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Genomic patenting and the utility requirement

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ABSTRACT *This paper analyses the ways in which genomic knowledge is portrayed as useful knowledge in gene patenting in order to fulfil the 'utility'/'industrial applicability' requirement for patentability. It gives examples of utility claims in gene patents and asks whether genomics (as opposed to genetics) changes our ideas about what is useful and what can be patented. It puts forward a provisional classification of different types of utility and argues that merely identifying the physiological function of a gene diverges radically from our commonsense understanding of what it is for an invention to be useful. Furthermore, social, political and ethical issues inevitably arise when discussing the utility requirement, because an invention cannot be useful in isolation from a social context.*

Introduction

Patenting has traditionally been the concern of lawyers and economists, but the advent of gene patents has led to broader public and academic interest in the field. In this paper I adopt an approach to genomic patenting which could be called 'semantic' because it attempts to capture the meanings of the 'utility requirement'. The discussion is not, however, restricted to the language used in gene patenting, since I suggest new ways of distinguishing types of utility in DNA patents. I also demonstrate how theoretical reflections on the nature of genes and genomes can have implications for the way we think about intellectual property.

In this article I review relevant patents, patent guidelines, reports and commentaries. The collection of documents analysed is not intended to be comprehensive, but does cover a sufficiently broad range of issues to allow a preliminary categorization scheme to be developed. The aim is to generate a provisional map of the different understandings of utility as they relate to genomic patents, which will, in later empirical stages of the project, be discussed with various actors involved in the patenting process.

The focus is on gene patenting in the context of genomics. Genomics is often presented as a field that will contribute enormous benefits to society. The Human Genome Project, for example, was funded on the basis of arguments that it would result in considerable medical benefits. The utility of research has

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become an important rationale for science funding in recent times and it is, in theory, the practical applications of discoveries that can be patented.

I begin with an introductory discussion of patenting and how it applies to genomics, assuming a non-legal background on the part of the reader. The aim is to provide a simple overview of the law in this area and to identify key issues relating to its application. A discussion of the utility requirement in gene patenting follows and I give some examples of patents where utility is contestable, such as patents on 'junk DNA'. Finally I put forward a categorization of the different arguments for utility found in the patenting literature, and show that an awareness of these various conceptions of utility can have implications for our understanding of gene patenting.

Patenting basics

The aim of patenting is to promote innovation by giving the inventor a limited monopoly on their invention, limited by time and geography. The promotion of innovation is assumed to be in the public good. A patent is a negative right 'to exclude others from making, using or selling' an invention (Adler, 1984, p. 357). The United States Code says that a patent can be obtained by 'Whoever invents or discovers any new and useful process, machine, manufacture, or composition of matter' (35 USC 101). The European Patent Convention[1] lists the requirements for patentability: 'European patents shall be granted for any inventions which are susceptible of industrial application, which are new and which involve an inventive step'. The requirements for patentability in the USA are similar but use slightly different terminology (utility, novelty and non-obviousness). Patents are for inventions that fulfil these requirements for patentability.[2] These requirements all have a legal meaning, which is not necessarily the same as their scientific or everyday meaning, and they allow flexible interpretation, which makes them interesting topics for analysis.

To outline very briefly the requirements: an invention is novel if it has not been made public previously. Non-obviousness (USA) or inventive step (Europe) means that an invention is not obvious to someone 'skilled in the art'. The utility (USA) or industrial applicability (Europe) requirement is the focus of the rest of this paper. I treat the utility requirement and the industrial applicability requirement as broadly the same, because the patent offices behave in a similar manner (Llewellyn, 1994). In addition to these requirements, patents must also be sufficiently disclosed and qualify as patentable subject matter. In Europe it is not possible to patent an invention if it is contrary to public policy or morality.

On the basis of these requirements for patentability we can ask how we are in a situation where genes can be patented at all. Since genes already exist in organisms they do not appear to qualify as new inventions. However, substances that are 'isolated and purified' can be patented (as long as they fulfil the other requirements for patentability) and, according to this logic, such substances include genes. Genes are treated as novel molecules and they are given 'composition of matter' patents, so any process that uses the molecule is infringing the

patent, just as it would with any other chemical compound. Text from the European Biotechnology Directive shows the importance of isolating the gene: 'An element isolated from the human body or otherwise produced by means of technical process, including the sequence or partial sequence of a gene, may constitute a patentable invention, even if the structure of that element is identical to that of a natural element' (EU Directive, Article 5.2).

The utility requirement in gene patenting

However unpalatable it may appear, we are currently in the situation where isolating and purifying a gene fulfils the novelty and non-obviousness requirements. But a gene can only be patented if it can be shown to have a utility, which is why the utility requirement is crucially important.

The European Patent Office (EPO) guidelines demonstrate the importance of utility: 'To find a previously unrecognised substance occurring in nature is mere discovery and therefore unpatentable. However, if a substance found in nature can be shown to produce a technical effect it may be patentable' (European Patent Office, 2003, p. 44). Here a 'technical effect' means that the discovery is useful (the example given here is an antibiotic effect). If a gene can be shown to be useful it is patentable. We see here why it becomes very important to clarify what we mean by a gene being useful.

Biagioli (2002) raises interesting issues about the relationship between utility and genes. He says that 'Nature becomes patentable by being turned into something that is less natural and more useful' and that when scientists patent natural objects 'they do so by making them potentially useful by carving them out of their state of nature' (p. 489). Interesting questions are raised here: why does something become *less* natural when it becomes more useful? By making something useful do we give it properties that it did not possess in nature? This point will be returned to below.

Another reason why utility is a particularly interesting requirement is because 'novelty' and 'inventive step' appear to be internal to the science itself, while 'utility' more clearly refers to something in the outside world. In this way the outside world is brought in to the patenting process (Leese, 1998). Here, we see why broader social, political and ethical questions are raised in the discussion of utility. When we are talking about utility we are necessarily asking 'useful for whom?', because an invention cannot be useful in isolation from a social context.

As we shall see from the following examples, in gene patenting there is the assumption that if the *function* of a gene is known then its utility is known. The EU Directive (1998) says that 'a mere DNA sequence without indication of a function does not contain any technical information and is therefore not a patentable invention' (paragraph 23). So if we do know the function of a gene, we potentially have a patentable invention. At first glance it seems strange that knowing the function of a gene is sufficient to show that the gene is a useful invention, since function is normally thought of as something a gene does which

contributes to the maintenance, operation or persistence of the organism. Physiological function does not intuitively seem to demonstrate the broader social utility that we might think would be necessary for a patent. Further analysis of the relationship between physiological function and utility reveals that the situation here is ambiguous. Some examples demonstrate this point.

Expressed Sequence Tags

Expressed Sequence Tags or ESTs are fragments of DNA which are expressed as messenger RNA, meaning that they are parts of genes. They have a known location, so they can be used for the identification of genes, but they do not have a known function. In applications for EST patents the utility was given as a 'scientific probe for the discovery of genes' (Cornish, Llewellyn & Adcock, 2003), which is a use for the research community. Since ESTs have a use for the research community, but not beyond it, we see that the 'useful for whom?' issue becomes relevant here. However, arguments were made that ESTs should not be patentable on the grounds that their physiological function was unknown.

It is interesting to examine the types of arguments that were advanced against patenting ESTs because they emphasize the importance of gene function. The US National Research Council (1997) maintained that patenting should move towards 'functional aspects of the genes, rather than being primarily descriptive' (p. 54). This sentiment is reflected in a Human Genome Organisation (1995) statement, which says that 'the patenting of partial and uncharacterized cDNA sequences will reward those who make routine discoveries but penalize those who determine biological function or application'. We see that determining biological function is considered to be an important pursuit in itself.

As a result of the contention over ESTs, the EU Directive states that full or partial gene sequences with no known function will not be patentable. The USA has no particular limitation on patenting ESTs, and Human Genome Sciences (HGS) has received patents on a number of ESTs which make broader utility claims than those originally advanced. But the ongoing row over EST patents has led to the US patent office changing its standard of utility.

Specific, substantial and credible

In January 2001 the United States Patent and Trademark Office (USPTO) added three new words to its utility guidelines: specific, substantial and credible. The significance of these changes spread beyond the USA since the EPO and the UK Patent Office have adopted very similar standards (Cornish *et al.*, 2003).[3] These revised guidelines do not unpack the previously under-characterized idea of utility, but instead qualify the notion of 'use' by bringing in other concepts.

For a utility to be s*pecific* it must be particular to the nucleotide sequence being claimed, rather than just stating a general utility. For example, it is not sufficient to state that a gene is a 'diagnostic', it is necessary to specify for which condition. For a utility to be s*ubstantial* there must be a real world use, meaning

that speculative utilities are not accepted. Substantial utility is not met if the invention is just used to learn about the properties of DNA itself (Kamstra *et al.*, 2002). For the utility to be *credible* the usefulness of the invention must be theoretically possible. These extra requirements are meant to overcome the more dubious claims to utility made for nucleotide sequences such as ESTs.

Patenting guidelines show that utility has many dimensions, but the situation is complicated still further when we consider the relationship between genes and function and when we recognize that genes can have multiple functions.

Genes and functions

It is interesting to ask what kind of understanding of the gene is assumed in patenting guidelines and whether patenting reifies the gene and black-boxes it. In patenting we see the apparently straightforward idea that a gene produces a protein. However, this does not take the role of contextual environmental, cellular and genomic factors into account. From a genomic perspective genes need a genomic context in order to function. In fact, it even becomes difficult to define a 'gene' when we consider the role of promoters and other parts of the DNA that regulate transcription (see Rheinberger, 2000). These factors mean that the idea of patenting a single gene becomes much less straightforward.

Another problem is that genes can have multiple functions. Many examples can be given where one gene has different functions in different cells in the body or where one gene is responsible for more than one illness or trait. Once an inventor patents a gene, since she has patented the chemical substance itself she can also attempt to claim rights to new functions when these are discovered. An example here is HGS's patent on a gene that belonged to a family of cell receptors which play a role in inflammatory disease. This gene (CCR5) was later found to be the entry path of the HIV virus into human cells, and HGS gained rights over this function too. We should be aware that patentees can make claims over future, currently unknown functions of genes, on the grounds that the new function would not have been discovered without the disclosure made in the original patent. It remains to be seen what consequences this type of patenting activity has for research (OECD, 2002).

With these complications in the background I turn to an example of gene patenting where the utility requirement appears to have been stretched to its limits.

The utility of 'junk'

'Junk DNA' is a popular term for the DNA in an organism which does not code for proteins. In scientific literature it is normally referred to as 'non-coding DNA'. It makes up over 97% of human DNA, including introns. Genetic Technologies, a small company in Australia, has patented a method of genomic mapping that uses non-coding DNA and is trying to compel anyone who uses

non-coding DNA to pay licensing fees. The question that arises is what is the utility here? The term 'junk DNA' implies that the function of the DNA is unknown.

We can examine the 'junk' patents and their claims for utility (it should be noted that all these patents were filed before the stricter utility guidelines). In the first patent we read that 'DNA sequences that include a sufficient number of intron sequence nucleotides can be used for direct determination of haplotype'. A haplotype is a stretch of DNA that is inherited as a unit. In other words, the utility here is that the non-coding DNA can inform us about genes that are linked together. This utility does not initially appear very convincing, especially in respect to what I have vaguely referred to above as 'broader social utility'. A later patent extends the utility, saying that the non-coding DNA can tell us about 'unknown human genetic disease genes identified by unique phenotypes', so a link is made to disease diagnosis. This is admittedly a clearer utility, but it does not give any indication of *which* diseases the non-coding DNA can inform us about.

A brief literature search reveals that non-coding DNA does have several other functions, not mentioned in the patents. It can be structural and provide a kind of 'scaffolding' for the genome (this is a function in the context of the genome, not in the context of the gene). Additionally, it can be a source of small RNAs which regulate cell differentiation and centromere function (Matzke & Matzke, 2003). Centromere function is, again, a function that makes the most sense in the context of the whole genome. Additionally, non-coding DNA is used in genetic fingerprinting and to enable us to distinguish between species in environmental genomics. It is clear that there are many uses for non-coding DNA which are not obvious at first sight, implying that 'junk DNA' has increasingly become a misnomer. Once we start thinking about the different uses for non-coding DNA suggested here, we see that they cover many different implicit ideas of 'use'. It is helpful at this point to analyse different kinds of claims for usefulness.

Different types of utility

A provisional classification of the different uses of DNA found in patents and patenting guidelines has been developed (see Table 1). This table was generated by reflecting on the different arguments for utility found in patents, patenting guidelines, reports and commentaries on gene patenting and sorting these arguments into types. When new material was encountered, it was assessed to see how well it fitted into the categories and the scheme was re-modelled in an interactive and iterative fashion. This is similar to Garfinkle's 'documentary method', where observations, which 'document' an underlying pattern, are in turn interpreted in the light of the underlying pattern (Heritage, 1984; Barnes, Bloor & Henry, 1996). This is an approach which combines both 'top-down' analysis, and 'bottom-up' engagement with the material. The aim here is not to produce an exhaustive taxonomy; it is one way of classifying the material which

TABLE 1. Types of utility in gene patenting

Type of utility	Examples
Anthropocentric	Marker for Diagnosis (EPO, USPTO, National Research Council, 1997) Forensic identification (National Research Council, 1997)
Manipulated physiological function	Gene Therapy (EPO) GM crops
Natural physiological function: broader use	Synthesis of therapeutic proteins (Nuffield Council on Bioethics, 2002) Antibiotic effect (EPO)
Mere natural physiological function	Making a certain polypeptide (EPO) Biological reaction involving the protein product (USPTO) Receptor function (Official Journal EPO, 2002) Gene-regulating activity (USPTO)

seems to be fruitful in distinguishing the types of utility claims that can be made in DNA patents.

The first type of utility I call 'anthropocentric' utility. This is utility that does not rely on what a gene does in the organism; it is something we impose on the gene from our human perspective. One example would be the utility of non-coding DNA in disease diagnosis; another would be genetic fingerprinting. In the case of genetic fingerprinting, the function of DNA is not to make it easier to identify criminals at a crime scene, but we can use the DNA for this purpose from our anthropocentric perspective. With anthropocentric utility it is not necessary to know anything about the physiological function of the DNA that is being used.

The second type of utility can be called 'physiological function'. An example of this type of utility is a gene that produces a protein that interacts with the HIV virus. This is something the gene does anyway, whether we pay any attention or not, it is not something we impose on it from our human perspective (although we do, of course, have a particularly human interest in the HIV virus).

A third type of utility falls between these two. It can be called 'manipulated physiological function'. This is where we (anthropocentrically) manipulate the natural function of the gene to fulfil a certain objective. Examples here would be GM crops and gene therapy. The natural functions of these genes have been anthropocentrically altered to be useful for our purposes.

Table 1 gives the three types of utility and examples of each taken from official documentation. Arguments can be put forward to challenge the claims to utility made in this table.

Natural physiological function has been subdivided into those functions that

appear to have a 'broader social use' and those functions where the mere physiological function of the gene is being claimed as a utility. In the former category we have the example of DNA sequences used in the synthesis of therapeutic proteins. The Nuffield Council on Bioethics (2002) says that it is clear that the utility requirement is met in this case, and many people would agree that producing therapeutic proteins is something which has broad social use. However, merely identifying the natural physiological function of a gene, as seen in the bottom category of the table, diverges radically from our common-sense understanding of what it is for a patent to be useful. From a lay perspective it seems far-fetched to claim that "the utility of a gene is its use in 'making a certain polypeptide'" since, according to some definitions of a gene, every gene makes a polypeptide. If the utility claimed is a 'biological reaction involving the protein product' this demands more knowledge, but it still does not provide us with broader social utility.

Others make the argument that knowing the physiological function of a gene is not a stringent enough requirement for utility. Rehmann-Sutter (1996), for example, notes that 'The function of the gene product is part of the organismic context of the examined cells and no human product' (p. 315). The Nuffield Council on Bioethics (2002, p. 31) similarly argues that

> the utility in question should be more than a biological function such as encoding a receptor. Even if the biological function ascribed is correct, it is only a description of a fact of nature, and not a practical utility in the usual sense applied to an invented product.

Here, a distinction is being made between a 'fact of nature' (a rather dubious concept itself) and a 'practical utility'. In trying to grasp what I have called 'broader social utility', Nuffield have added the word 'practical' to the word 'utility', which does not clarify the situation. Ilag, Ilag & Ilag (2002) also make the point that biochemical or physiological function does not necessarily translate to utility. They say that finding a nucleotide which codes for a protein that regulates transcription factor activity should not be seen to have utility unless it increases the expression of a gene that leads to a beneficial phenotype. Again more questions are raised than answered here; for example, how do we go about identifying a beneficial phenotype?

I have argued that mere physiological function is not necessarily adequate to demonstrate utility, but some argue that we should adopt a physiological function understanding of utility and that on these grounds *diagnosis* should not be patentable, because in diagnostic tests we do not know the physiological function of the DNA we are using (Nuffield Council on Bioethics, 2002). The utility requirement (strictly defined) is being used here to distinguish an invention from a discovery. In forensic identification we also do not know the physiological function of the DNA we are using, so we could, in principle, extend these objections to this and other anthropocentric utilities. There may be political and economic reasons why we might not want diagnostic tests for

genetic diseases to be privately owned, but it is interesting that it is the utility requirement that is drawn upon here.

Demaine & Fellmeth (2003) argue that merely being able to put the physiological function of a compound to use (even if it is what I have called a 'broader social use') is not adequate to get a patent. They think that an inventor should not be able to patent a substance as it is 'because most natural substances can be put to multiple human uses' (p. 1375), but should change it in some way. According to this logic, what I have called 'manipulated physiological function' should be the only thing that is patentable. Since a gene only works in a certain context, we can argue that if we put it in a new context we are manipulating its function. For example, the gene for *Bacillus thuringiensis* (Bt) toxin is a bacterial gene which can be put into a plant. The codon structure of the bacterial gene has to be changed so that it works in the plant and produces the toxin better than it does in the bacteria. In this way the function of the gene is manipulated and becomes different from its 'natural' function. Gene therapy could also be regarded as manipulating physiological function because it involves replacing a faulty gene with one that works. In these cases we are reminded of Biagioli's (2002) discussion of the relationship between what is natural and what is useful. The argument Demaine & Fellmeth are making is that a gene should only be patentable if we give it properties it did not posses in nature.

These examples could be contested on the grounds that they do not really demonstrate manipulated physiological function, because the gene is still doing what it was doing in nature. It is just doing it better, or in a different context. If we wanted to argue that the patented gene had to have a completely different function from its natural function (as Demaine & Fellmeth do), then we might choose not to accept the examples given above. However, I think it is helpful to retain this category, even if we dispute what belongs in it, because in the future it may become possible to radically change the functions of genes.

Conclusions

I have shown that we need to be aware of the different ideas of usefulness that are circulating in gene patenting, and the different assumptions on which these are based. Classifying different types of utility, as in Table 1, is helpful because we can see more clearly what is at issue and understand better the different objections to patentability. Being aware of the different types of utility, particularly the difference between physiological and anthropocentric utility, and considering the relationship between 'broader social utility' and 'physiological function' could help focus policy discussions in this area. The value of these distinctions 'on the ground' requires further research, however, and in the next stage of this project this classification scheme will be put to actors involved in gene patenting.

Several issues I have identified here (for example, that use needs a genomic context), have come from reflections on the complexity of genes and genomes, so we see that the science itself is challenging simplified notions of gene

patenting. We should also be aware of the multiple functions of genes and proteins, and the situation where the future functions of genes could be claimed by the original inventor of the gene patent. We have seen that substances that appear useless, such as 'junk' DNA, may later be discovered to have crucial functions.

I have not discussed explicitly political, economic and social assumptions surrounding patenting here but I have objected against the patenting of genes based merely on knowledge of their physiological function on the grounds that patents should fulfil what I have called 'broader social utility'. Pottage (1998) says that 'The use of a banal doctrinal distinction to disqualify political or ethical objections is quite routine in patent law' (p. 750). In the case of utility, the apparently banal doctrinal understanding of utility in the patenting guidelines is not only open to multiple interpretations, but can also be used to deflect political and ethical objections to patentability and the commercial exploitation of knowledge. However, political and ethical issues inevitably rise to the surface in discussing the utility requirement, because it is a requirement where we must ask who will benefit from using the invention.

This idea of social utility does not tie in very easily to the current system of intellectual property, which does not problematize the relationship between economic and social utility. This is clear in the European wording of the 'industrial applicability' requirement— there is no necessary requirement that the invention be of any benefit or use to society, beyond industry (Laurie, 2003). An underlying assumption in intellectual property is that patents are needed for scientific innovation which is at the root of competition and economic growth (Chon, 1993). But the patent system is meant to serve the 'public good', which we might assume should be broader than industry alone, and so I suggest that it would be productive to explore the idea of broader social use in more detail. This would involve analysing the public benefit that can be gained from the use of an invention (Llewellyn, 1994) and asking what role the conception of the 'public good' plays in genomic patenting today.

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Notes

1. The European Patent Convention members are the European Union states (excluding Latvia, Lithuania and Malta), plus Bulgaria, Liechtenstein, Monaco, Switzerland and Turkey.

2. For reasons of space, discussion in this paper is limited to the patenting requirements of Europe and the USA.
3. Although the UK Patent Office's Guidelines say that they would expect to see UK applications fulfilling these requirements, there is currently no case law, so this would not necessarily be upheld in court (UK Patent Office, 2003).

References

Adler, R.C. (1984) Biotechnology as Intellectual Property, *Science*, 224(4647, 27 April), pp. 357–363.

Barnes, B., Bloor, D. & Henry, J. (1996) *Scientific Knowledge: A Sociological Analysis* (London: Athlone).

Biagioli, M. (2002) The instability of authorship: credit and responsibility in contemporary biomedicine. In Mirowski, P. & Sent, E. (eds) *Science Bought and Sold: Essays in the Economics of Science*, pp. 486–514 (Chicago: The University of Chicago Press).

Chon, M. (1993) Postmodern 'progress'. Reconsidering the copyright and patent power, *DePaul Law Review*, 43(1), pp. 97–146.

Cornish, W.R., Llewellyn, M. & Adcock, M. (2003) *Intellectual Property Rights (IPRs) and Genetics: A Study into the Impact and Management of Intellectual Property Rights within the Healthcare Sector* (Cambridge: Public Health Genetics Unit).

Demaine, L.J. & Fellmeth, A.X. (2003) Natural substances and patentable inventions, *Science*, 300(30 May), pp. 1375–6.

EU Directive (1998) *Directive on the Legal Protection of Biotechnological Inventions* (98/44/EC) <http://europa.eu.int/eur-lex/pri/en/oj/dat/1998/l_213/l_21319980730en00130021.pdf> (accessed 8 August 2003).

European Patent Office (2003) *Guidelines for Examination in the European Patent Office* (Munich: European Patent Office) <http://www.european-patent-office.org/legal/gui_lines/pdf_2003/index.html> (accessed 4 January 2004).

Heritage, J. (1984) *Garfinkle and Ethnomethodology* (Cambridge: Polity Press).

Human Genome Organization (1995) *HUGO Statement on Patenting of DNA Sequences* (Bethesda, Maryland) <http://www.gene.ucl.ac.uk/hugo/patent.htm> (accessed 14 October 2003).

Kamstra, G., Doring, M., Scott-Ram, N., Sheard, A. & Wixon, H. (2002) *Patents on Biotechnological Inventions: the EC Directive* (London: Sweet and Maxwell).

Ilag, L.L., Ilag L.M. & Ilag L.L. (2002) From patenting genes to proteins: the search for utility via function, *TRENDS in Biotechnology*, 20(5), pp. 197–9.

Laurie, G. (2003) Intellectual property and protection of biotechnological inventions and related materials. Innogen working paper no.4 <http://www.innogen.ac.uk/ownPubs/G_Laurie_2003.pdf> (accessed 4 April 2003).

Leese, M. (1998) Is an American mouse a European mouse? Towards a sociology of patents. In Webster, A. & Packer, K. (eds) *Innovation and the IP system*, pp. 171–89 (The Hague: Kluwer).

Llewellyn, M. (1994) Industrial applicability/utility and genetic engineering: current practices in Europe and the United States. *European Intellectual Property Review*, 16, pp. 473–80.

Matzke, M. & Matzke, A.J.M. (2003) RNAi extends its reach. *Science*, 301(22 August), pp. 1060–1.

Nuffield Council on Bioethics (2002) *The Ethics of Patenting DNA* (London: Nuffield Council on Bioethics).

National Research Council (1997) *Intellectual Property Rights and Research Tools in Molecular Biology*. Summary of a Workshop Held at the National Academy of Sciences, February 15–16, 1996 (Washington DC: National Academy Press).

OECD (2002) *Genetic Inventions, Intellectual Property Rights and Licensing practices: Evidence and Policies* (Paris: OECD).

Official Journal EPO (2002) *Icos Decision* 6/2002 293. <http://www.european-patent-office.org/epo/pubs/oj002/06_02/06_2932.pdf> (accessed 8 August 2003).

Pottage, A. (1998) The inscription of life in law: genes, patents, and bio-politics, *Modern Law Review*, 61, pp. 740–65.

Rehmann-Sutter, C. (1996) On the legitimacy of intellectual property claims in biotechnology, *International Journal of Bioethics*, 7(4), pp. 311–16.

Rheinberger, H.J. (2000) Gene concepts: fragments from the perspective of molecular biology. In Beurton, P., Falk, R. & Rheinberger, H.J. (eds) *The Concept of the Gene in Development and Evolution*, pp. 219–39 Cambridge: Cambridge University Press).

UK Patent Office (2003) *Examination Guidelines for Patent Applications relation to Biotechnological Inventions in the UK Patent Office (November 2003)* <http://www.patent.gov.uk/patent/reference/biotechguide/industrial.htm> (accessed 2 March 2004).