QM Course 2024
Charles University, Prague

Bio-Image Analysis with napari

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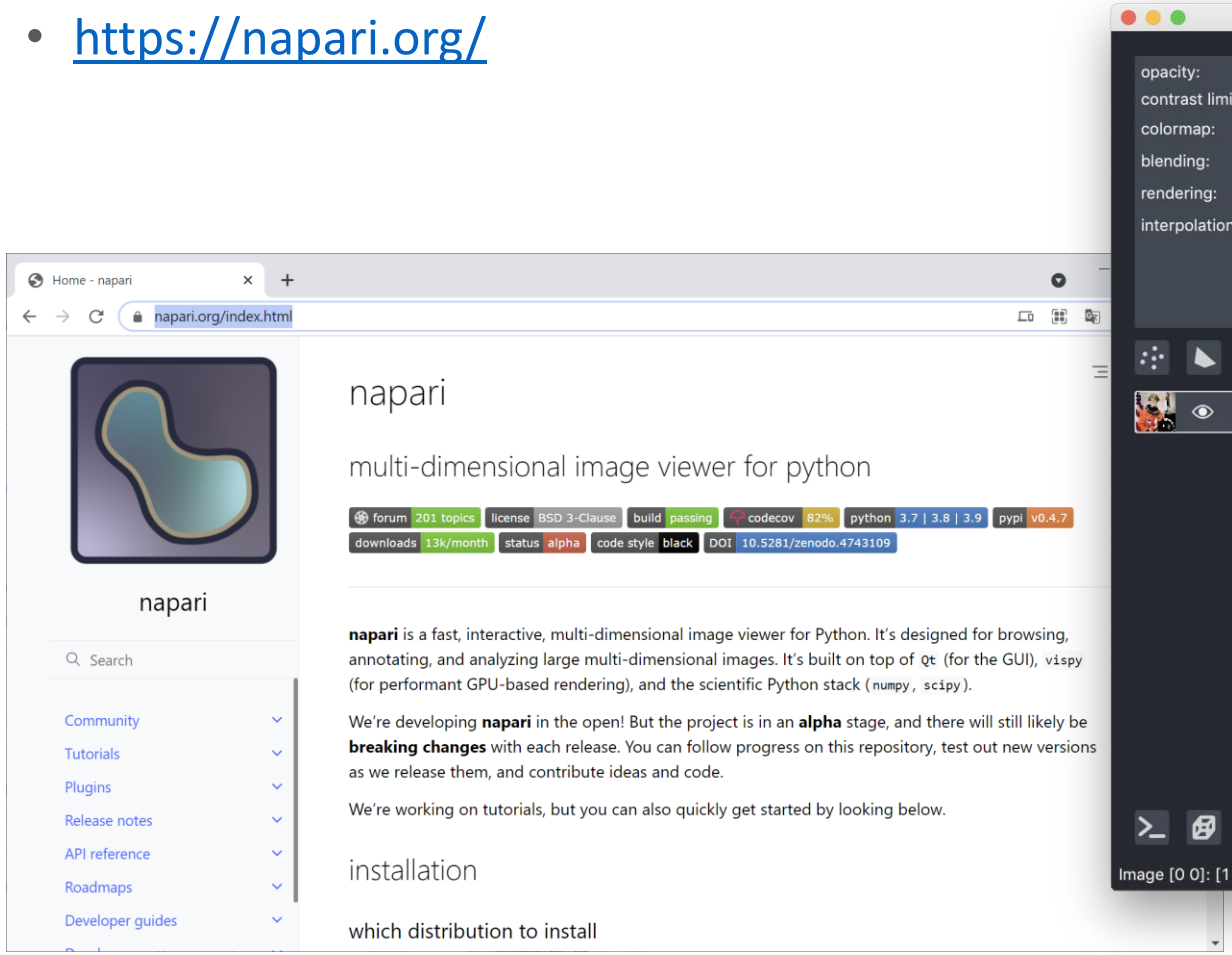
With material from:

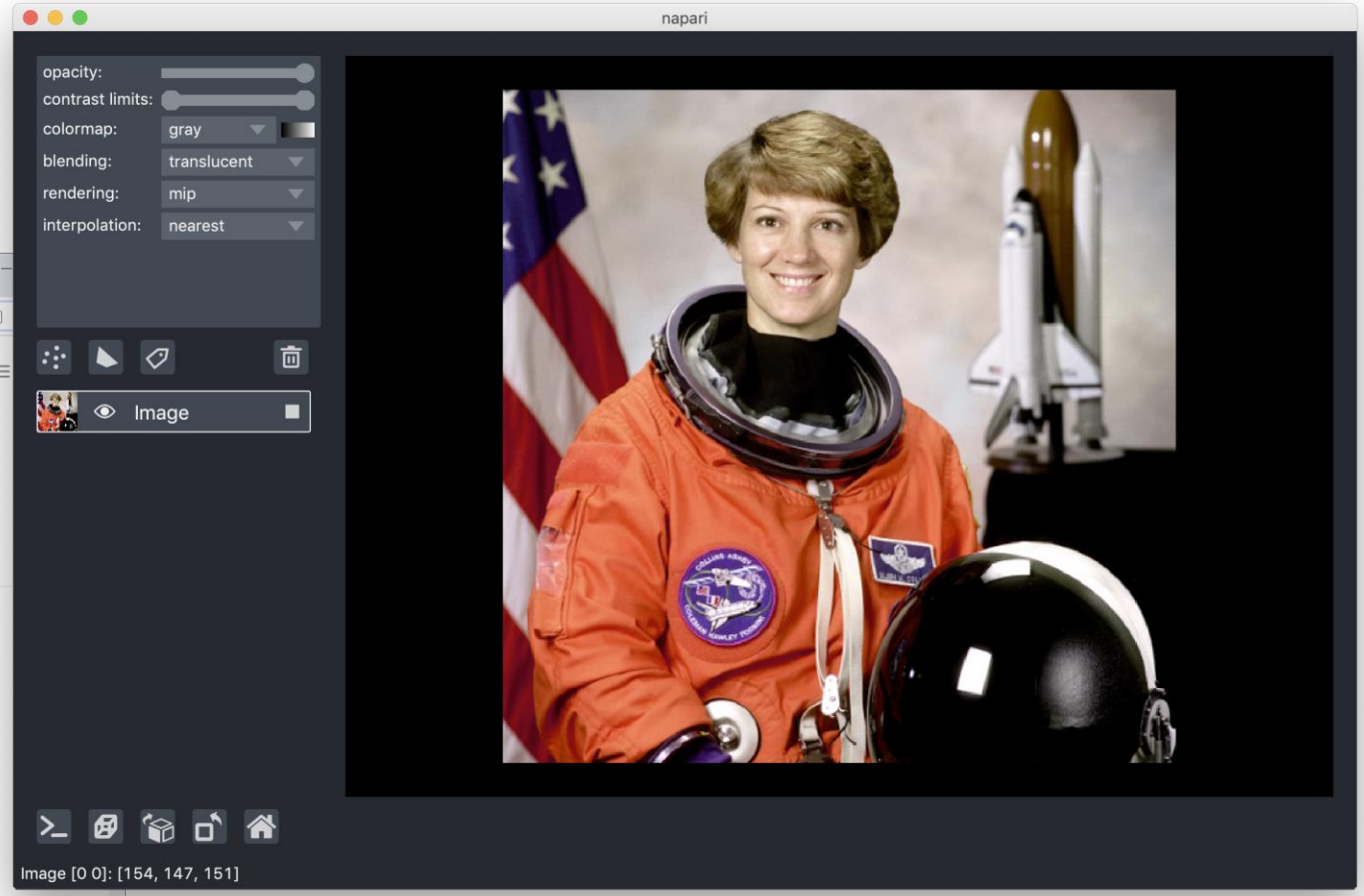
Robert Haase, PoL; Guillaume Witz, Universität Bern

@zoccolermarcelo

Napari: 3D viewer for Python

- Multi-dimensional image viewer in python
- https://napari.org/





https://napari.org/

Napari: 3D viewer for Python

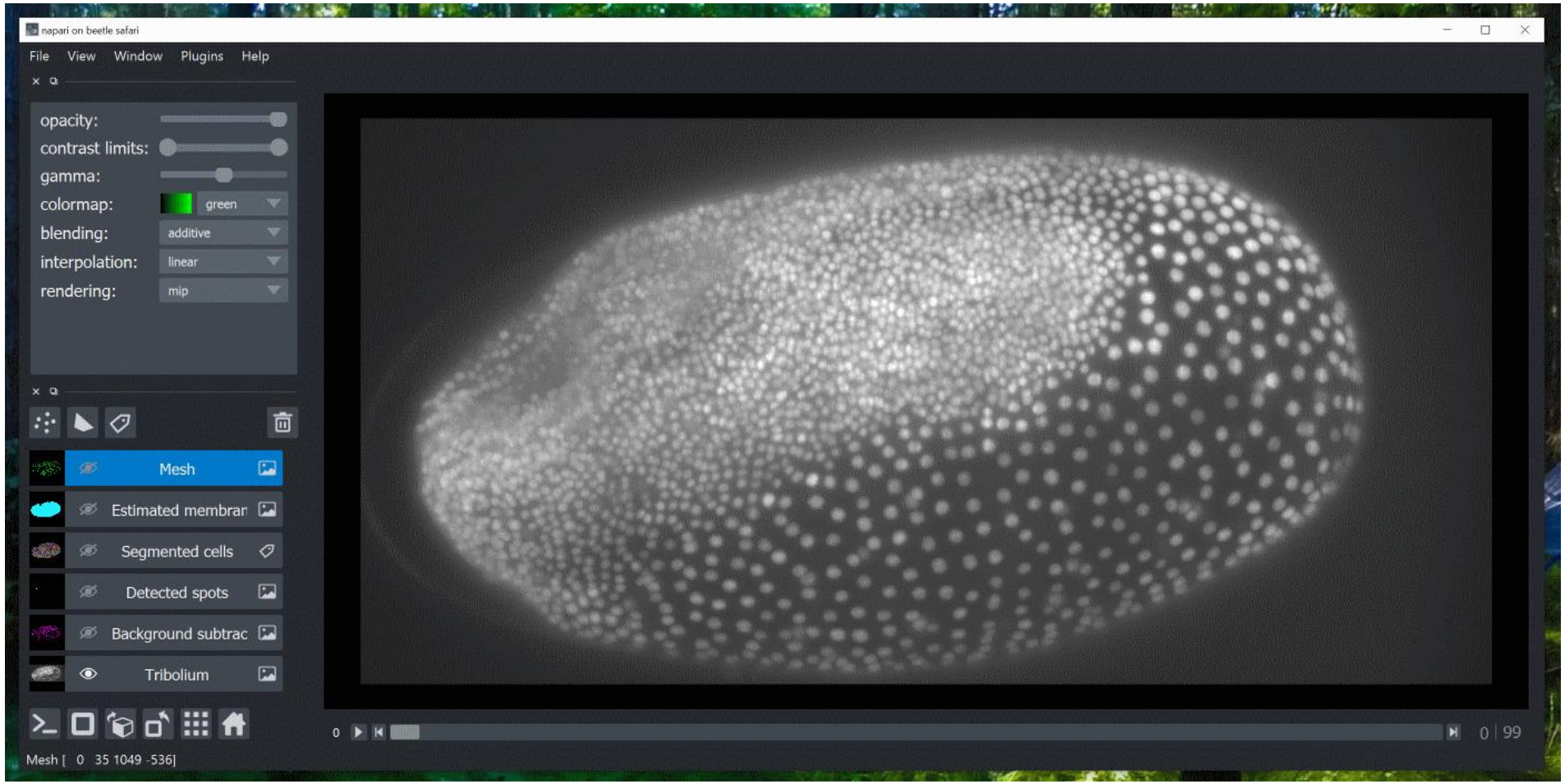


Image data source: Daniela Vorkel, Myers lab, MPI-CBG/CSBD

https://napari.org/

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Napari user interface

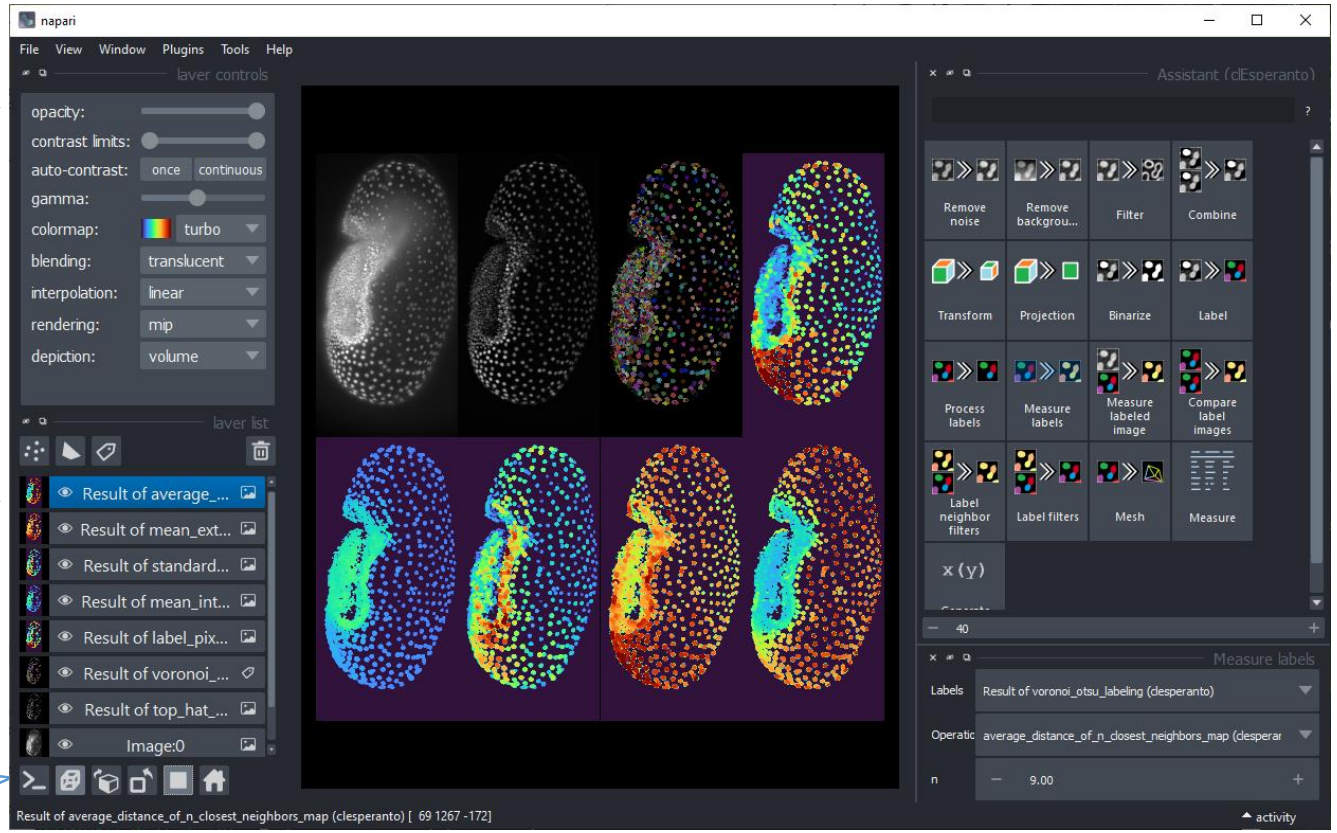
View configuration / tools

```
layer.opacity = 0.5
```

Layers

```
layer.visible = False
```

Viewer controls



Dock widgets (custom plugins)

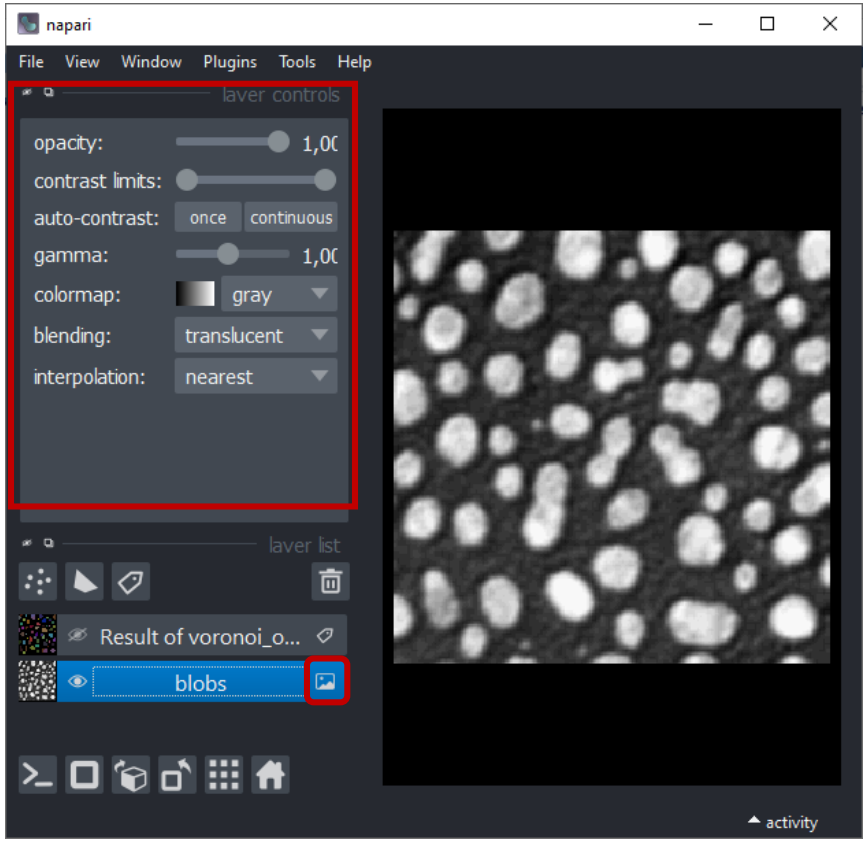
Function widgets (custom plugins)

https://napari.org/tutorials/fundamentals/viewer.html

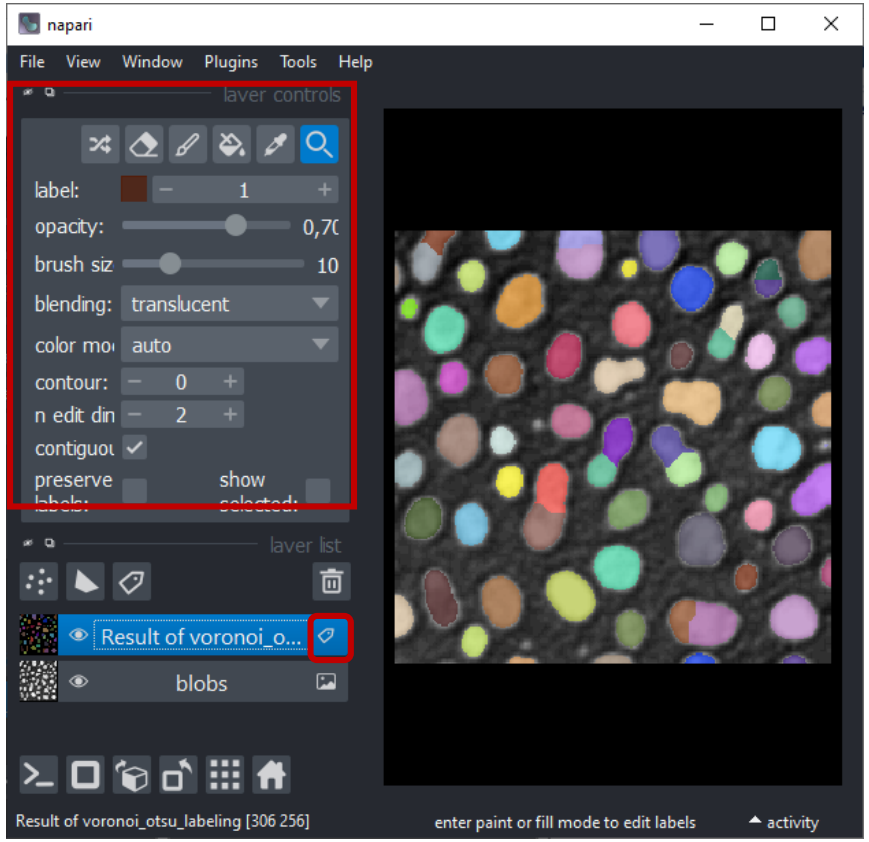
Layer types

- Different layers have different tools and options

Image Layer



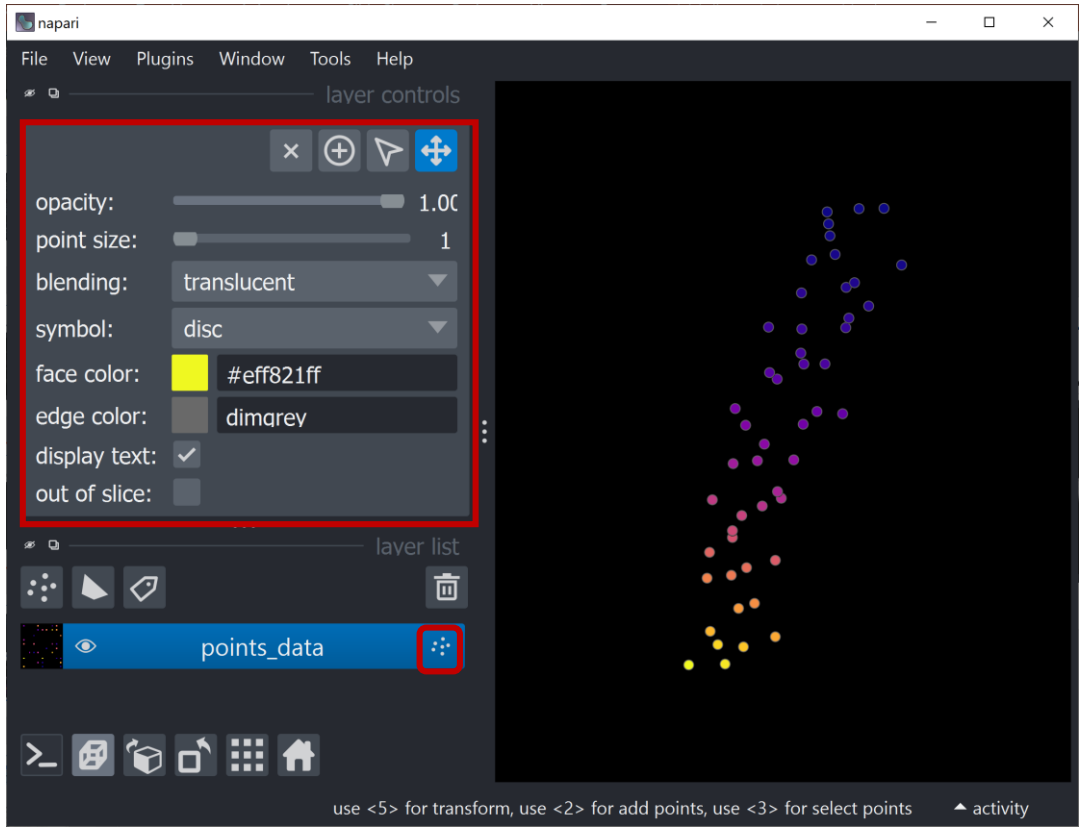
Labels Layer



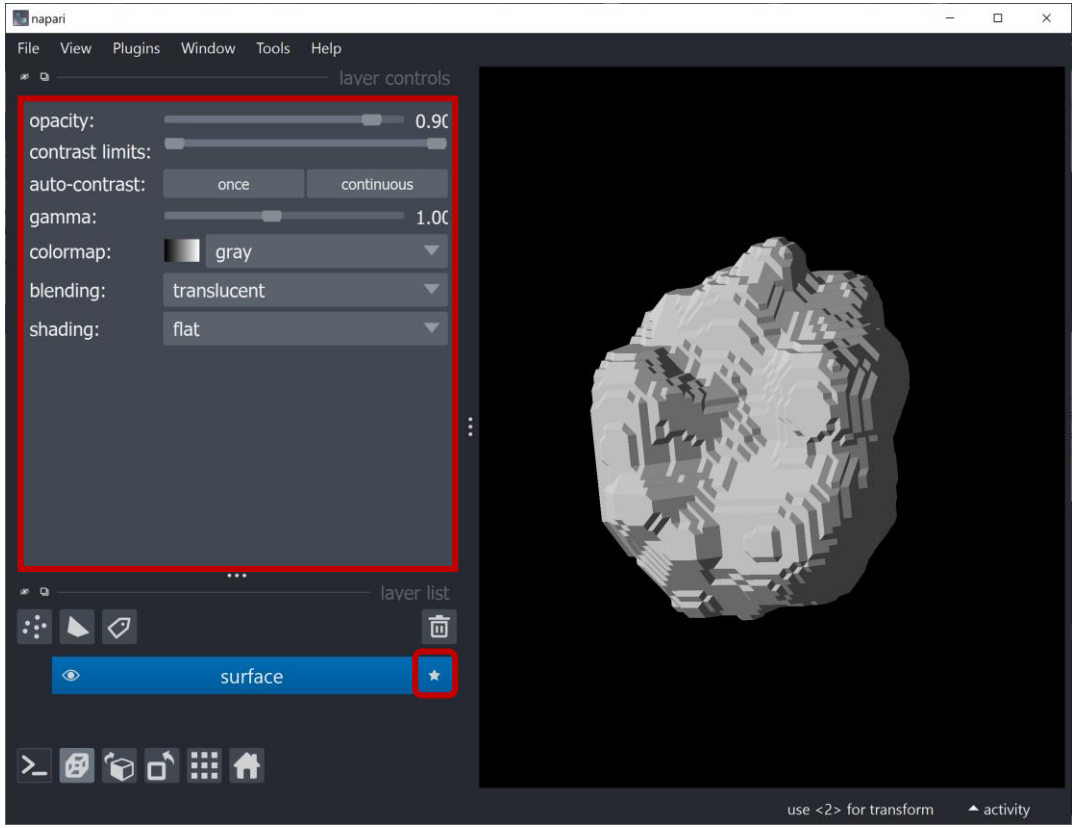
Layer types

- Different layers have different tools and options

Points Layer



Surface Layer



napari plugins

PoL
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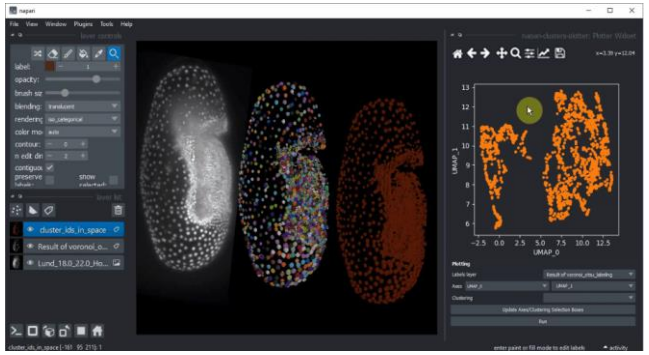
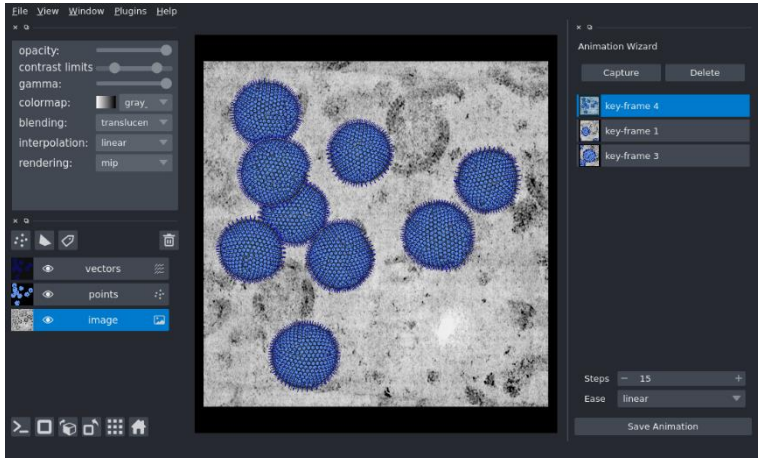
TU Dresden

clusters-plotter



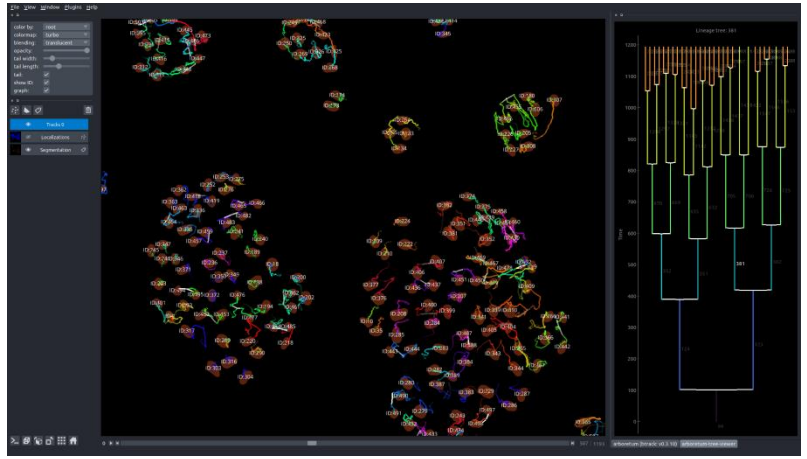
https://github.com/BiAPoL/napari-clusters-plotter

animation



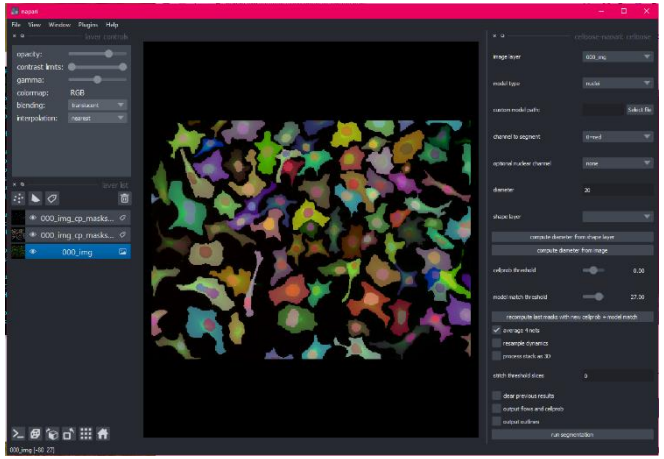
https://github.com/napari/napari-animation

arboretum



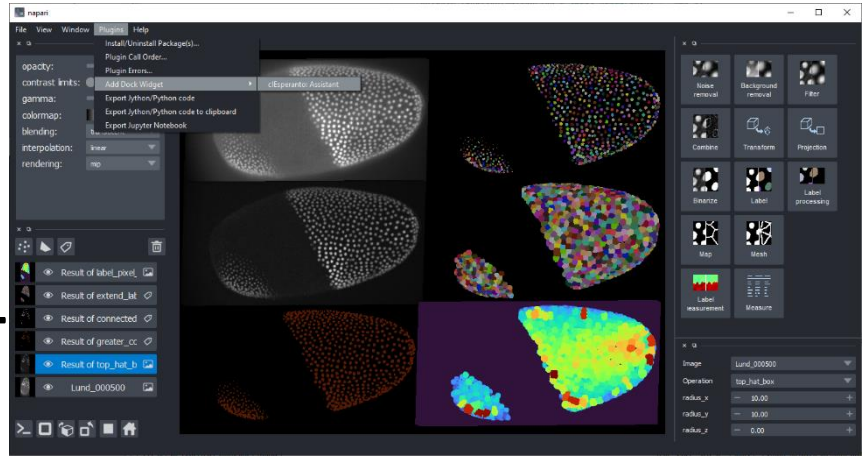
https://github.com/quantumjot/arboretum

cellpose



https://cellpose-napari.readthedocs.io/en/latest/

clesperanto

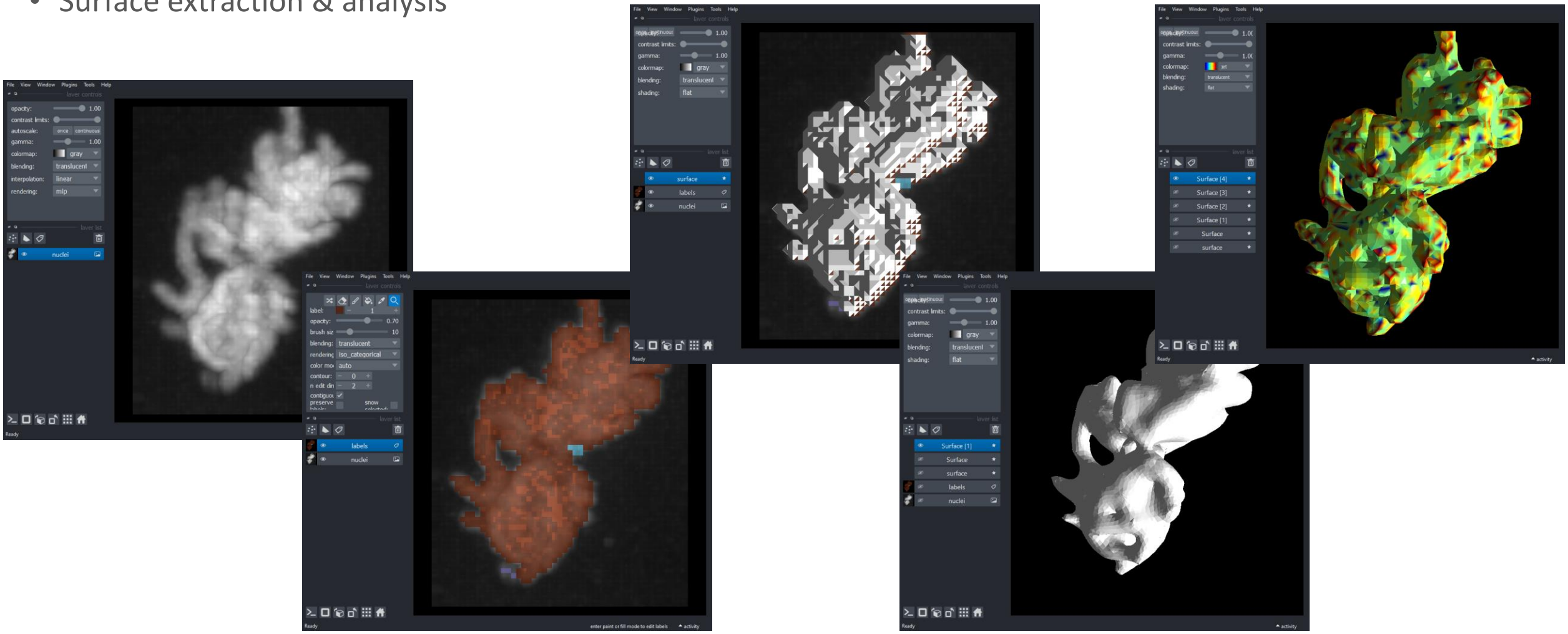


https://github.com/clEsperanto/napari_pyclesperanto_assistant

Napari process points and surfaces

PoL Physics of Life TU Dresden

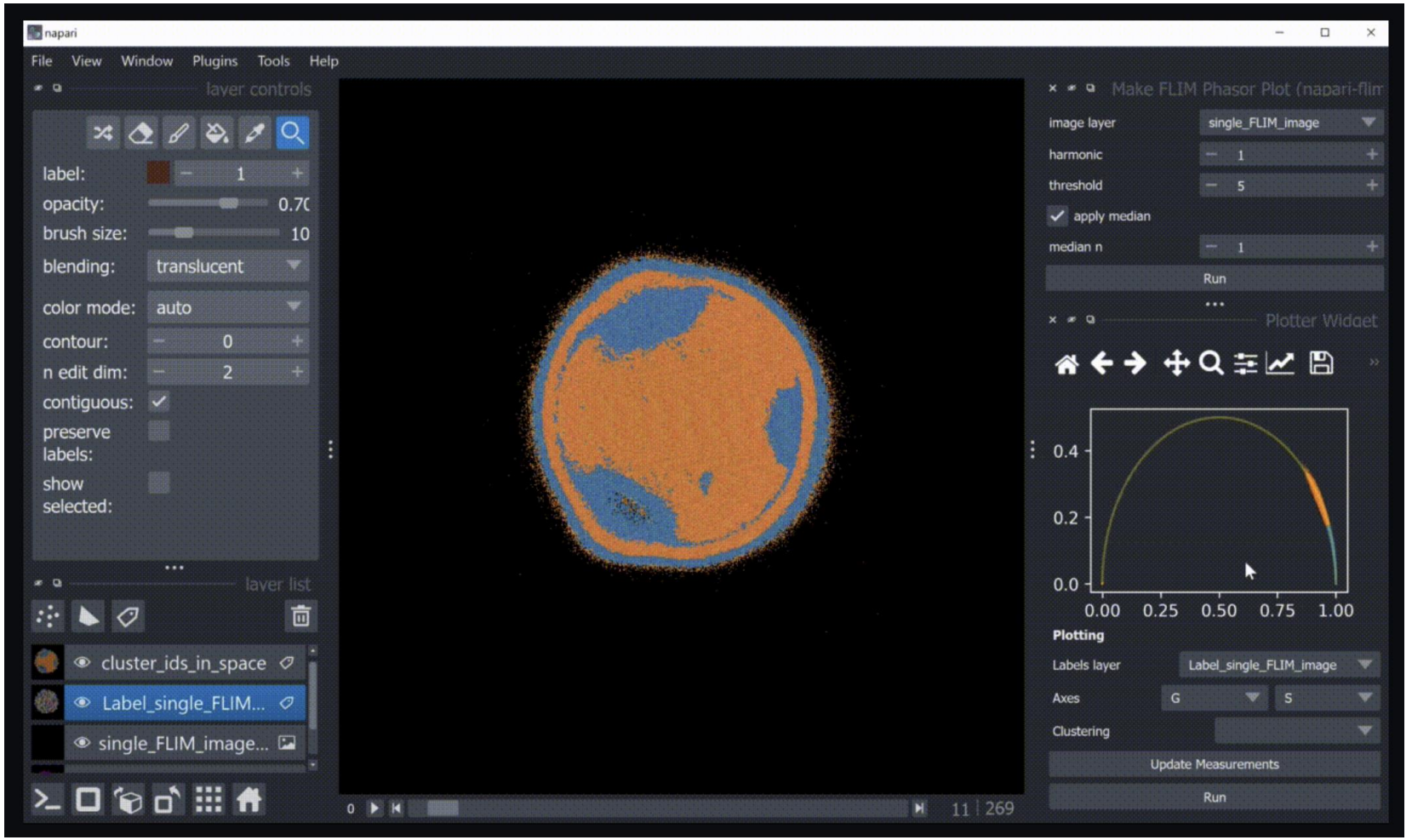
- Surface extraction & analysis



Work with Zach Marin https://github.com/zacsimile/napari-pymeshlab
https://github.com/haesleinhuepf/napari-process-points-and-surfaces

Napari-flim-phasor-plotter

Read raw TCSPC FLIM data and cluster the phasor plot for segmentation

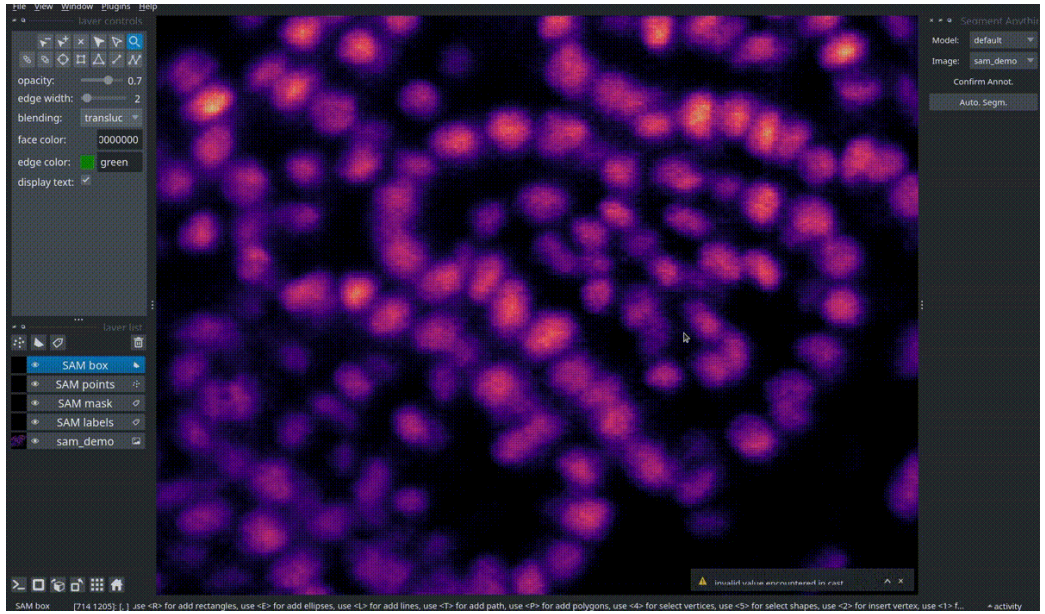


https://github.com/zoccoler/napari-flim-phasor-plotter

@zoccolermarcelo

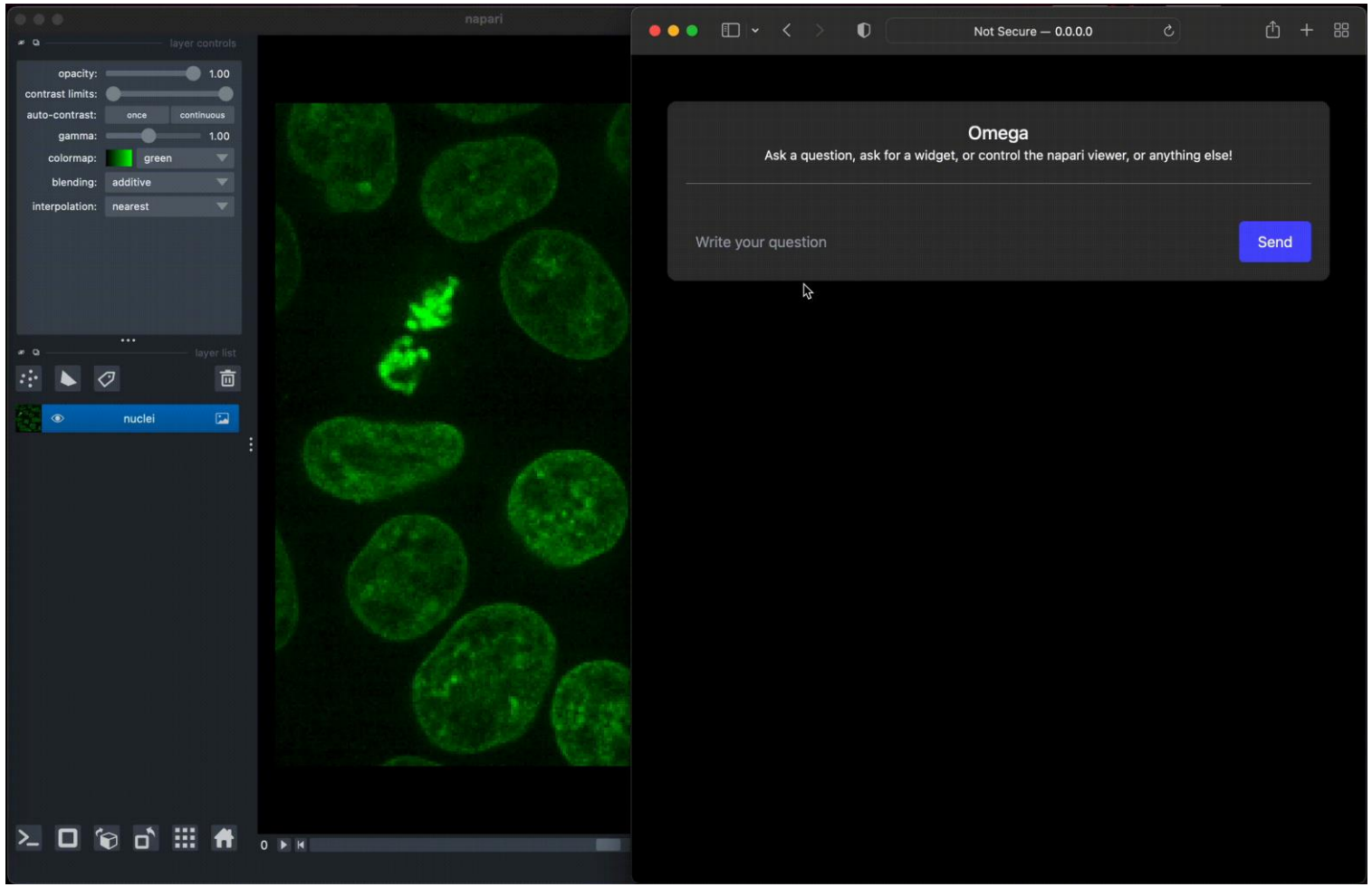
Napari-sam plugins

https://github.com/MIC-DKFZ/napari-sam



https://github.com/royerlab/napari-segment-anything

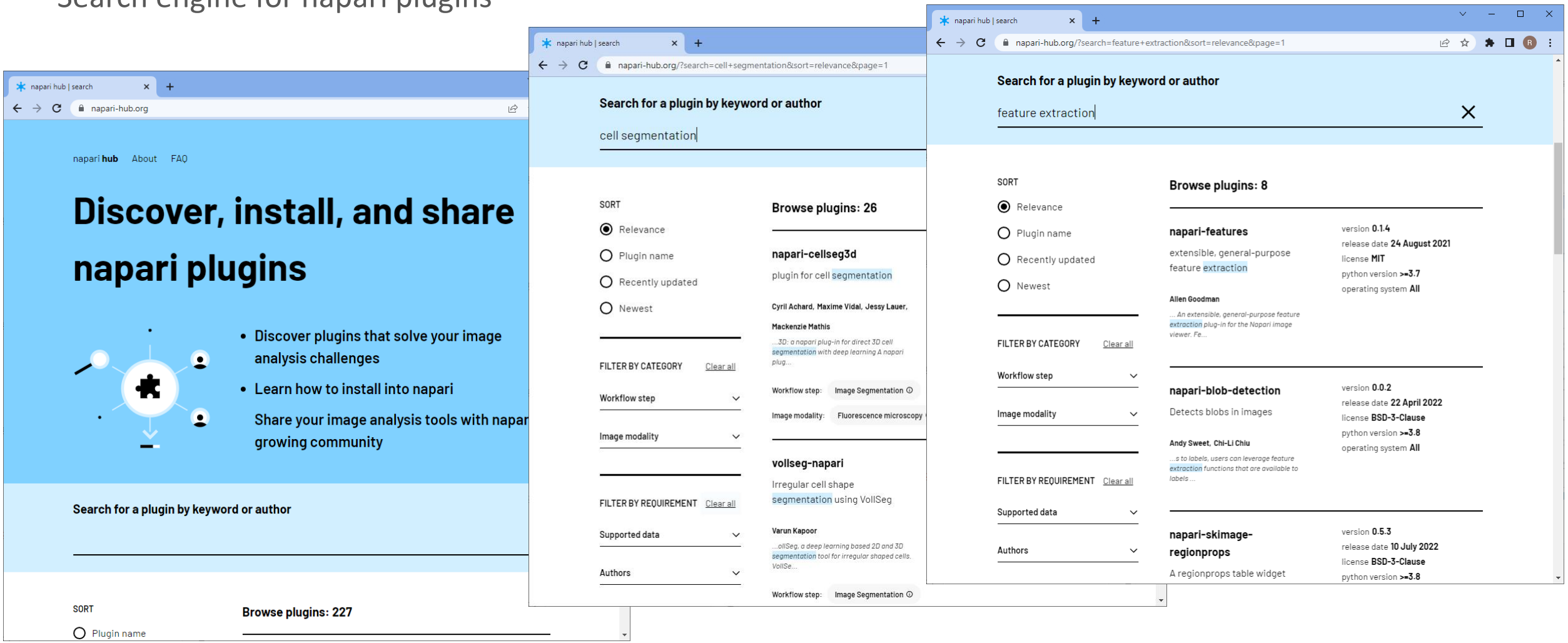
chatGPT plugin



https://github.com/royerlab/napari-chatgpt

The Napari Hub

- The plugin you are looking for may be near you!
- Search engine for napari plugins



https://www.napari-hub.org/

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Image Analysis Basics with Python

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Arrays in Python

- Modifying lists entries

```
numbers = [0, 1, 2, 3, 4]

# write in one array element
numbers[1] = 5

print(numbers)
```

```
[0, 5, 2, 3, 4]
```

Note: The first element has index 0!

- Creating lists of defined size

What?

How many?

```
zeros = [0] * 10
print(zeros)
```

```
[0, 0, 0, 0, 0, 0, 0, 0, 0, 0]
```

- Concatenating lists

```
ones = [1, 1, 1]
twos = [2, 2, 2, 2]

# concatenate arrays
numbers = ones + twos

print(numbers)
```

```
[1, 1, 1, 2, 2, 2, 2]
```

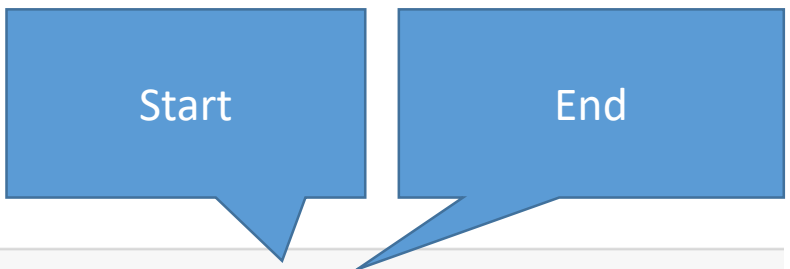
+ means appending

Subsets

```
# Arrays
numbers = [0, 1, 2, 3, 4, 5, 6, 7, 8, 9]
print(numbers)
```

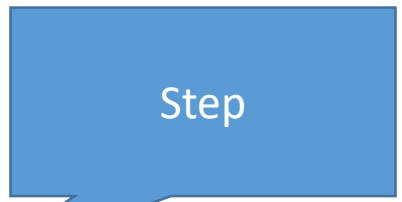
```
[0, 1, 2, 3, 4, 5, 6, 7, 8, 9]
```

- Creating subsets of lists




```
subset = numbers[2:4]
print(subset)
```

```
[2, 3]
```




```
subset_with_gaps = arr[1:8:2]
print(subset_with_gaps)
```

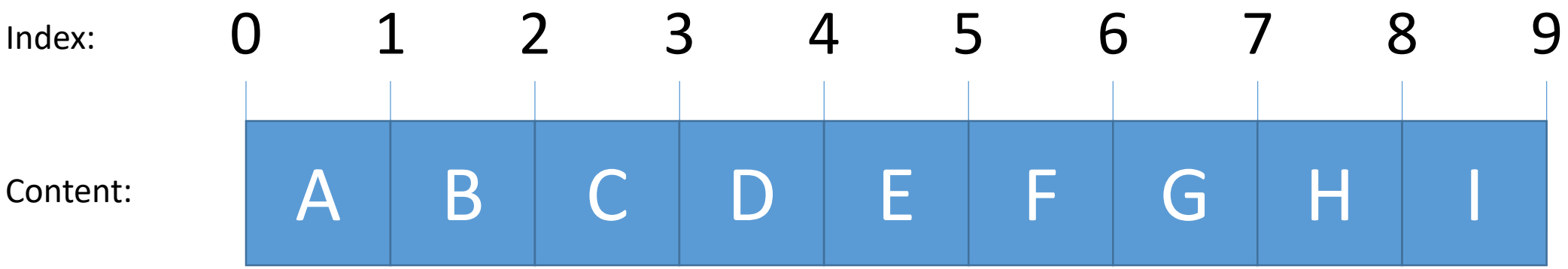
```
[1, 3, 5, 7]
```

data[start:stop:step]

Indexing, cropping, subsets

- “Indexing” is addressing certain elements in lists. The first element is “0” away from the start.

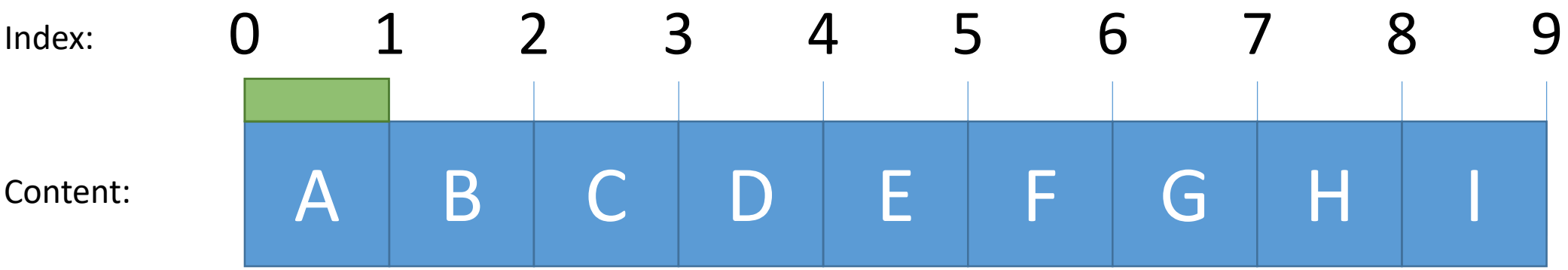
```
data = ['A', 'B', 'C', 'D', 'E', 'F', 'G', 'H', 'I']
```



Indexing, cropping, subsets

- “Indexing” is addressing certain elements in lists. The first element is “0” away from the start.

```
data = ['A', 'B', 'C', 'D', 'E', 'F', 'G', 'H', 'I']
```



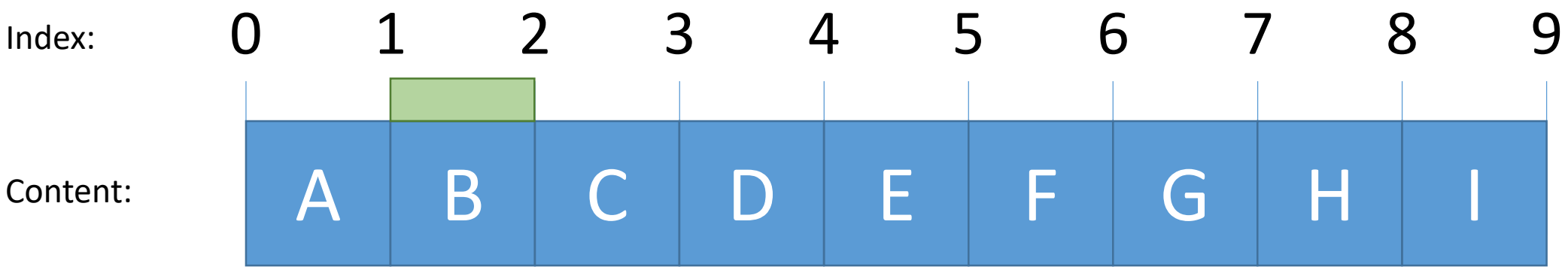

```
data[0]
```

```
'A'
```

Indexing, cropping, subsets

- “Indexing” is addressing certain elements in lists. The first element is “0” away from the start.

```
data = ['A', 'B', 'C', 'D', 'E', 'F', 'G', 'H', 'I']
```




```
data[0]
```

```
'A'
```

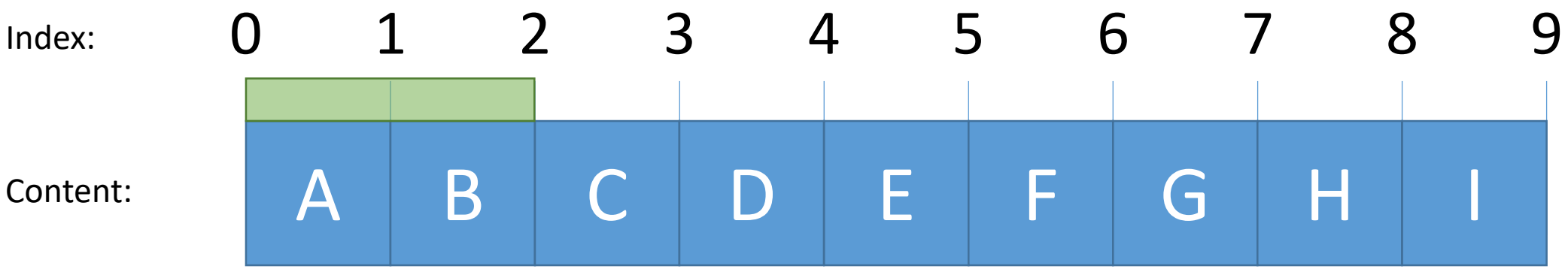
```
data[1]
```

```
'B'
```

Indexing, cropping, subsets

- “Indexing” is addressing certain elements in lists. The first element is “0” away from the start.

```
data = ['A', 'B', 'C', 'D', 'E', 'F', 'G', 'H', 'I']
```




```
data[0]
```

```
'A'
```

```
data[1]
```

```
'B'
```

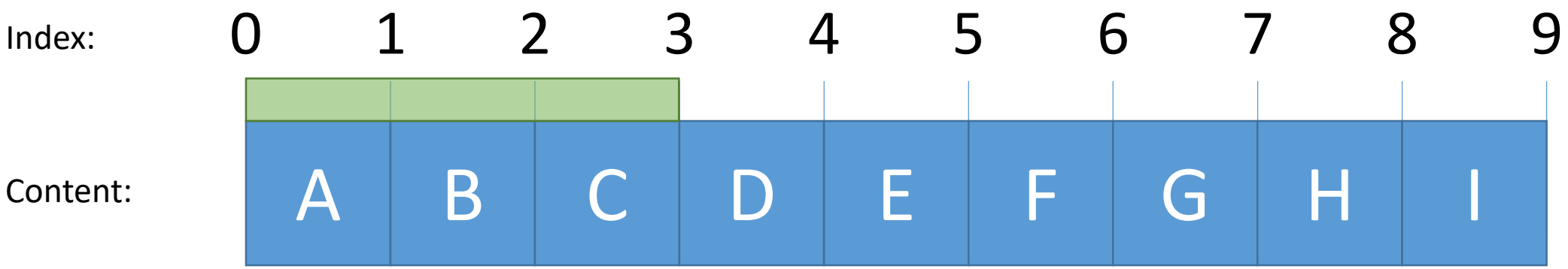
```
data[0:2]
```

```
['A', 'B']
```

Indexing, cropping, subsets

- “Indexing” is addressing certain elements in lists. The first element is “0” away from the start.

```
data = ['A', 'B', 'C', 'D', 'E', 'F', 'G', 'H', 'I']
```




```
data[0]
```
'A'

```
data[1]
```
'B'

```
data[0:2]
```
['A', 'B']

```
data[0:3]
```
['A', 'B', 'C']

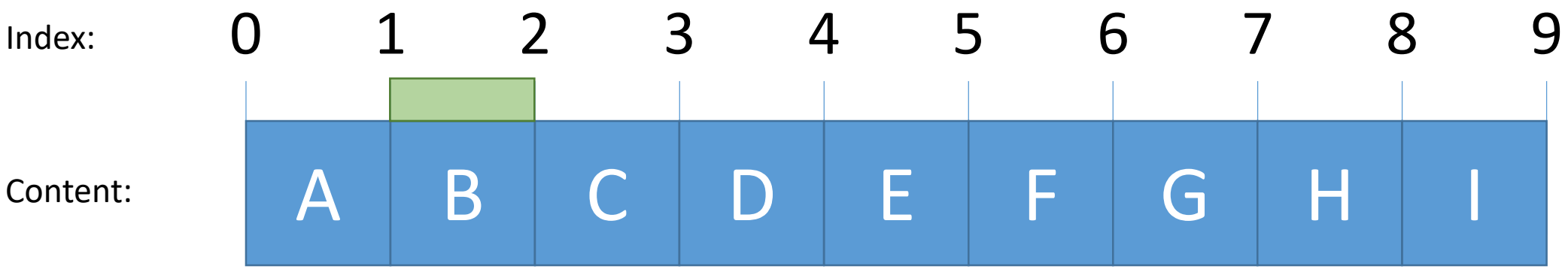
```
data[1:2]
```
['B']

```
len(data)
```
9

Indexing, cropping, subsets

- “Indexing” is addressing certain elements in lists. The first element is “0” away from the start.

```
data = ['A', 'B', 'C', 'D', 'E', 'F', 'G', 'H', 'I']
```




```
data[0]
```
```
'A'
```

```
data[1]
```
```
'B'
```

```
data[0:2]
```
```
['A', 'B']
```

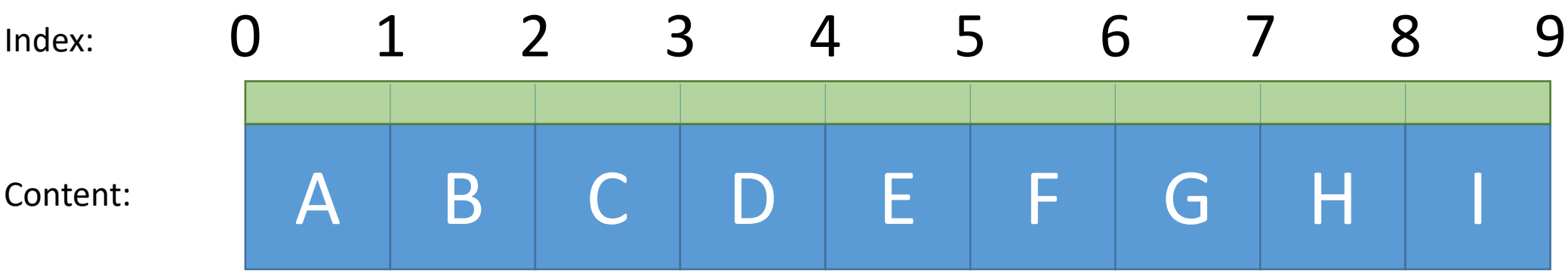
```
data[0:3]
```
```
['A', 'B', 'C']
```

```
data[1:2]
```
```
['B']
```

Indexing, cropping, subsets

- “Indexing” is addressing certain elements in lists. The first element is “0” away from the start.

```
data = ['A', 'B', 'C', 'D', 'E', 'F', 'G', 'H', 'I']
```

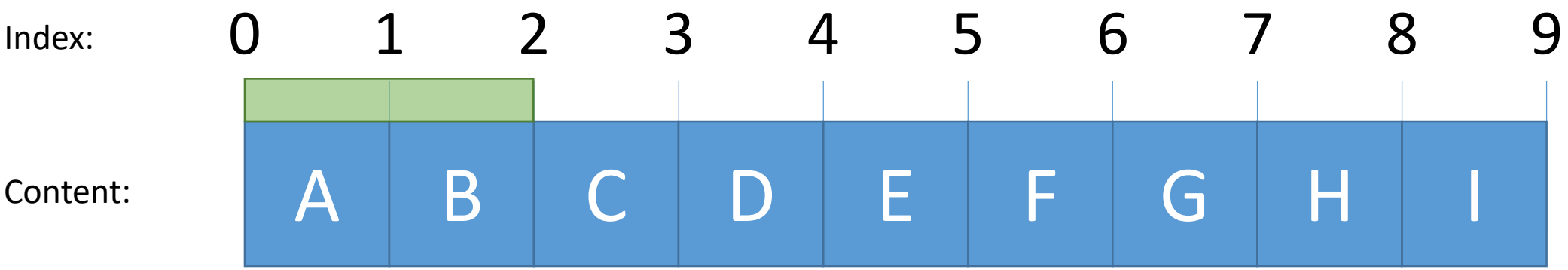


`data[0]`	`data[1]`	`data[0:2]`	`data[0:3]`	`data[1:2]`	`len(data)`
`'A'`	`'B'`	`['A', 'B']`	`['A', 'B', 'C']`	`['B']`	`9`

Indexing, cropping, subsets

- You can leave start and end out when specifying index ranges

```
data = ['A', 'B', 'C', 'D', 'E', 'F', 'G', 'H', 'I']
```




```
data[:2]
```

```
['A', 'B']
```

Indexing, cropping, subsets

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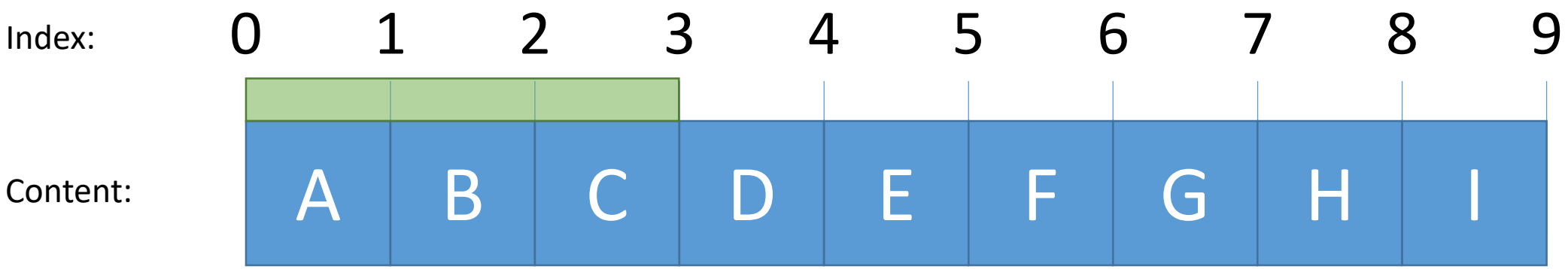
- You can leave start and end out when specifying index ranges

```
data = ['A', 'B', 'C', 'D', 'E', 'F', 'G', 'H', 'I']
```




```
data[:2]
```

```
['A', 'B']
```

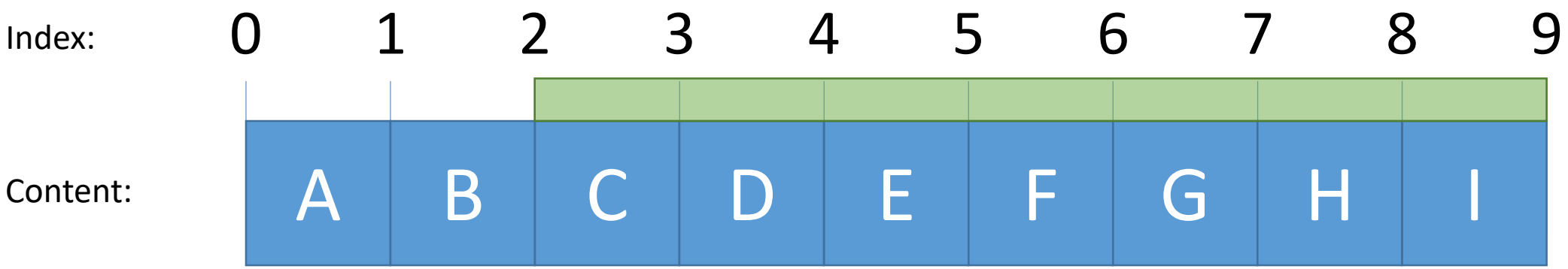
```
data[:3]
```

```
['A', 'B', 'C']
```

Indexing, cropping, subsets

- You can leave start and end out when specifying index ranges

```
data = ['A', 'B', 'C', 'D', 'E', 'F', 'G', 'H', 'I']
```




```
data[:2]
```

```
['A', 'B']
```

```
data[:3]
```

```
['A', 'B', 'C']
```

```
data[2:]
```

```
['C', 'D', 'E', 'F', 'G', 'H', 'I']
```

Indexing, cropping, subsets

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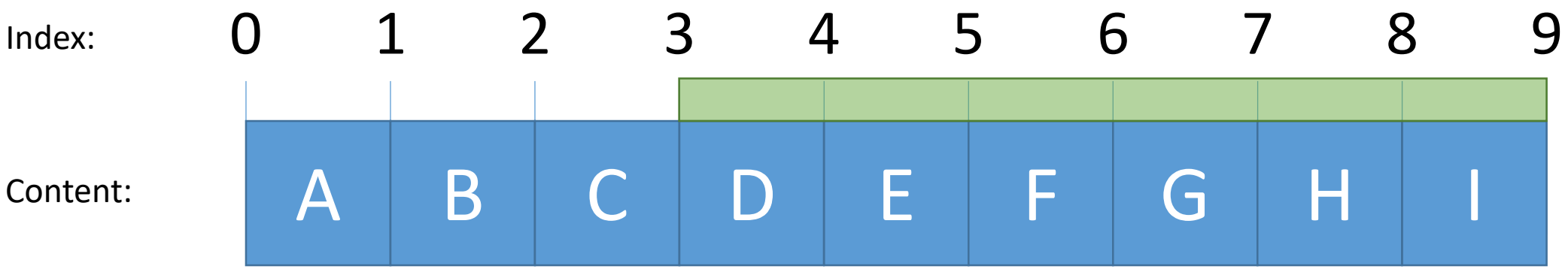
- You can leave start and end out when specifying index ranges

```
data = ['A', 'B', 'C', 'D', 'E', 'F', 'G', 'H', 'I']
```




```
data[:2]
```

```
['A', 'B']
```

```
data[:3]
```

```
['A', 'B', 'C']
```

```
data[2:]
```

```
['C', 'D', 'E', 'F', 'G', 'H', 'I']
```

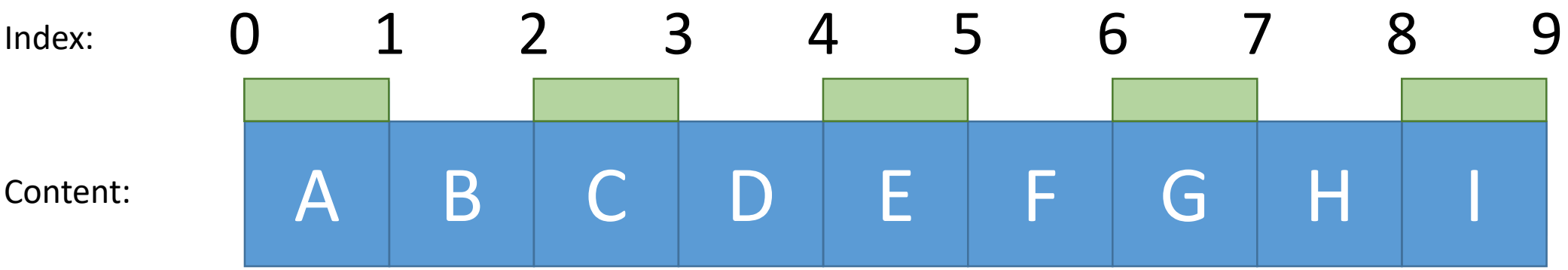
```
data[3:]
```

```
['D', 'E', 'F', 'G', 'H', 'I']
```

Indexing, cropping, subsets

- The step-size allows skipping elements

```
data = ['A', 'B', 'C', 'D', 'E', 'F', 'G', 'H', 'I']
```



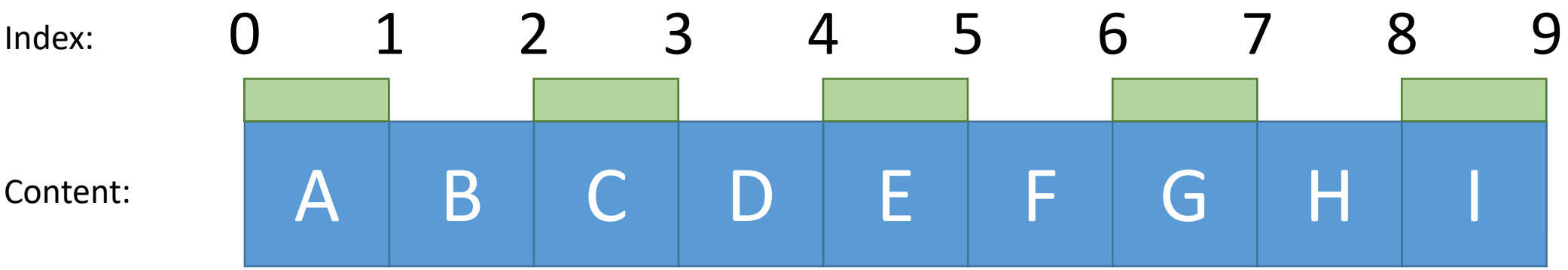

```
data[0:10:2]
```

```
['A', 'C', 'E', 'G', 'I']
```

Indexing, cropping, subsets

- The step-size allows skipping elements

```
data = ['A', 'B', 'C', 'D', 'E', 'F', 'G', 'H', 'I']
```




```
data[0:10:2]
```

```
['A', 'C', 'E', 'G', 'I']
```

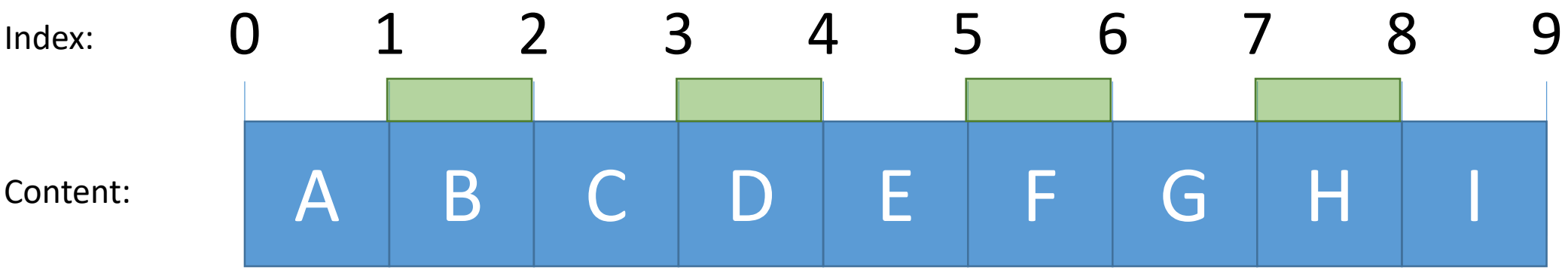
```
data[::2]
```

```
['A', 'C', 'E', 'G', 'I']
```

Indexing, cropping, subsets

- The step-size allows skipping elements

```
data = ['A', 'B', 'C', 'D', 'E', 'F', 'G', 'H', 'I']
```




```
data[0:10:2]
```

```
['A', 'C', 'E', 'G', 'I']
```

```
data[::2]
```

```
['A', 'C', 'E', 'G', 'I']
```

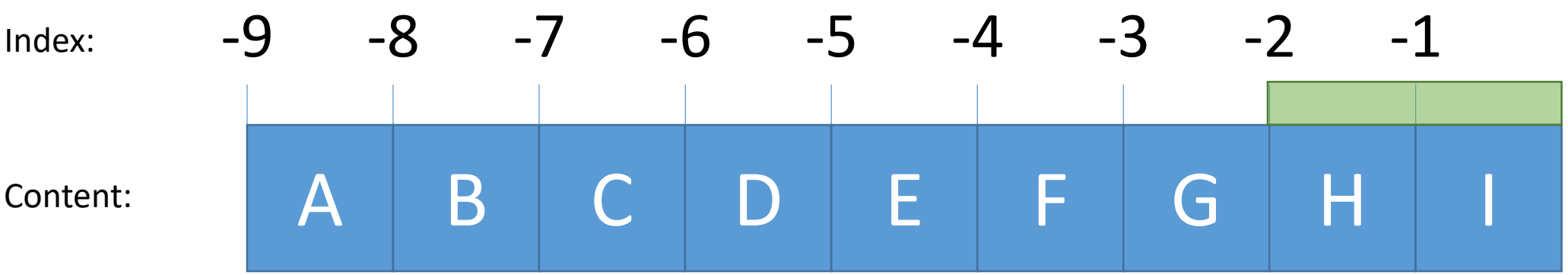
```
data[1::2]
```

```
['B', 'D', 'F', 'H']
```

Indexing, cropping, subsets

- Indexing also works with negative indices

```
data = ['A', 'B', 'C', 'D', 'E', 'F', 'G', 'H', 'I']
```



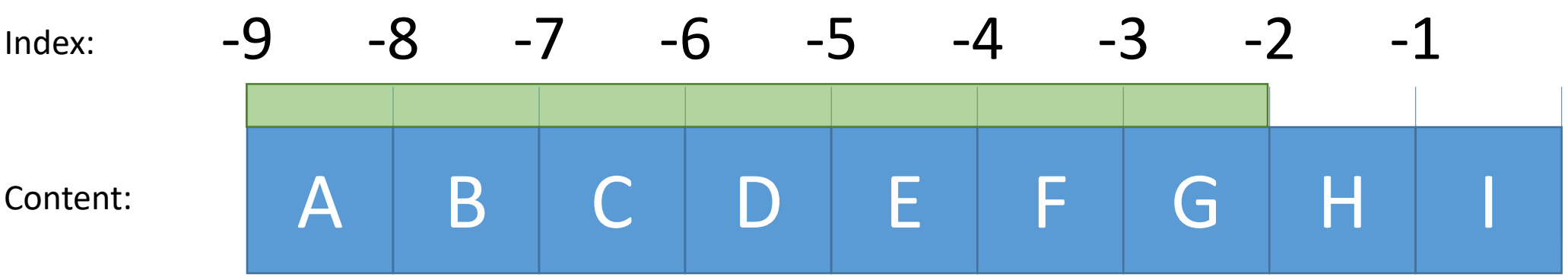

```
data[-2:]
```

```
['H', 'I']
```

Indexing, cropping, subsets

- Indexing also works with negative indices

```
data = ['A', 'B', 'C', 'D', 'E', 'F', 'G', 'H', 'I']
```




```
data[-2:]
```

```
['H', 'I']
```

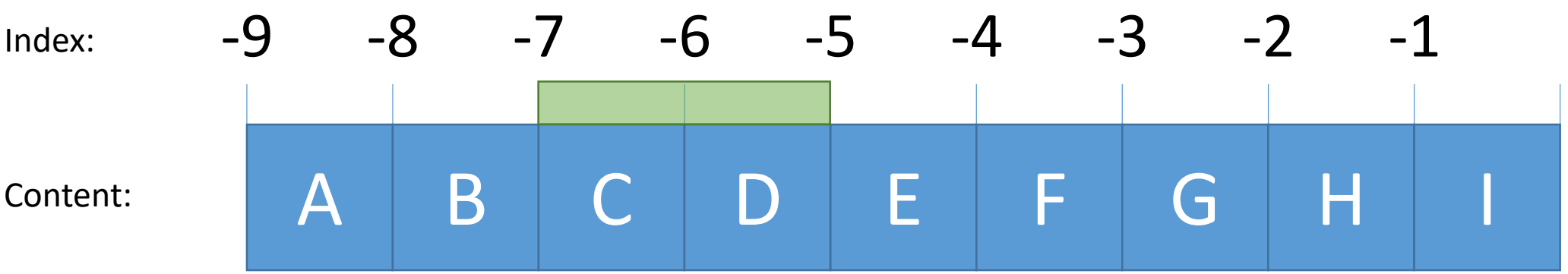
```
data[:-2]
```

```
['A', 'B', 'C', 'D', 'E', 'F', 'G']
```

Indexing, cropping, subsets

- Indexing also works with negative indices

```
data = ['A', 'B', 'C', 'D', 'E', 'F', 'G', 'H', 'I']
```




```
data[-2:]
```

```
['H', 'I']
```

```
data[:-2]
```

```
['A', 'B', 'C', 'D', 'E', 'F', 'G']
```

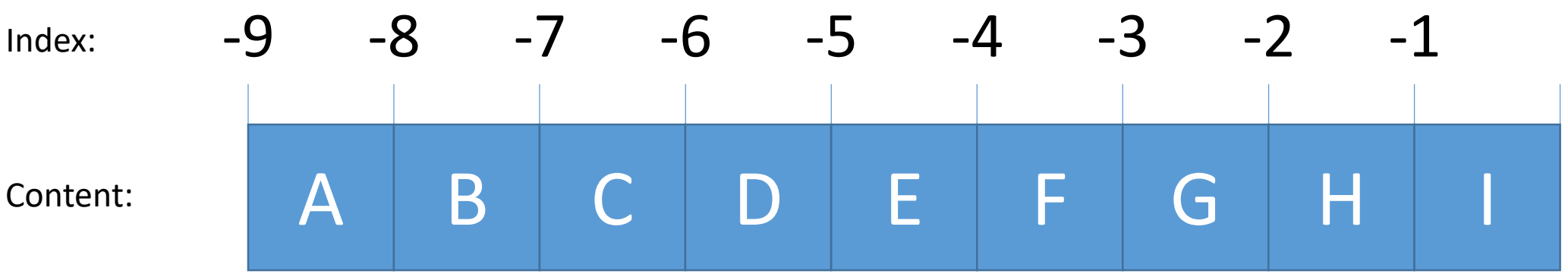
```
data[-7:-5]
```

```
['C', 'D']
```

Indexing, cropping, subsets

- Indexing also works with negative indices

```
data = ['A', 'B', 'C', 'D', 'E', 'F', 'G', 'H', 'I']
```




```
data[-2:]
```

```
['H', 'I']
```

```
data[:-2]
```

```
['A', 'B', 'C', 'D', 'E', 'F', 'G']
```

```
data[-7:-5]
```

```
['C', 'D']
```

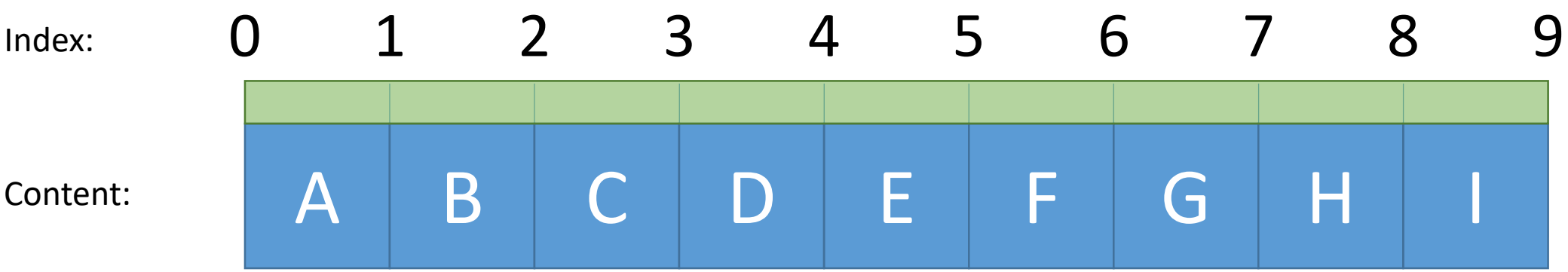
```
data[-5:-7]
```

```
[]
```

Indexing, cropping, subsets

- Negative stepping also works

```
data = ['A', 'B', 'C', 'D', 'E', 'F', 'G', 'H', 'I']
```



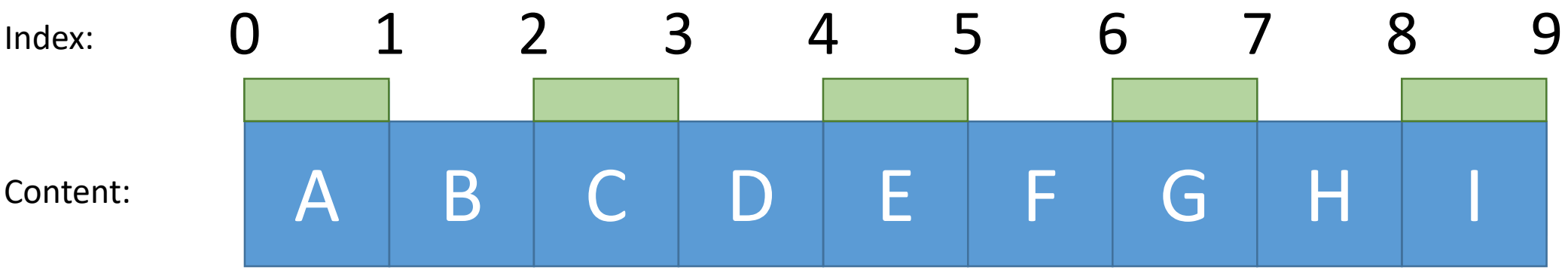

```
data[::-1]
```

```
['I', 'H', 'G', 'F', 'E', 'D', 'C', 'B', 'A']
```

Indexing, cropping, subsets

- Negative stepping also works

```
data = ['A', 'B', 'C', 'D', 'E', 'F', 'G', 'H', 'I']
```




```
data[::-1]
```

```
['I', 'H', 'G', 'F', 'E', 'D', 'C', 'B', 'A']
```

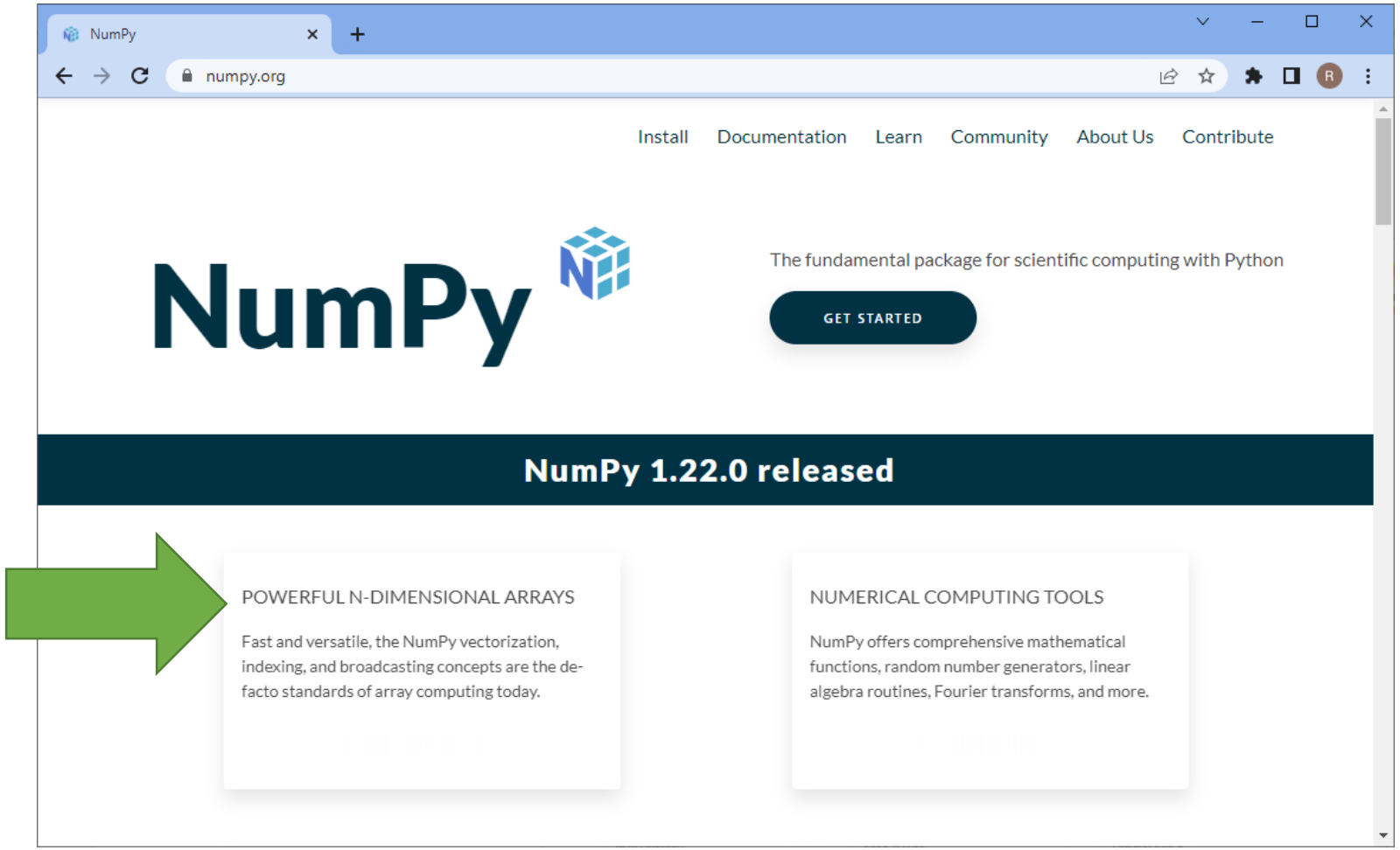
```
data[::-2]
```

```
['I', 'G', 'E', 'C', 'A']
```

numpy

- The fundamental package for scientific computing with python.

- `conda install numpy`



https://numpy.org/

numpy

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- Simplifying mathematical operations on n-dimensional arrays

- Python arrays of arrays (lists of lists)

```
# multidimensional arrays
matrix = [
    [1, 2, 3],
    [2, 3, 4],
    [3, 4, 5]
]

print(matrix)
```

```
[[1, 2, 3], [2, 3, 4], [3, 4, 5]]
```

```
result = matrix * 2
print(result)
```

```
[[1, 2, 3], [2, 3, 4], [3, 4, 5], [1, 2, 3], [2, 3, 4], [3, 4, 5]]
```

- numpy arrays

Tell python that you want to use a library called numpy

```
import numpy as np

np_matrix = np.asarray(matrix)

print(np_matrix)
```

If “numpy” is to long, you can give an alias “np”

```
[[1 2 3]
 [2 3 4]
 [3 4 5]]
```

```
np_result = np_matrix * 2
print(np_result)
```

```
[[ 2  4  6]
 [ 4  6  8]
 [ 6  8 10]]
```

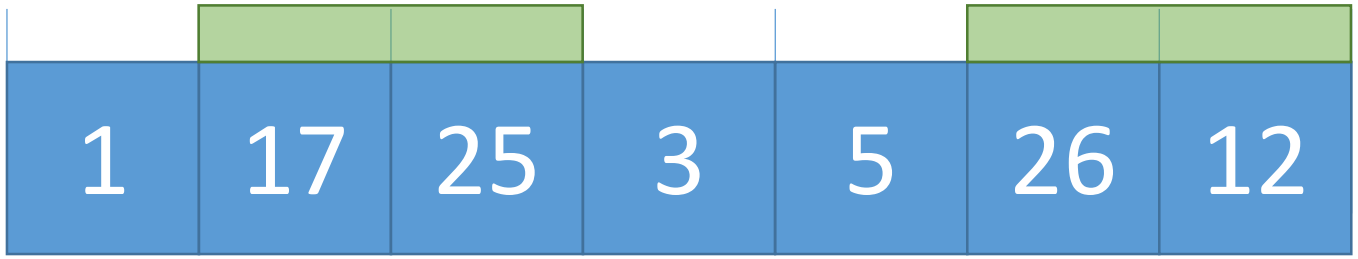
Masking

- “Masking” is addressing certain elements in numpy arrays, e.g. depending on their content

```
import numpy
measurements = numpy.asarray([1, 17, 25, 3, 5, 26, 12])
measurements
```

```
array([ 1, 17, 25,  3,  5, 26, 12])
```

Content:




```
mask = measurements > 10
mask
```

```
array([False,  True,  True, False, False,  True,  True])
```

```
measurements[mask]
```

```
array([17, 25, 26, 12])
```

Basic descriptive statistics using numpy

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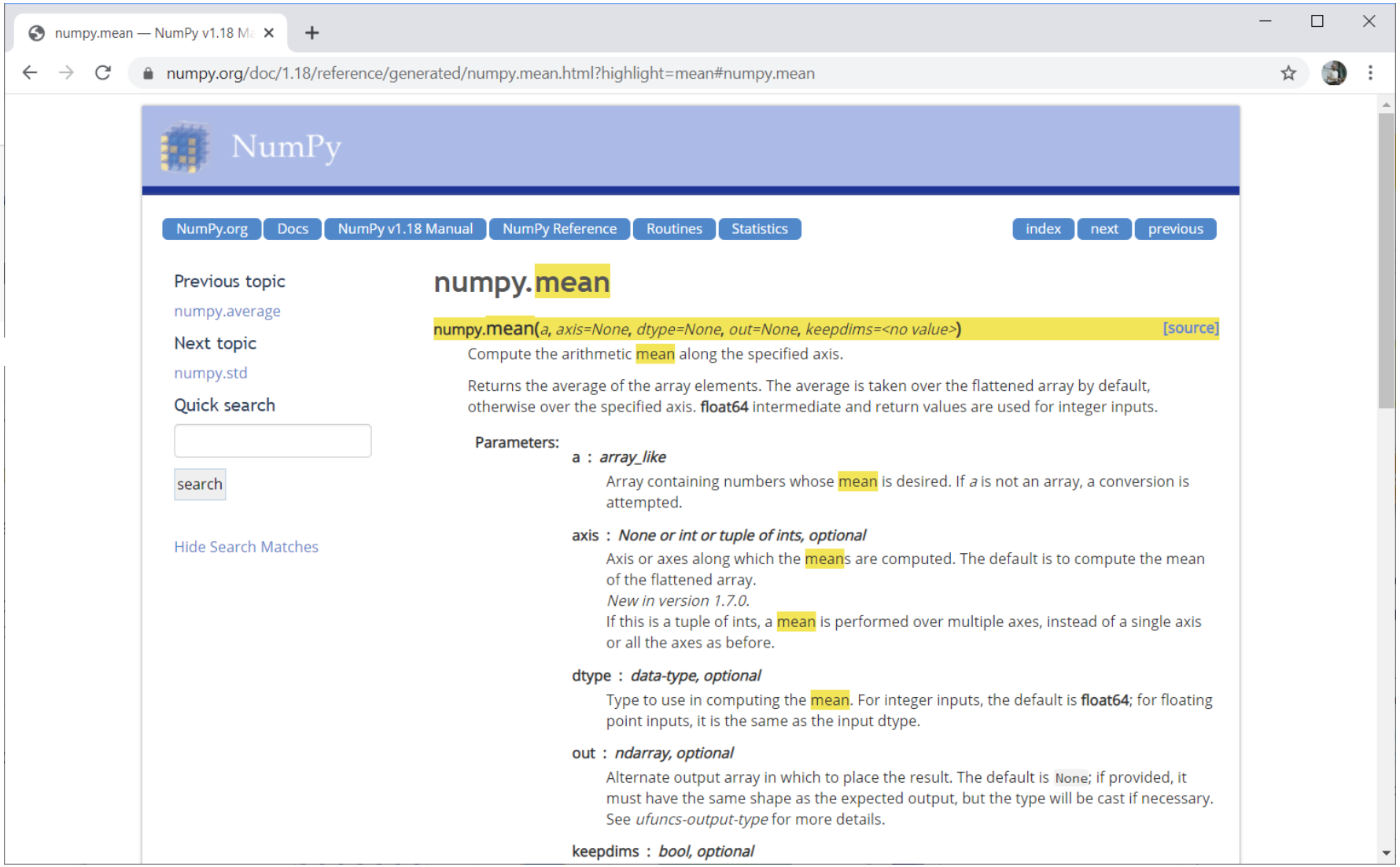
- Basic descriptive statistics

```
import numpy as np

measurements = [1, 4, 6, 7, 2]

mean = np.mean(measurements)
print("Mean: " + str(mean))
```

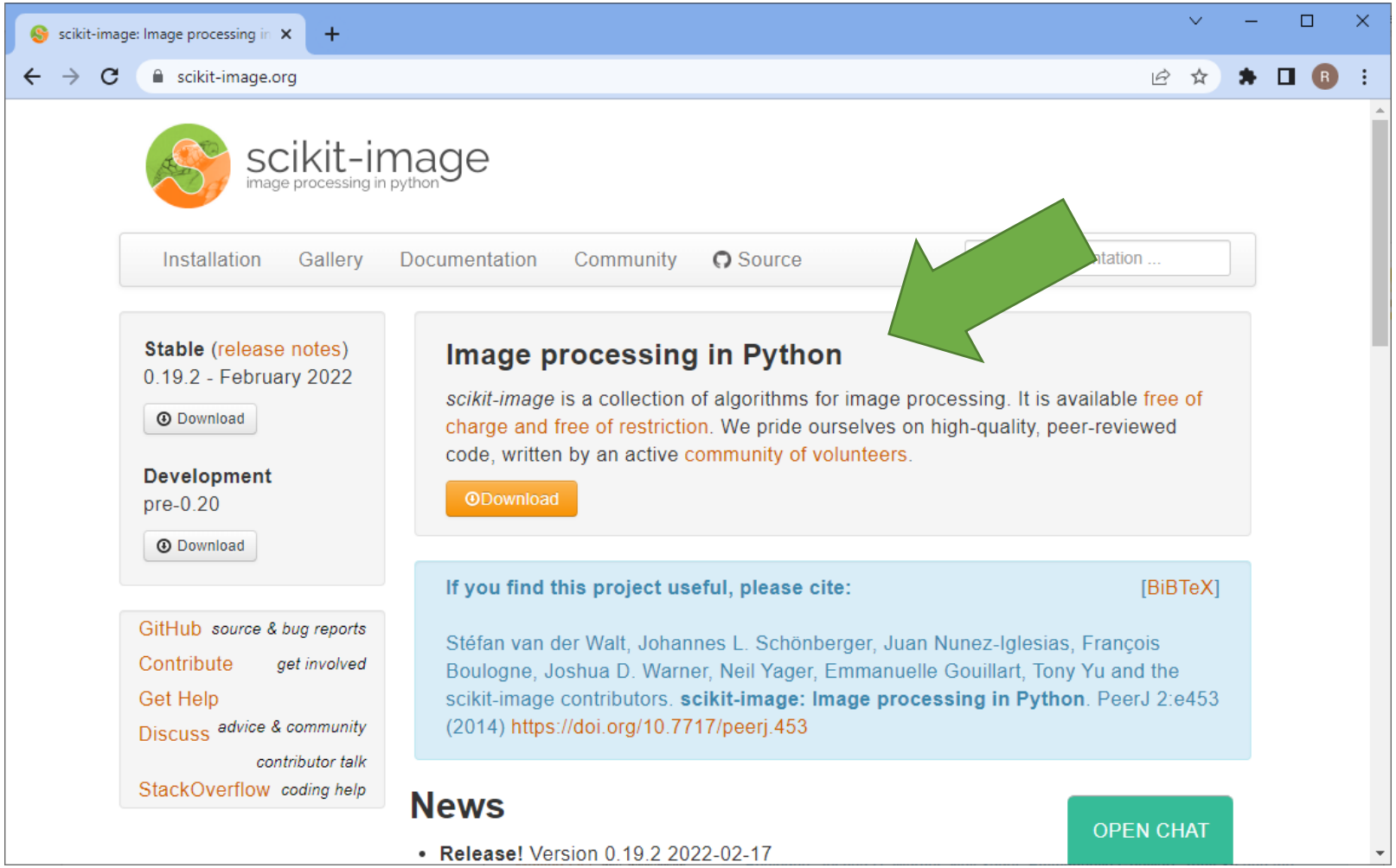
```
Mean: 4.0
```



scikit-image

- *scikit-image* is a collection of algorithms for image processing.

```
conda install scikit-image
```



https://scikit-image.org/

Tables

- Sneak preview: By the mid of the course, we will work with Pandas DataFrames, *fancy* Tables.

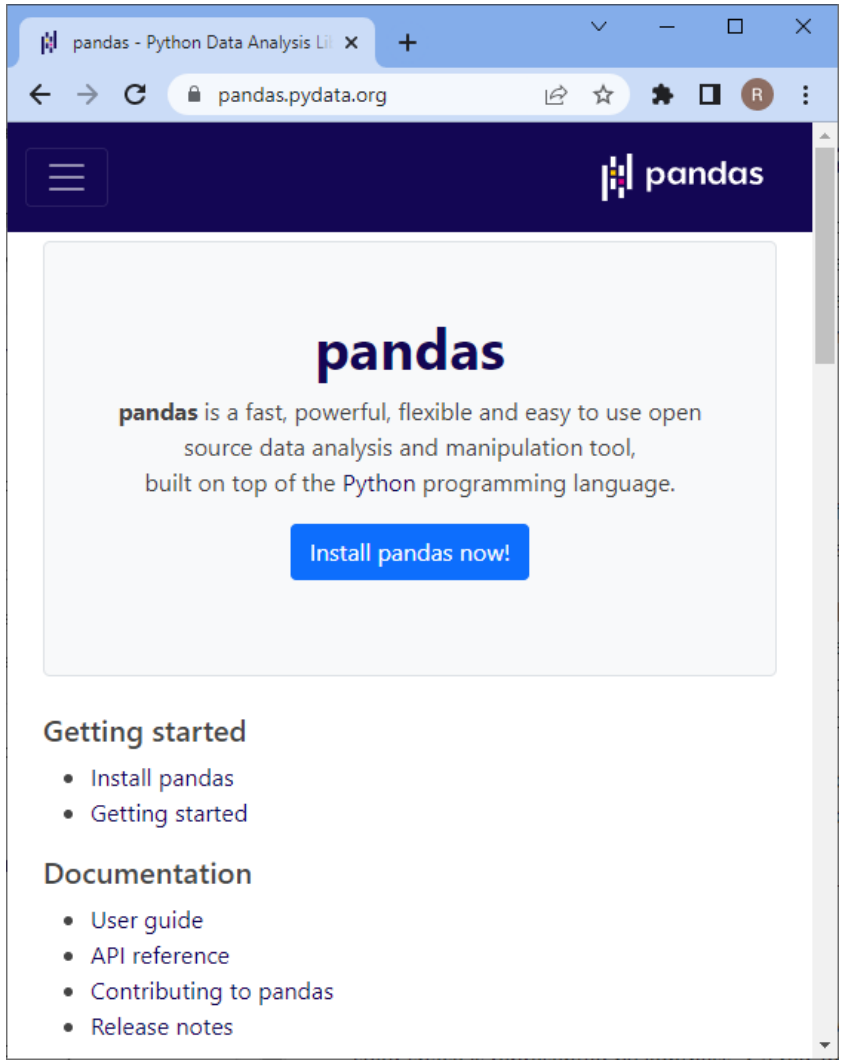
- `conda install pandas`

- Among many other features, Pandas allows to visualize tables nicely in Jupyter notebooks.

```
import pandas

pandas.DataFrame(measurements_week)
```

	Monday	Tuesday	Wednesday	Thursday	Friday
0	2.3	1.8	4.5	1.9	4.4
1	3.1	7.0	1.5	2.0	2.3
2	5.6	4.3	3.2	6.4	5.4



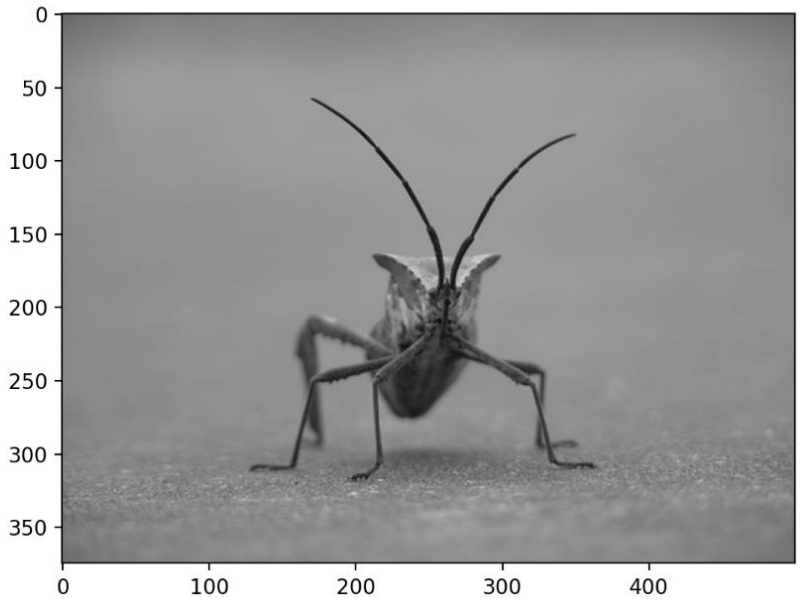
https://pandas.pydata.org/

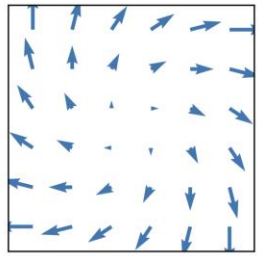
matplotlib

- *matplotlib* is the standard python library for plotting data.

```
conda install matplotlib
```

```
imgplot = plt.imshow(img)
```





https://matplotlib.org/

Working with images in python

- Open images

```
from skimage.io import imread

image = imread("blobs.tif")
```

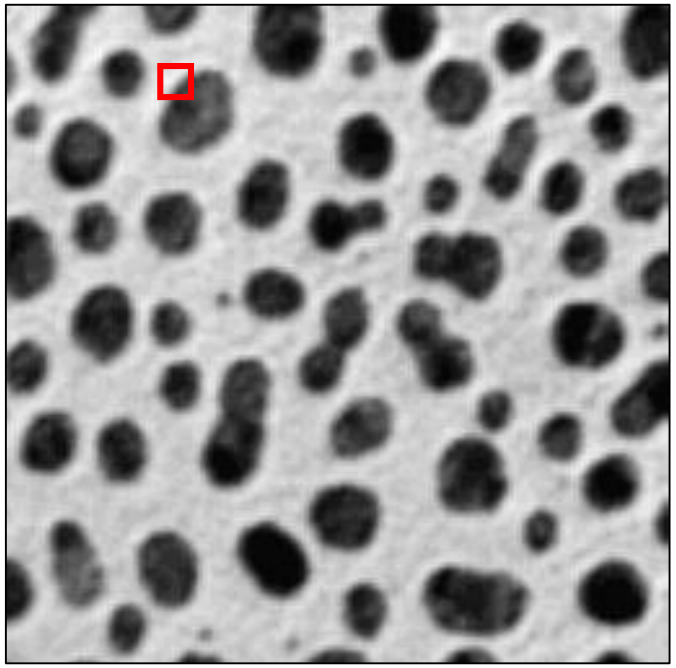
```
image
```

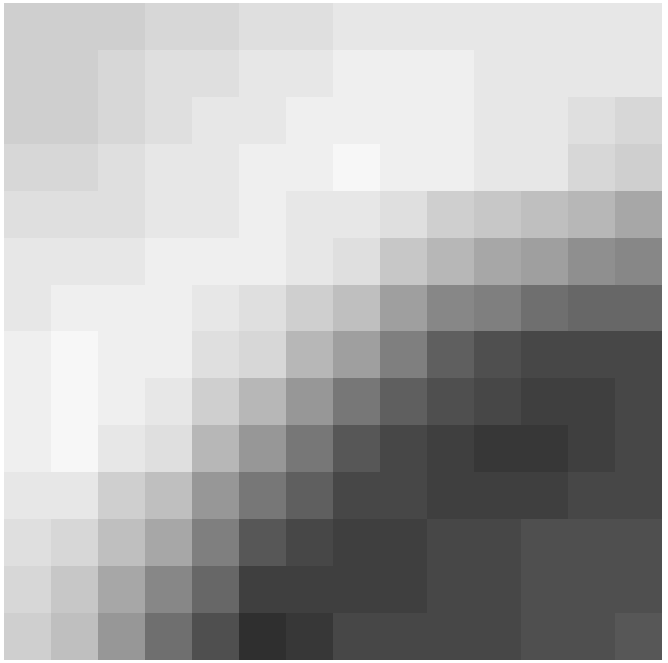
```
array([[ 40,  32,  24, ..., 216, 200, 200],
       [ 56,  40,  24, ..., 232, 216, 216],
       [ 64,  48,  24, ..., 240, 232, 232],
       ...,
       [ 72,  80,  80, ...,  48,  48,  48],
       [ 80,  80,  80, ...,  48,  48,  48],
       [ 96,  88,  80, ...,  48,  48,  48]], dtype=uint8)
```

Images are *just* multi-dimensional arrays or "arrays of arrays".

Images and pixels

- An image is just a matrix of numbers
- Pixel: “picture element”
- The edges between pixels are an artefact. In reality, they don’t exist!



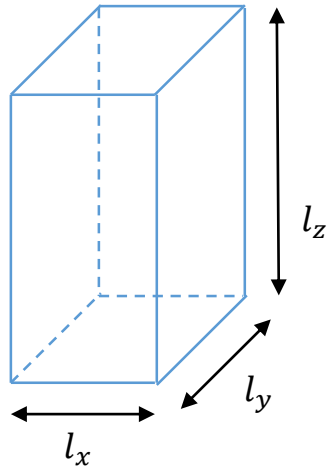


48	48	48	40	40	32	32	24	24	24	24	24	24	24
48	48	40	32	32	24	24	16	16	16	24	24	24	24
48	48	40	32	24	24	16	16	16	16	24	24	32	40
40	40	32	24	24	16	16	8	16	16	24	24	40	48
32	32	32	24	24	16	24	24	32	48	56	64	72	88
24	24	24	16	16	16	24	32	56	72	88	96	112	120
24	16	16	16	24	32	48	64	96	120	128	144	152	152
16	8	16	16	32	40	72	96	128	160	176	184	184	184
16	8	16	24	48	72	104	136	160	176	184	192	192	184
16	8	24	32	72	104	136	168	184	192	200	200	192	184
24	24	48	64	104	136	160	184	184	192	192	192	184	184
32	40	64	88	128	168	184	192	192	184	184	176	176	176
40	56	88	120	152	192	192	192	192	184	184	176	176	176
48	64	104	144	176	208	200	184	184	184	184	176	176	168

Voxels

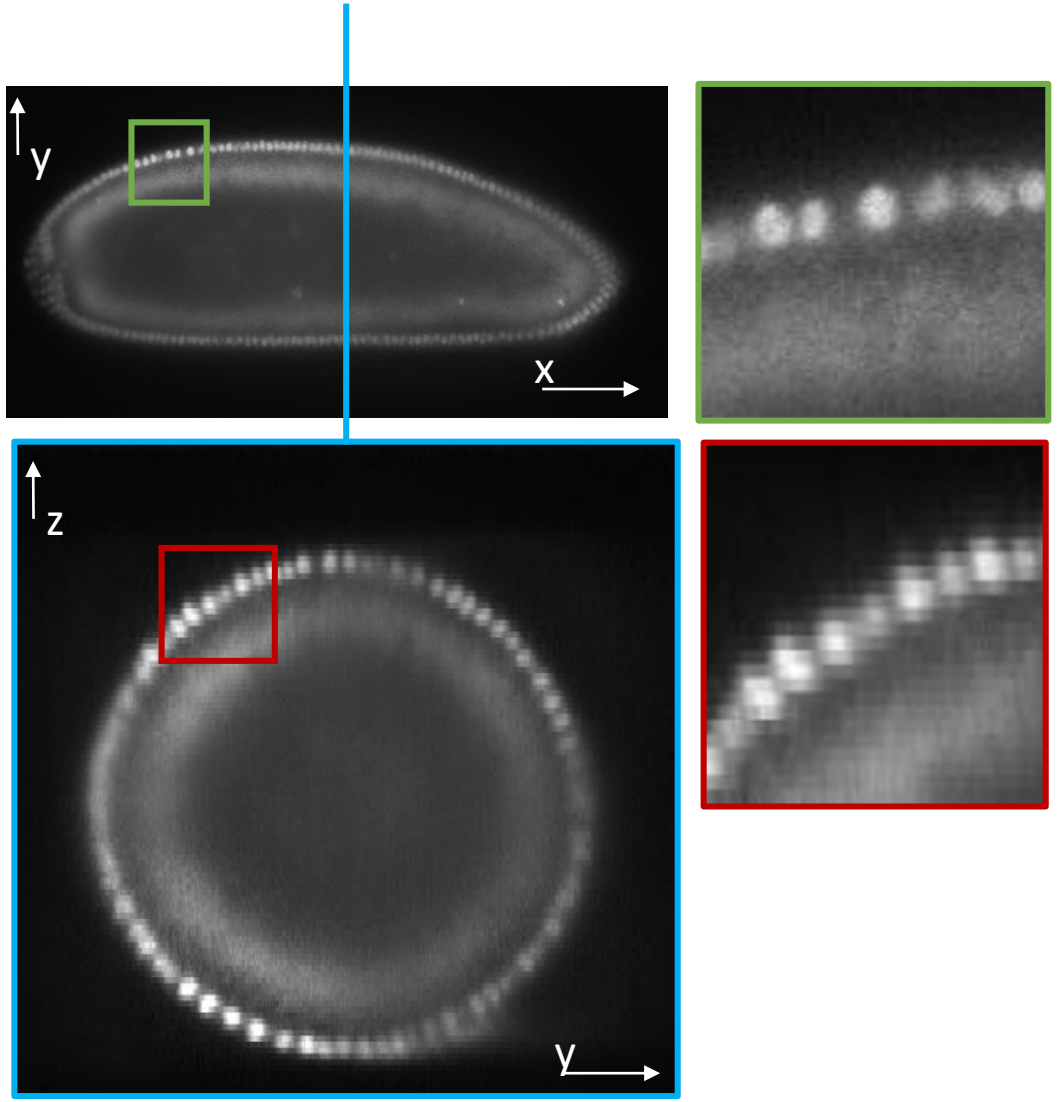
- Voxel: “Volume element”, usually anisotropic

- An-iso-tropy, from Greek:
  - ἀν- (not)
  - ἴσος *isos (equal)*
  - τρόπος *tropos (rotation, direction)*
- *Not the same in all directions*
- Usually in 3D image processing:



$$l_x = l_y \neq l_z$$

- Image analysts *love* to have isotropic voxels, but it’s often not possible.



Working with images in python

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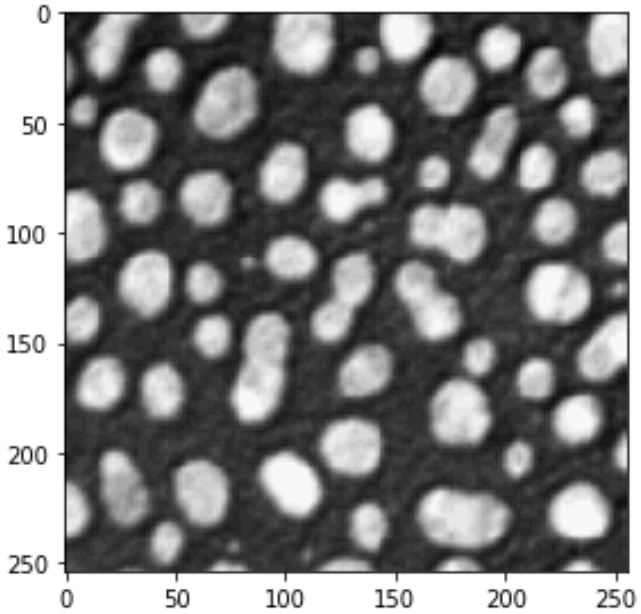
- Open images

```
from skimage.io import imread

image = imread("blobs.tif")
```

- Visualize images

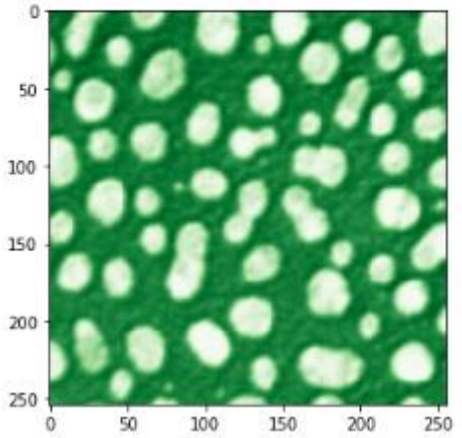
```
from skimage.io import imshow

imshow(image)
```

```
<matplotlib.image.AxesImage at 0x245e7
```



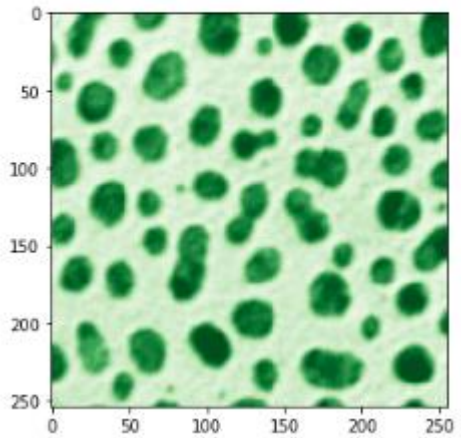

```
imshow(image, cmap="Greens_r")
```

```
<matplotlib.image.AxesImage at 0
```



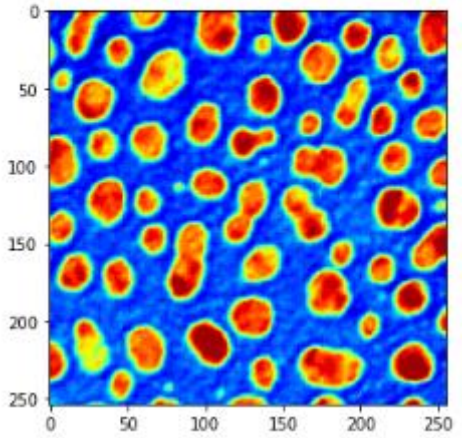

```
imshow(image, cmap="Greens")
```

```
<matplotlib.image.AxesImage at
```




```
imshow(image, cmap="jet")
```

```
<matplotlib.image.AxesImage at
```



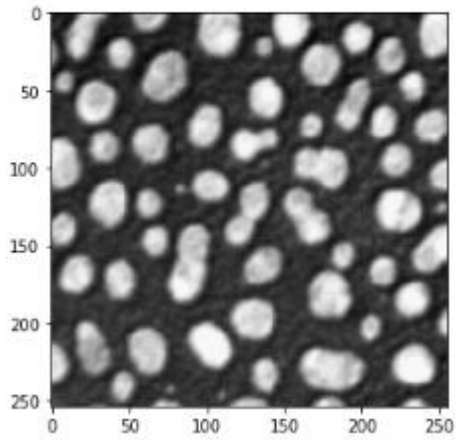
This does not modify the image data. The images are just shown with different colors representing the same values.

Cropping, sampling and flipping images

- Indexing and cropping *numpy-arrays* works like with python arrays.

```
imshow(image)
```

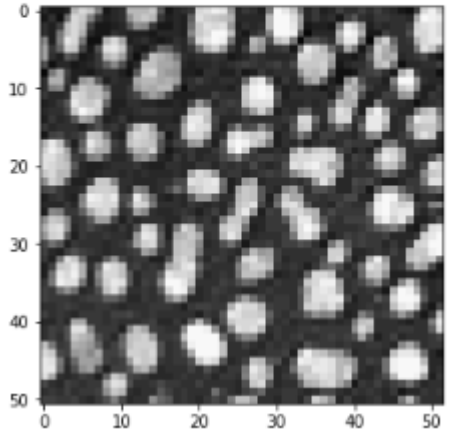
```
<matplotlib.image.AxesImage at 0
```



Original image

```
sampled_image = image[::5, ::5]

imshow(sampled_image)
```

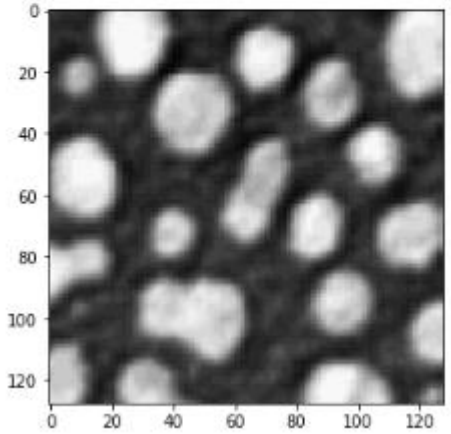
```
<matplotlib.image.AxesImage at 0
```



Sub-sampled image

```
cropped_image2 = image[0:128, 128:]

imshow(cropped_image2)
```

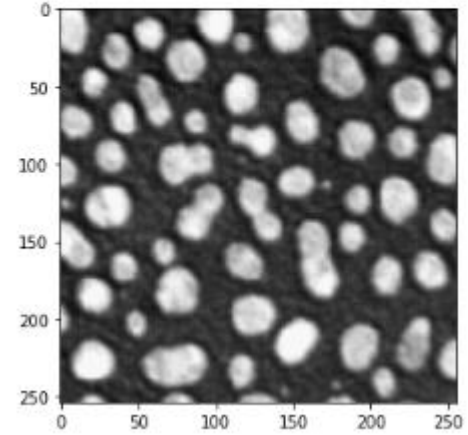
```
<matplotlib.image.AxesImage at 0x29e
```



Cropped image

```
flipped_image = image[:, ::-1]

imshow(flipped_image)
```

```
<matplotlib.image.AxesImage at 0x
```



Flipped image

Napari and Jupyter Notebooks

Napari from jupyter notebooks

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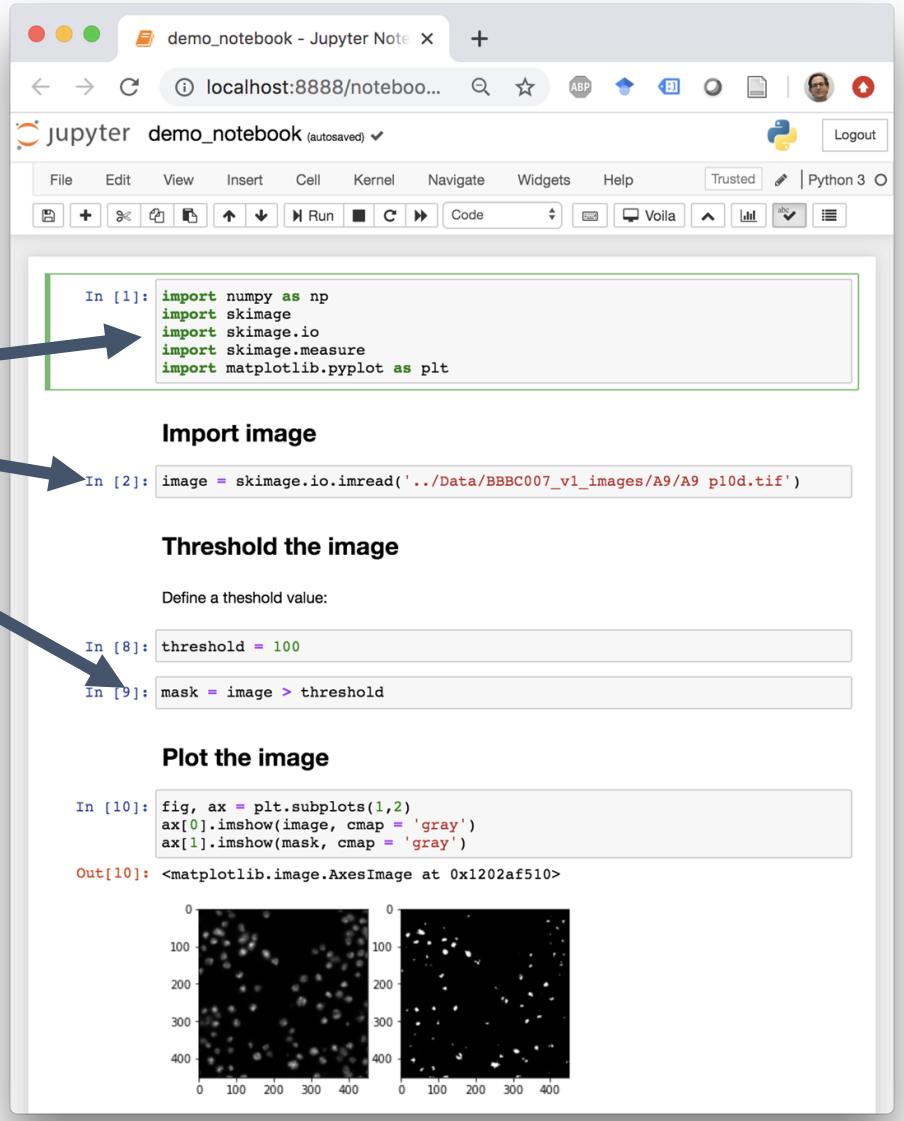
What is a jupyter notebook?

A text file (easily sent around)

Rendered by Jupyter in the browser

Split into sections called cells



Napari from jupyter notebooks

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What is a jupyter notebook?

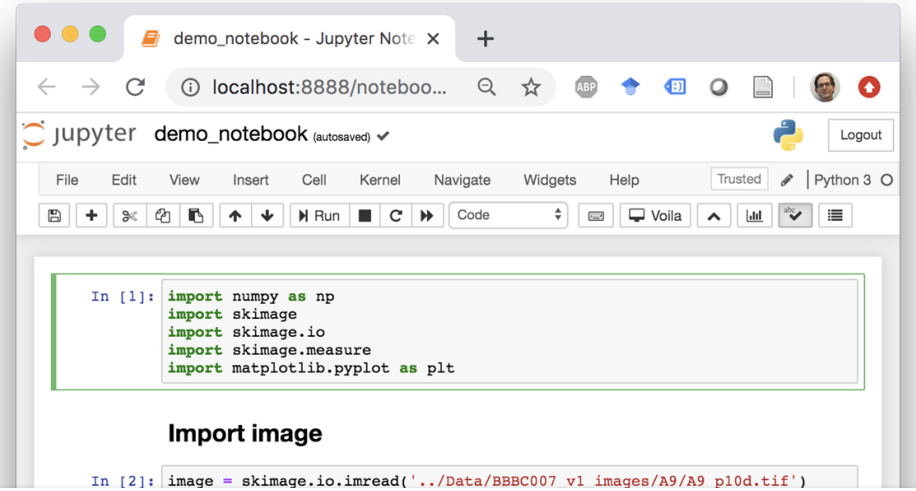
A text file (easily sent around)

Rendered by Jupyter in the browser

Split into sections called cells

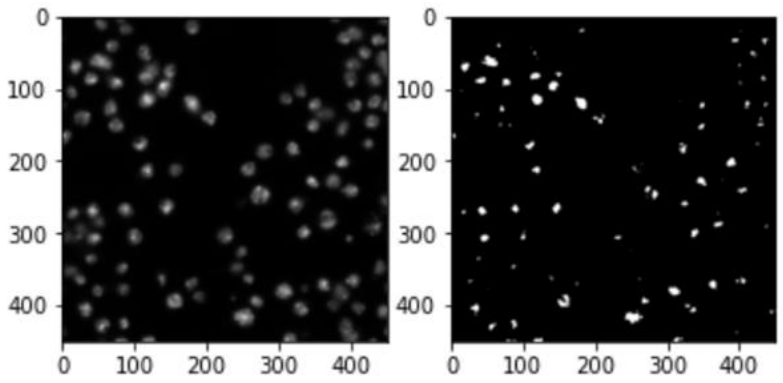
Cells can contain:

- Code
- Formatted text
- Rich output




```
In [2]: imag
```

```
In [10]: fig, ax = plt.subplots(1,2)
         ax[0].imshow(image, cmap = 'gray')
         ax[1].imshow(mask, cmap = 'gray')
Out[10]: <matplotlib.image.AxesImage at 0x1202af510>
```



Why using notebooks?

- Keep all the benefits from using code:

  - Batch processing

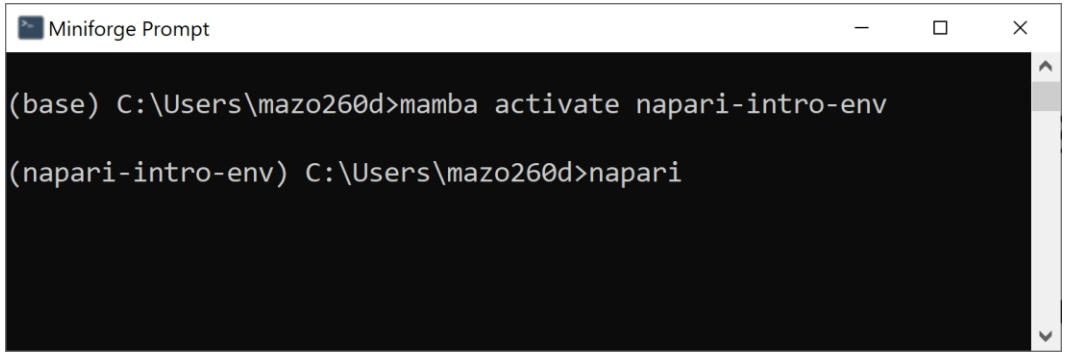
  - Running python functions/tools still unavailable as plugins

Why using notebooks with napari?

- Easy data interaction and visualization with napari:
    - Great for visualizing 3D (and more) data
    - Each processing step result can be displayed as a separate layer
- Data annotation

Opening napari

- From command line:

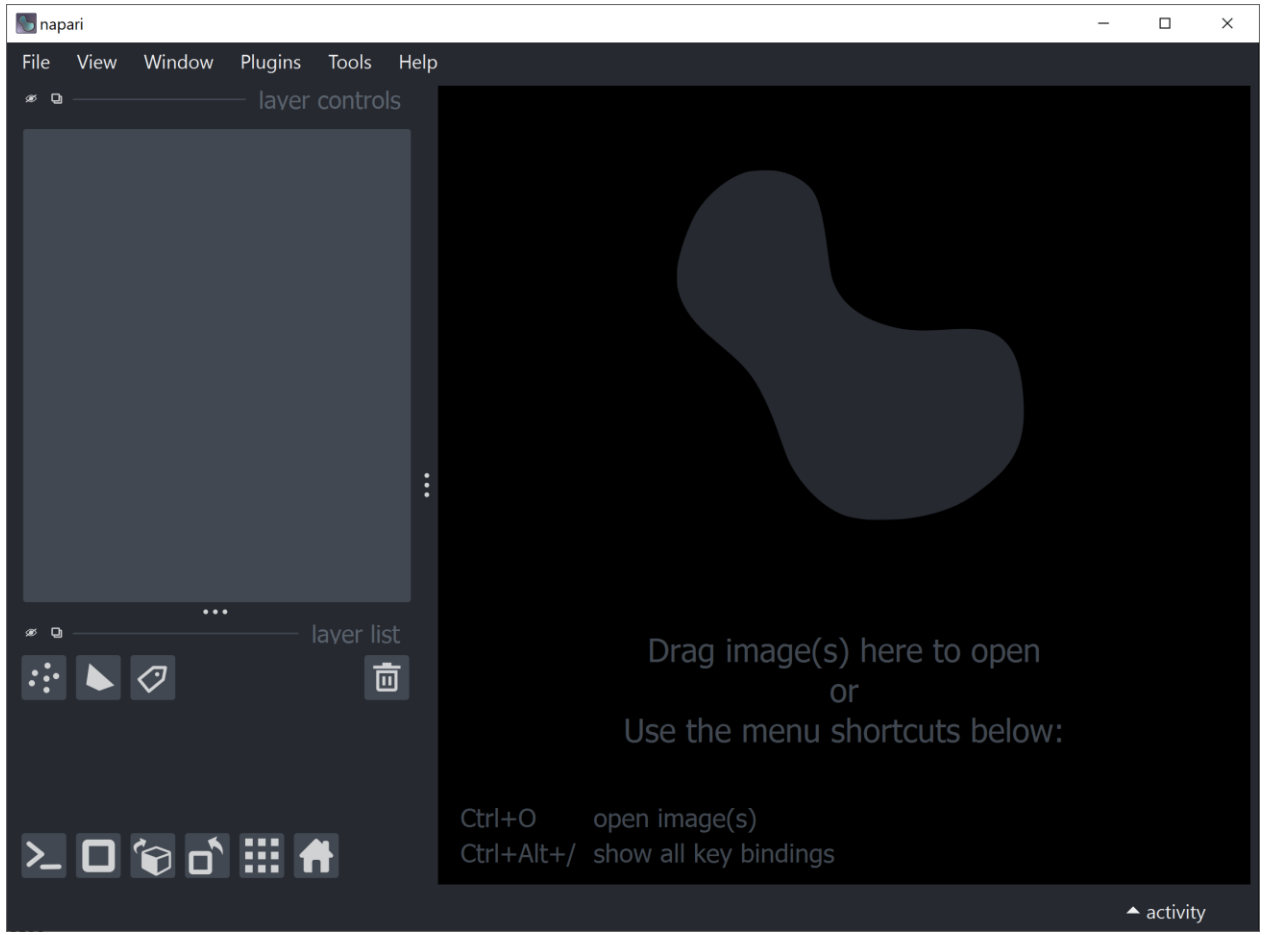


- From code (jupyter notebook):

```
[1]: import napari

[*]: viewer = napari.Viewer()

[ ]:
```



Opening Images in napari

- Drag and drop

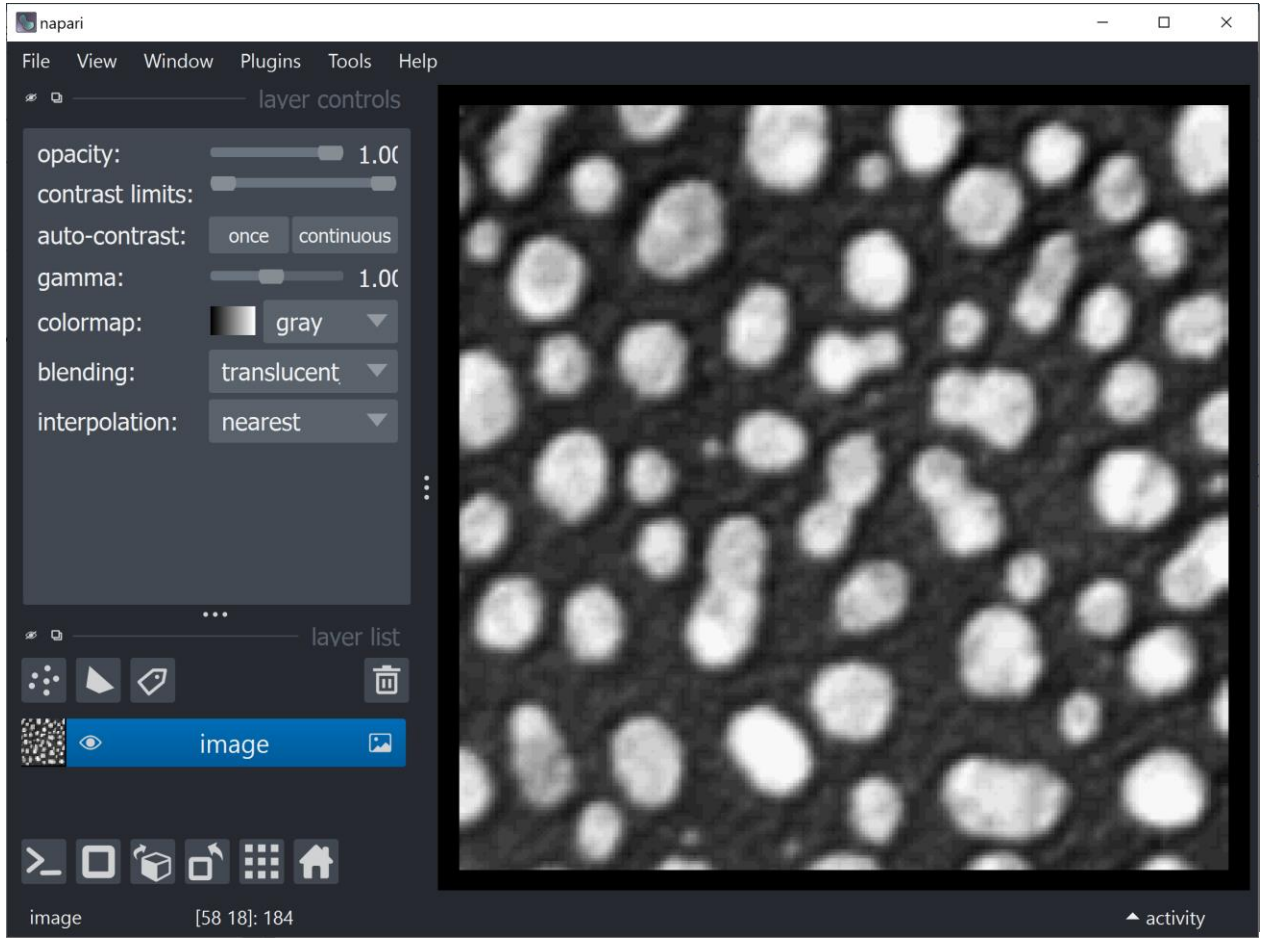
- File > Open File…

- From code:
  - Open an image with an “imread” function

```
image = imread(“image.tif”)
```

  - Load the image to the viewer

```
viewer.add_image(image)
```



Scripting napari in notebooks

- Add layers to napari to visualize intermediate processing results on top of each other or side by side.
- Change layer visualization within napari…

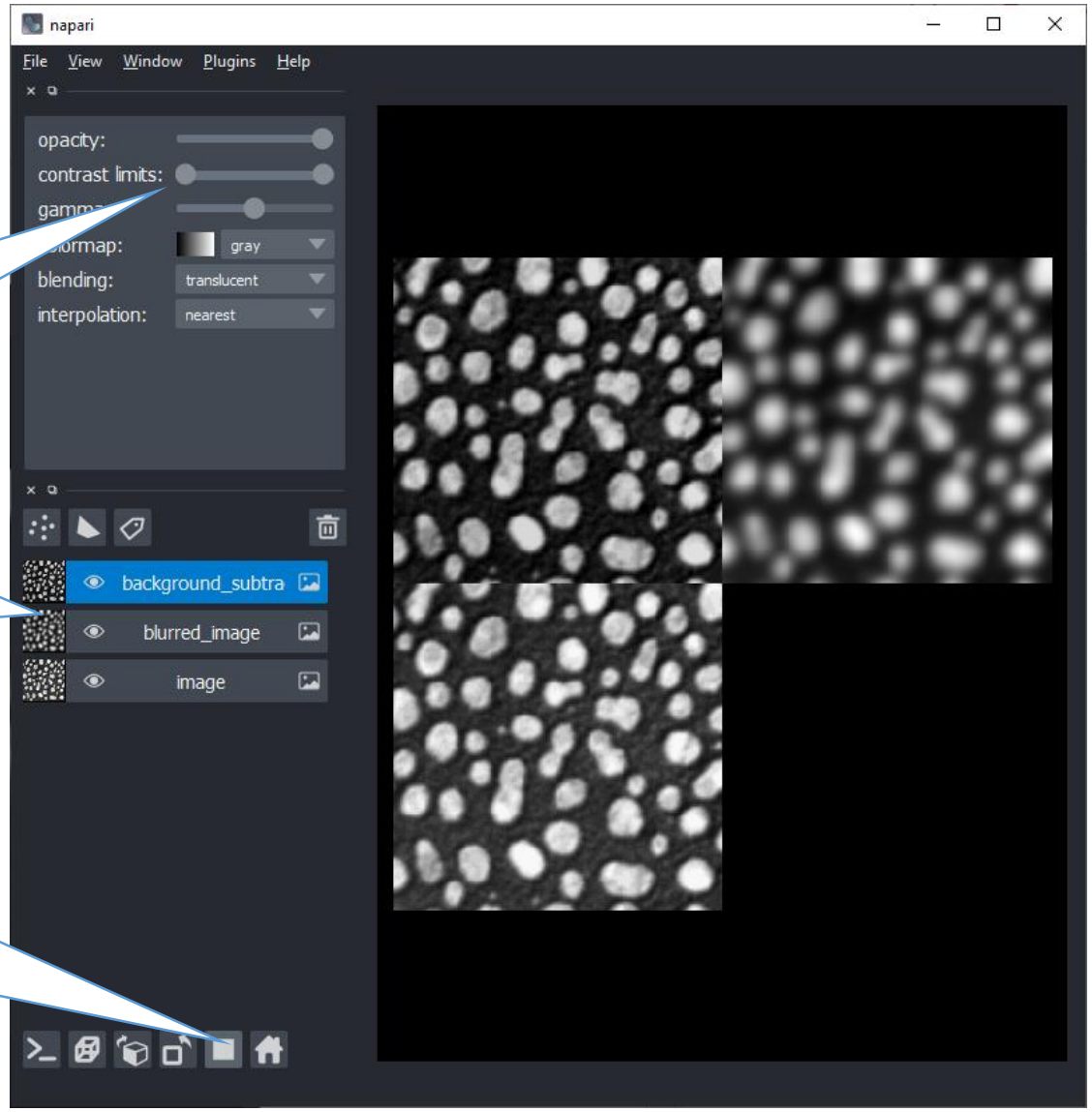
  … or via code in a jupyter notebook:

```
viewer.layers[0].contrast_limits
```

```
[0, 255]
```

1. Access the viewer
2. Access the layers
3. Choose a layer (by index or name)
4. “Press TAB” and check out available properties

```
viewer.layers[0].contrast_limits = [30,170]
```



Change Brightness and contrast here

Toggle visualization of layers here

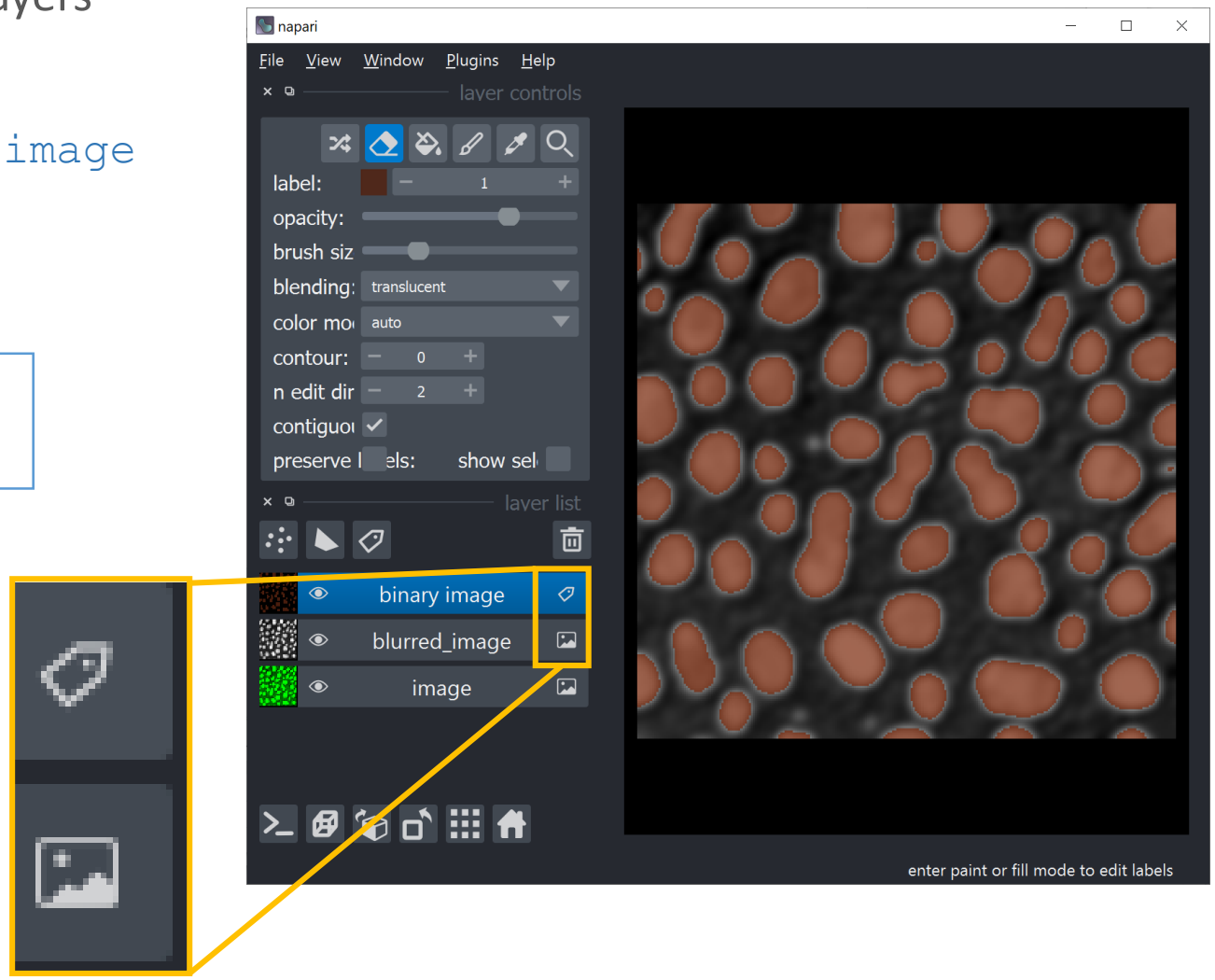
Gallery view

Visualizing image segmentation

- Binary images and label images visualized as label layers

```
# Add a new labels layer containing an image
viewer.add_labels(binary_image,
                  name="binary image")
```

Name your layers to keep track of what they contain



Labels Layer

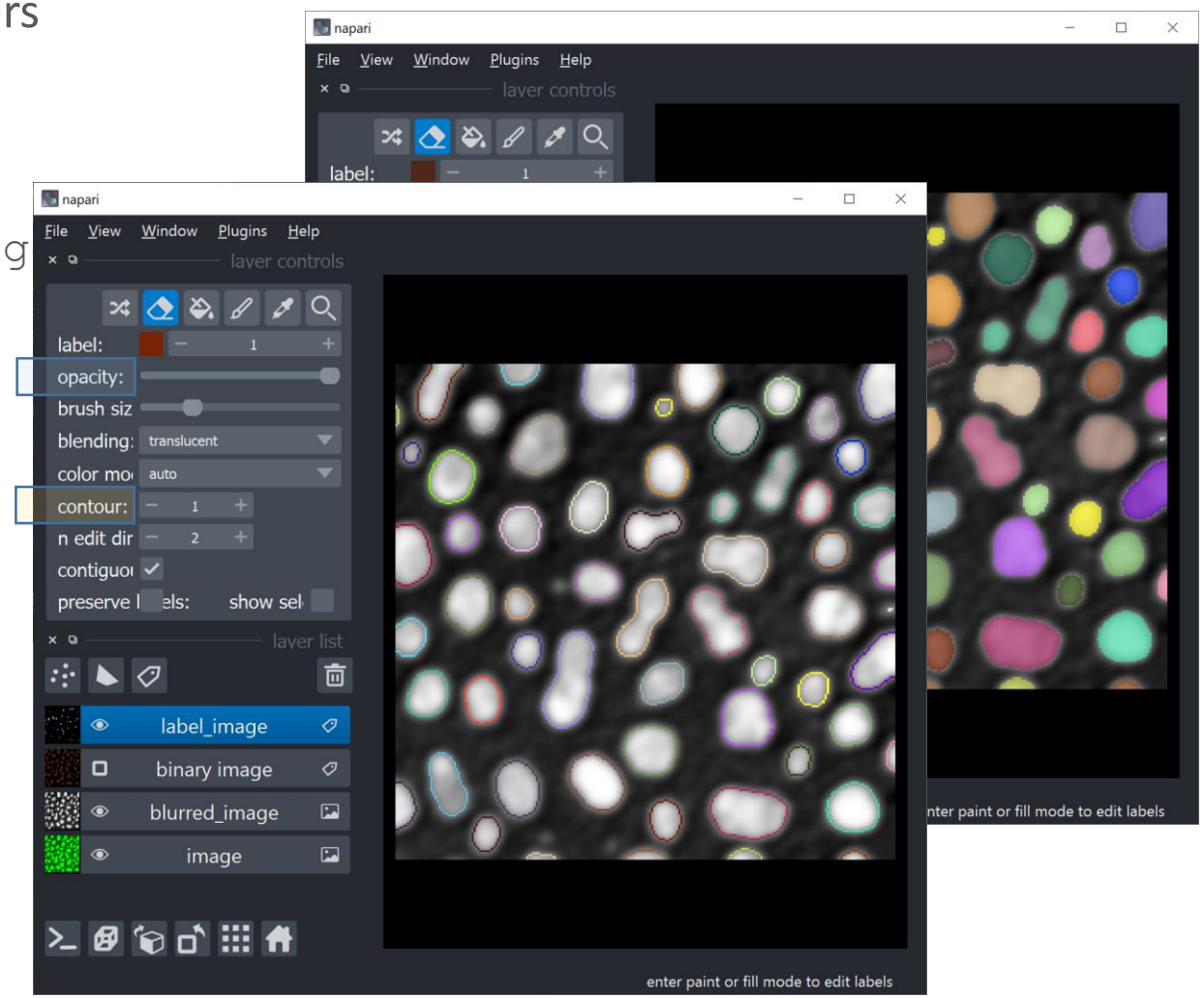
Image Layer

Visualizing image segmentation

- Binary images and label images visualized as label layers

- `# add labels to viewer`
- `label_layer = viewer.add_labels(label_imag`

- Visualize contours instead of the overlay
- `label_layer.contour = 1`
- `label_layer.opacity = 1`

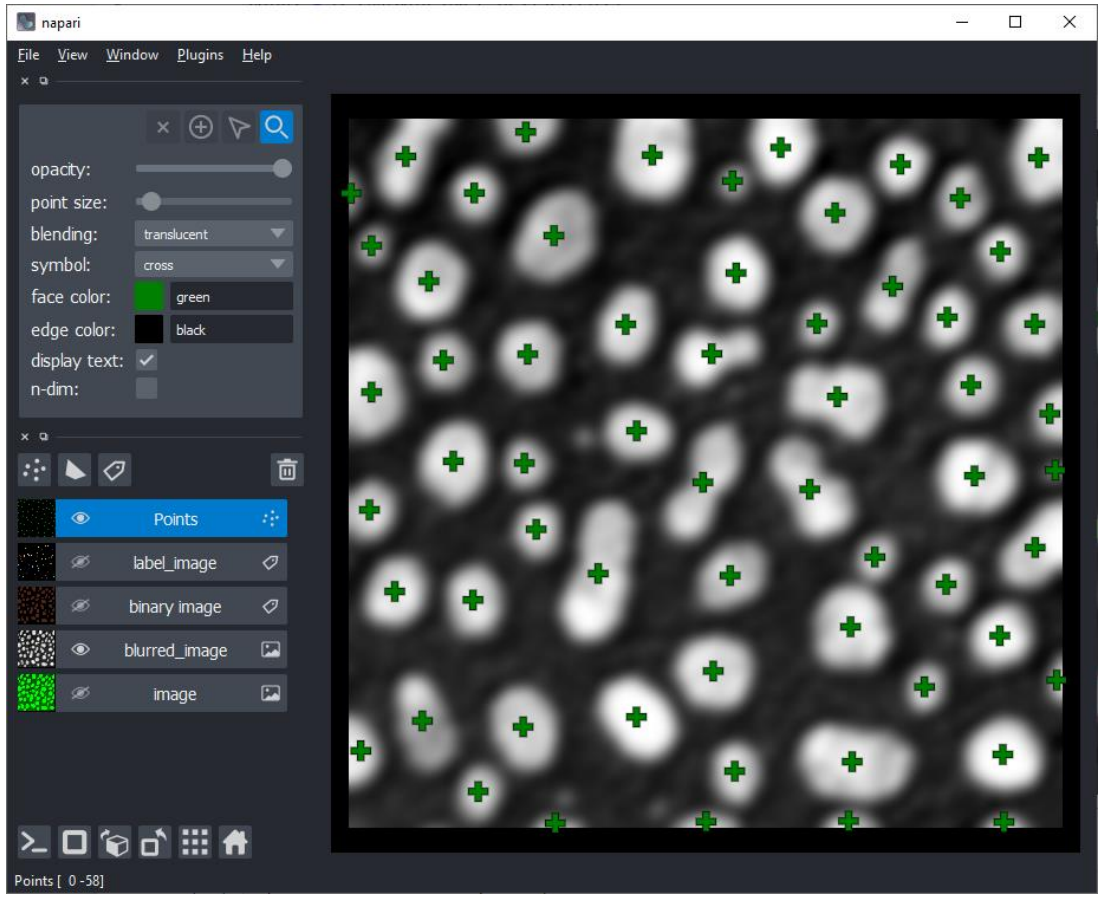


http://nbviewer.jupyter.org/github/BiAPoL/on_the_fly_image_processing_napari/blob/master/01_napari.ipynb

Points layers

- There is also other layer types
  - Shapes
  - Points
  - Surfaces
  - Tracks
  - Vectors

```
# add points to viewer
label_layer = viewer.add_points(points,
  face_color='green', symbol='cross', size=5)
```



Exercise

1. Start up a terminal
2. Activate the environment using
   `mamba activate napari-intro-env`
3. Run:
   `jupyter lab`

- Run these notebooks to practice opening and visualizing images in a jupyter notebook and with napari:
  - https://github.com/zoccoler/QM_Course_Bio_Image_Analysis_with_napari_2024/blob/main/docs/BioImage_Analysis_with_Jupyter_and_napari/01_images_are_numpy_arrays.ipynb
  - https://github.com/zoccoler/QM_Course_Bio_Image_Analysis_with_napari_2024/blob/main/docs/BioImage_Analysis_with_Jupyter_and_napari/02_Napari_from_Jupyter_introduction.ipynb

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Image Processing

Filters

- An image processing filter is an operation on an image.
- It takes an image and produces a new image out of it.
- Filters change pixel values.

- There is no “best” filter. Which filter fits your needs, depends on the context.
- Filters do not do magic. They can not make things visible which are not in the image.

- Application examples
  - Noise-reduction
  - Artefact-removal
  - Contrast enhancement
  - Correct uneven illumination

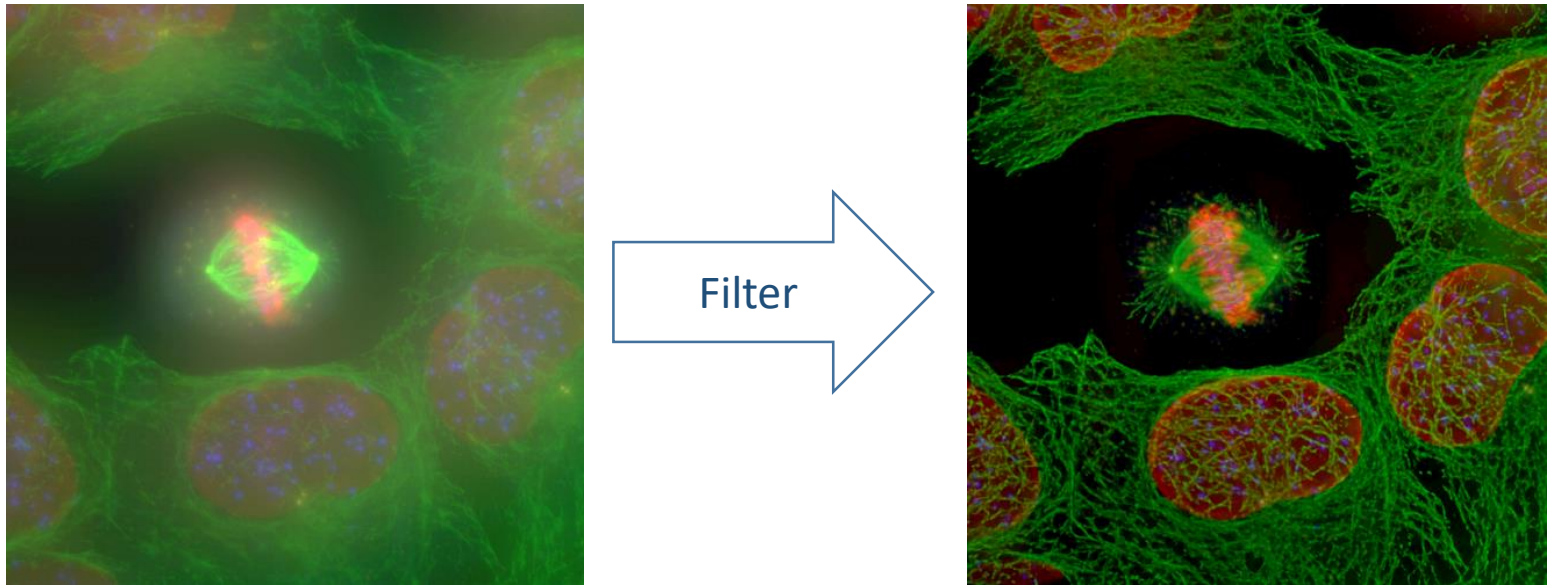


Image source: Alex Bird / Dan White MPI CBG

Image correction / noise removal

- We need to remove the noise to help the computer *interpreting* the image

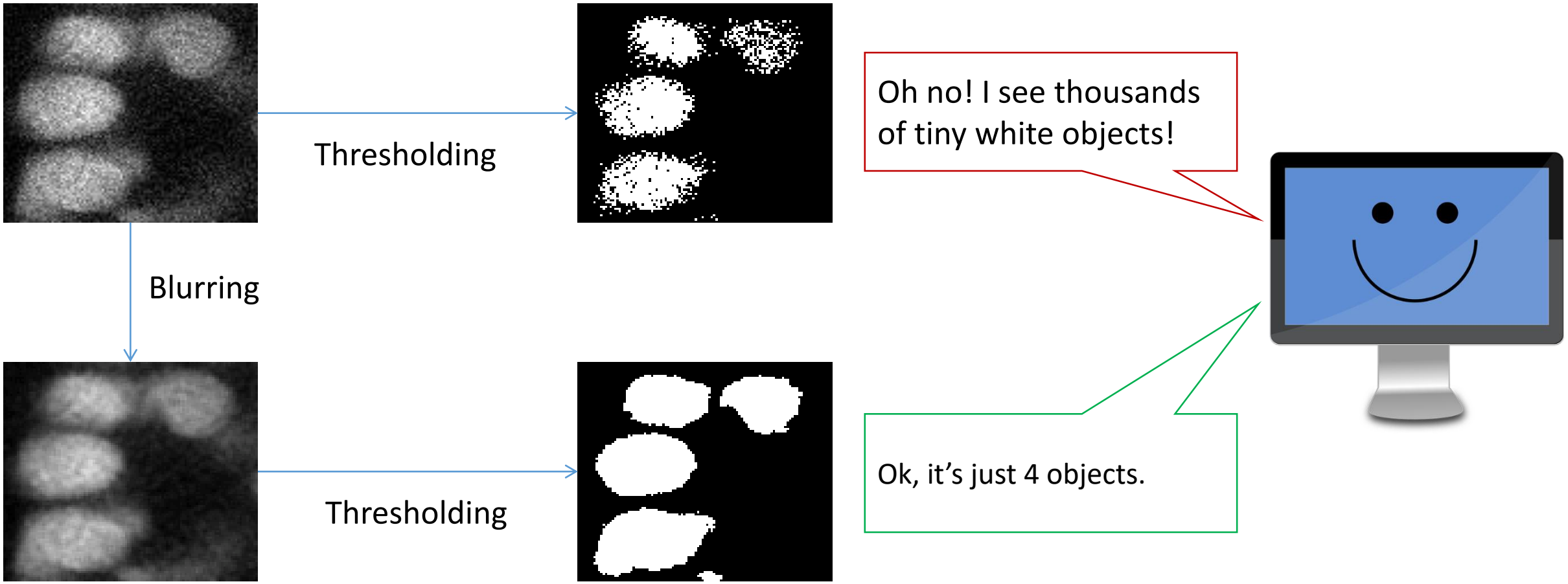
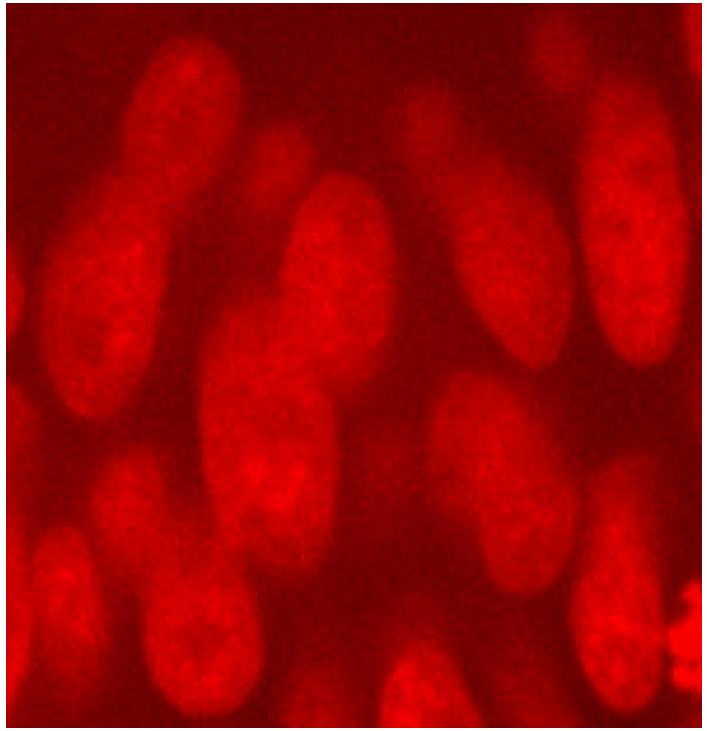
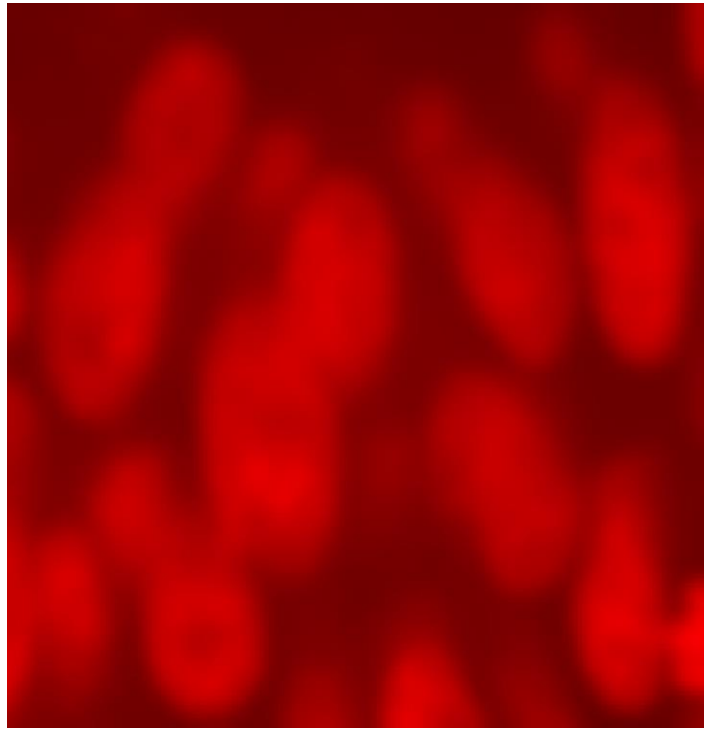


Image correction / noise removal

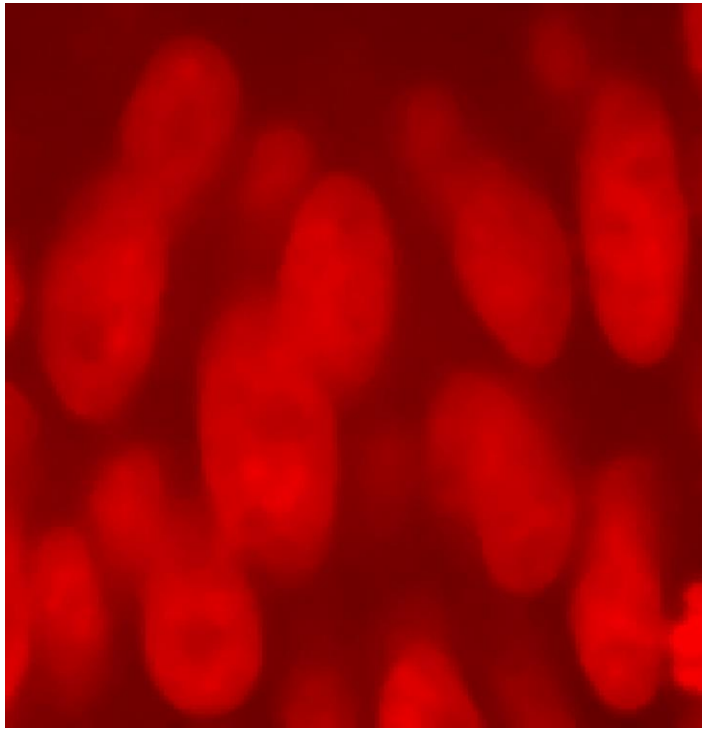
- Noise removal using *filters*



Original image



Gaussian blur filtered



Median filtered

Image source: Mauricio Rocha Martins (Norden/Myers lab, MPI CBG)

Background removal

- Differentiating objects is easier if their background intensity is equal.

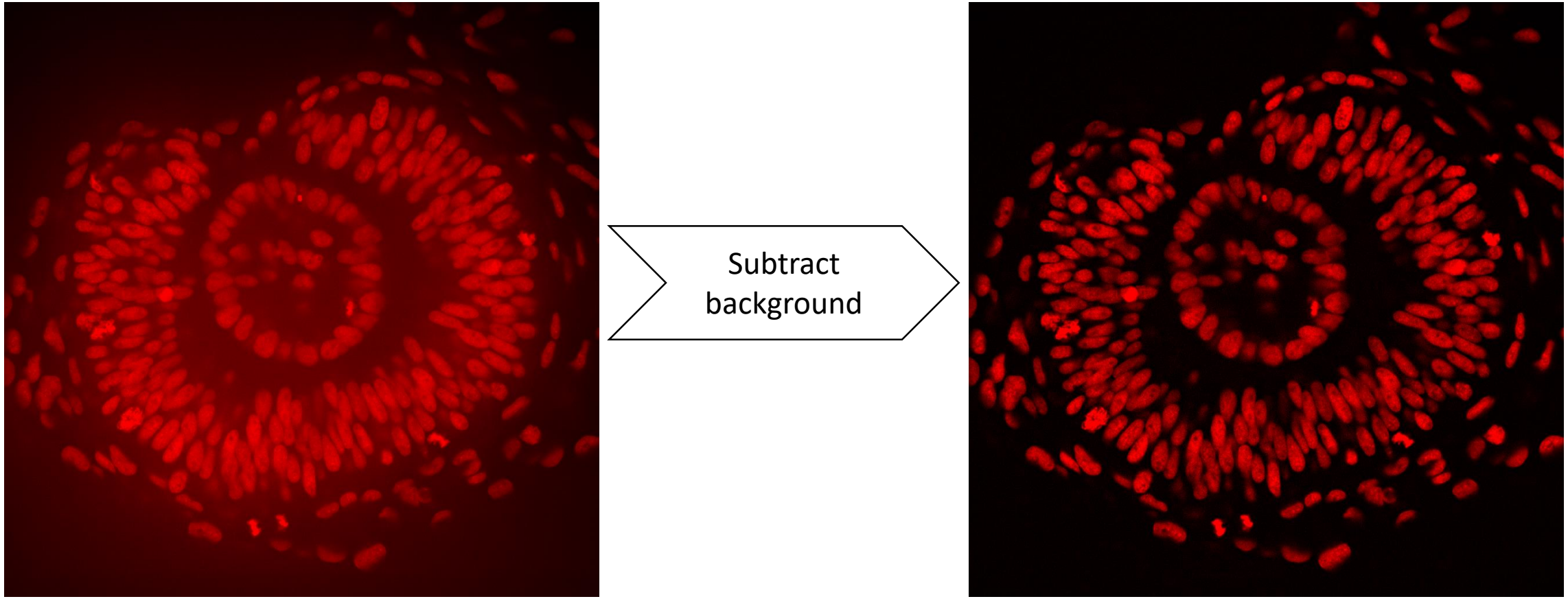
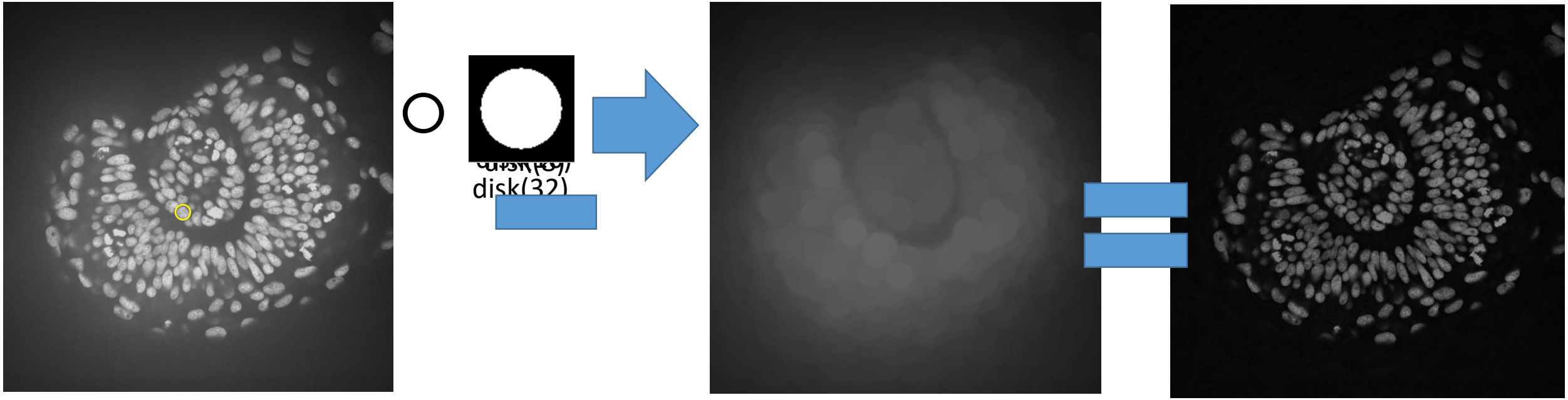


Image source: Mauricio Rocha Martins (Norden/Myers lab, MPI CBG)

Background removal

Opening



Original image

This is a good estimation of the background

Strucutres have a radius ≈ 12

You have just learned the white tophat filter!

Image source: Mauricio Rocha Martins (Norden/Myers lab, MPI CBG)

Filtering in 3D with Anisotropy

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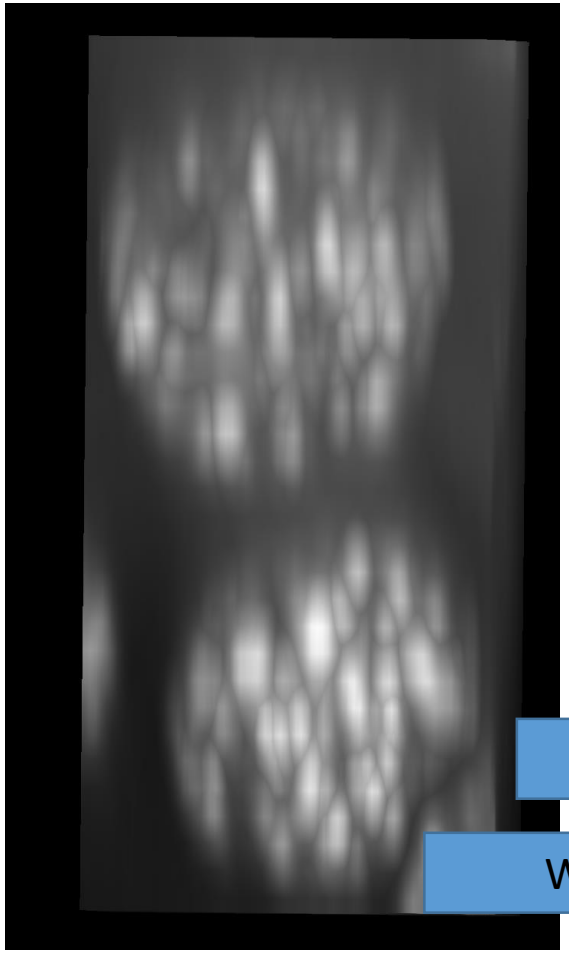
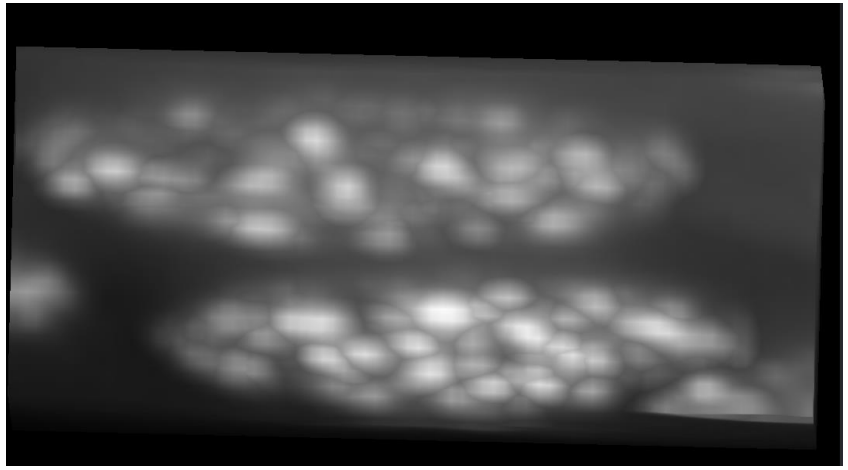
An image that should look like this…

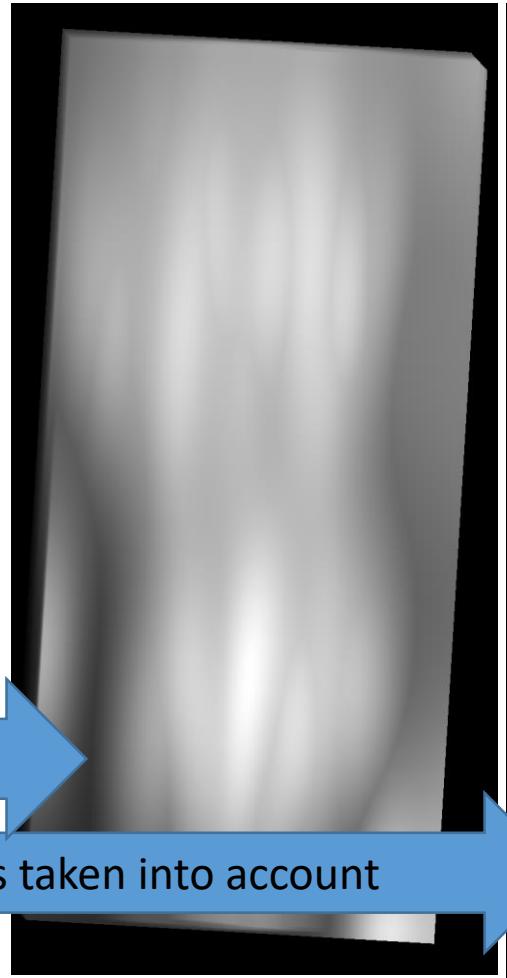


…may be displayed like this (if voxel size is ignored):

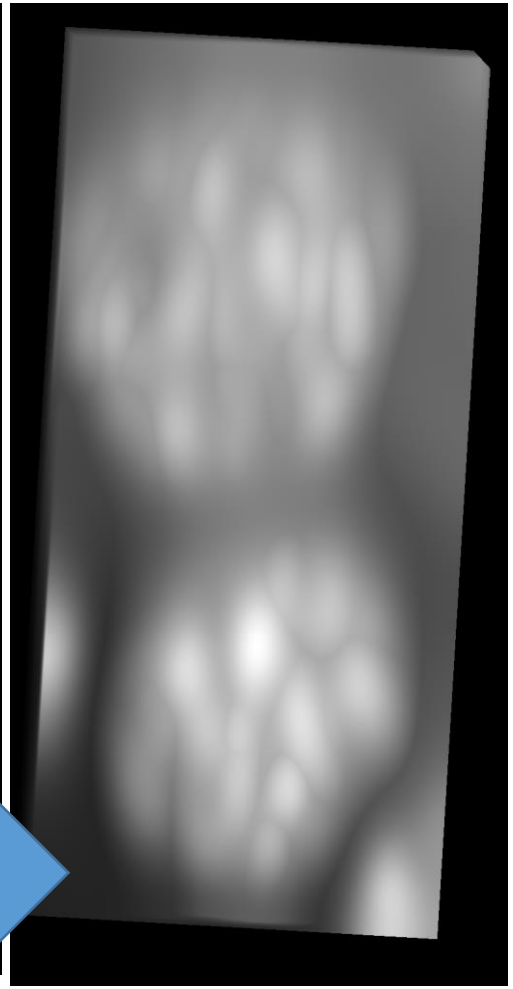


Many filter functions do not take anisotropy into account (always check documentation)

So applying a filter may do this



When in fact it should do this if anisotropy was taken into account



Re-scaling the image may be needed before filtering (unless function allows editing filter kernel)

@zoccolermarcelo

Exercise

1. Start up a terminal
2. Activate the environment using
   `mamba activate napari-intro-env`
3. Run:
   `jupyter lab`

- Run these notebooks to practice opening and visualizing images in a jupyter notebook and with napari:
  - https://github.com/zoccoler/QM_Course_Bio_Image_Analysis_with_napari_2024/blob/main/docs/BioImage_Analysis_with_Jupyter_and_napari/03_Filters_in_3D_Isotropic_Data.ipynb

  Optional:
  - https://github.com/zoccoler/QM_Course_Bio_Image_Analysis_with_napari_2024/blob/main/docs/BioImage_Analysis_with_Jupyter_and_napari/04_Brightness_and_Contrast_optional.ipynb
  - https://github.com/zoccoler/QM_Course_Bio_Image_Analysis_with_napari_2024/blob/main/docs/BioImage_Analysis_with_Jupyter_and_napari/05_Filters_optional.ipynb

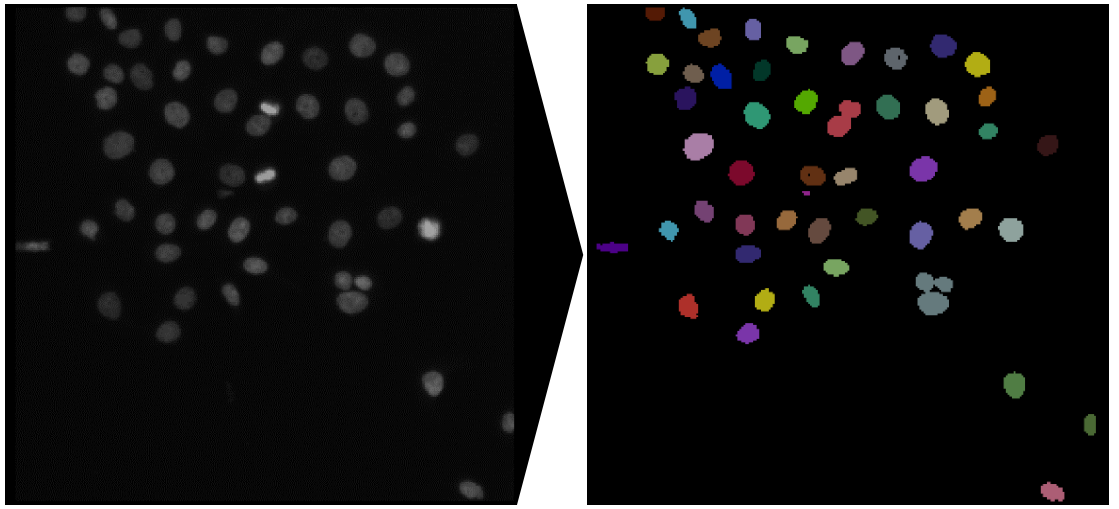
Segmentation

Aim:

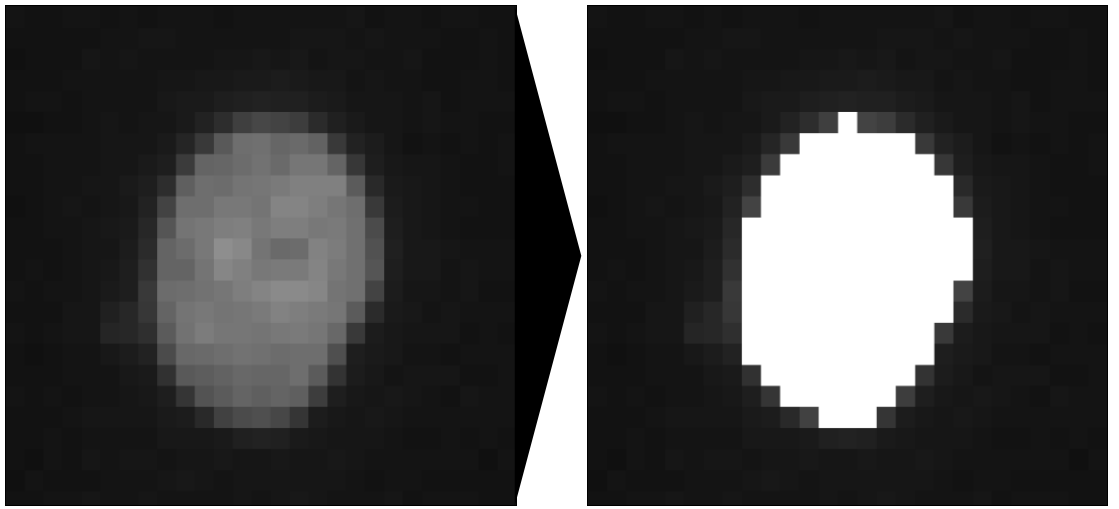
Separate background from foreground

Vocabulary:

- **Segmentation:**
  → Assigning a meaningful *label* to each pixel
  → Segmentation is a *classification* problem
- **Semantic segmentation:**
  Differentiate pixels into multiple *classes* (e.g., membrane, nucleus, cytosol, etc.)
- **Instance segmentation:**
  Differentiate multiple occurrences of the same class into separate instances of this class (e.g., separate *label* for each cell in image)



Instance segmentation

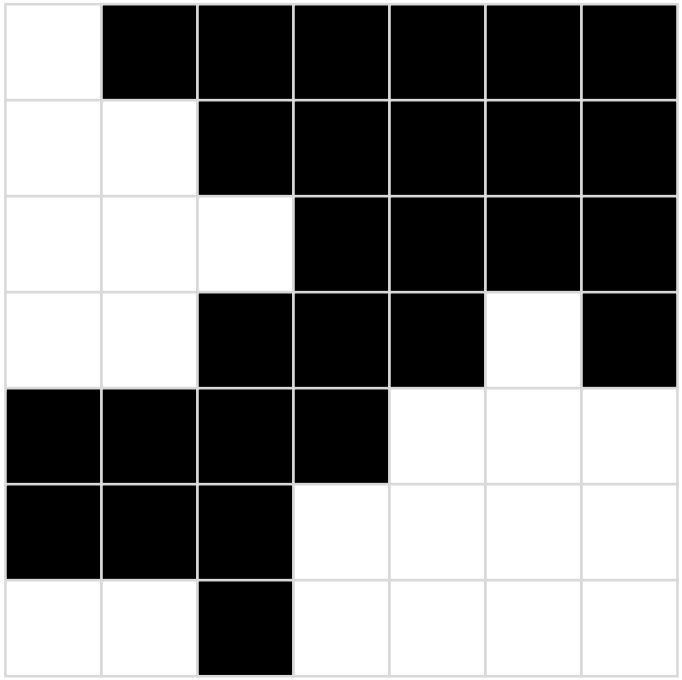


Semantic segmentation

https://scikit-image.org/docs/stable/api/skimage.data.html

Instance segmentation

- In order to allow the computer differentiating objects, connected component analysis (CCA) is used to mark pixels belonging to different objects with different numbers
- Background pixels are marked with 0.
- The maximum intensity of a labelled map corresponds to the number of objects.

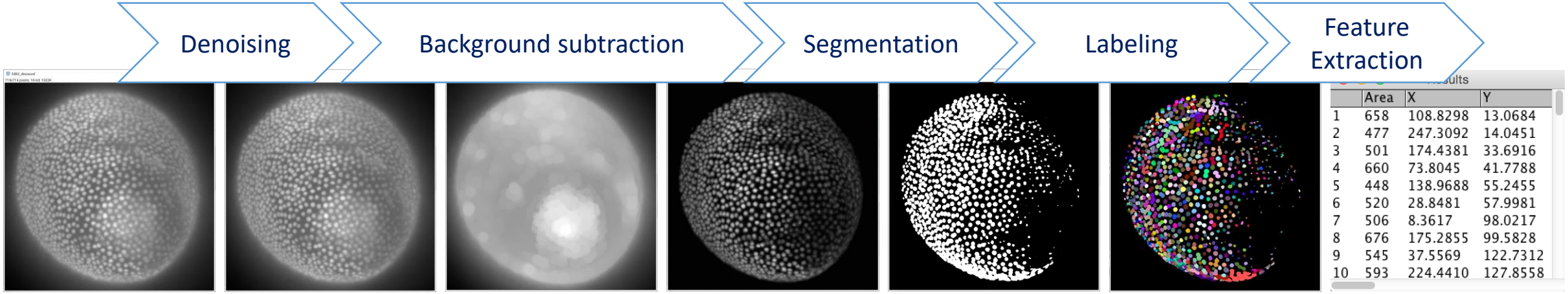


CCA

1	0	0	0	0	0	0
1	1	0	0	0	0	0
1	1	1	0	0	0	0
1	1	0	0	0	3	0
0	0	0	0	3	3	3
0	0	0	3	3	3	3
2	2	0	3	3	3	3

Image Analysis Workflows

- Image analysis workflow is a series of processes/functions (not always linear) applied to images to achieve a certain goal (usually some measurements)
- Here is a classic example:



- Batch processing is the process of applying the same image analysis workflow to several images (in a folder or data repository)
- In Python, that typically means putting the workflow inside a **for** loop that runs over all images of the folder/repository

Exercise

1. Start up a terminal
2. Activate the environment using
   `mamba activate napari-intro-env`
3. Run:
   `jupyter lab`

- Run these notebooks to practice opening and visualizing images in a jupyter notebook and with napari:
  - https://github.com/zoccoler/QM_Course_Bio_Image_Analysis_with_napari_2024/blob/main/docs/BioImage_Analysis_with_Jupyter_and_napari/06_Segmentation_workflow_example.ipynb
  - https://github.com/zoccoler/QM_Course_Bio_Image_Analysis_with_napari_2024/blob/main/docs/BioImage_Analysis_with_Jupyter_and_napari/07_batch_segmentation_workflow_example.ipynb

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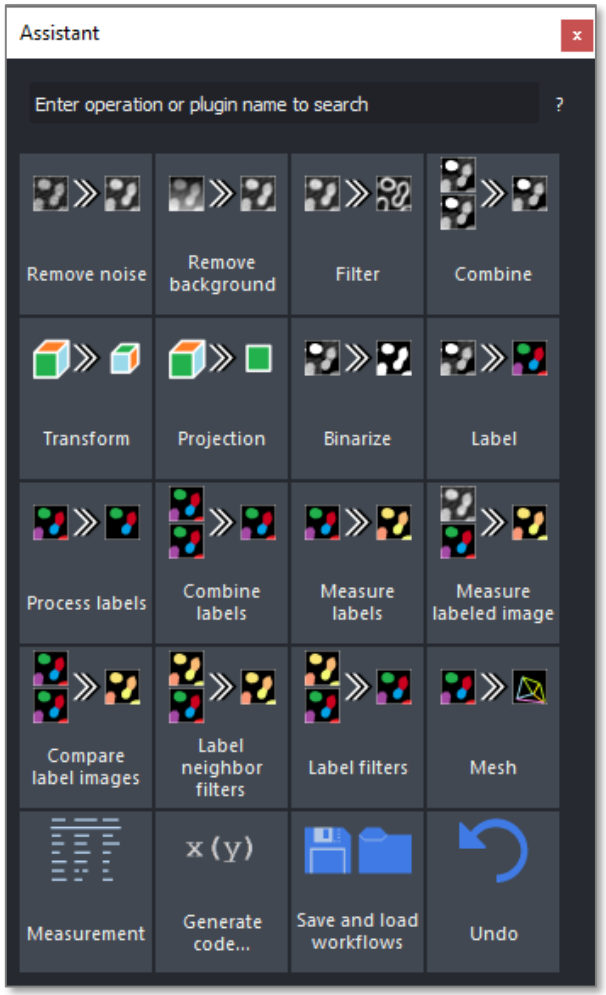
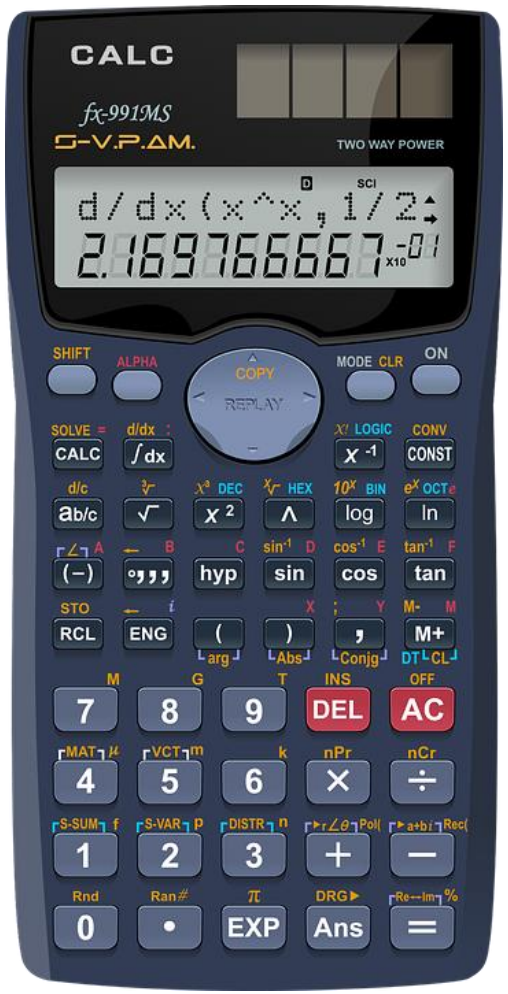
Napari-Assistant

The Napari Assistant

- A pocket-calculator-like interface to build image analysis workflows





https://www.napari-hub.org/plugins/napari-assistant

The Napari Assistant

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Viewer controls
(Napari core)

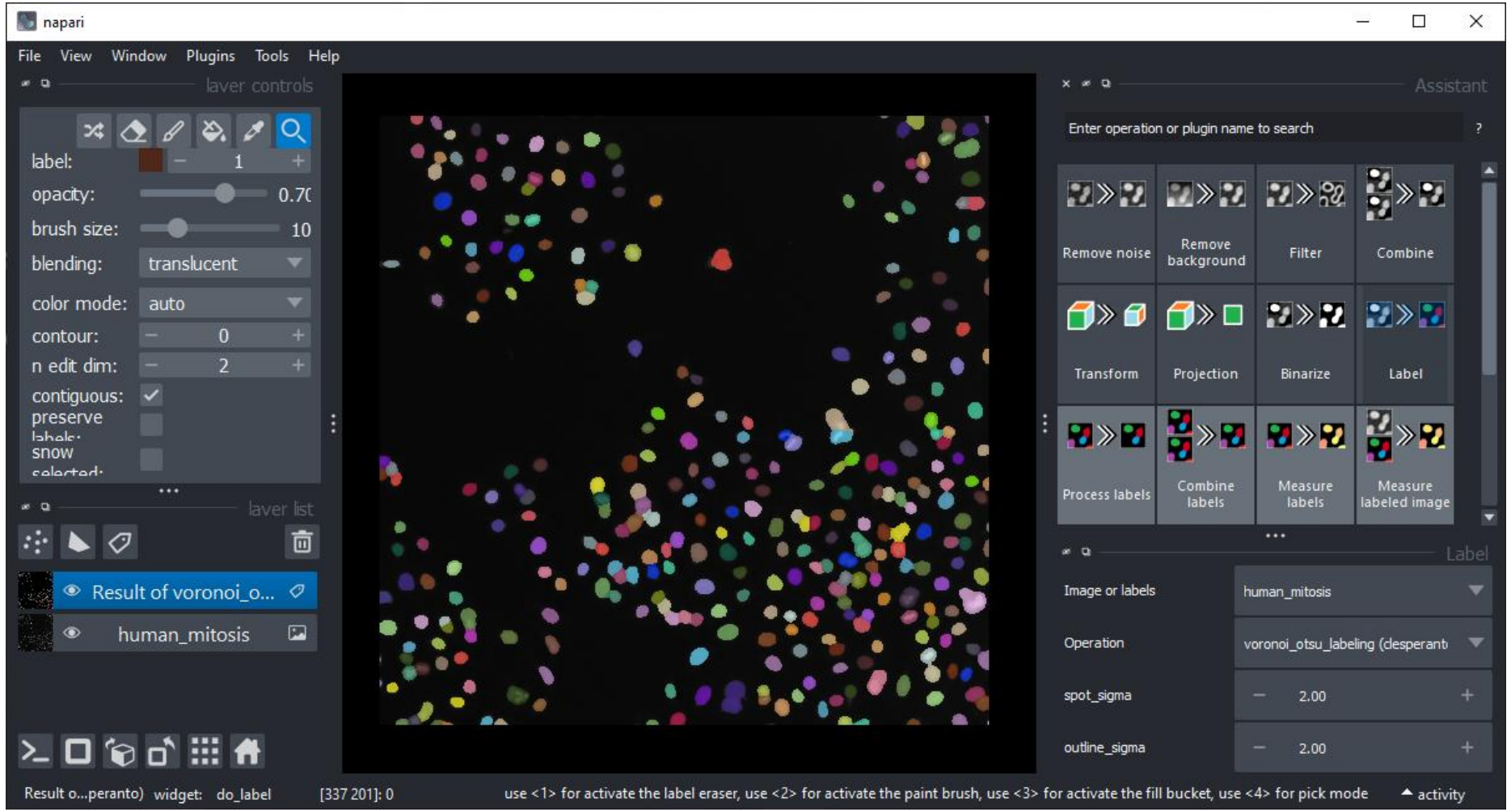
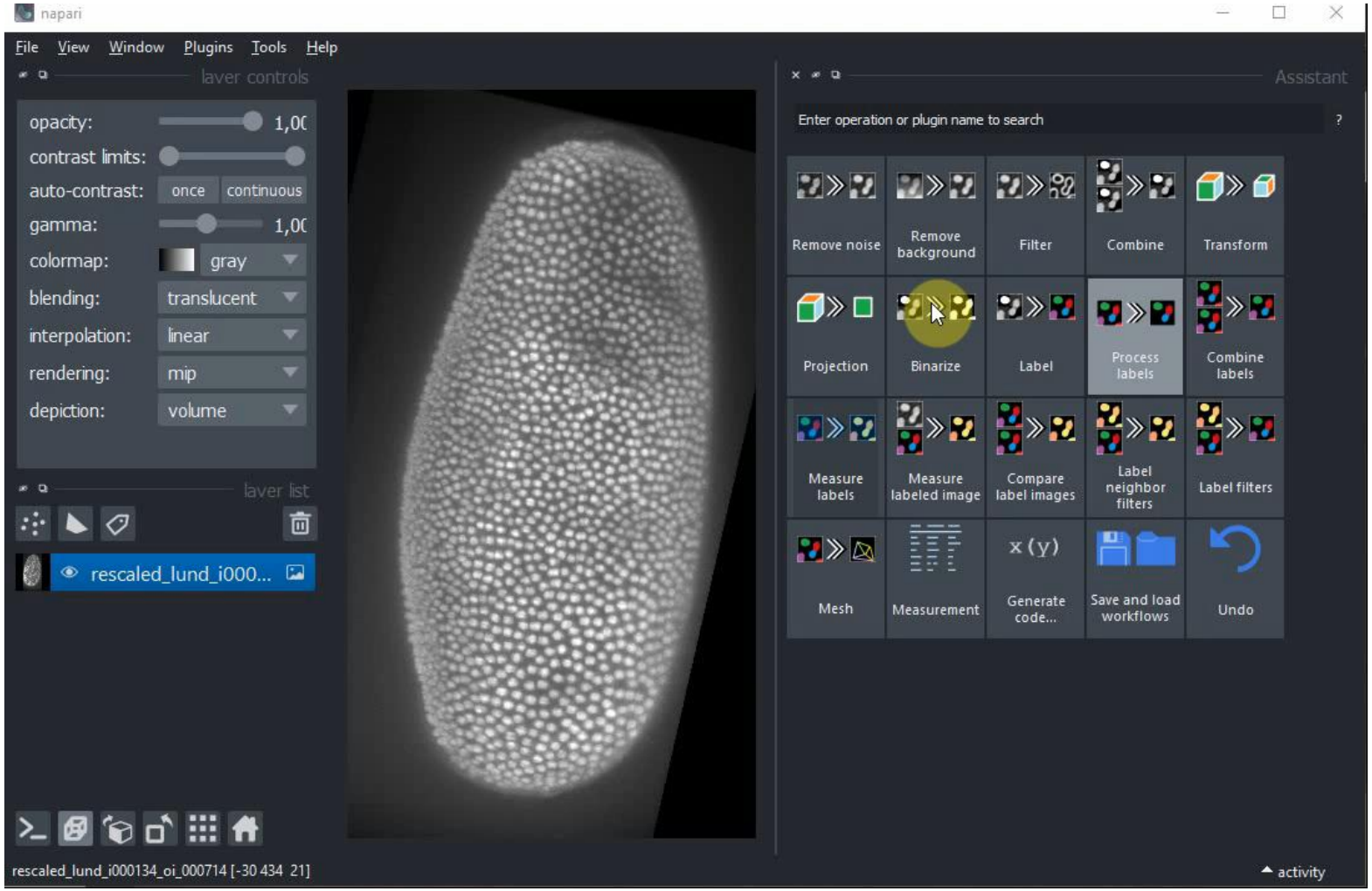


Image Analysis
(Napari Assistant)

https://www.napari-hub.org/plugins/napari-assistant

@zoccolermarcelo

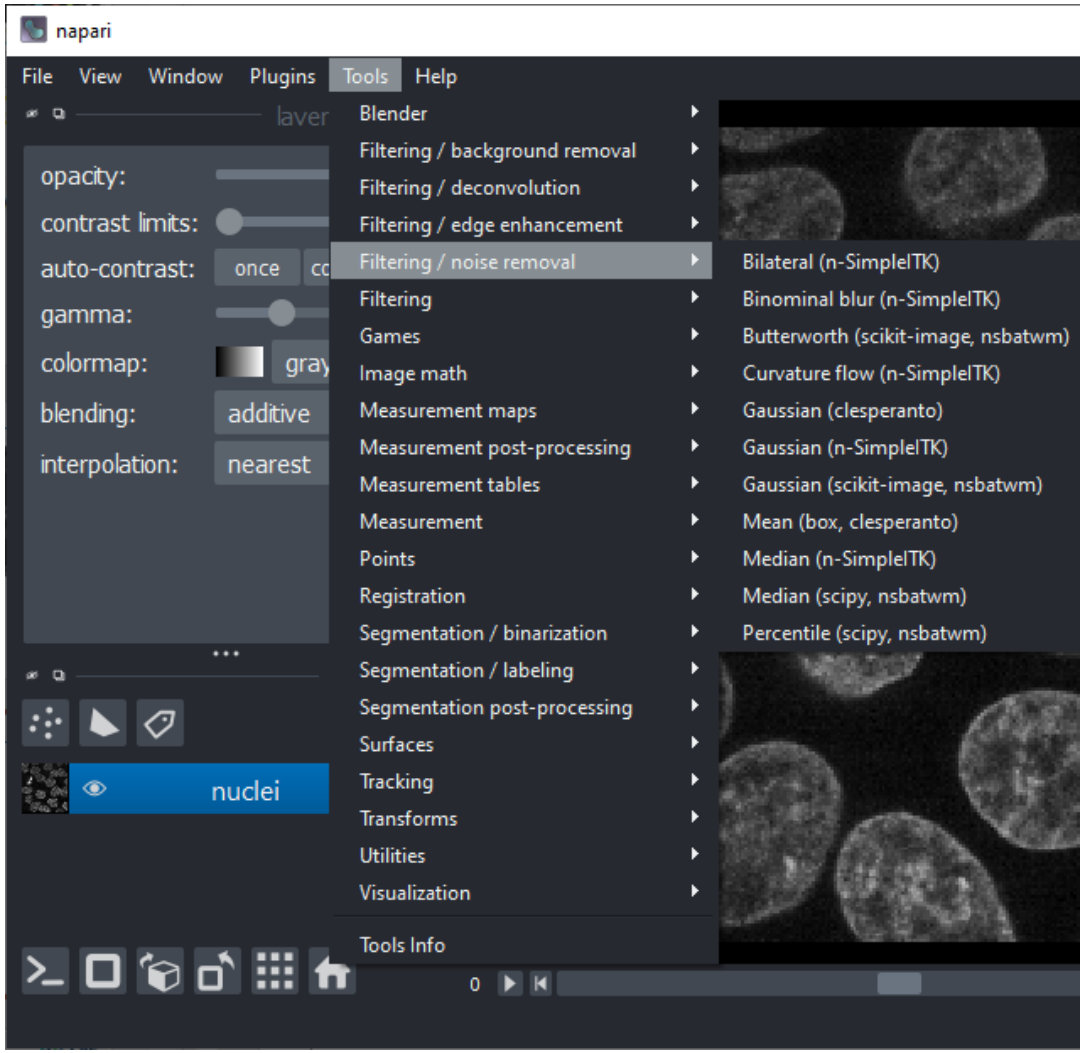
The Napari Assistant

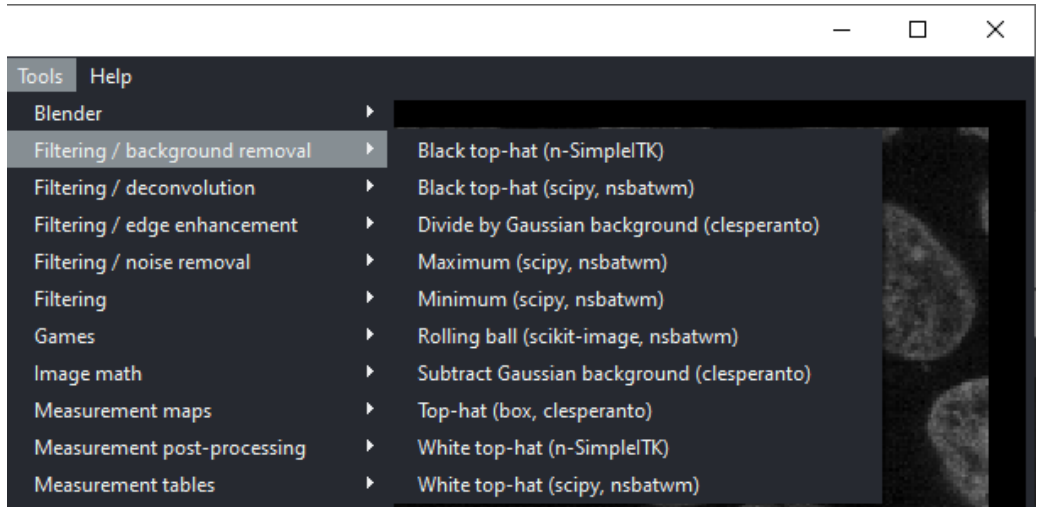


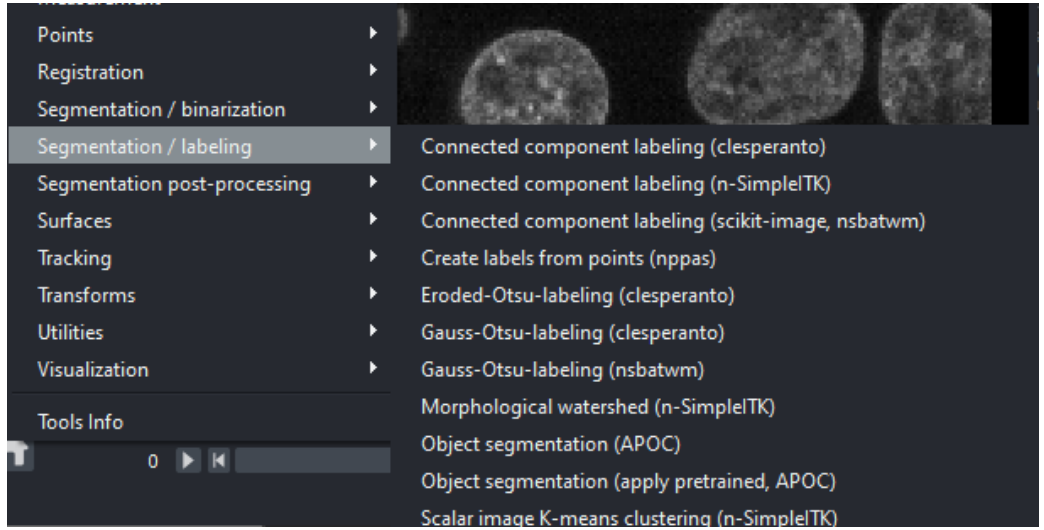
https://www.napari-hub.org/plugins/napari-assistant

The Tools menu

- Organized in categories

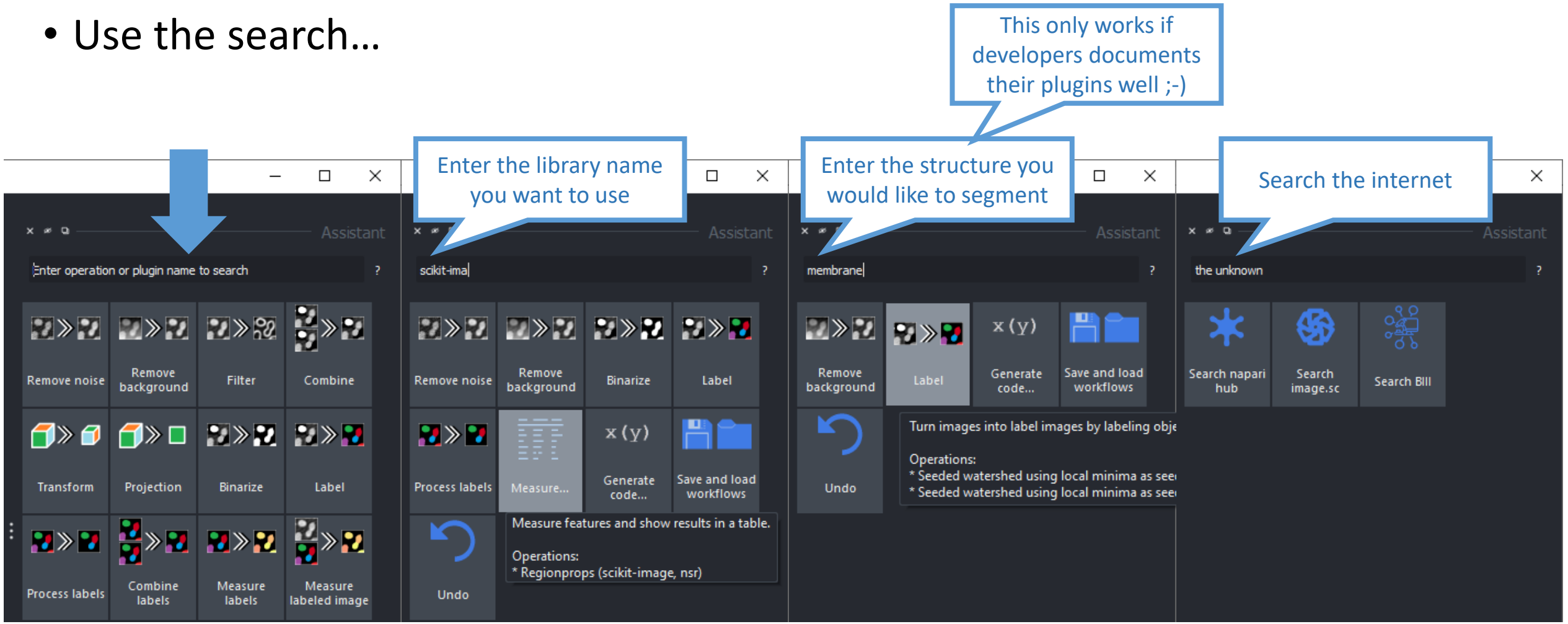






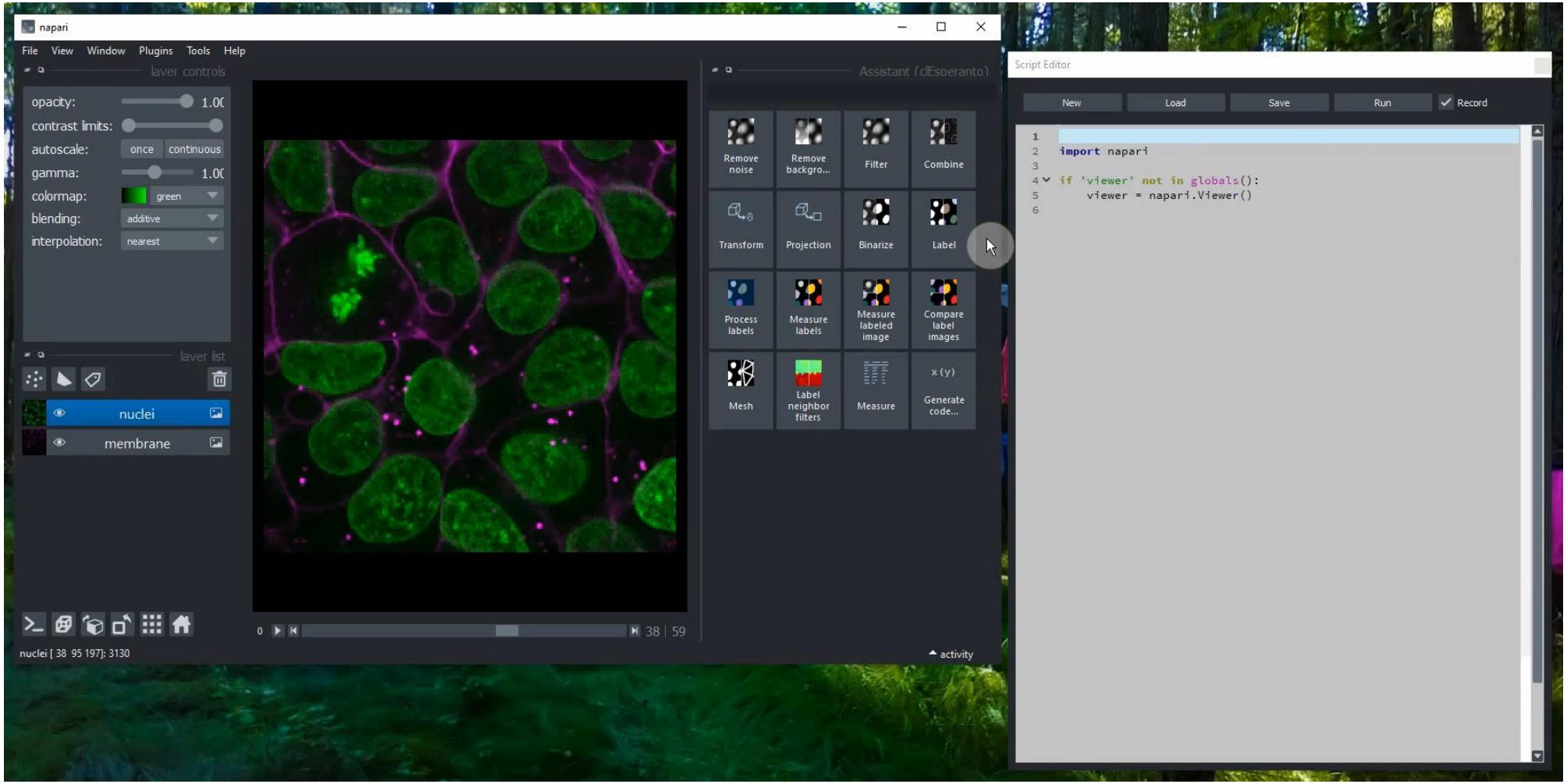
Browse operations

- Use the search…



https://www.napari-hub.org/plugins/napari-assistant

Export code to Python

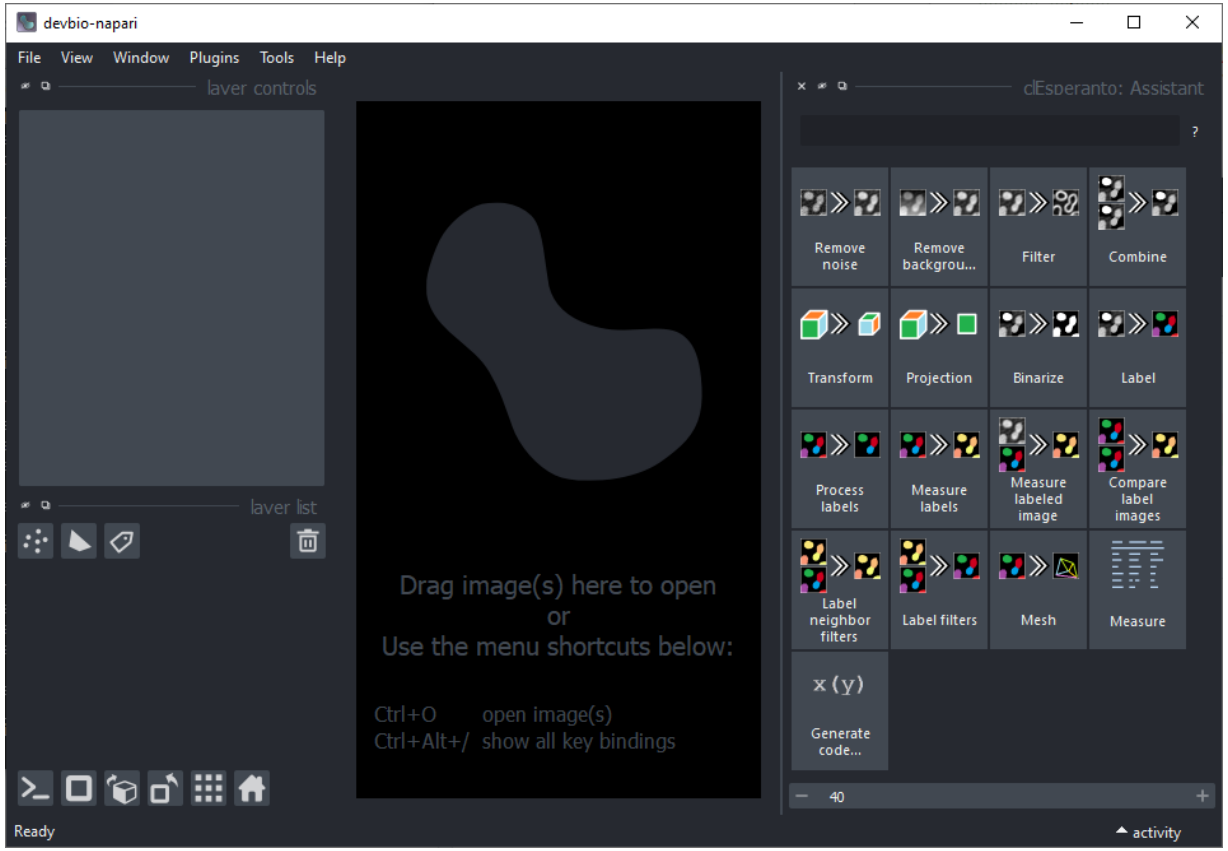


https://www.napari-hub.org/plugins/napari-script-editor

Exercise: run napari-assistant

1. Start up a terminal
2. Activate the environment using
   `mamba activate napari-intro-env`
3. Run:
   `naparia`

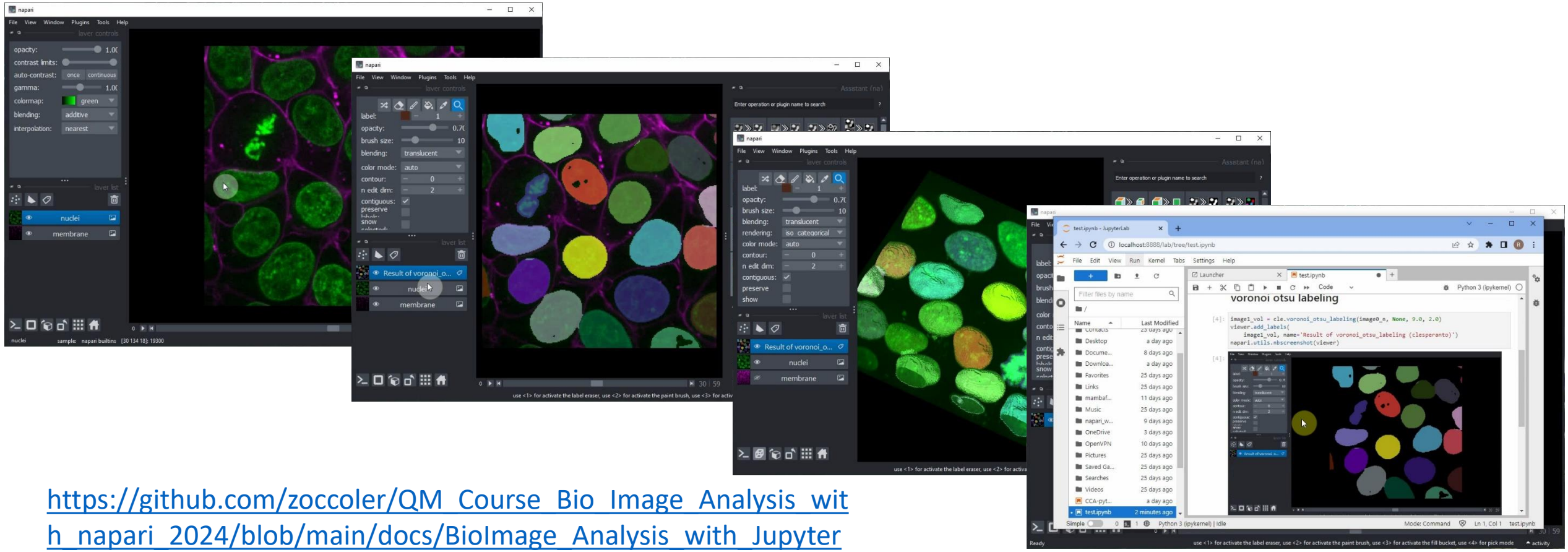
- https://github.com/zoccoler/QM_Course_Bio_Image_Analysis_with_napari_2024/blob/main/docs/BioImage_Analysis_with_Jupyter_and_napari/08_napari-assistant.md



https://github.com/clEsperanto/pyclesperanto_prototype#troubleshooting-graphics-cards-drivers

Exercise

- Use the Napari Assistant to generate a Jupyter Notebook



https://github.com/zoccoler/QM_Course_Bio_Image_Analysis_with_napari_2024/blob/main/docs/BioImage_Analysis_with_Jupyter_and_napari/09_notebook_export.md

Acknowledgements

PoL Physics of Life TU Dresden

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- Till Korten
- Mara Lampert
- Svetlana Iarovenko
- Ryan George Savill
- Laura Zigutyte

Networks

BioDIP Biopolis Dresden Imaging Platform

CENTER FOR SYSTEMS BIOLOGY DRESDEN

image.sc

NFDI4 BIOIMAGE

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DFG public

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