Genetic Screening: a Supplement to the 1993 Report by the Nuffield Council on Bioethics

NUFFIELD COUNCIL ON BIOETHICS

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The terms of reference of the Council are:

1 to identify and define ethical questions raised by recent advances in biological and medical research in order to respond to, and to anticipate, public concern;

2 to make arrangements for examining and reporting on such questions with a view to promoting public understanding and discussion; this may lead, where needed, to the formulation of new guidelines by the appropriate regulatory or other body;

3 in the light of the outcome of its work, to publish reports; and to make representations, as the Council may judge appropriate.

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Foreword

The Council's first Report on *Genetic Screening: Ethical issues* was published in 1993. Since then, there have been major developments in science and policy in the field of genetics. A small Working Group was therefore established by the Council to consider whether these changes raised ethical issues relating to genetic screening which merited further study. The Group concluded that the commissioning of a new Working Party would be premature and that the ethical principles identified in the 1993 Report remained relevant for guiding current research and practice.

However, the Council was presented with something of a dilemma. Although the original Report is over ten years old, approximately 20,000 copies continue to be downloaded from our website each year. The Council has therefore decided to publish this Supplement with the aim of bringing the original Report up to date by taking account of the changing context. In doing so, we have not attempted to provide a detailed account of the scientific advances which have occurred since 1993 or review the ethical issues identified in the 1993 Report.

We are assuming that most of our readers will have some familiarity with genetics. Even so, we have tried to avoid overly technical terminology and have included a glossary to provide definitions of some of the terms that we use. For brevity, some of the introductory sections that readers found helpful in the 1993 Report have been omitted.

The Council is indebted to the members of the Working Group that reviewed recent developments in genetic screening and whose advice led to the publication of this Supplement. The project would not have been possible without the continuing dedication and support of the Secretariat.

Professor Sir Bob Hepple QC, FBA

Chairman

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Terms of reference

1. To identify developments in the area of genetic screening since the publication of the Council's Report (1993), with particular reference to the Genetics White Paper published in June 2003.
2. To consider whether any further action is required and to produce a short paper.

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Chapter 1

Introduction

Introduction

1.1 Medical genetics differs from many areas of medicine because of its effects not only on individuals, but also on their families and society generally. The Nuffield Council on Bioethics selected the topic as the subject of its first Report. Published in 1993, *Genetic Screening: Ethical issues*, remains one of the Council's most cited and frequently accessed publications.[1]

1.2 In 1993, most genetic screening programmes were at the pilot stage, although there were some exceptions. For example, programmes had already been established to screen all newborn children for phenylketonuria (PKU) and certain sub-populations for recessively inherited diseases such as thalassaemia and sickle cell disease. Practical experience in clinical genetics was confined primarily to a small number of these single-gene disorders. Since then, policy developments, advances in scientific understanding and technological developments have led to the introduction of several other diagnostic tests, interventions and treatments.

1.3 There have also been changes in the UK regulatory and advisory framework for clinical genetics, with the formation of several committees such as the National Screening Committee (NSC) and the Human Genetics Commission (HGC) to advise Government, the medical profession and others. More recently, in June 2003, a White Paper, *Our Inheritance, Our Future*, set out the UK Government's plans for investment in genetic services within the National Health Service (NHS).

1.4 A small Working Group was therefore established by the Council to determine whether recent scientific, technological and policy-related developments raised any additional ethical issues which merited further study. Although the Group concluded that the commissioning of a new full Working Party would be premature, the Council took the view that others were likely to consider its findings useful in that they provided an update of recent developments. A decision was therefore taken to publish this Supplement to the 1993 Report.

1.5 The Working Group took the view that the focus of the original Report on genetic screening should be retained. Some of the specific issues discussed in this Supplement are common to other screening programmes for non-genetic conditions and some of the general issues arising from screening will also be relevant for genetic testing (see Box 1.1). The study encompasses developments in science and technology and policy, but a renewed ethical analysis was beyond the remit of the Working Group. Moreover, it was not clear that these developments raise new ethical issues that were not covered in the 1993 Report on Genetic Screening or in the Council's subsequent Reports.[2]

1.6 In this Supplement, the terms 'genetic disease' and 'genetic condition' are used to denote a disease or condition that develops as a result of alterations in the genetic make-up of an individual. Such alterations may arise through the inheritance of a particular gene variant or by means of a new gene mutation. So far, genetic screening programmes have been limited to disorders caused by mutations in a single gene. However, a great deal of research is currently directed at mutations in several genes with small effects which are thought to confer a predisposition or susceptibility to common diseases (see paragraph 2.16). Caution should be exercised in using the term 'genetic' to describe those polygenic diseases where environmental factors may override or modulate a genetic predisposition towards the onset and development of the disease (paragraph 2.18).

1.7 Some reflection upon the general nature of screening before we consider *genetic* screening may be useful. Screening aims to detect individuals within a population who are not already

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[1] *Genetic Screening: Ethical issues* was downloaded from the Council's website over 23,000 times in 2005.

[2] Nuffield Council on Bioethics (1998) *Mental Disorders and Genetics: The ethical context* (London: NCOB); Nuffield Council on Bioethics (2002) *Genetics and Human Behaviour: The ethical context* (London: NCOB).

affected by or who do not even necessarily perceive that they are at risk of a disease or its complications (see Box 1.1). It may involve the use of general information, such as maternal age during pregnancy, followed by a test if appropriate. The basis of a test may be the detection of a biological, non-genetic indicator of the disease, or a marker that indicates a risk of early disease, such as high levels of blood glucose. Alternatively, the test could be for a genetic alteration that is a marker for, or is the underlying cause of, the disease. Screening carries with it the risk of false-positive or false-negative results, the extent of which will depend upon the precision of the screening test and the prevalence of the disease (see paragraphs 3.2–3.3).

Box 1.1: Terminology—Genetic screening and genetic testing

The terms 'genetic screening' and 'genetic testing' are often used interchangeably. However, it is important to clarify how they are defined in this Supplement.

Genetic testing usually involves testing an individual for the genetic change (mutation) underlying a condition or abnormality that may be suggested by other evidence. Often, he or she would have sought advice from a medical practitioner. For example, individuals may be tested for the genetic mutation that causes Huntington's disease if they are known to be at high risk of developing the disorder because a member of their family is affected, or if they have symptoms.

Genetic screening may involve testing members of a population (or sub-population) for a defect or condition, usually where there is no prior evidence of its presence in individuals or their relatives, and as part of a public health service. For example, all parents in the UK are offered screening for phenylketonuria (PKU) for their newborn children. Alternatively, the offer of screening may be limited to a sub-population that is at particular risk of a genetic condition. For example, Ashkenazi Jews may decide to be screened to find out if they are carriers of Tay-Sachs disease. In the 1993 Report, genetic screening was defined as 'a search in a population to identify individuals who may have, or be susceptible to, a serious genetic disease, or who, though not at risk themselves, as gene carriers may be at risk of having children with that genetic disease'.

1.8 What makes a test or screening programme *genetic*? A genetic test has been defined as a test to detect the presence or absence of, or change in, a particular gene or chromosome.[3] The test can be done directly, by analysing an individual's DNA, or indirectly, for example by examining the proteins encoded by their DNA. An advantage of tests that use DNA is that they carry a high level of precision, which is not necessarily the case with tests based on other biological markers. In addition, tests for genetic alterations normally need to be done only once, because a person's genotype does not change significantly during his or her lifetime. In our view, the critical aspect to consider is the information, in particular the risk for disease, that a test reveals, rather than whether or not it analyses genetic material. We have therefore included tests that use non-genetic technology for a disorder that is clearly heritable or genetic, such as lipid analysis to test for familial hypercholesterolaemia, as well as tests that use DNA. However, we have excluded the use of tests that analyse genetic material for disorders that are not heritable, such as DNA analysis for bacterial pathogens or the analysis of tumours.

1.9 Since screening is usually carried out when there is usually no prior evidence of a condition, it brings with it ethical issues that are different to those that arise from the testing of individuals. These include how consent should be obtained and how professionals should convey any

[3] Advisory Committee on Genetic Testing (1997) *Code of Practice and Guidance on Human Genetic Testing Services Supplied Direct to the Public* (London: Health Departments of the United Kingdom), p6.

unexpected information. In addition, it is generally the government, advised by the appropriate health advisory bodies and by means of national health schemes, rather than the individual, that identifies the need for a screening programme and recommends that individuals should undergo screening.

1.10 The use of genetic information raises ethical issues that differ significantly from the normal rules and standards applied to the handling of personal medical records. As we have said, the results of tests may have implications for relatives of the person being tested. The high stability of DNA means that a sample can be stored and used for testing at a later date. DNA samples could also be used to test for gene variants that are not related to the initial screen, raising issues of consent. Even if testing is confined to a particular gene variant, there is the

Box 1.2: Summary of main points in the 1993 Report *Genetic Screening: Ethical issues*

(The full conclusions and recommendations of the 1993 Report are reproduced in Appendix A of this Supplement.*)

The aims of the Report were to survey recent and prospective advances in genetic screening and its applications, to review the benefits and to identify and define the ethical issues that arise, or could potentially arise from genetic screening. It examined consent, counselling and confidentiality in the light of experience of genetic testing for rare disorders such as Huntington's disease, and carrier screening for diseases which are less rare, such as cystic fibrosis and sickle cell anaemia. The Report recommended that participation in all screening programmes should only be on a voluntary basis and that adequately informed consent must be obtained from participants.†

It also recommended that counselling should be readily available for those being screened, as well as for those being tested on account of a family history of a genetic disorder. The Council recognised that the results of screening might have serious implications for members of a family. When genetic screening revealed information that might have implications for the relatives of the person being screened, the Report recommended that health professionals should explain why the information should be communicated to other family members. They should then seek to persuade individuals, if persuasion should be necessary, to allow the disclosure of relevant genetic information to other family members who might benefit from it. Where a screened individual did not wish to inform relatives of a genetic risk or to give permission for test results to be used by them, the Council accepted that under exceptional circumstances it may be appropriate to disclose genetic results 'without consent' to benefit family members.‡ The legal interpretation would be that there is an exception to the duty of confidentiality where the disclosure is in the public interest.

In the context of public policy, the Report recommended that the Department of Health, in consultation with the appropriate professional bodies, should formulate detailed criteria for the introduction of programmes for genetic screening and establish a central coordinating body to review such programmes and monitor their implementation. This was seen to be an essential safeguard against abuse.

The Report also considered implications for employment and insurance, proposing early discussions between government and the insurance industry about the future use of genetic data. It recommended that screening in the context of employment should be strictly limited and only be undertaken if accompanied by safeguards for employees after appropriate consultation.

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* All of the Council's Reports are available on its website, www.nuffieldbioethics.org.

† For details, see paragraphs 4.28–4.29 of the 1993 Report.

‡ For details, see paragraph 5.30 of the 1993 Report.

possibility that this variant may have multiple effects now or in the future. This means that if a particular screening programme were to be introduced, there might be health implications for the individual other than those related to the primary purpose of the screen. Finally, many genetic screening programmes are performed before or during pregnancy, shortly after birth or during early childhood. There are additional ethical issues associated with these life stages.

1.11 The Group noted that there remains the misapprenhension among some members of the public that everybody with a genetic predisposition for a particular disease will go on to develop that disorder, and that all genetically determined disease is passed on across generations. These misapprenhensions may cause much unnecessary anxiety, particularly in relation to issues of employment and insurance.

1.12 We begin by summarising the aims and recommendations of the 1993 Report (see Box 1.2). Technological advances over the past 13 years, and the current policy, advisory and regulatory situations are then briefly reviewed in Chapters 2 and 3, respectively. Consideration is given in Chapters 4 and 5 to the current delivery of screening services; the provision of information available to patients; procedures for consent, counselling and confidentiality; and education. We describe developments in employment and insurance policy relating to genetic screening in Chapter 6. The Supplement concludes with a number of recommendations.

Chapter 2

Genetic technologies: Advances and applications

Genetic technologies: Advances and applications

Introduction

2.1 The 1993 Report commented on the 'astonishing speed of development' of research in genetics. This pace has continued over the past 13 years, with rapid advances in the development of new technologies, scientific approaches and our understanding of the science of genetics. Scientists are now able to generate, manage and analyse very large amounts of genetic data, much of which are publicly available in databases, or though resources held in dedicated biobanks. Researchers are using these data to help them understand how genes function and what their role in causing disease might be. Some of this knowledge is likely to lead to the development of new treatments and diagnostic tools. Although the primary use of these technologies thus far is in research, some applications have already been developed, such as forensic databases. In this chapter, we describe some of the major technological developments which have applications that are relevant to genetic screening. We also make some general observations on scientific developments based on existing reviews.

Technological approaches in human genetics

2.2 Over the past decade, scientific advances in human genetics have made use of several large-scale genome projects that have used automated high-throughput technologies to generate genetic information. The complete sequencing of the human genome and the genomes of several other organisms is helping researchers to identify the location and function of genes by means of genome-wide scans, 'knock-out' mice and *in silico* comparisons between homologous genes of different organisms. Genetic mutations that are implicated in diseases and disorders can also be located by means of markers which are in close proximity and therefore co-inherited with the gene of interest. In this section, we briefly describe these approaches and the technologies on which they are based.

The Human Genome Project

2.3 The completion of the Human Genome Project in 2004 was a major milestone in scientific research. The Project was established in 1990 to coordinate the sequencing of the 2.85 billion nucleotides that make up human DNA. The scientific analysis of the finished human genome identified the position and sequence of most of the estimated 20,000–25,000 human genes.[1] Because many genes play a role in human disorders, their identification may be a first step in the development of new screening technologies and treatments.

Understanding genetic variation

2.4 The complete sequencing of the human genome has provided a vast amount of information for researchers to analyse. Genetic variations between individuals provide markers that can be used as tools to identify genetic and environmental factors responsible for susceptibility to disease. Some of the markers that are currently used are described below:

- Single nucleotide polymorphisms (SNPs): These are single variations in DNA nucleotides; for example, some people might have an 'A' nucleotide whereas others have a 'G' nucleotide at a particular position in the DNA sequence. It is estimated that SNPs occur at a frequency of

[1] At the time of the 1993 Report, it was estimated that there were about 75,000 different human genes. The Human Genome Project has revealed that the true number is significantly smaller. See International Human Genome Sequencing Consortium (2004) Finishing the euchromatic sequence of the human genome *Nature* **431**: 931–45.

about 1 in every 1,000 nucleotides. Although some have a biological effect on the individual, most have no effect. However, they may be used as genetic markers in order to locate genes that cause or predispose to disease or influence other traits (see paragraph 2.5). In 1999, ten pharmaceutical companies and the Wellcome Trust established a consortium to create a SNP map of the human genome to provide researchers with an informative and dense set of genetic markers. Originally intending to map 300,000 SNPs, the consortium characterised a total of 1.8 million.

- Haplotypes: A set of genetic markers (for example, SNPs) found together in a region of a chromosome is known as a haplotype. These closely linked alleles tend to be inherited together as a unit because recombination (when maternal and paternal chromosomes pair up and exchange segments of DNA) occurs only rarely between alleles that are close together. Most chromosomal regions have only a few common haplotypes (each with a frequency of at least five per cent), which account for the greater part of the genetic variation between people in a population.[2] Most of the more common haplotypes occur in all human populations, but frequencies differ between populations. The International HapMap Project was established in 2002 to create a haplotype map of the human genome. The project aims to describe common patterns of human DNA sequence variation and may be used to identify genes that affect health, disease and responses to medicines and environmental factors. The information produced by the project is being made freely available. In October 2005, the HapMap Consortium reported that their public database contained more than one million SNPs, identified from the DNA samples of 269 people from four populations. The second phase of the project involves identifying an additional 4.6 million SNPs in each of the samples.[3]

Mapping genes/association studies

2.5 Researchers take two broad approaches to mapping the location of genes on chromosomes:

- Linkage analysis: It has been recognised for more than a century that there is a tendency for genes and genetic markers that are in close proximity on a chromosome to be inherited together. It is possible to examine this linkage by studying how various genetic and phenotypic characters are co-inherited within families. Used widely since the 1980s, when a range of DNA markers became available, linkage analysis was the traditional way of defining the approximate position of genes associated with human diseases on chromosomes. It was made much more powerful by the compilation of dense maps of known markers. Useful for determining single-gene disorders, linkage analysis has proved less useful for identifying polygenic disorders because it is difficult to accumulate a sufficient number of suitable families to give the studies adequate statistical power.

- Association mapping: Researchers compare DNA from two groups from a population, one comprising healthy individuals (the control) and the other, individuals with a disease (the case). By examining the SNPs at a particular position, it is possible to compare allele frequencies in the two groups. Provided the groups are drawn from the same population, where a difference is found between them, the associated SNP is likely to be within or near a gene that influences susceptibility to the disease. However, research with very large numbers of SNPs poses technical and statistical problems and where a single haplotype contains many SNPs, it may be more efficient to use the haplotype as a marker (see paragraph 2.4).

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[2] A chromosomal region may contain many SNPs, but a few 'tag' SNPs can be selected and provide most of the information on the pattern of genetic variation in a particular region. See International HapMap Project (2002) *About the International HapMap Project*, available at: http://www.hapmap.org/abouthapmap.html.en, accessed on: 30 Jan 2006.

[3] The International HapMap Consortium (2005) A haplotype map of the human genome *Nature* **437**: 1299–1320.

Association studies are used to attempt to identify alleles of moderate risk for common diseases which are influenced by more than one gene (see also paragraph 2.18).[4]

Capabilities in high-throughput testing

2.6 The introduction of new tools that achieve high-throughput testing promises to allow fast, accurate and relatively affordable analysis of the human genome. Advances over the past five years mean that tens of thousands of genes or markers can now be analysed at the same time using a single DNA array or 'chip'. For example, in 1999, the company Affymetrix released a chip capable of simultaneously profiling 1,500 SNPs. More recently, the company has produced a set of two arrays that can identify 500,000 SNPs.[5]

2.7 The major improvements in analysis and understanding of genetic variation and the capability for high-throughput testing using microarray techniques are being used primarily in research. However, they could have the potential for a significant impact on the delivery of services for genetic screening in the future. In addition to being able to screen a larger number of individuals more quickly and at a lower cost, these new technologies have the potential to analyse many different genes or markers simultaneously. However, the possible impact of the patenting of DNA sequences on the affordability of genetic tests needs to be considered. If licences to use complex diagnostic tests should prove to be expensive, their provision as part of publicly funded genetic screening programmes could be limited.[6]

Bioinformatics

2.8 Analysis of the vast amounts of data produced by genomic research requires powerful computer technology. Novel analytical techniques have also depended on major advances in methods of data capture, processing and analysis. Developments in bioinformatics have enabled information on the sequence, structure and function of genes to be stored and easily accessed from databases. Software has also been developed to analyse and make predictions from the data. Bioinformatics has been described as the 'computational driving engine behind the analysis of massive data that support discovery science in genomics, proteomics, metabolomics and the other biological "-omic" subfields'.[7]

2.9 Many take the view that a full exploitation of developments in genomics will depend on unrestricted access to databases containing genetic information. The Human Genome Project was funded by the public sector and conducted within an ethos of strong commitment to open access to data. To this end, all sequence data were placed daily on public databases as they were generated. In contrast, industry has generally restricted access to the DNA sequence data that it has generated. For example, in 2005 the privately funded Celera Genomics Corporation allowed free access to one megabase per registered academic researcher per week, which was of limited use for research purposes.[8]

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[4] For reviews on the subject, see Colhoun HM, McKeigue PM and Davey Smith G (2003) Problems of reporting genetic associations with complex outcomes *Lancet* **361**: 865–72; Ioannidis JPA, Trikalinos TA, Ntzani EE and Contopoulos-Ioannidis DG (2003) Genetic associations in large versus small studies: an empirical assessment *Lancet* **361**: 567; Hirschhorn JN, Lohmueller K, Byrne E and Hirschhorn K (2002) A comprehensive review of genetic association studies *Genet Med* **4:** 45–61.

[5] Affymetrix (1999) *Affymetrix Introduces GeneChip® Husnp™ Mapping Assay*, available at: http://www.corporate-ir.net/ireye/ir_site.zhtml?ticker=AFFX&script=415&layout=-6&item_id=84950&sstring=snp, accessed on: 30 Jan 2006; Affymetrix *Mapping 500K Array Set*, available at: http://www.affymetrix.com/products/arrays/specific/500k.affx, accessed on: 30 Jan 2006.

[6] For further information on the patenting of DNA, see Nuffield Council on Bioethics (2002) *The ethics of patenting DNA* (London: NCOB), paragraphs 5.4–5.29.

[7] Maojo V and Kulikowski C (2003) Bioinformatics and Medical Informatics: Collaborations on the road to genomic medicine? *J Am Med Inform Assoc* **10**: 515–22.

[8] Researchers who wished to download more than this amount of data were required to sign an agreement stating that the data were for research purposes and would not be distributed. See *Celera Free Public Access Click-On Agreement*, available at: http://public.celera.com/humanpub/terms.html, accessed on: 8 July 2005.

Biobanks

2.10 Population genetic databases have been established to facilitate investigation of the interactions between genes and the environment, and their relationships to disease. Several projects are in progress, or planned, worldwide. Large numbers of participants are required in order to collect sufficient genetic and associated health data for statistical analyses to be robust.[9] Some of these studies included plans at the outset to collect biological samples for DNA extraction (for example, the Avon Longitudinal Study of Parents and Children). In others, a decision was taken to collect samples from pre-existing cohorts (for example, the 1958 National Child Development Study).

2.11 In the UK, Biobank, a major new project, will follow the health of 500,000 volunteers aged between 45 and 69 for up to 30 years. Information about environmental and lifestyle factors will be collected and linked anonymously to data in medical records and stored biological samples. A pilot study is under way and the main project is due to start later in 2006. Other biobanks worldwide include the Icelandic health sector database and the Estonian genome project.

2.12 A further type of database includes those used for forensic purposes, such as the UK National DNA Database. Launched in 1995, this was the first criminal intelligence database in the world.[10] It now contains DNA samples from over three million individuals. Following changes in the law in 2001 and 2003, samples can now be taken, without consent, from suspects at the time of arrest for a recordable offence[11] and retained indefinitely, regardless of whether the individual is later charged or convicted.[12]

2.13 There has been some concern about the lack of ethical debate surrounding the National DNA Database.[13] For example, its co-existence with health-related population databases, such as UK Biobank, may open up the potential for these large databases to be linked in the future. Other concerns relate to the size of the DNA database and its range of potential uses, the storage of samples, questions about confidentiality and privacy, and the accountability of the custodians. Although Biobank and the National DNA Database are both protected by agreements regarding their use, these issues are likely to require further consideration.

Advances in our understanding of genetics

2.14 Since 1993, researchers have made substantial progress in identifying genes which are associated directly or indirectly with human diseases. Applications of the new technological approaches described above have accelerated this process. More than 1,000 genes for heritable single-gene disorders have now been identified.[14] However, these diseases, such as cystic

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[9] Kaiser J (2002) Population databases boom, from Iceland to the US *Science* **298**: 1158–61.

[10] Forensic databases have also been established in the United States, Australia, Austria, Belgium, Canada, China, France, Germany, the Netherlands and Switzerland. However, the UK has the most wide-ranging legislative provisions. Most European countries remove the profiles of those who have been acquitted. France has strict rules for allowing DNA to be taken only with consent, and Germany specifies that all samples must be destroyed after profiling is completed, regardless of the outcome of the case. See Johnson P (2004) *Forensic DNA Databasing: A European perspective*, available at: http://www.dur.ac.uk/p.j.johnson/eu.html, accessed on: 31 Jan 2006; The Wellcome Trust (2004) *DNA Fingerprinting and National DNA Databases*, available at: http://www.wellcome.ac.uk/en/genome/ genesandbody/hg07f007.html, accessed on: 31 Jan 2006.

[11] A recordable offence is any offence held on the Police National Computer. This includes offences punishable by imprisonment and others specified in the National Police Records.

[12] Provisions detailed in the Criminal Justice and Public Order Act 1994, the Criminal Justice and Police Act (2001), and extended in the Criminal Justice Act (2003). See Johnson P (2004) *Genetic Information and Crime Investigation: Social, ethical and public policy aspects of the establishment, expansion and police use of the National DNA Database*, available at: http://www.dur.ac.uk/p.j.johnson/project.html, accessed on: 31 Jan 2006.

[13] The Wellcome Trust (2004) *DNA Fingerprinting and National DNA Databases*, available at: http://www.wellcome.ac.uk/en/genome/genesandbody/hg07f007.html, accessed on: 19 Oct 2004; The Wellcome Trust (2003) *Identification: Suspect*, available at: http://www.wellcome.ac.uk/en/genome/geneticsandsociety/hg14f004.html, accessed on: 19 Oct 2004.

[14] The International HapMap Consortium (2005) A haplotype map of the human genome *Nature* **437**: 1299–1320.

fibrosis and Huntington's disease, in which there is a clear link between a particular genetic mutation and a disorder, are comparatively rare. The modest number of genetic screening programmes that are currently available (see Chapter 3) are concerned with detecting this type of disease.

2.15 The root causes of many more common disorders, such as coronary heart disease, diabetes, psychiatric illnesses and cancers, remain largely unknown. Family history is one of the strongest risk factors indicating that genes have an important role. Since 1993, much attention has turned to identifying genes of small effect, which are implicated in such diseases. These confer susceptibility rather than a certainty that the disease will develop. Ultimately (beyond five to ten years) it may be possible to test for genetic variants that confer susceptibility, but much work remains to be done. In these multifactorial, polygenic diseases, multiple genes may interact with each other and the environment and each may have varying, often small effects. To give some idea of the complexity involved, we describe how the potential for biological variation arises and how scientists are seeking to identify associations between genes of small effect implicated in many common diseases.

2.16 We now know that most of the 20,000–25,000 human genes encode more than one, and sometimes several, proteins. This complex feature allows genes to have different functions depending on how they are regulated.[15] Thus, while genes that are implicated in cardiovascular disease, schizophrenia, diabetes and many other common disorders have been identified, our knowledge of their exact biological function remains incomplete.

2.17 The environment can also affect the way in which a person's genome is expressed. A genetic variant which confers susceptibility may increase the risk of a person developing a disease only in the presence of specific environmental factors, such as living conditions, smoking, or a particular diet. Scientists have tended to adopt a strategic approach to gene identification using one of the methods described in paragraphs 2.4 and 2.5 above. At present it is not possible to identify all the genetic variants and environmental factors which contribute to a particular disease, nor analyse which combinations have a significant effect.[16] Linkage studies are only feasible if a particular disease is strongly inherited within families and therefore likely to be strongly correlated with or caused by a single-gene mutation. Instead, gene association studies are commonly used to study populations (see paragraph 2.5). However, there have been concerns about their reproducibility.[17] Large-scale studies are expected to help us obtain a more complete understanding of the familial risks arising from shared genes or a shared environment and of the nature of the genetic interactions.[18] The Wellcome Trust Case Control Consortium was established to analyse thousands of DNA samples from patients suffering from different diseases to identify common genetic variations associated with each condition. Projects such as this will attempt to identify how many genes are involved in the pathology of common diseases, which variations put people at risk, the size of the effects, how these genes may interact with each other and any environmental factors. This is likely to take several years.

2.18 As we have said, we know that there are particular genetic mutations that put people who have them at higher risk of developing certain diseases. We distinguish this category from that where a single-gene mutation will almost definitely result in the presence of the disease usually from birth or early childhood (such as cystic fibrosis). In recent years, variants in genes

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[15] Human Genome Project Information (2005) *The Science Behind the Human Genome Project*, available at: http://www.ornl.gov/sci/techresources/Human_Genome/project/info.shtml, accessed on: 26 Jan 2006.

[16] Bentley DR (2004) Genomes for medicine *Nature* **429:** 440–5.

[17] Hattersley AT and McCarthy MI (2005) What makes a good genetic association study? *Lancet* **366**: 1315–23.

[18] See Hopper JL, Bishop DT and Easton DF (2005) Population–based family studies in genetic epidemiology *Lancet* **366**: 1397–406.

have been identified that predispose individuals to certain types of cancers, such as rare mutations in the *BRCA1* and *BRCA2* genes. If a person has a mutation in either of these genes, they are at higher risk of developing breast cancer during their lifetime. However, additional factors, such as environmental effects and other modulating genes (of smaller effect), appear to be involved. Therefore, unlike somebody with an inherited single-gene disorder, the person will not necessarily develop breast cancer. A particular genetic mutation that confers a high likelihood of disease is said to have high penetrance. For example, women who carry mutations in the *BRCA1* or *BRCA2* genes have a lifetime risk of breast cancer of up to 80 per cent, whereas the usual lifetime risk is 8–11 per cent. Gene mutations with high penetrance such as these are thought to be associated with only a small proportion of cancer cases. It appears that other types of breast cancer are caused by much more common genetic variants of low penetrance (i.e. those that increase a person's likelihood of developing cancer by a small degree). These mutations, acting together with other biological and environmental risk factors, probably account for over 90 per cent of all breast cancers.[19]

Applications: Genetic screening for multifactorial diseases

2.19 In 1993, the Report described population screening for common polygenic, multifactorial diseases as 'probably some way off' and this remains the view of many experts today because of the complexities described above. We have some concerns that commercial and political pressures could result in the premature introduction of programmes for genetic screening of these diseases. Such programmes would need to be carefully evaluated to ensure that the tests are sound; that the magnitude of the risk identified is sufficient to merit a test; that there are no negative consequences such as a change in behaviour; and whether, even if these criteria are satisfied, individuals would act on the results to improve their health (see paragraph 3.14 for a summary of the views of the Government on screening for multifactorial diseases in the 2003 Genetics White Paper). Apart from commercial interests, there may be pressures from lobbying groups for particular disorders whose perspectives on screening may not reflect the overall body of evidence.

Applications: Genetic screening for non-disease traits

Genes influencing normal behaviour

2.20 The 1993 Report covered genetic screening for serious diseases. However, it also highlighted a range of concerns about screening for human traits that are not associated with diseases but which have a genetic component. These traits have received increasing attention over the past 13 years. Researchers in the field of behavioural genetics are attempting to locate specific genes, or groups of genes, associated with behavioural traits and to understand the complex relationship between genes and the environment. The field covers human behaviour within the normal range of variation, including traits such as intelligence, personality, sexual orientation and antisocial behaviour. These kinds of traits are difficult to study because there are usually many genes involved, each of which may only have a small effect. In the Nuffield Council's Report *Genetics and Human Behaviour: The ethical context*, we draw some general conclusions from the research in the areas mentioned above and highlight a number of common themes. These included the difficulty of defining and measuring behavioural traits, the dangers of the misinterpretation and misapplication of heritability estimates, and the lack of replicated findings relating to specific genes.[20]

2.21 As yet, there are no tests that predict human behaviour accurately and there is disagreement about whether such tests could ever be developed. However, some researchers predict that

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[19] Dumitrescu RG and Cotarla I (2005) Understanding breast cancer risk – where do we stand in 2005? *J Cell Mol Med* **9**: 208–21.

[20] See Nuffield Council on Bioethics (2002) *Genetics and Human Behaviour: The ethical context* (London: NCOB).

these difficulties will be overcome and genes that influence behaviour will be reliably identified in the future. Yet, even if genetic tests could not yield predictions of a *definite* outcome, it may nonetheless be possible that tests that suggest an individual will have an *increased chance* of possessing a particular trait to a greater or lesser degree might be developed. Such hypothetical tests could conceivably form the basis for screening programmes for educational or employment purposes in the future. This possibility has raised serious concerns which are discussed in the Council's Report on the topic.

Pharmacogenetics: Genes influencing responses to medicines

2.22 The Council considered the implications of pharmacogenetics on the development and administration of medicines in its Report on the topic. Screening the population or sub-populations to determine the response of individuals to medicines could become feasible as it is already known that some gene variants which modify drug response occur at reasonably high frequencies.[21] However, the pharmacogenetic approach to medicine is unlikely to be in widespread use for another 15–20 years.

[21] See Nuffield Council on Bioethics (2003) *Pharmacogenetics: Ethical issues* (London: NCOB); Royal Society (2005) *Personalised Medicines: Hopes and realities* (London: Royal Society).

Chapter 3

Genetic screening programmes in the UK

Genetic screening programmes in the UK

Introduction

3.1 In this chapter we focus on policy developments relating to genetic screening programmes in the UK since the early 1990s. We begin by describing the establishment of the National Screening Committee (NSC) and the development of criteria for the introduction of national programmes. We then compare the programmes that were available in 1993 with those that are offered today, and also consider the implications of the 2003 White Paper on genetics for genetic screening. Issues raised by identifying carrier status and genetic profiling of the newborn are also briefly discussed.

The National Screening Committee (NSC)

3.2 In its 1993 Report, the Council recommended that further consideration should be given to the process whereby programmes for genetic screening might be introduced into clinical practice. It recommended that the Department of Health, in consultation with the appropriate professional bodies, should formulate detailed criteria for this purpose. It was suggested that the following factors for selection of proposed screening programmes should be taken into account:

- the aims and purposes of the entire programme;
- the predictive power and level of accuracy of the proposed screening test;
- the value to those being screened of the knowledge gained. For each programme this should be determined as an integral part of the follow-up to a pilot programme;
- the availability of therapy for the particular condition, accepting that lack of treatment does not necessarily mean that screening is not worthwhile;
- the potential social implications; and
- the costs of the programme.

The Council advised that screening for different conditions should be reviewed separately by a central coordinating body. Each review should include consideration of pilot studies and ethical issues.

3.3 In 1996, the NSC was established by the Department of Health with the remit to advise the Government on whether screening programmes (genetic or otherwise) should be started, continued or withdrawn. Programmes require ministerial endorsement before they can be established on a national basis. To review the potential effectiveness of new screening programmes, the NSC has developed criteria for appraising viability, effectiveness and appropriateness (see Appendix B). There was some concern that the general criteria developed initially by the NSC did not provide adequate safeguards when applied to genetic disorders. In response, members of the UK genetics community developed principles to guide the consideration of specific issues raised by genetic screening programmes, including the following:[1]

- Implications for members of the wider family.
- The need to be clear about the aims of the programme and the outcome of screening. Decisions should be made before starting the programme about appropriate ways of processing and disclosing possible consequences of the screening other than a simple positive or negative result, such as the generation of information about other conditions or carrier status.

[1] Department of Health (2003) *Our Inheritance, Our Future* (Norwich: TSO), paragraph 3.34.

- The importance of identifying and resolving any ethical issues, such as confidentiality, privacy, consent and those raised by storage and protection of genetic material.[2]

In 2003, the NSC agreed that the criteria should state that if carriers were to be identified as a result of the screening programme under review, the implications for this group should be understood. It also added the requirement that genetic screening programmes should be acceptable to carriers and other family members (see Appendix B).[3] The criteria do not refer specifically to the problem of screening programmes that could generate results about other conditions. However, an existing requirement stipulates that information explaining the consequences of testing should be made available to potential participants.

Developments in genetic screening programmes since 1993

3.4 The 1993 Genetic Screening Report listed 14 disorders for which screening programmes (or pilot studies) had been established at that time. Since then, only a small number of additional genetic screening programmes have been introduced. Table 3.1 compares current screening programmes with those that were available in 1993. Most developments in the 13-year period have concerned the expansion of existing restricted projects or pilot schemes into national programmes. For example, the screening programme for haemoglobinopathies (see paragraph 3.11), is an extension of services that were previously offered to individual families or members of particular ethnic groups (as these disorders occur at a higher frequency in people who have originated from Africa, the Caribbean, the Middle East, Asia and the Mediterranean). Antenatal screening for Down's syndrome was previously only offered in particular localities but is now being standardised across the UK. One of the pilot programmes current in 1993 is now due to be a national programme in the near future (neonatal cystic fibrosis screening), while two others (antenatal cystic fibrosis and neonatal Duchenne muscular dystrophy screening) have not been taken forward on a UK basis. Two additional programmes that included tests being carried out on an *ad hoc* basis (screening for fetal anomalies and neonatal hearing problems) have since been formalised into a UK-wide policy. As Table 3.1 shows, there are some differences in the screening programmes offered by the different countries within the UK. In Scotland, the Scottish Executive is responsible for developing and defining screening policy, taking into account recommendations and advice from the UK NSC.[4]

3.5 The criteria developed by the NSC to review each programme have meant that not all proposed or piloted screening programmes have been adopted. One particularly important criterion is that: 'There should be an effective treatment or intervention for patients identified through early detection, with evidence of early treatment leading to better outcomes than late treatment' (see Appendix B). Thus, there are some genetic diseases for which tests exist but where the benefits of screening have not been judged by the NSC to outweigh the

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[2] The Nuffield Council takes the view that genetic information does not necessarily raise different ethical issues from other types of medical information. The view that genetic information is special and distinctive has been termed 'genetic exceptionalism'. The Council's view is that the most important aspect to consider is the information that a test reveals and its implications for the patient, not whether the information is directly genetic. The HGC has identified seven factors, which although not unique to genetic information, could be used to argue that such information should be treated differently because of their cumulative effect. The HGC considers that genetic information is (1) uniquely identifying and provides information about family relationships; (2) can be obtained from a small sample, possibly taken without consent; (3) can be used to predict future events; (4) may be used for purposes other than those for which it was collected; (5) is of interest to third parties such as employers and insurers, families, friends, potential spouses; (6) may be important for determining susceptibility and effectiveness of treatment; and (7) can be recovered from stored specimens even after many years (see Nuffield Council on Bioethics (2003) *Pharmacogenetics: Ethical issues* (London: NCOB), paragraphs 1.8–1.11) and Human Genetics Commission (2002) *Inside Information: Balancing interests in the use of personal genetic data* (London: Department of Health), paragraph 1.18). The Nuffield Council has observed, however, that the majority of the seven features described have parallels in other areas of medical practice and thus do not support genetic exceptionalism.

[3] Three criteria for assessing new screening programmes were updated (Criteria numbers 4, 9, 22, see Appendix B).

[4] Gray JAM (2003) *Screening in Scotland NSC Programmes Director's Report Summer 2002–Spring 2003*, available at: http://www.show. scot.nhs.uk/sehd/publications/3rdannualreportscotland1.pdf, accessed on: 1 Feb 2006.

potential disadvantages. Serious diseases caused by single genes are quite rare in the population as a whole and therefore the potential risks of testing children and adults, such as causing anxiety, need to be carefully considered if there is no treatment or cure. Antenatal screening is not without physical risk and would also need to be justified. Possible grounds could include the opportunity to prepare parents for an affected baby, the availability of medical intervention (e.g. rhesus disease) or offering termination of an affected pregnancy.

3.6 The NSC has rejected proposals for some programmes. For example, it has reviewed the case for the screening of haemochromatosis, a disorder which causes the body to absorb excessive iron and which, if untreated, can lead to liver or heart problems. One of the criteria for selection states that the epidemiology of the condition should be known. In this case, it was concluded that there was considerable uncertainty about the epidemiology and further research was needed before a programme could be established.[5] Trials are under way to validate safe tests for the condition.

3.7 Other European countries have taken a similarly cautious approach to the introduction of genetic screening programmes. Several countries have introduced legislation on genetic screening, but there appears to have been uncertainty about introducing population-wide programmes. Reported problems include disagreement on the question of whether genetic information and conventional medical information should be regulated in the same way (see paragraph 3.3, footnote 2).[6]

Table 3.1. A comparison of genetic screening programmes in the UK in 1993 and 2005[7]

	Condition	1993: Population screened	Current NSC policy (2005) and implementation
Antenatal	Cystic fibrosis	Pilot studies	Screening should not be offered. The NSC Antenatal Subgroup is currently due to review this policy.
	Down's syndrome	All mothers over 35–37 (chromosome tests on fetus); In some areas, all mothers (serum test)	Screening should be offered to all pregnant women in the second trimester of pregnancy. In 2005, it was reported that the implementation of a national programme was continuing but some areas were yet to establish a programme.[8] **Scotland**: Implementation of first trimester screening is currently under consideration.
	Fetal anomalies[9]	Most fetuses were indirectly screened with ultrasound for congenital malformations	The NSC Fetal Anomaly Screening Group is in the process of assessing the current national service provision for ultrasound screening. **England**: A national programme is planned. **Wales**: All women are offered a fetal anomaly scan at 18–20 weeks of pregnancy.

[5] National Screening Committee (2001) *Evaluation of Haemochromatosis Screening Against NSC Criteria*, available at: http:// rms.nelh.nhs.uk/screening/viewResource.asp?categoryID = 5538&dg = 107&uri = http://libraries.nelh.nhs.uk/common/resources/?id=61006, accessed on: 9 Feb 2006.

[6] Godard B, ten Kate L, Evers-Kiebooms G and Ayme S (2003) Population genetic screening programmes: Principles, techniques, practices and policies *European Journal of Human Genetics* 11: Supplement 2 S49–87.

[7] Information from the NSC (2005) *UK National Screening Committee's Policy Positions July 2005*, available at: http:// www.nsc.nhs.uk/pdfs/policy_position_chart_july05.pdf, accessed on: 7 Feb 2006; and the NHS National Electronic Library for Health, available at: http://libraries.nelh.nhs.uk/screening/, accessed on: 7 Feb 2006. Unless otherwise specified, information refers to the UK. Details are provided for the different countries of the UK where applicable and available.

[8] Gray M (2005) *Screening in the United Kingdom Programme Director's Report Period Summer 2004–Summer 2005* (NHS and UK National Screening Committee).

[9] Not all fetal abnormalities are the result of an inherited genetic disorder.

			Northern Ireland: A decision is yet to be made.
	Haemoglobinopathies, thalassaemias and sickle cell disease (maternal carrier state)	All mothers not of North European origin	**England**: From April 2005, screening should be offered in high prevalence areas (estimated prevalence of sickle cell disorder as 1.5 per 10,000 pregnancies). **Wales**: Women at increased risk to be identified, and then offered test. **Scotland**: Policy under consideration. **Northern Ireland**: A decision is yet to be made (area of low prevalence). In low prevalence areas, a question about family origin is being assessed in pilot projects. The findings will inform policy for implementation in such areas. Almost all of the areas identified as high prevalence in England had implemented the programme by April 2005.
	Rhesus Haemolytic disease	All mothers	Testing is offered routinely.
	Tay-Sachs disease (parental carrier state)	—	The NSC supports screening of at-risk populations. Screening is currently offered to members of those sections of the Jewish population in which Tay-Sachs disease is relatively common.
Neonatal	Cystic fibrosis	Some areas only (pilot stage)	**England**: Screening is to be continued in those areas where it is already established and introduced to other areas by April 2007, following a decision by the Minister of State for Health (as part of newborn bloodspot screening). **Scotland**: Implementation complete, all babies offered screening. **Wales**: Plans to offer screening are in progress. **Northern Ireland**: Biochemical screening has been in place from 1985. DNA screening was expected to be introduced from April 2006.
	Duchenne muscular dystrophy	Pilot studies	The condition was assessed against NSC criteria in 2004 and newborn screening was not recommended. **Wales**: Screening was previously introduced as a pilot project and has been continued.
	Hearing defects (a substantial proportion of severe childhood deafness is monogenic)	Depended on routine assessment	Universal screening has been introduced in over two-thirds of the UK. **England**: It was expected that screening would be offered for all babies by the end of 2005 (indirect screening). **Wales**: Implementation complete. **Scotland**: Expected to be fully implemented by October 2005. **Northern Ireland**: Expected to be fully implemented by October 2005.
	Medium chain acyl coenzyme A dehydrogenase deficiency (MCADD)	—	An evaluative study to examine the effectiveness of MCADD screening as part of newborn bloodspot and to inform future policy has been commissioned. Six laboratories are taking part. Screening should not be offered outside this study. Interim results expected in 2006, final results due in 2008.

	Phenylketonuria	All newborns	Part of newborn bloodspot screening offered for all newborns.
	Sickle cell disease	All newborns in some areas; confined to certain ethnic groups in others (indirect screening)	A programme is being implemented in England as part of newborn bloodspot screening offered for all newborn babies. Coverage estimated at 87% (April 2005). **Wales**: A proposal has been submitted for newborn bloodspot screening. **Scotland**: Screening is under consideration.
Child	Hearing defects (a substantial proportion of severe childhood deafness is monogenic)	As part of routine assessment	The NSC found that, although most cases of hearing impairment should be identified before school entry, some cases are missed. Its Child Health Subgroup therefore recommended that screening in school-age children should continue while further research was being undertaken.
Adult	Breast cancer (contains rare single gene-determined subset)	The NHS Breast Screening Programme started in 1990, and national coverage was achieved by mid-1990s	NHS Breast Cancer Screening Programme offers mammography screening to women aged 50–70 every three years (indirect screening). Women over 70 are encouraged to make their own appointments. **Wales**: The programme was expected to extend to age 70 by March 2006. **Northern Ireland**: Policy confirmed to extend breast screening to age 70 but not yet implemented. Note on familial testing: The NICE guideline on familial breast cancer states that women from families with a 20% or greater chance of carrying a mutation in genes such as *BRCA1, BRCA2* (see paragraph 2.18 of this Supplement) should have access to testing.[10]
	Hyperlipidaemia (contains single gene-determined subset)	—	The NSC supports the current project on cascade screening of the relatives of patients with confirmed familial hypercholesterolaemia. The project is funded by the Department of Health as an initiative under the Genetics White Paper *Our Inheritance, Our Future* 2003.

Screening for monogenic disorders: implications of identifying carrier status

3.8 The introduction since 1993 of newborn screening for certain recessively inherited single-gene disorders, such as cystic fibrosis and sickle cell disease, raises issues concerning the identification of healthy carriers (people who carry one copy of the affected gene, whereas individuals with the disease have two affected copies). There are many more healthy heterozygous carriers of recessively inherited disorders than there are homozygous individuals who are affected: the ratio is often of the order of 100 to 1. Some genetic screening programmes detect carriers, even when the aim of the programme is to identify only the affected homozygotes. For example, in the UK, screening for cystic fibrosis identifies some but not all carriers. A person is only tested for the presence of the cystic fibrosis mutation if an initial biochemical test detects an abnormality. The test reveals some carriers as well as individuals who will actually be affected by the disorder. In the case of sickle cell disorders, the technology currently used to screen newborn babies identifies the majority of carriers. Other screening programmes do not detect carriers. For example, the screening test for

[10] National Institute for Clinical Excellence (2004) *Familial Breast Cancer: The classification and care of women at risk of familial breast cancer in primary, secondary and tertiary care* (London: NICE).

phenylketonuria is based on finding high levels of the amino acid phenylalanine in the blood and as carriers do not have this feature, they are not identified.[11]

3.9 A recent Cochrane Review concluded that there was a need to develop and evaluate best practice for disclosing carrier status to parents following newborn screening.[12] Knowledge of carrier status can lead to testing of the parents and family members, concern about possible affected future siblings if both parents are carriers, the possibility that screening might reveal that the male partner is not the biological father, concern about the child's future reproductive choices and unjustified anxiety about the health of the carrier newborn. Ways of addressing these concerns include the use of tests where available that do not identify carrier status, identifying acceptable ways of disclosing carrier status or identifying acceptable ways of not disclosing carrier status. For children, the HGC has recently recommended that efforts should be made to develop screening techniques that did not reveal carrier status unless to do so would compromise the reliability of the test or where knowledge about carrier status was clinically important.[13]

Our Inheritance, Our Future: the Genetics White Paper (2003)

3.10 Informed by the guidance of an advisory panel, the Government's White Paper on genetics *Our Inheritance, Our Future* (2003) set out the Department of Health's plans for investment in genetic services within the NHS. It described future potential benefits to patients from advances in genetics and aimed to raise awareness of the potential applications of genetics in healthcare. The screening programmes for genetic disorders that were specified are described below. In the Paper, the Government asked the HGC and the NSC to analyse the ethical, social, scientific, economic and practical considerations of genetic profiling at birth. Their joint report was published in 2005 and a brief summary of the conclusions are provided in paragraph 3.15.

Implementation of national screening for inherited blood disorders (haemoglobinopathies)

3.11 Screening for inherited blood disorders was formerly offered on a family basis from specialist centres. In 2000, an NHS Plan announced that a new national antenatal and neonatal screening programme for inherited blood disorders would be implemented by 2004.[14] Subsequently, the 2003 White Paper specified that the programme would include:

- an antenatal screening programme for sickle cell and thalassaemia to offer carrier screening to approximately 200,000 pregnant women a year, initially targeting areas of high prevalence for these diseases; and
- a newborn screening programme for sickle cell disease to cover approximately 320,000 births per year and identify approximately 90 per cent of affected infants.

3.12 Antenatal screening for sickle cell disease and thalassaemia in England is being phased in and will now be offered to all pregnant women as an integral part of early antenatal care by the end of 2005–6. In low prevalence areas, rather than a blood test as a first stage, screening may initially involve the use of an 'ethnic question' to identify women at high risk, followed by the offer of laboratory testing for those identified or who request screening. By April 2005, almost all of the areas identified as high prevalence had implemented the programme.[15]

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[11] See the website of the UK Newborn Screening Programme Centre, available at: http://www.newbornscreening-bloodspot.org.uk/, accessed on: 7 Apr 2006.

[12] Oliver S, Dezateux C, Kavanagh J, Lempert T and Stewart R (2004) Disclosing to parents newborn carrier status identified by routine blood spot screening *The Cochrane Database of Systematic Reviews*, Issue 4 Art. No.: CD003859 pub2.

[13] Human Genetics Commission (2006) *Making Babies: Reproductive decisions and genetic technologies* (London: HGC).

[14] National Health Service (2000) *The NHS Plan: A plan for investment, a plan for reform* (Norwich: HMSO).

[15] NHS Sickle Cell and Thalassaemia Screening Programme *Policy Framework for Antenatal Screening Programme for England* (London: NHS Sickle Cell and Thalassaemia Screening Programme); Gray M (2005) *Screening in the United Kingdom Programme Director's Report Period Summer 2004 – Summer 2005* (NHS and UK National Screening Committee).

Enhancement of existing screening for Down's syndrome and deafness

3.13 The White Paper also announced the enhancement of two existing screening programmes for genetic disorders and pledged that they would be fully implemented in England by 2004–5. The programmes would:

- offer all pregnant women antenatal screening for Down's syndrome, together with counselling by midwives to help those affected make a choice about whether to continue with the pregnancy; and
- test all babies for hearing defects using the otoacoustic emissions test and/or auditory brain stem response (some of the hearing problems which are detected will have a genetic cause).

These programmes have been expanding nationally and estimates of current coverage are included in Table 3.1.

Screening for multifactorial diseases

3.14 As we have said in Chapter 2, although some way off, it may be possible in the future to use genetic screening to identify people who have an increased susceptibility to common multifactorial diseases, such as heart disease or cancer. Concerns about this possibility were highlighted in the 2003 White Paper.[16] It was recognised that it is as yet unclear what benefits may accrue from alerting those people who have a higher genetic risk of such diseases. Whether the information would make them more likely to change their lifestyle or take other preventive measures is unknown. Indeed, there are fears that the opposite effect might be achieved, as people might think that preventive action is not worth taking because they are certain to develop the condition.[17] Furthermore, people whose test results indicate they are not at high risk may be more inclined to participate in harmful behaviour, such as smoking. The White Paper acknowledges that research will be needed to answer these questions.

Genetic profiling at birth

3.15 The White Paper also discussed the possibility of offering screening for babies at birth 'to produce a comprehensive map of their key genetic markers, or even their entire genome'. This 'genetic profile' could be securely stored on an electronic patient record and used throughout a person's lifetime to tailor prevention and treatment regimes to their needs. To assess the potential feasibility and desirability of this approach, the Government asked the HGC and the NSC to conduct an initial analysis of the ethical, social, scientific, economic and practical considerations of genetic profiling at birth. In their report, *Profiling the Newborn* (2005), a Joint Working Group concluded that there were significant ethical, legal and social barriers to the introduction of genetic profiling of the newborn as a public health service. There were concerns that information revealed might stigmatise people and lead to discrimination or be used by the police for unwarranted purposes.[18] The report concluded that genetic profiling at birth is unlikely to be publicly affordable within the next 20 years, though commercial services are likely to become available within this time. The introduction of genetic profiling was therefore not recommended.

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[16] Department of Health (2003) *Our Inheritance, Our Future* (Norwich: TSO), paragraph 3.35.

[17] A small number of studies in this area have been performed. For example, see Senior V, Marteau TM and Peters TJ (1999) Will genetic testing for predisposition for disease result in fatalism? A qualitative study of parents' responses to neonatal screening for familial hypercholesterolaemia *Soc Sci Med* **48**: 1857–60.

[18] Joint Working Group of the Human Genetics Commission and the UK National Screening Committee (2005) *Profiling the Newborn: A prospective gene technology* (London: HGC).

Chapter 4

Delivery of genetic screening services

Delivery of genetic screening services

Introduction

4.1 In its White Paper on genetics, *Our Inheritance, Our Future* (2003), the UK Government pledged to provide funding to support the expansion of genetics into mainstream NHS services, including a small number of genetic screening programmes (see paragraphs 3.11–3.13). In this chapter, we describe the current framework for the delivery of genetic services and more specifically, genetic screening programmes. We reflect on a possible expanded role for primary care in the delivery of genetic screening programmes in the future.

Delivery of genetic screening services

4.2 Currently, most genetic testing in the UK takes place in about 25 NHS Regional Genetics Centres, which offer clinical diagnoses, laboratory testing and counselling services for individuals and their families, usually on one site.[1] Each centre serves a population of two to six million people. By contrast, population genetic screening is delivered by services such as those listed in Table 4.1. Screening programmes include tests that analyse genetic material and also indirect tests such as physical, biochemical or ultrasound assessments (e.g. for Down's syndrome or fetal anomalies) that do not require specialist genetics laboratories. Primary Care Trusts are responsible for ensuring that members of their population are offered the opportunity to participate in the national screening programmes.[2]

4.3 For pregnant women, the doctor or midwife at the antenatal clinic is responsible for explaining the type of screening tests offered, and the implications of the results. This may include presenting the option of termination of the pregnancy if, for example, Down's syndrome is confirmed.

4.4 Genetic screening of newborn babies for the conditions listed in Table 3.1 is carried out by the midwife within five to eight days of the birth. A health professional will usually inform parents of the screening result and record it in the baby's health records by the time the child is six to eight weeks old. If the tests indicate cystic fibrosis, PKU or sickle cell disease, parents would be contacted within six weeks and given an appointment to see a specialist.[3]

Cascade screening

4.5 Cascade (or family) screening can be viewed as a bridge between the testing of individuals and population screening. Screening for carrier status (see paragraphs 3.8–3.9) may be offered to the parents of a child diagnosed with a genetic disorder. Whenever a carrier is detected, tests can then be made available to their relatives. In this way, testing is 'cascaded' out since the carrier risk of relatives of a person diagnosed with a genetic disorder is generally higher than the population risk. At present, this form of screening is usually initiated by concerned individuals and families contacting their general practitioners who may then refer them to a Regional Genetics Centre. This form of screening has led to debate over how tests should be offered; whether for example it would be preferable for the approach to come from relatives or from healthcare professionals.

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[1] DNA tests for around 300 rare single gene disorders are offered by the NHS. See Parliamentary Office of Science and Technology (2004) *Postnote No. 227–NHS Genetic Testing* (London: POST).

[2] Genetics Commissioning Advisory Group, Department of Health (2002) *Genetic Services: A guide for Primary Care Trusts*, available at: http://www.dh.gov.uk/assetRoot/04/11/89/33/04118933.pdf, accessed on: 22 Feb 2006.

[3] NHS Antenatal and Newborn Screening Programmes (2005) *Newborn Blood Spot Screening for Your Baby* (NSC).

Table 4.1. Examples of the specialist services involved in delivering genetic screening programmes in the UK

Disorder	Type of test	Taking sample/providing information	Specialist Laboratory service
Down's syndrome			
Antenatal	Biochemical markers and ultrasound observation	Antenatal clinic staff	Biochemistry
Antenatal	Cytogenetic (where pregnancy is identified as high risk)	Antenatal clinic staff	Cytogenetics
Sickle cell disease/thalassaemia			
Antenatal	Parental phenotypes and in some cases, genotypes	Antenatal clinic staff/haemoglobinopathy counsellor	Molecular genetics
Neonatal	Haemoglobin Phenotype analysis	Midwife/health visitor	Haematology
Cystic fibrosis			
Neonatal	Biochemical followed by DNA test	Midwife/health visitor	Biochemistry Molecular genetics

4.6 Cascade screening is more efficient than population screening, in the sense that fewer individuals have to be genotyped per detected carrier. However, the efficacy of cascade screening, as measured by the overall proportion of carriers detected in a given population, is lower than that for population-wide screening.[4] Identification of carriers of cystic fibrosis and testing for familial hypercholesterolaemia and genes that confer a susceptibility to forms of familial cancer are examples of cascade screening that are either currently being evaluated or are in place.

Delivery to sub-populations

4.7 Some genetic conditions are more common in people from particular ethnic groups, raising the question of whether screening programmes should be offered only to members of relevant sub-populations. For example, antenatal genetic screening for Tay-Sachs disease is currently offered to members of those sections of the Jewish population in which the disease is relatively common (see Table 3.1). This approach is not without its critics; it has been suggested that screening of specific ethnic groups could lead to stigmatisation of a sub-group based on its genetic identity or lead to cases being missed because others are not included in screening programmes. Universal screening may be more equitable in terms of the likelihood of identifying cases and assuring quality, but would generally be resource-intensive. It may also lead to large numbers of people receiving false-positive results arising from screening populations which have a low prevalence of disease.

The private sector

4.8 The majority of testing in the UK occurs within the NHS rather than in the private sector. In 2003, the HGC published the results of a survey about the provision of genetic tests more generally, which found that the majority of respondents supported a major role for the NHS.

[4] Krawczak M, Cooper DN and Schmidtke J (2001) Estimating the efficacy and efficiency of cascade genetic screening *Am J Hum Genet* **69**: 361–70.

The HGC concluded 'that there should be a well-funded NHS genetics service supported by a genetically literate primary care workforce, which can properly manage and allow access to new predictive genetic tests that are being developed'.[5]

4.9 One area where the private sector plays a role is that of antenatal screening for Down's syndrome for those people who decide to pay for private antenatal care or who have private health insurance. Some private healthcare providers could offer genetic screening in the future as part of their more general health screening service. As more becomes known about the human genome, it seems likely that opportunities for involvement of the private sector in genetic testing and screening will increase. We note that as the costs of DNA sequencing fall, the availability of affordable 'personalised genome sequencing' could precede our ability to apply the information in a clinically useful way by several years (see also paragraph 3.15).

4.10 At present, it is not clear that there will be any major demand for screening of serious genetic diseases by the private sector if a satisfactory service already exists through the NHS. However, a commercial market for testing of genes that confer susceptibility to multifactorial diseases may develop (see paragraph 2.19). Use of the Internet is now commonplace for patients wishing to learn more about their health problems and they may either seek or encounter advertising for genetic tests, some of which could be misleading. To help avoid such exploitation of vulnerable groups, which would include the young, the elderly and the 'worried well', the HGC has recommended that the commercial providers of genetics services should be encouraged to make responsible claims by following the codes of practice set out by the Advertising Standards Authority.[6]

Strengthening capacity in genetics services

4.11 The White Paper (2003) committed the Government to making an investment of £50 million in England to develop genetics knowledge, skills and provision within the NHS. Three main areas of improvement were identified:

- to strengthen existing specialised services;
- to modernise laboratories and fund more staff to provide the infrastructure to meet increased demands for testing; and
- to incorporate genetics into mainstream services: new initiatives in genetics-based care in the hospital sector, primary care and in screening programmes.

4.12 The commitments in the White Paper included setting up an NHS Genetics Education and Development Centre to drive and coordinate activity in training and education in genetics for NHS healthcare staff. The Centre is now established and managed by Birmingham Women's Healthcare Trust.[7] The White Paper also announced funding for the training of more clinical geneticists and genetic counsellors, a fellowship scheme and a training programme for healthcare commissioners. Additionally, funding for the introduction of ten part-time posts for general practitioners 'with a special interest in genetics' has since been awarded to ten

[5] Human Genetics Commission (2003) *Genes Direct: Ensuring the effective oversight of genetic tests supplied directly to the public* (London: Department of Health), paragraphs 3.29–3.30.

[6] Human Genetics Commission (2003) *Genes Direct: Ensuring the effective oversight of genetic tests supplied directly to the public* (London: Department of Health), paragraph 3.59.

[7] See the National Genetics Education and Development Centre website, available at: http://www.geneticseducation.nhs.uk/, accessed on: 22 Feb 2006.

[8] Department of Health (2005) *Genetics White Paper–GPs with a Special Interest in Genetics*, available at: http://www.dh.gov.uk/assetRoot/04/10/61/56/04106156.pdf, accessed on: 10 Apr 2006.

Primary Care Trusts. A number of the recipients name genetic screening as one of their areas of clinical interest.[8]

Expansion of the number of genetic screening programmes and the potential role of primary care

4.13 Screening programmes are necessarily larger in scale and generate more patient information than genetic testing of individuals. Any new programmes would result in an increased demand for counselling for affected individuals and carriers. Practical aspects of delivering new programmes, such as from where the offer of screening should come, which NHS staff should provide the service, whether specialist genetics services might be adapted to follow up from initial screening tests, or how standards might be harmonised would need to be addressed.

4.14 We consider that family doctors and other primary care staff are especially well placed to provide written and face-to-face information on genetic screening services for children and adults. The provision of clear, accurate written information, including Internet sources, will be of the utmost importance for both practitioners and patients, because if any new population-wide programmes were implemented, it is unlikely to be practicable to provide a personalised service for every person screened. We note the resources regarding neonatal screening currently provided on the UK Newborn Screening Programme Centre website.[9]

4.15 The extent to which primary care services could be responsible for the *actual* delivery of any new genetic screening programmes is unclear, particularly given the need for effective screening programmes to be uniform over a large population. Bringing about the necessary educational changes beyond the regional centres (see also paragraph 5.23–5.25) will be critically important because different professional groups in healthcare may be unfamiliar with the approaches that have been developed by clinical geneticists over the past ten years. These include the need to spend more time with each patient and the routine taking of family histories.

4.16 The increasing involvement of primary care in the commissioning of specialist services raises important issues about coverage of populations and the need for uniform standards in screening programmes. The Regional Genetics Centres may need to play a leading role in setting standards and models for wider genetic screening. Specialist staff from the centres would be well placed to liaise with staff in primary care or other outlets, to provide or advise on educational matters and the implementation of other aspects of the delivery of screening. Such specialists could include genetic counsellors and in some regions, antenatal and child health coordinators. The cost-effectiveness of transferring specialist care models for the delivery of wider primary care services merits further consideration.

[9] See the UK Newborn Screening Programme Centre website, available at: http://www.newbornscreening-bloodspot.org.uk/, accessed on: 24 Feb 2006.

Chapter 5

Consent, confidentiality, counselling and education

Consent, confidentiality, counselling and education

5.1 Issues relating to consent and confidentiality were particularly prominent at the time of the 1993 Report because there were concerns that they were not being considered adequately in practice. As we have said, genetic information, such as that revealed as a consequence of genetic screening programmes, differs from other forms of medical information in several ways. The results could have implications for relatives of the person who has been screened and for future reproductive choices of both the individual and members of his or her family. Additionally, the information could be of material interest to third parties including insurers and employers. It is therefore crucial to provide appropriate information before a screening test about the possible consequences of an abnormal result. In this chapter, we consider issues surrounding consent, confidentiality and counselling, particularly in the light of developments that have taken place since 1993.

5.2 The legal framework for genetic screening has also changed since the publication of the 1993 Report. A number of Acts of Parliament have been passed that could have an impact upon the provision and practice of genetic screening. The Human Rights Act 1998, the Data Protection Act 1998 and the Human Tissue Act 2004 will all have a bearing on consent and confidentiality issues for both genetic testing and screening.

Consent

5.3 The 1993 Report recommended that adequately informed consent should be a requirement for all genetic screening programmes (see also Appendix A). In this section we consider subsequent developments relating to consent. The Council has concluded in reports published since 1993 that the ethically significant requirement of consent is not that it should be complete, but rather that it should be genuine.[1] An important and necessary prior condition is the provision of information to the participant to allow reflection, questioning and further explanation. There is, therefore, an obligation on the test provider to communicate appropriately the nature of the information likely to be revealed and its possible implications for the participant. In practice, consent can only ever be given to actions that are incompletely described. Additionally, the descriptions offered may be incompletely understood. It is unlikely that this incompleteness could ever be remedied for everyone by, for example, devising more elaborate consent forms. Fully informed consent may, therefore, be thought of as an unobtainable ideal, against which, in practice, adequate and genuine consent may be judged.

Provision of information

5.4 Trying to obtain genuine consent is particularly pertinent to genetic screening, when the information revealed may be serious, complex and unfamiliar to the participant. It requires medical practitioners to do their best to communicate accurately as much as patients, volunteers or relatives can understand about procedures and risks. Practitioners need to react to the capacity of the people with whom they are communicating to deal with difficult information. If all reasonable care is exercised, adequate and genuine consent may be established.

5.5 With regard to the current provision of information as part of antenatal screening services, the HGC reports evidence that midwives and ultrasonographers may offer screening in such a

[1] Nuffield Council on Bioethics (1995) *Human Tissue: Ethical and legal issues* (London: NCOB), paragraph 6.19–6.21; Nuffield Council on Bioethics (2003) *Pharmacogenetics: Ethical issues* (London: NCOB), paragraph 5.16.

routine manner that it becomes normal practice rather than a considered choice.[2] The HGC therefore endorses guidelines from the National Institute for Clinical Excellence that the relevant health professionals should emphasise that participation is voluntary.[3]

5.6 The issue of screening programmes becoming 'routine' would need to be considered if any new programmes were to be introduced for common diseases across large sections of the population. A consequence could be that health professionals would be unable to spend adequate time discussing the implications of any possible abnormal results with participants. It would also be important not to cause unnecessary anxiety as participants in screening programmes are not expected to be at any greater risk than the general population risk (see definitions of screening and testing in Box 1.1). These factors would need to be considered as part of the consent process if any new screening programmes for common diseases were introduced via primary care (see paragraph 4.13–4.16).

5.7 Advances in technology based on DNA chips (see paragraph 2.6) will mean that a number of genetic disorders and multiple variants of specific genes could be tested for simultaneously. This would make it increasingly difficult to inform participants adequately about all the possible implications of such a test. Consequently, consideration would need to be given before their introduction as to how appropriate information could be provided.

Legal developments and guidance from other organisations and the Government

5.8 Since 1993, several other bodies have considered the issue of obtaining consent before a genetic test is undertaken. For example, the House of Commons Science and Technology Select Committee recommended that genetic screening should not be undertaken without the consent of the individual being screened, particularly when disorders could not be treated.[4] In 1998, the General Medical Council (GMC) also recognised that the uncertainties involved in screening healthy or asymptomatic people may be substantial. It therefore stipulated that doctors should ensure that anyone considering whether to consent to screening can make a properly informed decision and that particular attention must be paid to ensure that the information 'the person wants or ought to have is identified and provided'.[5]

5.9 Changes in the law since the publication of the 1993 Report have raised new questions. There could be implications for genetic screening arising from the Human Tissue Act 2004, the implementation of which will fall to the newly formed Human Tissue Authority (HTA). There is a requirement under the Act for 'qualifying consent' to authorise analysis of human DNA (Section 45) except for a number of 'excepted purposes'. These purposes include 'the medical diagnosis or treatment of the person whose body manufactured the DNA' and 'public health monitoring'. It is therefore as yet unclear whether it would be acceptable under the Human Tissue Act to conduct screening programmes without obtaining consent. However, we note that the Human Tissue Act does not replace the requirements for consent for use of personal data in the Data Protection Act 1998. The uncertainty of the relationships between these pieces of legislation exemplifies the growing complexity of the regulatory system since 1993 as it applies to genetic material and information. We note that there may be wide-reaching effects of these various Acts that go beyond those that were intended.

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[2] The House of Commons Science and Technology Select Committee expressed a similar concern should screening of adults for a range of disorders became a possibility. See House of Commons Science and Technology Committee (1995) *Human Genetics: The science and its consequences* (London: HMSO), paragraph 98.

[3] Human Genetics Commission (2006) *Making Babies: Reproductive decisions and genetic technologies* (London: HGC), paragraph 3.32.

[4] House of Commons Science and Technology Committee (1995) *Human Genetics: The science and its consequences* (London: HMSO), paragraph 98.

[5] General Medical Council (1998) *Seeking Patients' Consent: The ethical considerations*, paragraph 33–34.

Obtaining consent from those without capacity

5.10 The 1993 Report concluded that the screening of individuals who were unable to give 'properly informed' consent (minors, the mentally ill and those with severe learning difficulties) required special safeguards. Since then, several other bodies have provided guidance in this area. For example, on genetic testing, the HGC recently confirmed its position that great caution should be observed in the testing of children for late-onset disorders or in situations where they may not benefit directly.[6]

5.11 As regards adults who lack capacity, the Nuffield Council in 1998 concluded that genetic screening programmes to detect susceptibility to mental disorders were very unlikely to be possible. More generally, the Council took the view that, for a person deemed mentally incompetent to make his or her own treatment decisions, a doctor must act in that patient's best interests, although there are difficulties in determining them.[7] Other developments have focused on genetic testing rather than screening. For example, the HGC concluded that it would be ethically acceptable to carry out genetic tests on an individual who was unable to consent, if those tests were required for treatment to be provided and were in the individual's best interests.[8]

5.12 Similar provisions were set out in law in the Mental Capacity Act 2005, which aims to provide a statutory framework to empower and protect vulnerable people who are unable to make their own decisions.[9] The basic principles of the Act include: a person is assumed to have capacity unless it is established otherwise; a person is not to be treated as unable to make a decision merely because s/he makes an unwise decision; and that if an act is carried out or a decision made for a person who lacks capacity, it must be done in his/her best interests.

Confidentiality

5.13 Potentially difficult problems exist in applying the longstanding ethical principle of confidentiality between the professional and the individual who is screened (or the parents in situations of antenatal and neonatal screening). In 1993, the Council recommended that when genetic screening reveals information with implications for relatives, health professionals should seek, if necessary, to persuade individuals to allow the disclosure of relevant genetic information to other family members. In exceptional circumstances, when an individual cannot be persuaded to inform family members with a legitimate right to know, the individual's desire for confidentiality might be overridden. This approach to confidentiality accepts that, while information is assumed to be confidential, there are some occasions where the benefit of disclosure substantially outweighs the patient's claims to confidentiality. Most bodies considering this issue have since advised that the circumstances when an individual's confidentiality can be overridden should be exceptional and well documented. On such occasions, clinicians need a valid reason to override confidentiality and disclose medical information to a third party without consent. In the UK, the HGC, the GMC and the Department of Health have endorsed this approach.[10] The House of Commons Science and Technology Committee, however, concluded in the context of genetic diagnosis generally that 'the individual's decision

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[6] Human Genetics Commission (2006) *Making Babies: Reproductive decisions and genetic technologies* (London: HGC), paragraph 3.50.

[7] Nuffield Council on Bioethics (1998) *Mental Disorders and Genetics: The ethical context* (London: NCOB), paragraph 8.23.

[8] Human Genetics Commission (2002) *Inside Information: Balancing interests in the use of personal genetic data* (London: Department of Health), paragraph 4.48.

[9] Department of Health *Mental Capacity Act 2005 – summary*, available at: http://www.dh.gov.uk/assetRoot/04/10/85/96/04108596.pdf, accessed on: 13 Apr 2006.

[10] Human Genetics Commission (2002) *Inside Information: Balancing interests in the use of personal genetic data* (London: Department of Health), paragraph 3.62; Department of Health (2003) *NHS Code of Practice; Confidentiality*, Annex B, paragraph 30; General Medical Council (2004) *Confidentiality: Protecting and Providing Information*, paragraph 22.

to withhold information should be paramount'.[11] Taking the same stance, the Human Tissue Act 2004 (Section 45) does not appear to allow overriding an individual's consent and confidentiality as regards the analysis of their DNA to assist relatives. At present, the overriding of confidentiality happens very rarely in the UK, probably because counselling and other discussions with the healthcare team give patients the opportunity to deepen their understanding of their genetic condition and its implications for others.

5.14 It may be helpful to define what constitutes a 'valid reason' and the way in which such decisions should be taken. Proposals for what might constitute validity for overriding consent should be sensitive to whether or not the knowledge in question could be acquired, or conveyed, in some other way, without breaking confidence and what the consequences of a failure to inform the relative might be. Only in circumstances that met criteria relating to these issues would doctors be justified in breaching their obligation of confidentiality. Guidance from the GMC emphasises the importance of informing the individual about the breaking of confidentiality before the information is disclosed.

5.15 An alternative approach for information sharing has recently been proposed.[12] Recognising that genetic information is shared by more than one individual, it has been suggested that its use should be analogous to a joint bank account where relevant information is not withheld from account holders without good reason. Instead of an assumption of confidentiality, this model assumes that relevant information will be disclosed to all affected parties unless there is good reason (such as risk of harm) for it to be withheld.

Legislative changes

5.16 Since the 1993 Report, several legislative changes that may have an impact upon confidentiality in programmes for genetic screening have been passed. The relevant Acts are briefly introduced below. In addition, case law has produced a 'common law of confidentiality', whereby confidential information should not be used or disclosed further without the permission of the person involved. However, certain exceptional legal judgements have reached similar conclusions to the 1993 Nuffield Report and the other bodies mentioned in paragraph 5.14, establishing that confidentiality can be breached 'in the public interest'.[13]

5.17 The right to respect for a private and family life is enshrined in the Human Rights Act 1998, Article 8(1). However, the provision for derogation in Article 8(2) means that a public authority may override this right if necessary for 'the protection of health or [. . .] the rights and freedoms of others'. The NHS Code of Practice on Confidentiality states that compliance with the Data Protection Act 1998 (see below) and the common law of confidentiality should meet the requirements of the Human Rights Act. The Code emphasises that actions that interfere with the right to respect for private and family life must be proportionate to the need, which could result in differences in interpretation.[14]

5.18 The Data Protection Act 1998 was introduced in order to regulate the obtaining, holding, use or disclosure of personal information. It offers a high degree of protection to an individual's genetic data. The Act establishes a right for individuals to have access to data that are being held about them. It has been observed that health professionals may hold information directly pertinent to relatives of a person who has consented to be screened. The Information Commissioner has provided clarification to the Council that if a health professional discovers,

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[11] House of Commons Science and Technology Committee (1995) *Human Genetics: The science and its consequences* (London: HMSO), paragraph 228.

[12] Parker M and Lucassen A (2004) Genetic information: A joint account? *BMJ* **329**: 165–7.

[13] Department of Health (2003) *NHS Code of Practice: Confidentiality*, paragraph 30.

[14] Department of Health (2003) *NHS Code of Practice: Confidentiality*, paragraphs 33–5.

through genetic techniques, information that has a bearing on a person's genetic line, the Act does not impose an automatic obligation on the health professional to tell their relatives.[15]

Genetic counselling

5.19 The 1993 Report recommended that genetic counselling should be readily available for those being screened for a genetic disorder, as well as for those being tested on account of a family history of a genetic disorder. Over the past 13 years, genetic counselling has been increasingly incorporated into clinical practice by genetics specialists. However, there are some concerns that the wider medical profession is not sufficiently aware of the issues raised by genetic screening. We note in paragraph 4.13 that any new screening programmes for adults would result in an increased demand for counselling. We also conclude in paragraph 5.7 above that if any new programmes were to be introduced for common diseases, a consequence could be that health professionals would be unable to spend adequate time discussing the implications of any abnormal results with participants.

Training and professional bodies

5.20 Most, but not all, genetic counselling in the UK is currently provided in Regional Genetic Services by multi-disciplinary teams that include medical geneticists and specialist genetic counsellors. The Genetics White Paper (2003) committed funding for a new scheme to train over 50 new counsellors over five years.[16] The White Paper also supported moves to give genetic counsellors 'a strong professional identity'. The Association of Genetic Nurses and Counsellors (AGNC) was founded in 1995 and represents genetic associates, nurses, counsellors and other non-medical staff working within clinical genetics. The organisation aims to provide support for professionals, to encourage education and to prescribe good standards of clinical practice. The AGNC has recently introduced a professional registration process.

5.21 In addition to the AGNC, the Haemoglobinopathy Association of Counsellors (known as STAC) is an organisation for counsellors and other professionals dedicated to providing a service and support for those who are 'at risk' of sickle cell disease, thalassaemia and related conditions. The STAC aims to improve awareness, especially among ethnic communities at greatest risk, to further education of healthcare professionals and to participate in research.

Genetics education

Healthcare professionals

5.22 The 1993 Report recognised that if screening were to be more widely introduced, it would require diffusion of a wider understanding of genetics, in particular among those engaged in primary healthcare. More generally, the White Paper (2003), for example, describes how 'provision and coverage of genetics within training courses is patchy'.[17] A review in 2002 by the Public Health Genetics Unit in Cambridge concluded that education in genetics for health professionals throughout the UK had not kept abreast with scientific and clinical progress.[18]

5.23 The White Paper recognised the need to spread knowledge across the NHS, recommending the integration of genetics in undergraduate and pre-specialisation courses and emphasising the need to raise awareness of the potential of genetics with all clinical groups (see also paragraphs 4.11–4.12). One of the aims of the six Genetics Knowledge Parks that have been established was to encourage an understanding of genetics among healthcare professionals.

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[15] Personal communication from the Information Commissioner in response to the Council's Report on *Pharmacogenetics: Ethical Issues* (2004).

[16] Department of Health (2003) *Our Inheritance, Our Future* (Norwich: TSO), paragraph 2.9.

[17] Department of Health (2003) *Our Inheritance, Our Future* (Norwich: TSO), paragraph 4.4.

[18] Burton H (2002) *Education in Genetics for Health Professionals: Report to The Wellcome Trust* (Cambridge: Public Health Genetics Unit).

5.24 A recent study by the Public Health Genetics Unit, Cambridge, funded by the Wellcome Trust and the Department of Health, proposed a strategy for advancing the dissemination and application of genetics knowledge throughout the health professions. *Addressing Genetics: Delivering health* (2003) recommended the establishment of a national steering group and centre for genetics education, as well as a formal education programme for genetics.[19] Several professional groups have also developed initiatives to encourage wider training in genetics.[20]

Public understanding of genetics

5.25 Evidence in 1993 suggested that there was widespread misunderstanding of genetics among the public. The Report recommended that public bodies should encourage a greater awareness and understanding of genetics and that the topic should be included in the National Curriculum.

5.26 There has been increasing recognition of the importance of public understanding of, and engagement with, science over the past decade. In 2000, the House of Lords Select Committee on Science and Technology Report, *Science and Society*, described a 'crisis of confidence' in the relationship between science and society and stressed the importance of dialogue in promoting understanding between scientists, the public and other groups.[21] Since then, research councils, research charities and bodies such as the Royal Society have paid increasing attention to their role in improving public engagement and understanding of science. Several recent initiatives in this area have been established (see Appendix C).

5.27 The Genetics White Paper (2003) also acknowledged the importance of increasing people's awareness and understanding of the potential of genetics to improve health. Over three years, £200,000 funding was committed to the Progress Educational Trust (see Appendix C) and £1,000,000 to a series of events to celebrate the 50th anniversary of the discovery of the structure of DNA in 2003.[22] The influential role of the media was also acknowledged and it has been observed that the BBC has made human genetics the subject of a number of 'responsible and accessible' television and radio programmes.[23] There is also a large amount of educational material available on the BBC website. The Science for Public Understanding AS Level, the new Nuffield Twenty-First Century Science GCSE courses and the new curriculum subject, Citizenship, all include topics aimed at encouraging discussion in the classroom about the impact of genetics.

5.28 In 2002, the Department of Health announced the setting up of the six Genetics Knowledge Parks mentioned above 'to put Britain at the leading edge of advances in genetic technology which could transform treatments and services for NHS patients' (see paragraph 5.24).[24] Part of their remit is to encourage local debate about ethical and social implications of advances in human genetics.

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[19] Burton H (2003) *Addressing Genetics Delivering Health: A strategy for advancing the dissemination and application of genetics knowledge throughout our health professions* (London: Department of Health and The Wellcome Trust).

[20] For example, the British Society of Human Genetics has drawn up learning objectives for undergraduate medical curricula; the Joint Committee on Medical Genetics of the Royal Colleges and the British Society for Human Genetics has commissioned work to devise competencies for key types of specialist registrar; a group under the auspices of the Royal College of General Practitioners has drafted guidance for General Practitioner Vocational Training Courses; the Department of Health has funded a study which sets out different levels of competencies that may be acquired by nurses helping patients with genetic disorders; and the PEGASUS network of training and education centres provides training for healthcare professionals involved in sickle cell and thalassaemia screening programmes.

[21] House of Lords Science and Technology Committee (2000) *Third Report – Science and Society* (Norwich: HMSO).

[22] Department of Health (2003) *Our Inheritance, Our Future* (Norwich: TSO), paragraph 6.21.

[23] Department of Health (2003) *Our Inheritance, Our Future* (Norwich: TSO), paragraph 6.16.

[24] Department of Health (16 Jan 2002) Press Release *Britain must be at the leading edge of genetics – Milburn* (London: Department of Health), available at: http://www.dh.gov.uk/PublicationsAndStatistics/PressReleases/PressReleasesNotices/fs/en?CONTENT_ID=4013031&chk=7neKRv, accessed on: 5 May 2006.

5.29 Public debate about issues related to genetic testing and screening remains essential and this discussion must be well informed. Although both awareness of genetics and basic understanding of inheritance have improved over the past 13 years, there is still much confusion and misrepresentation of some information. It is not enough to make accurate information readily available: a person being screened needs to be able to understand that information and its significance, including the nature of genetic predisposition.

5.30 Research which claims to show an association between particular genetic variants and particular traits tends to receive significant attention in the scientific and lay media. Concerns remain that some reporting may give a misleading impression to the reader. Claims of discoveries are consistently exaggerated and the lack of reporting of negative or contradictory findings exacerbates this problem. The Council, in its Report *Genetics and Human Behaviour: The ethical context*, recommended that researchers and those who report research have a duty to communicate findings in a responsible manner and encouraged further initiatives in this area.[25] The Social Issues Research Centre, the Royal Society and the Royal Institution have published guidelines on *Science and Health Communication* which aim to improve the reporting of science news.[26]

5.31 The media has given much of its attention to single-gene disorders. However, this focus has often resulted in misleading explanations. In particular, the use of shorthand phrases such as 'a gene for X' are prevalent but not helpful. Such simplistic terminology can result in a poor understanding of the nature of genetics. It is increasingly necessary to convey information about multifactorial conditions, raising awareness of the complexity of many diseases that depend on interactions between several genes and the environment. The potential for unnecessary anxiety and discrimination will be as relevant for tests for multifactorial conditions as it is for directly inherited single-gene disorders.

5.32 A broad public understanding of the scientific basis of medical genetics is essential if informed public policy decisions are to be taken about the introduction of genetic screening programmes. Public understanding will have an influence on policy making and it is therefore crucial that policy makers are aware of the dangers of 'genetic hype'. Patient support and other lay groups also have a role to play, both in providing information and influencing policy making. Recently, there has been increasing emphasis on consultation with the public, for example the HGC has established a consultative panel (see Appendix C) composed of people affected by genetic disorders to provide advice.

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[25] Nuffield Council on Bioethics (2002) *Genetics and Human Behaviour: The ethical context* (London: NCOB), paragraph 11.14.

[26] Social Issues Research Centre (2001) *Guidelines on Science and Health Communication*, available at: http://www.sirc.org/news/guidelines.shtml, accessed on: 25 July 2005.

Chapter 6

Implications of genetic screening for employment and insurance

Implications of genetic screening for employment and insurance

Introduction

6.1 The possible implications of screening for both employment and insurance were discussed in the 1993 Report. Although there was no evidence that inappropriate applications or misuse of data were taking place in either area at this time, there were concerns about the potential for this to occur in the future. The topic remains controversial and is the subject of a number of reports published since 1993 which focus on the use of genetic knowledge in the workplace and for the purposes of insurance. Although there is little reported use of genetic screening in these contexts, new guidelines and policy developments have set out important principles that would be relevant to any programmes for genetic screening for risk factors, late-onset disorders or common diseases that may be introduced in the future.

Employment

The current situation

6.2 The 1993 Nuffield Report recommended that genetic screening of employees for increased occupational risks ought only to be contemplated where there was strong evidence that the working environment was linked to the development of the condition that was being screened for. For screening to be acceptable, the condition would have to be such that it could seriously endanger the health of the employee or where the affected person could present a serious danger to others. The condition should also be one for which the dangers could not be eliminated by reasonable measures taken by the employer.

6.3 Thirteen years after the original Report, there appears to be no evidence that UK employers are carrying out systematic genetic screening (or testing) or using genetic test results in recruitment or occupational health schemes. The single genetic screening programme that was in use in the UK at the time of the 1993 Report (screening of aircrew recruits for sickle cell carrier status by HM Forces) is no longer standard practice, although individuals may be tested on the basis of clinical indication.[1] We have already concluded that widespread screening programmes for common diseases are unlikely to be introduced in the near future and do not therefore currently represent a serious issue for employment practice (see paragraph 2.19). This also seems to be the case for screening programmes that would aim to identify people who are at particular risk of disease as a result of exposure to factors in their working environments, such as certain chemicals.

6.4 However, employers are allowed to have access to information about family history in the medical assessment of prospective employees. This may include details of conditions caused by a genetic predisposition. We endorse the recommendation from the committee established by the Council of Europe to consider issues related to the use of medical examinations for employment and insurance purposes that '[i]n principle, a pre-employment medical examination should be limited to assessing the ability of the applicant to perform the job at the moment of the examination or in the immediate future'.[2]

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[1] Human Genetics Commission (2002) *Inside Information: Balancing interests in the use of personal genetic data* (London: Department of Health), paragraph 8.8.

[2] Council of Europe (2000) *Medical Examinations Preceding Employment and/or Private Insurance: A proposal for European guidelines.*

Guidance from other organisations

6.5 Since 1993, a number of reports have been published that address the use of genetic information by employers. The Human Genetics Advisory Commission (HGAC) (operational from 1996 to 1999) concluded in 1999 that it would not be acceptable for results from genetic tests to be used to exclude people from employment or advancement on the grounds that they had a predisposition to ill health in the future. However, the Commission recognised situations where the use of results from genetic tests could be of advantage to both the employer and the employee, where for example a condition was detected that could put the employee or others at risk in the workplace.[3] The Government recorded its agreement with these principles in its response to the HGAC report in 2000. The response emphasised regulations made under the Health and Safety at Work Act 1974 that aimed to ensure that employers always try to remove risks, rather than workers, from the workplace.[4] Subsequently, in 2002, the HGC concluded that employers must not demand that an individual take a genetic test as a condition of employment.[5] A similar conclusion was reached by the Nuffield Council in 2002 in relation to genetic tests for behavioural traits.[6] In the following year, the European Group on Ethics in Science and New Technologies concluded that the use of genetic screening as part of an employer's medical examination was not ethically acceptable unless it was necessary to safeguard the health of workers or others.[7] The Information Commissioner's Office in its report *Employment Practices Data Protection Code*, took a similar position.[8] However, as noted by Genewatch, a not-for-profit group, in *Genetic Testing in the Workplace* (2003) current laws in the UK would not prevent employers refusing someone a job on the basis of their results from a genetic test. The group recommended that employers should not demand that an individual takes a genetic test or reveals a genetic test result as a condition of employment.[9]

Monitoring the use of genetic information by employers

6.6 In 1993, the Nuffield Report recommended that the Department of Employment keep the potential use of genetic screening by employers under review. The Occupational Health Advisory Committee of the Health and Safety Executive subsequently formed a Working Group on genetic tests and screening in the workplace. Since 2002, the HGC has taken the lead on the issue. In that year, it encouraged a voluntary undertaking by employers to notify it of any proposals to use genetic screening for health and safety or recruitment purposes.[10] It also recommended that a joint committee, to include representatives from HGC, the Health and Safety Commission, the Disability Rights Commission (DRC) and other interested parties, should be formed to monitor developments in genetic testing and employment. The establishment of a specific body, similar to the Genetics and Insurance Committee (GAIC) (see paragraph 6.11), to review the relevance of particular genetic tests was considered unnecessary. In 2003, the Government in its White Paper *Our Inheritance, Our Future* asked the HGC, together with organisations such as the DRC, to continue to monitor developments surrounding the

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[3] The Human Genetics Advisory Commission (1999) *The Implications of Genetic Testing for Employment*, paragraphs 3.12 and 3.14–3.15.

[4] Government Response to HGAC Report on Genetic Testing and Employment (2000) *Letter from Lord Sainsbury and Yvette Cooper to Baroness Helena Kennedy, Chair, Human Genetics Commission*.

[5] Human Genetics Commission (2002) *Inside Information: Balancing interests in the use of personal genetic data* (London: Department of Health), paragraph 8.15.

[6] Nuffield Council on Bioethics (2002) *Genetics and Human Behaviour: The ethical context* (London: NCOB), paragraph 15.21.

[7] European Group on Ethics in Science and New Technologies to the European Commission (2003) *Ethical Aspects of Genetic Testing in the Workplace*, paragraphs 2.10–2.11.

[8] Information Commissioner's Office (2005) *The Employment Practices Data Protection Code* (Cheshire: ICO), Section 4.5.

[9] Staley K (2003) *Genetic Testing in the Workplace: A report for GeneWatch UK* (Buxton: GeneWatch).

[10] Human Genetics Commission (2002) *Inside Information: Balancing interests in the use of personal genetic data* (London: Department of Health), paragraph 8.19.

possibility of unfair discrimination by employers on the basis of a person's genetic characteristics.[11] In response, the HGC established a Discrimination Monitoring Group to oversee and monitor developments relating to genetic non-discrimination, particularly in insurance and employment. Current work by the Group includes requesting relevant organisations to report the prevalence of genetic testing in the workplace in March 2006.[12]

Current legal framework

6.7 There is currently no legislation in the UK that directly regulates the use of genetic tests by employers. By contrast, half the states in the United States have enacted laws prohibiting genetic discrimination in employment. A discussion of the legal framework in the UK, the relevant discrimination laws, the Employment Rights Act and EU legislation, is provided in the Council's 2002 Report, *Genetics and Human Behaviour: The ethical context* (see Appendix D).[13]

6.8 The UK Disability Discrimination Act 1995 (DDA) aims to protect disabled persons from discrimination. A disability is defined as 'a physical or mental impairment which has a substantial and long-term adverse effect on [a person's] ability to carry out normal day-to-day activities'. The Genetics White Paper *Our Inheritance, Our Future* (2003) noted that the HGC and the DRC differed on their view as to whether the DDA should be amended to include people with pre-symptomatic genetic conditions.[14] The DRC recommended that the DDA should be extended to people who have a genetic predisposition to an impairment and that legislation should prohibit employers from viewing the results of genetic tests, except in very limited circumstances.[15] The HGC, however, proposed that, rather than amending the DDA, the Government should consider the possible need for separate legislation to prevent genetic discrimination.[16]

6.9 The Council of Europe's *Convention on Human Rights and Biomedicine* (Article 12) states that 'Tests which are predictive of genetic diseases or which serve either to identify the subject as a carrier of a gene responsible for a disease or to detect a genetic predisposition or susceptibility to a disease may be performed only for health purposes or for scientific research linked to health purposes . . .' This would therefore prevent the use of the results of genetic tests for non-health reasons by employers in those countries that have ratified the Convention (this does not include the UK).

Insurance

6.10 Genetic screening and testing for the purpose of setting insurance premiums has proved to be a contentious issue. In the 1993 Report, it was recognised that applicants, health professionals and insurers had different concerns. The Report recommended that insurance companies should adhere to their current policy of not requiring any genetic tests as a prerequisite of obtaining insurance.

Developments since 1993

Genetics and Insurance Committee (GAIC)

6.11 The UK GAIC was established in 1999 as a non-statutory advisory non-departmental public body. The Government established the GAIC following a recommendation from the HGAC in

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[11] Department of Health (2003) *Our Inheritance, Our Future* (Norwich: TSO), paragraph 6.35.

[12] This comes as a response to a letter from Lord Sainsbury to the HGC in September 2005, asking the Commission to assess the current situation. The letter followed up a Government pledge in 2000 to consider the HGAC's recommendation that a further review of genetic screening in employment should be conducted after five years.

[13] Nuffield Council on Bioethics (2002) *Genetics and Human Behaviour* (London: NCOB), pp175–82.

[14] Department of Health (2003) *Our Inheritance, Our Future* (Norwich: TSO), paragraph 6.34.

[15] Disability Rights Commission (2003) *Disability Equality: Making it happen: First review of the Disability Discrimination Act* (DRC), p 83.

[16] Human Genetics Commission (2002) *Inside Information: Balancing interests in the use of personal genetic data* (London: Department of Health), paragraphs 6.31 and 6.41.

1997 that a mechanism to evaluate the scientific and actuarial evidence presented in support of genetic tests or insurance products was needed.[17] The GAIC is responsible for developing criteria for the evaluation of specific genetic tests, their application to particular conditions and their reliability and relevance to particular types of insurance; evaluating applications from insurance providers to use such tests; and monitoring compliance by the industry with the terms of the Concordat and Moratorium agreed in 2005 on the use of genetic test results by insurance companies.

The Moratorium

6.12 The 1993 Nuffield Report advised that insurance companies should accept a temporary moratorium on requiring the disclosure of genetic data. In 2001, a moratorium was adopted by the Association of British Insurers (ABI) on the use of predictive genetic test results for five years. This followed a series of recommendations by the Science and Technology Committee of the House of Commons, the HGAC and the HGC.[18] In 2005, the moratorium was extended for a further five years, until November 2011.[19] One of its aims, as expressed by the Health Minister, was that people would not be discouraged from having a genetic test because they feared the result would affect their ability to purchase insurance.[20] The White Paper *Our Inheritance, Our Future* (2003) confirmed the Government's commitment to enforce compliance with the moratorium through legislation if necessary and to work with patient groups and the industry towards a longer-term solution.[21]

6.13 The moratorium specifies that insurers will not use genetic test results when selling life insurance polices of up to £500,000 and for critical illness, long-term care and income protection policies of up to £300,000. This decision is in line with the recommendation in the 1993 Nuffield Report that a moratorium should apply only to policies of moderate size. We consider that this remains a reasonable situation. Above these limits, the industry may use genetic test results but only if the tests have been approved by the GAIC, following assessment of their technical, clinical and actuarial relevance.[22]

6.14 The GAIC has to date only approved one application from insurers to use a predictive genetic test for Huntington's disease in determining premiums for life insurance policies over £500,000. There are currently no further applications under consideration. In February 2006, the ABI stated that it would not be submitting any applications to use predictive genetic tests until at least 2008. The GAIC has announced that if any applications were received in the future then the relevant charities for genetic disorders would be consulted as part of the review process.

The current situation

6.15 In the UK, the debate about genetics and insurance has focused primarily on life insurance while in the United States, health insurance has been the major concern. The debates in both

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[17] Human Genetics Advisory Commission (1997) *The Implications of Genetic Testing for Insurance* (London: Office of Science and Technology), paragraph 4.11.

[18] House of Commons Science and Technology Committee (2001) *Genetics and Insurance* (London: House of Commons); Human Genetics Advisory Commission (1997) *The Implications of Genetic Testing for Insurance* (London: Office of Science and Technology); Human Genetics Commission (2001) *The Use of Genetic Information in Insurance: Interim Recommendations*.

[19] HM Government and Association of British Insurers (2005) *Concordat and Moratorium on Genetics and Insurance* (Department of Health).

[20] Department of Health (2001) *Health Minister Lord Hunt welcomes five year moratorium on genetic tests and insurance*, available at: http://www.dh.gov.uk/PublicationsAndStatistics/PressReleases/PressReleasesNotices/fs/en?CONTENT_ID=4011400&chk=ckC26, accessed on: 28 Apr 2006.

[21] Department of Health (2003) *Our Inheritance, Our Future* (Norwich: TSO), paragraph 6.7.

[22] Genetics and Insurance Committee (2006) *Fourth Report from January 2005 to December 2005* (London: Department of Health).

countries have also related almost entirely to genetic testing of those thought to be at risk of serious inherited conditions, rather than to genetic screening. The principal areas of discussion have focused on:

- whether genetic tests raise any concerns that differ from those raised by the use of 'other medical information';
- whether the insurance industry is at significant financial risk from 'adverse selection', the situation where the applicant is in possession of relevant information (such as the result of a genetic test), but the information is not made available to the insurer; and
- whether any form of regulation is needed other than that normally carried out by the insurers themselves.

6.16 It has become clear since the 1993 Report that, while the number of healthy individuals seriously disadvantaged by a genetic test result may be small, there is a perception among the public that genetic information is different from other kinds of 'medical information', and further that it should not be used by insurance companies in considering applications for insurance.[23] Additionally, evidence, although sparse, suggests that adverse selection[24] to insurers is currently minimal in terms of both numbers of policies and range of disorders, since most genetic tests are carried out in the context of family history (which remains accessible to insurers under the moratorium). It may also be the case that the insurance industry has previously misjudged the risks of predisposing genetic factors, not recognising that in most cases predisposition is weak. **Therefore, we endorse the continuation of the moratorium which we consider places insurance companies at little disadvantage**.

6.17 It is currently unclear whether the issues surrounding genetic tests and insurance will be fully resolved by the end of the moratorium in 2011. For example, the GAIC has recognised that there may be people whose uncertainty about their situation after the moratorium is discouraging them from taking medically useful tests before it expires.[25]

[23] Human Genetic Commission (2001) *Public Attitudes to Human Genetic Information: People's Panel Quantitative Study*.

[24] 'Adverse selection': the situation where, due to asymmetry of information between the applicants and the insurance company, those known to be more at risk may insure themselves for greater amounts than other people.

[25] Genetics and Insurance Committee (2006) *Fourth Report from January 2005 to December 2005* (London: Department of Health).

Chapter 7

Conclusions

Conclusions

Developments since 1993

7.1 The 1993 Report set out the situation with regard to genetic screening at the time and the ethical issues raised, and made recommendations for policy and practice. Most of these recommendations, many of which were endorsed by other bodies, have been implemented. This Paper serves to clarify developments that have taken place in the past 13 years and provide an account of the current situation.

7.2 As the previous chapters have shown, several developments have taken place since 1993, both in genetics more widely and in relation to genetic screening programmes. They include:

- major advances in science and technology in the field of genetics;
- growth of genetics services to patients and families, in the UK and elsewhere;
- establishment of the NSC;
- greater understanding of how to introduce new programmes for genetic screening for the population;
- monitoring of ethical and social issues relating to insurance and employment by the HGC and other bodies; and
- consideration by government of the implications of developments in genetics for policy.

7.3 The technological advances in genetics since 1993 have been particularly influential. The developments have enabled researchers to produce and study very large amounts of data. Many more gene variants that are responsible for rare monogenic disorders have been identified. However, few of these have been included in new screening programmes. The NSC criteria state that the existence of a simple, safe, precise and validated screening test is a necessary, but not sufficient condition for its use in a screening programme. There should be evidence that the screening programme is effective in terms of cost and reducing mortality or morbidity. This is rarely the case for serious diseases with no cure.

7.4 The establishment of biobanks, the availability of new methods for identifying disease-associated gene variants and high throughput methods of analysis can be expected to improve our understanding of how individuals vary and the roles that genes play in disease causation. For some cancers, the development of new gene-based diagnostic tests is a likely prospect. However, for several common diseases, the likely involvement of a number of unidentified genes with small effects that may interact with each other and the environment currently limits the development of accurate tests that could be used in screening. As our knowledge of gene function and our understanding of gene–gene interactions increases, it is likely that the introduction of screening programmes for susceptibility to common diseases will be considered, although not for several years.

7.5 We have noted that there are major differences between the delivery of individual genetic tests to those at risk for specific inherited disorders as opposed to population screening programmes. Genetic testing is carried out for patients who are at risk and who are actively seeking advice, whereas screening could be viewed as an imposition (by the state) with a presumption of benefit. From this perspective, the ethical responsibilities of those introducing screening programmes are greater. Strong scientific evidence of effectiveness on clinical outcomes and the minimisation of harm should be fundamental requirements. This evidence base should also include explicit assessment of the ethical, social and legal issues which may be involved.

7.6 Ensuring that appropriate attention is given to issues of consent and counselling is both time- and resource-intensive and there are concerns that, if genetic screening became more widespread, these demands should not become so burdensome as to slow the introduction of new programmes or to restrict existing programmes. These concerns would be especially applicable if genetic screening programmes were to be introduced for common diseases, although as we have said, this is unlikely to occur in the near future. We note that counselling is not always offered prior to routine screening for non-genetic disorders, such as HIV in pregnant women. In current antenatal and neonatal genetic screening programmes, emphasis is given to the provision of written information for parents and counselling as a specialist service is reserved for those whose test is positive. **We propose that, in the context of possible widespread introduction of genetic screening for common diseases, genetic counselling should be concentrated on those conditions that threaten life or have a serious impact on the ability to live life fully**. For diseases that differ in their frequency of occurrence between ethnic groups, it remains important to ensure that families in low prevalence areas receive expert and culturally sensitive genetic counselling, whether or not there are local specialist services. This could be achieved by fostering closer links between genetic counsellors and regional screening coordinators.

7.7 We also recognise the concerns that certain types of screening are already offered in such a routine manner that they become normal practice rather than a considered choice. The provision of information and the way in which participation in screening programmes is offered should therefore be considered carefully when screening programmes are under development, particularly when reproductive choice, rather than improved therapy is the aim.

7.8 We welcome the new institutional arrangements, notably by the HGC and other bodies, that are now in place to allow concerns about new developments to be anticipated and debated. For example, in 2004, the HGC held a consultation with the public on the implications of developments in human genetics for the choices available for people who wish to have children and the wider social impact of these choices.[1] If there are commercial and other pressures for implementation of new screening programmes, especially for common diseases, it is essential that there should be a careful and independent assessment not only of the benefits, but also of difficulties that new applications may engender. This assessment should include seeking the views of the public.

7.9 Other developments include new legislation that could have an impact on the provision of genetic screening services. Concerns have been expressed that the Human Tissue Act 2004 will pave the way for screening tests to be carried out without consent, given that 'qualifying consent' to use human tissue is not required for 'medical diagnosis'. However, we note that the Human Tissue Act does not replace the requirements for consent for use of personal data in the Data Protection Act 1998. This example illustrates the growing complexity of the regulatory system in relation to its impact on the use of genetic material and information.

7.10 Since 1993, genetic screening for the purposes of employment and insurance has continued to be debated. Currently, there appears to be no evidence that UK employers are carrying out systematic genetic screening (or testing) or using genetic test results in recruitment or occupational health schemes. However, the controversial nature of the issue has meant that it has been addressed by several bodies in the UK and Europe. The HGC has concluded that employers must not demand that an individual take a genetic test as a condition of employment and has assumed a monitoring role relating to genetic non-discrimination at the request of the Government. The HGC has also recommended to the Government that it should consider the possible need for additional legislation to prevent genetic discrimination.

[1] Human Genetics Commission (2004) *Choosing the Future: Genetics and reproductive decision making* (London: Department of Health).

7.11 Genetic screening and testing for the purpose of setting insurance premiums has proved to be a contentious issue. In response to a range of concerns, the Government has established a mechanism through the GAIC to evaluate the scientific and actuarial evidence presented in support of genetic tests or insurance products. In addition, a moratorium adopted in 2001 has now been extended until 2011. We endorse the continuation of the moratorium which we consider places insurance companies at little disadvantage. We also note the Government's commitment to enforce compliance with the moratorium through legislation if necessary, and to work with patient groups and the industry towards a longer-term solution.

Future considerations

7.12 Improvements in technology that make genetic test results simpler to interpret and more reliable may encourage wider availability and uptake for use in screening programmes. Costs of laboratory procedures could be expected to fall as the use of particular tests becomes more widespread. However, very few susceptibility genes for common diseases have yet been discovered and many experts would still regard such findings as 'some way off'. However, there is a general presumption in the media that there will be widespread testing and use of genetic information for prediction of susceptibility to disease in the not too distant future. There is a danger that commercial pressures could result in premature application of screening programmes before they are clinically useful or where the benefits are weak. In addition, there are pressures from lobbying groups whose perspectives on screening for particular disorders may not reflect the overall body of evidence, but whose views can on occasion command considerable political attention. **We consider it important that care is taken not to exaggerate the potential of screening (or testing) for susceptibility genes to improve health, since to do so could lead to false assumptions and unnecessary anxiety. The Council recommends that this is an area which should be carefully monitored by the Human Genetics Commission**.

7.13 Most genetic screening in the UK is currently carried out by the NHS. Growing opportunities, however, are anticipated for involvement of the private sector. The HGC has recommended that the commercial providers of genetics services should be encouraged to make responsible claims by following the Codes of Practice set out by the Advertising Standards Authority. There is also a need for the standards for testing and screening that are being developed for the NHS to be applied in the private sector.

7.14 The value of a particular screening programme will be influenced by the potential severity of the condition, the availability of treatment and the implications for families. The likely economic impact of commercial screening is difficult to predict. It may lead to additional costs being placed on the NHS through the need to repeat commercial tests. However, these costs may be balanced out by the savings made through the early detection of disease.

7.15 The 1993 Report concluded that further consideration needed to be given to the process whereby genetic screening programmes could be introduced into wider practice. The transfer of knowledge from geneticists to non-geneticists was one of the main themes of the White Paper *Our Inheritance, Our Future*. Family doctors and other primary care staff may be well placed to provide written and face-to-face information on genetic screening services if programmes for common diseases were introduced. However, it has been observed that primary care staff are currently relatively unfamiliar with the issues raised by genetic testing and population screening and we note the many other calls on their time. Moreover, if very few genetic tests actually provide knowledge that is clinically useful to the wider population, there will not be such an imperative for medical professionals to provide genetic services. Nevertheless, professionals will still need appropriate information and to understand the limitations of genetic screening.

Appendices

Appendix A: Conclusions and Recommendations from *Genetic Screening: Ethical issues* 1993 (Chapter 10: Conclusions)

1 We set out our conclusions against the background of the following points established earlier in the report:-

(i) screening for **some** defective genes has become a practical possibility;

(ii) medical knowledge about genetic **susceptibility** to common multifactorial conditions (for example, some heart disease and some cancers) is still developing. Even with increased medical knowledge, the individual's risk may be difficult to evaluate;

(iii) many of the ethical issues associated with genetic screening arise from the inescapable involvement of families (both blood relations and spouses);

(iv) the benefits and disadvantages of screening programmes – for individuals, families and society in general – will need to be carefully assessed for each proposed screening programme. Factors to be taken into account include:-

(a) the predictive power and accuracy of the genetic test;

(b) the benefits of informed personal choice in reproductive decisions and their consequences;

(c) the psychological impact of the outcome of screening for both individuals and families;

(d) therapeutic possibilities;

(e) possible social and economic disadvantage relating for example, to insurance and stigma; and

(f) the resource costs and the relative priority, in view of limited resources, of establishing a screening programme.

2 Against this background our recommendations fall under six main headings. In making these recommendations we are conscious that no-one can lay down fixed and immutable guidelines for the future of genetic screening. Medical and scientific knowledge is developing rapidly: some of that development may alter the shape and the nature of some of the ethical issues discussed in this report. Nevertheless, certain ethical principles will remain unchanged and certain ethical responses will be required from the health professions, from health administrators, from the insurance industry, from employers and from Government.

What is not covered in this report

3 We emphasise once more that this report has covered genetic screening for **serious disease**. (We have explained our views on what constitutes serious disease in paragraph 3.10. Distinguishing between serious disease and other medical conditions would be a task that would fall naturally to the central coordinating body envisaged in paragraph 20.) We recognise that there is a whole area of serious concern about genetic screening for human traits that are in no sense diseases. These issues have been brought to the fore by recent controversies about gender choice, and about the so-called 'homosexuality gene'. We do not dismiss these issues. They call for discussion by professionals with skills other than those represented in our Working Party.

I: Providing information and obtaining consent

4 **We recommend that adequately informed consent should be a requirement for all genetic screening programmes**. The voluntary nature of the screening process must be emphasised. Adequate information must be provided for all those being invited to enter a genetic screening programme and should include information about the implications for other family members. Information for all genetic screening programmes is best delivered in both written and oral form. (Paragraph 4.29 summarising paragraphs 4.6–4.16)

5 **We recommend that counselling should be readily available for those being genetically screened, as well as for those being tested on account of a family history of a genetic disorder**. Counselling should be available at all stages of the screening process. This will require the diffusion of an understanding of genetics (at present mainly confined to genetic counsellors) in particular among those engaged in primary healthcare. The resource implications, including the need to train large numbers of practice nurses and health visitors in the subject matter and the basic principles of counselling, need to be assessed within the broader context of the expansion and extension of primary care. (Paragraph 4.30 summarising paragraphs 4.17–4.22)

6 Screening of individuals who are unable to give properly informed consent (minors, the mentally ill and those with severe learning difficulties) require special safeguards (paragraphs 4.24–4.26).

II: The results of genetic screening and confidentiality

7 The family implications of genetic screening and genetic testing will sometimes require health professionals to review the application of the current principles governing the confidentiality of medical information. We have in Chapter 5 made a start at examining the implications. This work will need to be carried further by the health professional bodies responsible for producing guidelines that govern the conduct of their members as experience is gained from the screening programmes now being introduced.

8 We regard it as axiomatic that:-

(i) individuals should normally be fully informed of the results of genetic screening, and in particular of the implications of those results for the family; and

(ii) the accepted standards of the confidentiality of medical information should be followed as far as possible.

9 When genetic screening reveals information that may have serious implications for relatives of those who have been screened, health professionals should explain why the information should be communicated to other family members. **We recommend that in such circumstances health professionals should seek to persuade individuals, if persuasion should be necessary, to allow the disclosure of relevant genetic information to other family members**. They should also seek to ensure that treatment, counselling and other appropriate support are made available to those to whom such unsought information is disclosed. (Paragraph 5.41 summarising paragraphs 5.23–5.31)

10 We note that both the law and professional guidelines provide for exceptional circumstances, when an individual cannot be persuaded to inform family members with a legitimate right to know. In such exceptional circumstances the individual's desire for confidentiality may be overridden. The decision can only be made case by case. **We recommend that the appropriate professional bodies prepare guidelines to help with these difficult decisions**. (Paragraph 5.42 summarising paragraphs 5.23 and 5.29–5.31)

11 **We recommend that the Department of Health should consider with health authorities and the appropriate professional bodies effective arrangements for the preservation of**

confidentiality, particularly in relation to genetic registers, and should issue the necessary guidance. (Paragraph 5.43 summarising paragraphs 5.32–5.39)

III: Employment

12 At present, the use of genetic screening by employers in the UK does not appear to be a cause for concern. We have found evidence of only one existing screening programme: that programme can be justified quite readily on the grounds of safety, not only of those being screened but also of third parties. Nevertheless we recognise that the matter needs to be kept under review. **We recommend that the Department of Employment keeps under review the potential use of genetic screening by employers**. (Paragraph 6.27 summarising paragraphs 6.24–6.26)

13 Subject to prior consultation with workplace representatives, and with, as necessary, the Health and Safety Commission, **we recommend that genetic screening of employees for increased occupational risks ought only to be contemplated where**:-

(i) there is strong evidence of a clear connection between the working environment and the development of the condition for which genetic screening can be conducted;

(ii) the condition in question is one which seriously endangers the health of the employee or is one in which an affected employee is likely to present a serious danger to third parties;

(iii) the condition is one for which the dangers cannot be eliminated or significantly reduced by reasonable measures taken by the employer to modify or respond to the environmental risks.

(iv) Although it may be appropriate to introduce a genetic screening programme on these limited grounds, it should only be done if accompanied by safeguards for the employee, and after consultation with the coordinating body recommended in paragraph 20. (Paragraph 6.28 summarising paragraphs 6.20–6.23)

IV: Insurance

14 Our recommendations about the use of genetic screening and genetic tests by insurance companies follow from the following considerations:-

(i) the difficulty of assessing what may be slender evidence on the genetic susceptibility of individuals to develop polygenic and multifactorial diseases (for example, some cancers and some heart disease);

(ii) an awareness that ordinary commercial practice will lead companies to be over-cautious in their assessment of the risks derived from medical data; and

(iii) the possibility of abuse.

15 **We recommend that British insurance companies should adhere to their current policy of not requiring any genetic tests as a prerequisite of obtaining insurance.** (Paragraph 7.37 summarising paragraphs 7.22–7.25)

16 **We recommend that there should be early discussions between the Government and the British insurance industry about the future use of genetic data, and that pending the outcome, the companies should accept a temporary moratorium on requiring the disclosure of genetic data.** There should, however, be two exceptions:-

(i) first, in the case of those individuals where there is a known family history of genetic disease that can be established by the conventional questions about proposers' families, then individuals may be asked to disclose the results of any relevant genetic tests (paragraph 7.28); and

(ii) the moratorium should apply only to policies of moderate size. The limit would be a matter to be settled between the Government and the industry in the context of arranging the moratorium.

The importance of the discussions that are recommended is highlighted by the considerations set out in paragraphs 7.7 and 7.8. (Paragraph 7.38 summarising paragraphs 7.26–7.35)

V: Public policy

17 The threat of eugenic abuse of genetic screening requires safeguards. In a democracy, public understanding of human genetics should serve to create awareness of the dangers of eugenics, and of the possible stigmatisation of those carrying or suffering from genetic disorders. **We recommend the need for improving public understanding of human genetics should be borne in mind in any review of the National Curriculum and in the work of all public bodies concerned with the public understanding of science**. (Paragraph 8.23 summarising paragraphs 8.4–8.7)

18 We recognise that there are limits to the effects of educational work, however good. We, therefore, regard as essential to the safeguards against eugenic abuse our recommendations on **adequately informed consent, confidentiality** and the **central coordination and monitoring** of genetic screening programmes. (Paragraph 8.24 summarising paragraphs 8.20–8.22)

VI: Implementation of screening programmes

19 Further consideration needs to be given to the process whereby genetic screening programmes might be introduced into routine practice. As we have emphasised, existing screening programmes are largely pilot programmes. Pilot programmes should be governed by the ethical codes applying to research procedures.

20 **We recommend that the Department of Health in consultation with the appropriate professional bodies formulate detailed criteria for introducing genetic screening programmes, and establish a central coordinating body to review genetic screening programmes and monitor their implementation and outcome**. (Paragraph 9.7 summarising paragraphs 9.1–9.4)

21 As a contribution to the discussion of criteria for screening programmes, we suggest they should include the following:-

(i) the aims and purposes of the entire programme;

(ii) the predictive power and level of accuracy of the particular screening test;

(iii) the value to those being screened of the knowledge gained. For each programme this should have been researched as an integral part of the follow-up to the pilot programme;

(iv) the availability of therapy for the particular condition, accepting that lack of treatment does not necessarily mean that screening is not worthwhile;

(v) the potential social implications; and

(vi) the resource costs.

Appendix B: UK National Screening Committee (March 2003) *Criteria for appraising the viability, effectiveness and appropriateness of a screening programme*

Ideally all the following criteria should be met before screening for a condition is initiated:

The Condition

1. The condition should be an important health problem.
2. The epidemiology and natural history of the condition, including development from latent to declared disease, should be adequately understood and there should be a detectable risk factor, disease marker, latent period or early symptomatic stage.
3. All the cost-effective primary prevention interventions should have been implemented as far as practicable.
4 If the carriers of a mutation are identified as a result of screening the natural history of people with this status should be understood, including the psychological implications.

The Test

5 There should be a simple, safe, precise and validated screening test.

6 The distribution of test values in the target population should be known and a suitable cut-off level defined and agreed.

7 The test should be acceptable to the population.

8 There should be an agreed policy on the further diagnostic investigation of individuals with a positive test result and on the choices available to those individuals.

9 If the test is for mutations the criteria used to select the subset of mutations to be covered by screening, if all possible mutations are not being tested, should be clearly set out.

The Treatment

10 There should be an effective treatment or intervention for patients identified through early detection, with evidence of early treatment leading to better outcomes than late treatment.

11 There should be agreed evidence based policies covering which individuals should be offered treatment and the appropriate treatment to be offered.

12 Clinical management of the condition and patient outcomes should be optimised in all health care providers prior to participation in a screening programme.

The Screening programme

13 There should be evidence from high quality Randomised Controlled Trials that the screening programme is effective in reducing mortality or morbidity.

Where screening is aimed solely at providing information to allow the person being screened to make an "informed choice" (eg. Down's syndrome, cystic fibrosis carrier screening), there must be evidence from high quality trials that the test accurately measures risk. The information that is provided about the test and its outcome must be of value and readily understood by the individual being screened.

14 There should be evidence that the complete screening programme (test, diagnostic procedures, treatment/intervention) is clinically, socially and ethically acceptable to health professionals and the public.

15 The benefit from the screening programme should outweigh the physical and psychological harm (caused by the test, diagnostic procedures and treatment).

16 The opportunity cost of the screening programme (including testing, diagnosis and treatment, administration, training and quality assurance) should be economically balanced in relation to expenditure on medical care as a whole (i.e. value for money).

17 There should be a plan for managing and monitoring the screening programme and an agreed set of quality assurance standards.

18 Adequate staffing and facilities for testing, diagnosis, treatment and programme management should be available prior to the commencement of the screening programme.

19 All other options for managing the condition should have been considered (e.g. improving treatment, providing other services), to ensure that no more cost effective intervention could be introduced or current interventions increased within the resources available.

20 Evidence-based information, explaining the consequences of testing, investigation and treatment, should be made available to potential participants to assist them in making an informed choice.

21 Public pressure for widening the eligibility criteria for reducing the screening interval, and for increasing the sensitivity of the testing process, should be anticipated. Decisions about these parameters should be scientifically justifiable to the public.

22 If screening is for a mutation the programme should be acceptable to people identified as carriers and to other family members.

Appendix C: Examples of UK initiatives for improving public engagement and education in genetics

Organisation(s)	Initiative
Human Genetics Commission	The HGC has set up a Consultative Panel of people affected by a genetic disorder. The panel, made up of approximately 100 people with direct experience of living with genetic disorders, acts as a sounding board for reports and recommendations, as well as providing insight into concerns about genetic issues.
The Wellcome Trust	The Human Genome website explores the human genome, and the impact of human genes on health, disease and society. This includes information and news items relating to genetic screening. Available at: http://www.wellcome.ac.uk/ en/genome/. The psci-com website includes information on genetic screening and links to relevant reports and other websites. Available at: http://psci-com.ac.uk/.
Royal Society	Science Brief: *Genetic Testing* The topic of the 2002–2003 'dialogue' programme was Genetic Testing. Four regional meetings were held, in association with the Policy, Ethics and Life Science Research Institute (PEALS). A National Forum, *Genetic Testing: Which way forward?* was held in March 2003. The focus of this meeting was the scenario that by 2023 all newborn children would have a genetic identity card, with their genome sequence. There was significant opposition to the idea of genetic profiling.
Research Councils and Department of Trade and Industry	*Demystifying Genomics*: a booklet explaining the science of genomics and the possibilities of these new tools has been produced by the Medical Research Council (MRC), the Biotechnology and Biological Sciences Research Council (BBSRC), the Natural Environment Research Council (NERC), the Engineering and Physical Sciences Research Council (EPSRC) and the Department of Trade and Industry (DTI).
Biotechnology and Biological Sciences Research Council (BBSRC)	The BBSRC developed an exhibition entitled *DNA in the garden, genomics and beyond*.
Institute of Biology	Educational programmes have included the teacher training course, *Gene Technology* sponsored by BBSRC, BioRad and the Institute of Biology.
Royal Institution	Public and educational activities have included: *DNA: The molecule of life*: series of lectures in 2003; and *Inside Out: Discover DNA*: an interactive resource for GCSE. Available at: http://insideout.rigb.org/ri/dna/index.html.
National Centre for Biotechnology Education	The Centre promotes biotechnology education in schools by providing advice and in-service training for teachers, developing innovative educational resources and equipment and materials for experiments, running practical workshops for teachers, sixth-form students and school technicians, see: http://www.ncbe.reading.ac.uk/menu.html.
Science Museum and Science Centres **Progress Educational Trust**	The *Who Am I?* Gallery in the Wellcome Wing of the London Science Museum focuses on genetics. Six Science and Discovery Centres in Bristol, Cardiff, Birmingham, Manchester, Newcastle, Dundee and Glasgow were opened or redeveloped in 2000 and include displays about genetics and inheritance. The Trust provides information and encourages debate about reproductive and genetic science, and resources for schools. Debates are held on areas of public interest in genetics.
Genetic Interest Group (GIG)	The GIG have produced the teaching pack *Genes and You* (1997).
Y Touring	Y Touring has developed several projects using drama to encourage understanding of science. The organisation runs workshops with school groups exploring ethical issues raised by genetic testing and provides background information about the science and its applications.

Appendix D: Nuffield Council on Bioethics (2002) *Genetics and Human Behaviour: The ethical context*

Extract from Chapter 15: Testing and selection in employment, education and insurance (pages 175–82)

15.1 As noted in Chapters 13 and 14, the selection of individuals on the basis of a genetic predisposition to behavioural traits may have potential applications in several different settings. These include the streaming of children in schools, aptitude testing for university entrance or employment, and the screening of potential or existing employees on the basis of genetic susceptibility to behavioural traits such as aggression, anxiety, novelty-seeking or sexual orientation. Insurers might also wish to make use of knowledge about genetic predispositions to certain behaviours, such as risk-taking, for some types of personal and life insurance and employer's liability and medical insurance. These possible uses of genetic information are discussed in this chapter, following an account of some relevant general principles.

15.2 One series of questions relevant to all these contexts is those relating to privacy, consent and confidentiality. These were investigated in relation to inherited disease and disability in the earlier Report of the Nuffield Council on Bioethics on *Genetic Screening: Ethical Issues* (1993), and in the report of the Human Genetic Commission (HGC), *Inside Information: Balancing Interests in the Use of Personal Genetic Data* (May 2002). Although issues regarding privacy, consent and confidentiality which are specific to behavioural genetics are discussed in this chapter, the reader is referred to those reports for consideration of the broader aspects.[1]

15.3 Another general question concerns the accuracy and predictive capacity of genetic tests. Earlier chapters of this Report have indicated that our behaviour is complex, influenced both by genetic and environmental factors, and by our own decisions. At present, accurate and reliable tests of the genetic components of behaviour in the normal range simply do not exist. If a screening device is not accurate and reliable, it cannot be the basis for fair and efficient decisions in relation to education, employment or insurance. In addition, if a behavioural trait is wrongly assumed to be immutable, then many personal achievements, which are the product of learning, individual initiative, determination and hard work, may be neglected. This is not a problem peculiar to genetic testing for behavioural traits. There is considerable use of IQ and aptitude tests for entrance to schools and universities. In the context of employment, interviewing is by far the most commonly used technique for the recruitment for managerial, professional and skilled manual jobs. However, a recent survey by the Chartered Institute for Personnel and Development (CIPD) revealed that questionnaires to evaluate personality traits are increasingly used.[2] These methods profess to assess cognitive ability, personality, propensity for dishonesty or other deviant behaviour and traits such as anger, aggression, anxiety, obsession and low self-esteem. There is much scepticism about the predictive validity of these tests.[3] The major risk is that of wrongly attributing to the individual the characteristics of the group. It is difficult to know how accurately the test will identify those who will act on a particular propensity.

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[1] The Reports are available at the websites of the Nuffield Council on Bioethics and the Human Genetics Commission, http://www.nuffieldbioethics.org/publications/index.asp and http://www.hgc.gov.uk/insideinformation/index.htm respectively (17 June 2002).

[2] CIPD. (2001). *Fifth Annual Report on UK Recruitment Practices*. Personality questionnaires were used by 40.7% of respondents; 54.5% used general ability tests; 60.1% used tests of specific skills and 44.6% literacy/numeracy tests.

[3] See Finkin, M. W. (2000). From anonymity to transparency: screening the workforce in the information age. *Colum. Bus. L. Rev.* 2000, 403–51, at pages 417–26 and 447–51 for a review.

Box 15.1: Guiding legal principles

The general legal principles relevant to policy and regulation of the use of genetic information can be derived in the main from three instruments:

- The Convention For the Protection of Human Rights and Dignity Of The Human Being with Regard To The Application of Biology and Medicine (Council of Europe, Oviedo, 4 April 1997) ('the Convention')
- The Universal Declaration on the Human Genome and Human Rights (UNESCO, 11 November 1997) ('the Declaration')
- Charter of Fundamental Rights of the European Union (EU, Nice, 7 December 2000) ('the Charter').

The relevant provisions of these instruments may be summarised as follows:

The Convention

The Convention expressly prohibits any form of discrimination on grounds of genetic heritage. Further, it provides that tests which are predictive of genetic diseases or which serve to identify a person as a carrier of a gene responsible for disease or to detect a genetic predisposition or susceptibility to a disease may be performed only for health purposes* or for scientific research linked to health purposes and subject to appropriate genetic counselling. Interventions on the human genome are prohibited unless undertaken for preventive, diagnostic or therapeutic purposes and only if the aim is not to introduce any modification to the genome of any descendants. The Convention has not yet been ratified by the UK and has no legal force in this country.

The Declaration

The Declaration provides that everyone has the right to respect for their dignity and their rights regardless of their genetic characteristics and that such dignity 'makes it imperative not to reduce individuals to their genetic characteristics and to respect their uniqueness and diversity' (Article 3). Research, treatment and diagnosis affecting an individual's genome shall only be undertaken after rigorous and prior assessment of the risks and benefits pertaining thereto. Like the Convention, the Declaration includes an express prohibition on discrimination based on genetic characteristics that is intended to or has the effect of infringing human rights. Genetic data must be held in conditions of confidence, and no research or applications of research concerning the human genome (in particular in the fields of biology, genetics and medicine) should prevail over respect of human rights and the dignity of individuals. The Declaration has no legal force and is intended only as a statement of principles which states are asked to promote.

The Charter

In common with the Convention and the Declaration, the Charter contains an express and free-standing provision which prohibits any discrimination based on genetic features. As part of the right to respect for physical and mental integrity, Article 2 provides that, in the fields of medicine and biology, particular respect must be given to prohibition of eugenic practices,† in particular those aimed at the selection of persons. The UK, as a Member of the European Union, is a party to the Charter. The Charter is a non-binding instrument which is likely to have only indirect legal force through resort to it by the European Court of Justice as a source of legal principle.

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* The Explanatory Report to the Convention (paragraphs 84 to 86) makes clear that genetic testing for employment or insurance purposes or other commercial purposes falls outside the legitimate testing for health care purposes, and is a disproportionate interference with the rights of the individual to privacy. Paragraph 86 provides: 'An insurance company will not be entitled to the holding of a predictive genetic test. Nor will it be able to refuse the conclusion of modification of such a policy on the ground that the applicant has not submitted to a test as the conclusion of a policy cannot reasonably be made conditional on the performance of an illegal act'. The Convention does, however, provide (in Article 26) that the restriction on predictive genetic tests may be overridden where prescribed by law and necessary in a democratic society in the interest of public safety, for the prevention of crime, for the protection of public health or for the protection of the rights and freedoms of others.

† It is to be noted that the European Group on Ethics in Science and New Technologies, when reporting on the draft Charter insisted (by a majority) that a specific additional provision dealing with eugenic practices be included. The minority considered that there was a difficulty in defining eugenics and the group as a whole recognised that certain current practices might be properly termed as eugenics. The majority, however, insisted on inclusion of a specific prohibition because otherwise 'the Charter would be missing the point if it did not refer to one of the main challenges of human genetics.' See European Group on Ethics in Science and New Technologies. Citizens Rights and New Technologies: A European Challenge (Brussels, 23 May, 2000). http://www.europarl.eu.int/charter/civil/pdf/con233_en.pdf (18 Jul 2002).

Employment

The current legal framework

15.4 In this section we set out how the law currently deals with the use of genetic information in the context of employment. It is important to note that, to date, most discussion in this area has focused on clinical disorders. The potential use of genetic information that concerns behavioural traits in the normal range of variation has not been widely considered.

15.5 At present there is no legislation in the UK that directly regulates genetic testing or the use of genetic information in employment. At common law, an employer may lawfully require an applicant to undertake genetic testing in order to be appointed to a particular job. Whether an existing employee can be required to submit to a genetic test depends on the express or implied terms of the individual's contract of employment. Employers have no general power to require employees to submit to medical examination (this would include a genetic test). However, it may be implied that the employee could be required to do so if the employer had reasonable grounds for believing that the employee might be suffering from a mental or physical disability likely to cause harm to the employee or to other people. This is an aspect of the so-called duty of mutual trust and confidence between employer and employee, which is an obligation of uncertain scope that depends upon judicial interpretation.[4] Similarly, at common law the right to use genetic information about an employee depends upon the express or implied terms of the employment contract. In some circumstances, discrimination law, the law on unfair dismissal and the developing law of privacy and confidentiality for employees might give rise to rights for jobseekers and employees (see paragraphs 15.11–15.15).

15.6 By contrast, about half the states in the US have enacted laws prohibiting genetic discrimination in employment. President Clinton signed a similar Executive Order applicable to federal employees, excluding the Armed Forces, on 8 February 2000. The main reasons for this legislation in the US are, first, that employers responsible for the medical costs of employees and their dependants have a strong incentive to exclude those genetically predisposed to certain illnesses and, secondly, that individuals who are at a genetic risk of illness may be discouraged from taking genetic tests if they believe that their employers will have access to this information. Both of these reasons are significant in the US because of the employer's role in financing health care. The existence of the National Health Service (NHS) means that these motivations are of less significance in the UK.

Discrimination laws

15.7 In both the US and the EU, genetic screening and the practice of using genetic information may run foul of employment discrimination laws, if the test or practice has a disproportionately adverse impact on a protected class such as women or ethnic minorities which cannot be objectively justified for reasons other than the gender, race and so on of the affected group. In the landmark case of *Griggs* v *Duke Power Co*.,[5] the US Supreme Court held that under Title VII of the Civil Rights Act, facially neutral standardised tests and high school graduation requirements had a disparate impact on black applicants and employees, and accordingly, the employer had to prove that the qualification requirements were job-related and consistent with business necessity.[6] Genetic testing would offend Title VII only if the effect of the test

[4] See, for example, *Bliss* v *South East Thames Regional Health Authority*. (1985). Industrial Relations Law Reports 308. The Court of Appeal found that a medical examination had been imposed without reasonable cause because what the employer did (according to Lord Justice Dillon) was 'by any objective standard outrageous'.

[5] *Griggs* v *Duke Power Co*. (1971). 401 US 424.

[6] A test is facially neutral if it does not appear to be discriminatory. As illustrated, facially neutral practices may be found in violation of law if they result in significant differences in the distribution of benefits or services to persons based on race, national origin, sex or disability without a substantial legitimate justification, or, if there are equally or comparably effective alternative practices available that meet the same goals with less disparate impact.

were to discriminate on the basis of race, colour, religion, sex or national origin. So far as is known, Title VII has not yet been invoked in respect of genetic testing. This may be due to the availability of the Americans with Disabilities Act 1990 (ADA) which can be used to challenge mandatory medical examinations that are not related to employment. However, even this is of limited significance because a genetic test that revealed the susceptibility of an employee to stress or other traits in certain working environments would be job-related and hence lawful.[7]

15.8 In the EU, a similar approach is taken to that in the US, under Article 141 (ex 119) of the European Community (EC) Treaty and the Equal Treatment Directive 76/207/EEC, in respect of what is termed 'indirect' sex discrimination. UK law has recently been amended, in line with the Burden of Proof Directive 97/80/EC, to define indirect sex discrimination as existing where 'an apparently neutral provision, criterion or practice disadvantages a substantially higher proportion of the members of one sex unless that provision criterion or practice is appropriate and necessary and can be justified by objective factors unrelated to sex.' For example, a factor which favours spatial ability may tend to be biased against women and the use of this criterion will have to be objectively justified. The Race Relations Act 1976, in section 1(1)(b), contains a slightly differently worded definition but the effect is also to make unlawful a requirement or condition which has an unjustifiable adverse impact on a particular racial group. On 29 June 2000, the EC adopted a directive on discrimination on grounds of race or ethnic origin, which must be implemented by the UK by 19 July 2003. This defines 'indirect discrimination' as occurring where a provision, criterion or practice 'puts persons of a racial or ethnic origin at a particular disadvantage' without objective justification. On 28 November 2000, the EC adopted Directive 2000/78/EC for combating direct and indirect discrimination in employment on the grounds of religion or belief, disability, age or sexual orientation.[8] This contains a definition of indirect discrimination similar to that in the UK Race Relations Act. The provisions in the EC Directive on sexual orientation must be implemented by the UK by 2 December 2003. They will effectively prevent the use of genetic information relating to sexual orientation in the field of employment. Those relating to disability must be implemented by 2 December 2006, but are unlikely to involve any significant change in existing UK law.

15.9 Although these prohibitions in indirect discrimination do provide a potential barrier to the use of genetic testing and information, their limitations are obvious. The employer can justify its actions on the grounds that the specific test is accurate and reliable and that the use of the information is 'appropriate and necessary' to the requirements of the job. Effectively, discrimination law leaves the control of genetic testing in the employer's hands and is not primarily concerned with its effect on the dignity or autonomy of the employee.

15.10 The Disability Discrimination Act 1995 (DDA) in the UK aims to protect disabled persons from discrimination. A disability is defined as 'a physical or mental impairment which has a substantial and long-term adverse effect on a person's ability to carry out normal day to day activities.' 'Impairment' is not defined but Regulations provide that addiction to alcohol, nicotine or any other substance is to be treated as not amounting to an impairment for purposes of the Act.[9] Similarly, the following conditions do not amount to impairments: a tendency to set fires, a tendency to steal, a tendency to physical or sexual abuse of other persons, exhibitionism and voyeurism. Although mental illness is covered by the Act, the illness must be 'clinically well-recognised'.[10] Moreover, a person is disabled only if their

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[7] Rothstein, M. A. (2000). Genetics and the work force of the next hundred years. *Colum. Bus. L. Rev.* 2000, 371–401. See p. 388.

[8] The Sex Discrimination Act and the EC Equal Treatment Directive do not apply to discrimination on grounds of sexual orientation: *Secretary of State for Defence* v *MacDonald*. (2001). *Industrial Relations Law Reports* 431.

[9] Disability Discrimination (Meaning of Disability) Regulations. (1996). SI 1996 No.1455.

[10] Disability Discrimination Act. (1995). Schedule 1, paragraph 1(1).

'ability to carry out normal day-to-day activities is impaired' and the impairment must have a 'substantial and long-term adverse effect' on the ability to carry out those activities.[11] While some 'progressive conditions' are covered, this does not include those who merely have a genetic or other predisposition to (or risk of) a progressive condition in the future. In the US, on the other hand, the Equal Employment Opportunity Commission has issued an interpretation of the ADA that an employer who discriminates against an individual on the basis of the results of a predictive genetic test would be 'regarding' the individual as having a disability and so violating the ADA. The view of at least one leading legal expert is that this interpretation will not withstand judicial scrutiny.[12] In any event, the UK legislation does not at present include those who are simply 'regarded' as having a disability. The DDA, therefore, at present has little relevance to genetic predisposition to behavioural traits in the normal range.

Unfair dismissal

15.11 An employee who is already working for an employer may have a remedy under the Employment Rights Act 1996 (ERA).[13] The weakness of this protection, from the employee's viewpoint, is that in determining this question, the tribunals give employers a broad margin of discretion (the so-called 'band of reasonable responses') in deciding whether or not to dismiss the employee. An employer would, however, be bound to follow a fair procedure, including a reasonable investigation and an opportunity for the employee to contest the facts or show why he or she should not be dismissed.

Privacy and confidentiality

15.12 Article 8 of the European Convention on Human Rights and Fundamental Freedoms (ECHR) provides that everyone has the right to respect for their 'private or family life'. The ECHR was incorporated into domestic law by the Human Rights Act 1998 (HRA), giving individuals the right to claim compensation against public authorities (including public employers) who violate this right. Courts and tribunals are bound to give effect to the ECHR, so that when interpreting the duty of mutual trust and confidence or the law on unfair dismissal (paragraph 15.11) they must have regard to Article 8.

15.13 It seems likely that aspects of biometric and genetic testing and the use of genetic information about an individual fall under the concept of 'private and family life'. This can be deduced from the case law of the European Court on Human Rights which has afforded a high degree of protection under Article 8 to personal health and bodily integrity. The right is not, however, absolute. The infringement may be justified if it is shown to be 'necessary in a democratic society in the interests of national security, public safety or the economic well-being of the country, for the prevention of crime or disorder, for the protection of health or morals, or for the protection of the rights and freedoms of others.'[14] In the employment field, it is likely that courts and tribunals will require the employer to show both that the use of genetic information was necessary in relation to a specific job, and that its use was proportionate to a legitimate aim such as protecting the health and safety of others. It seems

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[11] Disability Discrimination Act. (1995). Schedule 1, paragraph 1(1).

[12] Rothstein, M. A. (2000). Genetics and the work force of the next hundred years. *Colum. Bus. L. Rev.* 2000, 371–401. See p. 388.

[13] For example, an employee who is dismissed for refusing to submit to a genetic test or for not allowing the use of genetic information, where this is not provided for in the contract of employment and amounts to a breach of the duty of mutual trust and confidence may complain that the dismissal is unfair. Even short of actual dismissal, there may be a 'constructive' dismissal entitling the employee to resign and claim compensation. The employer will have to show that it genuinely believed that the dismissal related to the employee's 'capability' or 'conduct' or 'some other substantial reason' justifying dismissal. The employment tribunal will then assess whether the dismissal is fair or unfair 'having regard to equity and the substantial merits of the case'.

[14] European Convention on Human Rights and Fundamental Freedoms. Article 8(2).

that a contractual restriction on the right to privacy will also have to pass this strict test of justifiability.

15.14 Another possible form of protection for genetic information is the common law on breach of confidence. An obligation of confidence arises in an employment relationship, but it is by no means clear what kinds of personal information would be protected since nearly all the decided cases involve breach of commercial confidences. Accordingly, the Data Protection Act 1998 (DPA) is much more significant than the common law. Under the DPA 'sensitive personal data' is given special protection. This includes personal data of a person's 'physical or mental health or condition'. Most genetic information would appear to fall under this protection, as would genetic information about a person's 'sexual life'.

15.15 The handling of genetic test results is required to meet the DPA's principles of fairness and lawfulness. In particular, the explicit consent of the individual is required (unless there is a legal obligation to process the data). The EC Data Protection Directive 95/46/EC, on which the DPA is based, specifies that consent must be 'freely given, specific and informed'. The UK Information Commissioner has given guidance interpreting this as meaning that there must be some active communication between the parties.[15] An individual or organisation who uses data cannot infer consent simply from non-response to a communication. The Information Commissioner has issued a draft code of practice on the use of personal data within employer/employee relationships, under section 53 of the DPA. This contains a section dealing with the use of genetic testing in employment which is based on the recommendations of the 1999 report of the Human Genetics Advisory Commission's (HGAC) on *Implications of Genetic Testing for Employment*.[16] The final version of the Code relating to medical and genetic testing is due to be published by the end of 2002.

Earlier reform proposals

15.16 The potential uses of personal genetic information in employment have been the subject of several earlier reports. However, all of these focus on information that is predictive of inherited disease or information about particular genetic variations that might indicate that a person is susceptible to a specific occupational disease or workplace chemical. None of these reports has considered the use of personal genetic information relevant to particular traits within the normal range of behaviour. Our focus is on whether the conclusions in those earlier reports relating to inherited disease and occupational hazards are also applicable to normal behavioural traits.

15.17 The report of the HGC concluded that at present there is no evidence in this country of any systematic use of predictive personal genetic information in employment.[17] This confirms the findings of the earlier reports of the Nuffield Council and the HGAC.[18,19] Indeed, since the latter reports were published, the only employer that had been known to use such tests (the Ministry of Defence, to screen aircrew recruits for sickle cell disease) has ceased the practice. The HGAC concluded that 'it will take major developments both in our understanding of common diseases and in genetic testing itself before genetic testing becomes a

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[15] The Information Commissioner enforces and oversees the Data Protection Act 1998 and the Freedom of Information Act 2000. The Commissioner is an independent supervisory authority reporting directly to the UK Parliament.

[16] Human Genetics Advisory Commission. (July 1999). *Implications of Genetic Testing for Employment*.

[17] Human Genetics Commission. (2002). *Inside Information: Balancing Interests in the Use of Genetic Data*. paragraph 8.9.

[18] Nuffield Council on Bioethics. (1993). *Genetic Screening: Ethical Issue*s. Chapter 6.

[19] Human Genetics Advisory Commission. (1999). *The Implications of Genetic Testing for Employment*, para.3.5; Trade Union Congress. (1998). *Genetic Testing by Employers*. 2nd ed., reported that 'genetic testing by employers is still rare in this country'. The Health and Safety Commission. (1996). *Report of the Working Group on Genetic Screening and Monitoring*, p.7, made a similar finding.

serious issue for employment practice' and this conclusion applies equally strongly to behavioural traits and non-clinical characteristics.

15.18 The report of the HGAC proposed a common set of principles for policy, aimed at providing appropriate protection to the public if and when genetic testing for diseases in employment becomes a real possibility. We consider that these principles form a useful basis for policy-making and apply equally to behavioural traits as to diseases.

They are:

(i) An individual should not be required to take a genetic test for employment purposes – an individual's 'right not to know' their genetic constitution ought to be upheld.

(ii) An individual should not be required to disclose the results of a previous genetic test unless there is clear evidence that the information it provides is needed to assess either current ability to perform a job safely or susceptibility to harm from doing a certain job.

(iii) Employers should offer a genetic test (where available) if it is known that a specific working environment or practice, while meeting health and safety requirements, might pose specific risks to individuals with particular genetic variations. For certain jobs where issues of public safety arise, an employer should be able to refuse to employ a person who refuses to take a relevant genetic test.

(iv) Any genetic test used for employment purposes must be subject to assured levels of accuracy and reliability, reflecting best practice in accordance with the principles established by the Advisory Committee on Genetic Testing: '[A]ny use of genetic testing should be evidence-based and consensual. Results of any test undertaken should always be communicated to the person tested and professional advice should be available. Information about and resulting from the taking of any test should be treated in accordance with Data Protection principles . . . Furthermore, test results should be carefully interpreted, taking account of how they might be affected by working conditions.'

(v) If multiple genetic tests were to be performed simultaneously, then each test should meet the standards set out in (ii), (iii) and (iv).

15.19 The Report of the HGC concluded that genetic testing is unlikely to provide any information that cannot be gathered by means of existing medical and screening procedures. Given the current uncertainties about interpreting genetic information, the HGC considered that it would be more appropriate to monitor the health of a person by other more direct means.[20] It recommended a voluntary undertaking by employers to inform the HGC of any proposals to use genetic testing for health and safety purposes.[21] The HGC also recommended that genetic tests should not be a condition of employment.[22]

[20] Human Genetics Commission. (2002). *Inside Information: Balancing Interests in the Use of Genetic Data*. Paragraph 8.18.

[21] Ibid. paragraph 8.19.

[22] Ibid. paragraph 8.15.

Appendix E: Further sources of information

Clinical Genetics Society (1994) *The Genetic Testing of Children*

House of Commons Select Committee on Science and Technology (1995) *Human Genetics: The science and its consequences*

Genetics Advisory Commission (1997) *The Implications of Genetic Testing for Insurance*

Advisory Committee on Genetic Testing (1998) *Genetic Testing for Late-Onset Disorders*

General Medical Council (1998) *Seeking Patients' Consent: The ethical considerations*

Human Genetics Advisory Commission (1999) *The Implications of Genetic Testing for Employment*

Council of Europe (2000) *Medical Examinations Preceding Employment and/or Private Insurance: A proposal for European guidelines*

House of Commons Select Committee on Science and Technology (2001) *Genetics and Insurance*

Human Genetics Commission (2001) *The Use of Genetic Information in Insurance: Interim recommendations*

Human Genetics Commission (2002) *Inside Information: Balancing interests in the use of personal genetic data*

Department of Health White Paper (2003) *Our Inheritance, Our Future*

Department of Health (2003) *NHS Code of Practice: Confidentiality*

Opinion of the European Group on Ethics in Science and New Technologies to the European Commission (2003) *Ethical Aspects of Genetic Testing in the Workplace*

Joint Committee on Medical Genetics of the Royal College of Physicians, Royal College of Pathologists and British Society for Human Genetics (2003) Draft document for consultation *Consent and Confidentiality in Genetic Practice: Guidance on genetic testing and sharing genetic information*.

European Commission Community Research (2004) *Ethical, Legal and Social Aspects of Genetic Testing: Research, development and clinical applications*

General Medical Council (2004) *Confidentiality: Protecting and providing information*

British Medical Association (2005) *Population Screening and Genetic Testing*

Human Genetics Commission (2005) *Profiling the Newborn: A prospective gene technology?*

Information Commissioner (2005) *The Employment Practices Data Protection Code – Part 4: Information about workers' health*

Human Genetics Commission (2006) *Making Babies: Reproductive decisions and genetic technologies*

Glossary

Allele: A variant form of a **gene**, which differs in **DNA** sequence from alternative alleles of the same **gene**.

Antenatal: Existing or occurring before birth (i.e. during pregnancy).

Carrier: A healthy individual who has both an abnormal and a normal copy of a gene for a **genetic disorder** or character or characteristic. A carrier of a gene for a recessive disorder will usually remain unaffected through life but may pass on the abnormal copy to their offspring.

Cascade screening: Systematic identification and testing of relatives of people affected by a **genetic disorder** or identified as carriers of a disorder.

Chromosome: A threadlike structure containing **DNA** that carries genetic information arranged in a linear sequence. Humans have 46 chromosomes (23 pairs) in most cells of their body. The sex cells (eggs and sperm) contain only 23 (unpaired) chromosomes.

Deoxyribonucleic acid (DNA): The chemical substance of which a **gene** is made and which encodes genetic information.

False-negative result: A test result that shows a negative result when in fact the attribute that is being tested for actually exists.

False-positive result: A mistakenly positive response.

Fetus: The developing human during the pregnancy (usually more than eight weeks after conception).

Gene: The fundamental physical and functional unit of heredity consisting of a sequence of **DNA**, occupying a specific position within the **genome**.

Genetic disease or **disorder**: Conditions which are the result of alterations in the genetic make-up of an individual. They may be the direct consequences of defects in single **genes** (**mutations**), or in whole **chromosomes**, parts of which may be lost, duplicated or misplaced; or from the interaction of multiple genes and external factors.

Genetic map: The body of information on the relative positions of **genes** on **chromosomes**.

Genetic marker: A harmless variable inherited change in DNA or protein that can be used to locate a disease gene on a particular chromosome.

Genetic profiling: The analysis of a person's entire genome in order to reveal their genetic information.

Genome: The total genetic material of an individual, or of a species.

Genotype: An individual's genotype is their entire genetic constitution, as distinguished from their physical characteristics (see also **phenotype**).

Haemoglobin: The oxygen-carrying **protein** found in mammalian red blood cells. Various gene **mutations** can result in diseases called the **haemoglobin disorders**.

Haplotype: A haplotype is a set of genetic markers (for example, single nucleotide polymorphisms or SNPs) found together in a region of a chromosome.

Heterozygous: Possessing two different forms of a particular gene, one inherited from each parent.

Homozygous: Possessing two identical copies of the same gene.

in silico: A process that is carried out on a computer.

Knock out: Removal or inactivation of a gene.

Late-onset condition: A condition that does not manifest itself until later in life.

Monogenic: Caused by a single gene.

Multifactorial: A term which denotes that many factors, often environmental (such as diet and smoking) and genetic contribute to the development of a disease. Often used interchangeably with **polygenic**.

Mutation: A change in the structure of **DNA**, usually permanent and transmissible. Mutations within genes are the principal cause of genetic disease.

Neonatal: Relating to the period immediately after birth (usually refers to the first 28 days of life).

Nucleotide: Nucleotides are the subunits from which DNA molecules are assembled (the 'letters' of the DNA code).

Pharmacogenetics: The study of the effects of genetic differences between individuals in their response to medicines. These differences may or may not be related to the disease being treated.

Phenotype: The observable or measurable traits of an individual as produced by its genotype and the environment.

Phenylketonuria (PKU): An inherited inability to metabolise phenylalanine, ultimately leading to mental impairment if untreated.

Polygenic: Controlled by or associated with more than one gene.

Polymorphism: Where two or more alleles exist for a gene, such that at least two of the alleles are present in more than one per cent of the chromosomes in a population.

Protein: A molecule composed of many **amino acids**, folded into a particular shape so that it may form a specific function. There are many types of proteins, for example, **enzymes**.

Recessive: Refers to a version of a gene whose expression is masked by a dominant version unless there are two copies of the recessive gene present.

Single nucleotide polymorphism (SNP): Single DNA **nucleotide** variations. Most SNPs fall within the non-coding regions of human **DNA** and make no difference to the individual.

Tay-Sachs disease: An inherited metabolic disorder in which certain lipids accumulate in the brain, causing disability and death in childhood.

Trimester of pregnancy: One of the three periods of three months during pregnancy.

List of abbreviations

ABI	Association of British Insurers
AGNC	Association of Genetic Nurses and Counsellors
DDA	Disability Discrimination Act 1995
DNA	Deoxyribonucleic acid
DPA	Data Protection Act 1998
DRC	Disability Rights Commission
DTI	Department of Trade and Industry
GAIC	Genetics and Insurance Committee
GMC	General Medical Council
HGAC	Human Genetics Advisory Commission (operational from 1996 until 1999)
HGC	Human Genetics Commission
HTA	Human Tissue Authority
NHS	National Health Service
NSC	National Screening Committee
PKU	Phenylketonuria
SNPs	Single Nucleotide Polymorphisms
STAC	Sickle Cell and Thalassaemia Association of Counsellors

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