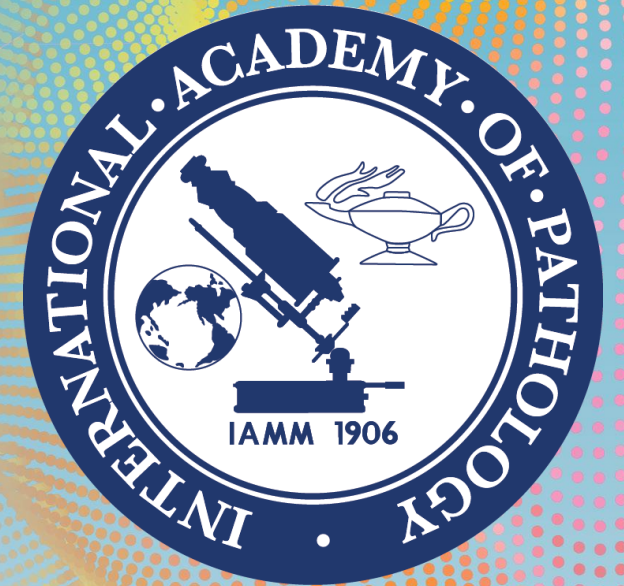


Artificial Intelligence and Cytopathology Friend or Foe?

- A/Professor Elizabeth Salisbury
- Clinical Director
- Tissue Pathology and Diagnostic Oncology
- NSW Health Pathology, Westmead Hospital



Disclosure of Relevant Financial Relationships

No relevant financial relationships

“Surely it is about the development and application of automated screening systems for cytopathology, especially gynaecologic cytology”

Dr Bernard Naylor, past president of American Society of Cytology and Papanicalou Award recipient in an address at 1999 American Society of Cytology Annual Meeting, when asked to make a prediction about the future of cytology

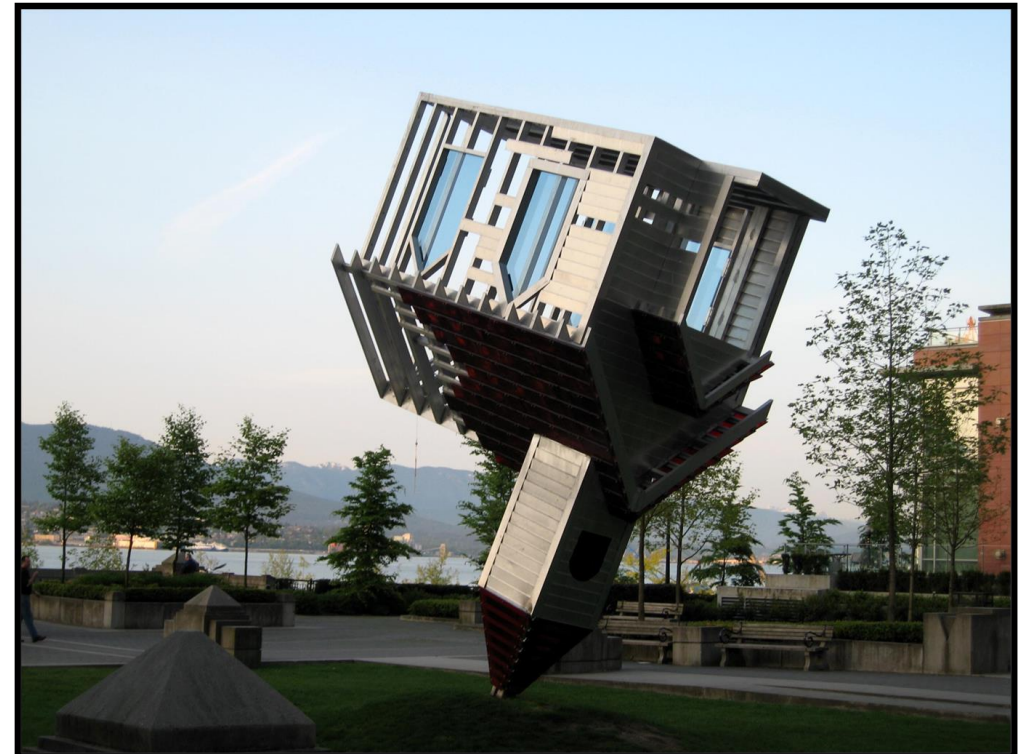
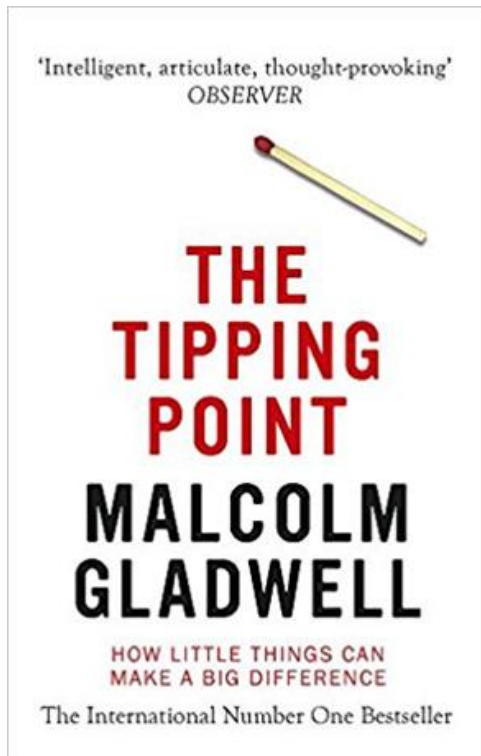
Outline

Tipping point of cytology

Digital pathology and AI

Applications of AI in cytology

Cytopathology is facing an uncertain future



Have we reached the tipping point for cytology?

This question has kept me awake at night for the past few years...

Is the profession about to be hit with a landslide that once started, cannot be stopped?



Cytology Tipping Points in the 20th Century

Pap smear

Gardasil vaccine

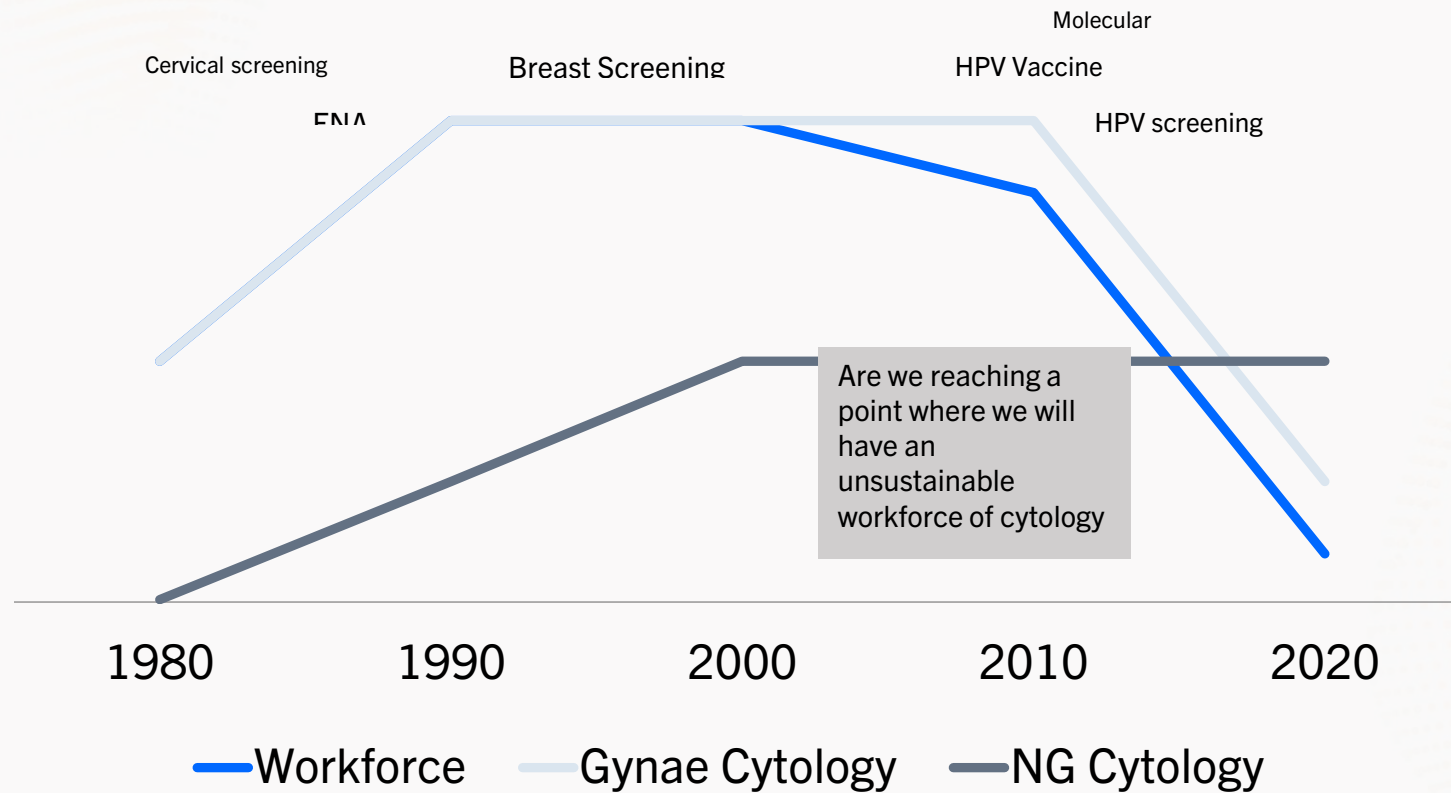
Changes to cervical screening programs
and HPV testing

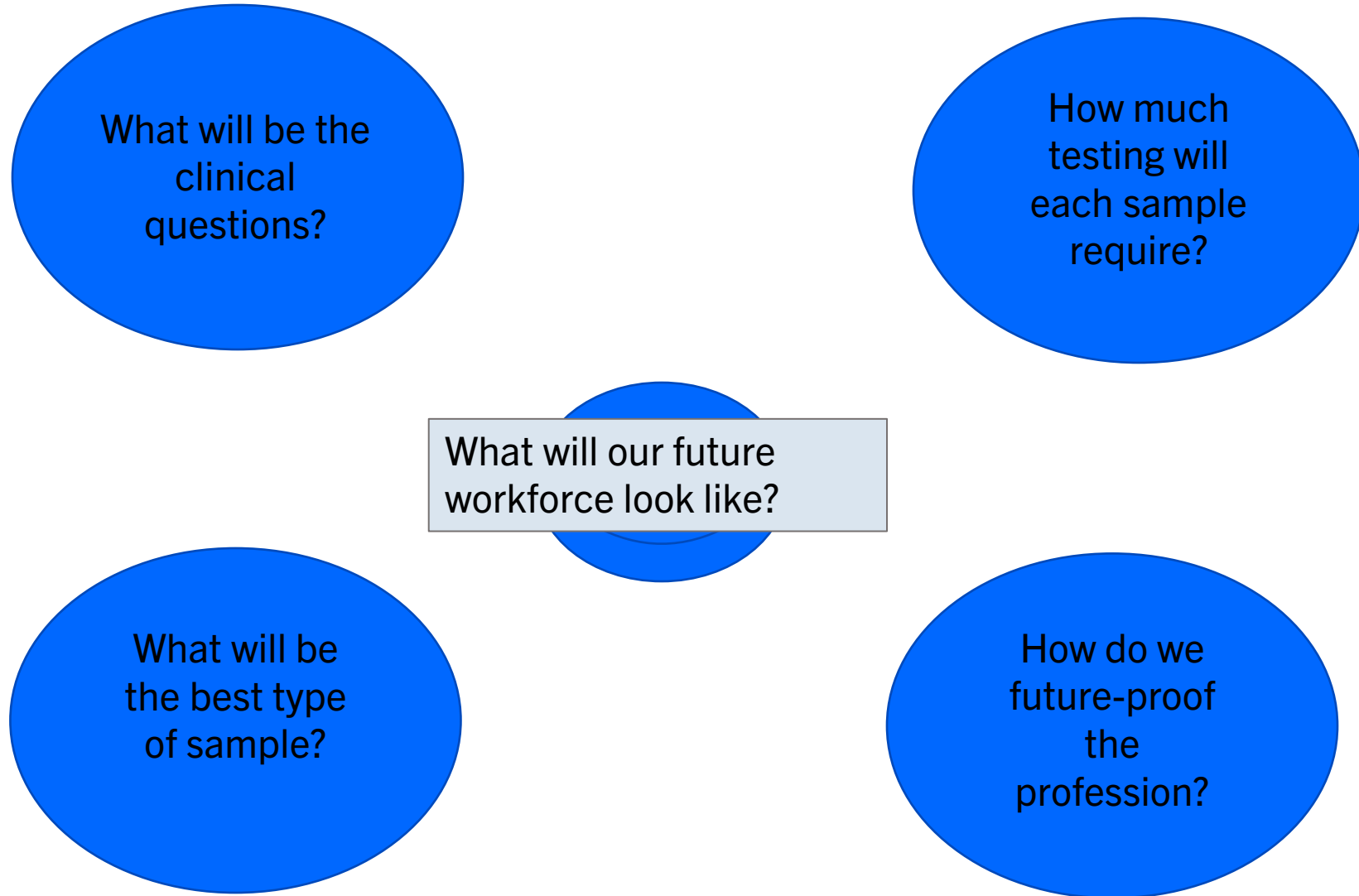
Breastscreening

U/S, CT Scanning and other radiological
platforms

EUS Technology

Workforce supply and demand





2024...

Will AI be
the great
disrupter?

NOT
on?

Histopathology is undergoing a revolution

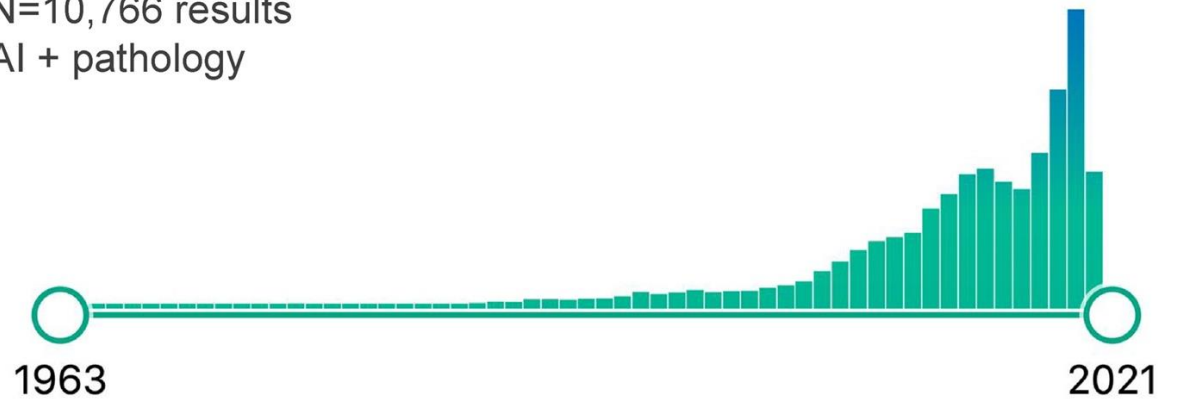
Diagnostic (Surgical Pathology) grows more complex by the day.

Sophisticated diagnoses and prognoses are driving “precision medicine” treatment decisions.

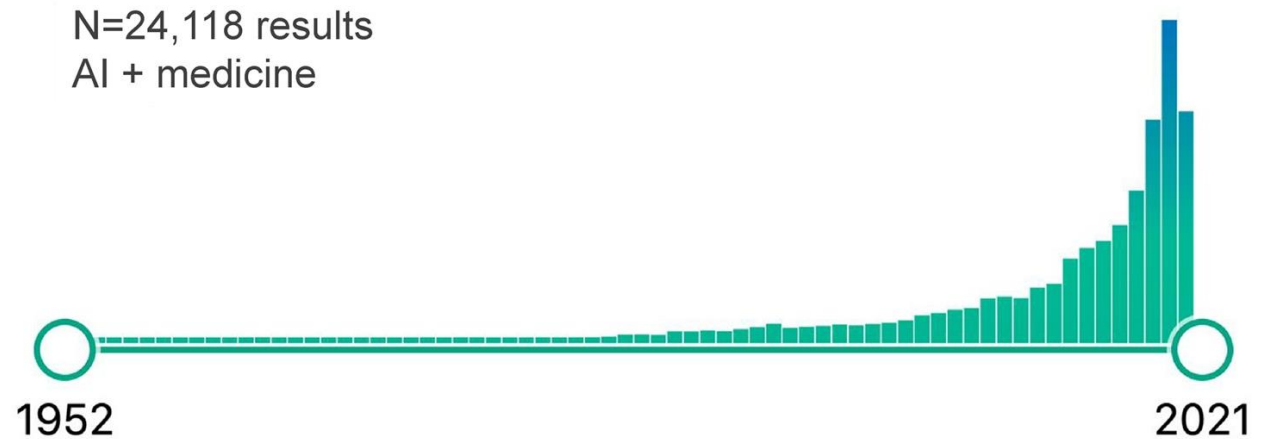
Recent advances in artificial intelligence are driving rapid changes in all areas of medicine.

The pathologists of tomorrow will use AI algorithms in ways we haven't yet imagined

N=10,766 results
AI + pathology



N=24,118 results
AI + medicine



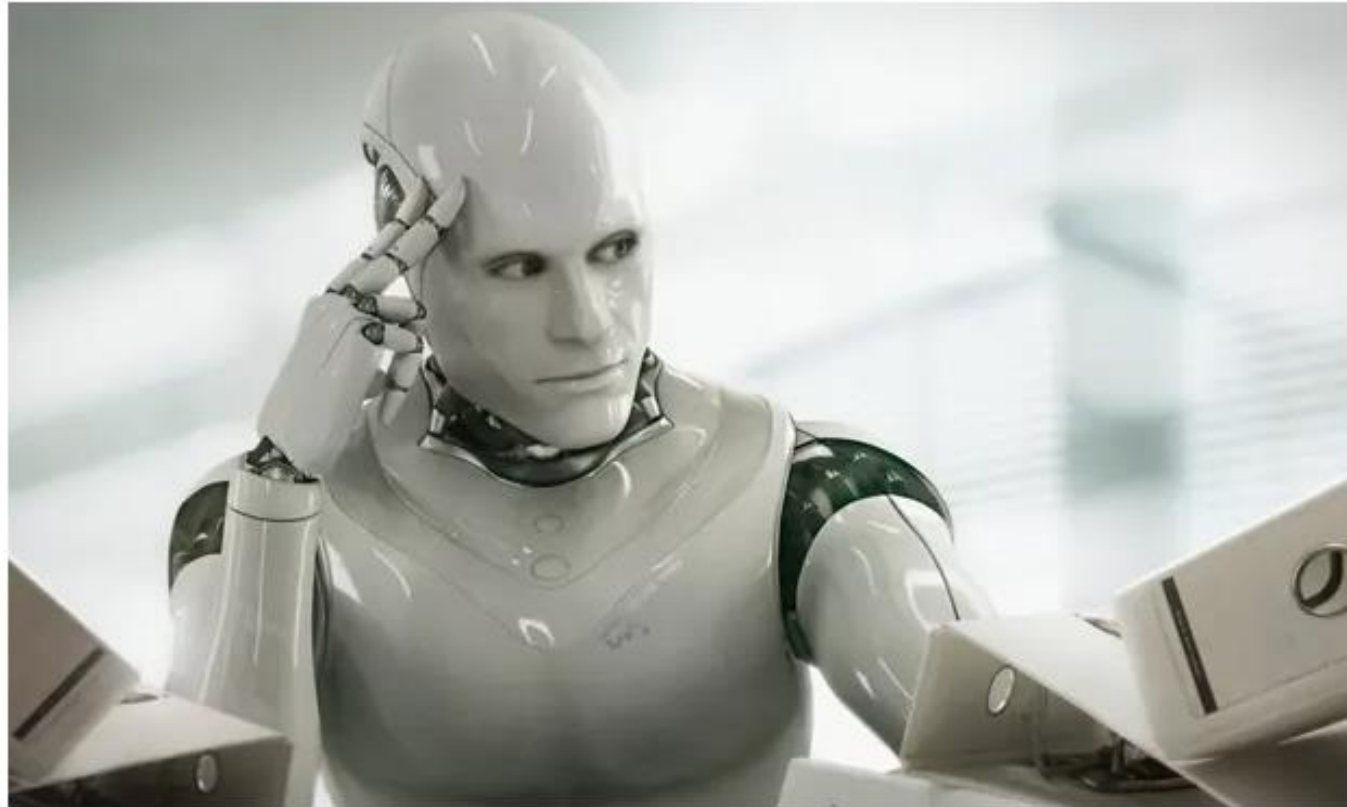
Artificial intelligence and pathology: From principles to practice and future applications in histomorphology and molecular profiling [RSS](#) [Download PDF](#)
Albrecht Stenzinger et al. *Seminars in Cancer Biology*, 2022-09-01, Volume 84, Pages 129-143,

All innovations have their
critics and
detractors.....

.....AI is no different

Elon Musk: artificial intelligence is our biggest existential threat

The AI investor says that humanity risks 'summoning a demon' and calls for more regulatory oversight



Elon Musk: artificial intelligence is our biggest existential threat

The AI investor says that humanity risks 'summoning a demon' and calls for more regulatory oversight

AI bot ChatGPT stuns academics with essay-writing skills and usability

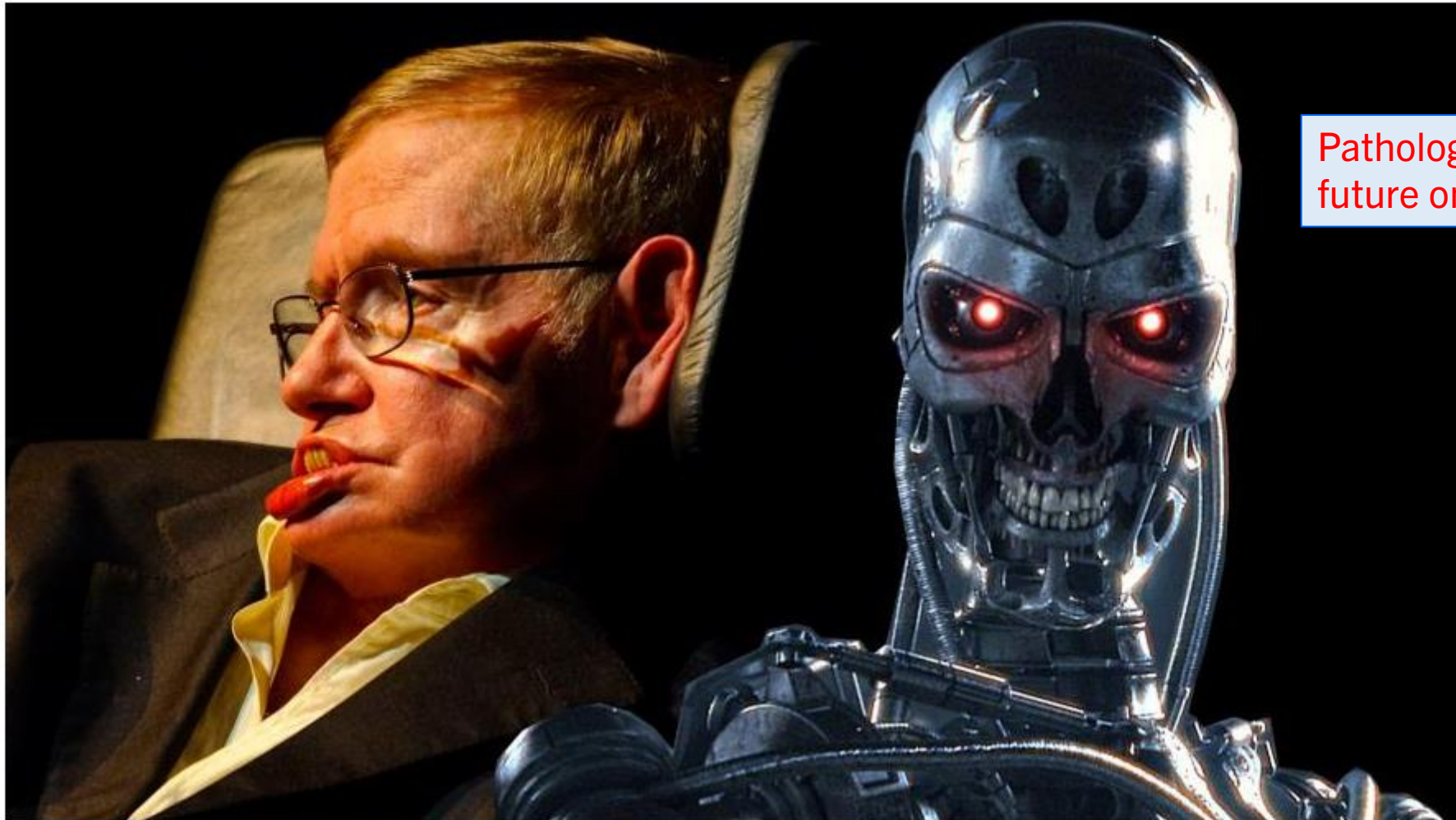
Latest chatbot from Elon Musk-founded OpenAI can identify incorrect premises and refuse to answer inappropriate requests



Artificial Intelligence and the Threat to Humanity

Prabir Purkayastha | 30 Jun 2017

The robots we create, may decide we are an obsolete model, deserving "retirement".



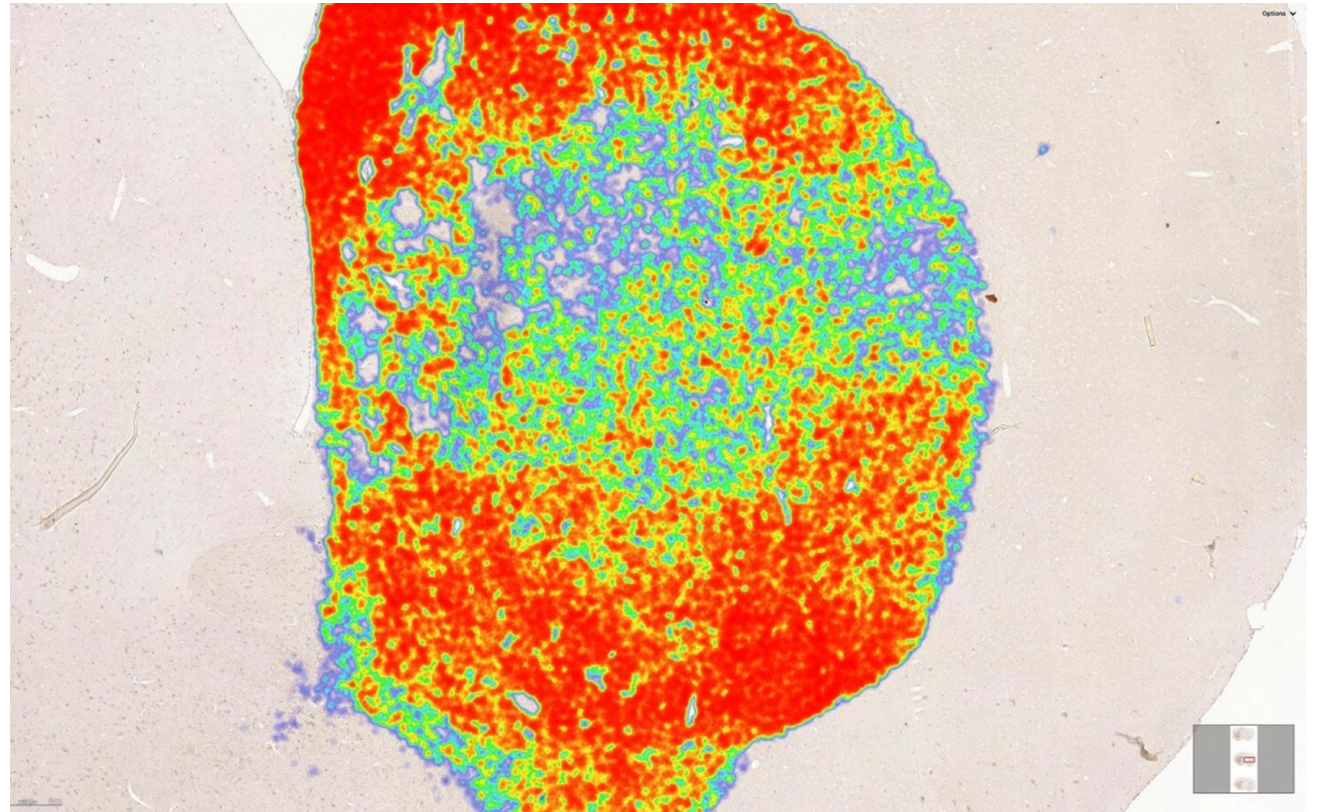
Pathologist of the future on Zoom MDT

Hawking warns A.I. could end mankind

The revolution in AP

FRIEND
OR
FOE?

THREAT
OR
OPPORTUNITY?



EMBRACE OR REJECT?

Technological advances are not occurring in a vacuum

- There are significant global work force issues that will inevitably change the way we practice pathology
- Under-resourced, image based specialities are ripe for automation



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

UK Regions International Regions Log in to MyRCPath

Discover PATHOLOGY For TRAINEES For the PROFESSION In your SPECIALIST AREA

HOMEPAGE DISCOVER PATHOLOGY NEWS COLLEGE REPORT FINDS UK WID...

COLLEGE REPORT FINDS UK WIDE HISTOPATHOLOGY STAFF SHORTAGES

16 SEPTEMBER 2018

Workforce census shows only 3% of NHS histopathology departments have enough staff to meet clinical demand.



<https://clpmag.com/diagnostic-technologies/digital-pathology/digital-pathology-gives-rise-computational-pathology/>

The technologies driving the “revolution”

DIGITAL PATHOLOGY

Digital pathology has been around for decades

Whole slide imaging (WSI) became available in 1990s

Data storage and handling have made DigPath more applicable to day to day work

The technologies driving the “revolution”

DIGITAL PATHOLOGY

Whole slide imaging (WSI)

Better specimen tracking

Reduced breakage of slides

Remote consultation and reporting with real time transmission

Cost saving: Couriers, control slides, efficiencies

Facilitates central processing with pathologists working remote to processing

The technologies driving the “revolution”

COMPUTATIONAL PATHOLOGY & IMAGE ANALYSIS

Can greatly assist with
“quantitative” histopathology

Automation : pre-screening for Ca

Augmentation and Precision

Numerical scoring – e.g. Ki67, PD-
L1

Margin measurement

Analysis of IHC, ISH, detection of
organisms, IF

The technologies driving the “revolution”

COMPUTATIONAL PATHOLOGY & IMAGE ANALYSIS

Prediction: Extraction of clinically relevant quantitative histology information

Apply “mathematical oncology” and deep-learning approaches to predict likelihood of metastases, disease progression etc.

Linkage and AI analysis of pathology data with imaging, genetics, pharmacogenetics, clinical information etc

The technologies driving the “revolution”

COMPUTER ASSISTED DIAGNOSIS/AI

Algorithms for diagnosis, grading, detection of rare events in cancer

Automated ordering of IHC for specific applications

Automated scoring of features outside oncology : liver fibrosis, steatosis, iron. Assessment of renal biopsies. Diagnosis of rejection.

Exclusion of benign or normal tissue sections

Extensive focus has been put
on AI for histopathology.

Why is cytopathology not as far advanced?

History of digital platforms and cytology

Relatively long history of adapting digital/image analysis technology to cytology

Gynaecological cytology was one of the first areas of pathology to use digital image analysis in a clinical setting

Early systems were used as QA/QC tool, pre-screening tool and to assist with workflow for cytologists and cytopathologists

Identification and curation of “regions of interest” presented for human interpretation

Early systems had FDA approval but reduction of gynae cytology as a screening tool has limited their development and usefulness



What is the current state of play?

The current state of digital cytology and artificial intelligence (AI): global survey results from the American Society of Cytopathology Digital Cytology Task Force

David Kim, MD^{a,*}, Michael J. Thrall, MD^b,
Pamela Michelow, MBBCh, FIAC^{c,d},
Fernando C. Schmitt, MD, PhD, FIAC^e,
Philippe R. Vielh, MD, PhD, FIAC^f, Momin T. Siddiqui, MD^g,
Kaitlin E. Sundling, MD, PhD^h, Renu Virk, MDⁱ,
Susan Alperstein, MS, CT(ASCP)^g, Marilyn M. Bui, MD, PhD^j,
Heather Chen-Yost, MD^k, Amber D. Donnelly, PhD, MPH, SCT(ASCP)^l,
Oscar Lin, MD, PhD^a, Xiaoying Liu, MD^m, Emilio Madrigal, DOⁿ,
Maureen F. Zakowski, MD^o, Anil V. Parwani, MD, PhD^p,
Elizabeth Jenkins, MS^q, Liron Pantanowitz, MD, PhD, MHA^r,
Zaibo Li, MD PhD^p

Journal of the American Society of Cytopathology
2024;13(2); p86-110.

- Concerns that cytology was excluded from validation of digital pathology for primary diagnosis in 2021 CAP guidelines
- Examined role of digital cytology in the era of remote pathology
- Current focus is largely on gynae cytology – LBC suitable for scanning, large number of archival samples, reported with standard Bethesda system
- The emerging need will be for non-gynae cytology BUT significant challenges due to institutional practice variations and diversity of specimen types

Challenges to adopting digital cytology and AI

Lack of uniformity in preparations – 3D, fixation, smearing.

Manual smears are particularly problematic – spread, thickness and coverage of slide can vary greatly

Air drying with flattening of cells can exaggerate morphological features making training of machine learning difficult

Large surface area of slide and variable thickness produce very large digital files

Standardisation within and across cytology labs much more difficult to achieve

Some deep learning takes >10k cases – may be difficult to obtain enough cases of suitable consistency to train with some types of cytology cases

New applications

Application of AI to LBC preparations – gynae and non-gynae (urine, effusions)

Assessment of cell blocks and IHC – particularly assessment of predictive markers such as ER, PR, Her 2, PD-L1. Histo nature of CB better suited to digital image analysis and AI

Multidisciplinary AI (combining ultrasound, FNA and molecular for Dx of thyroid nodules)

Use of AI for ROSE

Predictive capabilities of AI – able to “see” and make inferences beyond the human eye (eg AI on lung cancer H&E sections able to predict mutation status and prognosis) – this may remove need for histological confirmation

AI and Urine cytology

Development and validation of an artificial intelligence-based model for detecting urothelial carcinoma using urine cytology images: a multicentre, diagnostic study with prospective validation

Shaoxu Wu,^{a,h,c} Runnan Shen,^{a,j} Guibin Hong,^{a,i} Yun Luo,^{d,i} Huan Wan,^{e,j} Jiahao Feng,^{f,j} Zeshi Chen,^g Fan Jiang,^g Yun Wang,^g Chengxiao Liao,^g Xiaoyang Li,^d Bohao Liu,^d Xiaowei Huang,^f Kai Liu,^f Ping Qin,^g Yahui Wang,^h Ye Xie,^g Nengtai Ouyang,^e Jian Huang,^{a,h,c} and Tianxin Lin^{a,h,c,*}

The Lancet Vol 71 May 2024

- 2018 – 2022, 2641 patients retrospectively recruited to training cohort and 2335 validation cohorts. 400 patients in prospective validation cohort
- Lack of histopathology – exclusion
- Studied primary diagnosis and recurrent malignancy
- Sensitivity of over 0.84 for detecting malignancy.
- In recurrence scenario, negative predictive value of 96.4% - reduction in endoscopy of 57.5%

AI and ROSE

Provision of beside ROSE is emerging as a significant challenge to delivering cytology services.

Increased demand for ROSE in oncology settings

Initial studies into use of Telecytology as a way of delivering ROSE remotely

But still relies on adequately trained staff to provide rapid, real time interpretation and results

American Society of Cytopathology Telecytology validation recommendations for rapid on-site evaluation (ROSE)

Oscar Lin, MD, PhD^{a,*}, Susan Alperstein, CT (ASCP)^b,
Güliz A. Barkan, MD^c, Jacqueline M. Cuda, BS, SCT (ASCP)^d,
Brie Kezlarian, MD^a, Darshana Jhala, MD^e, Xiaobing Jin, MD PhD^f,
Swati Mehrotra, MD^c, Sara E. Monaco, MD^g, Jianyu Rao, MD^h,
Mauro Saieg, MD, PhDⁱ, Michael Thrall, MD^j, Liron Pantanowitz, MD^d

Journal of American Society of Cytology
(2024) 13, 111-121

Telecytology and ROSE

Recommendations address:

1. Equipment, platforms and IT requirements
2. Robotic microscope Vs WSI
3. Security and identification measures to ensure privacy and correct pt ID
4. Adequately trained staff at bedside and remotely
5. Validation – range and number of cases (CAP recommends >60 cases for each application)
6. Concordance rate should be ideally >90%
7. Ongoing QA processes

American Society of Cytopathology Telecytology validation recommendations for rapid on-site evaluation (ROSE)

Oscar Lin, MD, PhD^{a,*}, Susan Alperstein, CT (ASCP)^b,
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Mauro Saieg, MD, PhDⁱ, Michael Thrall, MD^j, Liron Pantanowitz, MD^d

Journal of American Society of Cytology
(2024) 13, 111-121

AI and ROSE

- ROSE-AI model developed and tested to replace manual ROSE
- Studied Pancreas and Coeliac Plexus EUS FNA
- 467 digitilised images of Diff-Quik stained EUS –FNA slides divided into training and internal validation datasets
- Then 693 image external dataset
- Assessed performance of AI model to detect cancer cells
- Accuracy of 83.4% internal validation dataset and 88.7% in external dataset
- Sensitivity and PPV 79.1% and 71.7% (Int) and 78% and 60.7% (Ext)



Journal of Gastroenterology and Hepatology 38 (2023) 883 - 887

Will this bring digital cytology and AI to the bedside and deliver “POCT” testing for cancer?

AI and intraoperative smears/squash preps

- 205 images from squash or smear preparations with histological correlations
- 4 major groups to train deep neural network : 1) High grade gliomas; 2) Low grade gliomas; 3) metastatic carcinomas; 4) non-neoplastic brain tissue samples
- 95% and 97% diagnostic accuracy in patch level classification and patient level classification tasks
- May facilitate intraoperative diagnosis and classification when expert neuropathologist not available

ORIGINAL ARTICLE

Intraoperative cytological diagnosis of brain tumours: A preliminary study using a deep learning model

Erdener Ozer^{1,2} | Ali Enver Bilecen³ | Nur Basak Ozer³ | Berrin Yanikoglu^{3,4}

Cytopathology 2023; 34:113-119

The future roles of Scientists and Technologists

Global challenges in maintaining cytology workforce



what

job title, keywords or company

where

city, state, or zip

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Cytotechnology is a dying field. Clinical Lab Science is where it's at.

[Get new commen](#)

Comments (1 to 50 of 399)

Page: [1](#) [2](#) [3](#) [4](#) [Ne](#)

CLS48 in
California
93 months ago

If you want to work in the [lab](#), forget about Cytotechnology. Cytotech is too specialized and can easily be replaced by imagers. As for CLS, even with automation, there are jobs all over the place and shortages of CLSs in all states. The reason because CLSs can do hematology, microbiology, [chemistry](#), special chemistry, immunology, molecular [biology](#), etc. To know a lot of things opens you to more job opportunities. To specialize in a narrow field makes you vulnerable to changes in specialty, which is what is happening to you guys right now.

[Reply](#) - [Report abuse](#)

- Was this comment helpful? [Yes](#) (20)

former
screener in
Westborough,
Massachusetts
93 months ago

true, except the part about being easily replaced by imagers. Many techs feel that imagers are downright DANGEROUS the way labs are ramping up the numbers. But in [general](#), you are right. It is an extremely narrow field, and when I was lai really rang true. Thank God I started a career changeover a few years back, and can now send out resumes for an entirely different field. Plus, 15 years of this crap has trashed my eyes. Plus, the UTTER stagnation and boredom of the job itse Honest to almighty God, I feel like I was released from PRISON when I was laid off. What a miserable way to earn a living. Now I guess I'll hear from CytoBonnie be jolly in sunny San Diego.....

[Reply](#) - [Report abuse](#)

- Was this comment helpful? [Yes](#) (

Sam
Kaiserblade in
Venice, Florida
93 months ago

Whatever CLS, you are in the same boat cytotechs, pathologists and all [lab](#) professionals are in. You honestly think specimens are gonna be sent to a reference lab forever?

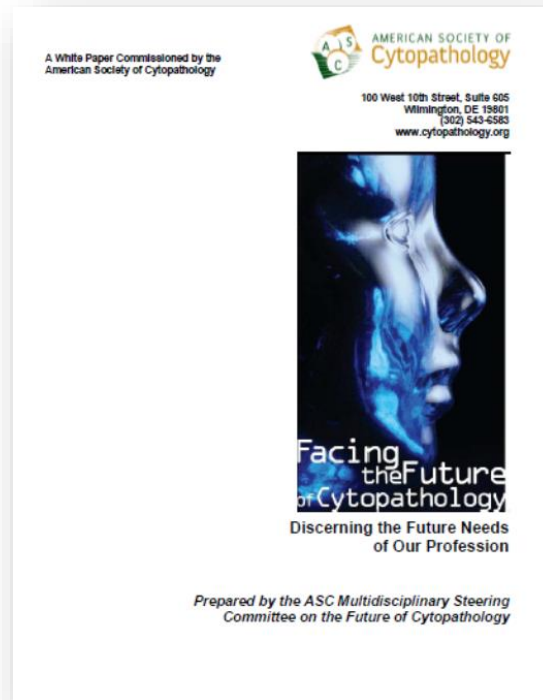
Point of care and in-vivo diagnostics are the future and they likely will not be performed by med techs. Why not just do the testing at the bedside so it doesn't get lost or need to be recollected? There are a lot of disruptive technology on the hor The projections for the number of lab workers needed in the future is laughable.

Automation is eliminating workers in some departments now. Just look at what the Q and the Corpse have been doing to Hematology departments. More will follow. You think the big labs dont wanna get rid of as many workers as possible? So will be necessary but not near as many as oriented

Artificial Intelligence and Cytopathology - A/Prof Elizabeth Salisbury

← → ↻ Secure | <https://www.indeed.com/forum/job/Cytotechnologist/Cytology-becoming-miserable-dying-field/t123054>

110 months ago	<p>I have to generally agree . the lady behind me said , " i am leaving the field . unless you can re-locate , there is nothing " .</p> <p>We have the imager and i think it is retarded . the pap mills are really sweat shops . hellish places to work , no thanks .</p> <p>Reply - Report abuse</p> <p>- Was this comment helpful? Yes (5) / No(2)</p>
dmf in La Crosse, Wisconsin 110 months ago	<p>Let me know what happens when you go look for a job after leaving CT...how does \$3 an hour waitressing sound?</p> <p>Reply - Report abuse</p> <p>- Was this comment helpful? Yes (2) / No(7)</p>
RGR in Frederick, Maryland 110 months ago	<p><i>dmf in La Crosse, Wisconsin said:</i> Let me know what happens when you go look for a job after leaving CT...how does \$3 an hour waitressing sound?</p> <p>Don't be obtuse. Technology always wins out. It happens in every industry; from automakers to medicine. Even in a clinical laboratory, except for microbiology and phlebotomy, all you really have to know is how to load specimens onto an analyzer, click a button and let the machine do all the work. Hell, if a result comes outside normal limits, no worries...the machine even lets you know!!</p> <p>Outside of "machinery" in gyn Cytology, factor in HPV DNA testing and the Gardasil HPV vaccine. In time, women won't even NEED a pap smear. They will just have their blood drawn and tested for the HPV virus. If you were a woman, what would you rather do...go out, put your feet in the stirrups and get a pap smear done or have a blood test instead? Hmmm, think about it.</p> <p>As with any vaccine (i.e. polio, flu and measles) new infection by the human papilloma virus will naturally fall dramatically over time and along with it, the number of women needing paps and thus the need for a "human" to screen them. And, in case you missed it, paps make up about 80-90% of most Cytology labs' workload, especially a reference lab such as LabCorp, Quest or BioReferences Labs.</p> <p>Look around...do a search for Cytotechnologist jobs in whatever area you live. Hell, do it nationwide and see how many jobs actually come up. Nine out of ten times, you're going to have to drive a very long way to work or move out of state for Cytology openings. The market for Cytotechnologists has already thinned out. It's common sense. And, you better stay ahead of it.</p> <p>Let me know how YOUR job hunting goes when technology kills the Gynecological Cytology field. Better keep up your skills with non-gyns and FNA's.</p> <p>Reply - Report abuse</p> <p>- Was this comment helpful? Yes (13) / No(5)</p>



“What skills will be needed to support the practice of cytopathology in the future and what kinds of professionals will be best suited to address these needs?”

Preparing for a Computational Pathology Future Through Informaticians and a Computational Technologist Workforce

S. Joseph Sirintrapun, MD

From the Department of Pathology, Memorial Sloan Kettering Cancer Center, New York, NY.

Am J Clin Pathol May 2018;149:369-372

DOI: 10.1093/AJCP/AQY009


Journal of Pathology

J Pathol 2019; **249**: 286–294

Published online 3 September 2019 in Wiley Online Library
(wileyonlinelibrary.com) DOI: 10.1002/path.5331

REVIEW

Computational pathology definitions, best practices, and recommendations for regulatory guidance: a white paper from the Digital Pathology Association

Esther Abels¹, Liron Pantanowitz², Famke Aeffner³, Mark D Zarella⁴, Jeroen van der Laak^{5,6}, Marilyn M Bui⁷, Venkata NP Vemuri⁸, Anil V Parwani⁹, Jeff Gibbs¹⁰, Emmanuel Agosto-Arroyo⁷, Andrew H Beck¹¹ and Cleopatra Kozlowski^{1,2*} 


Laboratory Investigation (2021) 101:412–422
<https://doi.org/10.1038/s41374-020-00514-0>

USCAP

REVIEW ARTICLE



Artificial intelligence and computational pathology

Miao Cui ¹ · David Y. Zhang²

Received: 8 June 2020 / Revised: 8 November 2020 / Accepted: 10 November 2020 / Published online: 16 January 2021
© The Author(s), under exclusive licence to United States and Canadian Academy of Pathology 2021

Averting a Histopathology Crisis

How can healthcare scientists ease the burden on histopathology labs to reduce turnaround times for patients?

Jo Horne | 07/03/2020 | Longer Read

UK – 2012 Pilot scheme for Advanced scientists to report independently alongside medical consultants.

Formal training program – GIT, Gynae, Skin : High volume, low complexity work

Examinations and competency assessments

Work closely with pathologists in subspecialty teams

The application of AI by suitably trained clinical scientists can greatly streamline case triaging, fast track measurements and pre-screening/workup.

Clinical scientists may play an important role in the quantitative aspects of histopathology

Computational pathology by clinical scientists will be crucial for managing quality measures with increasing automation and integration of AI

Areas of increased scientific oversight and input

Standardisation of pre-analytical processes (incl staining and cutting etc)

Interpretation of computationally derived measurements and evaluations

Validation and QA/QC

Operation of digital scanners and QA/QC of digitalised images

Digital device calibration

Quantification of certain tests – IHC, FISH, Scoring

How AI Can Help Address The Global Shortage of Pathologists



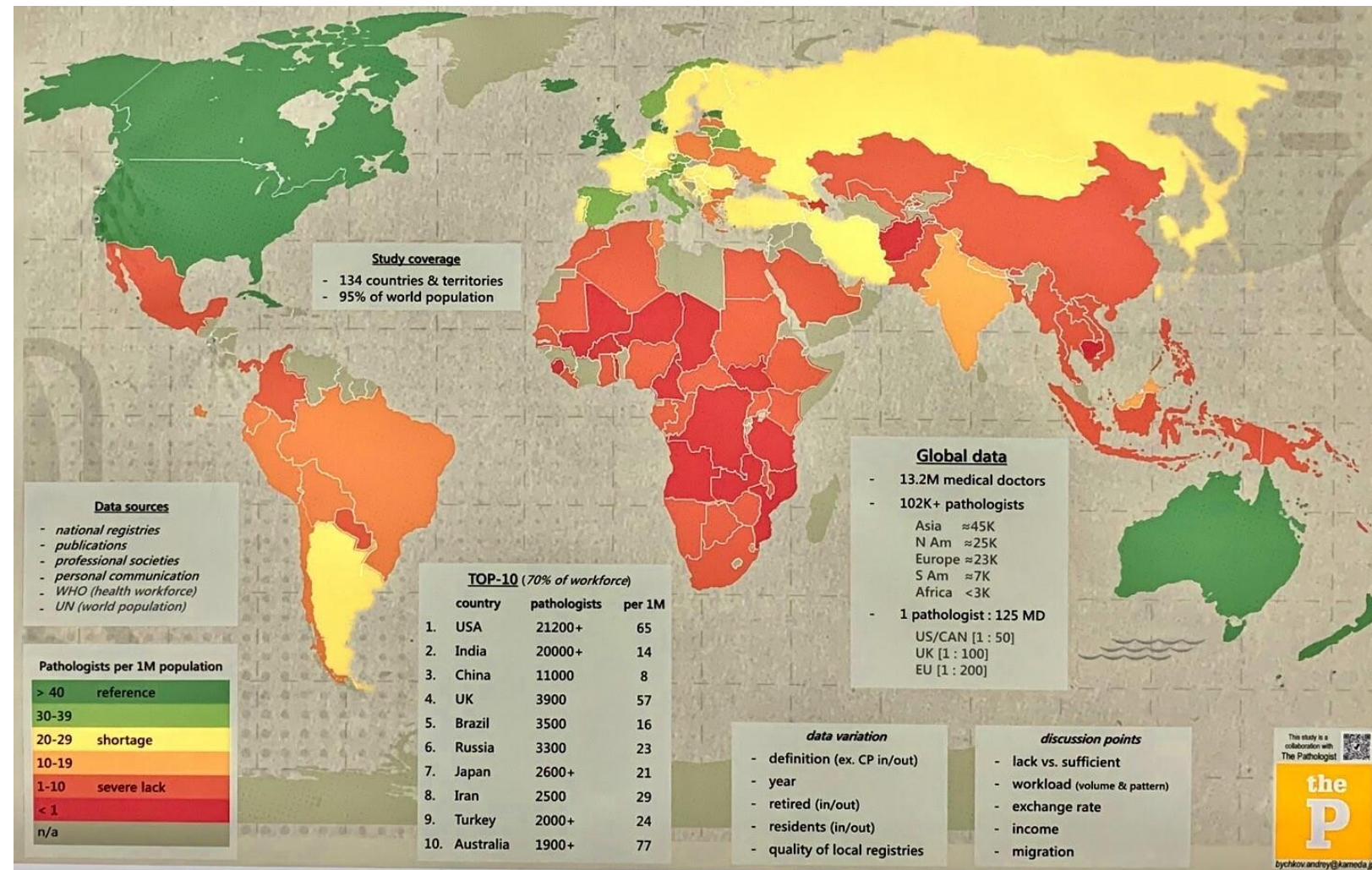
Margaretta Colangelo

Leading AI Analyst Consulting at Insilico Medicine (41,000+ followers)

Published May 11, 2022

+ Follow

“Today there are slightly more than 102,000 pathologists spread over 130+ countries worldwide. There are big disparities between regions. 2/3 of the pathologist workforce is located in just 10 countries.”



USA: 21,000+ pathologists (65/million)
India: 20,000+ pathologists (14/million)
China: 11,000 pathologists (8/million)
UK: 3,900 pathologists (57/million)
Brazil: 3,500 pathologists (16/million)
Russia: 3,300 pathologists (23/million)
Japan: 2,600+ pathologists (21/million)
Iran: 2,500 pathologists (29/million)
Turkey 2,000+ pathologists (24/million)
Australia 1,900+ pathologists (77/million)

Poster showing the global supply of pathologists presented by Andrey Bychkov MD, PhD, at the 2022 annual meeting of United States and Canadian Academy of Pathology (USCAP)

2024.....

Will AI be
the great
disrupter?

of
e
sion?

How will AI
change
cytopathology?

Friend or foe?



Something to cautiously embrace, with a clear understanding of the strengths and limitations of the technology

Thank you

