

Application of deep learning in diagnostic pathology: own experience and perspectives

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**UNIKLINIK
KÖLN**

University Hospital Cologne

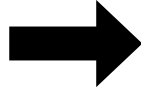
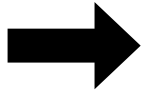
Institute of Pathology

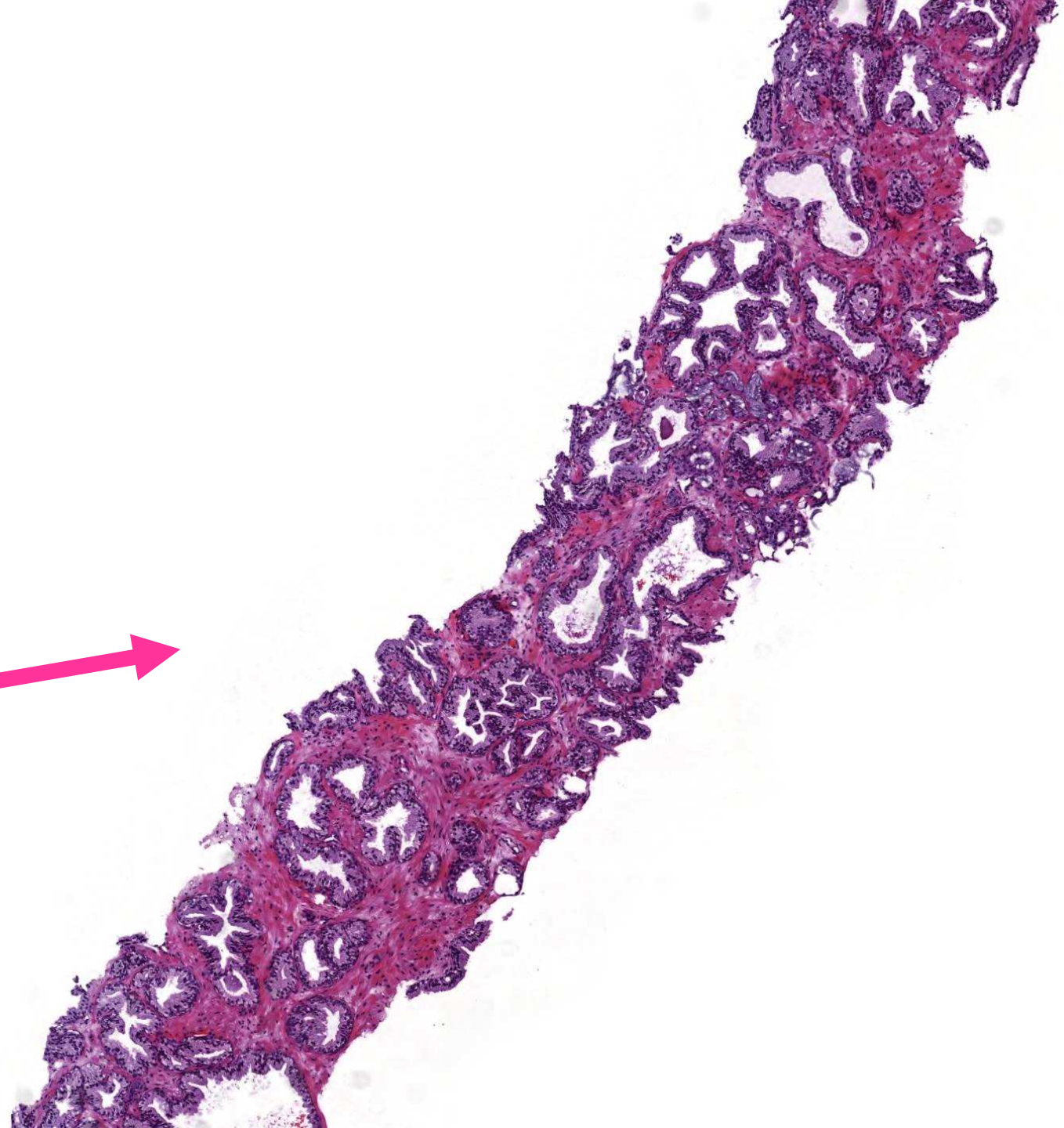
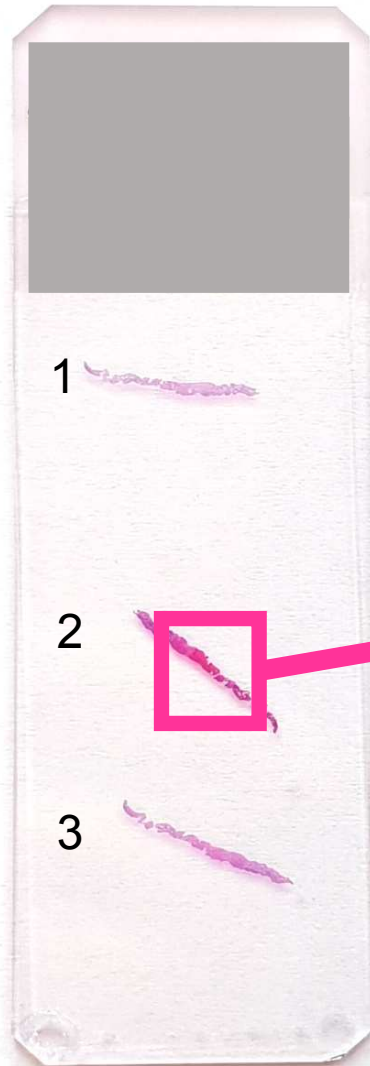
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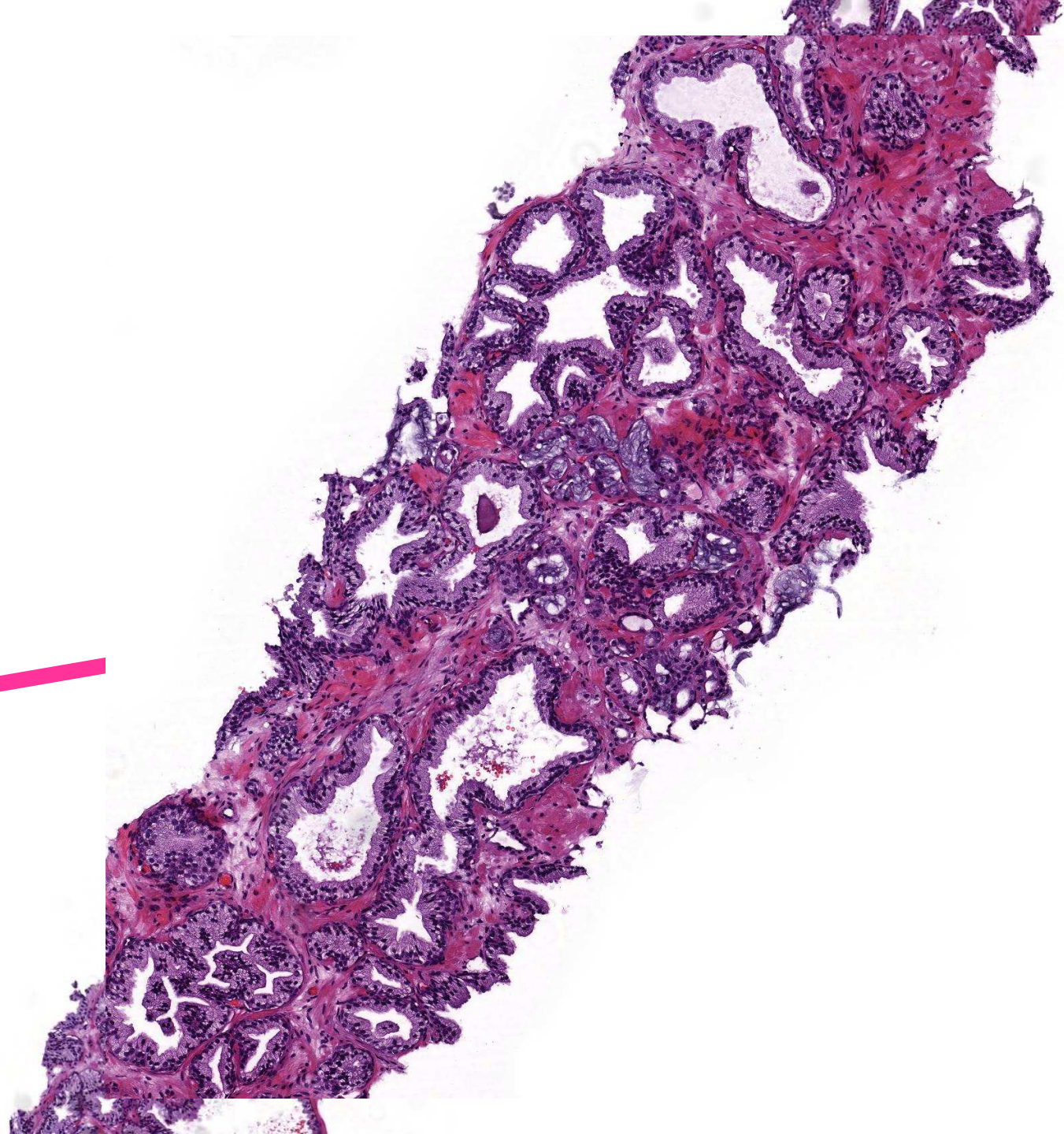
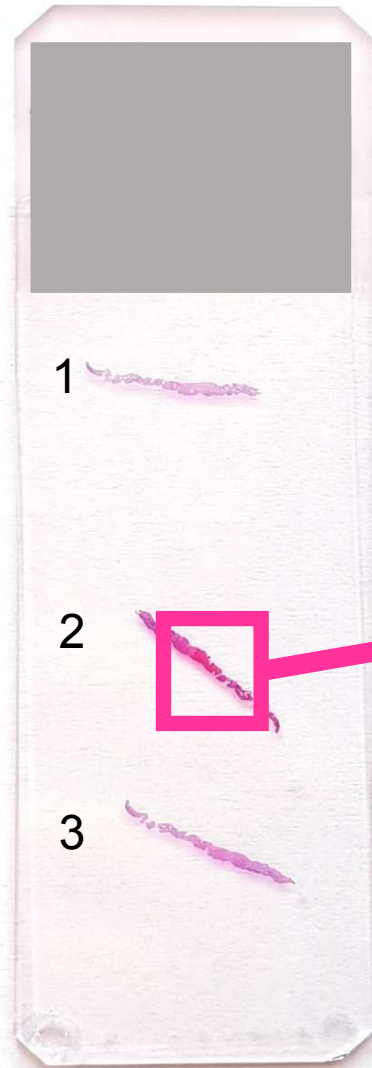
- Diagnostics
- Molecular pathology
- Oncology / Precision medicine
- Research

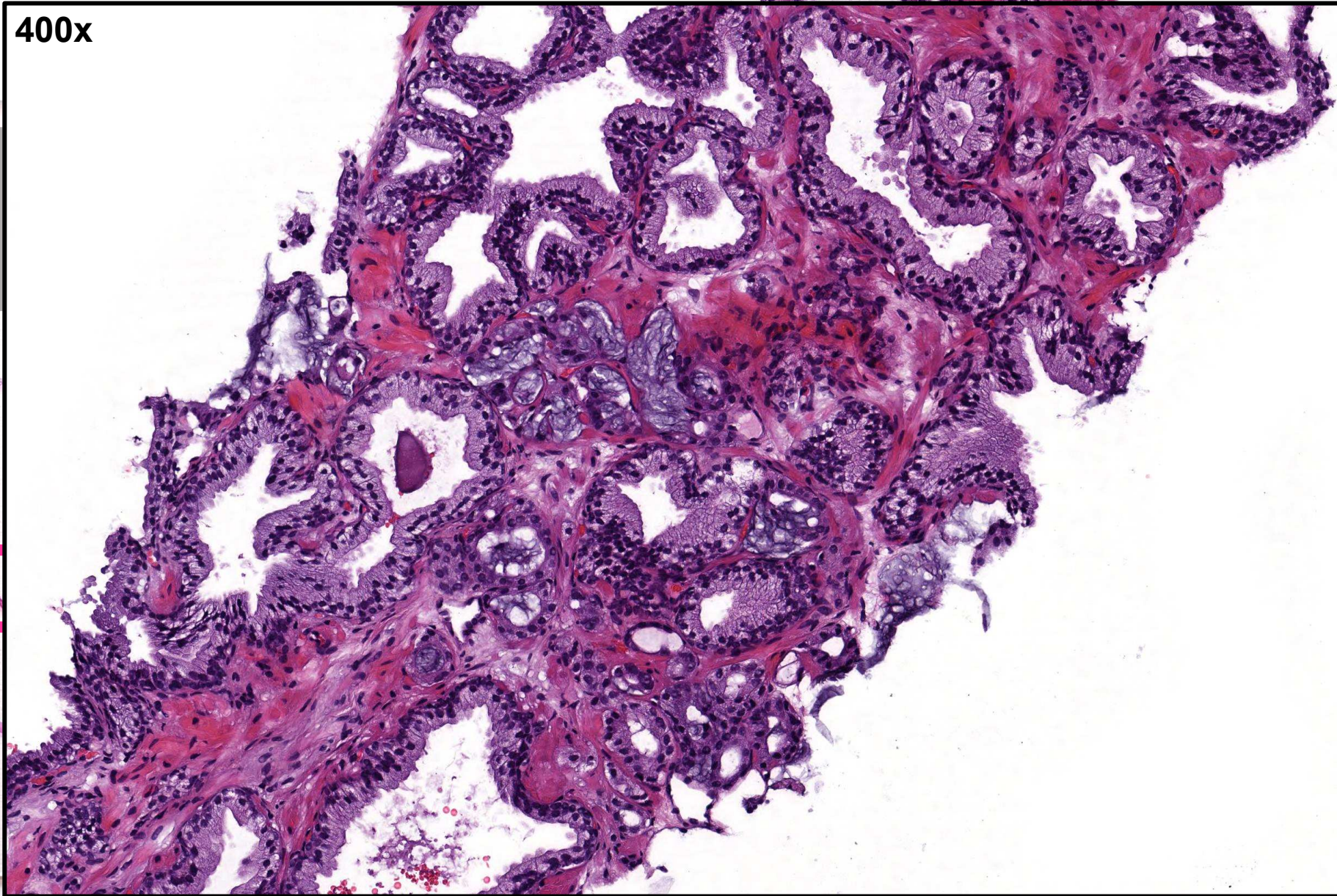


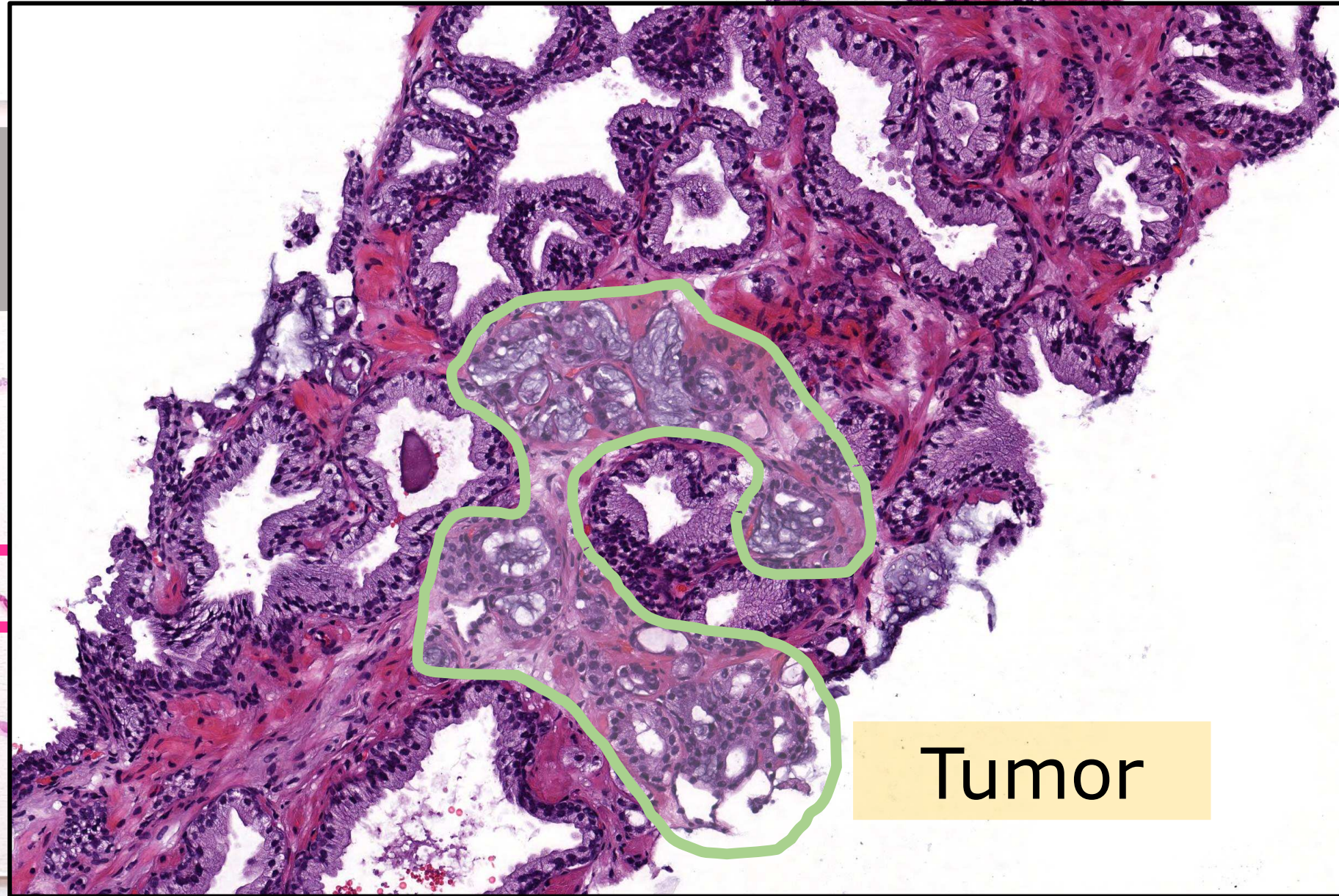
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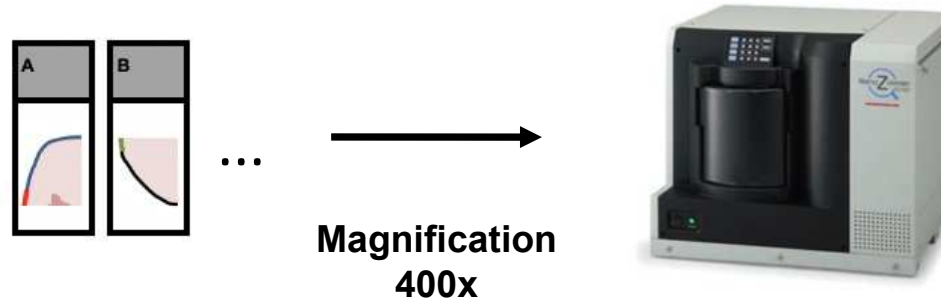


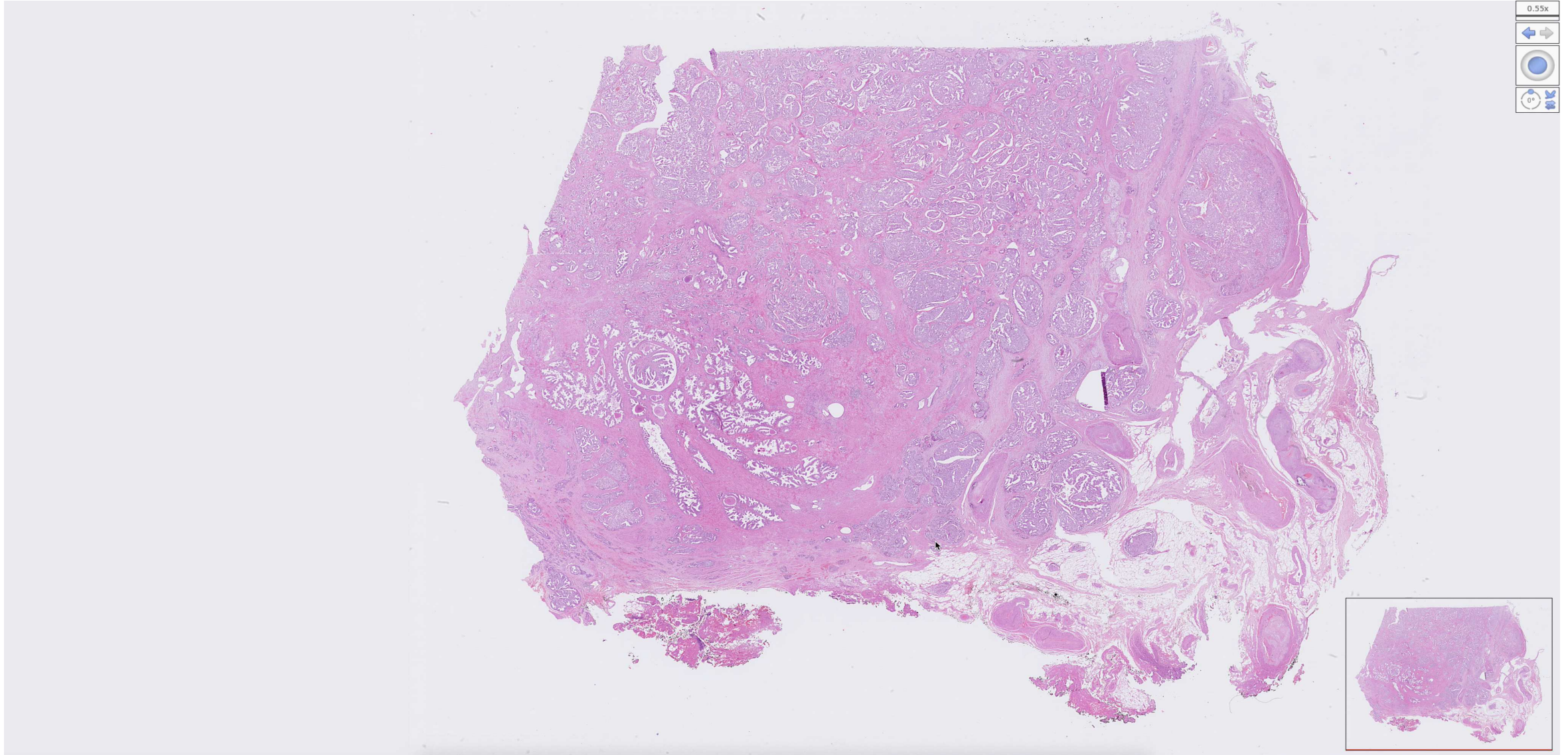
Tumor

Digital pathology

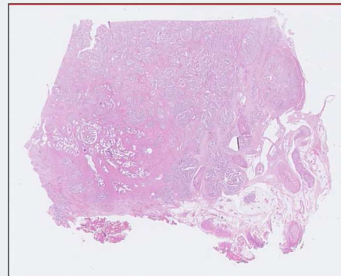
Digital pathology

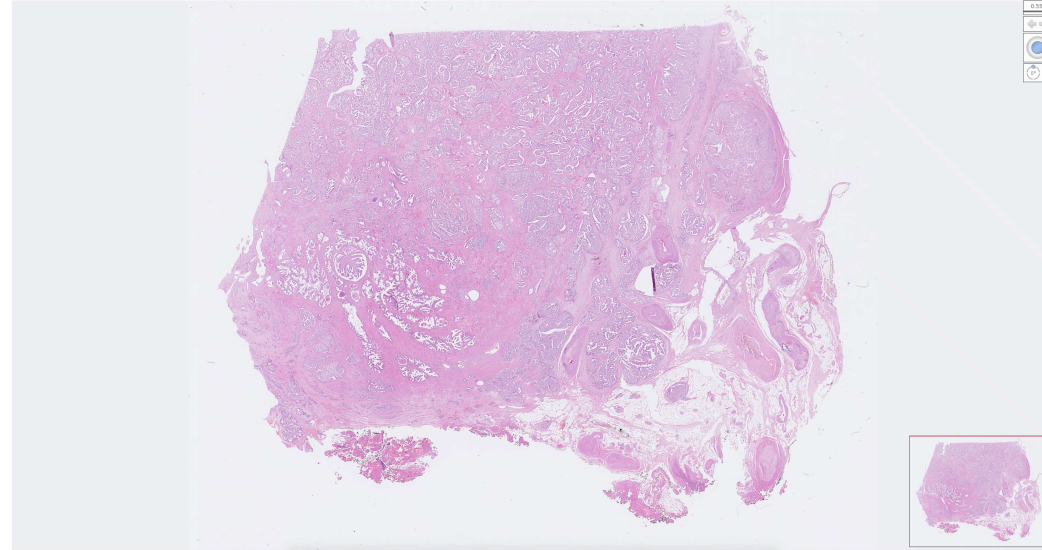
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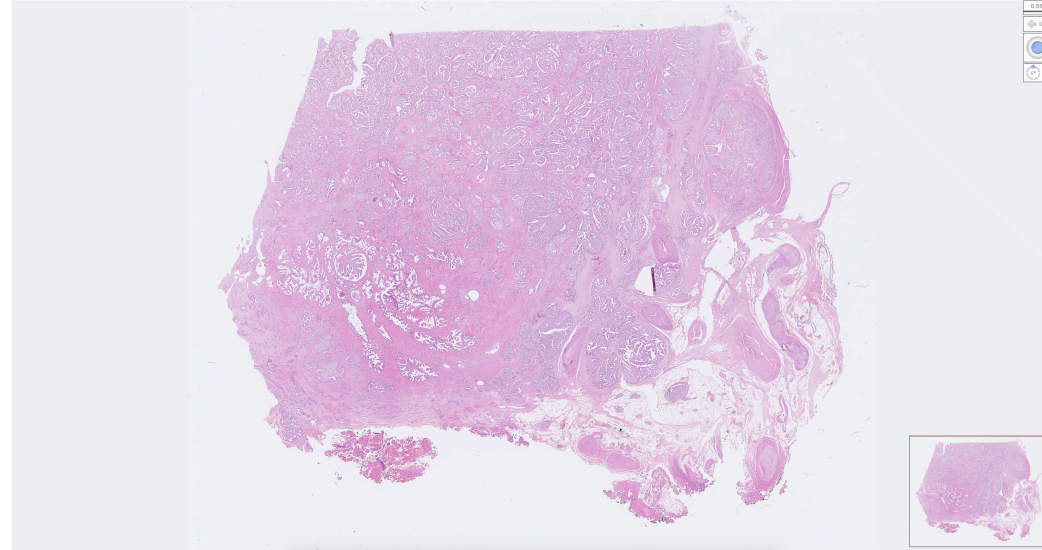




Digital pathology





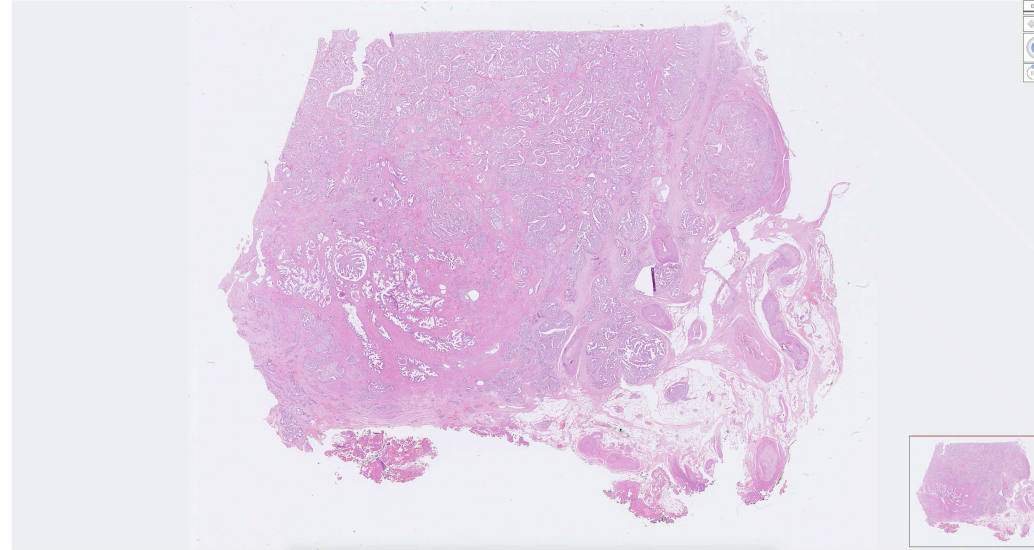


Timing

Dimensions

Sense

Digital pathology



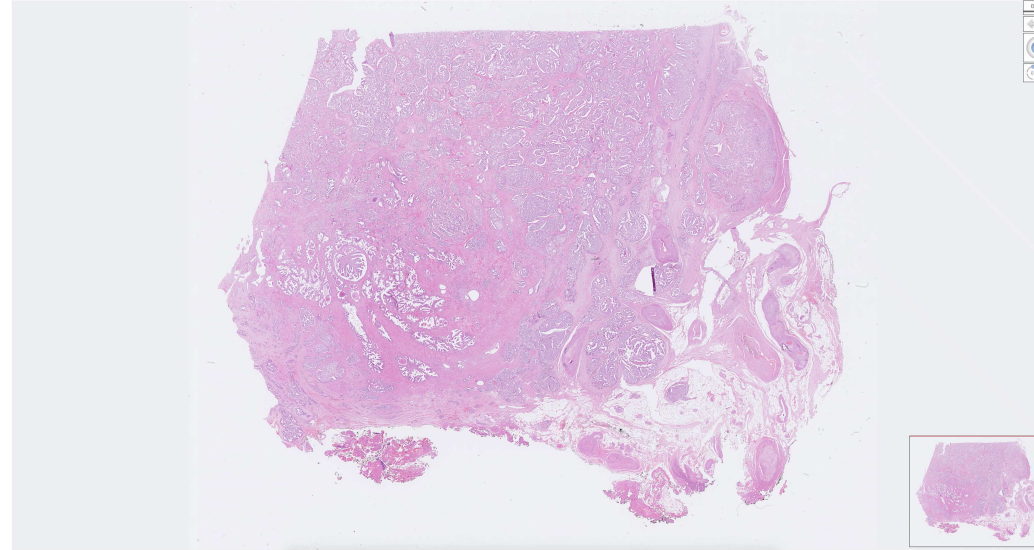
Timing

Transformation
next 5-10 years

Dimensions

Sense

Digital pathology



Timing

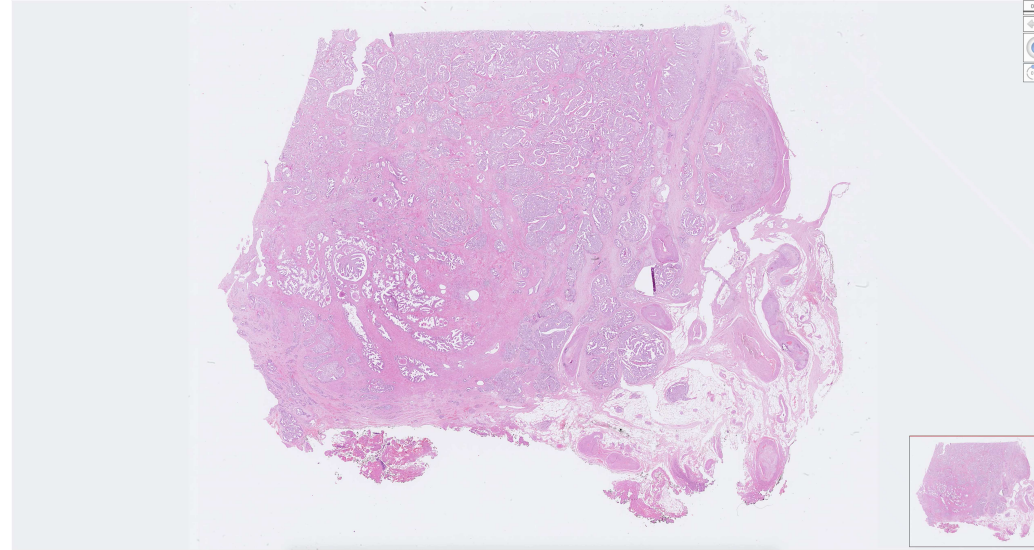
Transformation
next 5-10 years

Dimensions

1 Slide = 1-4 Gb

Sense

Digital pathology



Timing

Transformation
next 5-10 years

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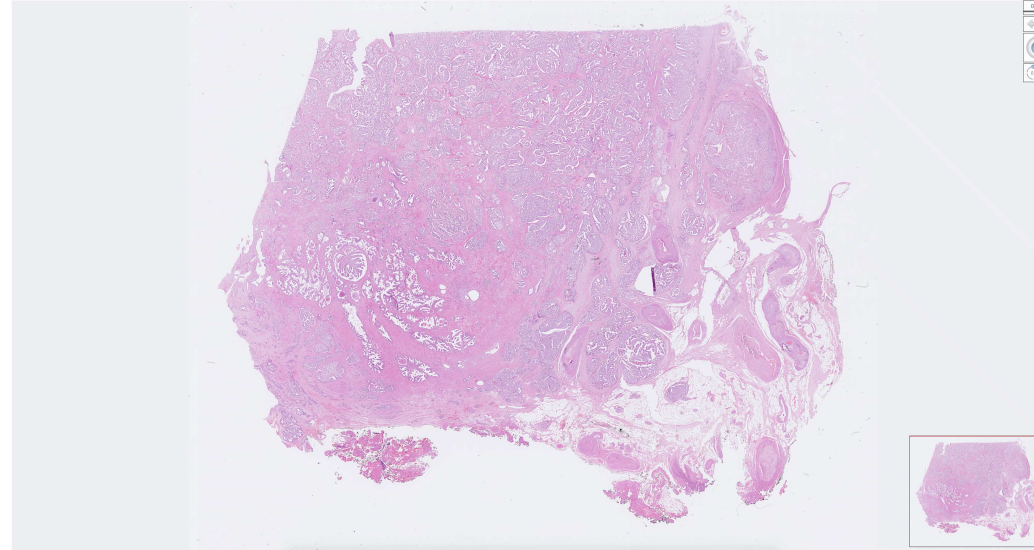
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UK Cologne:
>1000 Slides / day

up to 1 Tb / day

Sense

Digital pathology



Timing

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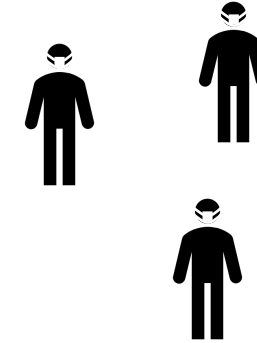
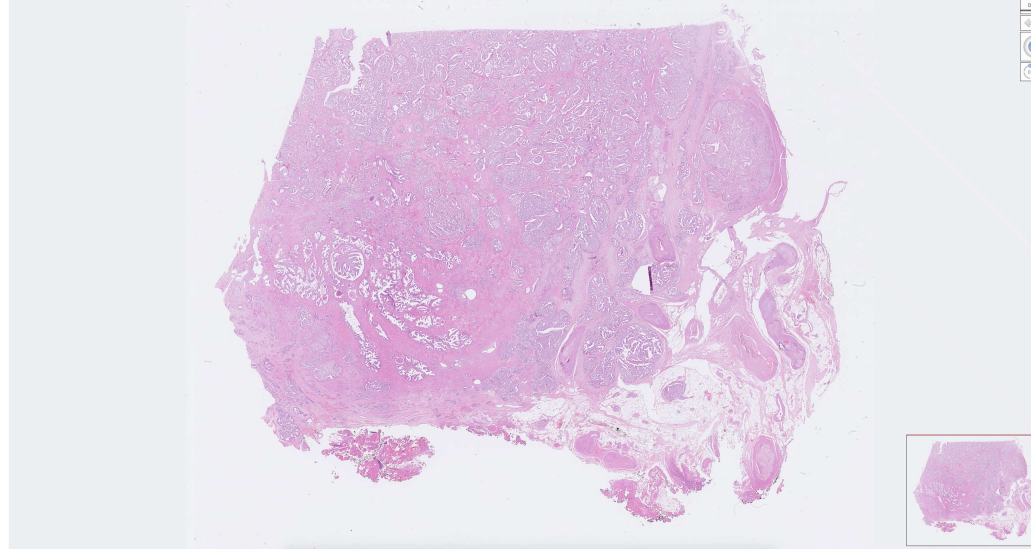
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Very Big Data

Sense

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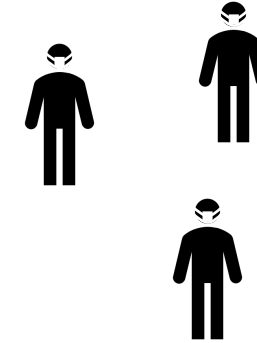
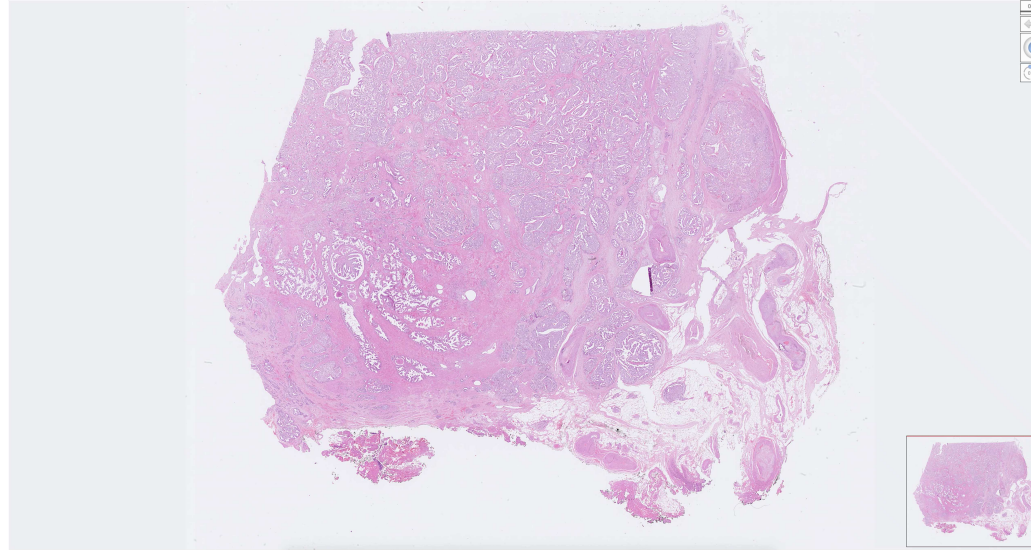
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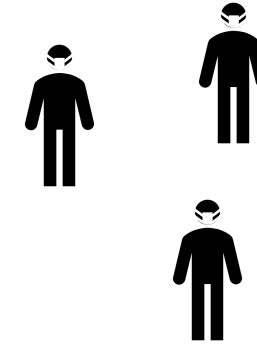
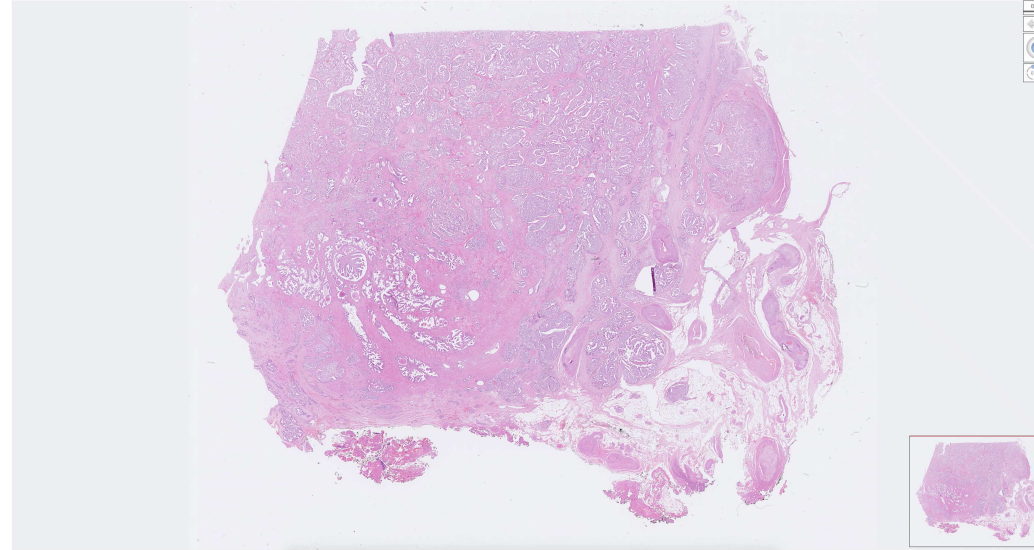
Very Big Data

Sense

Diagnostic

- Staging (size, local etc.)
- Aggressive?
- Metastasis?
- Resection complete?

Digital pathology



Timing

Transformation
next 5-10 years

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Very Big Data

Sense

Diagnostic

- Staging (size, local etc.)
- Aggressive?
- Metastasis?
- Resection complete?

Advanced

- Prognosis (recurrence, death)?
- Metastasis?
- Genetic changes?
- Individual therapy options?
- Response to therapy?

Bulk of evidence

- 1) “low-hanging fruit” effect
- 2) Wow! effect
- 3) Overestimation of modest results



Bulk of
evidence

Technology

Networks:

Classification

Segmentation

GANs

Architectures

Principles of training

AutoML



Bulk of
evidence

Technology

Networks:
Classification
Segmentation
GANs
Architectures
Principles of training
AutoML

Data

202
0

202
5

- Lack of ground truth



Bulk of evidence

Technology

Networks:

Classification

Segmentation

GANs

Architectures

Principles of training

AutoML

Data

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- Lack of ground truth

Performance

- Perspective directions

- Market formation

202
5



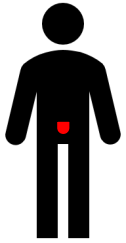
Diagnostic applications

*Tumor recognition
Aggressivity grading*

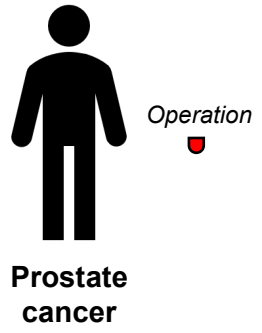


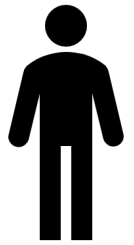
Advanced applications





**Prostate
cancer**

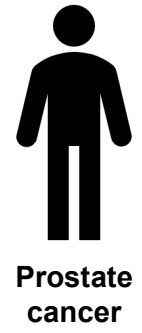




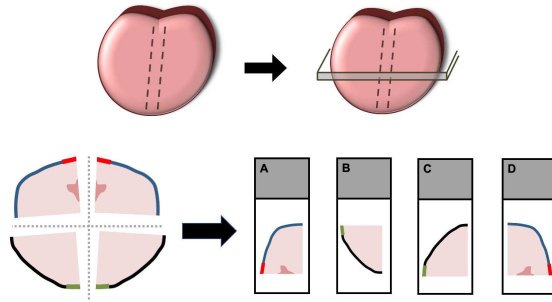
**Prostate
cancer**

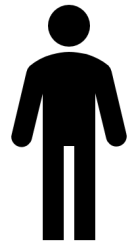


**Pathology
department**



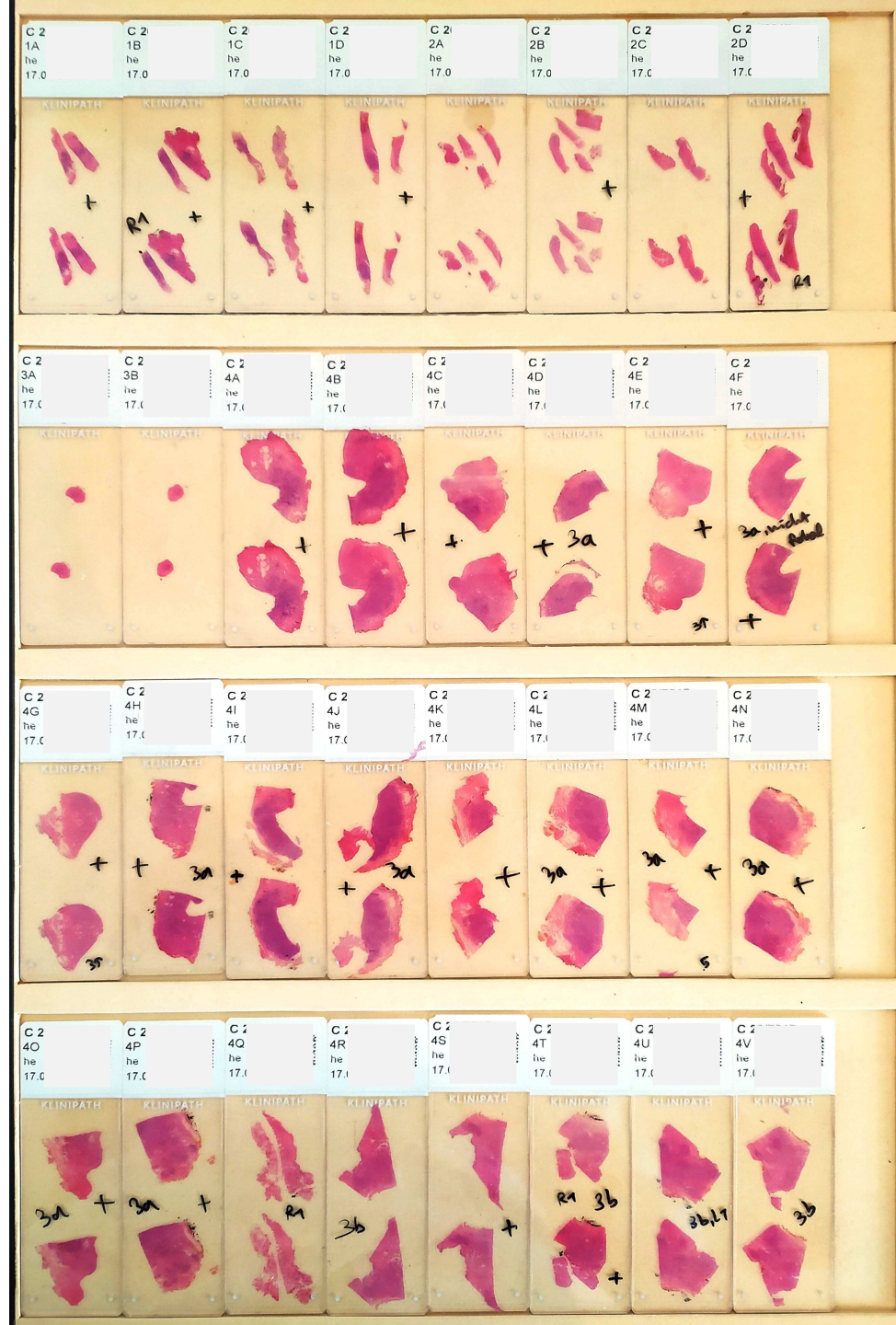
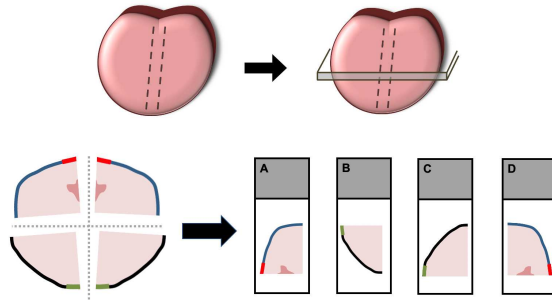
Pathology
department

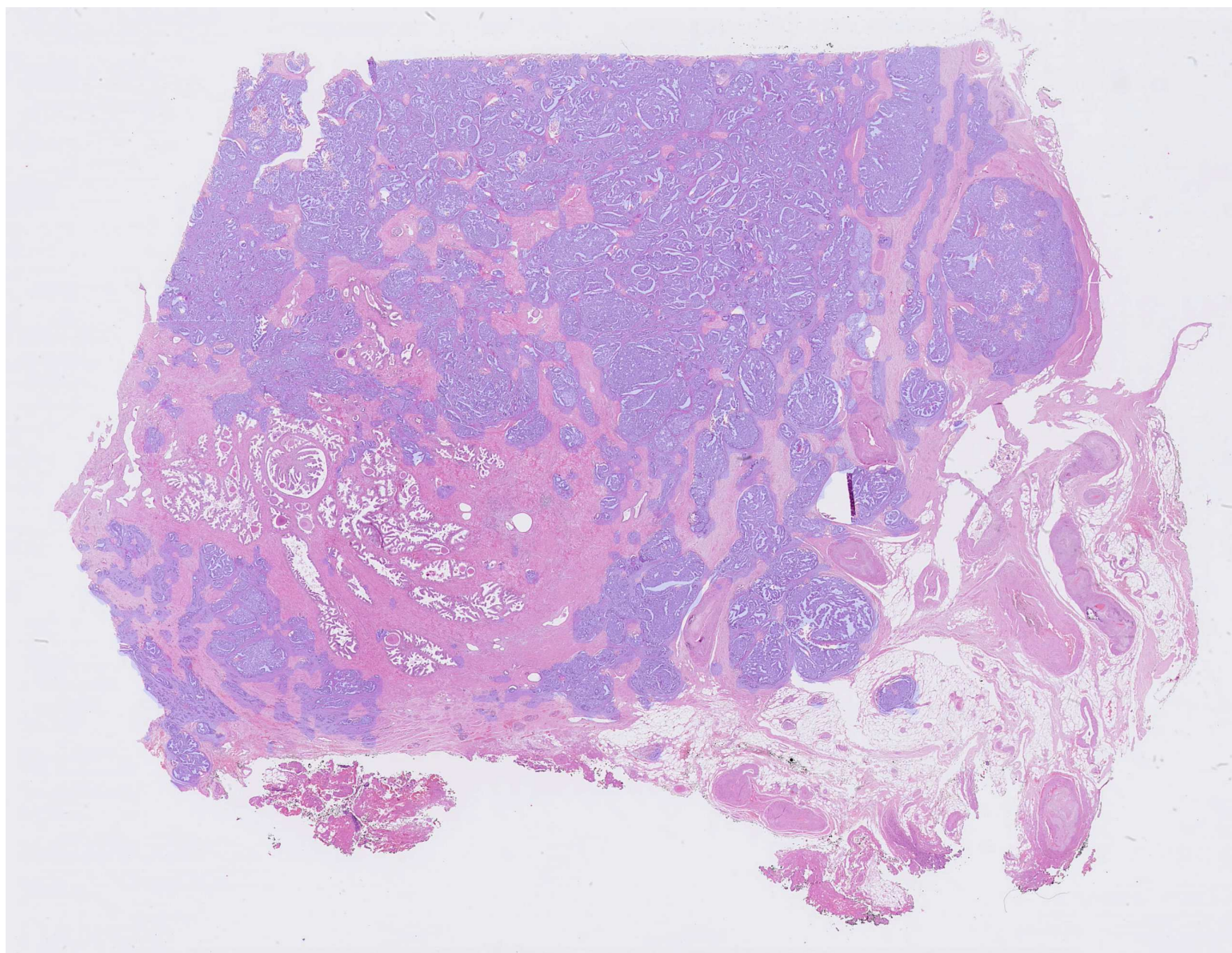




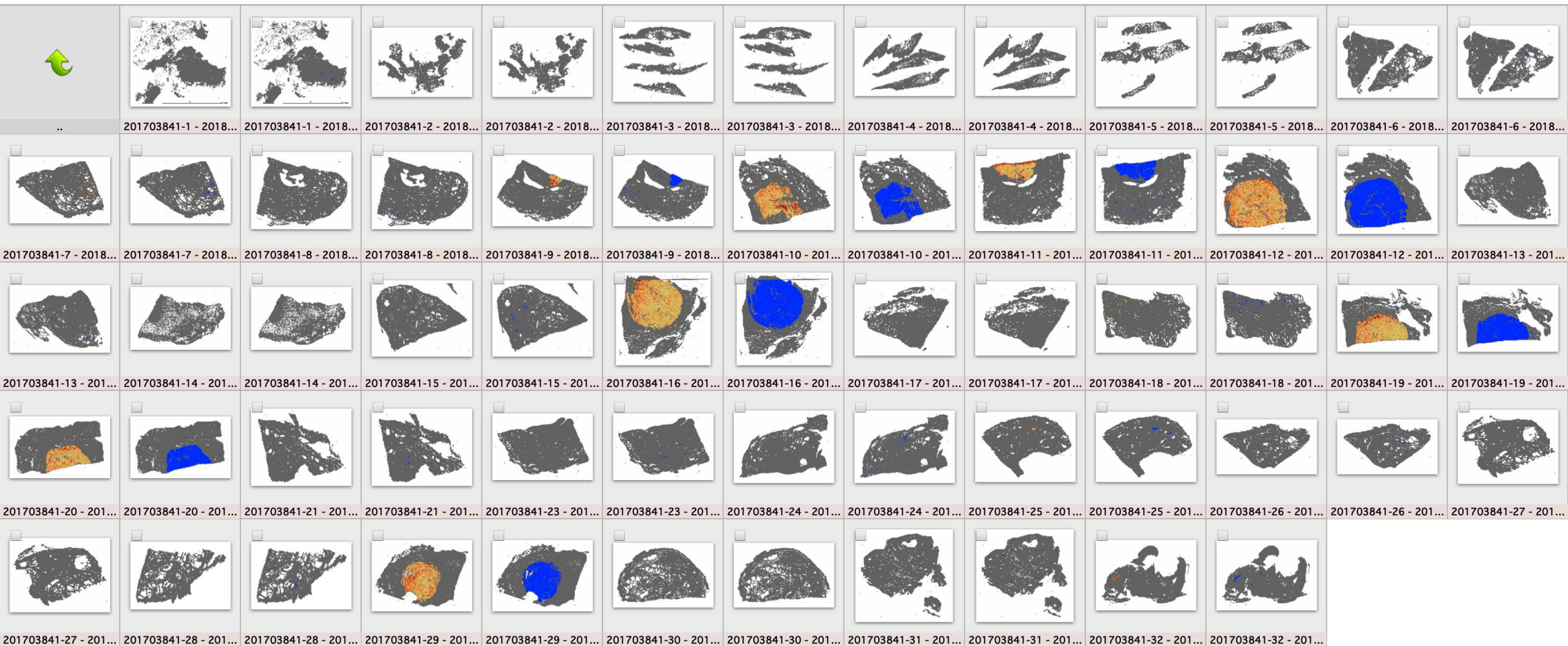
Prostate
cancer

Pathology
department





AI Tool

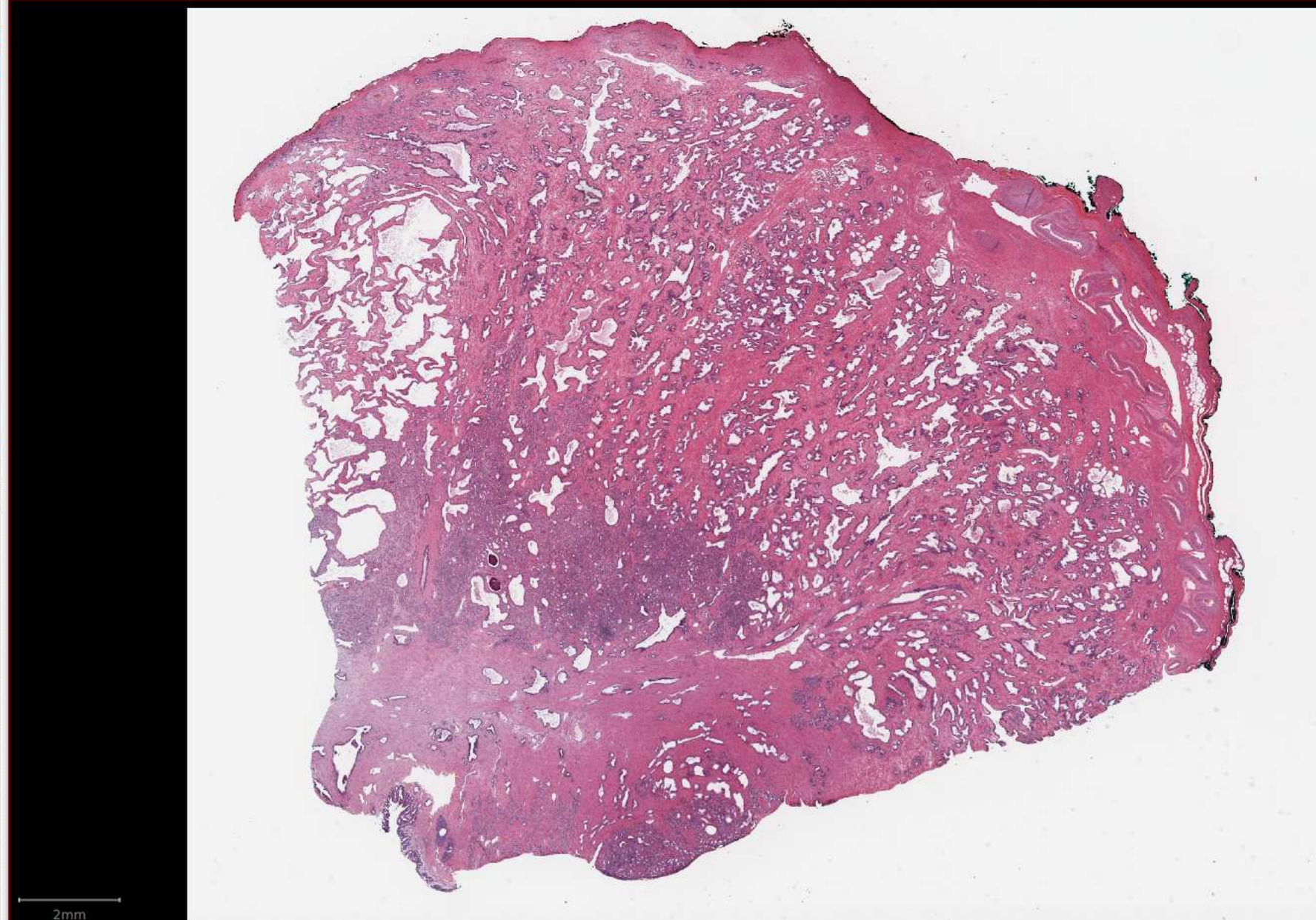


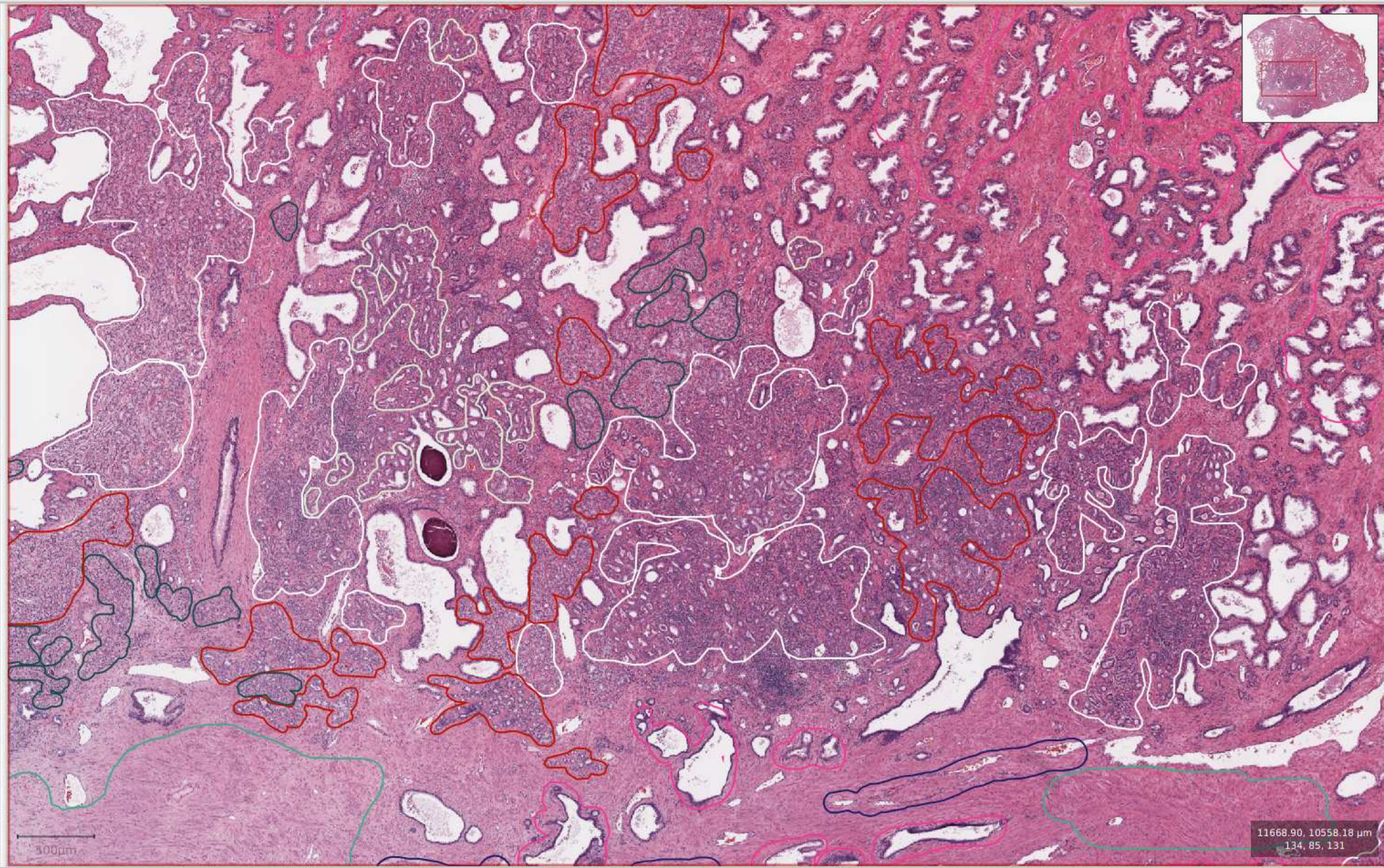
Pathology report

- None
- GP3
- GP4
- GP5
- 3+3
- 3+4
- 4+3
- 4+4
- N
- 5+4
- 4+5
- HGPIN
- N_STR
- TU_IDC
- SB
- TU_MUC
- N_NONGL

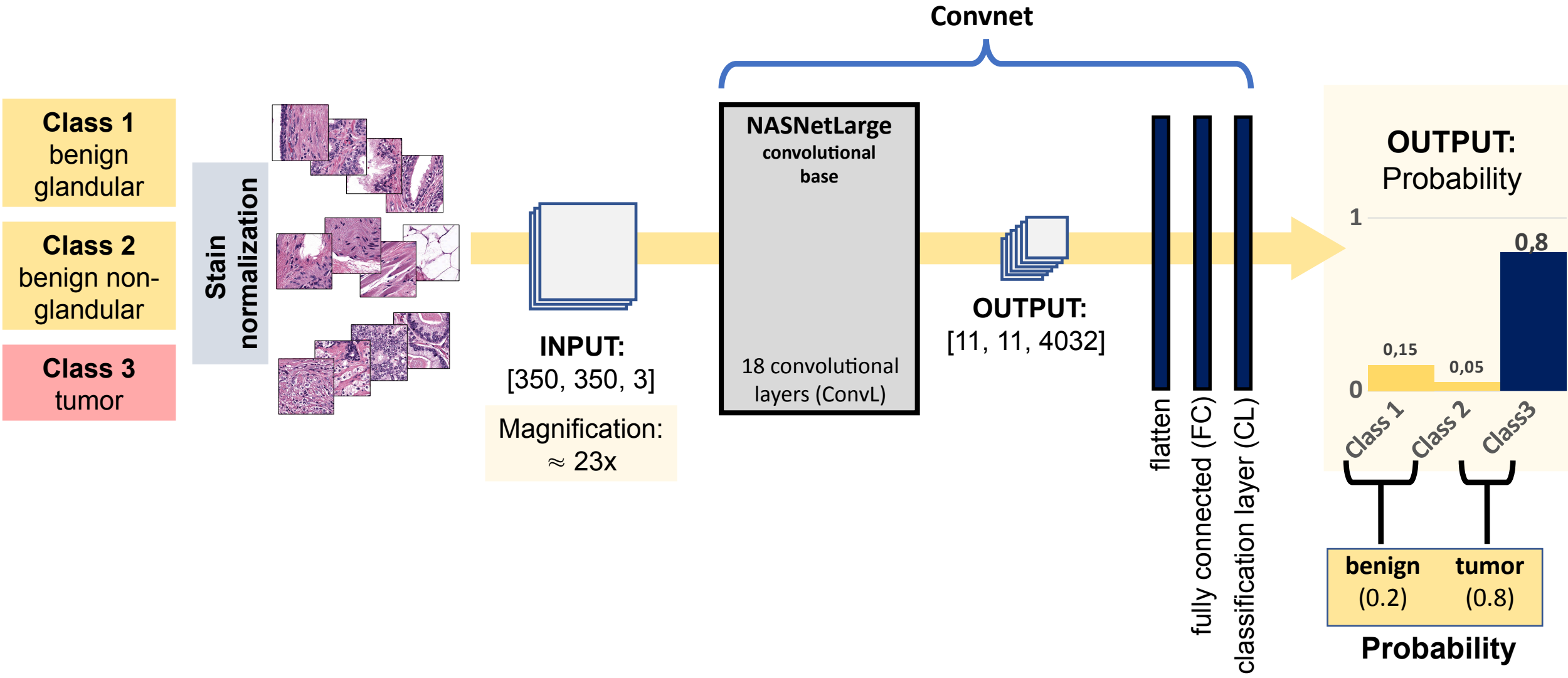
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Key	Value
Name	



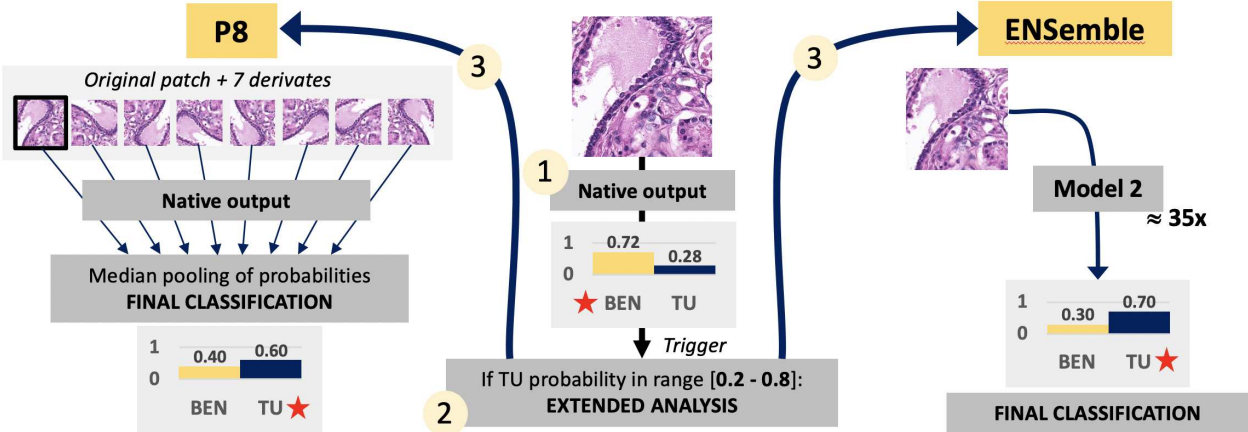


Convolutional neural network Architecture

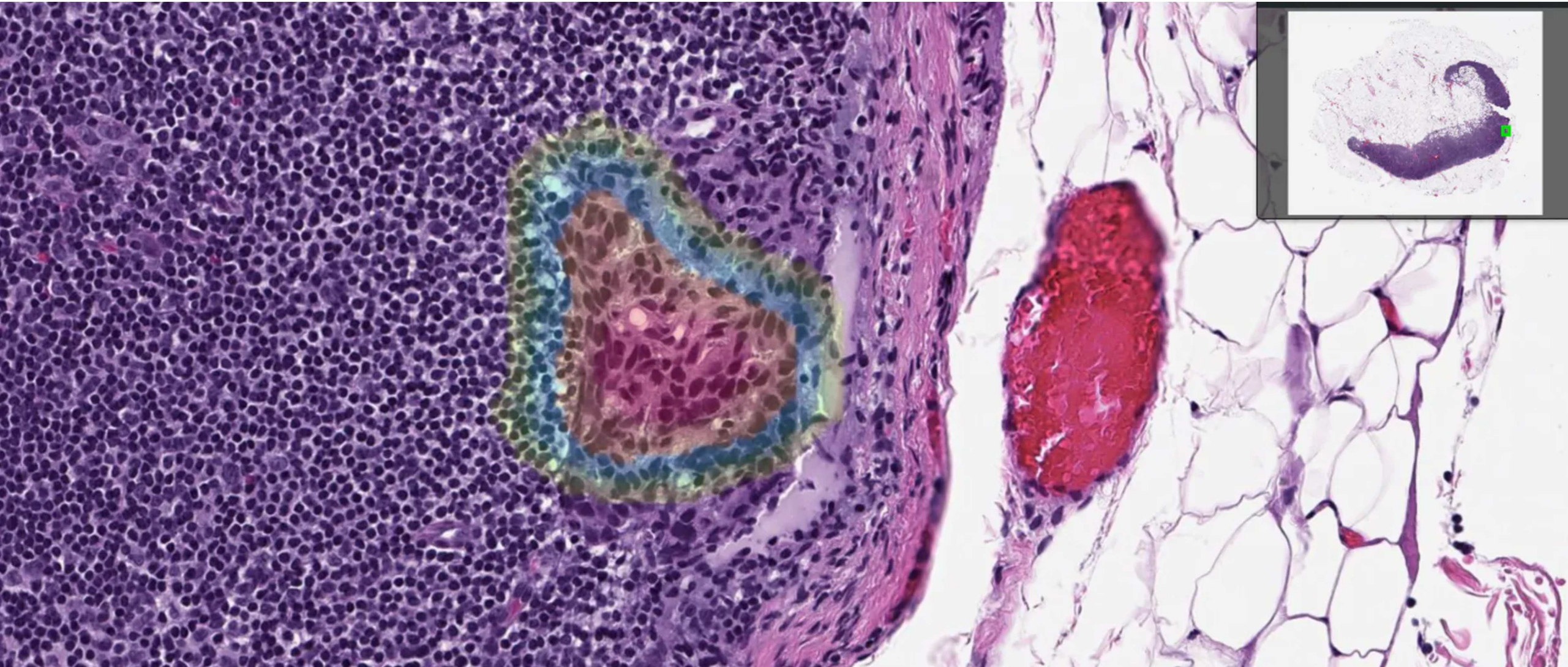


Accuracy

Tumor detection



Cohort	Precision	Recall	F1 Score	Overall accuracy
VAL 1 <i>native</i>	0.937	0.961	0.948	96.2%
VAL 2 <i>native</i>	0.927	0.957	0.942	96.7%
VAL 2 <i>p. VAL 1</i>	0.951	0.955	0.953	97.4%
VAL 1 <i>P8</i>	0.950	0.967	0.959	97.0%
VAL 2 <i>P8</i>	0.944	0.962	0.953	97.3%
VAL 1 <i>ENS</i>	0.936	0.967	0.951	96.4%
VAL 2 <i>ENS</i>	0.932	0.962	0.947	97.0%



Diagnostic applications

*Tumor recognition
Aggressivity grading*

Improvement

*Accuracy
gap 2-5%*

Identify problems

New, more advanced networks
Much more data (not only scan)
Context recognition (artefacts, staining, etc.)
Implementation of human-like interpretation behavior

Multi-level systems
(more than one convnet)

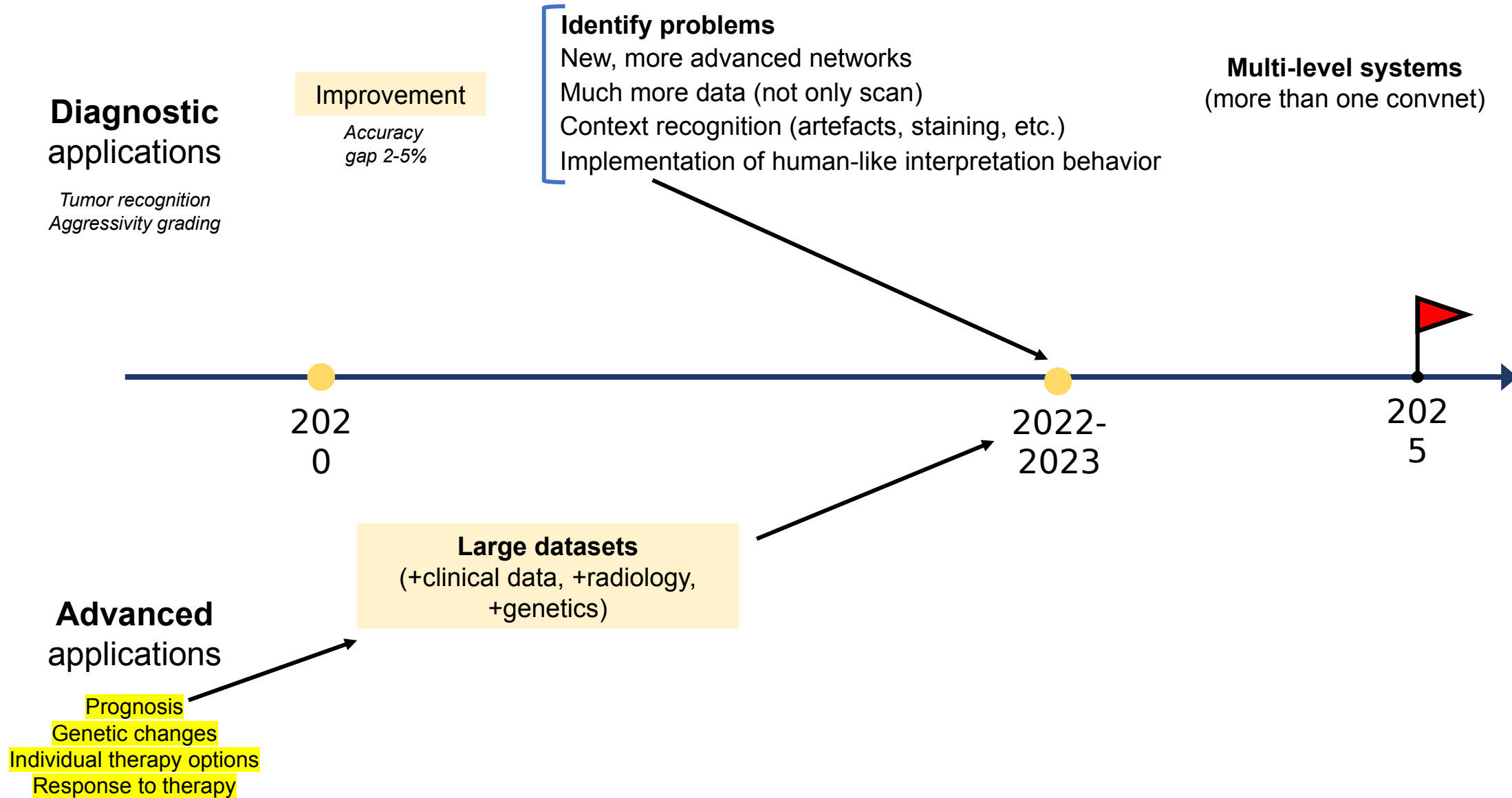
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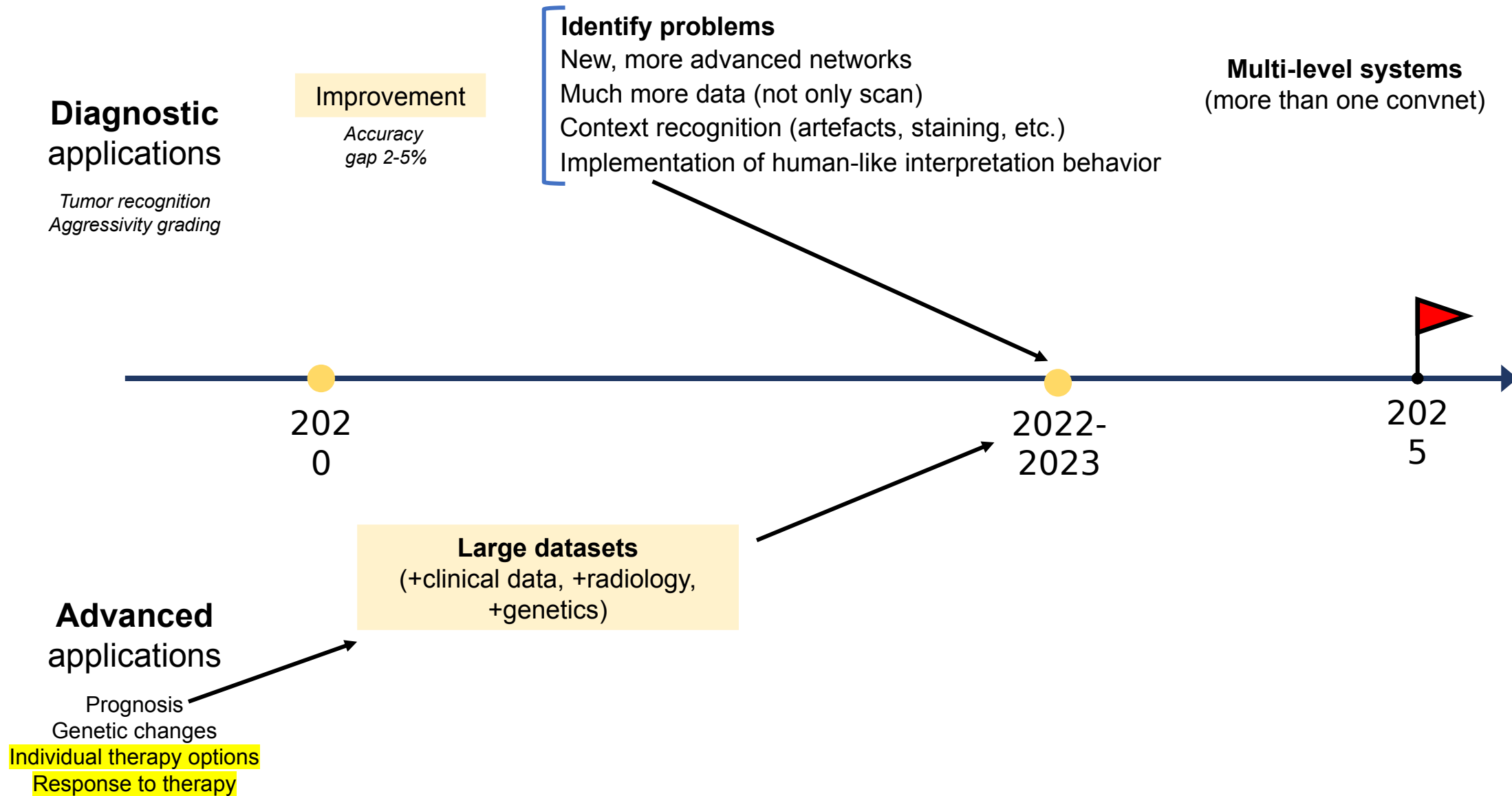
2022-
2023

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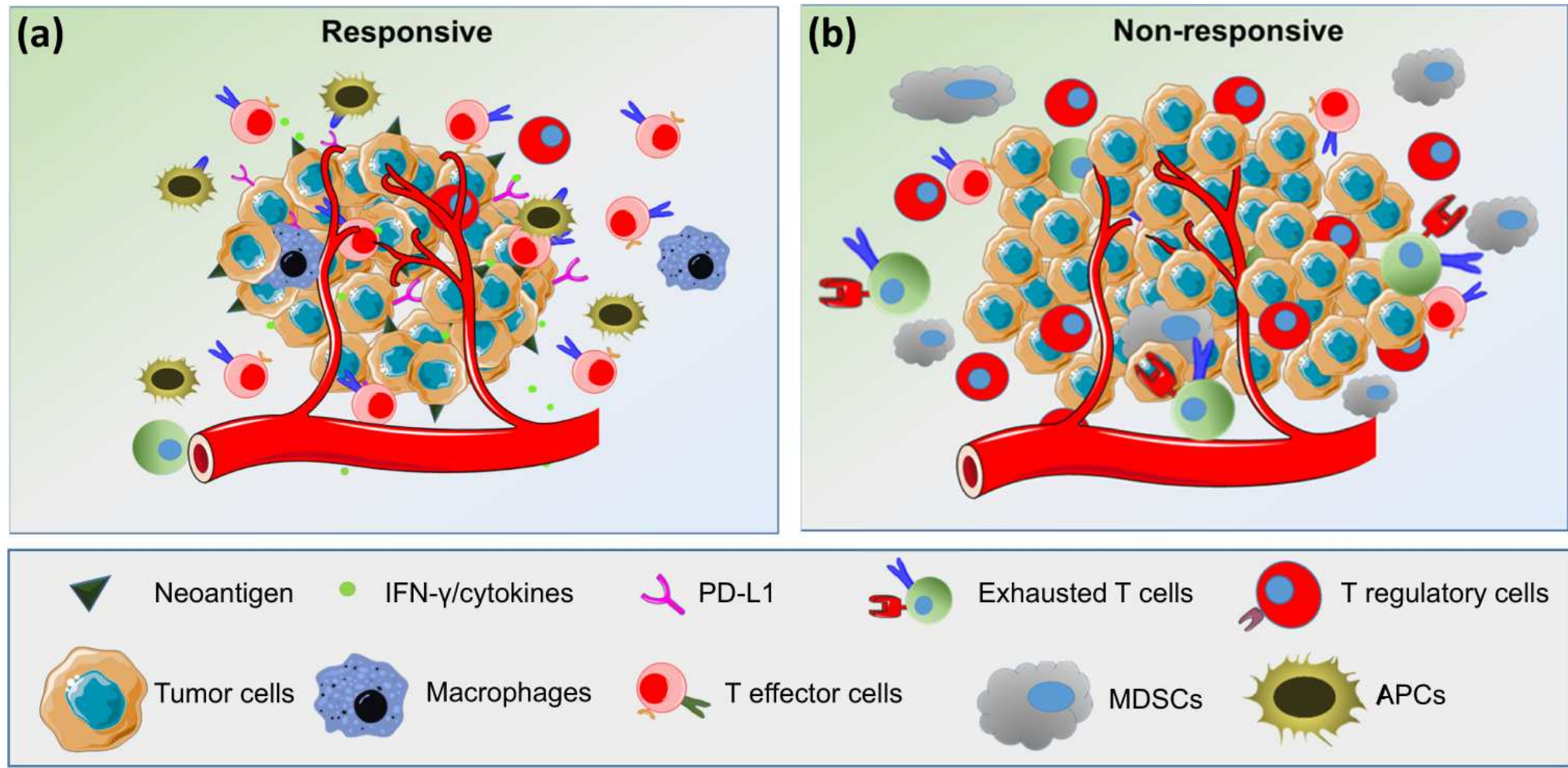
Advanced applications

Prognosis
Genetic changes
Individual therapy options
Response to therapy



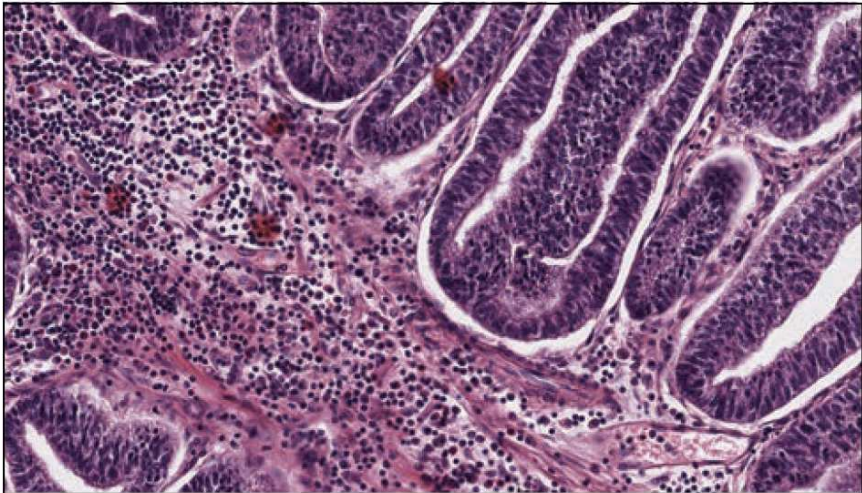


Immunooncology

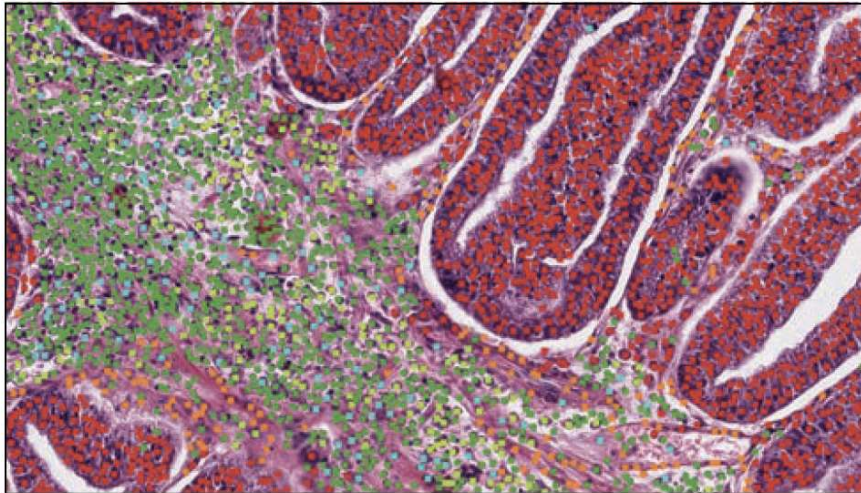


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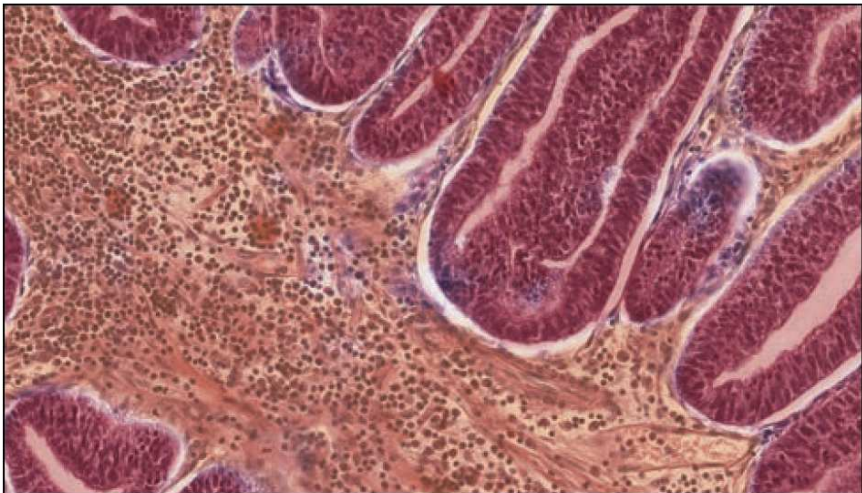
H&E Image



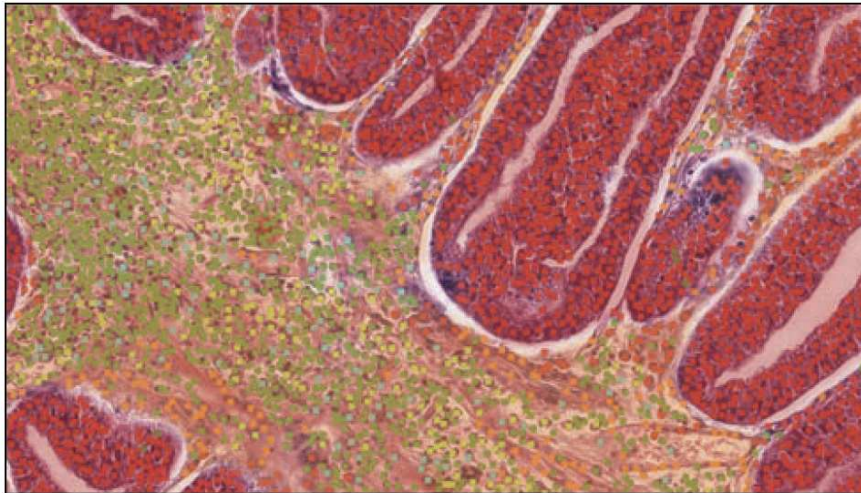
Cell-Type Predictions



Tissue-Type Predictions

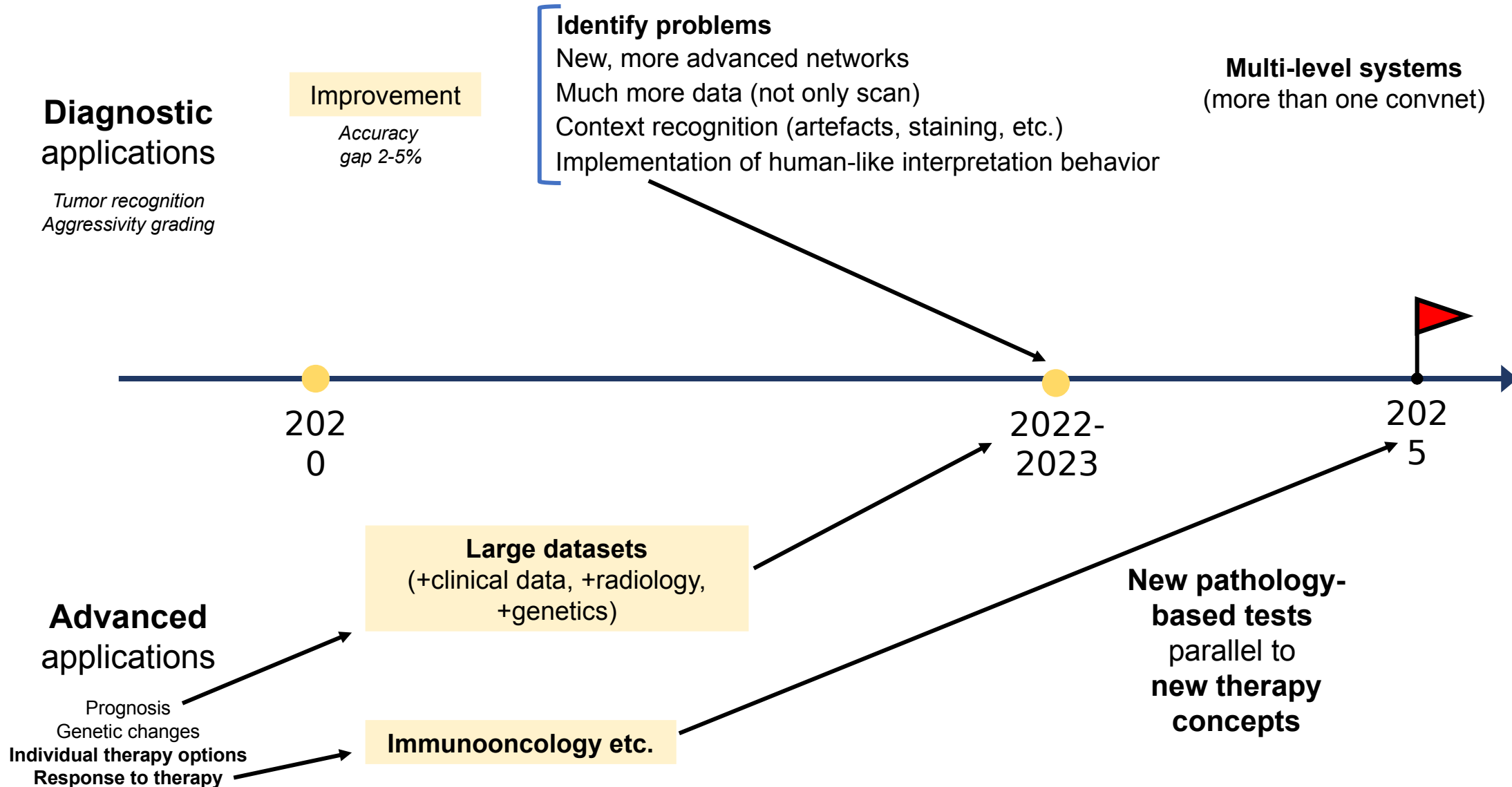


Combined Predictions



Tissue: ● Cancer-Associated Stroma ● Cancer Tissue ● Necrosis

Cells:  Macrophage  Plasma Cell  Lymphocyte  Cancer Cell  Fibroblast



Take home messages

- Digital transformation of pathology has just begun
- Impressive results from studies to diagnostical applications
 - *Commercialized field to 2025*
- New therapeutic agents (immunooncology) developed parallel to companion digital pathology tests
- High-quality data is everything
 - *Pathological archives*
- Big opportunities for research
- Cooperation of medical and technical specialists needed