



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

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KÖLN**

University Hospital Cologne

Institute of Pathology

What do we do:

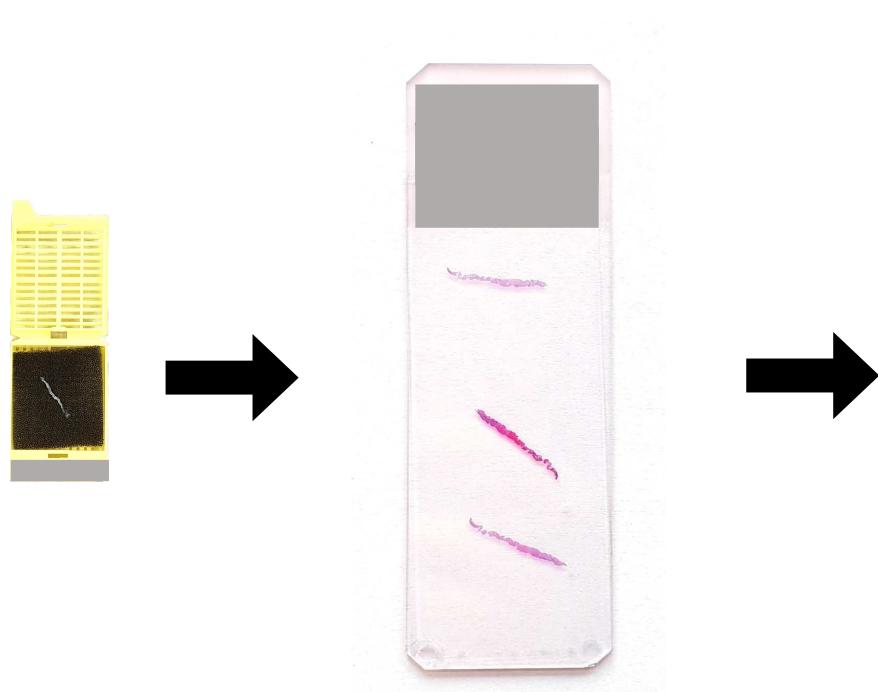
- Diagnostics
- Molecular pathology
- Oncology / Precision medicine
- Research

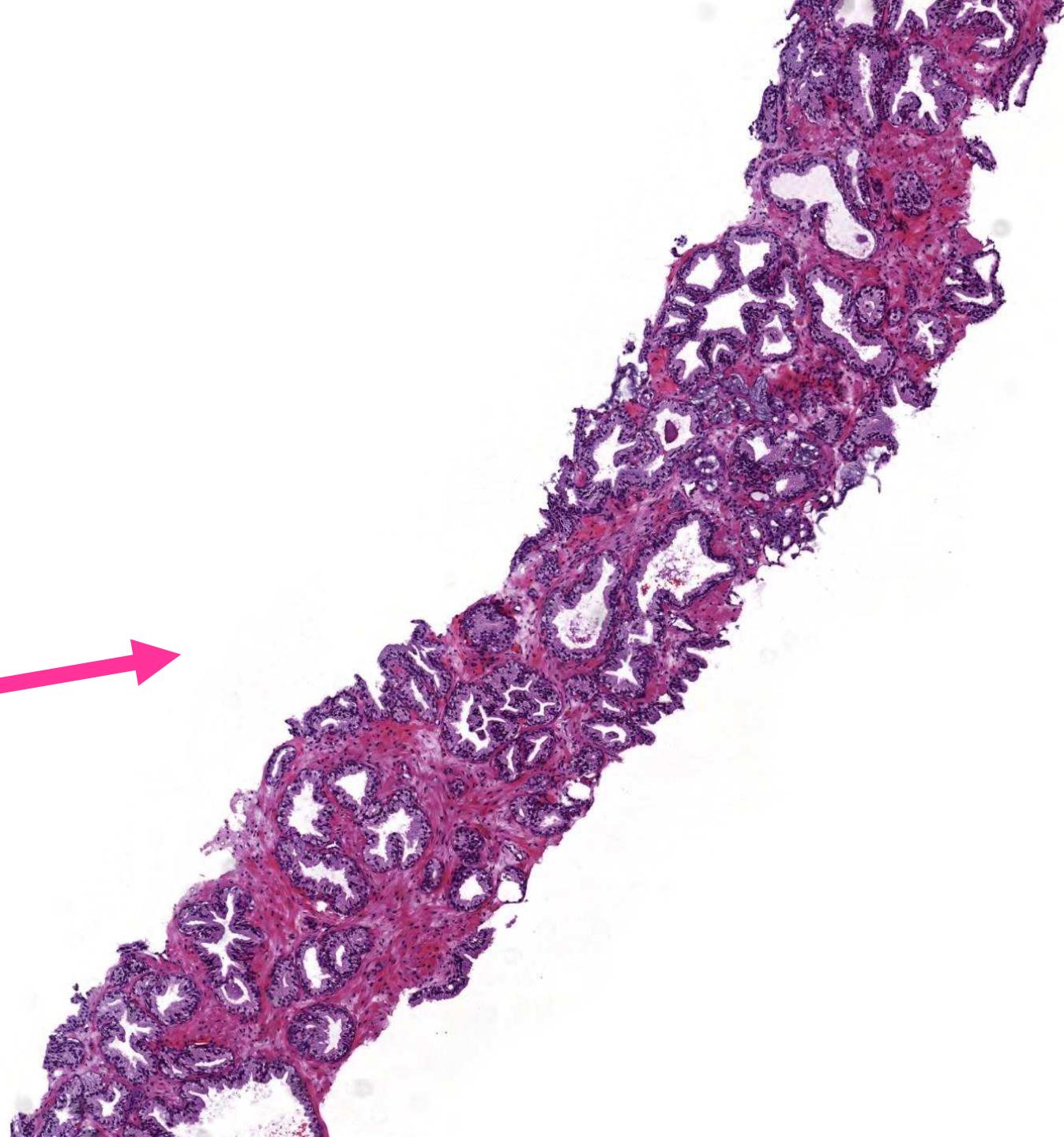
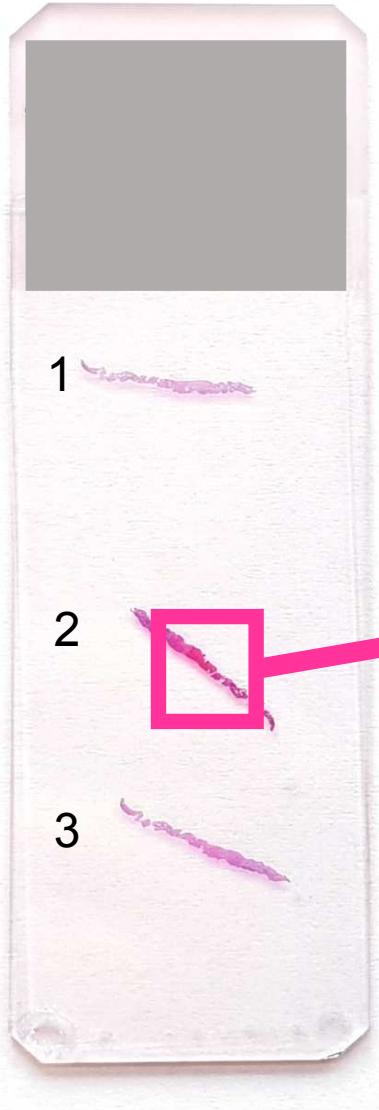
diagnostic pathology

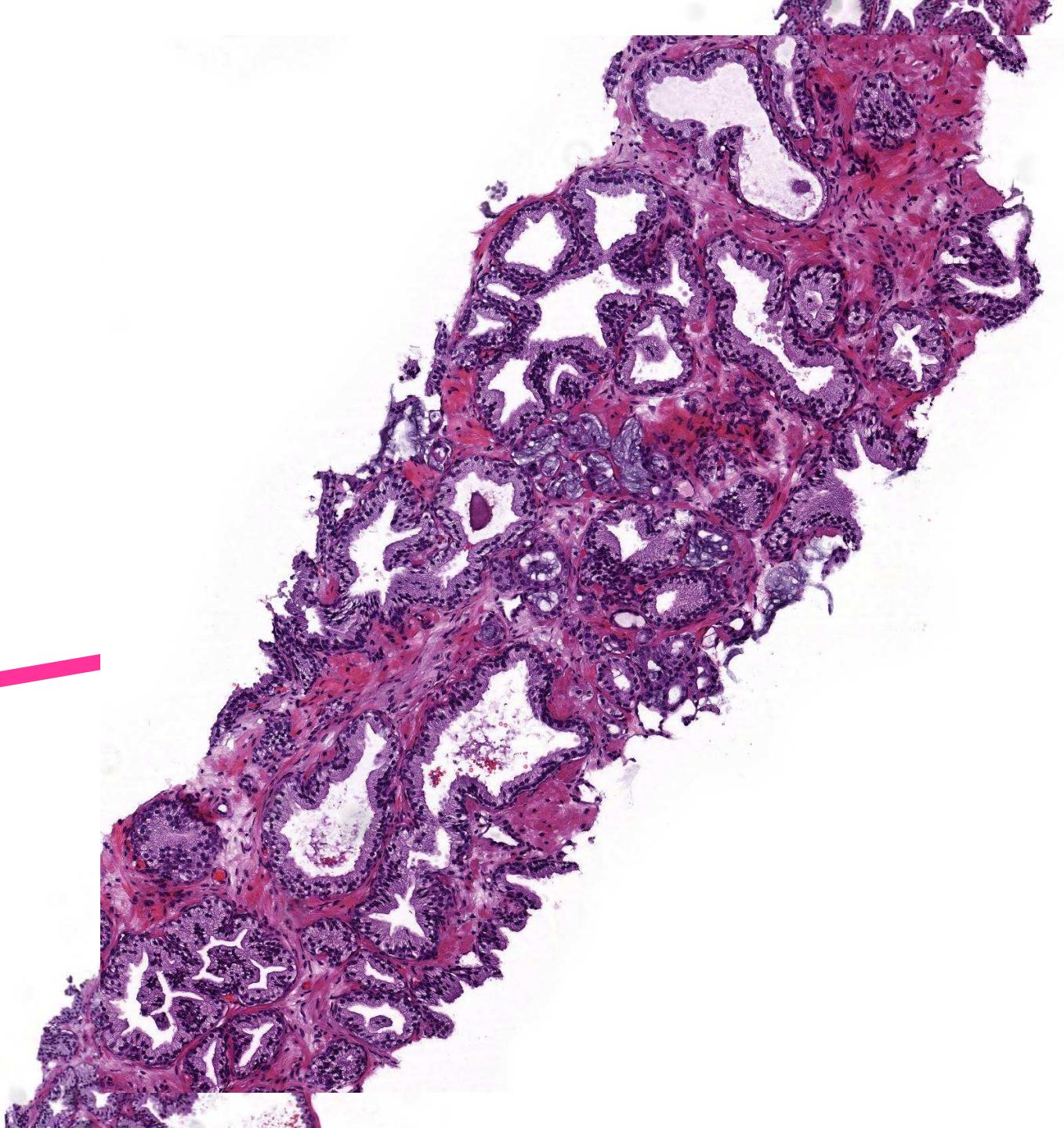
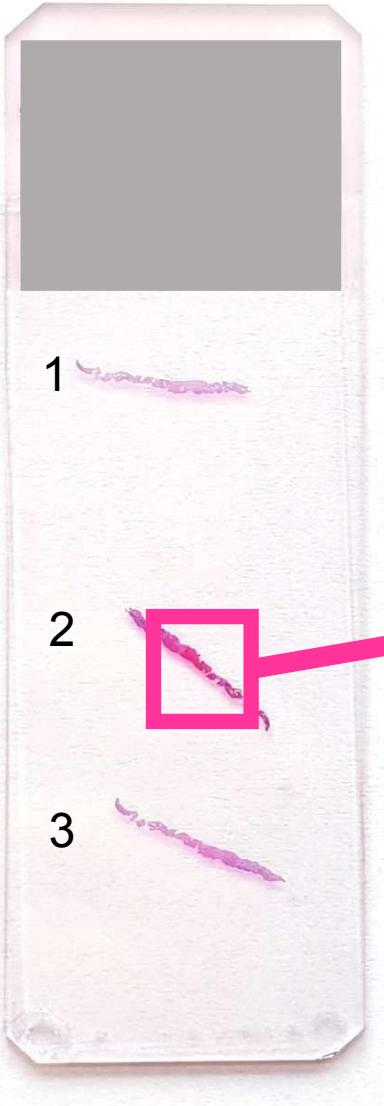


Microscopy

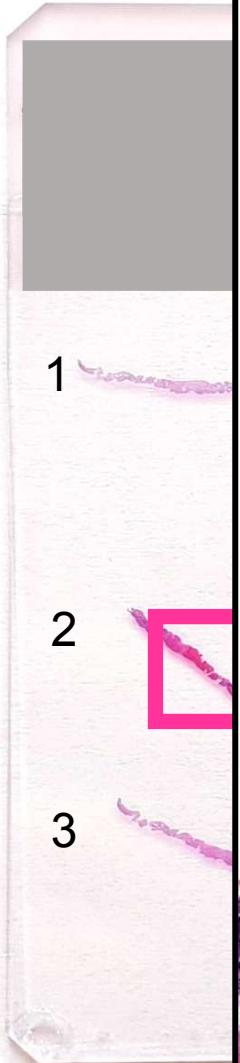
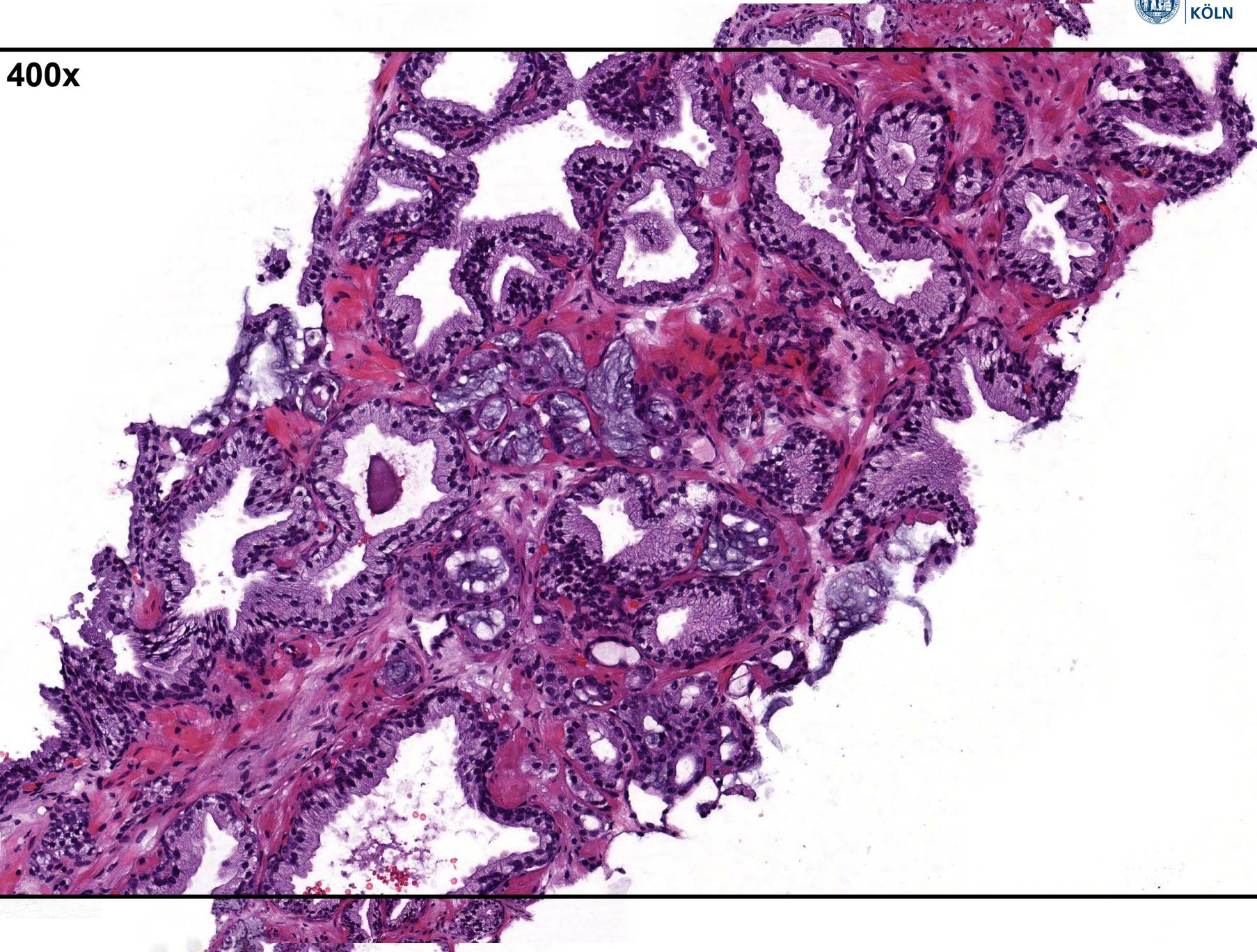
diagnostic pathology

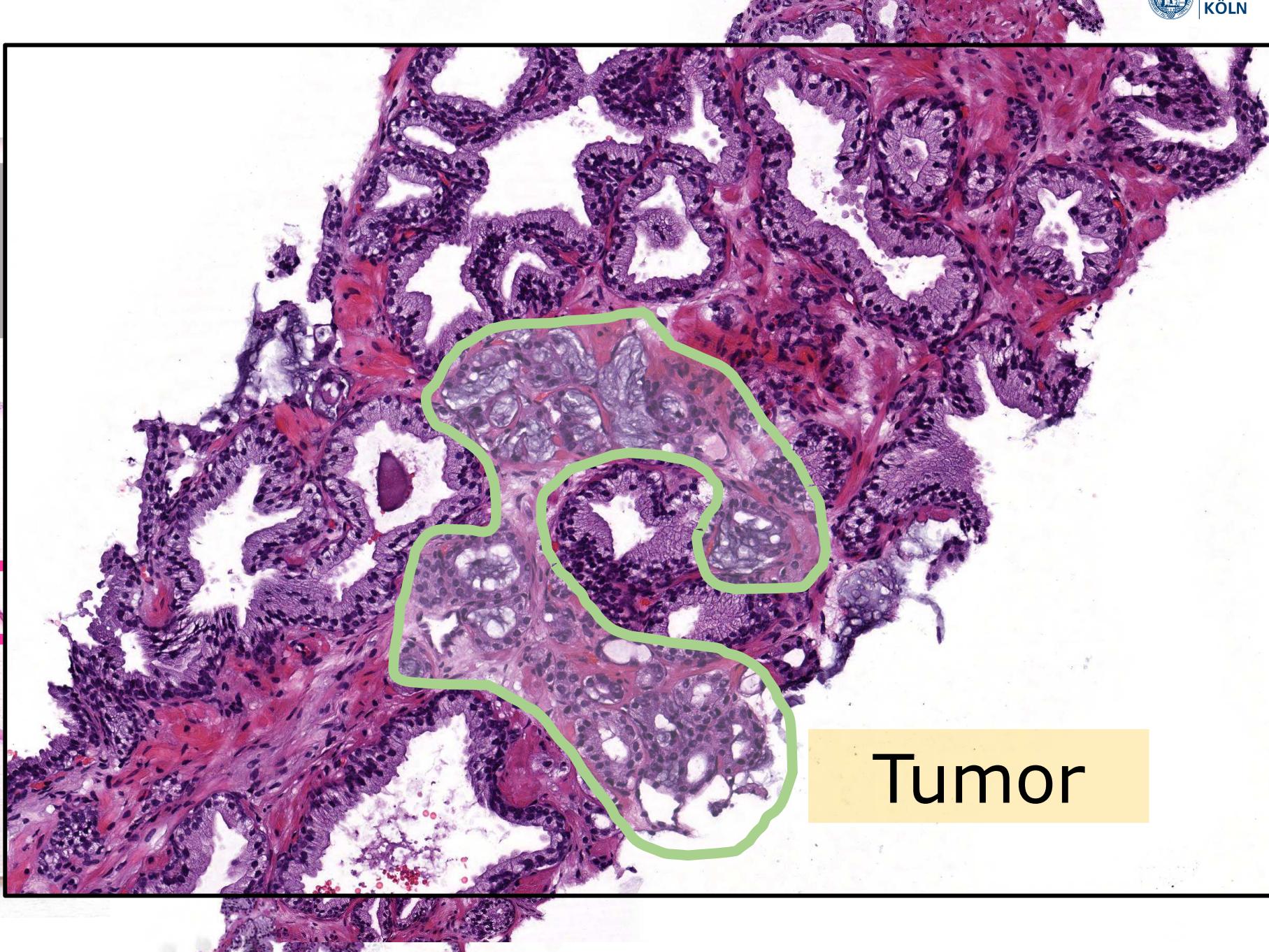






400x

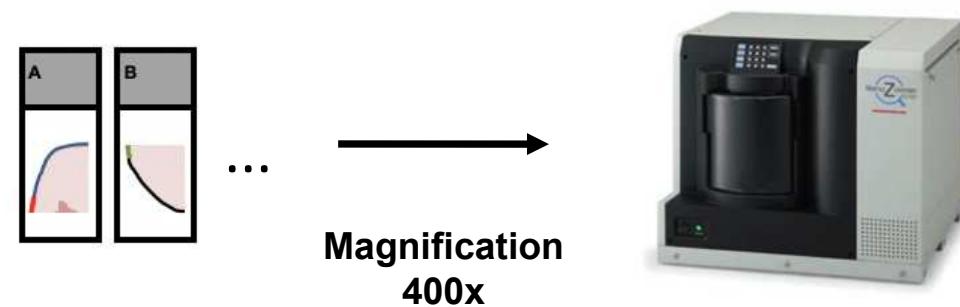


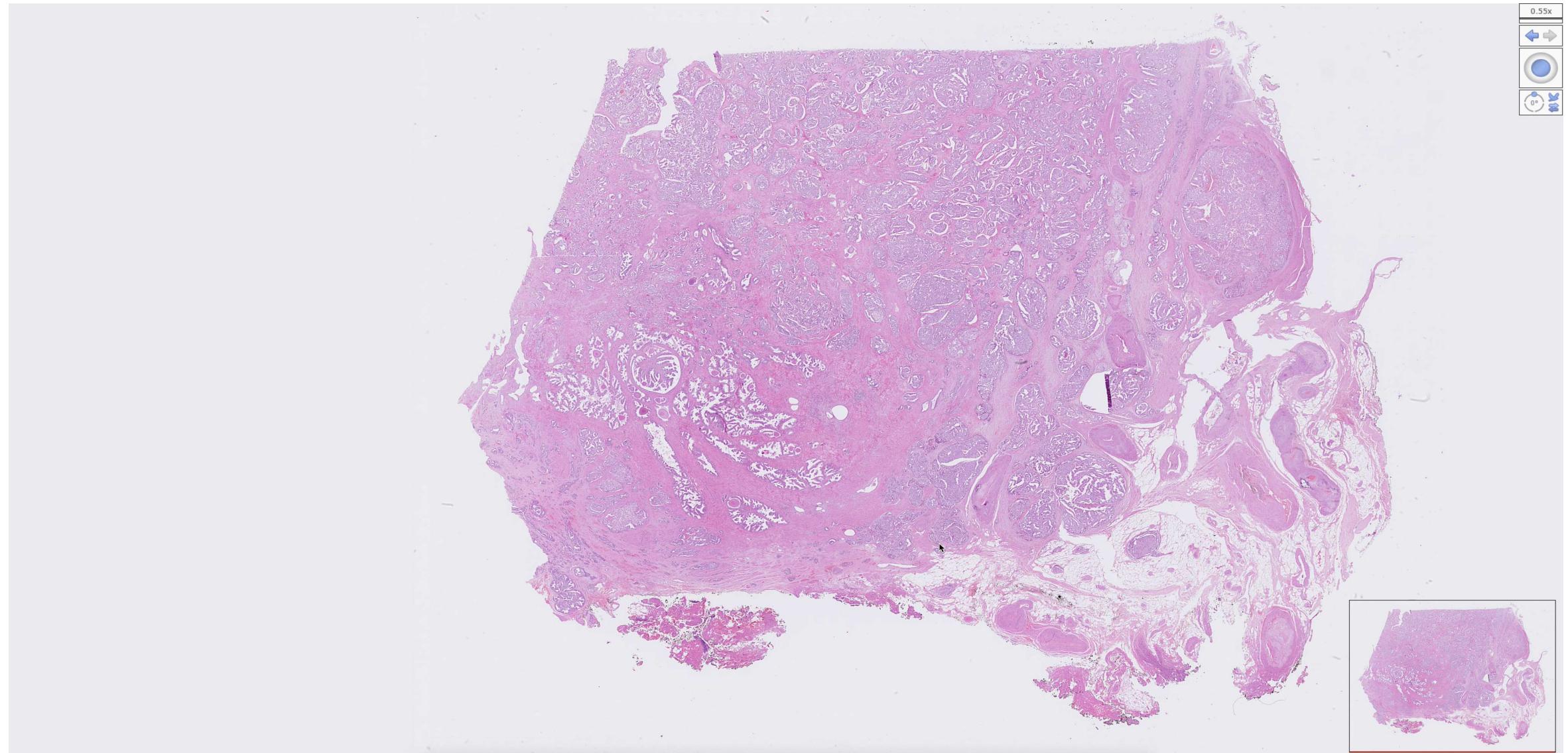


Digital pathology

Digital pathology

Digital pathology



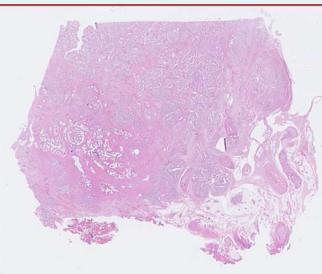
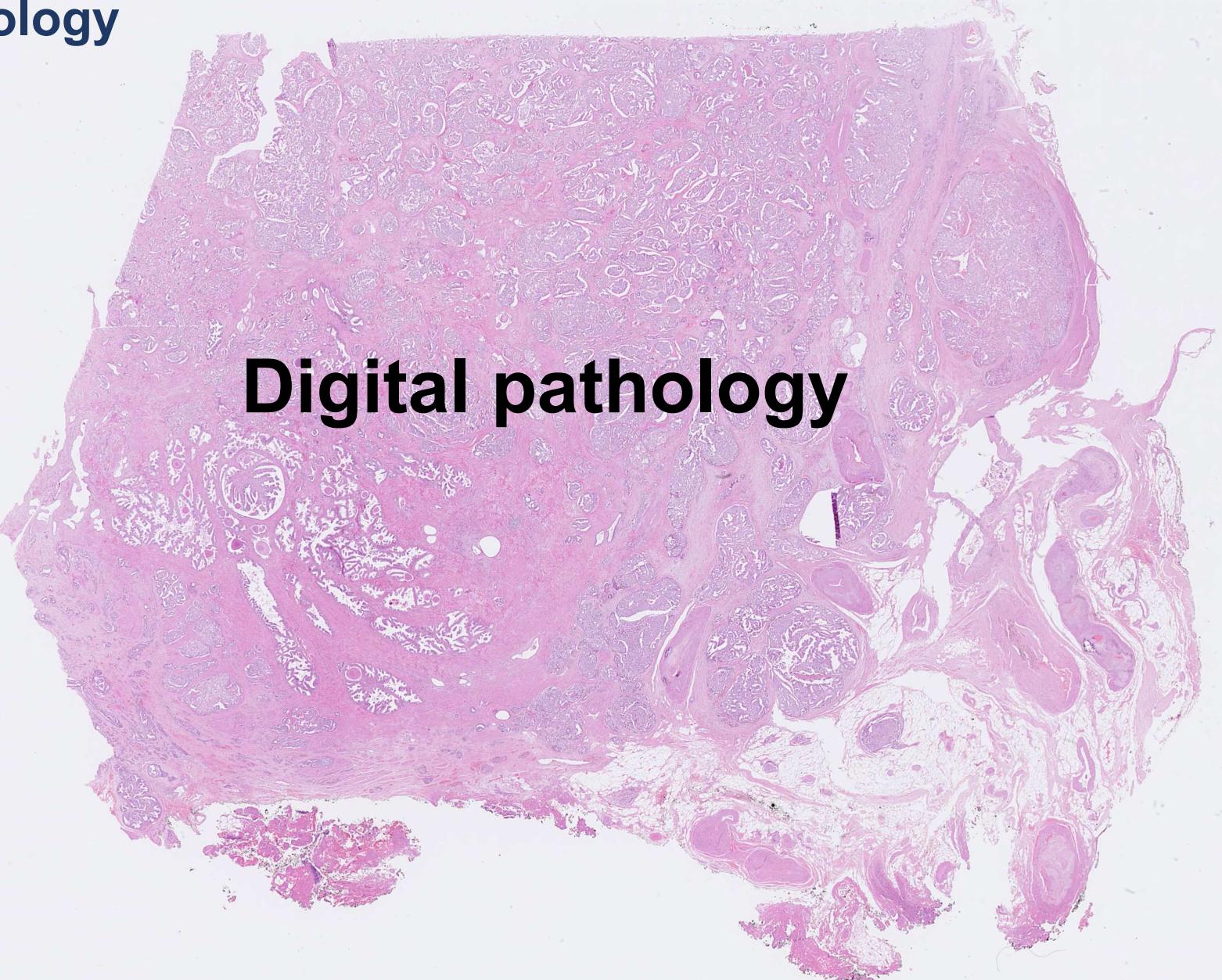


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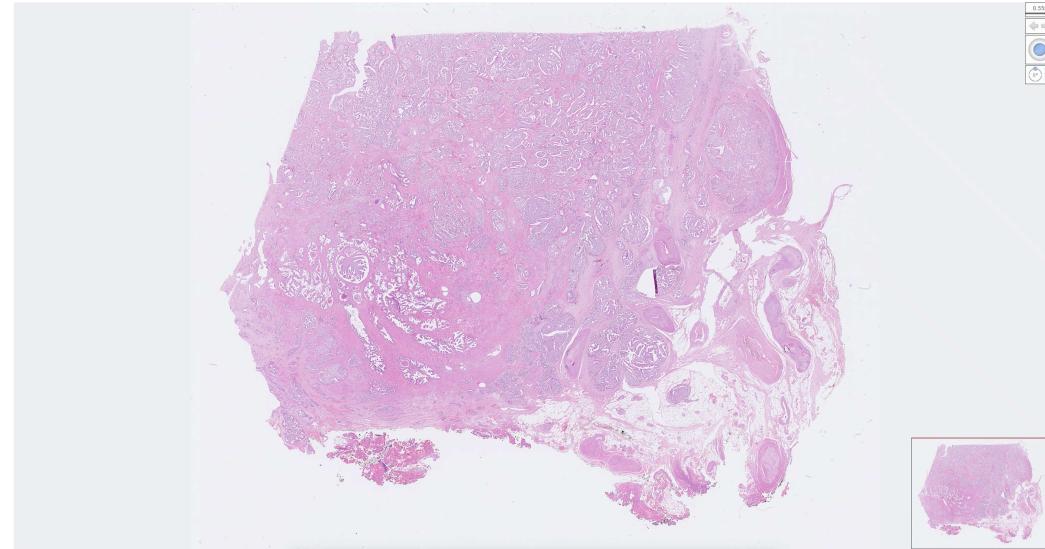




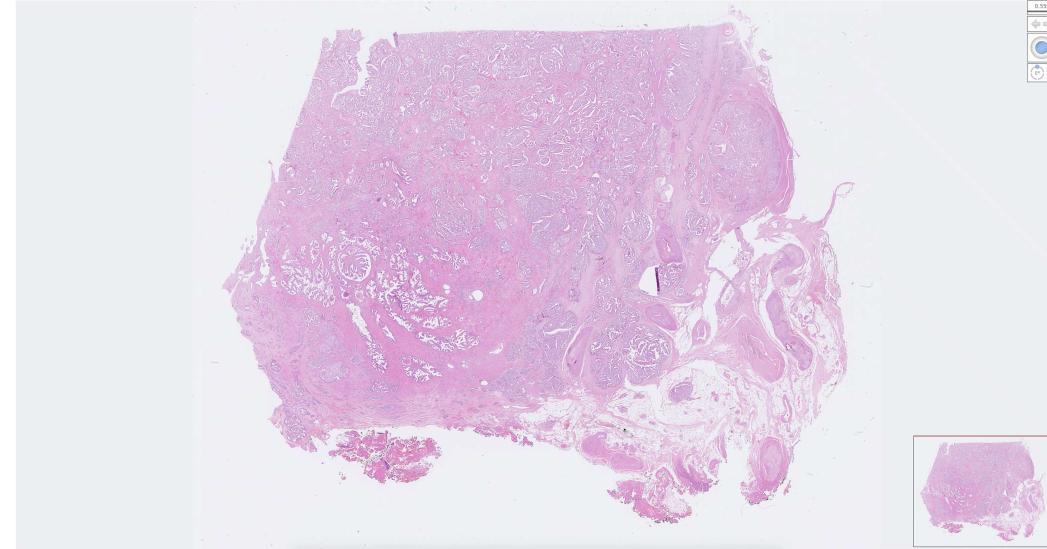
Digital pathology



Digital pathology



Digital pathology

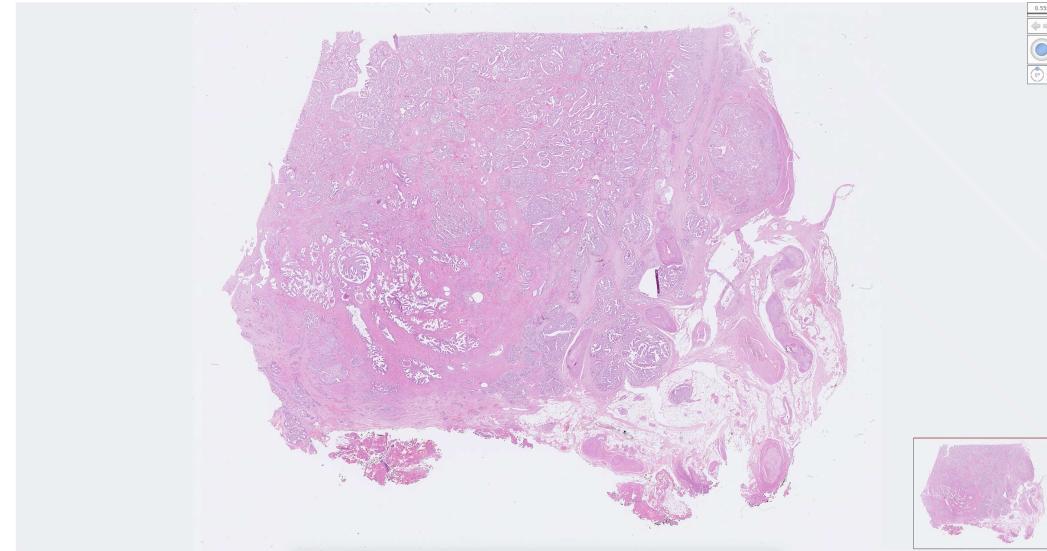


Timing

Dimensions

Sense

Digital pathology



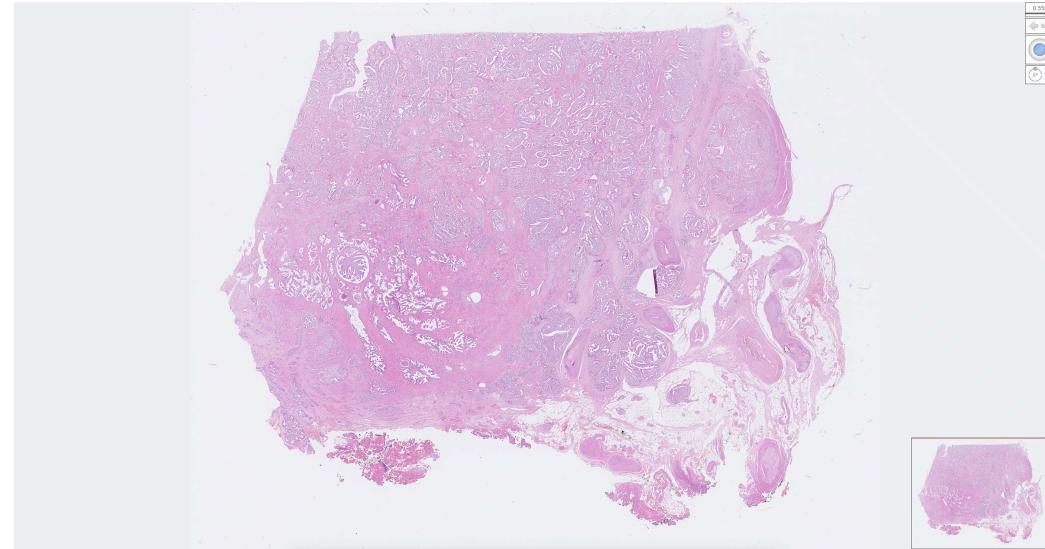
Timing

Transformation
next 5-10 years

Dimensions

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Timing

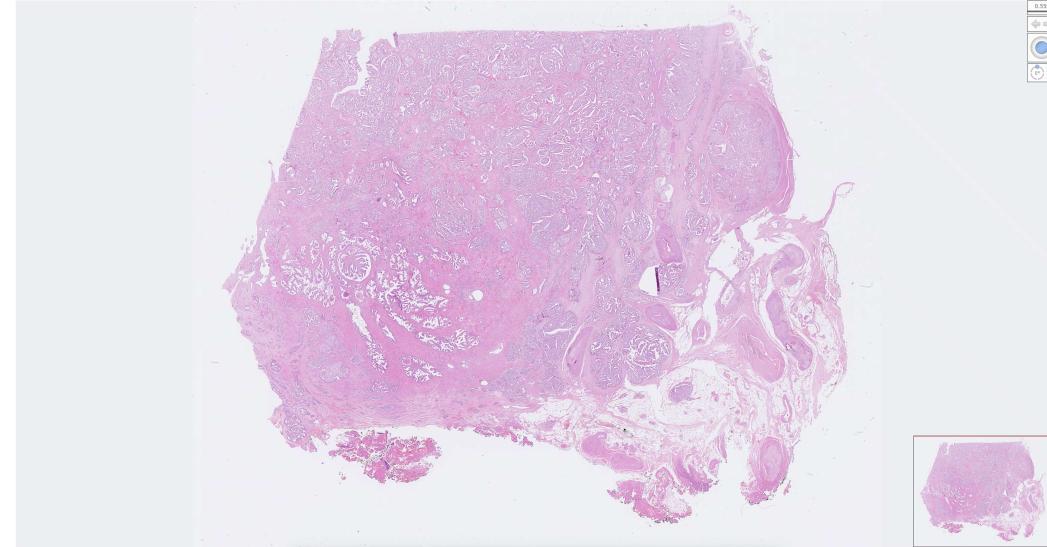
Transformation
next 5-10 years

Dimensions

1 Slide = 1-4 Gb

Sense

Digital pathology



Timing

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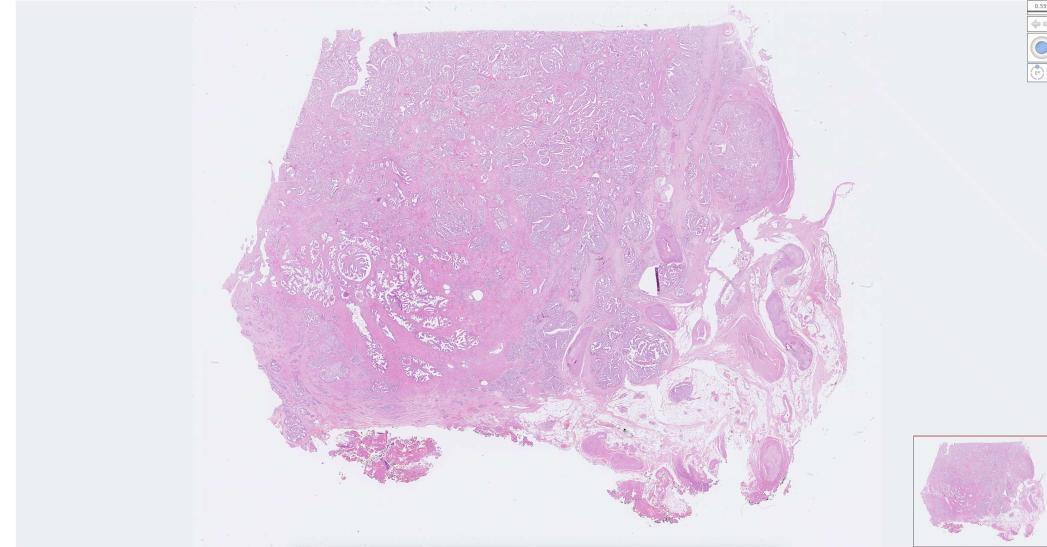
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UK Cologne:
>1000 Slides / day

up to 1 Tb / day

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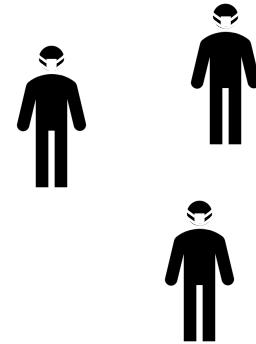
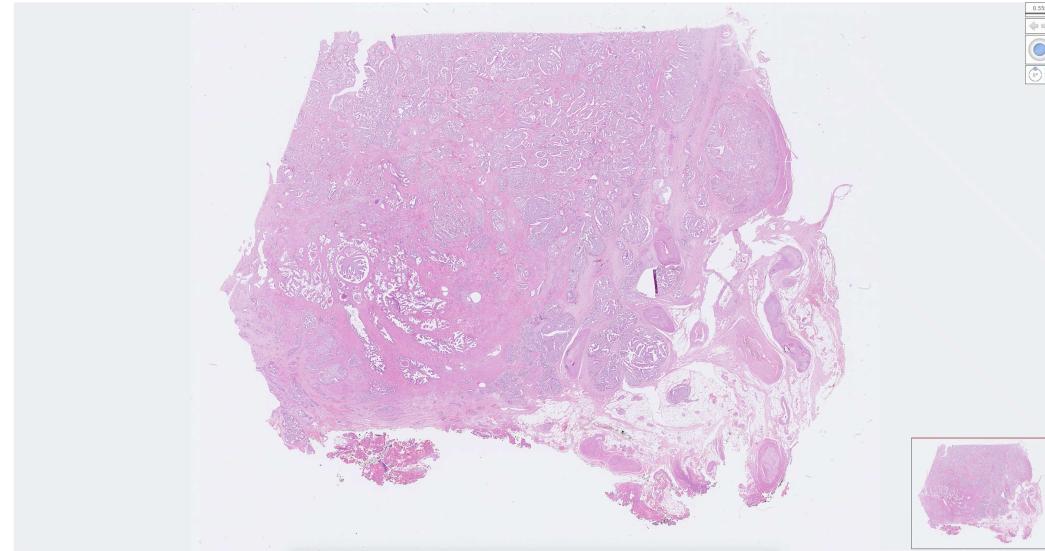
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Sense

Very Big Data

Digital pathology



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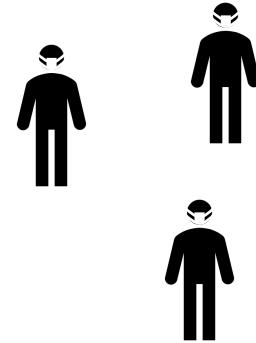
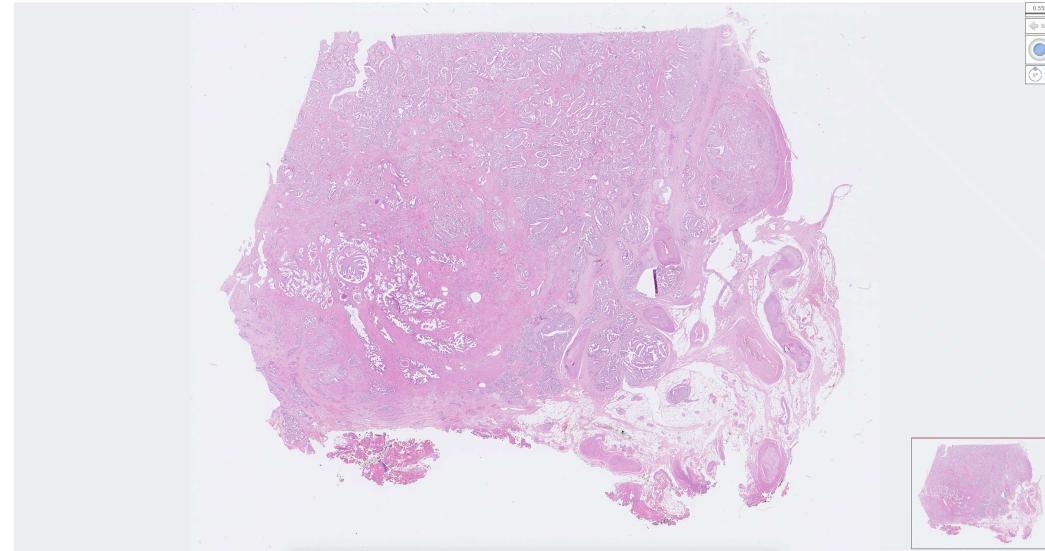
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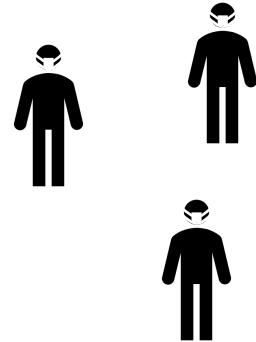
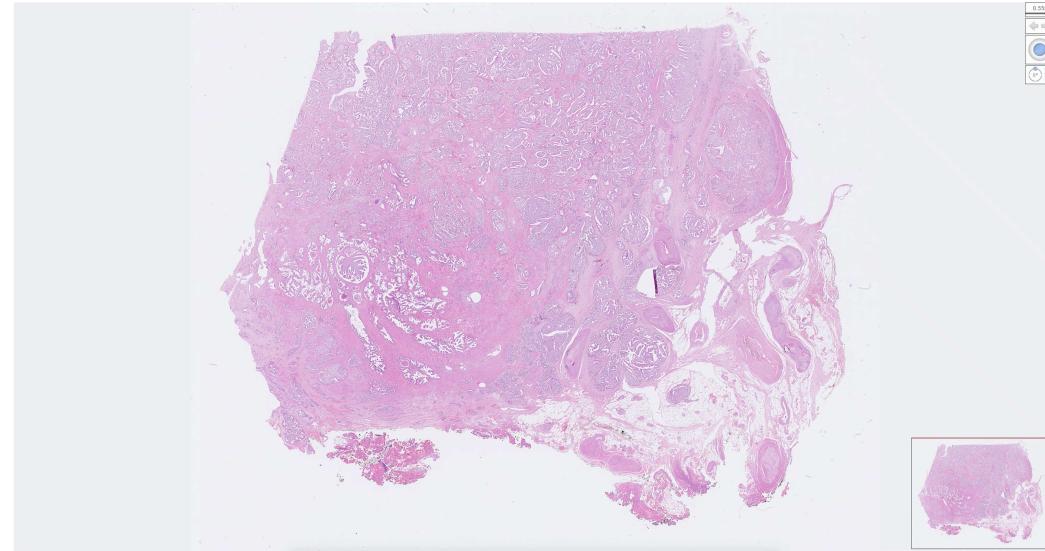
Sense

Diagnostic

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

Very Big Data

Digital pathology



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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

202
0

202
5

Data

- Lack of ground truth



Bulk of evidence

Technology

Networks:

Classification

Segmentation

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AutoML



Data

202
0

- Lack of ground truth

Performance

- Perspective directions
- Market formation

Diagnostic applications

Tumor recognition
Aggressivity grading

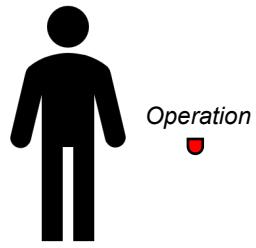


Advanced applications





**Prostate
cancer**

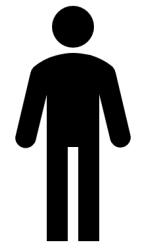


**Prostate
cancer**



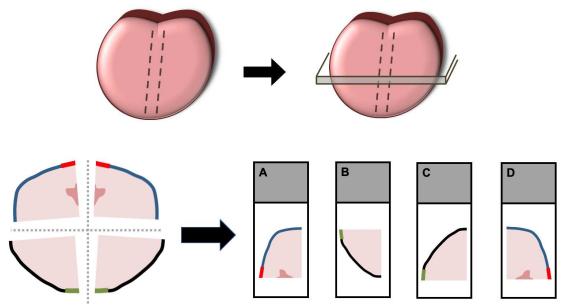
Pathology
department

Prostate
cancer



Prostate
cancer

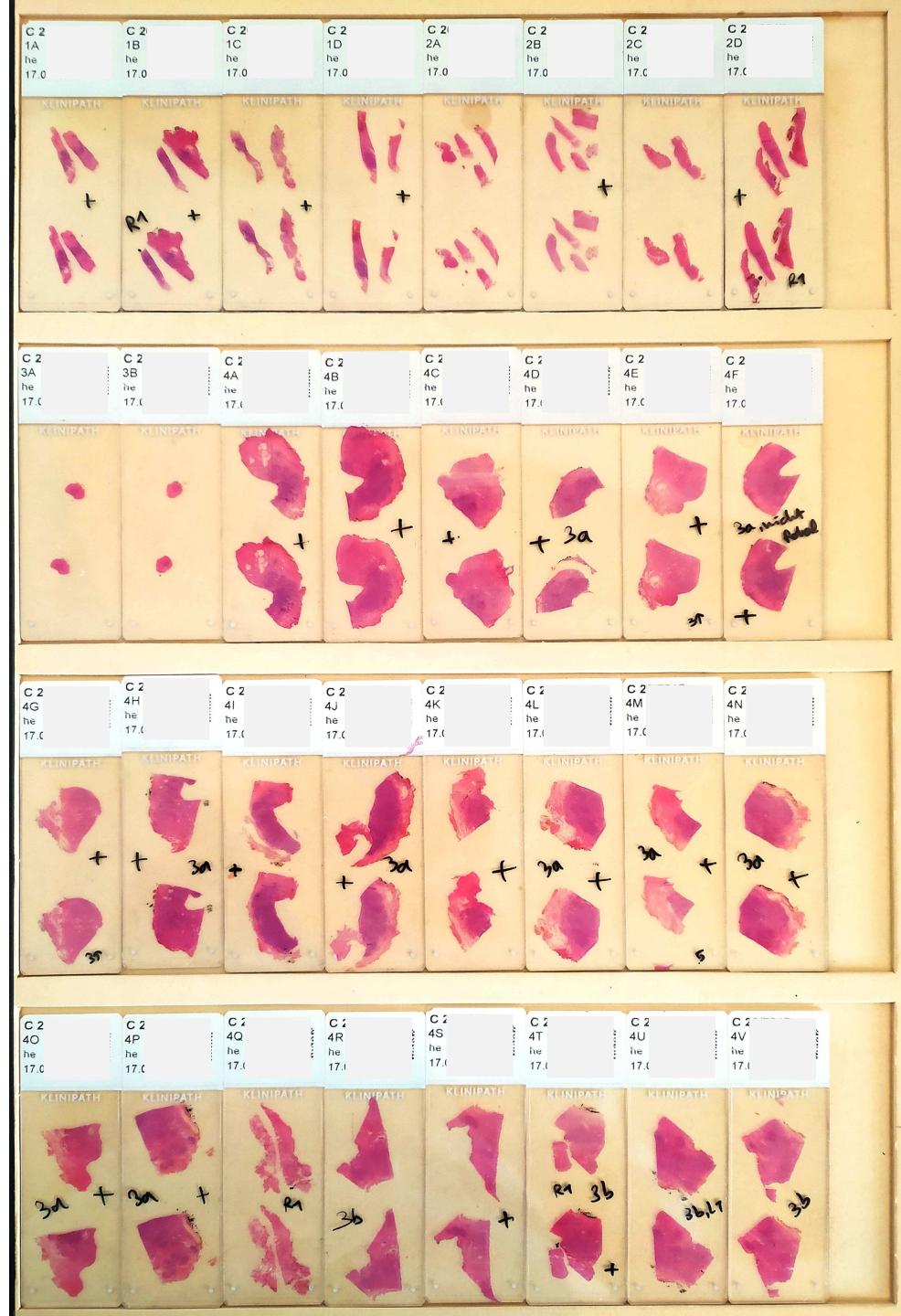
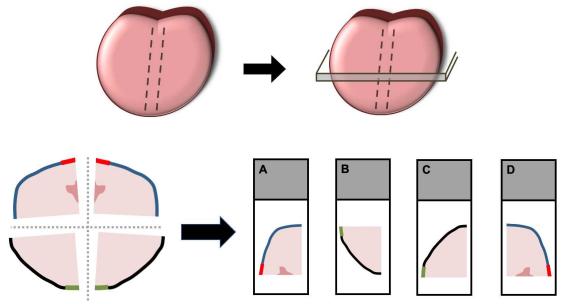
Pathology
department

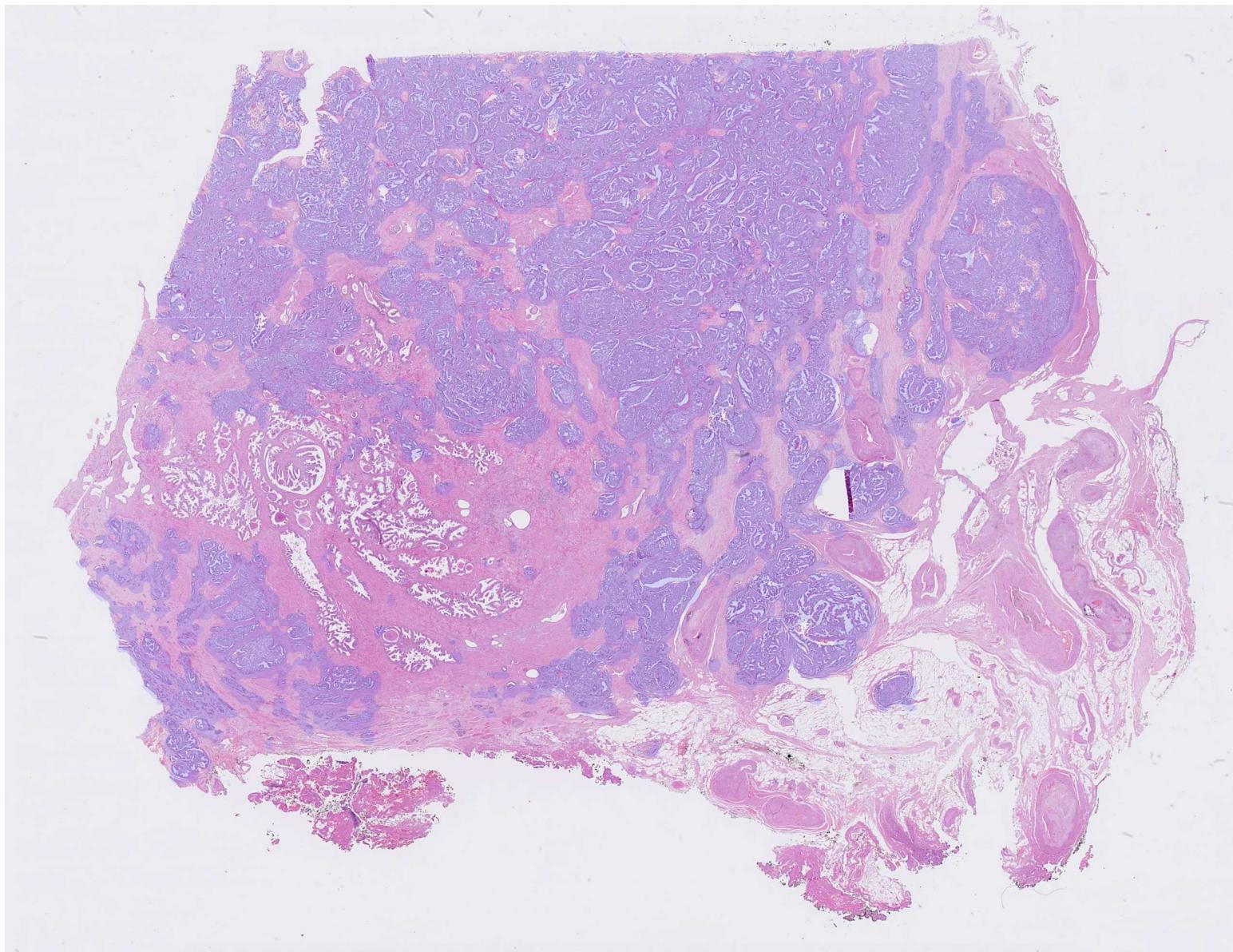




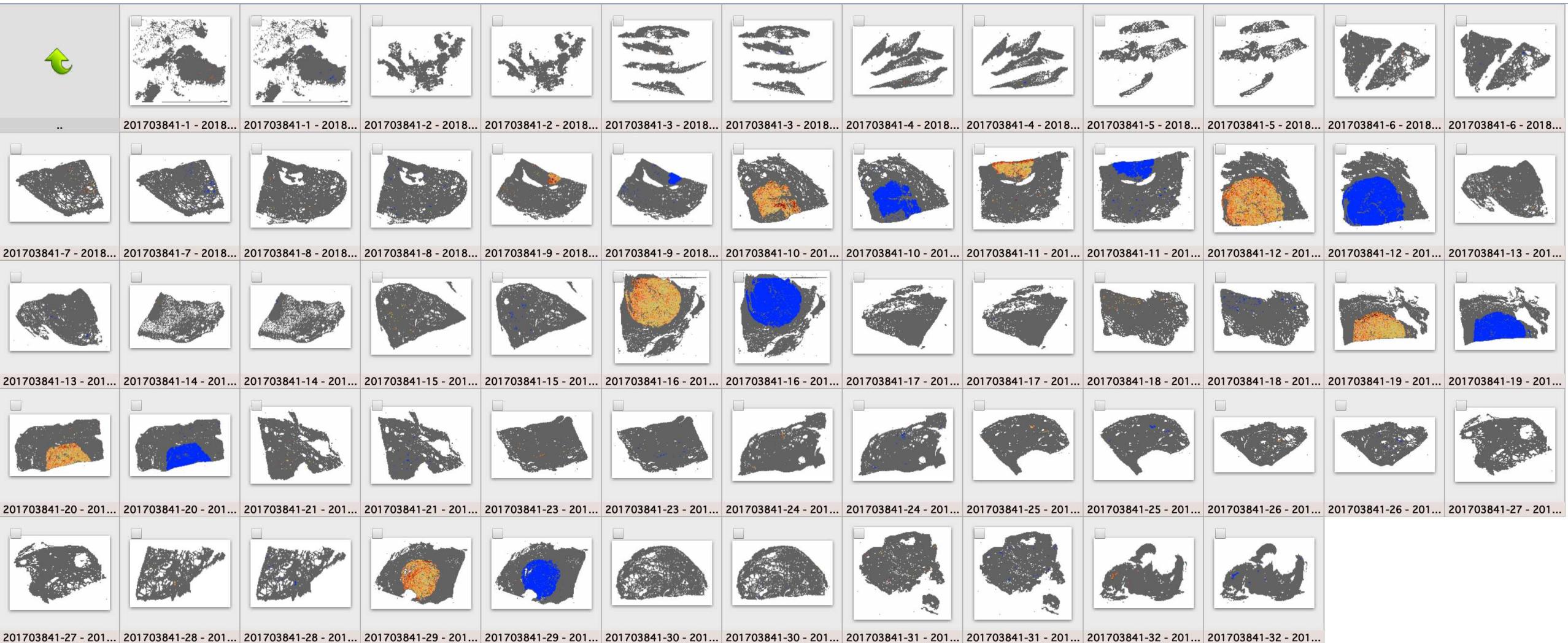
**Prostate
cancer**

**Pathology
department**





AI Tool



Pathology report

File Edit Tools View Objects TMA Measure Automate Analyze Classify Extensions Help



Project Image Annotations Hierarchy Workflow

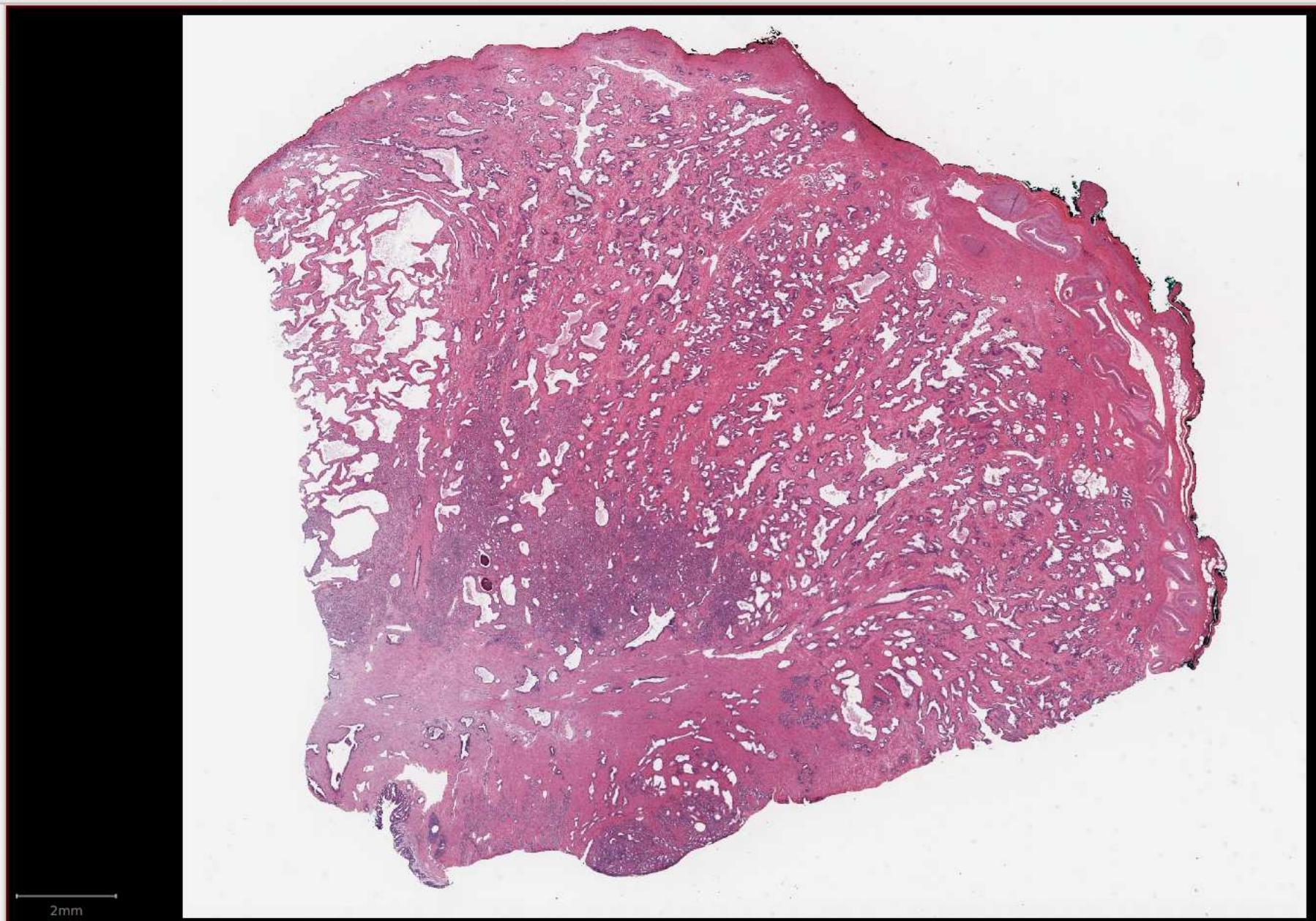
None

- 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

Delete Delete all Set class Auto set

Key Value

Name



22364.49, 12033.16 µm
242, 242, 242

File Edit Tools View Objects TMA Measure Automate Analyze Classify Extensions Help



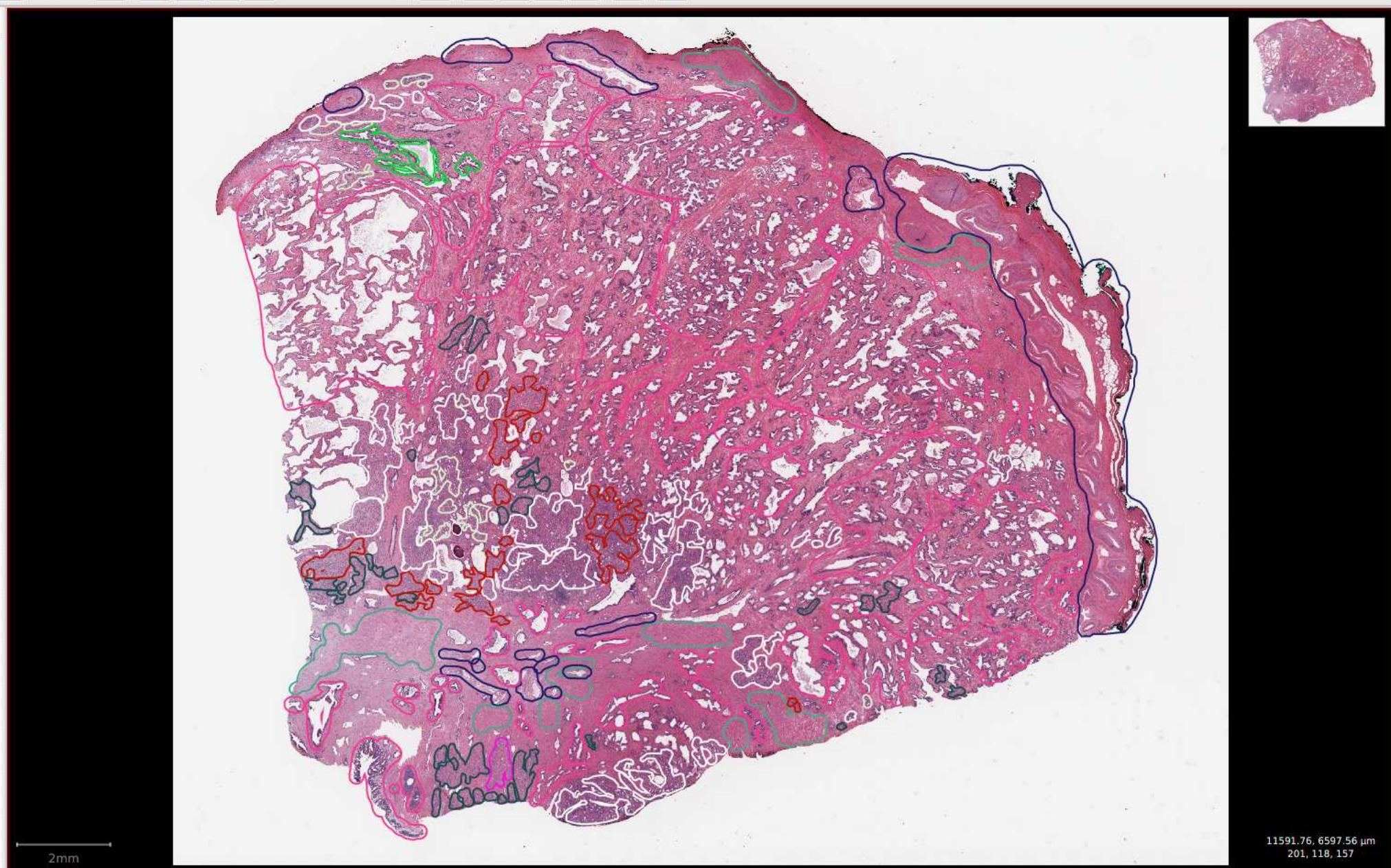
Project Image Annotations Hierarchy Workflow

- Area (3+4)
- Area (GP4)
- Area (4+3)
- Area (3+4)
- Area (GP4)
- Polygon (GP4)
- Polygon (GP4)
- Polygon (GP4)
- Area (GP4)
- Area (4+5)
- Polygon (GP4)

Delete Delete all Set class Auto set

Key	Value
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Name



File Edit Tools View Objects TMA Measure Automate Analyze Classify Extensions Help



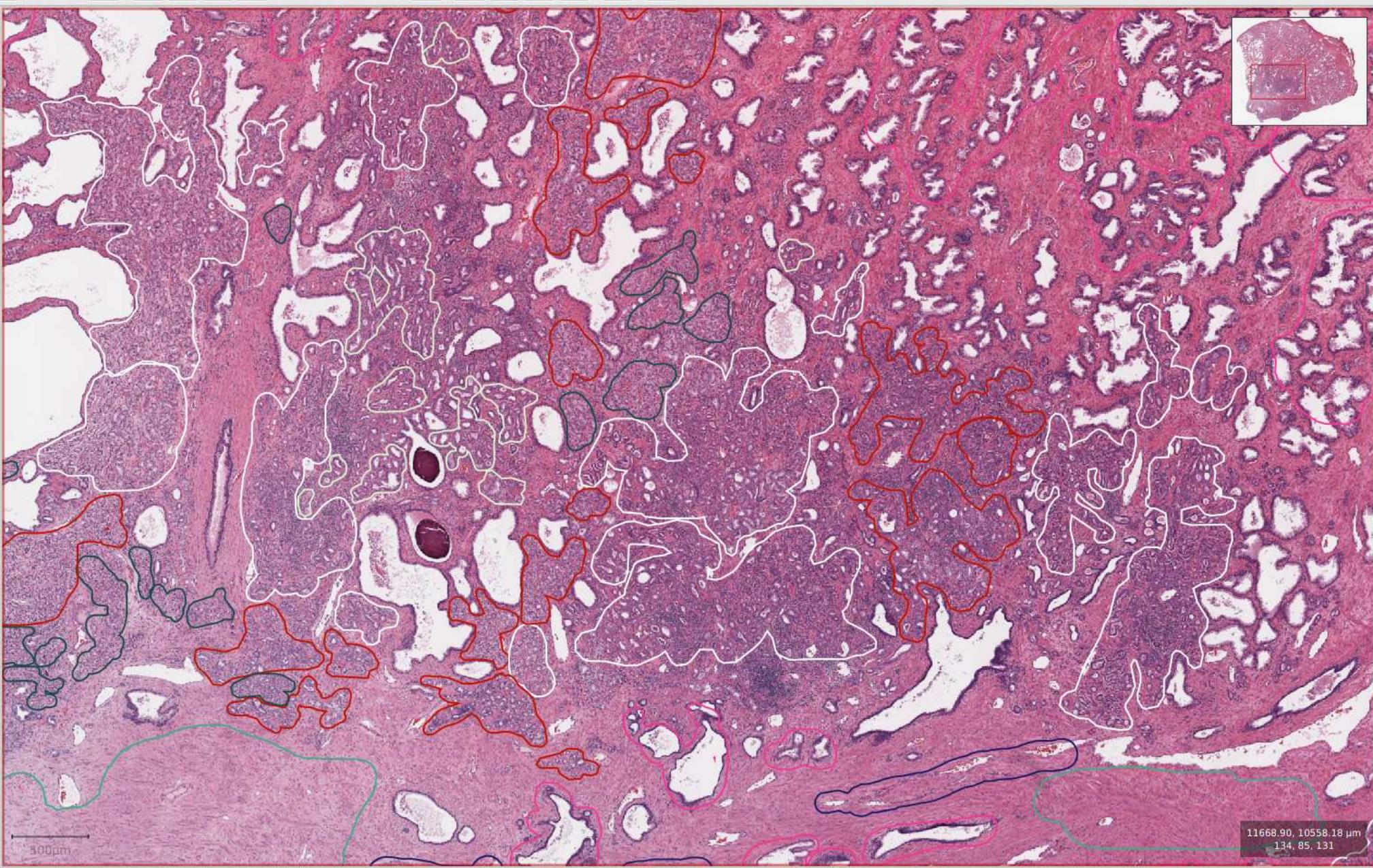
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- Polygon (GP4)
- Area (GP4)
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Delete Delete all Set class Auto set

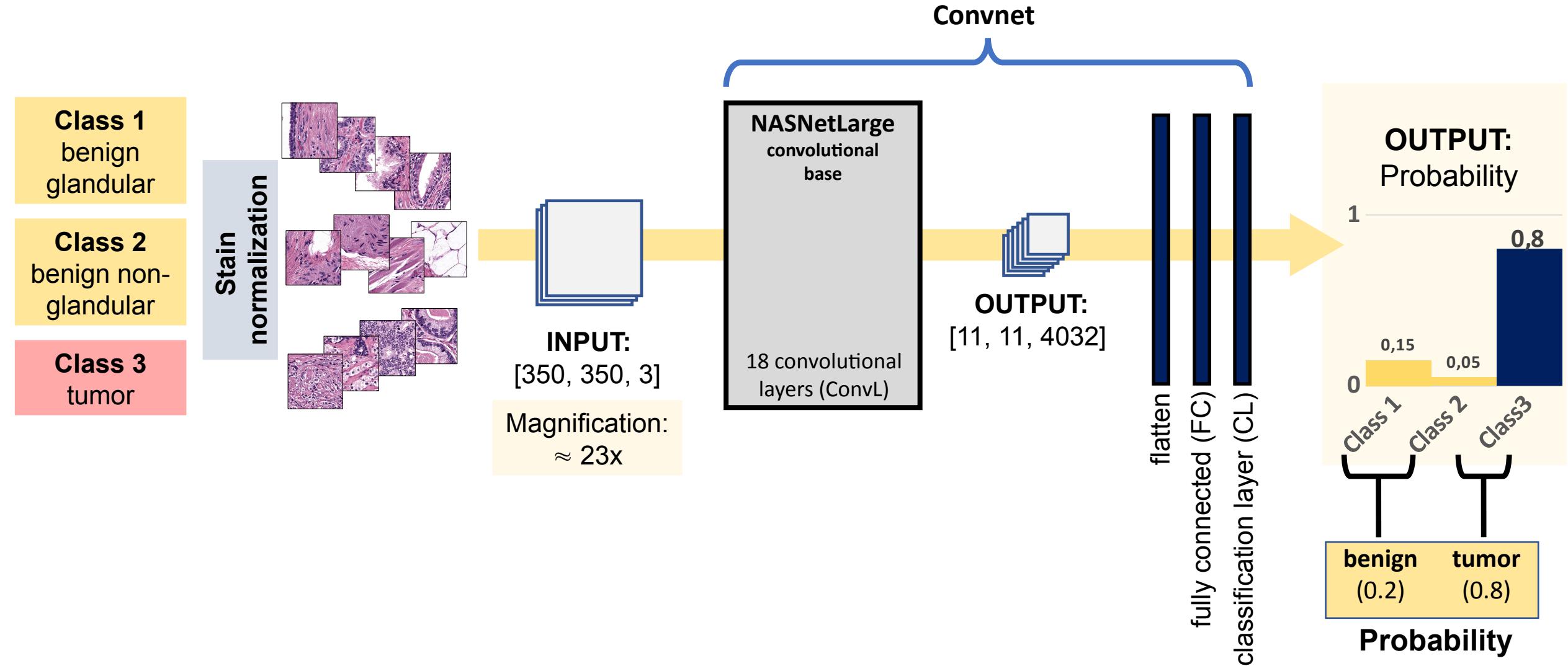
Key Value

Name



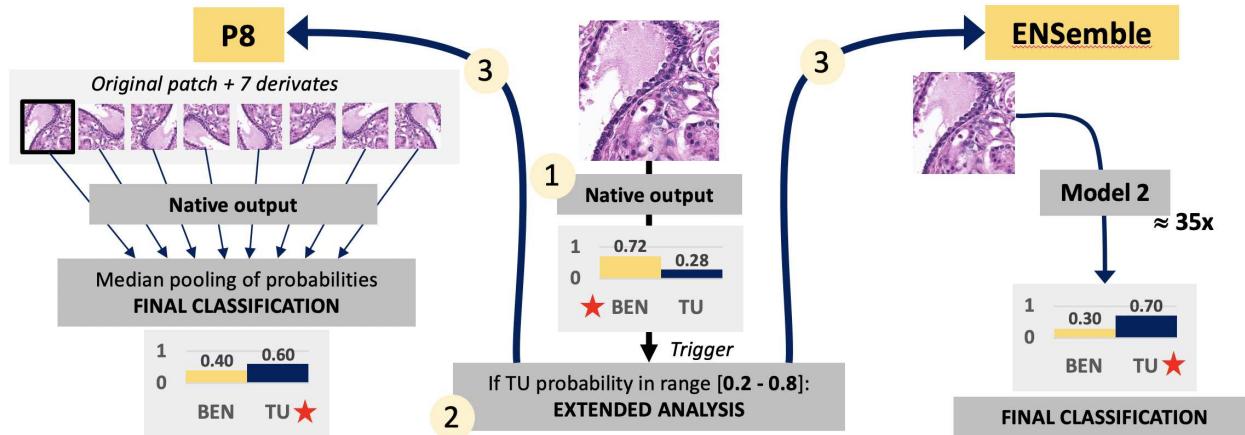
Convolutional neural network

Architecture

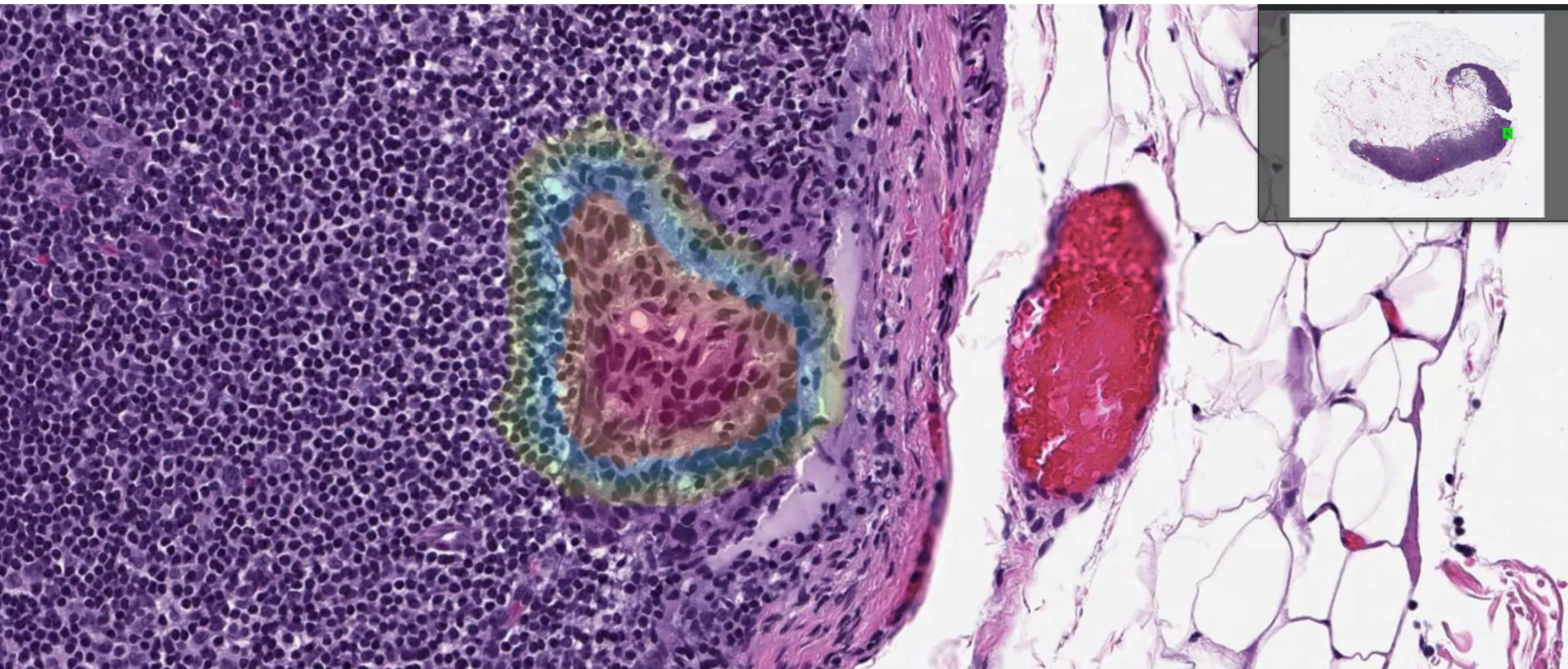


Accuracy

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 p. VAL 1	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*

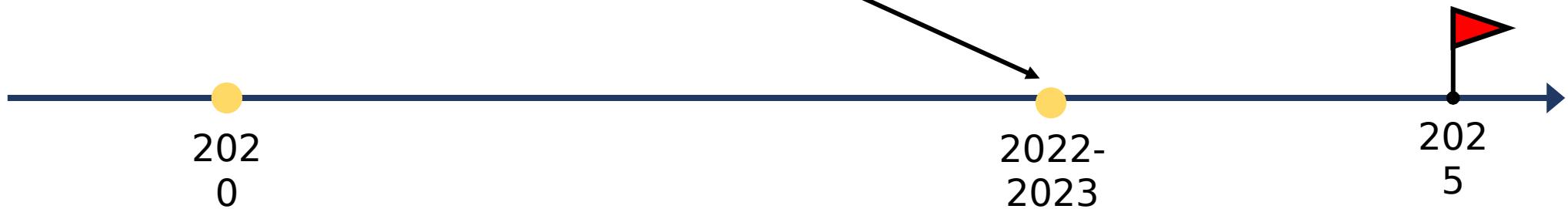
Improvement

Accuracy gap 2-5%

Identify problems

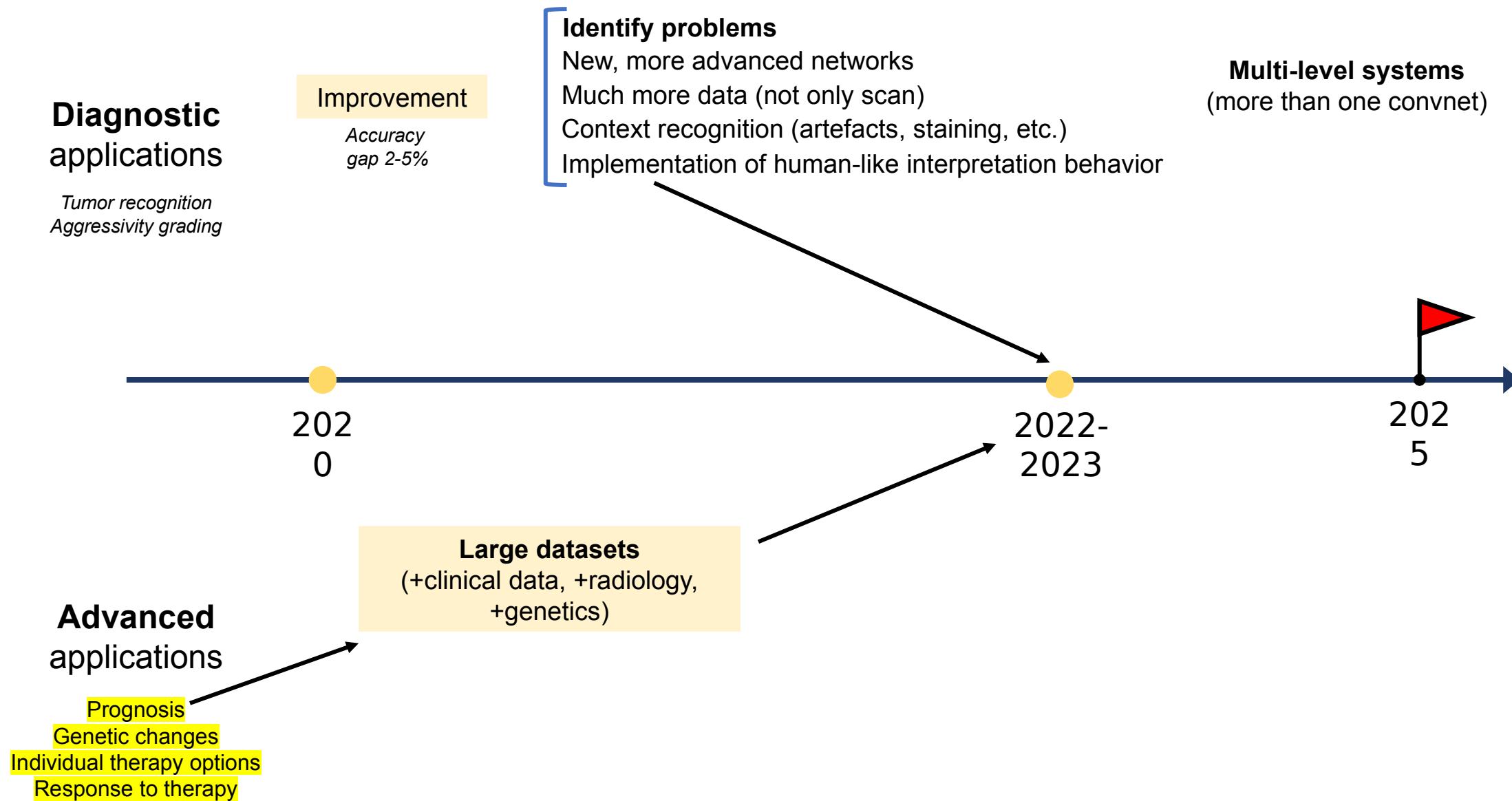
- New, more advanced networks
- Much more data (not only scan)
- Context recognition (artefacts, staining, etc.)
- Implementation of human-like interpretation behavior

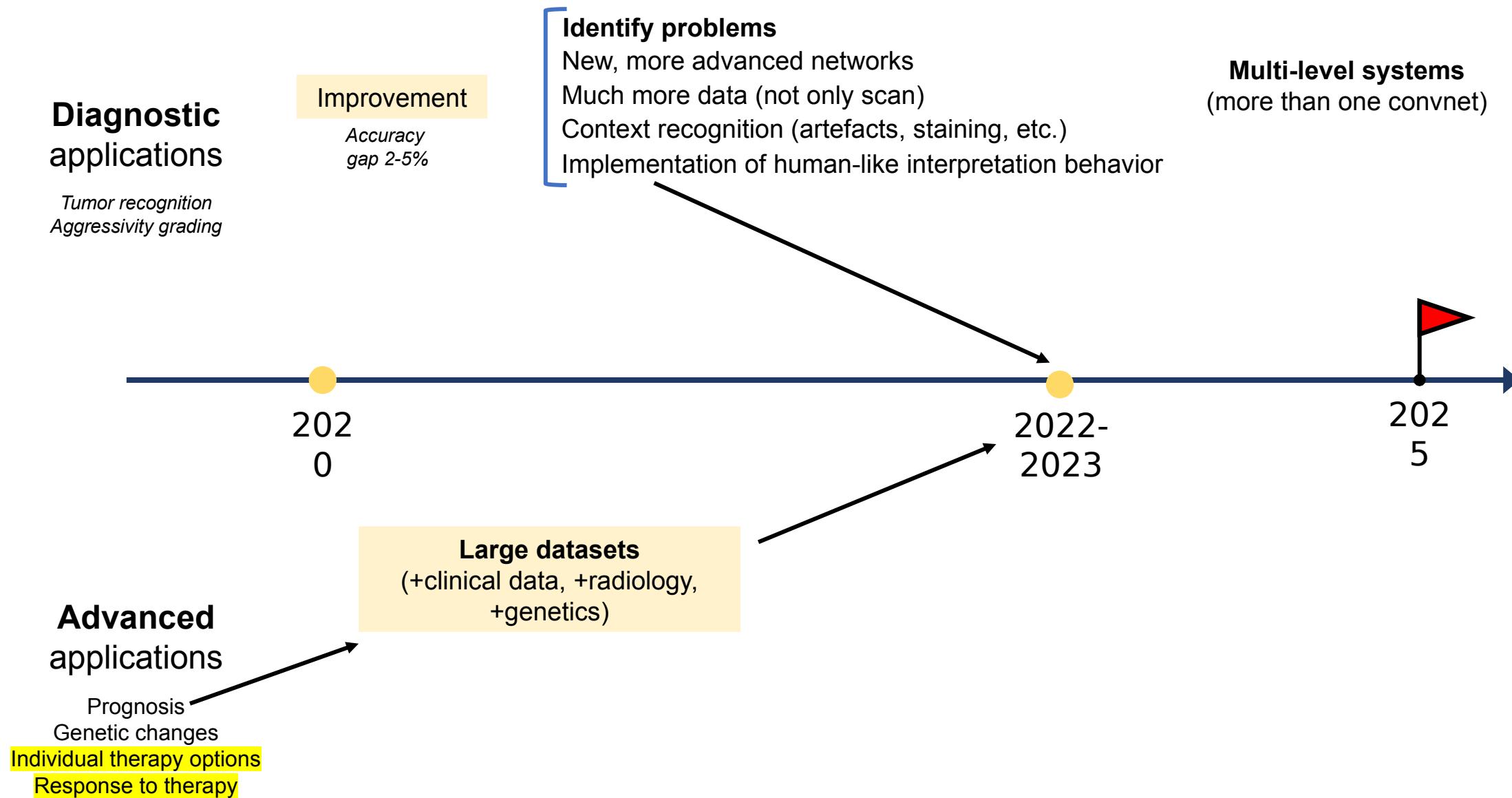
Multi-level systems (more than one convnet)



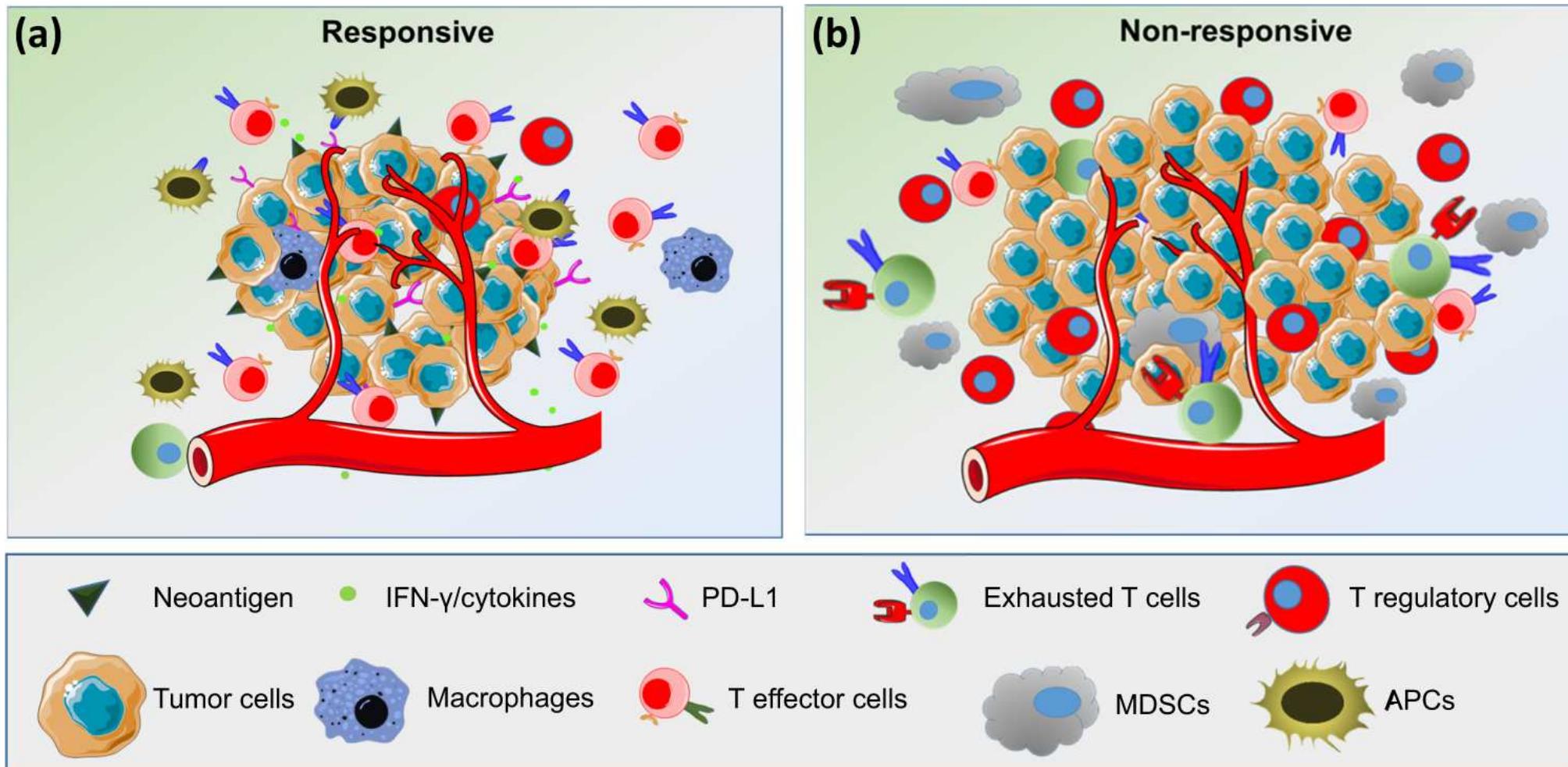
Advanced applications

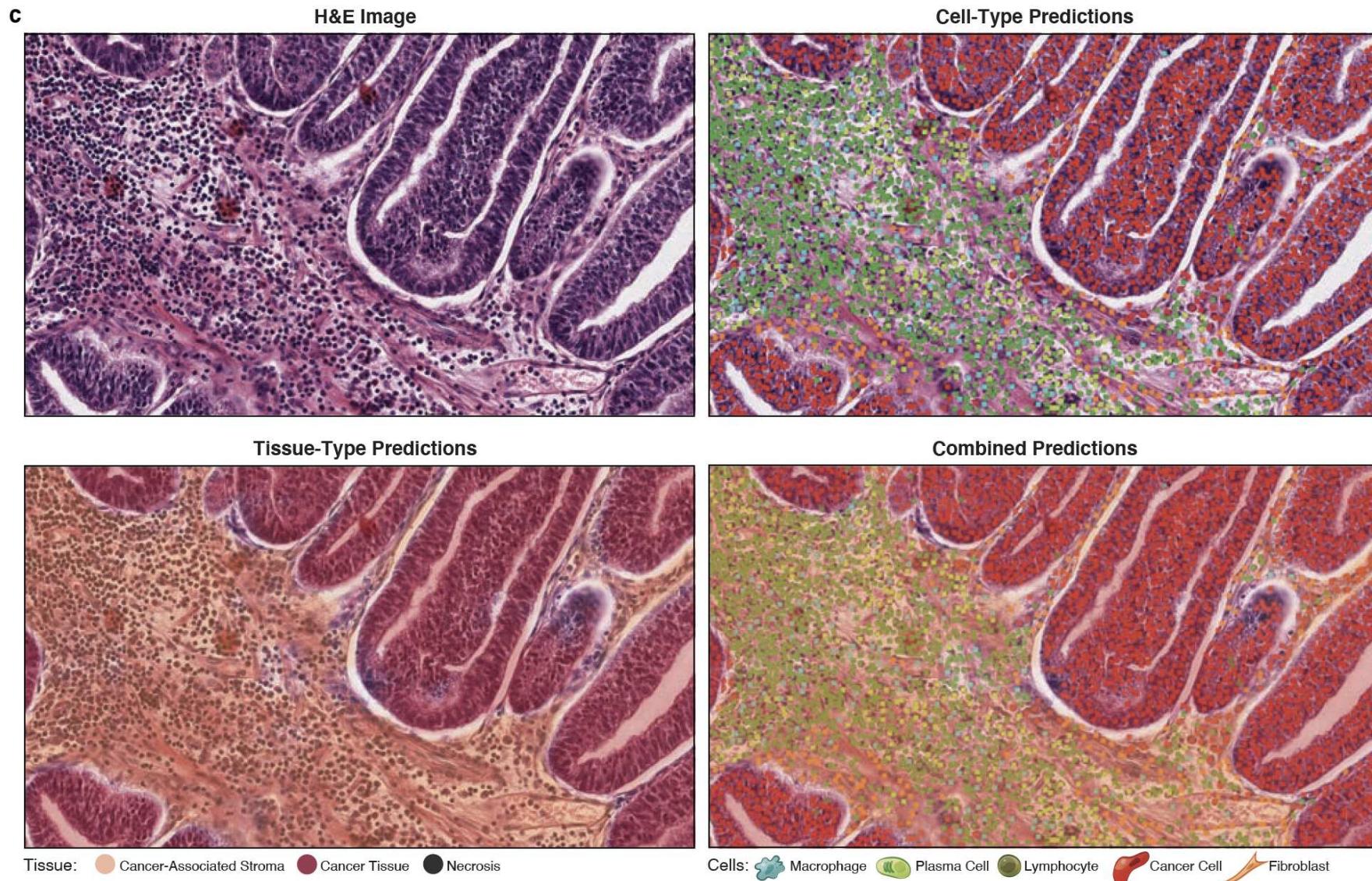
Prognosis
Genetic changes
Individual therapy options
Response to therapy

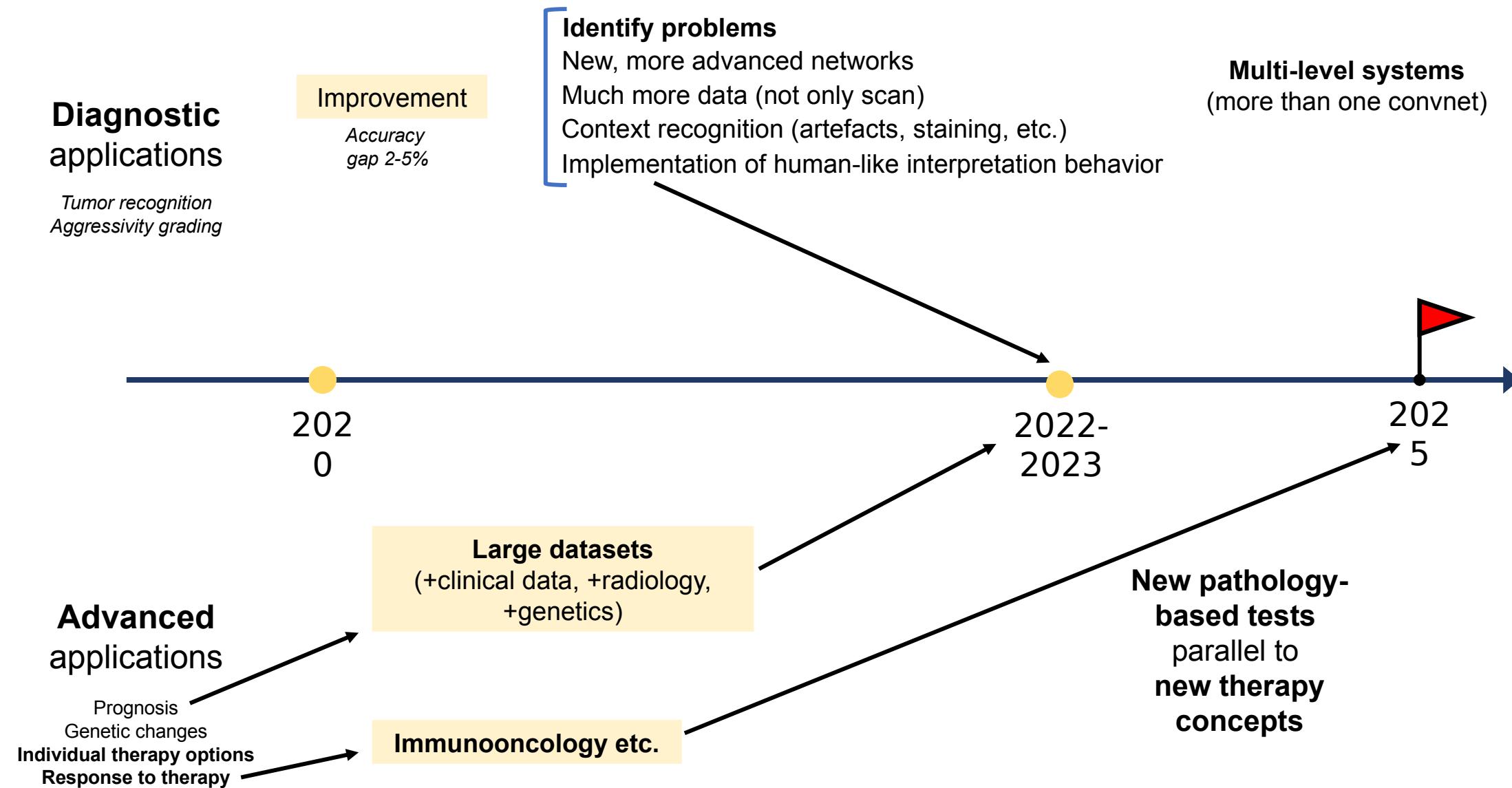




Immunooncology







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