Cajal BLUE BRAIN

CAJAL BLUE BRAIN PROJECT

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'Cell' in the Blue Brain Framework

One of the major accomplishments during 2015 has been the publication in Cell (vol. 163: 1–37, 2015) a draft digital reconstruction of the neocortical column of the rat brain. – a detailed computer representation of about a third of a cubic millimetre of brain tissue containing about 30,000 neurons connected by nearly 40 million synapses. Simulating the emergent electrical behavior of this virtual tissue on supercomputers reproduced a range of previous observations made in experiments on the brain, validating its biological accuracy and providing new insights into the functioning of the neocortex. The project has published the full set of experimental data and the digital reconstruction, in a public web portal, allowing researchers around the world to use them (https://bbp.epfl.ch/nmc-portal). The reconstruction represents the culmination of 20 years of biological experimentation that generated the core dataset, and 10 years of computational science work that developed the algorithms and built the software ecosystem required to digitally reconstruct and simulate the tissue. Importantly, this study is the result of a massive effort by 82 scientists and engineers at EPFL and at institutions in Israel, Spain, Hungary, USA, China, Sweden, and the UK. The publication represents a major milestone for the Blue Brain scientists (six authors are from the Cajal Blue Brain project, and one of them is a co-senior author). The study demonstrates that it is feasible to digitally reconstruct and simulate brain tissue. It is a first step and a significant contribution to Europe's Human Brain Project

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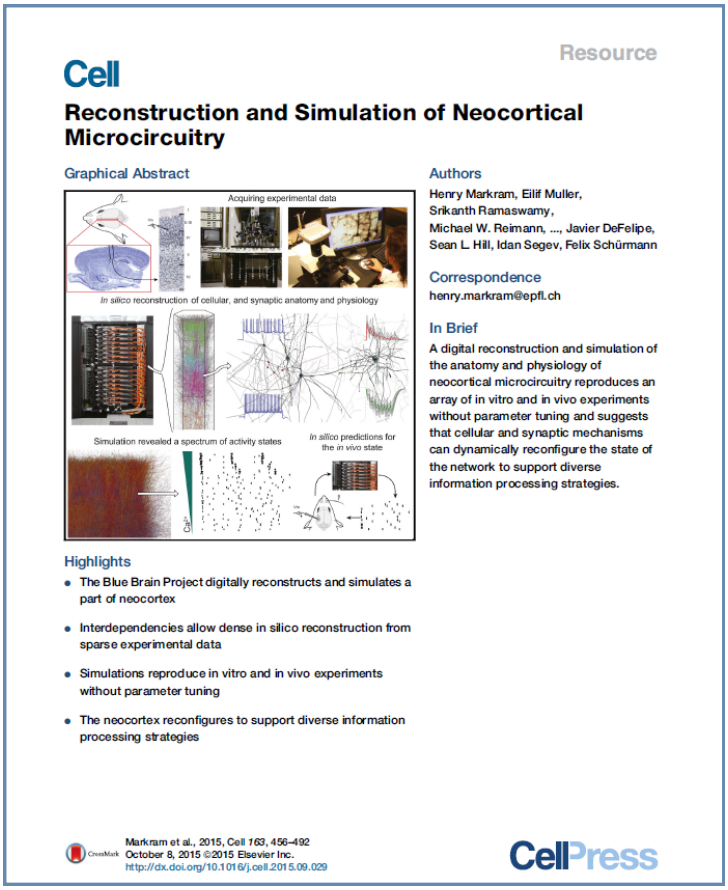
Special points of interest:

- ☐ 2015 Project main achievements and contributions



Resource

Cell

Reconstruction and Simulation of Neocortical Microcircuitry

Graphical Abstract

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In Brief

A digital reconstruction and simulation of the anatomy and physiology of neocortical microcircuitry reproduces an array of in vitro and in vivo experiments without parameter tuning and suggests that cellular and synaptic mechanisms can dynamically reconfigure the state of the network to support diverse information processing strategies.

Highlights

- The Blue Brain Project digitally reconstructs and simulates a part of neocortex
- Interdependencies allow dense in silico reconstruction from sparse experimental data
- Simulations reproduce in vitro and in vivo experiments without parameter tuning
- The neocortex reconfigures to support diverse information processing strategies

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CellPress

Cajal BLUE BRAIN

Any man can be, if he wants, the sculptor of his own brain

2015 Main Achievements

2015 Main Achievements

Neuroscience

- All the objectives proposed in 2015 have been achieved. In addition, one of the major accomplishments during 2015 has been the publication in Cell (vol. 163: 1–37, 2015) a draft digital reconstruction of the neocortical column of the rat brain.
- Release of the software tool for the 3D segmentation of cells
- A new method for the fast segmentation of mitochondria and synaptic junctions has been developed
- Two articles have been published regarding the structure of the dendritic arbor of pyramidal cells and branching angles
- Pyramidal Explorer: a new interactive tool to explore the morpho-functional relations of pyramidal neurons
- Tract-tracing experiments performed to analysis the connectivity of the cortical column
- A new method based on 3D reconstruction of data analysis have been used for modelling neurotransmitter diffusion and synaptic receptor activation

Data Analysis

- Uni–dimensional classification of GABA-ergic interneurons (gardener) (Mihaljevic et al., 2015a) and discovery of new subgroups (Mihaljevic et al., 2015b) with the aim of building the NeuroClassificator. We have developed a new R package for these models (Mihaljevic et al., submitted).
- Study of dendritic pyramidal neurons per layer in juvenile rat somatosensory cortex (Rojo et al., 2016) and their dendritic branching angles (Leguey et al., submitted), extended to humans (Fernandez-Gonzalez et al., submitted).
- Mathematical definition of a soma (Luengo et al., 2015).
- Dendritic and axonal neuronal wiring optimization (Anton-Sanchez et al., submitted and Master Thesis by Anton-Sanchez, 2015).
- The value of publishing data sets in neuroscience (Leitner et al., submitted).
- Bielza, C.: Associate Editor of Frontiers in Computational Neuroscience
- Bielza, C.: Bayesian Networks for Neuroscience Challenges, invited talk at 2015 Human Brain Project Summit, Madrid
- Proposal of the renewed participation in the Human Brain Project, with two tasks.

Neuroinformatics Tools

- Development of new versions of the EspINA framework
- Integration of new algorithms as plugins in the EspINA framework.
- Calibration of simulation models in collaboration with the Brain Mechanics and Trauma Lab (IBMTL Antoine Jérusalem's group at University of Oxford as well as in the parallel implementation of the algorithms in collaboration with Antonio García-Dopico from ETSIINF (UPM).
- Cell counting and annotation

Visualization Tools (GMRV, URJC & UPM)

- A new generic method for the interactive exploratory analysis of neuroscience developed
- Automatic data retrieval techniques
- Morphologically correct representations for large neuron populations, including additional improvements in RTNeuron, developed by Juan Hernando in collaboration with EPFL, and in on-the-fly neuron model remeshing for supporting multiresolution representations.
- Development of abstract representations for exploring large cortical neuronal circuits
- Combined abstract and morphologically correct representations within a framework of interactive exploratory analysis
- A first prototype finished

2015 Main Achievements

Physiology and Modelling (San Carlos Hospital, CTB-UPM, Hospital de Parapléjicos de Toledo): *In-vivo Electrophysiology*

- Research into experimental design in clinical trials
- Broadening knowledge on the matter of Alzheimer's Disease
- Theoretical research into deep brain stimulation techniques: DBS Review paper(in progress)

Cell Physiology Cajal's Laboratory (IC-CSIC)

- The experimental work performed has provided novel results regarding the role of astrocytes in the regulation of the synaptic transmission between the neuronal projections from the cortex to the dorsal striatum. These results have revealed the existence of circuit-specific signaling in astrocyte-neuron networks that selectively modulates cortico-striatal

2015 Main Contributions

2015 Main Contributions

Cross-publications between modules and/or groups:

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CTB

The Cajal Blue Brain Project is hosted by the Universidad Politécnica de Madrid (UPM) in the Scientific and Technological Park of Montegancedo Campus. Computational needs and support infrastructure required by CajalBBP are provided by two of the Research Centers of the Park, the Centro de Tecnología Biomédica (CTB) and the Centro de Supercomputación y Visualización de Madrid, CeSViMa, which is focused on the massive storage of information, high-performance computing and advanced interactive visualization.

More information: www.ctb.upm.es

Sponsorship