



AI Transforming Healthcare: The Future of AI in Pathology

Presenter Profile

- Founder of **Khayyam AI Innovation Lab**
- **10** years of experience in AI developing
- More than **20** projects in AI application in medicine
- Data Scientist in Tabriz Valiasr Hospital
(Clinical Research Development Unit)



Dr Saeed Primoradi (AI PhD)

AI Developer

The **First (TvAI) Skyroom**
International **Virtual Congress** on
the practical Application of Artificial
Intelligence in **Medical Sciences**

Date & Time: 1-5 February 2025 (09:00 Am-12:00)

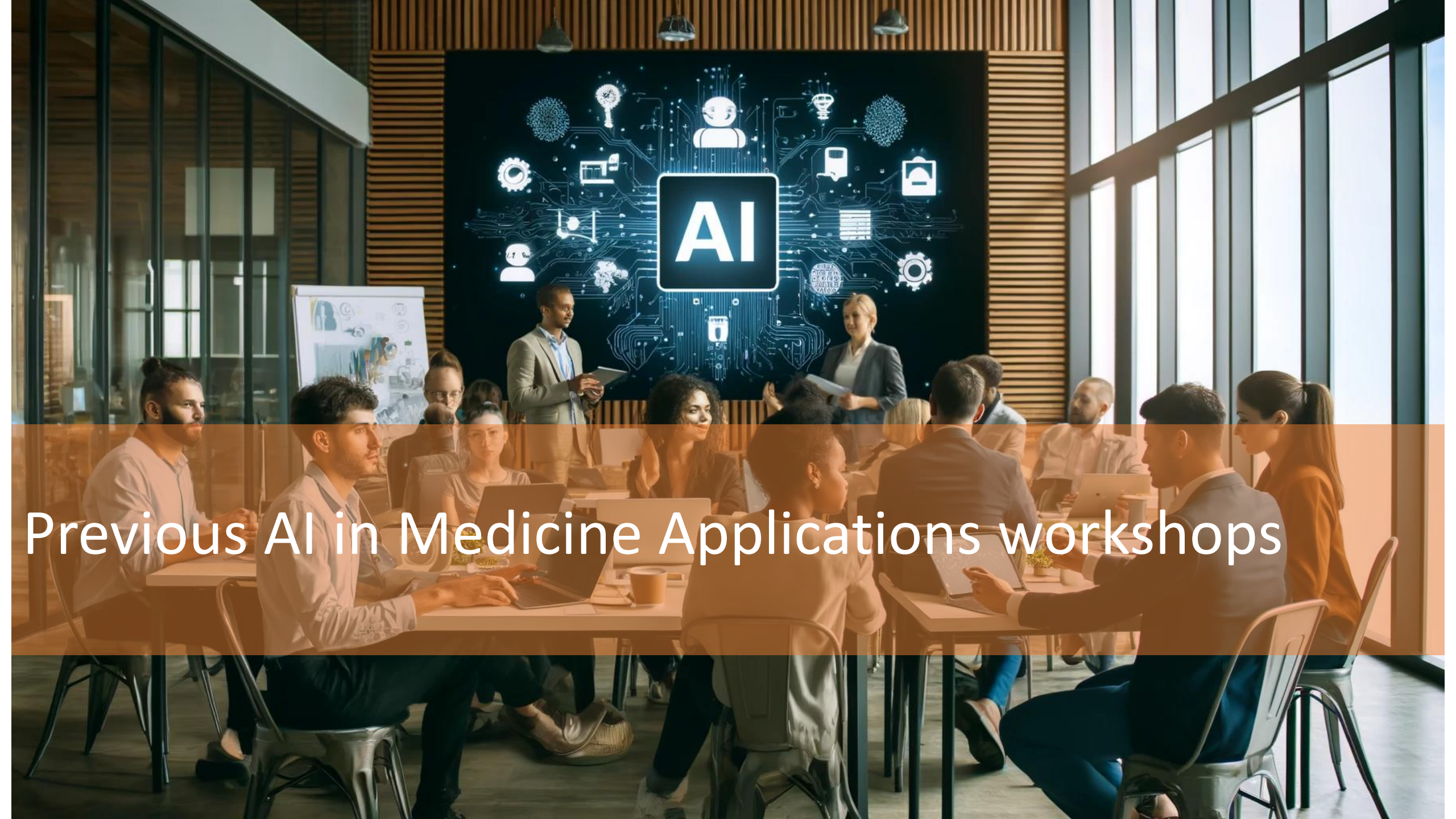


تاریخ و زمان برگزاری: ۳۰ تا ۰۳ بهمن ۱۴۰۳ (۰۹:۰۰ صبح - ۱۲:۰۰)
اولین کنگره بین المللی مجازی
کاربرد هوش مصنوعی
در علوم پزشکی




بیمارستان الوعظریه
واحد توسعه تحقیقات بالینی
CLINICAL RESEARCH DEVELOPMENT UNIT


KHAYYAM
AI Lab



Previous AI in Medicine Applications workshops

Facts

Americans experience **12 million** diagnostic errors a year.

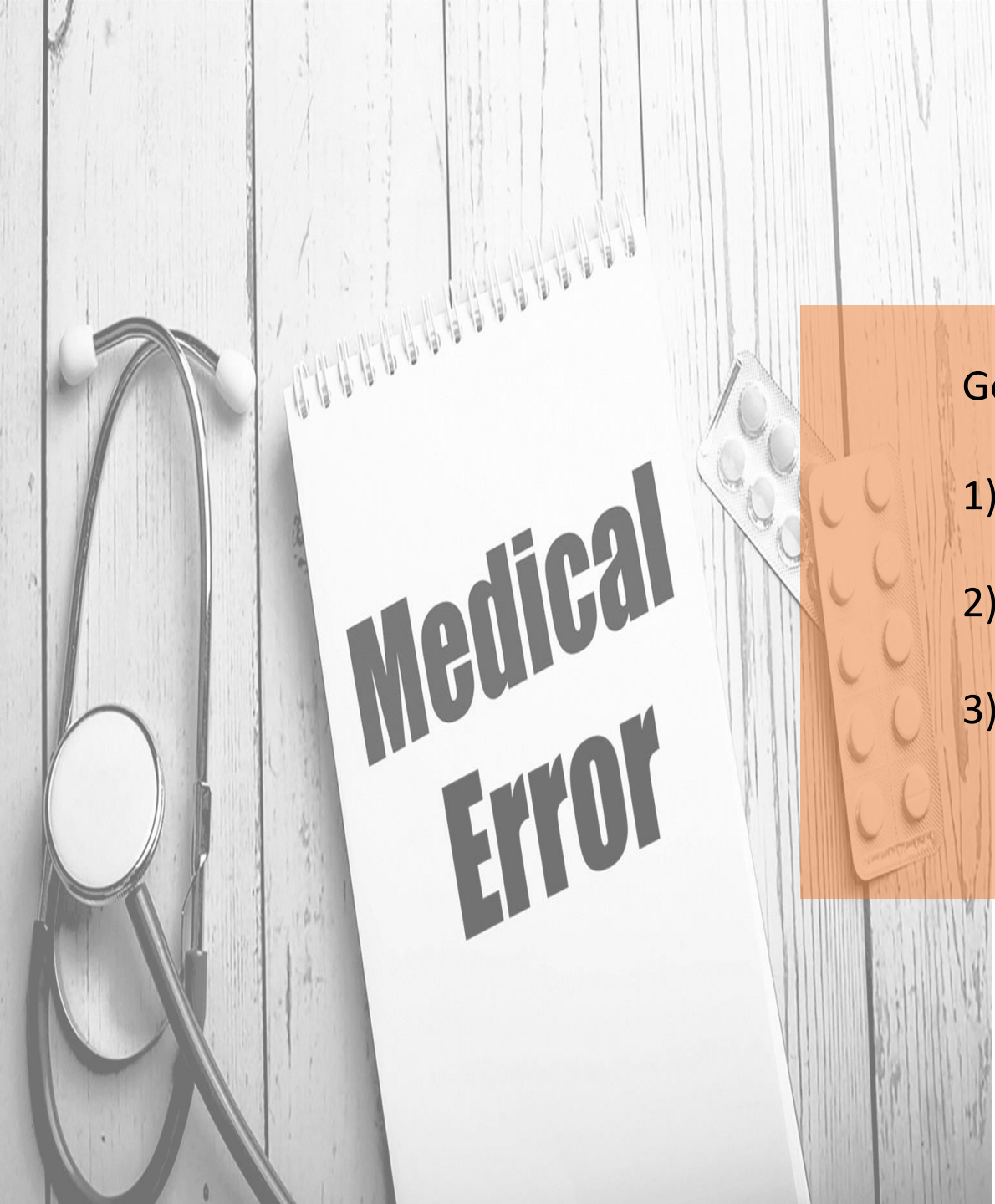
[\(Reference link from CBS news\)](#)

28 % of diagnostic mistakes are life threatening or result in death or permanent disability.

[\(Reference link from NCPA\)](#)

Breast cancer misdiagnosis costs **\$4B**/year.

[\(Reference link from CNBC news\)](#)



Medical Error

General Types of **error**:

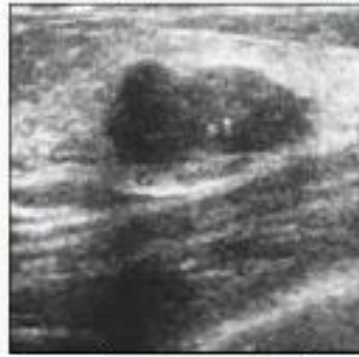
- 1) Scanning error
(we fail to fixate in specific areas)
- 2) Recognition error
(we fail to detect abnormality)
- 3) Decision-making error
(almost 50% of error by incorrect interpretation of a malignant/benign)

Medical imaging

Many modalities/case: **700 Billion** images/year
in the US alone



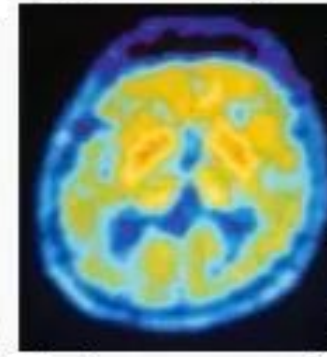
Prostate MR



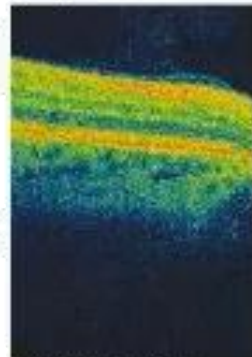
Breast U/S



Brain CT



Parkinson PET



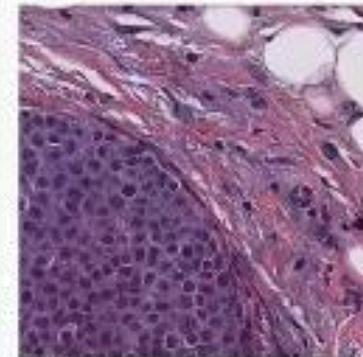
OCT retina



Prostate U/S



Lung X-Ray



Breast biopsy

Errors and misdiagnosis

We need to talk: Pathologists, Patients, and Diagnostic errors.

Survey of **260** pathologists and **81** laboratory medical directors with response rate 51%

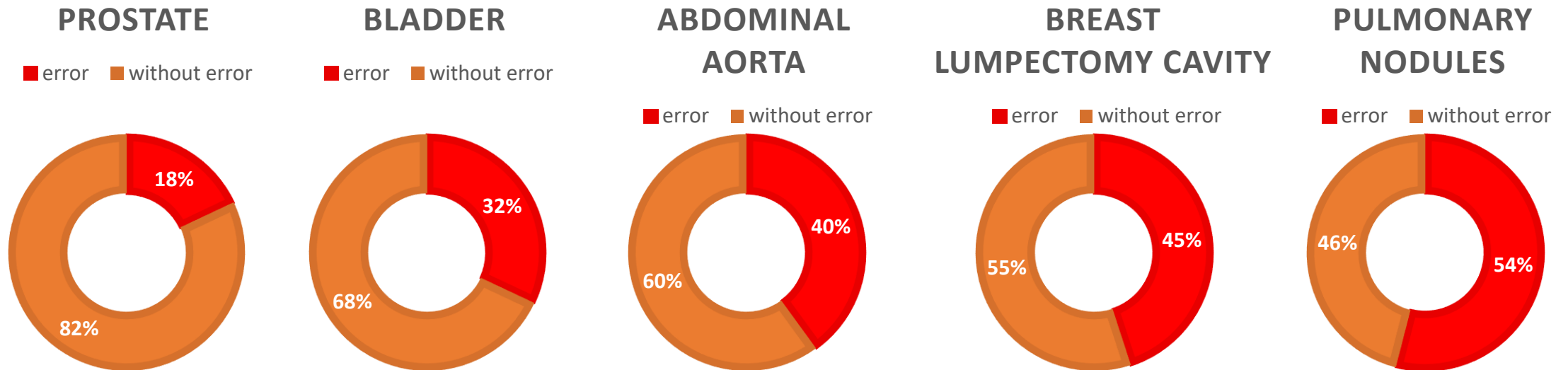
The pathologist 06/23/2016

[\(Reference link\)](#)



The source of all problems

Inter-Observer Variability

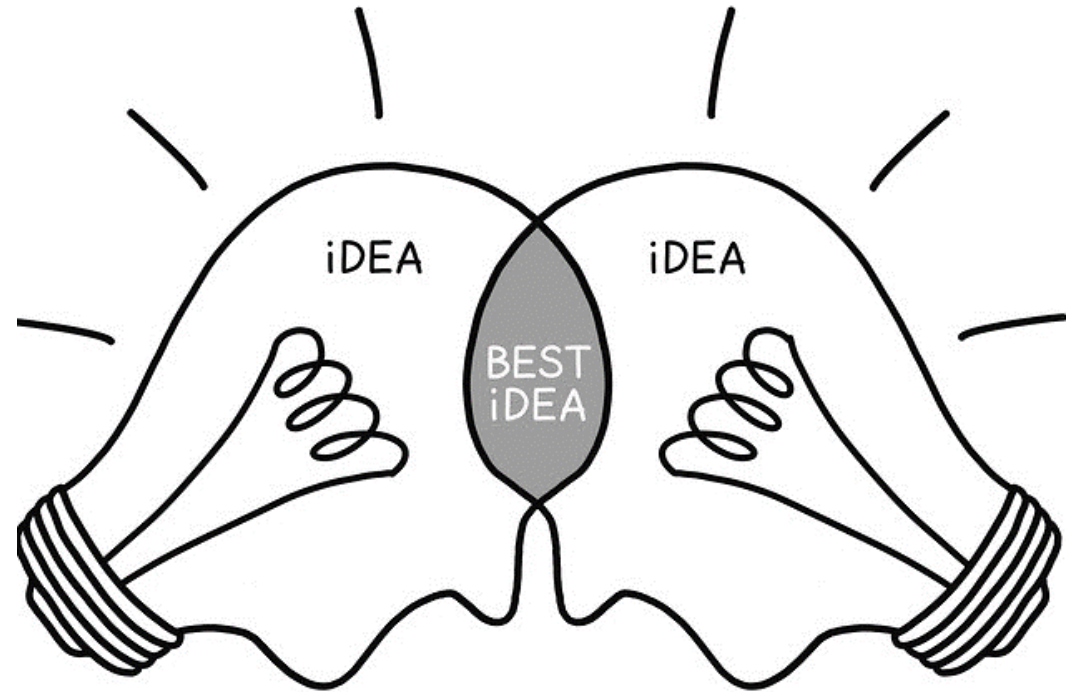


Inter-Observer Variability is more scary



Important question

What can **Artificial Intelligence** do?



A.I., especially **Machine Learning**, allows for a computer model to learn and extract **meaningful patterns** from data in a semi-automatic manner.

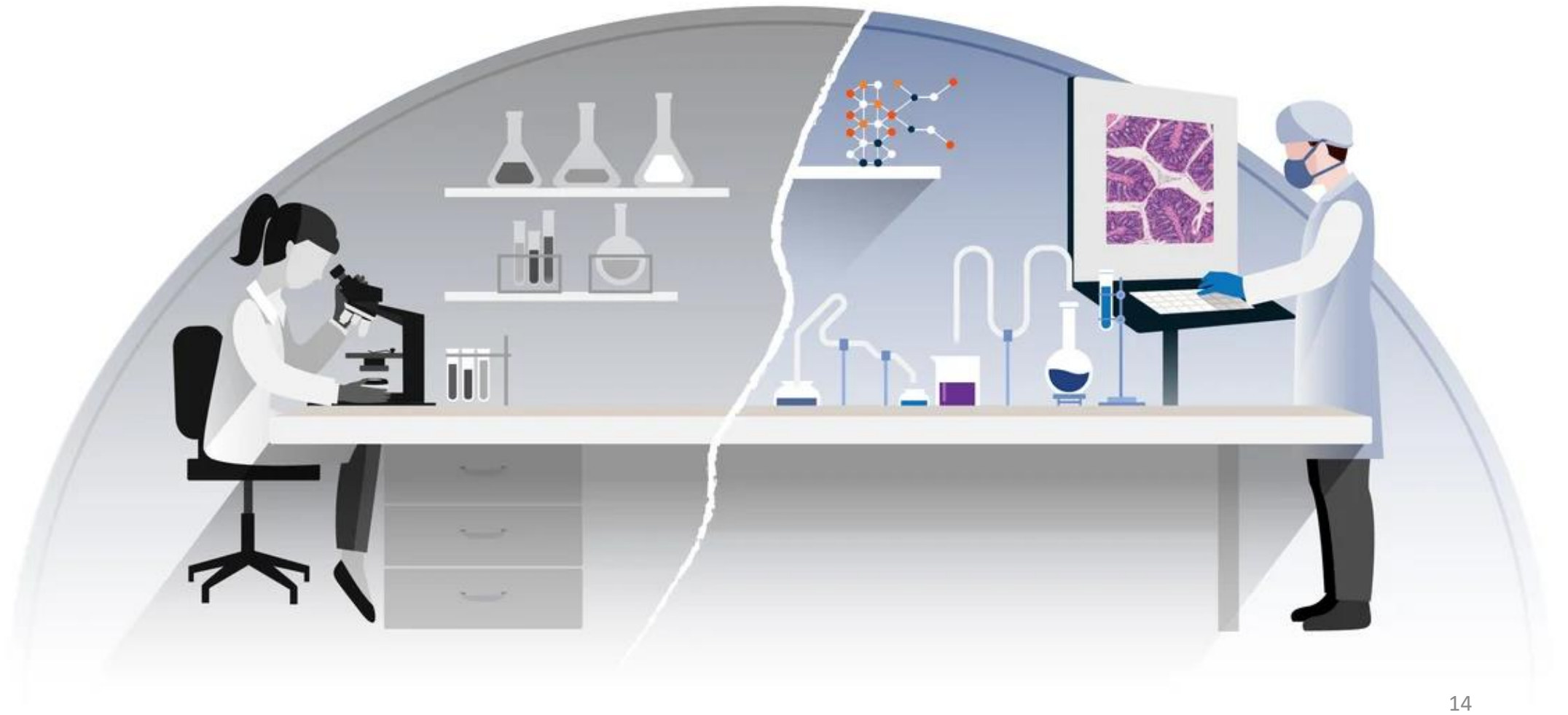
A close-up, shallow depth-of-field photograph of a microscope's objective lenses. The lenses are metallic and cylindrical, with some showing fine details like ridges and markings. The background is a soft, out-of-focus light gray.

Introduction to Digital Pathology

Pathology Process

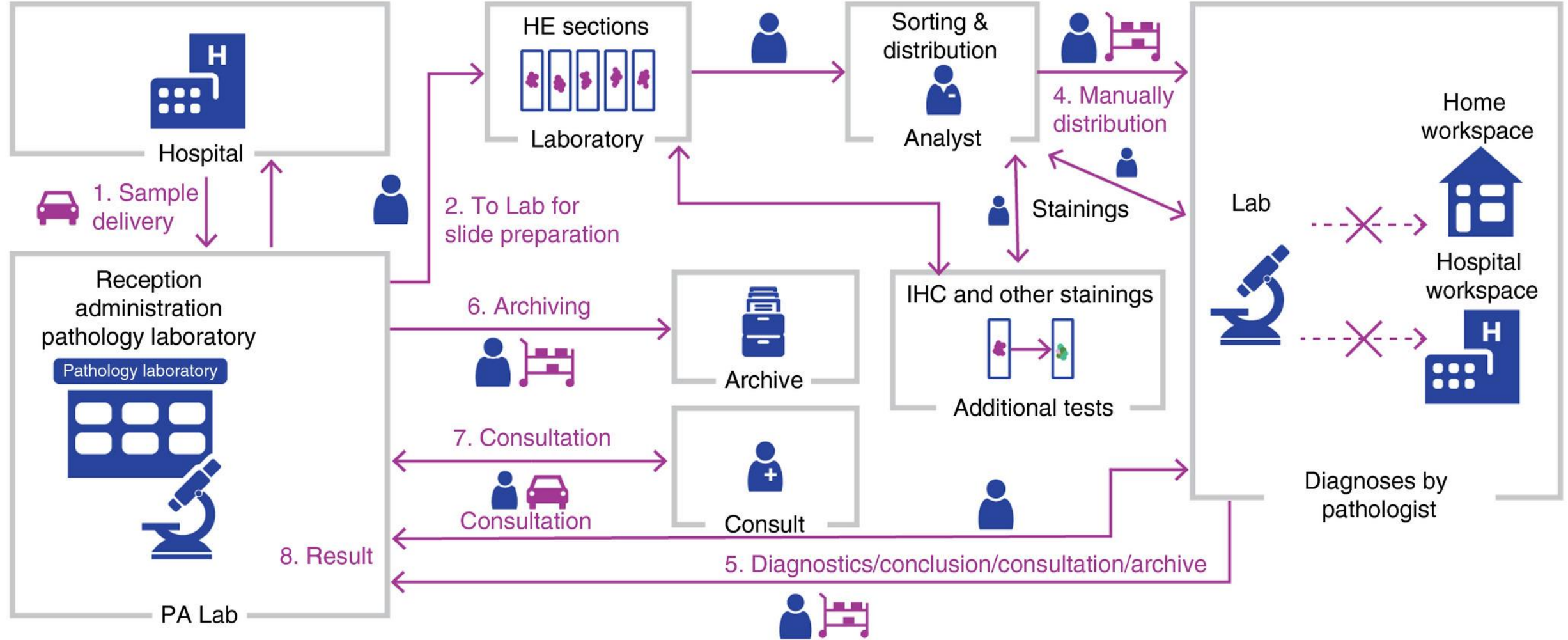


Digital Pathology

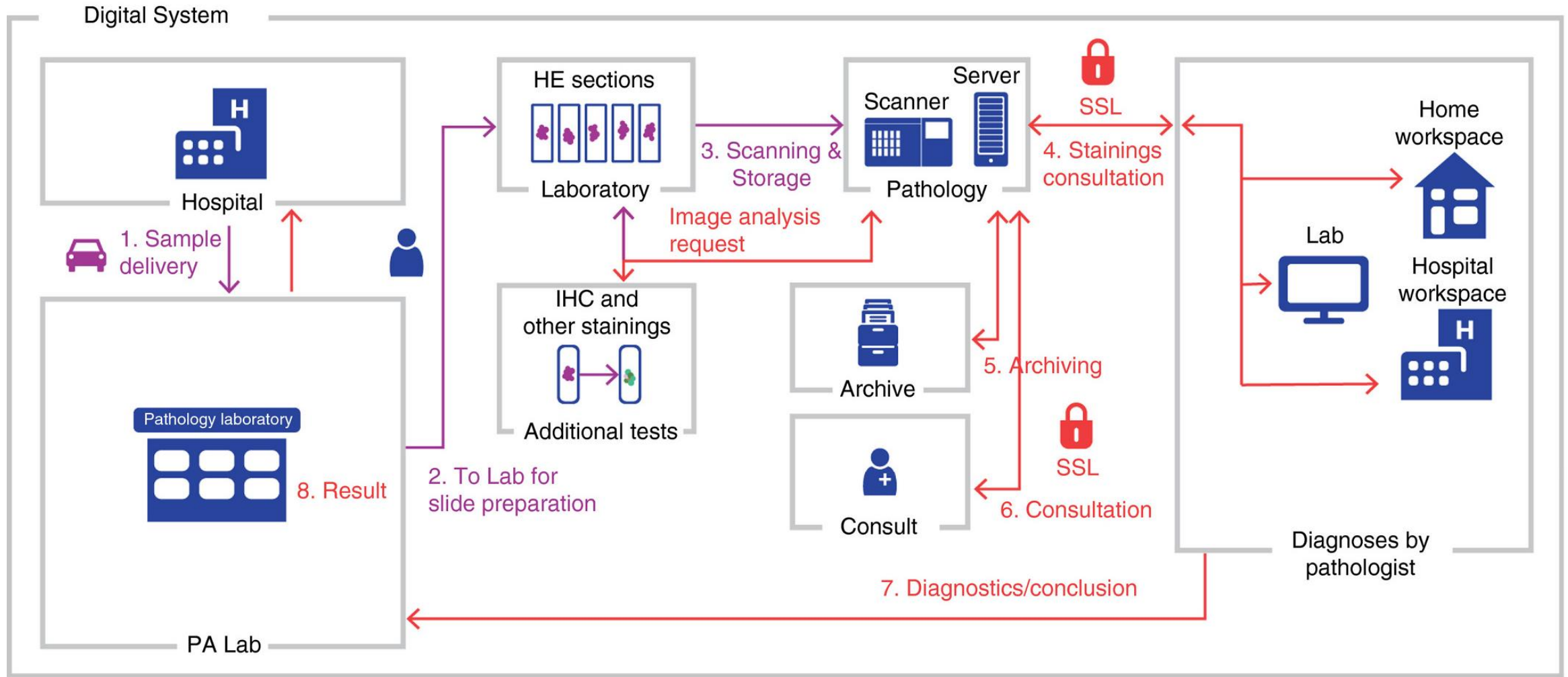


Pathology: Conventional Microscopy

Analog System



Pathology: Virtual Microscopy



the Pathologist[®]

10 YEARS

Going 100 % Digital

Making the move to 100 Percent Digital:
The **LabPon** is the first laboratory in the world to digitise its histopathology service fully

DP has four key benefits:

- Efficient workflows
- Connected teams
- Increased safety
- New insights from analysing large datasets





The potential operational cost savings for 5 years following the implementation of a digital pathology solution were estimated at around \$18 million.

The main contributing factors were gains in pathologist time by higher productivity and better workload distribution (\$12.4 million), and reduced costs of incorrect treatment.

The over- and under-treatment costs in oncology were estimated at \$5.4 million.



Digital Pathology: Scanners

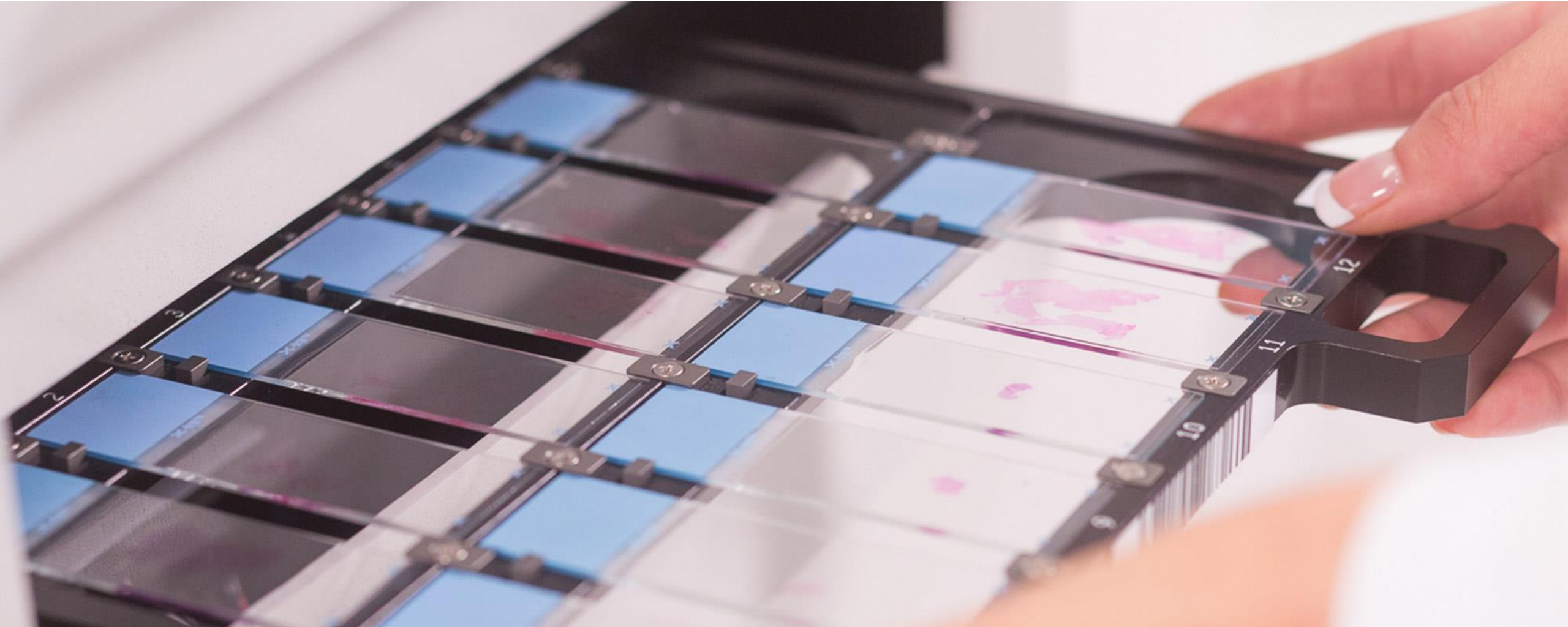
HURON Digital Pathology



Grundium



Whole Slide Images (WSI): Setup

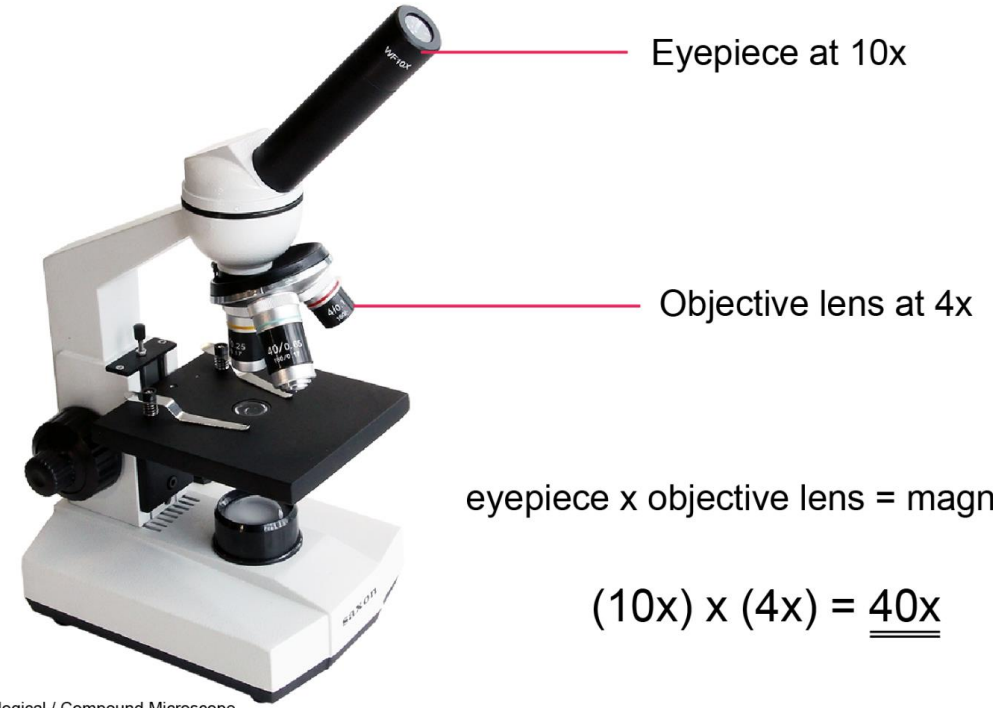




Whole Slide Images (WSI): Image View

Magnification

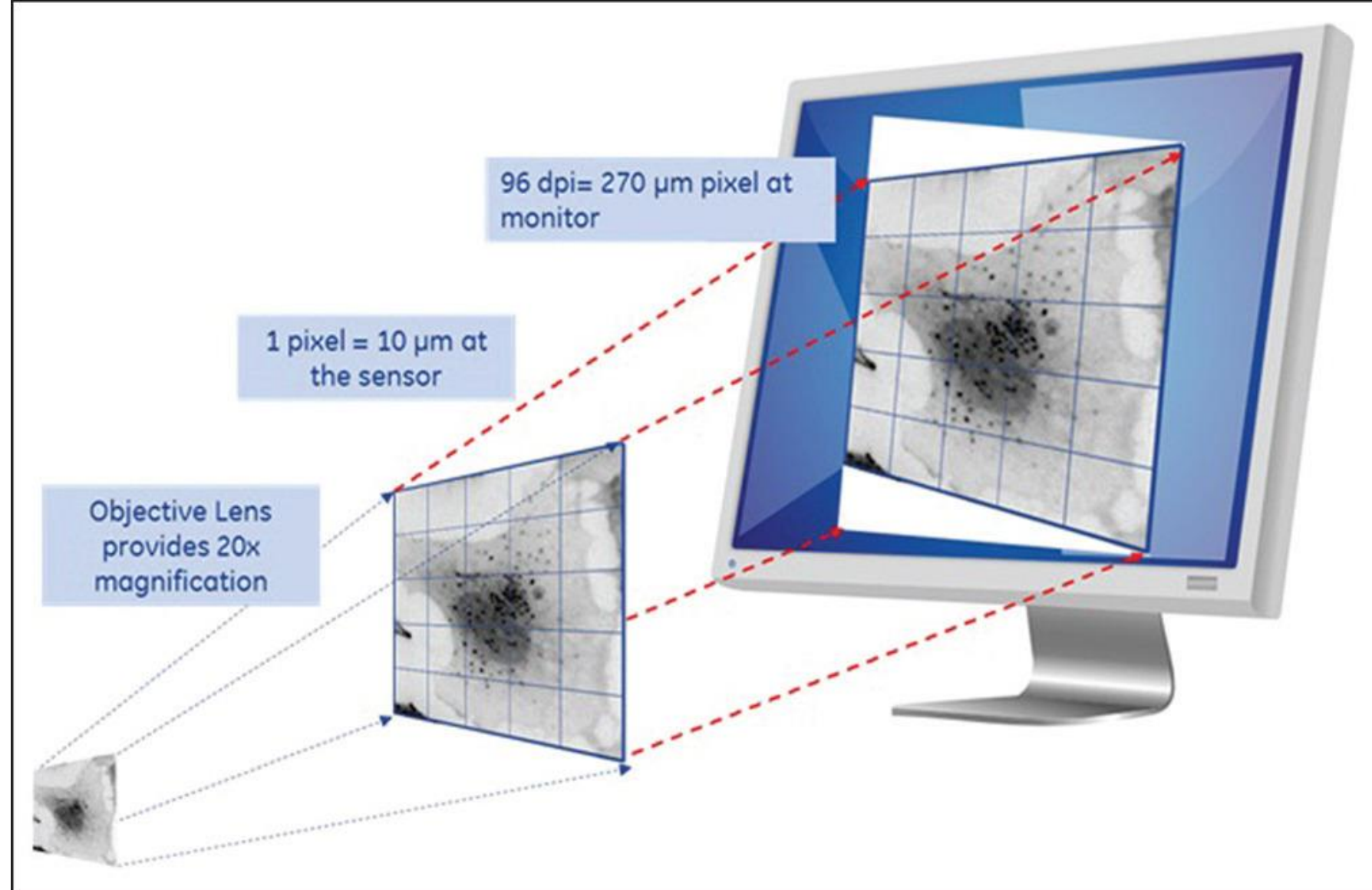
To calculate magnification



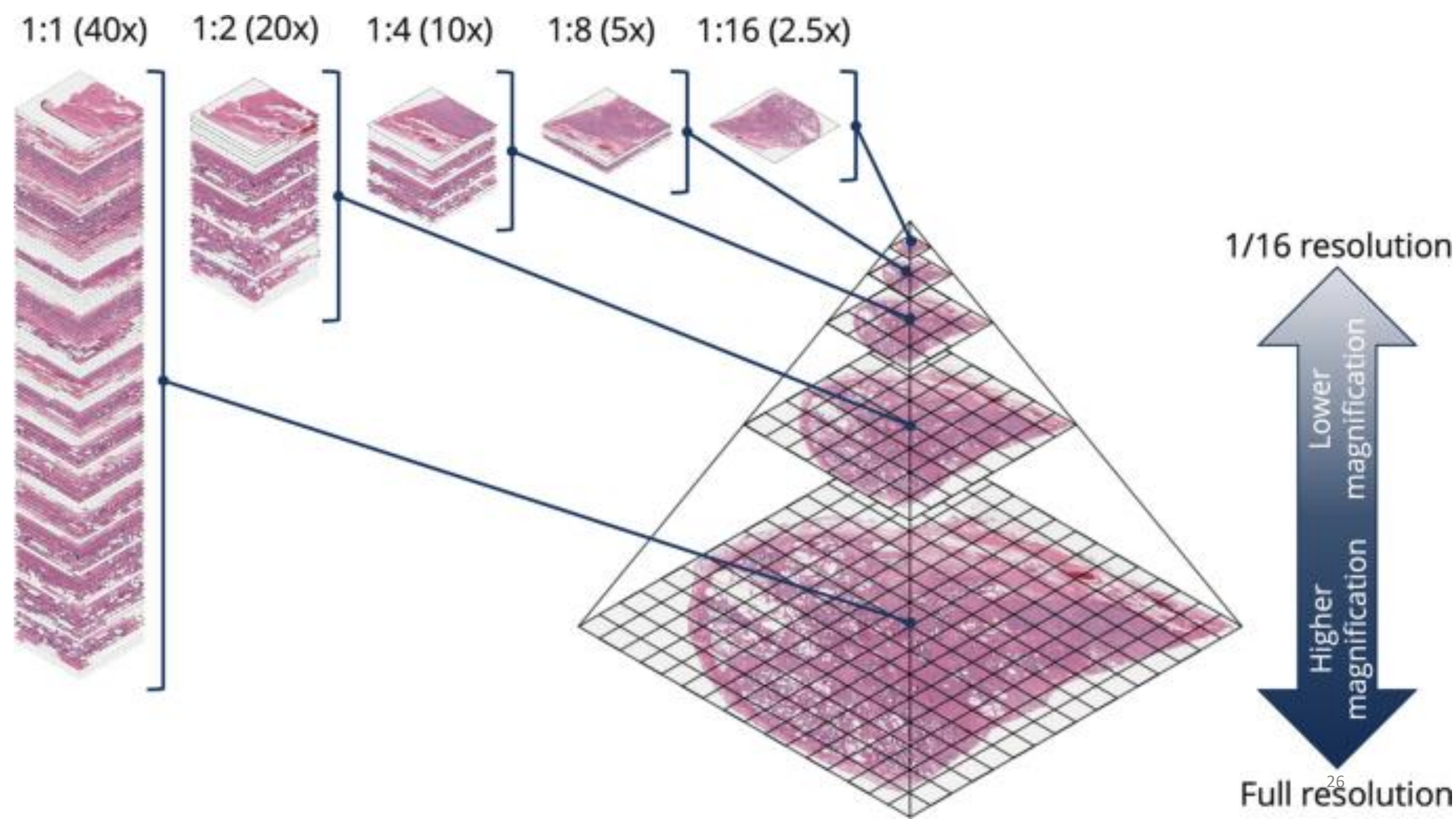
Magnification $\neq$ Resolution

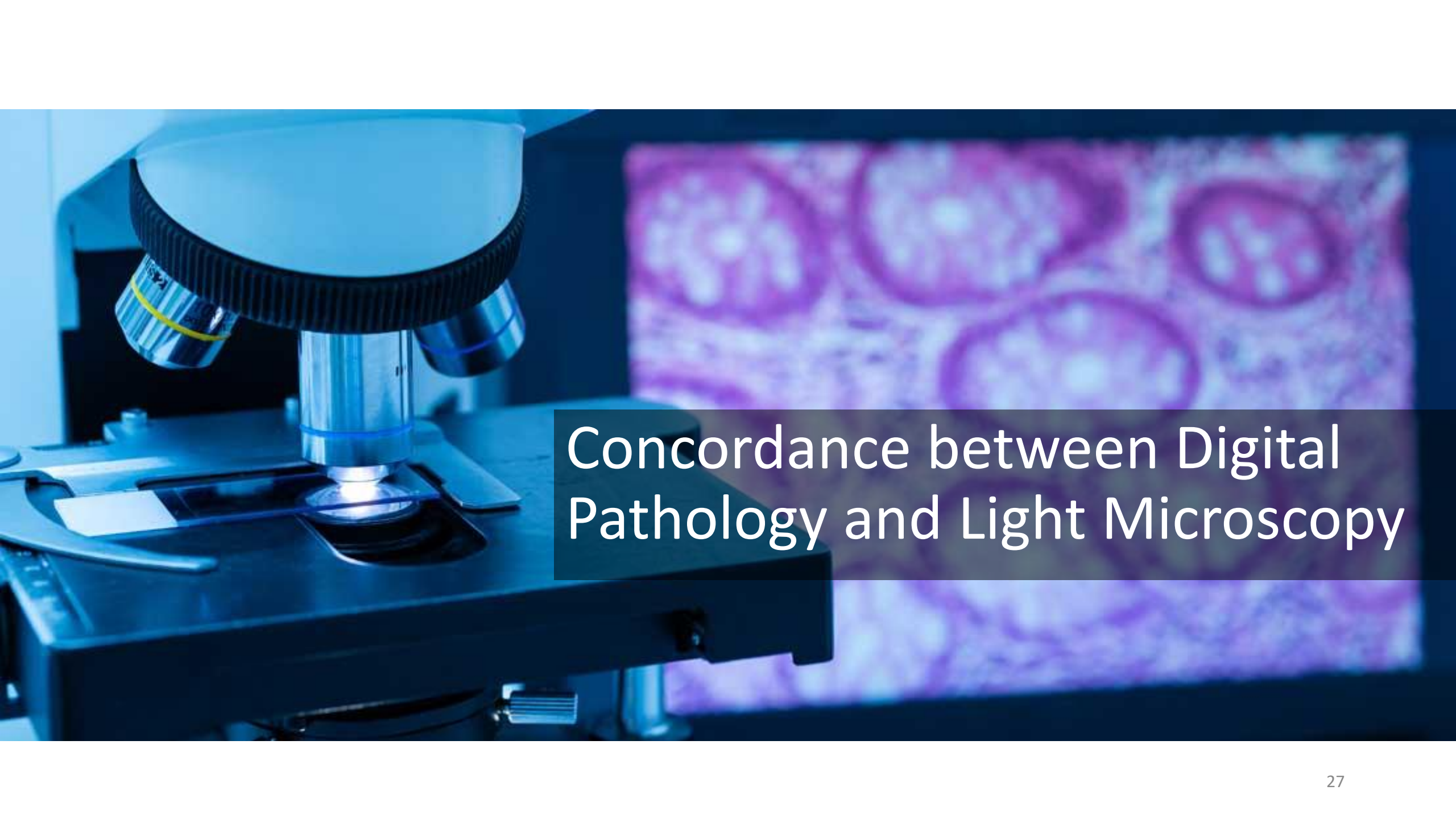
Optical Resolution = f(Objective Lenses)

The added boost at magnification comes from the monitor's workstation.



Digital Resolution = f(Objective Lens, Digital Camera Sensor, Monitor)





Concordance between Digital Pathology and Light Microscopy

2014

Concordance between digital pathology and light microscopy in general surgical pathology: a pilot study of 100 cases

Joseph P Houghton,¹ Aaron J Ervine,² Sarah L Kenny,² Paul J Kelly,²
Seamus S Napier,² W Glenn McCluggage,² Maureen Y Walsh,² Peter W Hamilton³

There was concordance between the original light microscopy diagnosis and digital pathology-based diagnosis in 95 of the 100 cases while the remaining 5 cases showed only slight discordance (with no clinical consequence). None of the cases were categorised as discordant. Participants had mixed experiences using digital pathology technology.

2017

The Diagnostic Concordance of Whole Slide Imaging and Light Microscopy

A Systematic Review

Edward Goacher, BSc; Rebecca Randell, PhD; Bethany Williams, MBBS; Darren Treanor, MB, BSc, PhD, FRCPath

Thirty-eight studies were included in the review. The mean diagnostic concordance of WSI and LM, weighted by the number of cases per study, was **92.4%**. The weighted mean κ coefficient between WSI and LM was 0.75, signifying substantial agreement. Of the 30 studies quoting percentage concordance, **18** (60%) showed a concordance of **90%** or greater, of which **10** (33%) showed a concordance of **95%** or greater. This review found evidence to support a high level of diagnostic concordance. However, there were few studies, many were small, and they varied in quality, suggesting that further validation studies are still needed.

2018

Digital pathology for the primary diagnosis of breast histopathological specimens: an innovative validation and concordance study on digital pathology validation and training

Bethany Jill Williams ✉ Andrew Hanby, Rebecca Millican-Slater, Anju Nijhawan, Eldo Verghese, Darren Treanor

Three specialty **breast pathologists** completed training in using a digital microscopy system. They were exposed to a training set of **20 challenging cases**, designed to help them identify personal digital diagnostic pitfalls. Following this, the **three pathologists viewed a total of 694 live, entire breast cases**. All primary diagnoses were made on digital slides, with immediate glass slide review and reconciliation before the final case sign-out. There was complete clinical concordance between the glass and digital impression of the case in 98.8% of cases.



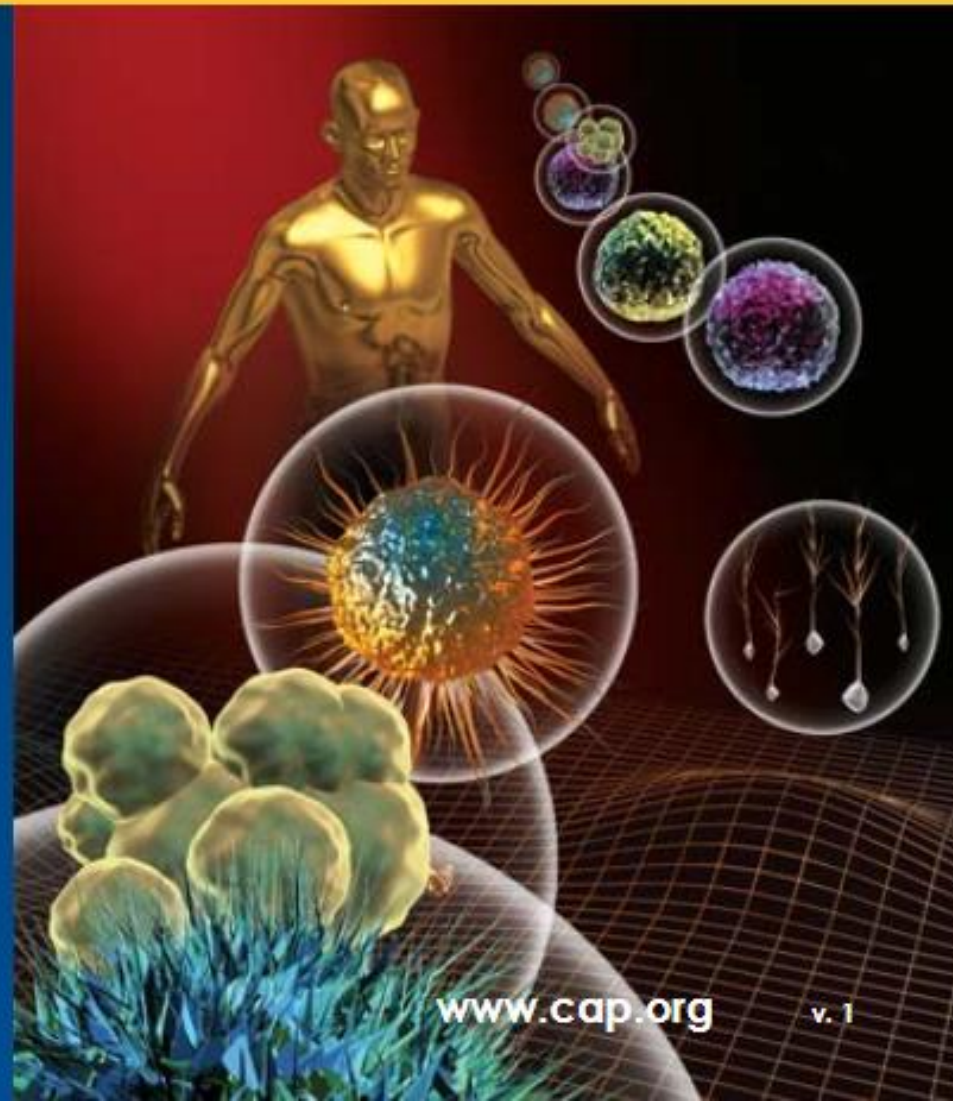


cap

Pathology and
Laboratory Quality
Center

Recommendations for Validating Whole Slide Imaging Systems for Diagnostic Purposes in Pathology

Anil V Parwani, MD, PhD
On behalf of the CAP
WSI Validation Expert
Panel



www.cap.org

v. 1

CAP Recommendations

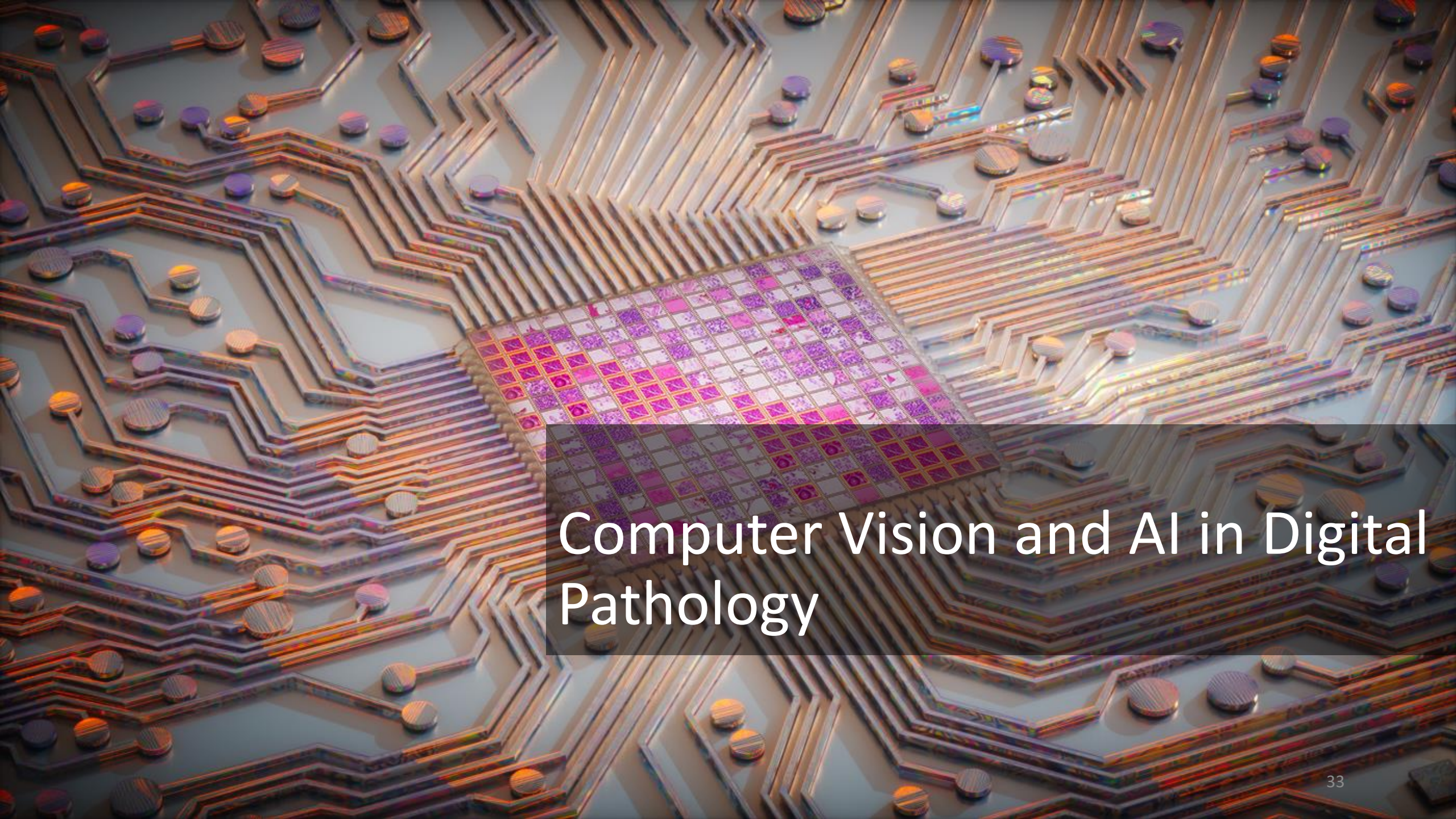


The validation study should encompass the entire WSI system

- The validation process should include at least 60 cases for one application... reflecting the spectrum and complexity of specimen types and diagnoses likely to be encountered during routine practice.

- The validation study should establish a diagnostic concordance between digital and glass slides for the same observer (i.e., intraobserver variability).

- The washout period of at least 2 weeks should occur between viewing digital and glass slides.

The background of the slide is a highly detailed, artistic rendering of a computer circuit board. The central focus is a square processor unit with a grid-like pattern of small, glowing purple and pink squares. This unit is surrounded by a complex network of golden-brown circuit traces that branch out across the board. Numerous small, circular components, some with a metallic sheen and others with a more matte finish, are scattered throughout the circuitry. The overall aesthetic is futuristic and technological, with a warm color palette dominated by golds, purples, and pinks.

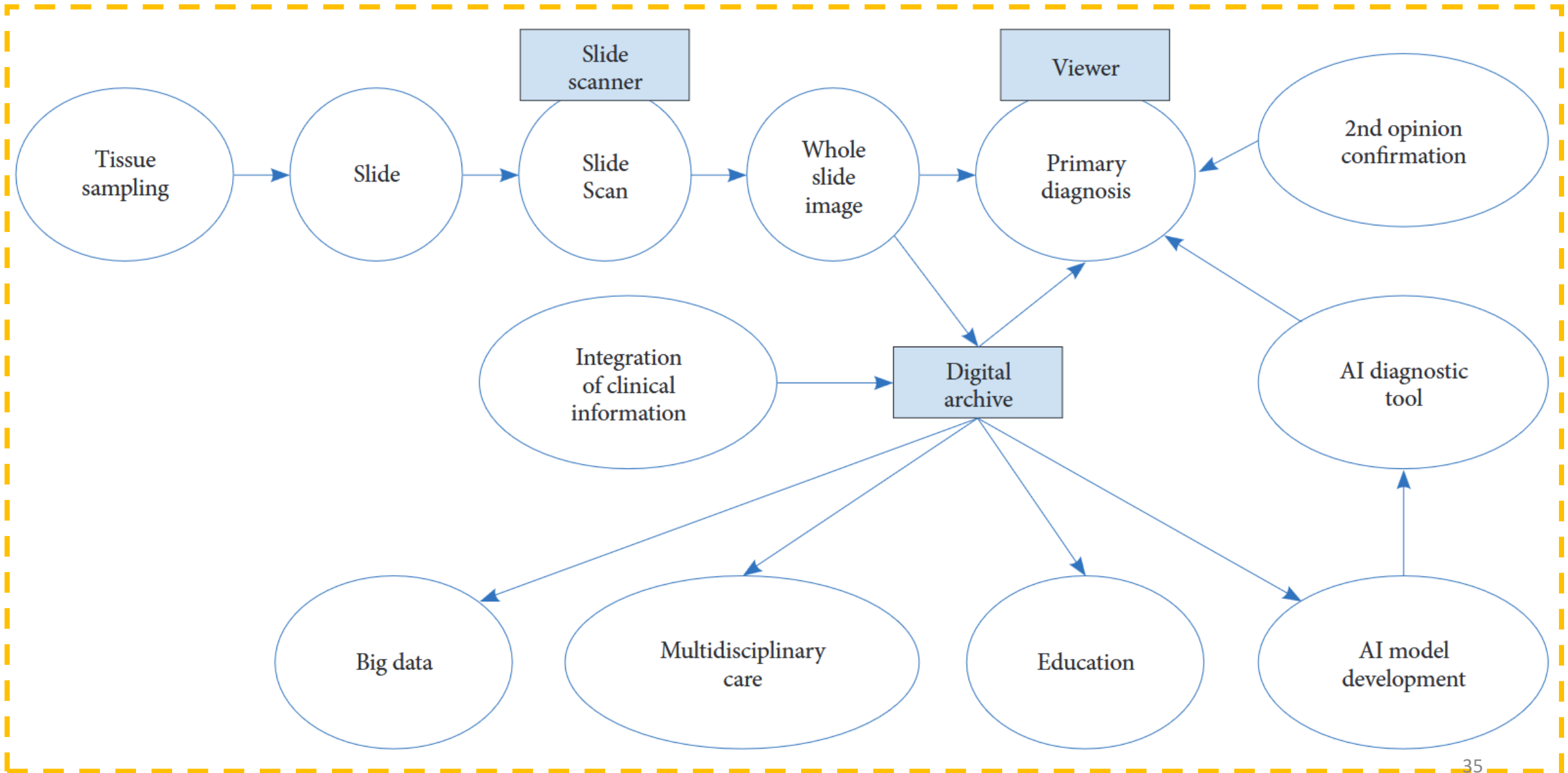
Computer Vision and AI in Digital Pathology

A male doctor with dark hair, wearing a white lab coat and a stethoscope, is looking through a microscope. The background is a blurred clinical setting.

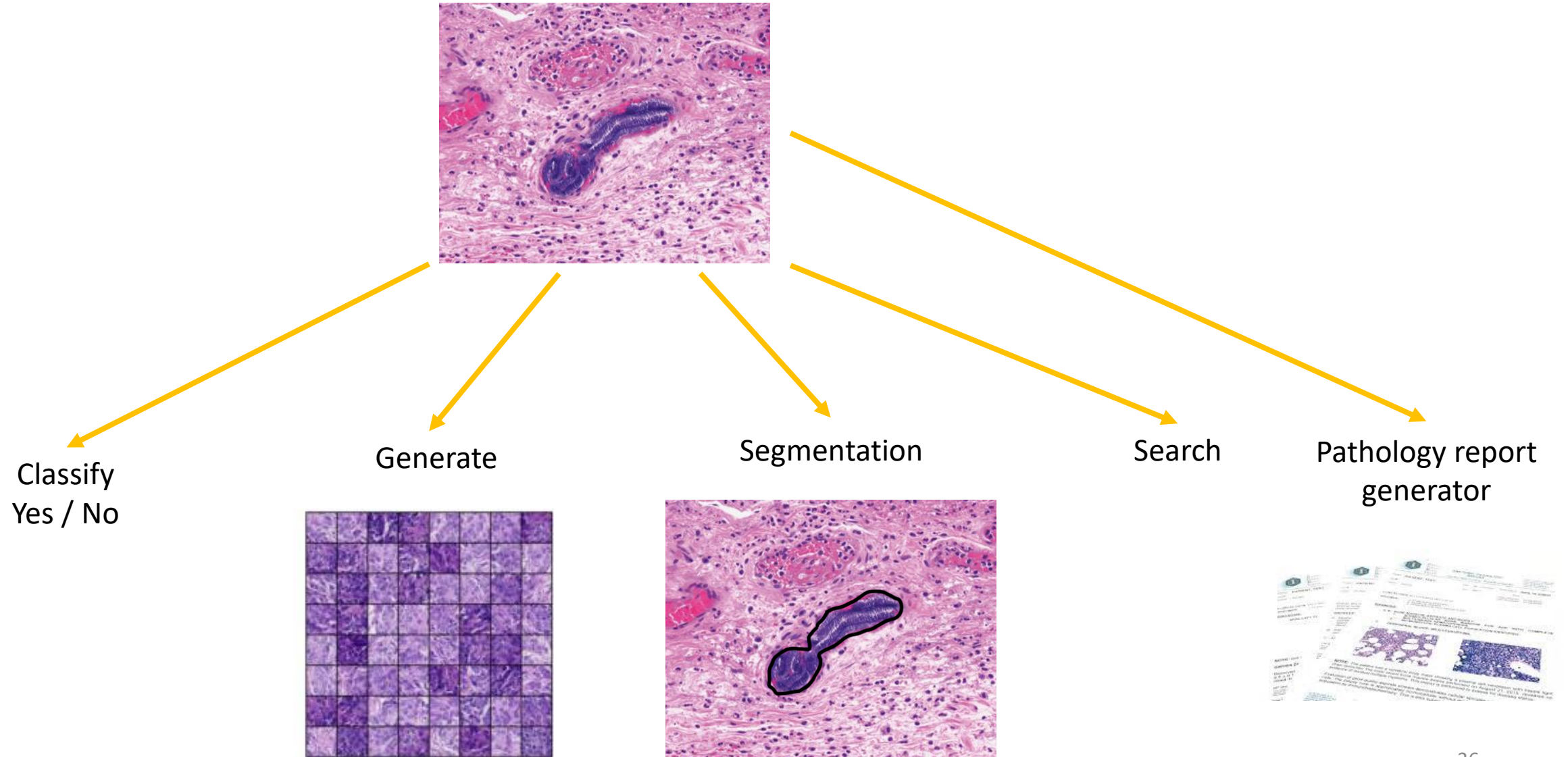
Clinical Pathology Challenges:

- Inter-observer variance
- Intra-observer variance
- Lack of quantitative, objective, and reproducible measures to assess patient biopsies
- The human brain can keep track of only a few variables

Workflow of digital pathology



What can AI do with images?





Genomic Data Commons Data Portal

Harmonized Cancer Datasets

A repository and computational platform for cancer researchers who need to understand cancer, its clinical progression, and response to therapy.

[Explore Our Cancer Datasets](#)

Data Portal Summary

[Data Release 41.0 - August 28, 2024](#)



86
Projects



69
Primary Sites



44,736
Cases



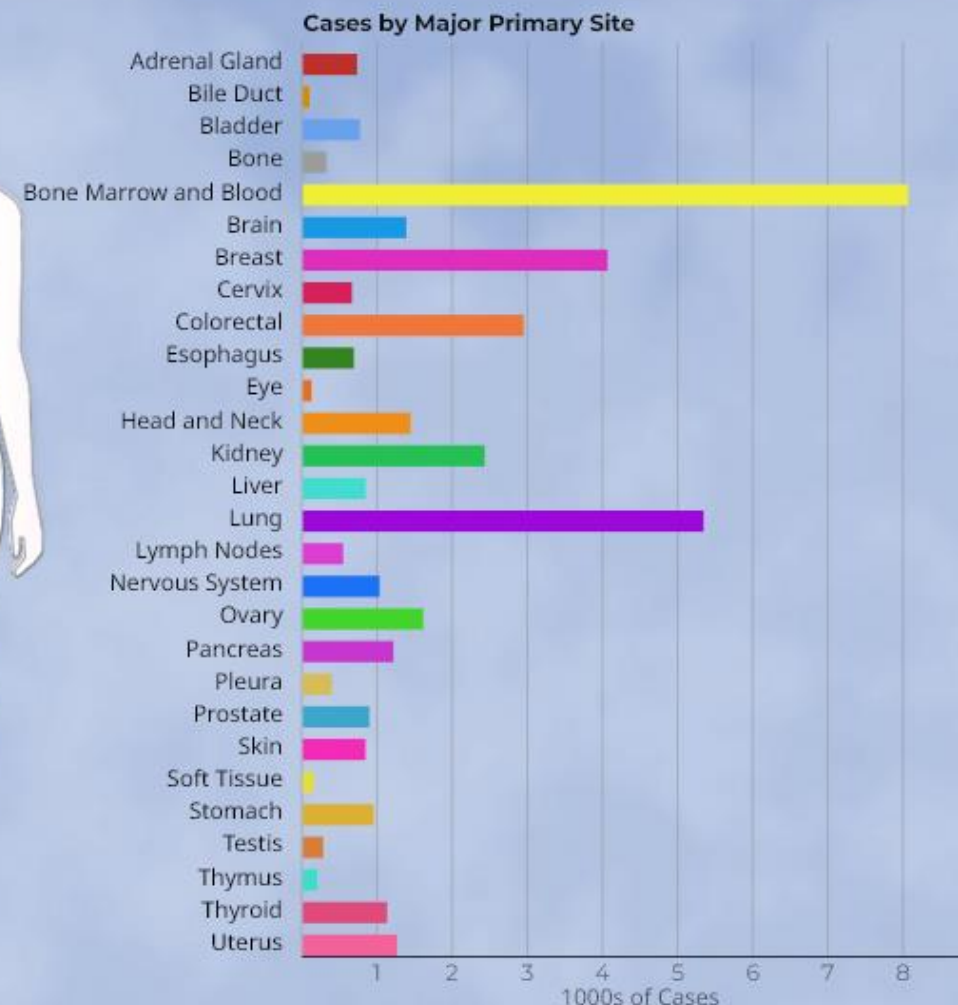
1,027,517
Files



22,534
Genes



2,940,240
Mutations

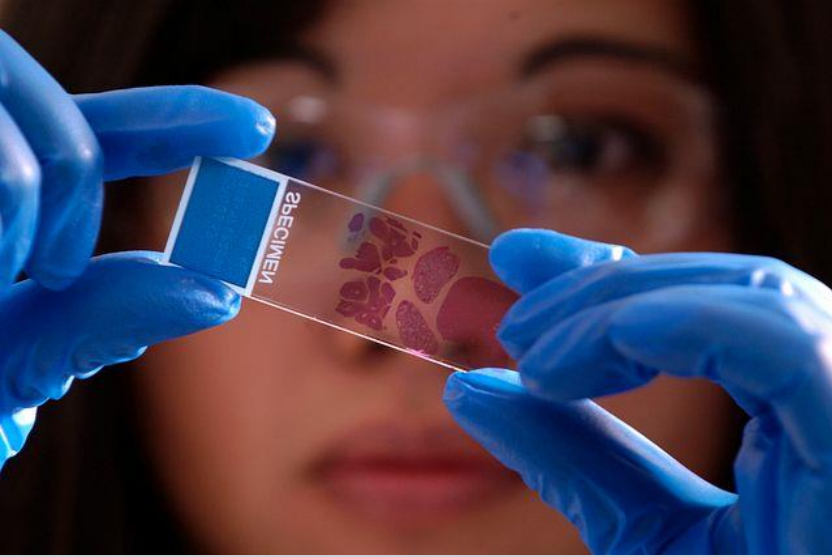




The data in this challenge contains whole-slide images (WSI) of hematoxylin and eosin (H&E) stained lymph node sections.

Depending on the particular data set (see below), ground truth is provided:

- On a **lesion-level**: with detailed annotations of metastases in WSI.
- On a **patient-level**: with a pN-stage label per patient.

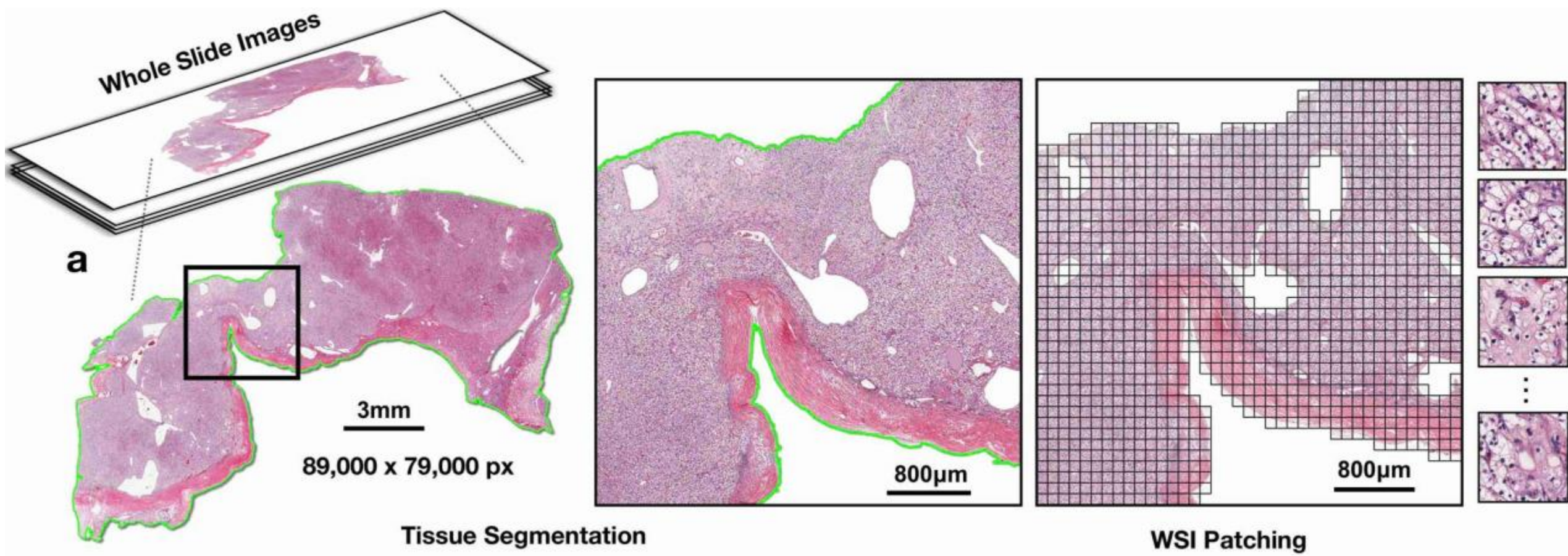


Datasets

The TCGA has many cancers, with over 1.2 petabytes of data, including pathology slides.

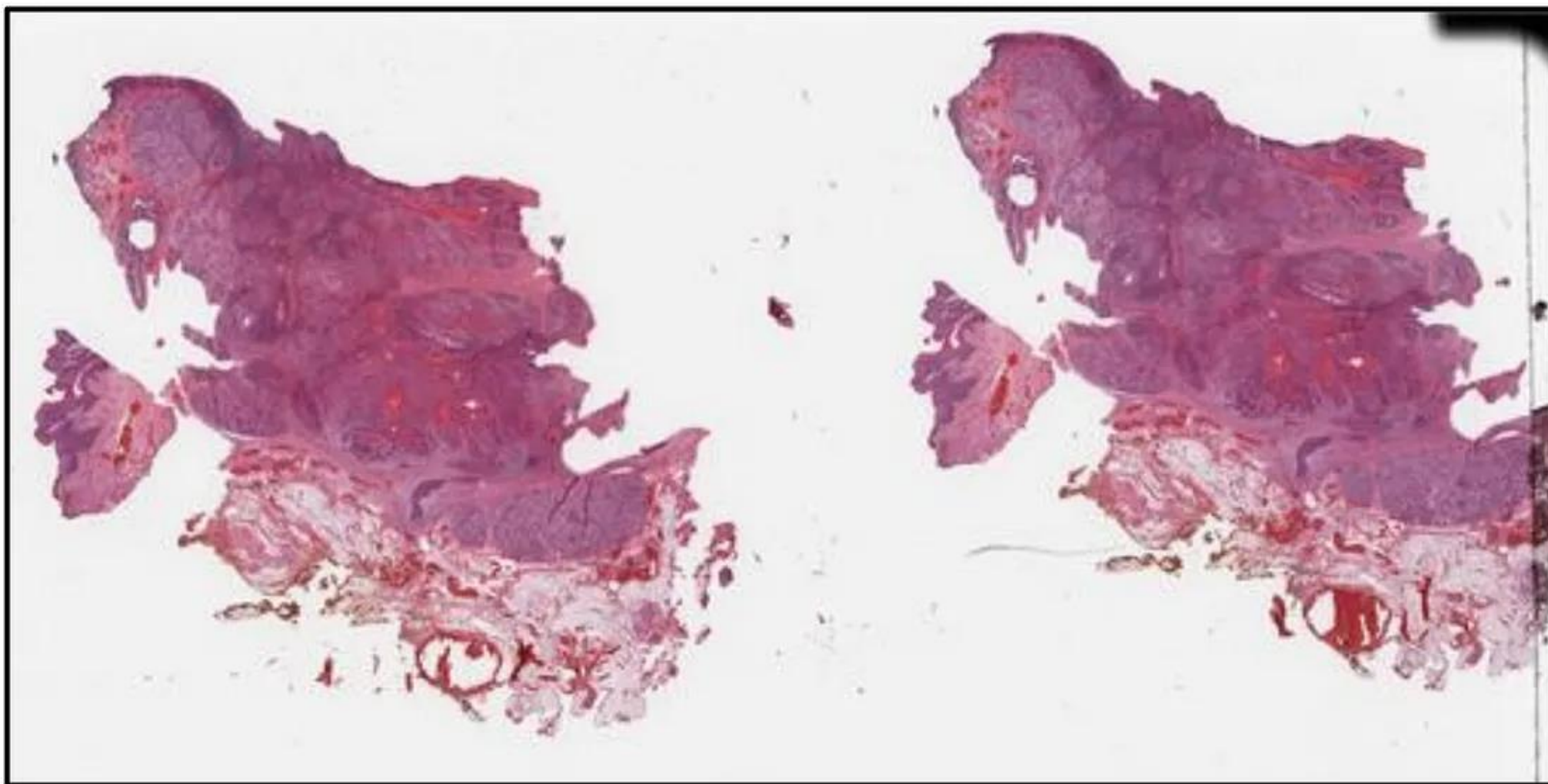
The Camelyon has 1399 WSIs with tumor marking in metastasis, without subtyping, not configuring a diagnosis.

However, most public datasets are not in WSIs or do not have pathologists' pixel-level annotations.



Images that can have more than 10 billion pixels, cannot be used fully as an input of a neural network without overflowing memory.

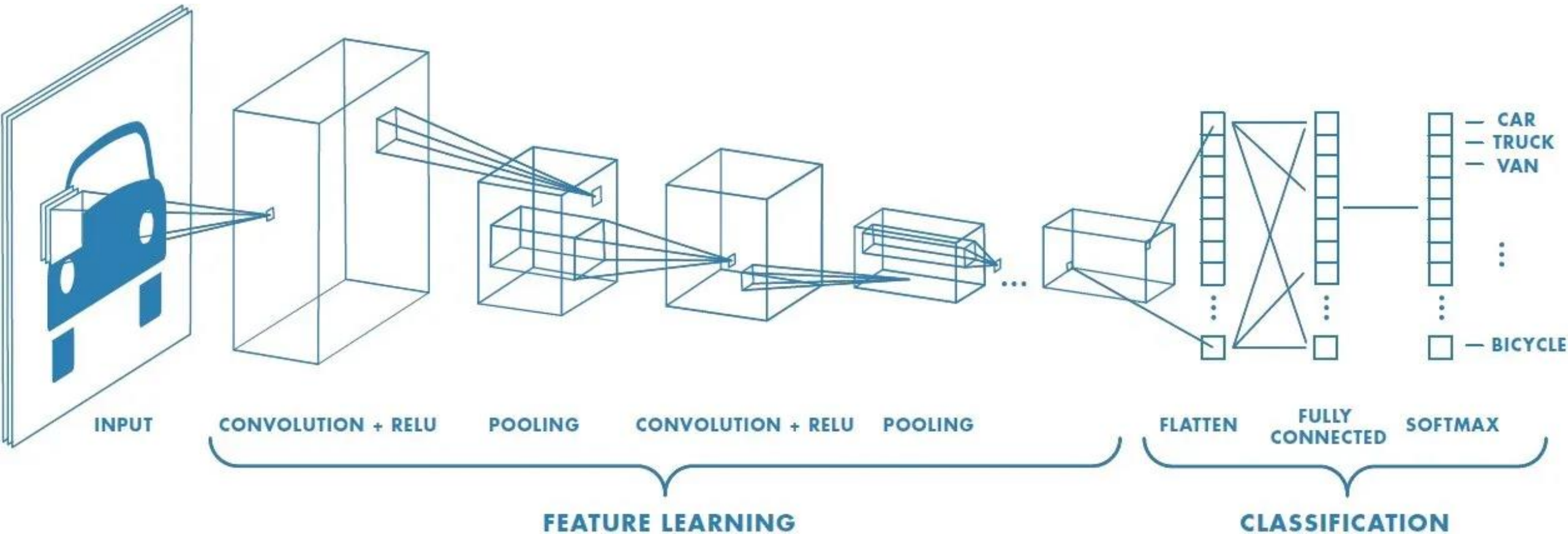
Therefore, all studies divided the WSIs into smaller patches (such as 256x256 pixels), using overlap or not as data augmentation, to feed their models.



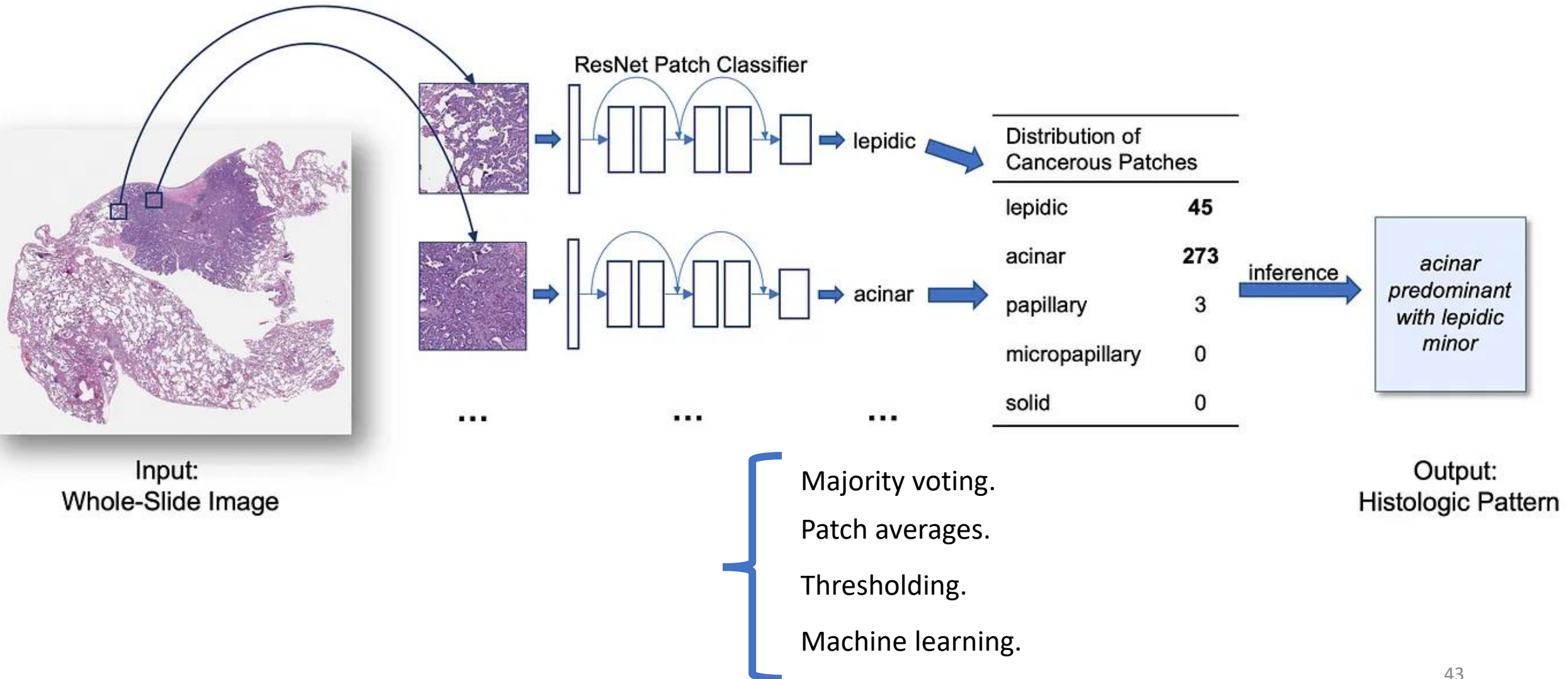
77781 pixels

158002 pixels

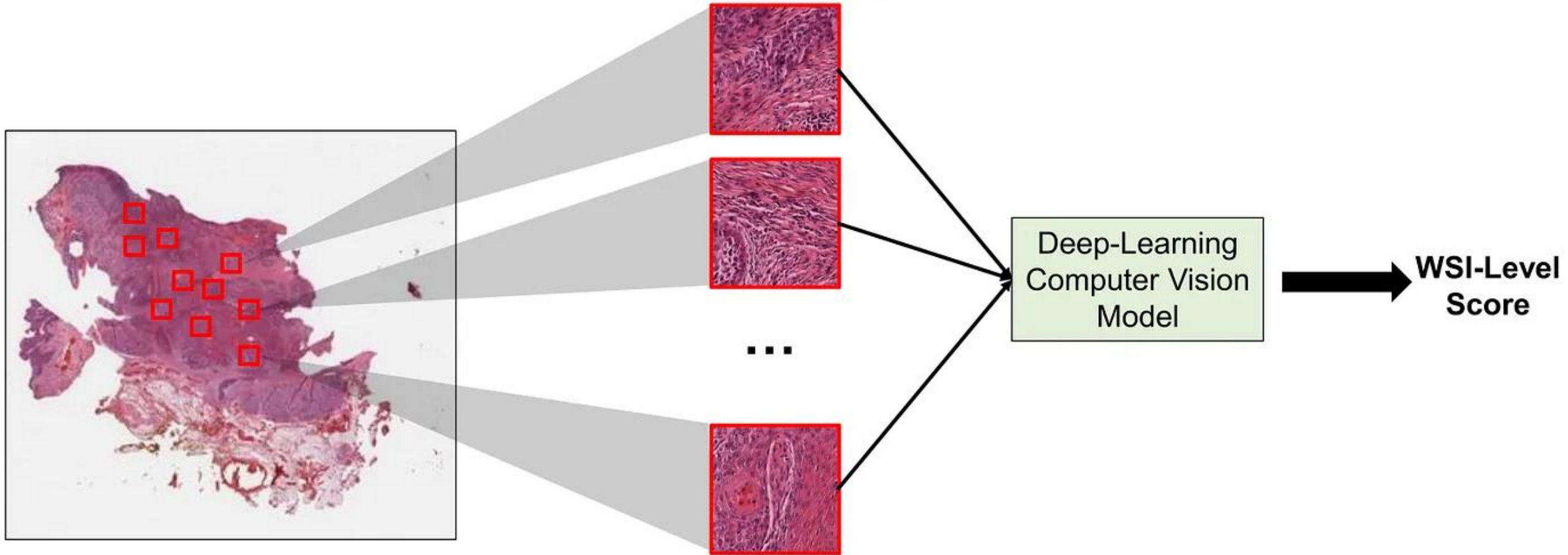
Deep Learning & Convolutional Neural Nets



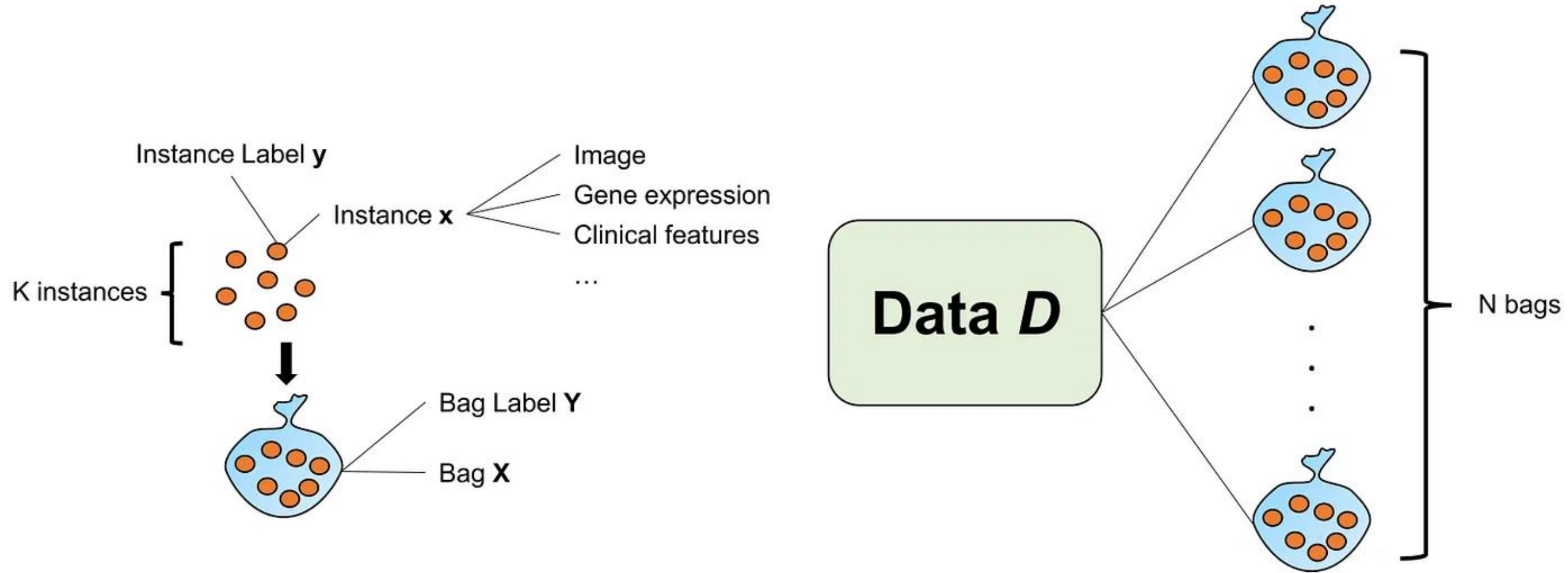
Whole-Slide Inference



The idea of Multiple Instance Learning (MIL) in WSI analyses



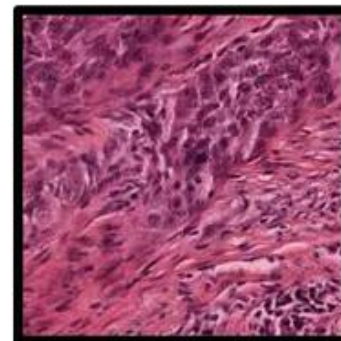
Problem Statement of general MIL (MIL-G)



Instance x

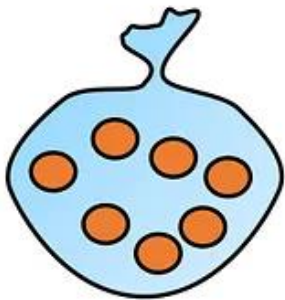


Patch x

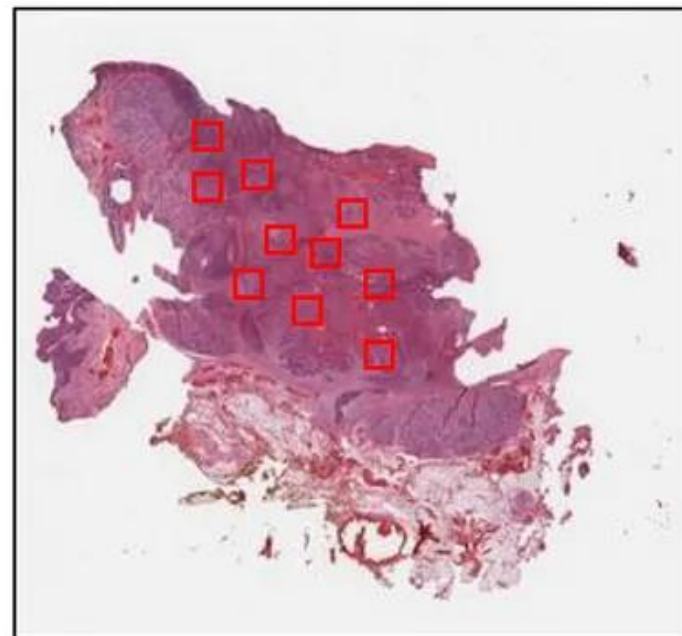


Refined Problem Statement of MIL-WSI

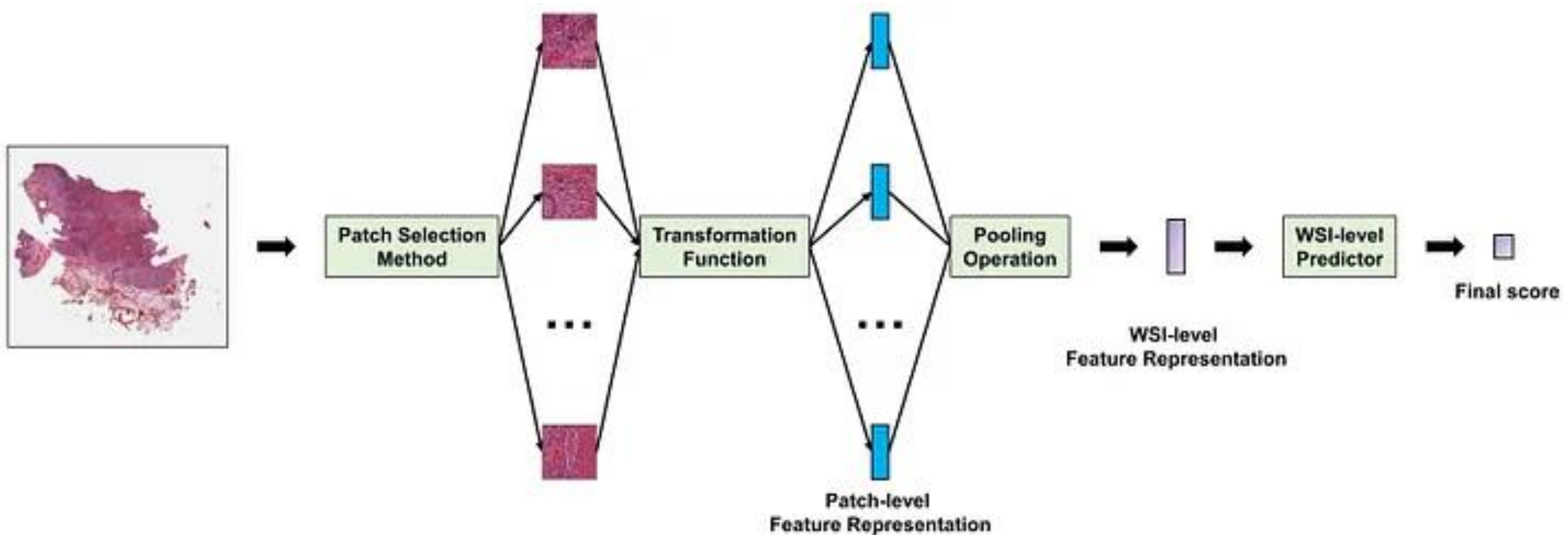
Bag X



WSI X



Main Components of MIL-WSI Framework



Categories of Patch Selection Methods

- (i) Completely random selection
- (ii) Random selection with the region of interest (ROI).
- (iii) Feature-based selection.
- (iv) Hierarchical selection.

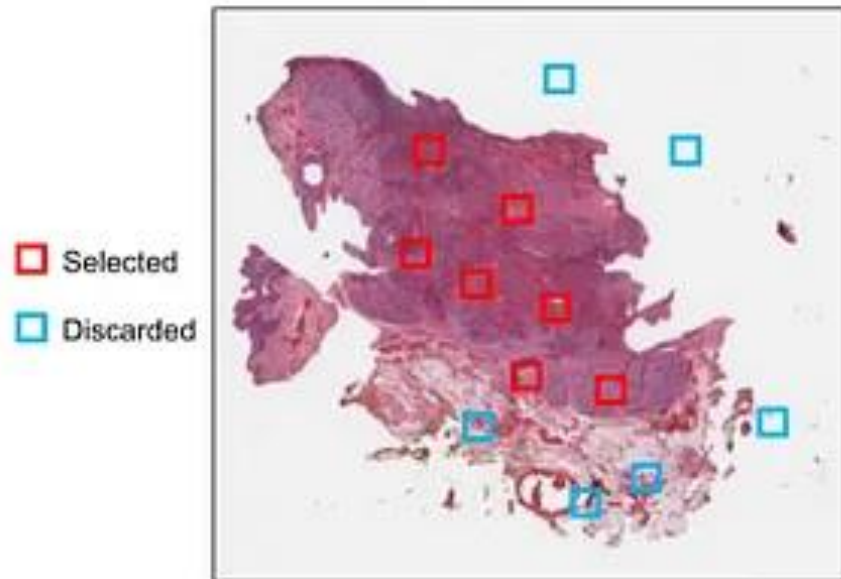
Completely Random Selection



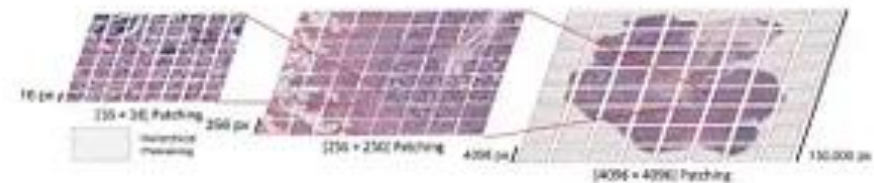
Random Selection with ROI



Feature-based Selection



Hierarchical Selection



Source: <https://github.com/mahmoodlab/HIPT>

Categories of Pooling Operations

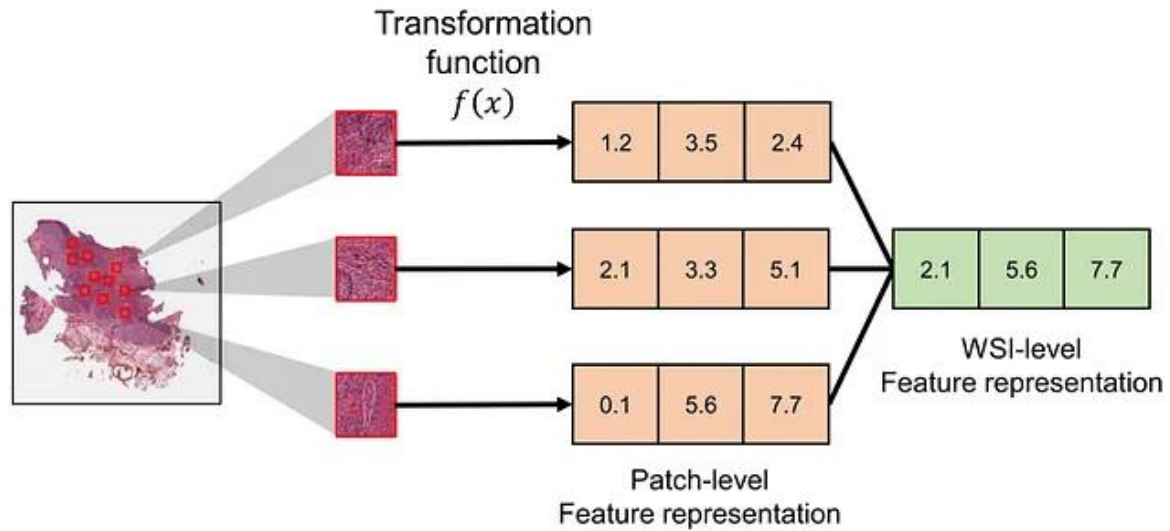
1- Static Pooling

2- Adaptive Pooling

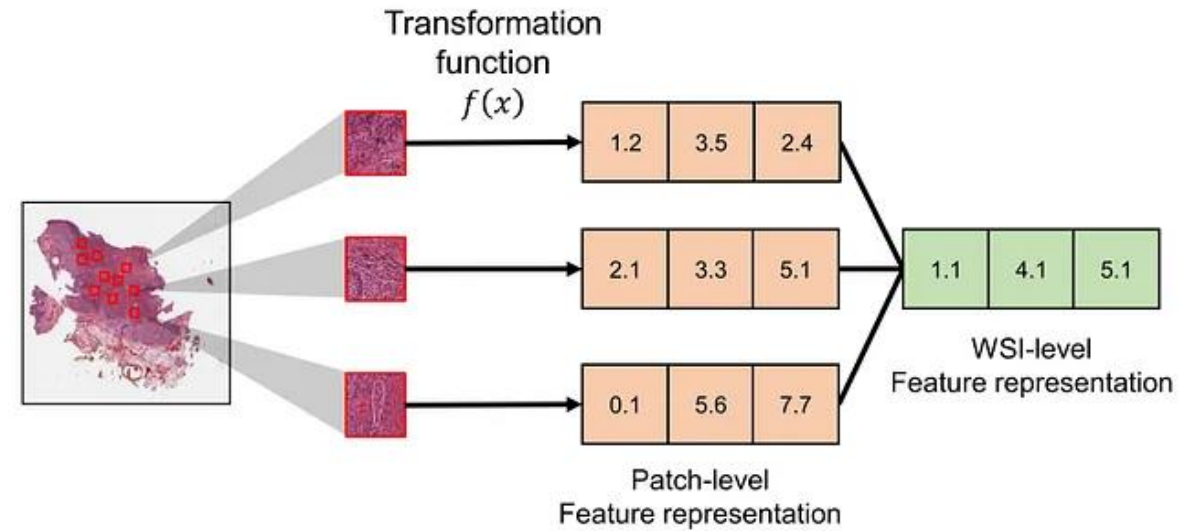
These methods adaptively update the patch contribution to its WSI. This category contains trainable pooling, dynamic pooling, differential evolutionary pooling, and so on. Generally, the adaptive pooling operation is changed iteration by iteration as we train the MIL-WSI framework. Interesting examples of this category are Attention-based pooling and Hopfield pooling, both of which belong to trainable pooling.

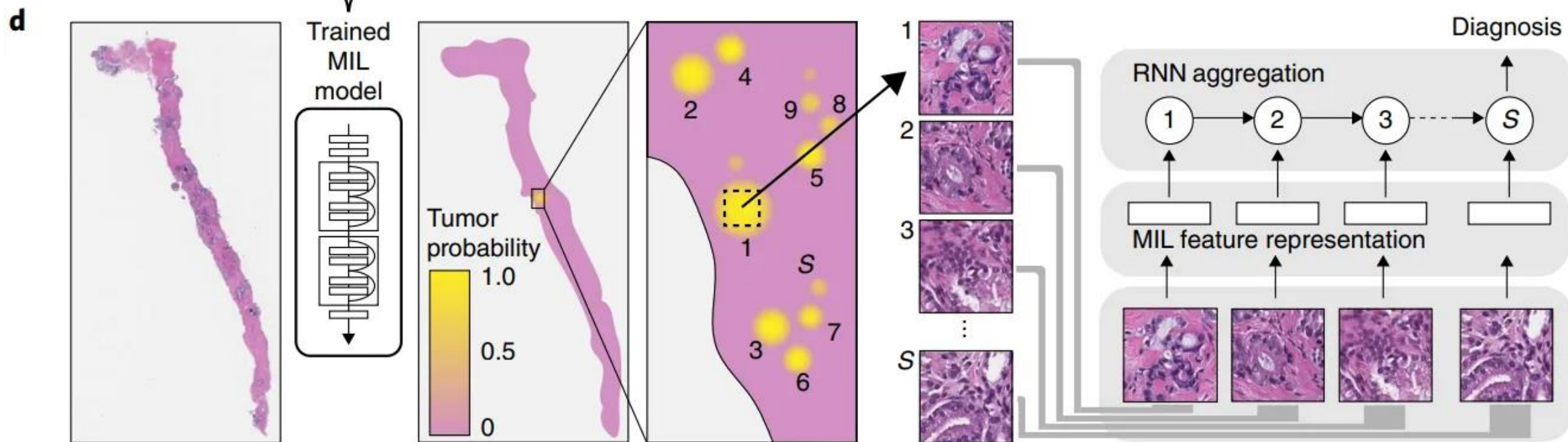
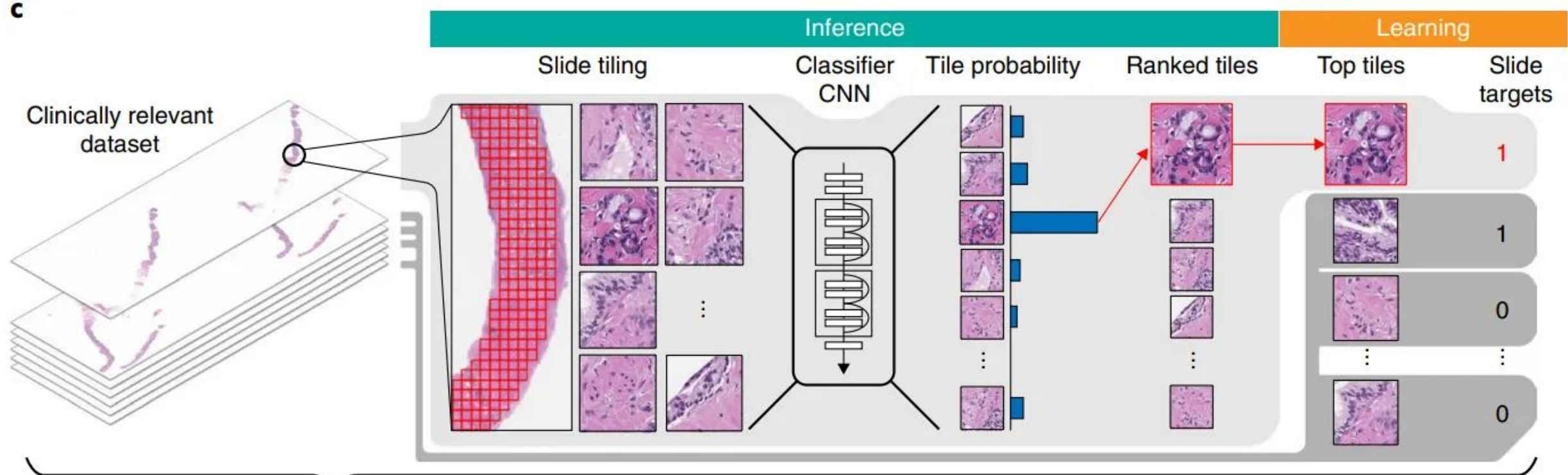
Static Pooling

Max Pooling



Average Pooling







Traditional Pathology

Education

Digital Pathology





Global **DIGITAL PATHOLOGY** Market

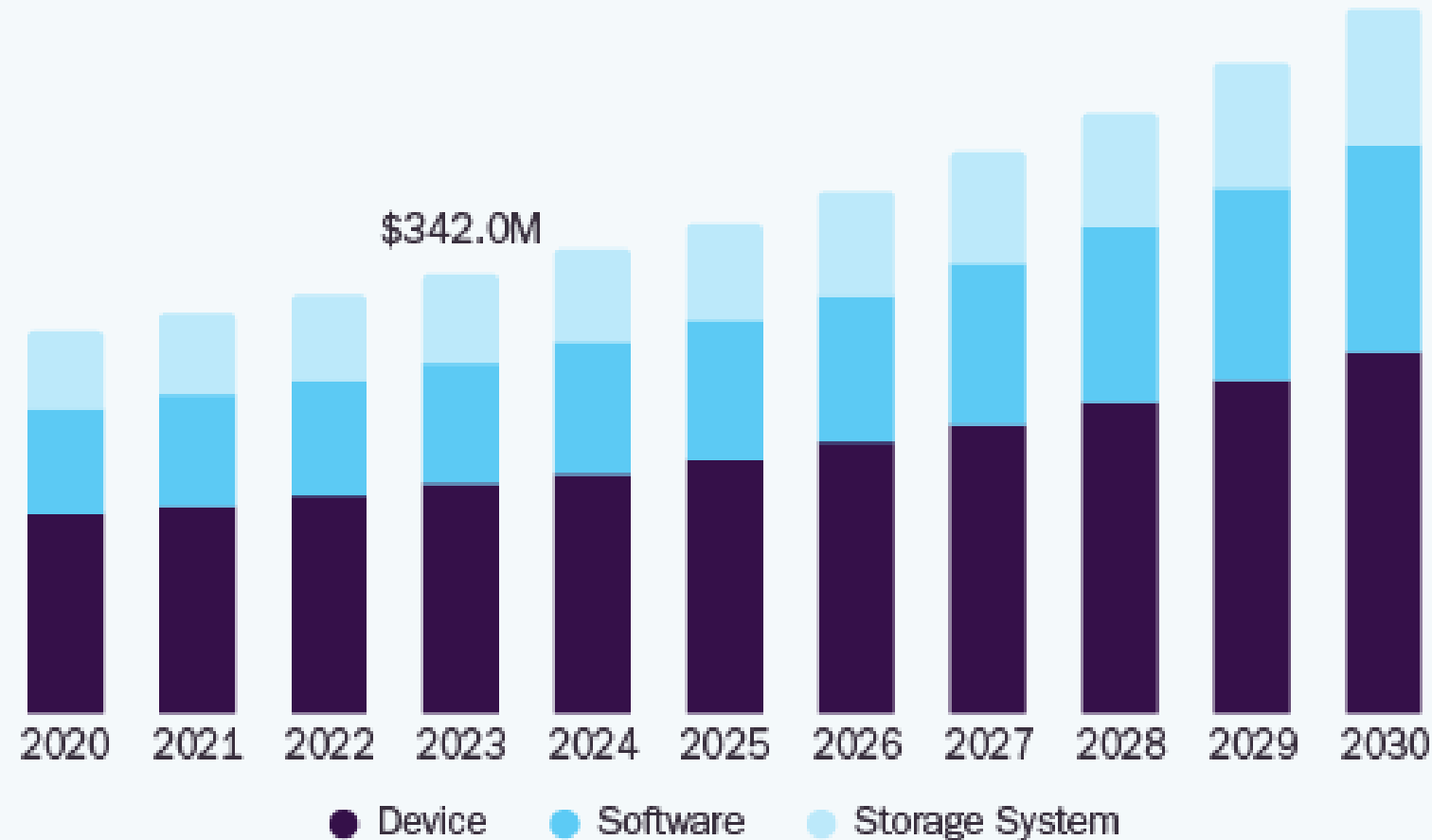
Opportunities and Forecasts,
2021-2030

Global Digital Pathology Market is expected
to reach **\$1791.3 Million** by 2030

Growing at a
CAGR of 9.3% (2021-2030)

U.S. Digital Pathology Market

Size, by Product, 2020 - 2030 (USD Million)



GRAND VIEW RESEARCH

7.2%

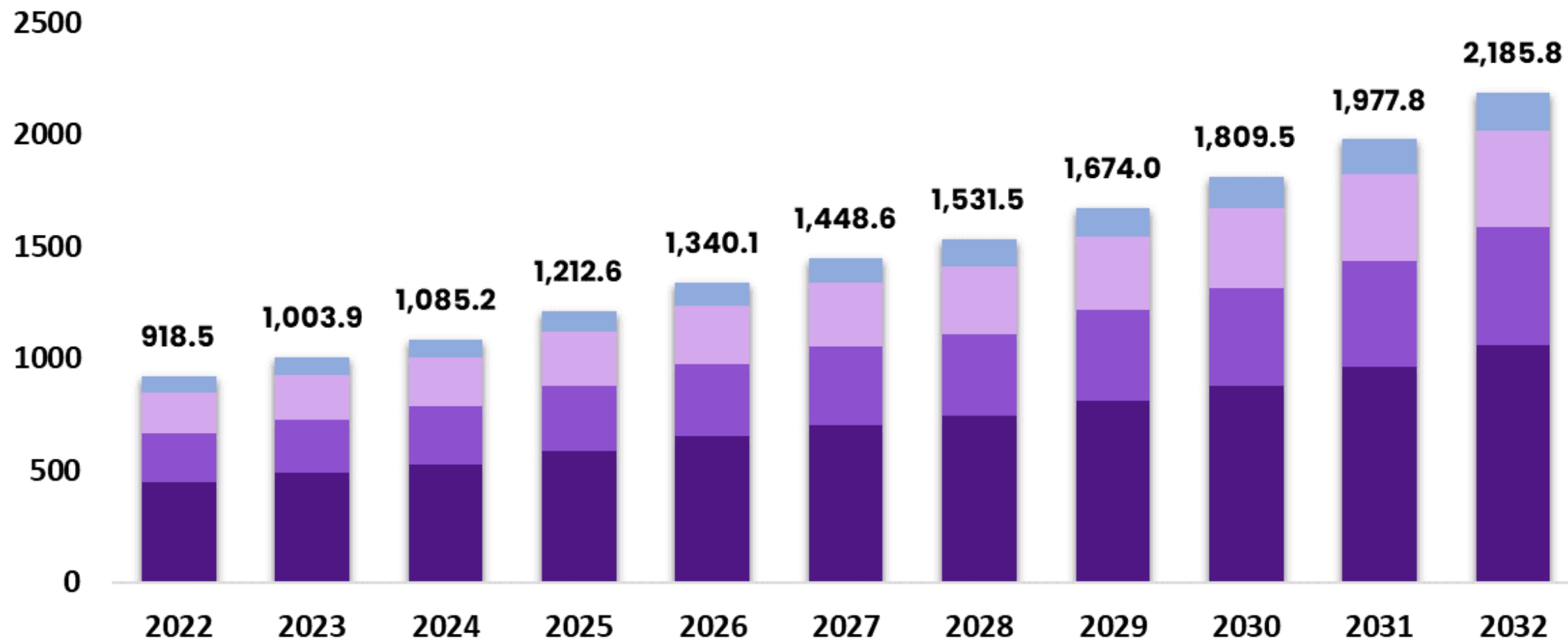
U.S. Market CAGR,
2024 - 2030

Source:
www.grandviewresearch.com

Global Digital Pathology Market

Size by Product 2022-2032 (USD Million)

- Scanner
- Storage Systems
- Software
- Other Products



The Market will Grow
At the CAGR of

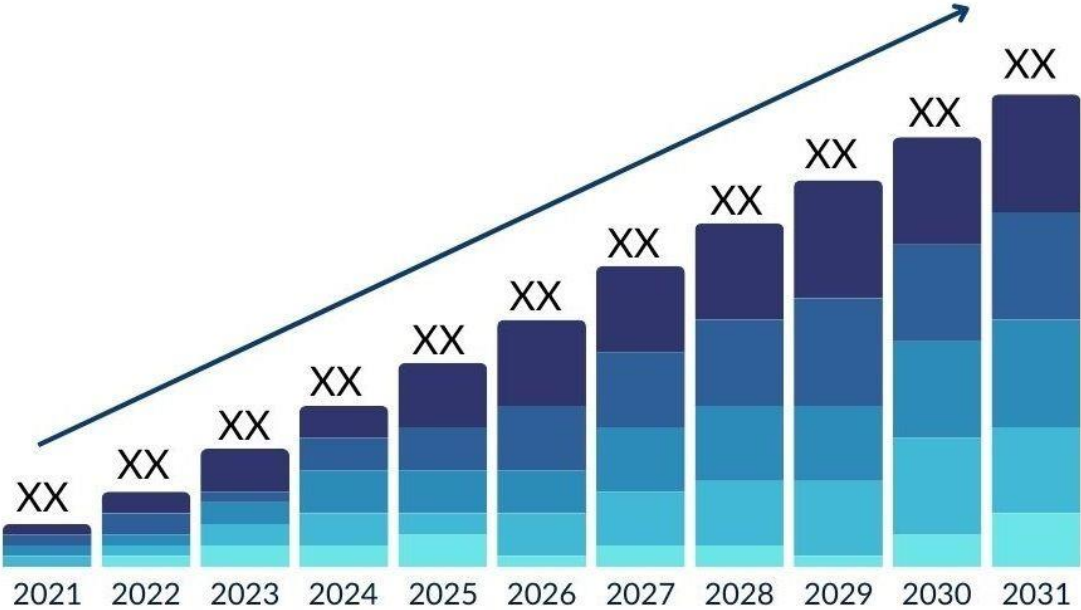
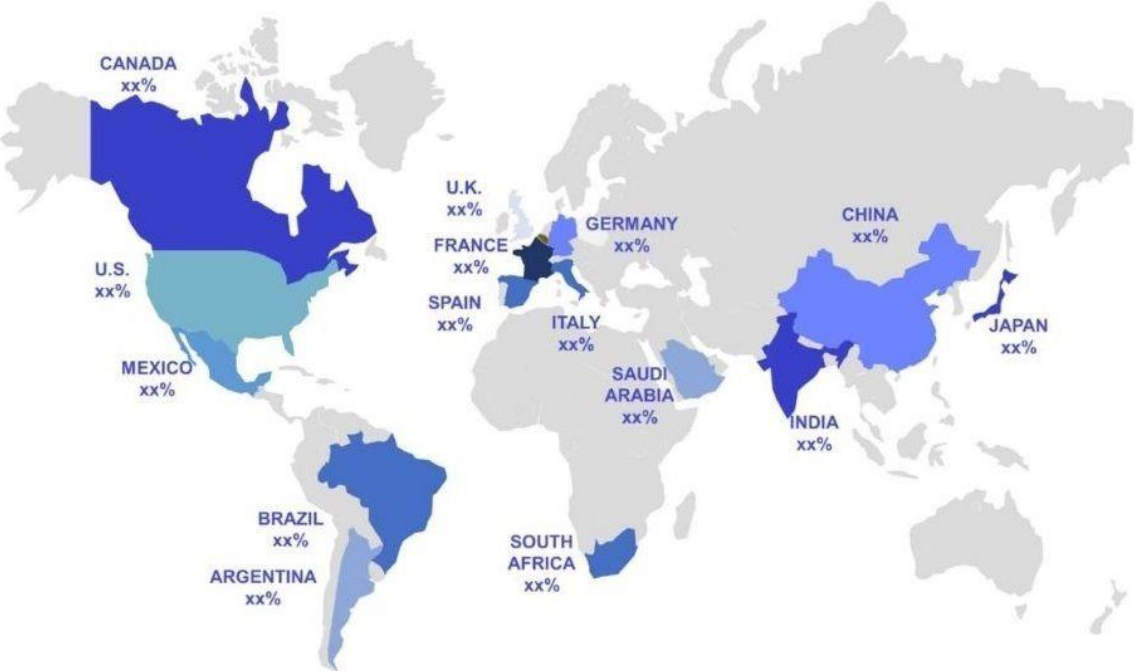
9.3% The forecasted market
size for 2032 in USD

\$2,185.8M

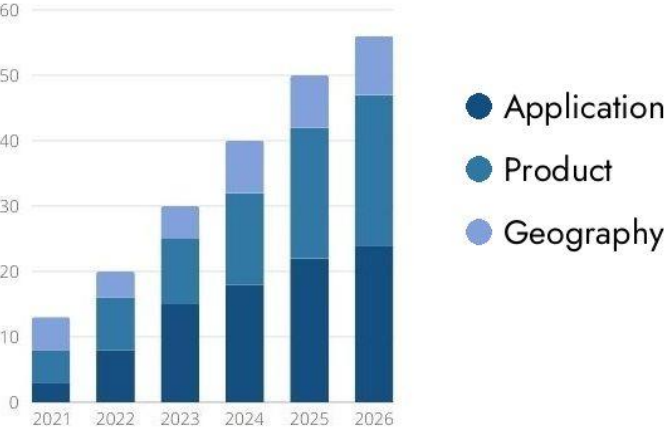


market.us
ONE STOP SHOP FOR THE REPORTS

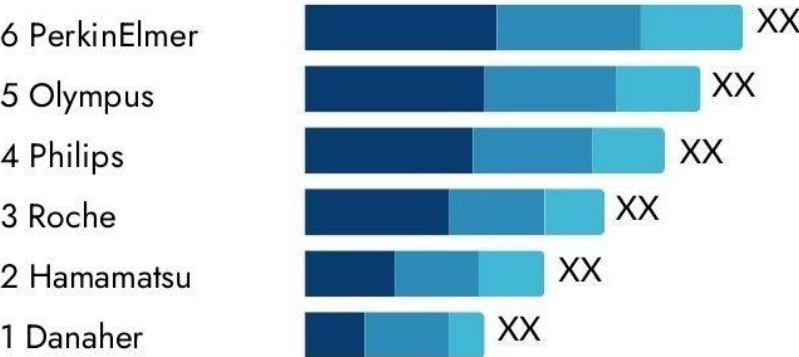
Global Digital Pathology Market Size and Scope



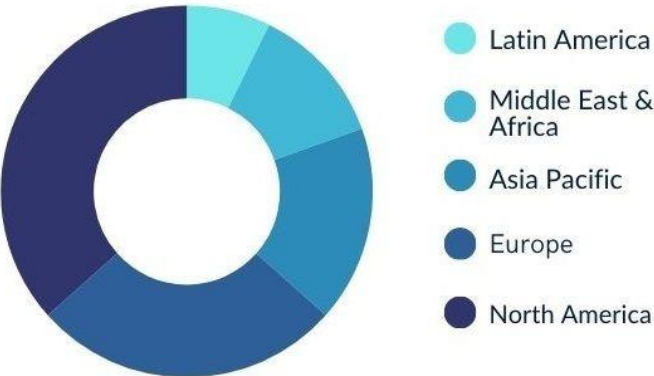
Market Segmentation



Top Key Players



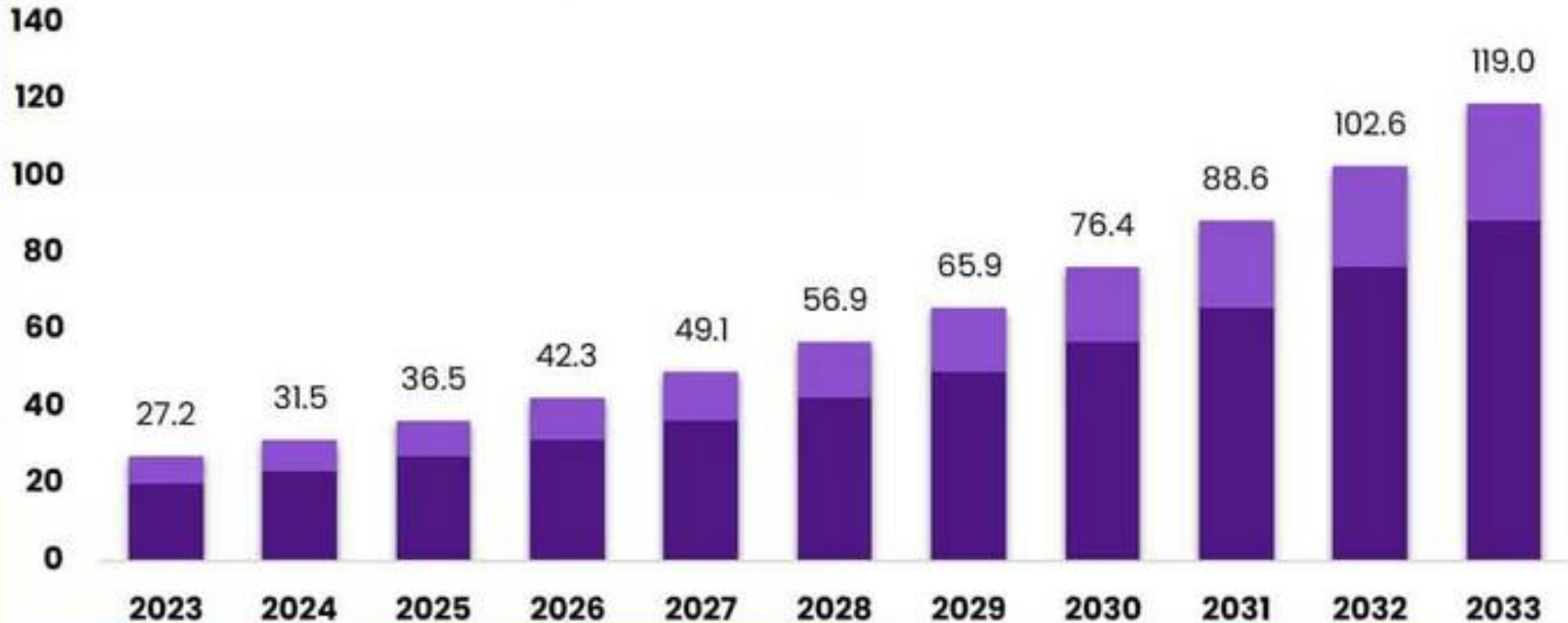
Regional Analysis



Global AI in Pathology Market

Size, by Component, 2023-2033 (USD Billion)

■ Software ■ Scanners



The Market will Grow
At the CAGR of:

15.9%

The Forecasted Market
Size for 2033 in USD:

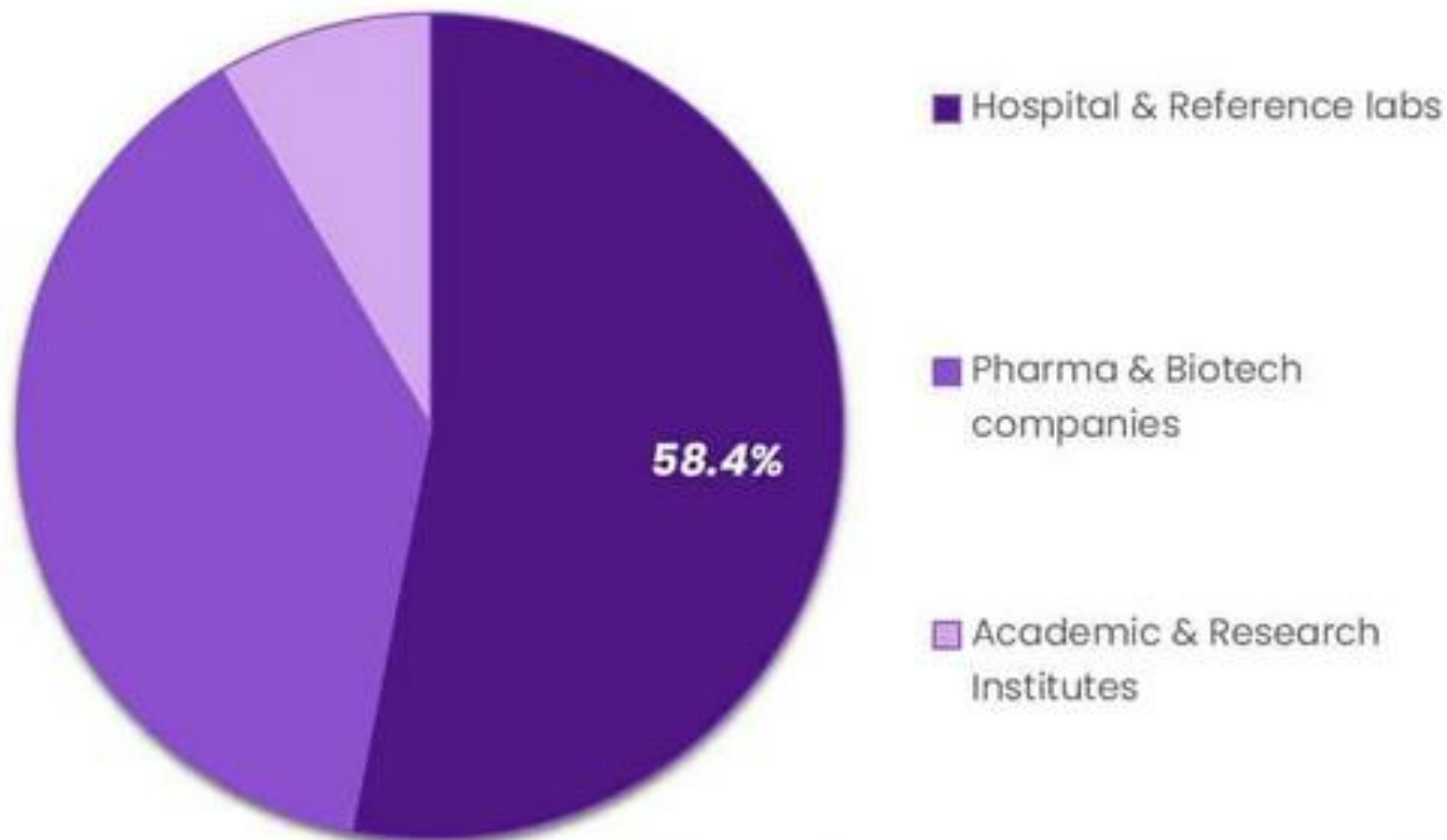
\$119.0 Bn



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Global AI in Pathology Market

Share, by End user, 2023 (%)



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\$27.2 B

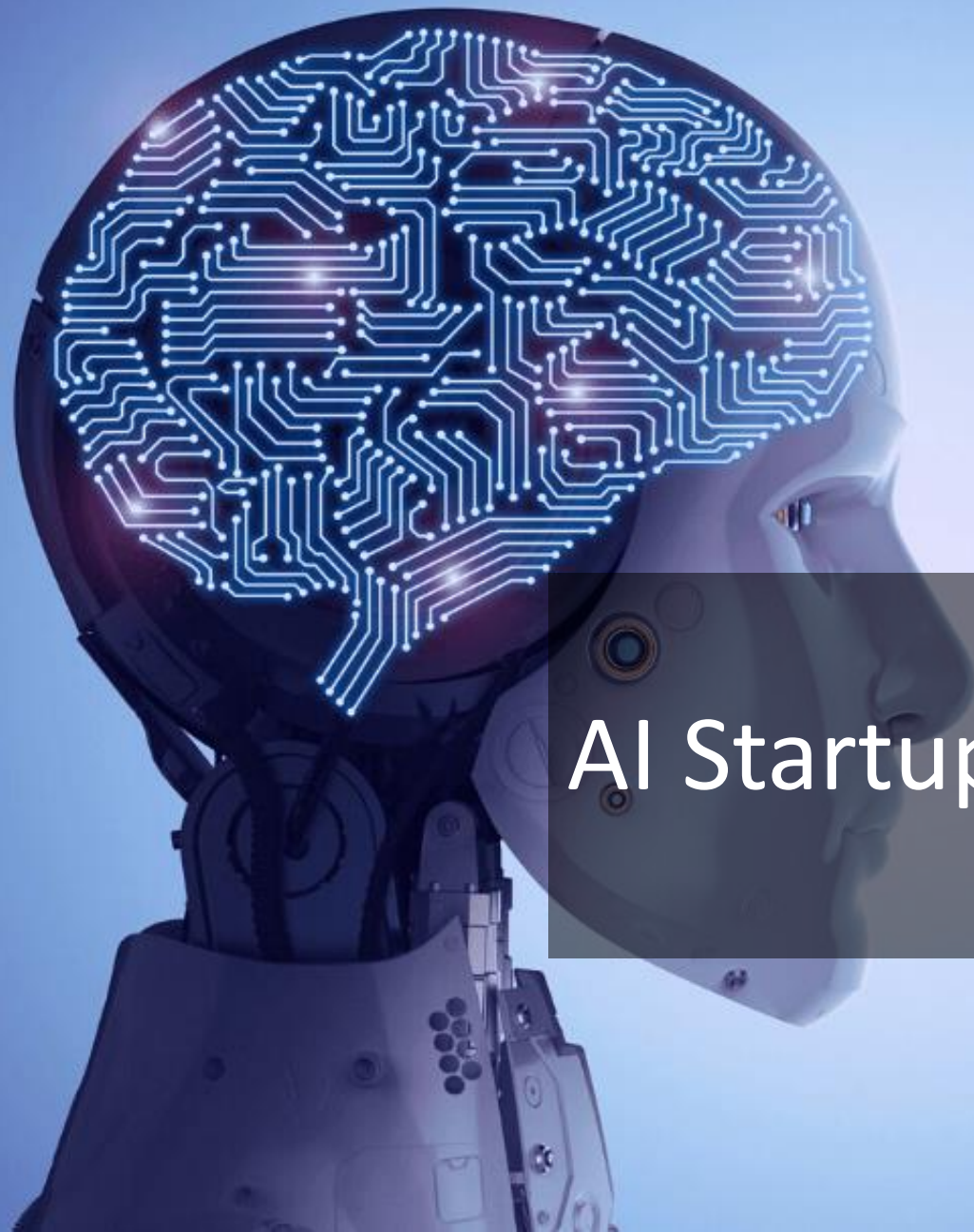
**Total Market Size
(USD Billion), 2023**

15.9%

**CAGR
2024-2033**

\$



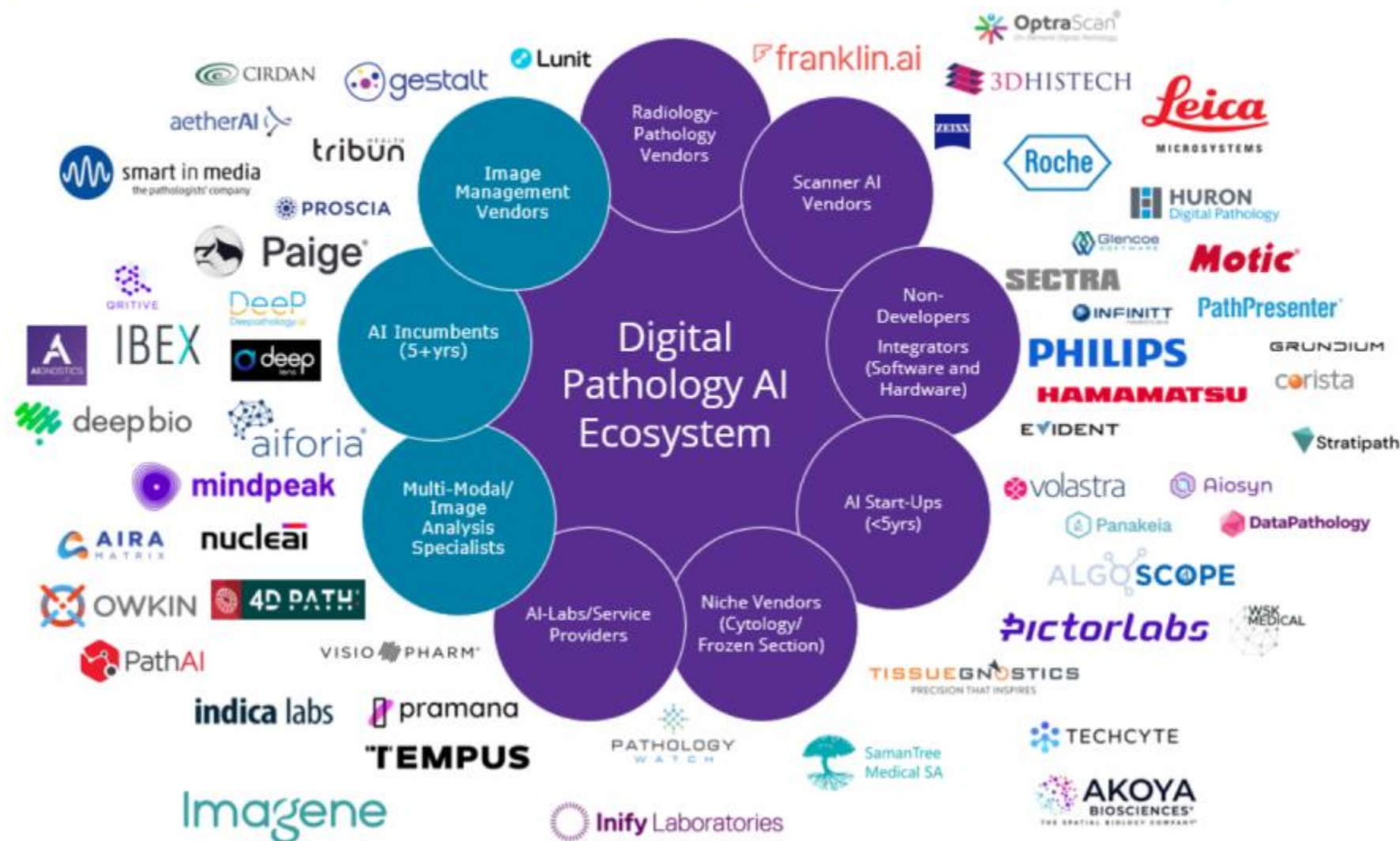


AI Startups and Companies

Companies



Digital Pathology AI Ecosystem







Thank you

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Email: said.Pirmoradi@gmail.com

Website: Khayyamlab.ir