17 Effective Protection of DNA Sequences and Gene Innovations

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This Article examines whether patenting DNA sequences and gene innovations is desirable from an economic perspective to encourage innovations. In order to evaluate this, the characteristics of DNA sequences and gene innovations are discussed. DNA sequences have a dual character as a chemical and as an information carrier. Gene innovations are incremental, sequential and cumulative. Because of these characters, DNA sequences and gene innovation should not automatically be regarded as patentable.

The main problem in the patent system is that it is based on an exclusive right that tends to impede innovations in sequential innovations. Many disadvantages of patent protection are revealed through the examination of the patent system in the context of the characteristics of gene innovation. Therefore, it is necessary to find a way to provide the first comer with incentives, and second comers with freedom to utilize the first comer's innovation if they are willing to pay.

In order to accomplish this goal, first, I suggest that clearly defined 'research exemptions,' enhanced patentability standards, and Purpose-bound Protection should be employed. Second, a clearinghouse, Genetic Sequence Right, and automatic licensing system should be introduced. Third, the patent system should integrate useful standards included in the Direct Protection of Innovation.

I Introduction

Patents have been used to protect DNA sequences and gene products. Copyright and trade secret also might be used to protect them. Many commentators have suggested the possibilities of copyright protection of biotechnology innovation. However, because of (1) the significant discrepancy between characteristics of DNA sequences and those of copyright and trade secret, and (2) the great incentives given to patent rights, DNA sequences and gene innovations are mainly protected by patents.

The patent system can be regarded as a means to induce the disclosure of secrets in return for the grant of exclusive rights. According to classical economic theory, patenting stimulates innovation. Patenting, however, tends to weaken competition, increase consumer prices, make market less flexible, and entail significant management costs. The patent system may also constrain innovation if the protection it gives is too broad.

Patenting DNA sequences has established a patent thicket. Any particular gene therapy requires the concurrent use of many of these patents. It requires the aggregation of multiple patents to create a single product. This results in anticommons problems. Thus, some oppose patenting human genes. Others argue that DNA sequences should not be subject-matter of patent because they are discoveries of nature, which are the common heritage of all, rather than man-made inventions. Nonetheless, many jurisdictions including the US, the EU, Korea and Japan, allow patents on DNA fragments and human genes.

II Patent Protection of DNA Sequences

1 Arguments for Patenting DNA Sequences

DNA sequences are vulnerable to easy acquisition of equivalence. If the cost of copying compared with the cost of innovation is small enough, it can destroy thelead-time. Recently, especially in the US, patent

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protection has been extended to protect DNA related inventions. However, there have been many debates between those for and against extending the patentability of these creations. Advocates assert that expanded protection will provide stronger incentives to develop new technologies, and that expanded protection will make it possible for new companies to secure finance.

Patent documents stimulate development, because the public can build on published gene patents. Without patents, the inventor would have no incentive to disclose his invention. He will keep the invention secret to maintain competitiveness over his competitors. Expanded protection may provide stronger incentives for the generation and diffusion of new technologies. Patents can also be used to bargain with companies for use of their patents. Thus, gene patentability makes it worthwhile for investors to invest large resources to R&D.

Genes neither operates independently nor performs a single function.(*1) Genomes are not just collections of separately functioning elements that can be combined and recombined precisely without any unintended consequences. Thus, proponents argue that there are sound legal and scientific grounds that genes could be recognized as a patentable subject-matter when their functions are disclosed, such as coding for a particular protein, or association with a disease.

The most important reason for applying for patent protection is to protect own technology from imitation and prevent competitors' patenting and application activities.(*2) In many cases the patent protection is essential to corporations in general, small and medium sized enterprises (SMEs) in particular, engaging in biotechnology R&D.(*3) If SMEs were unable to patent their discoveries, they have no choice but to join large companies which could commercialize and benefit from the research results by SMEs. This is because SMEs cannot commercialize their research result due to their limited resources. This trend would diminish research in the end because SMEs are a very important source of innovation. The biotechnology industry is still in its infancy. It is extremely expensive to discover new medicines and obtain approval for a new therapeutics and the use of technical information included in a specific DNA sequence could result in these medicines and therapeutic. Therefore, if the patent protection could be granted to gene fragments, the industry would benefit from the increased investment and improved security that such patents would provide.

Proponents for extended patentability for genes and gene fragments argue that inventors of research tools also require a return on their investment, and that allowing patents on end products only will further industry concentration.(*4) They argue that while genes are an essential element of life, if we consider the intellectual effort required to locate, characterize, and determine the role that genes play in disease, genes should be regarded as patentable inventions rather than mere discoveries. Most businesses and patent practitioners regard a disclosed DNA as a newly characterized chemical.(*5) Isolated and purified chemicals produced in living organisms including humans have been patented in Europe and the US for more than 100 years. For example, adrenaline was patented in 1903, and insulin in 1923. If DNA compounds are regarded only as a chemical, it is not surprising to patent them.

The possibilities to cure different types of cancer, heart disease or other sufferings support the view that the patent laws should

(*1) Graham Dutfield, *DNA Patenting: Implications for Public Health Research*, Bulletin of the World Health Organization, May 2006, vol.84, no.5 [cited 21 August 2006] at 388-392, [hereinafter Dutfield, *DNA Patenting*].
(*2) Nikolaus Thumm (and edited by Swiss Federal Institute of Intellectual Property), *Research and Patenting in Biotechnology – A Survey in Switzerland*, Publication No 1 (12.03) at 22-25, available at www.ige.ch/E/jurinfo/documents/j10005e.pdf, accessed on August 20, 2006.
(*3) Byron V. Olsen, *The Biotechnology Balancing Act: Patents for Gene Fragments, and Licensing the "Useful Arts"*, 7 Alb. L.J. Sci. & Tech. 295 (1997) at 321-322, [hereinafter Olsen, *Patents for Gene Fragments*].
(*4) John R.,*An Examination of the Issues Surrounding Biotechnology Patenting and Its Effect Upon Entrepreneurial Companies*, CRS Report for Congress (Order Code RL30648) August, 2000.
(*5) Dutfield, *DNA Patenting*, *supra* note 1 at 388-389.

reflect the societal need for gene technology.(*6) This view holds that society should provide every incentive to the corporations that can make life saving therapeutics through genetic engineering. Thus, patents might actually promote R&D because patents facilitate the allocation of research efforts and avert wasteful duplication. Companies will not spend resources reinventing an already patented product. Patents enable all interested parties to access the disclosed invention, because patents are granted only when the applicant discloses all details of the invention.

The public can access the new information and may practice freely when the patent expires. Even during the lifetime of a patent, other parties can practice patented inventions through licensing and royalty agreements.

2 Arguments against Patenting DNA Sequences

Patenting DNA sequences confers monopoly not only on the sequence but also on any uses that can be made of the sequence. A gene patent grants a monopoly over the gene for 20 years. Its owner can prevent others from conducting research, performing tests, or developing therapies for that gene without obtaining a license and paying royalties.(*7)

Objections to DNA patents are expressed in various ways. The Council of Europe and UNESCO argue that genes are part of our "common human heritage" and thus, are not appropriate patentable subject-matter. Others maintain that human genes are inalienable, and that patenting human genes is treating human beings as a market commodity. Others based on theology object gene patents on the ground that genes belong to God. Objections to gene patents are generally more favorably received in Europe than in the US. European patent system includes a "morality" or "*ordre public*" provision. Objections based on morality are those who think DNA patents are morally inappropriate because such patents create a property right on the material that composes lives including human beings.(*8) They would argue that all lives have equal rights. Gene patents could also result in a strong threat to human beings, such as genetically engineered crops destroying local biodiversity, increased bacterial resistance through overuse of antibiotics, and biological warfare through genetically created diseases. The following arguments against gene patenting are (1) that DNA sequences are product of nature, and (2) that gene patenting impedes follow-on innovations.

(1) Product of Nature and Laws of Nature

First, patents should not be granted on something that is not an invention but a product of nature. According to Demaine & Fellmeth, DNA sequences and proteins, discovered or undiscovered, purified or unpurified, isolated or insolated, whose functions are identified or unidentified, should be regarded as laws of nature or natural phenomena.(*9) Opponents argue that any of these technical processes cannot turn a product of nature into a human invention, and thus DNA sequences are explicitly a product of nature.(*10) As far as DNA sequences and proteins are laws of nature or natural phenomena, patenting these cannot be justified.

(2) Economics of Gene Innovations

Second, in economic perspective of gene innovation, patenting DNA sequences is inappropriate, because DNA patents could restrict research in genetic engineering areas and slow down medical progress in disease management. They result in prohibitively high cost of basic or applied research to academics and corporations.(*11) The

(*6) Olsen, *Patents for Gene Fragments*, *supra* note 3 at 321.
(*7) Michael J. Malinowski and Radhika Rao, *Legal History and Legal Theory: Legal Limitations on Genetic Research and the Commercialization of its Results*, 54 Am. J. Comp. L. 45 (2006) at 49-50.
(*8) Courtney J. Miller, *Patent Law and Human Genomics*, 26 Cap. U.L. Rev. 893 (1997) at 918.
(*9) Linda J. Demaine & Aaron Xavier Fellmeth, *Reinventing the Double Helix: A Novel and Nonobvious Reconceptualization of the Biotechnology Patent*, 55 Stan. L. Rev. 303 (2002) at 309, [hereinafter Demaine *et al.*, *Reinventing the Double Helix*].
(*10) Dutfield, *DNA Patenting*, *supra* note 1 at 388-389.
(*11) Olsen, *Patents for Gene Fragments*, *supra* note 3 at 323-324.

possibility of private ownership of segments of the human genome and the potential value of it can freeze the scientific research community. This prevents the free flow and disclosure of information, resulting in increased secrecy and scarce collaboration.

Incremental, sequential, cumulative innovations

Identifying DNA sequences is now a routine process. Most genetic discoveries are now incremental.(*12) Patent protection of incremental improvements is inadequate because to be patentable an invention should have an inventive step. Typical biomedical treatments comprise many components and innovations developed by earlier innovators. Due to this sequential and cumulative characteristic of gene innovations, almost all developers of any life saving treatments will involuntarily infringe a gene patent during the processes of their developments. It is difficult to check to ensure that none of these processes infringes one of the DNA patents already granted, and to license all of those patents.

According to the concept of 'sequential innovation' systems,(*13) which was generalized by Bessen and Maskin, patenting gene innovations is not economically adequate. They argue that when innovation is sequential and complementary, imitation becomes a spur to innovation and strong patents become an impediment.

In addition, because patent rights are exclusive, they hinder follow-on innovation in sequential innovation process. Critical problems in sequential innovation process exist in the relationship between the first innovator and follow-on innovators. Patent rights to a single gene or a single brief DNA sequence could result in a near monopoly on diagnostic tests and treatments for diseases.(*14) Private ownership of DNA sequences would encourage a company to prohibit using those sequences in developing a diagnostic test or therapy altogether. While most diseases are caused by both genetic and environmental components, private ownership of any contributing factor could be a cause to extract charges from those who develop a diagnostic test, therapy, or pharmaceutical. This results in higher medical costs and decreased availability to those in need.

Tragedy of the anticommons

Huge number of patents and patent applications for genes and DNA fragments has created a problem, the "tragedy of the anticommons" that is named by Michael Heller and Rebecca Eisenberg.(*15) The tragedy of the anticommons means the complex obstacles that arise when a user needs access to multiple patents to create a single useful product. Each upstream patent adds to the cost and slows the pace of downstream innovation. Because many companies attempting to produce a product well recognize the complications which blocking or complementary patents create, they search for ways to by-pass these problems. Describing a patenting problem with gene patents as "tragedy of the anticommons," Heller and Eisenberg assert that a proliferation of IPRs upstream may stifle life-saving downstream innovations.

Costs of blocking or complementary patents

The most common deterrent to gene innovation is the prohibitively high costs in using a patented DNA molecule, protein, etc.(*16) The costs impede research that relies on access to the patented biochemicals, and hinder the development of downstream products such as pharmaceuticals, medical therapies, and diagnostic tests.

Most biotechnological research involves

(*12) Demaine *et al.*,, *Reinventing the Double Helix*, *supra* note 9 at 410.
(*13) James Bessen and Eric Maskin, *Sequential Innovation, Patents, and Imitation*, Working Paper Department of Economics, Massachusetts Institute of Technology, No. 00-01, January 2000.
(*14) Demaine *et al.*, *Reinventing the Double Helix*, *supra* note 9 at 308-309.
(*15) Bradley J. Levang, *Evaluating the Use of Patent Pools For Biotechnology: A Refutation to the USPTO White Paper Concerning Biotechnology Patent Pools*, 19 Santa Clara Computer & High Tech. L.J. 229 (2002) at 234-235; Michael S. Mireles, *An Examination of Patents, Licensing, Research Tools, and the Tragedy of the Anticommons in Biotechnology innovation*, 38 U. Mich. J.L. Reform 141 (2004) at 171-172, [hereinafter Mireles, *Patents and Anticommons in Biotechnology innovation*].
(*16) Demaine *et al.*, *Reinventing the Double Helix*, *supra* note 9 at 415.

complicated interactions among many genes and proteins discovered by prior researchers.(*17) Thus, the transaction costs to obtain licenses can multiply quickly in a regime that private parties can own many basic natural products. These impediments would include "blocking patents" resulted from the cumulative and sequential nature of innovation, or "complementary patents" granted to different inventors who have invented components of a large invention.(*18)

Inventing around

Patenting DNA sequences prevents inventing around, e.g. developing a new drug, diagnostic tests, or tests using protein products based on a patented DNA sequence, because these developing activities are covered by the patent on a DNA sequence. DNA is special in the sense that downstream DNA patents are always substantially dependent on upstream DNA patents. For example, when a subsequent downstream inventor has developed a new medical application for a specific disease caused by a flawed gene that is the subject of an upstream patent, he is obliged to use the DNA patent because he has no alternative. This is not always in classical chemistry. In chemistry there might be different ways to cure a specific disease. Thus, gene patents are special in that inventing around a gene patent is impossible.(*19) For this reason, a patent provides a real monopoly.(*20)

3 Conclusion of Patent Protection

A number of patents have been granted to DNA sequences. These patents resulted in difficult problems such as the tragedy of anticommons, patent thicket, and blocking patents. These problems result from (1) intrinsic nature of DNA sequences carrying genetic code that could be regarded as laws of nature, and (2) the disharmony between characteristics of gene innovation and patent rights.

Patent protection of a DNA sequence impedes follow-on innovations because patents are based on proprietary rules.(*21) Under the current situations that a number of patents have already been granted to DNA sequences, it might not be realistic to suggest that further patents should not be granted anymore. If we have no choice but to patent, protection of gene innovation should not be too strong to hinder follow-on innovation. Any second comers should be allowed to access research tools freely as far as they are ready to pay for their use of the first comers' information.

III Copyright Protection

Copyright attaches to expressions of a scientific or technical nature. Copyright was originally devised to protect literary and artistic works. Copyright law forbids protection of "any idea, procedure, process, system, method of operation, concept, principle, or discovery, regardless of the form in which it is described…"(*22)

Copyright might be maintained over the written representation of the genetic sequence of modified genetic material, or genetic products such as proteins.(*23) N. Boorstyn asserts that DNA sequences can be protected by copyright.(*24) Sue Coke argues

(*17) *Ibid.*
(*18) Mireles, *Tragedy of Anticommons in Biotechnology Innovation*, *supra* note 15 at 168; Demaine *et al.*, *ibid.* at 419-421.
(*19) On the other hand, there are also similarities between DNA and chemistry in the sense that both DNA and chemical compounds, e.g. vigra and aspirin, are multifunctional. That is, both of them have various different functions and applications. See Sven J. R. Bostyn, *Patenting DNA sequences (polynucleotides) and scope of protection in the European Union: an evaluation*, Background study for the European Commission within the framework of the Expert Group of Biotechnological Inventions, European Commission, EUR 21122, 2004, at 60.
(*20) It is argued that granting such complete protection in exchange for a disclosure resulting from the work of one of the machines now available for automatic sequencing of DNA is far from the basic principle of the patent system.
(*21) Louis Kaplow and Steven Shavell, *Property Rules Versus Liability Rules: An Economic Analysis*, 109 Harv. L. Rev. 713 (1996) at 716.
(*22) *Copyright Act of 1976* § 102(b) and title 17 of the *United States Code* of 1993, section 102(b) (17 U.S.C. § 102(b) (1993)).
(*23) Australia Law Reform Commission, Issue Paper 27 *Gene Patenting and Human Health*, Part F Other Intellectual Property Issues, [hereinafter Australia Law Reform Commission, *Gene Patenting and Human Health*], available at http://www.austlii.edu.au/au/other/alrc/publications/issues/27/16._Copyright_Trade_Secrets_and_Designs.doc.html, accessed on August 21, 2006.
(*24) Neil Boorstyn, personal communication. See Willem P.C. Stemmer, Nature Biotechnology, vol.20, March 2002, at 217, [hereinafter Stemmer, Nature Biotechnology]..

that a DNA sequence could be protected by copyright when sufficient skill, labor and effort were involved in clarifying the sequence.(*25) Proponents of gene copyright often rely on the analogy between genetic sequences and computer programs.(*26) Like a computer program, a DNA sequence may be considered a set of instructions.(*27) A DNA molecule is a machine that makes functions.(*28) DNA sequences are both a chemical and an information carrier. The chemical structure of a DNA sequence is generally independent of its function caused by the information.(*29)

An important difference between DNA sequences and computer programs would exist in that while programs have a number of ways of expression to cause a specific function, DNA sequences have no alternative expression. Thus, copyright protection of DNA sequences is inappropriate because copyrighting DNA sequences may result in protection of processes coded by DNA sequences. Additionally, a DNA sequence cannot be copyrighted because DNA sequences are not an original work of any humans.(*30)

Recently Willem P. C. Stemmer suggested that DNA sequences can be protected by copyright.(*31) According to his proposal, genomics companies can make their sequences available to the public while retaining some IPRs. DNA sequences existed in genomics companies' databases would be transformed into 'music file' (e.g. mp3 file) by the companies. An external database user would copy this music file, transfer the copy to himself, and re-convert the music file into DNA sequences using a back-translation program. Although this back-translated DNA sequences itself would not be protected by copyright, copyright protection may exist in that the user cannot access a DNA sequence without copying a copyright-protected music file.

When a genomics company publishes its DNA sequences, the company might lose the possibility to receive a patent for the DNA sequences.(*32) Most genomics companies are reluctant to publish their genomics sequences and thus, most genomics sequences remain inaccessible to the scientific community. By using 'music file' approach and making unauthorized copying such a digital music file constitute copyright infringement, genomics companies would be able to publish their DNA sequences and retain IPRs for their published sequences.

IV Conclusion

DNA sequences are not suitable subject-matter of copyright protection. Trade secret cannot protect some of gene innovations involved in marketed products because trade secret does not protect what is not secret. Patent protection is inappropriate because patent rights are too strong compared with the contribution by the inventor.

In order to solve these problems, it is necessary to find a rule that could provide the first innovator with incentives to invest resources into R&D, and at the same time, follow-on innovators with free access to the first innovator's innovation. It is also needed for public institutions to effort to place genes and gene fragments within the public domain. In fact, as a result of the joint efforts of public institutions, databases comprising raw DNA sequences from human and other organisms are now publicly available. The more gene fragments make their way into the public domain, the more difficult to prove that a particular sequence is novel and non-obvious.

(*25) Australia Law Reform Commission, *Gene Patenting and Human Health*, *supra* note 23 at para. 16.24; See also Sue Coke, *Copyright and Gene Technology*, 10 Journal of Law and Medicine 97 (2002) at 102.
(*26) Iver P. Cooper, *Biotechnology and the Law*, 2005 Revision, (Eagan, Minn, U.S: Thomson/West Group, 2005) at 14-21, [hereinafter Cooper, *Biotechnology and the Law*]; Irving Kayton, *Copyright in Living Genetically Engineered Works*, 50 Geo. Wash. L. Rev. 191 (1982).
(*27) Cooper, *ibid.* at 14-23.
(*28) *Ibid.* at 14-36.
(*29) Program text and function are generally independent.
(*30) Cooper, *Biotechnology and the Law*, *supra* note 26 at 14-31.
(*31) Stemmer, Nature Biotechnology, *supra* note 24 at 217.
(*32) Conditions on grace period are different in jurisdictions..

The absence of proprietary rights in open source software allows for various uses and improvements of the products. There is no fear of being accused by a proprietary software company.(*33) In this respect, basic concepts of a new legal system would be found among liability regimes rather than exclusive proprietary ones. The new regime should solve the critical issue of the relationship between the first comer and second comers in sequential innovation, i.e. encouraging innovation without impeding follow-on innovations.

(*33) Disadvantages of open source software are the lack of guarantee that development will happen, and the possibility of being accessed by patent holders who are trying to detect infringement through the accessible source code.