

Mitral cell model with standard parameters for the paper: Shen, G.Y., Chen, W. R., Midtgaard, J., Shepherd, G.M., and Hines, M.L. (1999) Computational Analysis of Action Potential Initiation in Mitral Cell Soma and Dendrites Based on Dual Patch Recordings. Journal of Neurophysiology 82:3006. Contact Michael.Hines@yale.edu if you have any questions about the implementation of the model.
Reference: Shen GY, Chen WR, Midtgaard J, Shepherd GM, Hines ML (1999) Computational analysis of action potential initiation in mitral cell soma and dendrites based on dual patch recordings. J Neurophysiol 82:3006-20 [PubMed]

Citations Citation Browser

Model Information (Click on a link to find other models with that property)

Model Type:	Neuron;
Cell Type(s):	Olfactory bulb mitral cell;
Channel(s):	I Na,t; I K; I Sodium; I Potassium;
Receptor(s):	
Transmitter(s):	
Simulation Environment:	Neuron;
Model Concept(s):	Action Potential Initiation; Dendritic Action Potentials; Parameter Fitting; Active Dendrites;
Implementer(s):	Michael Hines ;

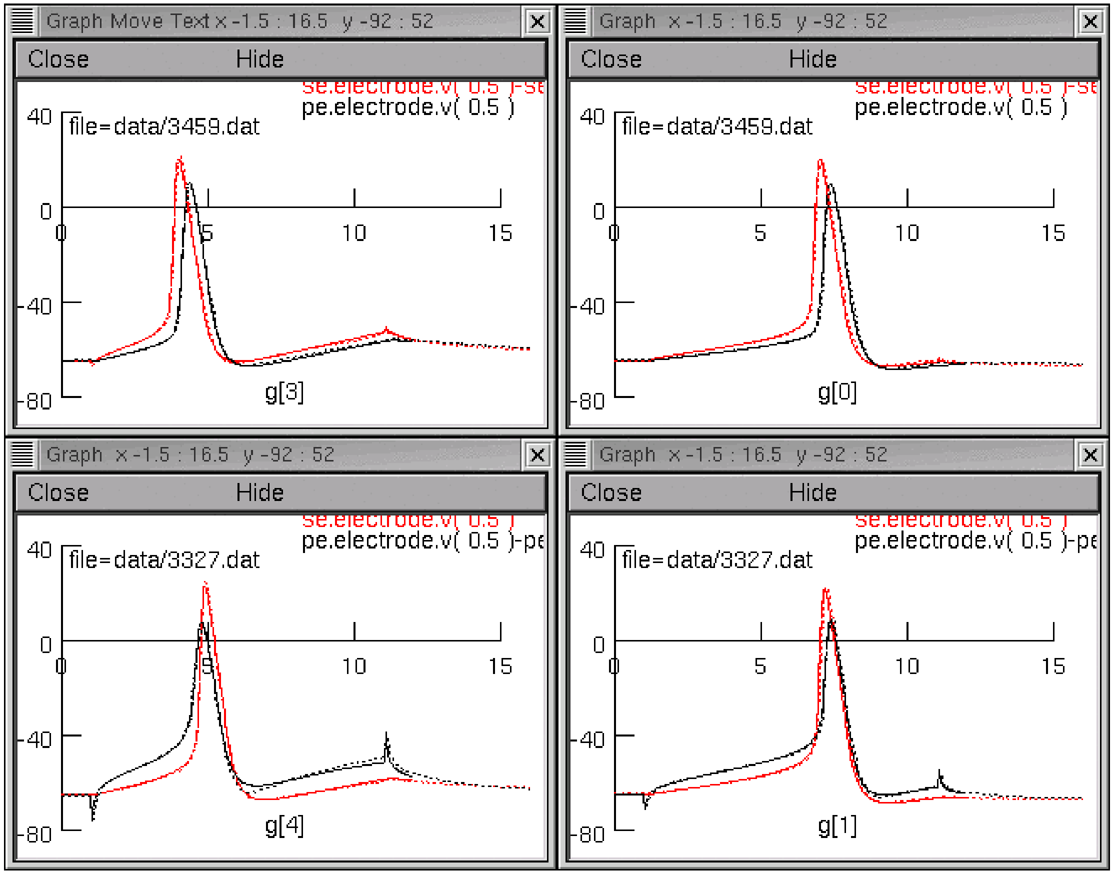
Search NeuronDB for information about: Olfactory bulb mitral cell; I Na,t; I K; I Sodium; I Potassium;

Model files Download zip file Auto-launch Help downloading and running models

- \
  - mitral
    - cell2
    - data
    - XtraStuf.mac
    - README
    - kd.mod
    - na.mod
    - elec1.hoc
    - memb.hoc
    - mitral.hoc
    - mosinit.hoc
    - init.hoc
    - data_in.hoc
    - mainpan.ses
    - nrnmac51.dll

```
Mitral cell model with standard parameters for the paper:

Shen, G.Y., Chen, W. R., Midtgaard, J., Shepherd, G.M., and Hines, M.L.
(1999)
Computational Analysis of Action Potential Initiation in Mitral
Cell Soma and Dendrites Based on Dual Patch Recordings.
Journal of Neurophysiology  82: 3006

Questions about how to use this simulation should be
directed to
        michael.hines@yale.edu

Running the model (execution of the mosinit.hoc file) will display
the data and simulation results as in  Fig 3 and 5.

The cell2 subdirectory contains cell data and simulation which shows
only a limited decrease in the action potential interval.
Running the model (cd cell2 and execute the mosinit.hoc file)
will display the data and simulation within a Multiple Run Fitter.
```

Mitral cell model simulation results



Who uses ModelDB?

	Hits	IP addresses	Sessions
United States	40180	2661	7613
Europe	28345	1444	3875
Asia	7956	430	1172
Israel	5317	33	581
Canada, Australia, and New Zealand	3490	264	387
Central and S. America	2489	132	197
Middle East, Africa, and Other	636	75	96
Totals	**88413**	**5039**	**13921**

Who uses ModelDB?

	Hits	IP addresses	Sessions	Sessions/IP addr	Hits/Session
United States	40180	2661	7613	2.9	5.3
Europe	28345	1444	3875	2.7	7.3
Asia	7956	430	1172	2.7	6.8
Israel	5317	33	581	17.6	9.2
Canada, Australia, and New Zealand	3490	264	387	1.5	9.0
Central and S. America	2489	132	197	1.5	12.7
Middle East, Africa, and Other	636	75	96	1.3	6.6
Totals	**88413**	**5039**	**13921**		

What ModelDB users like

"Complete models"

What ModelDB users like

"Complete models"

Specific morphologies or mechanisms

What ModelDB users like

"Complete models"

Specific morphologies or mechanisms

Bibliography search

What ModelDB users like

"Complete models"

Specific morphologies or mechanisms

Bibliography search

Ease of use

What ModelDB users recommend

Expand the bibliography

What ModelDB users recommend

Expand the bibliography

New search topics

What ModelDB users recommend

Expand the bibliography

New search topics

Advanced (Boolean) search

What ModelDB users recommend

Expand the bibliography

New search topics

Advanced (Boolean) search

Keep up-to-date

What ModelDB users recommend

Expand the bibliography

New search topics

Advanced (Boolean) search

Keep up-to-date

Model preview

What we plan to do

Expand the bibliography

New search topics

Advanced (Boolean) search

Keep up-to-date

Model preview

What we plan to do

- Expand the bibliography
- New search topics
- Advanced (Boolean) search
- Keep up-to-date
- Model preview
  - visual summary

What we plan to do

- Expand the bibliography
- New search topics
- Advanced (Boolean) search
- Keep up-to-date
- Model preview
  - visual summary
  - textual specification

What we plan to do

- Expand the bibliography
- New search topics
- Advanced (Boolean) search
- Keep up-to-date
- Model preview
  - visual summary
  - textual specification
- Interoperability

ModelDB

http://senselab.med.yale.edu/senselab/modeldb/

NEURON

http://www.neuron.yale.edu/