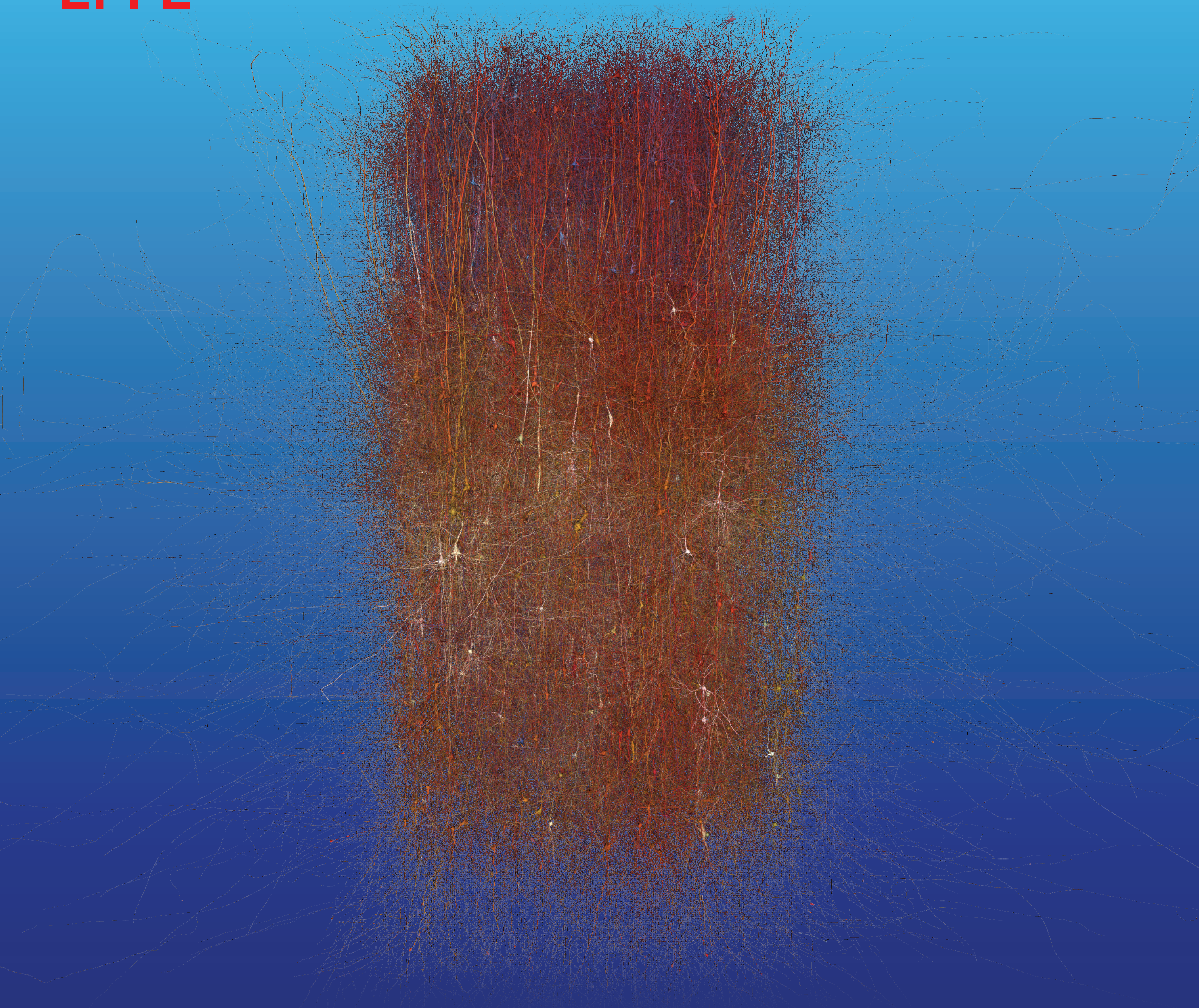
EPFL



Blue Brain
Neocortical Microcircuit Collaboration Portal

An online public resource of the Blue Brain Project's first release of a digital reconstruction of the microcircuitry of juvenile rat somatosensory cortex

The Blue Brain Neocortical Microcircuit Collaboration (NMC) Portal is the online public resource of the Blue Brain Project's first release of a digital reconstruction of the microcircuitry of the juvenile rat somatosensory cortex.

The NMC portal provides access to the data, literature, and models used in the digital reconstruction of P13-16 rat somatosensory cortex, together with interactive tools to browse and query its detailed anatomy and physiology. The resource also provides means for the community to explore, analyze, and annotate the properties of the reconstruction, to compare them against results from the literature, and to provide feedback for future releases.

The NMC portal allows users to access the experimental data used in the reconstruction process, download cellular and synaptic models, and analyze the predicted properties of the microcircuit: **six layers, ~31,000 neurons, 55 morphological types, 11 electrical types, 207 morpho-electrical types, anatomy and physiology of ~40 million intrinsic synapses and 1,941 unique synaptic connection types between neurons of specific morphological types.**

Overview of the **NMC Portal** – a collaborative resource for the Scientific Community

A close-up view of spines (inputs) highlighted in blue-green-yellows, and boutons (outputs) in red-oranges of a layer 5 pyramidal cell. Every colored part of the neuron is a connection with another cell.

Neocortical Microcircuit

An interactive browser across three levels: layers, neurons, and synapses. The layer level provides data on thickness, neuron, and synapse densities, and the distributions of neuron and synapse types for each of the six layers of the reconstruction. The neuronal level describes the anatomical and physiological properties of morphological (m-), electrical (e-), and morpho-electrical (me-) types. The synaptic level represents the anatomical and physiological properties of connections between specific pre-post combinations of m-types, and the complete map of intrinsic input and output synapses (three excitatory, and three inhibitory synaptic (s-) types), from and to neurons of different types.

Literature Consistency

Comparisons between the morphological, molecular, electrical, synaptic, and physiology properties of the reconstruction and its overall circuit anatomy against the published literature can be seen in this section.

Experimental Data

The portal provides access to the data sets used in the reconstruction process, together with descriptions of the experimental protocols used to generate the data. They include:

1. Measurements of individual layer heights.
2. Layer-wise distributions and densities of neurons.
3. Molecular characterization of single neurons based on the expression of calcium binding proteins [parvalbumin (PV), calbindin (CB), and calretinin (CR)], and neuropeptides [somatostatin (SOM), vasoactive intestinal polypeptide (VIP), neuropeptide Y (NPY), and cholecystokinin (CCK)].
4. More than **1,000 morphological reconstructions of neurons** of different m-types.
5. More than **1,500 electrical recordings from neurons** of different e-types.
6. More than **5,000 experiments** from synaptically connected neurons.

Videos

This section provides movies of simulated spontaneous and evoked activity in virtual cortical slices, obtained from the reconstructed microcircuit under a variety of simulated experimental conditions.

Images

The image gallery displays downloadable images, which illustrate the key steps in the reconstruction process.

To date, the NMC portal has been accessed more than 130,000 times by over 26,000 users, with more than 5,800 downloads of comprehensive models for detailed simulations of neuronal activity.

Tools

This section contains three tools used for the analysis, repair and cloning of neuronal morphologies.

1. **NeuroM** provides a range of morphometric analyses that allow a user to quantify properties of the axonal and dendritic morphologies of neurons, and classify different neurons into one of 55 m-types. github/BlueBrain/NeuroM
2. **NeuroR** utilizes the results of NeuroM to identify and repair arbors that were severed during slice preparation.
3. **NeuroC** produces clones of the neurons repaired by NeuroR, introducing statistical variations in the arbors of each cloned neuron. This procedure makes it possible to generate a limitless number of unique instances of neurons belonging to a given m-type.

The Morphology tools are complemented by two Electrophysiology Tools **– eFEL and BluePyOpt.**

The **Electrophys Feature Extraction Library (eFEL)** allows neuroscientists to automatically extract features from time series data recorded from neurons (both in vitro and in silico). github.com/BlueBrain/eFEL

The **Blue Brain Python Optimization Library (BluePyOpt)** is an extensible framework for data-driven model parameter optimization that wraps and standardizes several existing open-source tools. github.com/BlueBrain/BluePyOpt

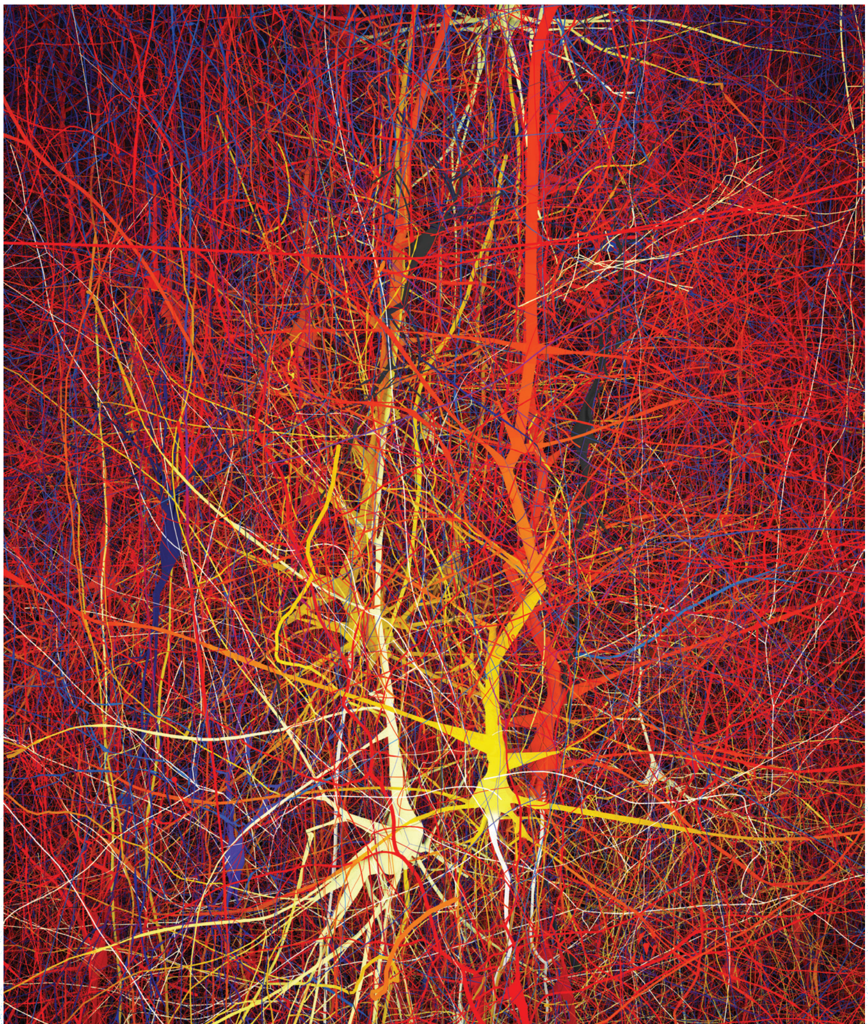
Downloads

The downloads section provides models of single neurons, synapses, and predicted maps of input-output synapses.

Models are available either in the native format used in the reconstruction process, based on the NEURON simulation environment, or in NeuroML 2.0.

Models of individual neurons (in the NEURON simulation environment) can also be obtained from the me-type fact sheets [see Morpho-Electrical Types (me-types)]. Model packages for individual neurons contain a 3D reconstructed morphological model, models of ion channels and synapses, synaptic model parameter descriptions, and a template model of the electrical type. Additional helper scripts for the NEURON simulation environment are provided to instantiate a morpho-electrical neuron model, distribute ion channel mechanisms on axonal and dendritic arbors, and simulate electrophysiological and synaptic experiments.

The in silico connectome of the neocortical microcircuit is also freely available for download.



A simulation of a dense network of neurons whose membranes are colored by voltage.

About EPFL's **Blue Brain Project**

The aim of the EPFL Blue Brain Project, a Swiss brain research initiative founded and directed by Professor Henry Markram, is to establish simulation neuroscience as a complementary approach alongside experimental, theoretical and clinical neuroscience to understanding the brain, by building the world's first biologically detailed digital reconstructions and simulations of the mouse brain.

Blue Brain NMC Portal has been made publicly available as an online resource at: bbp.epfl.ch/nmc-portal/welcome

Accompanying papers

1. Ramaswamy S, Courcol J-D, Abdellah M, Adaszewski SR, Antille N, Arsever S, Atenekeng G, Bilgili A, Brukau Y, Chalimourda A, Chindemi G, Delalondre F, Dumusc R, Eilemann S, Gevaert ME, Gleeson P, Graham JW, Hernando JB, Kanari L, Katkov Y, Keller D, King JG, Ranjan R, Reimann MW, Rössert C, Shi Y, Shillcock JC, Telefont M, Van Geit W, Villafranca Diaz J, Walker R, Wang Y, Zaninetta SM, DeFelipe J, Hill SL, Muller J, Segev I, Schürmann F, Muller EB and Markram H (2015). The neocortical microcircuit collaboration portal: a resource for rat somatosensory cortex. Front. Neural Circuits 9:44. doi: 10.3389/fncir.2015.00044
2. Markram H†, Muller E†, Ramaswamy S†, Reimann MW†, Abdellah M, Sanchez CA, Ailamaki A, Alonso-Nanclares L, Antille N, Arsever S et al. (2015). Reconstruction and Simulation of Neocortical Microcircuitry. Cell 163:2, 456 - 492. doi: 10.1016/j.cell.2015.09.029. †Co-first author.
3. Reimann MW, King JG, Muller EB, Ramaswamy S and Markram H (2015). An Algorithm to Predict the Connectome of Neural Microcircuits. Front. Comput Neurosci. 9:28. doi: 10.3389/fncom.2015.00120
4. Gal E, London M, Globerson A, Ramaswamy S, Reimann MW, Muller E, Markram H and Segev I, 2017. Rich cell-type-specific network topology in neocortical microcircuitry. Nature neuroscience, 20(7), p.1004.
5. Reimann MW, Horlemann A-L, Ramaswamy S, Muller EB, and Markram H (2017). Morphological Diversity Strongly Constrains Synaptic Connectivity and Plasticity. Cereb. Cortex 1-16.

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For more information on the NMC Portal, please contact:

Srikanth Ramaswamy
Group Leader, Circuits
Blue Brain Project
srikanth.ramaswamy@epfl.ch

Jean-Denis Courcol
Section Manager, Neuroscientific Software Engineering
Blue Brain Project
jean-denis.courcol@epfl.ch

Community Forum:

forum.humanbrainproject.eu/c/publications/markram-etal-2015
Email – nmc.portal@epfl.ch

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