Building the Functional Map of the Fruit Fly Brain

Aurel A. Lazar

Columbia University
Department of Electrical Engineering

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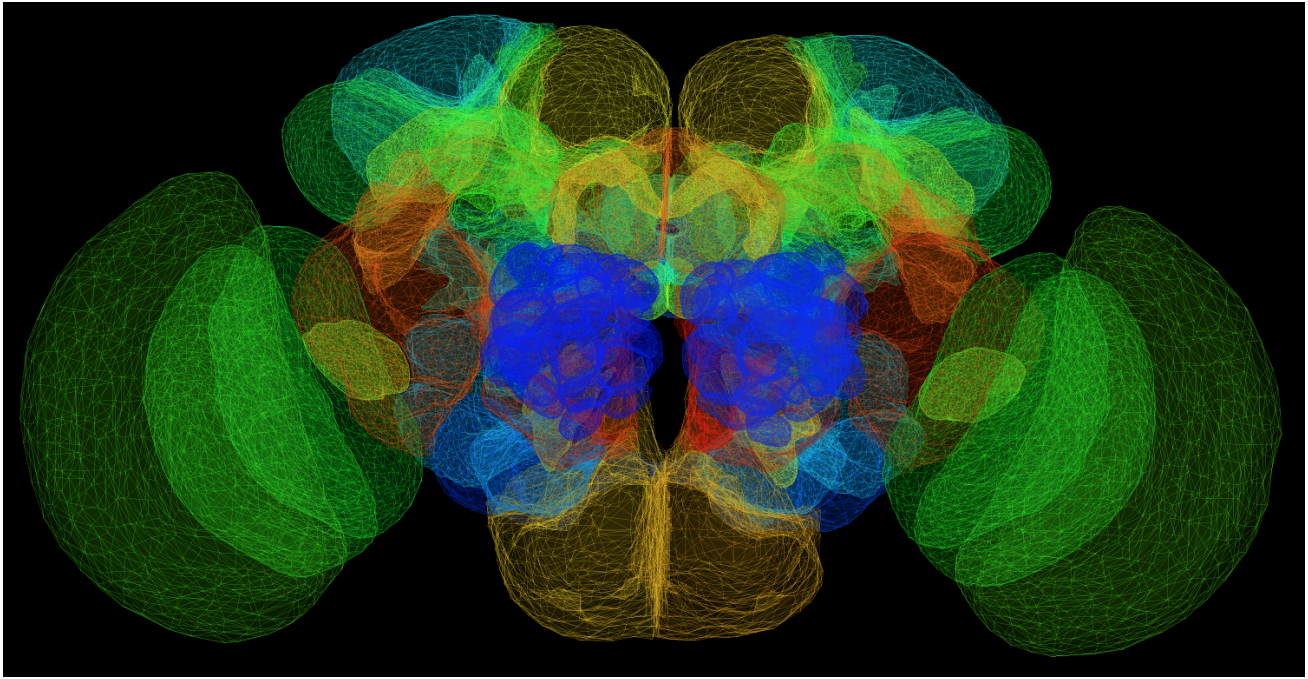
Part I

From Brain Structure to Function

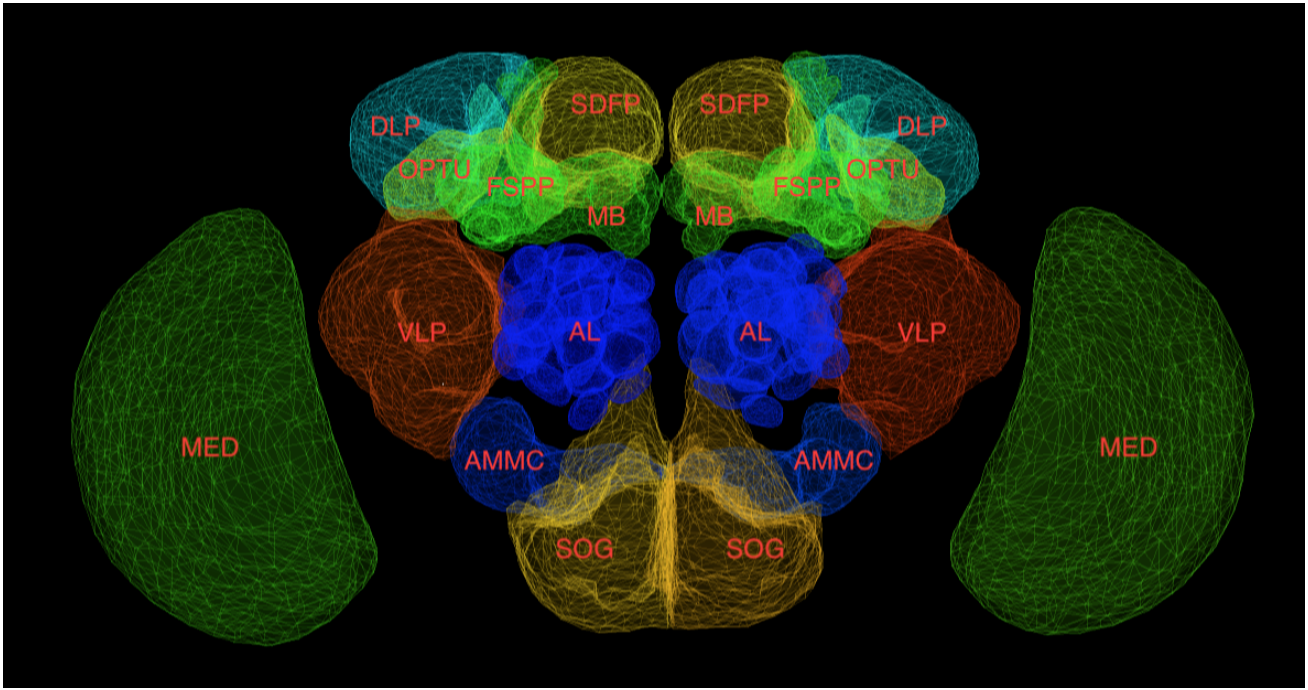
The Neuropils of the Fruit Fly Brain

3D View



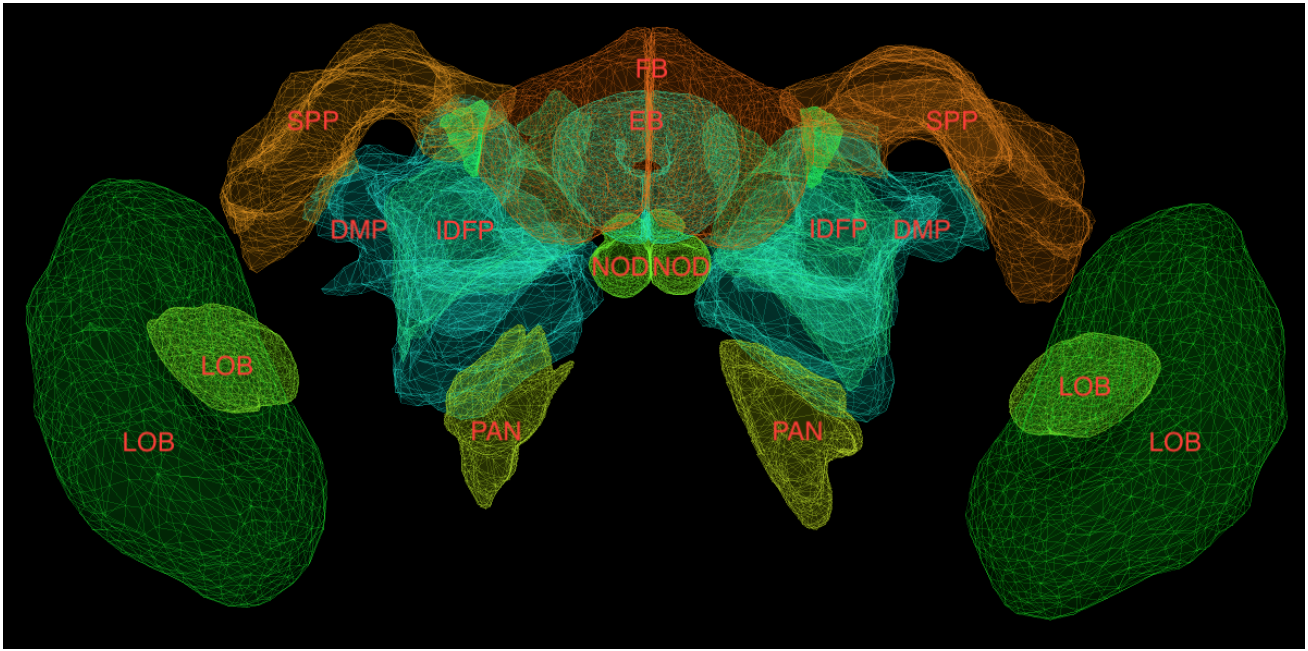
The Neuropils of the Fruit Fly Brain (cont'd)

Front View



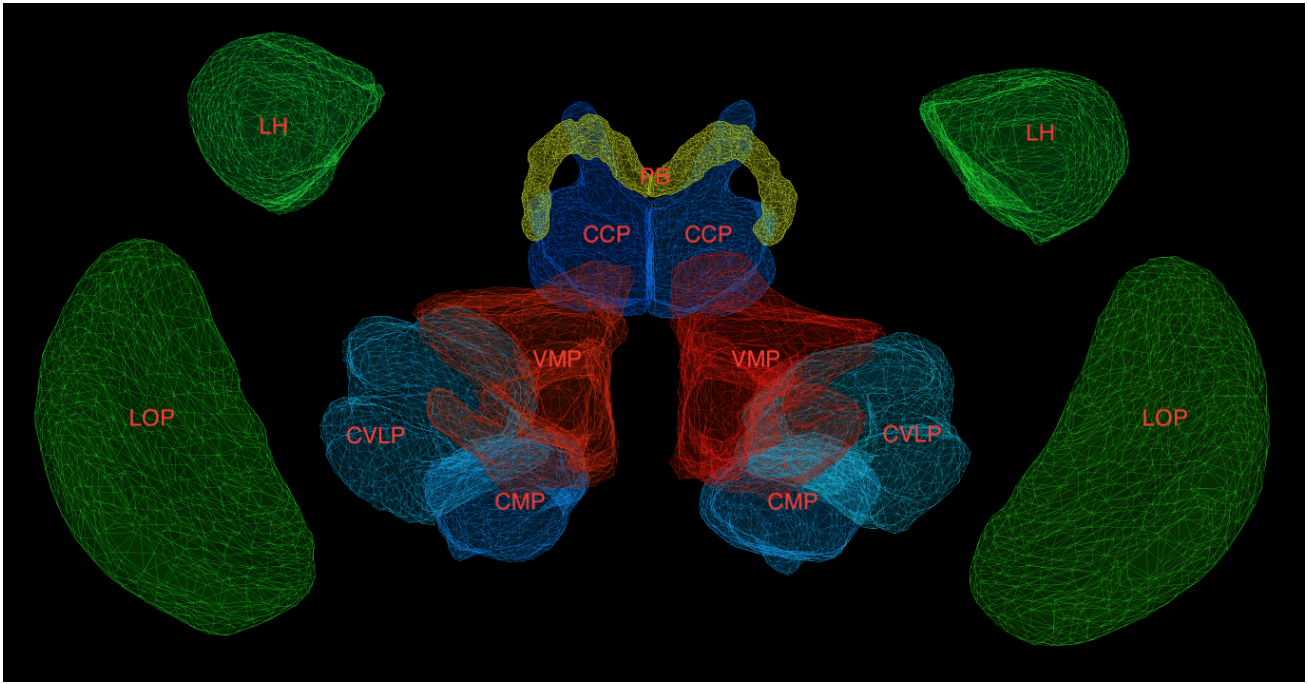
The Neuropils of the Fruit Fly Brain (cont'd)

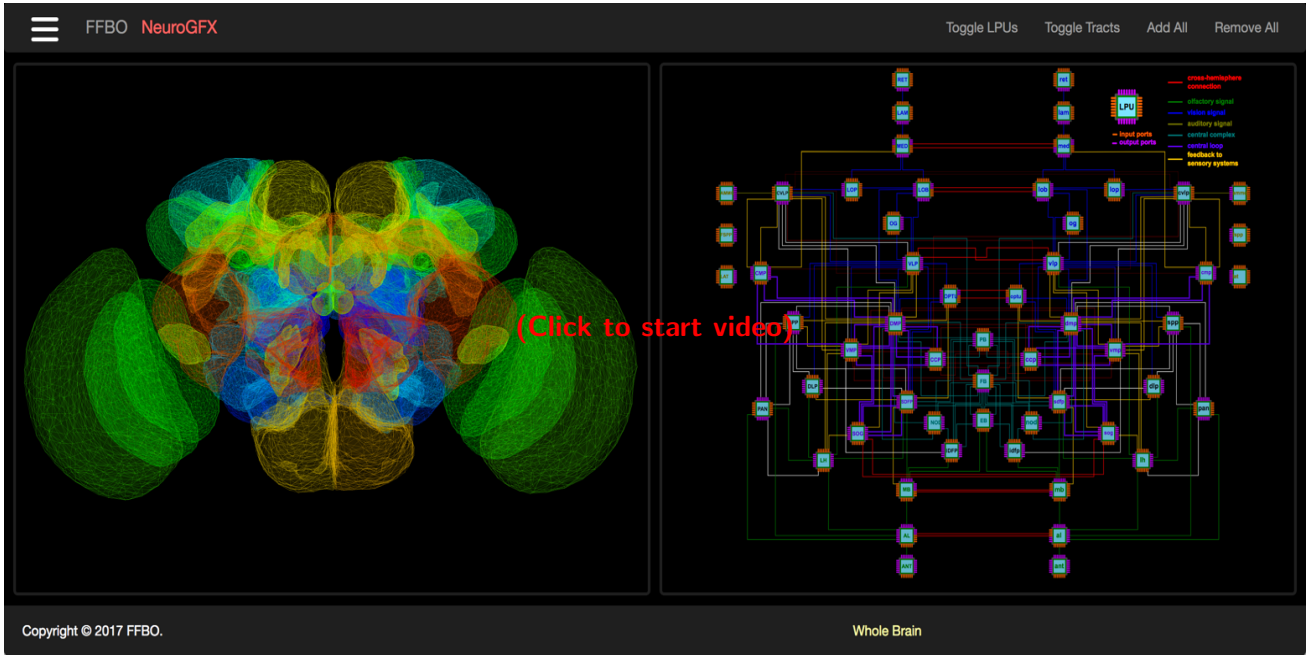
Mid View



The Neuropils of the Fruit Fly Brain (cont'd)

Back View




FFBO NeuroGFX
Toggle LPUs
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Add All
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(Click to start video)
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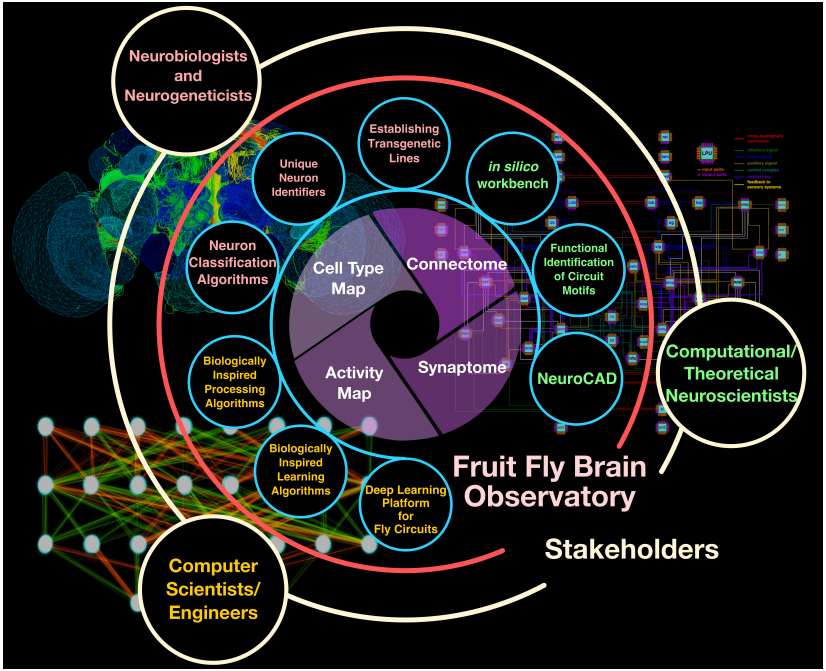
Whole Brain

The functional map of the fruit fly brain is the collection of canonical circuits and their I/O behavior evaluated at different levels of abstraction.

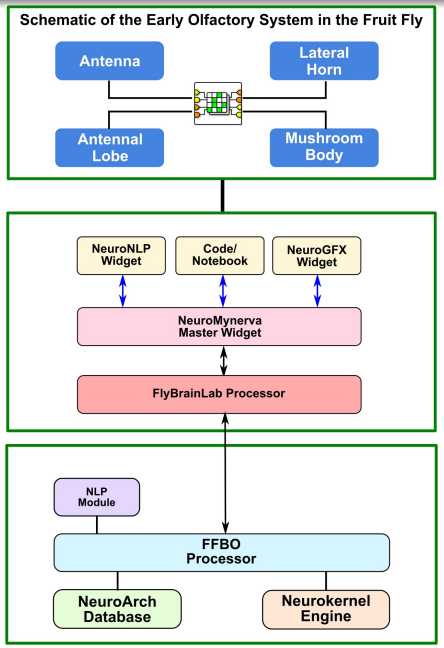
Characterizing the functional map is a central goal of three key stakeholders:

- neurogeneticists and neurobiologists exploring the state of the art of *Drosophila* genetics, anatomical and neurophysiological data as it pertains to classes of neurons, neural circuits, and behavior,
- computational/theoretical neuroscientists interested in executable models of neural circuits in health and disease and, more broadly, in the logic of computation with neural circuits, and
- computer scientists/engineers interested in using biological networks to improve machine learning and deep learning models and algorithms.



FFBO provides a

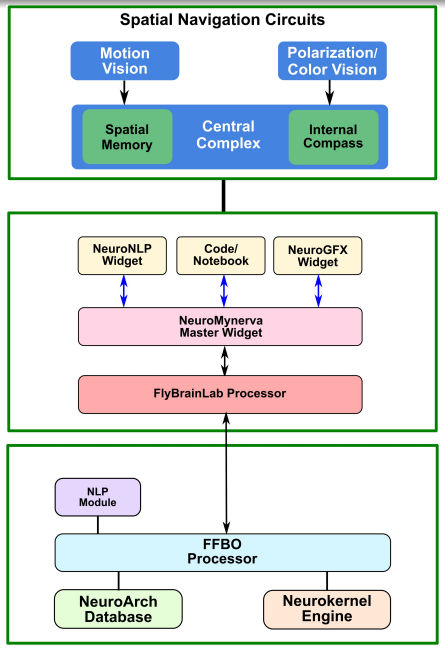
- hub for storing & integrating fruit fly brain research data from worldwide data sources,
- unified repository of tools and methods to build, emulate and compare fruit fly brain models in health and disease,
- an open framework for fruit fly brain data processing and model execution.



FlyBrainLab (FBL) systems architecture.

Underlying the FBL architecture are 3 key building blocks.

- NeuroArch Database: hosts both biological data and computational models of fly brain circuits.
- Neurokernel Engine: supports massively parallel execution of fly brain circuits on GPUs.
- NeuroMinerva: interactive computing interface based on JupyterLab with a suite of highly integrated applications for data query, visualization and circuit execution.



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Part II

Exploring Fruit Fly Brain Circuits with NeuroNLP

NeuroNLP: A Natural Language Portal for Aggregated Fruit Fly Brain Data

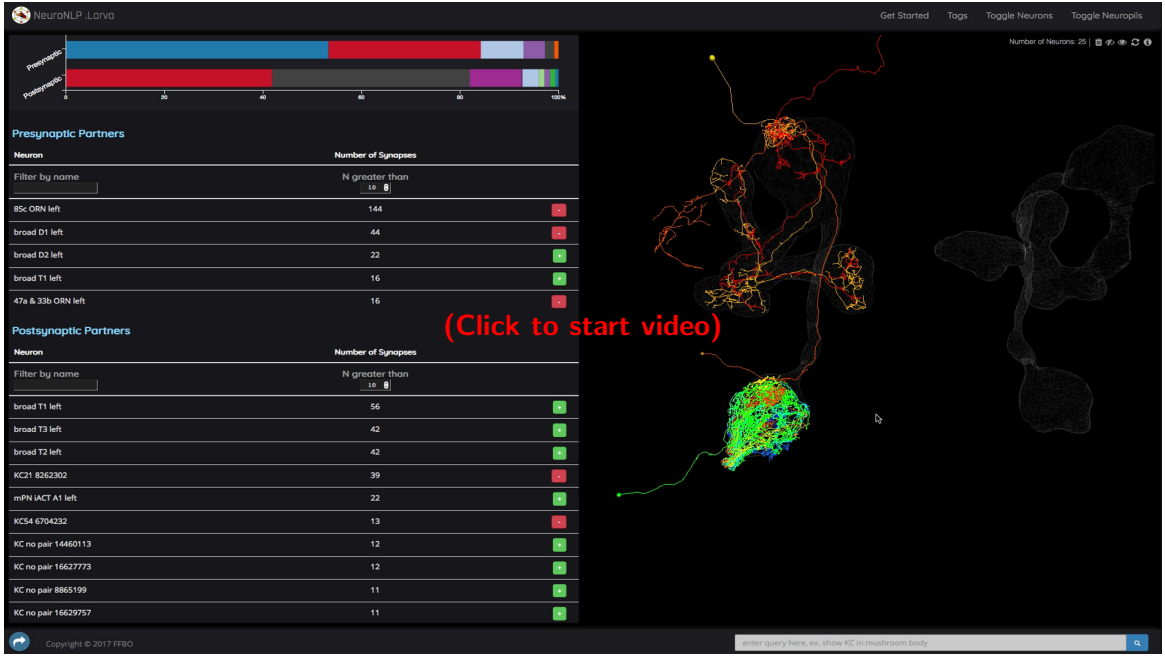
NeuroNLP is a unique natural language user interface for querying the NeuroArch fly brain database that

- enables in-depth exploration and investigation of brain structure, using intuitive plain English queries,
- provides powerful interactive visualization of neural circuits functionality,
- integrates neural circuits data from multiple sources,
- provides a modern web-based portal for navigating fruit fly brain circuit data,
- can be accessed from any browser supporting WebGL on laptops and smartphones (https://neuronlp.fruitflybrain.org).

Here, we provide examples outlining capabilities of NeuroNLP to:

- Visualize the early olfactory system of *Drosophila* larvae, showing OSNs, PNs, MBONs and DANs;
- Display the early visual system of adult *Drosophila* and focus on the motion detection pathway, starting with the L1 neurons and following up to Mi1 and T4 neurons;

Visualization of the Larva Early Olfactory System



NeuroNLP .Adult
Get Started
Tags
Neurons/Synapses
Neuropils
Postsynaptic Partners
Neuron
Number of Synapses
+/- Neuron
+/- Synapses
Filter by name
T4
N greater than
5
T4b-home 41
T4c-A 37
T4a-home 36
T4d-home 31
T4a-A 20
T4c-E 16
T4d-F 13
T4c-B 11
T4d-B 9
Number of Neurons: 7
(Click to start video)
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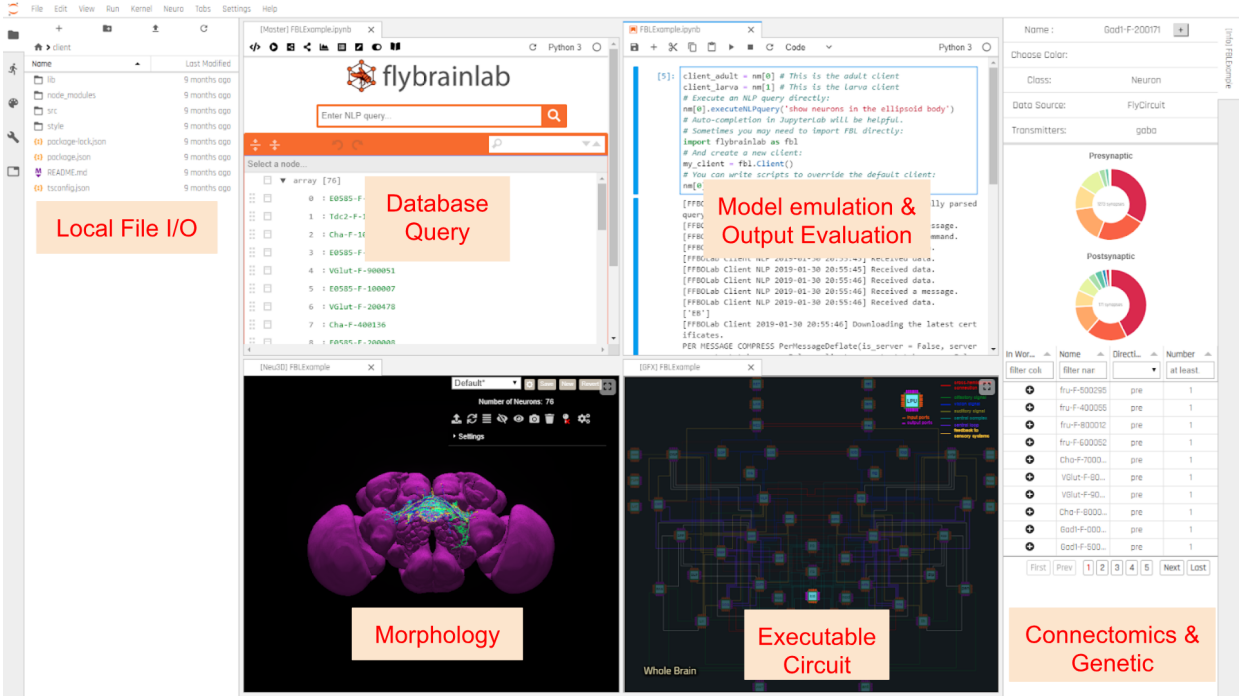
enter query here, ex. show gabaergic local neurons in ellipsoid body

Part III

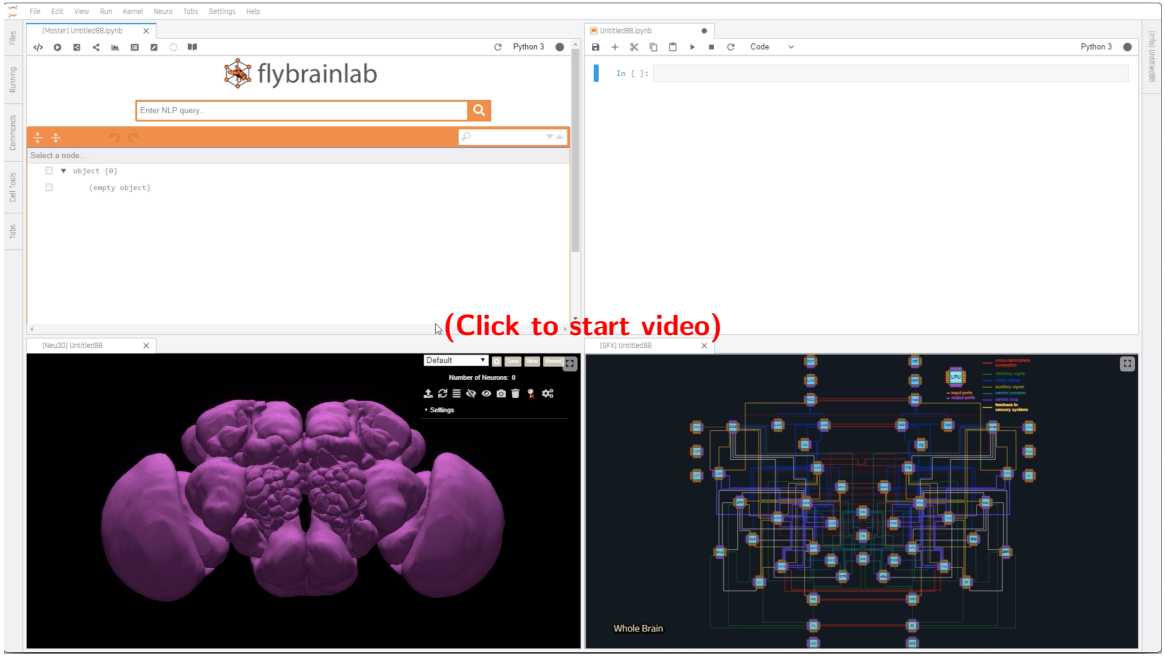
FlyBrainLab: Building the Functional Map One Circuit at a Time

FlyBrainLab

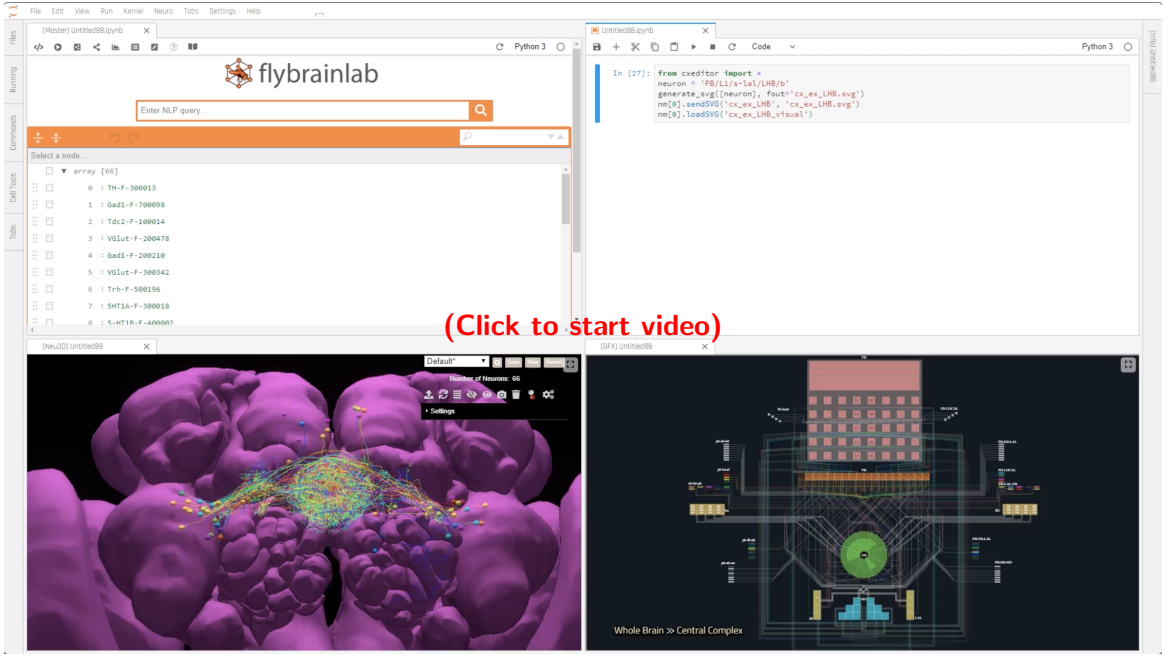
Think of "Matlab" for Fruit Fly Brains



Exploring the Functionality of the Central Complex



Exploring the Functionality of the Central Complex (cont'd)



Acknowledgments: Fruit Fly Brain Observatory

The Columbia University Team:

- Aurel A. Lazar (PI)
- Tingkai Liu
- Nikul H. Ukani
- Mehmet Kerem Turkcan
- Chung-Heng Yeh
- Yiyin Zhou

The National Tsing Hua University Team:

- Ann-Shyn Chiang (PI)
- Yu-Chi Huang
- Chung-Chuan Lo (PI)
- Cheng-Te Wang

The University of Sheffield Team:

- Daniel Coca (PI)
- Dorian Florescu
- Carlos Luna Ortiz
- Paul Richmond
- Adam Tomkins

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