PoL
Physics of Life
TU Dresden

CENTER FOR
SYSTEMS BIOLOGY
DRESDEN

Image Processing: Background removal

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Background removal

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

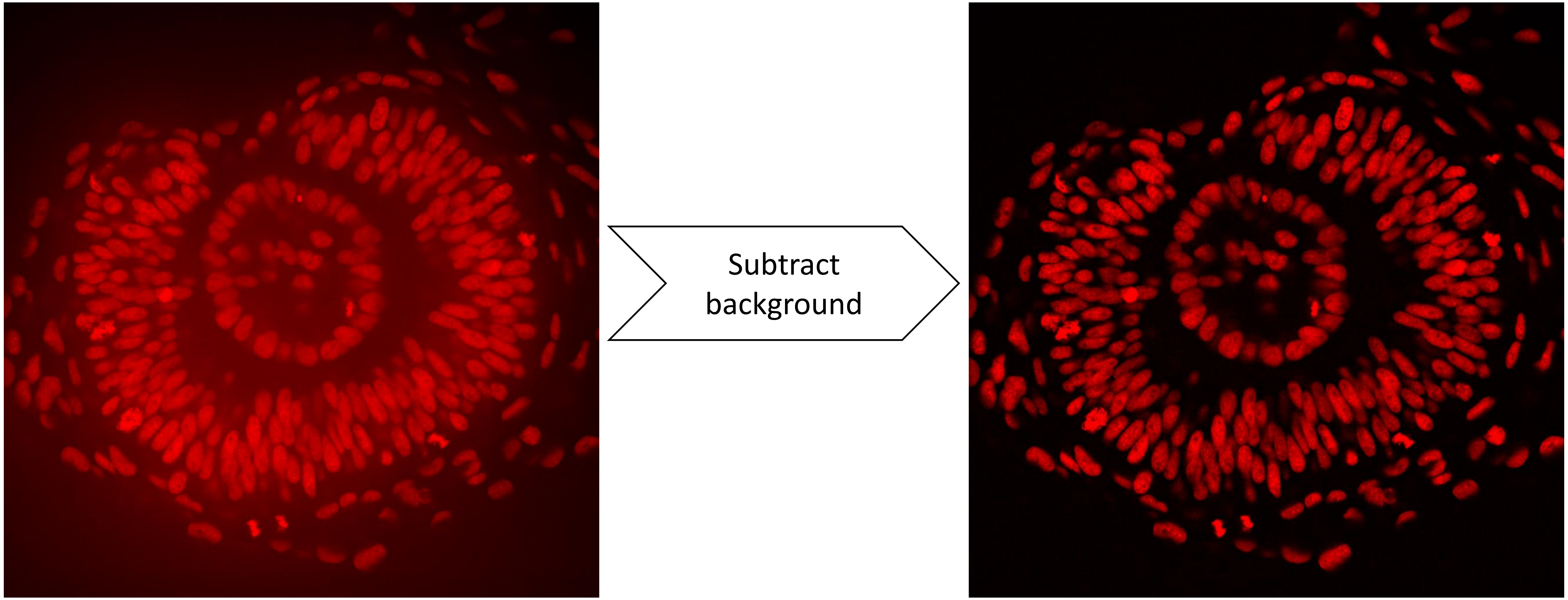

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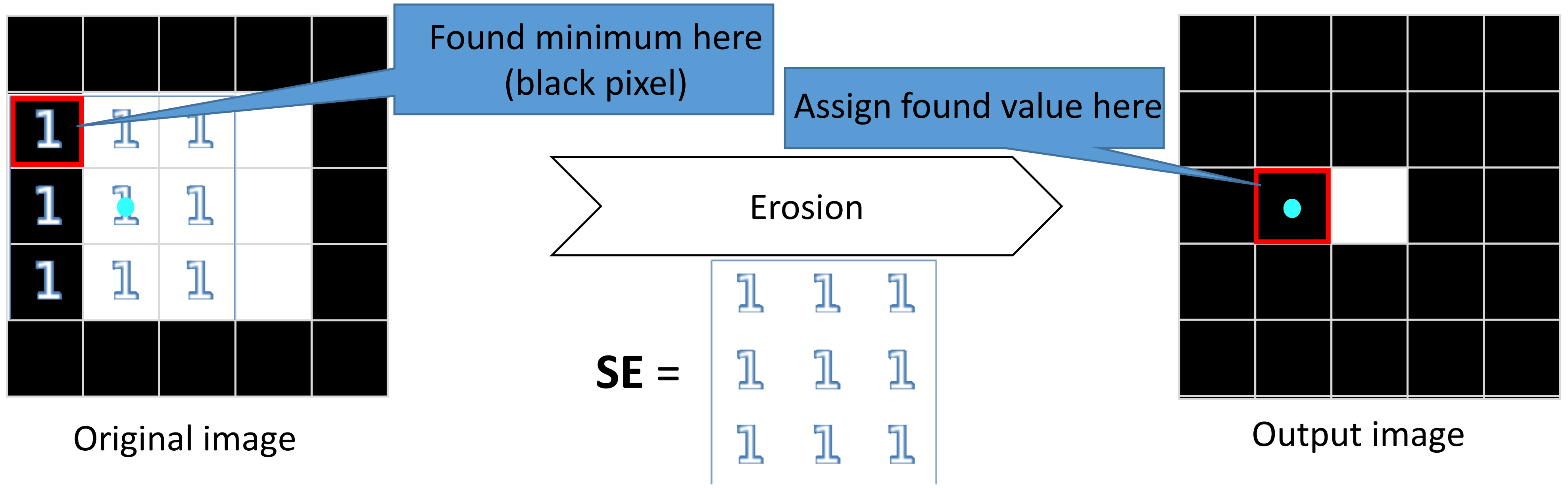
Image source: Mauricio Rocha Martins (Norden/Myers lab, MPI CBG)

Refining masks: Erosion

- Erosion: Every pixel with at least one black neighbor becomes black.



Erosion is essentially a minimum filter whose extent is defined by the kernel (footprint, structural element or **SE**) size and shape.

Dilation is essentially a maximum filter whose extent is defined by the kernel (footprint, structural element or **SE**) size and shape.

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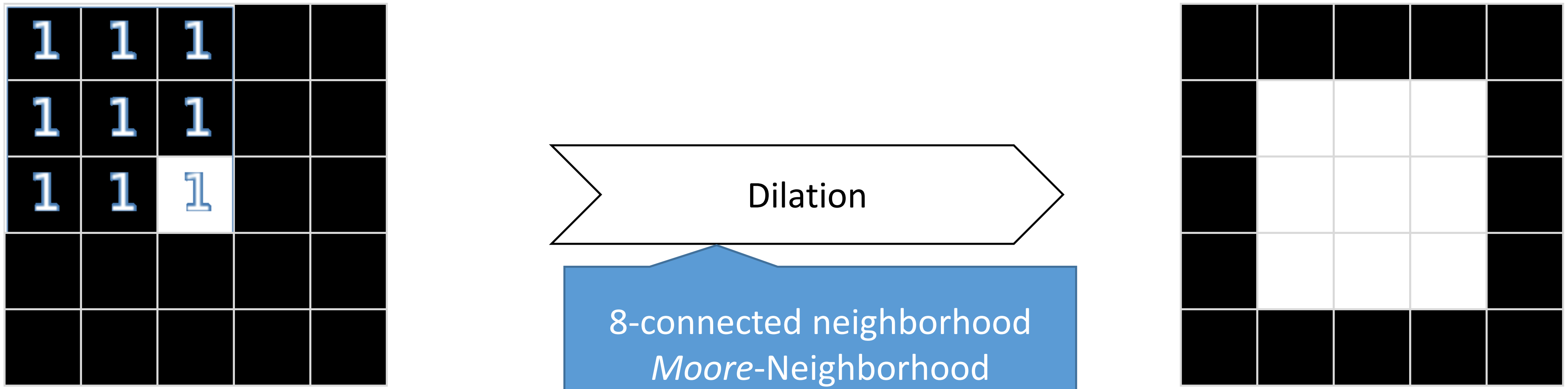
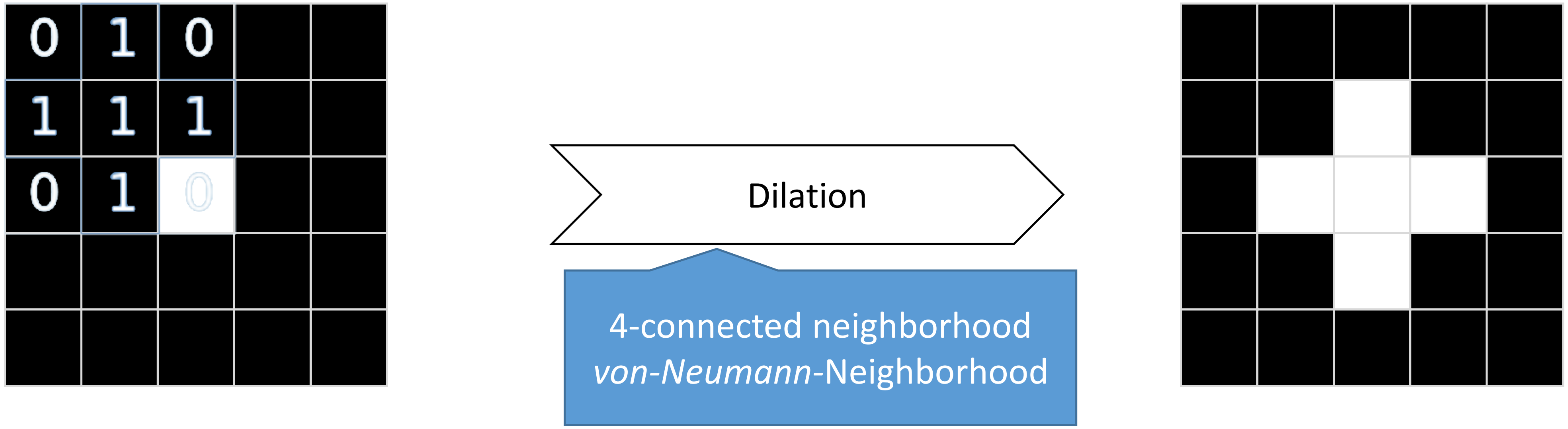
For an example with a grayscale image, check out this gif:
https://en.wikipedia.org/wiki/Erosion_(morphology)#/media/File:Grayscale_Morphological_Erosion.gif

Refining masks: Dilation

- Dilation: Every pixel with at least one white neighbor becomes white.





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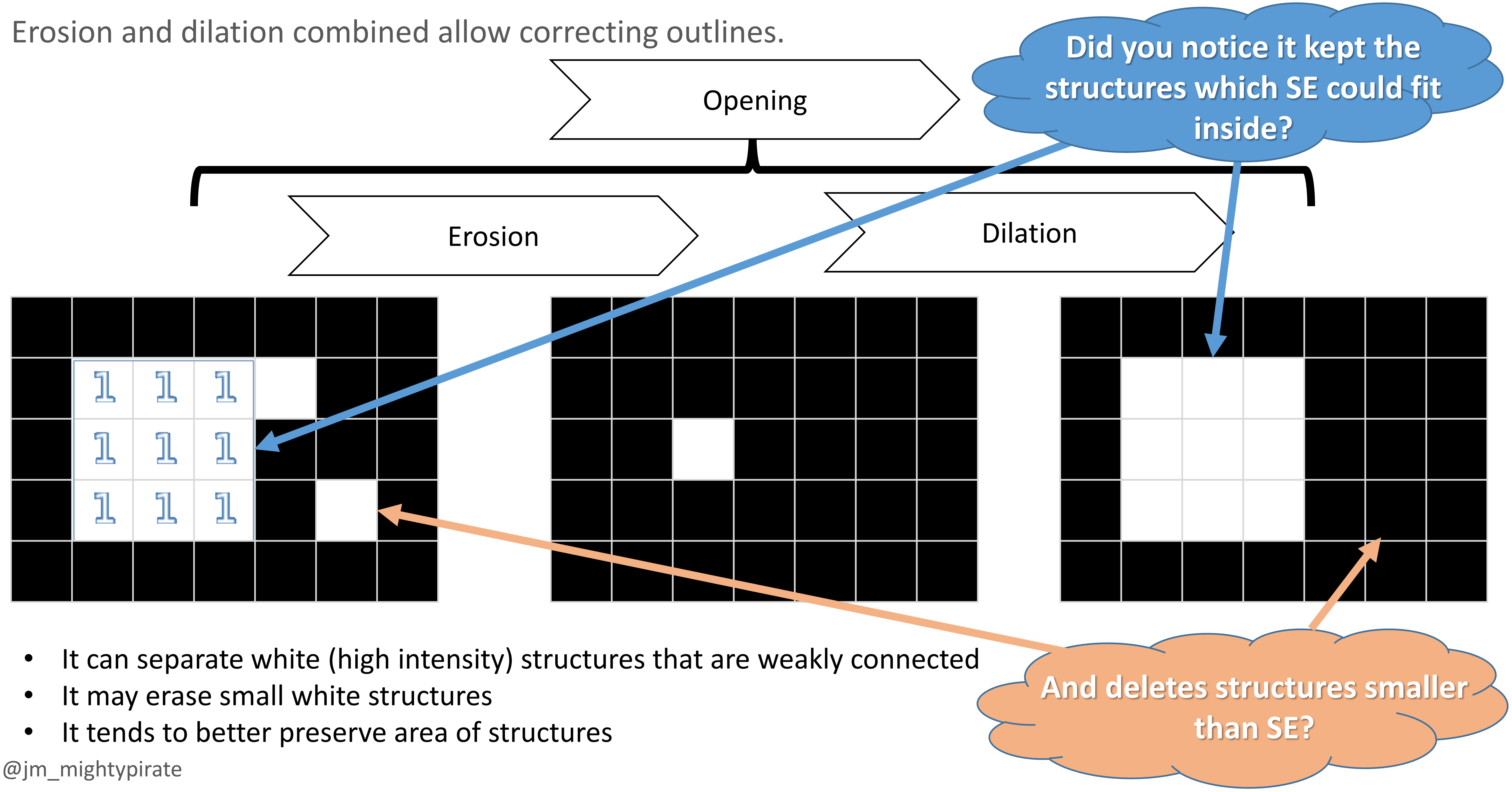
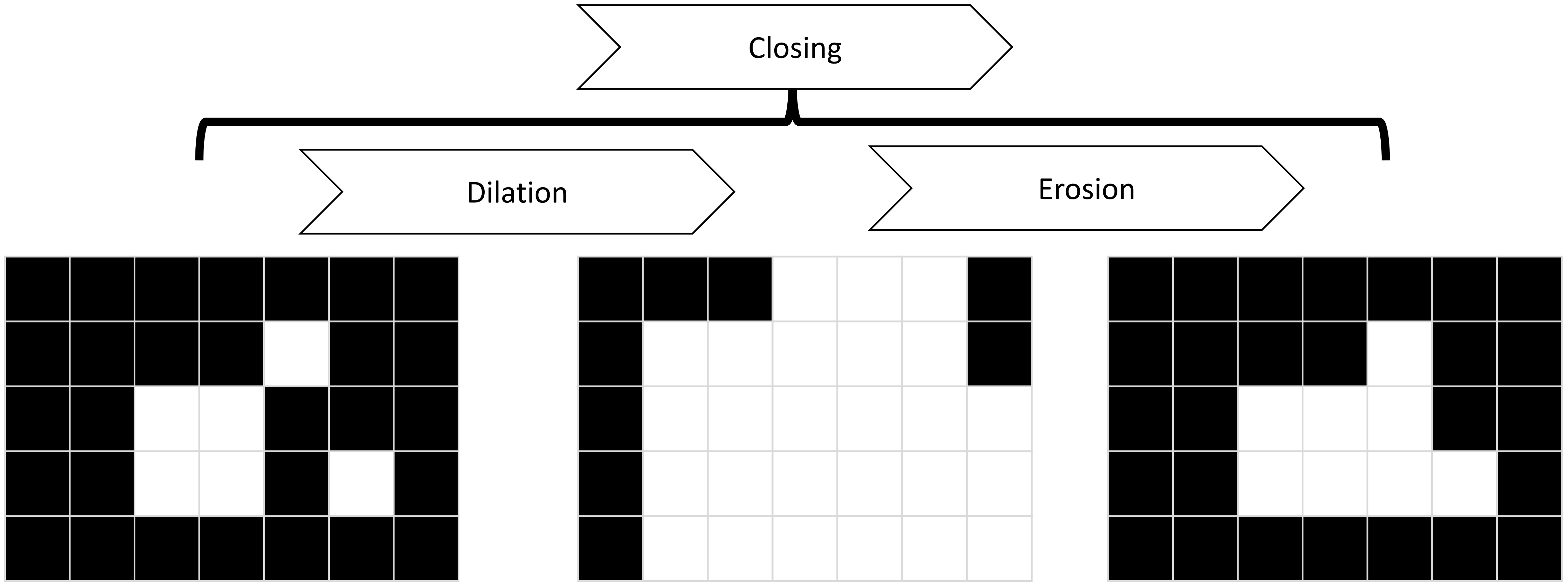
Refining masks: Erosion & Dilation

- Erosion and dilation combined allow correcting outlines.


Opening
Erosion
Dilation
1 1 1
1 1 1
1 1 1
Did you notice it kept the structures which SE could fit inside?
And deletes structures smaller than SE?

- It can separate white (high intensity) structures that are weakly connected
- It may erase small white structures
- It tends to better preserve area of structures

Refining masks: Erosion & Dilation



- It can connect white (high intensity) structures that are nearby
- It may close small holes inside structures
- It tends to better preserve area of structures

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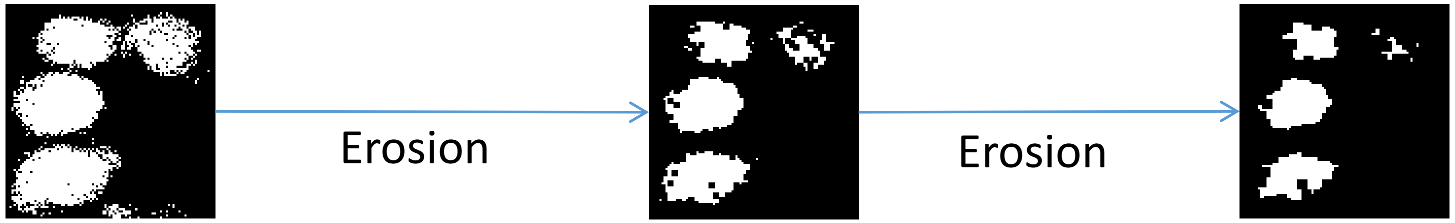
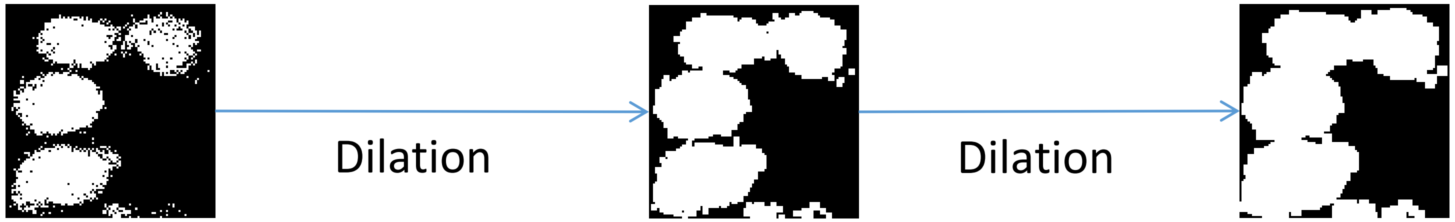
Refining masks: Erosion / dilation

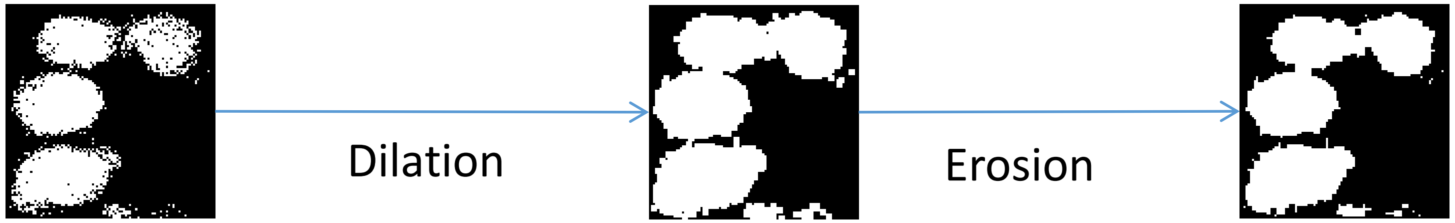
- Erosion: Set all pixels to black which have at least one black neighbor.



- Dilation: Set all pixels to white which have at least one white neighbor.



- Closing: Dilation + Erosion



- Opening: Erosion + Dilation

Are erosion/dilation/closing linear operations?
(i.e., can they be written as a multiplication with a kernel?)

Yes

No

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Morphological Operations in Python

Scikit-image has a sub-package called morphology

```
from skimage import morphology
```

You must define a SE first (also called footprint):

```
SE = morphology.square(3)
SE

array([[1, 1, 1],
       [1, 1, 1],
       [1, 1, 1]], dtype=uint8)
```

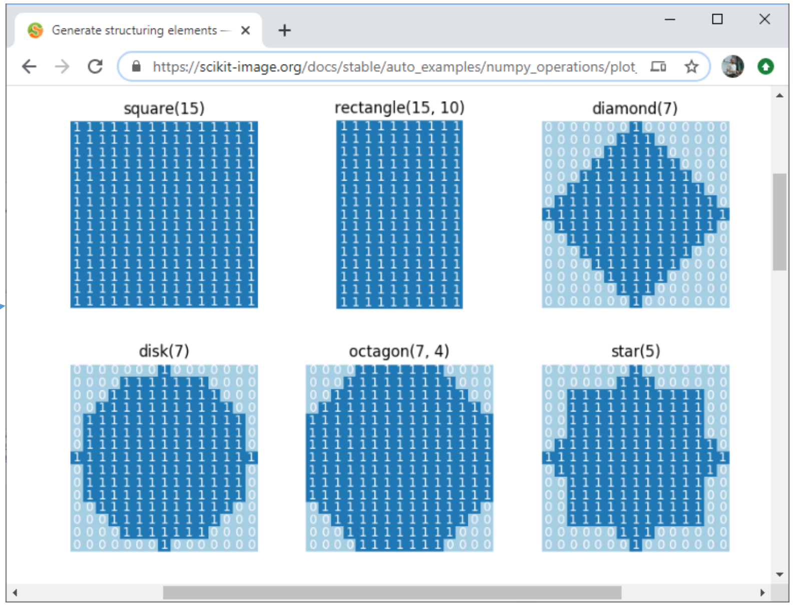
For a binary image, you apply it like this:

```
output = morphology.binary_dilation(binary_image, SE)
```

For a grayscale image, you apply it like this:

```
output = morphology.dilation(image, SE)
```

It can have other shapes/sizes:



Generate structuring elements –
https://scikit-image.org/docs/stable/auto_examples/numpy_operations/plot_
square(15)
rectangle(15, 10)
diamond(7)
disk(7)
octagon(7, 4)
star(5)

https://scikit-image.org/docs/stable/auto_examples/numpy_operations/plot_structuring_elements.html#sphx-glr-auto-examples-numpy-operations-plot-structuring-elements-py

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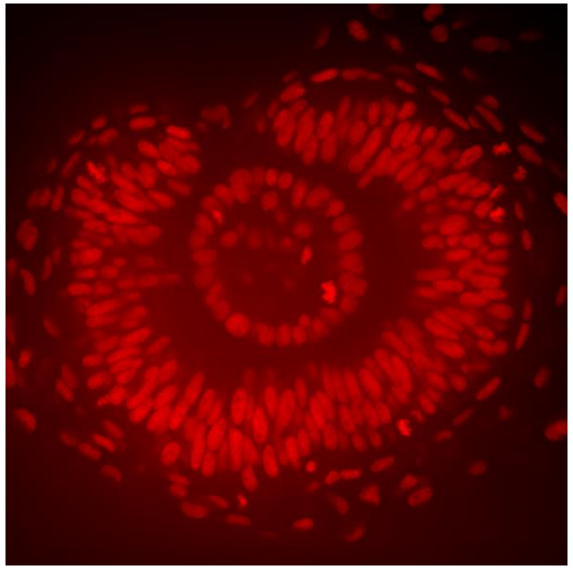
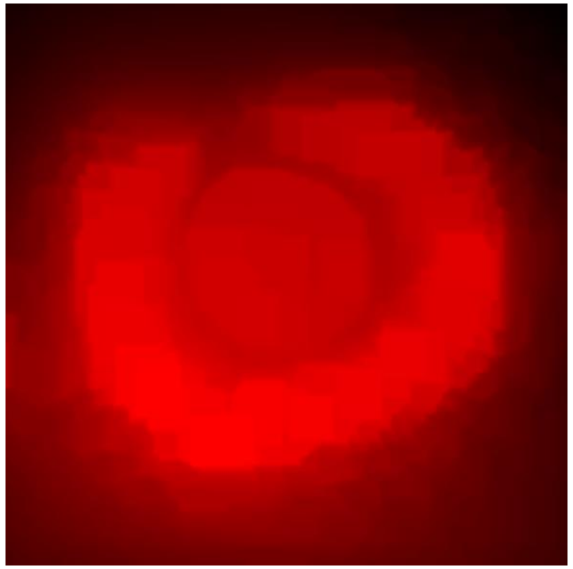
Background removal

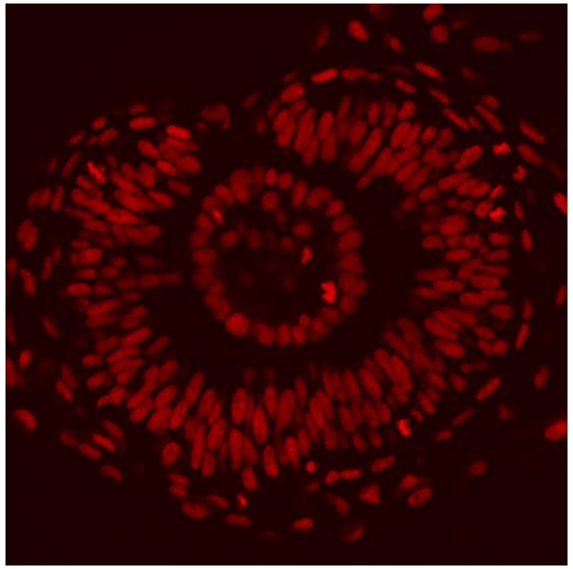
- Depending on the effect we want to correct for, it might make sense to divide an image by its background.

Do you remember that opening kept the structures which the SE could fit inside?

And do you remember that opening deletes structures smaller than SE?


Original image


Extracted background


Subtracted background

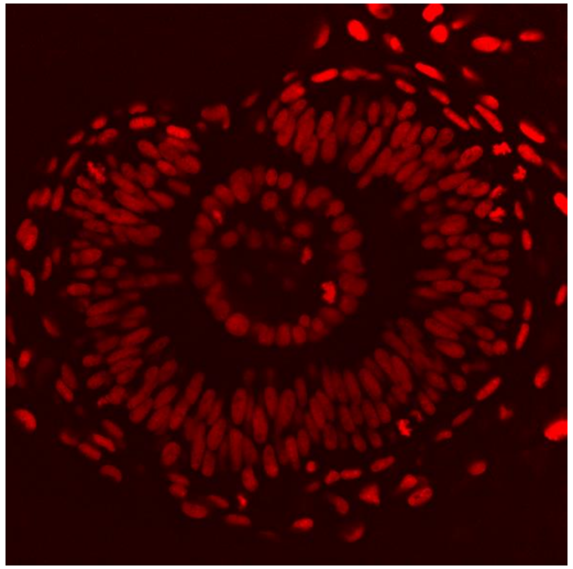
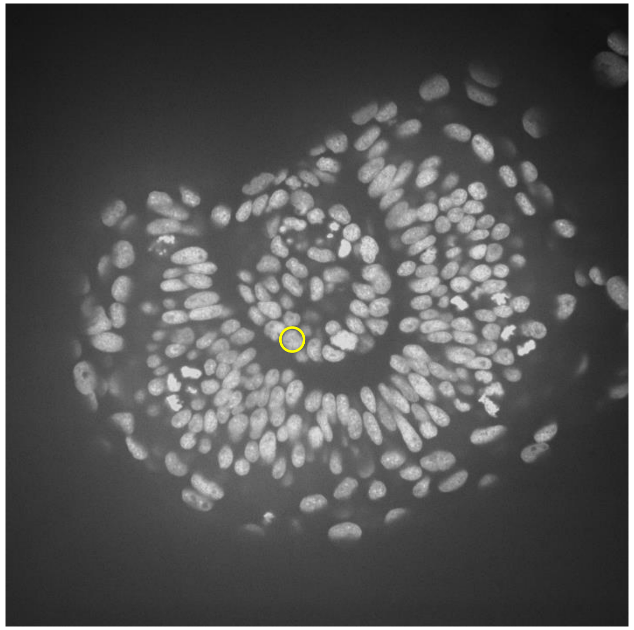


Image divided by background

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

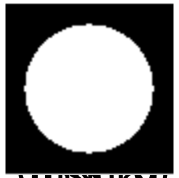
Background removal

Opening



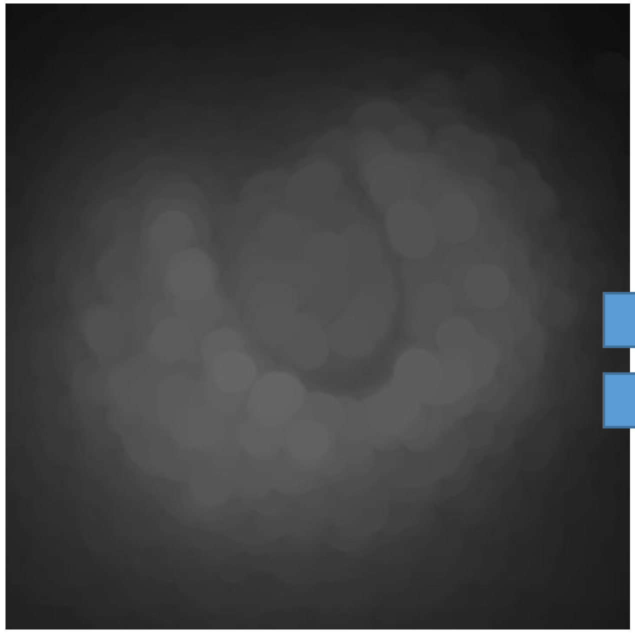
Original image

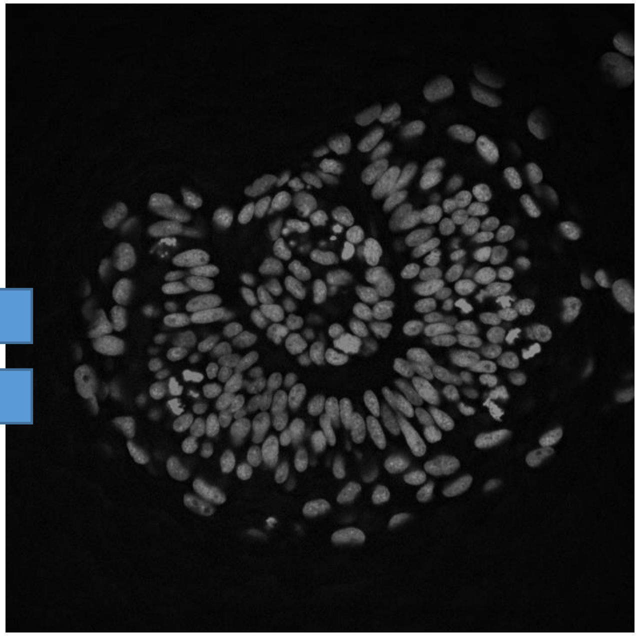
$\circ$



[illegible]

disk(32)





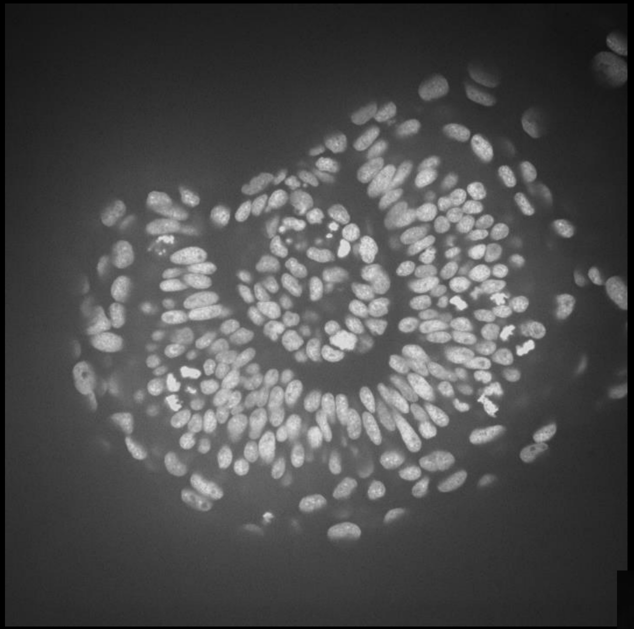
This is a good estimation of the background

Structures have a radius ≈ 12

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

Background removal

What happens for a small structuring element (e.g., disk (2))?



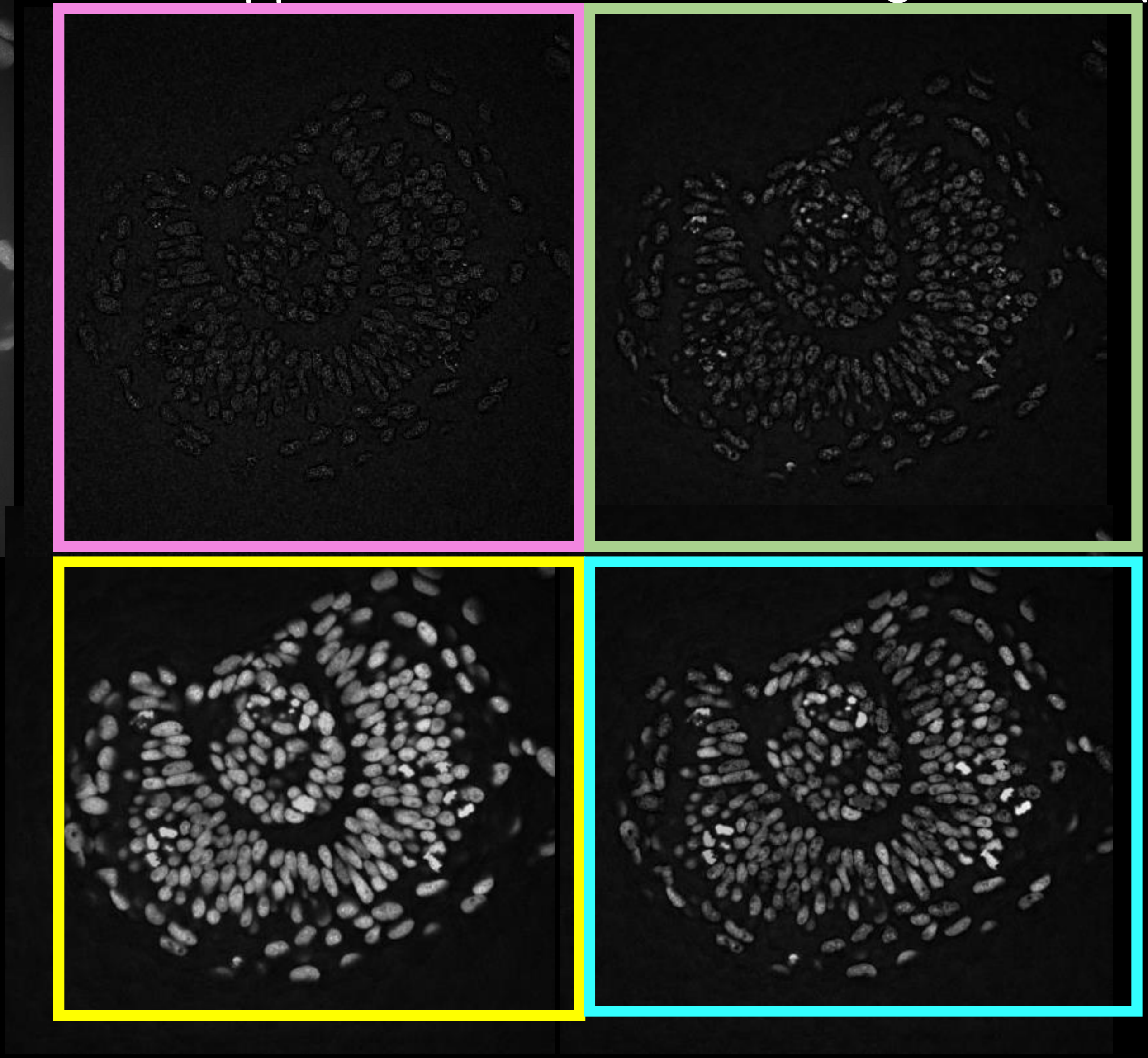


Image source: Mauricio Rocha Martins (Norden/Myers lab, MPI CBG)