The Fruit Fly Brain Observatory

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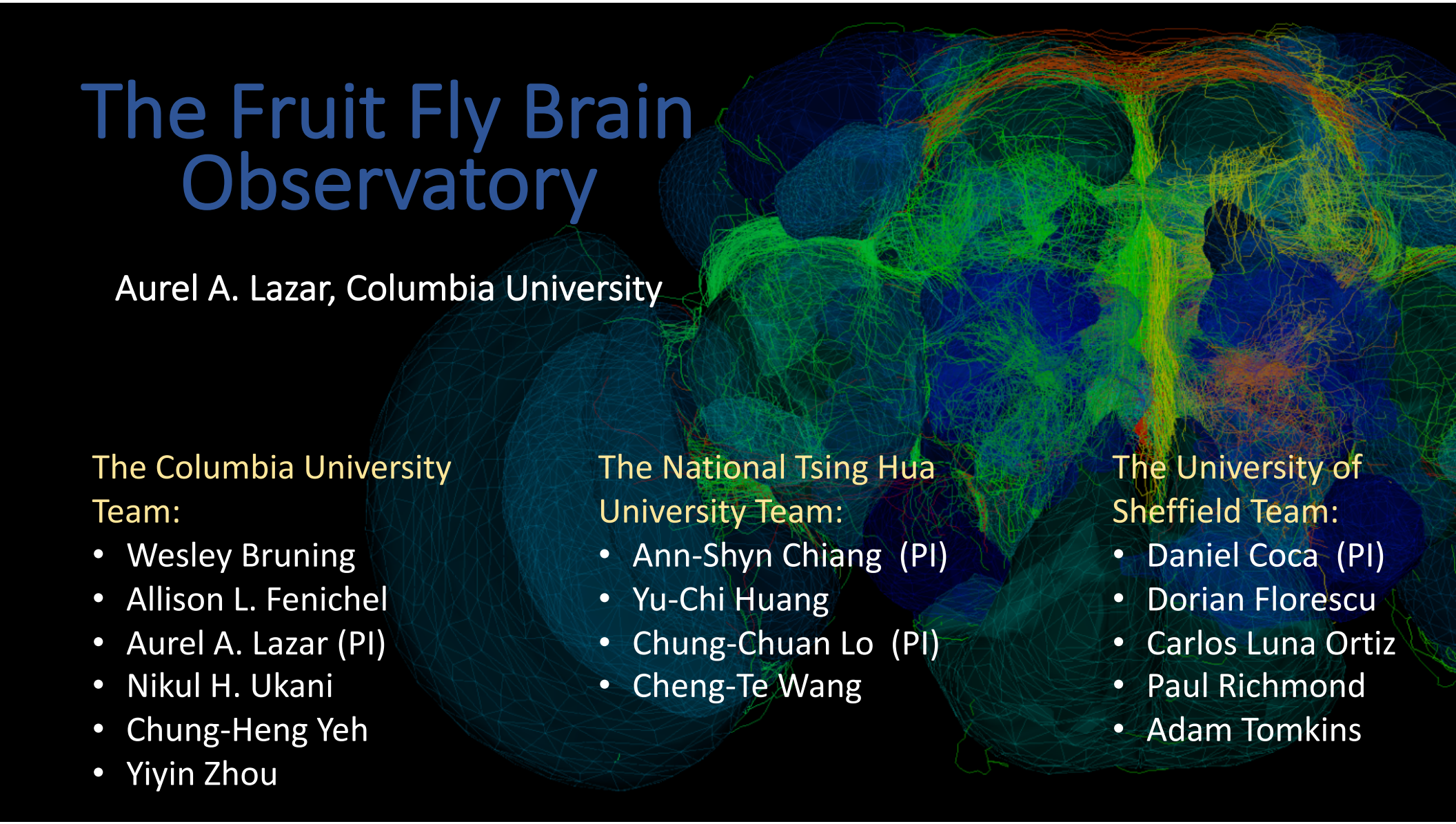

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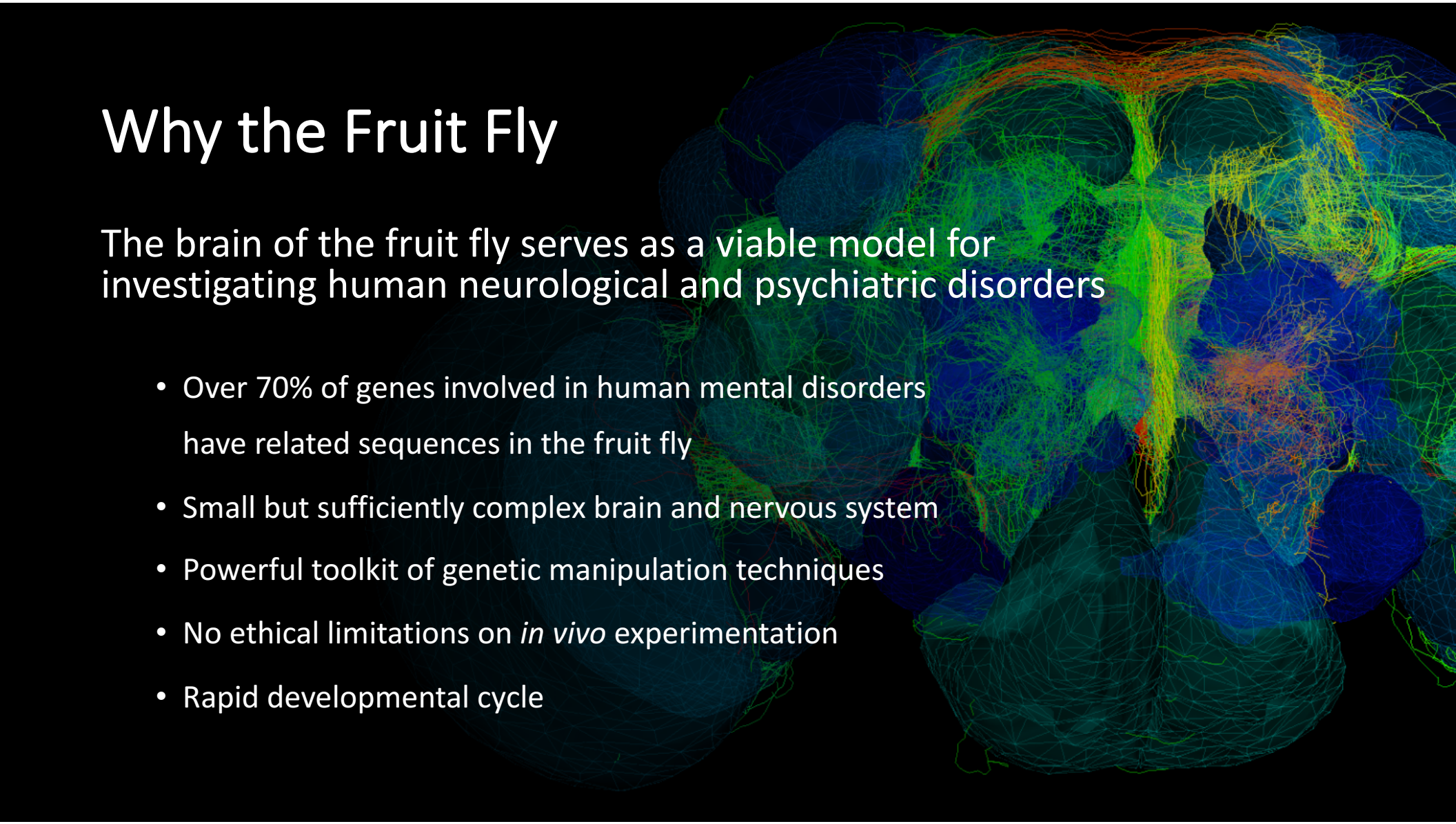
- Dorian Florescu
- Carlos Luna Ortiz
- Paul Richmond
- Adam Tomkins

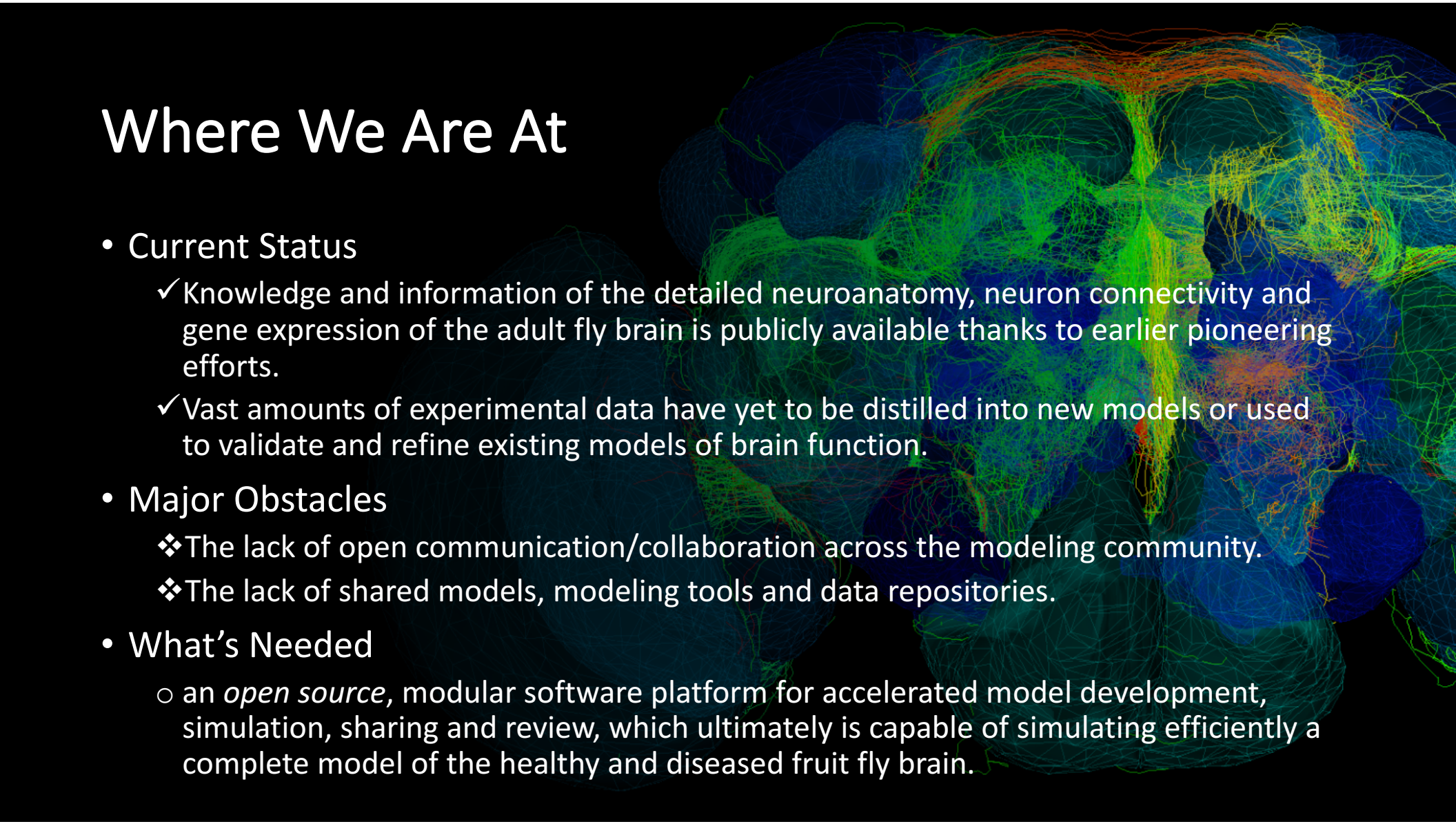
Why the Fruit Fly

The brain of the fruit fly serves as a viable model for investigating human neurological and psychiatric disorders

- Over 70% of genes involved in human mental disorders have related sequences in the fruit fly
- Small but sufficiently complex brain and nervous system
- Powerful toolkit of genetic manipulation techniques
- No ethical limitations on *in vivo* experimentation
- Rapid developmental cycle

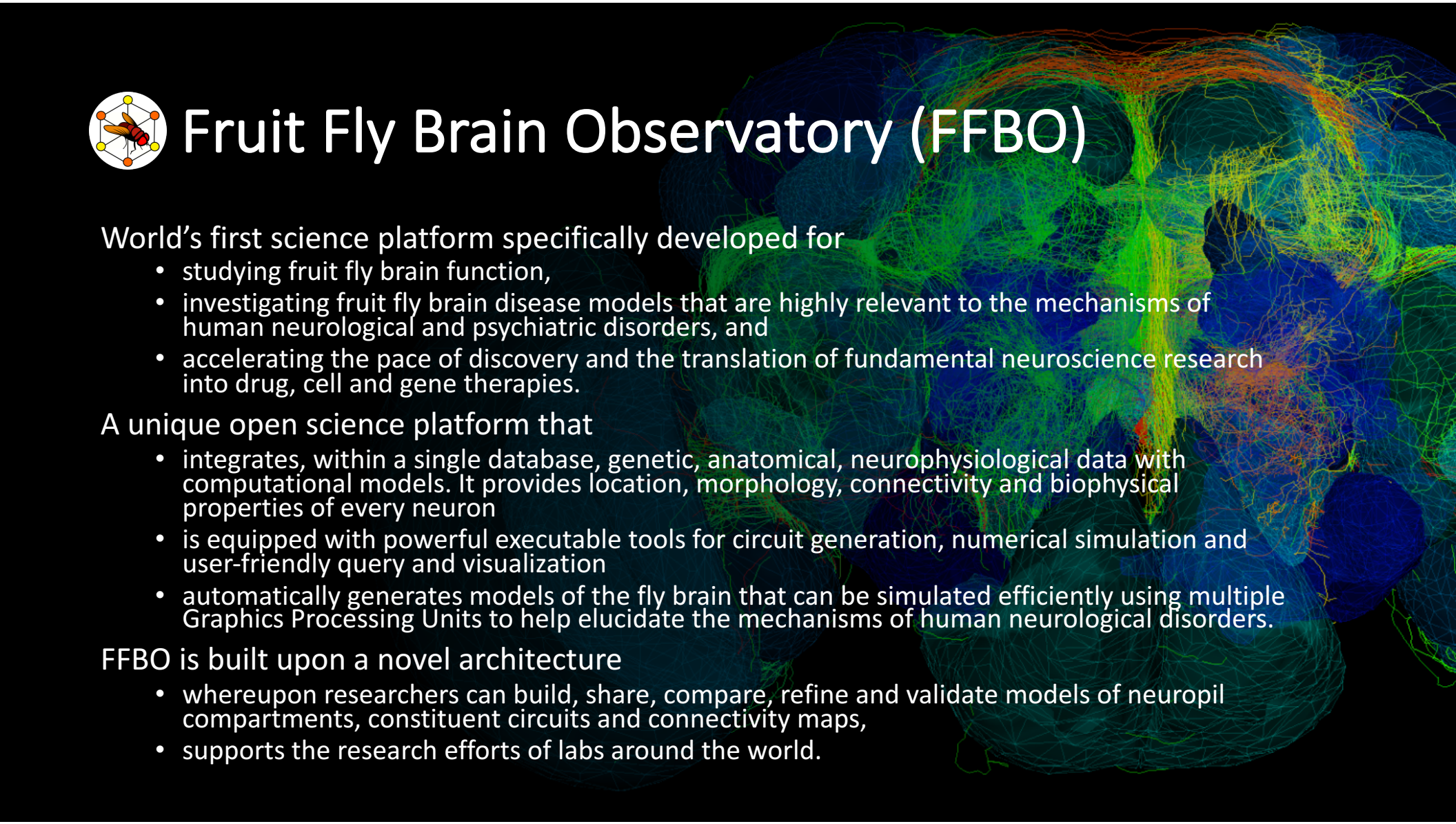


Where We Are At



- Current Status
  - ✓Knowledge and information of the detailed neuroanatomy, neuron connectivity and gene expression of the adult fly brain is publicly available thanks to earlier pioneering efforts.
  - ✓Vast amounts of experimental data have yet to be distilled into new models or used to validate and refine existing models of brain function.
- Major Obstacles
  - ❖The lack of open communication/collaboration across the modeling community.
  - ❖The lack of shared models, modeling tools and data repositories.
- What's Needed
  - an *open source*, modular software platform for accelerated model development, simulation, sharing and review, which ultimately is capable of simulating efficiently a complete model of the healthy and diseased fruit fly brain.

Fruit Fly Brain Observatory (FFBO)



World's first science platform specifically developed for

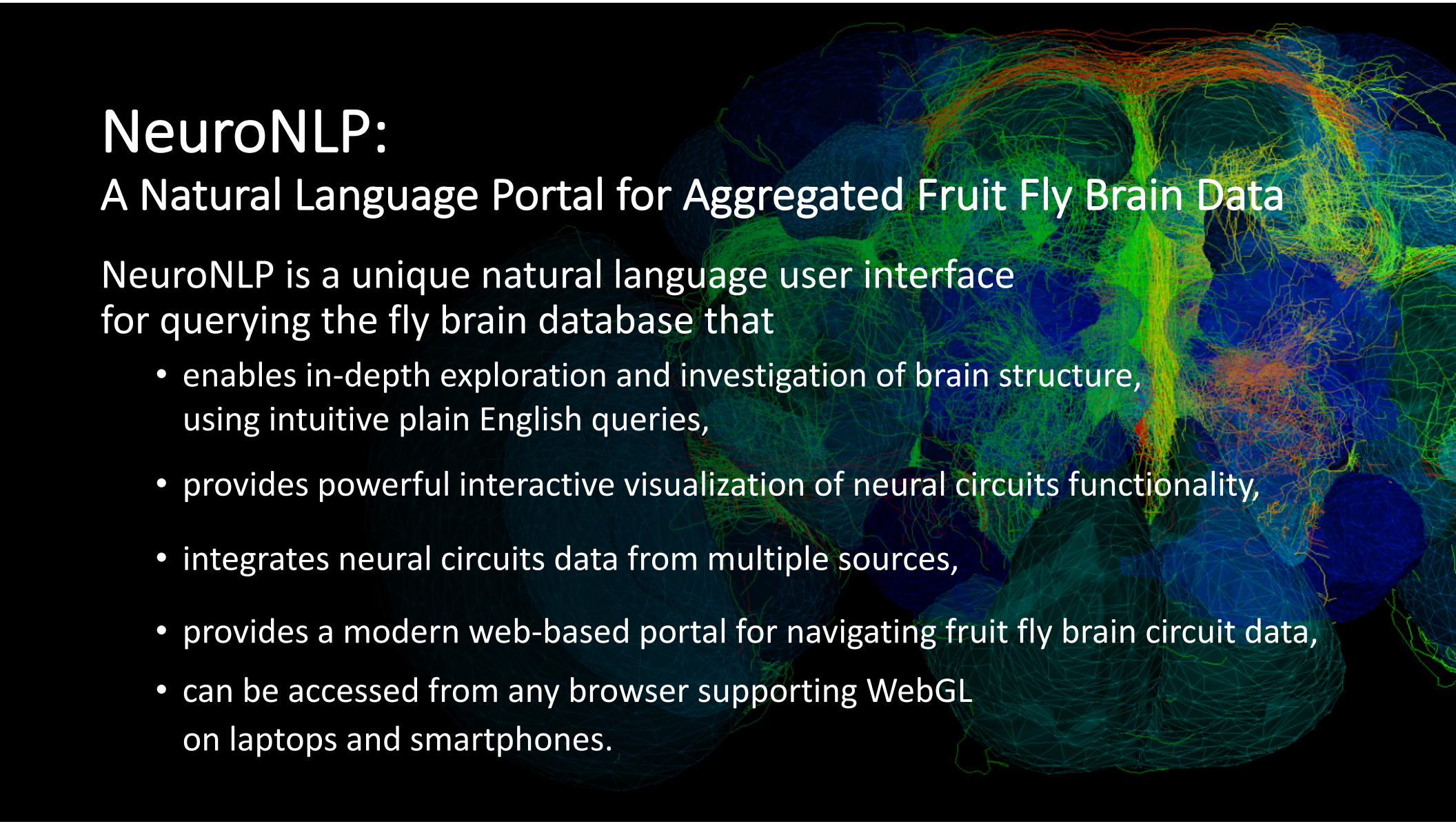
- studying fruit fly brain function,
- investigating fruit fly brain disease models that are highly relevant to the mechanisms of human neurological and psychiatric disorders, and
- accelerating the pace of discovery and the translation of fundamental neuroscience research into drug, cell and gene therapies.

A unique open science platform that

- integrates, within a single database, genetic, anatomical, neurophysiological data with computational models. It provides location, morphology, connectivity and biophysical properties of every neuron
- is equipped with powerful executable tools for circuit generation, numerical simulation and user-friendly query and visualization
- automatically generates models of the fly brain that can be simulated efficiently using multiple Graphics Processing Units to help elucidate the mechanisms of human neurological disorders.

FFBO is built upon a novel architecture

- whereupon researchers can build, share, compare, refine and validate models of neuropil compartments, constituent circuits and connectivity maps,
- supports the research efforts of labs around the world.

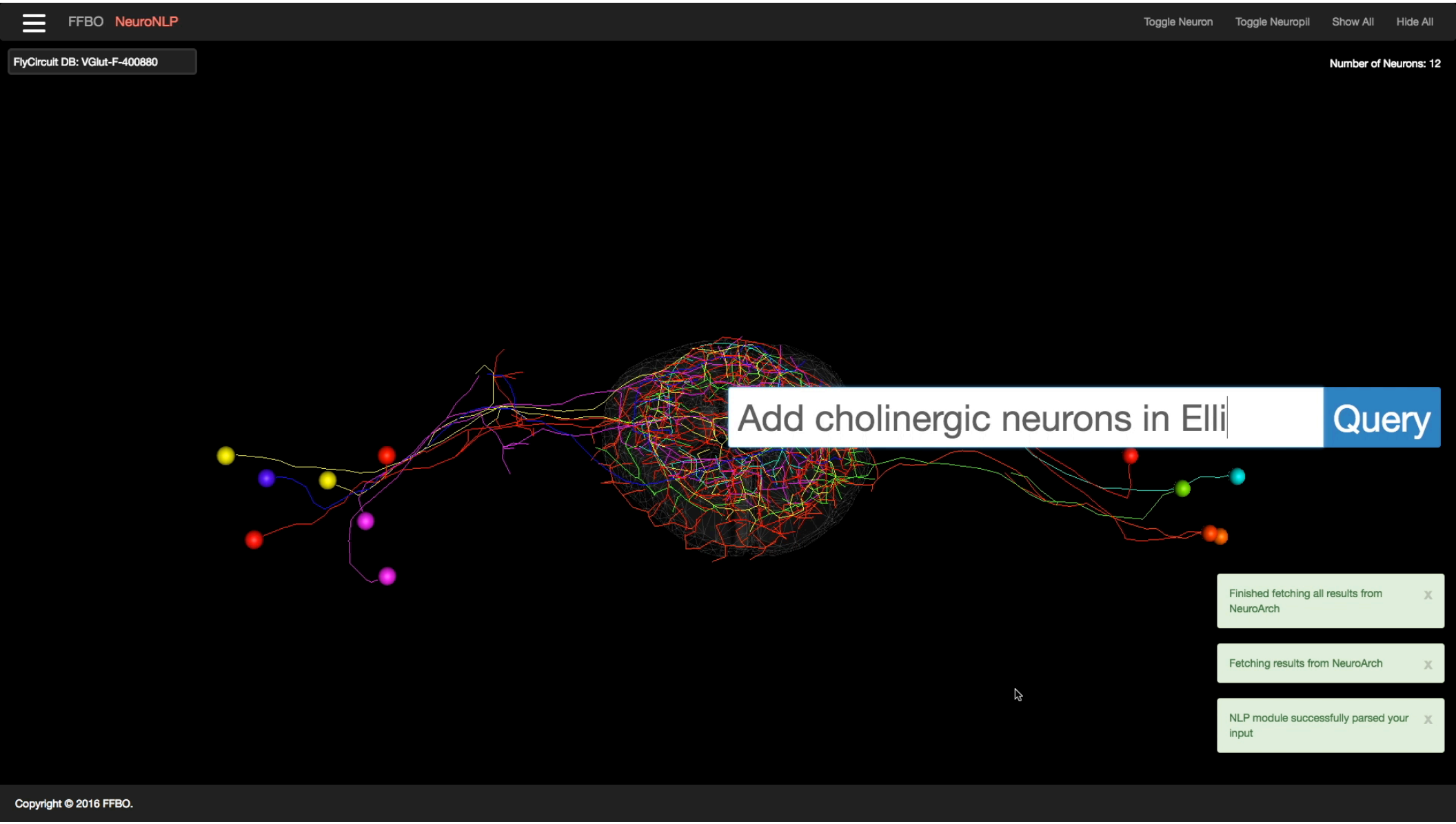


NeuroNLP:

A Natural Language Portal for Aggregated Fruit Fly Brain Data

NeuroNLP is a unique natural language user interface
for querying the 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.


FFBO NeuroNLP
Toggle Neuron
Toggle Neuropil
Show All
Hide All
FlyCircuit DB: VGlut-F-400880
Number of Neurons: 12
Add cholinergic neurons in Elli
Query
Finished fetching all results from NeuroArch
Fetching results from NeuroArch
NLP module successfully parsed your input
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NeuroGFX:

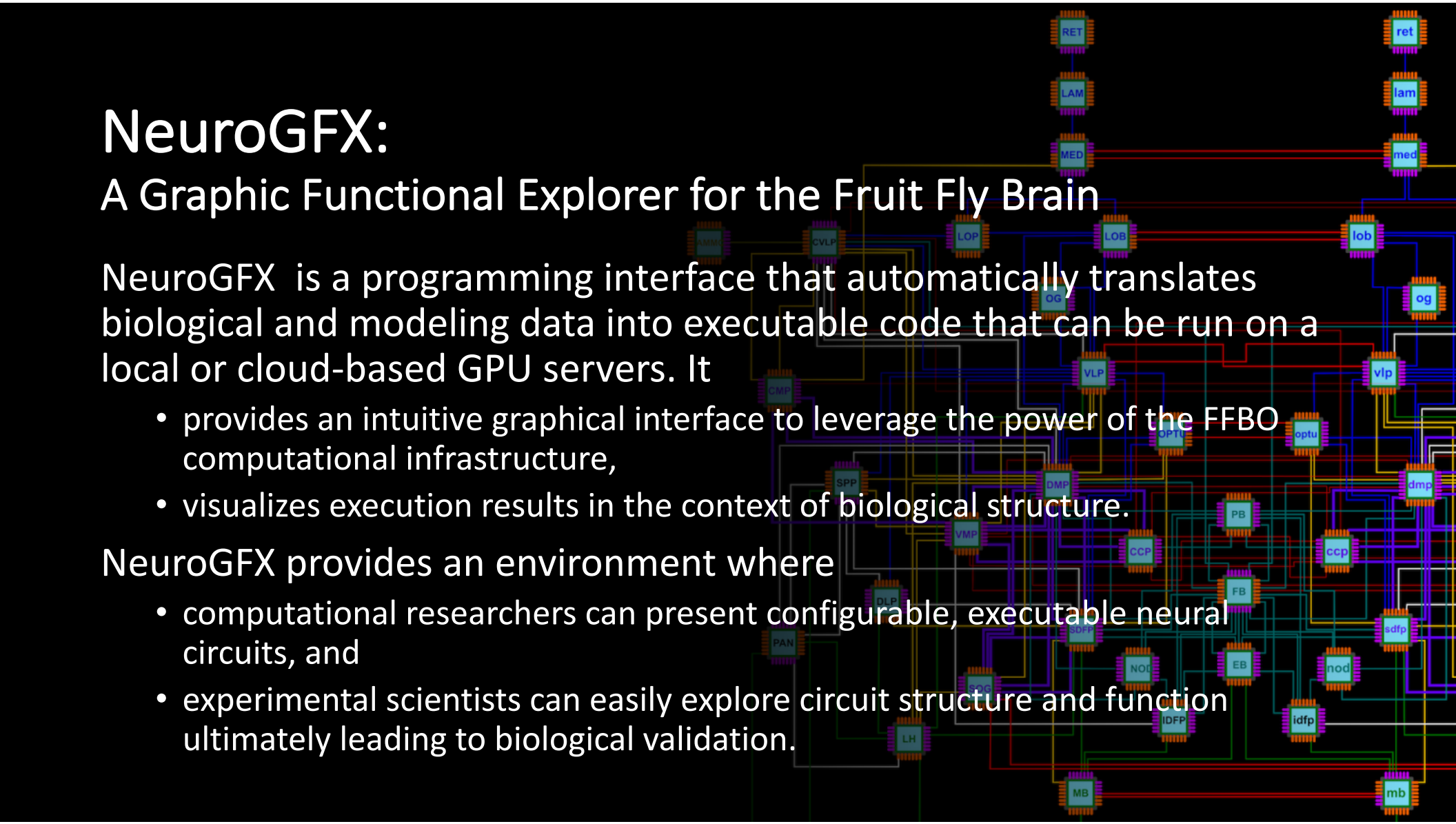
A Graphic Functional Explorer for the Fruit Fly Brain

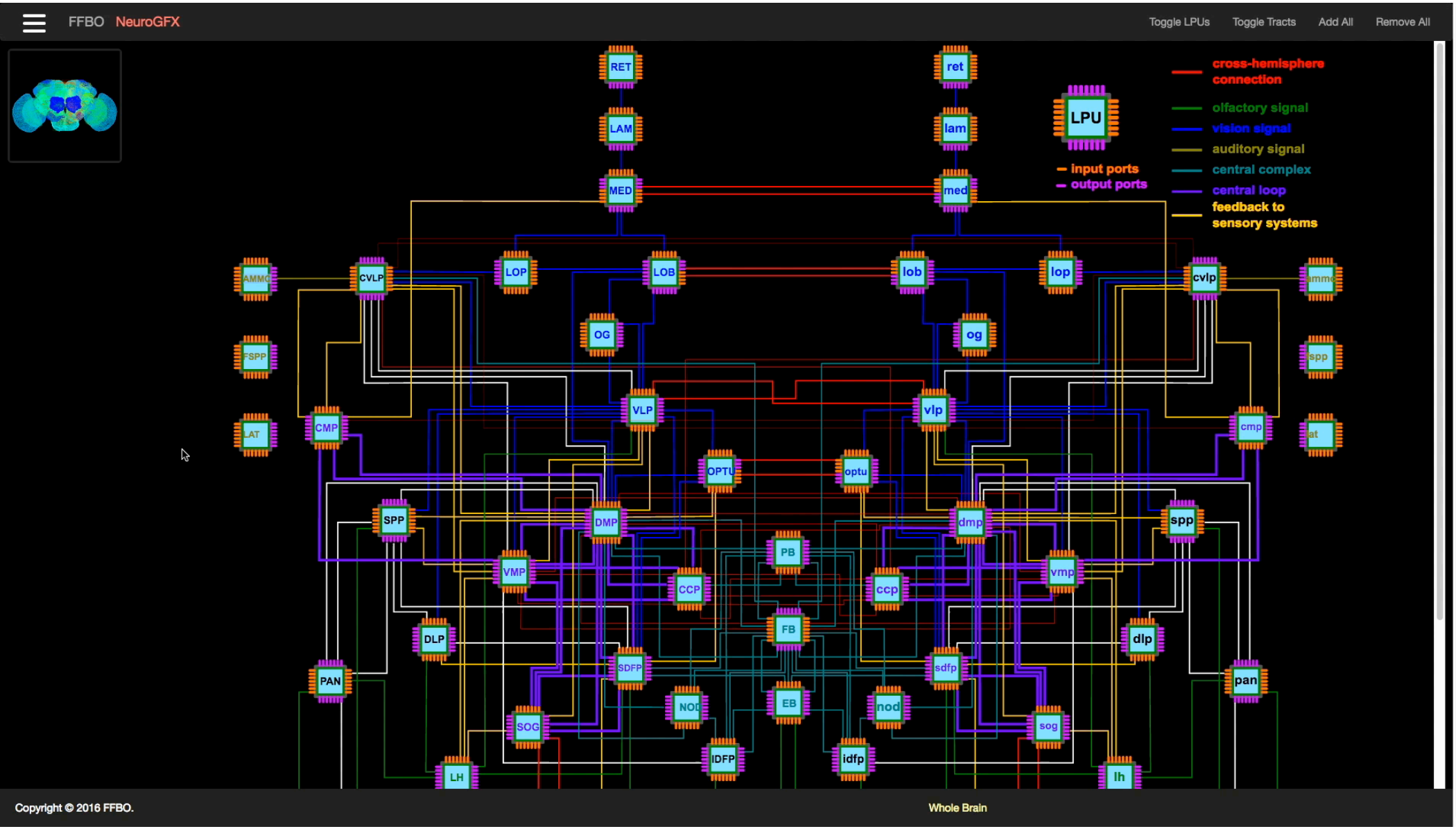
NeuroGFX is a programming interface that automatically translates biological and modeling data into executable code that can be run on a local or cloud-based GPU servers. It

- provides an intuitive graphical interface to leverage the power of the FFBO computational infrastructure,
- visualizes execution results in the context of biological structure.

NeuroGFX provides an environment where

- computational researchers can present configurable, executable neural circuits, and
- experimental scientists can easily explore circuit structure and function ultimately leading to biological validation.




FFBO NeuroGFX
Toggle LPUs
Toggle Tracts
Add All
Remove All
RET
LAM
MED
ret
lam
med
LPU
input ports
output ports
cross-hemisphere connection
olfactory signal
vision signal
auditory signal
central complex
central loop
feedback to sensory systems
AMMC
CVLP
LOP
LOB
lob
lop
cvlp
OG
og
FSPP
spp
VLP
vlp
LAT
CMP
cmp
OPTU
optu
SPP
DMP
dmp
spp
PB
VMP
CCP
ccp
vmp
FB
DLP
dlp
SDFP
sdfp
PAN
pan
NOD
EB
nod
SOG
sog
IDFP
idfp
LH
lh
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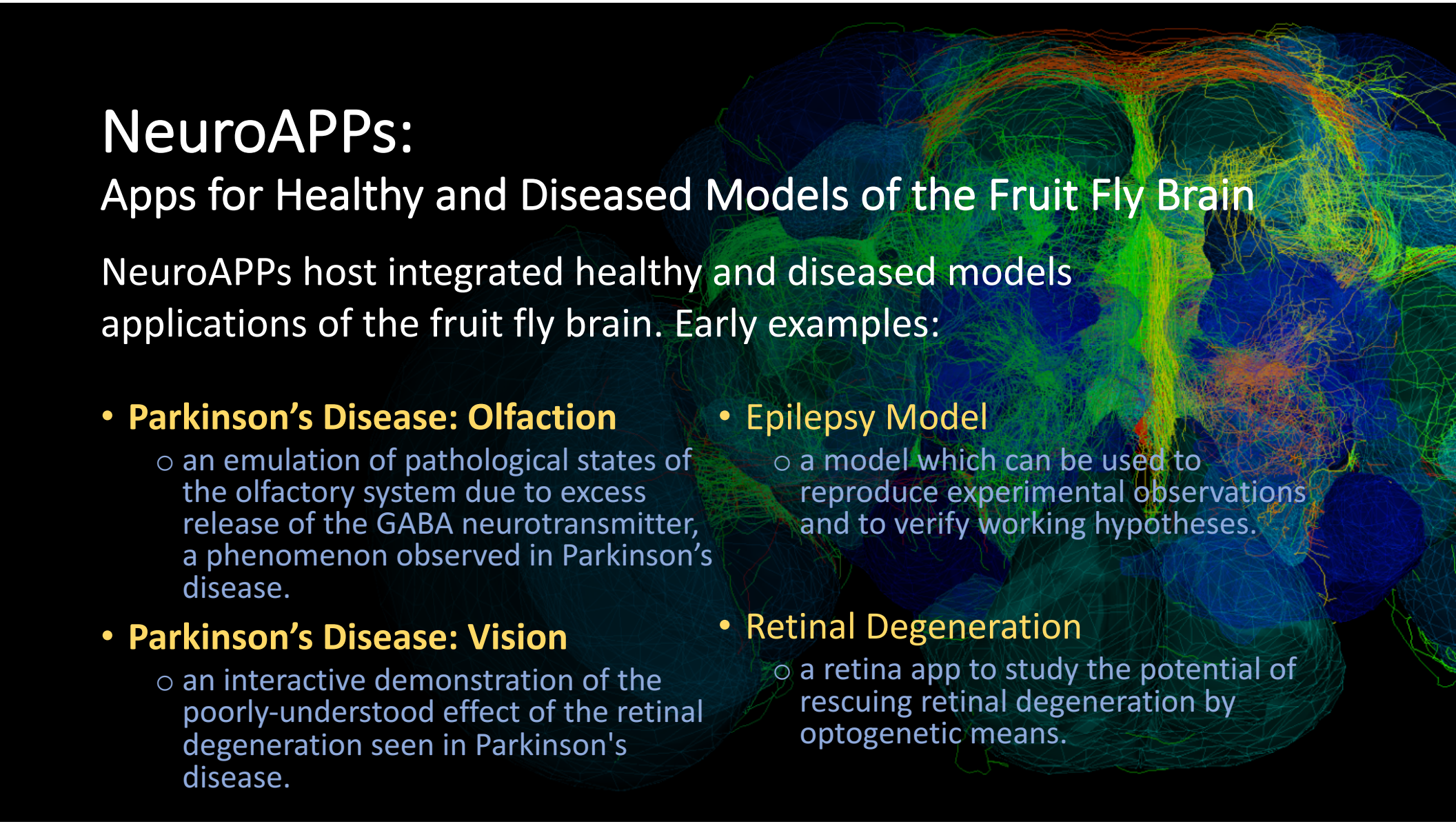
Whole Brain

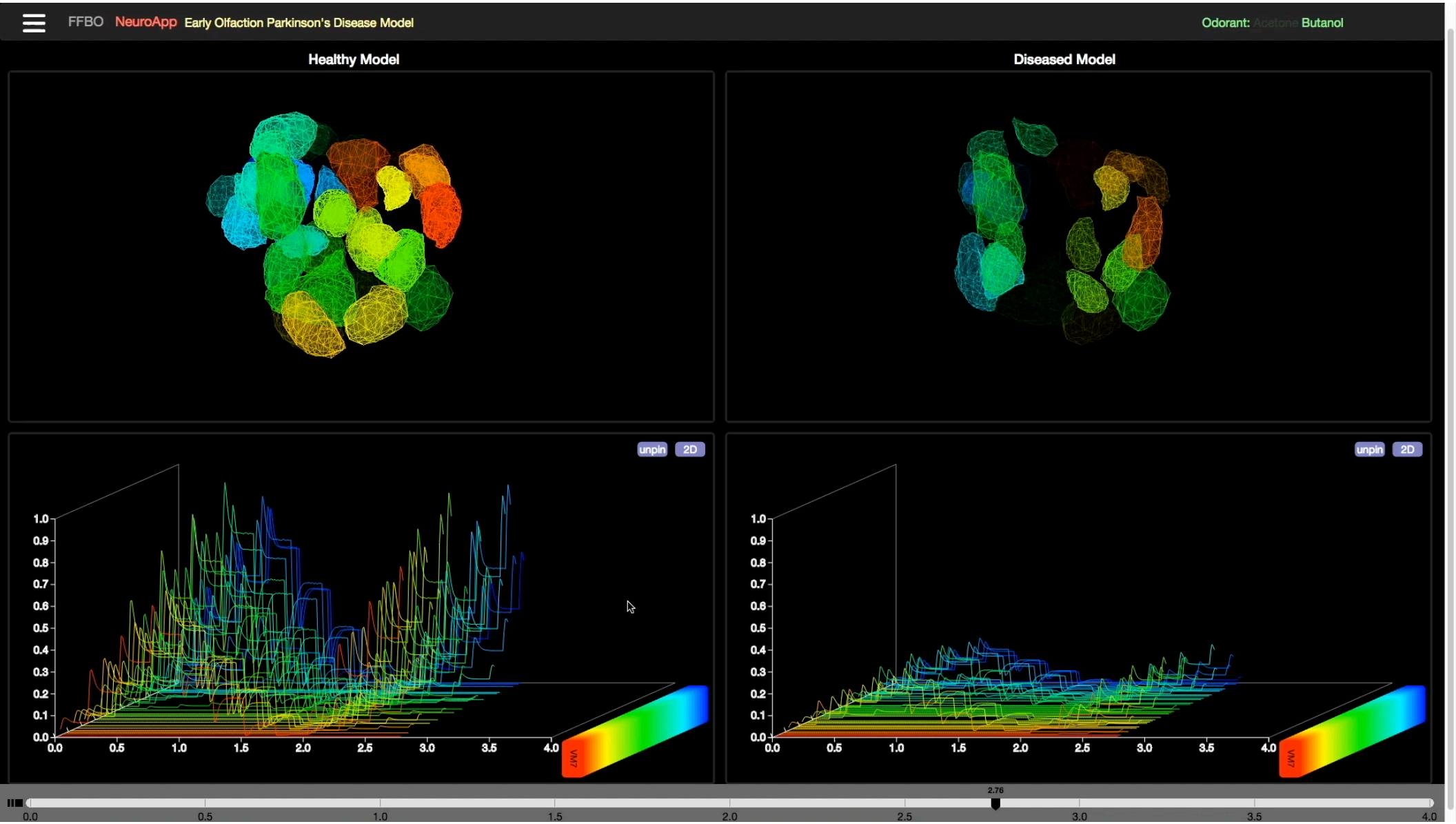
NeuroAPPs:

Apps for Healthy and Diseased Models of the Fruit Fly Brain

NeuroAPPs host integrated healthy and diseased models applications of the fruit fly brain. Early examples:



- **Parkinson's Disease: Olfaction**
  - an emulation of pathological states of the olfactory system due to excess release of the GABA neurotransmitter, a phenomenon observed in Parkinson's disease.
- **Parkinson's Disease: Vision**
  - an interactive demonstration of the poorly-understood effect of the retinal degeneration seen in Parkinson's disease.
- Epilepsy Model
  - a model which can be used to reproduce experimental observations and to verify working hypotheses.
- Retinal Degeneration
  - a retina app to study the potential of rescuing retinal degeneration by optogenetic means.


FFBO NeuroApp Early Olfaction Parkinson's Disease Model
Odorant: Acetone Butanol
Healthy Model
Diseased Model
unpin
2D
unpin
2D
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
VM7
2.76