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THE OHIO STATE UNIVERSITY
WEXNER MEDICAL CENTER

Implementing Digital Pathology For Clinical, Educational and Research Applications –The Nuts and Bolts

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The Ohio State University Comprehensive Cancer Center – Arthur G. James Cancer Hospital and Richard J. Solove Research Institute

The author has no relevant conflicts to disclose

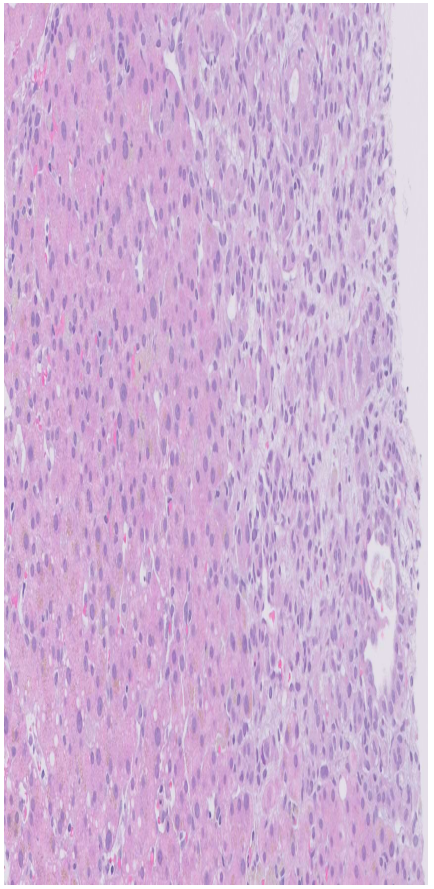

The Ohio State University
Medical Center


OHIO STATE


OHIO STATE

Objectives of my talks:

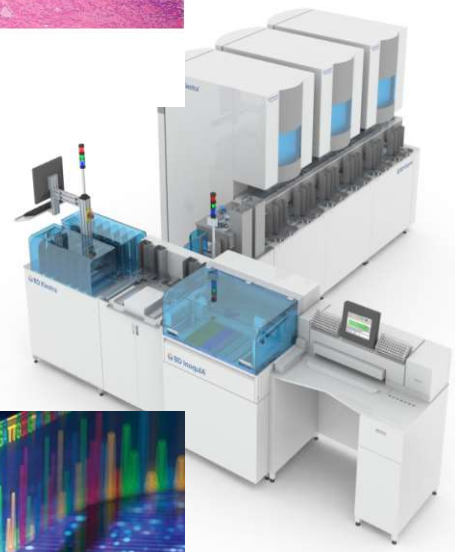
- *Provide an overview of the evolution of digital pathology and AI and its current state for clinical diagnostics, research and education*
- *Provide an understanding of the challenges and opportunities for implementing digital pathology and AI in the clinical areas using OSU as an example*
- *Explore the future directions of Digital Pathology /Artificial Intelligence technology's role in advanced diagnostics*

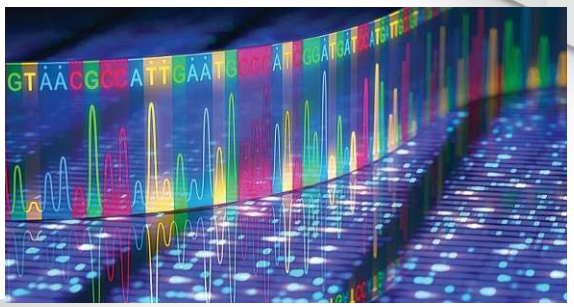


PATHOLOGY IS TRANSFORMING!!

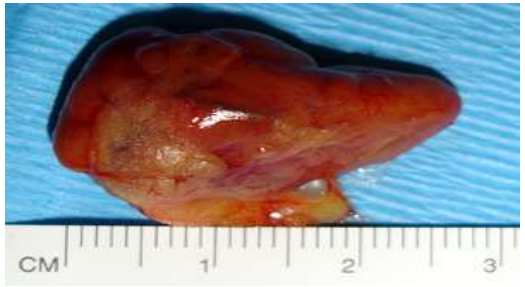
NEW TOOLS FOR HIGH VALUE CLINICAL DIAGNOSTICS

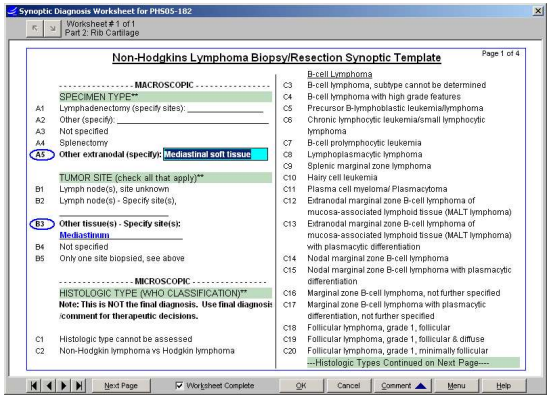
- Rapid innovations.
- More variety and complexities of available tests and services.
- New molecular tests, advanced equipment and testing techniques.
- More automation
- Digital and Computational pathology
- Artificial Intelligence





PATHOLOGY REPORTS ARE BECOMING MORE COMPLEX




Synoptic Diagnosis Worksheet for PHS05-182

Worksheet # 1 of 1
Part 2: Rib Cartilage

Non-Hodgkins Lymphoma Biopsy/Resection Synoptic Template

Page 1 of 4

MACROSCOPIC

SPECIMEN TYPE**

A1 Lymphadenectomy (specify sites): _____
A2 Other (specify): _____
A3 Not specified
A4 Splenectomy
A5 Other extranodal (specify): Mediastinal soft tissue

TUMOR SITE (check all that apply)**

B1 Lymph node(s), site unknown
B2 Lymph node(s) - Specify site(s), _____
B3 Other tissue(s) - Specify site(s): Mediastinum
B4 Not specified
B5 Only one site biopsied, see above

MICROSCOPIC

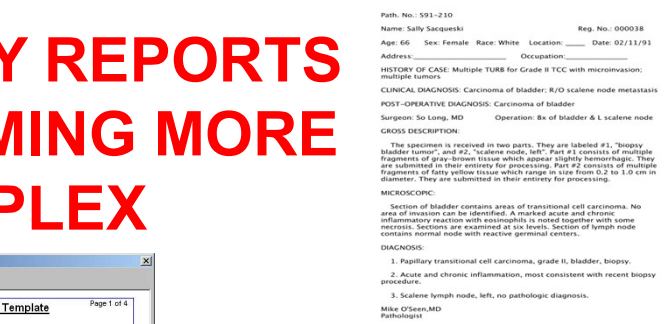
HISTOLOGIC TYPE (WHO CLASSIFICATION)**
Note: This is NOT the final diagnosis. Use final diagnosis /comment for therapeutic decisions.

C1 Histologic type cannot be assessed
C2 Non-Hodgkin lymphoma vs Hodgkin lymphoma

B-cell Lymphoma

C3 B-cell lymphoma, subtype cannot be determined
C4 B-cell lymphoma with high grade features
C5 Precursor B-lymphoblastic leukemia/lymphoma
C6 Chronic lymphocytic leukemia/small lymphocytic lymphoma
C7 B-cell prolymphocytic leukemia
C8 Lymphoplasmacytic lymphoma
C9 Splenic marginal zone lymphoma
C10 Hairy cell leukemia
C11 Plasma cell myeloma/ Plasmacytoma
C12 Extranodal marginal zone B-cell lymphoma of mucosa-associated lymphoid tissue (MALT lymphoma)
C13 Extranodal marginal zone B-cell lymphoma of mucosa-associated lymphoid tissue (MALT lymphoma) with plasmacytic differentiation
C14 Nodal marginal zone B-cell lymphoma
C15 Nodal marginal zone B-cell lymphoma with plasmacytic differentiation
C16 Marginal zone B-cell lymphoma, not further specified
C17 Marginal zone B-cell lymphoma with plasmacytic differentiation, not further specified
C18 Follicular lymphoma, grade 1, follicular
C19 Follicular lymphoma, grade 1, follicular & diffuse
C20 Follicular lymphoma, grade 1, minimally follicular
---Histologic Types Continued on Next Page----

Next Page | Worksheet Complete | OK | Cancel | Comment | Menu | Help


Path. No.: S91-210
Name: Sally Sacqueski Reg. No.: 000038
Age: 66 Sex: Female Race: White Location: ____ Date: 02/11/91
Address: _____ Occupation: _____

HISTORY OF CASE: Multiple TURB for Grade II TCC with microinvasion; multiple tumors

CLINICAL DIAGNOSIS: Carcinoma of bladder; R/O scalene node metastasis

POST-OPERATIVE DIAGNOSIS: Carcinoma of bladder

Surgeon: So Long, MD Operation: Bx of bladder & L scalene node

GROSS DESCRIPTION:

The specimen is received in two parts. They are labeled #1, "biopsy bladder tumor", and #2, "scalene node, left". Part #1 consists of multiple fragments of gray-brown tissue which appear slightly hemorrhagic. They are submitted in their entirety for processing. Part #2 consists of multiple fragments of fatty yellow tissue which range in size from 0.2 to 1.0 cm in diameter. They are submitted in their entirety for processing.

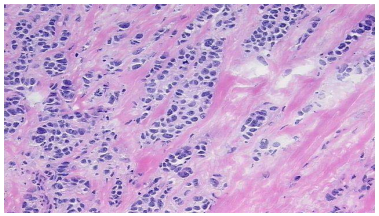
MICROSCOPIC:

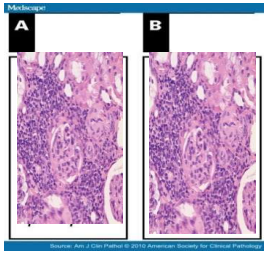
Section of bladder contains areas of transitional cell carcinoma. No area of invasion can be identified. A marked acute and chronic inflammatory reaction with eosinophils is noted together with some necrosis. Sections are examined at six levels. Section of lymph node contains normal node with reactive germinal centers.

DIAGNOSIS:

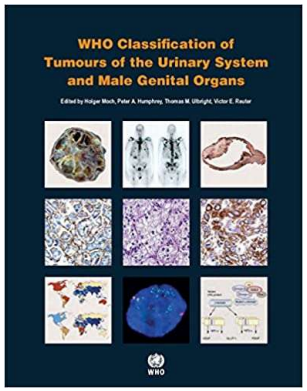
1. Papillary transitional cell carcinoma, grade II, bladder, biopsy.
2. Acute and chronic inflammation, most consistent with recent biopsy procedure.
3. Scalene lymph node, left, no pathologic diagnosis.

Mike O'Seen,MD
Pathologist





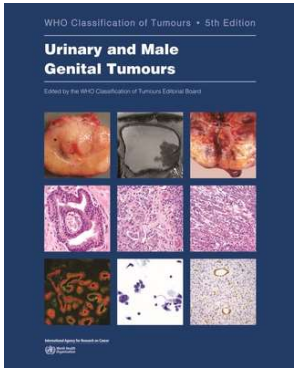
4th Edition, 2016



356 pages

EXPLOSION OF KNOWLEDGE!!!

5th Edition, 2022

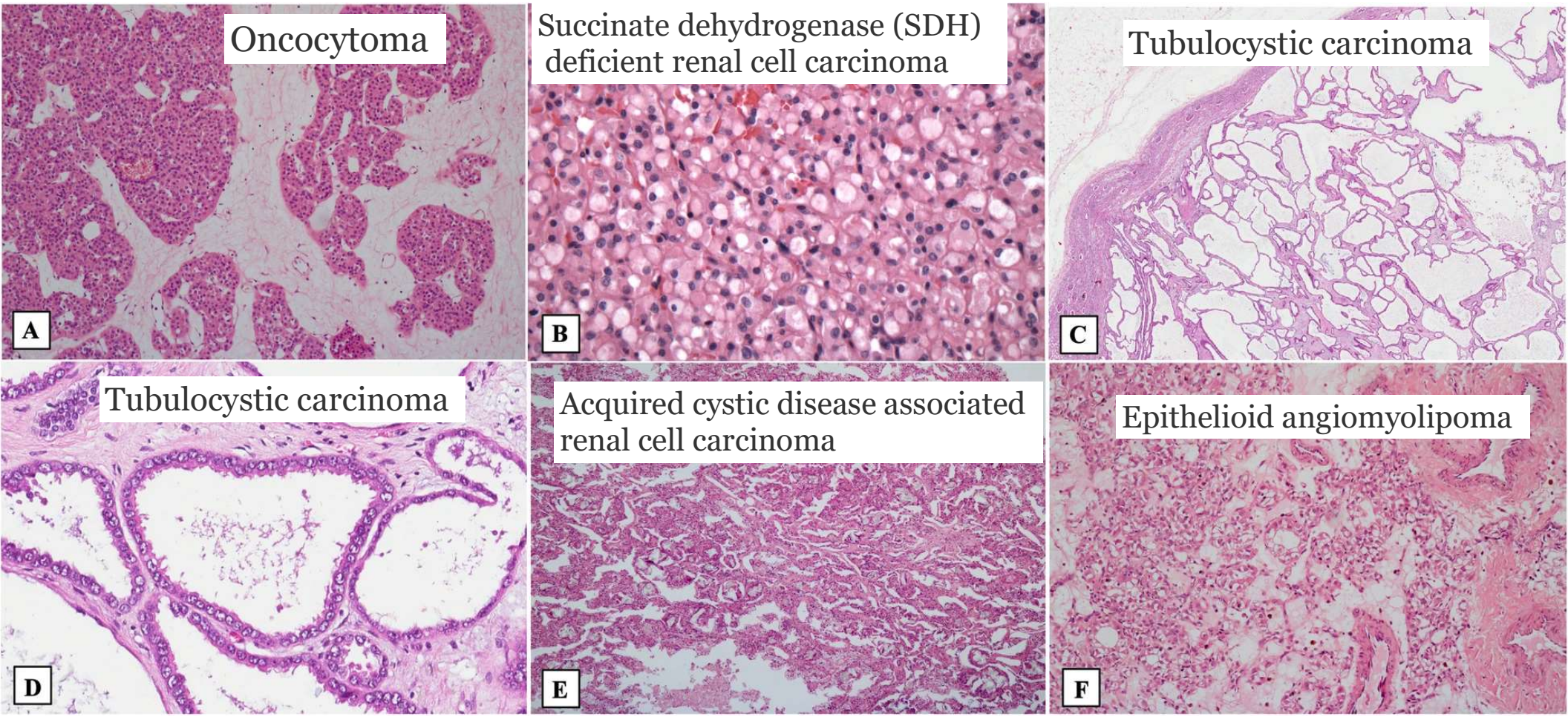


590 pages

The explosion of medical information

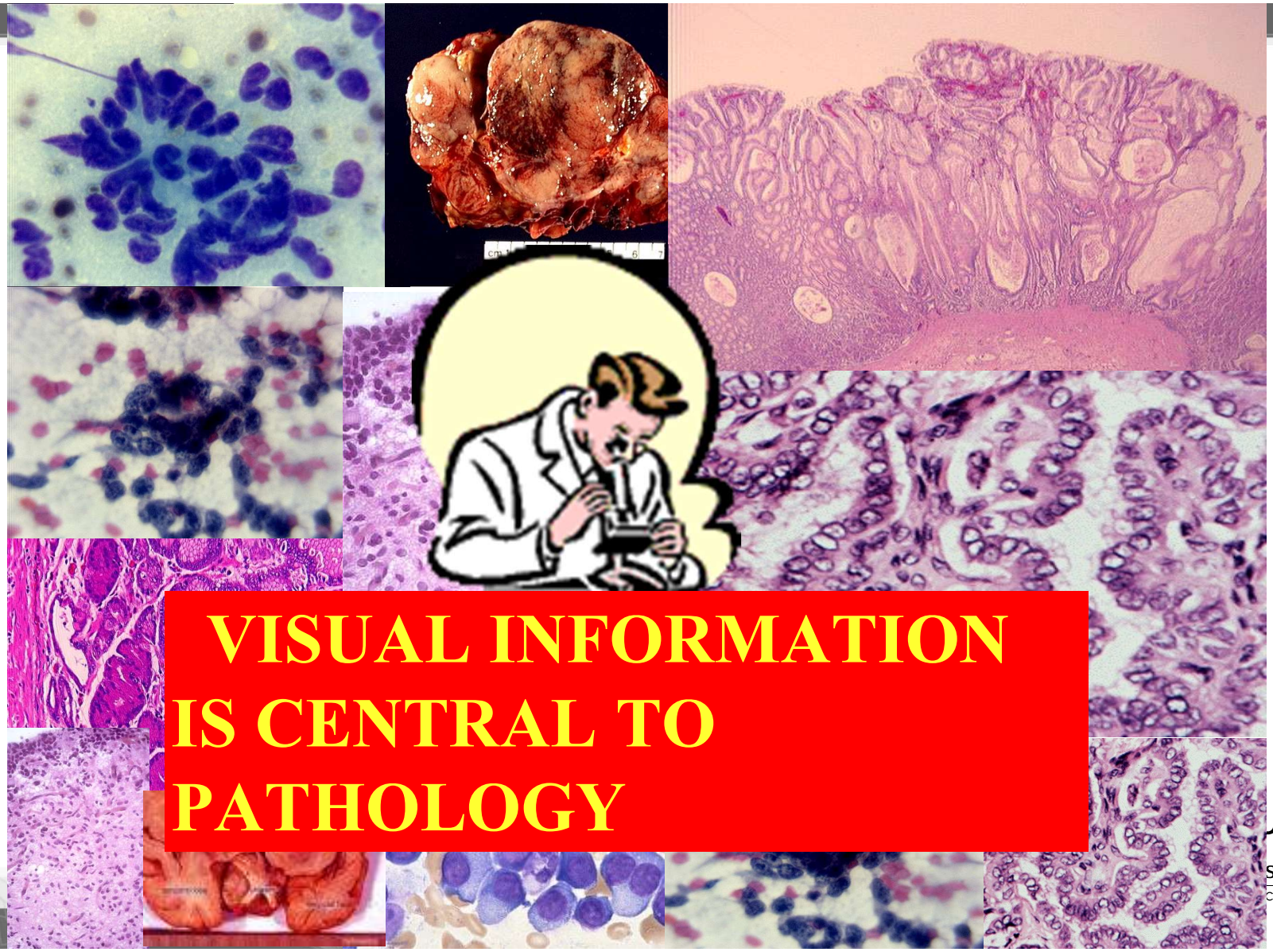
Molecular and Genomics

SITY



Oncocytic renal tumors and some of their differential diagnoses

Athanazio, D.A., Amorim, L.S., da Cunha, I.W. *et al.* Classification of renal cell tumors – current concepts and use of ancillary tests: recommendations of the Brazilian Society of Pathology. *Surg Exp Pathol* **4,** 4 (2021).



VISUAL INFORMATION IS CENTRAL TO PATHOLOGY

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STATE UNIVERSITY

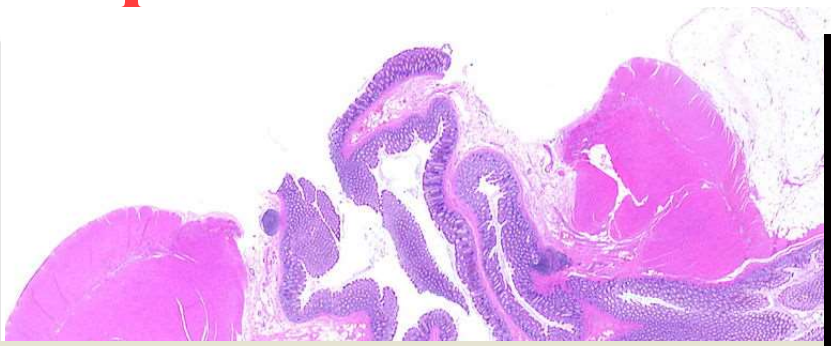
CAL CENTER

H&E SLIDE = THE GOLD STANDARD

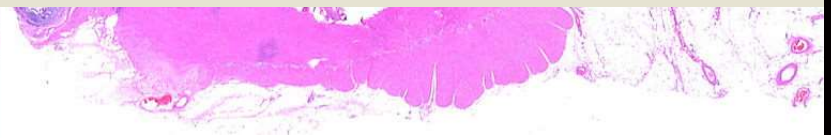
THE H&E SLIDE FOR THE PATHOLOGIST IS EQUIVALENT TO A GOOD H&P

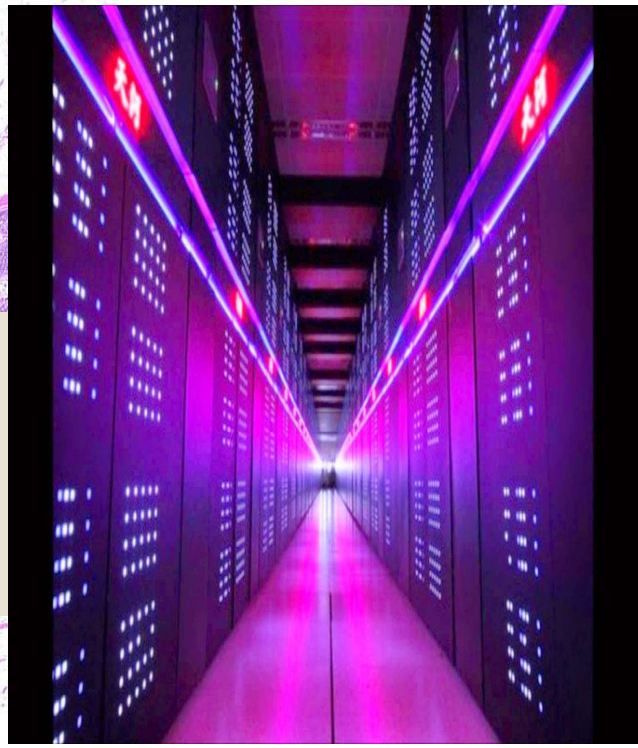
Accurate interpretation of the hematoxylin and eosin (H&E) slide has remained the foundation of pathological analysis and diagnostic medicine for over a century

Powerful microscope = Whole Slide Imaging (WSI)



COMPUTATIONAL PATHOLOGY/AI





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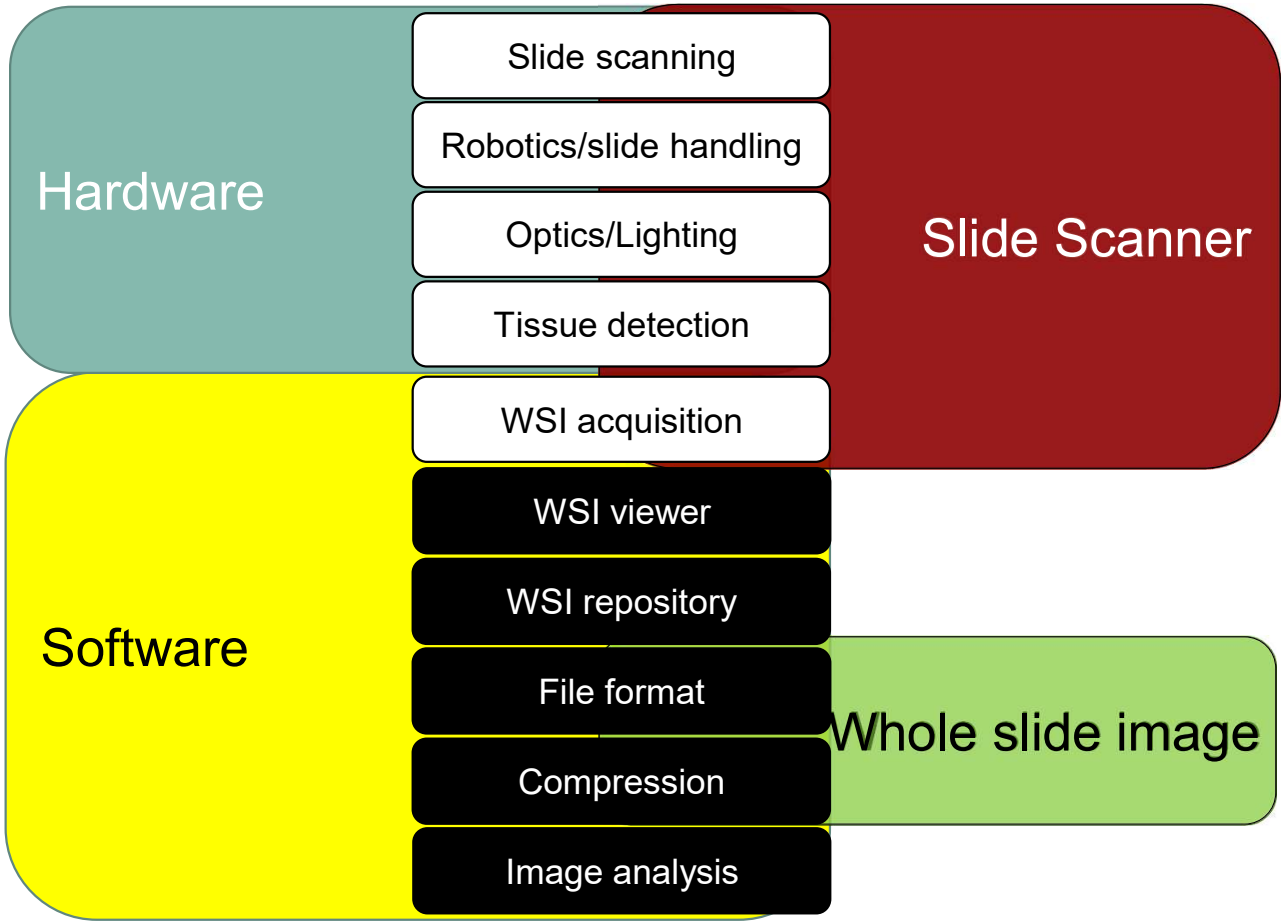
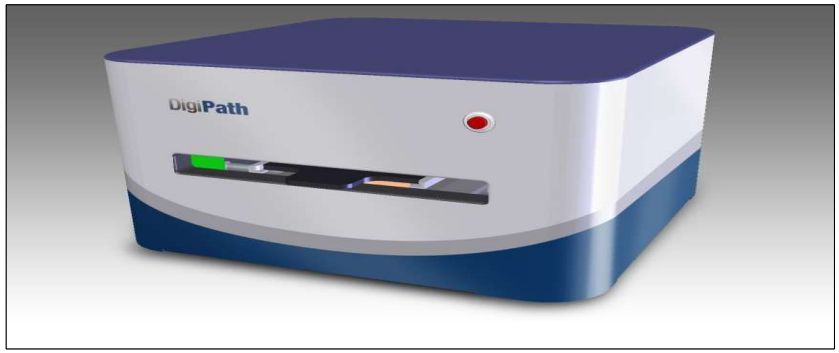
Digital Pathology Subsystem

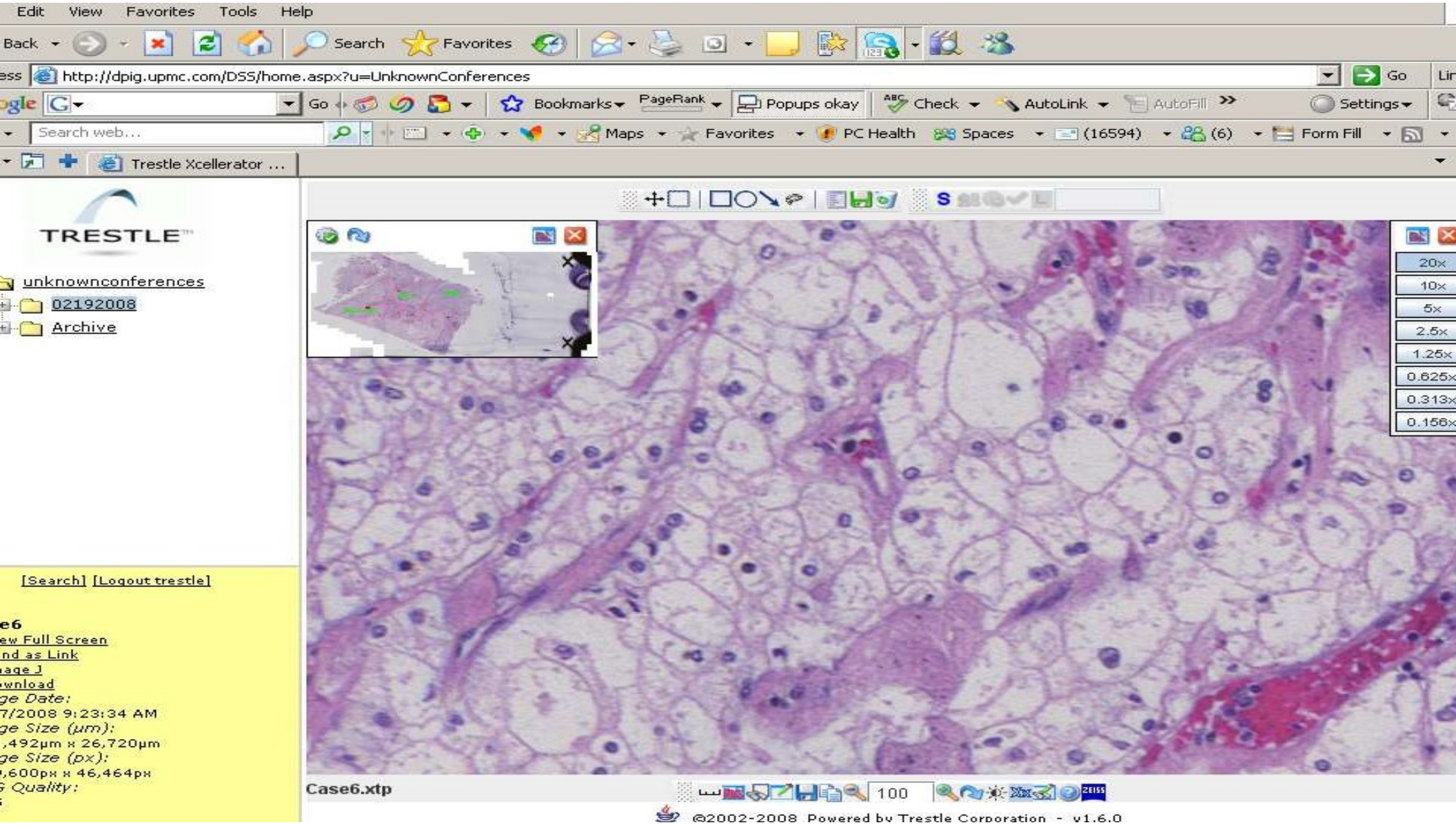
Hardware
- Whole slide scanner
- Robotic Scanners
- Monitors
- Input devices

Software
- WSI viewer
- Applications
- Algorithms



WSI scanners

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Bookmarks PageRank Popups okay Check AutoLink AutoFill Settings
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20x
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2.5x
1.25x
0.625x
0.313x
0.156x
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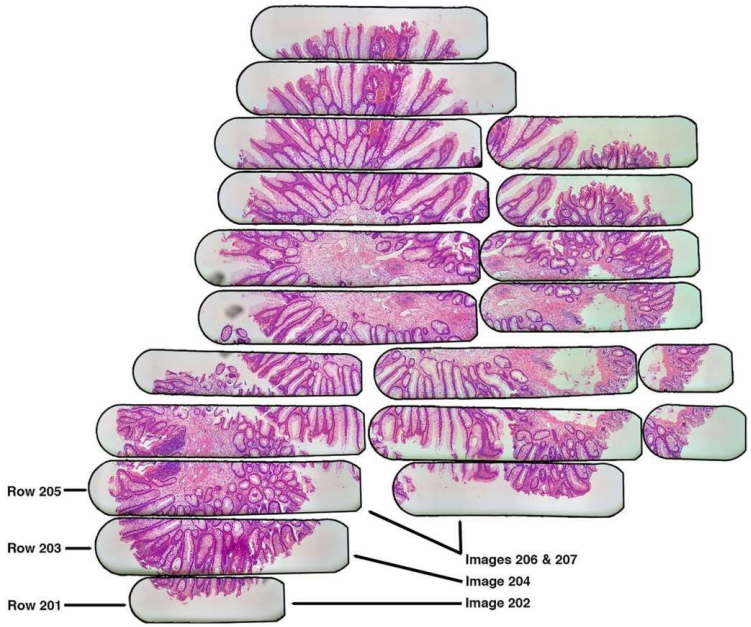
STATE OF THE WSI INDUSTRY

•Automated, high-speed, high resolution whole slide imaging systems

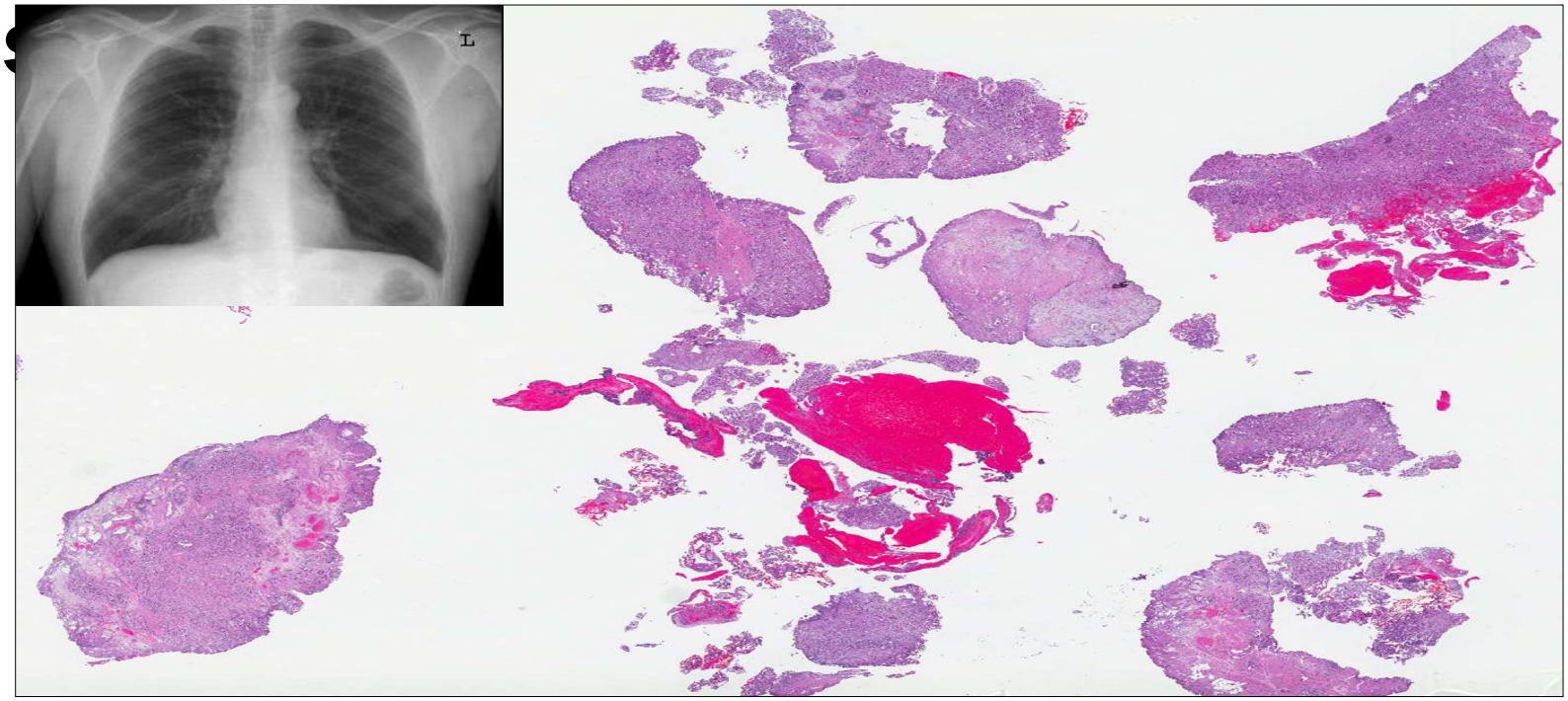
•Scan 1 to 1000 slides, even reading barcodes on slides.

•1.5 x1.5 cm tissue section in approximately 1-4 minutes with spatial sampling periods of between 0.25 to 0.5 microns/pixel.



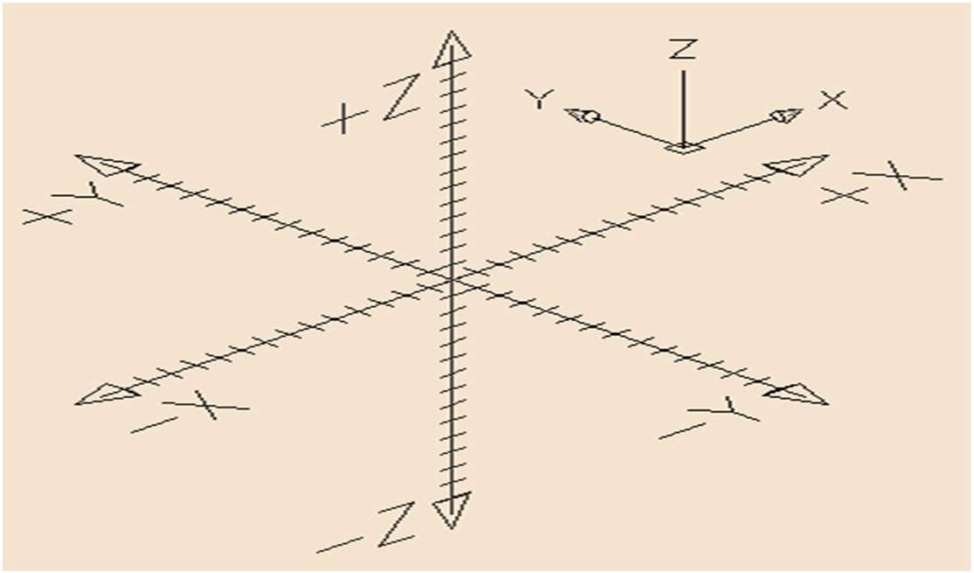
Up to 100 slides per hour, 2000 slides per day (at 40x resolution, 0.25 µm/pixel, single layer).

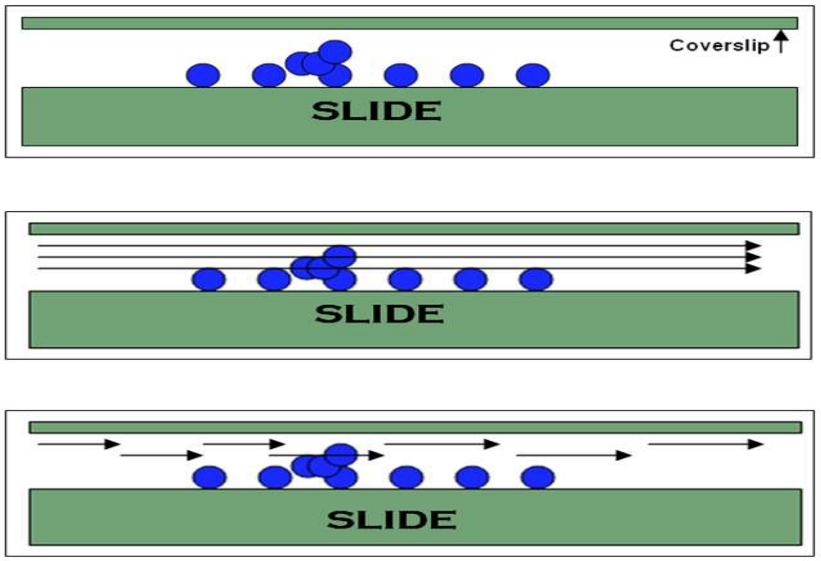
Magnitude of whole slide image dataset

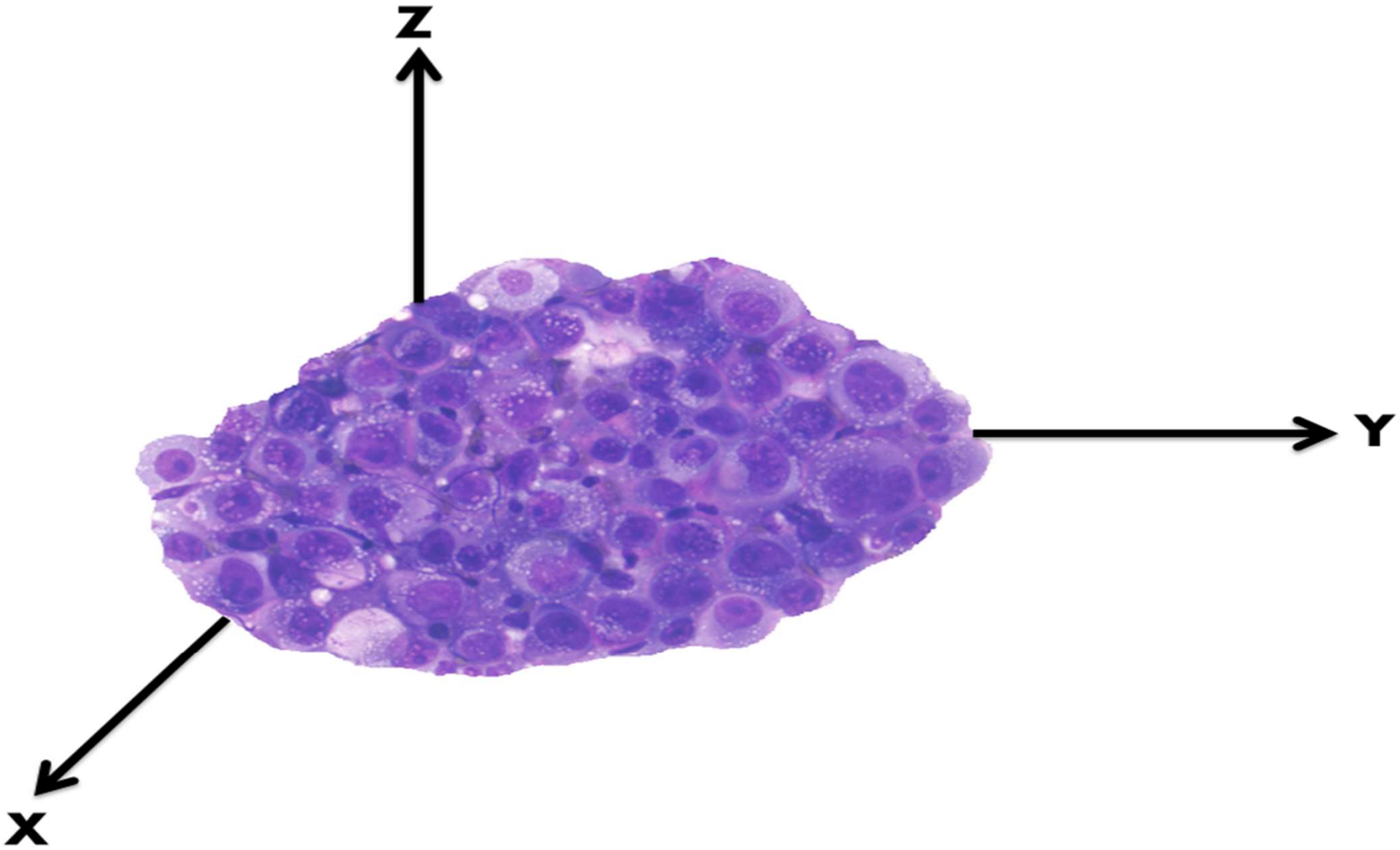


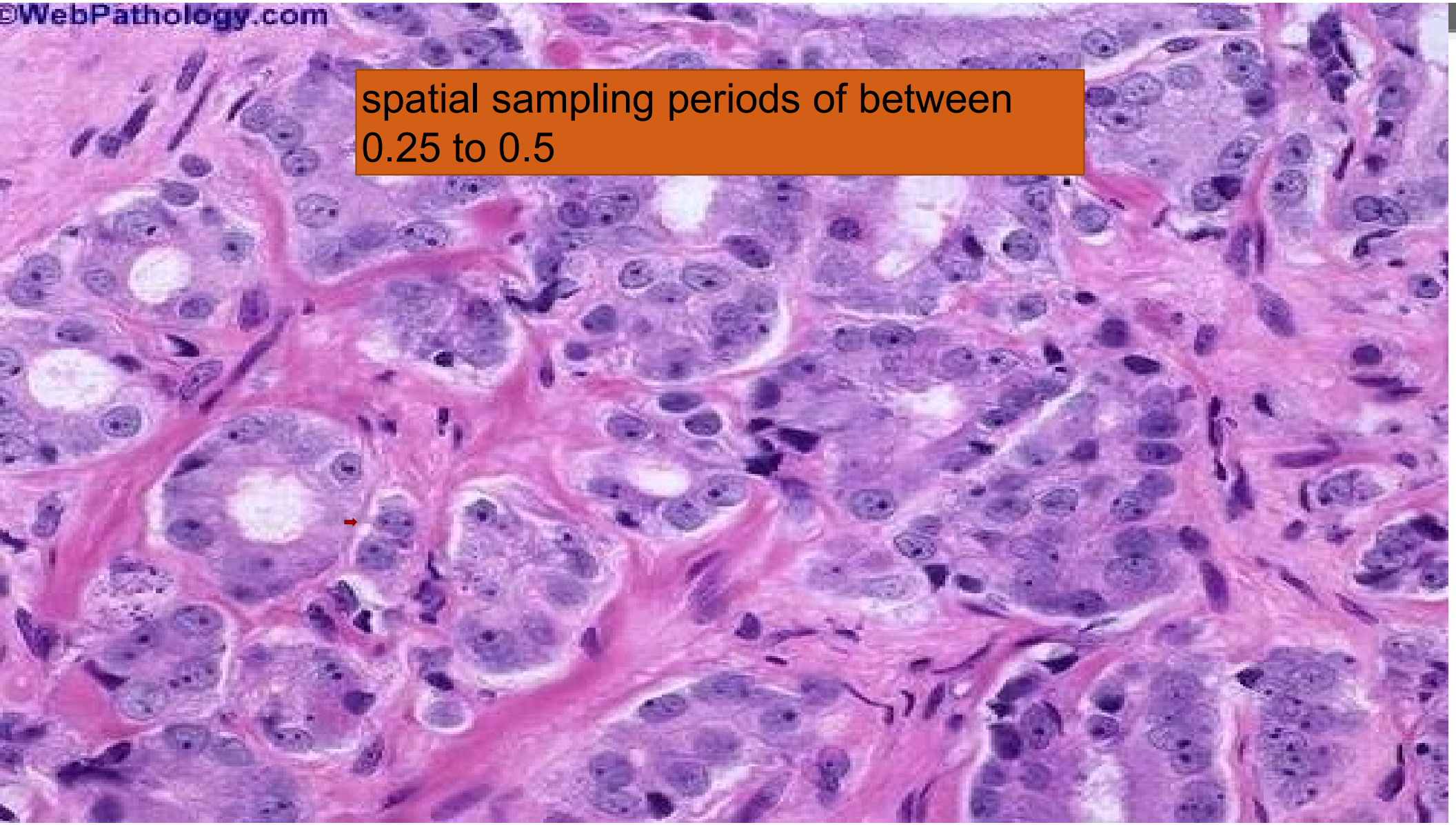
In terms of total pixel-normalized display in the same field of view, a 2k x 2k pixel digital radiographic chest X-ray image (A) is dwarfed when compared to a 40x scan of a typical 2.5 x 2.0 cm biopsy (654Mb with 20:1 loss compression).

Z stacking





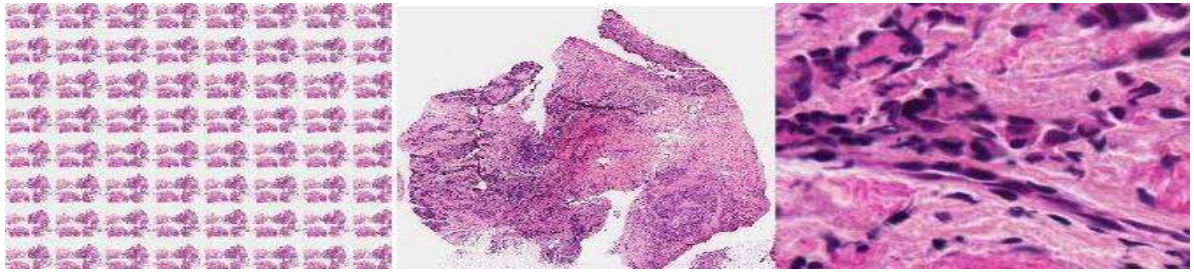

Z
Y
X

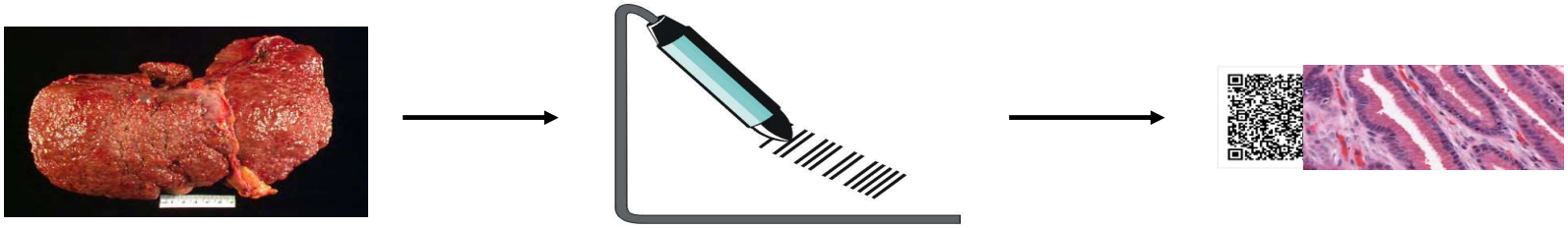

©WebPathology.com
spatial sampling periods of between
0.25 to 0.5

COMBINING MORPHOLOGY WITH PATIENT INFORMATION:
AP-LIS INTEGRATION IS KEY

AP-LIS ⟷ Digital Workstation

MULTIPLE AREAS OF THE PATHOLOGY LAB HAVE MANUAL STEPS, AND LACK STANDARDIZATION



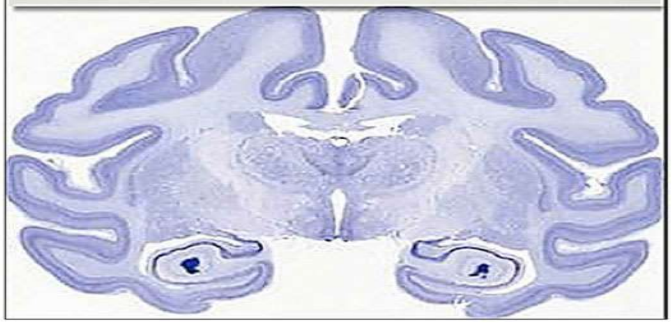


AUTOMATION AND STANDARDIZATION OF WORFLOW IS CRITICAL

FACTORS TO CONSIDER WHEN SELECTING AN WSI

- Type of lab and application
  - Reference/research/public health
  - Clinical
  - Hybrid
- Volume of specimens
- Types and number of slides
- Size of staff/users
- Existing system
  - Determine which areas will be affected
- Requirements and expectations
  - Be realistic
  - Adoption issues

Some WSI Imaging Devices



NEWER TECHNOLOGIES: COST DECREASING

MICROSCOPE WITH DIGITAL CAMERA	WHOLE SLIDE SCANNERS	ROBOTIC MICROSCOPES	IMAGE ANALYSIS SYSTEMS
			
			

WHOLE SLIDE IMAGING: Decade of Evolution

COST **ADOPTION**

Whole Slide Scanners

Favorable Regulatory Environment for AI/Digital Pathology

The Food and Drug Administration (FDA) has approved a number of digital pathology solutions for use in the United States

Paige

April 13, 2017

Philips receives FDA clearance to market Philips Intellisite Pathology Solution for primary diagnostic use in the US

May 29, 2019

Leica Biosystems receives FDA clearance for Aperio AT2 DX digital pathology system for primary diagnosis

Sept 21, 2021

(FDA) has granted de novo marketing authorization for Paige Prostate, a clinical-grade AI solution for prostate cancer detection

Favorable Regulatory Environment for AI/Digital Pathology

The Food and Drug Administration (FDA) has approved a number of digital pathology solutions for use in the United States

Hamamatsu Photonics Announces U.S. FDA clearance for the NanoZoomer S360MD Slide scanner system for Surgical Pathology Diagnostics

2022/10/04

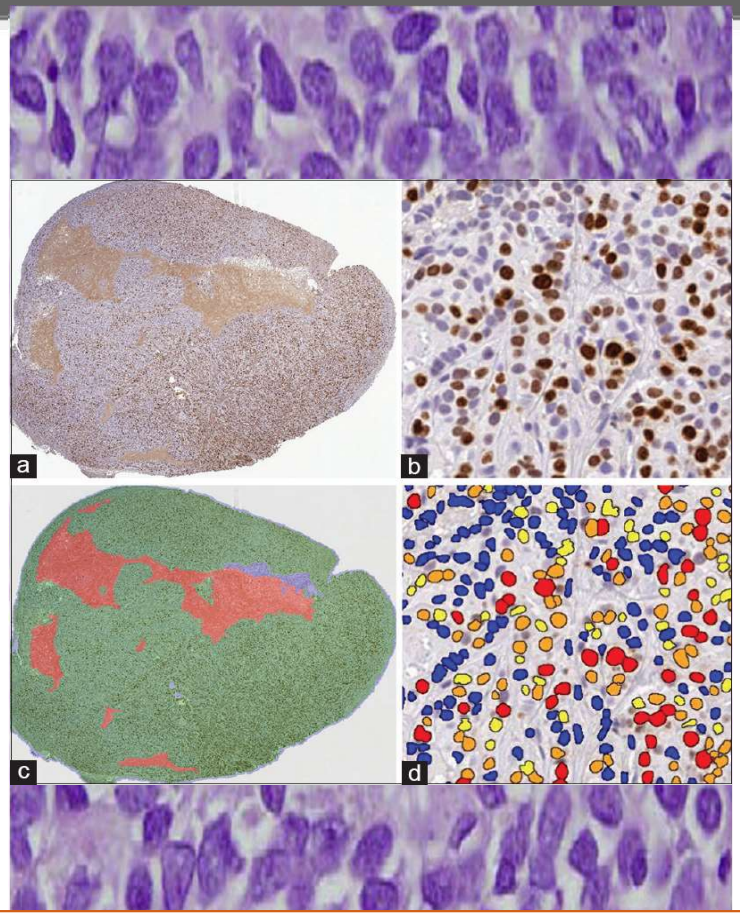
10/04/2022

Digital slides will introduce new costs!

- New capital equipment
  - Scanners
  - Servers
  - Storage (terabytes per week! But storage is cheap)
  - BARCODES are a MUST

Challenges in Pathology Today

- Lack of standardization
- Subjective diagnosis
- Manual process
- Shortage of pathologists worldwide
- Over-worked
- Explosion of medical knowledge
- Time-cosuming tasks such as counting cells

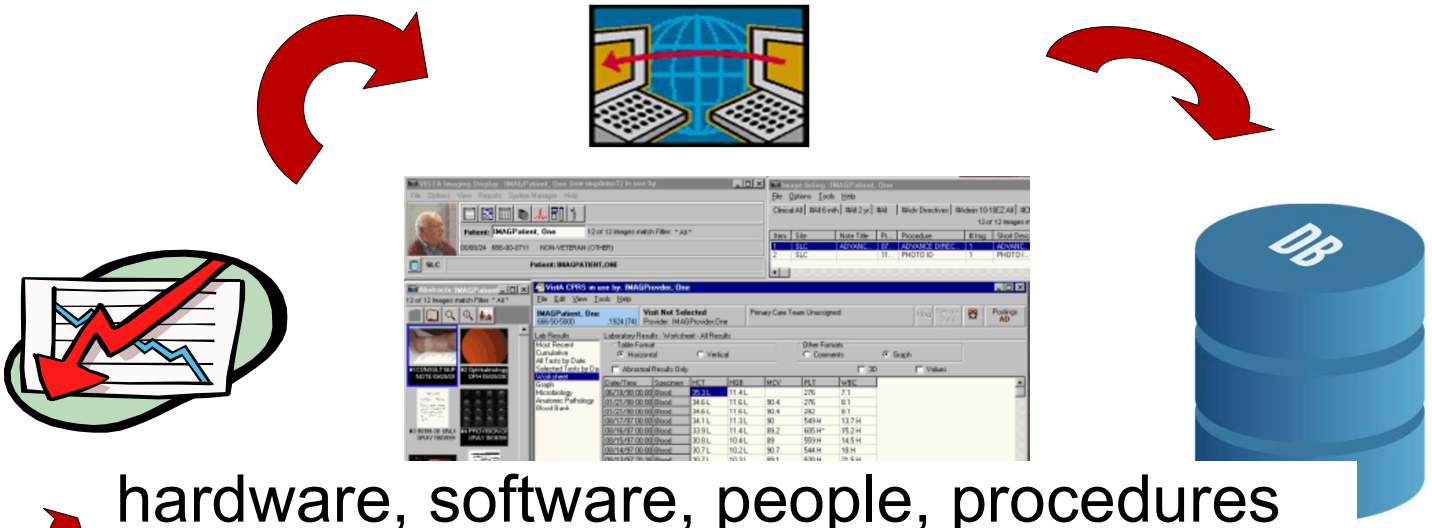


How can DP/AI help pathology?

- Standardization
- Objective Dx
- Automated process
- Accurate Dx
- Faster Dx
- More time to do other tasks
- Keep up with the knowledge

AI-POWERED PATHOLOGY

DIGITIZING PATHOLOGY: OPPORTUNITY TO IMPROVE ALL ASPECTS OF PATHOLOGY WORKFLOW



hardware, software, people, procedures and data

PATHOLOGY INFORMATICS DRIVEN WORKFLOWS
INTEGRATION OF EMR, LIS, WSI

ENTERPRISE IMAGING
INTEGRATED DATA AND IMAGES
MORE DIAGNOSTIC AND PROGNOSTIC TOOLS

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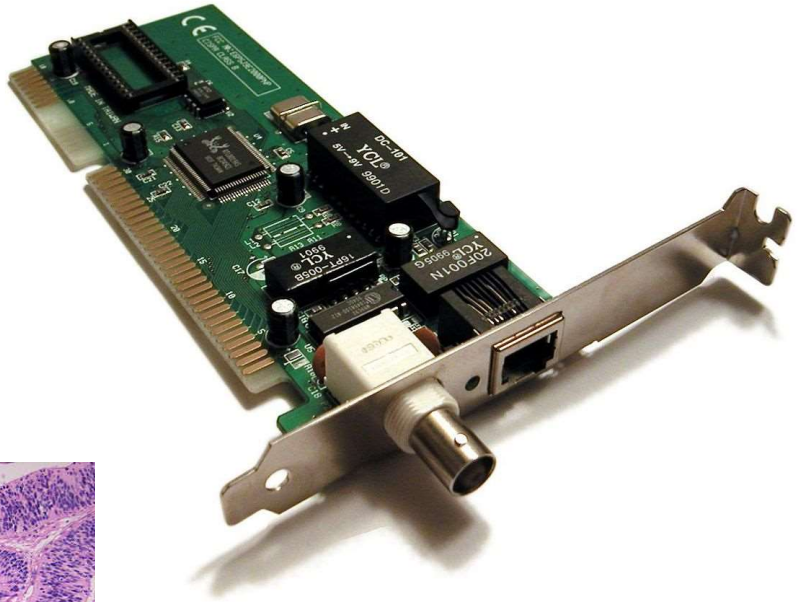
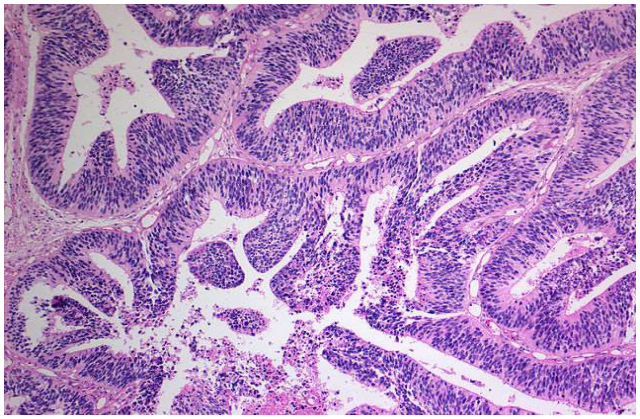
Integration: LIS, Scanner, Workstations

interfaces

between WSI systems, laboratory information systems and the electronic medical record





The Solution for Enterprise Digital Transformation

Scanners

Any Scanner.
Any LIS.
Any Image Analysis.

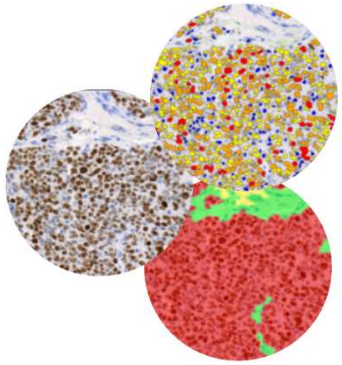


Image Analysis and AI Tools

Creating an OPEN platform for Digital Pathology and AI tools

Slide courtesy of Inspirata


460
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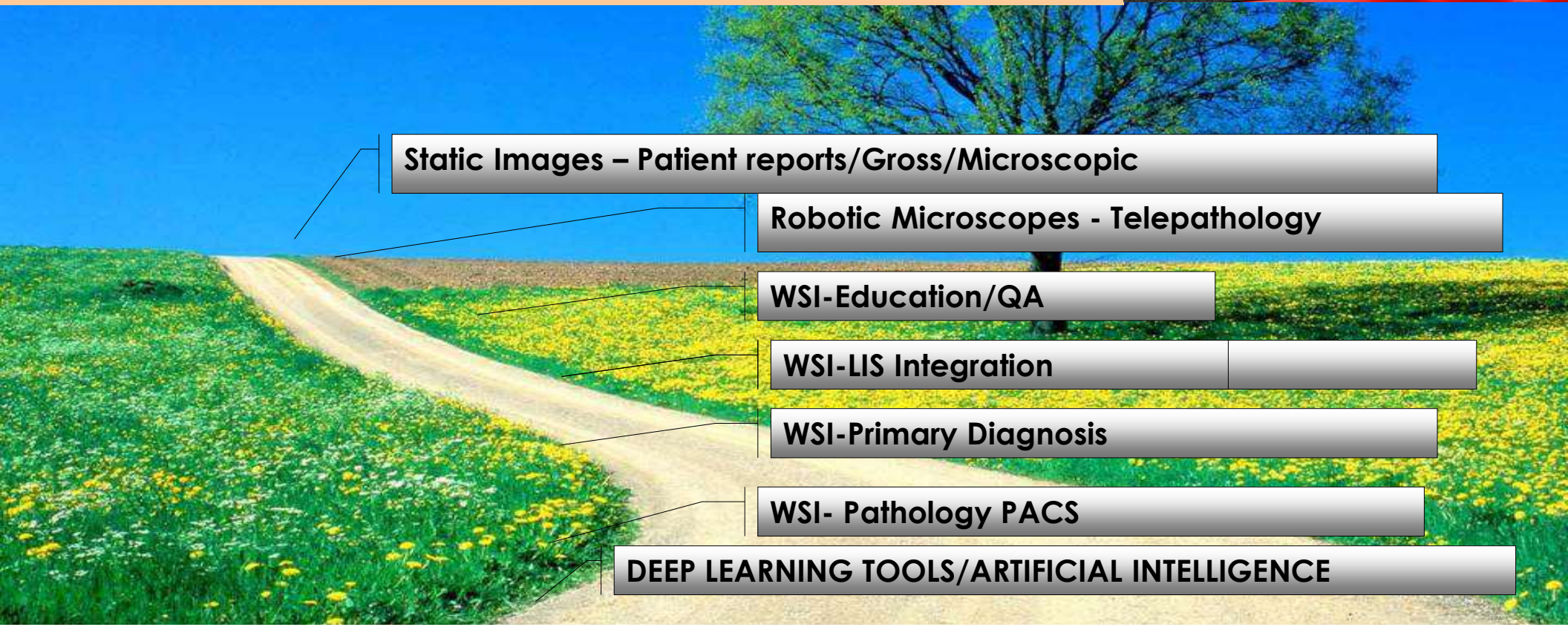
The Ohio State University
Wexner Medical Center
James Cancer Hospital and
Solove Research Institute
Solove Research Institute

TOP 5 REASONS FOR IMPLEMENTING DIGITAL PATHOLOGY and AI FOR DIAGNOSTICS

1. **INCREASED PRODUCTIVITY**
    - **IMPROVED INFORMATION MANAGEMENT, WORKFLOW DISTRIBUTION, INTEGRATION OF DATA**
2. **IMPROVED QUALITY/BETTER MEDICINE**
    - **QUALITY ASSURANCE, RAPID SECOND REVIEWS, EASIER ACCESS TO SUB-SPECIALIST**
3. **INCREASE REVENUES**
    - **INSOURICING (Digital Consults), PULL-THROUGH REVENUES, BRAND RECOGNITION**
4. **COST SAVINGS**
    - **CONSOLIDATION, REDUCED COSTS WITH MOVING SLIDES AROUND**
5. ***ARTIFICIAL INTELLIGENCE***
    - **IMAGE ANALYSIS/WORK FLOW ALGORITHMS, COMPUTER AIDED DIAGNOSIS**

OSU Strategic Pathology Imaging Roadmap



Department of Pathology OSUWMC

- 85 faculty
  - AP, CP, MP
  - Outreach
  - Experimental
  - Nationwide Children's Hospital (NCH)
- Sites
  - OSUWMC/James CCC
  - Molecular lab
  - OSU East
  - 3 outreach hospitals
  - NCH

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The Ohio State University
Wexner Medical Center

Clinical Volumes Increasing

Surgical Pathology cases – 90,000

Approximately 600,000 slides including H&E, IHCs and special stains

Approximately 3,000 slides/day

OSU Digital Pathology Timeline

January 2017

Digital pathology lab space secured on the 18th floor of the James

May 2017

Digital pathology scanners installed

July 2017

Full scale digital pathology WIS services are launched

July 2019

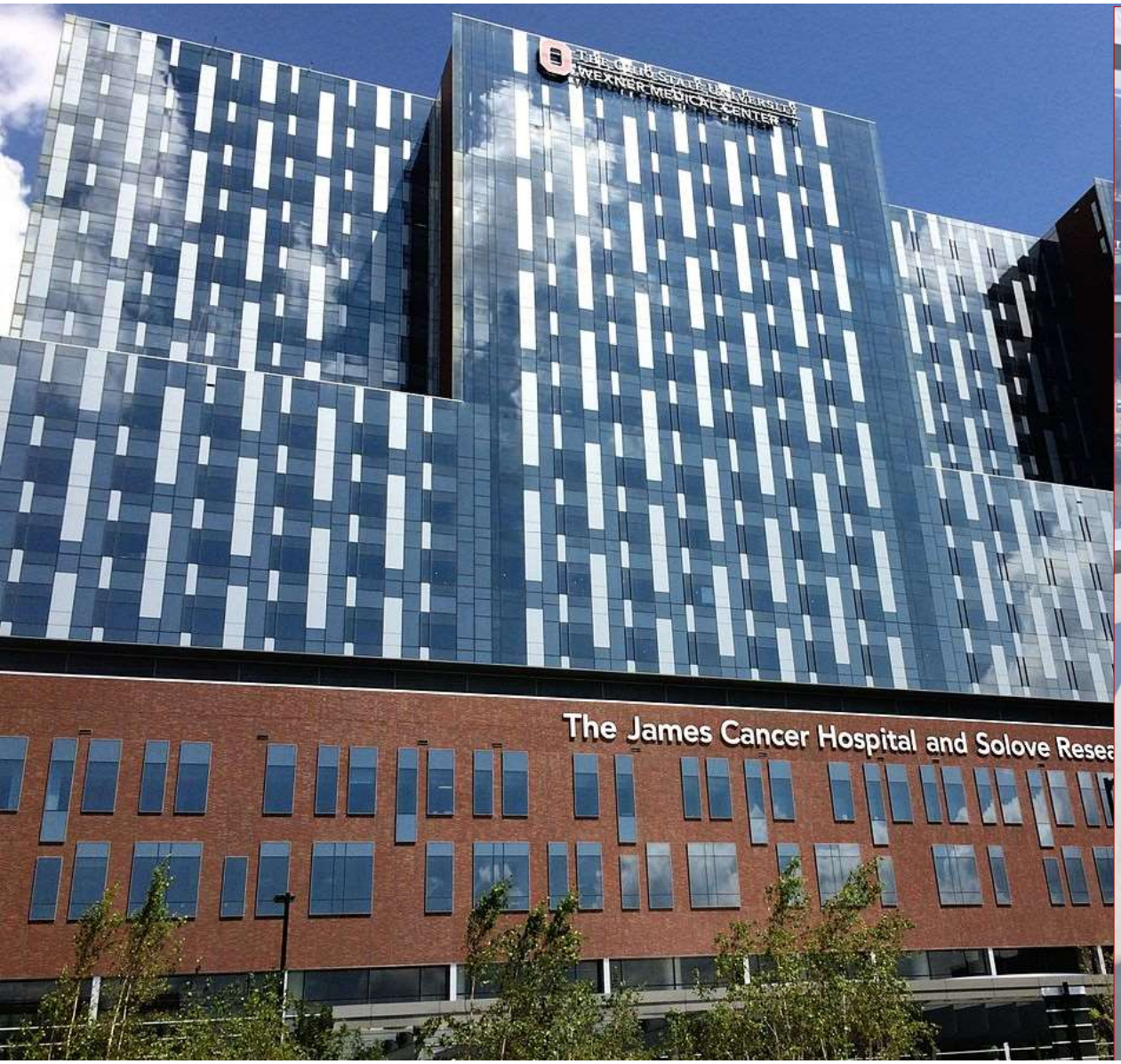
EPIC Beaker goes live. This allows for a list of scanned slides, easily accessible link to click through slides, and the ability to sort slides by Part ID, Block ID, Slide ID, Image creation time.

November 2019

Telepathology scanner installed at Adena Regional Medical Center

December 2019

A large portion of digital pathology services are moved to a larger centralized lab space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2/23/18
(eRAMP 251518)
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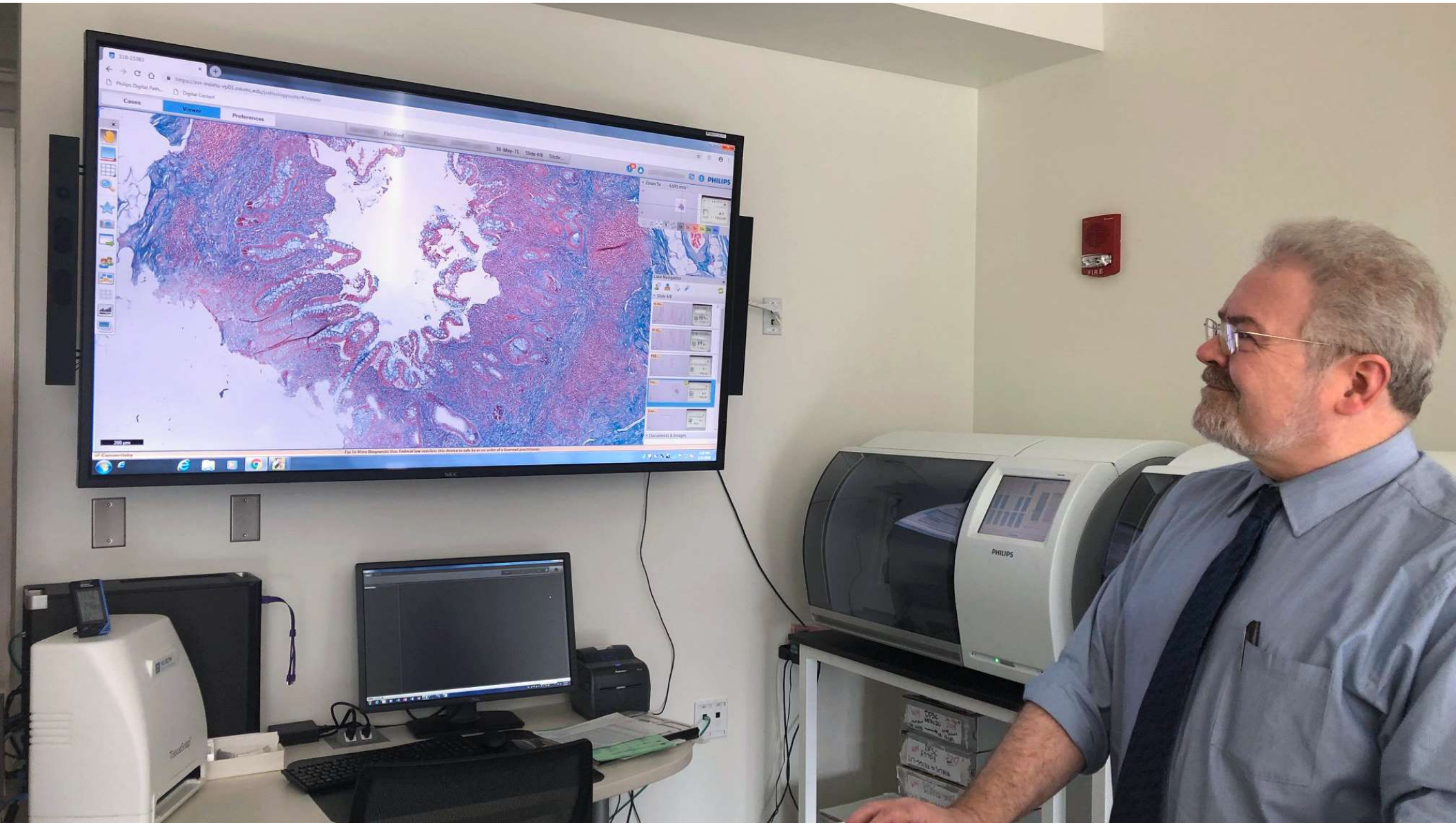
S17-

Thousands of Patient Slides in Archives

GLASS SLIDES IN RACKS


Cases
Viewer
Preferences
PHILIPS
FIRE
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NOV 2019

TRAINING THE NEXT GENERATION OF HISTOTECHS

DEC 12 2019

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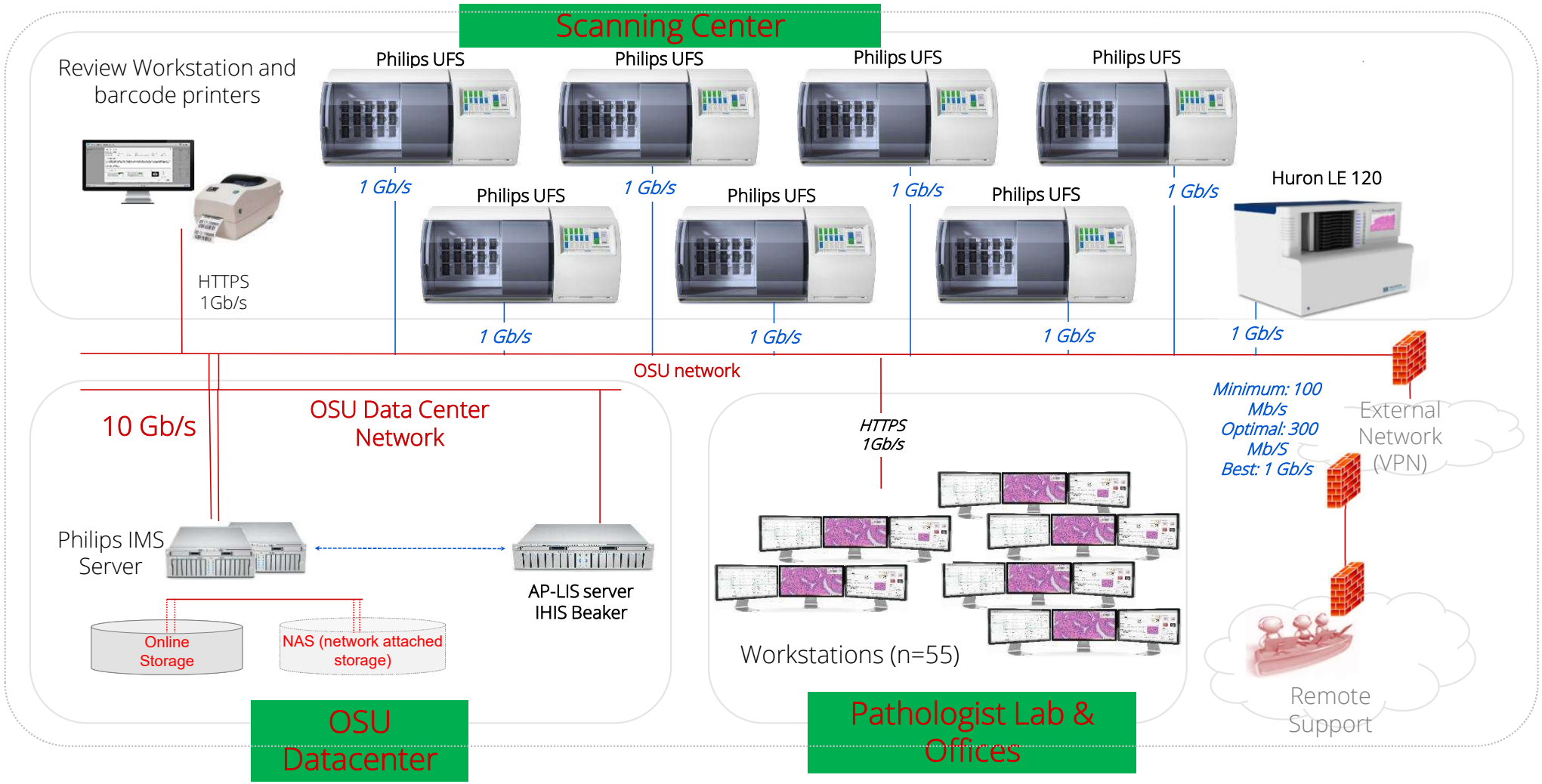
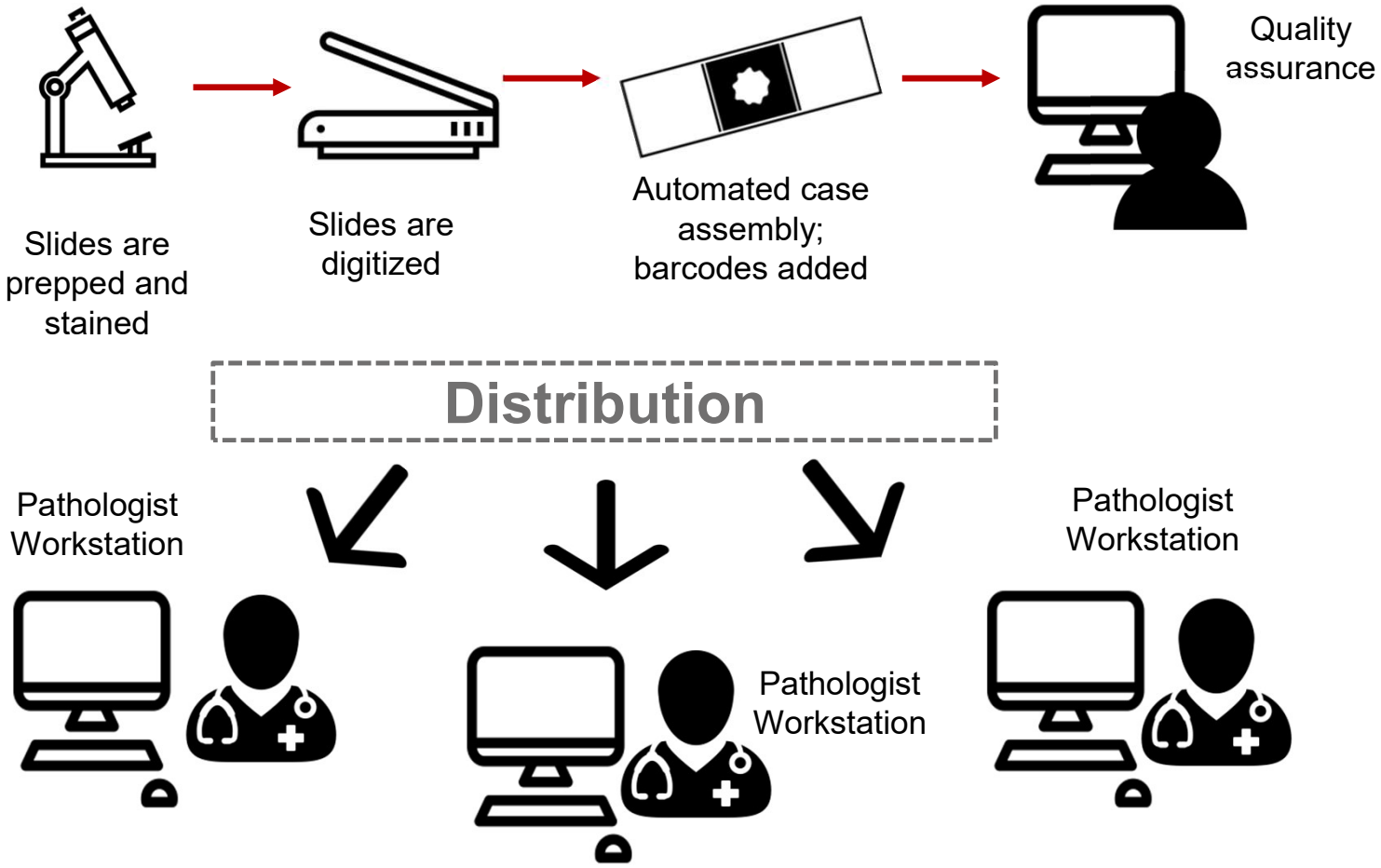
The Ohio State University
Wexner Medical Center

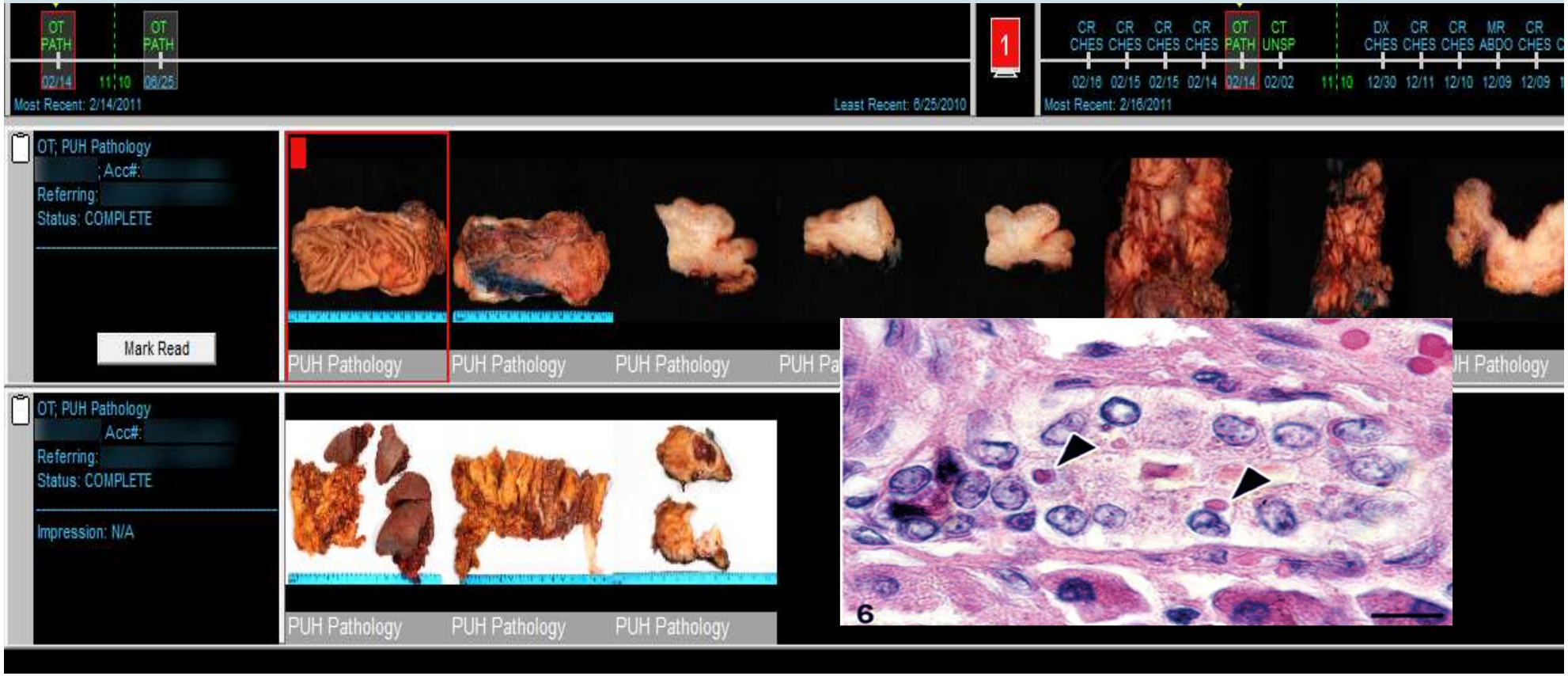
OSU Digital Pathology Clinical Workflow System



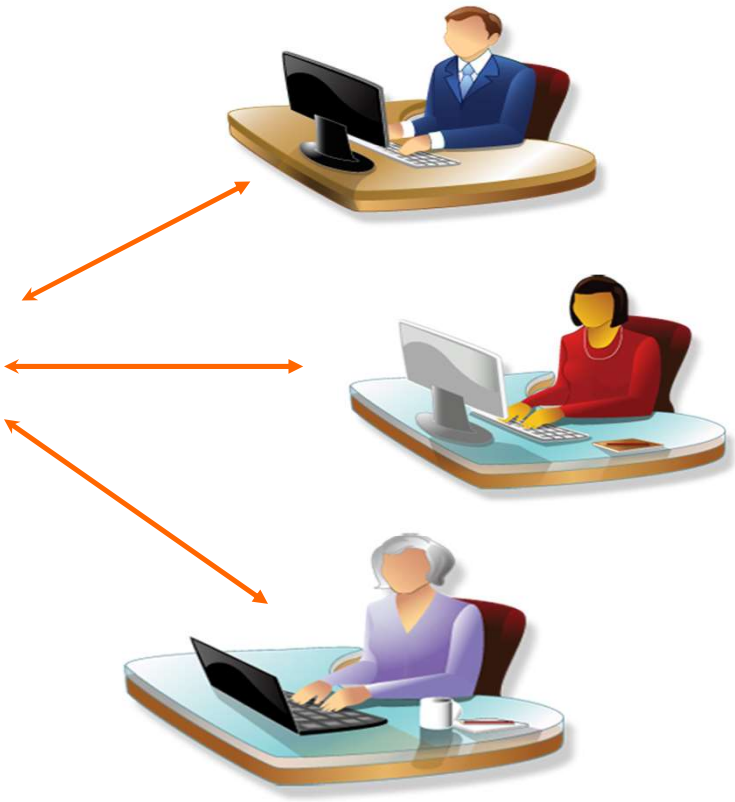
Whole Slide Imaging (WSI) Workflow



BETTER QUALITY: DIGITAL TUMOR BOARDS- REVIEWING PRIORS

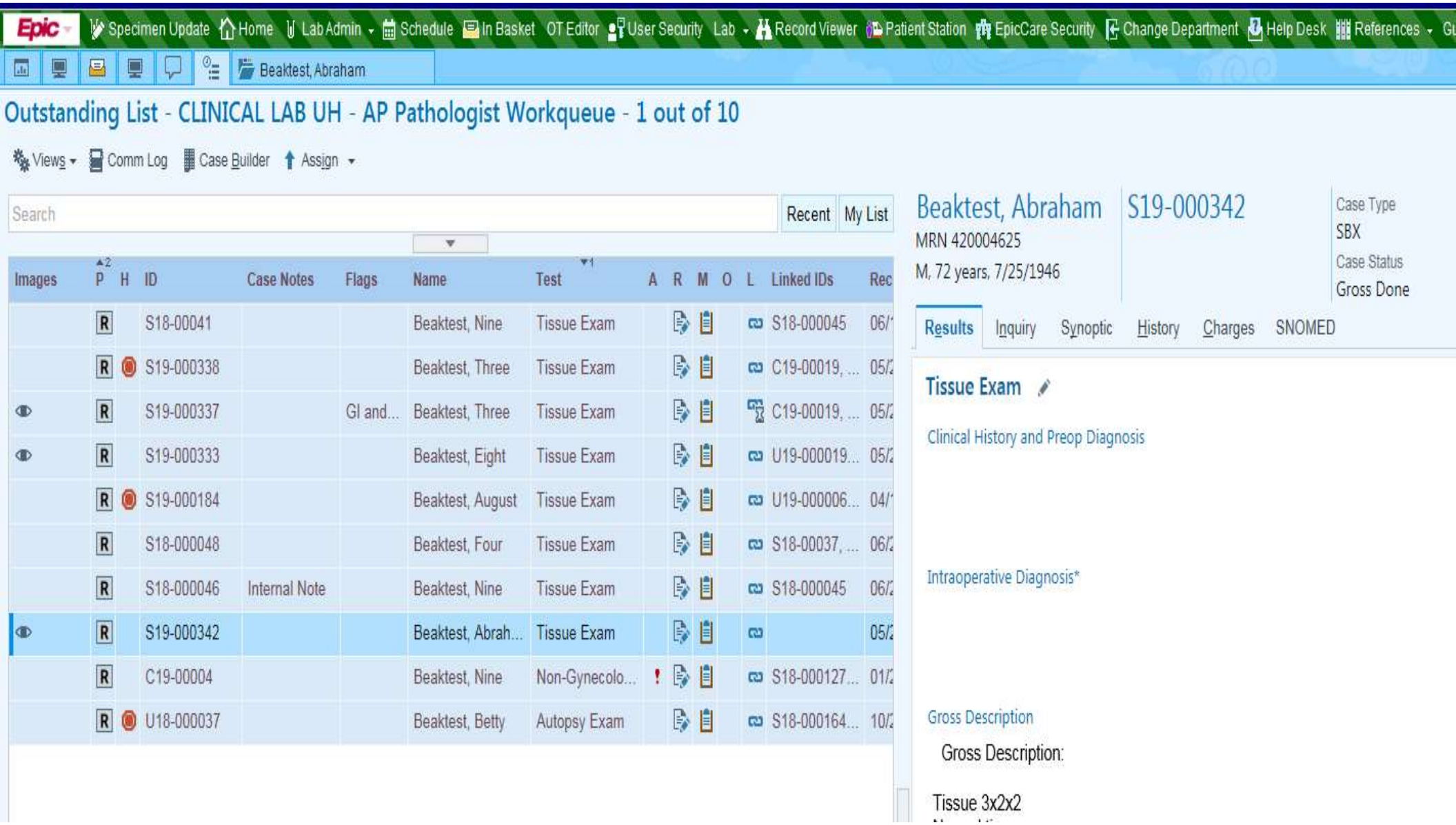


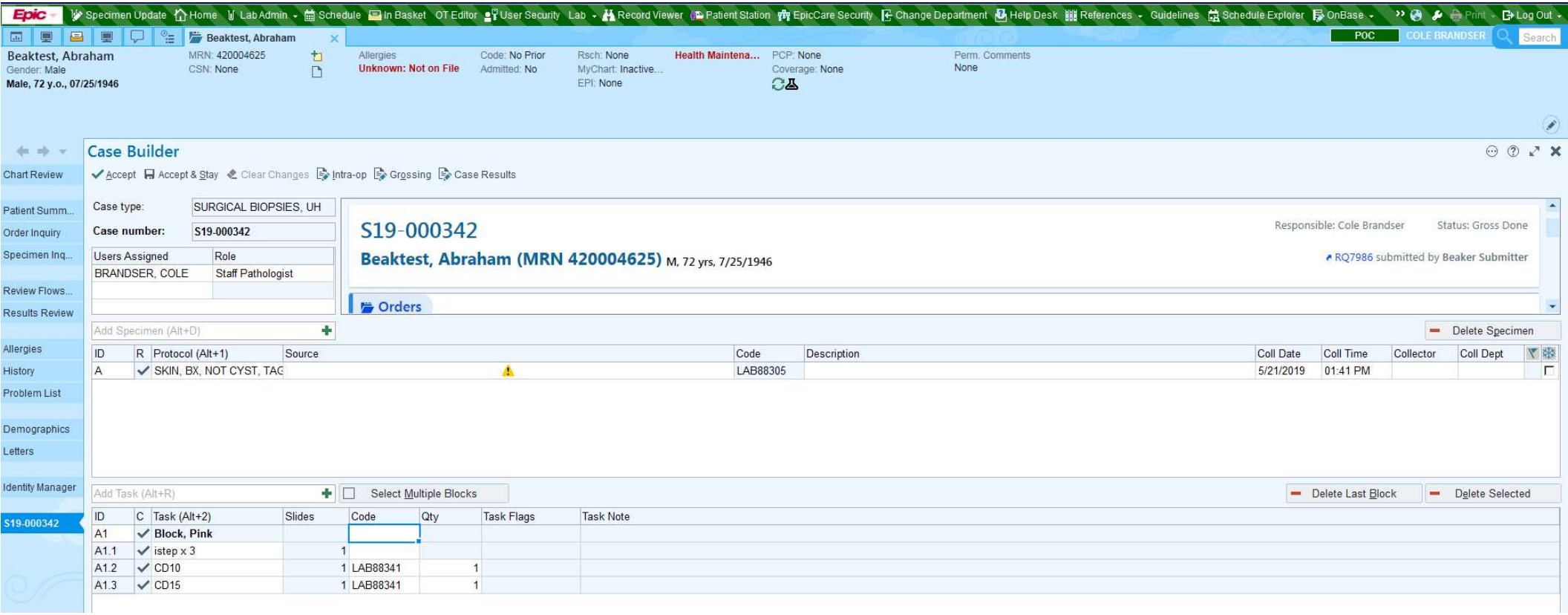
Quality Assurance



Impact on pathology workflows

CREATING A WORKPLACE


Epic
Specimen Update
Home
Lab Admin
Schedule
In Basket
OT Editor
User Security
Lab
Record Viewer
Patient Station
EpicCare Security
Change Department
Help Desk
References
Beaktest, Abraham
Outstanding List - CLINICAL LAB UH - AP Pathologist Workqueue - 1 out of 10
Views
Comm Log
Case Builder
Assign
Search
Recent
My List
Images
P
H
ID
Case Notes
Flags
Name
Test
A
R
M
O
L
Linked IDs
Rec
S18-00041 Beaktest, Nine Tissue Exam S18-000045
S19-000338 Beaktest, Three Tissue Exam C19-00019, ...
S19-000337 GI and... Beaktest, Three Tissue Exam C19-00019, ...
S19-000333 Beaktest, Eight Tissue Exam U19-000019...
S19-000184 Beaktest, August Tissue Exam U19-000006...
S18-000048 Beaktest, Four Tissue Exam S18-00037, ...
S18-000046 Internal Note Beaktest, Nine Tissue Exam S18-000045
S19-000342 Beaktest, Abrah... Tissue Exam
C19-00004 Beaktest, Nine Non-Gynecolo... S18-000127...
U18-000037 Beaktest, Betty Autopsy Exam S18-000164...
Beaktest, Abraham
MRN 420004625
M, 72 years, 7/25/1946
S19-000342
Case Type
SBX
Case Status
Gross Done
Results
Inquiry
Synoptic
History
Charges
SNOMED
Tissue Exam
Clinical History and Preop Diagnosis
Intraoperative Diagnosis*
Gross Description
Gross Description:
Tissue 3x2x2


Epic
Specimen Update
Home
Lab Admin
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OT Editor
User Security
Lab
Record Viewer
Patient Station
EpicCare Security
Change Department
Help Desk
References
Guidelines
Schedule Explorer
OnBase
Print
Log Out
Beaktest, Abraham
POC
COLE BRANDSER
Search
Beaktest, Abraham
Gender: Male
Male, 72 y.o., 07/25/1946
MRN: 420004625
CSN: None
Allergies
Unknown: Not on File
Code: No Prior
Admitted: No
Rsch: None
MyChart: Inactive...
EPI: None
Health Maintena...
PCP: None
Coverage: None
Perm. Comments
None
Case Builder
Chart Review
Patient Summ...
Order Inquiry
Specimen Inq...
Review Flows...
Results Review
Allergies
History
Problem List
Demographics
Letters
Identity Manager
S19-000342
Accept
Accept & Stay
Clear Changes
Intra-op
Grossing
Case Results
Case type:
SURGICAL BIOPSIES, UH
Case number:
S19-000342
Users Assigned
Role
BRANDSER, COLE
Staff Pathologist
S19-000342
Responsible: Cole Brandser
Status: Gross Done
Beaktest, Abraham (MRN 420004625) M, 72 yrs, 7/25/1946
RQ7986 submitted by Beaker Submitter
Orders
Add Specimen (Alt+D)
Delete Specimen
ID
R
Protocol (Alt+1)
Source
Code
Description
Coll Date
Coll Time
Collector
Coll Dept
A
SKIN, BX, NOT CYST, TAG
LAB88305
5/21/2019
01:41 PM
Add Task (Alt+R)
Select Multiple Blocks
Delete Last Block
Delete Selected
ID
C
Task (Alt+2)
Slides
Code
Qty
Task Flags
Task Note
A1
Block, Pink
A1.1
istep x 3
1
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1
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1
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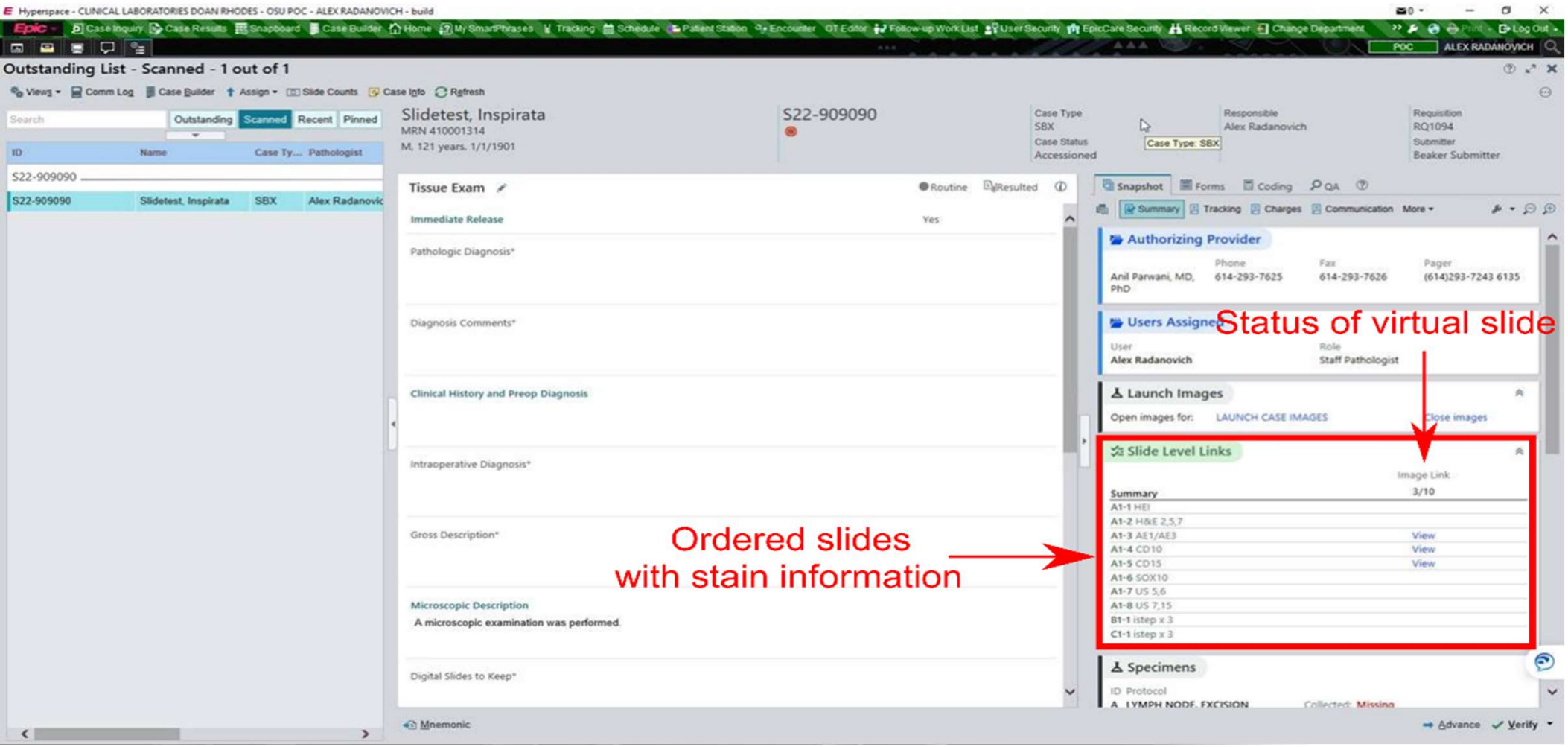
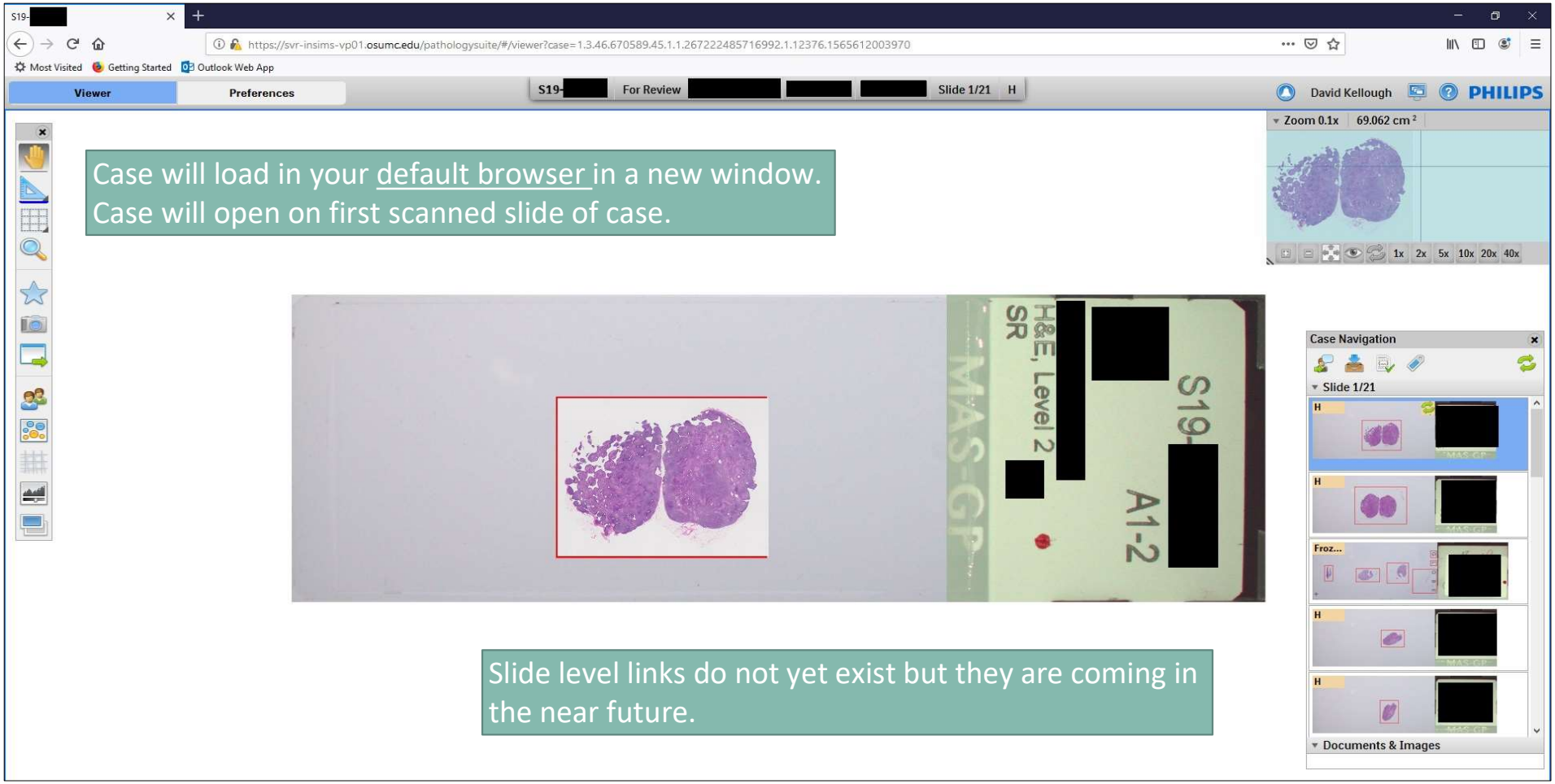
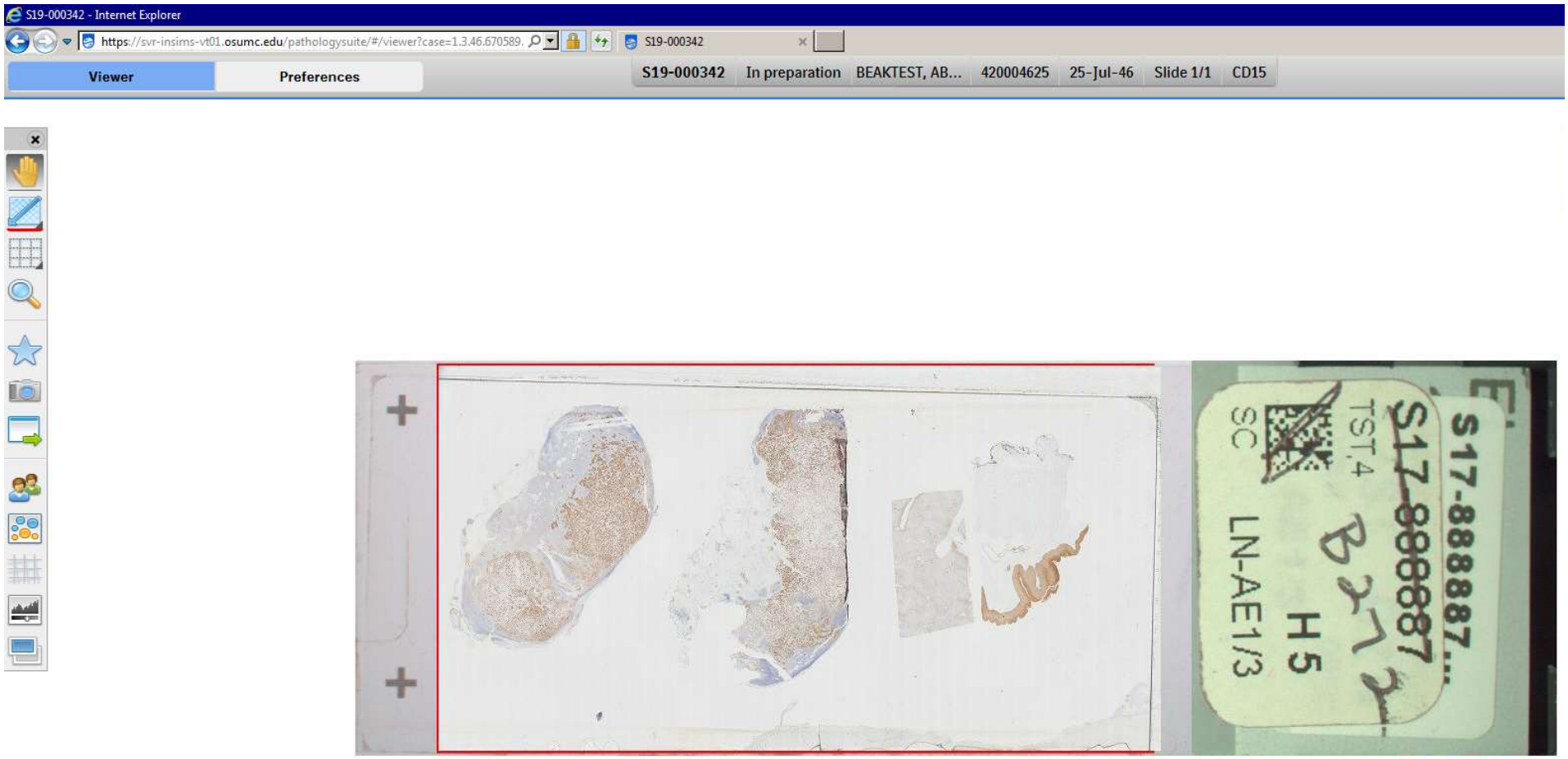
1

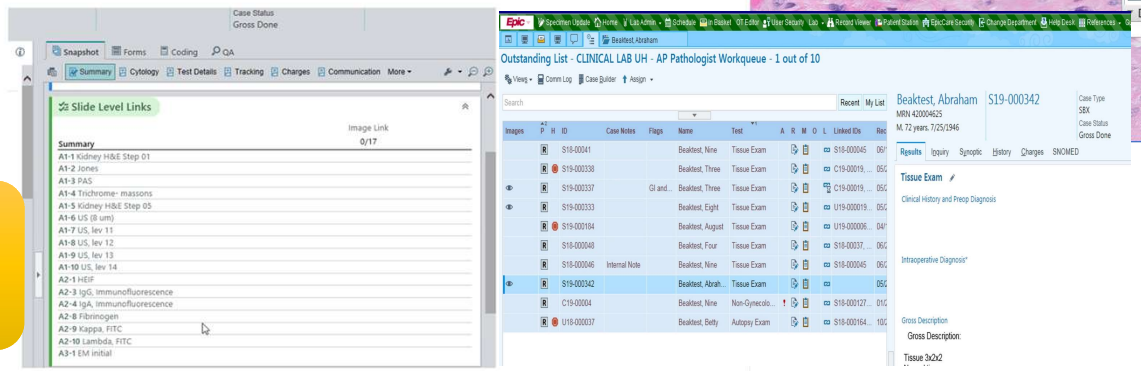
Slide-level Links in Laboratory Information System Provides a More Efficient Sign-out Workflows to the Pathologists




https://svr-insims-vp01.osumc.edu/pathologysuite/#/viewer?case=1.3.46.670589.45.1.1.267222485716992.1.12376.1565612003970
Most Visited
Getting Started
Outlook Web App
Viewer
Preferences
S19-[redacted]
For Review
Slide 1/21
H
David Kellough
PHILIPS
Zoom 0.1x
69.062 cm²
1x
2x
5x
10x
20x
40x
Case will load in your default browser in a new window.
Case will open on first scanned slide of case.
H&E, Level 2
SR
S19-
A1-2
MAS-GP
Case Navigation
Slide 1/21
Froz...
Documents & Images
Slide level links do not yet exist but they are coming in the near future.


S19-000342 - Internet Explorer
https://svr-insims-vt01.osumc.edu/pathologysuite/#/viewer?case=1.3.46.670589.
S19-000342
Viewer
Preferences
S19-000342
In preparation
BEAKTEST, AB...
420004625
25-Jul-46
Slide 1/1
CD15
S17-888887...
TST 4
SC
LN-AE1/3
H 5

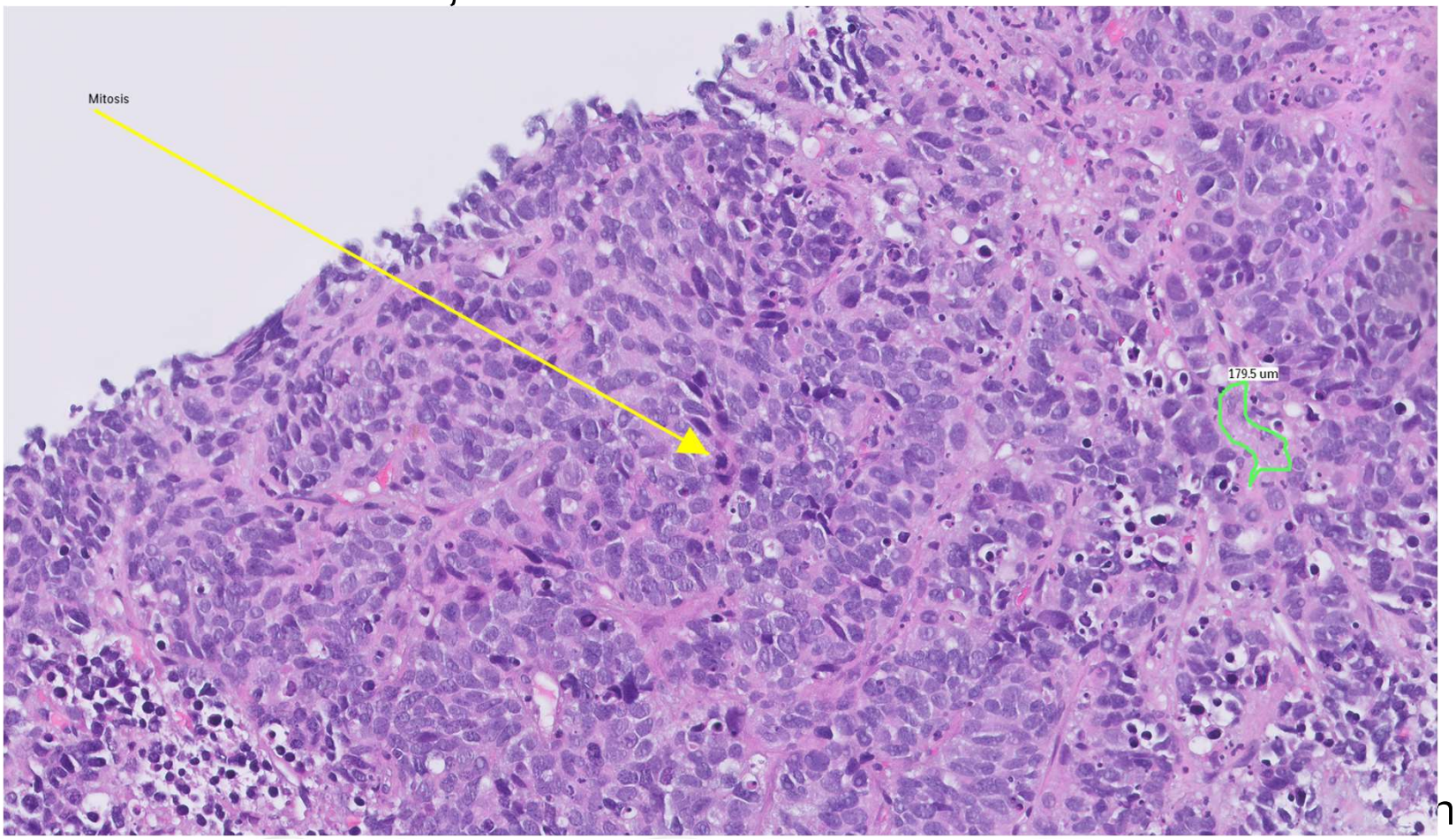
Fully Integrated Digital Pathology Workflow For Improved Patient Care: Digital Pathology for Primary Diagnosis

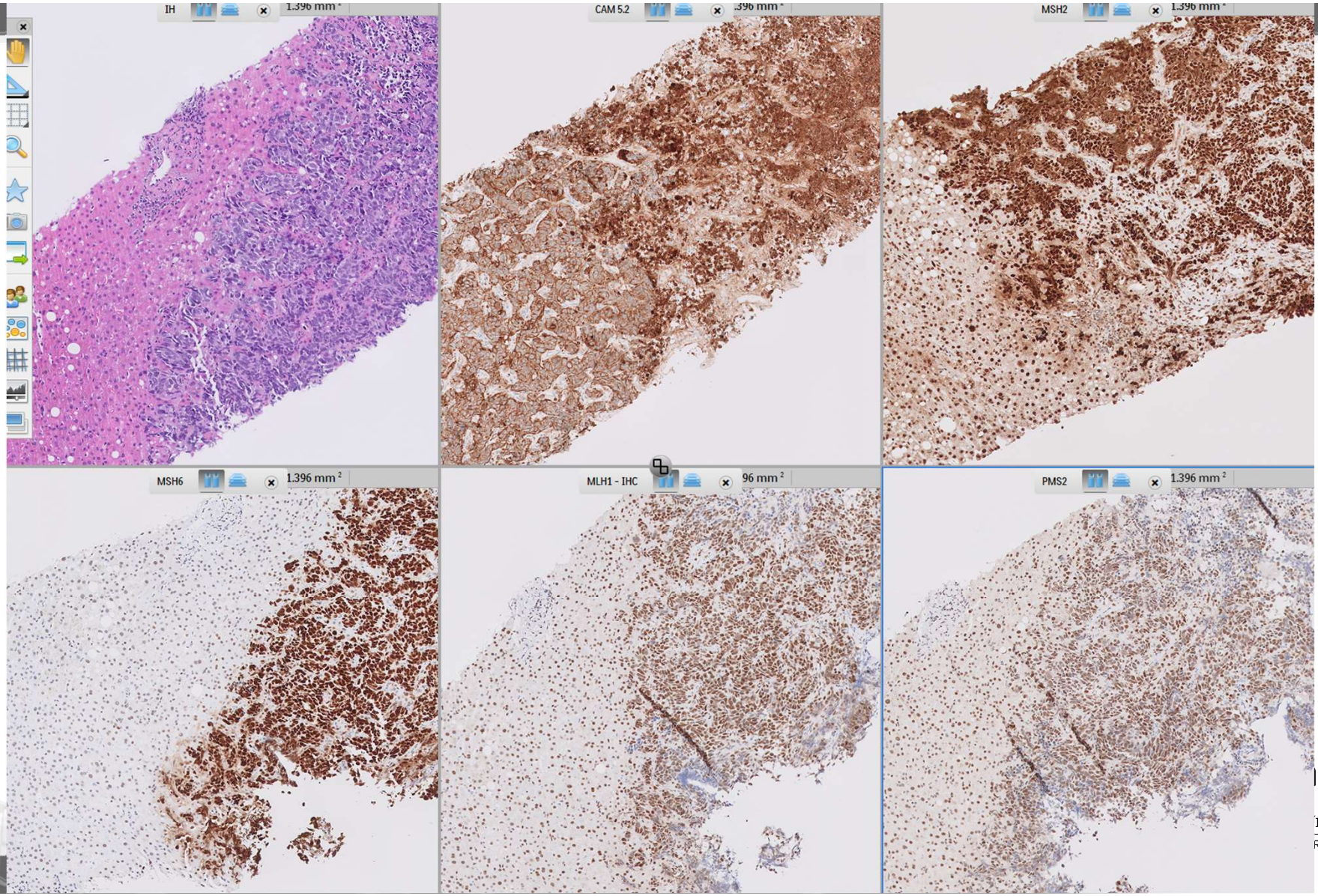


JULY 2002 SLIDE-LEVEL LINKS!!

Many New Features in 2022!

- Measurement, annotations





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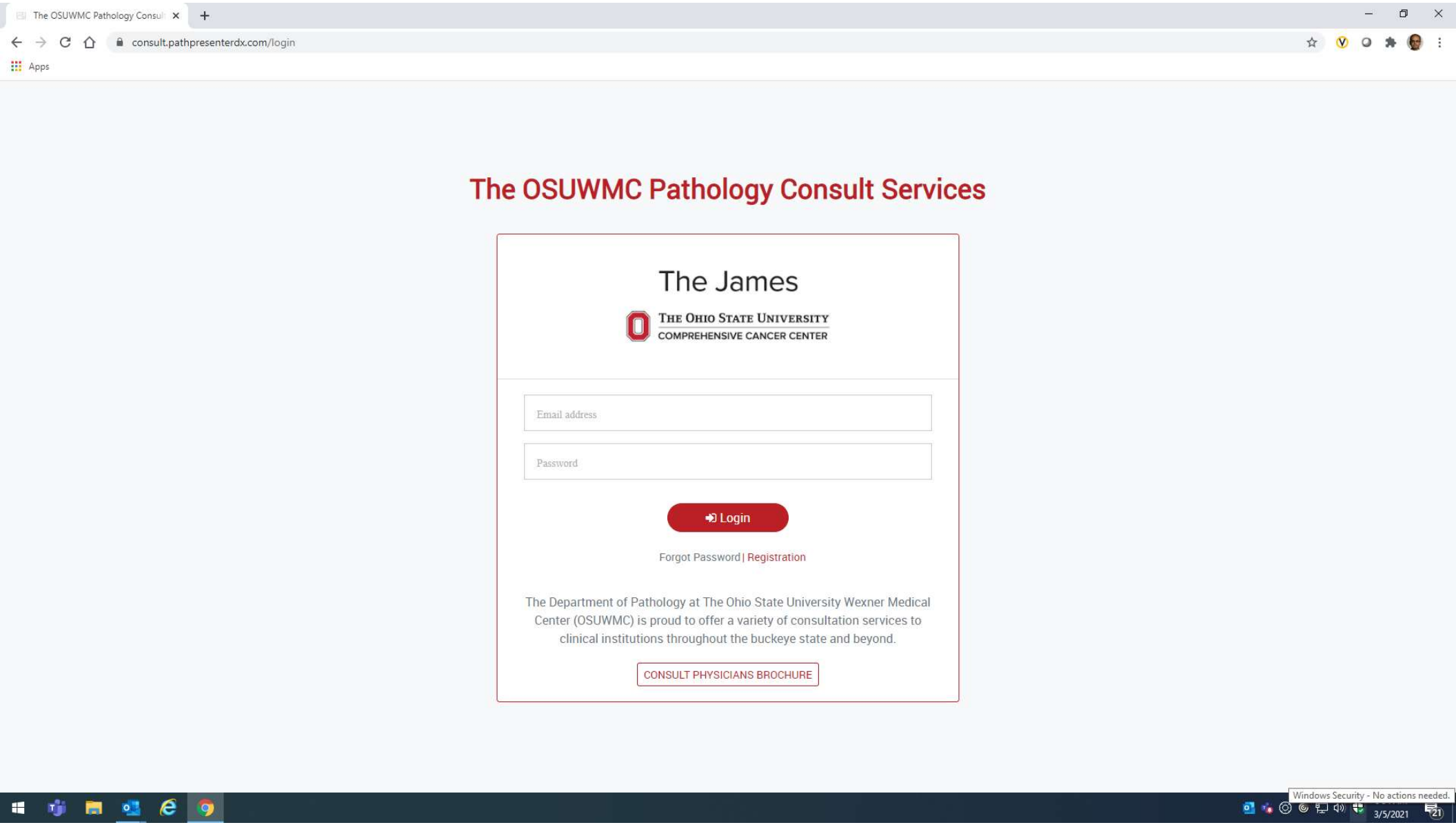
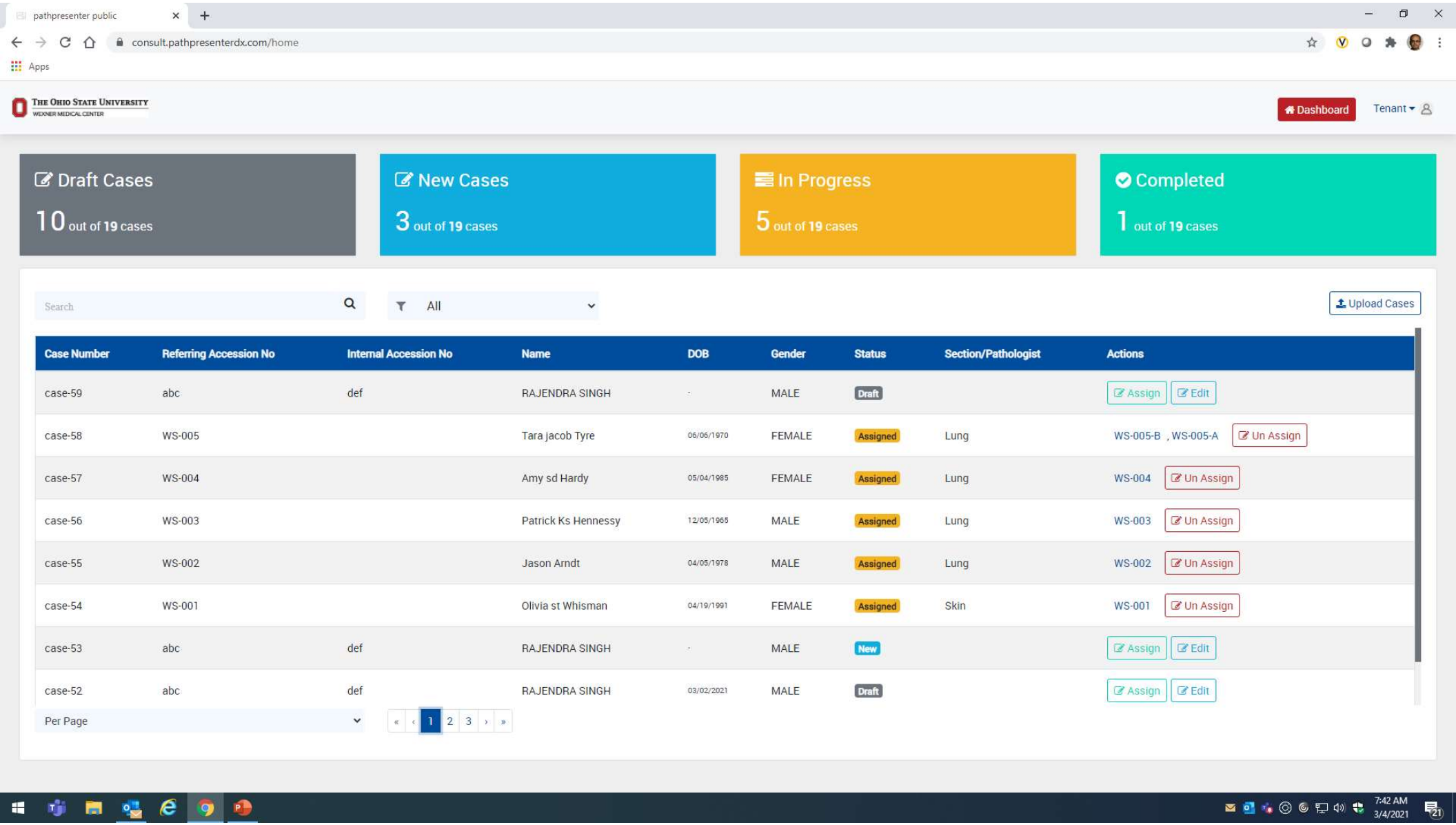
Consults with colleagues


The OSUWMC Pathology Consul
consult.pathpresenterdx.com/login
Apps
The OSUWMC Pathology Consult Services
The James
The Ohio State University
Comprehensive Cancer Center
Email address
Password
Login
Forgot Password | Registration
The Department of Pathology at The Ohio State University Wexner Medical Center (OSUWMC) is proud to offer a variety of consultation services to clinical institutions throughout the buckeye state and beyond.
CONSULT PHYSICIANS BROCHURE
Windows Security - No actions needed.
3/5/2021


pathpresenter public
consult.pathpresenterdx.com/home
Apps
THE OHIO STATE UNIVERSITY
WEXNER MEDICAL CENTER
Dashboard
Tenant
Draft Cases
10 out of 19 cases
New Cases
3 out of 19 cases
In Progress
5 out of 19 cases
Completed
1 out of 19 cases
Search
All
Upload Cases
Case Number
Referring Accession No
Internal Accession No
Name
DOB
Gender
Status
Section/Pathologist
Actions
case-59 abc def RAJENDRA SINGH - MALE Draft Assign Edit
case-58 WS-005 Tara jacob Tyre 06/06/1970 FEMALE Assigned Lung WS-005-B , WS-005-A Un Assign
case-57 WS-004 Amy sd Hardy 05/04/1985 FEMALE Assigned Lung WS-004 Un Assign
case-56 WS-003 Patrick Ks Hennessy 12/05/1965 MALE Assigned Lung WS-003 Un Assign
case-55 WS-002 Jason Arndt 04/05/1978 MALE Assigned Lung WS-002 Un Assign
case-54 WS-001 Olivia st Whisman 04/19/1991 FEMALE Assigned Skin WS-001 Un Assign
case-53 abc def RAJENDRA SINGH - MALE New Assign Edit
case-52 abc def RAJENDRA SINGH 03/02/2021 MALE Draft Assign Edit
Per Page
1 2 3
7:42 AM
3/4/2021

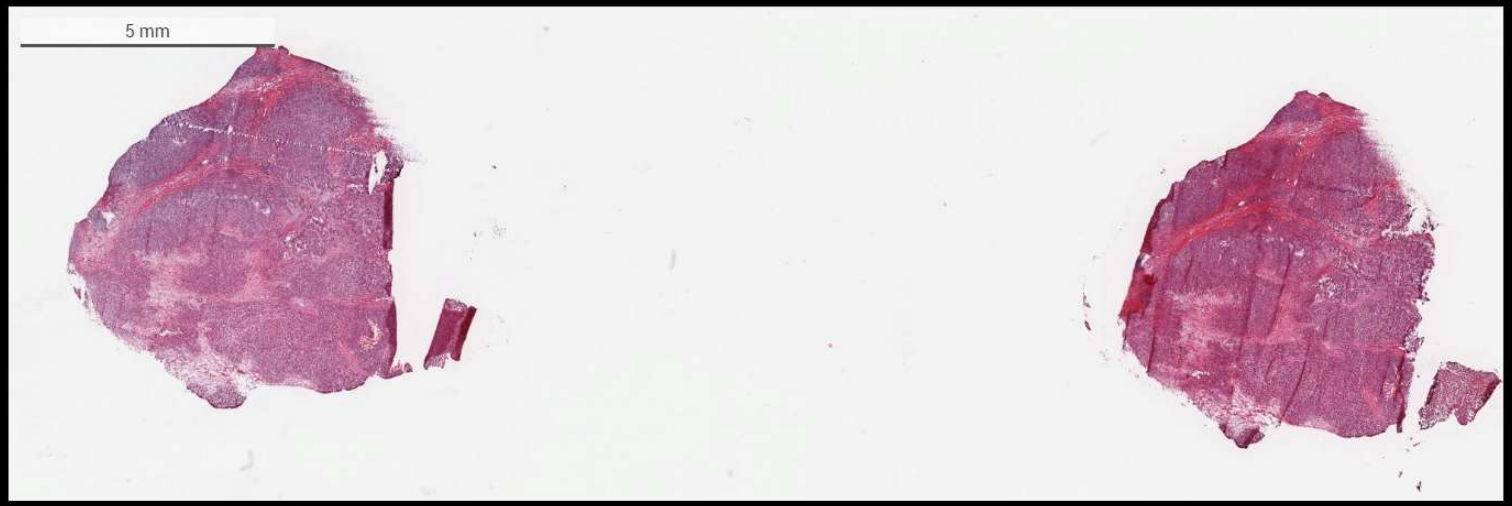
pathpresenter public | pathpresenter public | pathpresenter public | pathpresenter public

consult.pathpresenterdx.com/cases/a8e8ceb3adc5a6da99ae7f6d642a1c63964ad82b3164c6fa66248ff8616a46d7F6YXAz7B21zm3yf+z2LFag==?assNo=WS-003

Apps

2x 5x 10x 20x 40x 60x 100x Case Info DASHBOARD AI Tools

Patrick Hennessy | 12/05/1965



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SLIDES:

Download Info

Download Info

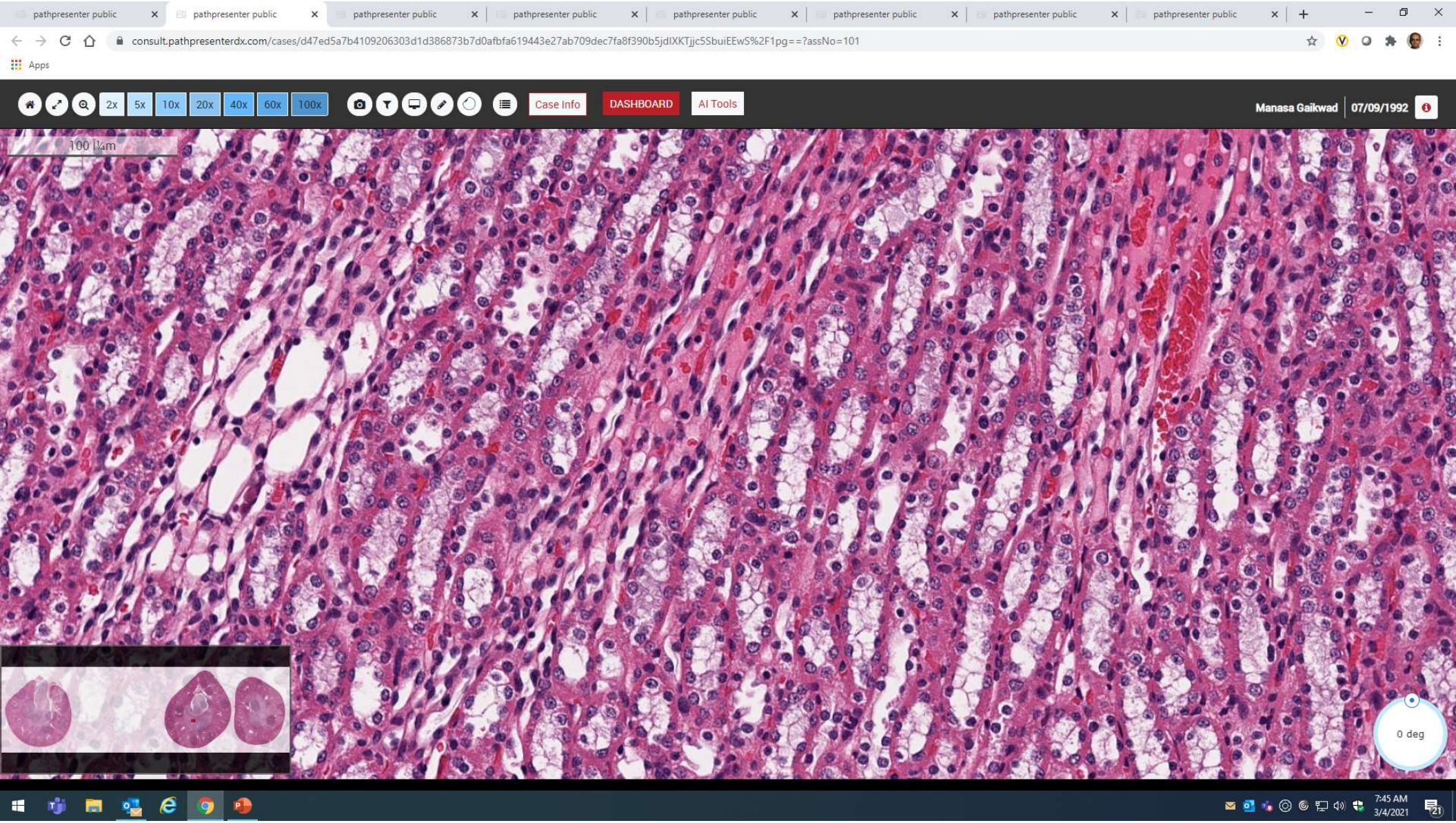
SLIDE INFORMATION:

Name:	TCGA-A8-A08R-01A-01-BS1.7d1f1daf-4f4f-4126-8b13-3febf866f042.Svs
Accession No:	WS-003
Site/Organ:	LUNG
Stain/Study:	Special
Block No:	B1

Chat with Referring Pathologist/Patient

Chat with Coordinator

7:44 AM 3/4/2021


pathpresenter public
consult.pathpresenterdx.com/cases/d47ed5a7b4109206303d1d386873b7d0afbfa619443e27ab709dec7fa8f390b5jdIXKTjjc5SbuiEEwS%2F1pg==?assNo=101
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40x
60x
100x
Case Info
DASHBOARD
AI Tools
Manasa Gaikwad
07/09/1992
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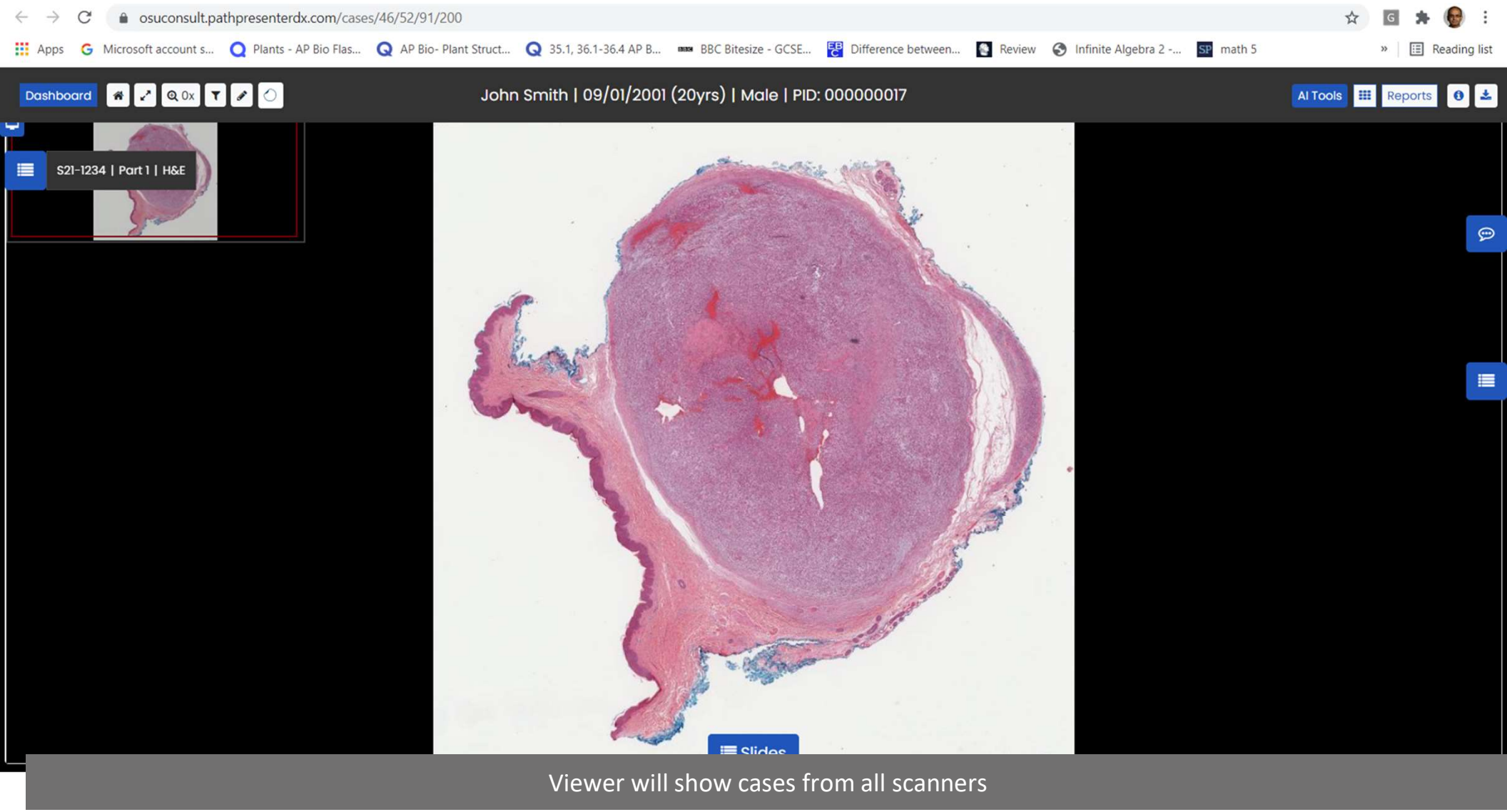
7:45 AM
3/4/2021



Viewer will show cases from all scanners

FINE NEEDLE ASPIRATION SERVICE

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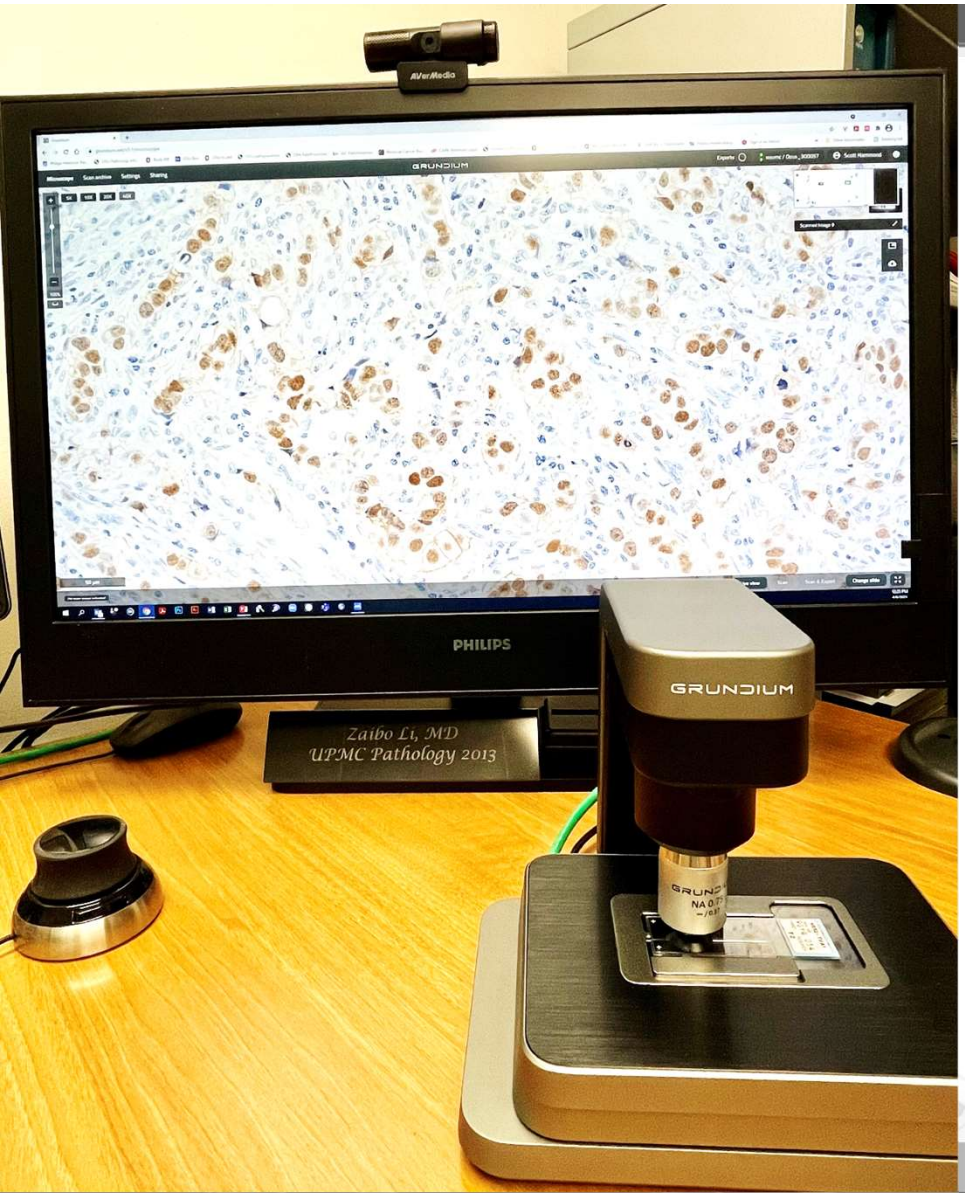
Solution for FNA

e James

Hybrid robotic microscope/WSI scanners

MikroScan SL5

Grandium OCUS40


AVerMedia
PHILIPS
GRUNDIUM
Zaibo Li, MD
UPMC Pathology 2013


OLYMPUS
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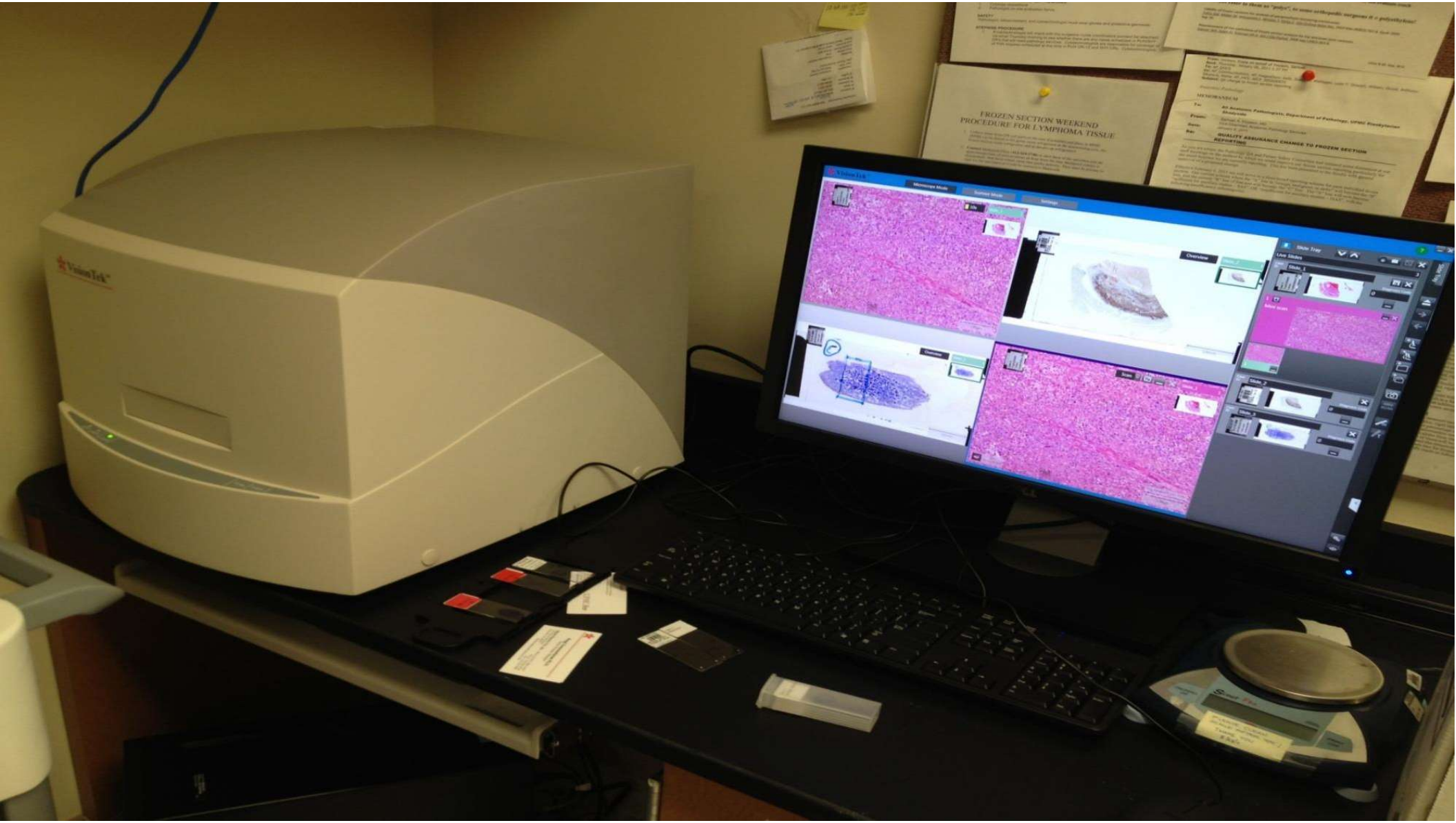
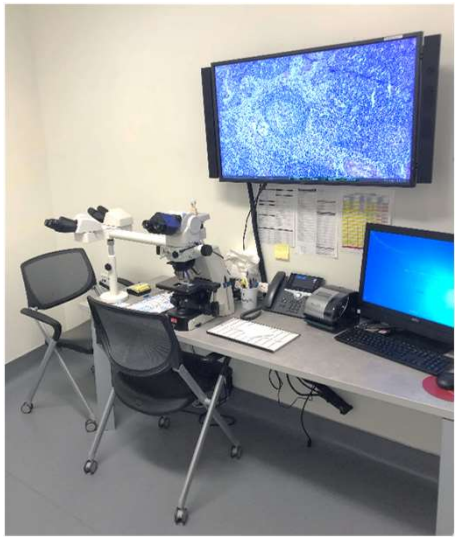
SET


FROZEN SECTION WEEKEND
PROCEDURE FOR LYMPHOMA TISSUE
MEMORANDUM
QUALITY ASSURANCE CHANGE TO FROZEN SECTION
REPORTING



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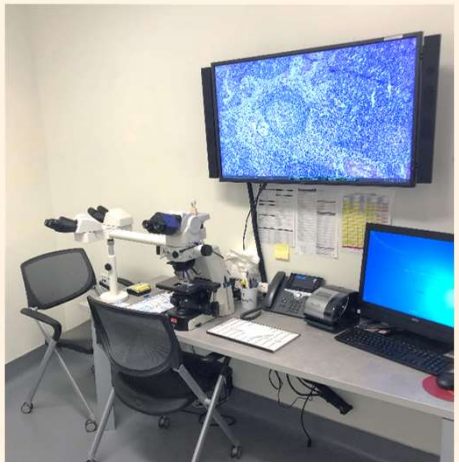
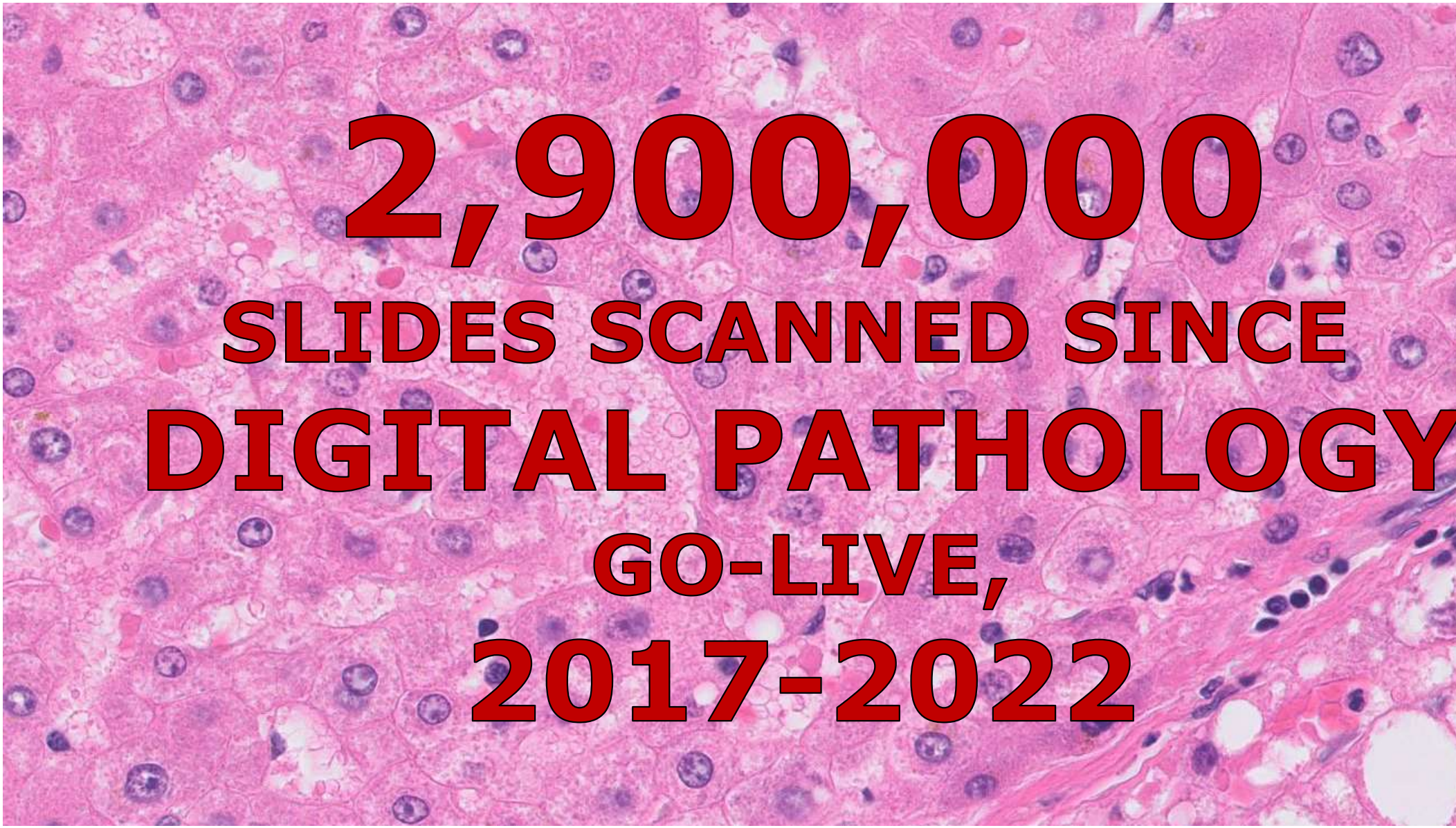
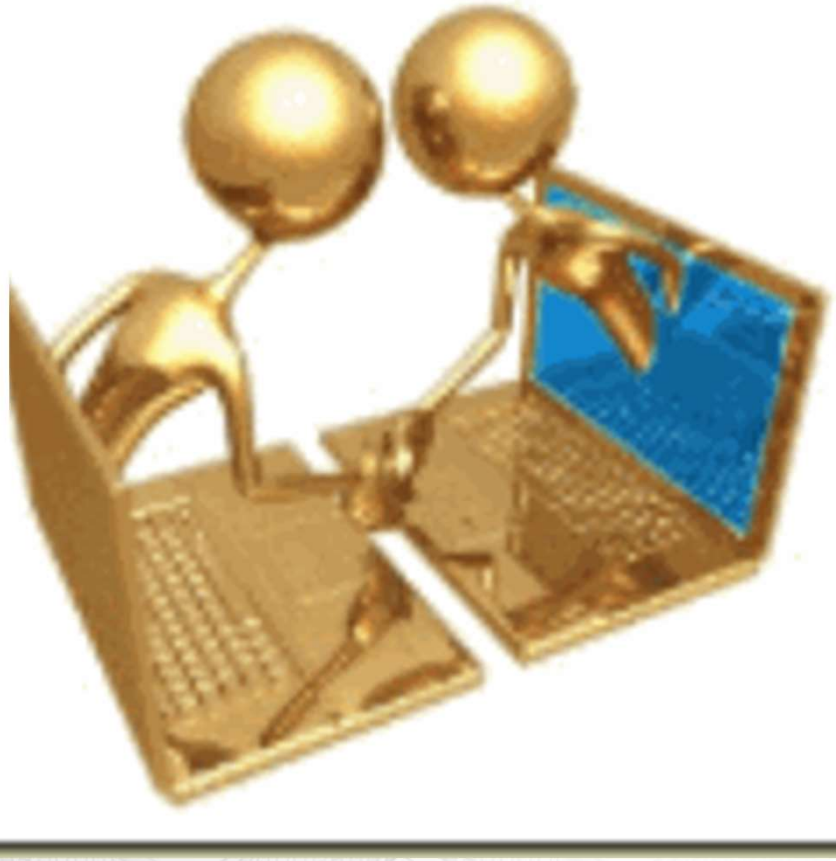


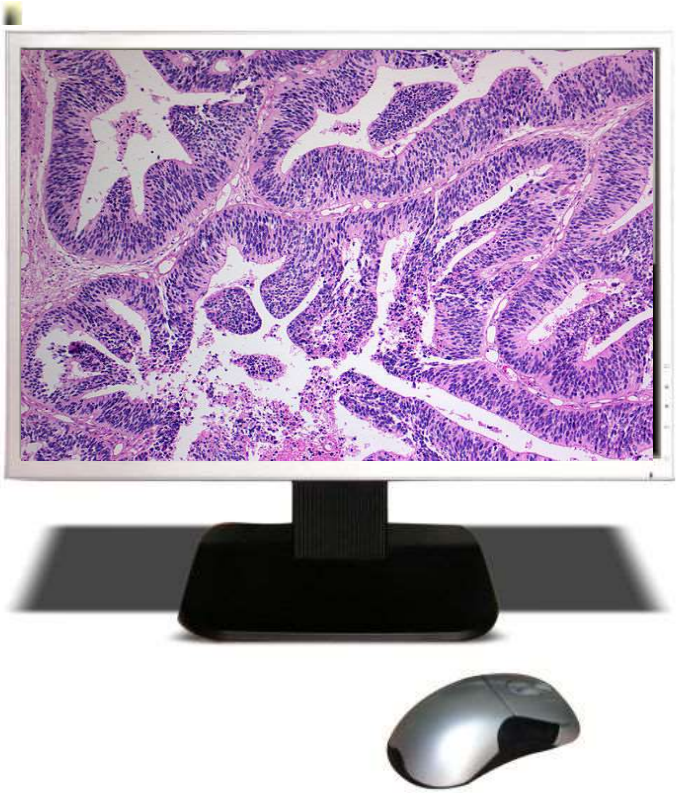
FROZEN SECTION LABORATORY – LEARNING IN A DIGITAL WORLD

Pathologist fully controls the computer which connects to the instrument remotely, can switch between slides, change magnification, move the slide and adjust the fine focus.


2,900,000
SLIDES SCANNED SINCE
DIGITAL PATHOLOGY
GO-LIVE,
2017-2022

PATHOLOGIST ADOPTION ISSUES





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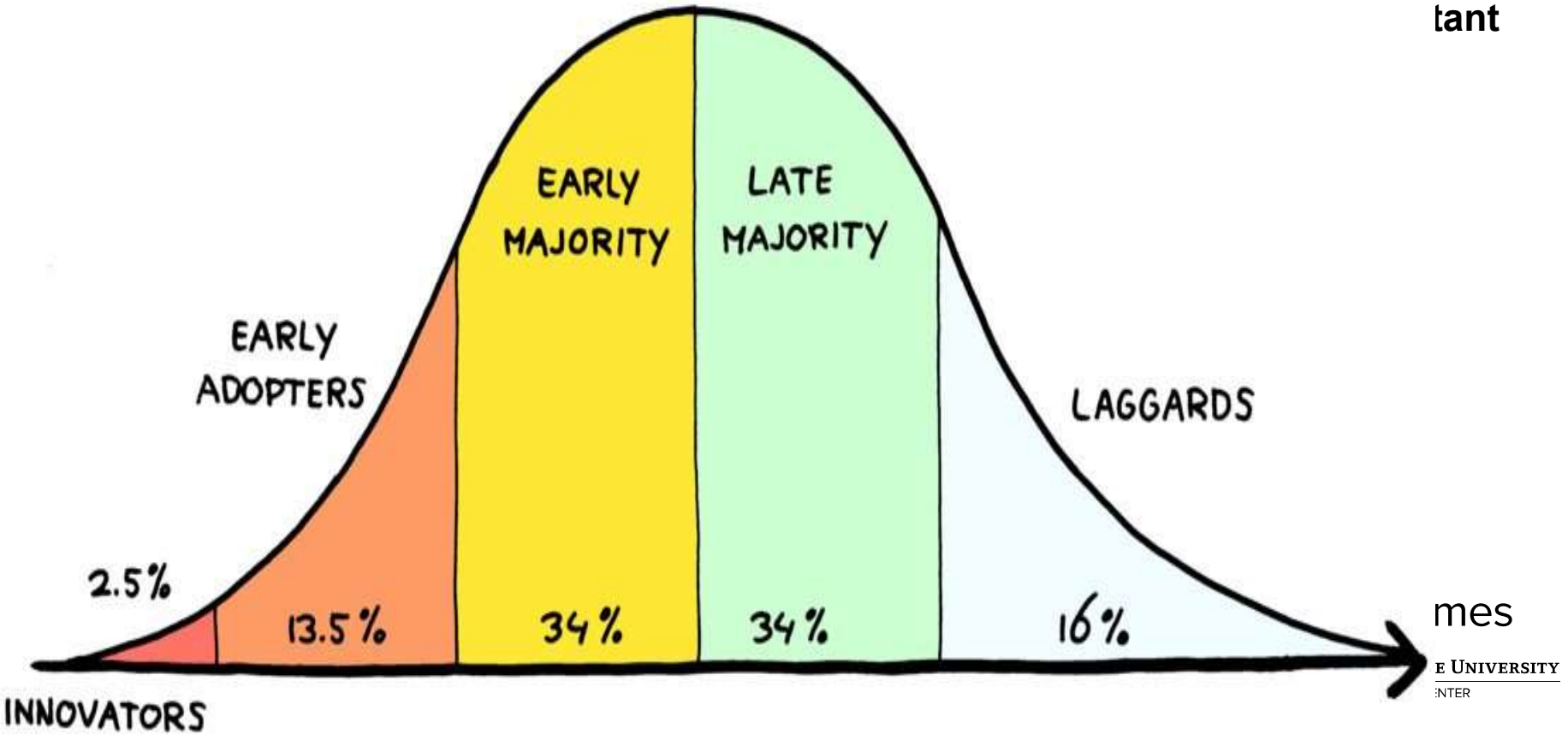
Pathologists slow to adopt this technology

- Alth … tant … to a …
- Do …
- Afra …
- Reg …
- Fina …



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Digital slides has <u>IMPROVED my workflow</u> by…

- Direct interface to LIS
- Sharing cases with consultants, clinicians
  - Tumor conferences
- Flagging cases
- Controls instantly available

Digital slides has <u>IMPROVED my TAT</u> by…

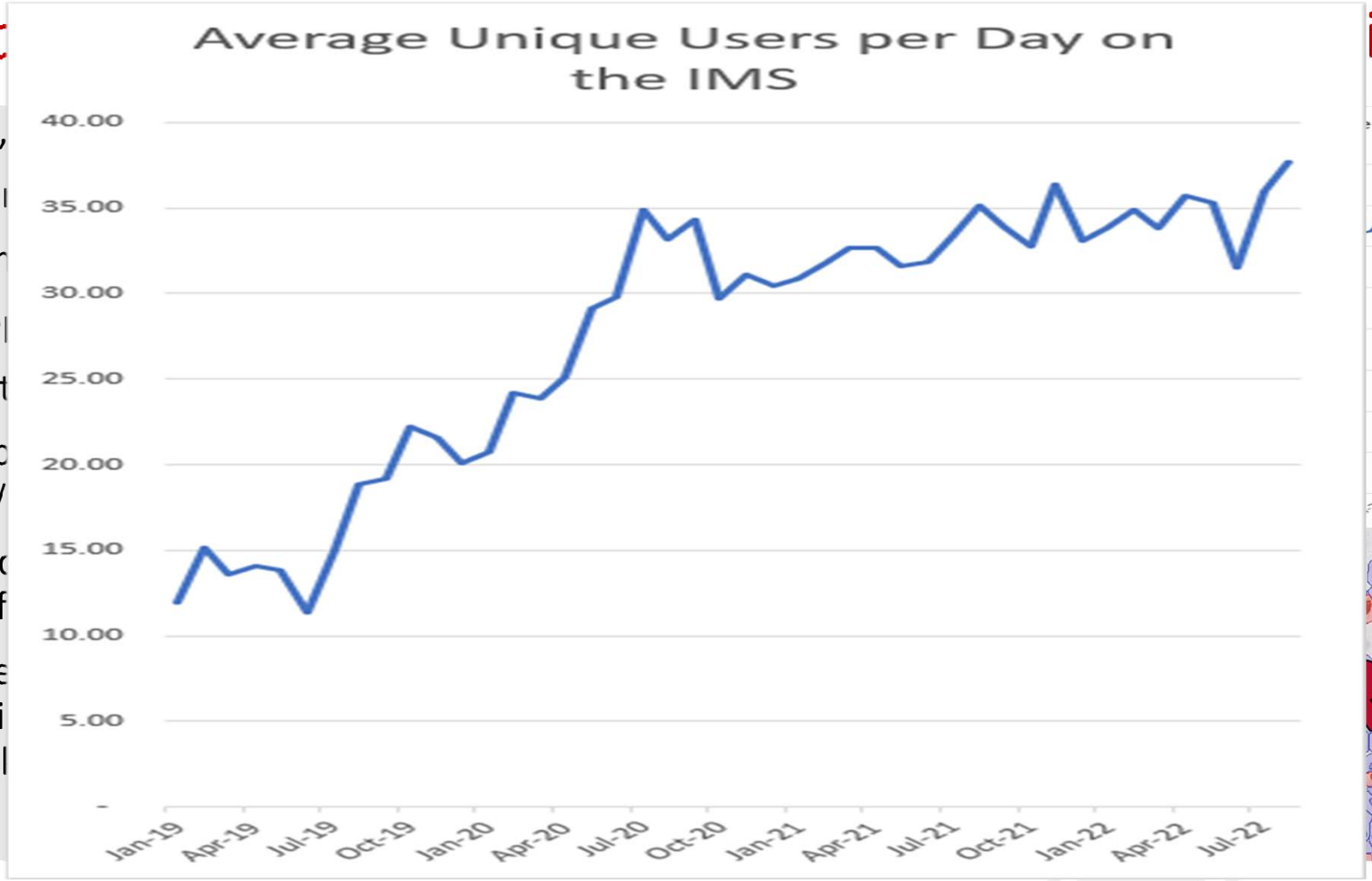
- automatically distributing workload
- Glass slides go directly from cover slipper to scanner to proper pathologist
- Cases are instantly available upon scanning
- Previous cases are instantly available

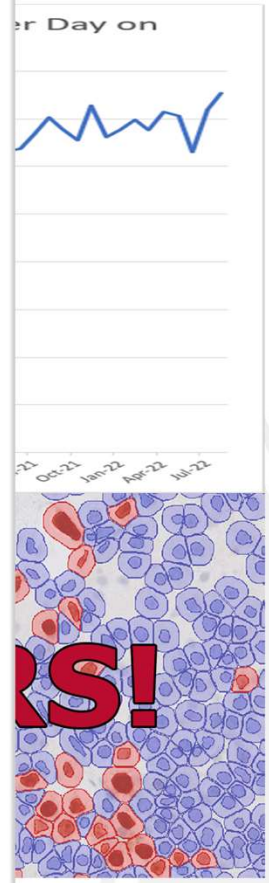
THINGS THAT STILL ARE AN ISSUE

- We still can't use digital slides to perform some necessary tasks!
- Polarization to identify foreign material
- New ways to teach residents?
- 3D imaging for cytopathology - - Z stacking- Expensive
- Oil for the hemepath guys – Messy and not a good solution out there

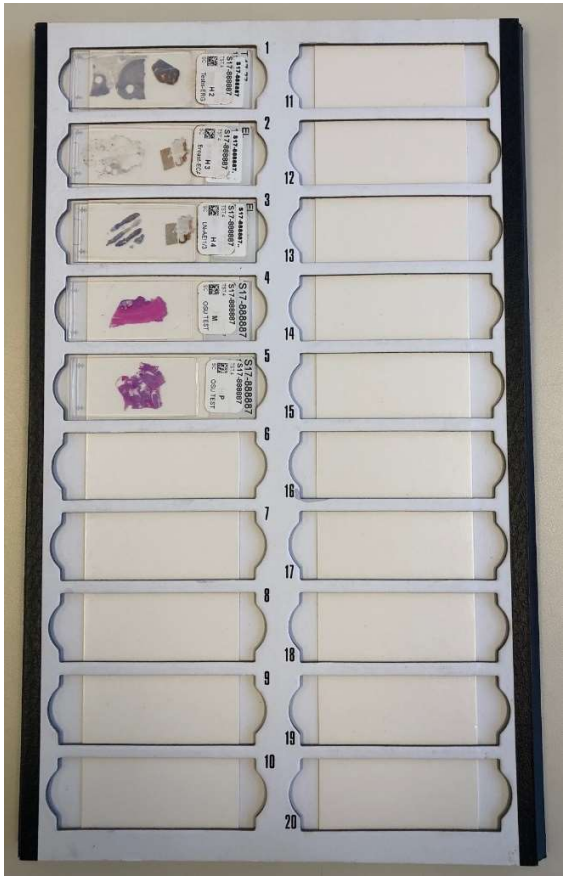
Digit ieved!!

- 307,
- Near
- Prim
- Tele
- Digit
- Help COV
- Educ conf
- Rese Engi worl





Those 2,900,000 slides and 307,000 cases include:



Clinical cases:

Sep 2011 to the present day.

All consults:

2017 to the present day

Tumor boards

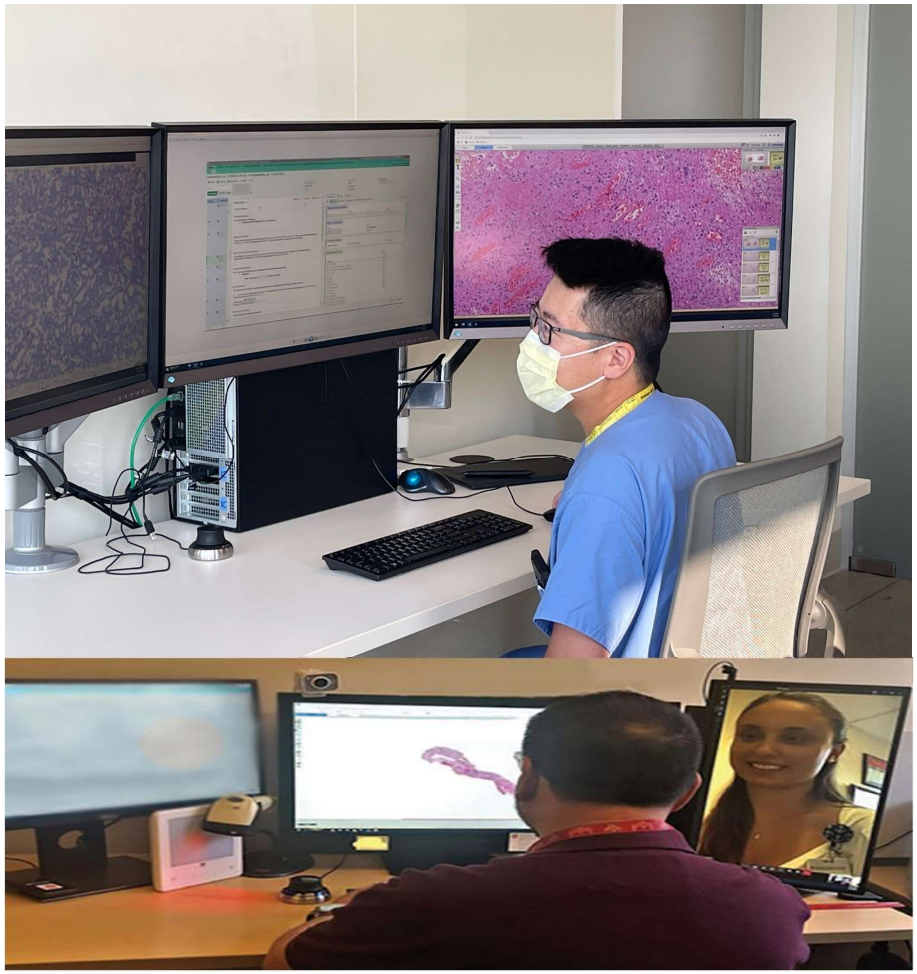
Residents' Slide Set

Teaching sets

Various research collections

Special requests.

Digital Pathology Enhanced Resident Training



Over 200 primary diagnosis sign-outs a day via digital pathology.

Nearly 80 consult sign-outs a day.

Supports numerous tumor boards.

Digital images used for dozens of research endeavors.

System used regularly by 144 faculty, residents, fellows, and staff.

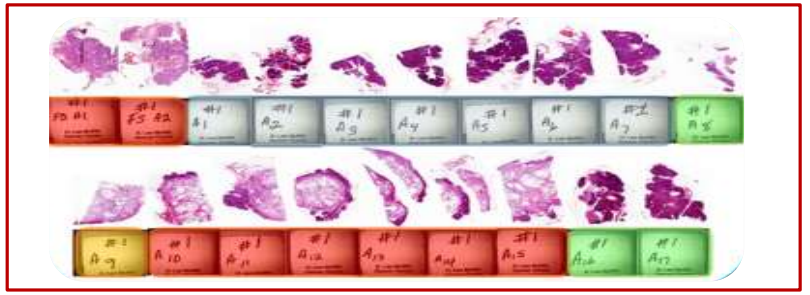
Pathology Department Benefits: The Quality Advantage

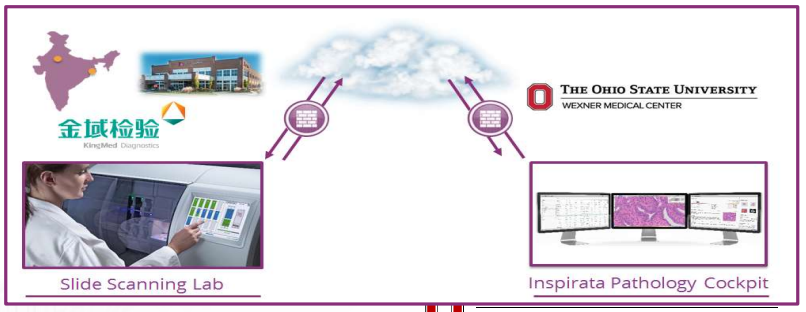
1 Decrease the time to diagnosis

- The digital pathology cockpit focuses pathologists time on what they do best—diagnose disease
- Diagnostic algorithm support make pathologists even faster

2 Consult Instantly

- Telepathology to load balance in real time
- Consult locally, regionally and globally
- Gain access to complex cases
- Rapid second reviews
- Improved and streamlined quality reviews





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Al-Janabi, Shaimaa, André Huisman, and Paul J. Van Diest. "Digital pathology: current status and future perspectives." *Histopathology* 61.1 (2012): 1-9.

QUESTIONS???

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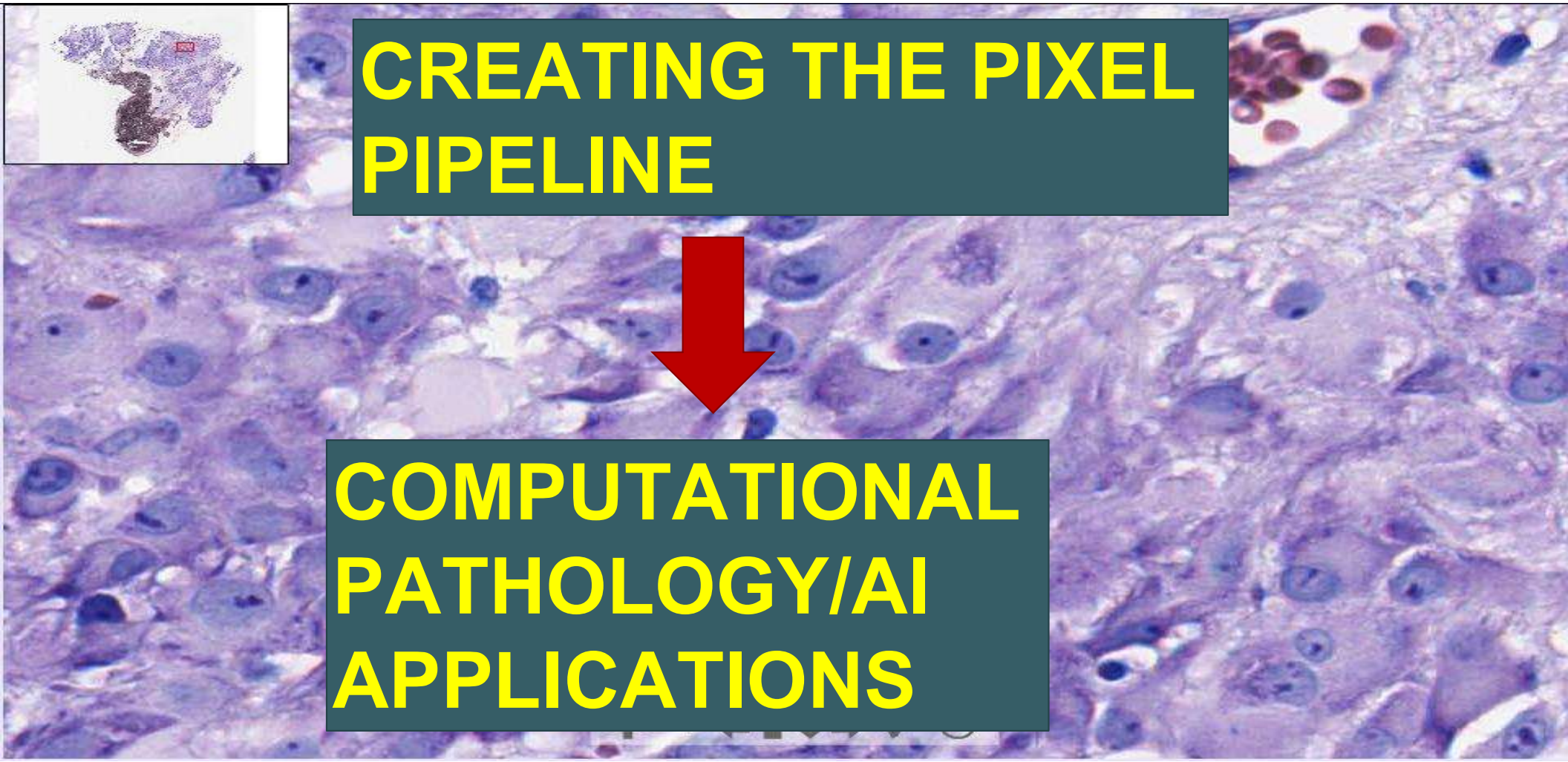
Current and Future Applications of Artificial Intelligence in Pathology: Are we ready for prime time?

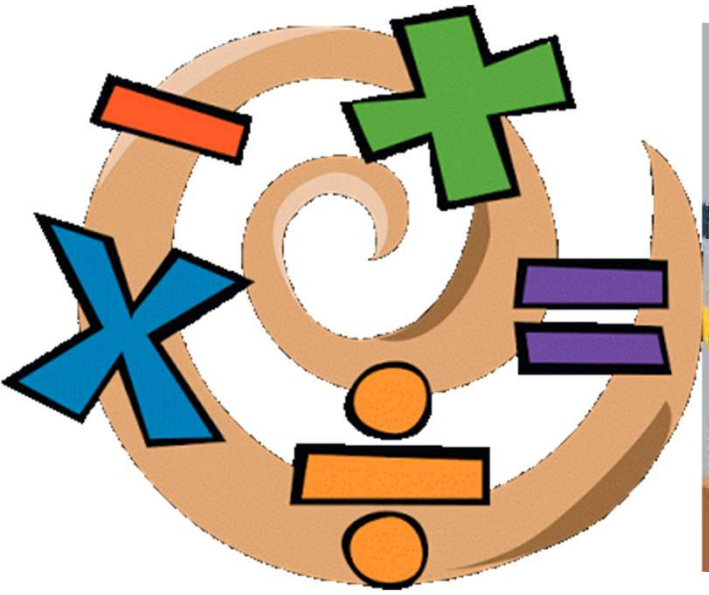
Anil V Parwani, MD, PhD, MBA

The Ohio State University Comprehensive Cancer Center – Arthur G. James Cancer Hospital and Richard J. Solove Research Institute


CREATING THE PIXEL PIPELINE
COMPUTATIONAL PATHOLOGY/AI APPLICATIONS

WHAT CAN WE DO WITH THE PIXELS??

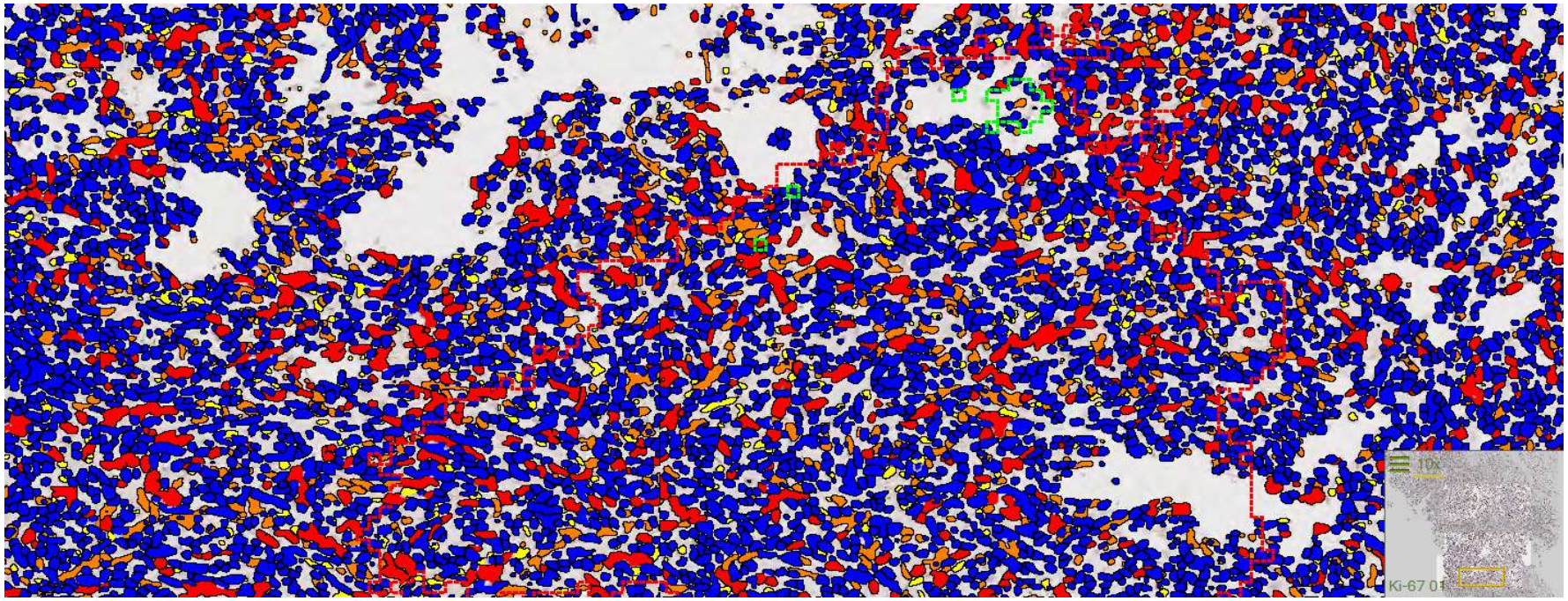
Pathologists today perform many complex manual tasks



AI can automate many of the complex manual tasks – such as object quantification, tissue classification based on morphology and rare target identification – that used to take hours or days to perform.

Some of those tasks now only take minutes using image analysis and AI

Quantification of Biomarkers: MORE OBJECTIVE, ACCURATE AND FASTER



Study Unit	Measurement	Count Low	Count Medium	Count High	Count Negative	Total Cell Count	Total Positive Ki-67	% Positive Ki-67	% Low Ki-67	% Medium Ki-67	% High Ki-67
Demo Images	Ki-67 01	22011	16710	12652	94943	146316	51373	35.11100006	15.0434999	11.4204998	8.64704037
Demo Images	Ki-67 02	6735	4662	2337	24939	38673	13734	35.51309967	17.4153004	12.05490017	6.04298019

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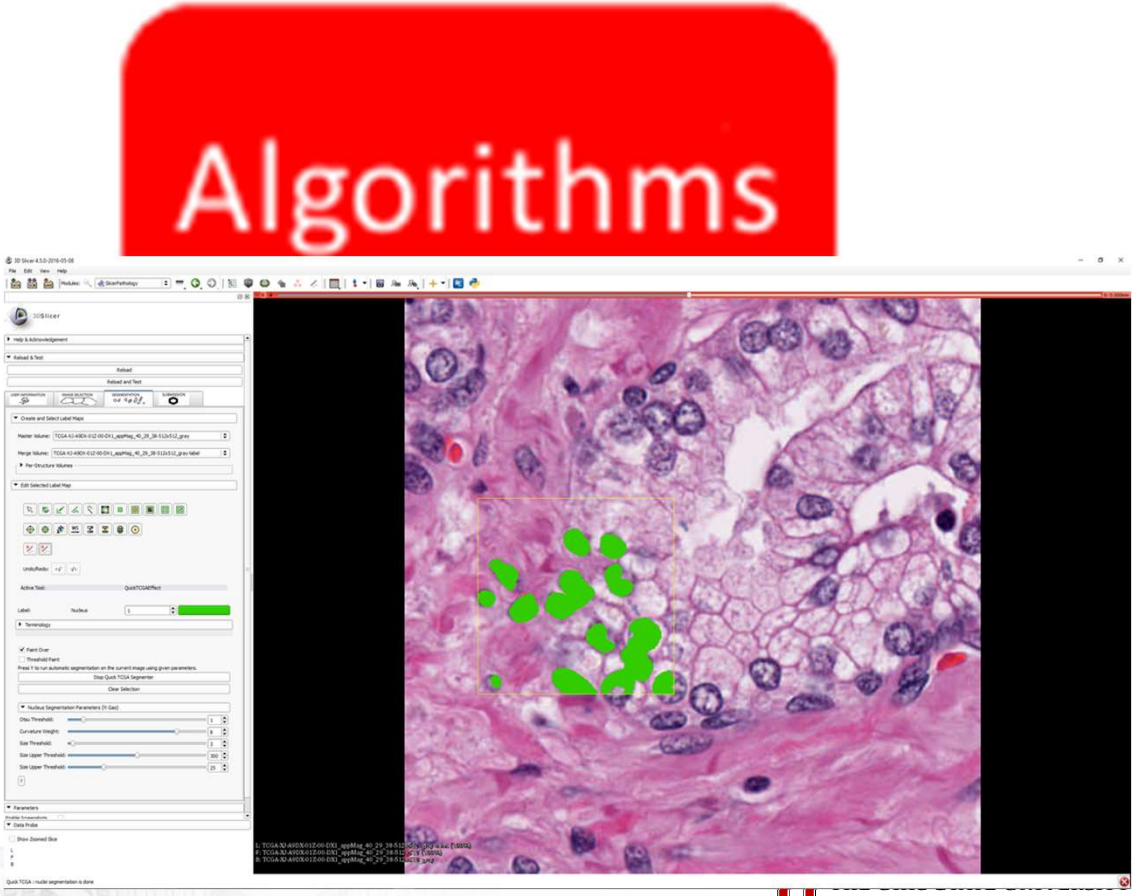
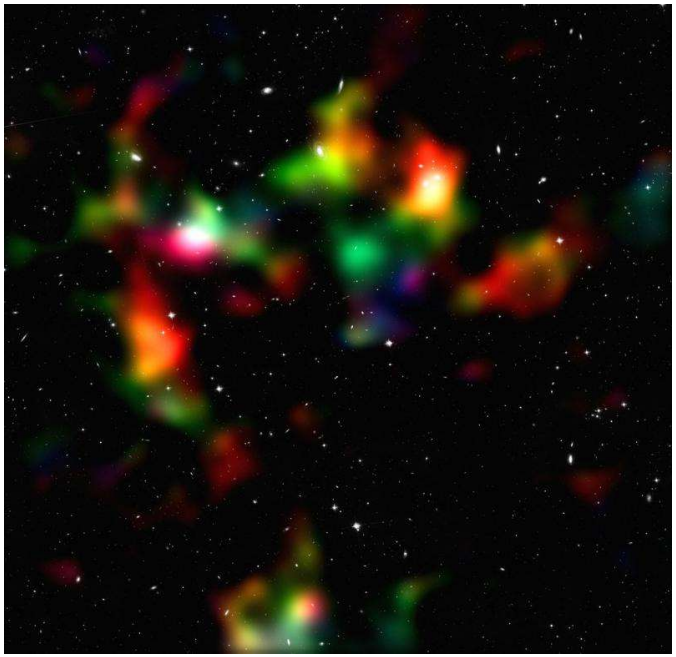
GOING BEYOND THE GLASS SLIDE

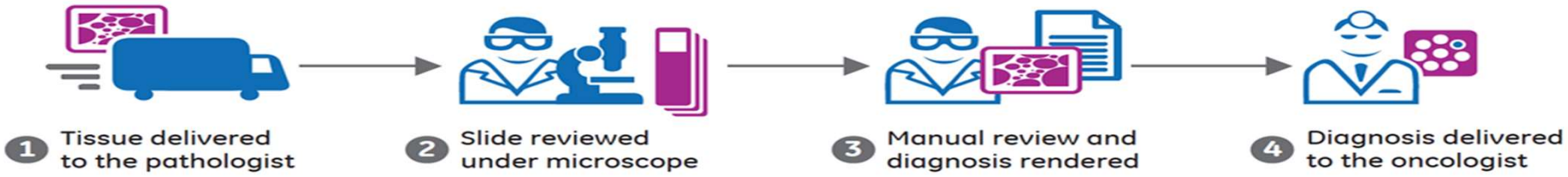
- Digital pathology/AI opens new doors in algorithms
  - Identification
  - Quantification
  - Synthesis



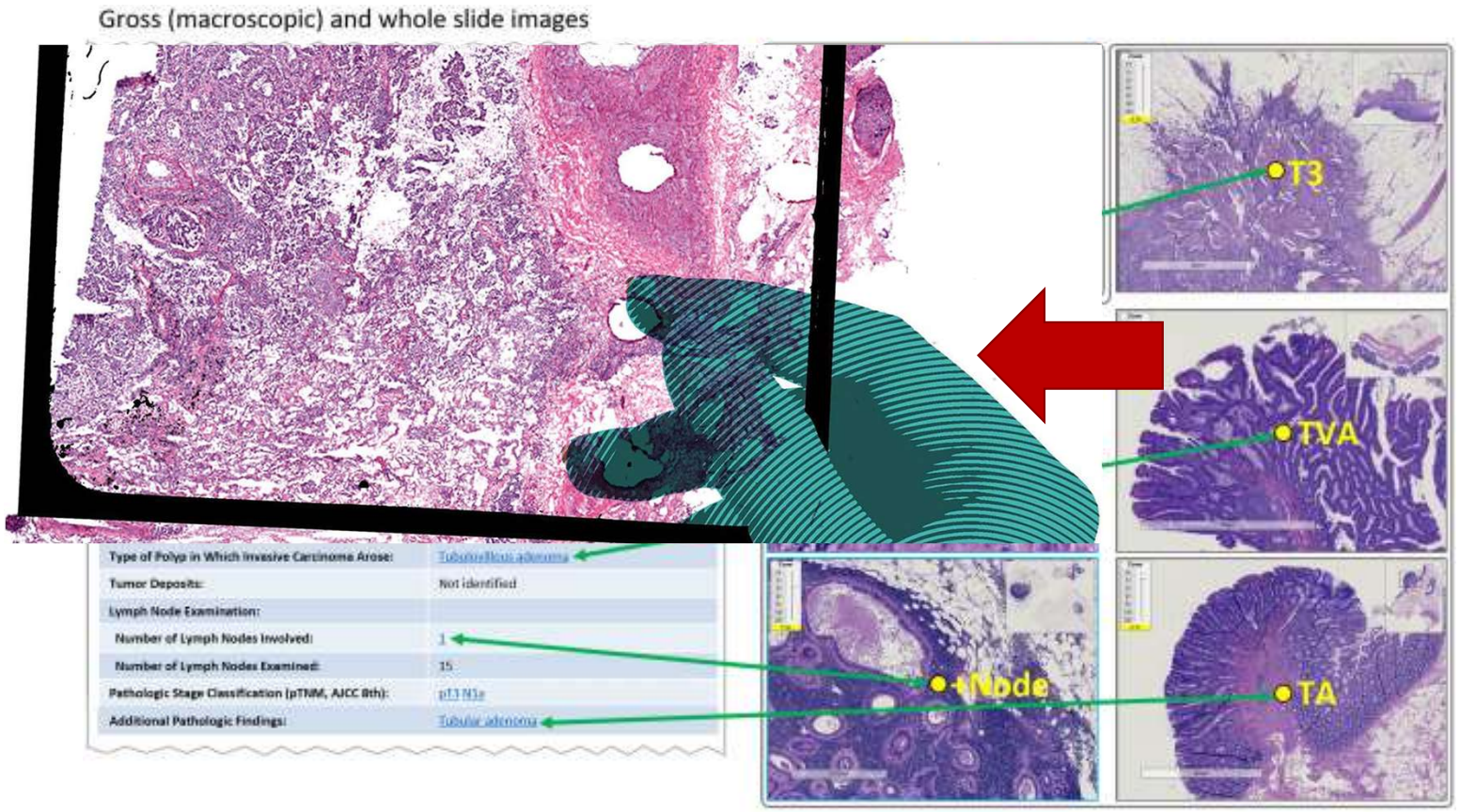
What ELSE can we do now?



Traditional Pathology

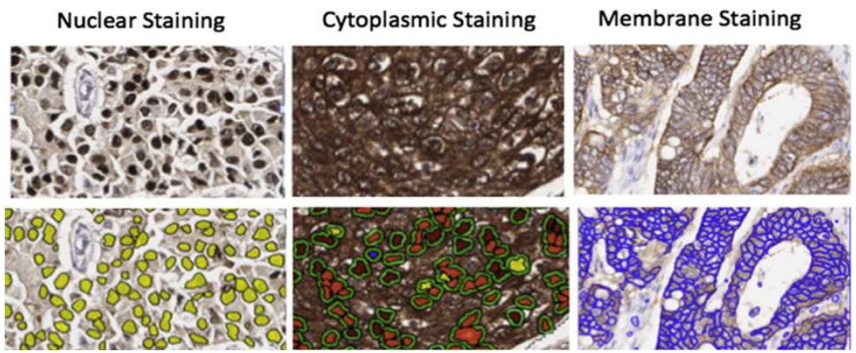


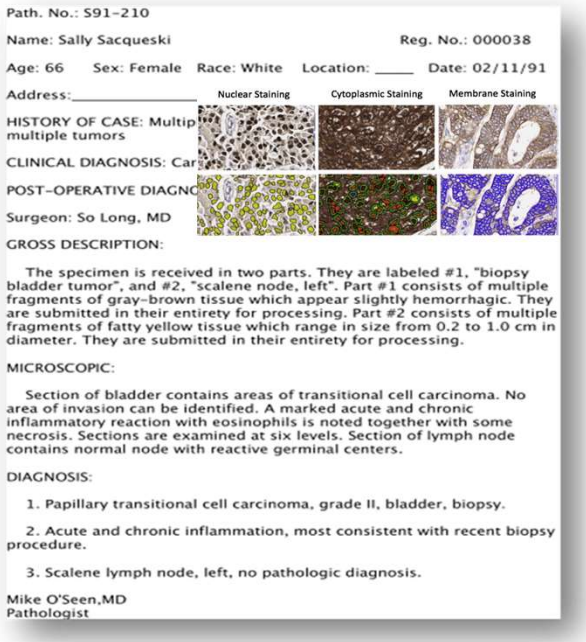
Interactive Multimedia Pathology Reporting



Roth, Christopher J et al. "Multispecialty Enterprise Imaging Workgroup Consensus on Interactive Multimedia Reporting Current State and Road to the Future: HIMSS-SIIM Collaborative White Paper." *Journal of digital imaging* vol. 34,3 (2021): 495-522. doi:10.1007/s10278-021-00450-5

Future State: Quantitative Immunohistochemistry Objective Data Directly to Patient Chart and Integrated Reporting





Path. No.: S91-210

Name: Sally Sacqueski Reg. No.: 000038

Age: 66 Sex: Female Race: White Location: ____ Date: 02/11/91

Address:_____

Nuclear Staining Cytoplasmic Staining Membrane Staining

HISTORY OF CASE: Multip
multiple tumors

CLINICAL DIAGNOSIS: Car

POST-OPERATIVE DIAGNO

Surgeon: So Long, MD

GROSS DESCRIPTION:

The specimen is received in two parts. They are labeled #1, "biopsy bladder tumor", and #2, "scalene node, left". Part #1 consists of multiple fragments of gray-brown tissue which appear slightly hemorrhagic. They are submitted in their entirety for processing. Part #2 consists of multiple fragments of fatty yellow tissue which range in size from 0.2 to 1.0 cm in diameter. They are submitted in their entirety for processing.

MICROSCOPIC:

Section of bladder contains areas of transitional cell carcinoma. No area of invasion can be identified. A marked acute and chronic inflammatory reaction with eosinophils is noted together with some necrosis. Sections are examined at six levels. Section of lymph node contains normal node with reactive germinal centers.

DIAGNOSIS:

1. Papillary transitional cell carcinoma, grade II, bladder, biopsy.

2. Acute and chronic inflammation, most consistent with recent biopsy procedure.

3. Scalene lymph node, left, no pathologic diagnosis.

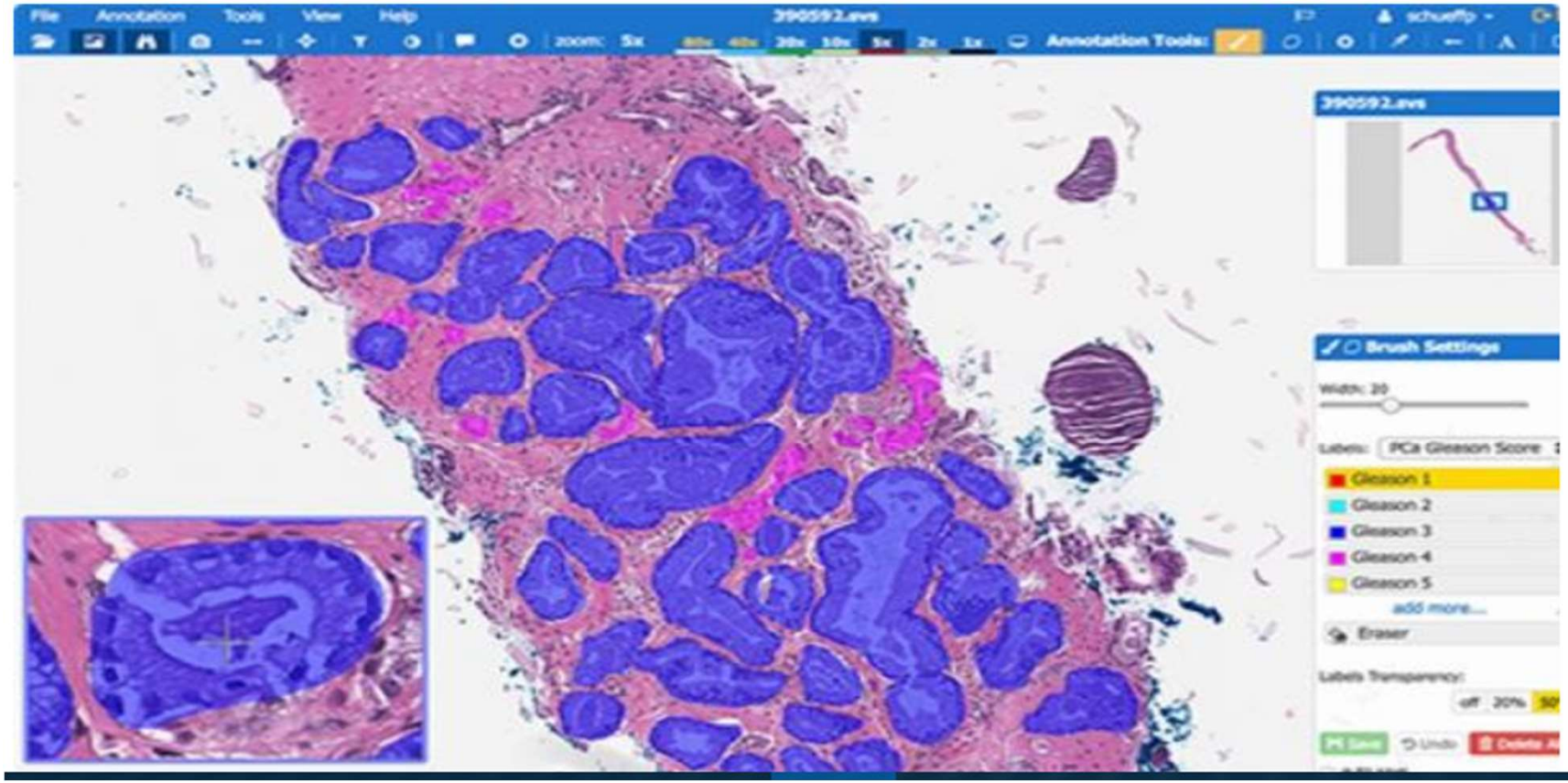
Mike O'Seen,MD
Pathologist

INTEGRATED AI-DRIVEN SMART REPORTING SYSTEMS..MULTIMODALITY DRIVEN WITH DATA ANALYTICS AND VISUALIZATION

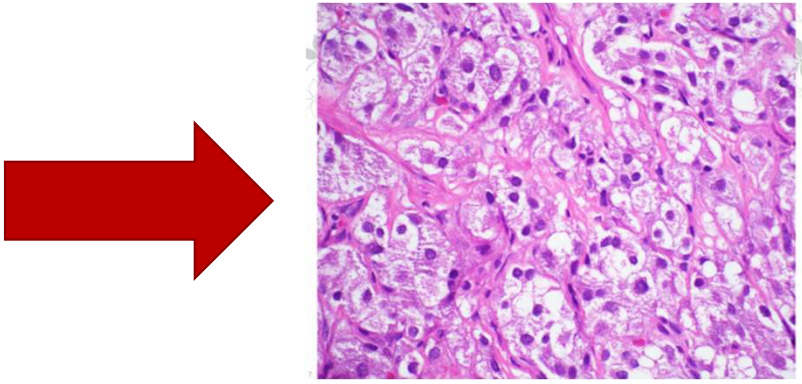
Hamilton PW, et al. Digital pathology and image analysis in tissue biomarker research. Methods. 2014 Nov;70(1):59-73.

FDA Grants Breakthrough Designation to Paige.AI

Designation expedites product development and provides priority regulatory review for clinical-grade artificial intelligence in pathology



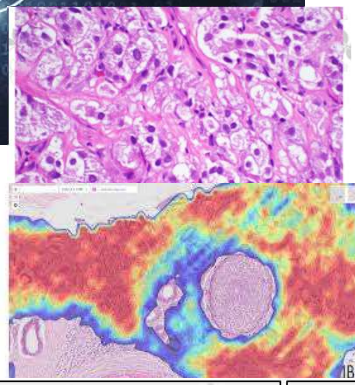
HOW CAN AI TOOLS HELP A PATHOLOGIST?

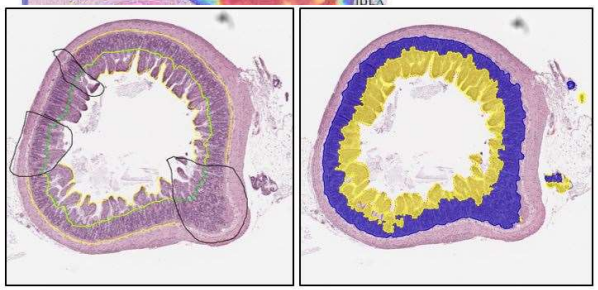


ASSIST

AUGMENT

AUTONOMOUS



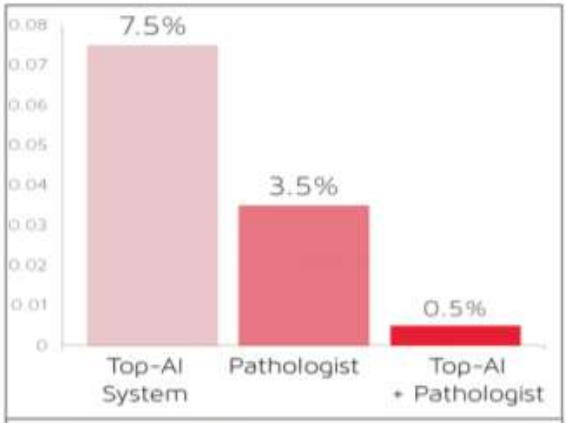


Deep Learning in Breast Pathology

National Institutes of Health (NIH) grants-supported research

ARTIFICIAL INTELLIGENCE FOR COMPUTATIONAL PATHOLOGY

Image interpretation plays a central role in the pathologic diagnosis of cancer. Since the late 19th century, the primary tool used by pathologists to make definitive cancer diagnoses is the microscope. Pathologists diagnose cancer by manually examining stained sections of cancer tissues to determine the cancer subtype. Pathologic diagnosis using conventional methods is labor-intensive with poor reproducibility and quality concerns. New approaches use fundamental AI research to build tools to make pathologic analysis more efficient, accurate, and predictive. In the 2016 Camelyon Grand Challenge for metastatic cancer detection,[69] the top-performing entry in the competition was an AI-based computational system that achieved an error rate of 7.5%.[70] A pathologist reviewing the same set of evaluation images achieved an error rate of 3.5%. Combining the predictions of the AI system with the pathologist lowered the error rate to down to 0.5%, representing an 85% reduction in error (see image).[71] This example illustrates how fundamental research in AI can drive the development of high performing computational systems that offer great potential for making pathological diagnoses more efficient and more accurate.



AI significantly reduces pathologist error rate in the identification of metastatic breast cancer from sentinel lymph node biopsies.

THE NATIONAL ARTIFICIAL INTELLIGENCE RESEARCH AND DEVELOPMENT STRATEGIC PLAN

National Science and Technology Council

Networking and Information Technology Research and Development Subcommittee

October 2016

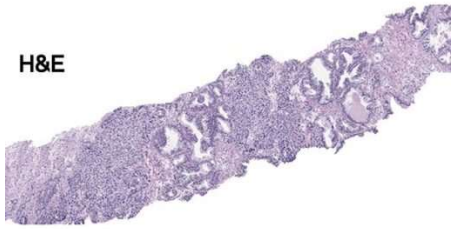
Automated Biomarker Analysis for Clinical Diagnostics
Regions of Interest Scoring Methods

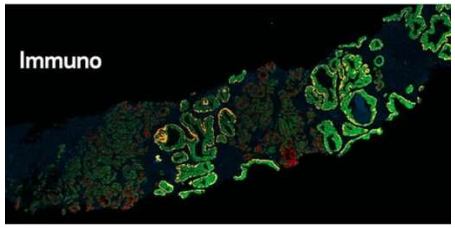
Slide Score: Multiple Regions

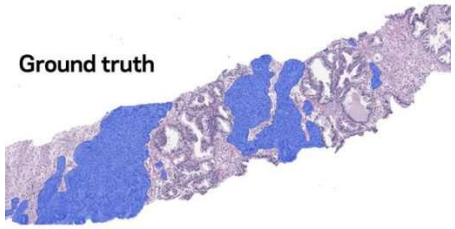
Highlighted Region Score(s)

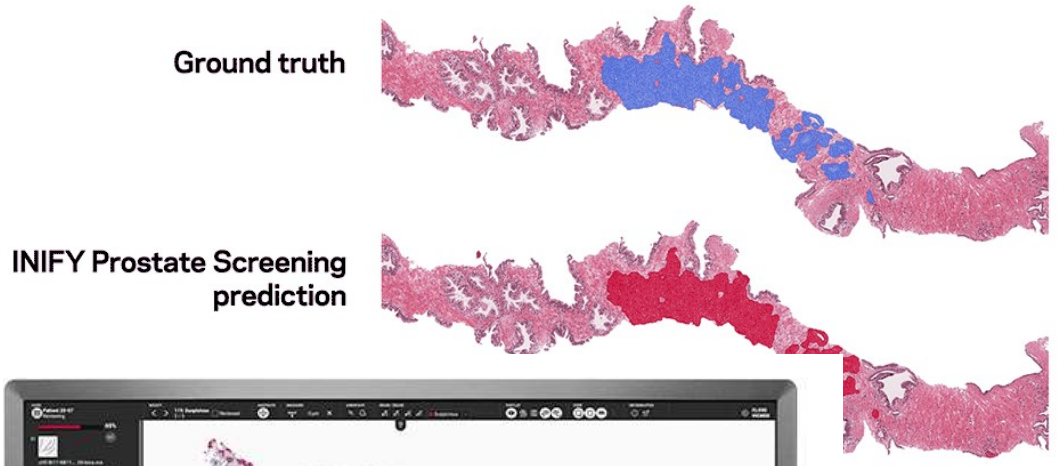
Future State: DP/QIA Standardized Diagnostic Tests

AI-powered tool that provides pathologists with valuable decision support when identifying cancer in prostate biopsies









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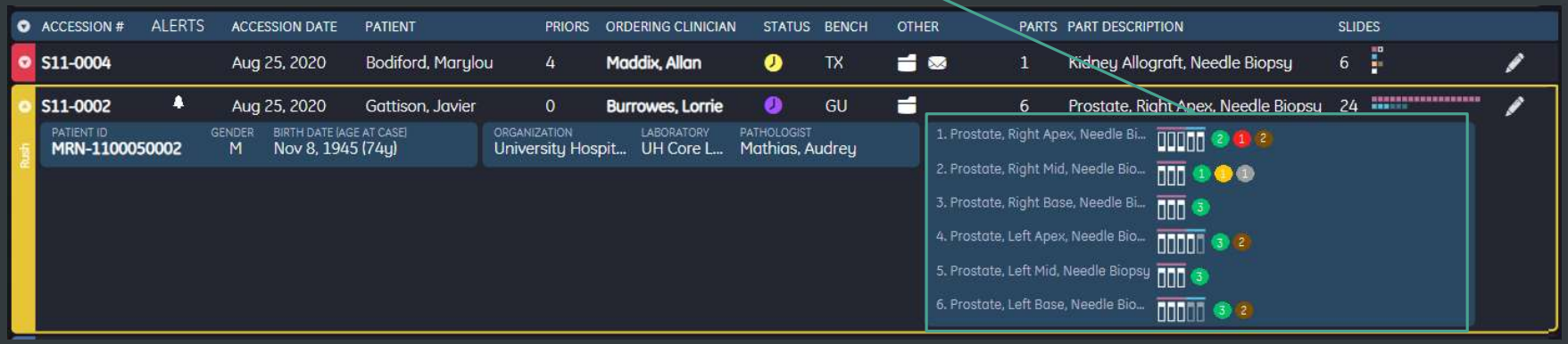
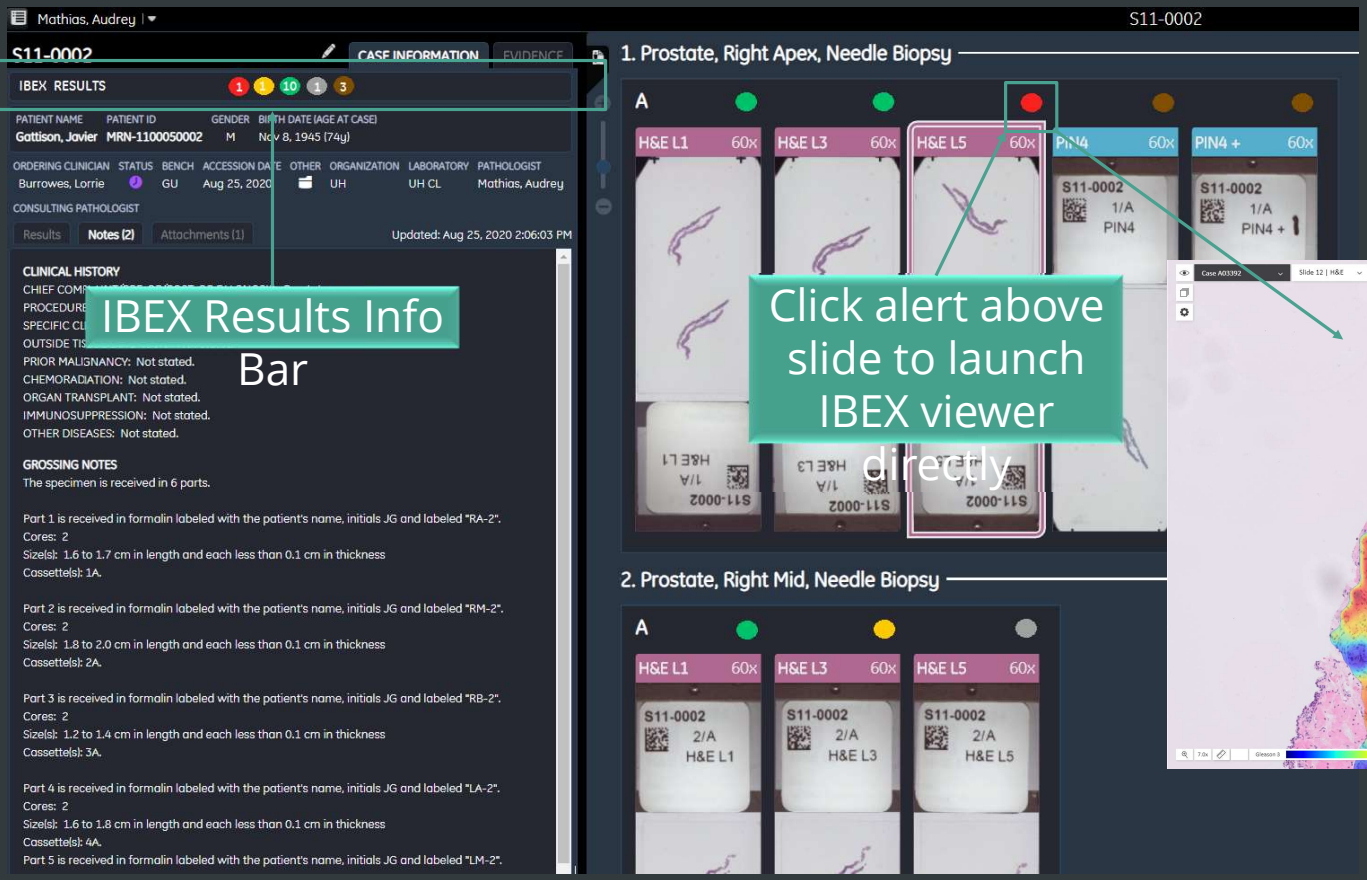
IBEX: Suspicious Lesions in Prostate Biopsies

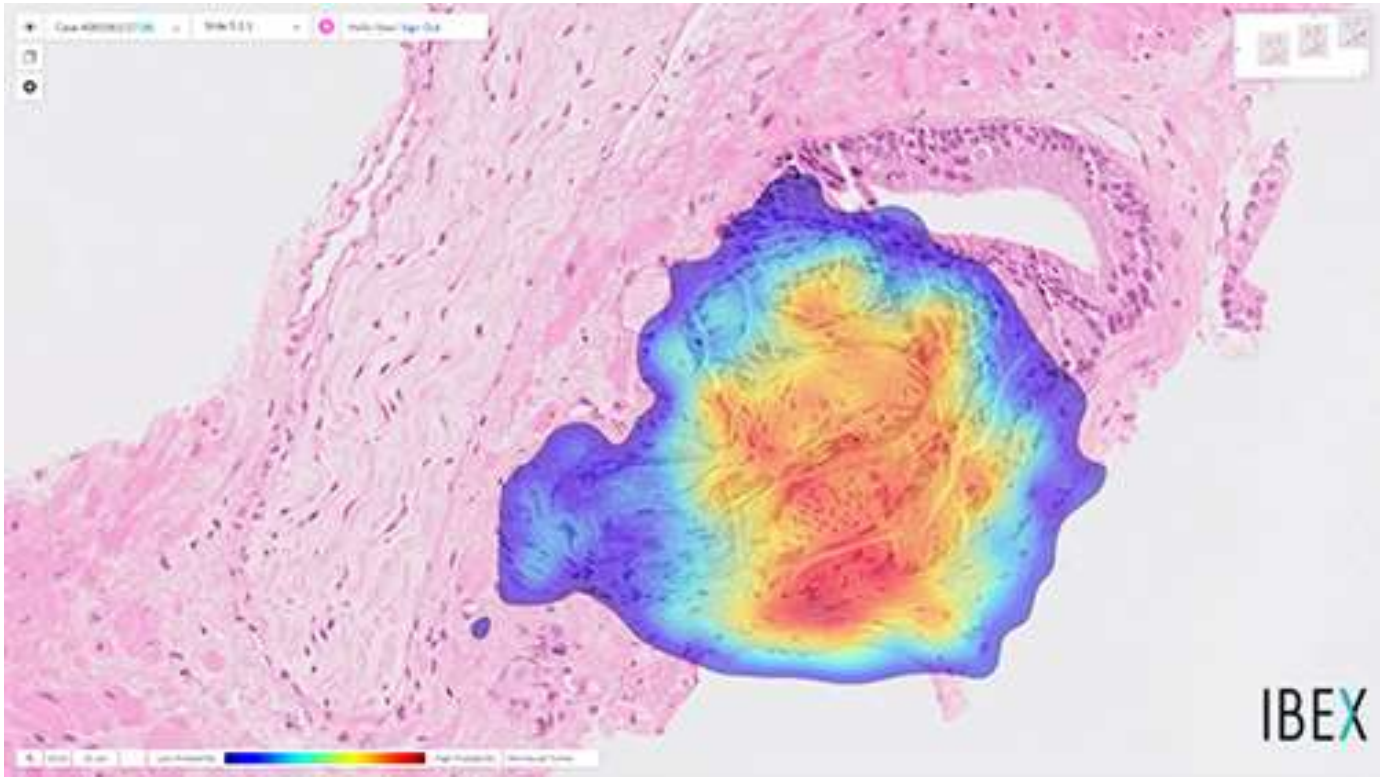
Notification in the Case List

Notifications in expanded case row



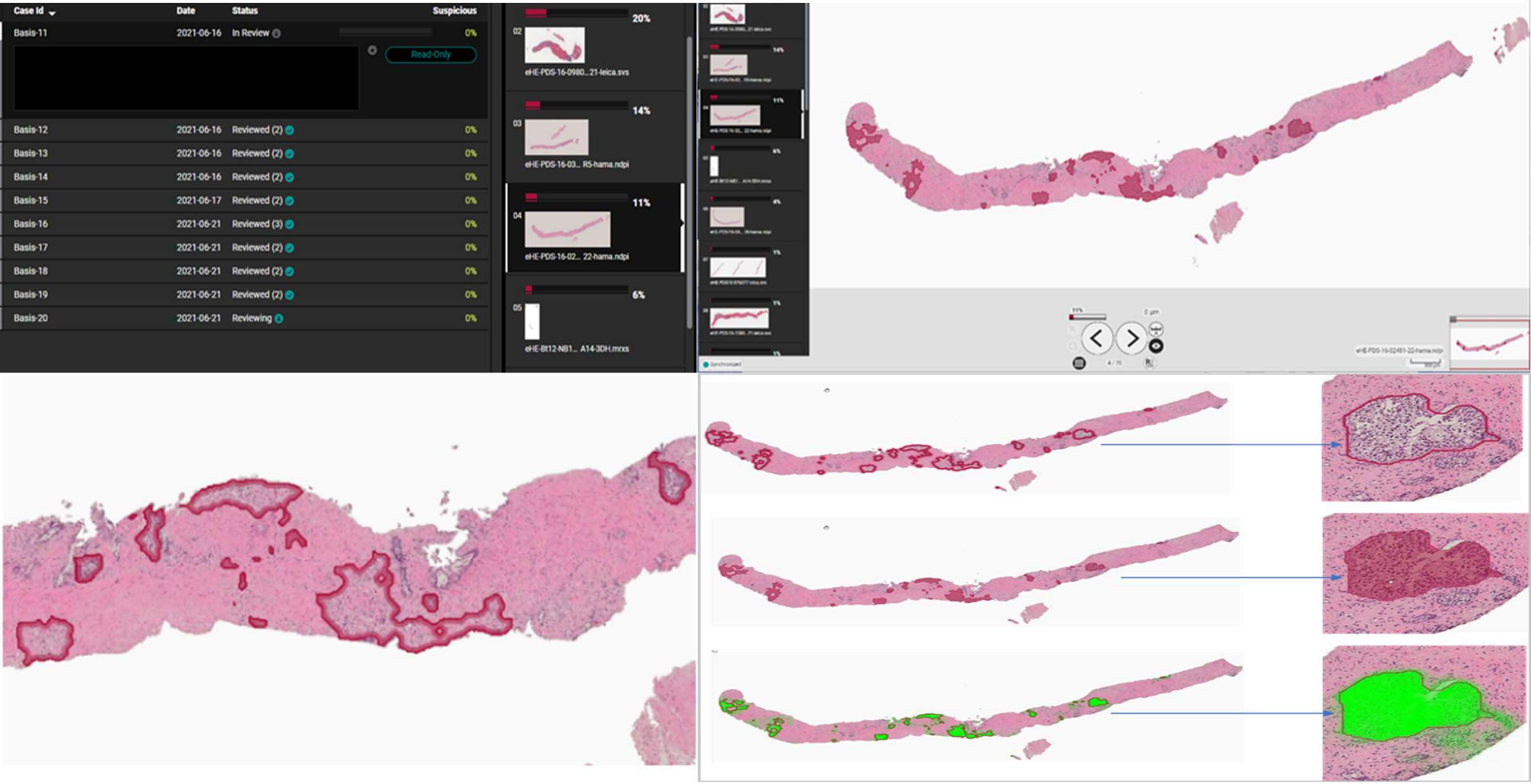
IBEX: Suspicious Lesions in Prostate Biopsies



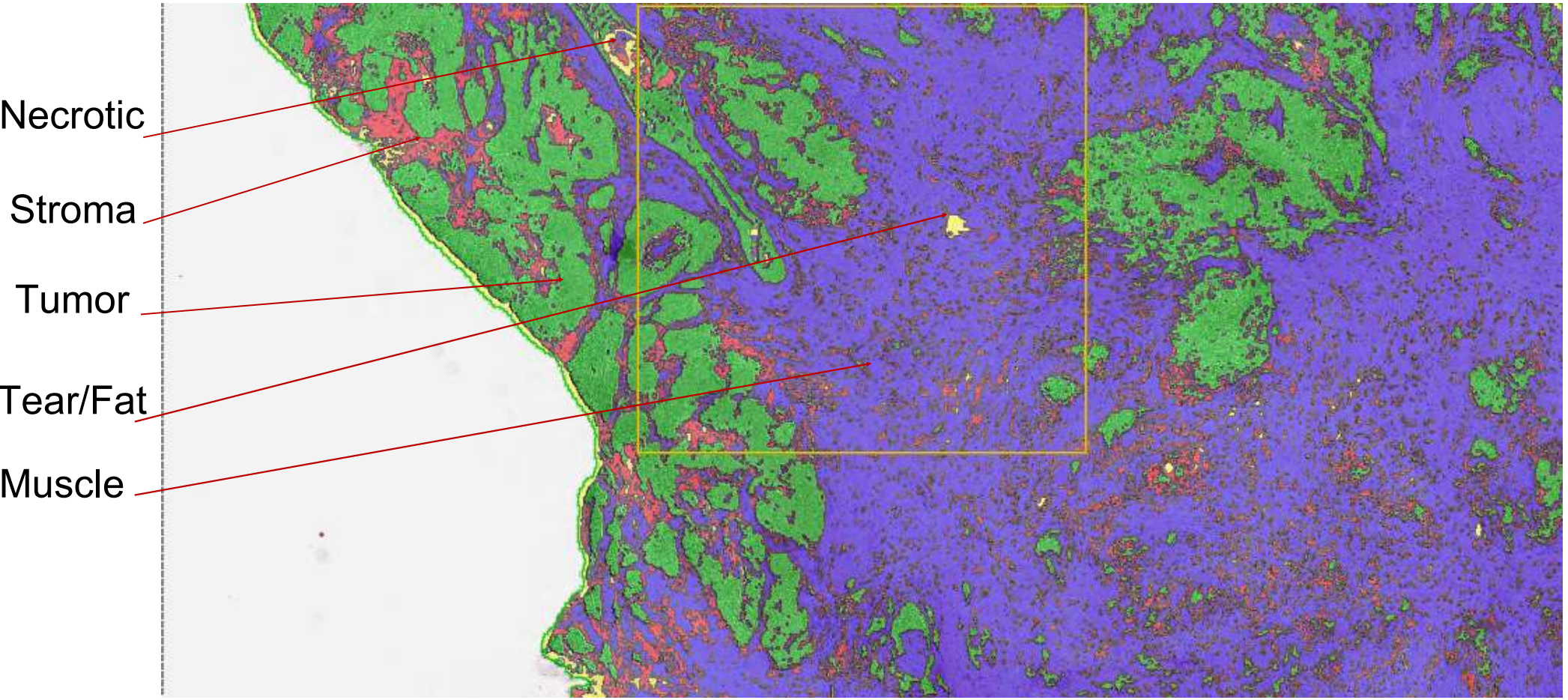


The algorithm achieved an AUC of 0·997 (95% CI 0·995 to 0·998) for cancer detection in the internal test set and 0·991 (0·979 to 1·00) in the external validation set. The AUC for distinguishing between a low-grade (Gleason score 6 or ASAP) and high-grade (Gleason score 7–10) cancer diagnosis was 0·941 (0·905 to 0·977) and the AUC for detecting Gleason pattern 5 was 0·971 (0·943 to 0·998) in the external validation set. Cancer percentage calculated by pathologists and the algorithm showed good agreement (r=0·882, 95% CI 0·834 to 0·915; p<0·0001) with a mean bias of −4·14% (−6·36 to −1·91)

Evaluation of 3 different scanners’ performance to create prostate biopsy images with suitable quality for accurate INIFY Prostate predictions. Impact of preanalytical factors and user experience.



Classifying Treatment Changes: Precise diagnosis leads to precise treatment for the right patient



Renal Cell Carcinoma Whole-Slide Image Classification and Search Using Deep Learning

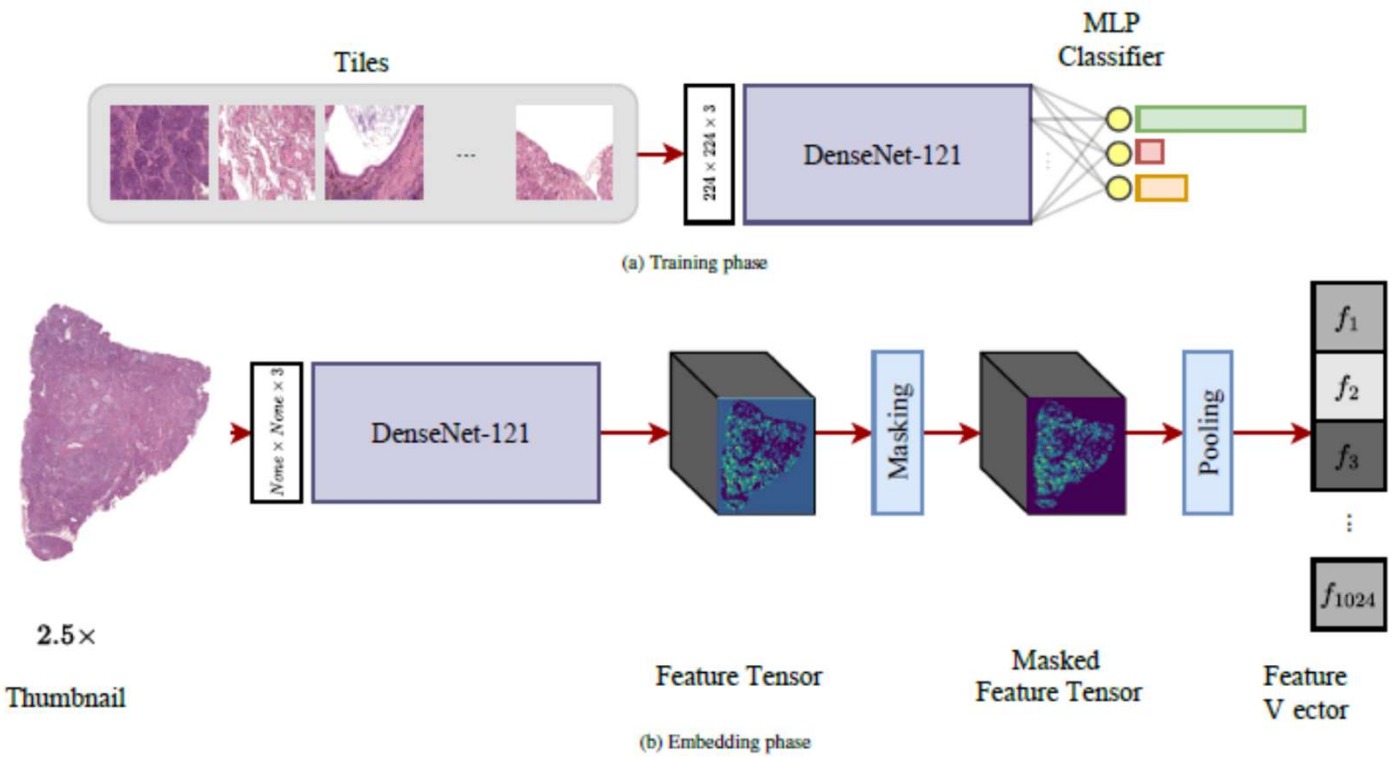
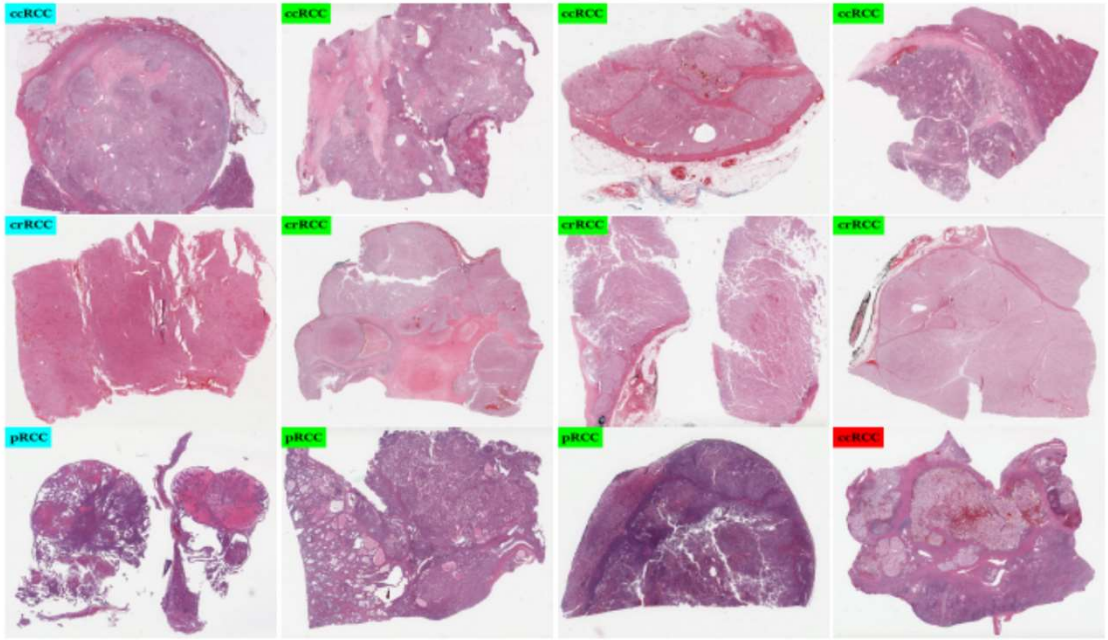


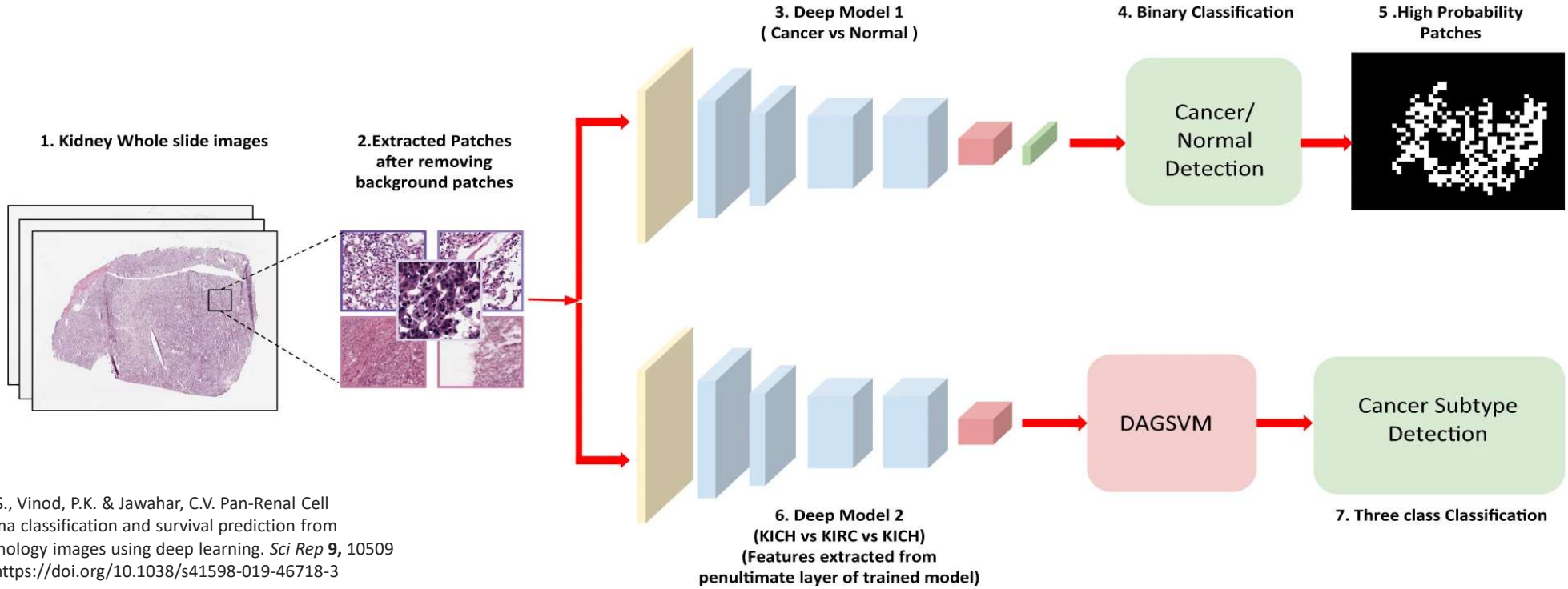
Figure 1: The outline of the proposed algorithm for encoding WSIs. (a) shows the training step in the algorithm. In this step, a DenseNet-121 [27] is trained using 224 × 224 × 3 tiles extracted from 2.5× WSIs in the training subsets to classify different RCC subtypes

Renal Cell Carcinoma Whole-Slide Image Classification and Search Using Deep Learning



The top three search results for queries related to different RCC subtypes from the TCGA search dataset. The images with a light blue tag are the query WSIs, while the correct and the wrong retrievals are shown in green and red tags, respectively.

Pan-Renal cell carcinoma classification using Deep Learning



Tabibu, S., Vinod, P.K. & Jawahar, C.V. Pan-Renal Cell Carcinoma classification and survival prediction from histopathology images using deep learning. *Sci Rep* **9,** 10509 (2019). https://doi.org/10.1038/s41598-019-46718-3

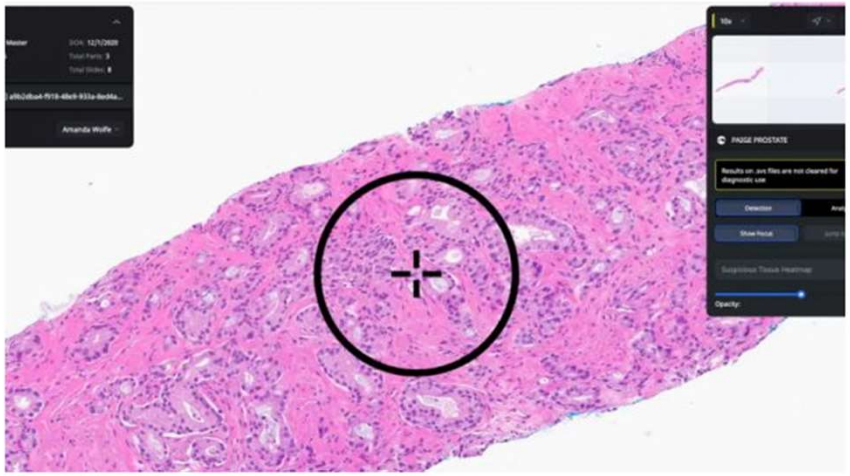
Classification Pipeline

Cancer Classification Pipeline. (1) Kidney Whole slide images. (2) 512*512 patches extracted from images with 50% overlap and background removed using pixel thresholding. (3) Patches from normal and cancerous slides fed to the deep network. (4) Patches classified as cancerous or non-cancerous. (5) High probability patches identified by the trained network and binary mask is applied. (6) The patches from three subtypes used to train a similar deep architecture for a three-way classification. (7) Features extracted from the penultimate layer of the network and fed to DAG-SVM and a three-way classification is performed by it.

AI-BASED PATHOLOGY DIAGNOSTIC TOOLS ARE NOW AVAILABLE!!

Trending | Boehringer backs AI-powered anti-infective startup ArrePath

BACK



FDA clears AI-powered prostate cancer detection software

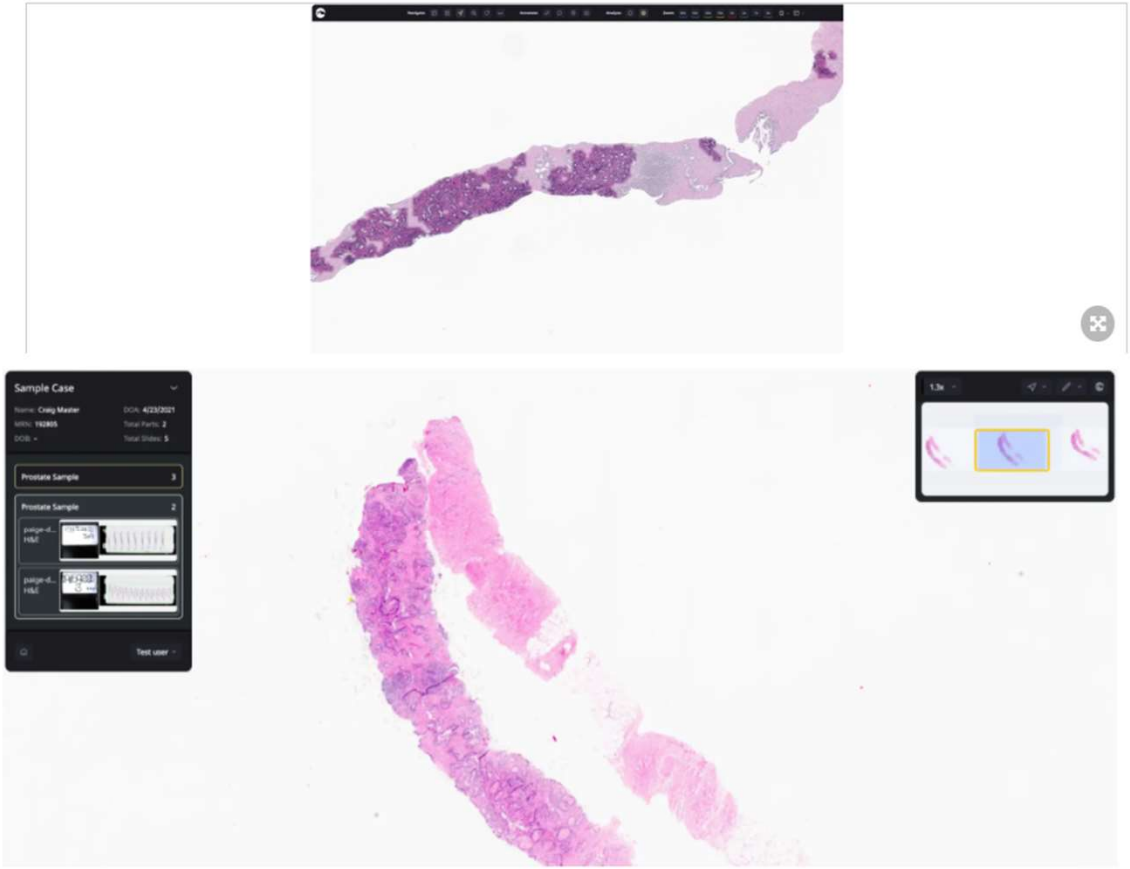
Phil Taylor

September 22, 2021

Software that can help pathologists detect prostate cancer from slides of biopsies more effectively has been approved by the FDA.

ge, a

commercial distribution agreement for Paige's comprehensive portfolio of diagnostic software solutions.



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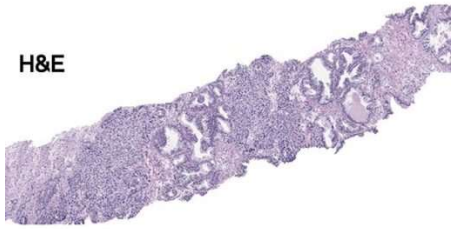
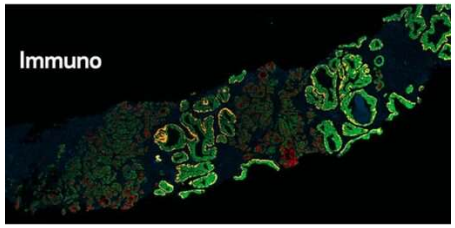
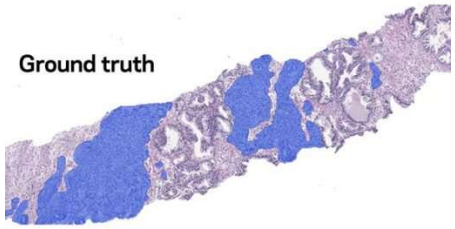
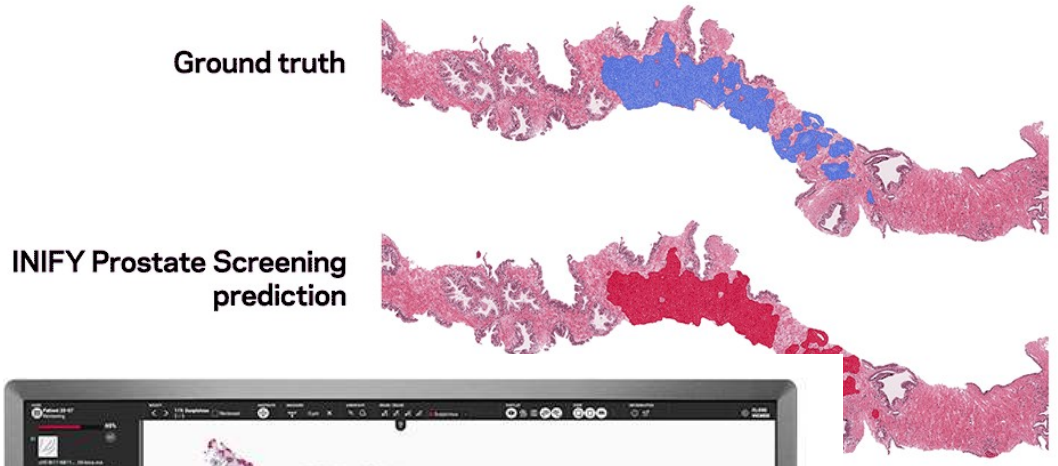
AI-powered tool that provides pathologists with valuable decision support when identifying cancer in prostate biopsies









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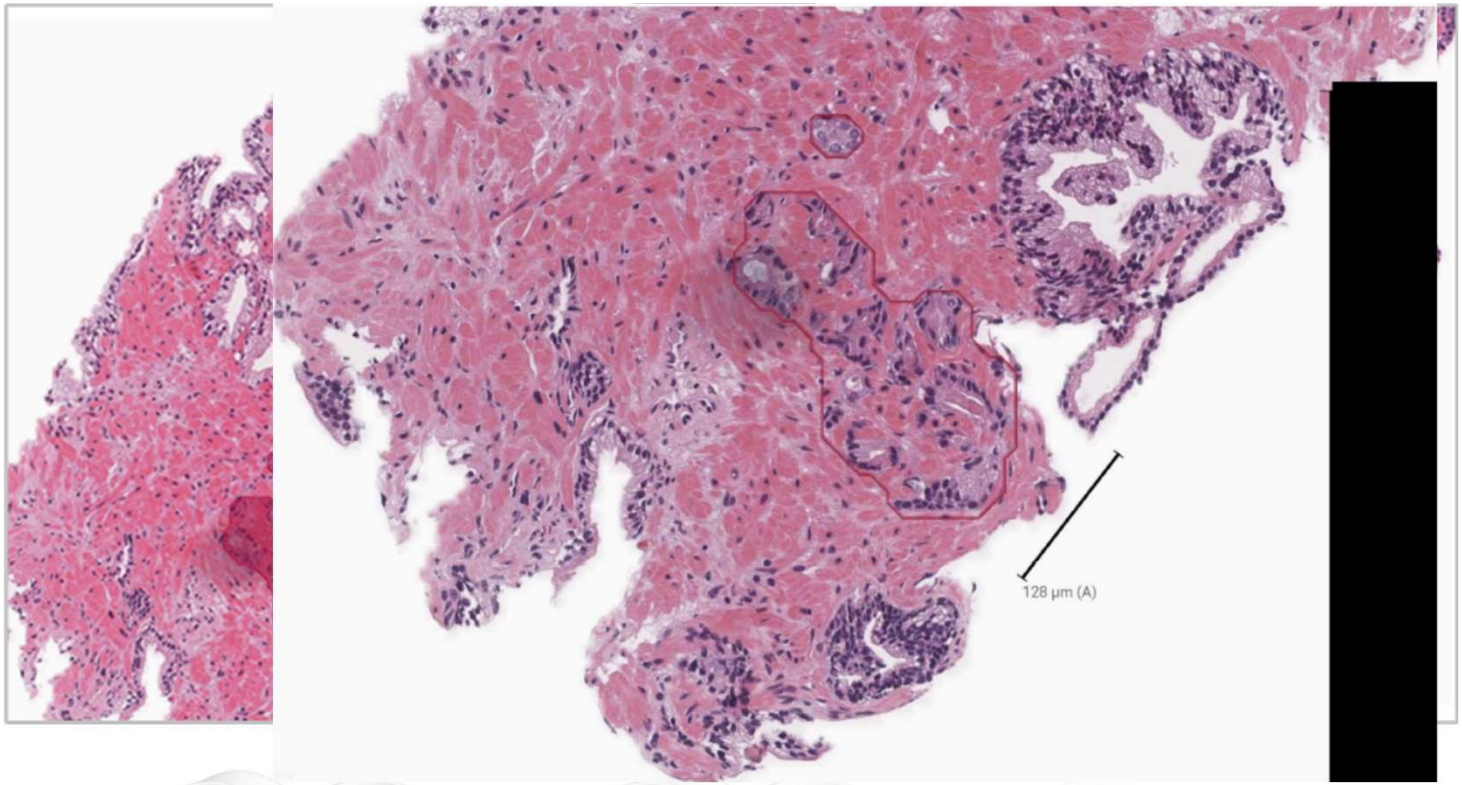
WEXNER MEDICAL CENTER

Artificial intelligence (AI) algorithms can be used as a tool to augment diagnosis, grading and volume quantification of prostate cancer (PCa) in prostate biopsy (PBx)



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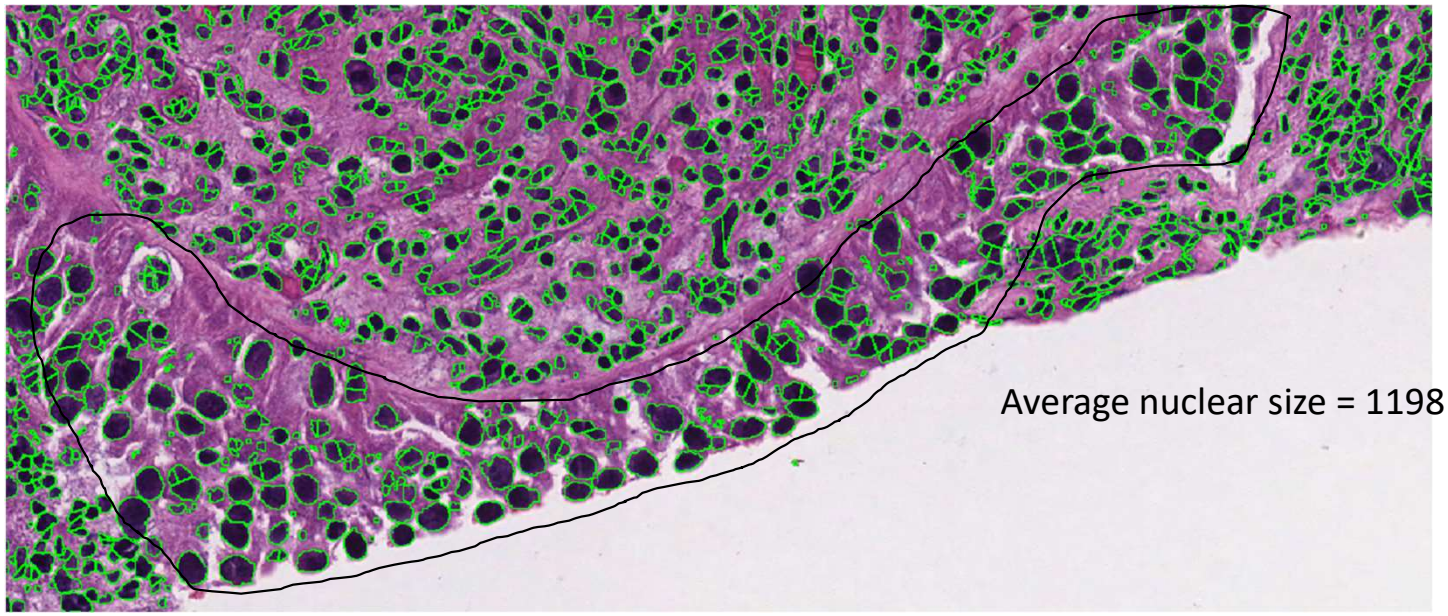
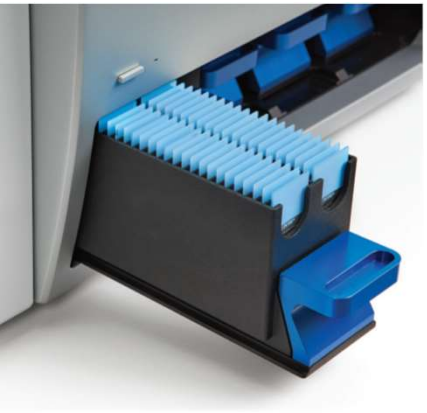
The Ohio State University
Wexner Medical Center

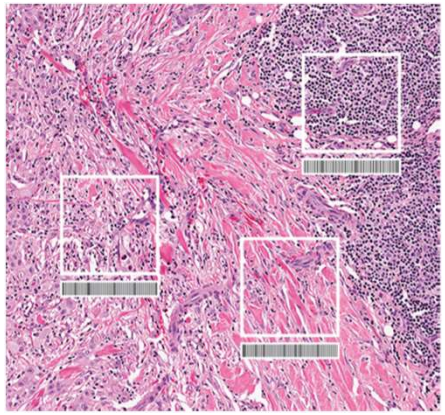

DYSPLASIA
400X

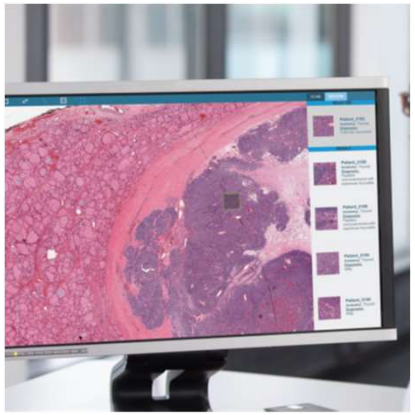
End-to-end system example: Bladder cancer diagnosis

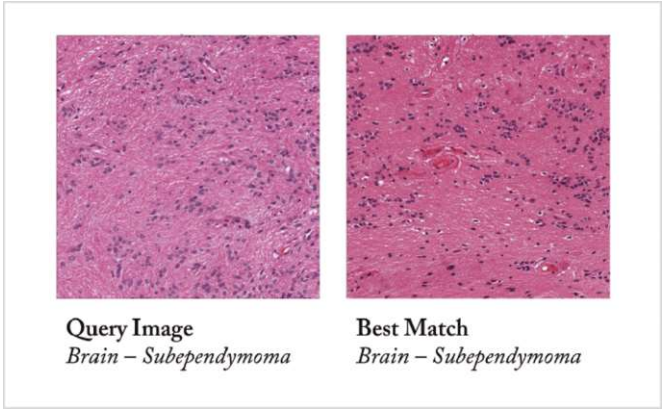


Searching WSIs: Image retrieval: Another Clinical Tool





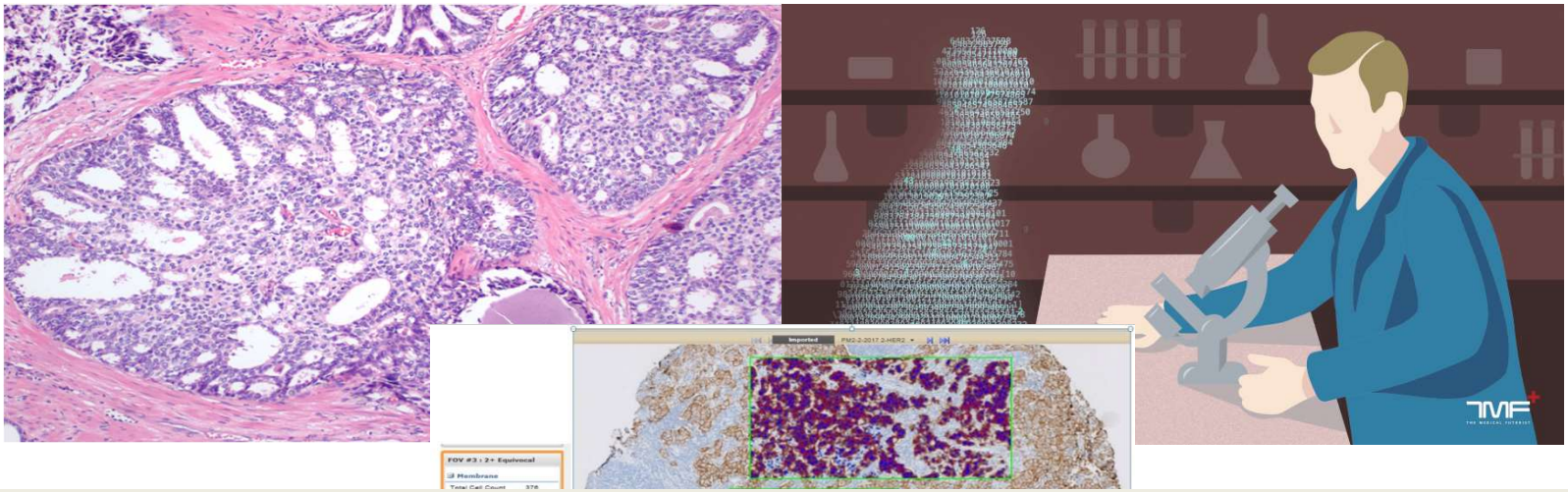




Scan Index/label Search Match

Searching Is Intelligence. Image retrieval – the next revolution in pathology. Hamid Tizhoosh | 10/11/2018. The Pathologist

Digital Pathology and AI is here...NOW!

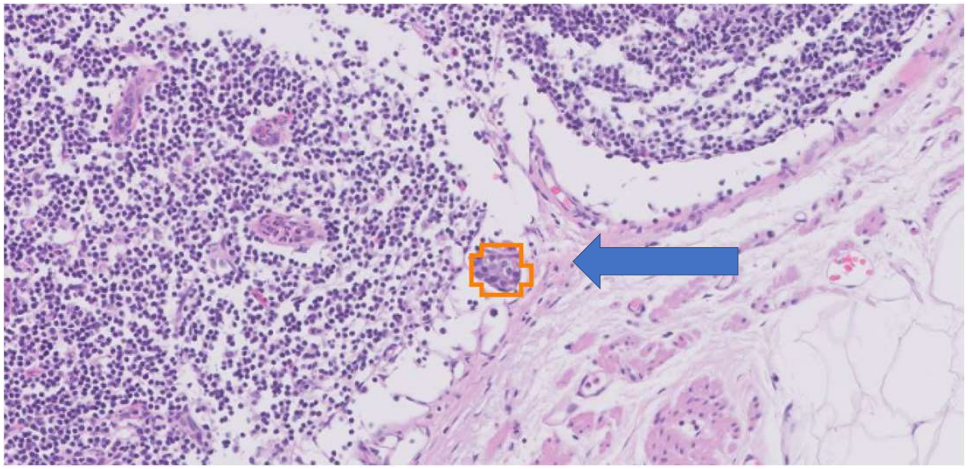


IMPACTING CLINICAL DIAGNOSTICS AND RESEARCH

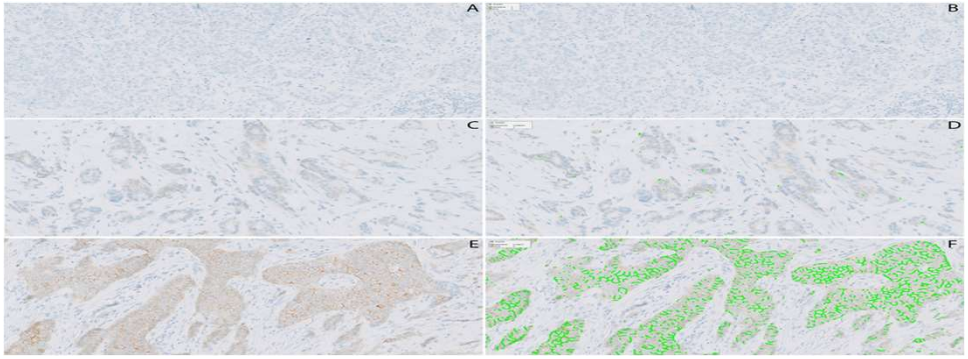
Research, Clinical, Education, Innovations

Examples of Quantitative Image Analysis and AI Algorithms Validated at OSU in the last 12 months

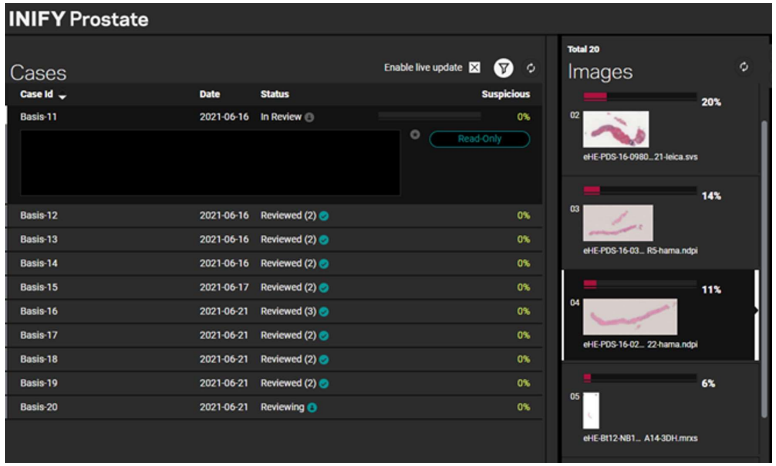
FINDING METASTATIC CANCER IN LYMPH NODES



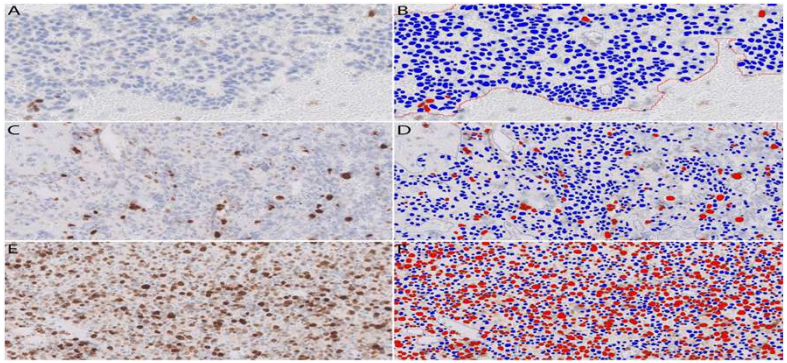
HER2 IHC analyzed by Visiopharm HER2 IHC algorithm



DETECTING AND GRADING PROSTATE CANCER



Digital imaging analysis of Ki-67 in cytology



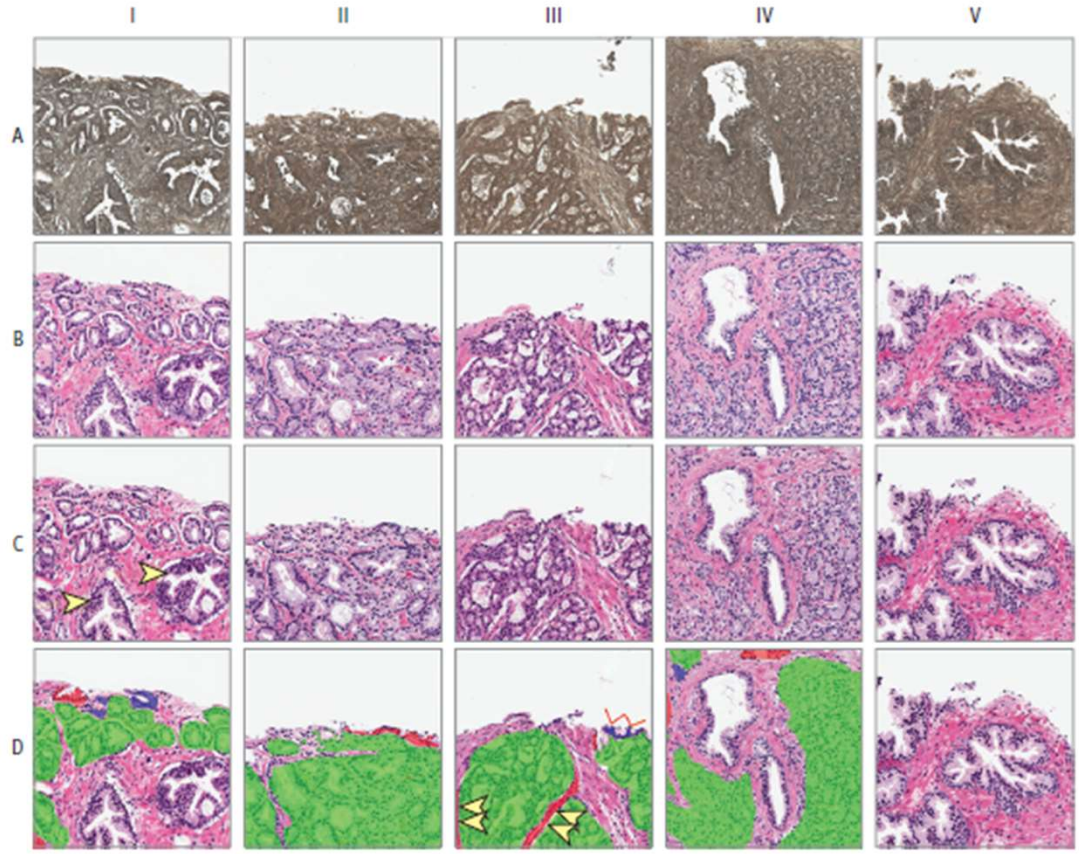
JAMA Network | Open

Original Investigation | Health Informatics

Use of Deep Learning to Develop and Analyze Computational Hematoxylin and Eosin Staining of Prostate Core Biopsy Images for Tumor Diagnosis

Aman Rana, MS; Alarice Lowe, MD; Marie Lithgow, MD; Katharine Horback, MD; Tyler Janovitz, MD; Annacarolina Da Silva, MD; Harrison Tsai, MD; Vignesh Shanmugam, MD; Akram Bayat, PhD; Pratik Shah, PhD

Figure 2. Representative Image Patches Generated by the Computational Staining Neural Network and Their Comparison With Corresponding Ground Truth Hematoxylin and Eosin (H&E) Dye-Stained Images



Row A, Deparaffinized native nonstained image patches entered into the neural network. Row B, Ground truth H&E dye–stained patches. Row C, computationally H&E stained patches generated by the neural network. Arrows in C-I indicate the 2 benign glands, all other glands represent tumors. Row D, shows computationally H&E stained patches overlaid with colors indicating agreements and disagreements between physician annotations on these images compared with ground truth H&E dye–stained images. Variation in labeling detail by annotators (arrows) are shown in D-III. Green indicates true positive; blue, falsenegative; and red, false positive.

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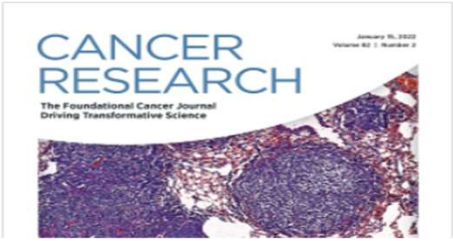

CONVERGENCE AND TECHNOLOGIES | JANUARY 18 2022

Prostate Cancer Risk Stratification via Nondestructive 3D Pathology with Deep Learning–Assisted Gland Analysis

Weisi Xie ; Nicholas P. Reder; Can Koyuncu ; Patrick Leo; Sarah Hawley; Hongyi Huang; Chenyi Mao; Nadia Postupna ; Soyoung Kang; Robert Serafin; Gan Gao; Qinghua Han;

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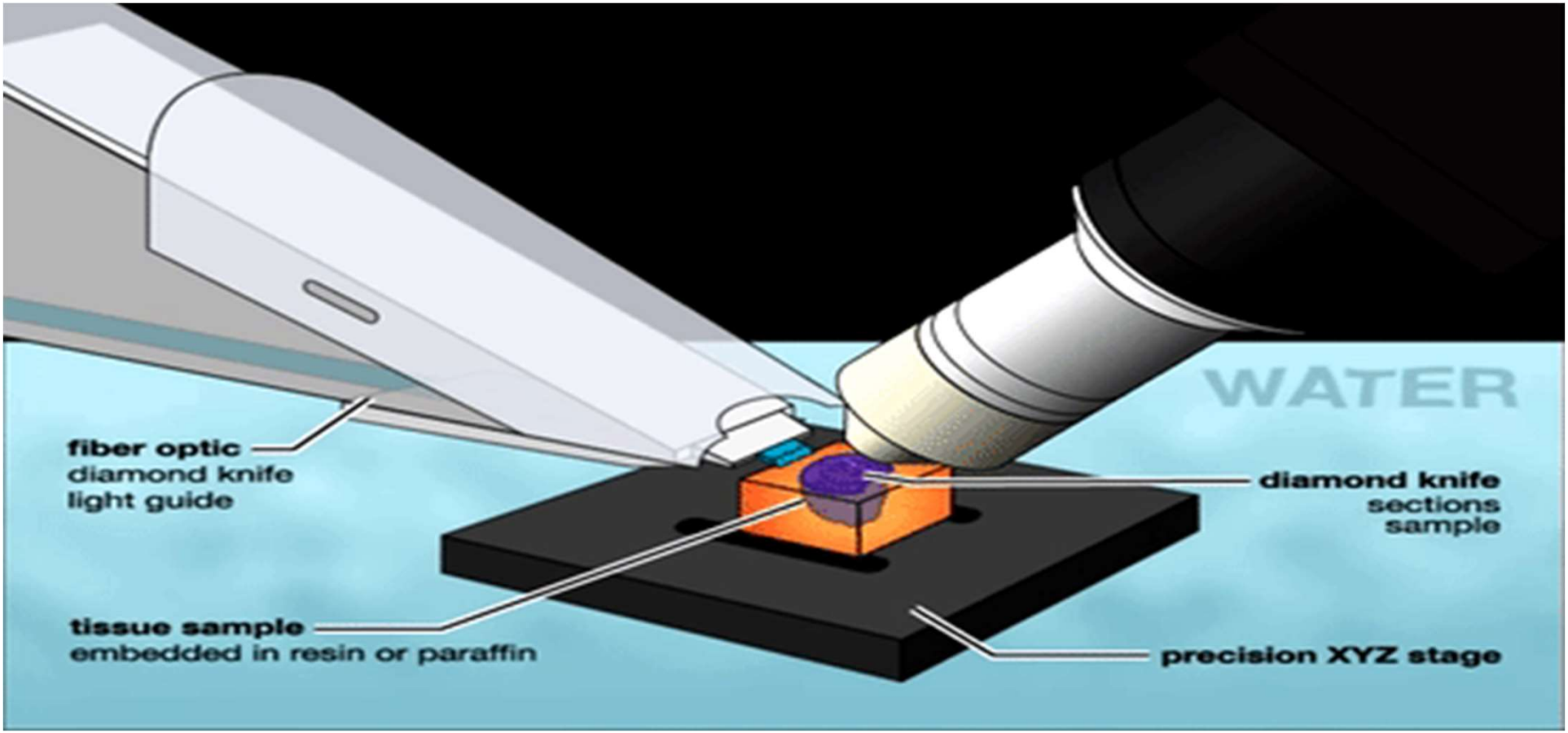
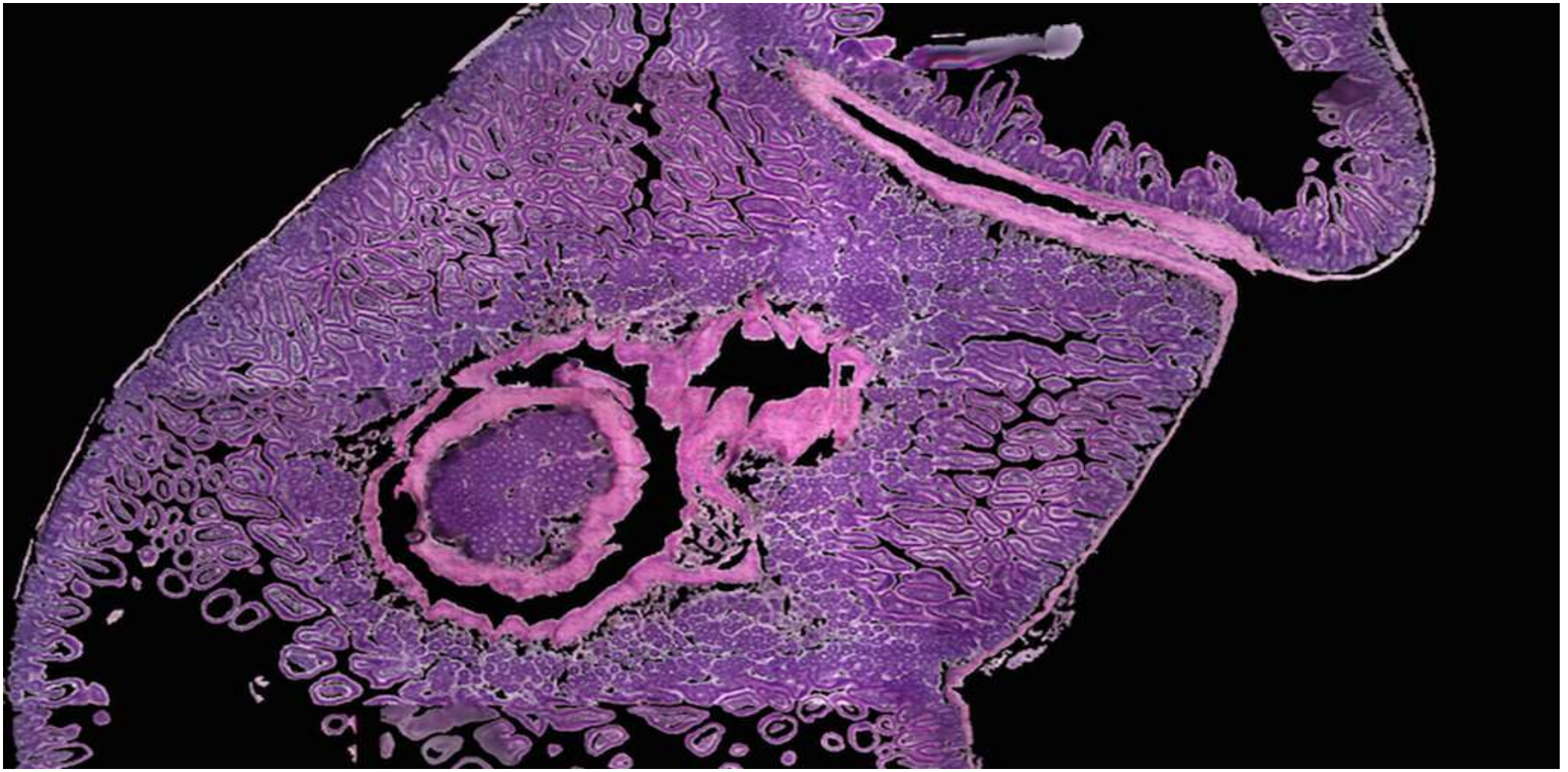
BEYOND WHOLE SLIDE IMAGING

Knife Edge Scanning Microscope



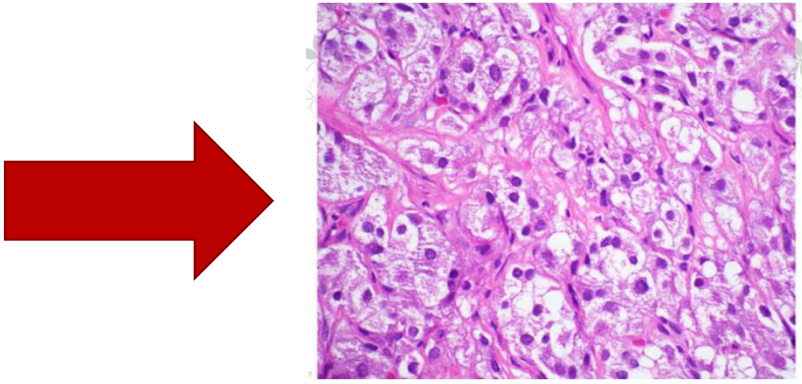
http://www.3scan.com/

Knife Edge Scanning Microscope



PUTTING IT ALL TOGETHER

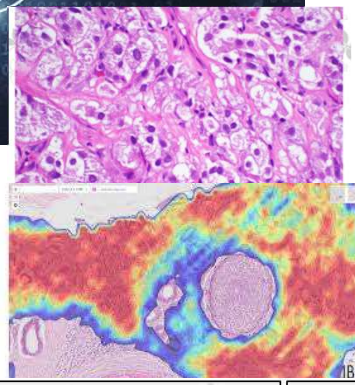
HOW CAN AI TOOLS HELP A PATHOLOGIST?

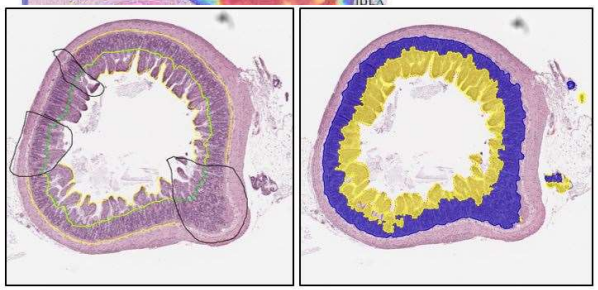


ASSIST

AUGMENT

AUTONOMOUS





DIGITAL **WORKFLOW**: WHAT WORKS WELL AND WHAT NEEDS TO BE FIXED?

WHAT WORKS WELL!

- IMAGE QUALITY
- ANNOTATIONS
- MEASURING THINGS
- IMAGE ACCESSIBILITY
- SHARING IMAGES
- REVIEWING CASES
- CO-REGISTRATION
- COLLABORATION
- MANY NEWS TOOLS ON THE HORIZON

DIGITAL **WORKFLOW**: WHAT WORKS WELL AND WHAT NEEDS TO BE FIXED?

WHAT WORKS OK!

- ERGONOMICS
- INTEGATION WITH LIS – NEEDS TO BE IMPROVED
- ANNOTATIONS TRANSFER TO REPORT
- MEASUREMENTS – NO LINK TO LIS
- IMAGE ACCOUNTABILITY
- AUDIT SYSTEMS

DIGITAL **WORKFLOW**: WHAT WORKS WELL AND WHAT NEEDS TO BE FIXED?

WHAT WE NEED TO FIX

- MANY IMAGE FORMATS
- CLOSED SYSTEMS BY VENDORS
- AI TOOLS – STILL NOT WELL-INTEGRATED
- IMAGE WORKFLOW AND STORAGE – NOT STANDARDIZED
- COMPRESSION ISSUES
- MONITORS – IT IS A WILD WILD WEST

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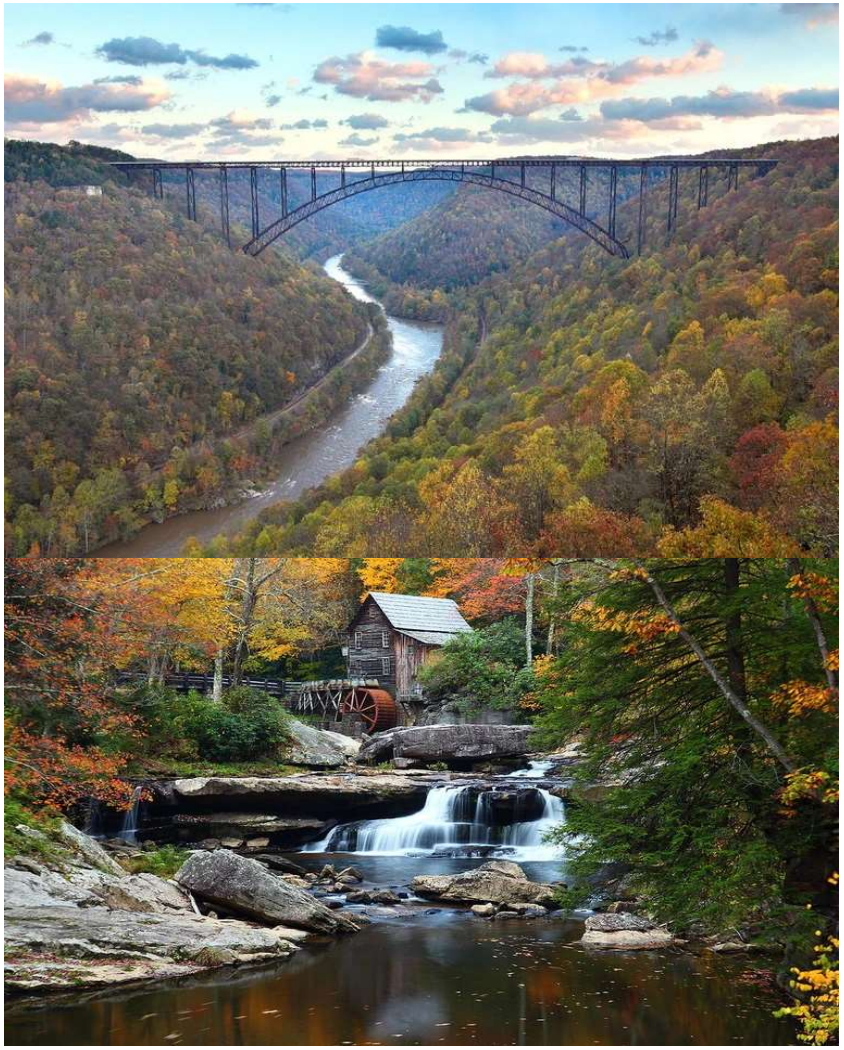
Conclusions

- New tools such as digital pathology, image analysis and deep learning are here and transforming pathology and integration with LIS/EMR is vital to this.
- The pandemic served as a catalyst to pathologists adopting a digital workflow.
- Our journey into digital pathology/AI has allowed us to improve our pathology practice, workflows, quality of our diagnosis.
- The use of AI in pathology continues to evolve and will likely be use in mainstream pathology within this decade



Future Directions

- Cyto, Renal Pathology, Hematopathology digital signout
- Look at Compression algorithms to improve storage
- Continue to deploy more AI solutions for pathologists
- Work on integrating AI solutions within the LIS to perform analysis and improve result reporting
- Create easier de-identification of Images and data for helping with education and translational research
- Create additional revenue streams from digital pathology program
- CPT codes for image analysis- CLIA tests- implement 2022
- CPT codes for WSI. Implement 2023
- Launch an online Masters Program in Digital and Computational Pathology in 2023

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Thank You to Our Amazing Digital Pathology Team

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