So, what will the pathologist be doing in ten years time?

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Introduction

"The main qualification for political office is the ability to foretell what is going to happen tomorrow, next week, next month and next year....And to have the ability afterwards to explain why it didn't happen."[1]

Winston Churchill offered this word of warning to anyone seeking to predict the future of politics. Yet only a few decades later, the British Government formed the Foresight Programme to meet this exact purpose.[2] This think tank of the nation's top academics and business leaders analyses the trajectory of current trends in society. Their predictions help shape the decisions the government makes today.

The essay title invites valuable discussion over the future of pathology. What current trends in medicine and society are shaping the tradition of pathology? How will the pathologist's role differ in 2021 from 2011? How should we respond to these shifts in how pathology is understood and practiced?

This essay will take a structured approach in answering the title question. First, I will outline today's pathologist: who he is and what he does.[a] Second, I will discuss some of the major trends within society that will change the practice of pathology. Third, I

[a] For simplicity of reading, the pronoun 'he' will be used to denote the pathologist throughout.

will summarise some of the recommendations made by leading pathologists to prepare for these potential changes.

So, who is the pathologist and what does he do?

Pathology is the study (*logos*) of disease (*pathos*).[3] It is both a basic science and a clinical speciality. The pathologist therefore stands at the interface of lab-based research and medical practice. Today, the Royal College of Pathologists (RCPath) welcomes members without medical training but who have demonstrated dedication to the science of pathology. For the purposes of this essay, however, the pathologist will be understood as a clinician and scientist. Most of the pathologist's roles fit into three categories:

1. **The pathologist studies the mechanism of disease**

The pathologist deals almost exclusively with *physical* health and disease. He can expect to investigate infection and inflammation, ischaemia and thrombosis, neoplasm and degeneration – to name only a few disease processes. The depth and variety of disease challenges the most curious minds. It's no surprise then to find pathologists who seek first the mental stimulation of pathology. Nicholas Wright, Warden of Barts and the London School of Medicine and Dentistry says:

"I think there should be room in the profession for people like me, who are not interested in people as suffering patients, but in the disease processes that they suffer from -- as an intellectual exercise basically."[4]

Yet, the clinical application of pathology remains the goal for many more. The medical student or doctor discovers the benefit of pathology tutorials at the patient's bedside. What kind of empathy, diagnosis or treatment plan can they offer without a good understanding of their patient's disorder? The responsibility and privilege of teaching the principles of disease still belongs to the academic pathologist.

2. The pathologist diagnoses disease

Diagnosis is an evidence-based decision about a patient's medical state.[5] Many diagnoses can be made clinically and these are increasing as medical knowledge and technology advances. However for many more conditions, the *definitive* diagnosis is still made by the pathologist. Cancer remains one of the most prominent conditions the pathologist sees. Much of their routine work is examining excised tumours and biopsy specimens. Their role is to diagnose the type of cancer and stage it for prognosis. The importance of the pathologist's report is no better demonstrated than when the clinician sits down to break bad news to their patient.

The pathologist diagnoses disease in the deceased patient also. The coroner may ask the pathologist to perform a post-mortem autopsy where the cause of death is unknown. Other indications include where death has been sudden, unnatural, due to medical negligence or resulting from occupational exposure to hazards such as asbestos.[6] Often, this has the benefit of resolving questions for the deceased's relatives and providing forensic evidence for an inquest.

3. **The pathologist contributes to patient treatment**

The pathologist provides therapeutic as well as diagnostic services. Direct patient management is often determined by the pathologist's subspecialty. Thus, a chemical pathologist may have an outpatients' clinic for patients with diabetes mellitus. A clinical biochemist may review patients with inherited metabolic disorders. And microbiologists often advise on anti-microbial therapy for serious or rare microbial infections.

The pathologist also contributes indirectly to patient management by assessing their response to treatment. For example, the pathologist examines the margins of excised tumours to determine whether it has been completely removed. Later, he advises the Multidisplinary Team on the best therapeutic approach for the patient's type and stage of tumour.

How does the pathologist do his work?

To set the context for the pathologist's changing world, let us consider the technologies he currently uses and the structure of pathology services.

The pathologist uses a variety of laboratory techniques to examine human tissue samples. These techniques can be categorised as macroscopic, microscopic and molecular. Macroscopic investigation deals with gross sections of tissue. The mainstay of macroscopic examination is autopsy on the deceased patient. Many terminal events that were hidden clinically can be discovered at autopsy such as cerebrovascular emboli and tuberculosis.[7]

Microscopy includes the subspecialties of histopathology, cytology and immunohistochemistry. Histopathology is the microscopic study of sliced and stained tissue samples. The histopathologist can see cellular features such as the pleomorphic nucleoli and mitotic spindles which are relevant to cancer diagnosis.[8]

Cytology is the microscopic examination of free floating cells. These usually come from needle biopsies of suspected tumours where cell morphology indicates malignancy. Cytology, along with clinical examination and radiological imaging, forms part of the 'Triple Assessment' for suspected breast cancer.[9]

Immunohistochemistry uses labeled antibodies to detect antigens in a tissue sample. These antigens are indicative of an underlying disorder like Non-Hodgkins Lymphoma.[10] It has been especially useful in diagnosing and monitoring the treatment of solid tumours and haemotological malignancies.

Molecular techniques reveal the genetic and sub-cellular features of disease. Molecular genetics has come to the forefront of laboratory diagnosis within the last few decades. In particular, it is worth mentioning the polymerase chain reaction (PCR) and fluorescent in situ hybridisation (FISH).

PCR targets and amplifies sections of DNA that contain clinically significant genes. For example, when used on patient samples PCR can detect mutations in the *ACR* gene which predisposes to Familial Adenomatous Polyposis.[11]

FISH attaches fluorescent probes to cell chromosomes and outlines their structure. It allows pathologists to see the chromosomal abnormalities give rise to certain phenotypes. For instance, chronic myeloid leukaemia is characterised by transposition of sections of chromosomes 9 and 11 to make a chimera known as the 'Philadelphia Chromosome'. [12]

Let us turn to the pathologist's working environment. Most clinical pathologists are currently based in hospital laboratories. Routinely, they will only see patients in their local Trust except to consult on difficult or rare cases. They mostly operate on a daytime basis with a limited 'on-call' cover for emergencies.

The Health Service is designed to serve urban and rural communities. Most hospitals will have the general facilities appropriate for managing common clinical presentations: biochemistry, haematology, microbiology and so on. Specialist lab facilities and personnel are located at strategic national sites like the National Centre for Amyloidosis and Acute Phase Proteins at the Royal Free Hospital in London.[13]

So, what will the pathologist be doing in ten years time?

This section explores five trends within society and medicine which could significantly change the pathologist's practice in ten years time. These trends are advances in medical knowledge, advances in human technology, demographic changes, economic changes and socio-cultural changes.

1. Advances in Medical Knowledge

The first to consider is the ever expanding base of human knowledge. Disease is being understood increasingly in terms of molecular and sub-cellular processes. This will have at least three major implications. The first and most promising will be the improvement to patient care. Patients can expect earlier diagnosis, more accurate prognosis and improved therapies as their clinicians better understand their disorders.

The second implication will be increasing specialisation of medicine. Pathology is already specialised broadly into chemical pathology, histopathology, haematology, microbiology and immunology. However, each of these is likely to see further sub-specialisation. For instance, the field of 'radiopathology' may emerge from application of magnetic resonance imaging on cell and tissue samples. This sub-specialisation will require more co-operation between pathologists to maintain the same standard of care.

A third consequence of increasing medical knowledge will be the drive towards personalised medicine. Under the $1000 Genome project, a patient could make their entire genome available to their clinician.[14] Diagnostic tests would be requested for conditions for which the patient is genetically susceptible. Therapies would be optimally designed to match their genetic constitution. As a result, the pathologist may find a general shift in his workload away from diagnostics towards screening for early or potential disease.

2. Advances in Human Technology

The next trend to consider is the rapid development of technology. Diagnostic tests are being refined which reveal the genomic and proteomic features of disease. Two examples are the DNA microarray and expressional proteomics.

The DNA microarray is a chip-device infused with a library of complementary DNA (cDNA) strands. The library can be designed to reflect the genes expressed in particular cells under particular conditions, such as malignant transformation. The nucleic acid from a patient's cell is added to the microarray and reacts with the library of cDNA. The result is a display of the genes that are being expressed or down-regulated. For example, the gene patterns of inflammatory markers reveal the severity of an ulcerative colitis episode. Similarly, the presence of specific rDNA alerts to infections like *mycobacterium* or Hepatitis viruses.[15] The extensive range of tests that can be performed on such a small platform gives rise to its name "lab-on-a-chip".

Expressional proteomics uses mass spectrometry to detect concentration changes of clinically-significant proteins. Mass spectrometry sorts the protein content of a sample by mass, electric charge or affinity to an antibody. The patient's sample can be compared to standard protein profiles for normal and tumour cells. This technique has already shown promise for early detection of ovarian carcinoma which usually presents at an advanced stage.[16]

The explosion of molecular genetics is creating some controversy among pathologists who pit it against traditional techniques.[17] Most pathologists, however, value the best of the old and new, like Juan Rosia, Director for Pathology Consultations at the Centro Diagnostico Italiano:

"The new tests are improving our capacity to categorise disease, and in particular fields like haematopathology they are becoming very important. But for most solid tumours, microscopic examination remains essential – and often the only thing you need."[18]

Technological revolutions happening outside the medical world will also affect the way pathologists work in the lab. Automation and digitalisation are perhaps the most prominent examples.

Automation through robotics is expected to become more prevalent in all aspects of society and may prove particularly useful in the lab environment. Tasks that could be 'delegated' to A.I. technology include preparing specimens, recording data and communicating results. This may release the pathologist to do the work of analysing and interpreting findings.[19]

Digitalisation has already made its mark on the field of radiology. With a computer and internet connection, radiological images can now be sent and accessed anywhere in the world. Something similar is likely to happen within pathology. In the past, the pathologist examined tissue specimens directly under the microscope,

usually local to the patient's centre of care. But now patient samples are being digitally scanned and viewed on a computer monitor. The advantages are clear: the image is easier to examine, lasts longer and can be accessed remotely. One can imagine the 'medical globalisation' which will occur, characterised by international co-operation between pathology specialists.[20]

3. Demographic trends

There are two aspects to the demographic trends affecting the health of society which will impact pathologists.

The first is the UK's ageing population. This is accompanied by increasing incidence of age-related conditions such as neurodegenerative disease, stroke and osteoporosis.[21] The worldwide prevalence of dementia is estimated at 26 million and is expected to double every 20 years. This will eventually set Alzheimer's disease against cancer as society's most prevalent and feared medical condition.[22] It is very possible that much of the funding currently devoted to cancer research will be transferred to neurodegenerative disorders. Many more academic pathologists may be recruited to explore early diagnostic and therapeutic strategies for Alzheimer's disease in ten years time.

The second is changes in disease prevalence. Conditions that are associated with sedentary lifestyle are increasing in prevalence. This includes obesity, cardiovascular disease and diabetes mellitus. Metabolic medicine is a sub-discipline set to expand as the UK faces its 'obesity epidemic'. Chemical pathologists will review and treat

many more patients with type 2 diabetes mellitus.[23] Sexually transmitted diseases (STDs) are also on the rise.[24] Microbiologists will join with Public Health Strategists to improve ways of preventing and treating STDs. The introduction of the HPV vaccine for schoolgirls represents this continuing endeavour to eradicate the most prevalent STDs in society.

4. **Economic trends**

The Economic Downturn of 2008 will continue to impact public services in the future. The consequences for the NHS will be two-fold. First, the limited resources will inevitably result in labour shortages. Second, there will be a drive to improve efficiency. The expected response to these pressures will be a major re-structuring of the NHS.[25] The government has already committed to reforming primary health care. Tertiary health services are likely to be re-structured to a "spoke and hub" framework: centralisation of specialist services with general services being provided more peripherally. This model has already had successful pilots for stroke thrombolysis.[26] Pathology services are likely to be reformed into a similar model There will be a concentration of pathologists at the "hub" (probably the capital and major cities), with referrals and queries coming from clinicians at the "spokes" (smaller cities and rural areas).

However, the academic pathologist is likely to suffer also. In a 'lean' climate there will be less tolerance for the academic who pursues pathology for the joy of learning. They will feel increasing pressure to prove the clinical relevance of the research they undertake. A reduction of pathology to its mere diagnostic and therapeutic elements

would surely impoverish the discipline and discourage the best candidates from pursuing it.

5. **Socio-cultural trends**

Socio-cultural factors can be understood as the prevailing attitudes and values in society. In particular, we will consider society's changing attitude towards personal healthcare and pathologists.

Personal healthcare is increasingly being characterised by consumerism.[27] This is approaching medicine as the commodity of the individual, rather than a service to the public. If this trend continues, pathologists may be inundated with unnecessary investigations and screening requests. Moreover, the risk of ligation in a consumer society may require protective regulations which the pathologist will find restrictive.

Society's attitude towards pathologists is in constant flux. The long-standing contribution of pathologists to public health can be overshadowed by a crisis like the Alder Hey scandal. Correcting the public perception of pathology is undoubtedly complicated by its apparent obscurity. Clinicians, by contrast, are readily accessible and their role is clear to the public. It is questionable whether society will esteem pathologists in ten years time if their work remains shrouded in mystery.

How should pathologists respond to these trends?

Leading pathologists on in the UK and the USA have observed these societal trends and foreseen the potential implications.[28, 29] Their recommendations for shaping

their future fall into three main themes.

First, pathologists must consider modernisation. Not all of these changes are welcome, though some are inevitable. To embrace these trends indiscriminately would ultimately prove toxic. The best response is to decide which to adopt and which to resist. The criteria for deciding one way or the other will require much deliberation. For example, should pathologists focus on managing the obesity epidemic or trying to avert it? How should they approach complex ethical problems to be raised by personalised medicine and technological advances?

Second, pathologists must develop communication with clinicians, medical students and the public. This involves making sure their role is well understood within the MDT and defending the importance of pathology teaching in the undergraduate curriculum. They must also take initiatives to improve the public understanding of pathology. The RCPath and the PathSoc are already developing this through their patient resources and Public Engagement Scheme respectively.

Thirdly, pathologists ought to strategise deliberately for their future provision. A long-term plan for education, research, recruitment and service development is essential to maintain the quality of learning and practice. Professor John J. O'Leary suggests pathologists may have to "think like a business" to compete for resources in a diminished public sector.[28]

Conclusion

So, in conclusion, what will the pathologist be doing in ten years time? His role will not change: the specialist doctor at the interface of basic and clinical science. He will study the mechanisms of disease, make definitive diagnoses and contribute to patient management.

However, the pathologist will adapt his practice to reflect changes in medicine and society: He will sub-specialise and provide more personalised healthcare as medical knowledge continues to increase. Age-related diseases and metabolic disorders will displace cancer at the fore of his workload. Advances in molecular diagnostics will shift attention from microscopy work to lab-on-a-chip devices. Digitalisation will allow pathologists to access data remotely and foster international collaborations. And yet, his local work will be centralised in major urban centres where he will receive samples from a wider catchment area.

These changes in society have not gone unnoticed by reflective pathologists. The best responses to these trends they can recommend are selective modernisation, improving communication and strategising provision. They must plot their next ten-year journey with a clear vision of where they want to go: “So, what *should* the pathologist be doing in ten years time?”

2993 words

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