
Whole-brain microscopy image analysis

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Fluorescence

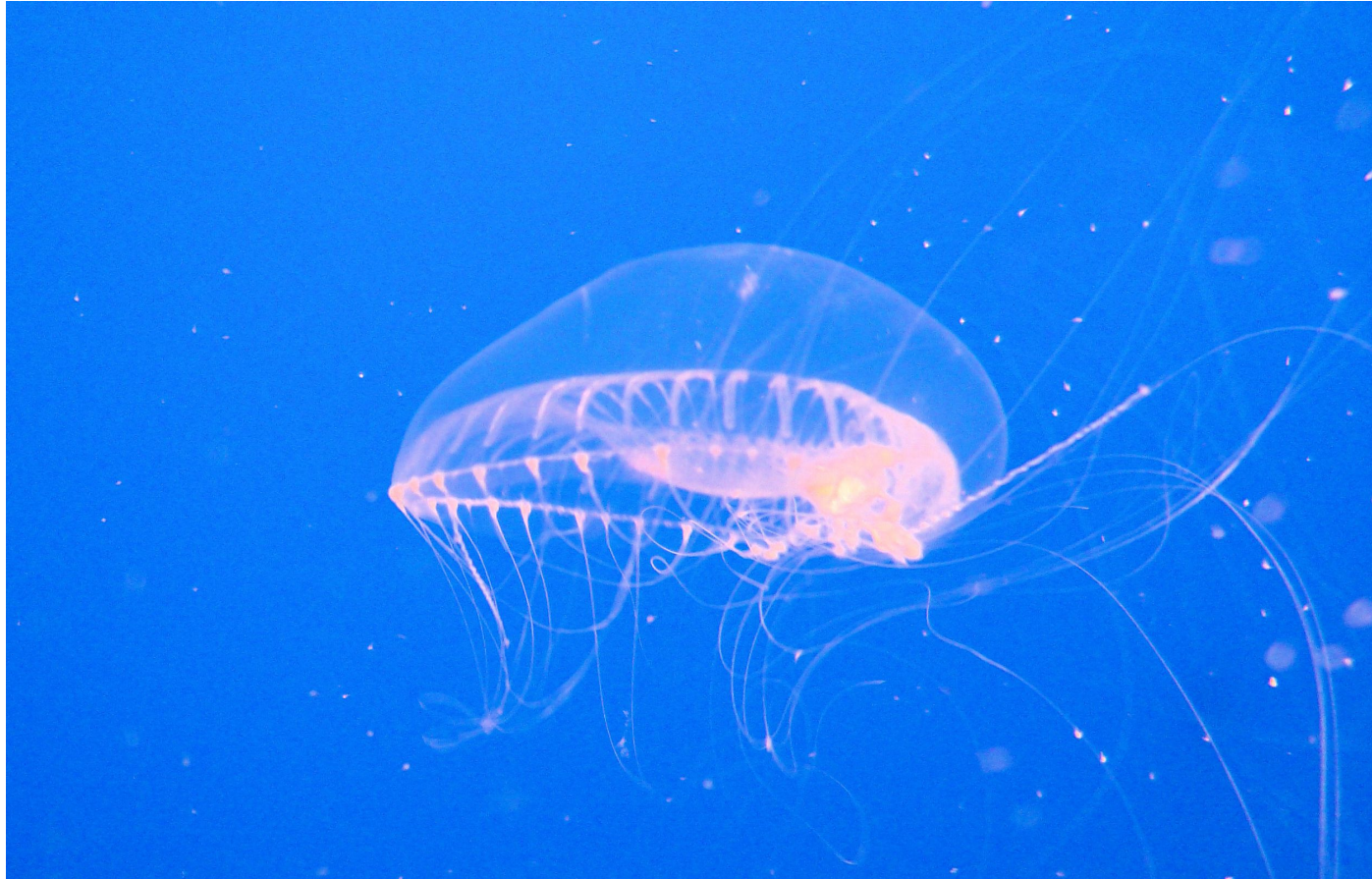
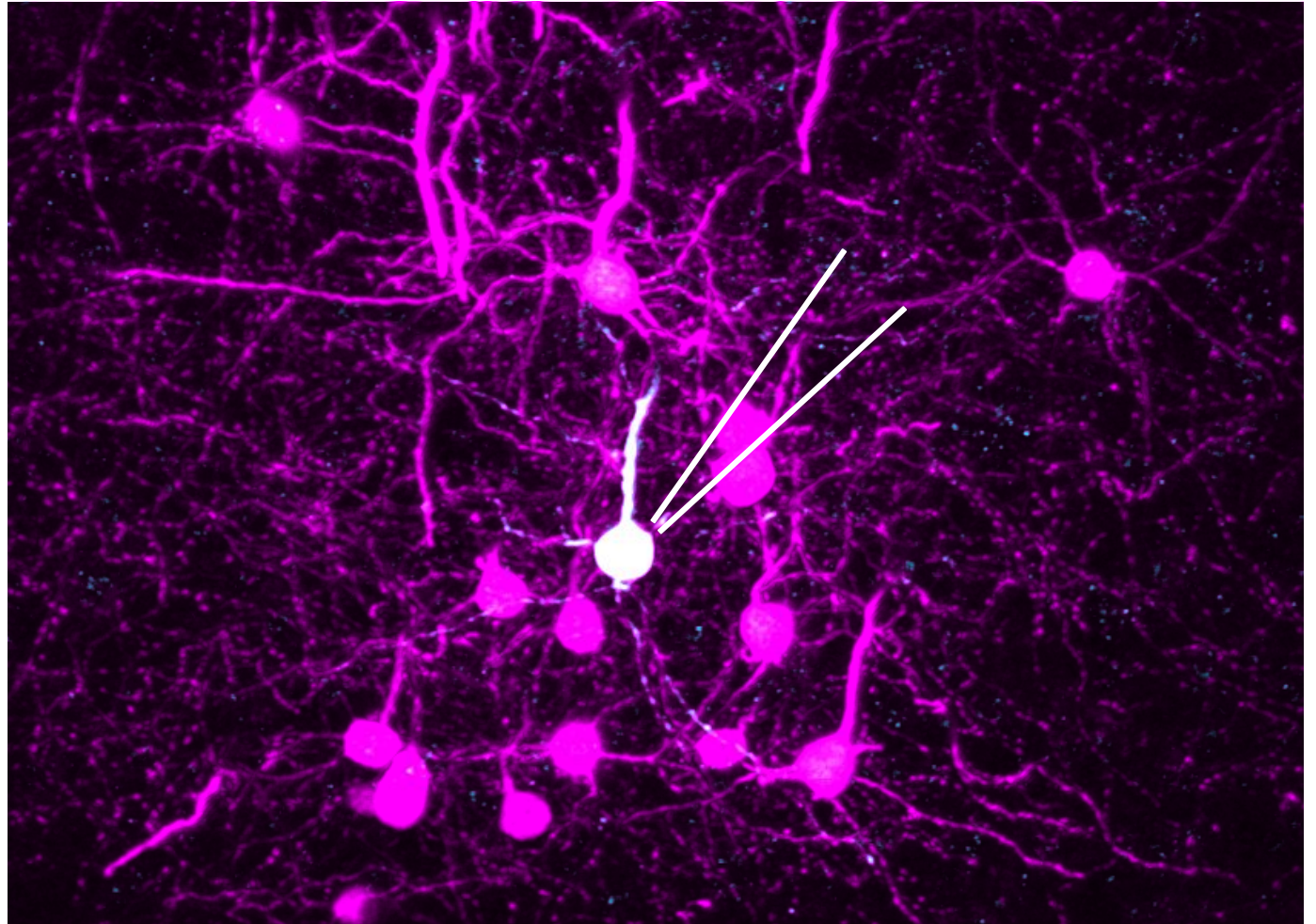
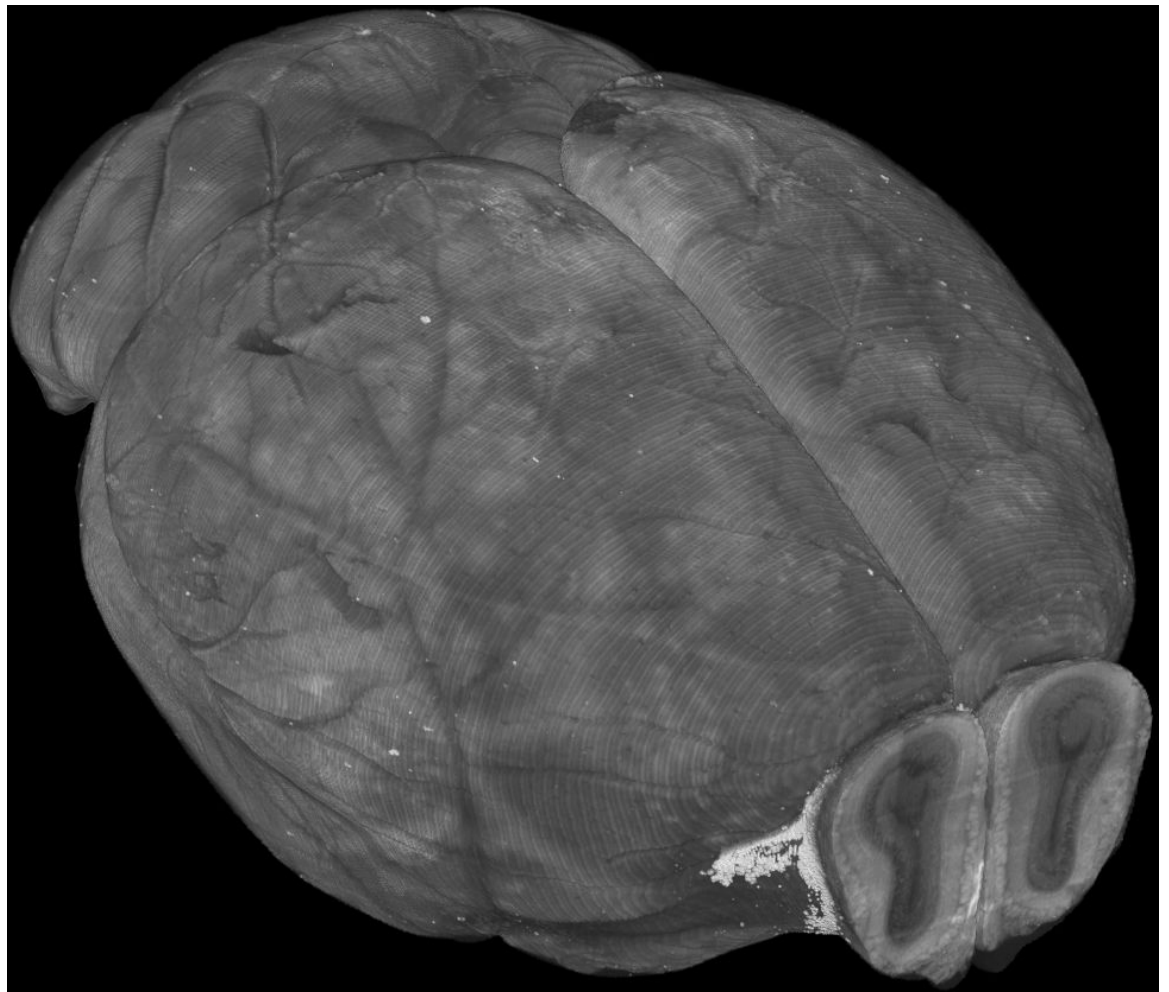


Photo: <https://www.flickr.com/photos/jimg944/5085398602/>

Viral tracing

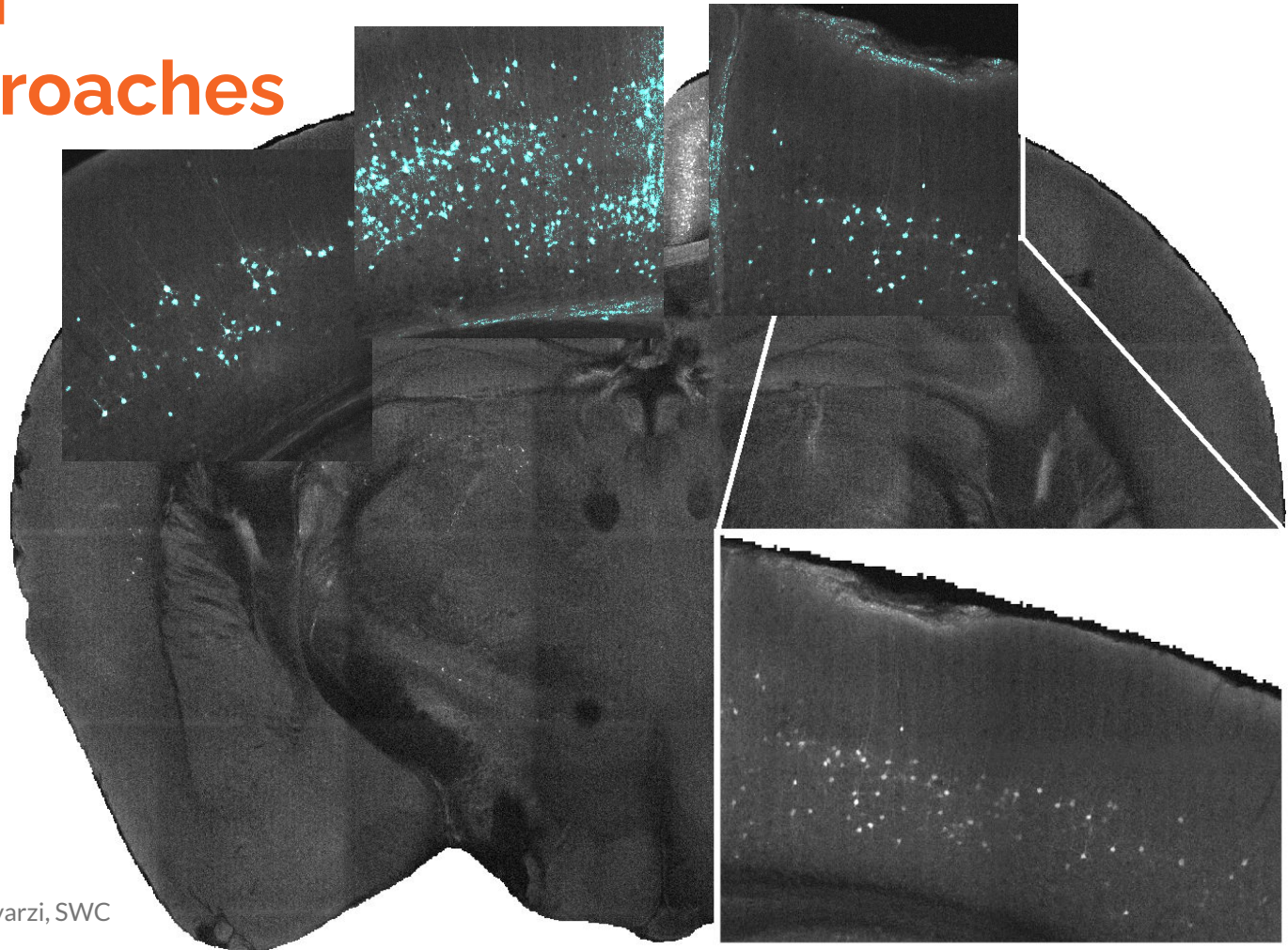


Whole-brain microscopy

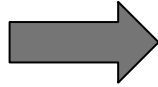
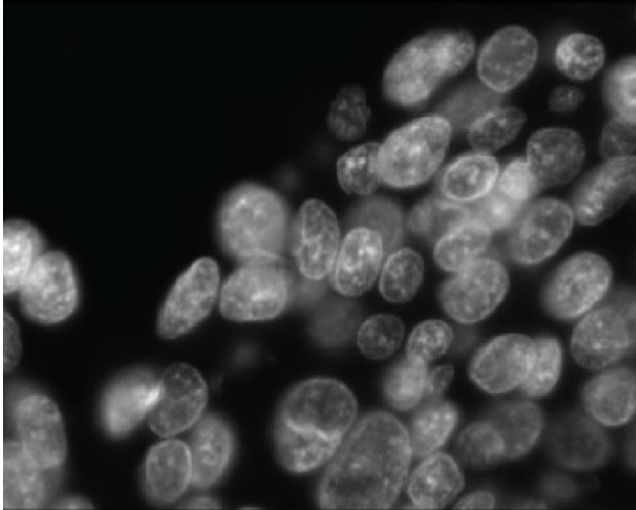


Data: Chryssanthi Tsitoura & Sepiedeh Keshavarzi, SWC

Cell detection -classical approaches

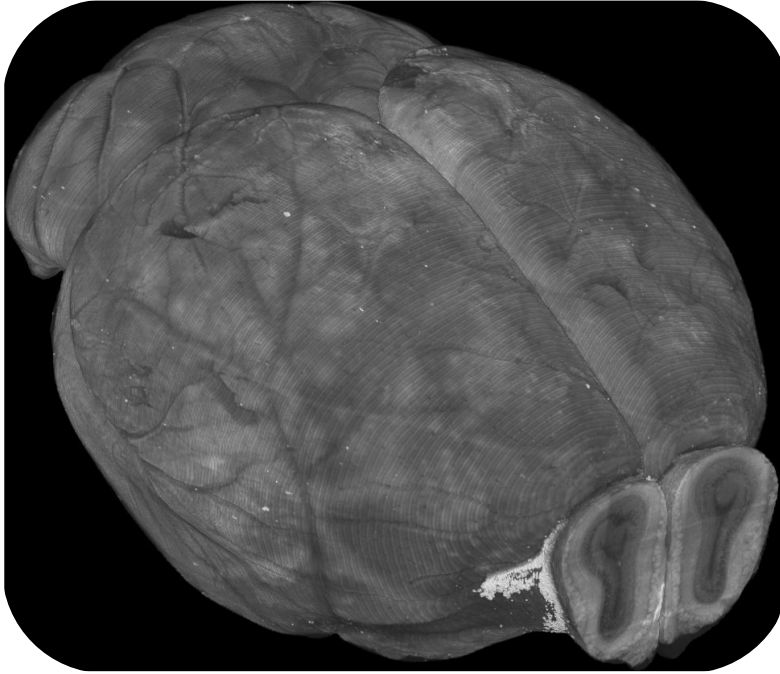


Cell detection - deep learning



StarDist - Weigert et al. (2020) WACV

Cell detection - deep learning

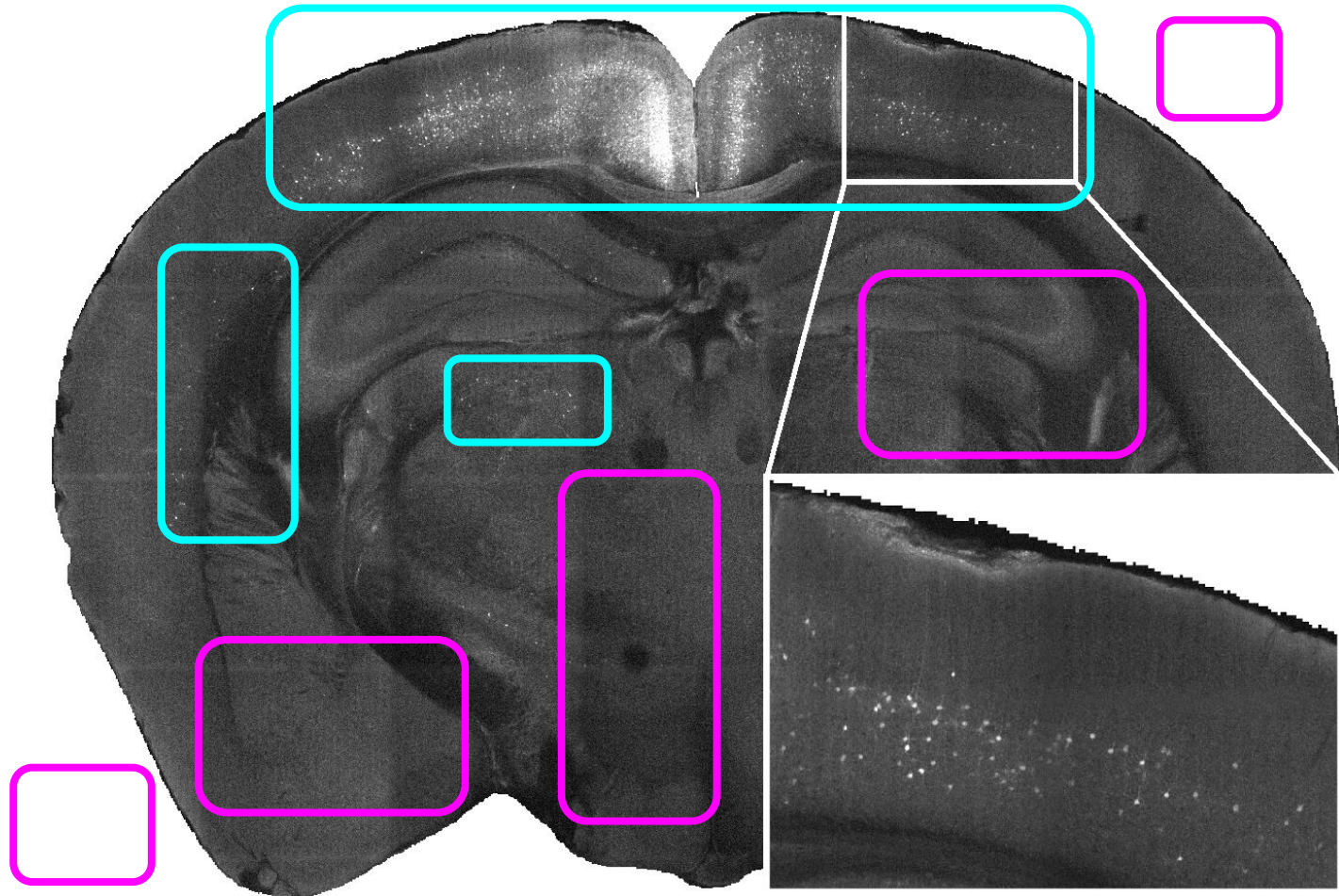


200-1000 GB

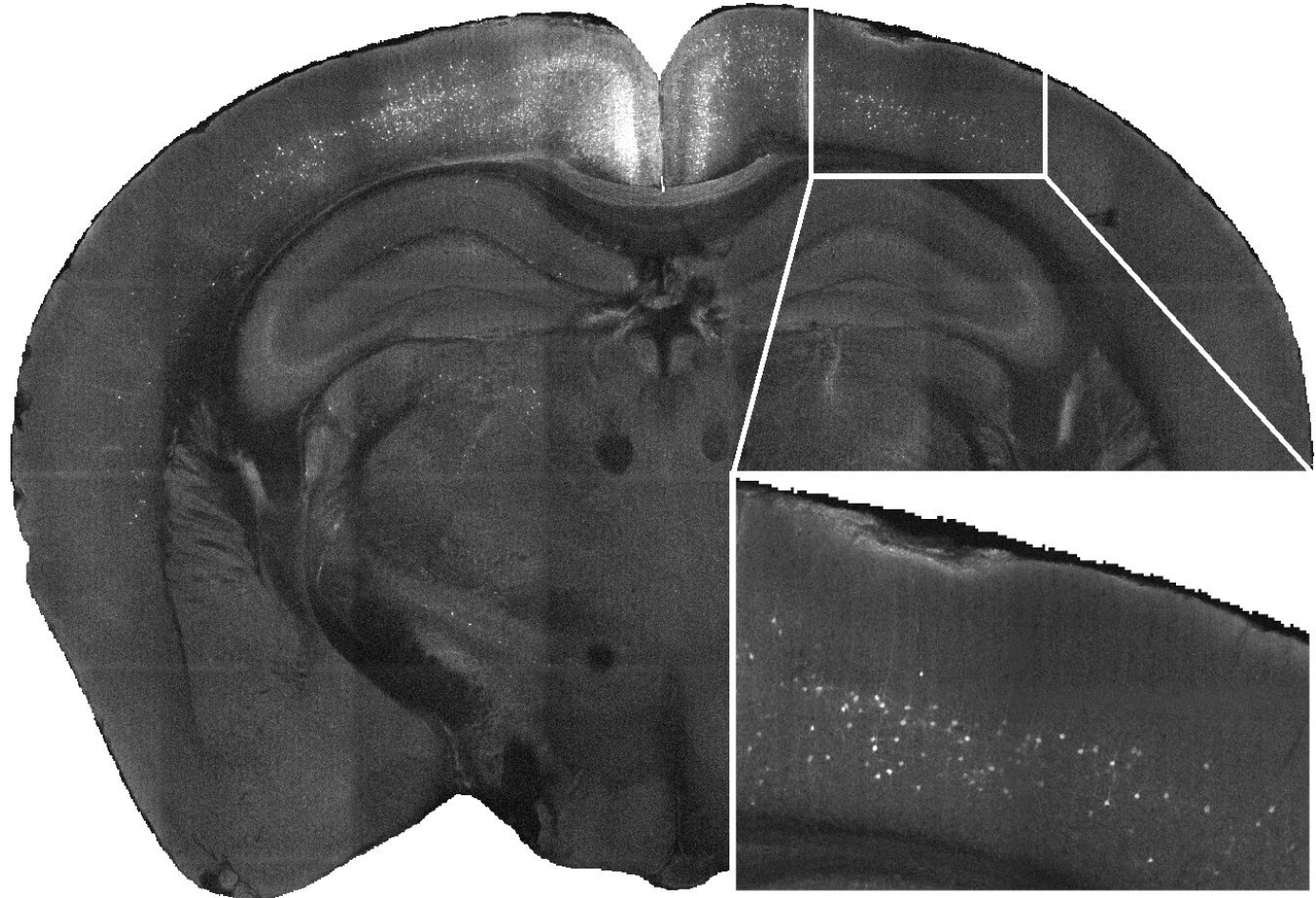


24GB VRAM

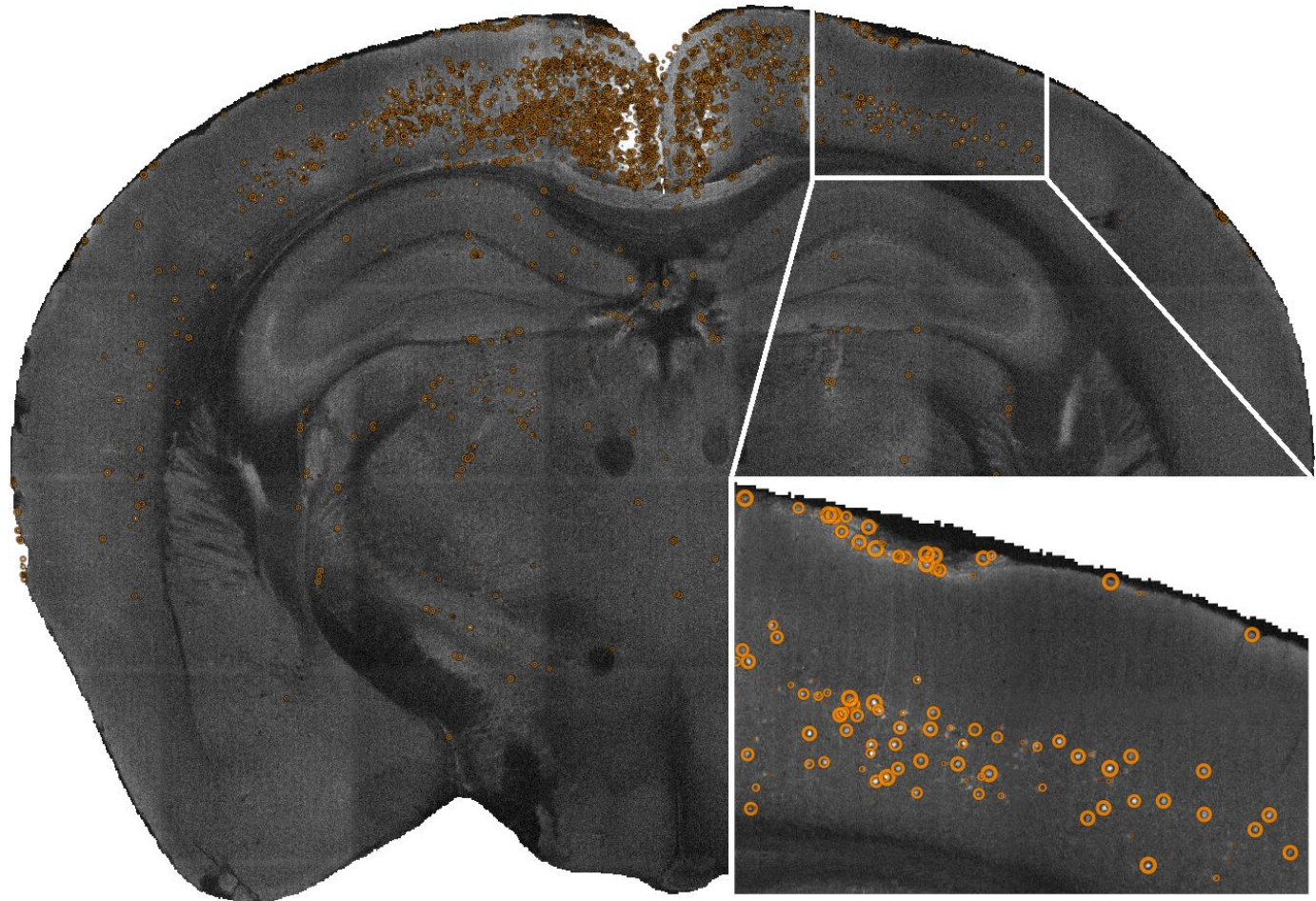
Cell detection - data reduction



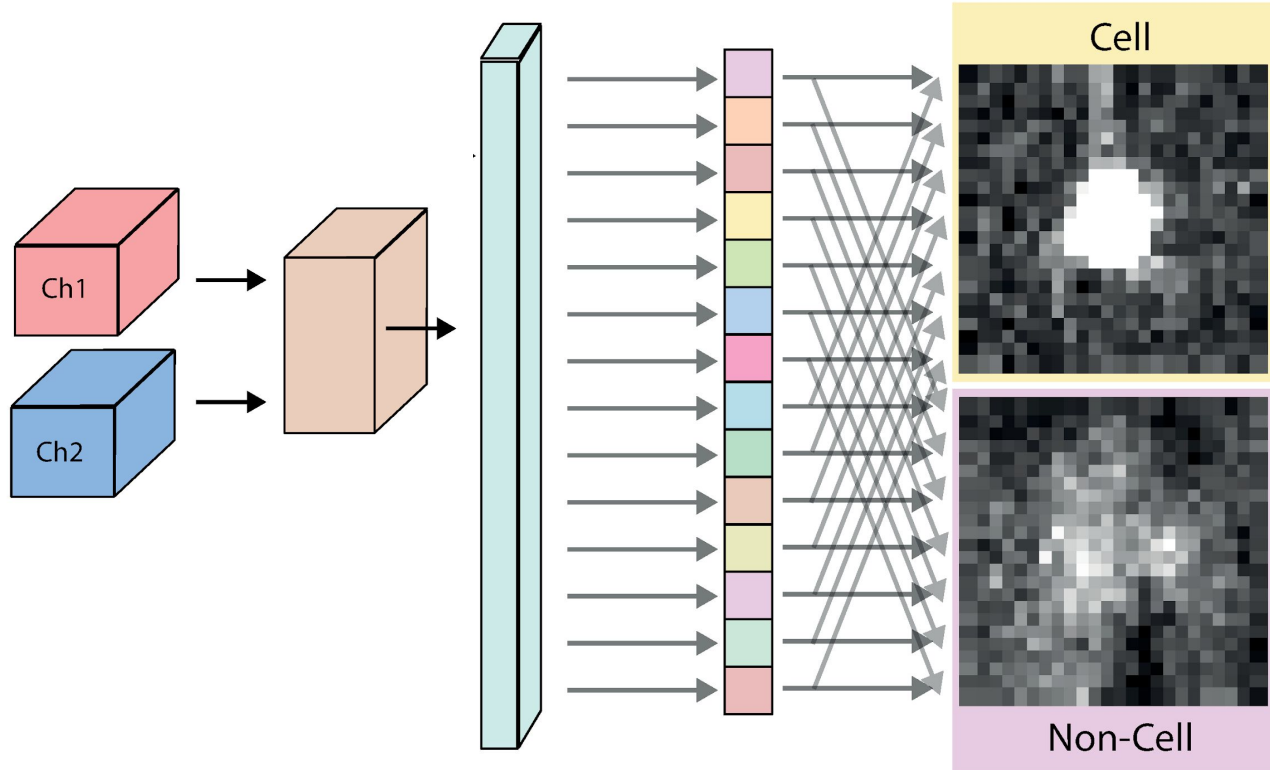
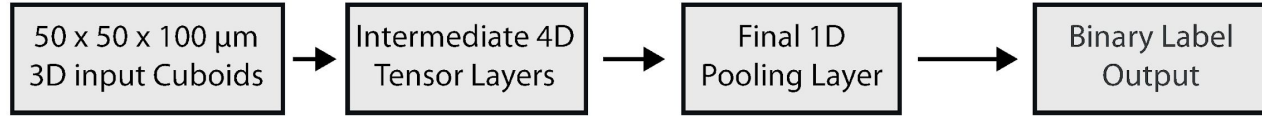
Cell detection - data reduction



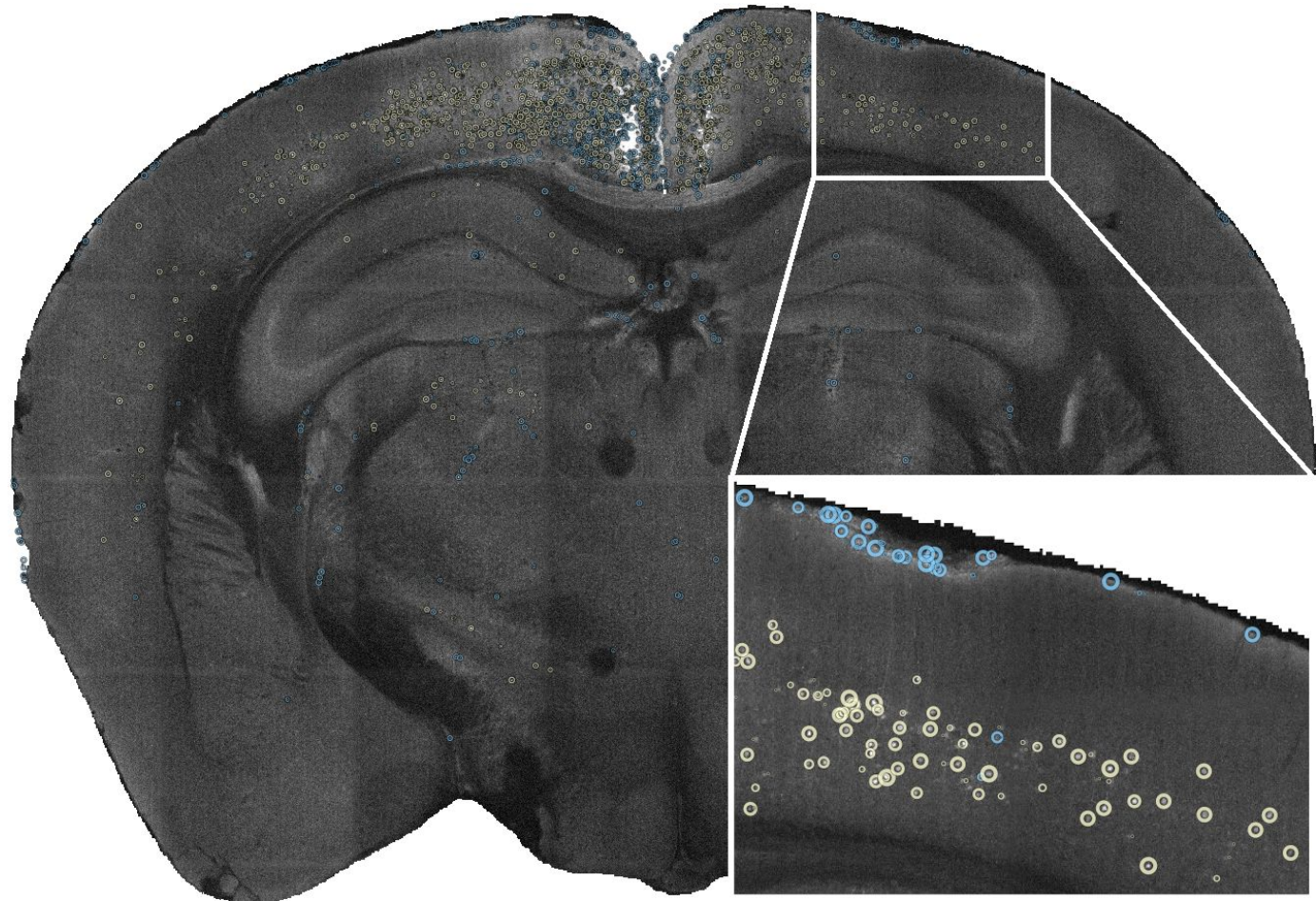
Cell detection - detection



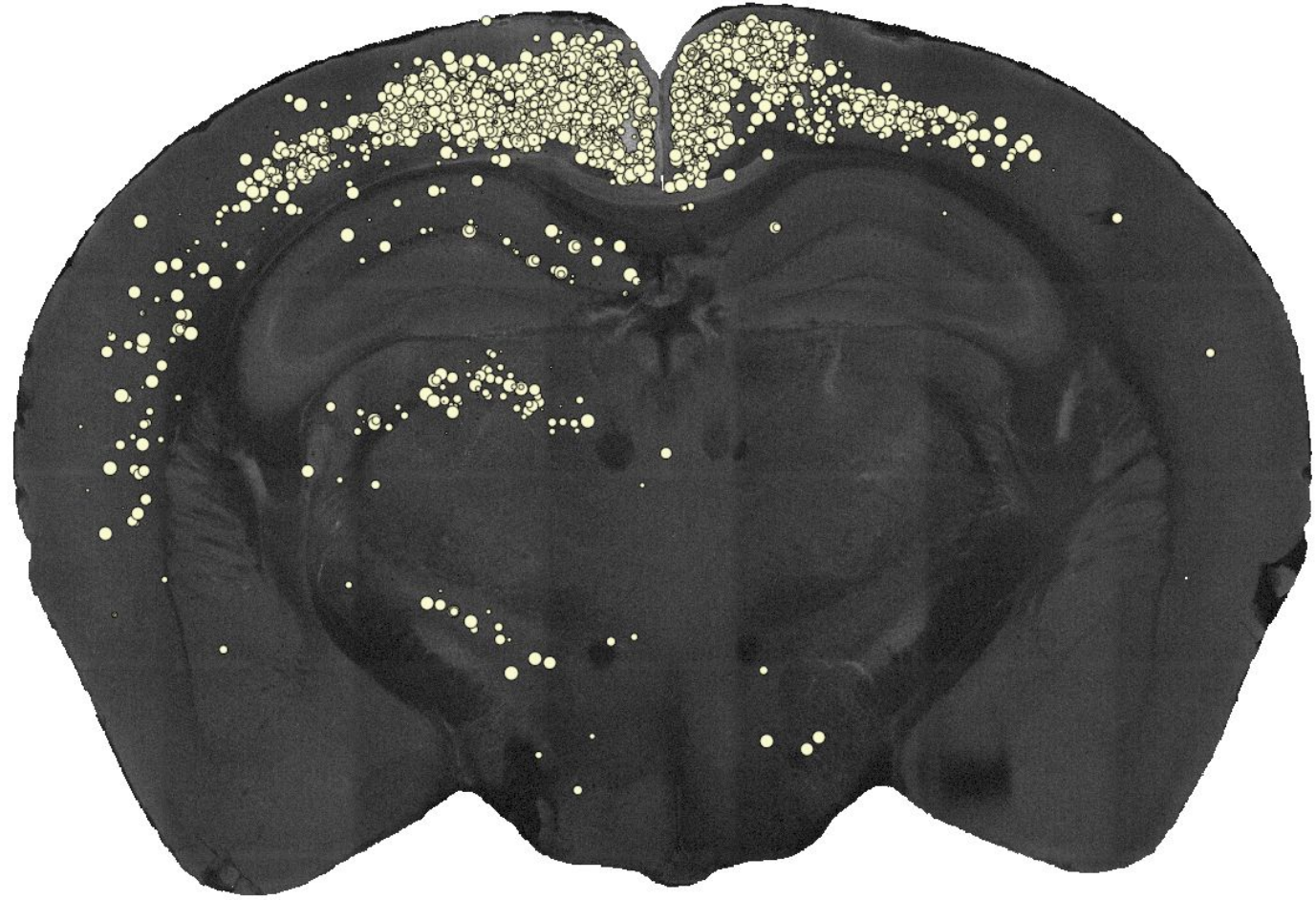
Cell detection - classification



Cell detection - classification

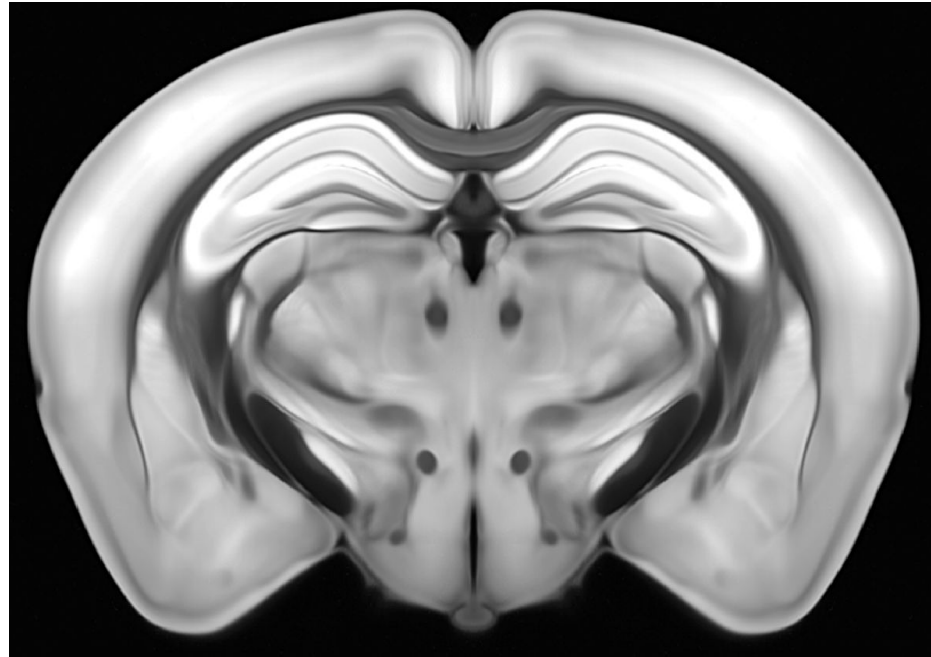


Brain segmentation



Registration

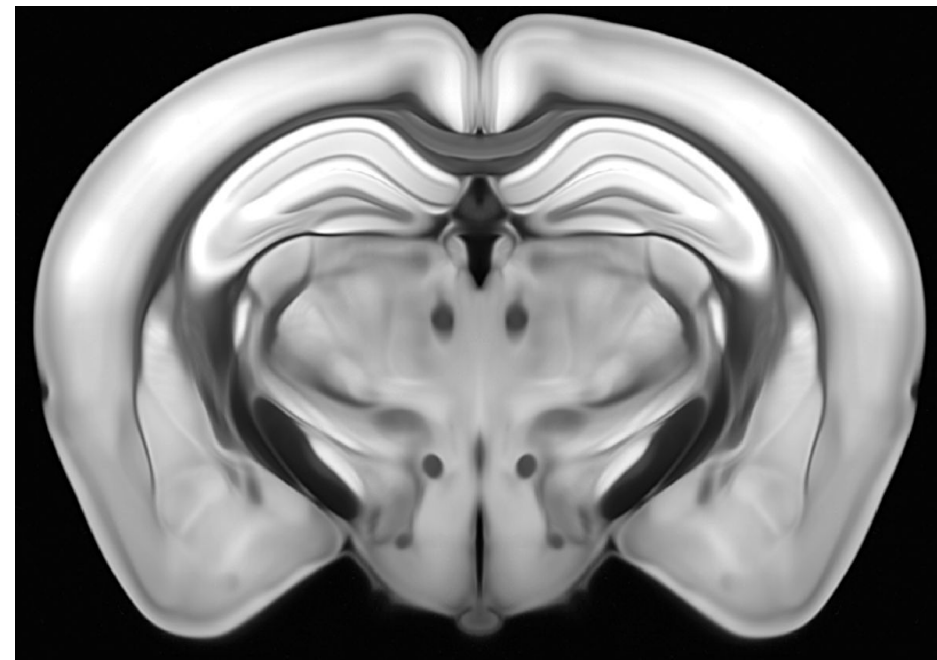
Allen mouse brain reference atlas



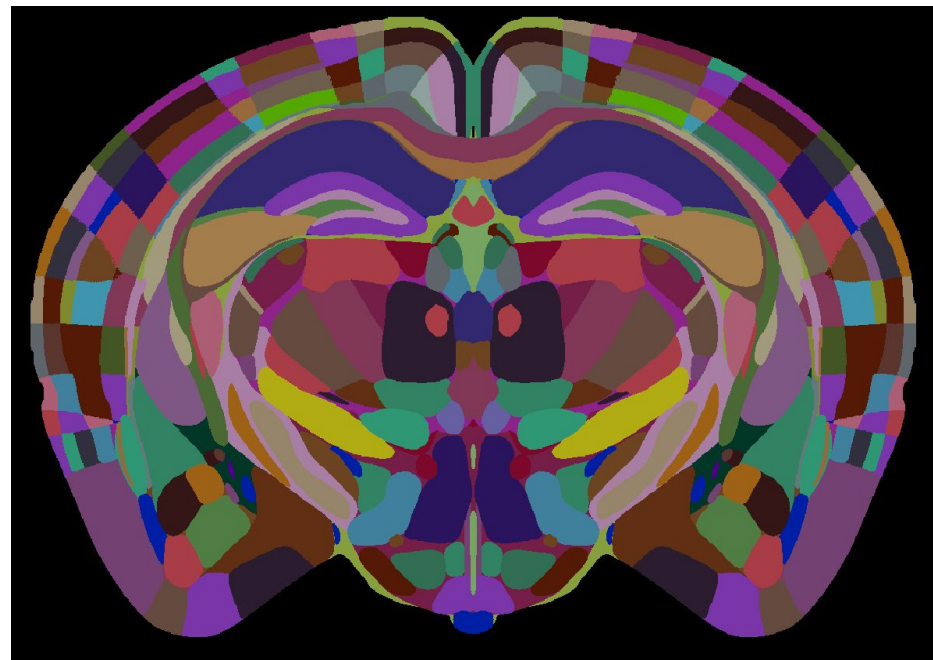
Reference image

Registration

Allen mouse brain reference atlas

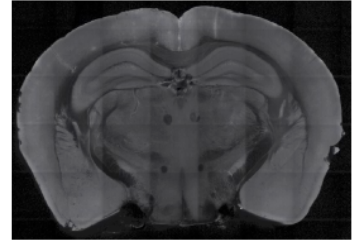
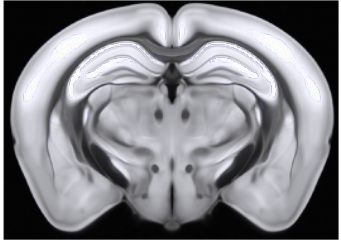


Reference image

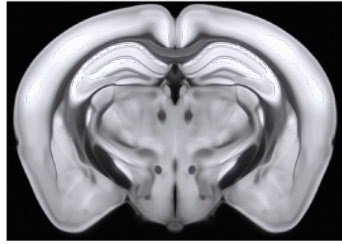


Annotation image

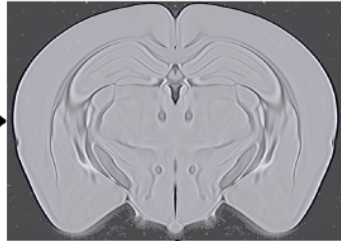
Registration



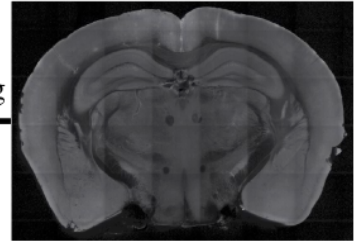
Registration



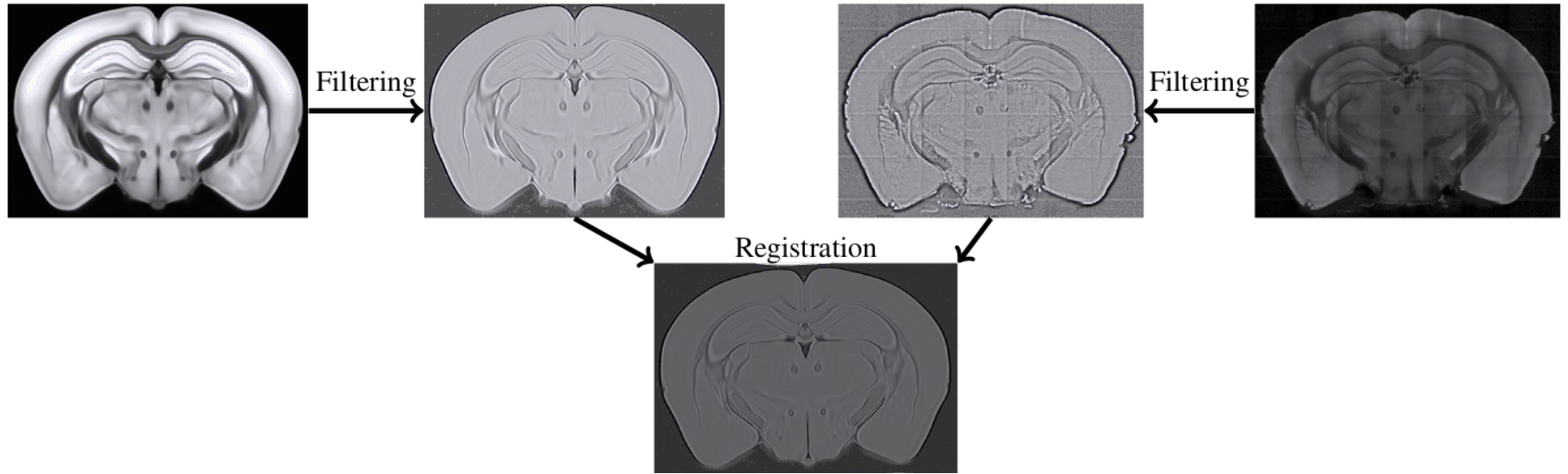
Filtering



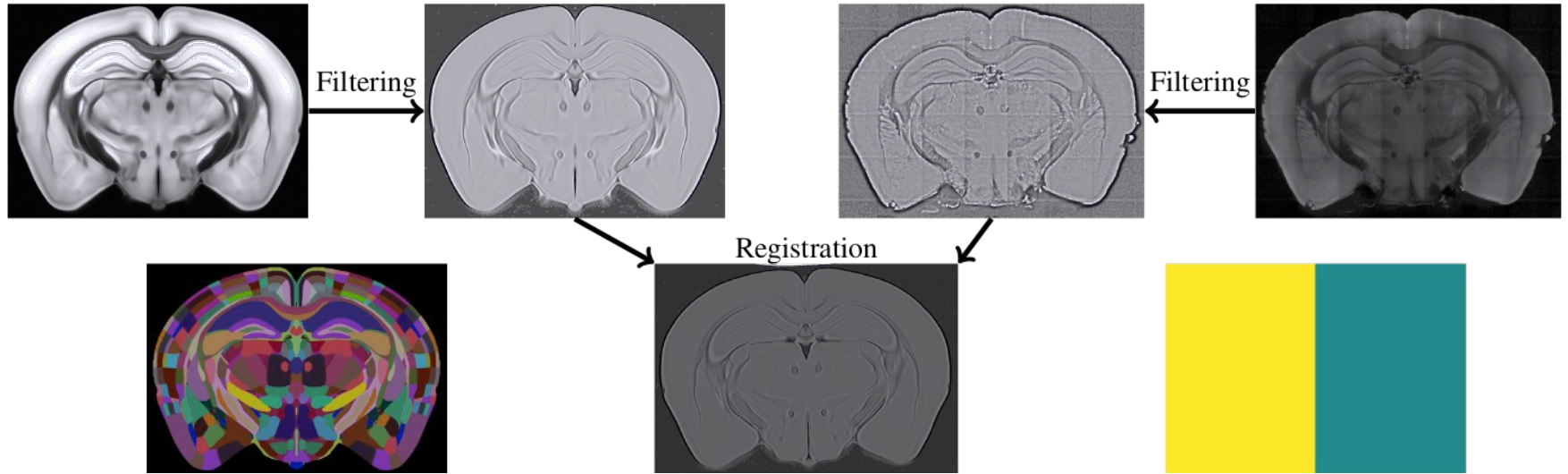
Filtering



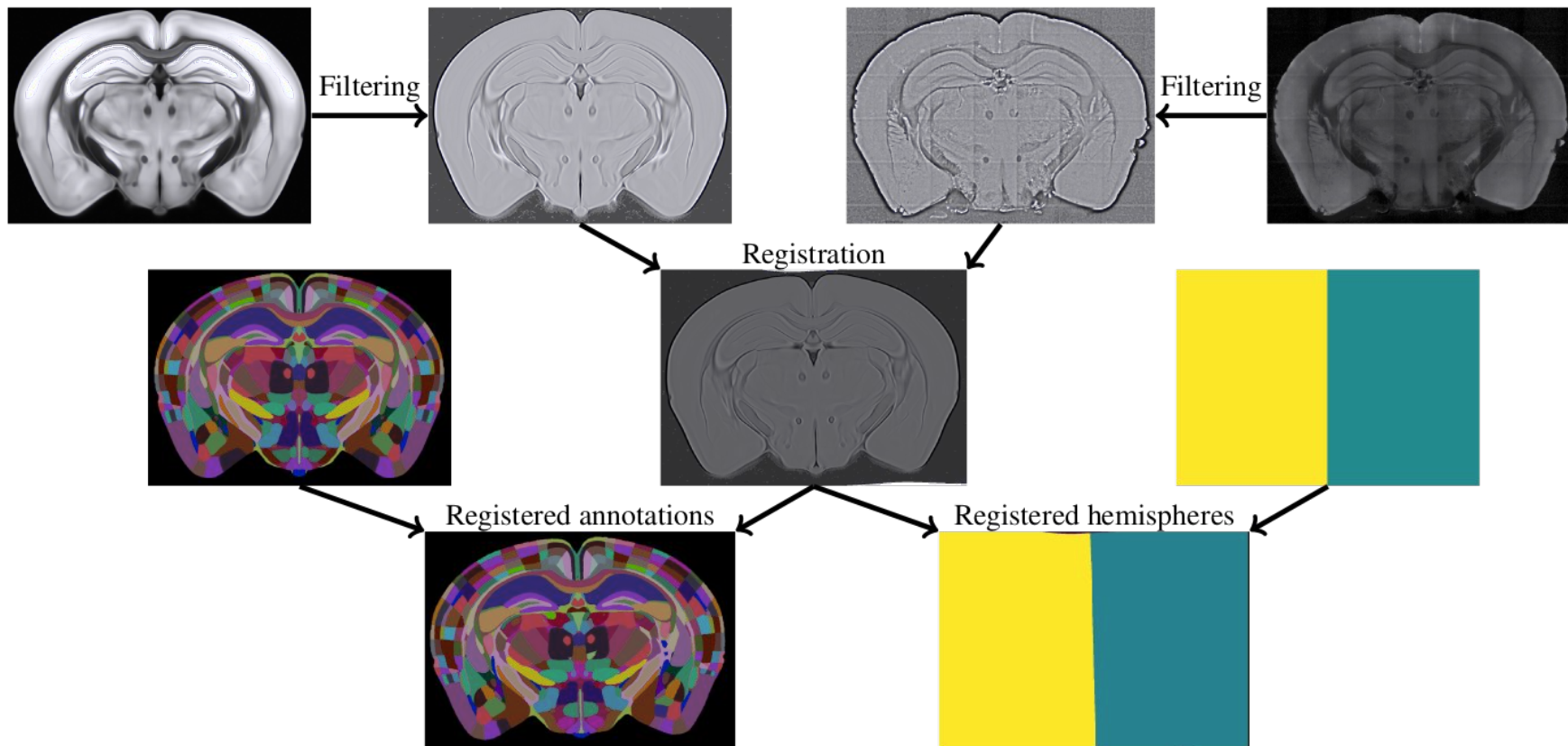
Registration



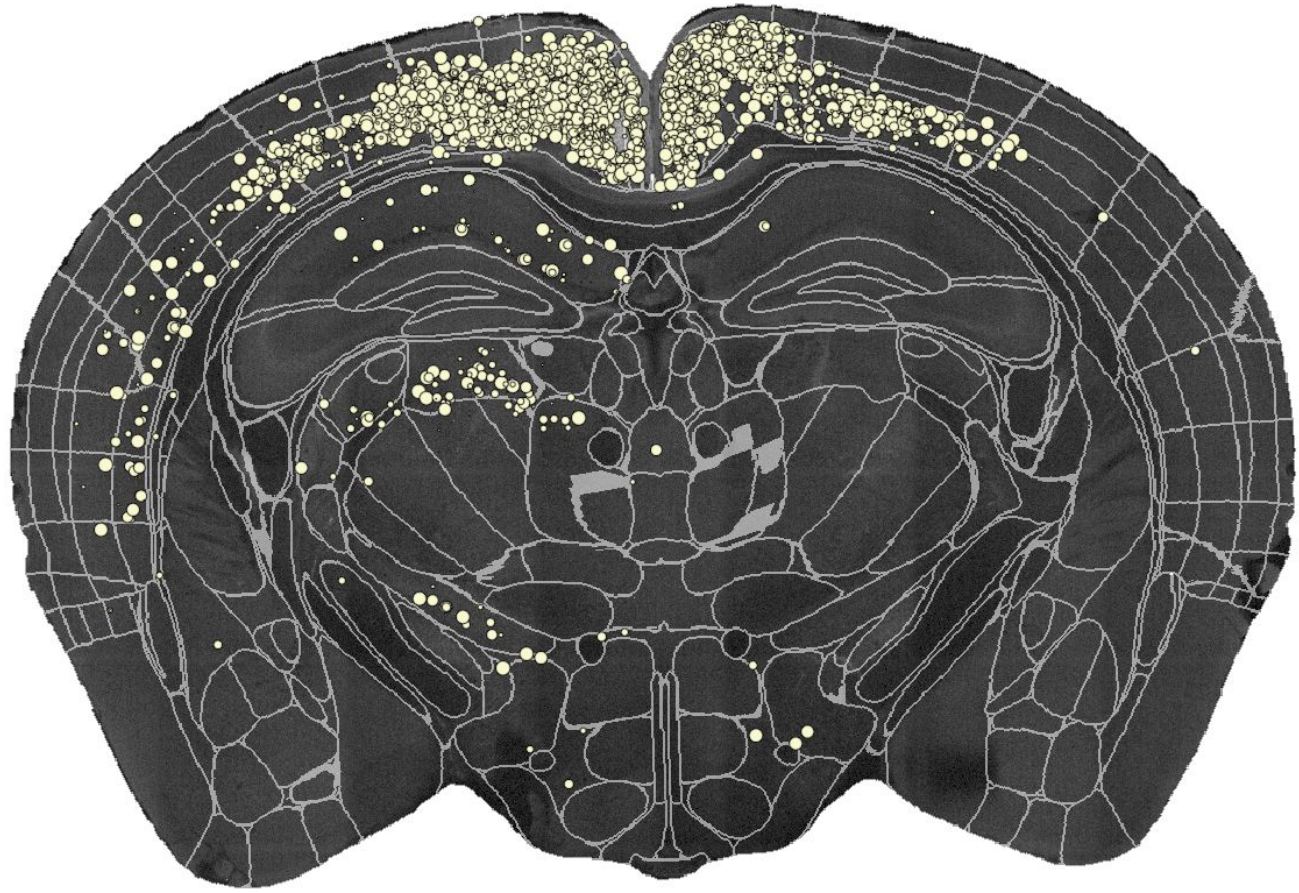
Registration



Registration



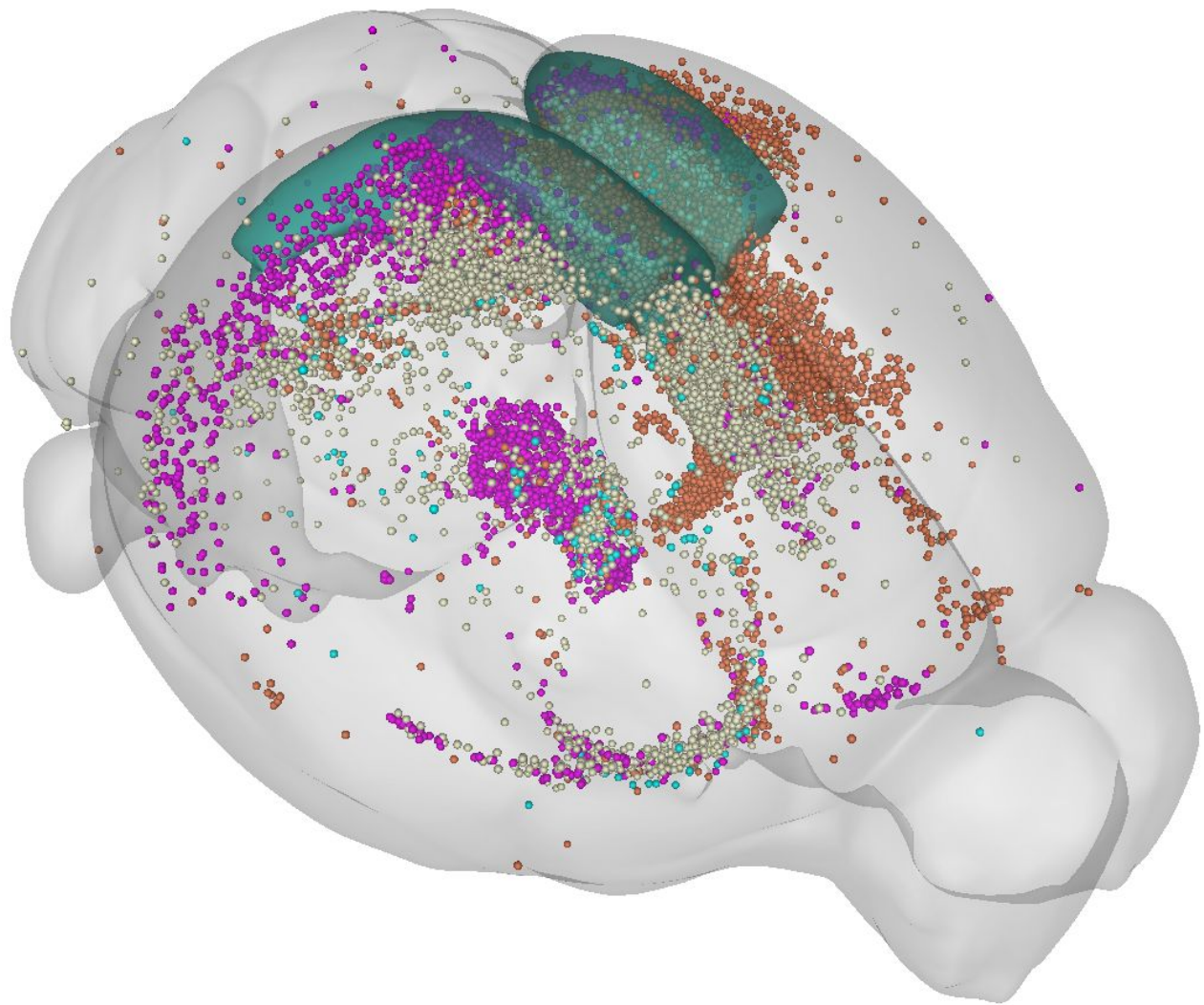
Registration



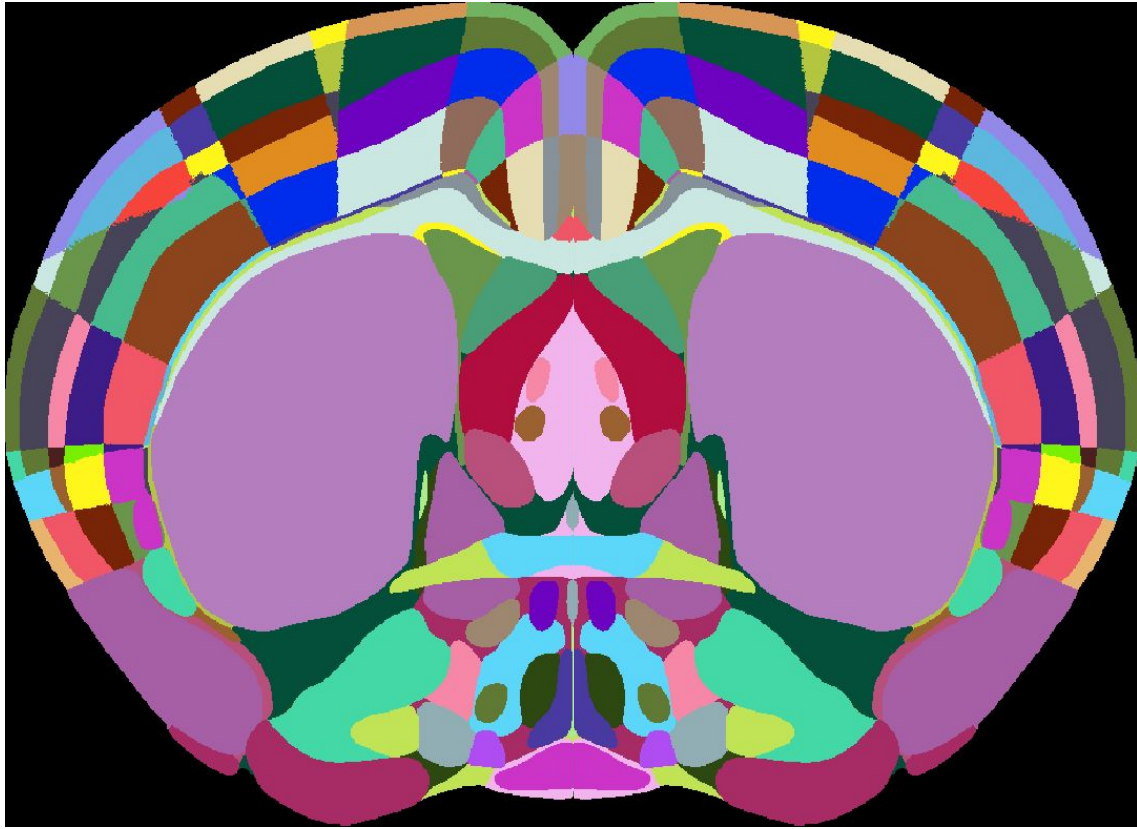
Registration

Brain structure name	Left hemisphere count	Right hemisphere count	Total count
Retrosplenial area, ventral part, layer 5	1853	814	2667
Lateral dorsal nucleus of thalamus	1541	0	1541
Retrosplenial area, ventral part, layer 2/3	163	686	849
Retrosplenial area, dorsal part, layer 5	561	82	643
Retrosplenial area, dorsal part, layer 2/3	194	245	439
Ventral anterior-lateral complex of the thalamus	412	0	412
Anterior cingulate area, dorsal part, layer 5	340	40	380
Anteroventral nucleus of thalamus	374	0	374
...

Registration



Brain atlases - mouse



Allen Mouse Brain CCFv3
(Wang et al., 2020)

Brain atlases - mouse

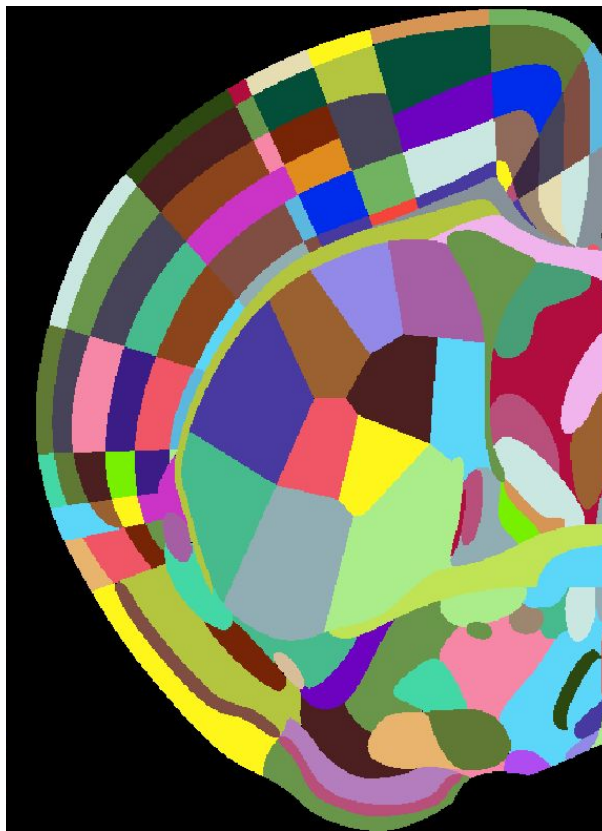


Allen Mouse Brain CCFv3
(Wang et al., 2020)

Brain atlases - mouse



Allen Mouse Brain CCFv3
(Wang et al., 2020)

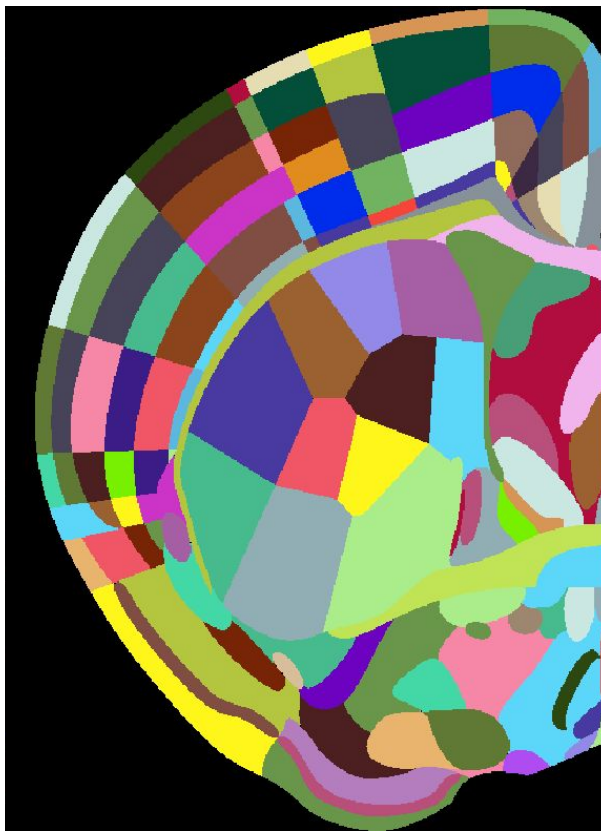


Enhanced and Unified Mouse
Brain Atlas (Chon et al., 2019).

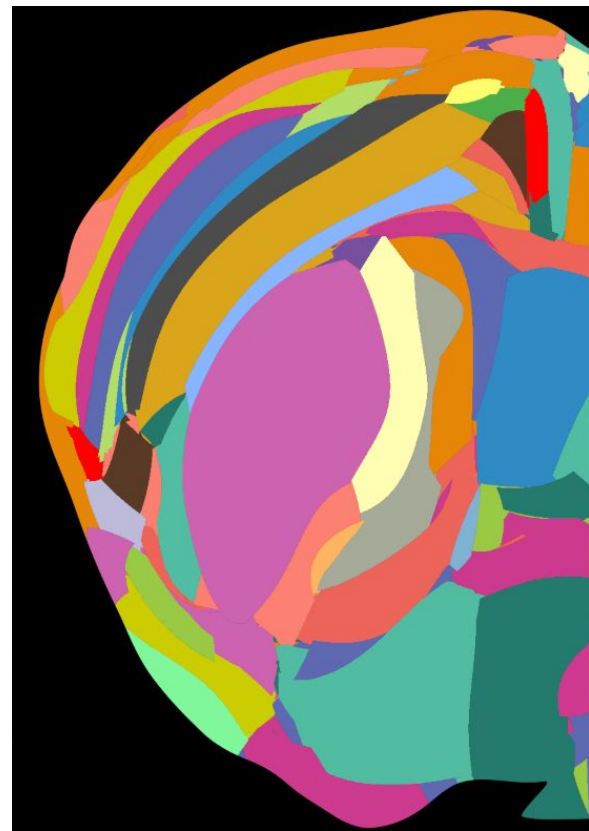
Brain atlases - mouse



Allen Mouse Brain CCFv3
(Wang et al., 2020)

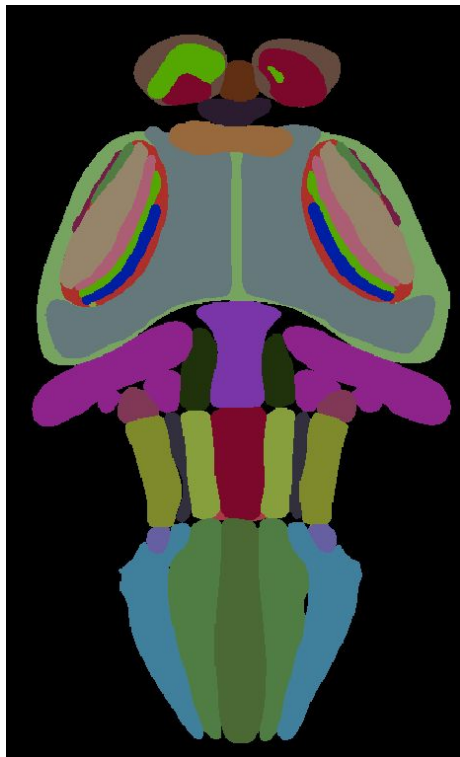


Enhanced and Unified Mouse
Brain Atlas (Chon et al., 2019).



Molecular atlas of the adult
mouse brain (Ortiz et al., 2020)

Brain atlases - other species



Max Planck Larval Zebrafish Atlas
(Kunst et al., 2019)



Allen human atlas
(Ding et al., 2020)

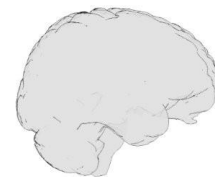
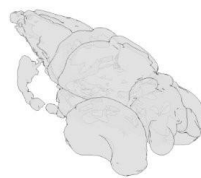


Waxholm Space atlas of the Sprague
Dawley rat brain (Papp et al., 2014).



NeuroNames macaque atlas
(Rohlfing et al., 2012)

BrainGlobe Atlas API



Python API

```
from bg_atlasapi.bg_atlas import BrainGlobeAtlas
atlas = BrainGlobeAtlas("allen_mouse_25um")

# reference image
reference_image = atlas.reference
print(reference_image.shape)
# (528, 320, 456)

# hemispheres image (value 1 in left hemisphere, 2 in right)
hemispheres_image = atlas.hemispheres
print(hemispheres_image.shape)
# (528, 320, 456)

from pprint import pprint
VISp = atlas.structures["VISp"]
pprint(VISp)
# {'acronym': 'VISp',
#  'id': 385,
#  'mesh': None,
#  'mesh_filename': PosixPath('/home/user/.brainglobe/allen_mouse_25um_v0.3/meshes/385.obj'),
#  'name': 'Primary visual area',
#  'rgb_triplet': [8, 133, 140],
#  'structure_id_path': [997, 8, 567, 688, 695, 315, 669, 385]}
```

Command line interface

```
adam@garfield: ~
File Edit View Search Terminal Help
(brainreg) adam@garfield:~$ brainglobe list

Brainglobe Atlases

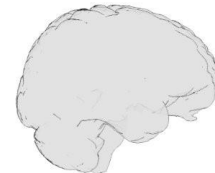
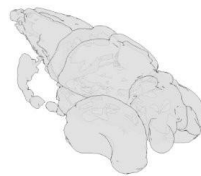


| Name                | Downloaded | Local version | Latest version |
|---------------------|------------|---------------|----------------|
| allen_human_500um   | ✓          | 0.1           | 0.1            |
| ngin_zfish_1um      | ✓          | 0.3           | 1.0            |
| allen_mouse_100um   | ✓          | 1.1           | 1.1            |
| allen_mouse_50um    | ✓          | 0.3           | 0.3            |
| kin_unified_25um    | ✓          | 0.1           | 0.1            |
| allen_mouse_10um    | ✓          | 1.1           | 1.1            |
| example_mouse_100um | ✓          | 1.0           | 1.1            |
| allen_mouse_25um    | ✓          | 1.1           | 1.1            |



(brainreg) adam@garfield:~$ brainglobe update -a allen_mouse_10um
allen mouse atlas (res. 10um)
From: http://www.brain-map.com (Wang et al 2020, https://doi.org/10.1016/j.cell.2020.04.007 )
bg_atlasapi: allen_mouse_10um is already updated (version: 1.1)
(brainreg) adam@garfield:~$
```

BrainGlobe Atlas API



Currently implemented atlases

- The [Allen Mouse Brain Atlas](#) (10, 25, 50 and 100 micron)
- The [Allen Human Brain Atlas](#) (100 micron)
- The [Max Planck Zebrafish Brain Atlas](#) (1 micron)
- The [Enhanced and Unified Mouse Brain Atlas](#) (10, 25, 50 and 100 micron)
- The [Smoothed Kim et al. Mouse Brain Atlas](#) (10, 25, 50 and 100 micron)

BrainGlobe

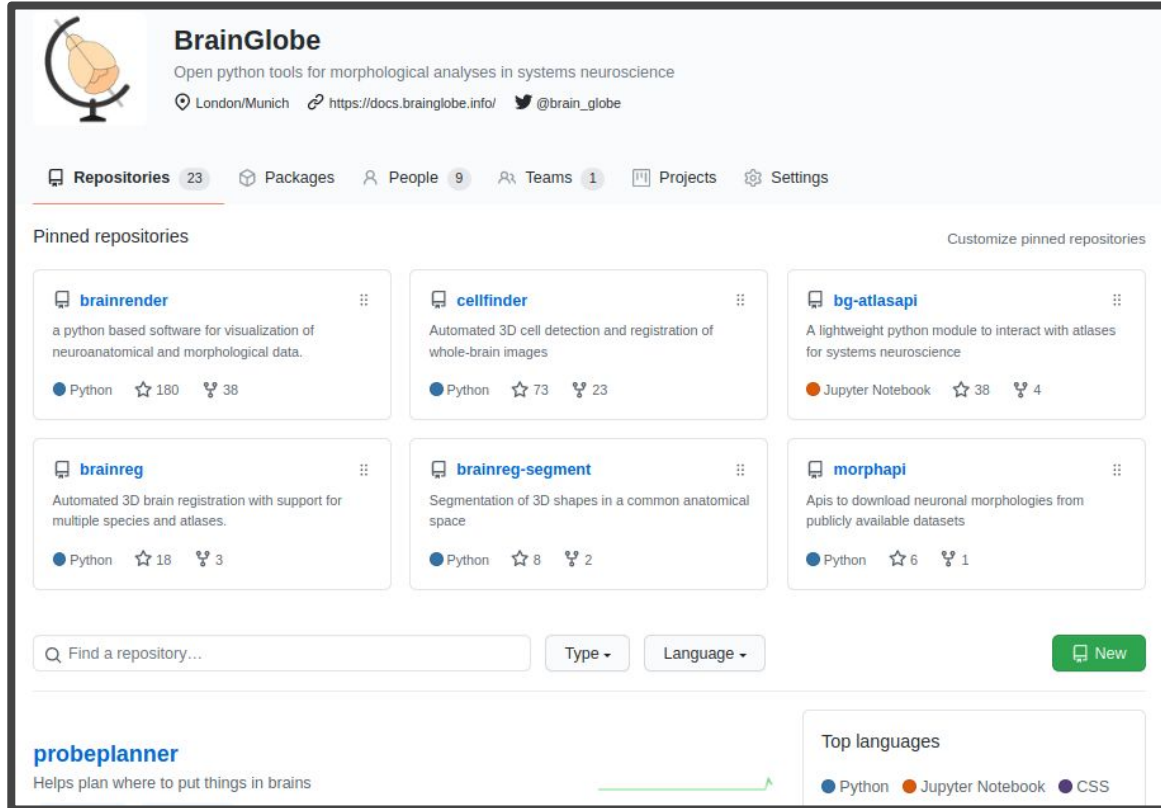
Building an open-source community

Currently

- 23 repositories
- 17 total contributors
- ~2.5k downloads/month

Future

- New contributors
- Biologists adopt tools
- Developers use core tools



The screenshot displays the GitHub profile for BrainGlobe, which is described as "Open python tools for morphological analyses in systems neuroscience". The profile includes a location of "London/Munich", a website link "https://docs.brainglobe.info/", and a Twitter handle "@brain_globe".

The navigation bar shows the following statistics: 23 Repositories, Packages, 9 People, 1 Teams, Projects, and Settings.

The "Pinned repositories" section features a search bar and a "New" button. The pinned repositories are:

- brainrender**: a python based software for visualization of neuroanatomical and morphological data. (Python, 180 stars, 38 forks)
- cellfinder**: Automated 3D cell detection and registration of whole-brain images. (Python, 73 stars, 23 forks)
- bg-atlasapi**: A lightweight python module to interact with atlases for systems neuroscience. (Jupyter Notebook, 38 stars, 4 forks)
- brainreg**: Automated 3D brain registration with support for multiple species and atlases. (Python, 18 stars, 3 forks)
- brainreg-segment**: Segmentation of 3D shapes in a common anatomical space. (Python, 8 stars, 2 forks)
- morphapi**: Apis to download neuronal morphologies from publicly available datasets. (Python, 6 stars, 1 fork)

At the bottom, there is a search bar for repositories, filters for "Type" and "Language", and a "Top languages" section showing Python, Jupyter Notebook, and CSS.

Acknowledgements



Cell detection

Charly Rousseau^{1,2}
Christian Niedworok¹
Sepiedeh Keshavarzi¹
Chryssanthi Tsitoura¹
Lee Cossell¹
Molly Strom¹
Troy Margrie¹

3D Atlas registration

Charly Rousseau^{1,2}
Christian Niedworok¹
Troy Margrie¹

Funding



3D Visualisation

Federico Claudi¹
Luigi Petrucco^{2,3}
Ruben Portuges^{2,3,4}
Troy Margrie¹
Tiago Branco¹

Atlas API

Federico Claudi¹
Luigi Petrucco^{3,4}
Ruben
Portuges^{3,4,5}
Troy Margrie¹
Tiago Branco¹

1) Sainsbury Wellcome Centre, UCL

2) Sorbonne Université, Institut du Cerveau - Paris Brain Institute - ICM, Inserm, CNRS

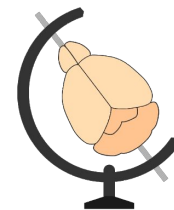
3) Institute of Neuroscience, Technical University of Munich

4) Max Planck Institute of Neurobiology

5) Munich Cluster for Systems Neurology (SyNergy)

Software

All available as part of the BrainGlobe computational neuroanatomy software suite:



Cell detection cellfinder

 github.com/brainlobe/cellfinder

 [@findingcells](https://twitter.com/findingcells)

Tyson, A. L., Rousseau, C. V., Niedworok, C. J., et al. (2021) "A deep learning algorithm for 3D cell detection in whole mouse brain image datasets" bioRxiv, doi.org/10.1101/2020.10.21.348771

 github.com/brainlobe

docs.brainlobe.info

 [@brain_globe](https://twitter.com/brain_globe)

gitter.im/BrainGlobe

3D atlas registration brainreg

 github.com/brainlobe/brainreg

3D visualisation brainrender

 github.com/brainlobe/brainrender

Claudi, F., et al. (2021) "Visualizing anatomically registered data with Brainrender" doi.org/10.7554/eLife.65751

Atlas API BrainGlobe Atlas API

 github.com/brainlobe/bg-atlasapi

Claudi, F., Petrucco, L., Tyson, A. L., et al. (2020) "BrainGlobe Atlas API: a common interface for neuroanatomical atlases" Journal of Open Source Software, v5(54), 2668 doi.org/10.21105/joss.02668

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 [@adamltyson](https://twitter.com/adamltyson)