NeuroElectro.org: a window to the world's intrinsic electrophysiology data

http://neuroelectro.org

The goal of the NeuroElectro Project is to extract information about the intrinsic electrophysiological properties of diverse neuron types from the neuroscience literature and place it into a centralized database for widespread comparison, reuse, and reanalysis.

Database population

Neurophysiology articles
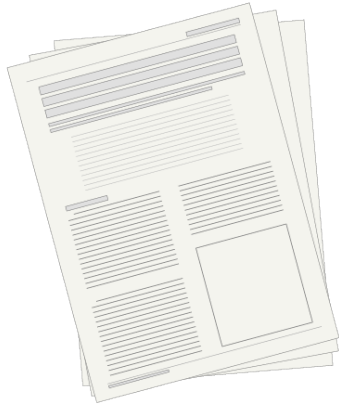
Algorithm-assisted manual curation →
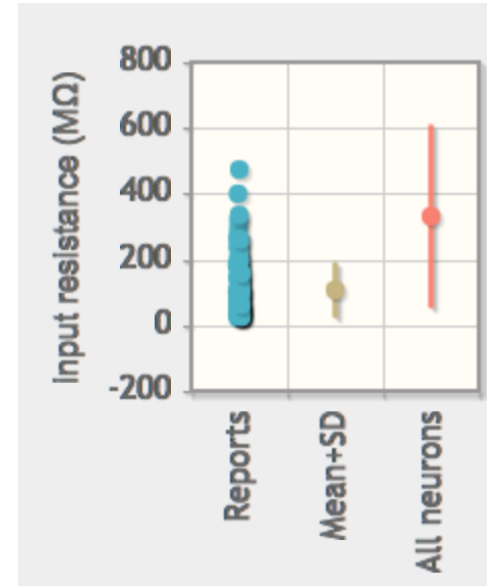
Intrinsic ephys values

CA1 pyramidal cell

V_{rest}	−66.2 ± 1.1 mV
R_{input}	55.4 ± 3.7 MΩ
FR_{max}	140 ± 2.1 Hz

Experimental conditions

Species	Rat
Animal Age	14 - 63 days
Rec. Temp	35.0 ± 2.0°C
$Mg^{2+}_{external}$	2 mM
...	...

968 curated articles from ~100 neuron types recorded under control conditions (as of 2016)

Visualization

Neuron search

"layer 2-3 fast-spiking cell"

↓

32 hits from 19 articles

Methodology-based normalization

Curated NeuroElectro data

Ephys data
Ephys data

Ephys data

R_{input}	930 MΩ
AP_{hw}	1.65 ms

Exp conditions

Animal age	17 days
Temp	22 °C
...	...

→

Statistical models

neuron electrophys = fxn(Exp conds)

→

Normalized NeuroElectro data

Adjusted ephys data
Adjusted ephys data

Adjusted ephys data

R_{input}	610 MΩ
AP_{hw}	1.16 ms

Normalized exp conds

Animal age	27 days
Temp	30 °C
...	...

REST API for Applications

URL Request -> JSON containing a statistical summary of a neuron's ephys properties

Documentation: http://neuroelectro.org/api/docs/

Used to create data-driven tests for model development and validation


```python
import sciunit
from neuronunit import neuroelectro
from neuronunit.tests import InputResistanceTest,RestingPotentialTest

neuron = {'nlex_id': 'nifext_50'} # Layer V pyramidal cell
my_tests = []
for cls in (InputResistanceTest,RestingPotentialTest):
    observation = cls.neuroelectro_summary_observation(neuron)
    my_tests.append(cls(observation))
my_test_suite = sciunit.TestSuite("vm_suite",my_tests)
my_test_suite.judge(my_model)
```

How do academic lineage, experimental conditions, and gene expression determine reported physiological properties?
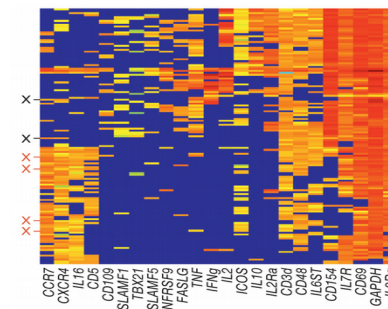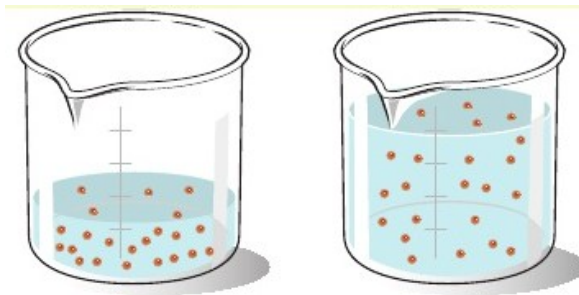
Hippocampome.org: An open-access knowledge base of neuronal type properties for the rodent hippocampus

http://hippocampome.org

Hippocampome.org is a resource that combines approximately 21,000 pieces of experimental evidence about neuron types in the rodent hippocampus into a unified database. Analyzing these data has revealed about 10,500 different neuron properties and has identified over one hundred different neuron types.
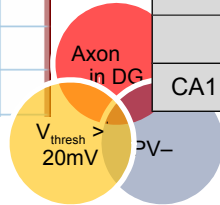
Browse by morphology

Neuron Type	DG				CA1			
	SMo	SMi	SG	H	SLM	SR	SP	SO
CA1 Ivy						▦	▦	▦
CA1 LMR					▦	▦		
CA1 LMR Projecting	▬	▬	▬		▦	▦		
CA1 Neurogliaform					▦			
CA1 Neurogliaform Projecting	▦				▦			

▬ Axon present

▦ Axon & Dendrite present

• Possible somata locations

Search by property

	Neuron Types
DG	Granule
	Mossy
CA3	Spiny Lucidum
	Mossy Fiber-Associated
CA1	CA1 Neurogliaform Proj

Axon in DG

$V_{thresh} > 20mV$

PV−

Search by author/PMID

Fuentealba P

Year	Journal	Neuron Types
2005	J Neurosci	Schaffer Collateral-Associated
2007	J Neurosci	CA1 Trilaminar
2008	Neuron	CA1 Neurogliaform CA1 Neurogliaform Proj
2008	J Neurosci	CA1 Hippocampo-Subicular Proj ENK+
2010	J Neurosci	CA1 Pyramidal CA1 Neurogliaform CA1 Neurogliaform Proj

Browse by biomarker

Neuron Type	CB	CR	PV	CCK	VIP	CoupTF II	RLN	DYN
CA1 Ivy	▶◀	◀	◀	◀	◀		▢	▢
CA1 LMR		◀	▶	◀	▶	◀		
CA1 LMR Projecting		▶		◀		◀	▢	▢
CA1 Neurogliaform	◀	▶	◀	◀		▶	▶	◀
CA1 Neurogliaform Projecting		▶	◀	▶	◀	▶	▶	◀

▶ Positive ▢ No data found

◀ Negative ▢ Search incomplete

▶◀ Positive-Negative (subtypes)

Browse by electrophysiology

| Neuron Type	Vrest (mV)	Rin (MΩ)	τm (ms)	Vthresh (mV)
CA1 Ivy	-71.0	72.8	7.6	30.1
CA1 LMR	-53.1	352.0	32.9	36.9
CA1 LMR Projecting				
CA1 Neurogliaform	-63.1	215.3	12.4	32.4
CA1 Neurogliaform Projecting	-63.1	215.3	12.4	44.4

Neuron type page

CA1 Neurogliaform Proj

Synonyms

List of articles

Morphology
- Soma: CA1 SLM
- Axons: DG SMo, CA1 SLM
- Dendrites: DG SMo, CA1 SLM

Representative figure

SMo

SLM

(Price et al., 2005)
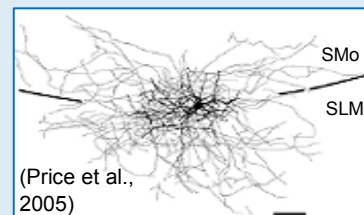
Molecular markers
- Positive: CoupTFII, RLN, ...
- Negative: CB, DYN, PV, VIP, ...
- Mixed expression: CCK, CR, ...

Electrophysiological Parameters
- V_{rest}, R_{in}, τ_m, V_{thresh}, AP_{width}, ...

Connectivity
- Sources of input
- Targets of output

Evidence pages

CA1 Neurogliaform Proj
V_{thresh} Evidence Page

Interpretation

Protocol: pa

Source: Pric
Kulik A, Lam
Capogna M.
novel inhibito
hippocampa
25 (29), page
16033887

Page location
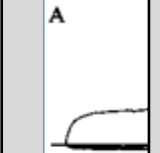
Linking PM
Linking quo

CA1 Neurogliaform Proj
PV Evidence Page

Interpretation

Protocol: mF

Source: Pric
Kulik A, Lam
Capogna M.
novel inhibito
CA1 area. J
pages: 6775-

Page location

Table 2. Multiplexed PCR res
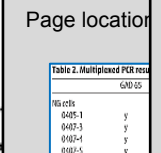
Linking PM
Linking quo

CA1 Neurogliaform Proj
Axon Evidence Page

Interpretation: Axons in DG SMo

Source: Fuentealba P, Klausberger T, Karayannis T, Suen WY, Huck J, Tomioka R, Rockland K, Capogna M, Studer M, Morales M, Somogyi P. Expression of COUP-TFII nuclear receptor in restricted GABAergic neuronal populations in the adult rat hippocampus. J Neurosci, 2010, 30 (5), pages: 1595-1609. PMID: 20130170

Page location: p1602, Figure 6

DG SMo

CA1 SLM

CA1 SR
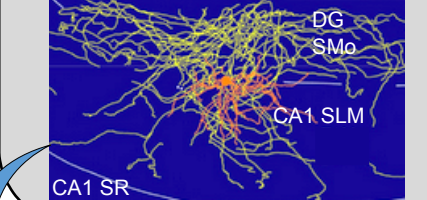
"Axodendritic distribution and molecular profile of neurogliaform cells recorded in vivo. ... B, Partial reconstruction of the neurogliaform cell (T126c). Top: soma and dendrites complete (orange), axonal arborization (yellow) only from 5 coronal sections (60 μm). Note the dendrites biased to [SLM]."

Neuron Term Portal

Initial	Neuron Term - Selector
S ⌄	soma ⌄

| Resource	Definition
Neurolex	The portion of a neuron that includes the nucleus, but excludes cell projections such as axons & dendrites.
CRISP	The cell body of a neuron.
Gene Ontology	The portion of a cell bearing surface projections such as axons, dendrites, cilia, or flagella that includes the nucleus, but excludes all cell projections.

Allen Mouse Brain Atlas data

- Focus on principal cell layers of DG, CA3, CA2, CA1.
- Mouse in situ hybridization data.
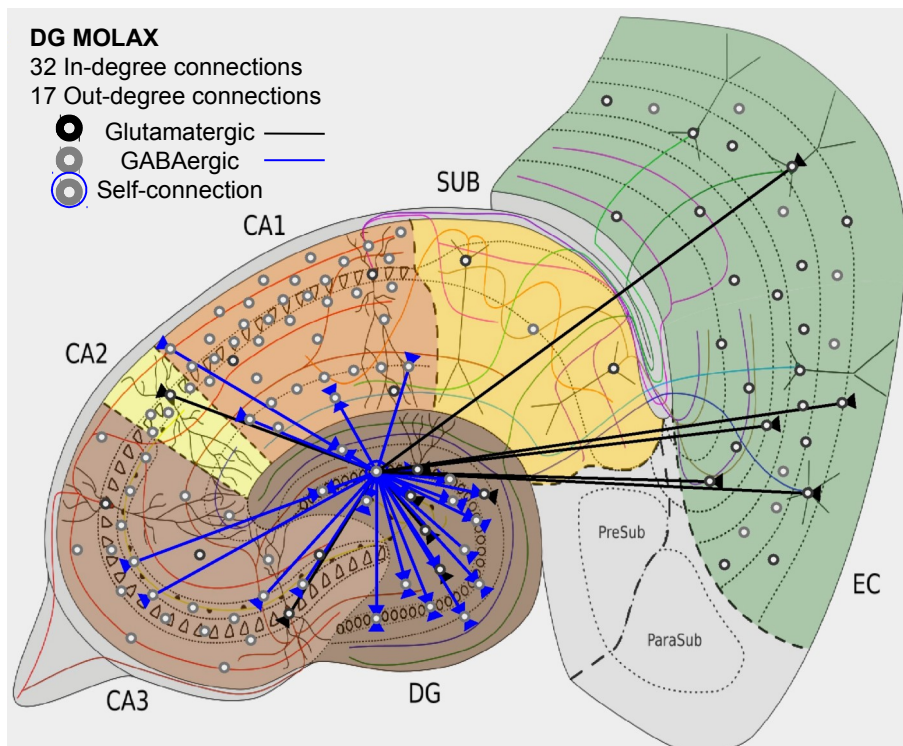- Increases the biomarker pieces of knowledge (PoK) from ~1100 to more than ~6800.
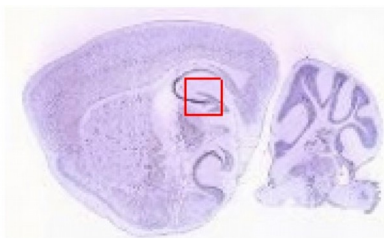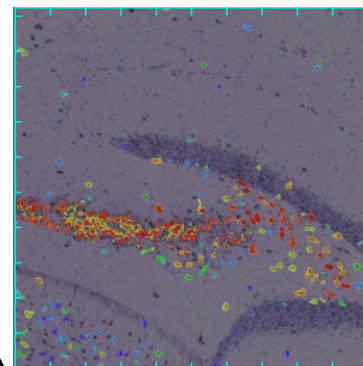
Acetylcholinesterase (Ache) is expressed in CA3c Pyramidal cells and not expressed in DG Granule cells.

Interactive connectivity navigator

DG MOLAX
32 In-degree connections
17 Out-degree connections
- ◯ Glutamatergic ——
- ◎ GABAergic ——
- ◉ Self-connection

SUB
CA1
CA2
CA3
DG
PreSub
ParaSub
EC

Forthcoming additions
Biomolecular marker inferences

- Relational expression inferences supplement direct expression evidence.
- Contrapositive inferences.

Firing pattern phenotypes

- 9 firing pattern elements.

Modeling firing patterns

- Firing patterns simulated using Izhikevich models (IEEE Trans Neural Netw 14:1569-1572 (2003)).

New neuron types

- Splitting of CA1 Pyramidal cells into Superficial and Deep types.
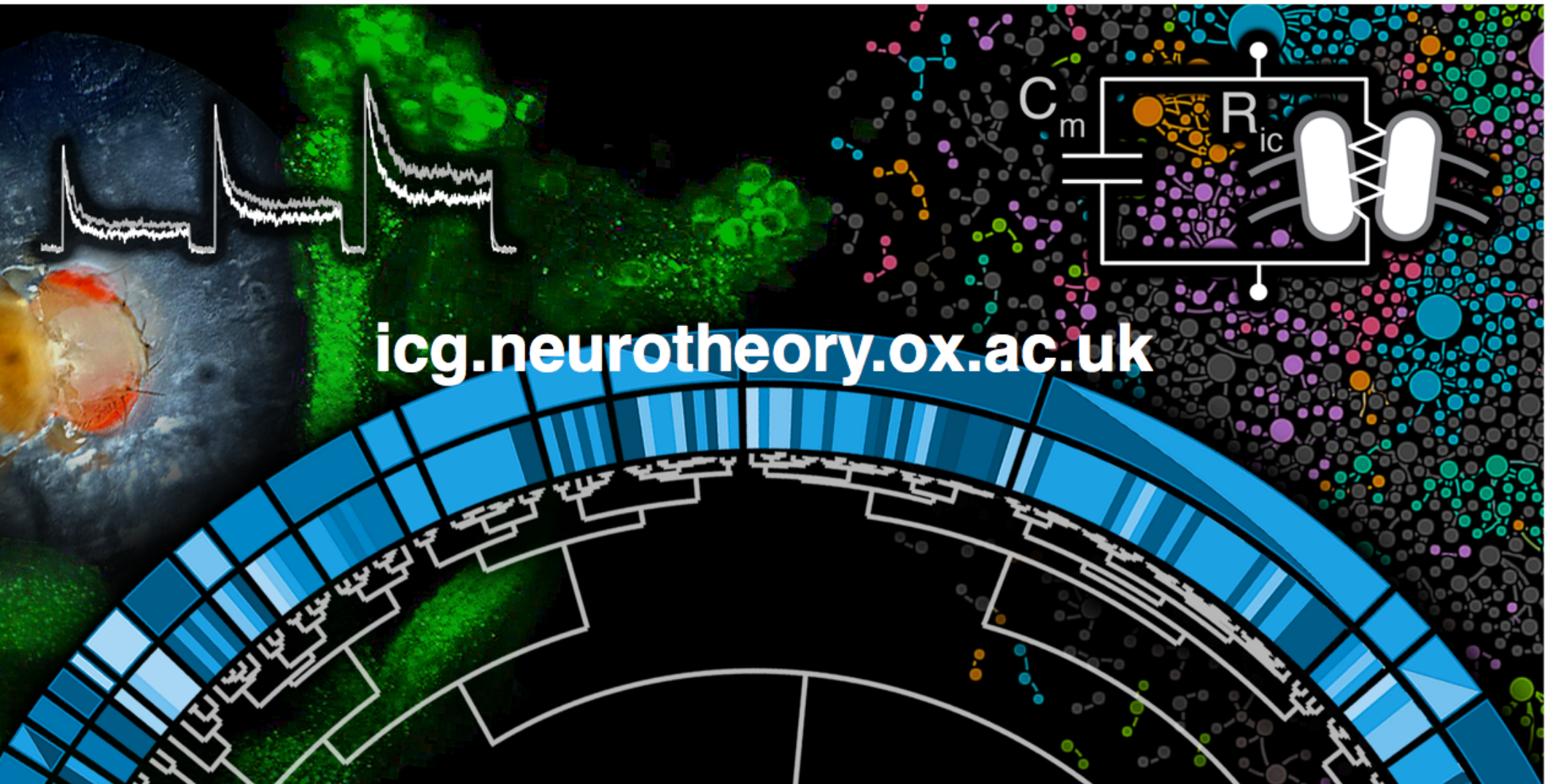- Inclusion of Adult-Born Immature Granule cells.

IonChannelGenealogy

https://icg.neurotheory.ox.ac.uk

The ICG database provides a comprehensive and quantitative assay of ion channel models currently available in the neuroscientific modeling community, all browsable in interactive visualizations.

Mapping the function of neuronal ion channels in model and experiment
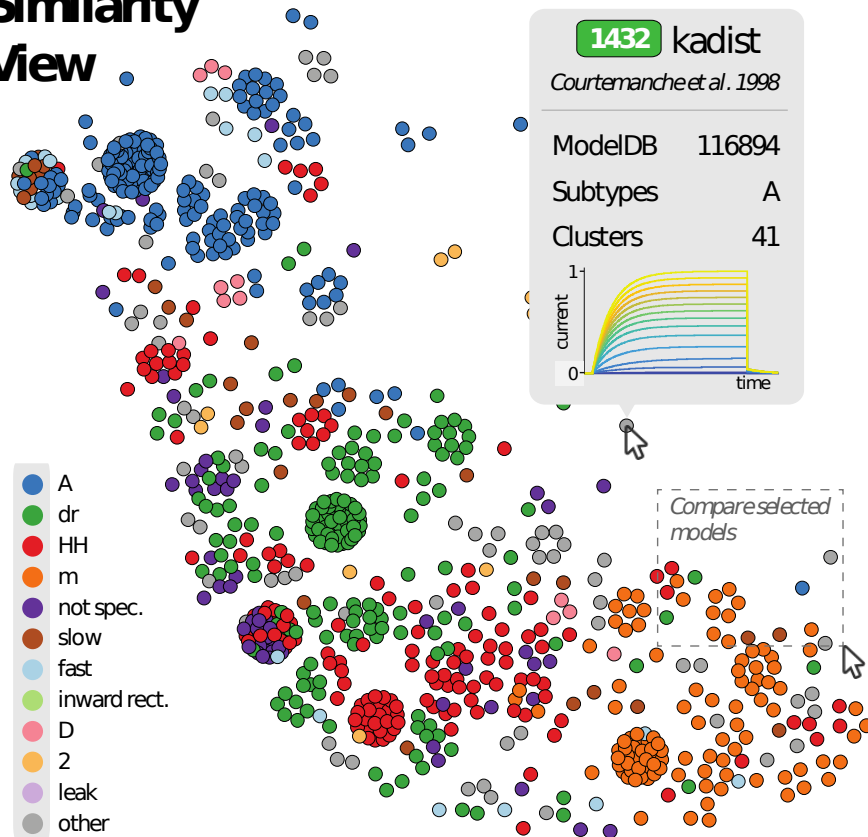
William F Podlaski, Alexander Seeholzer, Lukas N Groschner, Gero Miesenböck, Rajnish Ranjan, Tim P Vogels

The ICG website

(1) Browse database through four interactive views:

Similarity View

1432 kadist		
Courtemanche et al. 1998		
ModelDB		116894
Subtypes		A
Clusters		41

current / time

TYPE ▶ Similarity / Family

FAMILY ▶ Kv Nav / Cav KCa Ih

COLOR ▶ Subtype / Date ...

FILTERS ▶ Text ... / Cluster

Legend:
- A
- dr
- HH
- m
- not spec.
- slow
- fast
- inward rect.
- D
- 2
- leak
- other

Compare selected models

CHANNEL DETAILS

1432 kadist

MODELDB 279

ION TYPE	K
SUBTYPE	HH
NEURON TYPE	TCR cell
RUNTIME Q	Q2
TEMPERATURE	model f t at...
COMMENTS	model from...

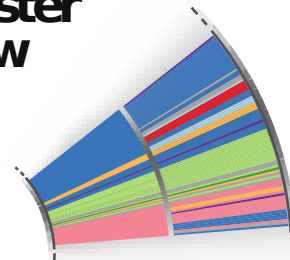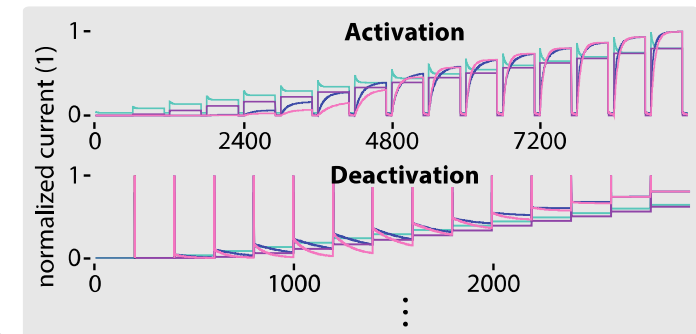### Hierarchy view
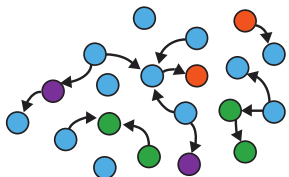
XY view
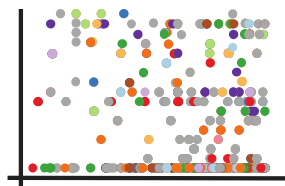
Cluster view

(2) Compare ion channel metadata and kinetics side by side:

Channel Comparison

Model	Ion Type	Subtype	Neuron Type	...
2568 97860_kv4hh	K	4	dopaminergic	
276 116094_kM	K	m	mitral	
970 136715_hh	K	HH	pyramidal	
12 101629_km	K	m	pyramidal	

Activation

normalized current (1)

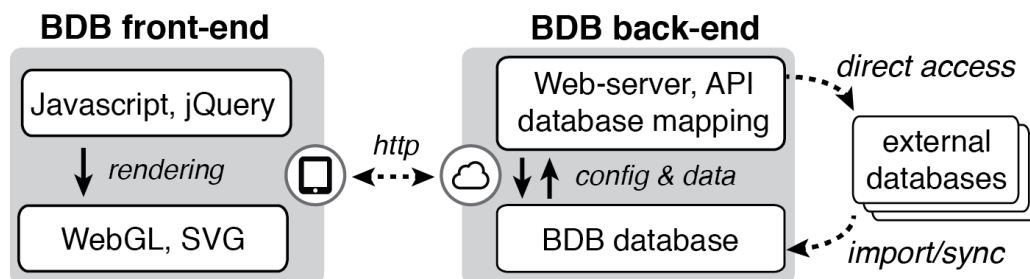0   2400   4800   7200

Deactivation

0   1000   2000

For more details on methods and analyses, refer to our publication in eLife!

Current and future work

- *Maintenance of database with new models & collection of experimental traces*
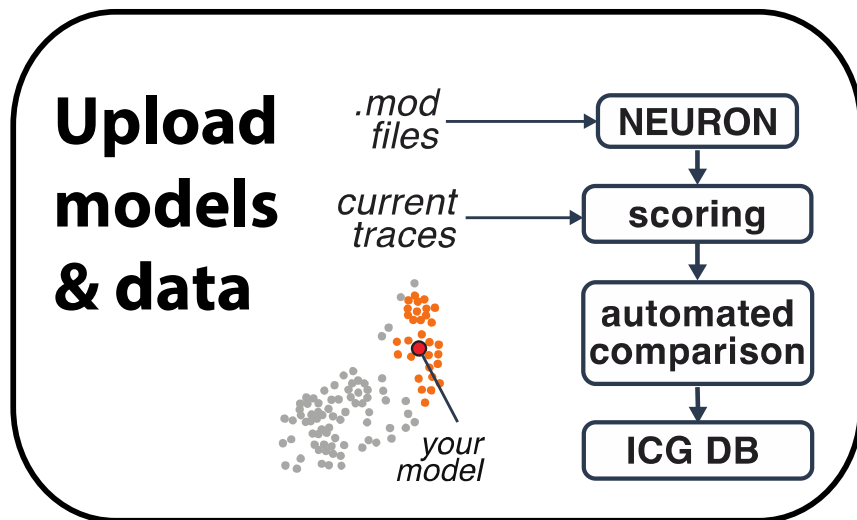
- *Generalisation of the database and visualisation software*

- *Addition of models in other programming languages & channel types*

- *Integration with existing resources (ModelDB, NeuroML, etc.)*

- *Extension to combinations of ion channel models, morphology, and other neuroscience datasets*
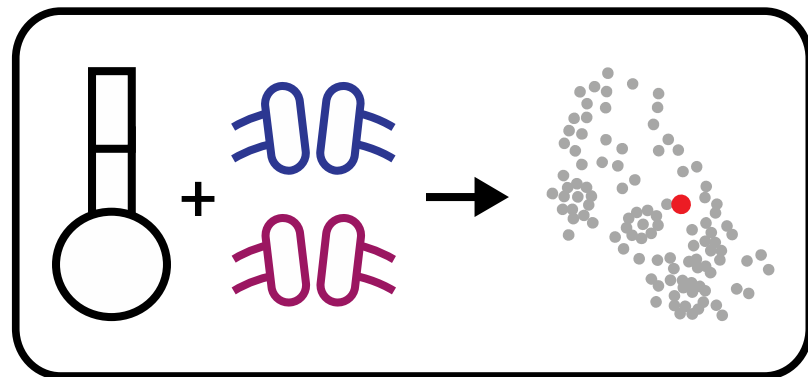
- *Continued support thanks to funding from the BBSRC*