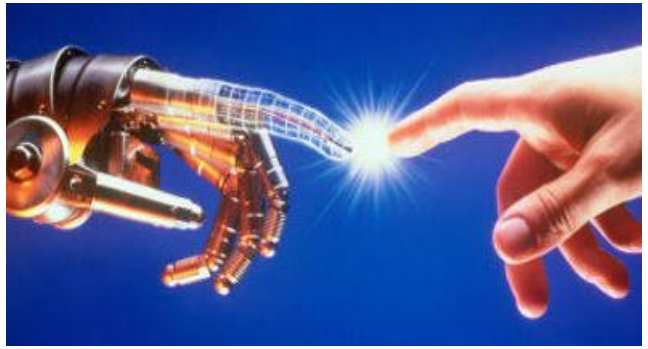
European Society of Pathology
31st European Congress of Pathology
Pathology is Nice
7 - 11 September 2019 | Nice, France

Embracing Digital and Computational Pathology: A Calling for Pathologists as Leaders in Precision Medicine



Marilyn M. Bui, MD. PhD

Moffitt Cancer Center, Tampa, FL. USA

DIGITAL PATHOLOGY DPA ASSOCIATION

One-Day Computational Pathology Symposium

CP-02 1-Day CP Symposium
14:45–16:45 Clio
DPA Session
Chair: Darren Treanor, United Kingdom

001 14:45–15:25
Embracing digital and computational pathology: a calling for pathologists as leaders in precision medicine
***Marilyn Bui**, USA*

002 15:25–16:05
Embedding AI into digital pathology workflows
***Liron Pantanowitz**, USA*

003 16:05–16:45
Enhancing digital pathology with artificial intelligence
***Francesco Ciompi**, The Netherlands*

DIGITAL PATHOLOGY DPA ASSOCIATION

About the Presenter

No financial conflict of interest

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Marilyn M. Bui | Moffitt Cancer Center
https://moffitt.org/providers/marilyn-bui/

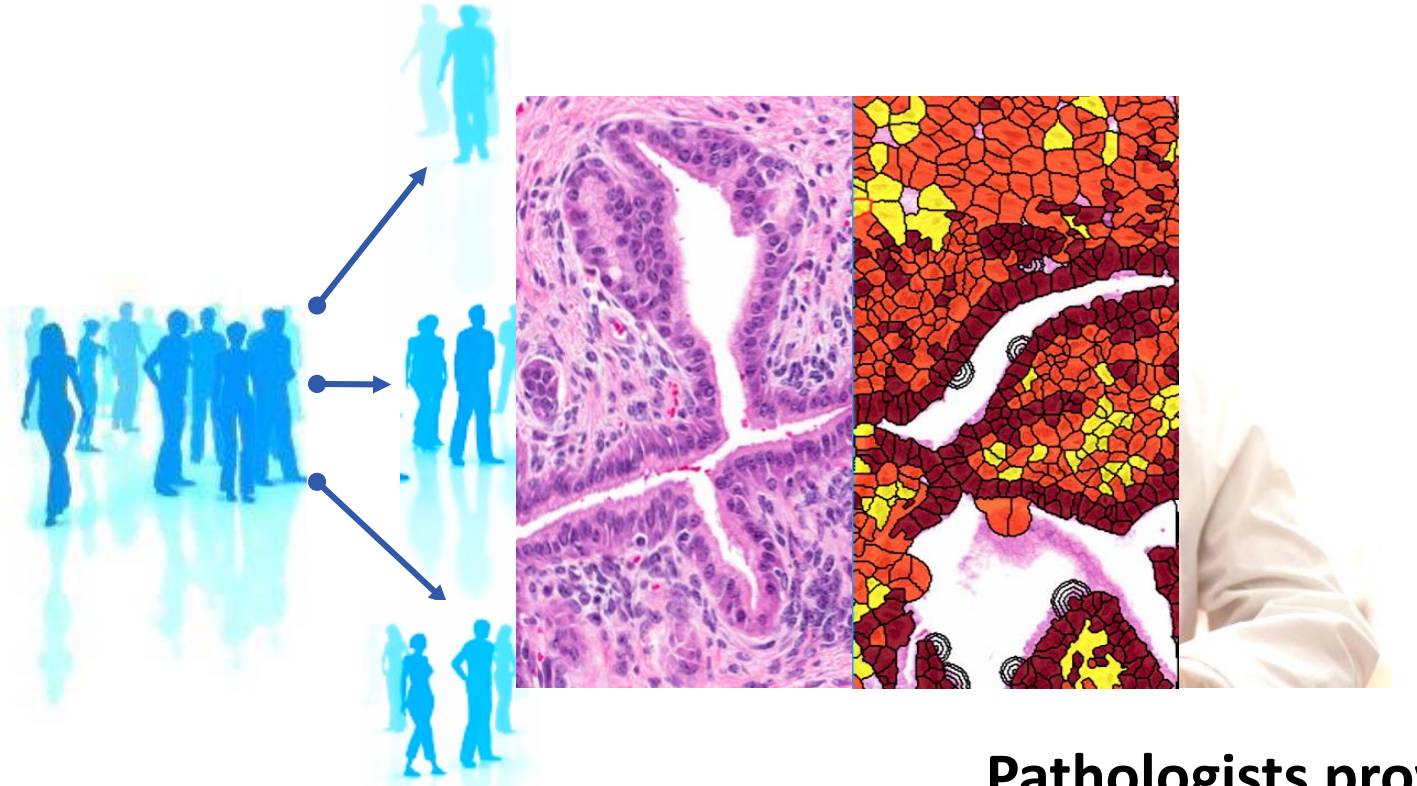
@DrBuiPathology

- Senior Member/Professor of Pathology, Scientific Director of Analytic Microscopy Core, President of Medical Staff and Cytopathology Fellowship Program Director at the Moffitt Cancer Center https://moffitt.org in Tampa, Florida
- President of the Digital Pathology Association https://digitalpathologyassociation.org/
- Chair of the College of American Pathologists (CAP) www.cap.org/ Guidelines Committee Expert Panel for Quantitative Image Analysis of HER2 Immunohistochemistry for Breast Cancer.
- Vice Chair of the CAP Digital Pathology Committee
- Editorial Board member of *Journal of Pathology Informatics*

Objectives

- Review the revolution of digital pathology (DP) and its impact on precision medicine
- Discuss lessons learned and challenges exist
- Identify resources, guidelines, opportunities and collaboration potential
- Highlight DPA recent accomplishments

A patient's medical journey begins with their diagnosis…



…Pathologists provide <u>forecast of</u>

Diagnosis

Prognosis

& Therapy

Pathologists are natural leaders in precision medicine

Pathologist Supply Down Relative to Diagnostic Demands

Medscape

The number of pathologists in the United States decreased by 17.53% from 2007 to 2017, despite a corresponding 41.73% rise in diagnostic workload per pathologist, a study published online May 31 in *JAMA Network Open* shows.

News > Medscape Medical News

NEWS flash!

Shortage of Histopathologists in the United Kingdom Now Contributing to Record-Long Cancer-Treatment Waiting Times in England

DARK Daily
Serving Clinical Labs & Pathology Groups

Oct 31, 2018 | Laboratory Hiring & Human Resources, Laboratory Management and Operations, Laboratory News, Laboratory Operations, Laboratory Pathology, Laboratory Testing

Only 3% of histopathology departments that responded to the Royal College of Pathologists' workforce census reported enough staff to meet clinical demand

In its most recent workforce report, The Royal College of Pathologists is reiterating its call for:

- Increased funding for training;
- Better information technology (IT) for day-to-day work;
- Capital investment to implement digital pathology more widely; and,
- Development of advanced clinical practitioner apprenticeships to help more biomedical scientists become independent practitioners who would work alongside medically-qualified histopathologists.

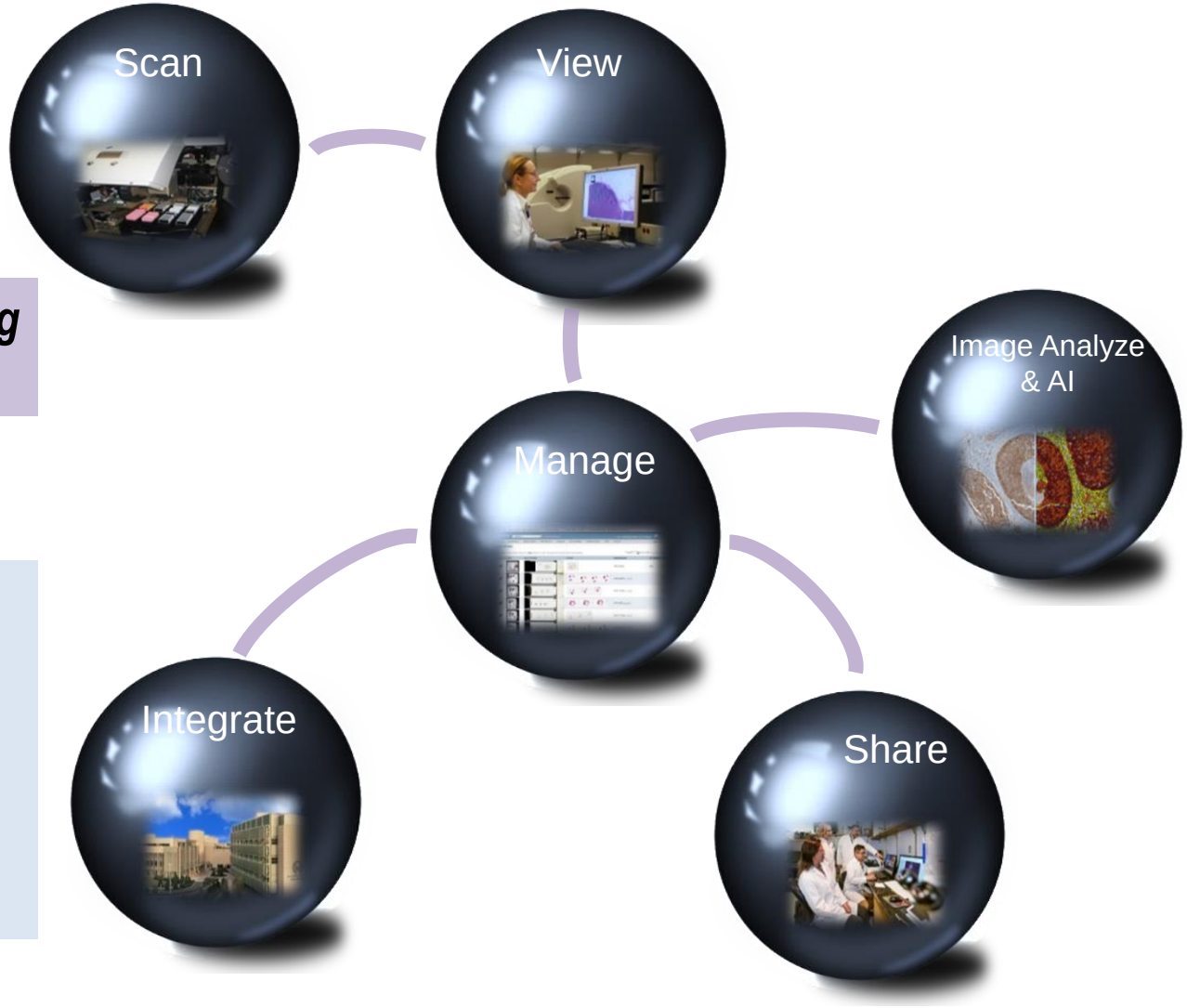
The number of seniors applying for pathology positions dropped by 27.5% between 2008 and 2017, according to a study by Dr. Ryan Jajosky et al published in *Human Pathology* (March 2018, Vol. 73, pp. 26-32).

LABPULSE.COM

DP – Foundation of Computational Pathology & AI

One of the most promising fields of digital medicine

- ***Computational pathology/integrated pathology informatics***
- ***Transform pathology data into clinically actionable knowledge***



- ***Connectivity & accessibility***
- ***Image analysis, artificial intelligence and automation***
- ***Improved quality & efficiency***

DP & AI - The Third Revolution in Pathology

Early 20th century — Pathology as a Clinical Discipline

1953 — Discovery of the DNA Double Helix

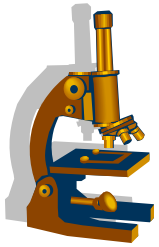
1980 — IHC is introduced in Pathology with widespread adoption

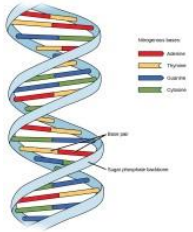
2004 — First mutational assays for personalized medicine available

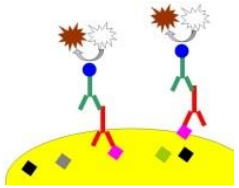
2010 — NGS becomes widely available

2017 — First digital scanner is cleared for primary diagnosis by FDA

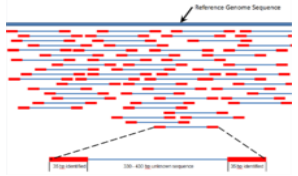
2018 — Artificial Intelligence (AI) in pathology solutions released







First Revolution in Pathology



Second Revolution in Pathology

Third Revolution in Pathology

Artificial Intelligence - The Third Revolution in Pathology

Manuel Salto-Tellez, Perry Maxwell, Peter Hamilton

First published: 01 October 2018 | https://doi.org/10.1111/his.13760

DP & AI in Precision Medicine

Application

- Detection
- Quantification
- Classification
- Prognosis
- Prediction

Materials & Methods

- H&E, special stain, IHC, fluorescence, live cells, etc.
- Image analysis through machine learning, deep learning/artificial intelligence

Desirable Results

- Improved quality & efficiency
- Pathology data → clinically actionable knowledge

Digital pathology is not just the transfer of histopathological slides into digital representations. The combination of different data sources (images, patient records, and *omics data) together with current advances in artificial intelligence/machine learning enable to make novel information accessible and quantifiable to a human expert, which is not yet available and not exploited in current medical settings.

Augmented Pathologist

Explainable Artificial Intelligence in Digital Pathology by Holzinger, Malle, Kieseberg, Roth, Muller, Reihs, Zatloukal

https://arxiv.org/pdf/1712.06657.pdf

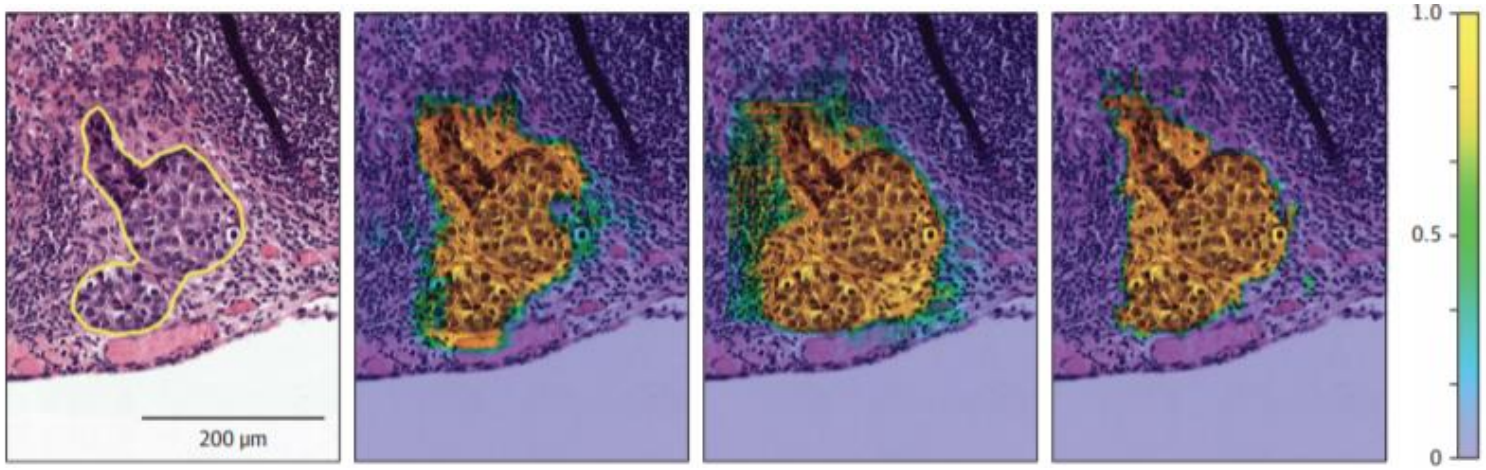
Deep Learning in Breast Pathology

CAMELYON17

Automated classification of patients with metastatic breast cancer in lymph node

1. *Babak Ehteshami Bejnordi, Mitko Veta, Paul Johannes van Diest, et al. and the CAMELYON16 Consortium.* **Diagnostic Assessment of Deep Learning Algorithms for Detection of Lymph Node Metastases in Women With Breast Cancer.** JAMA. 2017;318(22):2199–2210. DOI: 10.1001/jama.2017.14585

2. *Peter Bandi, Oscar Geessink, Quirine Manson, et al.* **From detection of individual metastases to classification of lymph node status at the patient level: the CAMELYON17 challenge.** IEEE-TMI (Early Access) DOI: 10.1109/TMI.2018.2867350



Downloading the data set

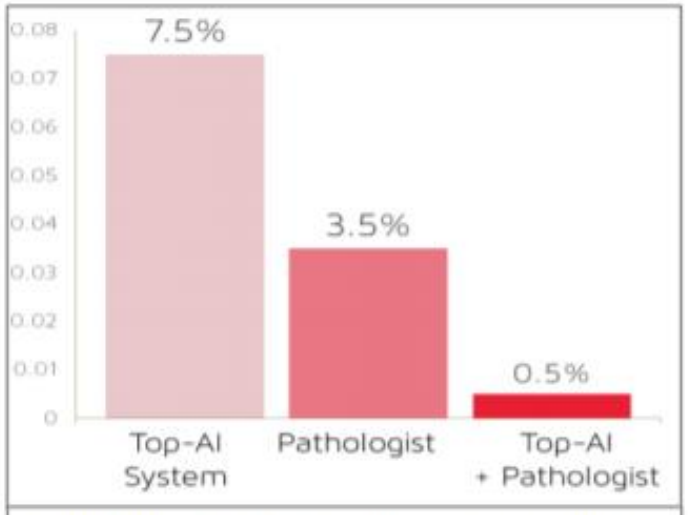
CAMELYON16 and CAMELYON17 data sets are open access and shared publicly on **GigaScience**, **Google Drive** and on **Baidu Pan.**

AI Reduced Error 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

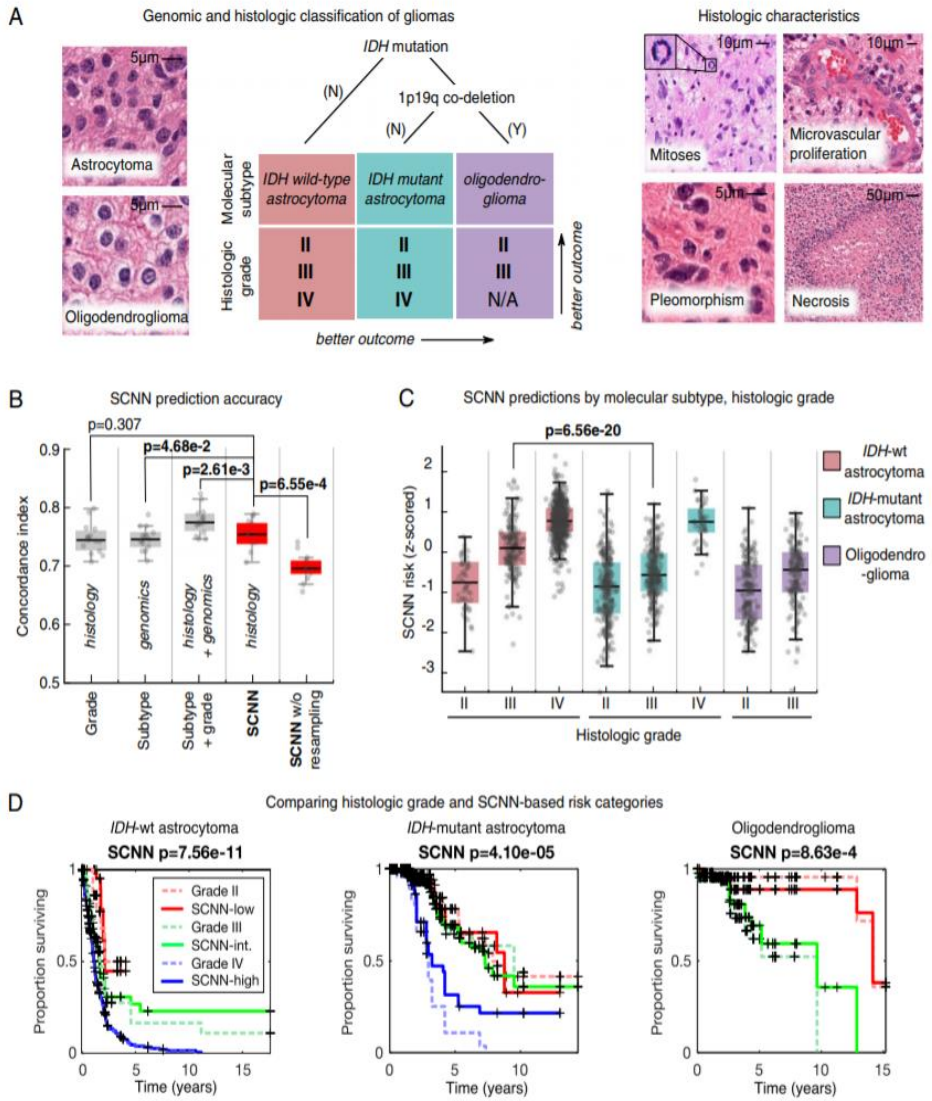
Prognostication Criteria for Diffuse Gliomas

Predicting cancer outcomes from histology and genomics using convolutional networks

Pooya Mobadersany[a], Safoora Yousefi[a], Mohamed Amgad[a], David A. Gutman[b], Jill S. Barnholtz-Sloan[c], José E. Velázquez Vega[d], Daniel J. Brat[e], and Lee A. D. Cooper[a,f,g,1]

www.pnas.org/cgi/doi/10.1073/pnas.1717139115 E2970–E2979 | PNAS | vol. 115 | no. 13

- A deep learning approach for learning survival directly from histological images and creating a unified framework for integrating histology and genomic biomarkers for predicting time-to-event outcomes.
- Systematically evaluated the prognostic accuracy of this approach in the context of the current clinical standard based on genomic classification and histologic grading of gliomas.
- **This approach rivals or exceeds the accuracy of highly trained human experts in predicting survival.**
- Improving the accuracy and objectivity of grading will directly impact patient care.



Deep Learning in Lung Cancer

nature medicine

ARTICLES

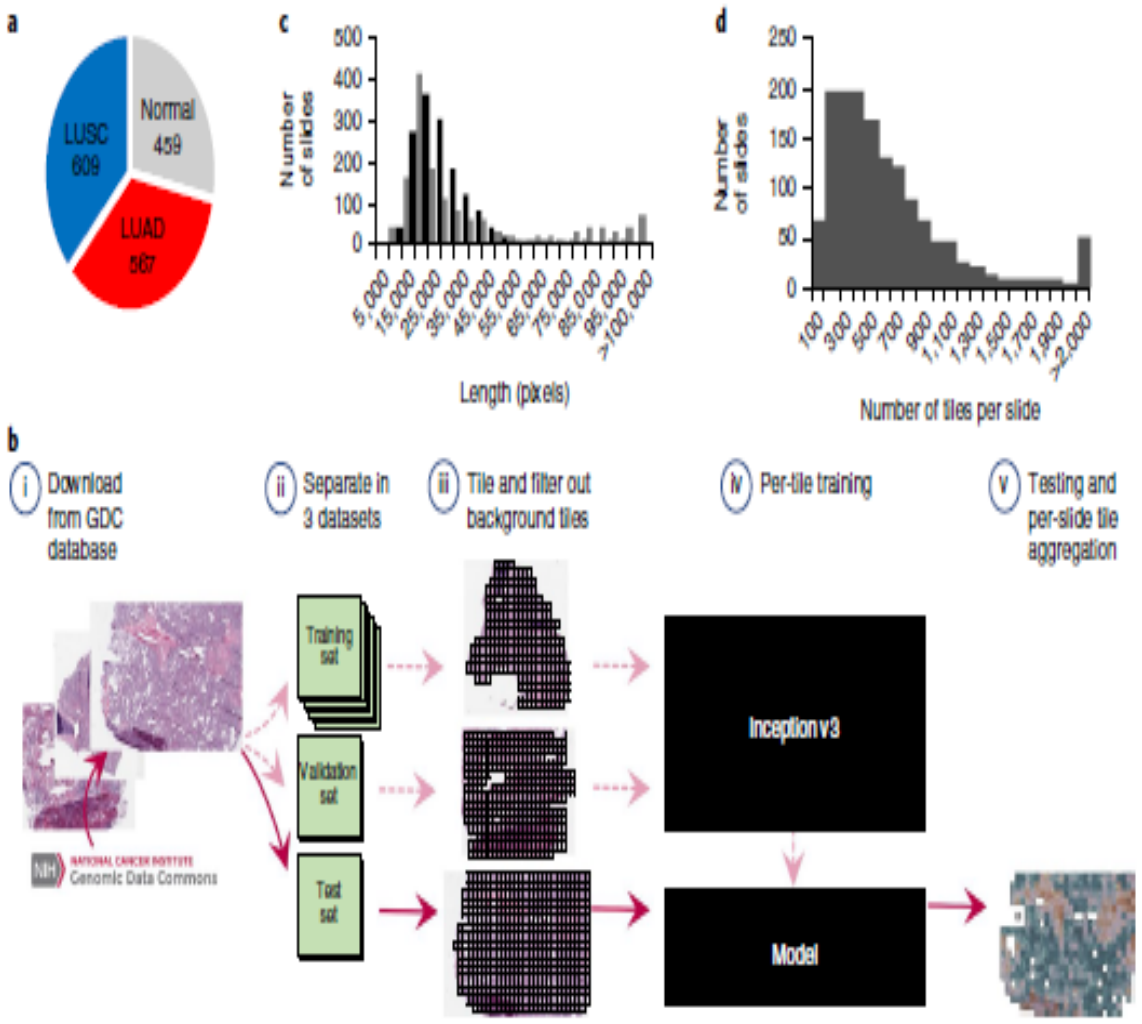
https://doi.org/10.1038/s41591-018-0177-5

NATURE MEDICINE | VOL 24 | OCTOBER 2018 | 1559–1567 | www.nature.com/naturemedicine

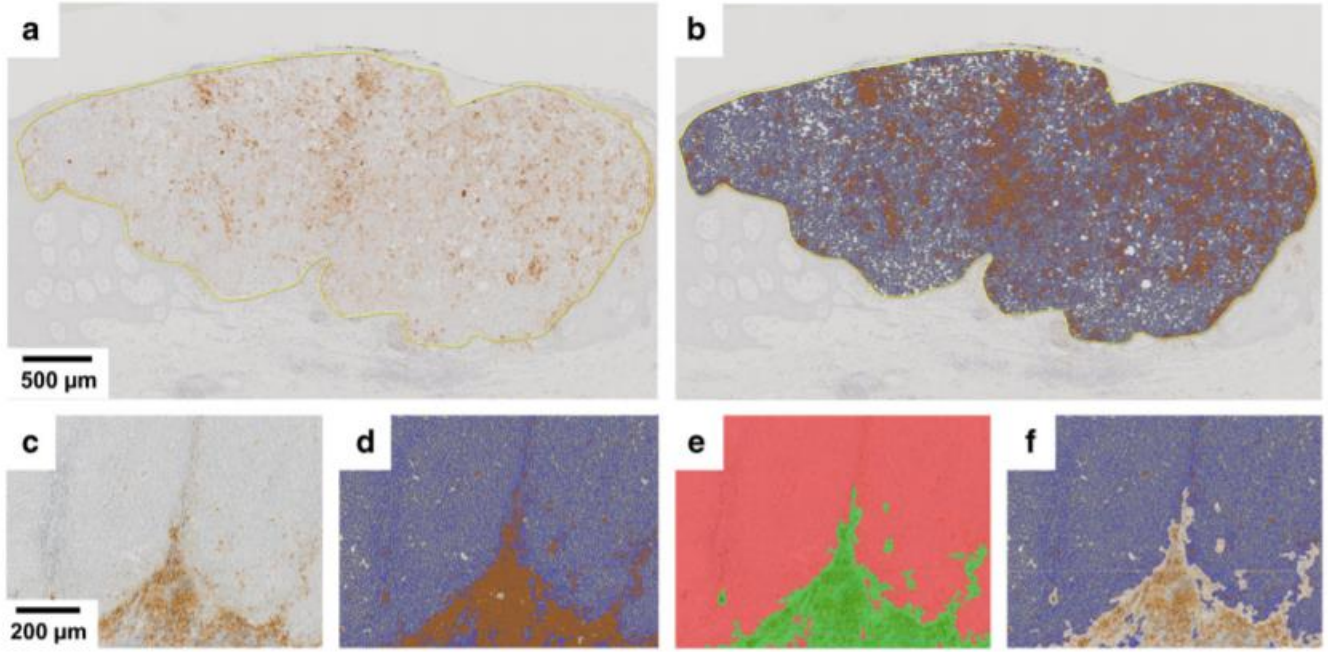
Classification and mutation prediction from non-small cell lung cancer histopathology images using deep learning

Nicolas Coudray[1,2,9], Paolo Santiago Ocampo[3,9], Theodore Sakellaropoulos[4], Navneet Narula[3], Matija Snuderl[3], David Fenyö[5,6], Andre L. Moreira[3,7], Narges Razavian[8]* and Aristotelis Tsirigos[1,3]*

Visual inspection of histopathology slides is one of the main methods used by pathologists to assess the stage, type and subtype of lung tumors. Adenocarcinoma (LUAD) and squamous cell carcinoma (LUSC) are the most prevalent subtypes of lung cancer, and their distinction requires visual inspection by an experienced pathologist. In this study, we trained a deep convolutional neural network (inception v3) on whole-slide images obtained from The Cancer Genome Atlas to accurately and automatically classify them into LUAD, LUSC or normal lung tissue. The performance of our method is comparable to that of pathologists, with an average area under the curve (AUC) of 0.97. Our model was validated on independent datasets of frozen tissues, formalin-fixed paraffin-embedded tissues and biopsies. Furthermore, we trained the network to predict the ten most commonly mutated genes in LUAD. We found that six of them—STK11, EGFR, FAT1, SETBP1, KRAS and TP53—can be predicted from pathology images, with AUCs from 0.733 to 0.856 as measured on a held-out population. These findings suggest that deep-learning models can assist pathologists in the detection of cancer subtype or gene mutations. Our approach can be applied to any cancer type, and the code is available at https://github.com/ncoudray/DeepPATH.



Assessment of PD-L1 Expression & Immune Cell Infiltrates



Virchows Archiv
https://doi.org/10.1007/s00428-018-2485-z

REVIEW ARTICLE

CrossMark

Precision immunoprofiling by image analysis and artificial intelligence

Viktor H. Koelzer[1,2] · Korsuk Sirinukunwattana[3] · Jens Rittscher[3,4,5] · Kirsten D. Mertz[6]

Received: 15 May 2018 / Revised: 6 November 2018 / Accepted: 9 November 2018
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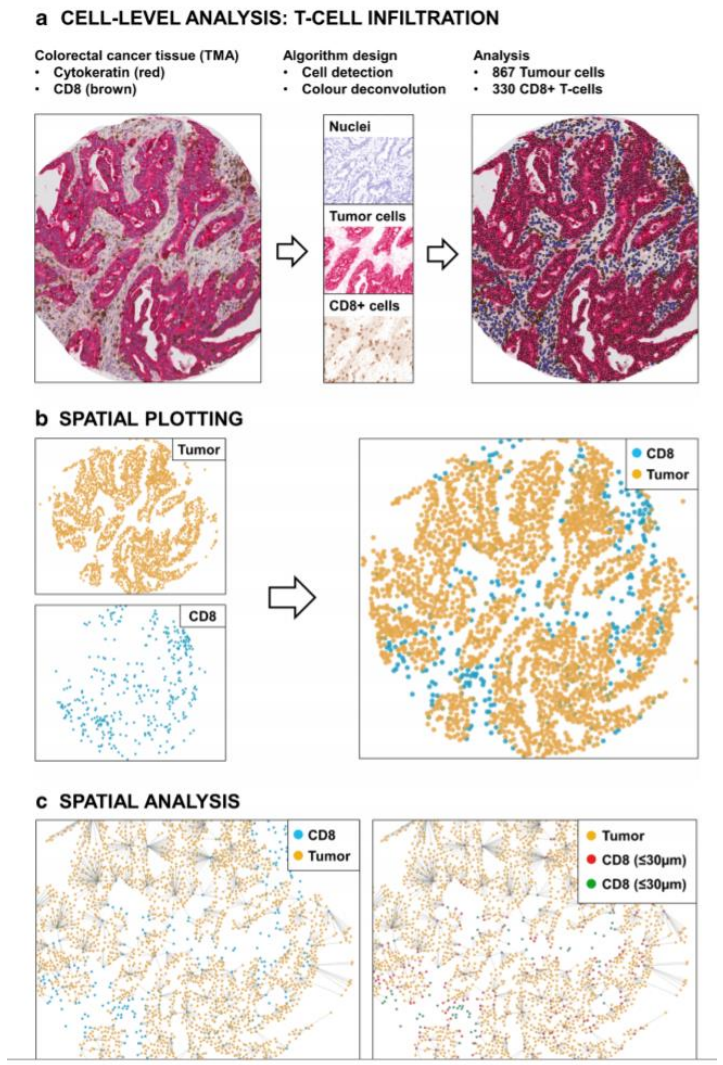
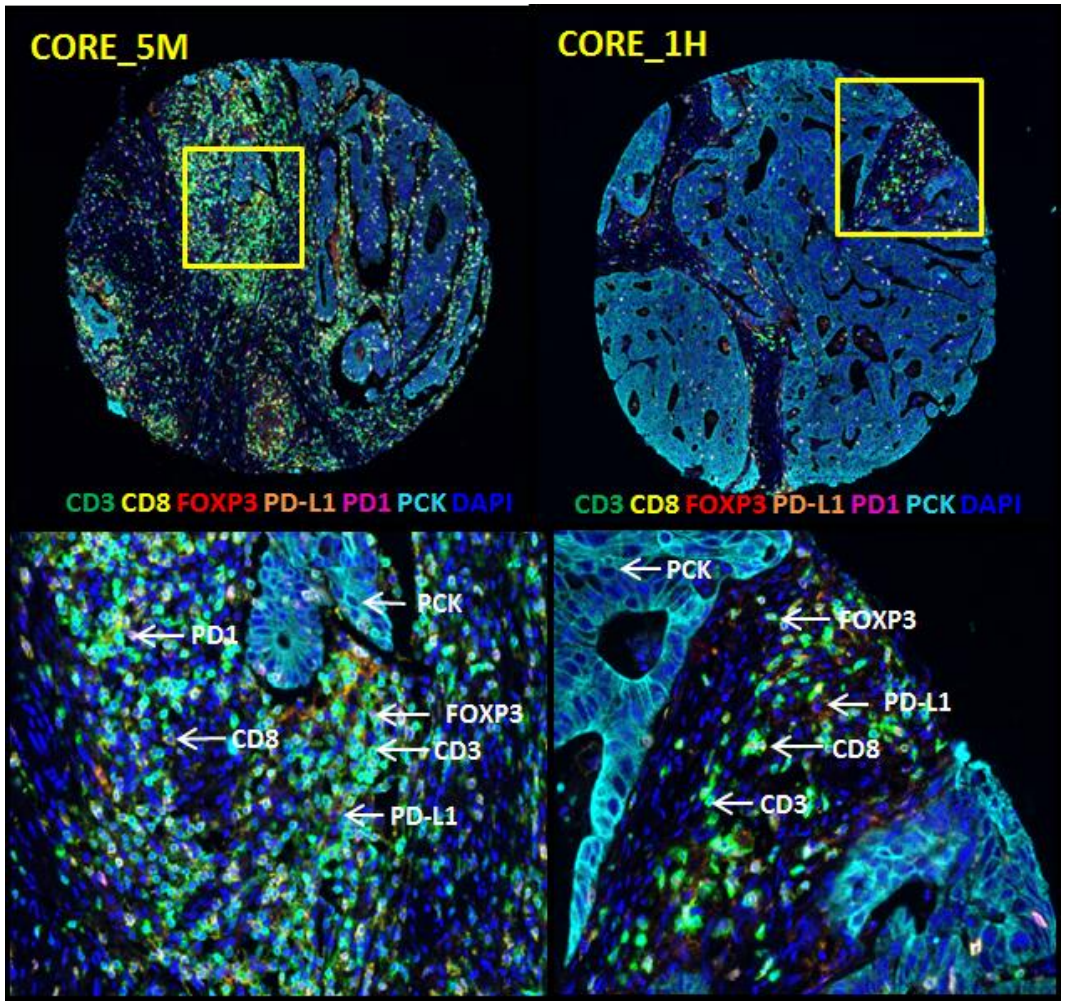
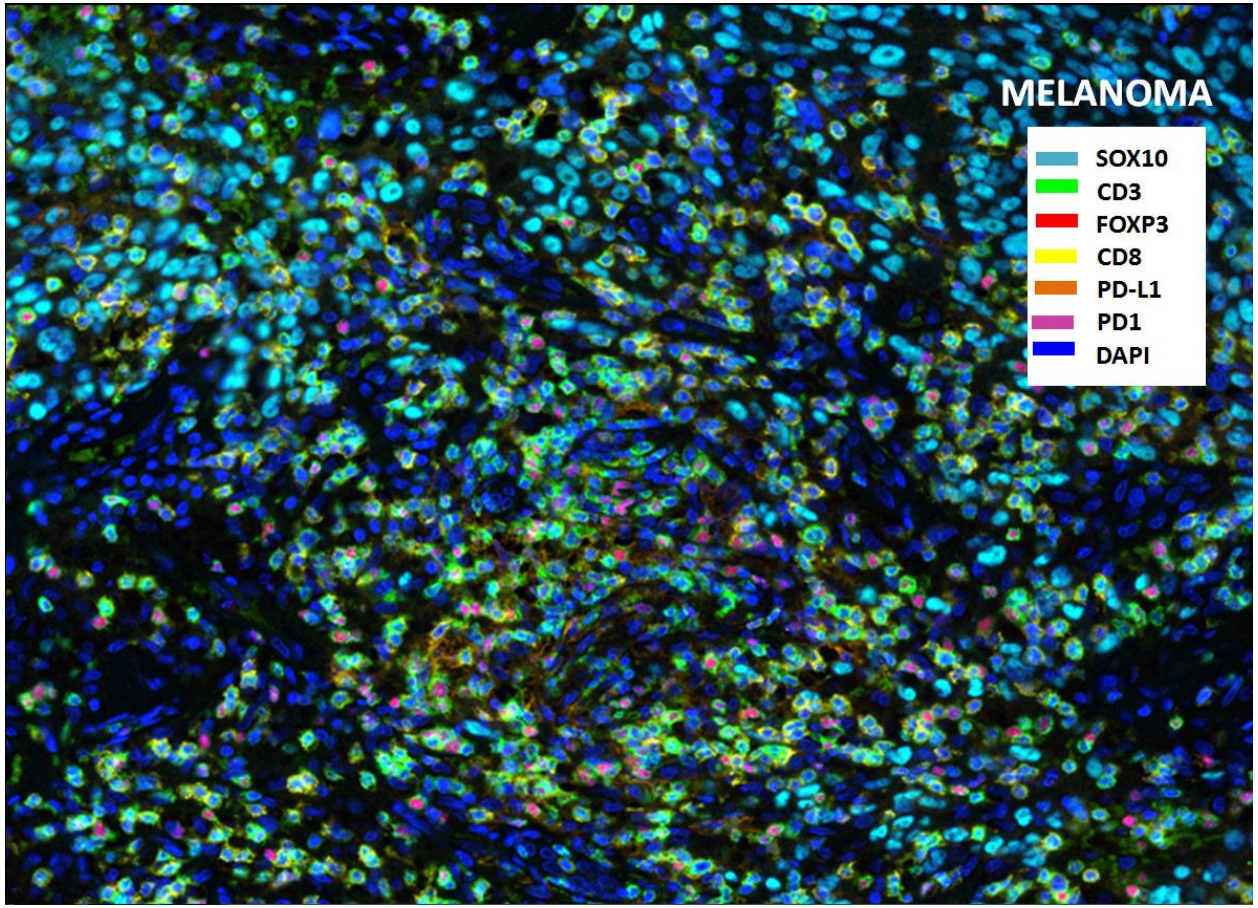


Multiplex Biomarker Testing for Clinical Trials

Assessment of Immune Cells



Multiplex IF Stained Section



Courtesy of Susan McCarthy of Moffitt Cancer Center using Vectra in a CLIA lab for clinical trials

High-Plex Spatial Analysis of Tissue Microenvironments

Pancreatic Ductal Adenocarcinoma Analysis

Pancreatic ductal adenocarcinoma (PDAC) has been refractory to immunotherapy and is characterized by a complex, stroma-rich tumor microenvironment. Most patients undergo treatment with aggressive chemotherapeutic regimens, which may alter the cellular composition and immunologic landscape within these tumors. To date, few studies have characterized the impact of chemotherapy on individual cellular compartments within PDAC tumors. We *hypothesized* that neoadjuvant chemotherapy may differentially modulate immune factors in the tumor, stroma and immune-cell rich regions of human PDAC tumors. We compared the spatial expression of 31 immuno-oncology targets across PDAC FFPE specimens from FOLFIRINOX and non-treated patients (n=5 each). Using the Digital Spatial Profiling technology from Nanostring®, we were able to identify FOLFIRINOX treatment results in significant spatially-distinct changes in protein expression.

Courtesy of Doug Hinerfeld, PhD of NanoString Technologies

Barriers to DP Adoption

- Regulatory
- Financial
- Technical
- Cultural

Breaking Regulatory Barriers

- Leading digital pathology companies have recently received **FDA approval** for a whole slide imaging system for primary diagnosis in US

An official website of the United States government

U.S. FOOD & DRUG ADMINISTRATION

Quality and reliability of the imaging system

SEAL OF APPROVED APPROVAL

FDA NEWS RELEASE

FDA allows marketing of first whole slide imaging system for digital pathology

Share | Tweet | Linkedin | Email | Print

For Immediate Release: April 12, 2017

The U.S. Food and Drug Administration today permitted marketing of the Philips IntelliSite Pathology Solution (PIPS), the first whole slide imaging (WSI) system that allows for review and interpretation of digital surgical pathology slides prepared from biopsied tissue. This is the first time the FDA has permitted the marketing of a WSI system for these purposes.

"The system enables pathologists to read tissue slides digitally in order to make diagnoses, rather than looking directly at a tissue sample mounted on a glass slide under a conventional light microscope," said Alberto Gutierrez, Ph.D., Director of the Office of In Vitro Diagnostics and Radiological Health in the FDA's Center for Devices and Radiological Health. "Because the system digitizes slides that would otherwise be stored in physical files, it also provides a streamlined slide storage and retrieval system that may ultimately help make critical health information available to pathologists, other health care professionals and patients faster."

TECHNOLOGY | DIGITAL PATHOLOGY | MAY 29, 2019

Leica Biosystems Receives FDA Clearance for Aperio AT2 DX Digital Pathology System

Digital pathology system cleared for primary diagnosis following multi-center study at five clinical sites in the U.S.

Breaking Financial Barriers

- ~ 12-13% (published) efficiency gain at pathologist level
- ~ Saving on retrieval of archived slides
- ~ Merger of departments/labs with flexible pathologist availability
- ~ Reduced turn around time changes patient pathways
  - reducing visits and in-patient time
  - better more efficient use of resources
- ~ Facilitates review improving diagnostic accuracy

J Pathol Inform

Editor-in-Chief:
Anil V. Parwani , Pittsburgh, PA, USA
Liron Pantanowitz, Pittsburgh, PA, USA
For entire Editorial Board visit : www.jpathinformatics.org

Research Article

Can Digital Pathology Result In Cost Savings? A Financial Projection For Digital Pathology Implementation At A Large Integrated Health Care Organization

Jonhan Ho, Stefan M. Ahlers[1], Curtis Stratman[2], Orly Aridor[3], Liron Pantanowitz[4], Jeffrey L. Fine[4], John A. Kuzmishin[1], Michael C. Montalto[2], Anil V. Parwani[4]

Review

Future-proofing pathology part 2: building a business case for digital pathology

Bethany Jill Williams[1, 2], David Bottoms[3], David Clark[4], Darren Treanor[1, 2]

Breaking Technical Barriers

- Image quality
- Open software solutions
  - Open to many scanners
  - Open to many image analysis suites
- System (LIS/LIMS) integration
- Speed, file storage and IT infrastructure

Breaking Technical Barriers

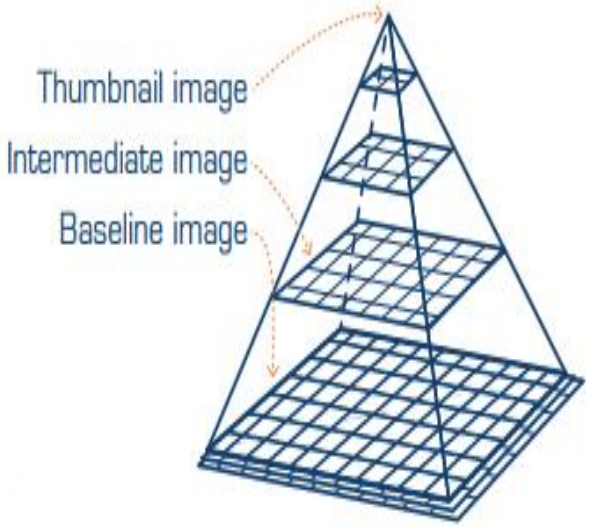
- ***Integrating the Heath Care Enterprise (IHE) Pathology and Laboratory Domain (PALM)***

  An initiative by healthcare professionals and industry to improve the way computer systems in healthcare share information; an international standards organization that bundles existing standards into profiles that solve particular medical communication problems

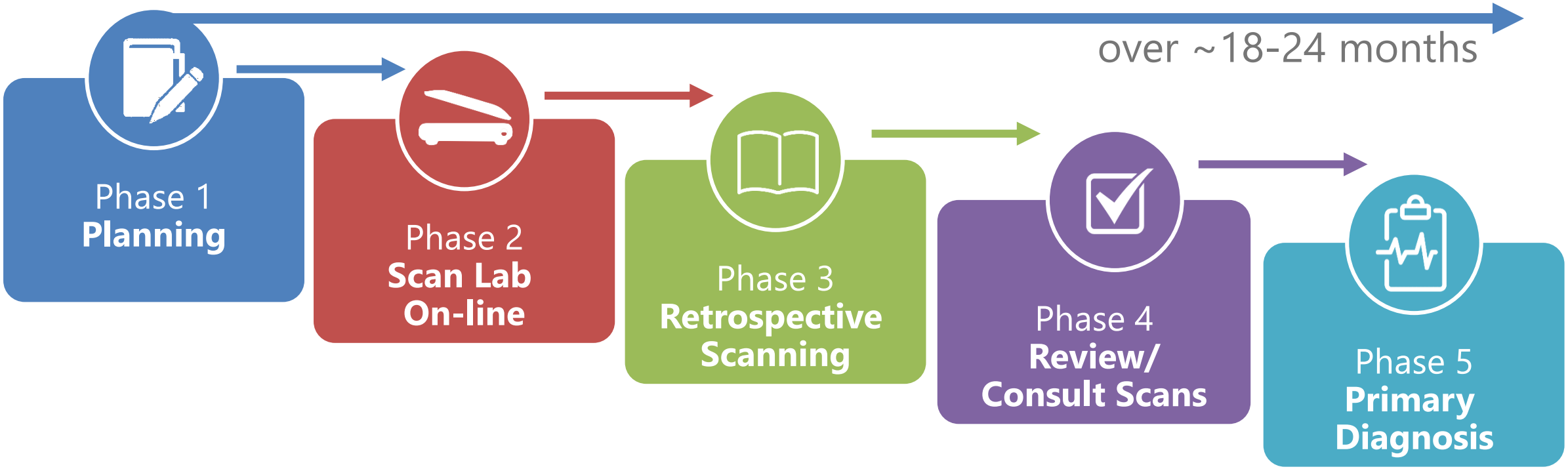
- ***Digital Imaging and Communication in Medicine (DICOM)***

  The standard file format definition and communication profile for radiological and many other medical images

- **IHE/PLAM & DICOM collaborative digital pathology initiative starting in 2017 to create *interoperability for digital pathology***



Breaking Cultural Barriers



Proven Phased Adoption Strategy

OSU Wexner Medical Center Leads the Way

All in, >one million slides scanned!

CAP TODAY

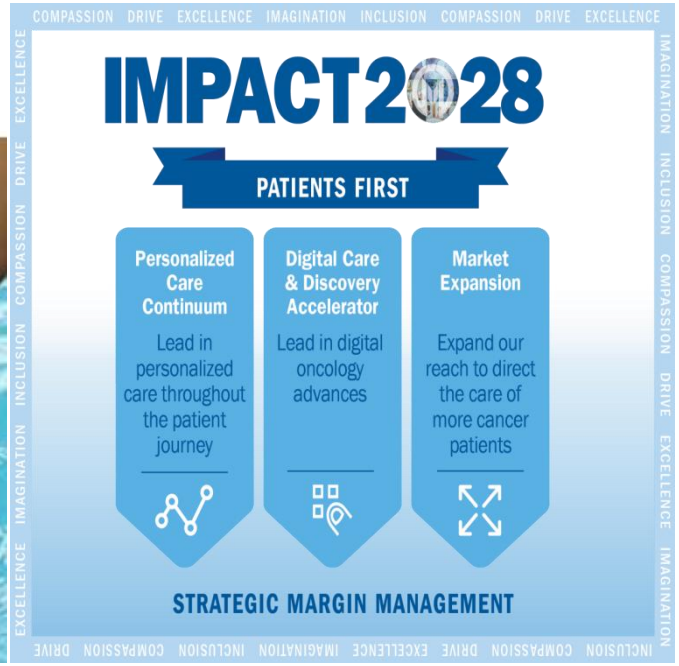
The one publication most important to your job!

Digital pathology matchmaking: people, pixels

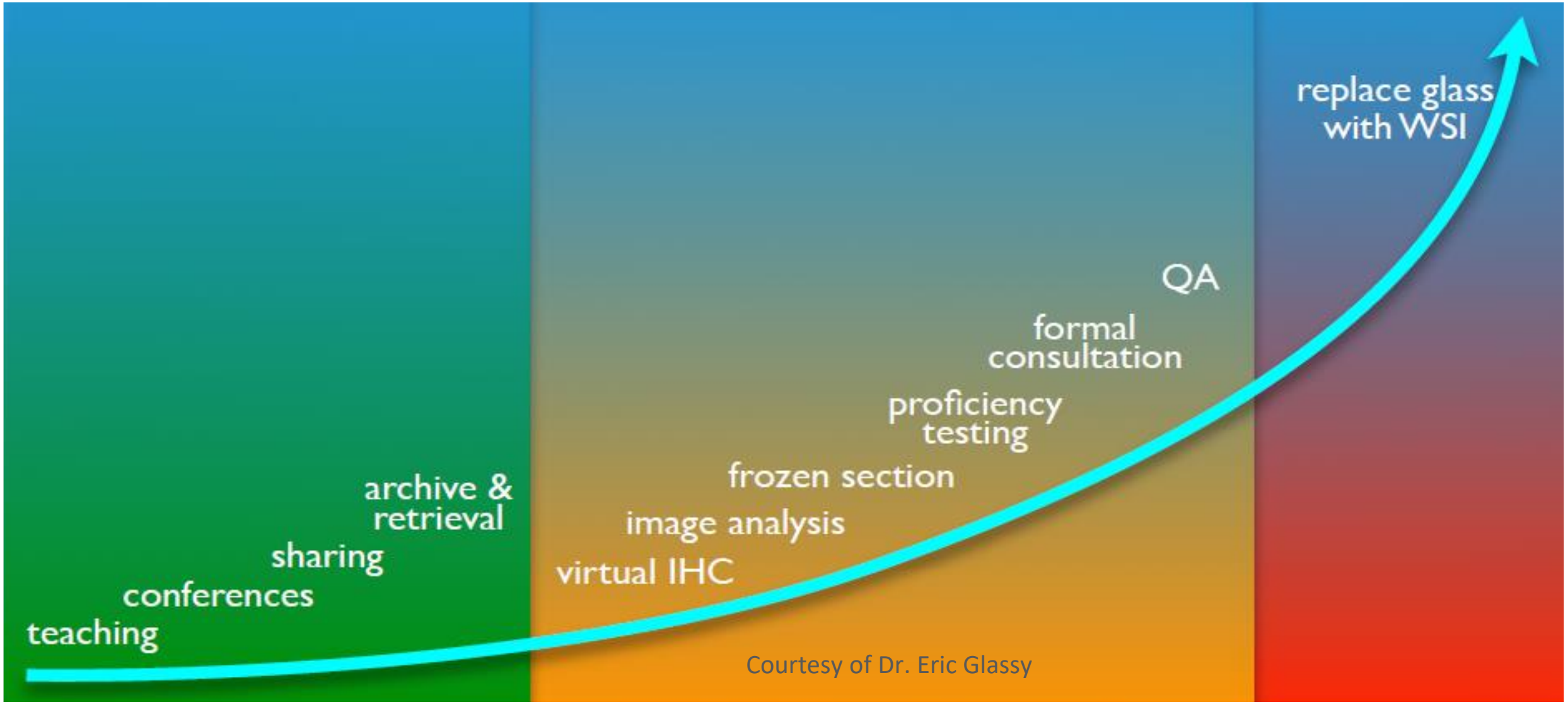
captodayonline.com/digital-pathology-matchmaking-people-pixels

Dr. Anil Parwani and Dr. Wendy Frankel at OSU Wexner Medical Center, where pathologists are using digital

Alternative approach



Opportunities



Courtesy of Dr. Eric Glassy

What’s next?

Developing value-added tools

- Cancer finding tool
- Region of interest finder tool
- Mitotic count tool
- Pre-screening of IHC slides with quantitative scores
- Bug finder (e.g. mycobacteria)
- More accurate, faster measurements
- Tumor grading tools
- Application of image analysis to routine practice
- Image capture and export to the report

Opportunities

Integrated Pathology Informatics Enables High-Quality Personalized and Precision Medicine

Digital Pathology and Beyond

Zoya Volynskaya, PhD; Hung Chow, BSc, MLT; Andrew Evans, MD, PhD; Alan Wolff, MLT; Cecilia Lagmay-Traya; Sylvia L. Asa, MD, PhD

CAP ARCHIVES of Pathology & Laboratory Medicine

Arch Pathol Lab Med. 2018;142:369–382; doi: 10.5858/ arpa.2017-0139-OA

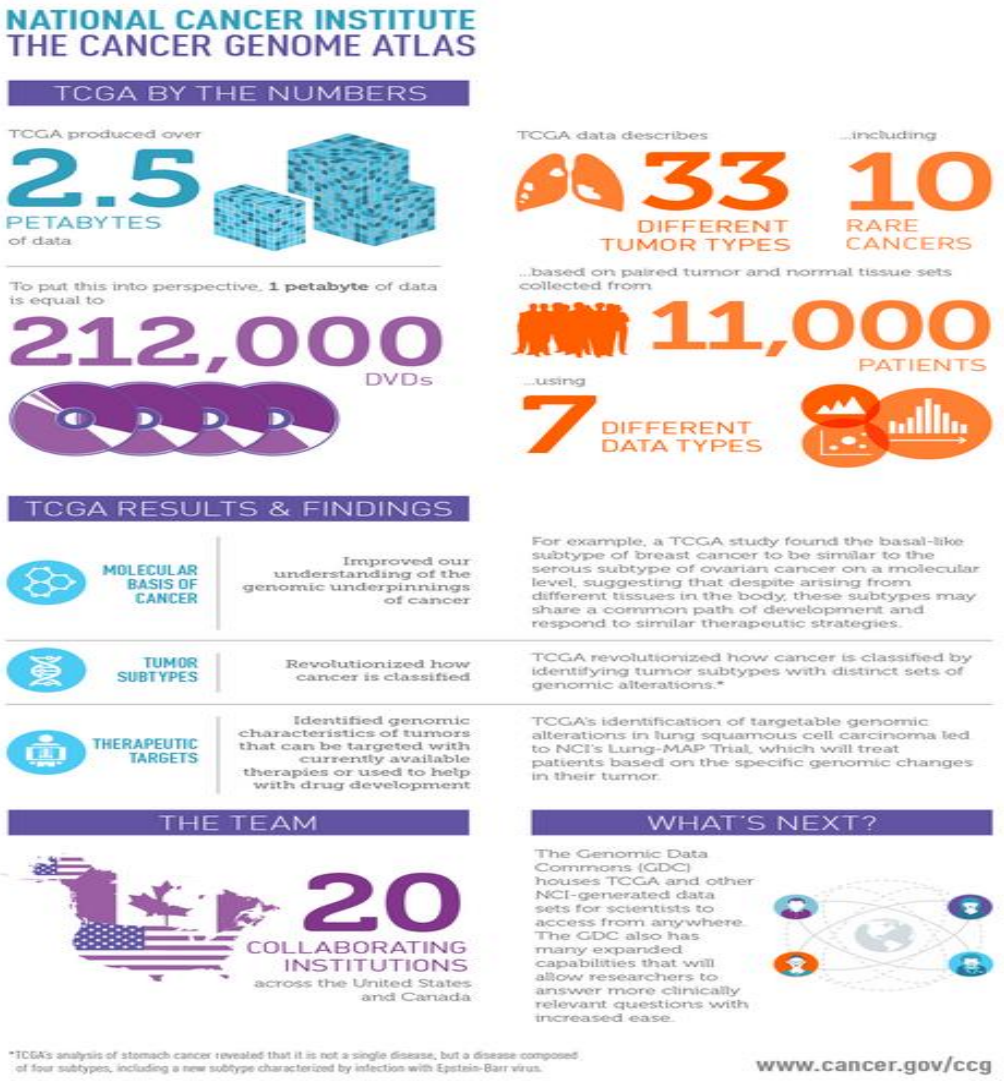
- The digitization of pathology in WSI will provide a huge source of data that will ultimately lead to computer-assisted diagnostics.
- The integration of all the various data obtained in laboratories is the future of pathology.
- The pathologist is a trained physician who has expertise in making the correct diagnosis, determining the likely prognosis, and, with the additional information derived from multiple tests, providing a consultative opinion about treatment approaches.
- As laboratory testing plays an increasing role in the era of personalized medicine, the role of the pathologist increases, and the need for consolidated interpretive reporting becomes critical.
- The depth of knowledge required to integrate these various ancillary technologies demands the insight of subspecialty pathology and promotes a critical role for pathologists in the implementation of precision medicine.

Opportunities: The Cancer Genome Atlas

The Cancer Genome Atlas (TCGA)

- A collaboration between the National Cancer Institute (NCI) and the National Human Genome Research Institute (NHGRI).
- **Free public dataset** with comprehensive, multi-dimensional maps of the key genomic changes in 33 types of cancer.
- Comprising more than two petabytes of genomic data.
- This **genomic information** helps the cancer research community to improve the prevention, diagnosis, and treatment of cancer.

https://wiki.nci.nih.gov/display/TCGA/Introduction+to+TCGA
http://cancer.digitalslidearchive.net/



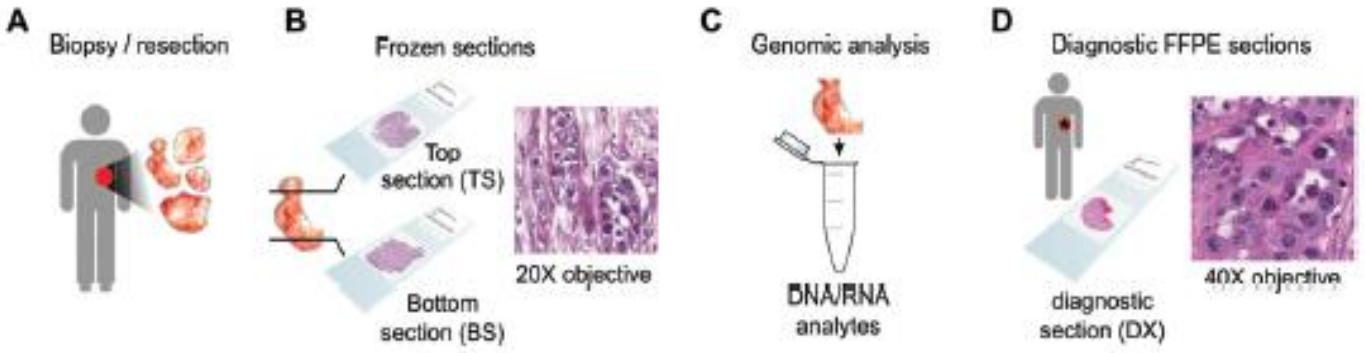
Opportunities: TCGA Data

Journal of Pathology
J Pathol 2018; **244:** 512–524
Published online 22 February 2018 in Wiley Online Library
(wileyonlinelibrary.com) DOI: 10.1002/path.5028

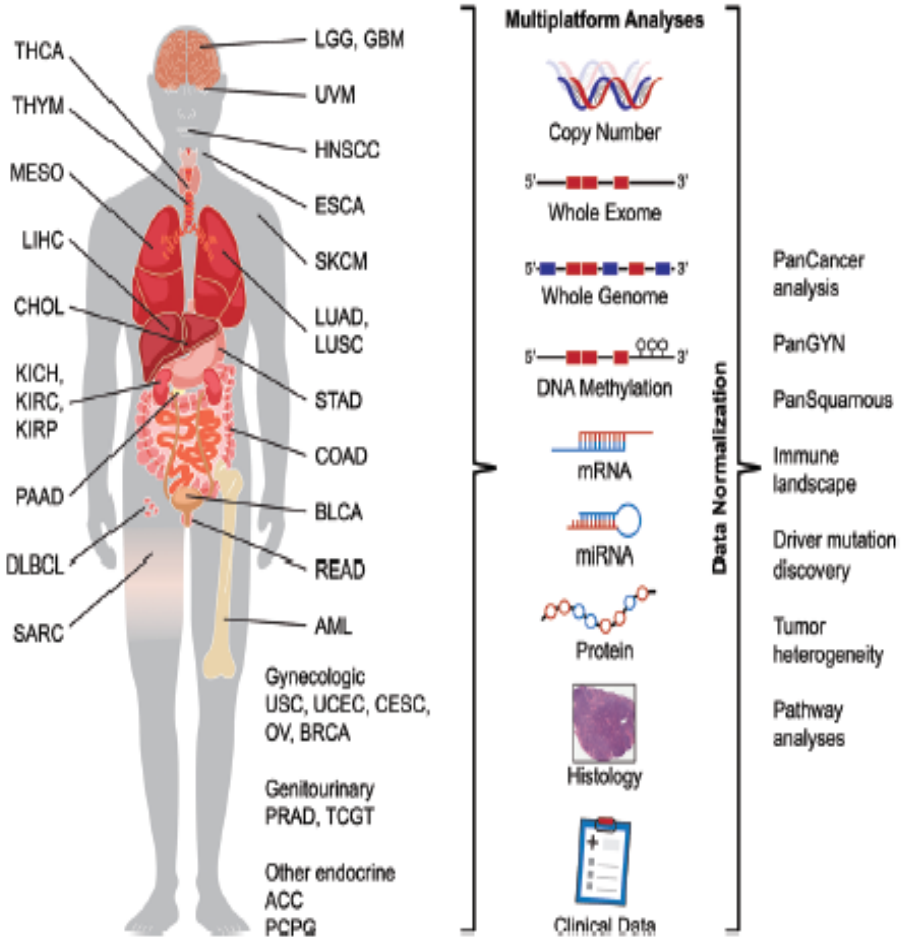
INVITED REVIEW

PanCancer insights from The Cancer Genome Atlas: the pathologist's perspective

Lee AD Cooper[1,2,3†], Elizabeth G Demicco[4†], Joel H Saltz[5], Reid T Powell[6], Arvind Rao[7,8] and Alexander J Lazar[9*]

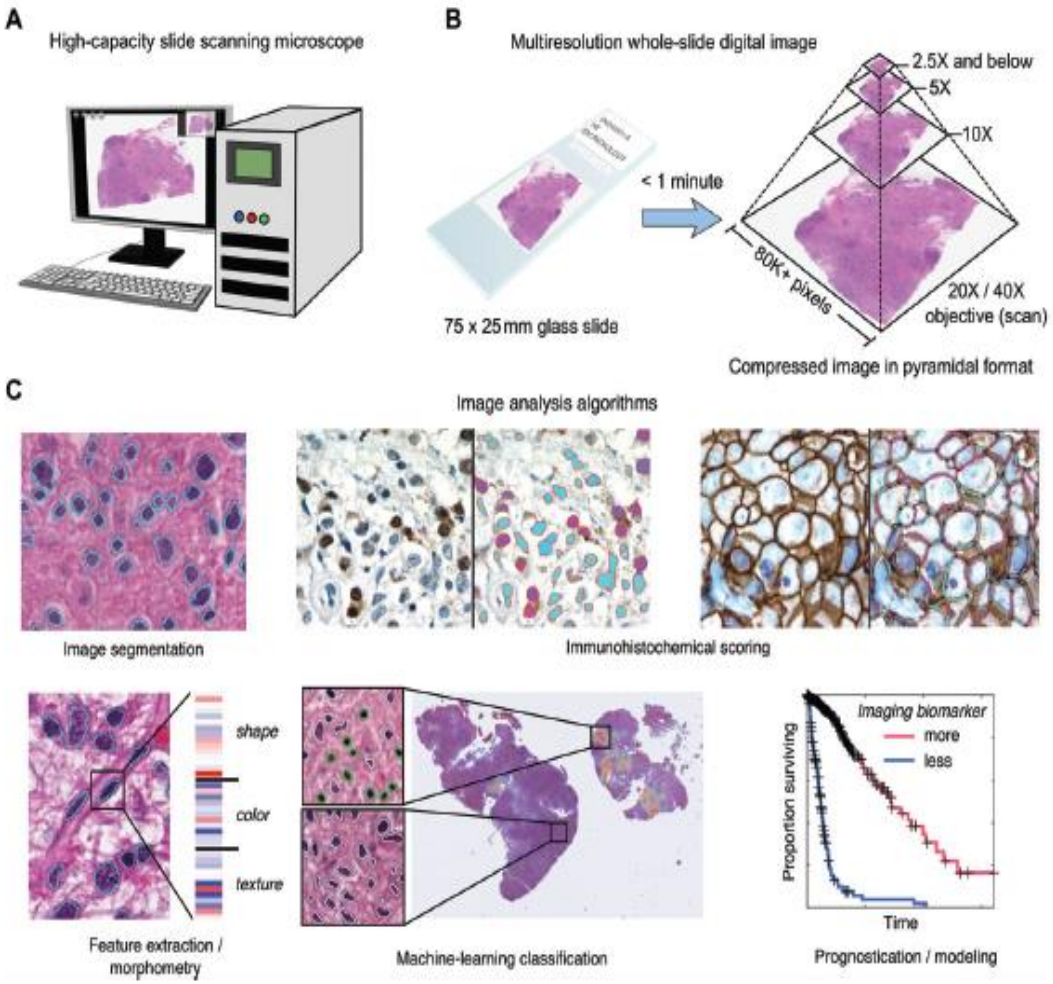


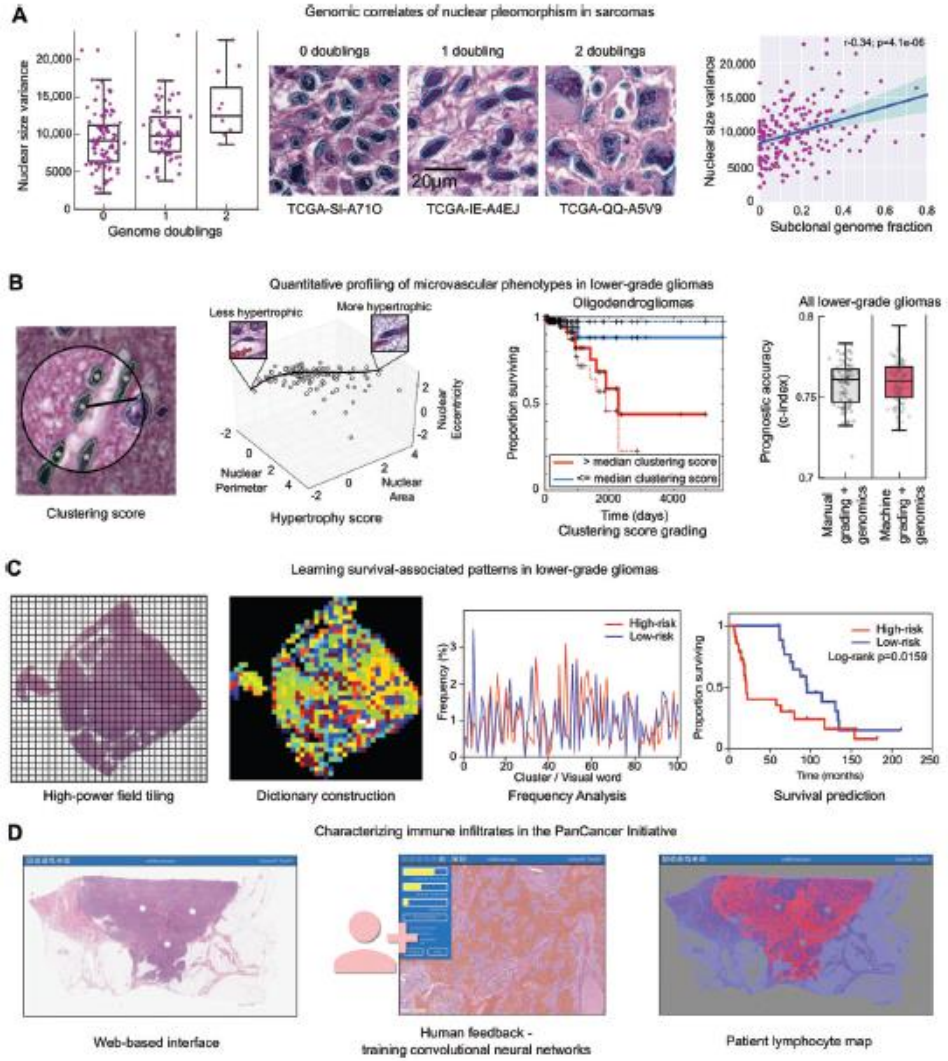
TCGA Tissue Procurement



TCGA Overview

Opportunities: TCGA Image Analysis





Future Collaborations

Future clinical demands will be best met by

- Dedicated research at the interface of pathology and bioinformatics, supported by professional societies
- Integration of data sciences and digital image analysis in the professional education of pathologists.

Virchows Archiv
https://doi.org/10.1007/s00428-018-2485-z

REVIEW ARTICLE

CrossMark

Precision immunoprofiling by image analysis and artificial intelligence

Viktor H. Koelzer[1,2] · Korsuk Sirinukunwattana[3] · Jens Rittscher[3,4,5] · Kirsten D. Mertz[6]

Received: 15 May 2018 / Revised: 6 November 2018 / Accepted: 9 November 2018
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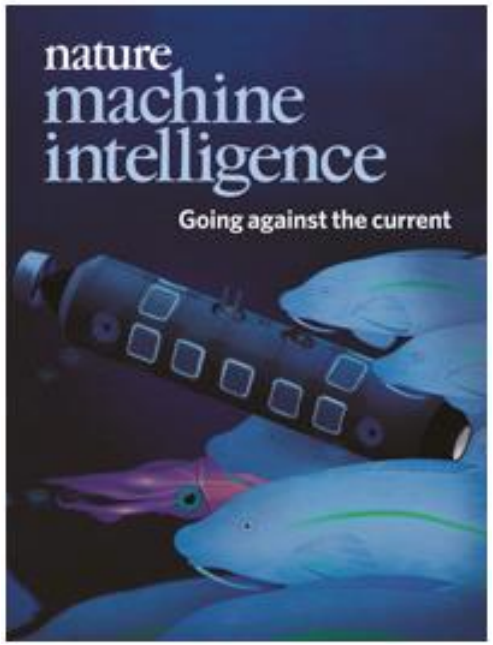
Institutional Collaboration Example



Article | Published: 13 May 2019

Pathologist-level interpretable whole-slide cancer diagnosis with deep learning

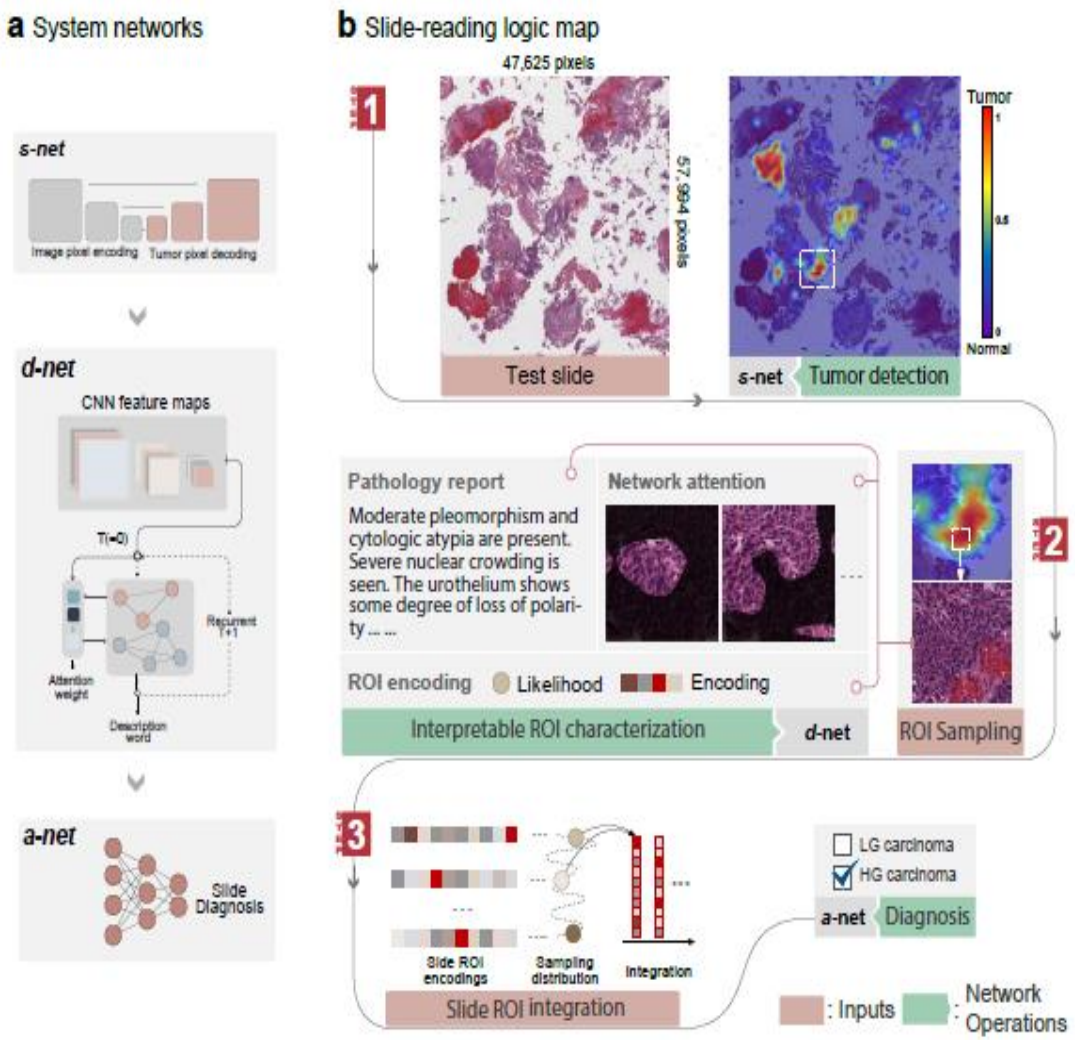
Zizhao Zhang, Pingjun Chen, Mason McGough, Fuyong Xing, Chunbao Wang, Marilyn Bui, Yuanpu Xie, Manish Sapkota, Lei Cui, Jasreman Dhillon, Nazeel Ahmad, Farah K. Khalil, Shohreh I. Dickinson, Xiaoshuang Shi, Fujun Liu, Hai Su, Jinzheng Cai & Lin Yang

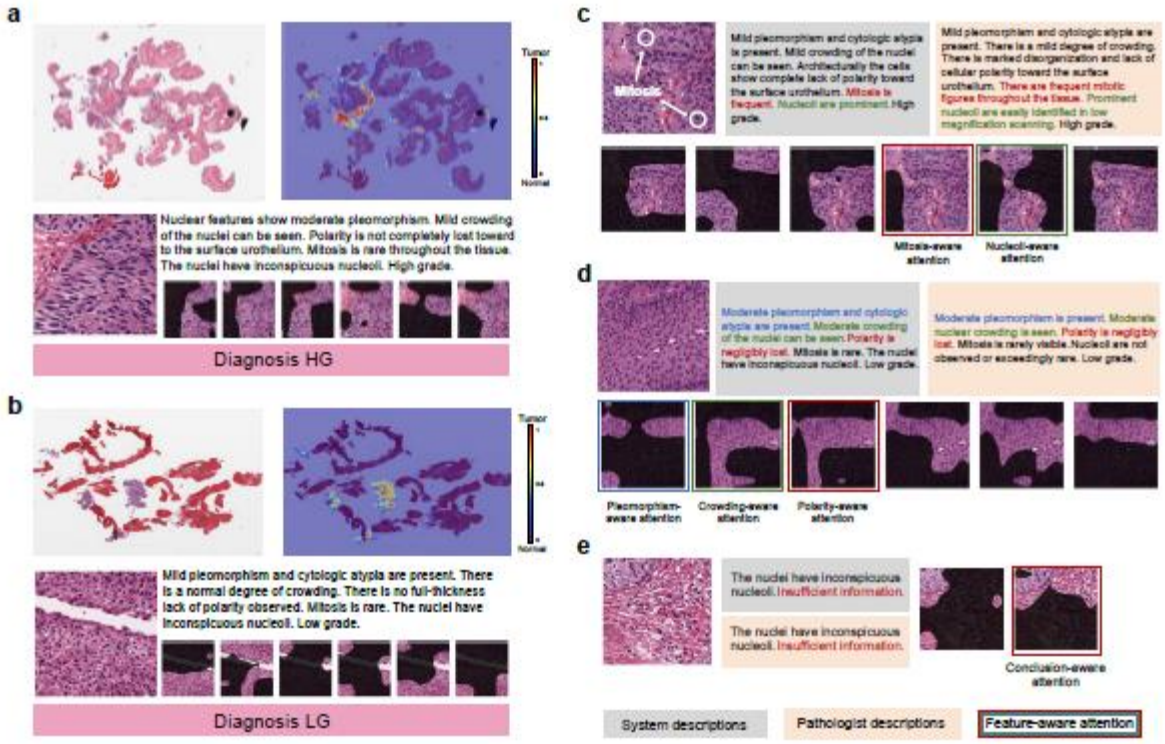
Nature Machine Intelligence **1**, 236–245 (2019) | Download Citation

Abstract

Diagnostic pathology is the foundation and gold standard for identifying carcinomas. However, high inter-observer variability substantially affects productivity in routine pathology and is especially ubiquitous in diagnostician-deficient medical centres. Despite rapid growth in computer-aided diagnosis (CAD), the application of whole-slide pathology diagnosis remains impractical. Here, we present a novel pathology whole-slide diagnosis method, powered by artificial intelligence, to address the lack of interpretable diagnosis. The proposed method masters the ability to automate the human-like diagnostic reasoning process and translate gigapixels directly to a series of interpretable predictions, providing second opinions and thereby encouraging consensus in clinics. Moreover, using 913 collected examples of whole-slide data representing patients with bladder cancer, we show that our method matches the performance of 17 pathologists in the diagnosis of urothelial carcinoma. We believe that our method provides an innovative and reliable means for making diagnostic suggestions and can be deployed at low cost as next-generation, artificial intelligence-enhanced CAD technology for use in diagnostic pathology.

A Pathologist-level Interpretable Diagnosis System with Deep Learning

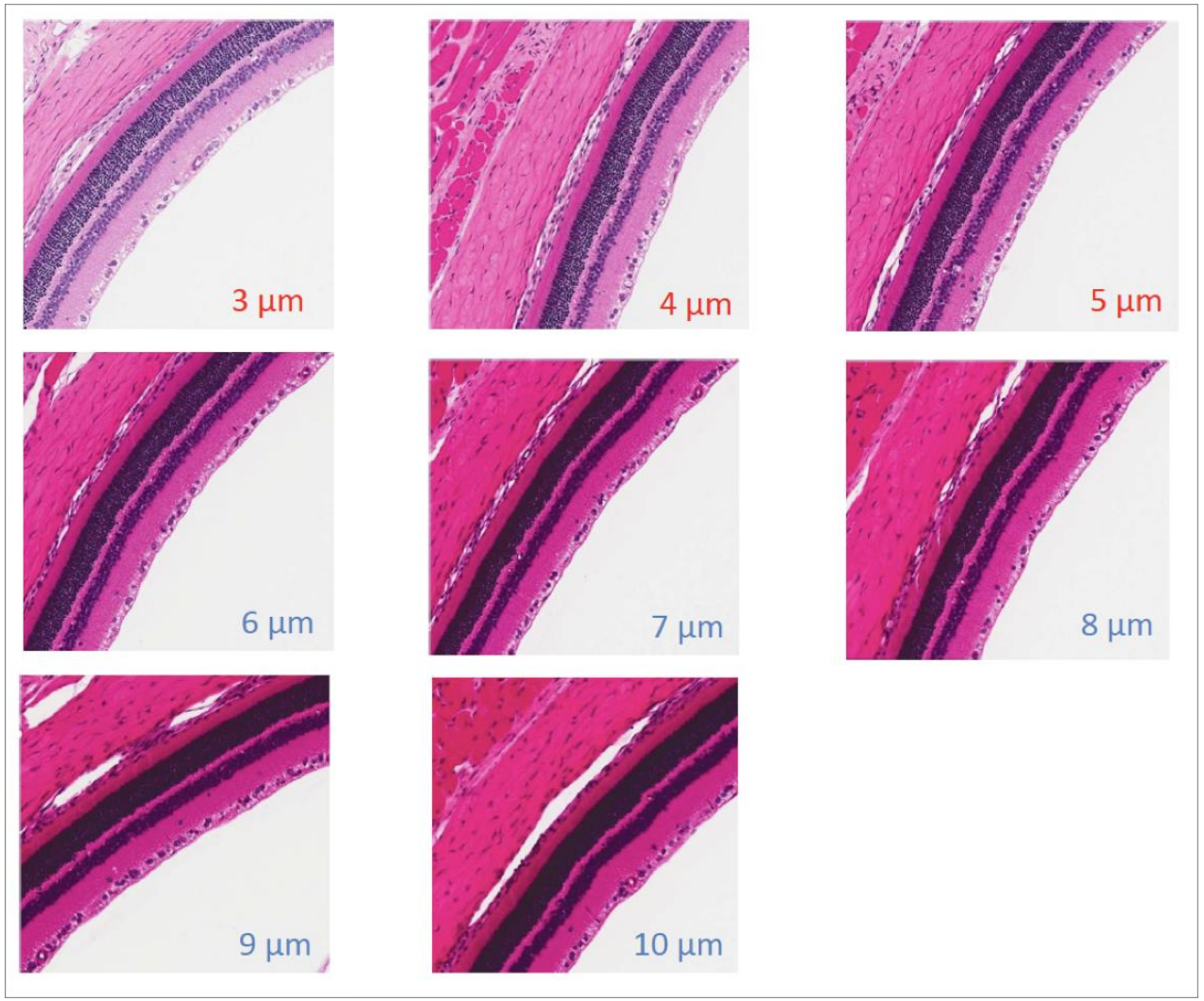




- Diagnosis of papillary urothelial carcinoma
- Collaboration of 17 board-certified pathologists with deep learning scientists
- A novel pathology computer-aided diagnosis system

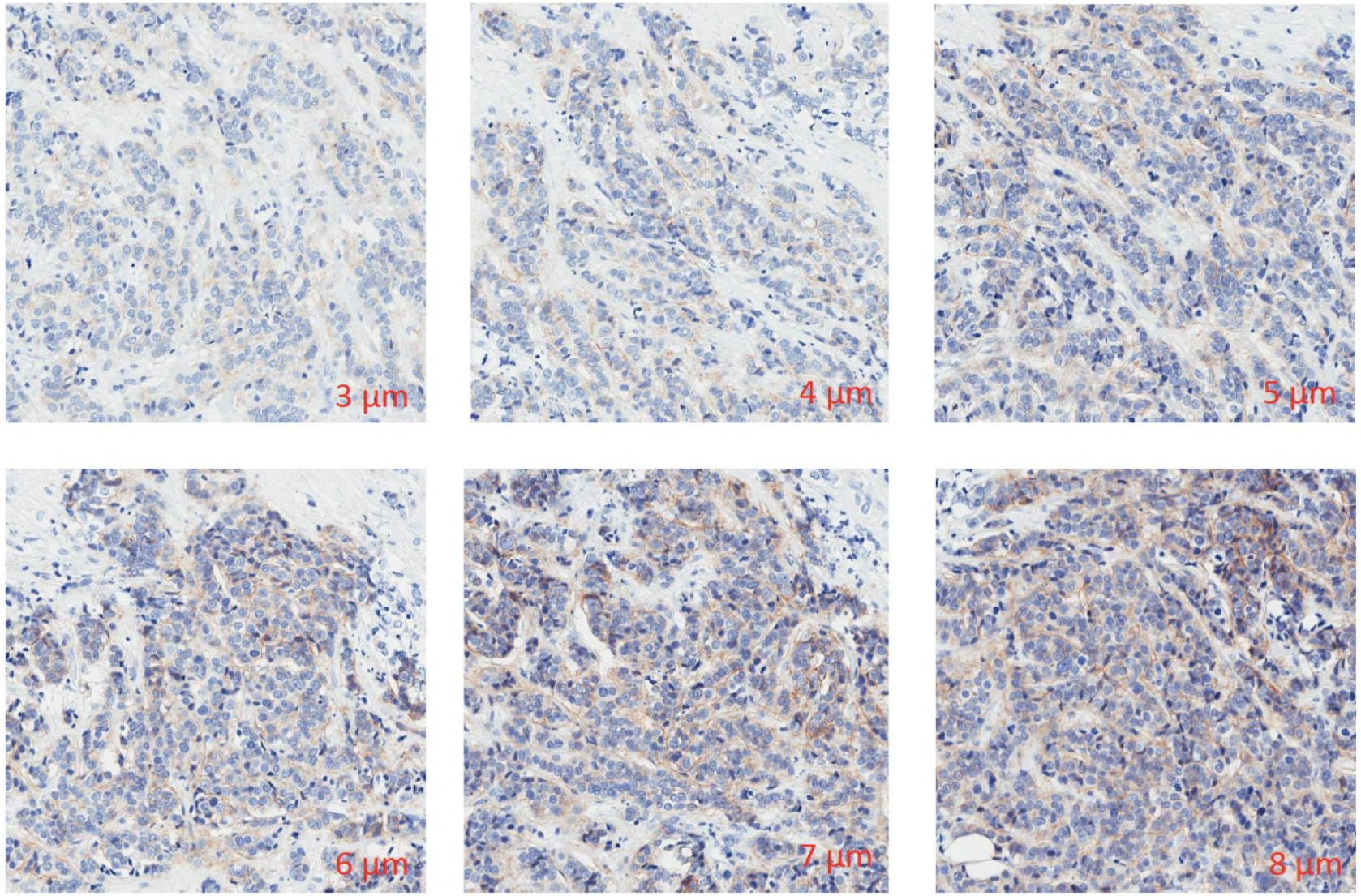
Quality Improvement Opportunity

Preanalyticals Affect H&E



Quality Improvement Opportunity

Preanalyticals Affect Immunostains



CAP Quality Improvement Opportunity

HISTOQIP

COLLEGE of AMERICAN PATHOLOGISTS
Laboratory Quality Solutions

2019 Surveys and Anatomic Pathology Education Programs

NEW

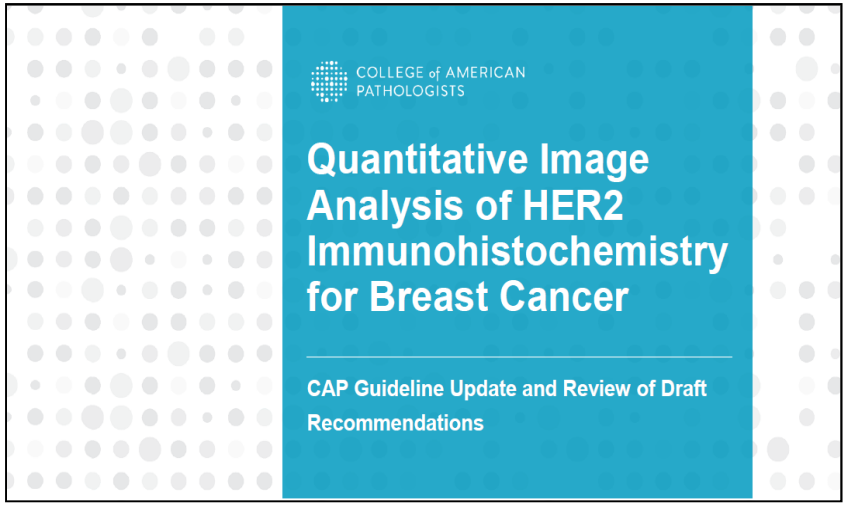
HQIP Whole Slide Image Quality Improvement Program HQWSI

Stain/Tissue	Program Code	Challenges per Shipment	
	HQWSI	A	B
H&E - Breast resection	▮	1	
H&E - Lung resection	▮	1	
H&E - Breast needle core biopsy	▮	1	
H&E - Prostate needle core biopsy	▮	1	
H&E - Colon resection	▮		1
H&E - Kidney resection	▮		1
H&E - Colon biopsy	▮		1
H&E - Skin punch biopsy	▮		1

Program Information

- Participant laboratories may submit up to four stained coverslipped glass slides and upload their scanned whole slide images per mailing
- Two shipments per year

CAP HER2 QIA Guideline



https://digitalpathologyassociation.org/_data/files/API/QIA_-_API_2017_CAP_DPA_Bui.pdf

ARCHIVES of Pathology & Laboratory Medicine

Bui MM, Riben MW, Allison KH, et al. Quantitative image analysis of HER2 immunohistochemistry for breast cancer: guideline from the College of American Pathologists. *Arch Pathol Lab Med.* doi: 10.5858/arpa.2018-0378-CP

11 recommendations

7 recommendations (based on laboratory accreditation requirements)

New Pathology Guideline Advances Accuracy in Breast Cancer Testing

Updated: Jan 17, 2019

Evidence-based guideline supports HER2 quantitative image analysis for breast cancer

COLLEGE of AMERICAN PATHOLOGISTS

Press Releases

The guideline is available at no charge on cap.org. Additional resources including an instructional presentation and summary of the recommendations are also available.

CAP HER2 QIA Guideline

Quantitative Image Analysis of HER2 Immunohistochemistry for ...
documents.cap.org/.../teaching_presentation_qia.pdf
• Marilyn **Bui**, MD, PhD, FCAP, chair ... matches the scoring system of the ASCO/CAP **HER2 guideline** ... •It is the consensus of the expert panel that **HER2 QIA**

CAP Quantitative Image Analysis of HER2 Immunohistochemistry ...
digitalpathologyassociation.org/_data/files/API/...
Marilyn M. **Bui**, MD, PhD, FCAP ... need of **guideline** for **HER2** IHC **QIA** . ... CAP Quantitative Image Analysis of **HER2** Immunohistochemistry for Breast Cancer ...

Guide for HER2 Testing That's Not 'by Eye' - medscape.com
www.medscape.com/viewarticle/908336
Guideline lead author Marilyn **Bui**, MD, PhD, Moffitt Cancer Center, Tampa, Florida, explained the importance of the new automated technology. ... The pathologist who oversees the entire **HER2 QIA** ...

Quantitative Image Analysis of HER2 Immunohistochemistry for ...
documents.cap.org/documents/summary...
Bui M, Riben MW, Allison KH, et al. Quantitative image analysis of **HER2** immunohistochemistry for **breast** cancer: **guideline** from the College of American Pathologists.

New Pathology Guideline Advances Accuracy in Breast Cancer ...
www.itnonline.com/content/new-pathology...
January 25, 2019 — The College of American Pathologists (CAP) published the first-ever evidence-based clinical practice **guideline** to help laboratories use quantitative image analysis (**QIA**) in **HER2** immunohistochemistry (IHC) testing for breast cancer.

Use of image analysis to ID HER2 status in breast cancer outlined
medicalxpress.com › Cancer
Marilyn M. **Bui**, M.D., Ph.D., from the H. Lee Moffitt Cancer Center in Tampa, Florida, and colleagues developed evidence-based recommendations for the use of **QIA** in the interpretation of **HER2** IHC ...

Guide for HER2 Testing That's Not 'by Eye' - HCP Feed
www.hcpfeed.com/2019/01/28/guide-for-her2...
QIA, on the other hand, electronically detects and tallies **HER2** membranous immunohistochemical staining of invasive **breast** cancer cells and then provides a quantitative measure of that **HER2** histologic feature. **Guideline** lead author Marilyn **Bui**, MD, PhD, Moffitt Cancer Center, Tampa, Florida, explained the importance of the new automated technology.

New Pathology Guideline Advances Accuracy in Breast Cancer ...
www.biospace.com/article/releases/new-pathology...
NORTHFIELD, Ill., Jan. 17, 2019 /PRNewswire/ -- The College of American Pathologists (CAP) today published the first-ever evidence-based clinical practice **guideline** to help laboratories use quantitative image analysis (**QIA**) in **HER2** immunohistochemistry (IHC) testing for breast cancer.

EARLY ONLINE RELEASE - archivesofpathology.org
www.archivesofpathology.org/doi/pdf/10.5858/arpa...
the **guideline** statements below, the discussion of the benefits and harms of the **guideline** statements are included in the supplemental digital content. **Guideline** Statements 1. Expert Consensus Opinion. —Laboratories that choose to implement **QIA** for **HER2** IHC interpretation for clinical testing should select a **QIA** system that is validated

Quantitative Image Analysis of HER2 | College of American ...
www.cap.org/.../qia-her2-ihc-for-breast-cancer
Evidence-based **guideline** for **Quantitative Image Analysis** (**QIA**) Of **HER2** Immunohistochemistry (IHC) for Breast Cancer.

CAP and Other Pathology Societies *Guidelines*

Updated CAP WSI validation guidelines

CAP Laboratory Improvement Programs

Validating Whole Slide Imaging for Diagnostic Purposes in Pathology

Guideline from the College of American Pathologists Pathology and Laboratory Quality Center

Liron Pantanowitz, MD; John H. Sinard, MD, PhD; Walter H. Henricks, MD; Lisa A. Fatheree, BS, SCT(ASCP); Alexis B. Carter, MD; Lydia Contis, MD; Bruce A. Beckwith, MD; Andrew J. Evans, MD, PhD; Christopher N. Otis, MD; Avtar Lal, MD, PhD; Anil V. Parwani, MD, PhD

• *Context.*—There is increasing interest in using whole slide imaging (WSI) for diagnostic purposes (primary and/or consultation). An important consideration is whether WSI can safely replace conventional light microscopy as the method by which pathologists review histologic sections, cytology slides, and/or hematology slides to render diagnoses. Validation of WSI is crucial to ensure that diagnostic performance based on digitized slides is at least equivalent to that of glass slides and light microscopy. Currently, there are no standard guidelines regarding validation of WSI for diagnostic use.

Objective.—To recommend validation requirements for WSI systems to be used for diagnostic purposes.

Design.—The College of American Pathologists Pathology and Laboratory Quality Center convened a nonvend panel from North America with expe in pathology to develop these validation recom A literature review was performed in which tional publications that met sear were identified. Studies outside th those related solely to technical elements, education, and image analysis were excluded. A total of 27 publications were graded and underwent data extraction for evidence evaluation. Recommendations were derived f the strength of evidence determined from 27 published studies, open comment feedback, panel consensus.

Results.—Twelve to help patholog systems intended WSI system, invo system, should be perform labor actual clinical e ed a validati include at least 60 routine ca pe plication, paring intraobserver diagnostic co e between digitized and glass slides viewed at ast part. It is important that the validation oc that all material present on a glass slide to sca ded in the digital image.

Con—Validation should demonstrate that the WSI system under review produces acceptable digital slides for diagnostic interpretation. The intention of validating WSI systems is to permit the clinical use of this technology in a manner that does not compromise patient care.

(*Arch Pathol Lab Med.* 2013;137:1710–1722; doi: 10.5858/arpa.2013-0093-CP)

Accepted for publication 12, 2 ished as 1, 2 the ntis of ology, iversity of Pittsburgh edical Cen Pittsbu Pen ania (Drs Pantanowitz, Contis, nd Parwani) Depar for ology, Yale University School of Medicine, Ne ven, nnecticut (Dr Sinard); the Pathology and aboratory Me tute, Cleveland Clinic, Cleveland, Ohio r Henric lege of American Pathologists, Northfield, is (Ms Fatheree); the Department of Pathology and Laboratory mory University, Atlanta, Georgia (Dr Carter); the Department of Pathology, North Shore Medical Center, Salem, Massachusetts (Dr Beckwith); the Laboratory Medicine Program, University Health Network, Toronto, Ontario, Canada (Dr Evans); the Department of Pathology, Baystate Medical Center, Tufts University School of Medicine, Springfield, Massachusetts (Dr Otis); and University Hospital, London Health Science Center, London, Ontario, Canada (Dr Lal).

For author conflict of interest disclosures, see the Appendix.

Supplemental digital content is available for this article at www.archivesofpathology.org in the December 2013 Table of Contents.

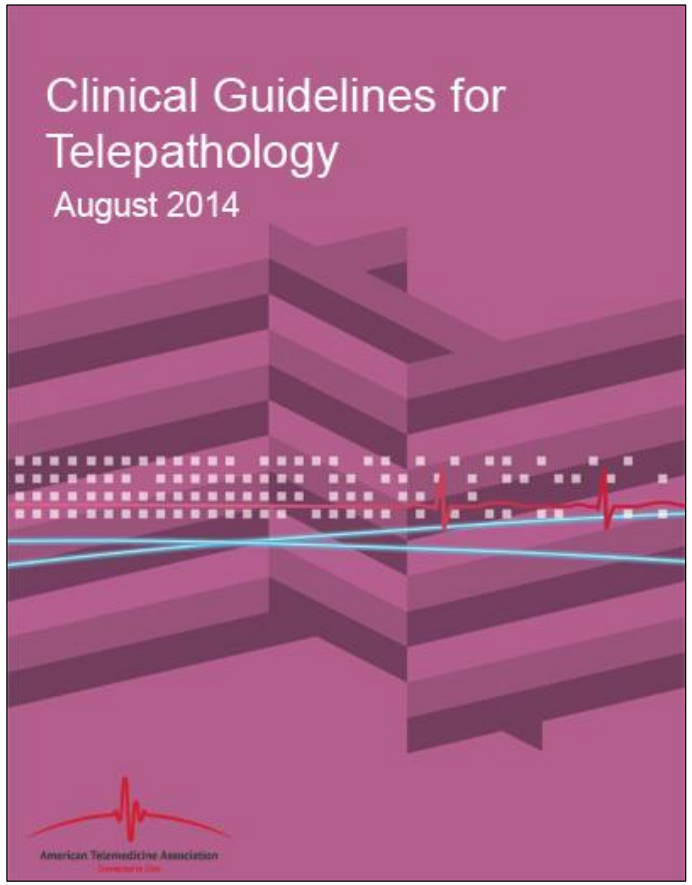
Reprints: Liron Pantanowitz, MD, University of Pittsburgh Medical Center, Department of Pathology, UPMC Shadyside, UPMC Cancer Pavilion, Suite 201, 5150 Centre Ave, Pittsburgh, PA 15232 (e-mail: pantanowitzl@upmc.edu).

In the last decade, digital imaging in pathology has been significantly impacted by the development and application of whole slide imaging (WSI) technology.[1–7] The automated WSI scanner is a robotic microscope capable of digitizing an entire glass slide, using software to merge or stitch individually captured images into a composite digital image. The critical components of an automated WSI device (system) include the hardware (scanner composed of an optical microscope and digital camera connected to a computer), software (responsible for image creation and management, viewing of images, and image analysis where applicable), and network connectivity. Whole slide imaging technology has evolved to the point where digital slide

1710 Arch Pathol Lab Med—Vol 137, December 2013 *Validating Whole Slide Imaging*—Pantanowitz et al

Coming Soon

http://www.archivesofpathology.org/doi/full/10.5858/arpa.2013-0093-CP



http://www.jpathinformatics.org/article.asp?issn=2153-3539;year=2014;volume=5;issue=1;spage=39;epage=39;aulast=Pantanowitz

The Royal College of Pathologists
Pathology: the science behind the cure

Best practice recommendations for implementing digital pathology

January 2018

Authors: Simon Cross, Peter Furness, Laszlo Igali, David Snead, Darren Treanor

Unique document number	G162
Document name	Best practice recommendations for implementing digital pathology
Version number	1
Produced by	Simon Cross, Peter Furness, Laszlo Igali, David Snead and Darren Treanor on behalf of the Specialty Advisory Committee on Cellular Pathology.
Date active	January 2018
Date for review	January 2023
Comments	In accordance with the College's pre-publication policy, this document was on The Royal College of Pathologists' website for consultation from 12 May 2017 to 12 June 2017. Responses and authors' comments are available to view on request. **Dr Lorna Williamson** **Director of Publishing and Engagement**

050118 1 V1 INVESTORS IN PEOPLE

https://www.rcpath.org/uploads/assets/uploaded/d6b14330-a8b9-4f5e-bbe443f0d56de24a.pdf

Digital Pathology Association

- Founded in 2009, the DPA is a nonprofit organization comprised of pathologists, scientists, technologists and industry representatives dedicated to advancing the field of digital pathology.
- The organization's mission is to facilitate awareness, education and adoption of digital pathology and AI applications in healthcare and life sciences.
- Members are encouraged to share best practices and promote the use of the technology among colleagues in order to demonstrate efficiencies, share knowledge and its ultimate benefits to patient care.
- 1000+ active members across all membership categories

http://digitalpathologyassociation.org

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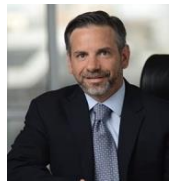

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Membership Levels

FOR A DETAILED LIST OF ALL MEMBER OPPORTUNITIES AND BENEFITS, SEE OUR MEMBERSHIP LEVELS

INDIVIDUAL MEMBERSHIP LEVELS

- INDIVIDUAL
- TECHNICIAN / TECHNOLOGIST
- RESIDENT / FELLOW / PHD CANDIDATE / MD STUDENT

GROUP MEMBERSHIP LEVELS

- BENEFACTOR
- COUNCILOR
- CHAMPION
- INDUSTRY
- MEDICAL PRACTICE / LABORATORY
- HOSPITAL / UNIVERSITY
- ALLIED SOCIETY

DIGITAL PATHOLOGY DPA ASSOCIATION

Committees and Task Forces

Membership

Michael Quick, Hologic (Chair)

The DPA Membership/Member Benefits Committee recommends policies, procedures, and strategies for enhancing the membership of the DPA. The Committee recommends initiatives to assure a growing and vital membership organization.

Education

Mike Isaacs, Washington University School of Medicine (Co-Chair)
Anil Parwani, The Ohio State University (Co-Chair)

The DPA Education Committee is responsible for the planning and execution of webinars, identifying white paper topics to be developed and presented on behalf of DPA membership at the annual conference, Pathology Visions as well as other educational opportunities. The Committee will ensure that all of the educational outreach opportunities of the various DPA committees and task forces have a similar direction and complement each other

Reg. & Stan'rds

Esther Abels, PathAI (Co-Chair)
Joachim Schmidt, Roche (Co-Chair)

The mission of the Digital Pathology Association Regulatory and Standards Task Force is to advance digital pathology by bringing clarity to the regulatory pathway for digital pathology including its evolution and creating awareness thereof and working towards the development and adoption of standards as well as promoting interoperability in digital pathology for clinical use.

Program

Sylvia Asa, MD, PhD, University Health Network (Co-Chair)
Liron Pantanowitz, MD, UPMC (Co-Chair)

The DPA Program Committee is responsible for the planning and execution of the Pathology Visions Conference, including speaker and abstract selection and program development for the conference.

Website

Chris Garcia, LabCorp Diagnostics (Chair)

The DPA Website Task Force is responsible for keeping the Digital Pathology Association website current and providing resources to those who access it.

+ 55 Dedicated Volunteer Members!!

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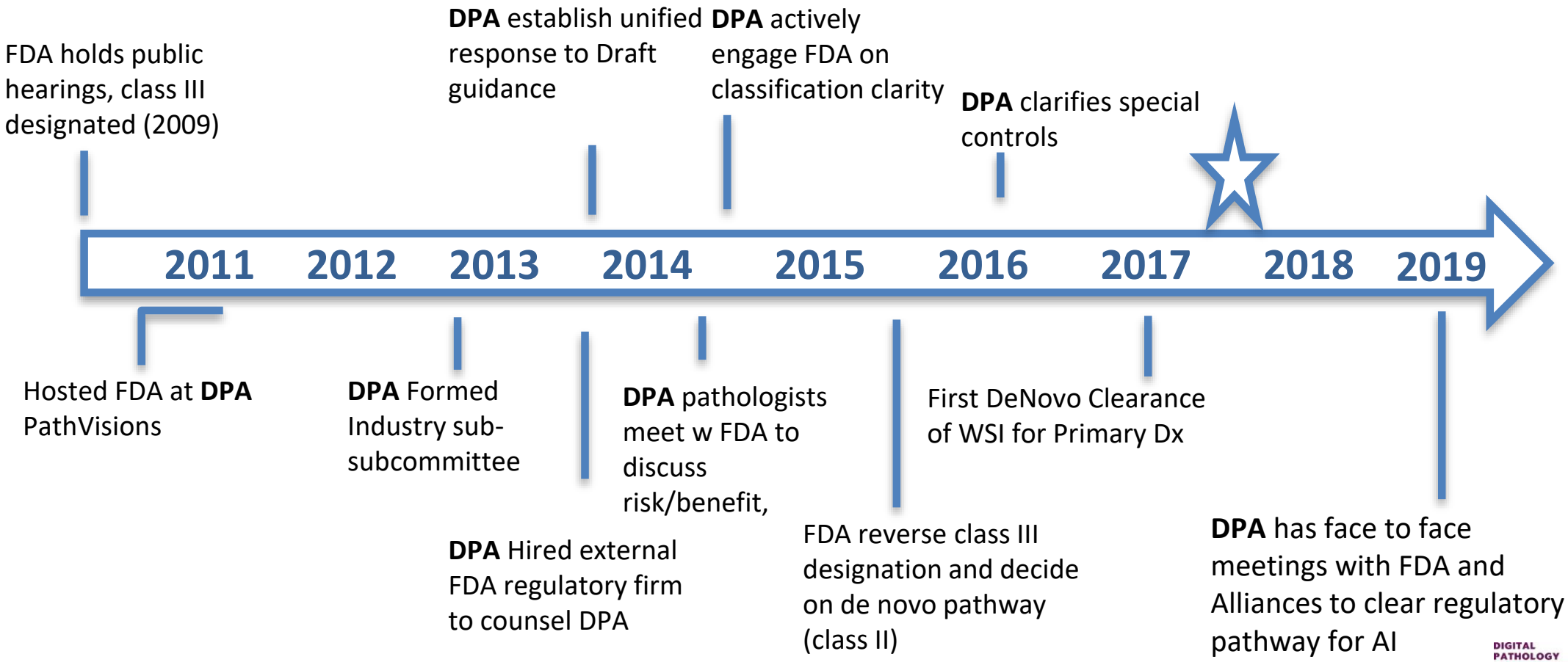
DPA in Advocacy for Regulatory Path Clarity



DIGITAL PATHOLOGY DPA ASSOCIATION

DPA in Interoperability with DICOM

- **DPA hosted the first Connectathon at Pathology Visions 2017**
- **Formation of DICOM & Standards Task Force**

CAP TODAY

The one publication most important to your job!

"We learned more in this one event than we did in the past 7 year"

Dr. David Clunie, DICOM WG 26 Co-chair

'Connectathon' opens door to interoperability in digital pathology

Valerie Neff Newitt

December 2017—With the FDA having approved whole slide imaging for primary diagnosis this year, one obstacle to full acceptance of digital pathology remains: lack of interoperability. To topple that barrier, the Digital Pathology Association, the CAP through its Digital Pathology Committee, and DICOM Working Group 26 convened in October, during the Pathology Visions conference, the first Connectathon for digital pathology.

"The uptake of digital pathology hasn't been as rapid as everyone had anticipated," says Liron Pantanowitz, MD, professor of pathology and biomedical informatics, University of Pittsburgh Medical Center. "Many pathology departments know that if they purchase a digital pathology system it will not be easy to bring it back to the lab, plug it in, and get it to interact with everything else. There has been no plug-and-play option in digital pathology, and that has been a huge stumbling block."

Dr. Pantanowitz, a member of the CAP Digital Pathology Committee, says Connectathon was a milestone almost as big as the FDA's recent approval itself. "Connectathon not only provided a venue for connecting machines able to talk to each other, but also it connected an entire industry with a commitment to move digital pathology forward."


Dr. Parwani

Anil Parwani, MD, PhD, MBA, a member of the CAP committee and a professor of pathology, vice chair of anatomic pathology, and director of pathology informatics and digital pathology shared resources, Ohio State University Wexner Medical Center, says of Connect-athon: "We thought it would be great if we could bring vendors together and have them show us that, yes, they can all connect and, yes, we can use standards"—in the way radiology does, for example—"and, yes, we can share these images."

PATHOLOGY DPA ASSOCIATION

DPA in Education Partnership with NSH

Digital Pathology Association (DPA) https://digitalpathologyassociation.org/ in collaboration with NSH, developed the first ever certificate program for digital pathology

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NATIONAL SOCIETY FOR HISTOTECHNOLOGY

DPA in Education of Pathology Trainees

Digital Anatomic Pathology Academy (DAPA)

- A web-based whole slide image teaching platform for pathology residents and fellows
- Prepare the next generation pathologists for the era of digital medicine
- Experienced pathologists, mostly academic pathologists are faculty
- High yielded cases that trainees must know before their certification exam
- Organized in organ systems for supervised and unsupervised learning
- Virtual multiscope lectures and didactic lectures are in development
- Free to all DPA members

Chief Editors

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@mydermpath
Pathpreesnter.net

Dr. Marilyn Bui

DIGITAL PATHOLOGY DPA ASSOCIATION

DPA in Education and Awareness

Publication & White Papers

- Abstracts of all Pathology Visions presentation are published in the *Journal of Pathology Informatics* since 2017.
- Member publication posting on DPA website is available per request.
- Previous white paper presentations are on DPA website.
- Various new white papers are published or in progress.

Zarella MD, Bowman D, Aeffner F, Farahani N, Xthona A, Absar SF, Parwani A, Bui M, Hartman DJ. A Practical Guide to Whole Slide Imaging: A White Paper From the Digital Pathology Association. Arch Pathol Lab Med. 2019 Feb;143(2):222-234. Pubmedid: 30307746.

Aeffner F, Zarella MD, Buchbinder N, Bui MM, Goodman MR, Hartman DJ, Lujan GM, Molani MA, Parwani AV, Lillard K, Turner OC, Vemuri VNP, Yuil-Valdes AG, Bowman D. Introduction to Digital Image Analysis in Whole-slide Imaging: A White Paper from the Digital Pathology Association. J Pathol Inform. 2019 Mar;10:9. Pubmedid: 30984469. Pmcid: PMC6437786.

WP3: Computational Pathology – *Esther Abels/Cleo Kozlowski/Liron Pantanowitz*
WP4: Business Case – *Jennifer Quigley/Giovanni Lujan*
WP5: IVM – *Jeff Fine/Mark Zarella*

Webinars & Blogs

- DPA members have access to all archived webinars.
- DPA members are welcome to post blogs.

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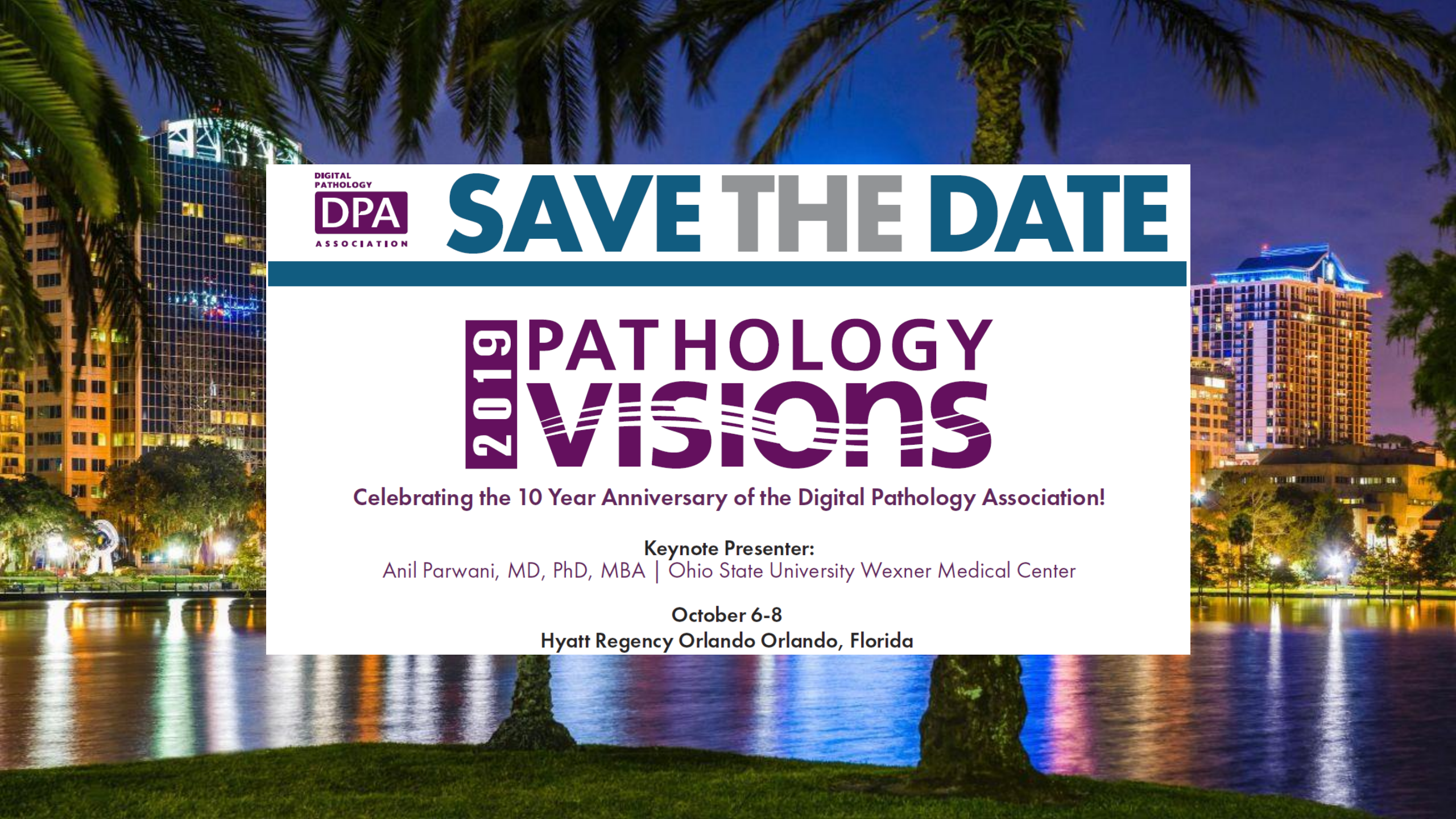


DIGITAL PATHOLOGY DPA ASSOCIATION

SAVE THE DATE

2019 PATHOLOGY VISIONS

Celebrating the 10 Year Anniversary of the Digital Pathology Association!

Keynote Presenter:
Anil Parwani, MD, PhD, MBA | Ohio State University Wexner Medical Center

October 6-8
Hyatt Regency Orlando Orlando, Florida

Conclusions

- Digital pathology and artificial intelligence are here to stay and will continuously transform the delivery of precision medicine.
- Collaboration of pathologists, scientists and industry is important to move the field forward in an impactful way.
- Each individual can make a difference.

Catalyst for change

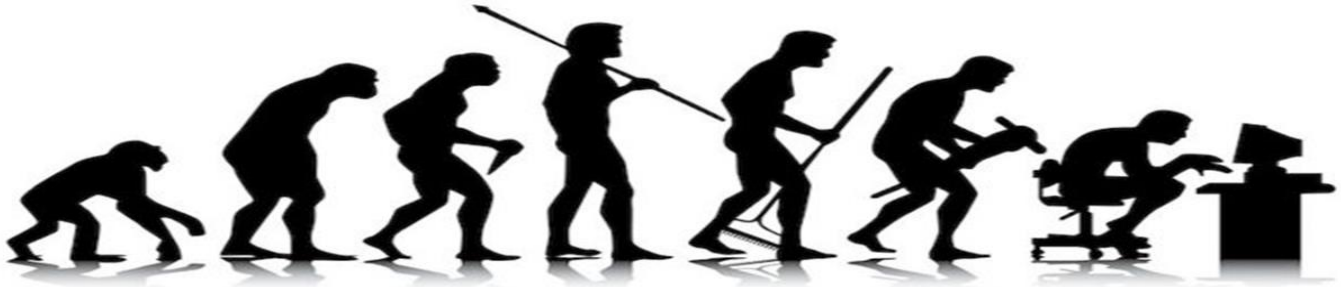
Facilitator for collaboration

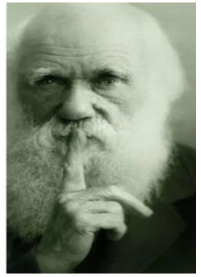
- Digital Pathology Association is your community.

DIGITAL PATHOLOGY DPA ASSOCIATION

Revolution vs Evolution

- “In the long history of humankind (and animal kind, too) those who learned to collaborate and improvise most effectively have prevailed.”
- “It is not the strongest of the species that survives, nor the most intelligent that survives. It is the one that is the most adaptable to change.” **– Charles Darwin**





Any Questions?

No financial conflict of interest

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Email: Marilyn.Bui@Moffitt.org

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- Senior Member/Professor of Pathology, Scientific Director of Analytic Microscopy Core, President of Medical Staff and Cytopathology Fellowship Program Director at the Moffitt Cancer Center https://moffitt.org in Tampa, Florida
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