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The Job Market Outlook for Residency Graduates

Clear Weather Ahead for the Butterflies?

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The current condition of the job market for new graduates emerging from the cocoon of residency or fellowship training programs remains good, according to the detailed, informative, and reassuring report by Gratzinger et al,[1] summarizing the job market surveys from the past 5 years of the College of American Pathologists (Northfield, Illinois), in this issue of the ARCHIVES. Newly emerging pathologists who are spreading their wings, residents and fellows maturing in their training ecdysis, and aspiring candidate caterpillars preparing to enter the profession, not to mention the training programs and the academic and private pathology communities, can all take some comfort from the current snapshot of the past 5 years. There appears to be a stable and balanced supply and demand condition, suggesting that the immediate future, at least, looks promising. Reporting the annual job search surveys of the College of American Pathologists' junior members and fellows in practice 3 years or fewer who have actively searched for a nonfellowship position indicates that the job market in our specialty has maintained a steady course, with a zero net slope. Although most respondents had accepted a position at the time of the survey and were satisfied or very satisfied with the outcome, they did report that the search was not easy, and the experience was more difficult still for international medical school graduates.

There is room for some satisfaction in these statistics but not cause for complacency. The pathology residency education community has experienced periods of uncertainty in the past, with "fake news" and predictions of an impending drought in the pathology job market and our companion diagnostic specialty of radiology. Those errant prognostications resulted in a precipitous downturn in the number of US graduate applicants to training programs in

both disciplines and in the other hospital-based, "ancillary" field of anesthesiology. Because it affected pathology, that bombshell (although emanating from fake news) nevertheless made waves. The additional credentialing year for board certification that had been adopted in 1985 was eliminated in 2002, partly with the intent of making pathology specialty training less forbidding for debt-laden medical school graduates. Although successful, there were resulting ripples, primarily the superimposition of the double-wave of 2 graduating cohorts of board-eligible trainees in 2006.[2] This mega-influx of trainees entering an already-tight job market gave further impetus to the already existing trend toward fellowship training instigated by prospective employers who had collectively expressed the view that 4 years of generic, categorical training in pathology did not adequately prepare graduates for successful, independent practice.[3]

Other demographic megatrends have buffeted the employment landscape in pathology. Based on a comprehensive analysis of the pathology workforce in the United States through 2010, Robboy et al[4] developed a predictive model to assess the effects of dynamic market forces and emerging technologies on the supply of pathologists' services through the next 20 years. The model predicted that the attrition of pathologists would exceed the number of pathologists entering practice, with a cumulative net decrease of approximately 3500 pathologists by 2030. Against the demographic backdrop of a growing population, that would result in an even greater decrease in the ratio of pathologists to population, with the further challenge that those future pathologists would have to deal with a progressively aging population prone to more chronic illness. One conclusion drawn by these authors was that the net deficit of pathologists would result in a shortfall of 5700 or more full-time equivalent positions, a meaningful deficit given the overall projected need in pathologist numbers of nearly 20 000 full-time equivalent positions by 2030. That, they predicted, would require an increase of approximately 8.1% more residency positions than the number in 2010. How will that growth imperative fare, given the financial pressures being imposed on the specialty with the "double whammy" of relentless ratcheting down of inflation-adjusted part B pathologist (professional fee) reimbursement through Centers for Medicare & Medicaid Services (CMS) and the tightening vice-grip of reduced disbursement by hospitals

of payment for oversight of part A (technical fees)? Simply put, if the Robboy et al[4] model is right, we will need more pathologists and more or bigger residency training programs, despite the reality that there is less money to pay them. The equation does not balance. In the interim, and in the absence of a foreseeable increased reimbursement schedule through CMS, many pathology group practices appear to be absorbing the increased caseload without increasing their group size. Technologic advances during the past decade that have been incorporated into pathology practices have enabled more-efficient practice environments, with improved efficiency making it possible, thus far, to absorb greater caseloads without adversely affecting patient care delivery.

So far, so good, perhaps. However, faced with the inexorable growth of workload and the asymptotic attainment of maximum practice efficiency (expressed as cases or procedures per pathologist), a limit will inevitably be reached if the workforce remains in status quo. Two principal factors will influence whether a saturation point is reached and what will happen if it is: (1) changes in the number of practicing (and available) pathologists; and (2) whether, and to what extent, new technologic tools can still further enhance practice efficiency. One key technology in this regard is artificial intelligence (AI). The AI technology has tremendous potential to change the current paradigm of pathology practice and is one that could have potentially profound effects on the job market for pathologists at some time in the not-too-distant future. If harnessed correctly, AI is a force that has the potential to benefit the specialty. There is also the possibility, however, that unbridled growth and the application of AI recently bolstered by the exponential, autoamplification property of machine self-learning could prove to be a disruptive technology with negative, if not dire, consequences to the job market in pathology.

From its ascribed birth at a 1956 summer conference held at Dartmouth College (Hanover, New Hampshire), infant AI has grown rapidly to assume a formidable and dominant size whose shadow falls over several fields of human endeavor. Its gargantuan appetite has gobbled up many functions that share the feature of complex information processing. Provided with established facts or rules AI can apply that knowledge framework to provide solutions to problems that extend from the simple binary to the complex polynomial, with the capacity to incorporate probabilistic logic to arrive at hierarchies of likely answers. It can do all that as well as perform image or pattern recognition. This essentially simulates certain aspects of what a trained pathologist's brain does during a workday. "Ah," you might say, "but the trained pathologist has experience and judgment and an 'eye' for recognizing patterns that defy simple algorithmic learning." It would, however, be a mistake to consider the preeminence of the brain of Homo sapiens in image recognition and diagnosis to be unassailable. Consider the impressive accomplishments of Columba livia (the common pigeon) in the correct identification of pathology and radiology images of breast cancer.[5] Can the sophisticated neural networks of AI be far behind? Consider the following impressive rate of progress that AI has accomplished in only the past 20 years, after International Business Machines'[4] (IBM, Armonk, New York) Deep Blue computer handily defeated Garry Kasparov, then reigning world chess champion. Since then, IBM's Watson took on and beat 2 former winners at the game of Jeopardy in real time, having been given access to 200 million pages of content that included the full text of Wikipedia which it "memorized" on 4 terabytes of disc space (it was not connected to the Internet during the competition). Only a year ago, AlphaGo (Alphabet, Mountain View, California) beat the European champion at the infinitely complex board game of Go, after it trained on a data set of 160 000 game permutations, using deep neural networks through supervised learning from human expert moves and then reinforcement learning from self-play.[6] This tour de force, which had been considered to be at least a decade away, was then speedily surpassed when, for an encore, AlphaGo Zero, the next generation of Alphabet's stable of AI thoroughbreds, demolished its predecessor by 100 games to 0! The remarkable thing is that AlphaGo Zero was essentially self-taught. It used an algorithm based solely on reinforcement learning without any previously accumulated human wisdom.[7] That impressive feat of deep learning is what we need to contemplate as the architects of AI and their iterative creations begin to tackle medicine from diagnosis to treatment.

Already, AI has made inroads in the health care space. Having shown off its prowess on Jeopardy, Watson's creators at IBM have since purveyed it to leaders in fields as diverse as utilization management and oncology practice. WellPoint Health Networks (Indianapolis, Indiana) and Memorial Sloan Kettering Cancer Center (New York, New York) both adopted a Watson clone, of dramatically reduced physical size but computing power equal to the conquering Jeopardy prototype, to assist with decision-support functions in line with their overlapping core line of business—best practice decisions for the management of patients with cancer. The success of that enterprise is evident from the numerous other health care providers who have also licensed this technology or are in the process of doing so.[8] Moreover, IBM's Watson has been designed to simulate the cognitive approach of the human brain from initial observation through interpretation, hypothesis generation, data processing, and final decision making. That logical pathway has been applied to the interpretation of next-generation sequencing data, which is cognate to the decision-tree activities undertaken by a diagnostic pathologist in the era of personalized medicine, who is categorizing a disease based on microscopic appearances and molecular genetic signatures.[9]

Setting aside the question of whether a "son-of-Watson" clone that incorporates the impressive added power of quantum computing could "outplay" the crème de la crème of subspecialty pathologists, there are other considerations. Repetitive, laborious, and time-consuming tasks that require meticulous attention to detail can be performed with greater precision and accuracy by AI. Examples abound, and already, pattern recognition software has alleviated much of the drudgery of lengthy slide scanning in cytopathology and laborious reviews of blood smears, particularly when searching for rare events or parasites. The landscape of possibilities is broad. Some prime examples include immunohistochemical stains, including the nuances of which particular cell types show positivity, and the detection of acid-fast and other microorganisms. Furthermore, AI may help in generating differential diagnoses based on standardized immunostain panels, which could ultimately decrease costs and diagnostic errors. It is not unreasonable to anticipate that the staffing needs at all levels in the diagnostic pathology pipeline will be diminished by the advent of sophisticated AI configurations, making AI a potential solution to the shortfall forecast by Robboy and coworkers.[4,10,11]

The inevitable incorporation of AI into the domain of diagnostic medicine is already underway, but its full impact

has not yet occurred. In radiology, the issue has been raised, and one prediction is that machine learning and artificial intelligence will be a boon to radiologists increasing their value through efficiency, accuracy, and personal satisfaction.[12] Examples of applications have already been reported in the field of chest radiography, where machine learning using deep convolutional neural networks can accurately classify tuberculosis by chest radiography with a receiver operator characteristic area under the curve of 0.99.[13] There is also the suggestion that the capabilities of mammography performed by AI may be harnessed for population breast cancer screening.[14] Pathology may not be far behind. Deep learning is achieving increasingly accurate results in several key histology image-analysis tasks required for computerized, feature-based classification.[15] Screening of breast fine-needle aspiration biopsies could be the next frontier. Recent use of deep learning, employing convolutional neural networks to distinguish benign in situ carcinoma and invasive carcinoma, in hematoxylin-eosin–stained breast biopsy images has been encouraging.[16] If one considers the combination of deep-learning image classification fused with computerized genomic and proteomic measurements, the role of the pathologist is likely to change fundamentally.[17,18]

Purists and Luddites may protest, but the inexorable advances of machine learning are moving forward, and regardless of the debate that continues to rage concerning the pitting of man against machine, one thing is clear—things will change as the disruptive technology of AI applications continues to expand. Examples of how disruptive technologies have created major upheavals in industries and professions abound. Consider the impact of digital on film-based photography, electronic messaging on the mail system and print media, or the imminent introduction of driverless vehicles on transportation. Digital media spelled the end of brick-and-mortar stores like Blockbuster, Tower Records, and many others. The digital-content revolution continues creating havoc for decades-old media empires constructed on traditional publishing and entertainment business models. Online booking systems like Orbitz (Chicago, Illinois), Travelocity (Dallas, Texas), and Hotels.com (Bellevue, Washington) have likewise profoundly disrupted the travel industry, and AirBnB (San Francisco, California) poses a significant economic challenge to the hotel industry. A potential opportunity to harness the power of AI in pathology is provided by the sudden explosion of knowledge in the field of genomic and personalized medicine. A human-machine interface for analysis of deep cancer genomic data sets may provide potentially clinically actionable calls for individual patients in a more-timely and efficient manner than is currently possible (operating without the benefit of the data-integrating celerity of AI).[19]

It is difficult to predict what effect AI will have on pathology practice, but inevitably, it will change the way that pathologists expend their professional efforts and how they divide their time between anatomic, clinical laboratory, and other services. Based on the history of how other technologic tools (eg, digital pathology) became incorporated into practice, adaptation of AI to pathologic diagnosis will likely take time because of regulatory barriers. Conversely, it is ultimately quite likely that, with increased efficiency, fewer pathologists will be required to perform any given workload when AI becomes part of routine pathology practice—and that would ultimately have the upstream effect of solving the shortfall predicted by Robboy and coworkers.[4] Although it is unlikely that there will be a *Brave New World* of an elite group of specialists who commandeer an army of machine pathologists, we may reasonably anticipate an opportunity for creative, value-based roles to evolve for the profession. In addition, AI could provide the pathologist with the opportunity to integrate complex diagnostic data for the health care team, enabling greater efficiency in making correct diagnoses and decreasing the time to implement effective, indeed optimal, treatment plans. This is an opportunity to put the pathologist closer to the patient by further integration into all health care teams; we will need to change our residency training to prepare young pathologists to practice 21st century medicine.[20]

It is too soon to predict the magnitude and timing of the impending meteorologic changes that may result from changes in machine capabilities in the pathology space and what effects those changes will have on the waves of neophyte pathologist butterflies who enter the job market. Still, it certainly behooves pathologist leadership to consider not only whether the skies overhead are currently clear but also how to best prepare ourselves for the potential squalls that could result from a major disruptive technology driven by advances in machine learning and how to best harness the energy contained in the coming weather.

References

1. Gratzinger D, Johnson KA, Brissette MD, et al. The recent pathology residency graduate job search experience: a synthesis of 5 Years of College of American Pathologists Job Market Surveys. *Arch Pathol Lab Med*. 2018;142(4): 490–495.
2. Black-Schaffer WS, Crawford JM. The evolving landscape for pathology subspecialty fellowship applications. *Am J Clin Pathol*. 2012;137(4):513–515.
3. Horowitz RE. Expectations and essentials for the community practice of pathology. *Hum Pathol*. 2006;37(8):969–973.
4. Robboy SJ, Weintraub S, Horvath AE, et al. Pathologist workforce in the United States, I: development of a predictive model to examine factors influencing supply. *Arch Pathol Lab Med*. 2013;137(12):1723–1732.
5. Levenson RM, Krupinski EA, Navarro VM, Wasserman EA. Pigeons (*Columba livia*) as trainable observers of pathology and radiology breast cancer images. *PLoS One*. 2015;10(11):e0141357.
6. Silver D, Huang A, Maddison CJ, et al. Mastering the game of Go with deep neural networks and tree search. *Nature*. 2016;529(7587):484–489.
7. Silver D, Schrittwieser J, Simonyan K, et al. Mastering the game of Go without human knowledge. *Nature*. 2017;550(7676):354–359.
8. Upbin B. IBM's Watson gets its first piece of business in healthcare. https://www.forbes.com/sites/bruceupbin/2013/02/08/ibms-watson-gets-its-first-piece-of-business-in-healthcare/#373713c55402. Published February 8, 2013. Accessed December 1, 2017.
9. Sharma G, Carter A. Artificial intelligence and the pathologist: future frenemies [editorial]? *Arch Pathol Lab Med*. 2017;141(5):622–623.
10. Esteva A, Kuprel B, Novoa RA, et al. Dermatologist-level classification of skin cancer with deep neural networks [published correction appears in *Nature*. 2017;546(7660):686]. *Nature*. 2017;542(7639):115–118.
11. Liu Y, Gadepalli K, Norouzi M, et al. Detecting cancer metastases on gigapixel pathology images. *ArXin*. 1703.02442v2. Ithaca, NY: Cornell University; 2017.
12. Recht M, Bryan RN. Artificial intelligence: threat or boon to radiologists? *J Am Coll Radiol*. 2017;14(11):1476–1480.
13. Lakhani P, Sundaram B. Deep learning at chest radiography: automated classification of pulmonary tuberculosis by using convolutional neural networks. *Radiology*. 2017;284(2):574–582.
14. Houssami N, Lee CI, Buist DSM, Tao D. Artificial intelligence for breast cancer screening: opportunity or hype? *Breast*. 2017;36:31–33.
15. Janowczyk A, Madabhushi A. Deep learning for digital pathology image analysis: a comprehensive tutorial with selected use cases. *J Pathol Inform*. 2016; 7:29.
16. Araujo T, Aresta G, Castro E, et al. Classification of breast cancer histology images using convolutional neural networks. *PLoS One*. 2017;12(6):e0177544.
17. LeCun Y, Bengio Y, Hinton G. Deep learning. *Nature*. 2015;521(7553): 436–444.
18. Madabhushi A, Lee G. Image analysis and machine learning in digital pathology: challenges and opportunities. *Med Image Anal*. 2016;33:170–175.
19. Wrzeszczynski KO, Frank MO, Koyama T, et al. Comparing sequencing assays and human-machine analyses in actionable genomics for glioblastoma. *Neurol Genet*. 2017;3(4):e164.
20. Black-Schaffer WS, Morrow JS, Prystowsky MB, Steinberg JJ. Training pathology residents to practice 21st century medicine: a proposal. *Acad Pathol*. 2016;3:2374289516665393.