"The number one benefit of Information Technology is that it empowers people to... be creative... [to] be productive... [to] learn things they didn't think they could learn before" (Steve Ballmer). The demonstrable benefit to patients and the wider healthcare service have been the guiding principles underlying the acquisition and utilisation of Information Technology (IT) in Pathology. In this essay, I argue that the role IT is not limited to its cost-saving and service improvement benefits; IT is actively redefining the roles and moulding the constitution of both aspiring and experienced pathologists alike. Harnessing the capabilities of IT to communicate and transform raw data into meaningful information empowers pathologists to assume active roles in patient management and to lead the forefront of personalised medicine and translational research.

**Connectivity and clinical decision support systems**

IT enables the bridging of geographical boundaries and supports communication and connectivity required by Pathology services. Digitisation of patient records and test ordering complement the roll-out of the National Pathology Exchange platform to catalyse the linking of laboratory and clinical services across the nation for the seamless transmission of information[1]. Electronic communications and patient-unique barcodes reduce the requirement for paper and postage and support a prompt, responsive service to both patients and clinicians. A reduced opportunity for errors during handling and data entry also help to minimise costs borne onto patients and the healthcare service from unnecessary repeat testing.

Digital pathology, comprising the use of high-resolution digital slide representation through Whole Slide Imaging, depends heavily on Cloud-based storage and robust digital communication pathways between laboratories for its realisation. The electronic transfer of static slide images or real-time visualisation using robotic microscopes work to reduce health inequalities; patients living in remote regions can benefit from second opinions and diagnostic support from centres of expertise without incurring the risk of slides being mixed up in transit[2]. Image databases, unlike tissue samples, do not degrade and may be easily accessed by trainees and academics for research and education, audit, and clinical service improvement projects.

There is latent potential to exploit IT in Pathology diagnostics through the use of clinical decision support systems. Intelligent algorithms can be designed to highlight potential confounding variables from the patient's record for review by the pathologist during image analysis. For example, the presence of steroid or chemotherapy use can be flagged up in the analysis of giant cell arteritis and cancer biopsy specimens respectively, allowing the histopathologist to make adjustments for potential false-negative results. Clinical decision support systems also help to optimise routine tasks. In breast cancer receptor typing, computer-based detection of Fluorescence In-Situ Hybridization has supplanted manual visualisation of HER-2 amplification via immunohistochemistry[3]. Artificial intelligence image analysis systems with in-built machine learning can conduct morphological analysis in histopathology and

cytology with minimal user intervention[4,5]. PAPNET, for example, is programmed to detect and interpret features of abnormal cervical smear cells for operator review[6]. Workflow harmonisation through delegation of primary tasks to the computer enables the pathologist to lend more attention towards the diagnosis of complex cases, education of trainees, and multidisciplinary working.

## Translational medicine

In the domain of translational medicine, appraising the genetic, mRNA and protein composition in biological samples generates extensive data processing and storage requirements. IT manifests in supervised or unsupervised learning tools and mathematical models used to examine biomedical data repositories to advance the understanding of disease pathogenesis and treatment[6,7]. As an example, informatics tools employed in the data mining of the Cancer Genome Anatomy Project gene catalogue have enabled the identification of novel human genes implicated in cancer and overexpressed genes in multiple tumour types [8]. Molecular profiling, histopathology, and morphometrics provide pathologists with the means to integrate data obtained from different sources to generate integrative reports that reflect cancer heterogeneity and its intracellular and intercellular interactions[9]. Beyond the provision of a diagnosis, pathologists will be tasked to predict disease progression and the complement of therapeutic agents which will be efficacious in a particular patient[10]. An era of informatics will thus necessitate pathologists to implement personalised medicine and take up more active roles in patient management in multidisciplinary clinical settings.

## Patient engagement

Pathology reports are arguably one of the most important documents in the total clinical pathway of cancer patients[11]. Owing to the increasing ubiquity of digitisation, patient access to their records and laboratory results has increased; despite so, it is not uncommon for patients' curiosity to be overwhelmed when attempting to decipher technical terms and meaning contained in their pathology reports[12]. The current construct of clinical pathways needs to factor in channels of communication between pathologists and patients to convey the diagnostic, prognostic, and treatment-related information of relevance and importance. IT platforms, such as internet-based or telehealth applications can provide the means to involve expert pathologists as patient-educators[13,14]. Improved outreach and engagement methods allow patients to be more cognizant of the role of Pathology in monitoring their progress and change. It also empowers them to understand their disease and to obtain higher standards of care by having meaningful discussions about their management with their clinicians.

## Conclusion

As IT platforms and novel molecular techniques rapidly expand and gain a foothold in the workflow of Pathology services, it is imperative that current and future pathologists be accustomed to navigating digital communication systems and image analysis interfaces. Specialist trainees must also be comfortable with and skilled in molecular profiling techniques and their interpretation. The revised architecture of pathology information systems and analytics warrant rethinking of the design of Pathology training programs. The acquisition of technological literacy as well as knowledge in molecular biology and translational science must receive adequate emphasis and complement the development of core competencies.

Embracing the effects of IT on the changing nature of Pathology service provision and the role of the pathologist demands considerable flexibility to create positive change for the benefit of patients. As algorithms and applications evolve, the role of IT must continue to be challenged by studies of efficacy and cost-effectiveness, and safeguarded by the judicious use of patient data.

(Word Count: 993)

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