B5 | Gene technology

Genohype: high hopes and poor returns?

High hopes were raised in the mid-1990s by the study of the genome – heralded as a revolution for humankind by scientists, industry and governments. The genetic makeup of human beings and of microbes and other life forms would be unravelled, paving the way for a host of improvements. Tests would establish each person's vulnerability to developing health problems such as a heart attack or a stroke, or to catching infections such as TB or HIV, and would also identify those who would respond to certain preventive measures, or to treatments with different kinds of drugs. It would allow the development of new vaccines, drugs and other treatments.

There has been significant progress in identifying and elucidating the sequences of genes from humans and other species. Much of the data is publicly and freely available, as on the website of the Sanger Institute, which benefits both publicly-funded scientists and for-profit companies in their quest for patentable inventions and process technologies.

Billions of dollars have been invested by governments, research institutes and industry. Governments of countries such as the US, Canada and China believed it was a key area for development and shaped their policies accordingly, driven not only by a genuine belief in the promises and prestige of genome technology, but also by the lure of new markets. Genome technology was seen as central to the European Commission's aim of becoming the most competitive and dynamic knowledge-based economy in the world (CEC 2001). On the whole, however, there is precious little return as yet in terms of diagnostics, preventative interventions and therapeutics that are clinically significant and of proven efficacy and safety (Sample 2004). Some even wonder whether the whole idea is a flop, prompting the British Broadcasting Corporation to air a radio programme called 'What's wrong with my genes? What went wrong with the human genome project' (BBC 2004). Others speak of 'genohype': the overblown expectations of the benefits genomics can bring to patient care and population health (Holtzman 1999).

This chapter will explore the positive and negative effects of the reorientation of health research towards genome technology. It begins by highlighting some illustrative key issues that emerged from the successful control of the SARS epidemic of 2002–2003. It assesses the economic importance of

genome research. Finally it reviews the threat of further monopolization of knowledge and its commercial applications, and the implications for trust and trustworthiness in health care. It concludes with suggestions for action.

Questioning the 'genohype': some pertinent questions from the SARS epidemic

The microbial agent involved in the severe acute respiratory syndrome (SARS) epidemic of 2002–3 was swiftly identified and sequenced in a remarkable collaboration between otherwise highly competitive laboratories in Asia, Europe, and North America. These early exchanges, however, soon gave way to mutual wariness at the point when intellectual property claims were filed for the pathogen's sequences and other patentable findings with commercial potential. And regardless of the rapid success, the epidemic quickly subsided despite the absence of reliable diagnostics, vaccines or efficacious therapies – an outcome attributable to traditional institutional responses such as isolation and contact tracing, and possibly also to personal risk avoidance, the contributions of seasonality effects and cross-reacting immunity from related endemic microorganisms.

Most importantly, the economic and financial stakes involved ensured that SARS would not be a 'neglected disease' of the world's poor.

The case of SARS prompts a number of questions that could be asked of emerging biomedical technologies in general:

- How important are biomedical advances (including genomics) to population health and to patient care (distinguishing perhaps between knowledge-based practices and coping responses, as opposed to consumable commodities)?
- What is the relative significance of genetics in the etiology (and social ecology) of health and disease?
- What advances can genomics be realistically expected to contribute to disease control, diagnostic aids and treatment?
- What are the likely trajectories of genomics research and development, given the trends in funding of biomedical research, patent regimes, intellectual property rights and market-driven product development, and the unresolved problems of the neglected diseases?
- What environment would enable the useful potential of genomics to be realized – for an equitable harvest of benefits and a humane deployment of genomic technologies?
- What processes and institutions are needed to deal with these policy and ethical issues?

The social ecology of health and disease

The decline in mortality from infectious diseases in early industrializing countries in the 19th century owed little to medical science and its derived technologies (McKeown 1971). In England and Wales, for example, the mortality rate from respiratory tuberculosis, a major killer, declined by more than 85% between 1838 and 1945, well before the discovery and isolation of the antibiotic streptomycin in 1947 and also well before the widespread availability of BCG vaccination for protection against tuberculosis from the 1950s onwards. McKeown and others identified food intake and nutritional status, potable water supplies and environmental hygiene as the key factors in the decline of infectious mortality.

Mortality alone is an inadequate measure of population health. Nonetheless, recent efforts to devise more discriminating measures of disease burden that take into account morbidity, disability and functional capacities, and quality of life have not seriously undermined McKeown's thesis, notwithstanding the efficacy of some modern therapeutics and procedures in controlled, favourable circumstances. Biomedicine at best has contributed only modestly to improvements in population health. This is the context in which the future benefits of genomics must be evaluated.

The current focus on genome technology and the particular imagery around the human genome is unfortunately diverting attention from public health approaches to combating disease, ill health and poverty. Life is much more complex than the pattern of the molecules in our genes. It is also important to know why and when some genes in some people are switched on and why others are switched off. A major part is played by the microenvironment inside cells, but this is influenced by the macroenvironment, the body as a whole and the outside world. A host of physical and social factors play a role, and public health approaches, embedded in socioeconomic policies, will probably remain much more important than high-tech solutions in improving global health.

Justifiable exuberance or premature genohype?

Is genomics the panacea for human illness and infirmity? The director of the US National Human Genome Research Institute declared in 1999 that the benefits of mapping and sequencing the human genome 'would include a new understanding of genetic contributions to human disease and the development of rational strategies for minimizing or preventing disease phenotypes altogether'. There would be further prospects of 'genetic prediction of individual risks of disease and responsiveness to drugs…and the development of designer

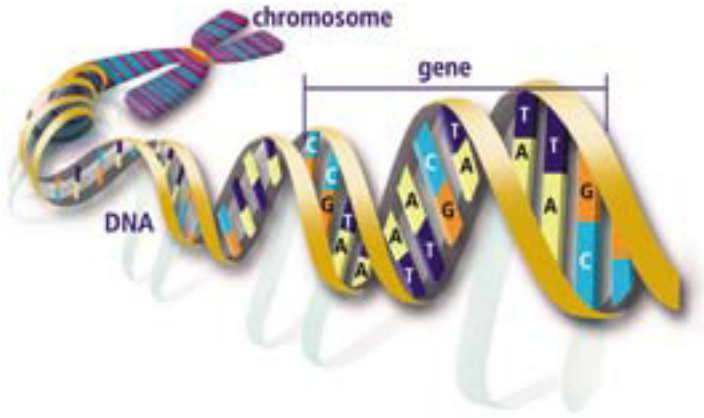
drugs based on a genomic approach to targeting molecular pathways that [have] been disrupted in disease' (Collins 1999, Collins and McKusick, 2001).

Five years on, participants at a conference on genomics and health held by the US National Academy of Sciences (Institute of Medicine) reflected on the progress made in far more modest tones. Hopes had been high of dramatic advances in cancer treatment, but the media quoted prominent scientist Dr Gilbert Omenn as saying that despite an 'avalanche of genomic information… cancers remain a largely unsolved set of medical problems [for which] we continue to rely on highly toxic drugs' (Boyd 2004; see also Hernandez 2005).

One recent addition to the cancer armamentarium which has benefited from advances in molecular cancer biology is trastuzumab (Herceptin), used to treat HER2–positive metastatic breast cancer. It has been welcomed by clinicians but is not considered revolutionary. It extends lifetimes by a matter of months but does not avoid side-effects, is suitable for rather a small number of patients and is costly (Hedgecoe 2004). Gefitinib (Iressa), for non-small cell lung cancer, has been hailed as the next 'genetically targeted' treatment (Langreth 2004), but its manufacturer recently withdrew its application for European regulatory approval, following the release of clinical trial data that showed the drug did not increase lifespan (Tomlinson 2005). More generally, genomics had made little impact on clinical practice and outputs such as new treatments have failed to keep pace with increased research and development (R&D) spending (Nightingale and Martin 2004).

The relatively rare Mendelian disorders such as cystic fibrosis, phenylketonuria and Huntington's disease allow for relatively easy study of the associated molecular genetics because the risk of disease is dominated by mutations in a single gene. Prominent geneticists have pointed out that the overwhelming bulk of common chronic diseases (diabetes, coronary heart disease, cancers) have much more complex etiology that may include a familial component in addition to social, economic, psychological and biological factors. The relationship between genotype (DNA sequence at the gene locus of interest) and phenotype (manifest traits) therefore becomes correspondingly murky and contingent for those common diseases. The proportion of cases that can be attributed to susceptibility-conferring genotypes in a given population is typically small for common diseases such as breast cancer and colon cancer, making it both more difficult and less useful to identify the gene (ensembles) involved (Holtzman and Marteau 2000).

Even when the molecular genetics are tractable, knowledge of the molecular basis of a disease is not easily translatable into prevention or treatment. It took 70 years for streptomycin to become available for TB treatment from the



11 The human genome under threat of commercialization.

time Mycobacterium tuberculosis was identified as the agent involved. The molecular (genetic) basis of sickle-cell anemia was elucidated in the 1950s but palliative therapy has only recently become available. There has been little advance in the treatment of cystic fibrosis since the crucial gene was identified and cloned in 1989 and details of the molecular pathogenesis worked out. More encouragingly protease inhibitors, used in combination therapy along with reverse transcriptase inhibitors for treating HIV/AIDS patients, became available in the mid-1990s, about 10 years after the discovery of HIV-1.

Given that the success of gene-based therapies has so far been modest, with few promising candidates on the horizon, commercial interest is likely to shift towards genetic testing for 'disease susceptibility' – in line with a paradigm shift towards 'predictive medicine', or individual genetic profiling to assess the risk of future illnesses. This has the added attraction of mass markets, since genetic testing for disease susceptibility may be conducted routinely as part of well-person care and screening. Corporate R&D is seeking 'pills for the healthy ill' or worried well (Wallace 2002), to carve out new markets not just for screening tests but also for 'prophylactics' for those deemed to be at risk.

While busily seeking to create markets for its commodifiable biomedical outputs, market-driven R&D and its corporate sponsors will continue to ignore and bypass the diseases of the poor. This is also discussed at length in part B chapter 2 on medicines. Global spending on health research tripled from US$ 30 billion in 1990 to almost US$ 106 billion in 2001. It was split roughly between the public and private sectors, with the private nonprofit sector (including charities) playing a small but growing role. However, most R&D is still done by high-income countries in high-income countries to generate products tailored to those markets.

Complete figures are not available for spending on genomics. In 2000 the World Survey of Funding for Genomics estimated that private spending on R&D was around double the government and nonprofit spending, at US$ 1–2 billion. 'Even more than for medical research in general, the skew of research funding is heavily directed toward the developed economies with large pharmaceutical markets,' it concluded (Cook-Deegan et al. 2000). Research is mostly directed towards conditions affecting large populations in rich countries (see part E, chapter 7).

Even in rich countries, health research priorities do not reflect priority health needs. In the UK, for example, public research funds tend to follow the research investment strategies set by industry, rather than the needs of public health or health services. Research that is unlikely to be profitable or is of little scientific interest tends to be neglected (Harrison and New 2002) – including public health research, despite its enormous importance in reducing disease.

Genetics and the knowledge economy: who owns life?

Scientific effort leads to discoveries and inventions. Some harmful, such as weapons of mass destruction, but many useful. Until a decade ago most countries were free to define their laws governing the use of scientific knowledge, and it was felt to be beneficial to put such knowledge in the public domain for everyone to use. An ethos of scientific pride, and the respectability and honour from contributing to humanity's progress (and, more ominously, its military prowess) drove the mushrooming of discoveries and inventions in the 19th and 20th centuries. Funding by the public purse, industries and charities all played a role.

Lobbying by a few large companies and rich countries changed this. Its vehicle was the World Trade Organization (WTO) and its agreement on Trade Related Intellectual Property Rights (TRIPS), outlined in detail in part B, chapter 2 on medicines. The discourse moved away from the idea of scientific knowledge being publicly available towards the notion that private for-profit firms were well placed to create new knowledge and to translate that into useful products. It was argued that the discovery of molecules and other microaspects of life was painstaking and onerous, and it would be unfair if other countries could use this information freely.

This allowed the hitherto unthinkable idea of patenting discoveries, including life forms. Not everyone in the North agrees with this, of course: the Wellcome Trust continues to make newly discovered information freely available, while Cancer Research UK allows its patent on the breast cancer gene

BRCA2 to be used at no cost (Matthijs 2004). But the EU and its governments and the US shed long-held moral convictions in pursuit of competitive and technological advantage despite objections from UNESCO, European medical associations and WHO. The TRIPS agreement caused another sea change: patent-lifes were extended to 20 years (often 12 in the past) on highly contestable grounds (CIPR 2002). Patents are also now more likely to cover products as well as process technologies. This extraordinary expansion of monopolies in the knowledge economy is one of the defining paradoxes of modern times. It came about through a mixture of open debate and bullying behind the scenes (Elliott and Denny 2003, Jawara and Kwa 2003). It follows the rules of centuries-old mercantilism – the protection and expansion of one's own economy, usually at the expense of others – and contradicts the supposedly open spirit of competition and free trade.

Consumers are now expected to pay many times over, edging the poor and developing countries out of the buyers' market. They even dig in their pockets as taxpayers: many discoveries and inventions are based on freely accessible information generated by research financed by government institutions. Publicly funded researchers in biotechnology now have to negotiate their way through a maze of patents. The costs of this include paying licensing fees or having to send their specimens for tests to the laboratory of the monopoly holder of the licence, as well as the fees and opportunity costs of legal and administrative processes. This can lead to bizarre and unfair situations. In the US, families of patients with Canavan disease volunteered for gene research but found that its useful applications became commercialized and beyond their reach (AMA 2000). The patenting and licensing system slows down innovation (Matthijs 2004, AMA 2000), skews research towards the development of profitable products and offers no incentives for innovations which promote health for the poor. Moreover, the secrecy associated with commercial competition makes it more difficult to monitor and supervise the dangers and risks of manipulating and spreading life forms (Kimmelman 2005).

These developments disenfranchise developing countries. Alternative proposals include a global coalition to regain lost ground (Drahos and Braithwaite 2004) and alternatives to the patent regime (Love 2003, Baker 2004).

Owning your own genome: can you trust health care?

The implications of genetic screening dilemmas are problematic. Most of the tests on the market have not been approved by health care insurers, owing to their poor predictive value. It is quite unlikely that a person will develop a common illness such as Alzheimer's, coronary heart disease or diabetes, even

when a test has shown they have a particular genetic makeup thought to be related to that disease. Nevertheless, a positive test result may cause anxiety and fear (Boseley 2004).

Insurers and some employers are keen on assessing medical information about their clients and employees, including genetic information. They also fear that people with bad risks could overinsure themselves for their own and their dependants' protection. In the marketplace, if one competitor demands information of a particular kind the others should do the same to maintain a level playing field. This was the case some 15 years ago in the developed world when HIV infection was, for most, a death sentence. It was in people's interests to know their HIV status, to be able to plan their future and protect their partners and children. At the same time, knowledge of your HIV status could ruin your prospects for decent housing, insurance or even a job, and expose you to other forms of discrimination.

In employment, however, there are no known situations where a genetic test appears fully justified. For example, genetic testing for sickle-cell disease was used on air crew in the US and UK who might be prone to blackouts when exposed to low atmospheric pressure. This policy, criticised as racist, has now been reversed: both countries recognized that it was unjustified because a pilot is extremely unlikely to develop the disease unnoticed and have a first blackout while flying a plane.

Most western countries have either banned or suspended the use of genetic test information for the purpose of risk selection. However, even in a highly regulated country such as the UK the voluntary system for limiting the use of genetic information has been ignored (Meek and Bachelor 2001). Some British insurers now demand the divulging of negative genetic test results, while requesting a huge amount of medical information from doctors. From there on, insurers will be able to analyse databases, develop actuarial tables and make informed guesses about applicants' genes. This could lead to the loading of premiums and if unchecked will open Pandora's box: with the further development of genetic profiling and sets of longitudinal data, risk assessment could eventually extend to applicants' children.

Trust and trustworthiness Most people do not question the collection of medical information, assuming that doctors and other health professionals act in their best interests (Fugelli 2001, O'Neill 2002). Few people, when baring body and soul, think that medical information may be used in evidence against them. Many volunteer to participate in medical research, often after advice or persuasion by their doctors, but few suspect that the spin-offs of

that research may be commercialized, potentially blocking its use for poor, uninsured people and developing countries. Patients should be offered an informed choice including a warning of that possibility.

The current trend for doctors and nurses to initiate the collection of huge amounts of biomedical data about their patients is both scientifically and ethically wrong. Truly informed consent (Thornton 2003) and patient autonomy are often ignored and the medical benefits overstated (Getz et al. 2003). The negative effects on patients include anxiety about being at risk (Melzer and Zimmern 2002) and becoming one of the worried well. Issues include the conflict between acting as a truly confidential counsellor on potential genetic conditions and a collector of data for the purposes of the administration and control of health care, public health and risk selection.

Doctors may increasingly be asked to play a role in requests for selection of sex or other features of babies. Such requests may be used as conditions for marriage and lead to marginalization or exclusion and the further control and oppression of women and their reproductive rights. The eugenicist flavour of some of the proposed applications of genetic research, and their implications for people with disabilities, is a linked concern discussed in more detail in part C, chapter 2 on disability.

Trust in health professionals will not be greatly undermined by these developments in the short or medium term. Doctors and nurses come top in many countries' surveys of who is most trusted and respected, and this is unlikely to change. However, the commercialization of health care and commercial risk selection are progressing fast. Against this background, can health care, and can doctors and nurses, be trusted? Are they Trojan horses, whether they like it or not? How can they help ensure that patients' interests come first, individually and globally? Health professionals, their organizations and health-related NGOs need to respond to these questions.

Conclusions and proposals

The assumptions and activities of the scientific and commercial enterprises around biotechnology, especially genome technology, merit close scrutiny. A legal armamentarium has emerged to bring the human body and other life forms within the ambit of intellectual property, and present life as a commodity which can be patented, traded and made to yield a profit. The quest for competitive advantage and dominance in biotechnology has spurred governments and corporations to promote the privatization and commercialization of biotechnological knowledge. Current developments also threaten reproductive rights and undermine global and national equity. Governments, industry and scientists

are allowing a runaway agenda to shape new paradigms for the way we see life, health and health care, with global justice and equity on the losing end. To help restore the balance, the following proposals should be considered:

Democratization of the health research agenda. The national and international systems for setting the agenda for health research need to be overhauled. The relative importance of biotechnology research, including the study of the genome, should be weighed against research into diseases of poverty and the social ecology of health and disease. There should be genuine representation and participation of community groups in setting priorities and research design.

Global equity and justice first. Organizations focusing on health and equity should insist that genome technologies and their applications are guided by the core values of national and global equity, human rights including gender rights, and medical ethics (UN 1966 and 2001, WMA 1983, EFMA-WHO 2001, UNESCO 1997).

Health and equity impact and risk assessments. Civil society, and international groups of interested scientists, should demand that states and international organizations like WHO carry out health and equity impact assessments and risk assessments using such criteria as internationally agreed human rights in health and health care. They should be participatory, with genuine representation of civil society, and free from pressures arising from international economic and donor policies. Assessments should include the potential effects of different scenarios of genome applications on health and equity, nationally and internationally, in different social and health care systems. Expertise and experience on risk assessments and the precautionary principle can be drawn from environmental campaigns.

Equitable access to and use of knowledge. States and research funders should develop ways by which researchers give up or selectively forgo patent rights to help make useful inventions cheaply available for all.

Overhaul of regimes for intellectual property rights. This is needed to create a lasting solution to the crisis in the knowledge economy (see also part B, chapter 2). Solutions include reducing the length and coverage of patents, and liberal provisions for governments and UN institutions to buy patent rights from patent-holders if this is in the public interest, and/or arrangements for compulsory licensing (Love 2003, Baker 2004). Pressure on countries to accept deals unfavourable to their populations should be ended. There should be credible monitoring systems and sanctions. These improvements should be seen in the context of the need to establish a fair and equitable international trade system.

Monitor organizations. Organizations focusing on health and equity should monitor governments and international organizations such as WHO so that they do not lend legitimacy to the commercialization of human (and other) life and to 'genohype', which draws away resources and attention from addressing diseases of poverty and inequity.

Rethink the data collection role of health care providers. Confidentiality and human rights need to come first. Health professionals should rethink their role in collecting data that can be used for the purposes of insurances, risk selection for employment, health care administration and public health.

Ensure research meets priority needs. Health-related NGOs should explore the roles of individuals and groups who participate in biotechnology research (e.g. by allowing their samples to be used for genome research). NGOs could develop guidelines and a standard contract that stipulates that individuals will only participate in research if its eventual useful spin-offs are made available to poor users and poor countries at affordable prices. More fundamentally, citizens and NGOs should play a role in ensuring research projects make health needs, not market needs, the priority.

Risk selection and insurance in the public interest. The developments in human genomics confirm and strengthen arguments in favour of the establishment of inclusive non-discriminatory systems of health care and sickness insurance. NGOs should stress that such regulated or non-profit systems, characterized by cross-subsidization of the sick by the healthy and the poor by the rich, offer the only just approach to avoiding discrimination, inequity and exclusion whilst capturing the benefits of a humane and responsible development of genomics.

References

American Medical Association (AMA) (2000). *Report 9 of the Council of Scientific Affairs (I-00): Patenting of genes and their mutations*. Chicago, AMA (http://www.ama-assn.org/ama/pub/category/13570.html, accessed 5 January 2005).

Baker D (2004). *Financing Drug research: What are the issues?* Center for Economic and Policy Research, Washington DC.

BBC (2004). What's wrong with my genes? What went wrong with the Human Genome Project? *BBC Radio 4*, 29 September 2100–2130 hr (UK time).

Boseley S (2004). Watchdog seeks controls on scary gene tests. Critics attack landmark decision on gene screening. *The Guardian*, September 9 (http://www.guardian.co.uk/uk_news/story/0,,1300119,00.html, accessed 14 March 2005).

Boyd R S (2004). Patients Have Yet to Benefit From Genome Research. *Miami Herald*, 12 October, pg 4A (http://www.miami.com/mld/miamiherald/2004/10/13/living/9895562.htm, accessed 14 March 2005).

Commission of the European Communities (CEC) (2001). *Towards a strategic vision*

of life sciences and biotechnology: consultation document. Brussels (COM (2001) 454 final).

Commission on Intellectual Property Rights (CIPR) (2002). *Integrating intellectual property rights and development policy.* London, CIPR.

Collins FS (1999). Shattuck Lecture – Medical and Societal Consequences of the Human Genome Project. *New England Journal of Medicine,* 341:28–37.

Collins FS, McKusick VA (2001). Implications of the Human Genome Project for Medical Science. *Journal of the American Medical Association*, 285(5).

Cook-Deegan R, Chan C, Johnson A (2000). *World survey of funding for genomics research. Final report to the Global Forum for Health Research and WHO.* Washington, DC, Stanford-in-Washington Program (http://www.stanford.edu/class/siw198q/websites/genomics/finalrpt.pdf, accessed on 14 March 2004).

Drahos P, Braithwaite J (2004). *Who owns the knowledge economy? Political organising behind TRIPS* (Briefing 32). Dorset, The Corner House (http://www.thecornerhouse.org.uk/item.shtml?x=85821, accessed 14 March 2005).

European Forum of Medical Associations and World Health Organisation (EFMA-WHO) (2001). *Statement on the Human genome and International Patent Law*. Ljubljana, 9–11 March.

Elliott L, Denny C (2003). EU's secret plans hold poor countries to ransom. *The Guardian*, 25 February (http://www.guardian.co.uk/business/story/0,3604,902296,00.html, accessed on 14 March 2005).

Fugelli P (2001). Trust – in General Practice. *British Journal of General Practice* 5 1:575–9.

Getz L, Sigurdsson J, Hetlevik I (2003). Is opportunistic disease prevention in the consultation ethically justifiable? *British Medical Journal*, 327:498–500.

Harrison A, New B (2002). *Public interest, private decisions: health related research in the UK.* London, Kings Fund.

Hedgecoe A (2004). *The politics of personalised medicine: pharmacogenetics in the clinic.* Cambridge, Cambridge University Press.

Herandez L (ed.) (2005). *Implications of Genomics for Public Health: Workshop Summary*. Washington DC, The National Academies Press.

Holtzman NA (1999). Are genetic tests adequately regulated? [editorial]. *Science* 286(5439):409.

Holtzman NA and Marteau T (2000). Will genetics revolutionize medicine? *The New England Journal of Medicine*, 343:141–144.

Jawara F and Kwa A (2003). *Behind the scenes at the WTO. The real world of international trade negotiations.* London, Zed Books.

Kimmelman J (2005). Recent developments in gene transfer: risk and ethics. *British Medical Journal,* 330:79–82.

Langreth R (2004). Gene predicts cancer drug effectiveness. *Forbes Magazine,* 29 April.

Love J (2003). A new trade framework for global healthcare R&D. In: *Workshop on Access to Medicines and the Financing of Innovations in Health Care*. New York, NY, The Earth Institute at Columbia University and the Consumer Project on Technology (http://www.earthinstitute.columbia.edu/cgsd/documents/love_000.pdf, accessed 23 February 2005).

Matthijs G (2004). Patenting Genes. May slow down innovation and delay availability of cheaper genetic tests. *British Medical Journal*, 329:1358–60.

McKeown T (1971). A Historical Appraisal of the Medical Task. In: *Medical History and Medical Care*. London, Oxford University Press.

Meek J, Bachelor L (2001). Insurers 'broke code on gene information'. *The Guardian Weekly*, 10 May, p8 (http://www.guardian.co.uk/Archive/Article/0,4273,4179375,00.html accessed 14 March 2005).

Melzer D, Zimmern R (2002). Genetics and medicalisation. *British Medical Journal* 324:863–4.

Nightingale P, Martin P (2004). The myth of the biotech revolution. *Trends in Biotechnology*, 22:564–569.

O'Neill O (2002). *A question of Trust*. BBC Reith Lectures (http://www.bbc.co.uk/radio4/reith2002/, accessed 23 February 2005).

Sample I (2004). The revolution is not won yet. *The Guardian,* 22 Jan (http://www.guardian.co.uk/life/feature/story/0,,1128145,00.html accessed 14 March 2005).

Thornton P (2003). Confidentiality: consent is not sufficient. *British Journal of General Practice,* 269–70.

Tomlinson H (2005). AstraZeneca withdraws application for cancer drug sale in EU. *The Guardian,* 5 Jan (http://www.guardian.co.uk/business/story/0,,1383338,00.html, accessed 14 March 2005).

UN (1966). *International Covenant on Economic, Social and Cultural Rights*. New York, NY, UN.

UN (2000). *The right to the highest attainable standard of health.* 11/08/2000. E/C.12/2000/4. (General Comments). Geneva, UN (http://www.unhchr.ch/tbs/doc.nsf/385c2add1632f4a8c12565a9004dc311/40d009901358b0e2c1256915005090be?OpenDocument, accessed 15 March 2005).

UNESCO (1997). *Universal Declaration on the Human Genome and Human Rights*. Paris, UNESCO (http://portal.unesco.org/en/ev.php-URL_ID=13177&URL_DO=DO_TOPIC&URL_SECTION=201.html, accessed 14 March 2005).

Wallace H (2002). *Genetics and 'Predictive Medicine': Selling Pills, Ignoring Causes.* Briefing Paper Number 18, May. Buxton, GeneWatch (http://www.genewatch.org/Publications/Briefs/Brief18.pdf, accessed 14 March 2005).

World Medical Association (WMA) (1983). *International Code of Medical Ethics*. Ferney-Voltaire, WMA (http://www.wma.net/e/policy/c8.htm, accessed 14 March 2005).

Useful websites

http://www.genewatch.org

http://www.genetics-and-society.org