

CELL SPATIAL POSITIONING ANALYSIS FOR GLAND SEGMENTATION IN DIGITAL PATHOLOGY

Bassem BEN CHEIKH

Daniel RACOCEANU

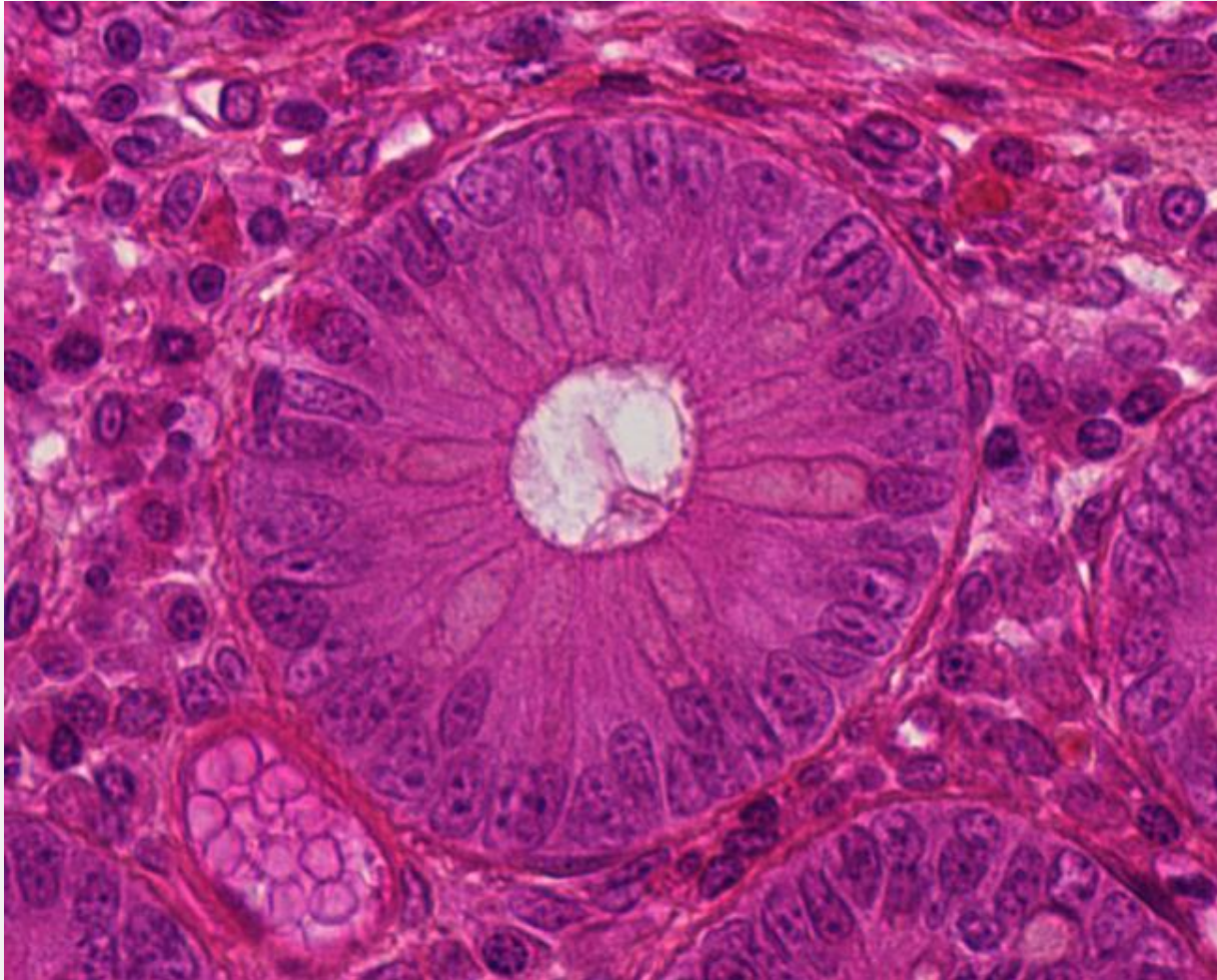
**Sorbonne Universités, UPMC Univ Paris 06, CNRS, INSERM,
Biomedical Imaging Laboratory (LIB), Paris, France**

bassem.bencheikh@lib.upmc.fr

October 5, 2015

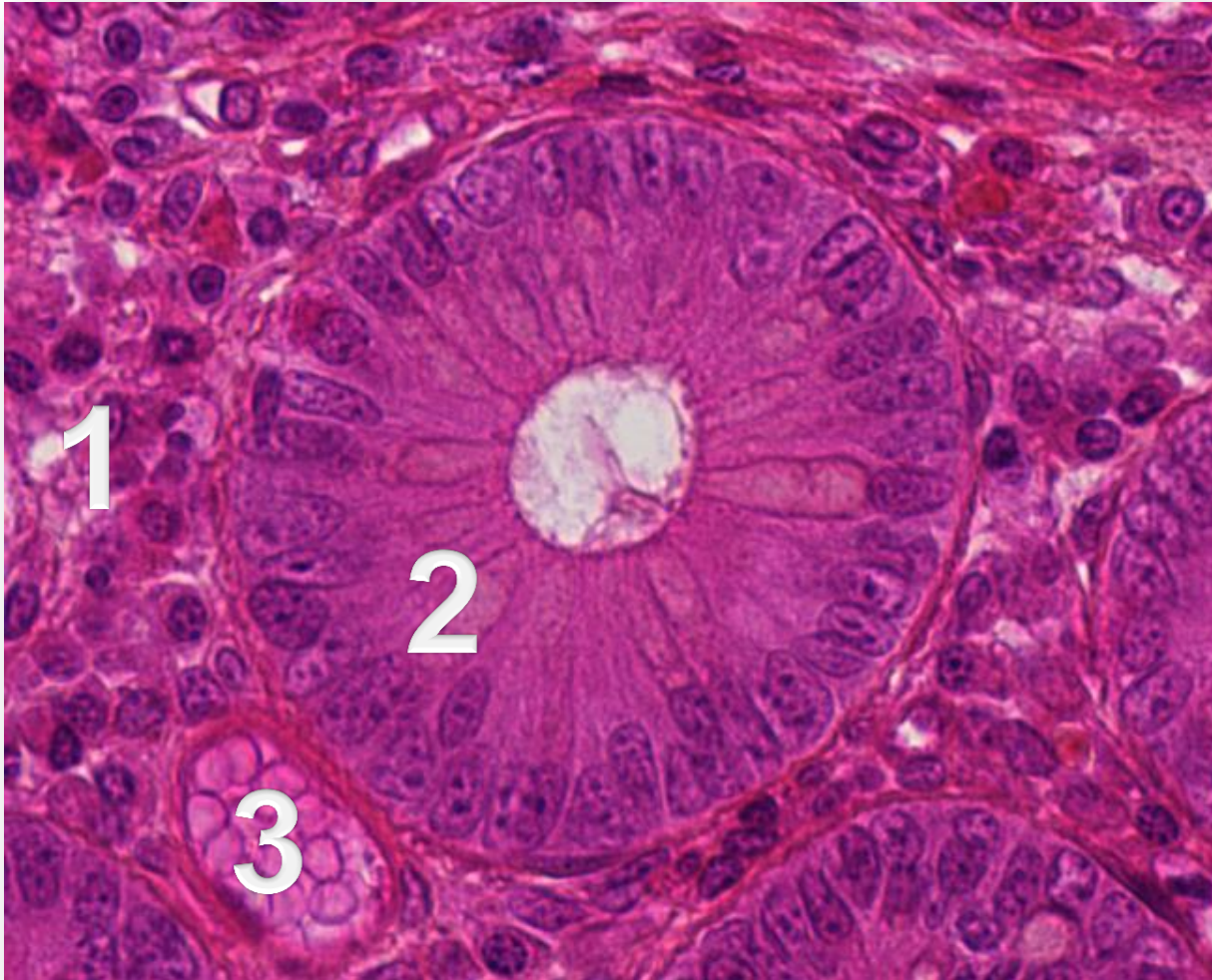
Intestinal Glands

Healthy tissue structure:



Intestinal Glands

Healthy tissue structure:



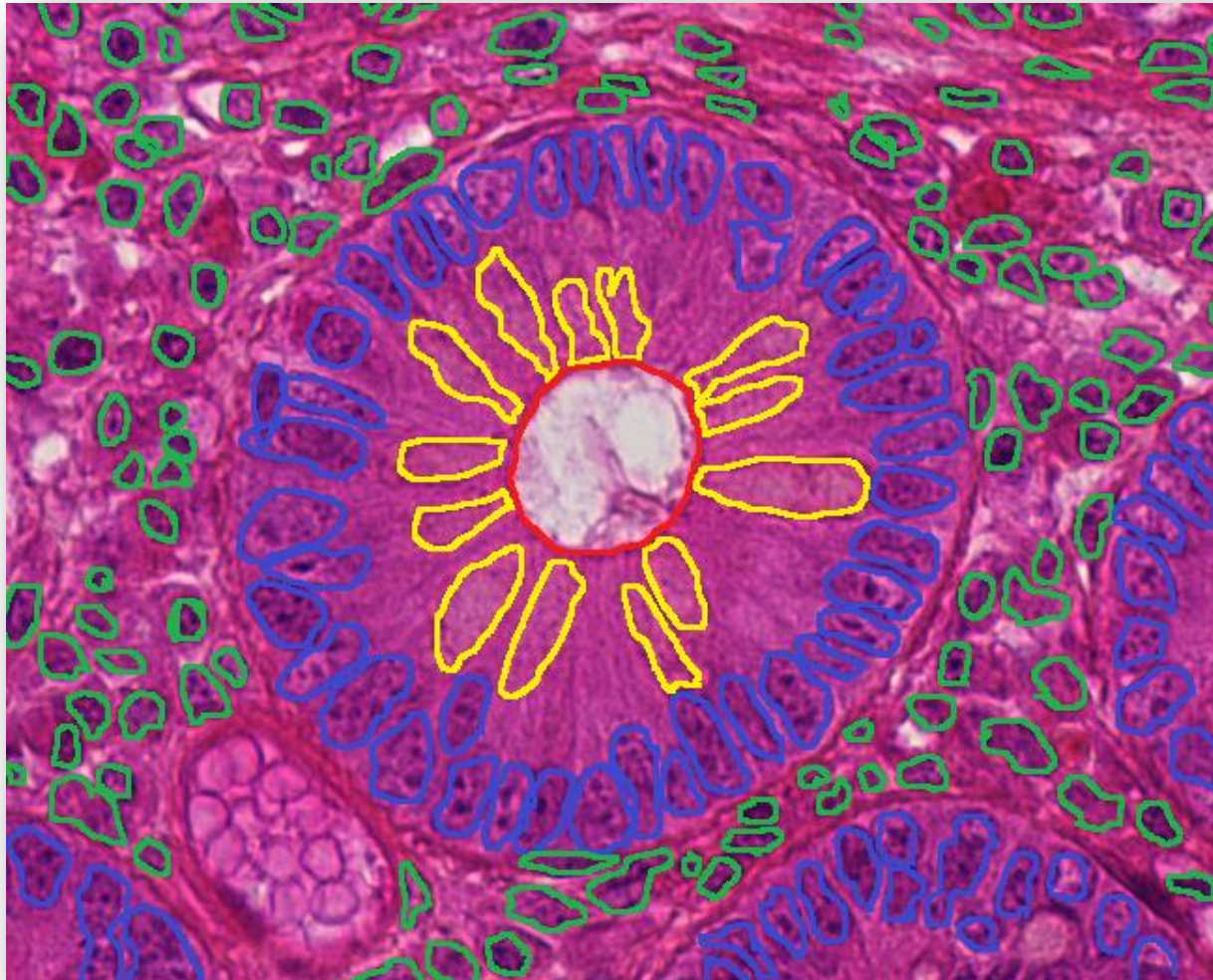
1 : Connective Tissue

2 : Crypt of Lieberkühn

3 : Blood vessel

Intestinal Glands

Healthy tissue structure:



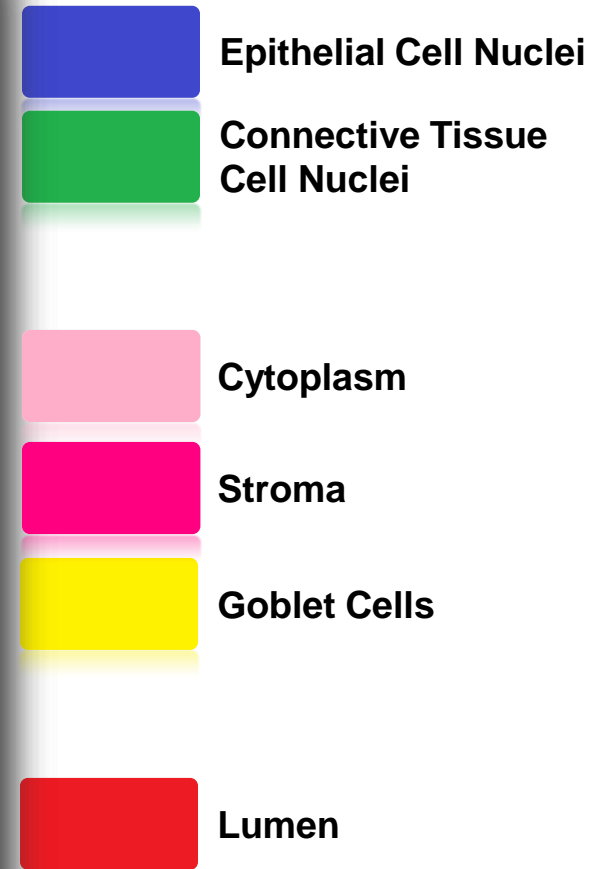
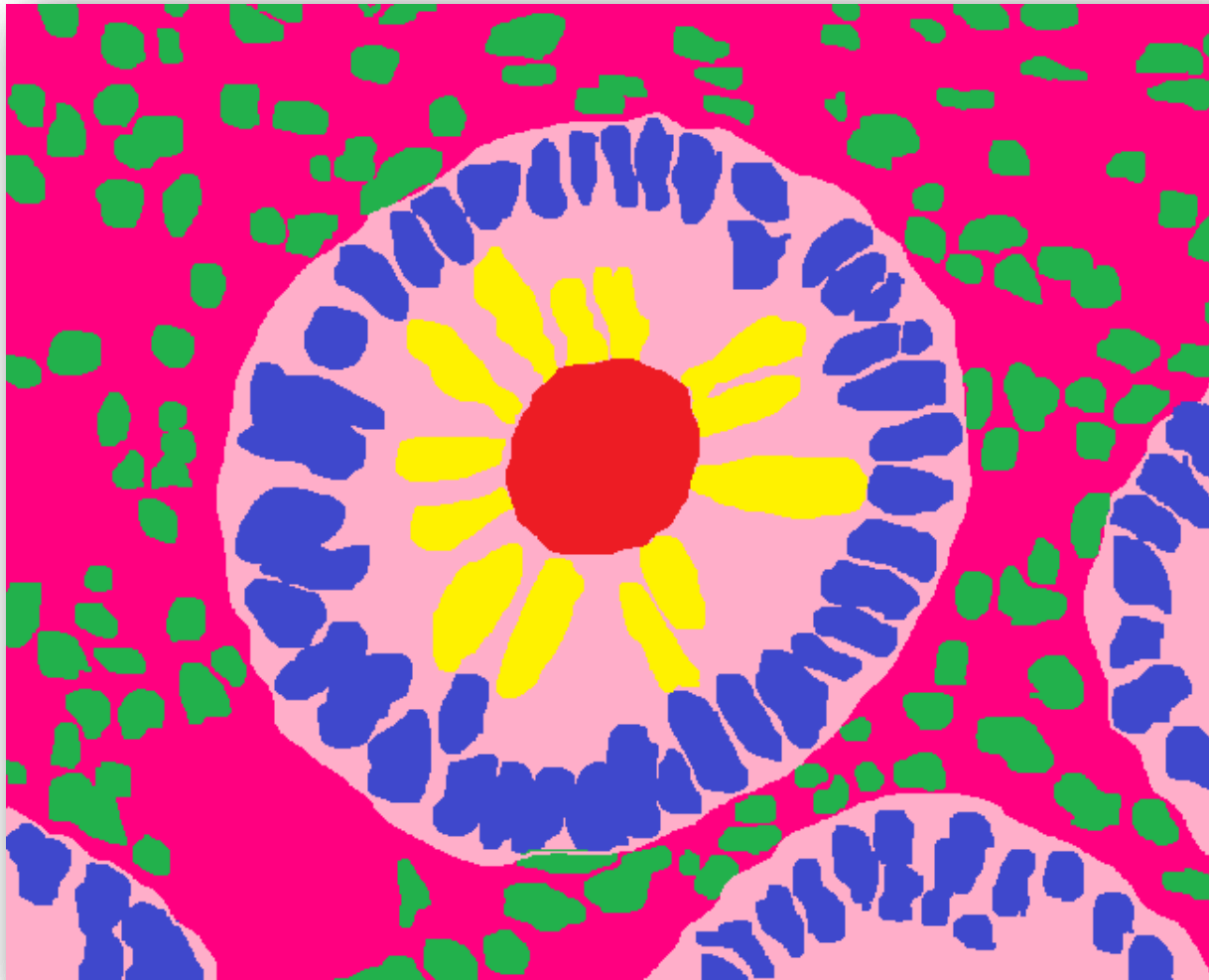
Epithelial Cell Nuclei
Connective Tissue
Cell Nuclei

Goblet Cells

Lumen

Intestinal Glands

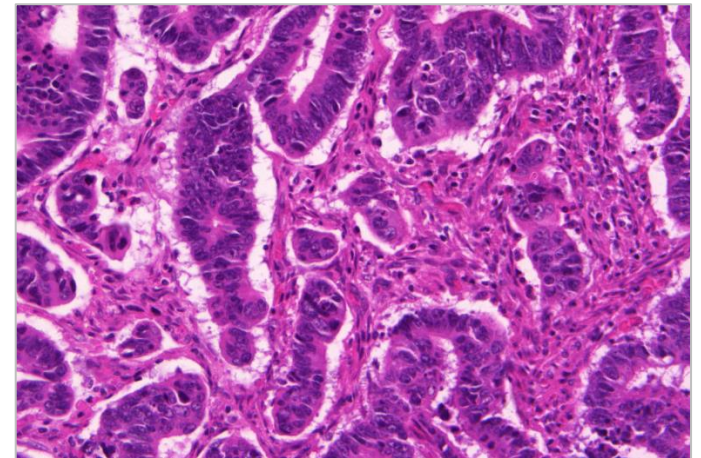
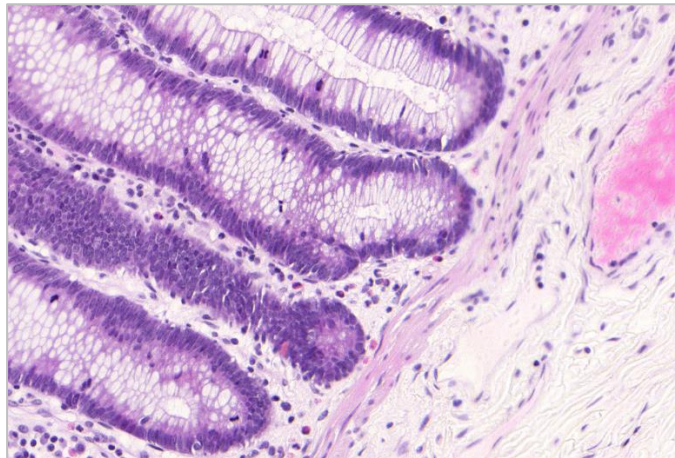
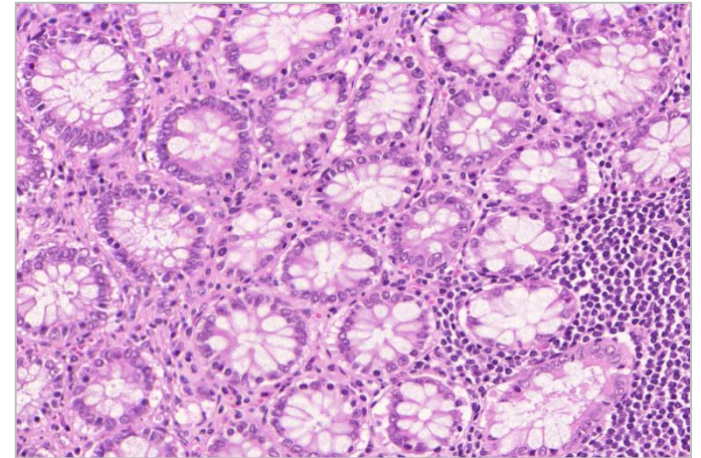
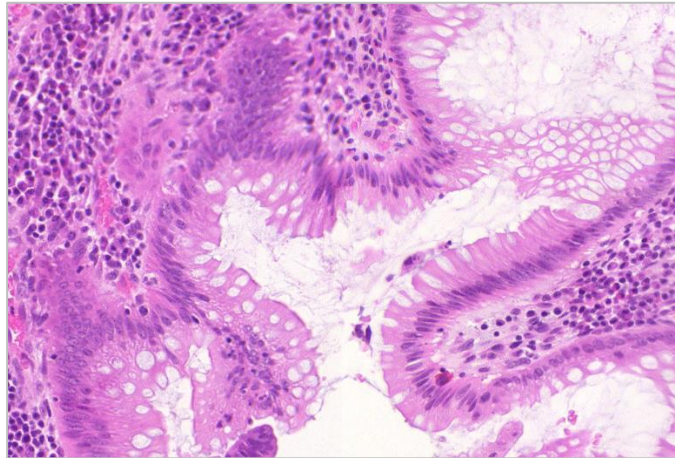
Healthy tissue structure:



Intestinal Glands

Gland Morphology:

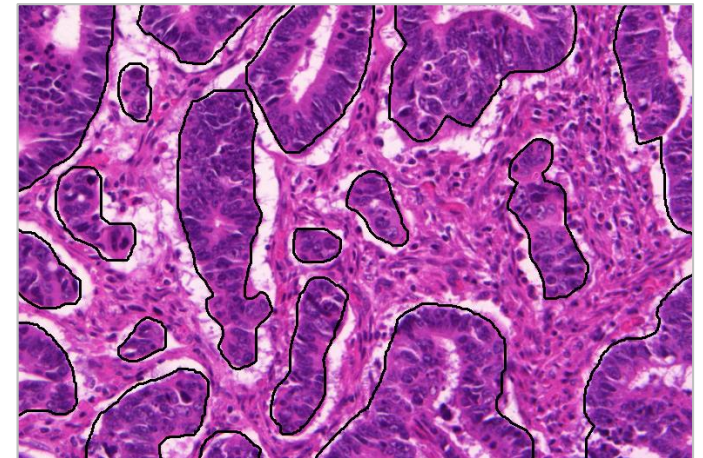
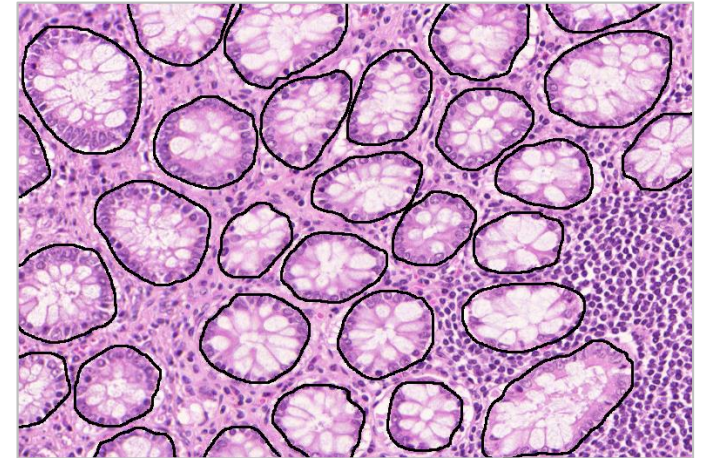
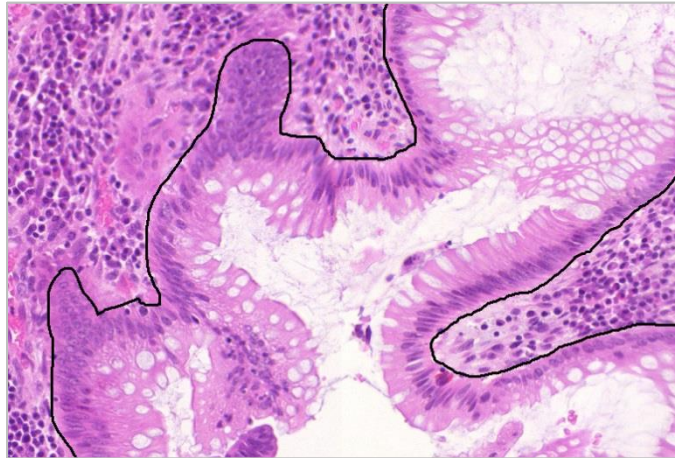
Great variation in different histologic grades



Intestinal Glands

Gland Morphology:

Great variation in different histologic grades



Intestinal Glands

Gland Morphology:

Great variation in different histologic grades

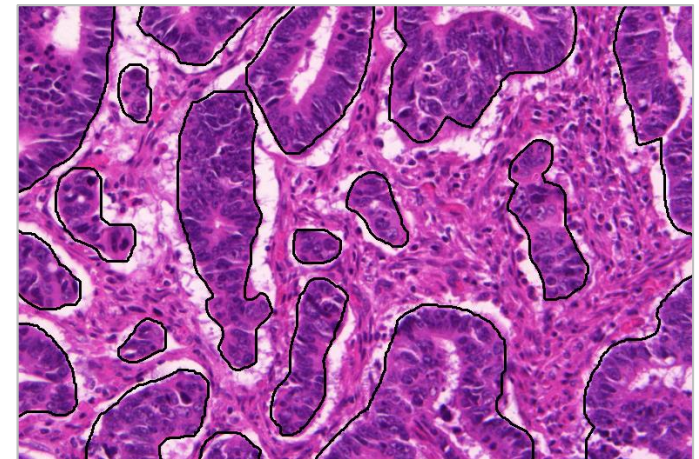
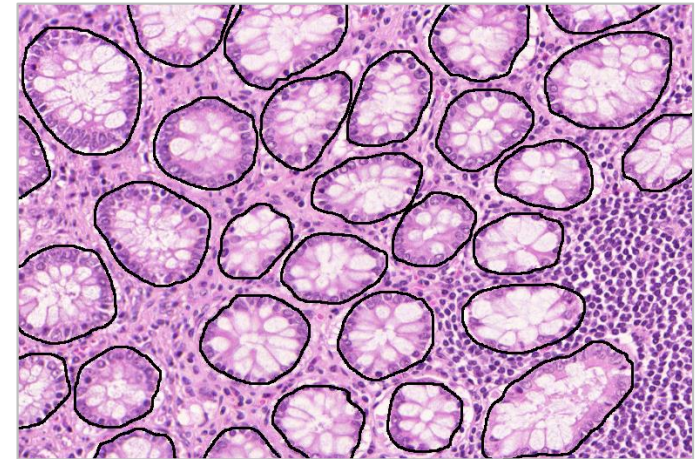
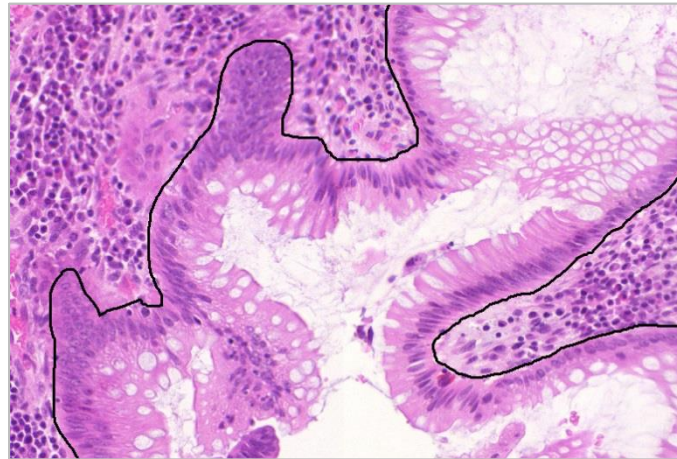
Color

Texture

Shape

Size

Contents



Intestinal Glands

Gland Morphology:

Great variation in different histologic grades

Color

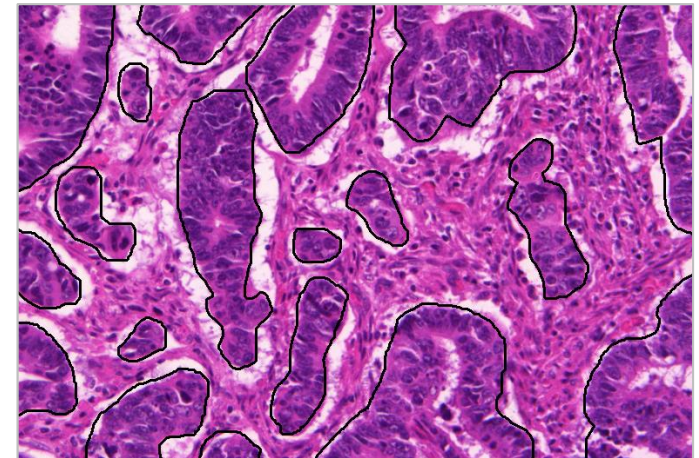
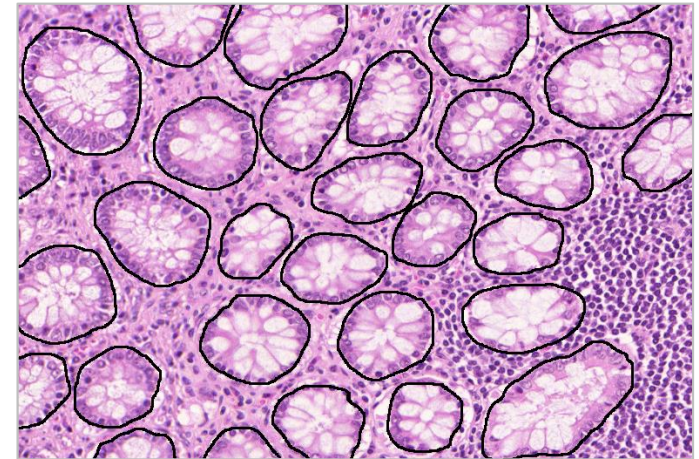
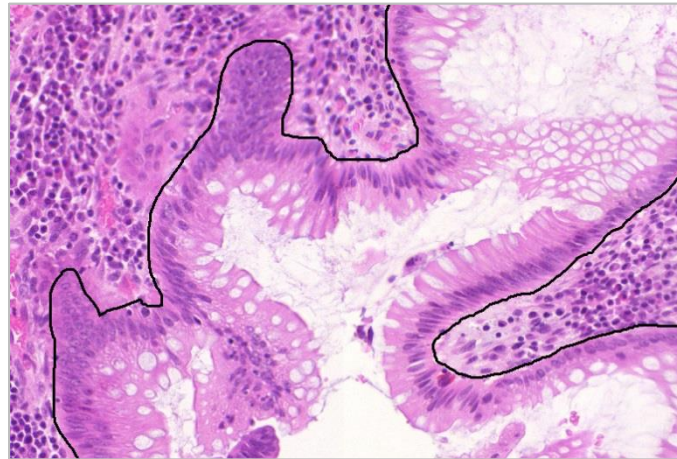
Texture

Shape

Size

Contents

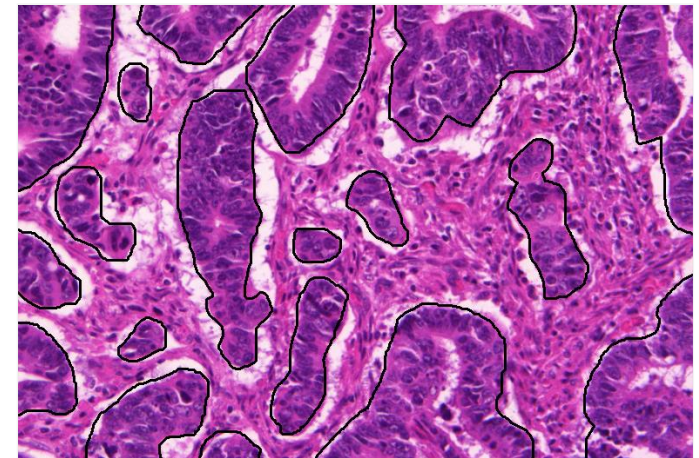
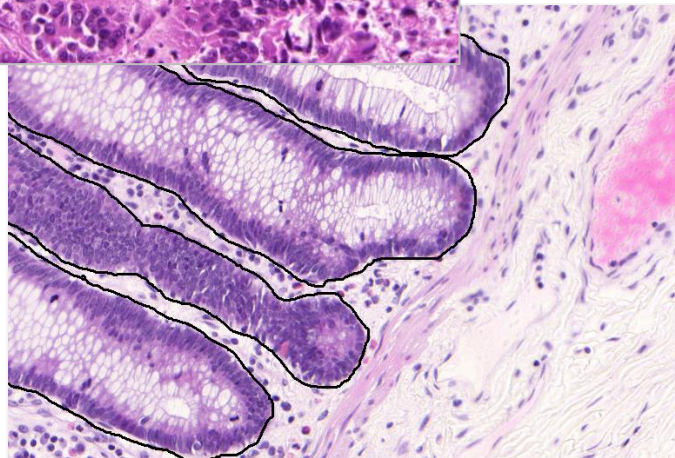
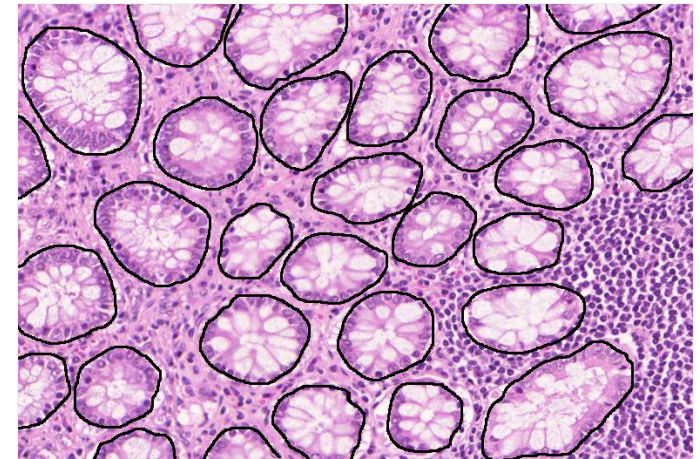
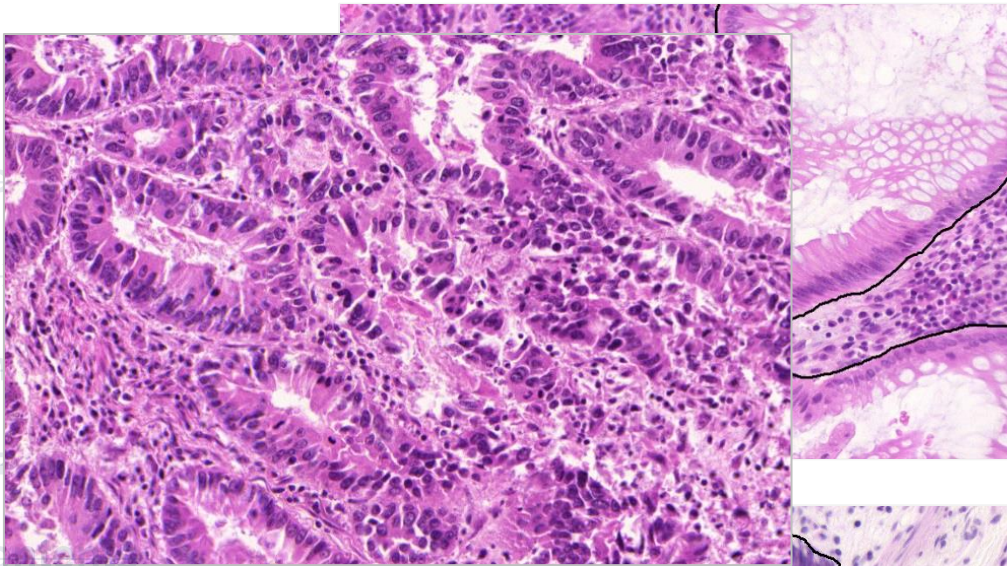
What do they have in common??!



Intestinal Glands

Gland Morphology:

Great variation in different histologic grades

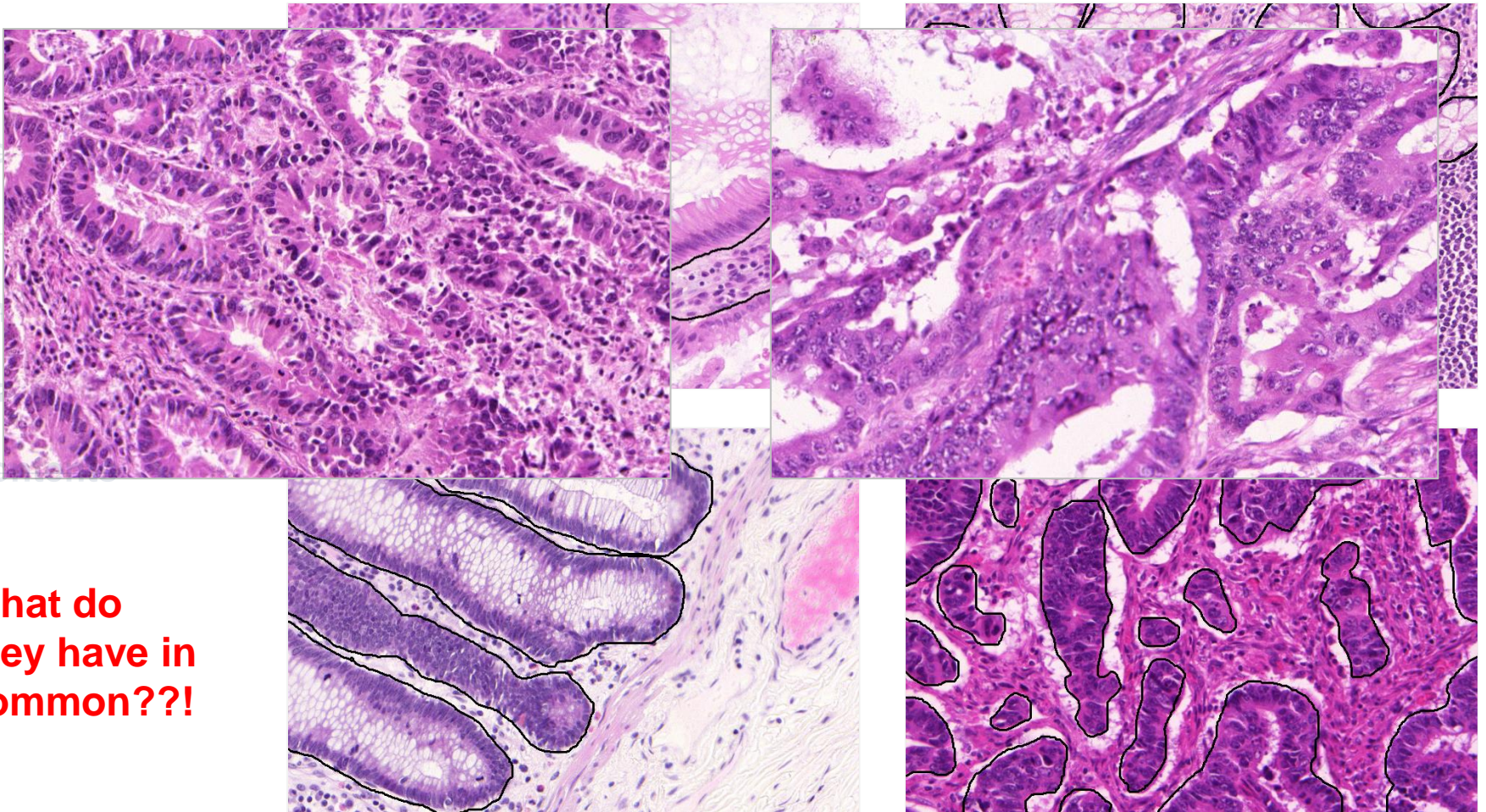


What do they have in common??!

Intestinal Glands

Gland Morphology:

Great variation in different histologic grades

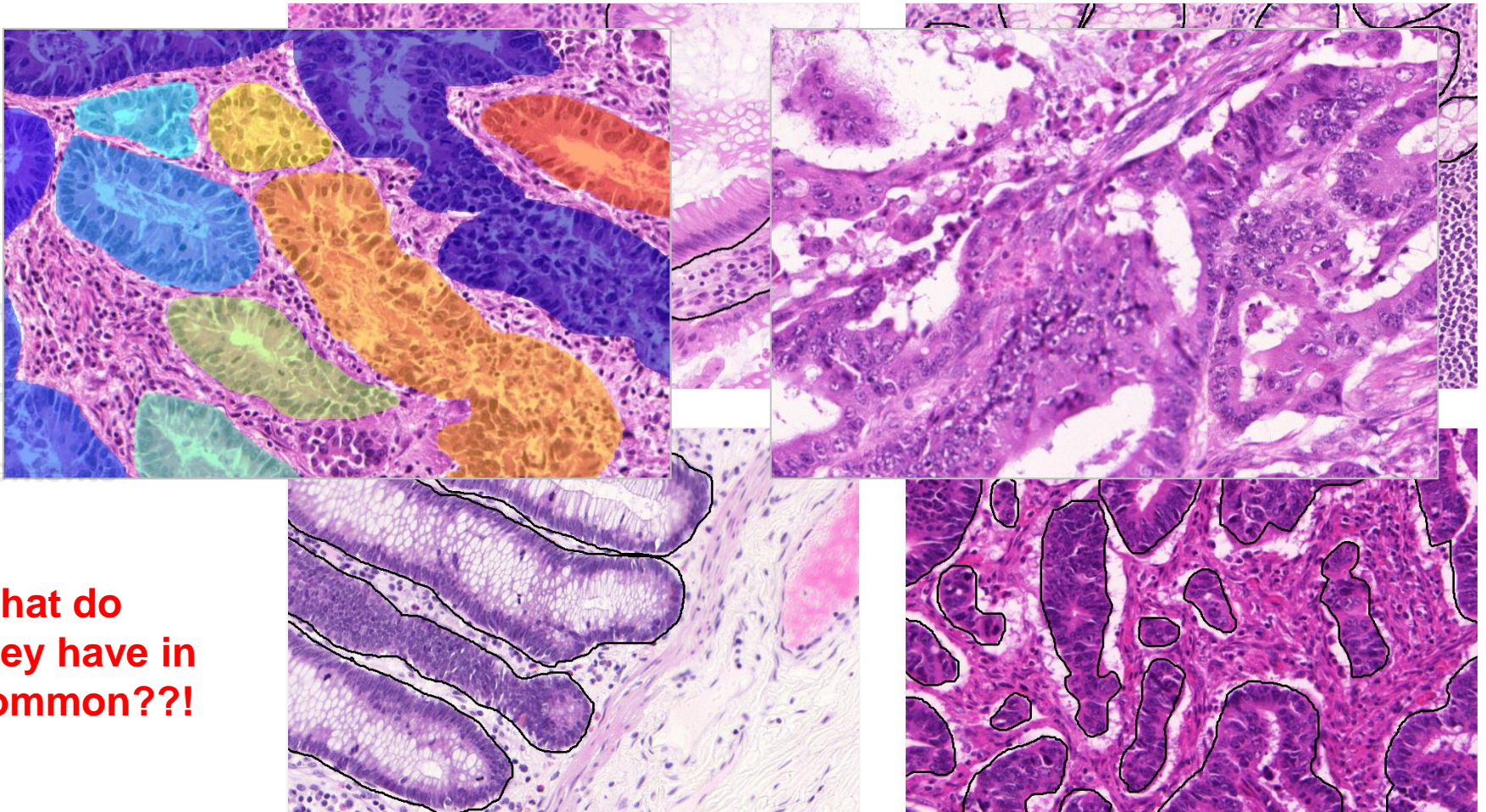


What do they have in common??!

Intestinal Glands

Gland Morphology:

Great variation in different histologic grades

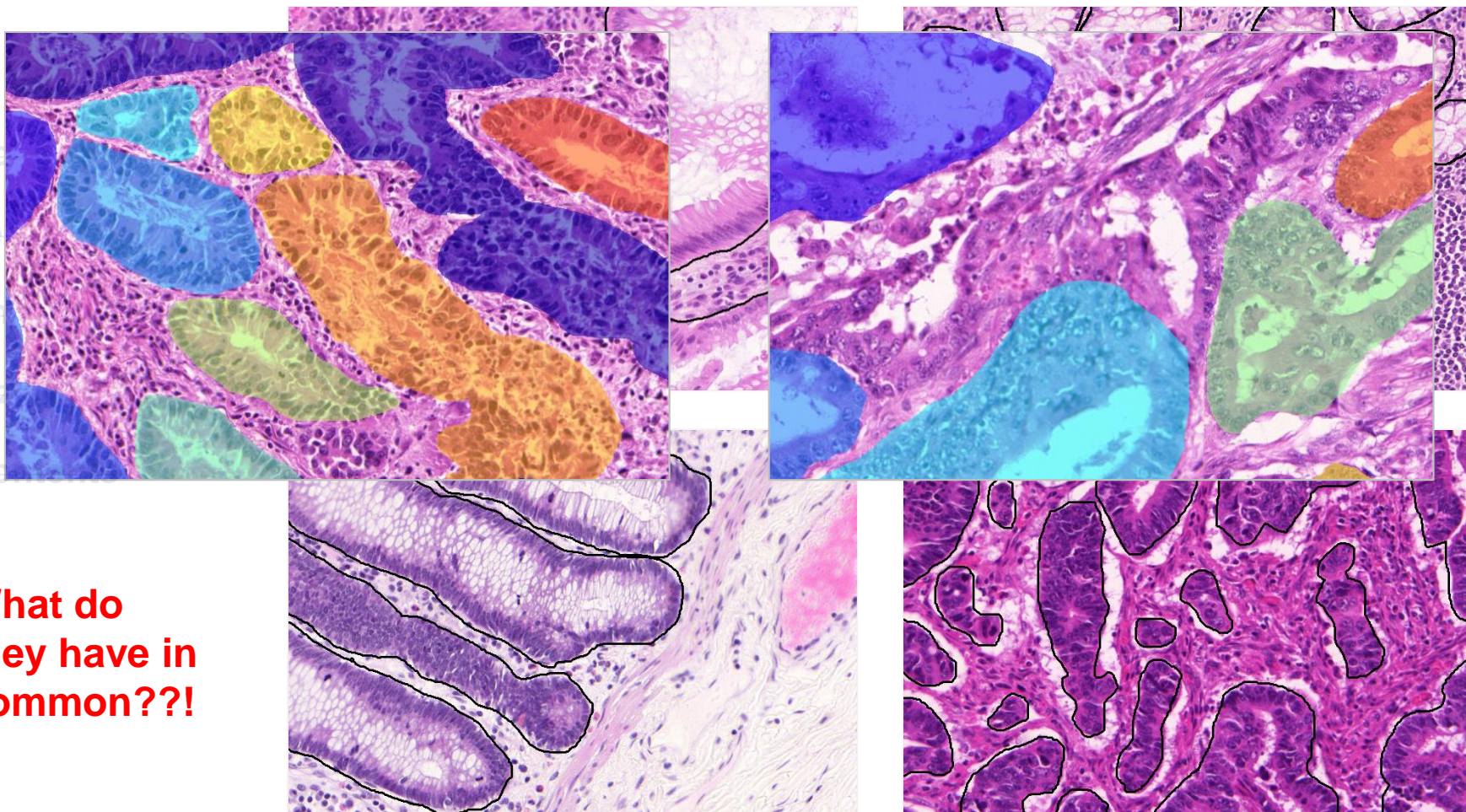


What do they have in common??!

Intestinal Glands

Gland Morphology:

Great variation in different histologic grades

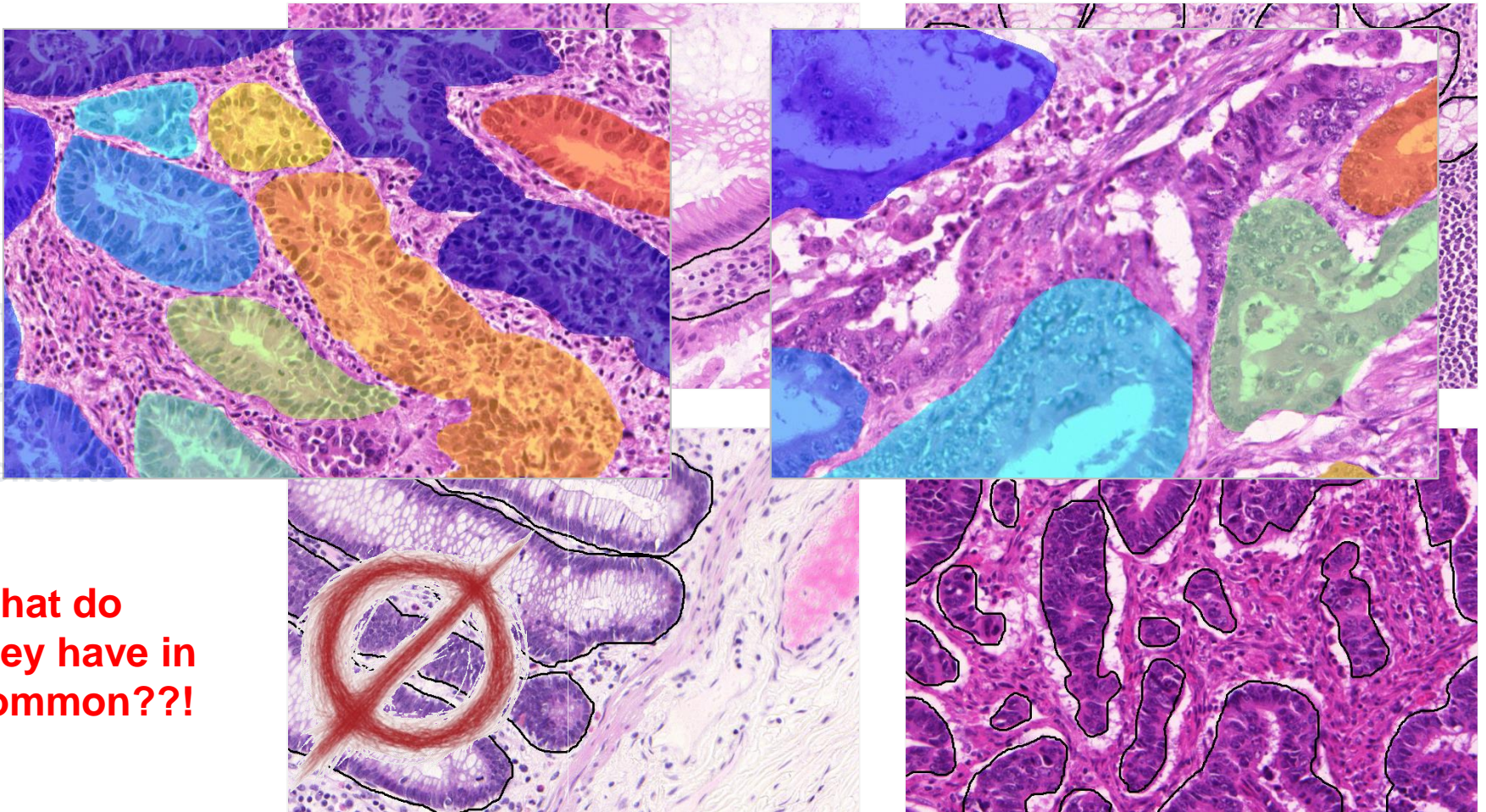


What do they have in common??!

Intestinal Glands

Gland Morphology:

Great variation in different histologic grades

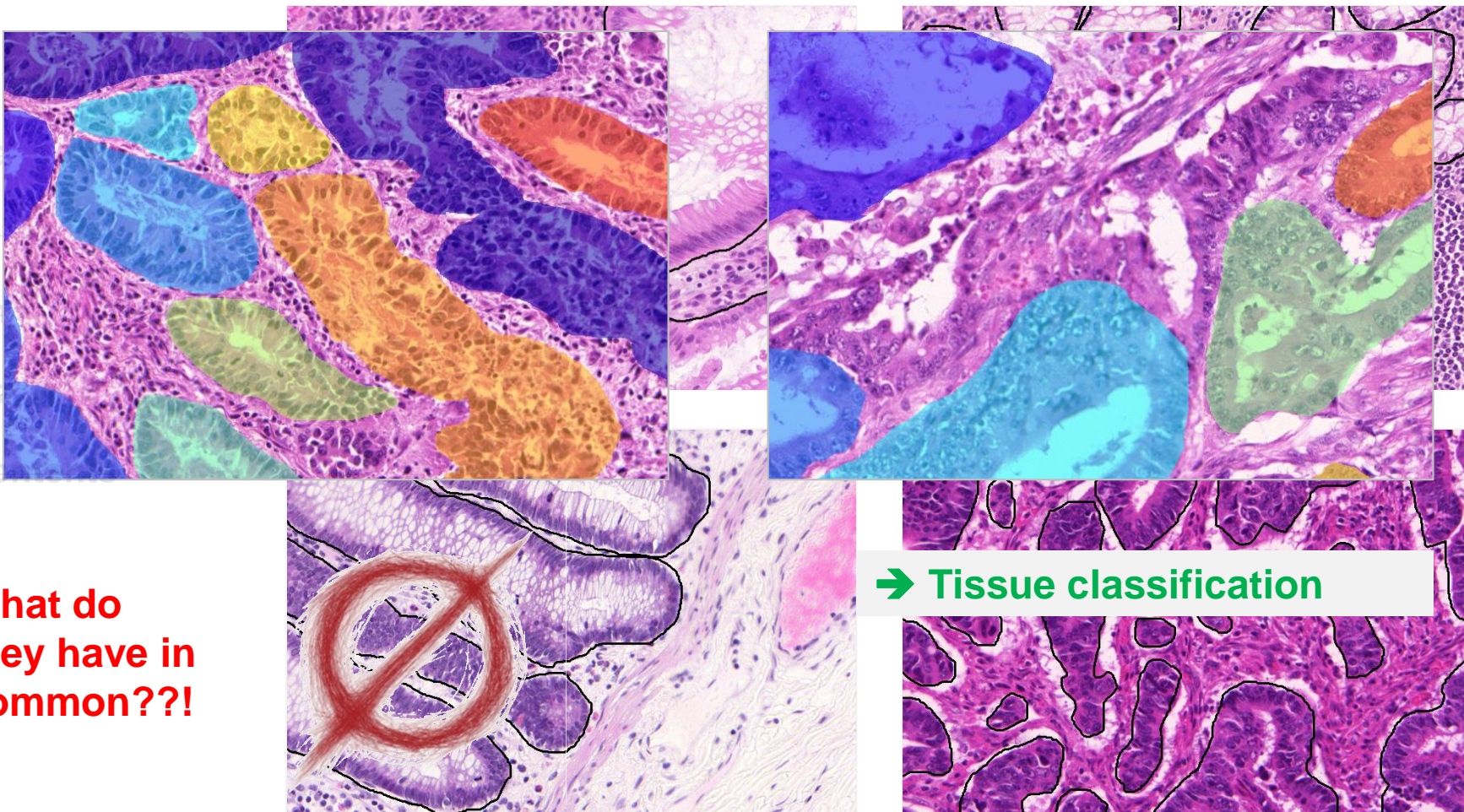


What do they have in common??!

Intestinal Glands

Gland Morphology:

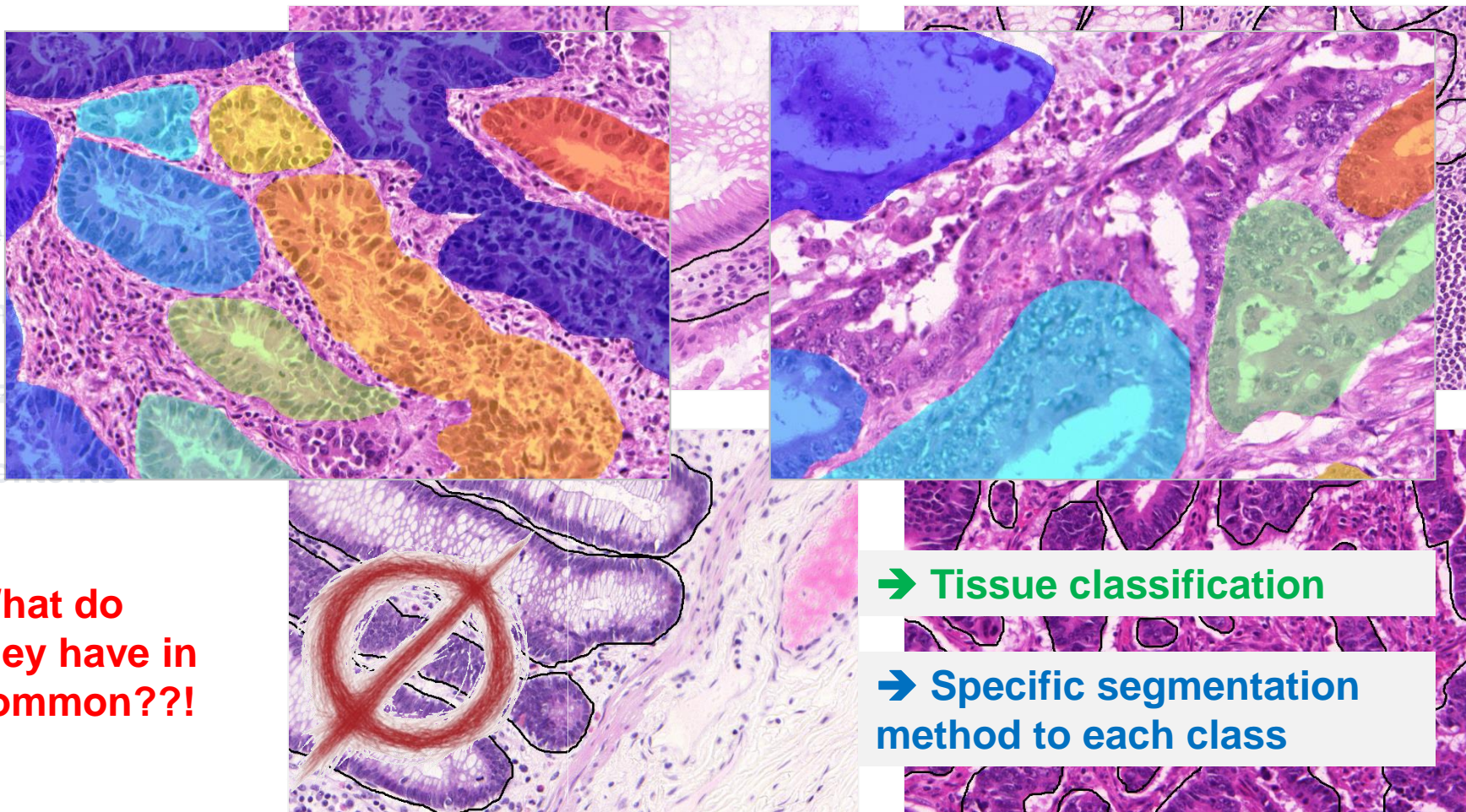
Great variation in different histologic grades



Intestinal Glands

Gland Morphology:

Great variation in different histologic grades



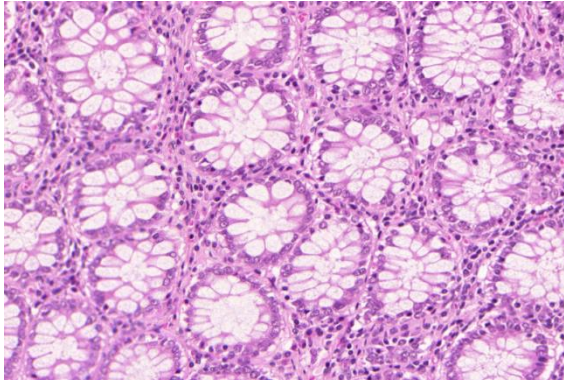
What do they have in common??!

→ Tissue classification

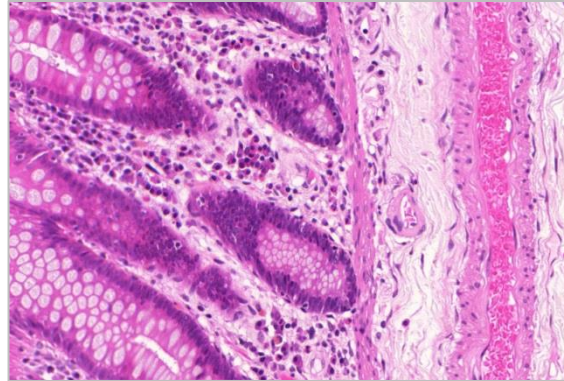
→ Specific segmentation method to each class

Tissue Classification

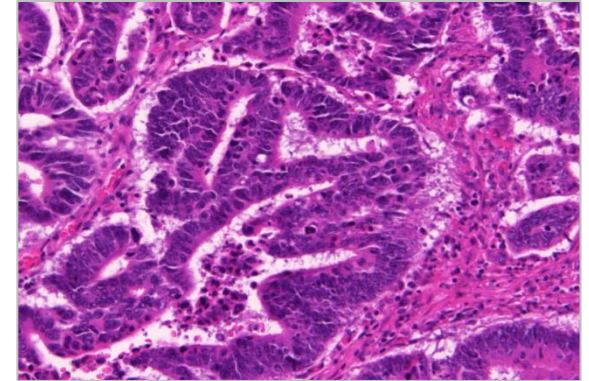
3 classes:



Hollow Glands
thin epithelial layer



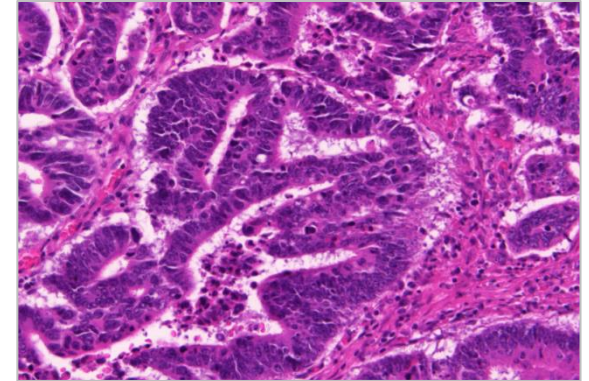
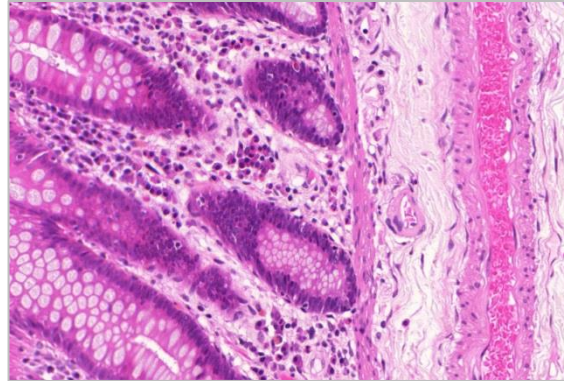
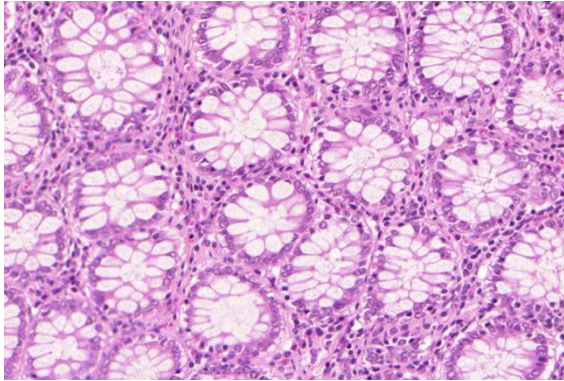
Bounded Glands
thick epithelial layer



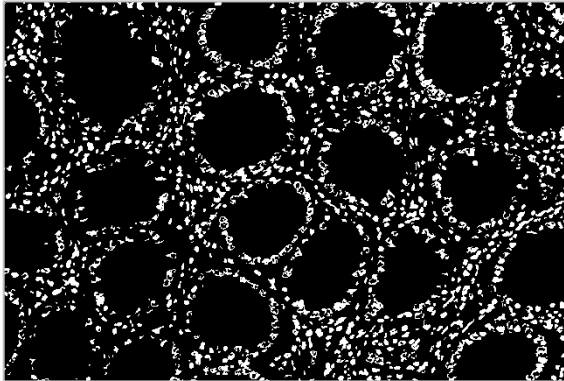
Crowded Glands

Tissue Classification

3 classes:



- Reinhard color normalization
- K-means L*a*b color space



Hollow Glands
thin epithelial layer



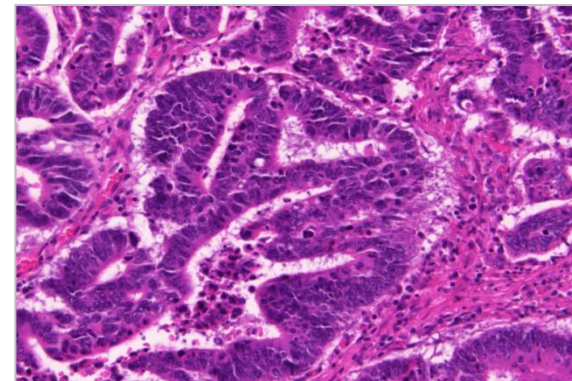
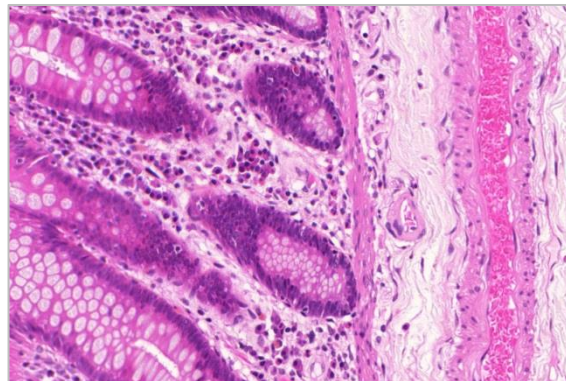
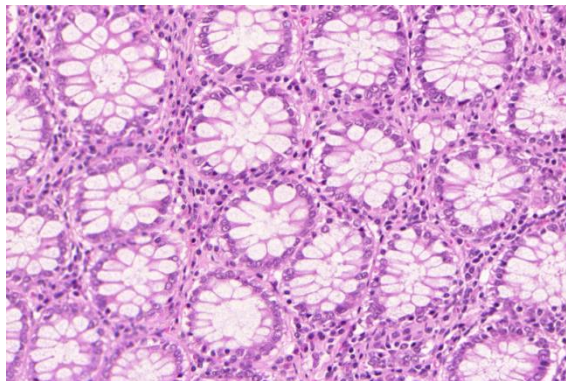
Bounded Glands
thick epithelial layer



Crowded Glands

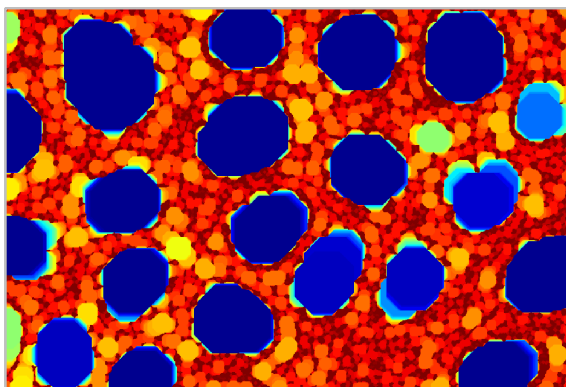
Tissue Classification

3 classes:

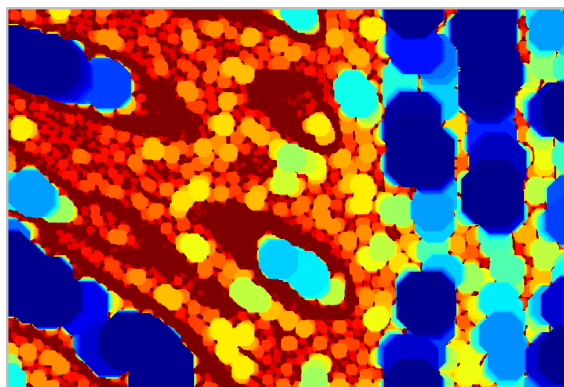


- Reinhard color normalization
- K-means L*a*b color space

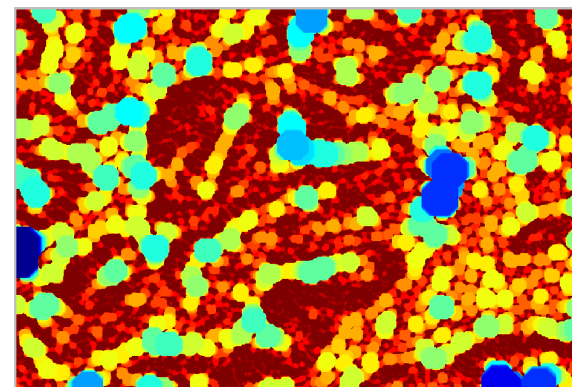
$$P_{map} = \frac{1}{40} \sum_{r=1}^{40} C_r(I_N)$$



Hollow Glands
thin epithelial layer



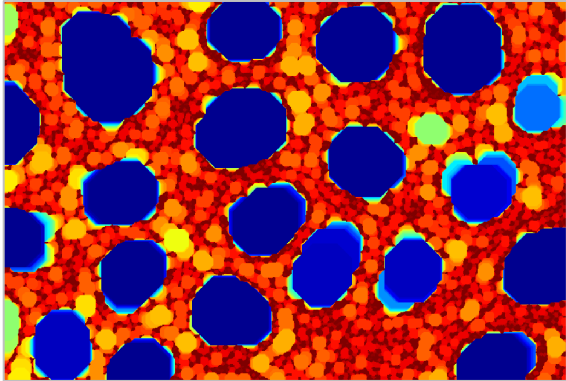
Bounded Glands
thick epithelial layer



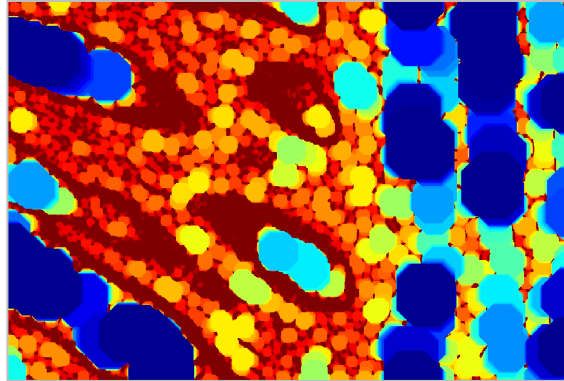
Crowded Glands

Tissue Classification

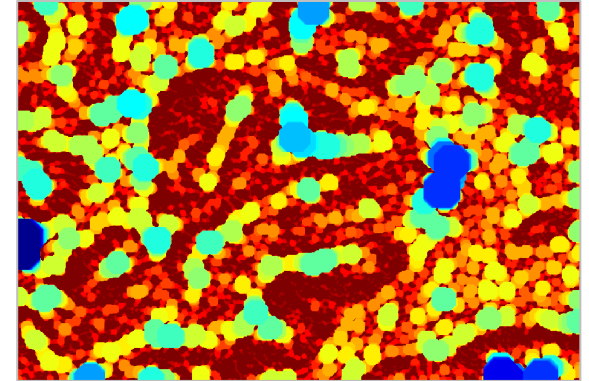
Morphological Features:



Hollow Glands
thin epithelial layer



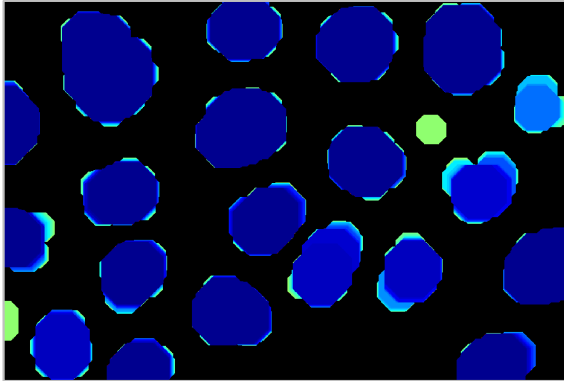
Bounded Glands
thick epithelial layer



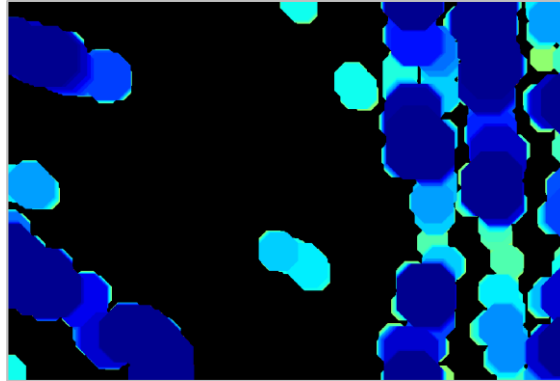
Crowded Glands

Tissue Classification

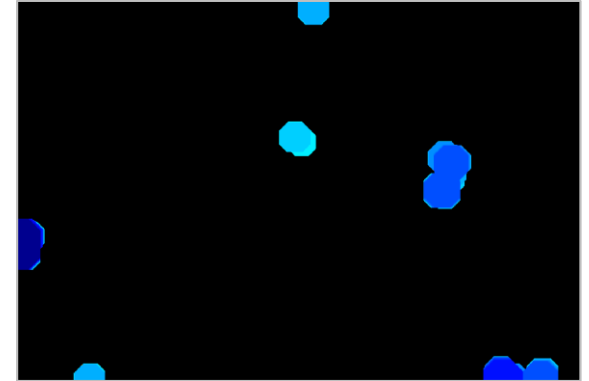
Morphological Features:



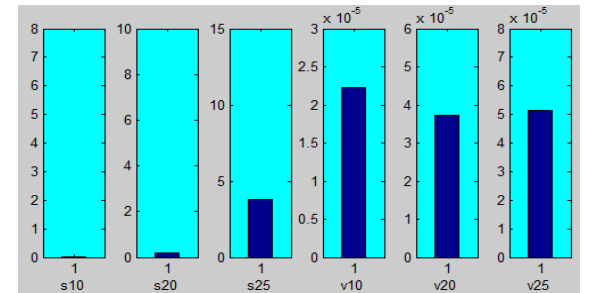
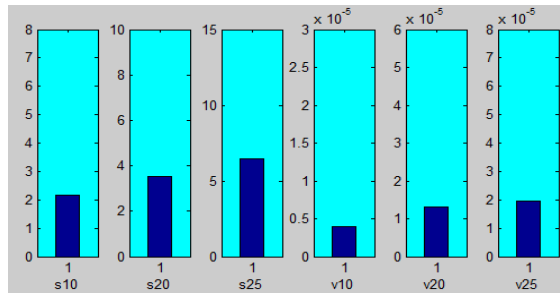
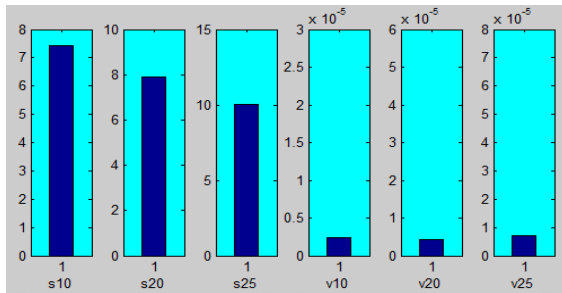
Hallow Glands
thin epithelial layer



Bounded Glands
thick epithelial layer



Crowded Glands

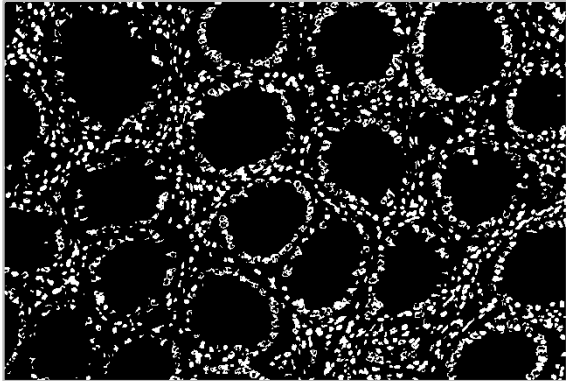


size of holes

Value in holes

Tissue Classification

Morphological Features:



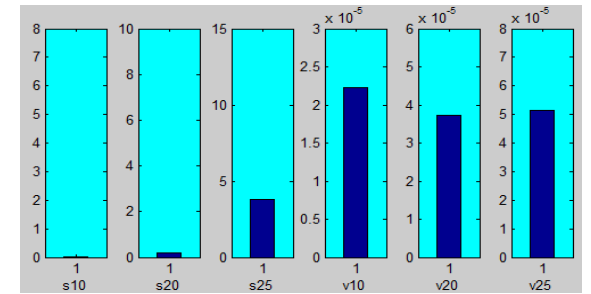
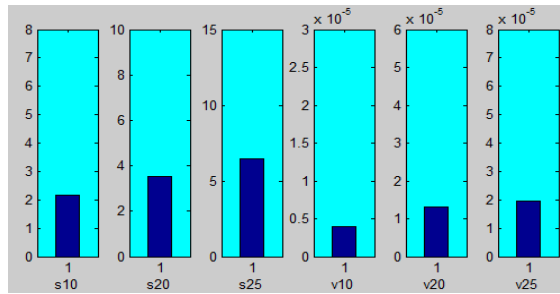
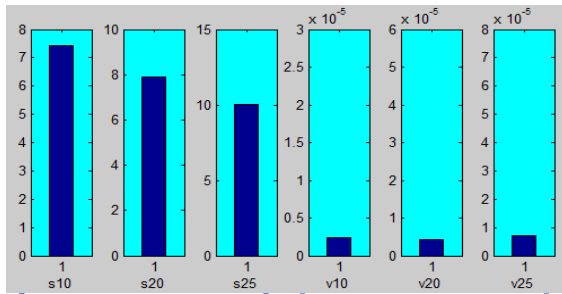
Hollow Glands
thin epithelial layer



Bounded Glands
thick epithelial layer



Crowded Glands

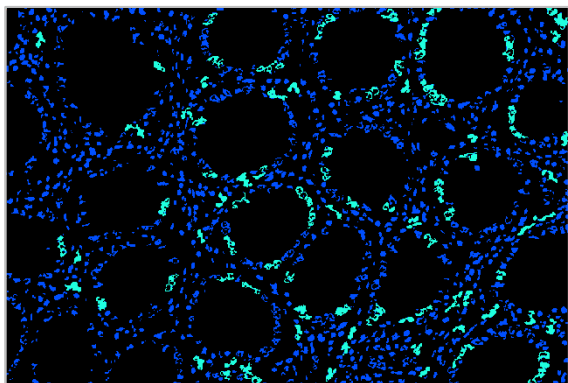


size of holes

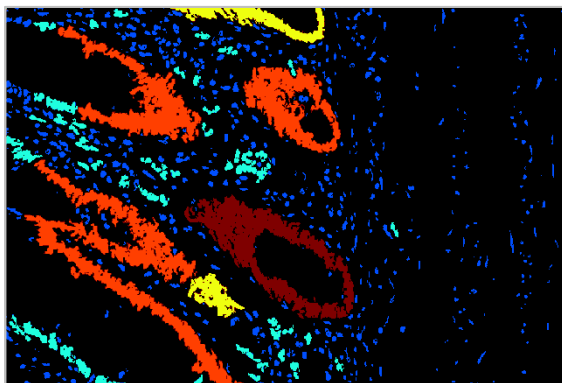
Value in holes

Tissue Classification

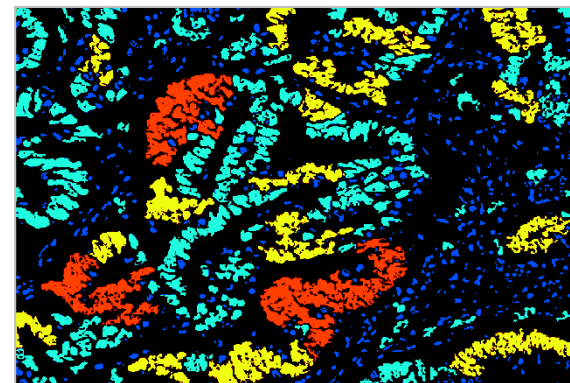
Morphological Features:



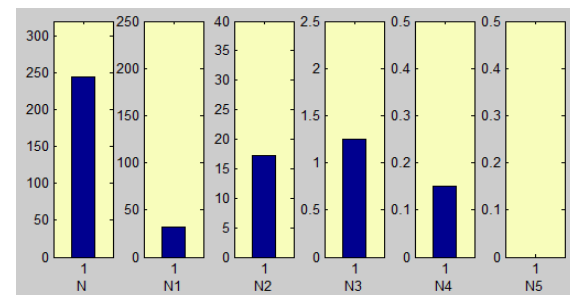
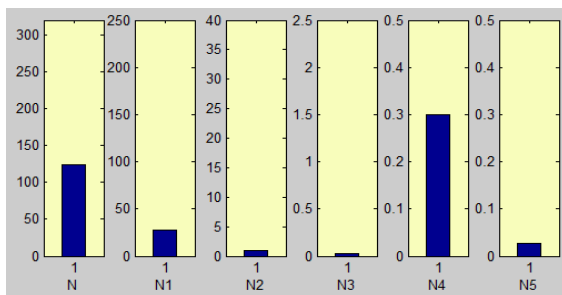
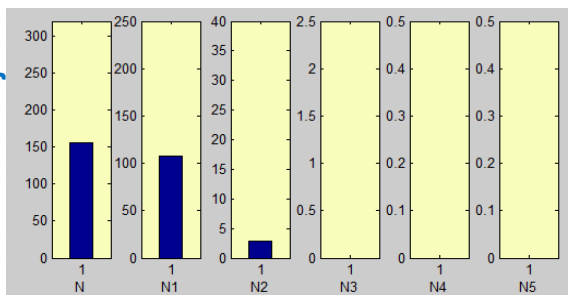
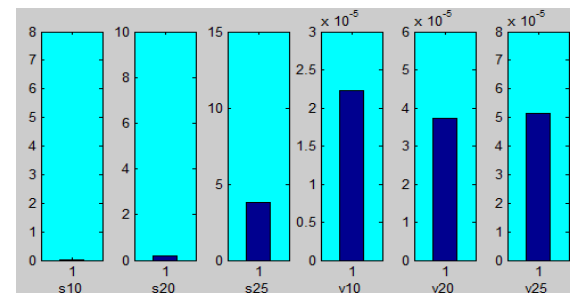
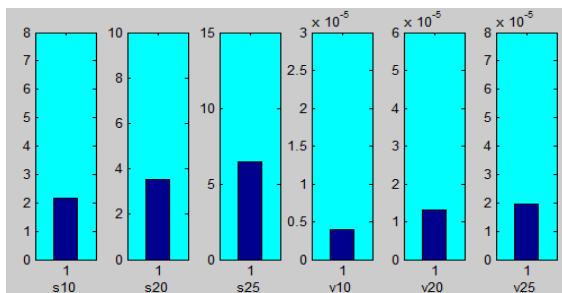
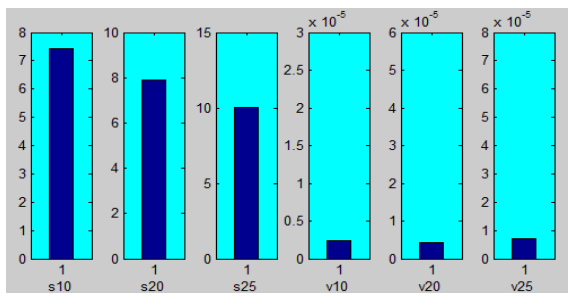
Hollow Glands
thin epithelial layer



Bounded Glands
thick epithelial layer



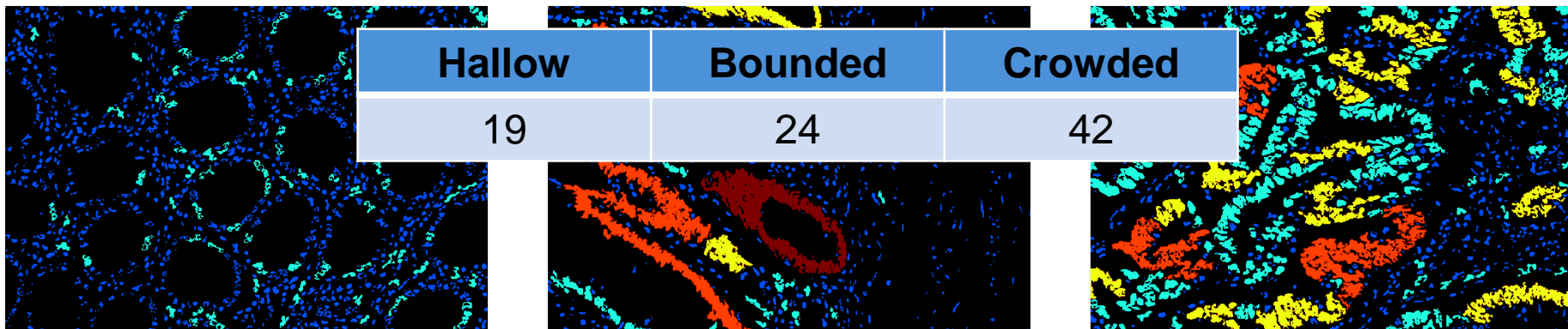
Crowded Glands



size of nuclei objects

Tissue Classification

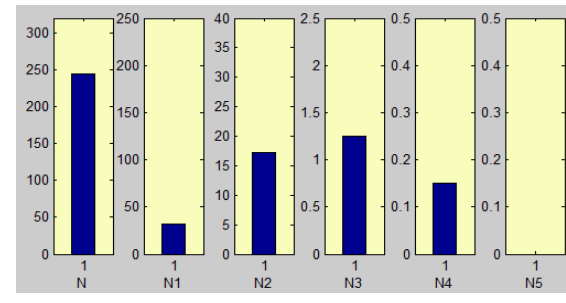
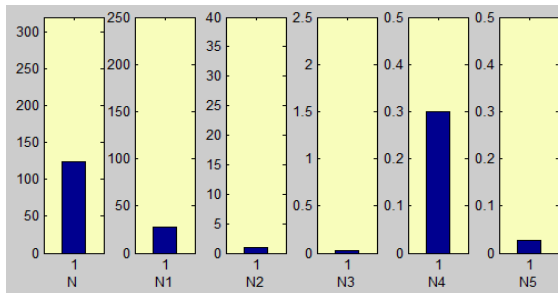
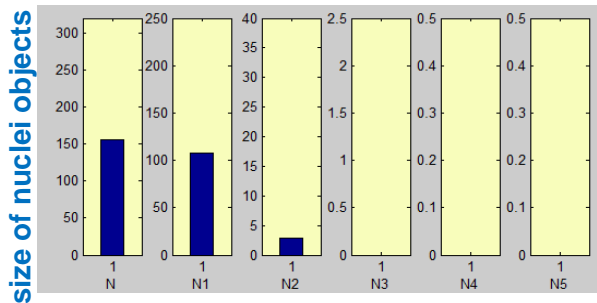
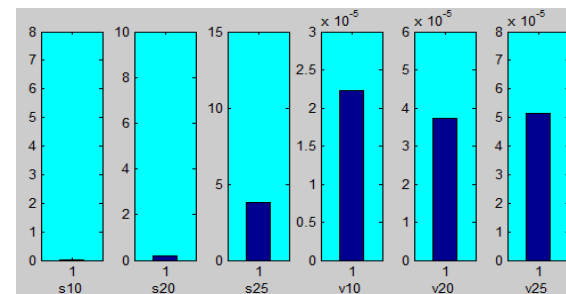
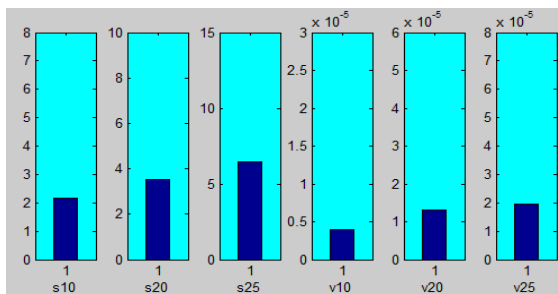
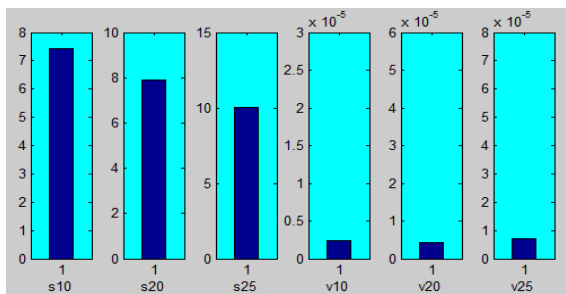
Morphological Features:



Hallow Glands
thin epithelial layer

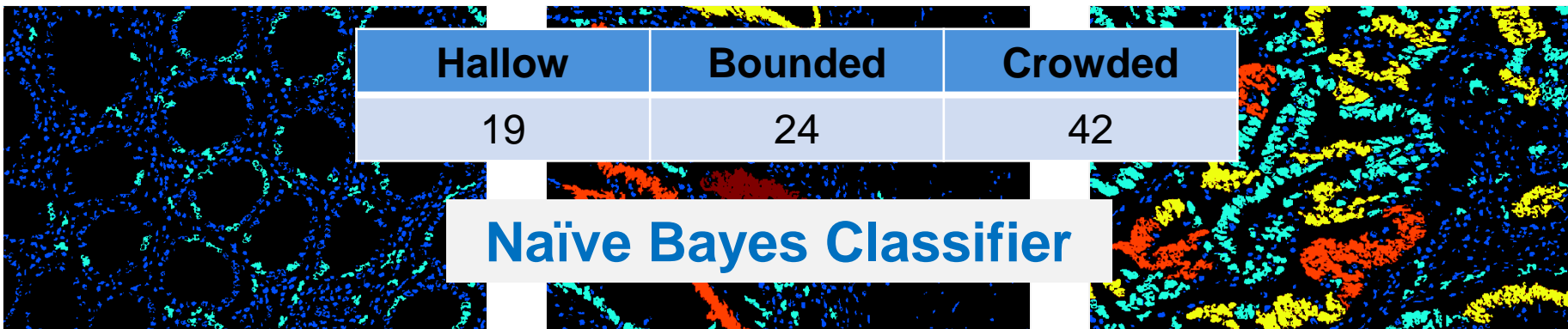
Bounded Glands
thick epithelial layer

Crowded Glands



Tissue Classification

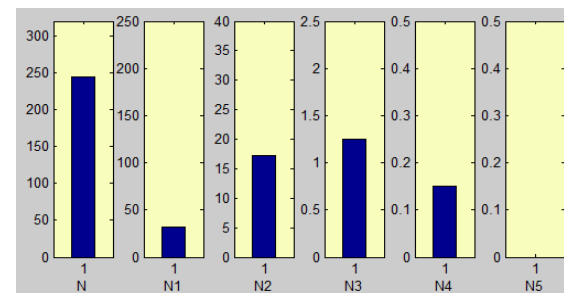
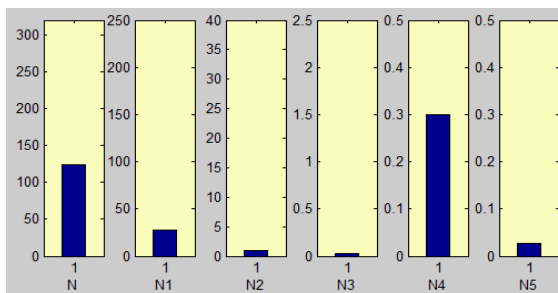
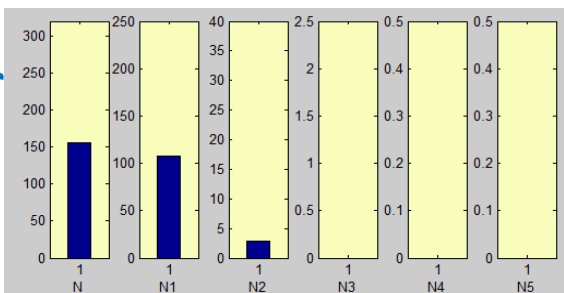
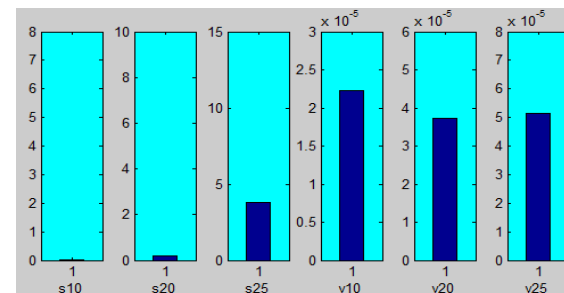
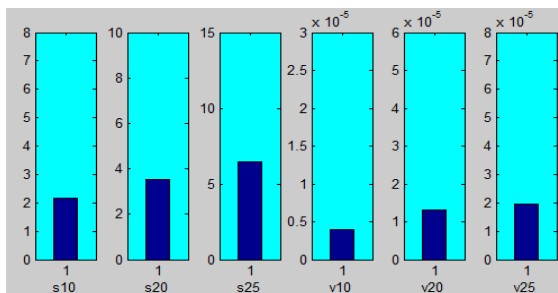
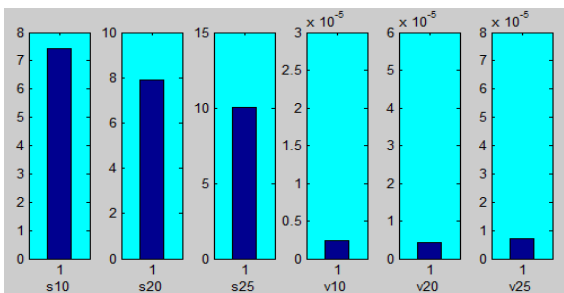
Morphological Features:



Hallow Glands
thin epithelial layer

Bounded Glands
thick epithelial layer

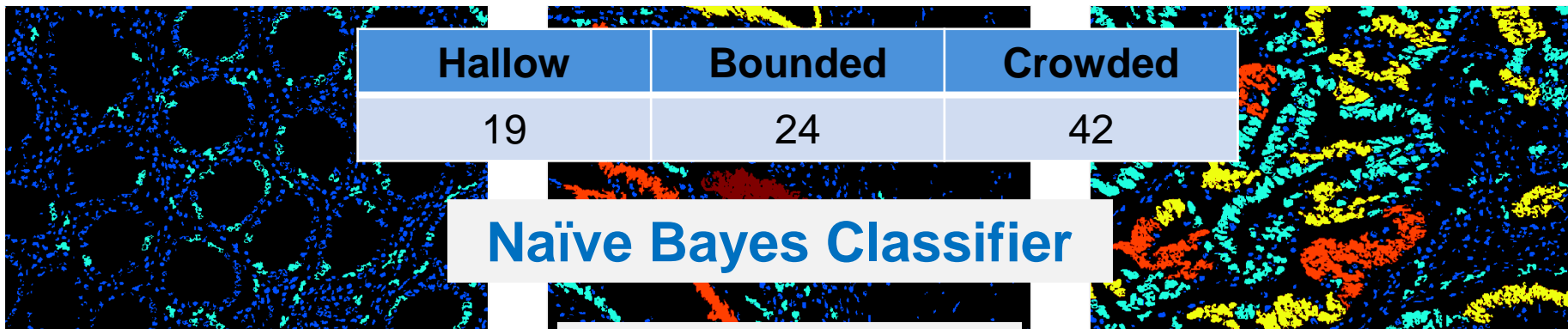
Crowded Glands



size of nuclei objects

Tissue Classification

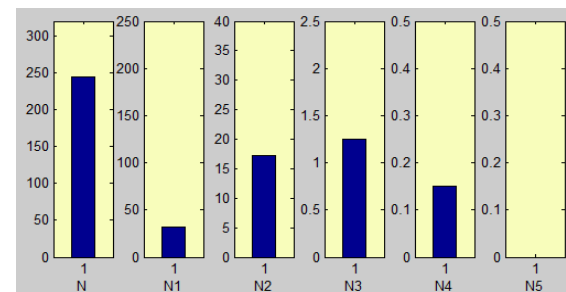
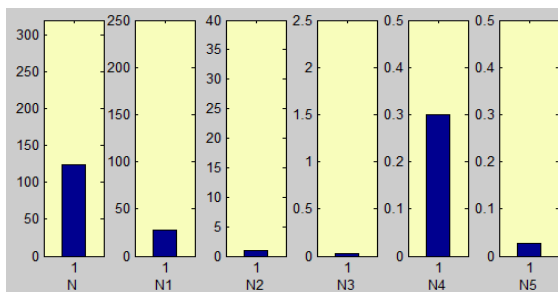
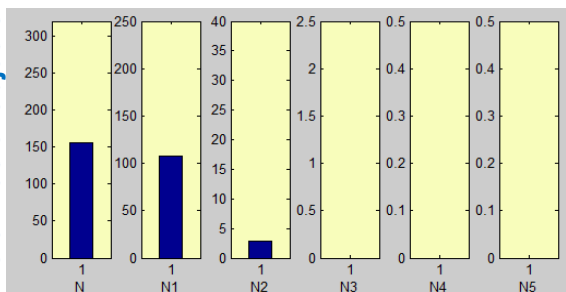
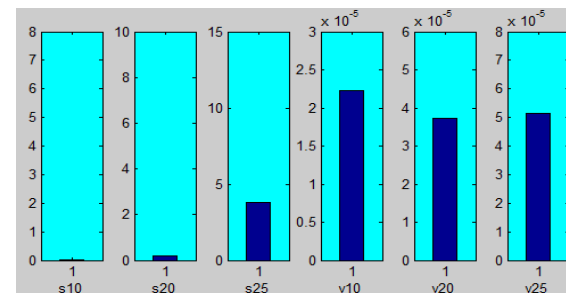
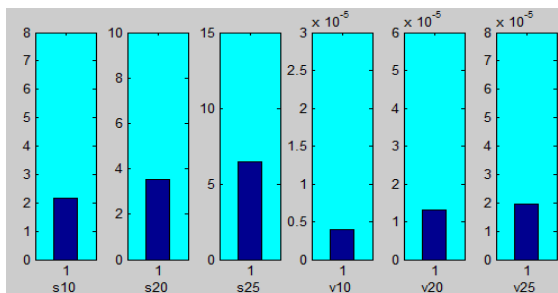
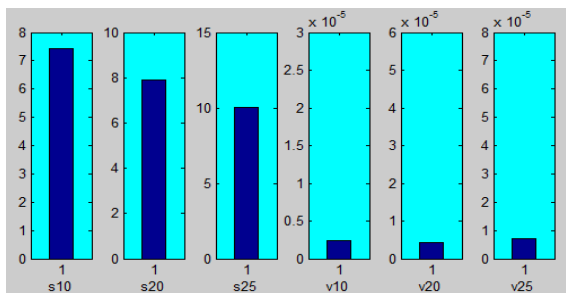
Morphological Features:



Accuracy 0.93%

Hallow Glands
thin epithelial layer

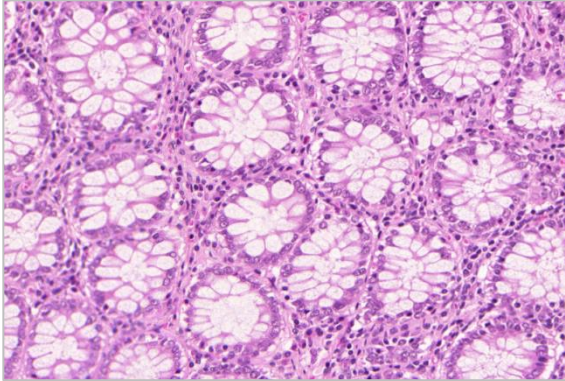
Crowded Glands



size of nuclei objects

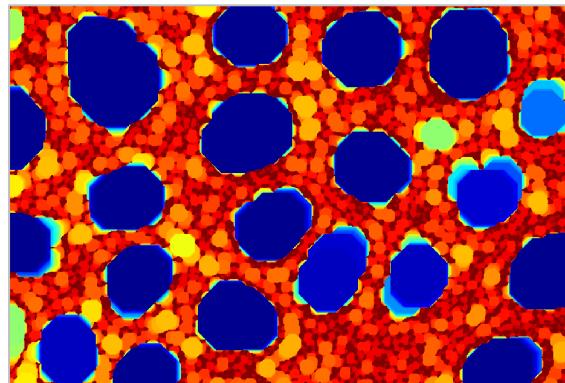
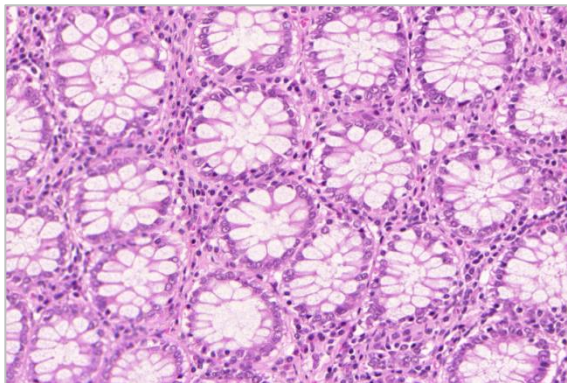
Gland Segmentation

Hallow:



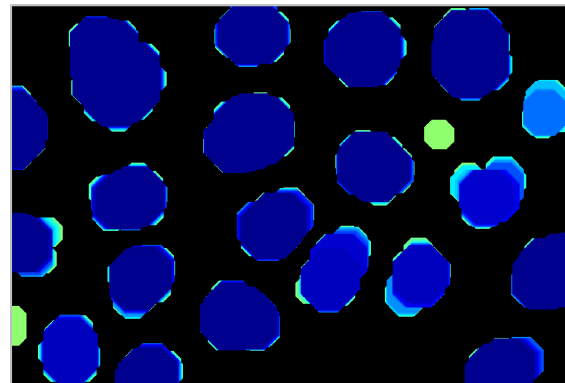
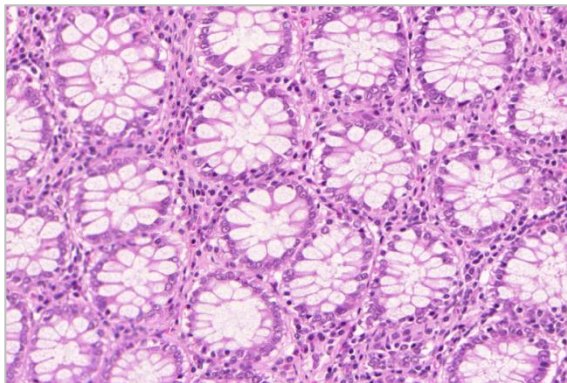
Gland Segmentation

Hallow:



Gland Segmentation

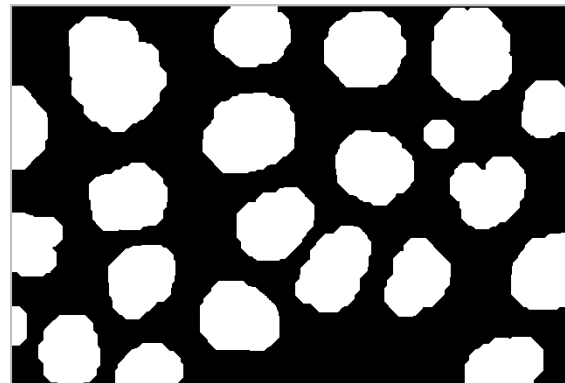
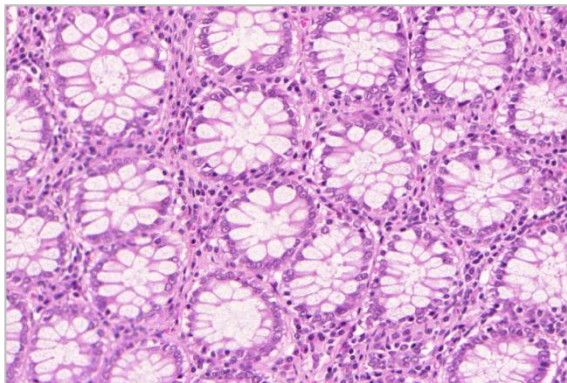
Hallow:



$P_{map} < 0.5$

Gland Segmentation

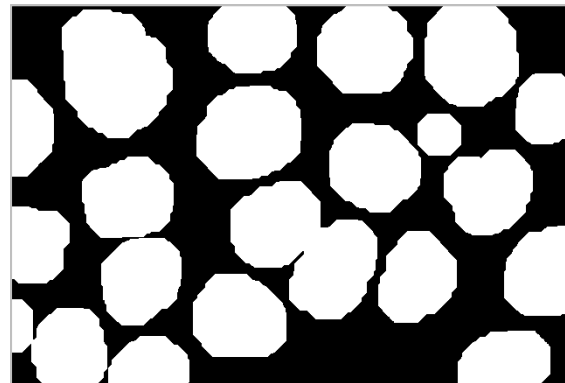
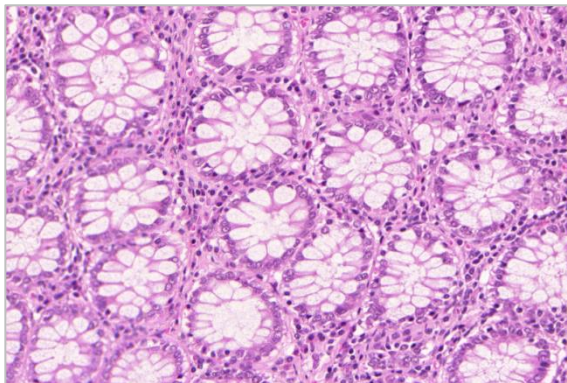
Hallow:



$P_{map} < 0.5$

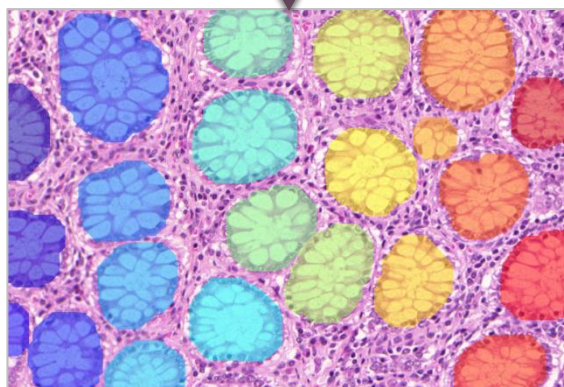
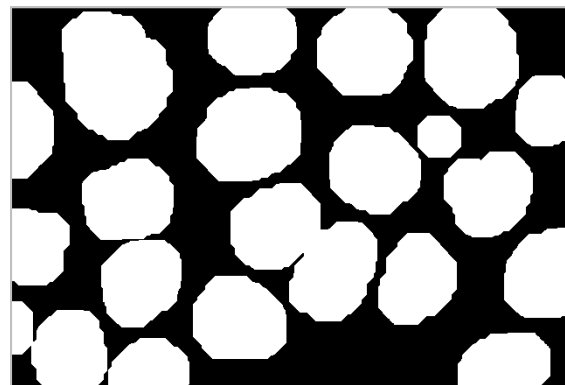
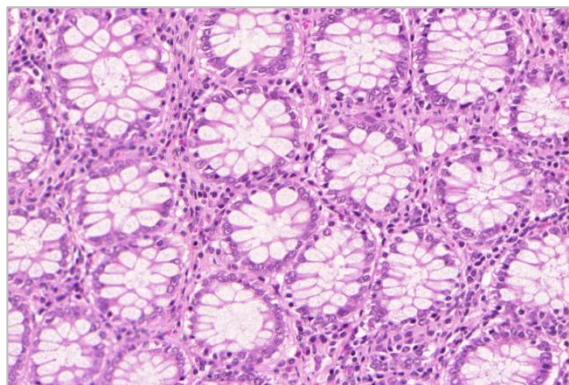
Gland Segmentation

Hallow:



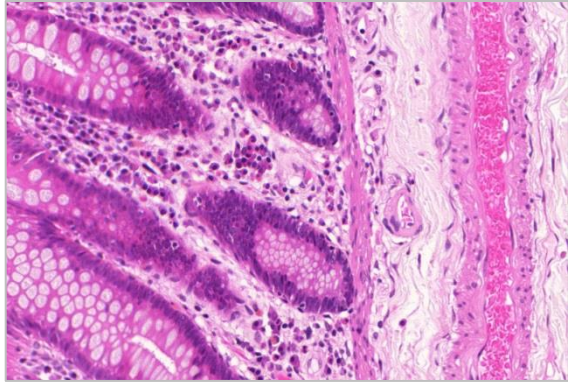
Gland Segmentation

Hallow:



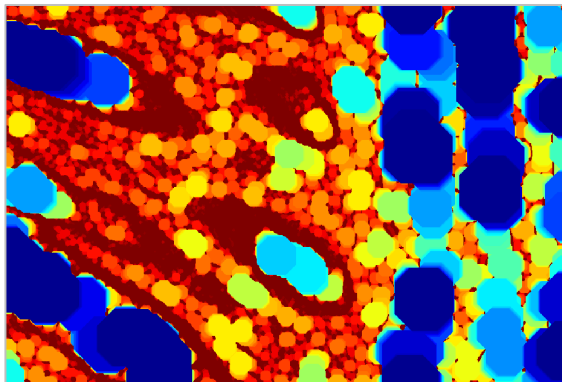
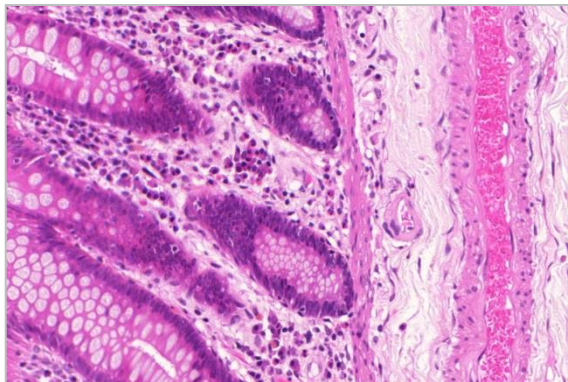
Gland Segmentation

Bounded:



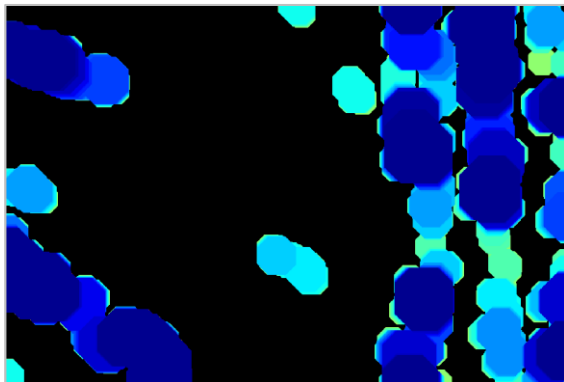
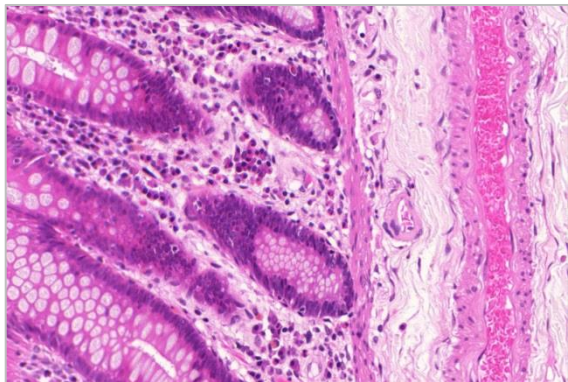
Gland Segmentation

Bounded:



Gland Segmentation

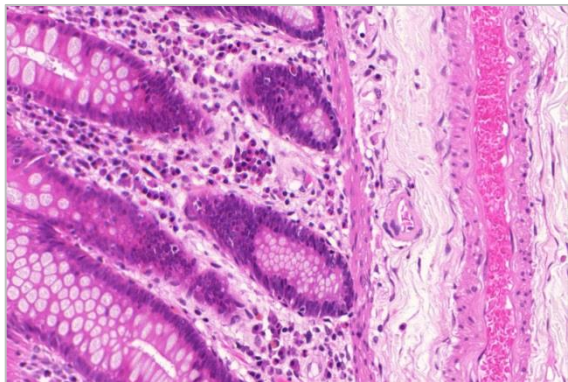
Bounded:



$P_{map} < 0.5$

Gland Segmentation

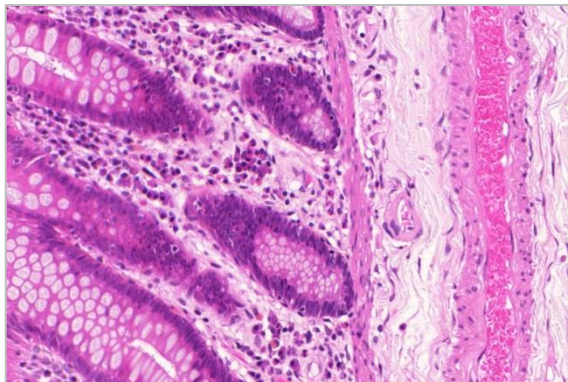
Bounded:



Gland Candidates

Gland Segmentation

Bounded:

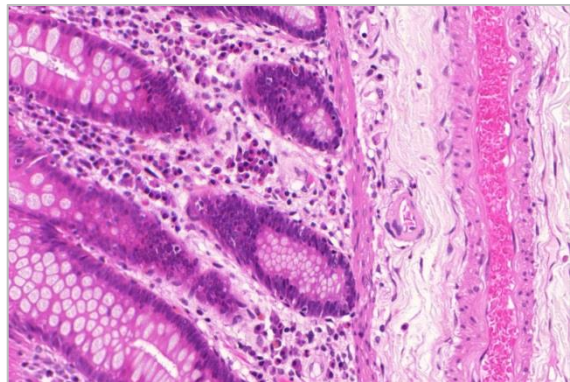


Gland Candidates

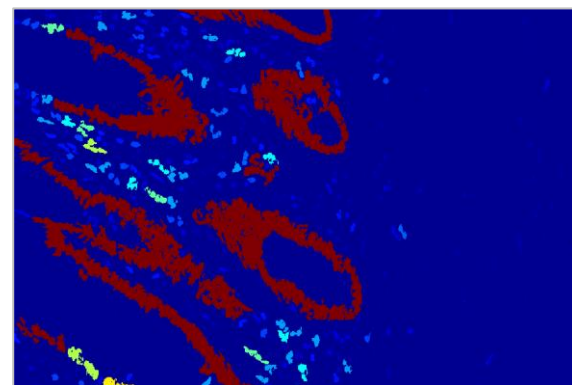


Gland Segmentation

Bounded:



Gland Candidates

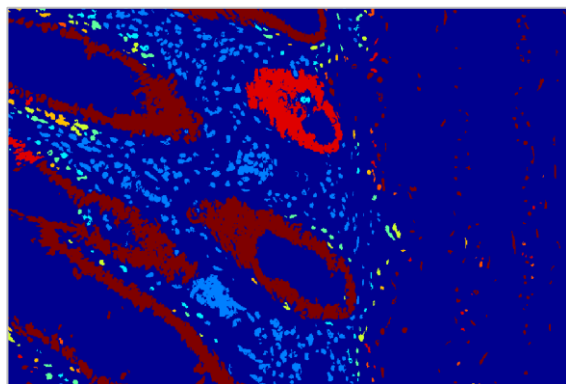
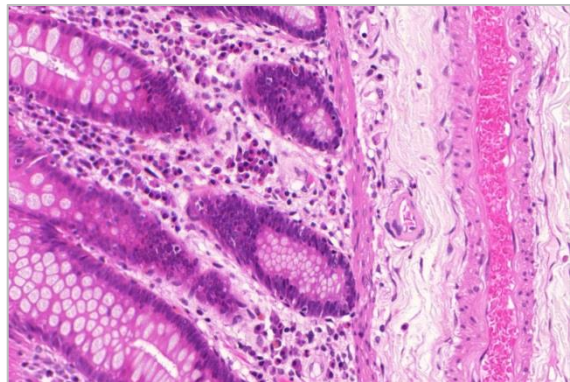


Solidity map

$$S_{map} = \sum_{r=1}^4 \sum_{s=1}^{50} J_s(\rho_{I_N}(\mathcal{O}_r(I_N)))$$

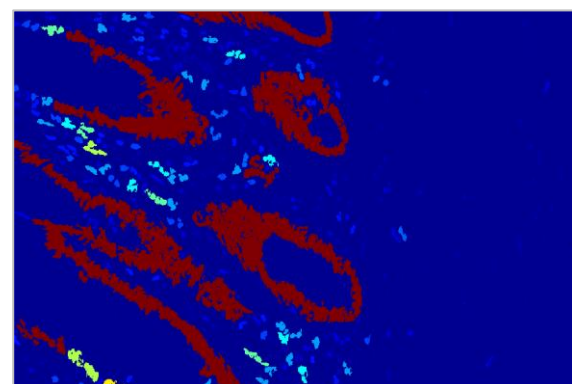
Gland Segmentation

Bounded:



Girth map

$$G_{map} = \sum_{r=1}^{40} \rho_{I_N}(\delta_r(H) \cdot I_N)$$

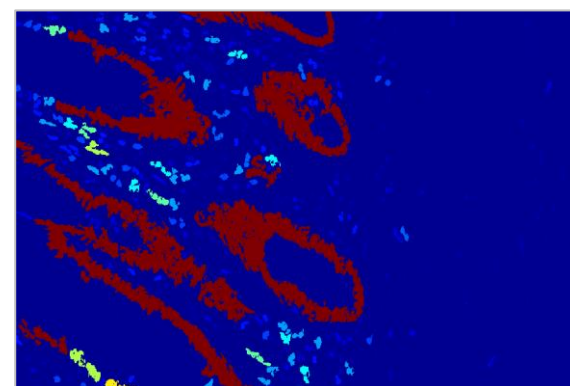
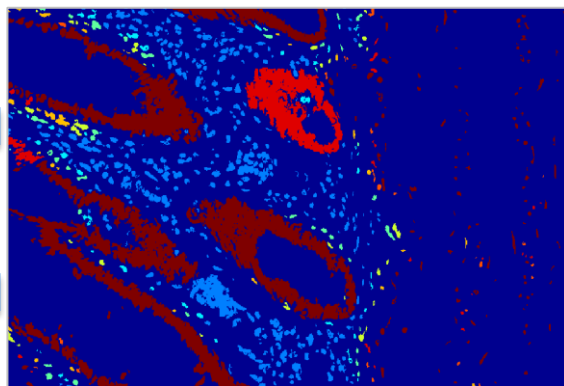
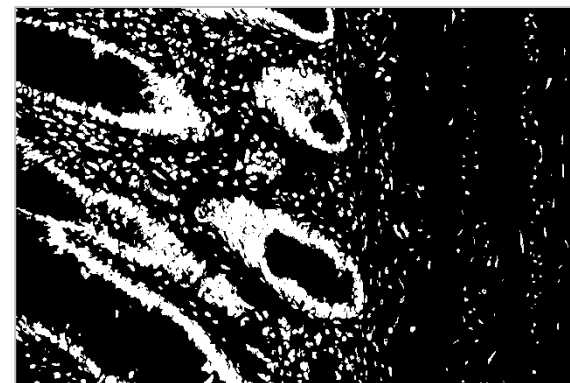
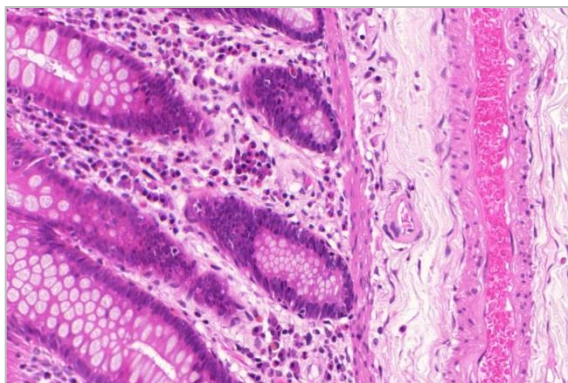


Solidity map

$$S_{map} = \sum_{r=1}^4 \sum_{s=1}^{50} J_s(\rho_{I_N}(\mathcal{O}_r(I_N)))$$

Gland Segmentation

Bounded:



**K-means
Classification**

Girth map

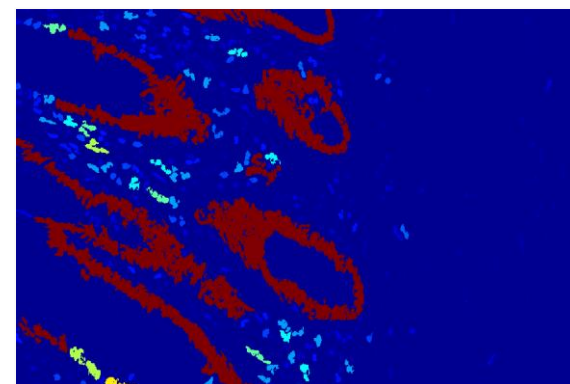
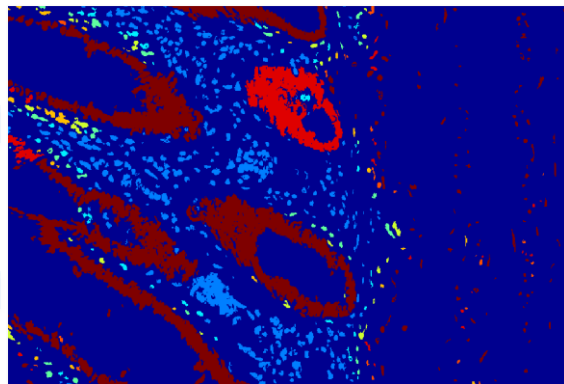
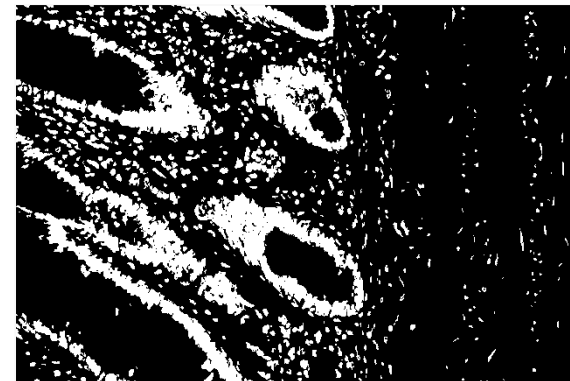
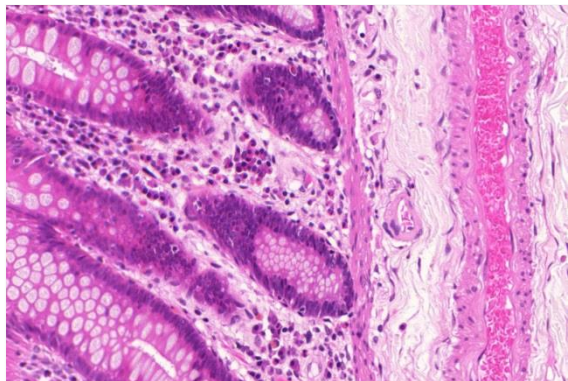
$$G_{map} = \sum_{r=1}^{40} \rho_{I_N}(\delta_r(H) \cdot I_N)$$

Solidity map

$$S_{map} = \sum_{r=1}^4 \sum_{s=1}^{50} J_s(\rho_{I_N}(\mathcal{O}_r(I_N)))$$

Gland Segmentation

Bounded:



K-means
Classification

Girth map

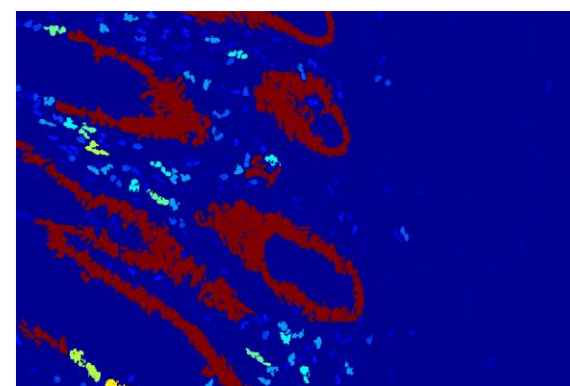
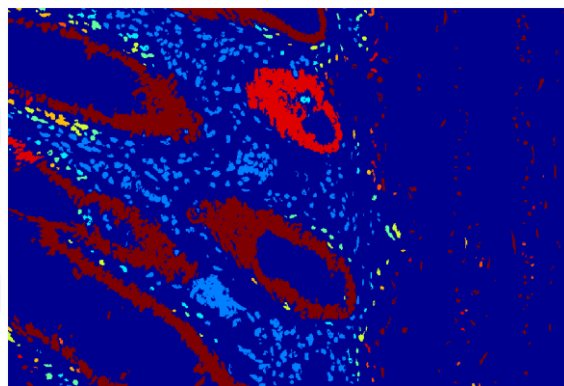
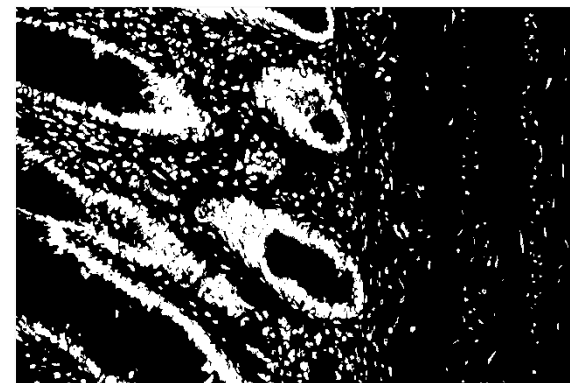
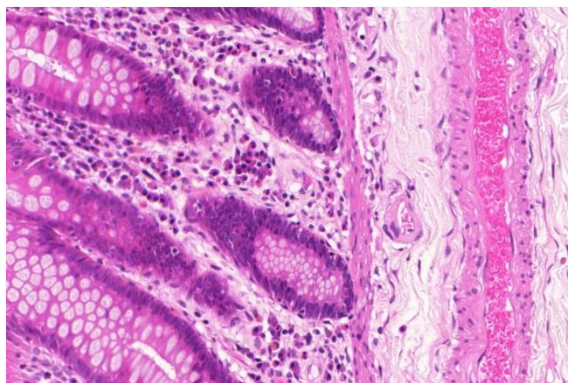
$$G_{map} = \sum_{r=1}^{40} \rho_{I_N}(\delta_r(H) \cdot I_N)$$

Solidity map

$$S_{map} = \sum_{r=1}^4 \sum_{s=1}^{50} J_s(\rho_{I_N}(\mathcal{O}_r(I_N)))$$

Gland Segmentation

Bounded:



K-means
Classification

Girth map

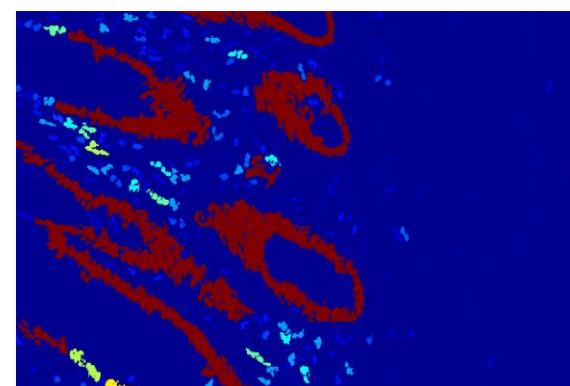
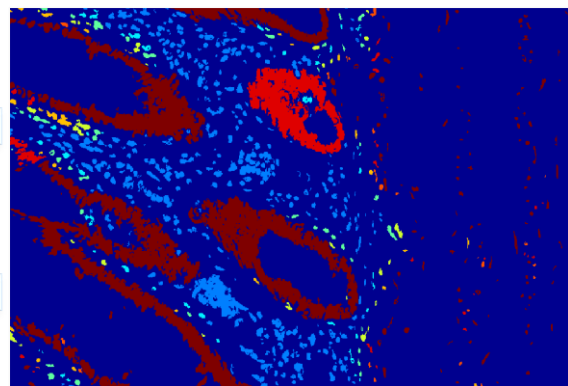
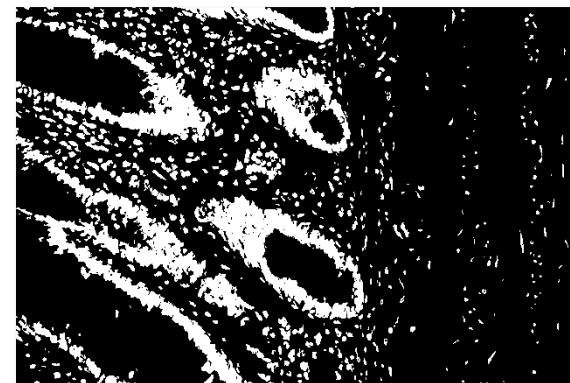
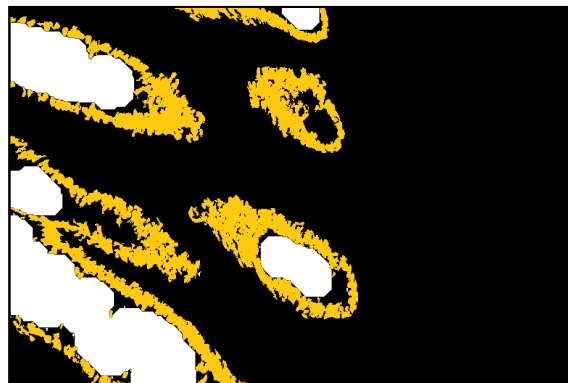
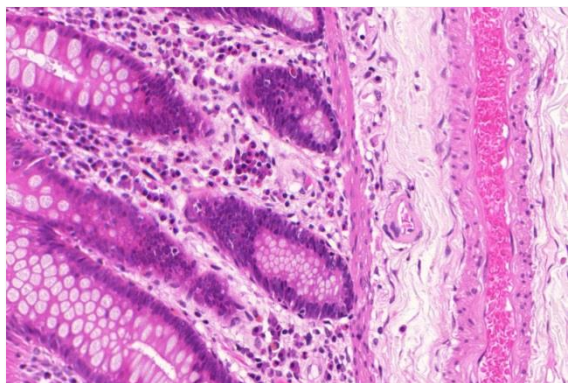
$$G_{map} = \sum_{r=1}^{40} \rho_{I_N}(\delta_r(H) \cdot I_N)$$

Solidity map

$$S_{map} = \sum_{r=1}^4 \sum_{s=1}^{50} J_s(\rho_{I_N}(O_r(I_N)))$$

Gland Segmentation

Bounded:



K-means
Classification

Girth map

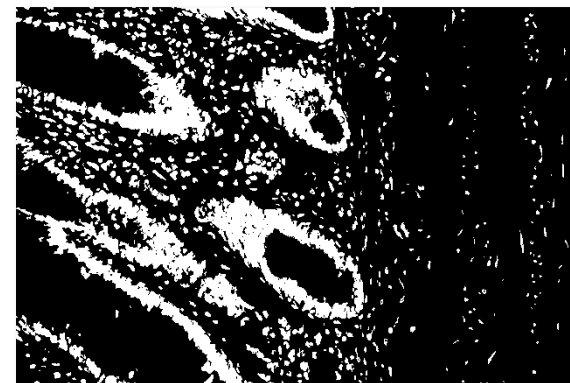
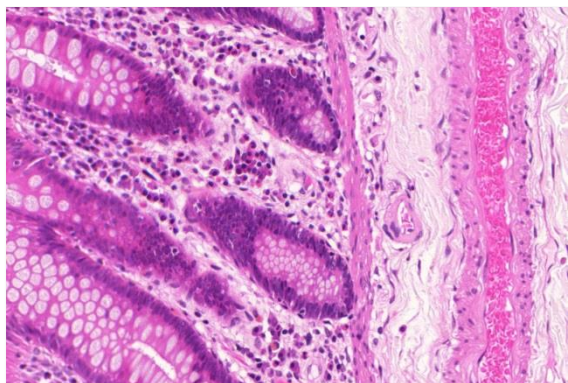
$$G_{map} = \sum_{r=1}^{40} \rho_{I_N}(\delta_r(H) \cdot I_N)$$

Solidity map

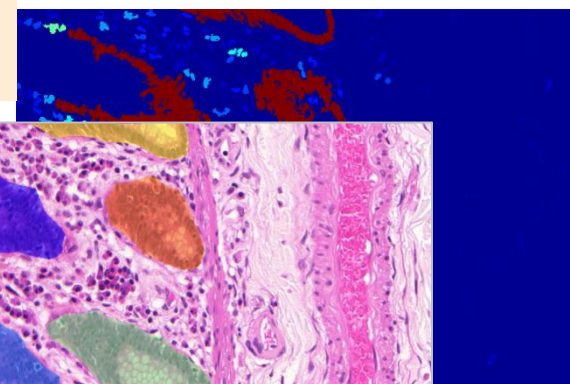
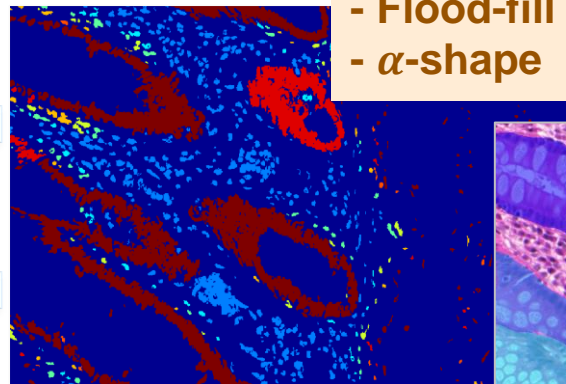
$$S_{map} = \sum_{r=1}^4 \sum_{s=1}^{50} J_s(\rho_{I_N}(O_r(I_N)))$$

Gland Segmentation

Bounded:



- Refinement
- Flood-fill
- α -shape



K-means
Classification

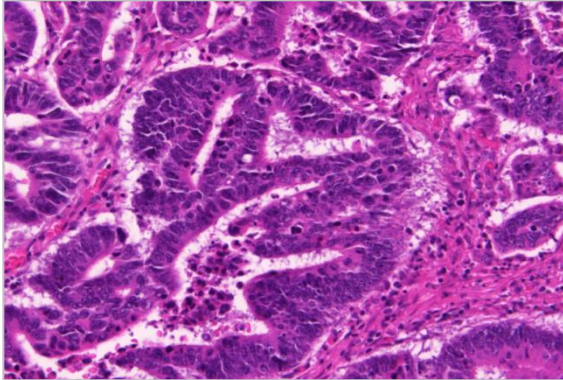
Girth map

$$G_{map} = \sum_{r=1}^{40} \rho_{I_N}(\delta_r(H) \cdot I_N)$$

$$S_{map} = \sum_{r=1} \sum_{s=1} \mathcal{J}_s(\rho_{I_N}(O_r(I_N)))$$

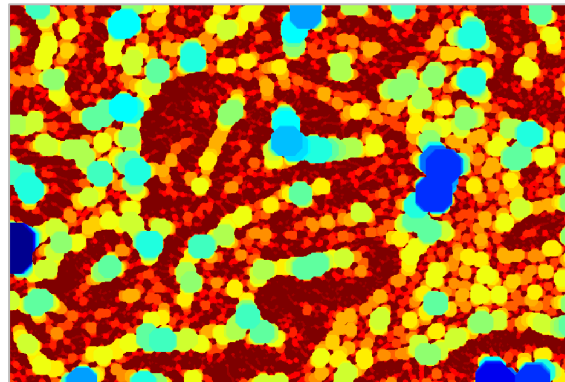
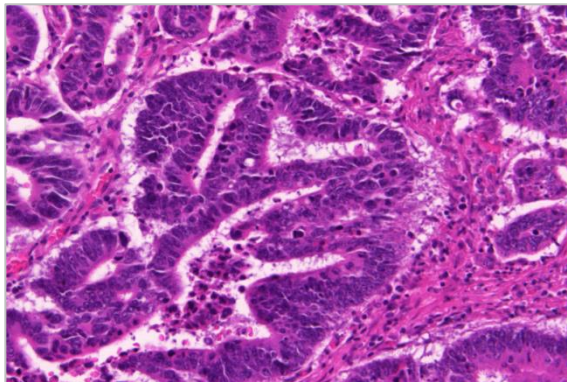
Gland Segmentation

Crowded:



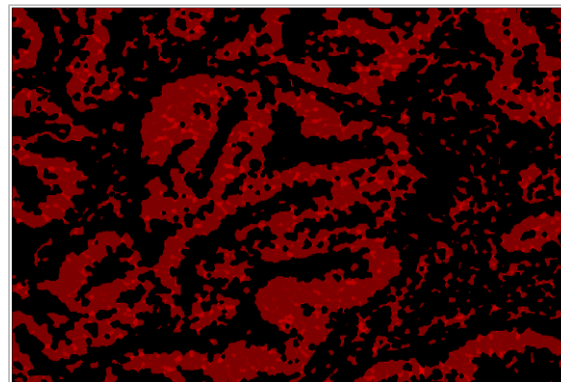
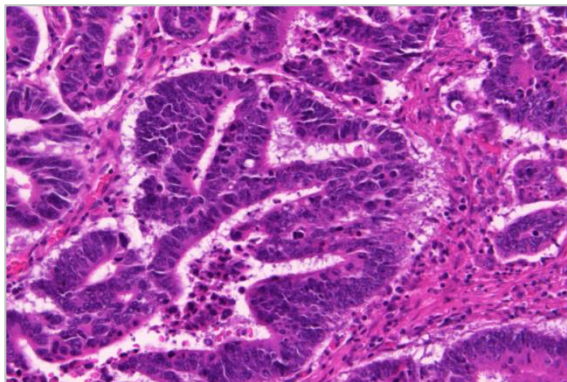
Gland Segmentation

Crowded:



Gland Segmentation

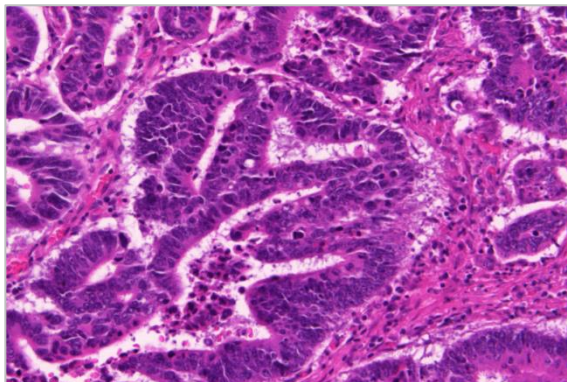
Crowded:



$P_{map} > 0.9$

Gland Segmentation

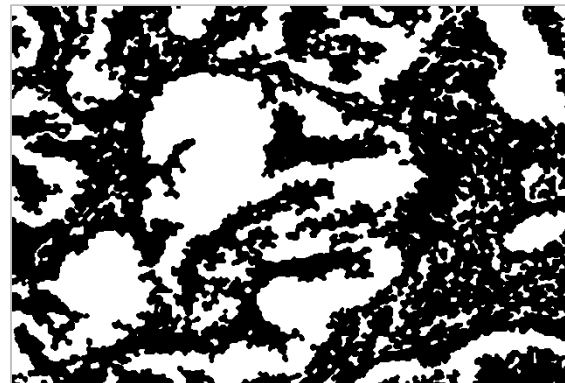
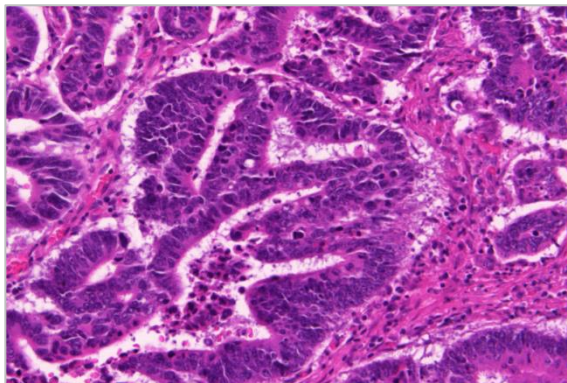
Crowded:



$P_{map} > 0.9$

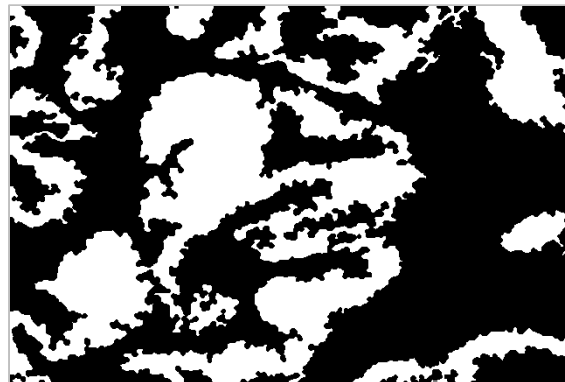
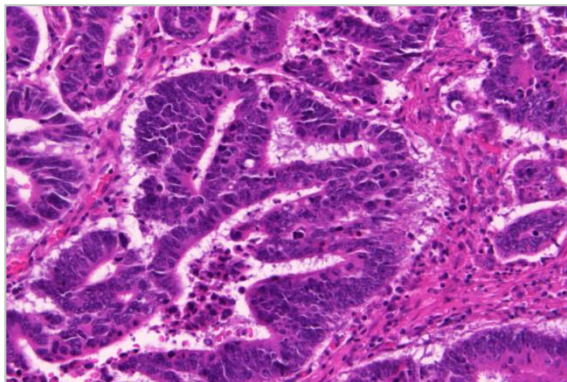
Gland Segmentation

Crowded:



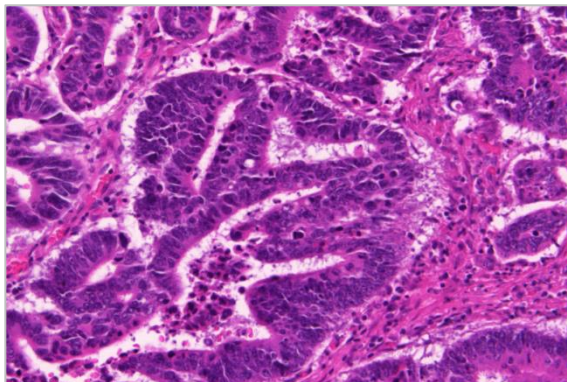
Gland Segmentation

Crowded:



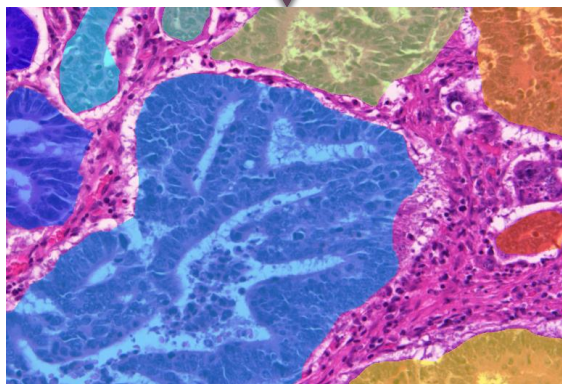
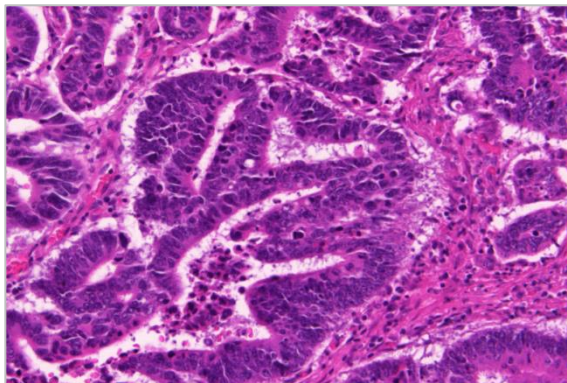
Gland Segmentation

Crowded:



Gland Segmentation

Crowded:



Results & Conclusion

Quantitative Results (training dataset):

	F-score	Dice Index	Hausdorff Distance
Benign (37)	0.8512	0.8314	53.4473
Malignant (48)	0.5770	0.6437	160.3051
Total (85)	0.6963	0.7254	113.7905

Results & Conclusion

Quantitative Results (training dataset):

	F-score	Dice Index	Hausdorff Distance
Benign (37)	0.8512	0.8314	53.4473
Malignant (48)	0.5770	0.6437	160.3051
Total (85)	0.6963	0.7254	113.7905

Advantages:

- Scalability
- Time
- Classification

Thanks For Your Attention

Qualitative Results

