

Introduction to Biomedical Image Analysis using Examples from Cell Detection & Identification

Pinaki Sarder, Ph.D.

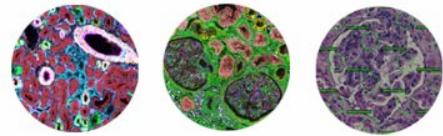
Associate Professor

Section of Quantitative Health, Medicine – Nephrology

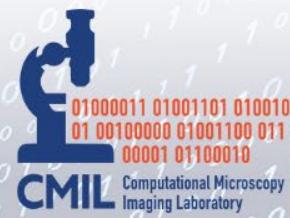
Electrical & Computer Engineering

Biomedical Engineering

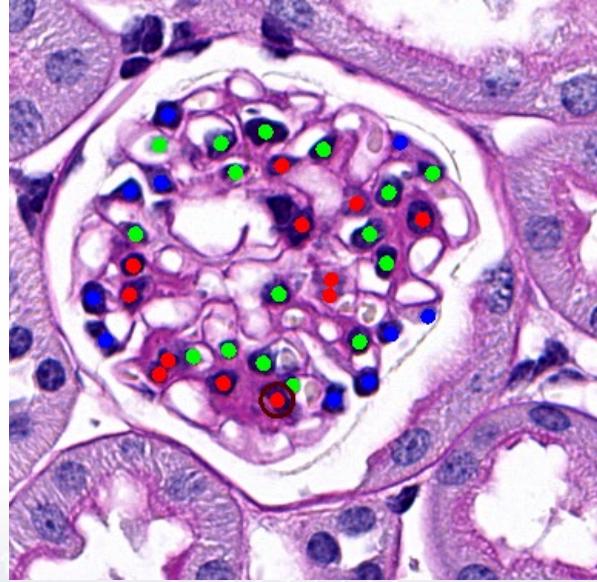
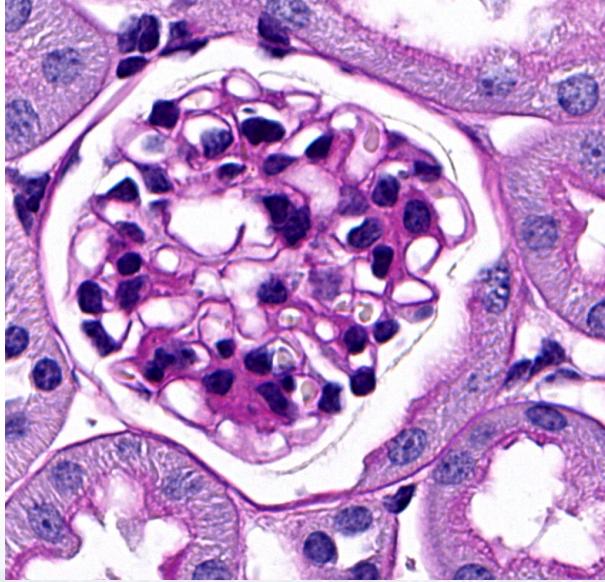
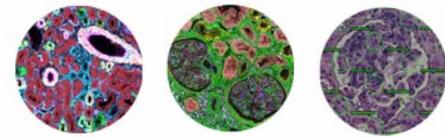
Associate Director for Imaging, Intelligent Critical Care Center



Where it all starts eventually!



Cell Counting (Does this Problem Look Familiar?)

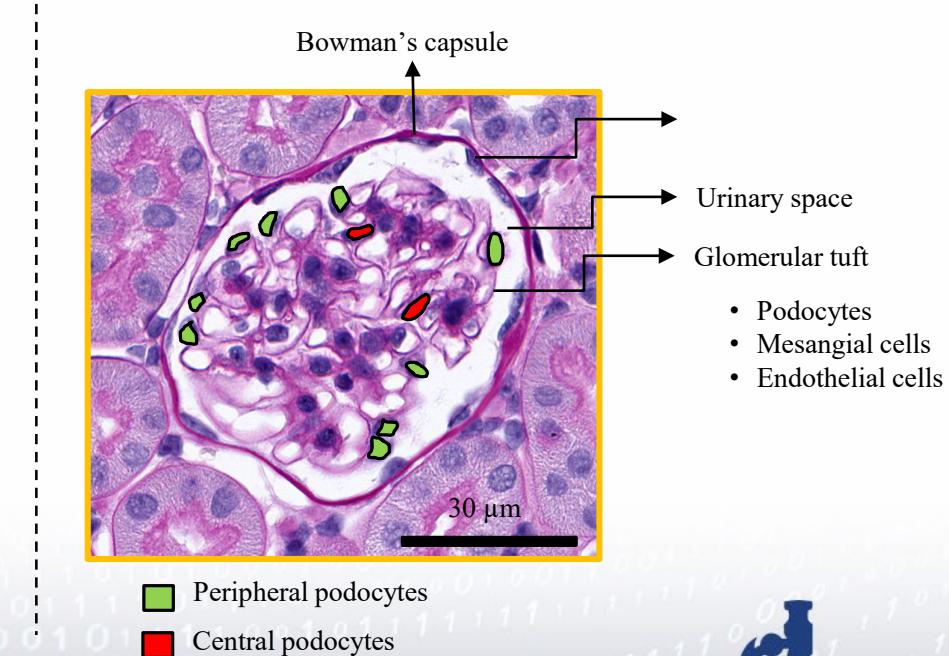
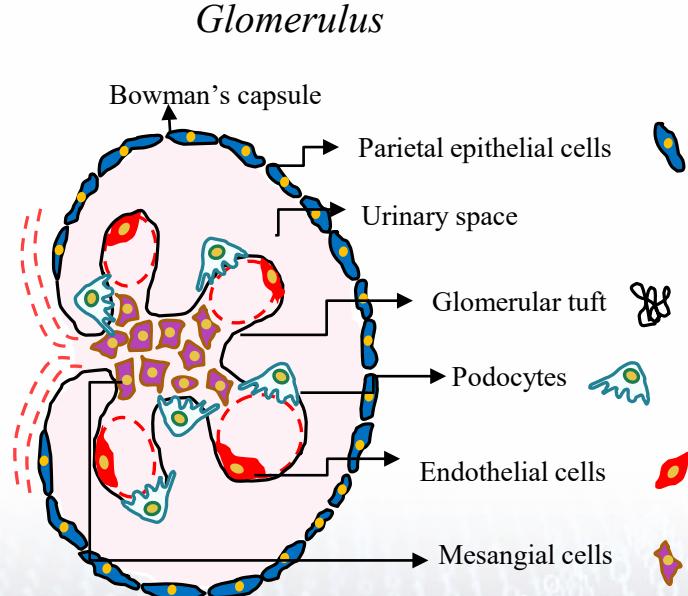
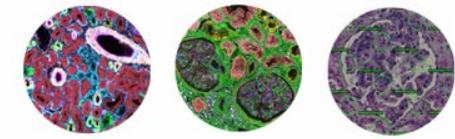


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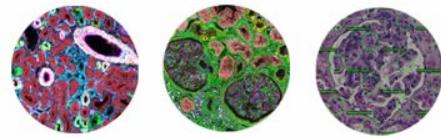
00001 01100010

CMIL Computational Microscopy
Imaging Laboratory

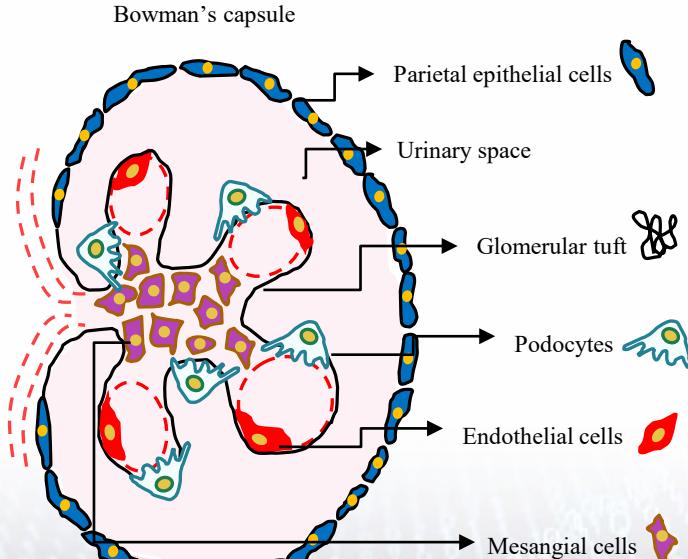
Task Complexity: Identification of a Specific Cell – Podocytes



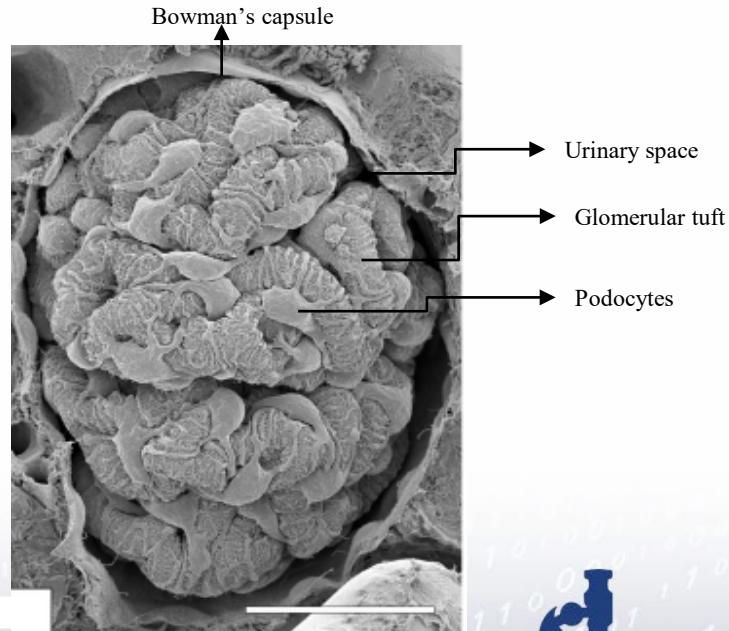
Task Complexity: 3D vs 2D



Glomerulus

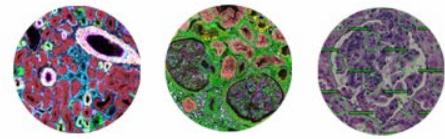


Glomerulus



Miyaki et al., *Cell and tissue research*, 2020

Task Complexity: Cell Identification in Disease

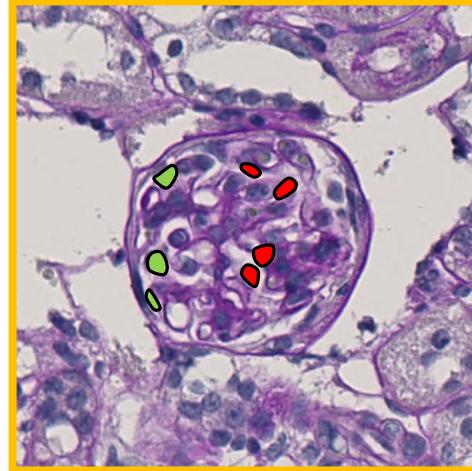


Normal



- Peripheral podocytes
- Central podocytes

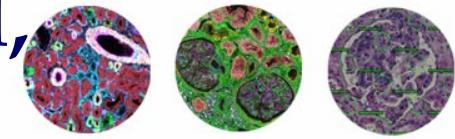
Crescentic glomerulonephritis



- Peripheral podocytes
- Central podocytes

- ❖ Histologic manifestation of severe glomerular damage
- ❖ Podocyte injury and loss

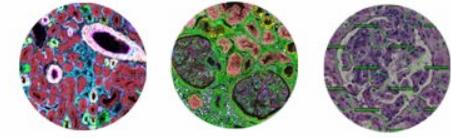
Questions we are interested, in general, at microscopic scale:



For tissue from any organ, regardless of whether the tissue is normal or diseased:

- What type of cells are there?
- How many of each cell type is present?
- What are their biological states?
- How do they interact with other components in a tissue (e.g., lumen, matrix, or other structural units or sub-units)?

PodoSighter: Label-Free Podocyte Detection



0011 01001101 010010
100000 01001100 011
00001 01100010

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Detection & Identification of Multiple Cells

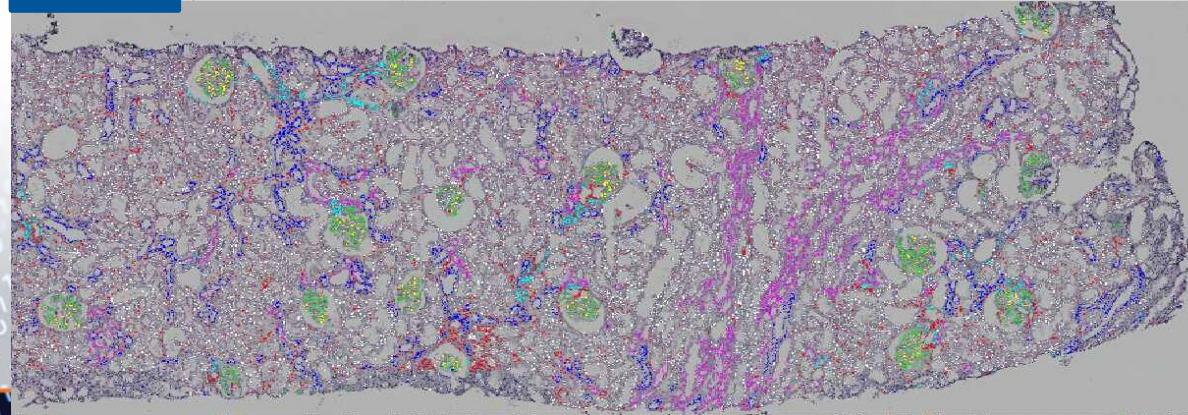
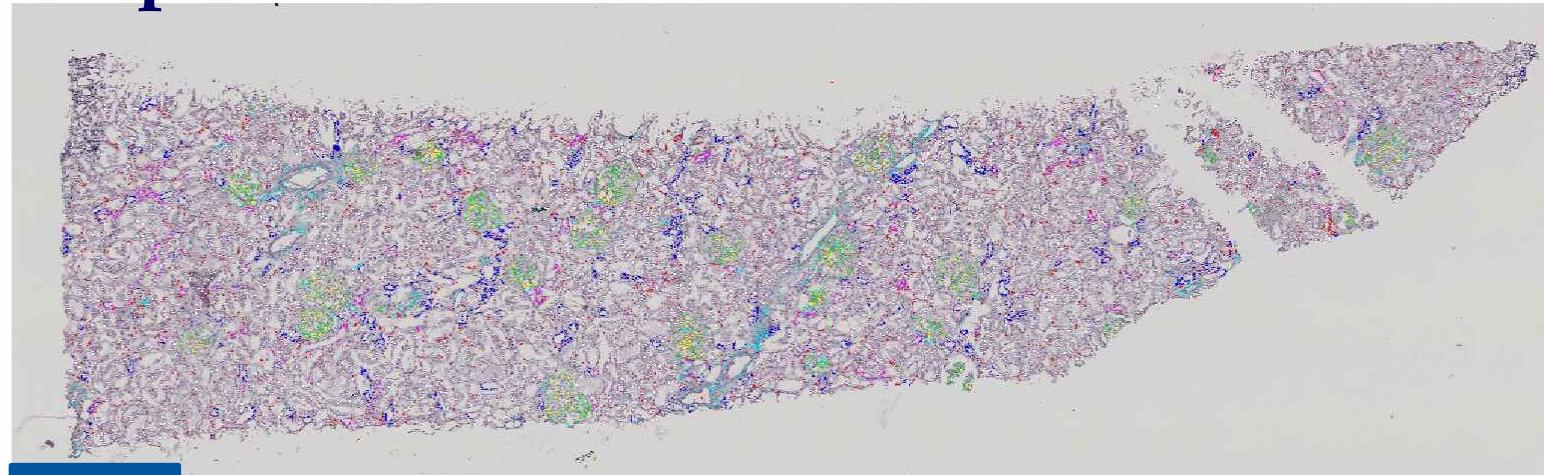
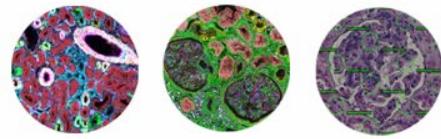
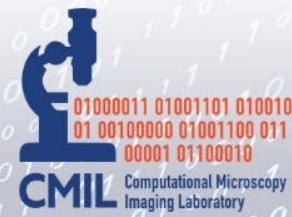
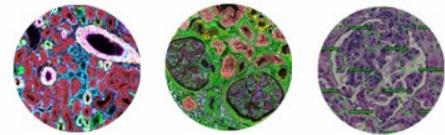




Image Analysis 101 to get there

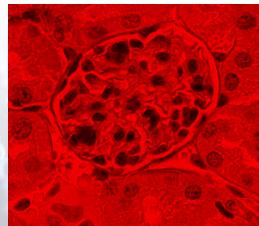
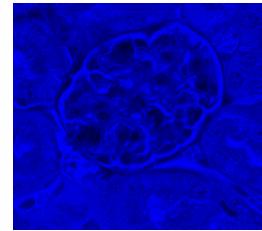
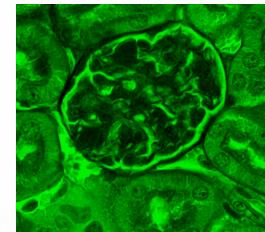
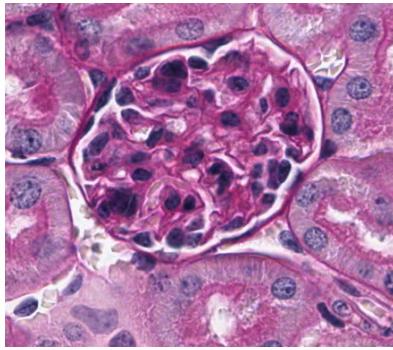
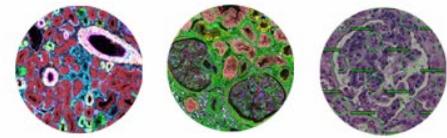


What will we learn next?

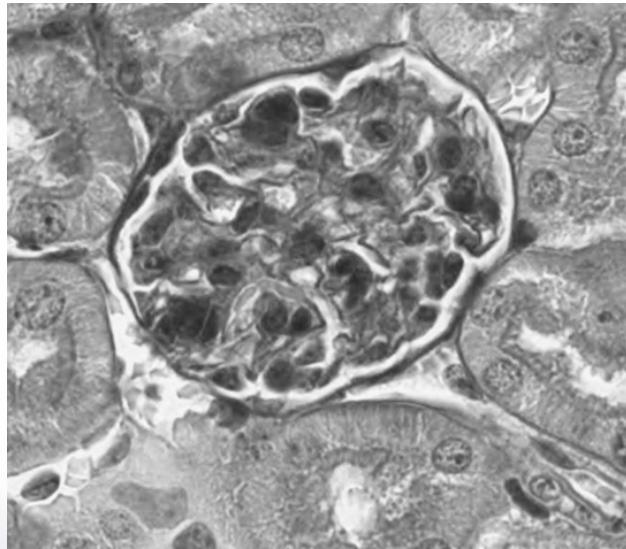
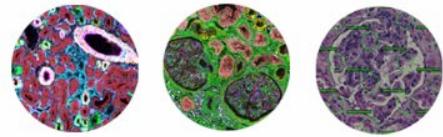


- How to read image using computer
- R, G, and B component of an image
- Intensity image and binary image
- Separating stain components in histology images
- Basics of training a computer for segmenting structures from histology images

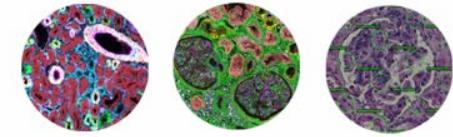
Histology image as a color image



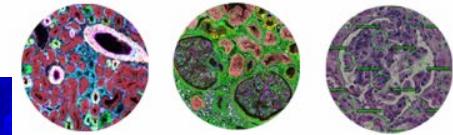
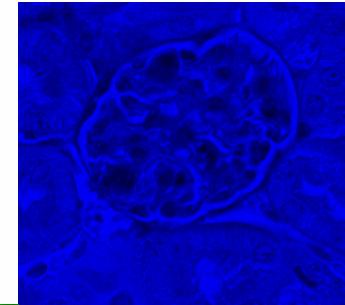
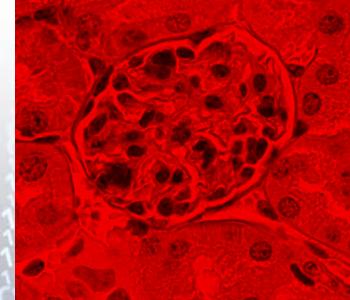
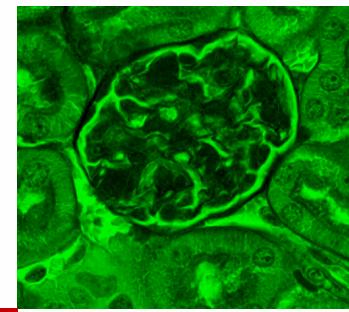
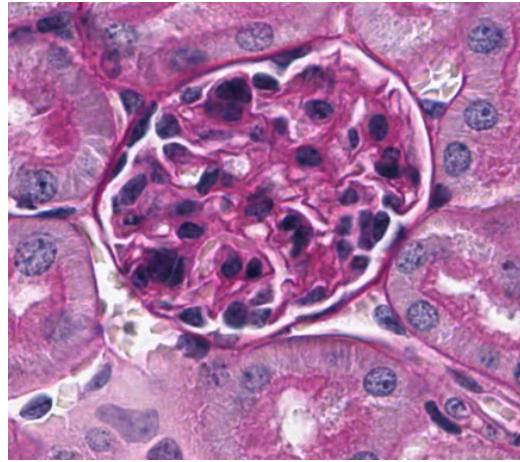
Intensity Image



Binary Image

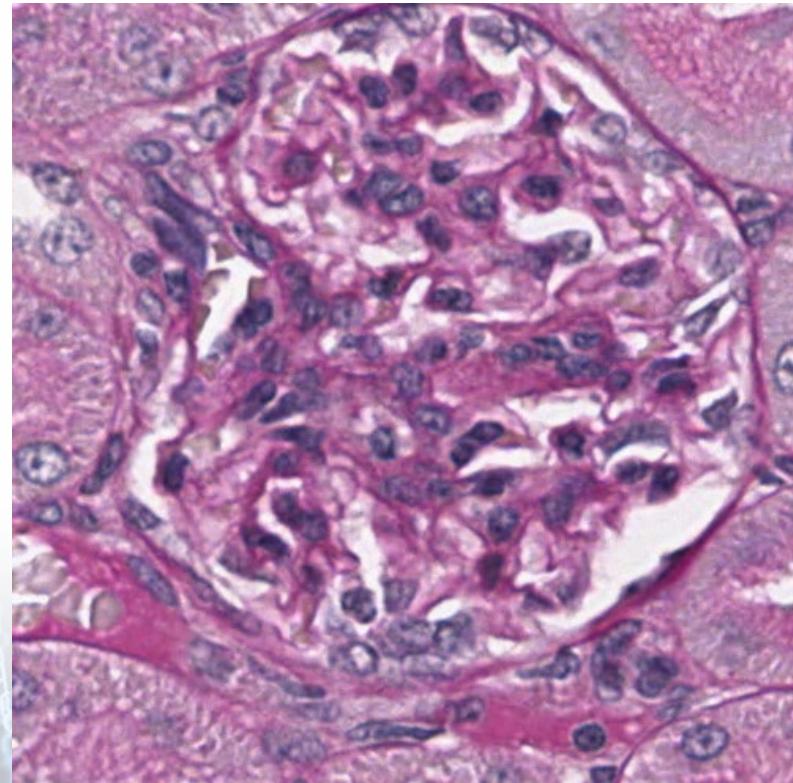
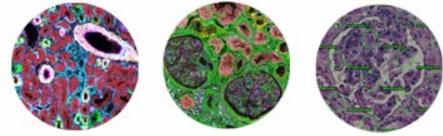


Color Deconvolution

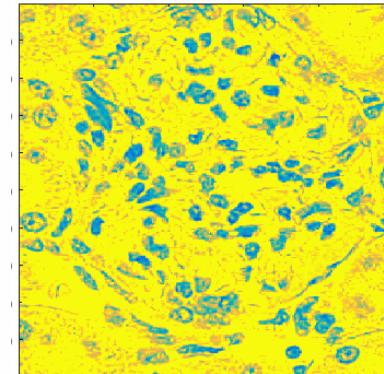
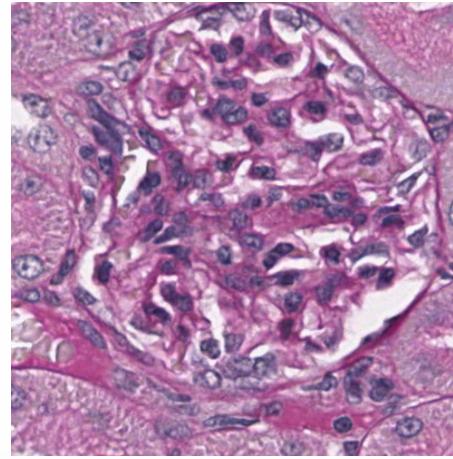


Are these the best
decomposition?

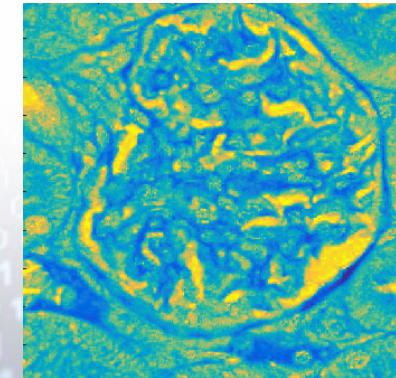
Hematoxylin + Periodic acid-Schiff Stain



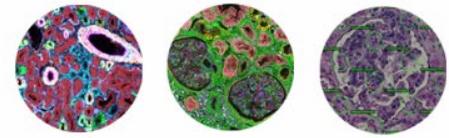
Color Deconvolution



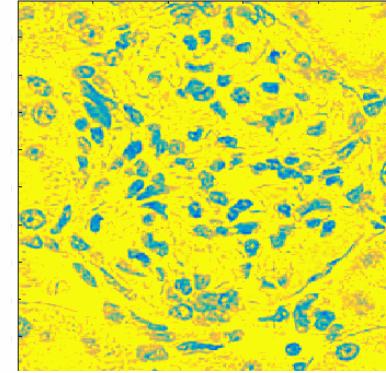
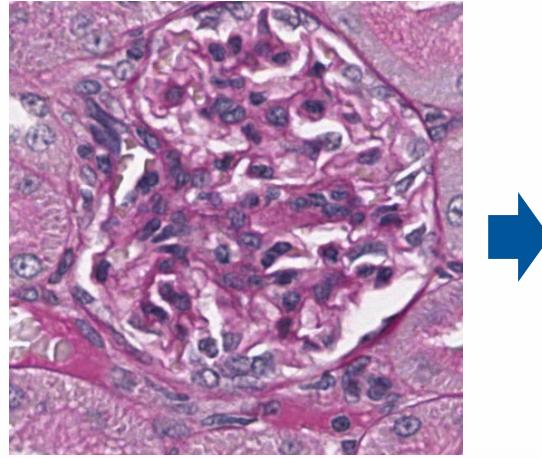
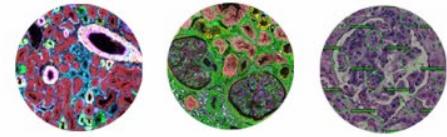
Hematoxylin



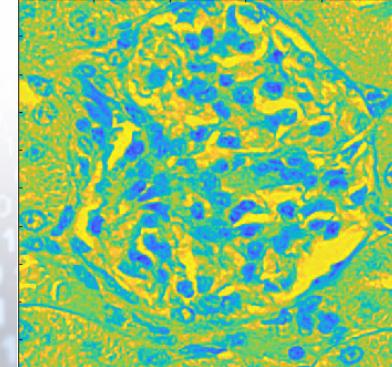
PAS



So which one will you use for nuclei segmentation?

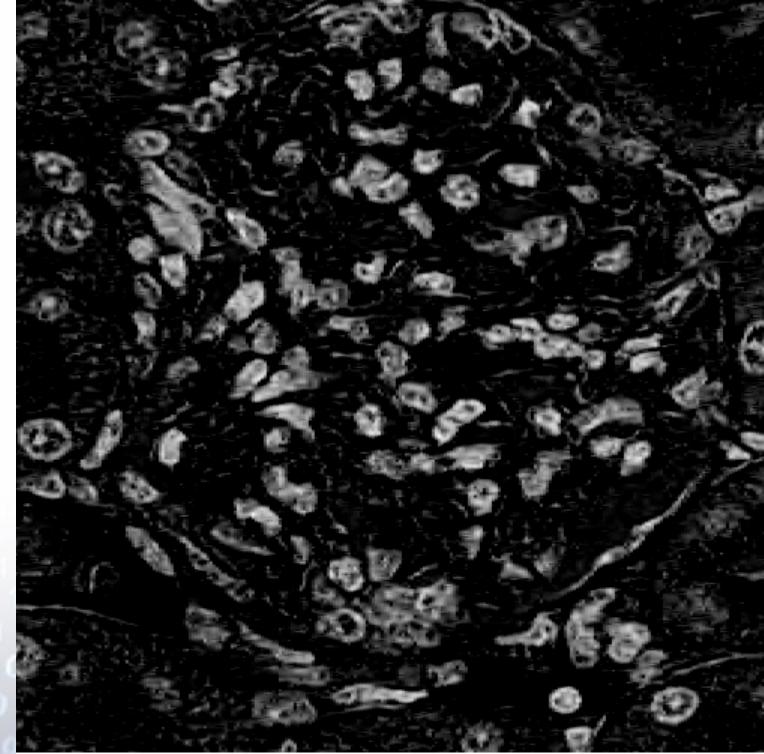
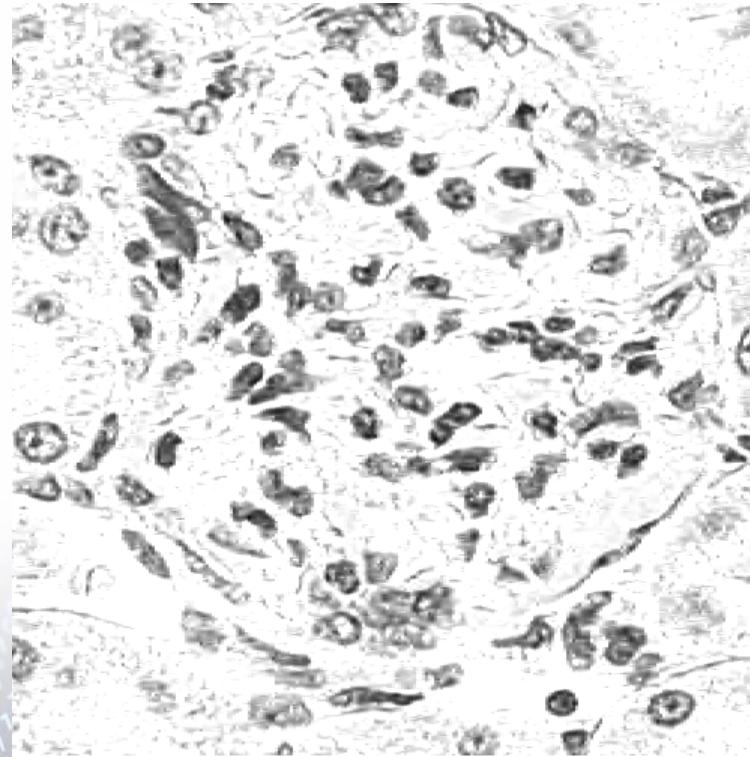
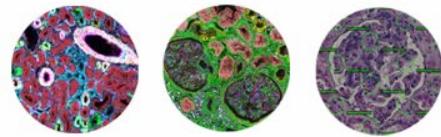


Color deconvolution

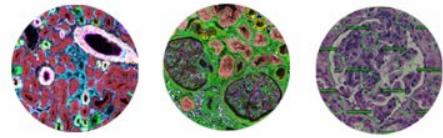


R component

What artifacts do you want your computer to remove to segment the nuclei?

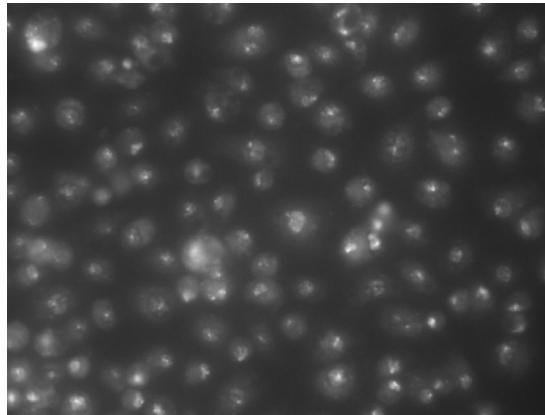
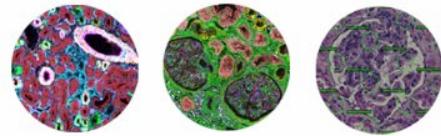


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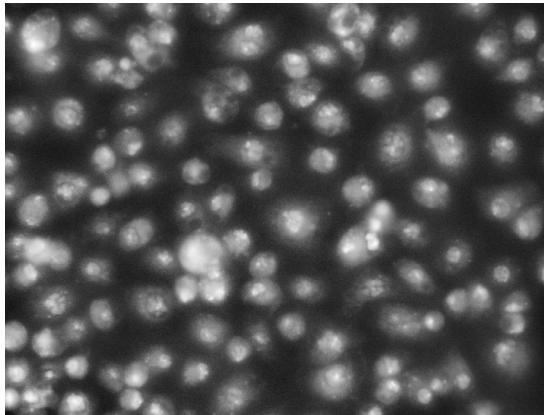


Let's pause for a moment and look at a simpler problem

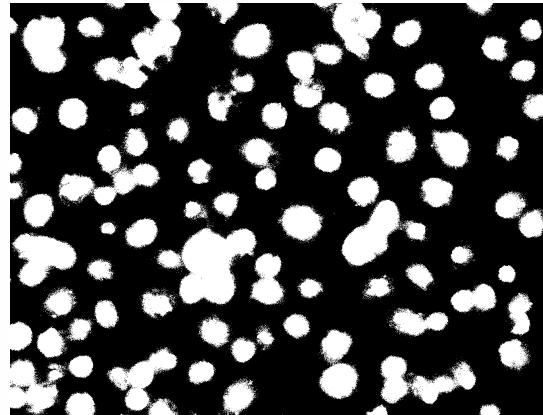
A Simple Workflow



Raw fluorescence images of cells

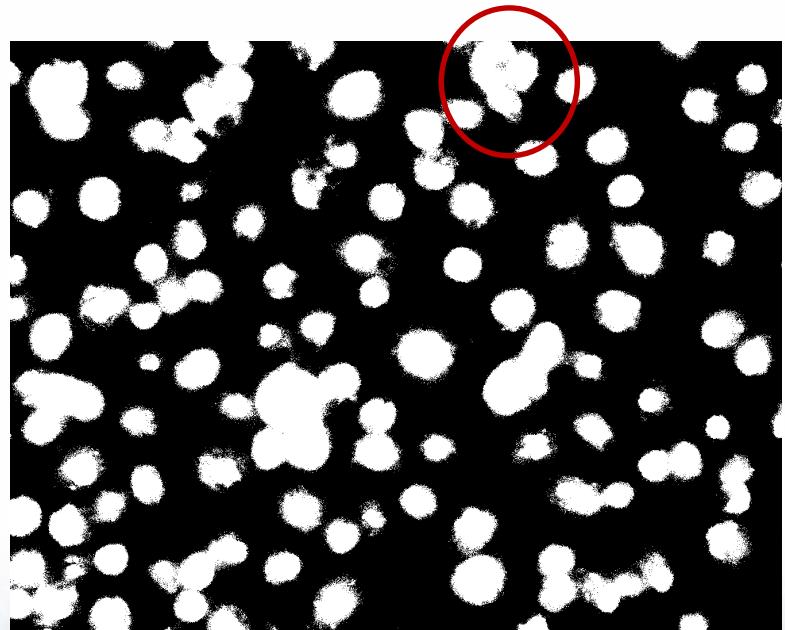


Contrast enhancement

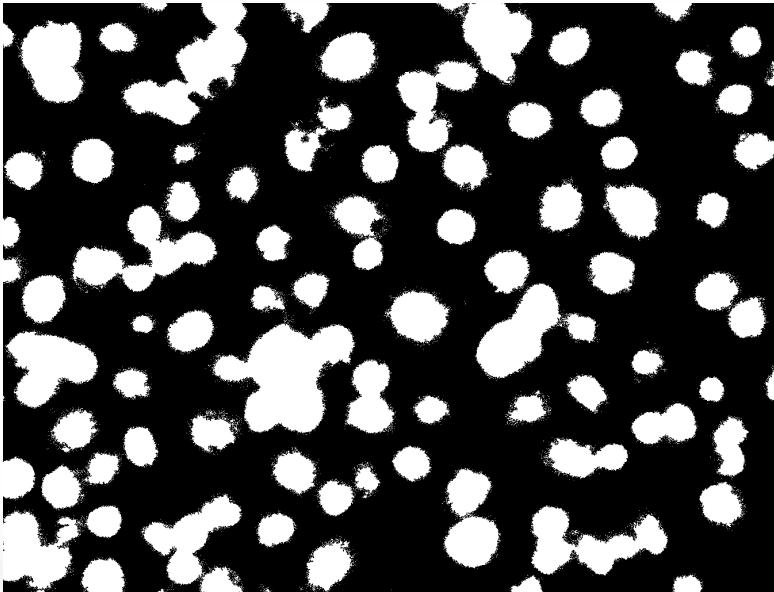


Binarization

A Simple Workflow (cont.)

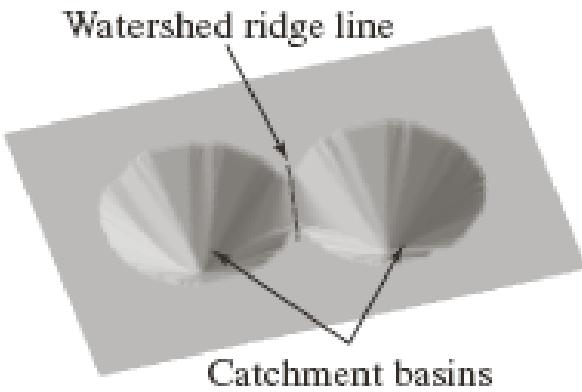
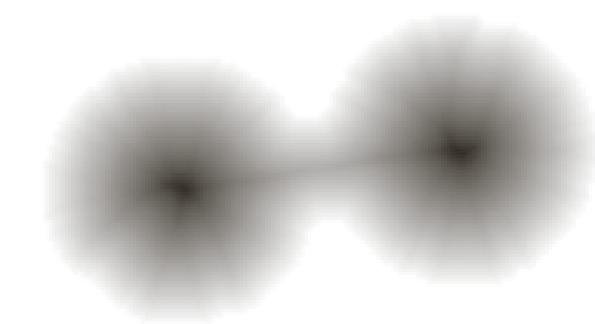
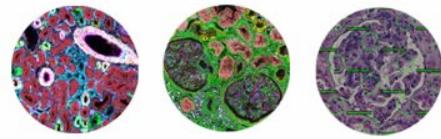


Binary Image



Morphological Processing

Watershed Transformation: Tool we Need

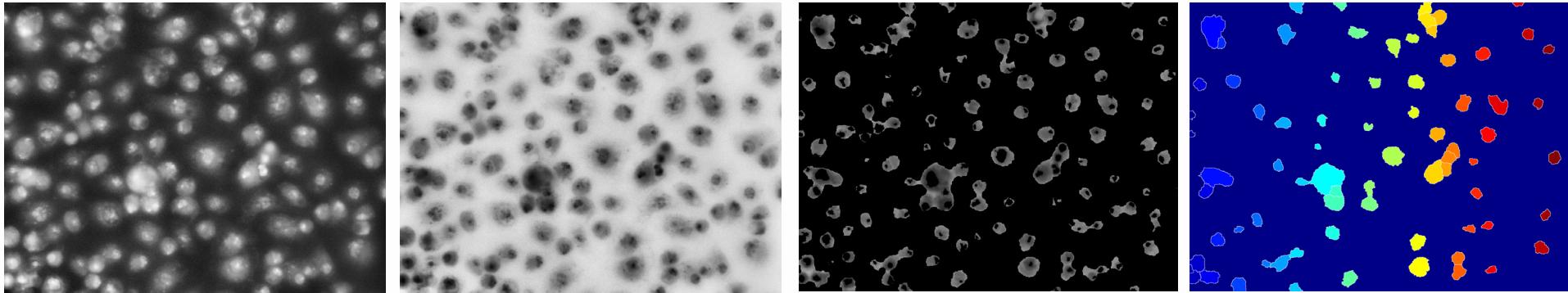
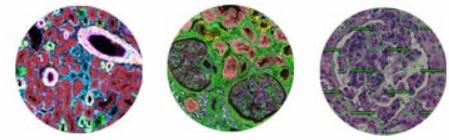


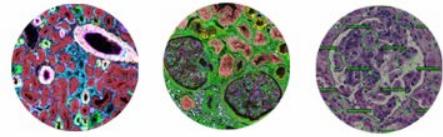
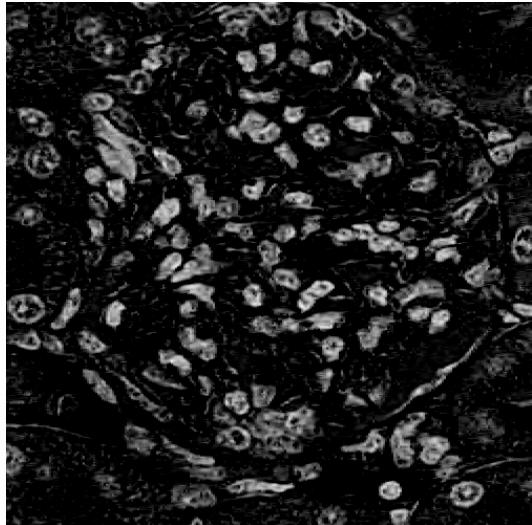
a b

FIGURE 11.24
(a) Gray-scale
scale image. (b)
Image viewed as
a surface, showing
a watershed ridge
line and catchment
basins.



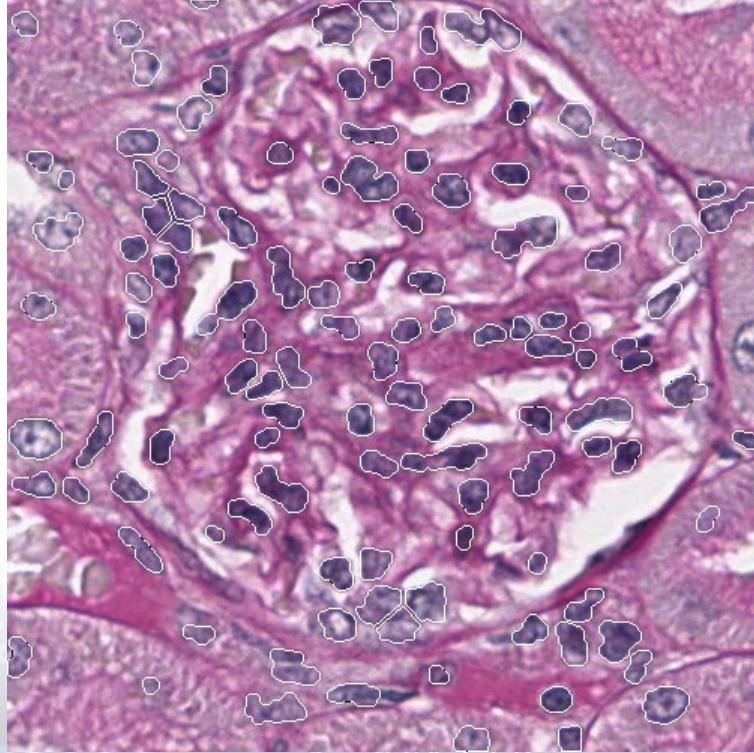
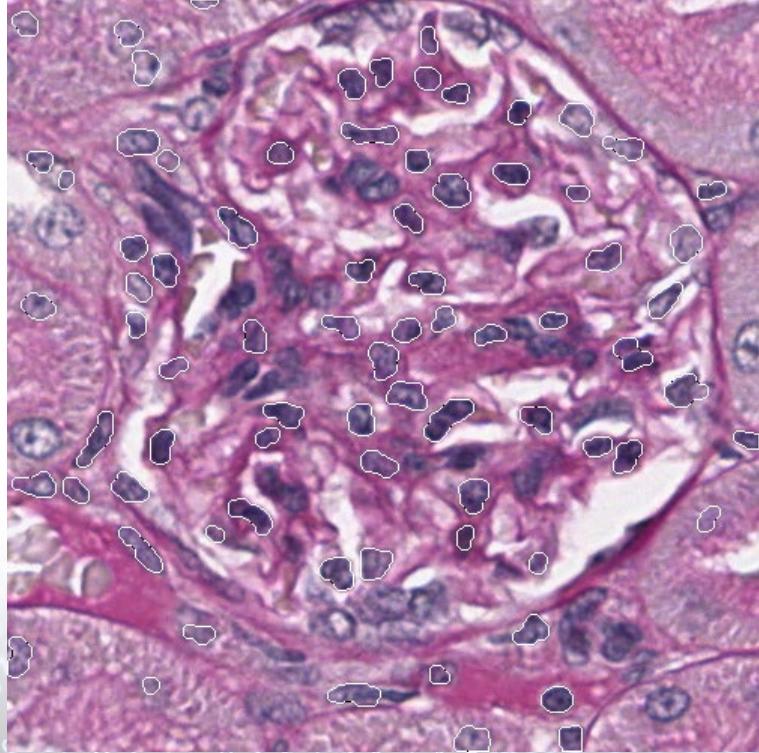
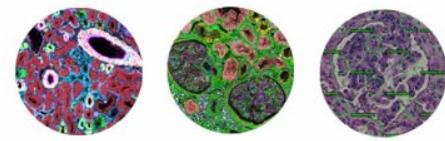
A Simple Workflow (cont.): Watershed Pipeline





Hopefully you have a solution now to that old problem!!

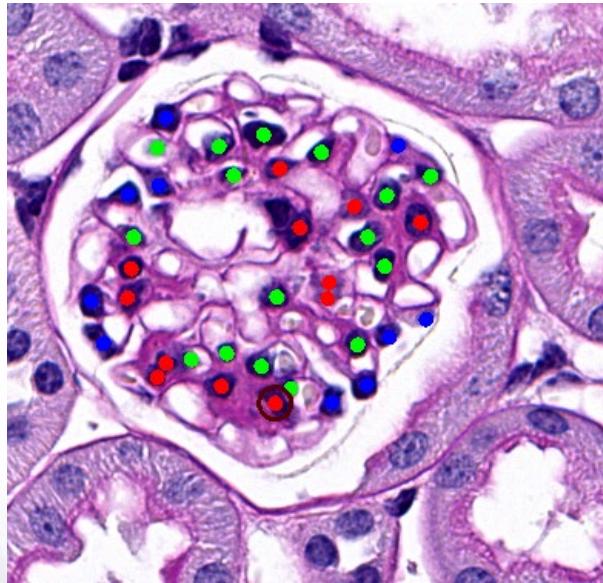
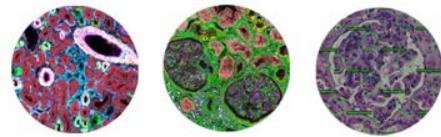
After Learning Image Analysis, You Can Get Here (Detection!)....



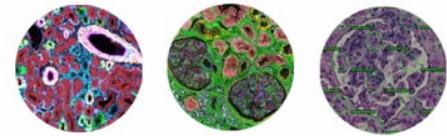
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CMIL Computational Microscopy
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Classification is for Another Day!!



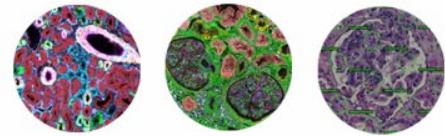
Wrap-Up



We learned today:

- Cell detection & identification is a common problem to tackle in every lab
- Basics of image analysis
- Concept of algorithm
- Cell classification is a harder problem, requiring advanced concept

Online Tools for Clinicians & Basic Scientists



- HistoCloud: <https://athena.rc.ufl.edu/>
- FUSION: <http://ec2-44-211-199-123.compute-1.amazonaws.com/>

Thank you!

