

The Institute of Medical Genetics, Cardiff

*A response to the House of Lords Science and Technology Sub-Committee II
call for evidence on Genomic Medicine*

21st April 2008

Overview

The Institute of Medical Genetics was founded in 1987 and comprises *The Department of Medical Genetics, Cardiff University* and *The All-Wales Medical Genetics Service*. Its name was chosen to reflect the wider implications of genetics in medicine, rather than just clinical genetics.

This document provides information relating more to developments and opportunities in genomic medicine in Wales and seeks to compliment rather than reiterate evidence provided by relevant UK professional bodies including the British Society for Human Genetics (BSHG), the Joint Committee on Medical Genetics (JCMG) and Royal Colleges, although aspects of the development of genomic medicine as they apply to the whole of the UK are discussed. Whilst research, translation and service application of genomics in medicine in Wales are co-ordinated with activity and policy at a UK level, the devolution of responsibilities in health and education to the Wales Assembly Government has created a number of specific opportunities and challenges and some unique areas of activity.

For a summary of the issues surrounding genomic medicine we would draw attention to the foreword written by Francis Collins, Head of the Human Genome Project, in *Genomics and Clinical Medicine*, Dhavendra Kumar and Sir David Weatherall (Eds). Oxford University Press (2008).**[Appendix 1]**

NB Where the term *NHS* is used in this document it should be taken to include all four National Health Services in the UK. Use of the term *NHS Wales* will indicate where the item is specific to the NHS in Wales.

1. Policy Framework

- Who is in charge of setting and reviewing policy in this area?
- Who provides scientific advice on policy development? Who monitors and anticipates potential scientific developments and their relevance to future policy? How effective are these mechanisms?
- Does the existing regulatory and advisory framework provide for optimal development and translation of new technologies? Are there any regulatory gaps?
- In what way is science and clinical policy decision-making informed by social, ethical and legal considerations?
- How does the framework compare internationally?

1.1 The devolution of responsibilities for health and education to the Wales Assembly Government (WAG) has led to some divergence from England in the setting and reviewing of policy, including policies for research and teaching in the University sector and the strategic prioritisation, development and commissioning of health services in the NHS.

1.2 Scientific advice to WAG, and the monitoring of scientific developments comes largely from a small number of experts working in the field in Wales in the academic and NHS sectors and from horizon scanning activity by the Wales Gene Park that has an external advisory board of experts from outside of Wales. Medical Genetics has a representative on WAG's Welsh Scientific Advisory Committee (WSAC: Prof Julian Sampson) and on WSAC's Laboratory Services Sub-Committee (LSSC: Dr Ian Frayling). Dr Frayling also represents Laboratory Genetics on the Pathology Modernisation Forum in Wales. The Chief Medical Officer for Wales has a representative on the UK Human Genetics Commission (currently Professor Angus Clarke).

1.3 We believe that the current UK regulatory and advisory framework performs well in relation to its roles relating to the development and translation of new technologies but that there are important gaps in completing translation via service implementation and ongoing assessment. Specifically, while the development and scientific evaluation of new technologies and tests may be undertaken adequately (in the academic and commercial communities) there has been less success in evaluating the costs and benefits of these technologies in the health delivery setting (e.g. within the NHS) where local as well as generic issues may be important. Improvement in this situation requires better integration of health service research, health economics and the social sciences. In Wales this major challenge is being addressed to some extent through work (including joint projects) of centres of expertise including the Wales Gene Park (funded from WAG) and CESAgen (the Centre for Economic and Social Aspects of Genetics, with funding from ESRC) at Cardiff University and the Genomics Policy Unit at the University of Glamorgan.

1.4 In Wales, public engagement projects are run by the Wales Gene Park and research projects that address the ethical, legal and social issues (ELSI) are mainly run in Wales by CESAgen and through the Institute of Medical Genetics. Their experience and findings are reported to WAG and to DH and UK Government bodies (for example the Human Genetics Commission and HFEA). Examples of projects include a Citizens' Jury on designer babies, a DH-funded project on hereditary deafness, projects on genetics and insurance and a Wellcome Trust funded drama project for Schools on genetics, mental health and identity. These initiatives have revealed considerable public interest and liberal attitudes to the application of genetic technologies in health settings, especially amongst the young.

1.5 Most practitioners consider the regulatory framework in the UK to be well balanced. In common with other areas of rapid technological change, guidance from regulatory bodies is often "playing catch-up" with newly emerging research possibilities and the maintenance of an active dialogue between parties is essential.

2. Research and Scientific Development

- What is the state of the science? What new developments are there? What is the rate of change?

2.1 Technological developments in genomic science are advancing rapidly, but here we focus on NHS-related R&D, as submissions from other bodies will consider R&D in academia and industry. New platforms for analysis are becoming available, such as next-generation sequencing and high density arrays ("DNA chips"). Existing sequencing platforms used in NHS regional genetics laboratories have a capacity for ca. 100,000 bp per day, although rather less than this is analysed, because there is a limitation on how fast data can currently be interpreted by Clinical Scientists. Next generation sequencing platforms could be generating millions of bp of DNA sequence per day. Similarly, DNA arrays (as used for comparative genomic hybridisation) have rapidly advanced of late,

from 3500 probes, to 32,000, and now up to 1.2 million or more. But, as data production methods are increasing the amount of analysable data, so investment will need to be made in IT and data interpretation software, as well as the genomic data-gathering equipment, plus the staff to carry out this work, for any benefit to be seen by patients.

2.2 It should be noted that most work on technological development of platforms is currently directed at the research end of the market, but manufacturers are aware of diagnostic needs and moreover would wish to work closely with the NHS to develop diagnostic methods, and the NHS wishes to reciprocate. Indeed, because of the NHS the UK is probably in one of the most advantageous positions in being able to offer manufacturers a favourable environment in which to assess and develop products, and the Institute in Cardiff would wish to play its part.

- Who is taking the lead in the consideration and co-ordination of research and the development of new technologies?

2.3 The National Genetics Reference Laboratories (NGRLs) in England (Manchester and Wessex) have limited resources, and they are doing what they can to co-ordinate work on developing new technologies such as high density arrays and next generation sequencing. The All-Wales Medical Genetics Service, recognising the essential nature of developing new technologies and methods, has always invested some resources in having a small NHS R&D Genetics Laboratory, which strategy has proved most useful, especially when combined in recent years with the resources of the Wales Gene Park. We would wish to stress, however, that this is minimal resources, and developments in the wider field of genomic medicine must include co-ordinated investment across all four of the National Health Services in the UK. Political and administrative barriers must be set aside to achieve this for the greater good.

- How effective is the policy and investment framework in supporting research in this area?

2.4 It is problematic. Funding of development work in the NHS in England has barriers (as described in the submission from the JCMG), but funding in Wales (through e.g. the Welsh Office of R&D) suffers through being low in comparison with England and Scotland. In addition, clear direction needs to be given that funding for the development of diagnostics is included in the remit of governmental research-granting bodies. The investment framework also needs to change, to recognise and reflect the fact that this rapidly advancing technology is obsolescent almost as soon as it is installed, and NHS rules regarding e.g. capital charges, make it a high risk enterprise for individual NHS Trusts to invest in such technology. As has recently been proposed in Scotland, a rolling system of capital replacement would be an excellent option, and if central support for capital charges could be obtained, so much the better. As a fraction of the total amount of capital in the NHS it would be very small, and thus a special case for its treatment would not be destabilising, rather it would highlight the special and particular nature of the area.

- How does research in the UK compare internationally? How much collaboration is there?

2.5 Research in the UK in this area compares well with the best in the world. There is considerable co-operation and collaboration, and professional bodies such as the Association of Clinical Cytogeneticists (ACC), and the Clinical Molecular Genetics Society (CMGS), under the umbrella of the British Society for Human Genetics (BSHG), are in an advantageous position within the NHS second to none. However, this is dependent on the administrative and political barriers between the four NHSs being addressed. The Institute of Medical Genetics in Wales works as closely as it can with e.g. the NGRLs in England, but, for example, funds provided to the NGRLs are not allowed to pass into Wales and vice versa: rather "equivalent funding is expected to follow in the devolved countries" which does not always happen. Development of genomic medicine in the UK is a matter for the whole UK.

- What are the current research priorities?

2.6 The two NGRLs in England are doing some work on next generation sequencing and high density arrays, but their resources are strictly limited. Equivalent resources in Wales, such as they are, are directed to co-ordinate with and complement the NGRLs' activity, but currently this is largely directed at genetic, rather than genomic medicine.

- What is the role of industry? How much cross-sector collaboration takes place?

2.7 The role of industry is critical, as the nature of the technology means that the NHS itself is in no position to develop it independently, even if it had the resources. Co-operation between industry and the NHS is essential, but NHS resources to collaborate with industry are at best miniscule, if only because actual and perceived rules, such as commissioners not being allowed to fund "R&D", create huge barriers to progress. If R&D were regarded more as R, D & S, indicating "Research, Development and Service", that might help break down this barrier. Research then would be thought more of the remit of research funding bodies, and D&S rightly the remit of the NHS.

2.8 Much mention is currently made of translational research, without much definition of what is actually meant. From an NHS perspective it means the development of a diagnostic test that can actually be provided to patients, not a research paper in a scientific journal presenting a new gene. Once the basic work has been done, an individual accredited service laboratory has to do a considerable amount of work in, often, completely redesigning an analytical method used in research to suit it for patient diagnostics. This is a crucial area of activity for which the NHS makes minimal provision in support and funding. It is not something that can be delegated to national laboratories, rather it is the responsibility of each and every service laboratory, or rather each Trust's pathology directorate, certainly those in major teaching centres.

3. Data Use and Interpretation

- Is genomic information published, annotated and presented in a useful way? Should there be a common, public database? If so, who should fund, and have responsibility for, such an initiative?

3.1 There should be central co-ordination of databases, made available publicly. Funding for any such enterprise should be provided *in perpetuum*, so must be as secure as possible. The NHS has a Diagnostic Mutation Database (DMuDB) run out of resources allocated to the NGRL in Manchester, but this funding is short term and unsecured, and only covers some aspects of genetic, not genomic data. From now on, genetic and genomic data will be required for healthcare, hence the need to provide for it effectively on a permanent basis. The Human Gene Mutation Database (HGMD; www.cardiff.ac.uk/img/hmd) is run by Prof David Cooper and his team in the Institute in Cardiff. HGMD strives to standardise, organise and record all data on published mutations associated with human phenotypes. However, it is obliged to exist on short term monies, by partnership with a private company in Germany, but it is thus vulnerable because of commercial ownership. In terms of co-ordination and forward thinking, the International Society for the Investigation of Gastrointestinal Hereditary Tumours (InSiGHT) is actively working towards a means of presenting the contents of a number of related international databases on a single website: such databases containing e.g. information on mutations, interpretation of mutations, associated scientific literature, pathology.

3.2 There are few dedicated journals in which new information on medical and health applications of genomic science and technology is published. By contrast, several journals are aimed at basic biotechnological research covering a range of genomes. Examples include *Genomics* (Johns Hopkins University Press) and *Genome Research* (Cold Spring Harbor Laboratory Press). For material that could be ascribed more generally to genomic medicine, the Institute of Medical Genetics in Cardiff has taken the initiative in launching a new quarterly biomedical journal *Genomic Medicine*. This is published by Springer and the first issue appeared in September 2007 (www.Springer.com/journals/biomed/11568). The remit of this journal is broad and covers all aspects of medical and health applications of genome science and technology.

- Is other medical information recorded in a suitable format to allow optimal interpretation of genomic data?

3.3 No. Complete integration of the electronic patient record (EPR) and laboratory information management systems (LIMS) must occur, and this must include communication between LIMS in different Trusts and NHSs. The NGRL(Manchester) has done a considerable amount of good work in co-ordinating genetics LIMS across the UK, but funding for the local implementation of LIMS is left up to individual Trusts, so it is patchy, and risks inefficiency and inequality. Within Wales much progress is being made in health service IT, and in particular having a single LIMS across the whole country, linked to a single web-based clinical portal. We would urge those involved in NHS IT in England to benefit by seeing what is being achieved in the Principality.

- How should genomic data be brought together with other health information?

3.4 As with all other clinically relevant data, within the electronic patient record. However, there is an extra dimension in this, as genomic data is genetic data, and biological relationships must be provided for within the various NHS IT system/s. And all various IT systems within the NHS must be compatible, co-ordinated, and speak to each other.

- What are the implications of the generation and storage of genome data on personal data security and privacy, and on its potential use or abuse in employment and insurance? How should these be addressed?

3.5 The are, of course, implications for medical confidentiality of genomic and genetic data, but there is no good reason to exceptionalise genomics or genetics. NHS IT system/s should continue to be developed so as to maximise the confidentiality of all medical data, but at the same time actual and perceived barriers between Trusts and the individual NHSs in the UK must be overcome. It should be

at least as safe for two doctors to discuss an individual case by email within the NHS, as it is to speak on the telephone or write letters on paper.

3.6 In any event, data within accredited service laboratories is subject to medical confidentiality and the Data Protection Acts, as well as a raft of Standard Operating Procedures (SOPs) – as required by the laboratory accrediting body (Clinical Pathology Accreditation; CPA). It is thus as secure as can be under existing rules and regulations. There is no need to increase or augment existing provisions.

4. Translation

- What opportunities are there for diagnostics, therapeutics and prognostics – now and in the future?

4.1 Opportunities in diagnostics, therapeutics and prognostics are presented by the increased resolution of genomic technologies for categorising disease. Current diagnostic and prognostic categories are often defined very broadly, concealing genetic heterogeneity. Increasing capacity to define disease at genetic and genomic levels is enabling progressive improvement in individualisation and targeting of treatment. In Wales major steps have been made in relation to molecular diagnosis and individualised treatment for leukaemia and analogous research is underway in bowel cancer (by means of MRC Clinical Trials Unit funding to Prof. Tim Maughan, Chair of Cancer Studies, University of Cardiff, in collaboration with the Institute of Medical Genetics).

4.2 Translation to clinical practice has been the focus of reviews, commentaries and debate. The leading editorial in the first issue of *Genomic Medicine* examined the evidence and described genomic medicine as the new medical frontier for the twenty first century (Reference: Dhavendra Kumar (2007). Editorial - Genomic medicine: a new frontier of medicine in the twenty first century. *Genomic Medicine* 1(1&2):3-7.

- Who is responsible for translation to clinical practice?

4.3 Currently, this responsibility rests with a number of institutions and individuals, primarily within the NHS. Individual departments, Trusts and services all play a part. Within NHS genetics the NGRLs are able to assist. Individual scientists and academic medics do what they can, in a background of financial stricture continually eating into what little funding there is for development work. Any industry that fails to support its R&D activities does not survive for very long. NHS staff are ideally placed to translate genomic medicine into clinical practice and just require the resources to do this. Effort should be put into streamlining and simplifying the availability of funds for this within the NHS.

- Given the pace of technological advance, how ‘future-proof’ is healthcare investment in this area?

4.4 As mentioned above, the pace of advance means that future-proofing is minimal. The NHS typically thinks of a piece of capital equipment within pathology as being written off in a 10 year timeframe. That items of genetic laboratory equipment can be obsolete within less than half this time is immensely stressing to NHS finances and Trusts, who are required to cover capital charges. This is a very great barrier to progress. It is recommended that a rolling system of capital funding be provided throughout the four NHSs, with central provision of capital charges, and that adequate provision also be made in recurrent funding for maintenance charges of such equipment (for a diagnostic laboratory to maintain its accreditation, its equipment must be maintained under service contracts – this often puts a considerable barrier in the way of acquiring perfectly good and usable equipment second-hand from research bodies, e.g. the Wellcome Trust and Universities.)

- How does the UK compare to other countries and what lessons can be learnt?

4.5 The UK compares well, but is perhaps not the best at translating research into diagnostics. In The Netherlands, for example, service diagnostic laboratories are more easily able to acquire new state-of-the-art equipment, and the staff to develop and run them. Genetics laboratory services within the Netherlands are probably the best in the world, and it is suggested that the UK look more closely to see how they, and others, manage this.

- How meaningful are genetic tests which use genome variation data? What progress has been made in the regulation of such tests?

4.6 Much work requires to be done, to establish a sufficient knowledge and logic base to interpret genomic findings for clinical use. However, it is evident that work by the likes of Prof Donnelly’s Department in Oxford, and others, is addressing this. In such a cutting-edge area, however, it is essential that a balance be struck between those who wish to pioneer such new services and what might be termed “acceptable medical practice”. The public should be left in no doubt as to the risks of obtaining advice and tests from outside of the NHS, given that such services may not be provided by experienced, trained, qualified and registered individuals working within appropriately accredited laboratories. This has been highlighted to the HGC by Dr Frayling and Prof. Angus Clarke *inter alia*,

subsequent to the television program *The Killer in Me* (ITV1 9pm Thursday 8 November 2007), but the HGC having no statutory powers is only able to offer the advice that trading standards law be invoked. [see also: Lenzer J and Brownlee S. (2008) Knowing me, knowing you: Direct to consumer genetic testing. *BMJ* **336**, 858-860.]

5. Biomarkers and Epidemiology

- In what way do genome-wide association studies contribute to the identification of biomarkers? How is the study of genetic factors and biomarkers integrated for translational purposes?
- What impact will genomic data have on data emerging from projects such as UK Biobank, Generation Scotland and other biobanks?

5.1 The value of biobanks depends on the quality of clinical, environmental and biological data (including genomic data) they contain. Their processes of data accrual are usually incremental. We (as others) expect the value of the information associated with biobanks to increase over the long term. Limiting factors are more likely to relate to resources for data analysis (particularly human resources for bioinformatics) and clinical data quality than genomic data. Wales is making a significant contribution to UK Biobank, and the Wales Cancer Bank is the leading UK resource of its kind for cancer research.

6. Use of genomic information in a healthcare setting

- What impact will genomic information have on the classification of disease? How will it affect disease aetiology and diagnostic labels?

6.1 Genetic information is already having a significant impact on the classification of disease. Using genetic tests that link specific genes or chromosomal regions with disorders that follow Mendelian inheritance patterns or that result from gains or losses of parts of chromosomes provides a robust way of defining and diagnosing many genetic and genomic disorders.

6.2 Genomic information is also impacting on classification of many complex disorders in which gene play a role. Psychiatric disorders have, until now, been classified on the basis of their symptoms. Genetic approaches are likely to change this as the genes and biochemical pathways that are perturbed in these disorders are defined enabling new and more functional possibilities for classification that may better predict response to alternative treatments at an individual level. The Neuropsychiatric Genetics Unit at Cardiff University is making a significant contribution to research in this area and projects supported by the Wales Gene Park and CESAgen are enabling social scientists to investigate the impact of this new knowledge on professionals and patients.

6.3 The classification of cancers is entering a period of rapid change as cancers that were previously "lumped together" by the organ involved and histopathological characteristics are recognised as comprising several distinct genetic sub-groups that can be defined by genetic testing and that have differing prognoses and treatment needs.

[See also *Dhavendra Kumar (2008). Genetic and genomic approaches to taxonomy of human disease. In 'Genomics and Clinical Medicine', Dhavendra Kumar and Sir David Weatherall (Eds), Oxford University Press, New York, pp 75-92.*]

- How useful will genomic information be as part of individualised medical advice? What provisions are there for ensuring that the individual will be able to understand and manage genomic information, uncertainty and risk?

6.4 Genetic advice is given at many levels in health care. It is not possible or desirable to restrict this. Rather, health professionals should achieve core competencies appropriate to the settings in which they work. This approach has been adopted in the work of the National Genetics Education and Development Centre and the element of its work focused on genetics competencies for nurses that have been developed in Wales. However, it is desirable to regulate laboratories that generate genetic and genomic information on individuals for their health care. The NHS laboratories that comprise UKGTN (UK Genetics Testing Network) already work within a tightly regulated system and link coherently with health care professionals working in the clinical setting to ensure appropriateness and accuracy of genetic test information.

6.5 There is very little disagreement on the importance of individual genomic information as a prerequisite for the practise of personalised medicine. This would undoubtedly require a number of provisions to be put in place including accuracy of the genomic data, confidentiality of the data, consent for specific uses of the data, evidence for clinical usefulness (diagnosis, prognosis,

therapeutic decisions etc.), ensuring that the individual has understood the need and limitations of the genomic information, uncertainty and risks involved.

6.6 Despite intensive debate and some reservations, the modern clinical practice has become 'evidence-based'. This depends on the level of evidence, nature of evidence, specific clinical circumstances and some limitations. Nevertheless all clinicians do their best to follow 'evidence-based' style of clinical practice. Regular clinical audit cycles based on accepted standards are now routinely conducted in majority of the clinical settings. The emergence of genomic medicine revalidates the argument in favour of 'evidence-based medicine' (Kumar, 2007). The practice of modern medicine, including health promotion and prevention of disease, stands now at a wide-open road as the scientific and medical community embraces itself with the rapidly expanding and revolutionising field of genomic medicine. Khoury and Bradley (2007) strongly support the move of 'evidence-based genomic medicine' and caution to avoid taking shortcuts on the "translation highway" from genome discoveries to clinical medicine and population health. They are optimistic as genomic medicine offers a crucial window of opportunity to embrace evidence-based medicine and use its tools to conduct appropriate research and evaluation of genome-based technologies. The rapprochement of genomic medicine and evidence-based medicine is an essential step to fulfil the promise of genomic medicine in the 21st century.

Khoury MJ and Bradley LA (2007). Why should genomic medicine become more evidence-based? *Genomic Medicine* 1:91-93.

Kumar, D (2007). From evidence-based medicine to genomic medicine. *Genomic Medicine* 1:95-104.

- Should there be a regulatory code (mandatory or voluntary) covering the provision of this advice?

6.7 Yes, but such powers as are necessary could be invested in a body such as the HGC, so that they are able to regulate activities in this area. This would have little if any impact on NHS services, employing as they do registered, trained and experienced personnel, and utilising accredited laboratories. However, services outside of the NHS that do not work in this fashion might thus need to justify their actions, for the protection of the public, without necessarily stifling the development of new approaches. Simply for other practitioners to be aware that there was a regulatory body would mean that they sought advice about offering new services before potentially finding themselves in difficult territory.

- What are the implications of developments in genomic technologies for the training of medical specialists and other health professionals? Are there any gaps that need addressing? What is the assessment and planning for future needs in capacity?

6.8 In order to realise the potential for these direct benefits to patient care there will need to be investment in high throughput genomic technologies and changes in the training of clinical scientists to handle and interpret large amounts of genomic data. In parallel, there is a significant educational challenge in familiarising health care professionals with these concepts and introducing genetic and genomic information into patient care. In Wales, the University of Glamorgan is leading on genetic education for nursing professionals in an integrated programme of wider genetic education in the UK run through the *NHS National Genetics Education and Development Centre* in Birmingham. The Wales Gene Park runs a full programme of educational events for health professionals from across the UK and a wide range of events to raise public awareness, particularly through schools. These measures will help to ensure that risk information relating to inherited predisposition to disease can be communicated adequately to patients and families and understood.

6.9 Similarly, there are very considerable implications in respect of genomic medicine for the training and education of health professionals in clinical laboratories. To understand this it is necessary to understand how genetics laboratories are currently staffed. Laboratories in the UK are headed by Clinical Scientists of Consultant status (NHS Agenda for Change Bands 8c-9), with test development, data interpretation and test reporting carried out by Clinical Scientists (Bands 7-8b). Data production is by Medical Technical Officers (MTOs), mostly in Band 5. This structure has developed because such laboratories have grown relatively recently from research laboratories, but it means that laboratory genetics has developed in the UK without the development of a cadre of medically-trained genetic pathologists. Such medical input as there is to NHS genetics laboratories is via Clinical Geneticists, who are trained as physicians, not pathologists. For genomic medicine to progress as well as it might, the combined skills of both clinical scientists and medically-trained pathologists will be required.

6.10 A number of years ago, pre-genomics, the medical specialty of *Clinical Cytogenetics and Molecular Genetics* (aka Genetic Pathology) was set up with a view to training a cadre of pathologists specialised in laboratory genetics. Specialist Registrar training posts were established in three UK centres (Cambridge, Cardiff and London). Despite this, there have only been four individuals trained in the specialty, one of whom has emigrated to Australia, one is employed as an NHS clinical geneticist,

one is a senior research scientist, and the other is the only one employed as an NHS Genetic Pathologist – as the Laboratory Director of the All-Wales Medical Genetics Service. Part of their remit is specifically to foster development of molecular and genomic medicine. There are a number of individuals in the UK qualified in Genetic Pathology via an academic route, including the Dean of a medical school and two Professors of Cancer Genetics (one of whom was, until recently, Director General of Cancer Research UK), however, there are no NHS posts other than the one in Wales, despite attempts by the specialty and the Royal College of Pathologists to highlight this via the NHS Workforce Review Team and the RCPATH's Workforce Advisory Group. A number of junior doctors were interested in training in the specialty last year, but in the absence of funding for the specialist registrar posts, and more importantly in the absence of any funding for Consultant posts, they had to be dissuaded, and indeed the RCPATH was reluctantly obliged to recommend decommissioning of the specialty for training purposes this year. The RCPATH has made it clear that both clinical scientists and medically-trained genetic pathologists are needed, and this is highlighted in the submission from the SAC in Histopathology.[see also: *The Future Role of Medical Graduates and Consultants in Pathology Services*. RCPATH 2004]

6.11 As genomic medicine progresses there will be an ever burgeoning requirement to interpret highly complicated data in the setting of clinical care. In all other pathology specialties this is generally provided by medically trained individuals, because it is precisely their training that allows the synthesis of data from many streams and to put that in the context of clinical care. There is also a need to integrate genomic medicine into all other pathology specialities (let alone the rest of medicine), and medically trained individuals with a broad background are better placed to do this. If the NHS in Wales finds it useful to employ a Genetic Pathologist, we would argue that this practice should be extended across the UK, but there will need to be central direction and support in establishing Consultant posts in the specialty outside of Wales, because Trusts will inevitably see such posts as low priority compared with more front line specialties.

APPENDIX 1

Foreword by *Francis Collins* to *“Genomics and Clinical Medicine”*, *Dhavendra Kumar and Sir David Weatherall (Eds)*. Oxford University Press, New York, pp viii. (2008).

A scant twenty years have passed since the word “genomics” was coined by Victor McKusick, Frank Ruddle, and Tom Roderick to describe a new discipline. The suffix of the word derives from the Greek *ome* meaning all, and aptly conveyed an intention to transition the study of heredity from a focus on single genes (genetics) to the more global perspective of all of the hereditary material. A proliferation of other “omics” disciplines has subsequently erupted – including proteomics, metabolomics, transcriptomics, glycomics, microbiomics, and many more.

But genomics remains the foundation of the rest, reflecting as it does a comprehensive analysis of the DNA instruction book. The success of the Human Genome Project has now laid that instruction book wide open. As a result, the life sciences have been catapulted forward, and biology has now taken its rightful place alongside physics and chemistry as a truly digital and quantitative science.

It is the application of genomics to medicine that carries its greatest promise of benefit to humankind (Francis Collins, 2008). Here in the early years of the third millennium we can see the emerging outlines of a new synthesis of the noble tradition of the healing arts with an increasingly precise way of understanding the causes of disease, based on an understanding of the human genome. There are still many practicing physicians who would say they see no evidence of genetics or genomics as part of their daily medical practice. Surely, however, that reveals a problem with the successful communication of rapid new developments in this field, not the facts of the matter.

The pace of progress in genomics has been astounding. Over just the last fifteen years, largely as a consequence of the tools made available through the Human Genome Project, genes have been identified for more than two thousand inherited conditions. With recent rapid advances in the understanding of human genetic variation, the specific hereditary contributions to common diseases like diabetes, heart disease, cancer, and mental illness are emerging at an unprecedented rate. The very real possibility of offering individuals who are currently healthy a personalized prediction of future risks of illness is no longer a distant dream. And given that many of the common disorders for which predictions are becoming possible are associated with proven means of reducing risk through diet, exercise, lifestyle change, medical surveillance, or pharmacotherapy, the real likelihood of widespread individualized programs of preventive medicine grows by the day. Similarly, the ability to make predictions about the possibility of a beneficial or undesirable response to drug therapy, the field of pharmacogenomics, is advancing rapidly, and will soon require health care providers to determine the genotype before writing the prescription, at least for certain drugs. Many of us predict that the complete genome sequence of an individual will become part of that person’s medical record within about ten years, at a cost of US \$1000 or less. And the therapeutics that we use in the future will likely be heavily dependent upon an understanding of the genomic basis of illness, leading to interventions that are both more accurately targeted to the underlying problem and less likely to cause side effects.

All of these advances should be welcomed by anyone interested in the alleviation of human suffering. Yet a number of major ethical, legal and social challenges lie along the path if this vision is going to be realized. In the United States, for example, we still lack effective federal legislation to prevent discriminatory uses of predictive genetic information. Major challenges also lie ahead with regard to ensuring equitable access to new genomic technologies, especially as our medical care system seems to undervalue opportunities for preventive medicine, focusing instead on treating disease once it has already appeared. But perhaps the greatest barrier, and the one which this book admirably seeks to address, is an educational one. Most members of the public are interested in genomics, but relatively unsure of the details. Seeking advice, they generally turn to their health care providers, but many of those professionals are poorly prepared to become practitioners of this new art. After all, most physicians have had little or no training in genetics or genomics, and will be hard pressed to quickly acquire the scientific principles, the medical knowledge, and the psychosocial skills that will be necessary for the successful introduction of genomic medicine.