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ROAD MAP TO REVOLUTION? PATENT-BASED OPEN SCIENCE

Lee Petherbridge, Ph.D

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ROAD MAP TO REVOLUTION? PATENT-BASED OPEN SCIENCE

Lee Petherbridge, Ph.D.

The contemporary approach to innovation in the life sciences relies on a patent-based proprietary model. Limitations on patent rights and business concerns often focus innovation to markets where the near-term monetary rewards are highest. This is “efficient” under an austere understanding of the term, but the proprietary model can be problematic from a practical perspective because it may not focus innovation to certain deserving markets. This Article contends that the property rights conferred by patent law may still serve as a positive base for innovation directed to underserved markets. The comparatively strong rights conferred by patent law provide upstream or pioneering innovators the power to establish some of the environmental conditions in which subsequent innovation takes place. This includes a power to create an environment of relatively open access to rights, which in appropriate cases may foster efficiency gains, reduce innovation suppressive costs, and achieve production for ultimate consumers at closer to marginal cost. In several parts, this paper discusses the topography of law and innovation in the life sciences, the characteristics of innovation in the life sciences that may support the use of patents to impose an “open science” framework, a legal means of imposing such a framework using servitudes, and some of the legal and economic implications of using patents in this manner. This Article concludes that there are reasons why universities and research-oriented medical schools should sometimes favor this approach and that limited testing should be performed to determine the efficacy of the approach.

I. INTRODUCTION

The difficult economic conditions of the 1970s gave rise to important changes in the innovation infrastructure of the life sciences. Where before patents were not sought as a matter of course for inventions made in publicly funded university and medical...
school laboratories, the policy choices given effect in the Bayh-Dole Act encouraged the patenting of university inventions. The increase in university patenting, in turn, altered the relationship between public science and private science. Where before the inventions, e.g., the discovery and/or creation of new and useful knowledge, information, and materials, of public science would, through publication, disclosure at meetings, and other informal networks, eventually surface as public goods unfettered with formal property rights, the policy choices given effect by the Bayh-Dole Act, while perhaps encouraging earlier disclosure, also encouraged the consistent attachment of formal property rights to the products of public science.

The consequence is that in the contemporary approach to innovation, formal property rights, rather than being the feature which distinguishes public science from private science, becomes a tool of their integration. Concepts of property, particularly property as envisioned by the patent laws, now connect upstream public invention with downstream innovation, e.g., research and development directed to the creation and commercialization of products. Because of the cumulative nature of innovation in the life sciences, now more than ever, universities and firms are supposed to take into account property rights when they make decisions on what experiments to perform and how to spend precious research and development dollars.

The goal of the policy of encouraging universities to patent their diverse range of inventive output is to encourage innovation. By mechanisms now familiar to even first-year law students, the legal rights conveyed in a patent, particularly the right to exclude, allow rights holders to appropriate some of the benefits of innovative work. The ability to appropriate benefits serves as an ex ante incentive to take on economic risk—the risk involved with the uncertainty-laden task of attempting to create new and useful products and processes.

While this approach logically encourages investment in innovation, it has the drawback of concentrating capital for innovation directed to either the highest benefit expected innovations, or at a minimum, innovations where the benefits can be predicted to be greater than the cost of innovation. In particular, innovation may be directed away from: (1) diseases that are perceived as having low commercial value because they either affect large numbers of the economically disenfranchised or


4. The purpose of the Bayh-Dole Act is "to promote the utilization of inventions arising from federally supported research or development." 35 U.S.C. § 200 (2000).

5. By some estimates, "[d]eveloping countries account for four-fifths of the world's population, but less than ten percent of the global pharmaceutical market." Ellen F. Hoen, The Responsibility of Research Universities to Promote Access to Essential Medicines, 3 YALE J. OF HEALTH POL'Y, L & ETHICS 293, 295 (2003). See Stephen M. Maurer, et al., Finding Cures for Tropical Diseases: Is Open Source an Answer, PLoS 1(3): e56 (2004) (discussing neglected diseases such as leishmaniasis, sleeping sickness, chagas, and malaria); Patrice Trouiller & Pietro Olliaro, Drug Development Output from 1975 to 1996: What Proportion for Tropical Diseases, 3(2) INT'L J. OF INFECTIOUS DISEASES 61 (1998-99) (reporting that only about one-percent of chemical entities commercialized were directed to these and other important tropical diseases including filariasis, helminthic infections, trypanosomiasis, leishmaniasis, malaria, and schistosomiasis; also reporting that only a fraction of those drugs were other than incidental discoveries).
because they affect small numbers of individuals\(^6\) (almost) regardless of their economic status; or (2) projects involving highly complex scientific research of the sort that requires such a large number of participants that it may not be efficiently performed by a single lab,\(^7\) or even by a single commercial entity.

More primary information revealing the broad impact of these diseases can be found at the World Health Organization website. One example includes

**Lymphatic Filariasis, known as Elephantiasis, [which] puts at risk more than a billion people . . . . Over 120 million have already been affected by it, [and] over 40 million of them are seriously incapacitated and disfigured by the disease. One-third of the people infected with the disease live in India, one third are in Africa[,] and most of the remainder are in South Asia, the Pacific[,] and the Americas . . . .**

Lymphatic filariasis causes a heavy social burden because it is "primarily a disease of the poor . . . [and] . . . has steadily increased because of the expansion of slum areas and poverty, especially in Africa and the Indian sub-continent. As many filariasis patients are physically incapacitated, it is also a disease that prevents patients from having a normal working life." WORLD HEALTH ORGANIZATION, FACT SHEET NO. 102: LYMPHATIC FILARIASIS (2000), http://www.who.int/mediacentre/factsheets/fs102/en/.

Another example is "malaria[, which] is an infection caused by a parasite and carried from person to person by mosquitoes. It is preventable and curable but kills more than one million people—most of them young children living in Africa—each year." World Health Organization, Global Malaria Programme, http://malaria.who.int/ (last visited Jan. 22, 2007).

Annual economic growth in countries with high malaria transmission has historically been lower than in countries without malaria. Economists believe that malaria is responsible for a 'growth penalty' of up to 1.3% per year in some African countries. When compounded over the years, this penalty leads to substantial differences in GDP between countries with and without malaria and severely restrains the economic growth of the entire region.


Regarding Dengue Fever: "Some 2500 million people—two fifths of the world's population—are now at risk from dengue. WHO currently estimates there may be 50 million cases of dengue infection worldwide every year." There are over five hundred thousand hospitalizations each year and up to a 20 percent mortality rate when an infection is not properly treated. WORLD HEALTH ORGANIZATION FACT SHEET NO. 117: DENGUE AND DENGUE HAEMORRHAGIC FEVER (2002), http://www.who.int/mediacentre/factsheets/fs117/en/.

It is worth noting that while the fatalities associated with these and other neglected diseases are clearly significant, the social impact of these diseases goes well beyond causing deaths. Those who do not die may be chronically affected. Thus, in many of these cases it may be myopic to think of innovation directed to these diseases as having low commercial value. It is perhaps another imperfection of a property-based system that it is structurally unable to appropriate the social benefits lost to these diseases.

6. The list of these diseases would be, perhaps, impossibly long. A few examples of diseases with low commercial value include Epidermolytic Hyperkeratosis, which is characterized by blistering and scaling of the skin that looks similar in appearance to corrugated cardboard and is caused by mutations in epidermal keratins. See J.A. Rothnagel et al., *Mutations in the Rod Domains of Keratins 1 and 10 in Epidermolytic Hyperkeratosis*, 257 SCIENCE 1128, 1128 (1992). Epidermolysis Bullosa Simplex causes a severe form of blistering due to basal keratinocyte cytolysis in about 1 in every 50,000 people. See Pierre A. Coulombe et al., *Point Mutations in Human Keratin 14 Genes of Epidermolysis Bullosa Simplex Patients: Genetic and Functional Analyses*, 66 CELL 1301, 1301 (1991). Another example is Rett syndrome, which

is a genetic disorder that strikes roughly one in 10,000 girls just as they are beginning to walk and talk. After developing normally for about a year, girls with the syndrome regress, losing any words they've learned as well as the ability to make purposeful movements. They end up with severe mental and physical disabilities and require full-time care.


7. See, e.g., R. Taussig et al., *Overview of the Alliance for Cell Signaling*, 420 NATURE 703, 703
In several parts, this Article explains that the prudent use of a patent-based open science approach may provide an appropriate complement to current paradigms of innovation in the life sciences. Part II begins by setting forth a topography of innovation in the life sciences. As is nearly universally acknowledged, that topography reveals universities and medical schools performing broad-based scientific research funded in significant part by public monies. This section also notes how the outputs of this "public" science, often too undeveloped for broad commercial application, frequently serve as substrates, or inputs, for subsequent "private" scientific research performed by for-profit firms. This leveraging of public science in service of national economic policy is, Part II explains, imposed in part through propertization of the outputs of public science. As this part of the Article further explains, propertization is importantly imposed through the patent laws, creating a rights environment with several significant features and implications. One implication is the necessary production of what this Article terms "innovation suppressive costs," which can affect the path and progress of innovation. Thus, Part II sketches a picture of an innovation framework that is both sequential and cumulative in quality, one involving different actors with different motivations, but who share a nexus in property rights. A framework in which downstream "private" science actors depend on the information, materials, and rights created by upstream "public" science actors.

Part III acknowledges the perceived significance of property rights to innovation, and from that perspective observes that efforts to develop innovation frameworks that may better serve certain markets should be complementary to patent-based approaches. From this view, it is suggested that the focus should be on refining the deployment of property rights to encourage innovation ends rather than attenuating or disrupting what is widely accepted to be a general usefulness of property rights in promoting investment in, and the production of, innovation. In seeking a framework for refinement, this part focuses on mechanisms that might reduce innovation suppressive costs and, additionally, provide positive efficiency gains by encouraging the participation of peer innovators. This part discusses features of innovation in the life sciences that suggest that an open science approach (one crafted to provide relatively liberal access to rights) may sometimes be not only appropriate, but also desirable. It finds helpful analogies by comparing innovation in the life sciences to aspects of the open source software framework and recent works generalizing principles important for peer production. This part concludes that some life science research and development is amenable to an open science approach.

The theoretical and factual points developed in Parts II and III are brought together and applied in Part IV in search of a legal means of imposing a patent-based open science framework. After considering other possible approaches to directing innovation to underserved markets, this part proposes the use of a servitude on a patent. As discussed, this approach can fit comfortably within the current proprietary framework, can be deployed in forms that do not pose the threat of serious harm to the

ubiquitous rights-based innovative framework, and is especially useful when a potential commercial product is perceived to be far off or of uncertain commercial value. Thus, this part sets forth and discusses a framework for the measured application of patent servitudes in life sciences research.

Part V offers some concluding remarks and points to a number of reasons why it may sometimes be in the best interest of universities and research-oriented medical schools to use the approach described in Part IV. It also proposes that the approach be tested experimentally, so information can be gathered on potential drawbacks, the interest in working subject matter with the “open” restriction, and metrics that may reveal the practical desirability vel non of the approach. Data should be collected and reported upon periodically.

II. A TOPOGRAPHY OF INNOVATION AND LAW IN THE LIFE SCIENCES

A. The Industrial Infrastructure: Integrating Public and Private Science

For most of the twentieth century innovation in the life sciences has been dominated by the firms of the pharmaceutical industry. Until the last thirty years or so, a typical firm was both large and fully integrated in terms of its capacity to process innovation from drug discovery, to clinical trials, to regulatory approval for marketing, to manufacturing and quality control. These firms relied heavily on patents and other forms of intellectual property to appropriate returns from innovation (i.e., downstream research and development).

During the same period, publicly funded science performed in laboratories at universities and medical schools was rarely patented. Instead the new and useful knowledge, information, and materials created by public science made its way into the public domain as it gradually surfaced at study sections, at scientific conferences, in publications, or through a variety of informal networks of scientific communication. Thus, pharmaceutical firms typically accessed publicly funded upstream inventions at low cost. Moreover, upon being sufficiently distributed the inventions generated by public science generally took on the trappings of public goods, serving as tools and resources to scientists in both private and public science in a nonrivalrous manner.

In the 1970s, economic conditions caused the United States to take stock of its economic strengths and weaknesses. According to Circuit Judge Pauline Newman it was “recognized then . . . that our economic strength as a nation depends on technological leadership, the balance of trade, and a culture that favors creativity, entrepreneurship, and industrial activity.” This period of introspection also produced the understanding that some of the identified aspects of national economic strength

9. See id.
11. Newman, supra note 1, at 822 (citing “economic recession, high unemployment, mass layoffs of scientists and engineers, and extreme inflation”).
12. Id. at 821.
could be encouraged or discouraged by governmental policy. One aspect of government policy implicated by the studies and testimony of the time was the law and policy of patents. What was concluded was that the patent system had become so weakened over the preceding years that it had lost its ability to support investment in the creation and commercialization of new and improved products.

What followed in the 1980s was a wave of legislative action intended to encourage innovation and rescue the country from recession. Perhaps the most notable pieces of legislation were targeted to the patent system: the Bayh-Dole Act and the Federal Courts Improvement Act of 1982, which created the United States Court of Appeals for the Federal Circuit. The purpose of the Bayh-Dole Act is "to promote the utilization of the inventions arising from federally supported research or development." Its policy goal is largely achieved by clarifying the rules concerning the ownership of patents on inventions created using federally funded research. The purposes of the Federal Courts Improvement Act of 1982 are several, but one important purpose is to unify appellate jurisdiction to promote clarity, predictability, and certainty in the patent law.

These policy choices took place in a background environment of very broadly written patent statutes and case law that already permitted making property of a wide range of life science outputs. Adding to the mix was the advent in (mostly) university laboratories of immunological, cellular, and molecular technologies, which made useable a new array of materials and methods important in the prosecution of innovation in the life sciences. The market consequences of this combination of political, legal, and technological change were that university patenting behavior increased by a fold. In 1980, the year the Bayh-Dole Act was passed, universities were issued fewer than 250 patents. In 2004, they received 3,680 patents and filed over 10,500 patent applications.

The consequence to public science of these technological and legal changes has been substantial. Encouraging universities to engage in the formal propertization of publicly funded discovery, invention, and in some cases, innovation has significantly increased the influence of public science on private science as well as the reverse. Universities are now active participants in the patent system. Although they are less

13. Id. at 822.
14. Id.
18. The Federal Circuit was created for a number of other reasons, as its broad subject matter jurisdiction attests. See, e.g., Newman, supra note 1, at 823-24 (describing the various jurisdictions). However, one important reason for the creation of the Federal Circuit was to unify patent jurisprudence and bring clarity and certainty to the law. See, e.g., Rochelle Cooper Dreyfuss, The Federal Circuit: A Case Study in Specialized Courts, 64 N.Y.U. L. REV. 1, 2 (1989).
22. Id.
likely than commercial entities to patent therapeutic end products, universities often obtain patent rights to "upstream" inventions that in terms of innovation serve primarily as substrates for future research and development. Upstream inventions may include tools and reagents necessary for future research\(^{23}\) such as nucleic acid sequences\(^{24}\) and proteomic targets,\(^{25}\) which may serve as potential targets for chemical or small-molecule therapeutics. Other upstream inventions patented by universities may include new techniques\(^{26}\) and important materials derived from the application of new techniques,\(^{27}\) both of which may serve as important platforms for subsequent advances across a large number of life science disciplines.\(^{28}\)

In many cases involving patents directed to "upstream" inventions, universities license the patents to smaller biotechnology firms or startups. Relying on the licensed patents, these smaller firms seek to attract funding sufficient to perform additional research and development. The goals of smaller firms can be varied, but common goals include advancing the state of development by, e.g., perfecting a technique, applying a technique to acquire a new or important substrate or target, or manipulating and testing genomic or proteomic inventions in animal models to establish a key understanding or proof of principle. These incremental advances can then be used to garner more financial support or can be sold or licensed to larger biotechnology or pharmaceutical firms.

Broadly speaking, it is larger biotechnology and pharmaceutical firms that perform the tasks associated with later-stage innovation in the life sciences. This generally includes advancing promising technologies to the point where products can be profitably produced and marketed to consumers. Because these larger firms often sell the commercial embodiments of research outputs to consumers, they typically have positive revenue streams and have proven consistently capable of concentrating capital through both revenues and access to financial markets. As licensing partners of universities or smaller firms, or both, these larger firms have the expertise to identify


\(^{25}\) See, e.g., Nucleic Acid and Amino Acid Sequences for Mammalian Sulfonylurea Receptor, U.S. Patent No. 6,054,313 (filed June 7, 1995).


and select upstream work that seems most promising from both a technical and profitability standpoint. With some of the risk concentrated on universities and smaller firms, these larger firms can focus on other cost-intensive aspects of innovation in the life sciences such as later-stage drug development with its attendant animal and clinical trials, registration and marketing approvals, manufacture, quality control, and marketing and sales.

As described in more detail below, principles of property, and particularly of patent rights, play a central role in the relationship between these market actors and therefore in the path and progress of innovation in the life sciences. Universities and research-oriented medical schools create and collect important property rights but are generally not structured to engage in later-stage innovation. Subsequent innovation performed by start-ups and smaller biotechnology companies often rely on property rights established first by universities and research-oriented medical schools. Further innovation creates additional property rights, which, like other upstream rights, must be identified and bundled for use by later innovators or by firms that market products to consumers. Thus, the path and progress of innovation in the life sciences is closely tied to the existence of property rights, the number and variety of those rights, and the relationships and business acumen of rights holders.

B. The Legal Infrastructure: A Proprietary Approach

While traditional notions of property rights as applied to chattels\(^\text{29}\) apply to goods and services produced by the life sciences industry, the intangible quality of intellectual goods combined with a low cost of imitation may seriously degrade or even largely destroy the ability of innovators to appropriate benefits from very cost-heavy innovations. This innovation suppressive effect is compensated for by complementing basic common law property principles with statutory patent law.\(^\text{30}\) This creates

\(^{29}\) See, e.g., Cheney Bros. v. Doris Silk Corp., 35 F.2d 279, 280 (2d Cir. 1929).

\(^{30}\) 35 U.S.C. §§ 1-376 (2000). The copyright laws, codified at 17 U.S.C. §§ 1-1,332 (2000), are another example of a statutory complement to common law property principles in pursuit of the production of intangible goods. One thing that separates the rights conferred by the patent laws from the rights conferred by the copyright laws is the breadth and depth of protection. Copyright law protects original works of authorship fixed in a tangible medium of expression. 17 U.S.C. § 102 (2000); see Feist Publ'ns, Inc. v. Rural Tel. Serv. Co., 499 U.S. 340, 345 (1991). But while copyright law creates a lengthy term and imposes liability for derivative works, copyright law affords a scope of propertization that is thin in comparison to patent law. Copyright protection does not extend to facts, see Feist, 499 U.S. at 345, nor to "any idea," see Baker v. Selden, 101 U.S. 99, 102 (1879), "procedure, process, system, method of operation, concept, principle, or discovery," 17 U.S.C. § 102(b) (2000). Patent law stands in sharp relief because it allows for the protection of the innovation of nearly all of these things to some extent depending on the degree to which an applicant can capture them by strategic claiming. 35 U.S.C. § 101 (2000) ("Whoever invents or discovers any new and useful process, machine, manufacture, or composition of matter, or any new and useful improvement thereof, may obtain a patent therefor, subject to the conditions and requirements of this title."). The exceptions in the patent laws are reflected in the general unpatentability of laws of nature, physical phenomena, and abstract ideas. See, e.g., Diamond v. Chakrabarty, 447 U.S. 303, 309-10 (1980) (collecting cases prohibiting such patents but finding patentable claims to genetically modified living organisms); see also Diamond v. Diehr, 450 U.S. 175, 184 (1981) (finding patentable subject matter involving an algorithm); Parke-Davis & Co. v. H. K. Mulford Co., 189 F. 95, 102-14 (S.D.N.Y. 1911), aff'd in part, 196 F. 496, 498 (2d Cir. 1912) (finding patentable a natural biochemical substance purified from its natural environs).
property rights in intangible goods,31 thereby enhancing the ability of the owner to appropriate the benefits of innovative work.32 Consequently, the formal proprietary tool most often used in connection with life sciences research is patent law.33

The putative benefit of this legal infrastructure is the well-worn concept of the patent bargain. Its deep normative basis is evident in the U.S. Constitution, which authorizes Congress to “promote the Progress of Science and useful Arts, by securing for limited Times to . . . Inventors the exclusive Right to their respective . . . Discoveries.”34 In the bargain, the public grants property rights and accepts the potential of supramarginal cost pricing in exchange for the disclosure of new and useful information and an increase in quality of life derived from innovation—the development and production of new or improved processes, machines, manufactures, and compositions of matter.

In the United States, patents are generally available for “anything under the sun that is made by man”35 and that is new,36 useful,37 and nonobvious.38 Indeed, most of the industrialized and developing world has either implemented or agreed to implement standards that are roughly the same.39 Patents are available on a wide range of life science inputs and outputs. A limited list might include patents directed to nucleic acid sequences that comprise genes,40 complementary DNA,41 and/or polypeptides.42

32. Id. at § 271 (2000) (defining an infringer as someone who “without authority makes, uses, offers to sell, or sells any patented invention, within the United States, or imports into the United States any patented invention”).
33. See, e.g., Edwin Mansfield, Patents and Innovation: An Empirical Study, 32 MGMT. SCI. 173, 175 (1986) (reporting that patents are very important in the development of pharmaceuticals).
35. Chakrabarty, 447 U.S. at 309.
37. Id. at § 101.
38. Id. at § 103(a), (b)(1).
39. The Agreement requiring harmonization referred to here is the “TRIPS Agreement.” Agreement on Trade-Related Aspects of Intellectual Property Rights, Apr. 15, 1994, 31, 33 I.L.M. 81 (1994) [hereinafter TRIPS Agreement]. The express standards contained in the TRIPS Agreement are “new, involve an inventive step and are capable of industrial application.” Id. at Art. 27, para. 1. The TRIPS Agreement further explains that “[f]or the purposes of this Article, the terms ‘inventive step’ and ‘capable of industrial application’ may be deemed by a Member to be synonymous with the terms ‘non-obvious’ and ‘useful’ respectively.” Id. at n.5.
40. See, e.g., Clontech Labs, Inc. v. Invitrogen Corp., 406 F.3d 1347, 1349 (Fed. Cir. 2005) (citing a claim of U.S. Patent No. 5,405,776 directed to a polynucleotide); Cyclin E Genes and Proteins, U.S. Patent No. 5,973,119 (filed June 5, 1998); see also, supra note 24 (U.S. Patents Nos. 5,914,265 and 5,545,563).
42. See, e.g., Clontech Labs, Inc., 406 F.3d at 1350 (citing a claim of U.S. Patent No. 5,244,797 directed to a polypeptide).
Patents are also available for cell lines, screening methods, expression systems, transgenic animals, and a host of other research outputs, tools, and methods.

In law, patent rights are protected by the right to exclude, a property rule. Theoretically, any stranger to the right who desires to make, use, or sell embodiments of patented subject matter must negotiate permission from the right holder. This principle gives rise to two features of the patent law important when considering sequential or other cumulative innovation. First, an infringer of patent rights (e.g., someone who without authority uses the claimed subject matter) who knows nothing of a patent will still be found to infringe that patent and under general principles of equity subject to an injunction. Second, the principle extends to situations where a patentee seeks to practice an invention claimed in the patentee's own patent(s). The consequence is that the owner of a patent and its attendant rights does not possess the affirmative legal right to practice the subject matter claimed in a patent. Thus, a patent

43. See, e.g., supra note 27.  
44. See, e.g., supra note 26.  
46. See, e.g., supra note 26.  
47. 35 U.S.C. § 154(a)(1) (2000) (stating that a patent shall contain a grant of "the right to exclude others from making, using, offering for sale, or selling . . . importing . . . ."). See also id. at §§ 271, 283 (establishing infringement and authorizing injunctions for "violation of any right secured by patent"); TRIPS Agreement, supra note 39, at Art. 28 (a patent "confer[s] on its owner . . . exclusive rights").  
48. See Guido Calabresi & A. Douglas Melamed, Property Rules, Liability Rules and Inalienability: One View of the Cathedral, 85 HARV. L. REV. 1089 (1972) (describing property rules and liability rules). The normal remedy for patent infringement includes the equitable remedy of injunction to prevent the continued violation of rights secured by a patent. Compare Richardson v. Suzuki Motor Co. Ltd., 868 F.2d 1226, 1246-47 (Fed. Cir. 1989) (noting the general rule that a permanent injunction will issue once infringement and validity have been determined) with eBay, Inc. v. MercExchange, L.L.C., 126 S. Ct. 1837 (2006) (suggesting the differing views of the Justices as to the validity of the use of a property rule in most patent cases) and Richard A. Epstein et al., Brief of Various Law & Economics Professors et al. as Amici Curiae in Support of Respondent, eBay, Inc., 126 S. Ct. 1837 (2006) (arguing for maintaining a property rule). Despite a strong preference for a property rule in the case of patents, equity has always recognized limitations. Thus, a court may decline to enter an injunction after determining infringement and validity when the patentee's failure to practice an invention frustrates an important public need. See Rite-Hite Corp. v. Kelly Co., 56 F.3d 1538, 1547 (Fed. Cir. 1995). That is not to say that there are not jurisdictions where patents are occasionally treated as though they were protected by a liability rule. For instance, the TRIPS Agreement permits compulsory licensing under certain circumstances. See TRIPS Agreement, supra note 39, at Art. 27 para. 3. Even in the United States, a compulsory license is possible. See 28 U.S.C. § 1498 (2000). However, such a license seems rarely to have been taken.  
49. Because notice problems and strategic behavior make for an imperfect reality, patent rights are additionally protected by a liability rule. 35 U.S.C. § 284 (2000) (authorizing damages "adequate to compensate for the infringement, but in no event less than a reasonable royalty" for periods where an infringer is without knowledge of the patentee's rights). Liability is also the remedy where an infringer knowingly disregards a patentee's rights. In such situations, however, liability is enhanced. See generally id. at § 284 (stating that "the court may increase the damages up to three times").  
50. Id. at § 283; see, e.g., eBay, Inc., 126 S. Ct. at 1841 ("injunctive relief rests within the equitable discretion of the . . . court, and . . . such discretion must be exercised consistent with traditional principles of equity . . . .").
The owner using the subject matter claimed in her own patent can still be adjudged an infringer, subject to damages and equitable relief, where the practice of her own patent infringes overlapping rights granted to a competitor by a different patent.

The first feature follows from a straightforward application of the right to exclude. While the first is not generally known by a special title, the application of the property rule acts to "block" the use of claimed subject matter without permission. This allows the patentee to "holdout." As a general matter, this is the contemplated mechanism of the patent system. In the context of sequential innovation the block may be of special impact where by its nature sequential innovation presents one or very few paths forward.

In the parlance of the patent law, the second feature refers to the patent law phenomenon of "blocking patents." The earlier patentee may be "blocked" from practicing his invention by another patent directed to an improvement unless permission can be obtained from the downstream innovator. Naturally, the law of property and contracts make such permissions possible. However, as later discussed, as more rights need to be collected, the more likely it becomes that inefficient friction may develop in the transfer of rights.

It is not too facile to suspect that the blocking nature of the rights conferred by patent laws has an impact on the path and progress of sequential or cumulative innovation. On the one hand, it is the blocking feature of the patent laws that is thought to encourage the production of intangible property. On the other hand, the blocking feature of the patent laws may allow a patentee to establish a monopoly and may increase the costs of transaction where numerous rights must be bundled to practice an invention or engage in subsequent innovation. These latter two situations give rise to two types of what shall be referred to as "innovation suppressive costs."
1. The Innovation Suppressive Cost of Monopoly

The consequences of a monopoly in innovation generally are much debated.\(^5^6\) Under one view, largely attributed to Joseph A. Schumpeter,\(^5^7\) larger firms are expected to be more innovative than smaller firms. The nature of capitalism, characterized by its inherent feature of “Creative Destruction,”\(^5^8\) drives a form of competition directed not to incremental increases in marginal profits, but directed instead to changes that provide more radical selective advantage.\(^5^9\) The threat of selective disadvantage (i.e., being left behind) is “ever-present”\(^6^0\) and because of the catastrophic consequences that follow from a failure to evolve, a monopolist can never sit on his hands; he must run, i.e., innovate, as fast as he can to stay just where he is.

According to this view, an environment that includes monopolies or oligopolies may not only foster innovation, but may be particularly important to achieving innovation.\(^6^1\) Because of supramarginal cost profits, it is these entities that have the ability to hedge the risks associated with innovation.\(^6^2\) Moreover, the profits and market position enjoyed by the monopolist or oligopolist make it likely that such firms will be able to more fully appropriate the benefits of their innovations, which in turn supports subsequent innovation.\(^6^3\) Firms unable to maintain supramarginal cost pricing can be expected to have a more difficult time concentrating the capital necessary for innovation and have a greater likelihood of expiring when costly innovation does not produce profitable products.
The legal rights attending a patent can sometimes confer a monopoly on the holder, and may thus provide the patent owner market power useful to hedge the risks associated with innovation. But even where the property rights conferred by a patent do not create a monopoly, they may be capable of serving a similar centralizing purpose. Under this view, patents directed to substrates for future research and development serve as “prospects.” Broader rights, the thinking goes, increase the efficiency with which investment in innovation can be managed. As long as information about patent rights is both available and reasonably clear, it is unlikely that a competitor will make a significant investment in commercializing a patent owned by another unless an agreement on appropriation can be reached. Structurally, this permits the property rights holder to coordinate innovation concerning the property. Having more concentrated the costs and benefits of innovation on the rights holder, he or she should be highly motivated to organize subsequent innovation in order to avoid wasting resources. Moreover, because broader rights can be expected to increase appropriability, a patent owner has the possibility of greater return, which justifies greater investment in the commercialization of the patented subject matter.

Thus, from at least a theoretical perspective, granting broad upstream patent rights may be an efficient approach to innovation because centralization may have a cost-reducing effect. This allows for at least some innovation that might not happen in a higher cost environment. In addition, cost-reducing centralization may increase the rate of innovation. Lower cost advances consume fewer resources and capital available for innovation, permitting their redeployment to other projects capable of generating new innovation. Alternatively, an increase in the rate of innovation could occur because the upstream rights holder focuses subsequent innovative work on, and applies the resources and capital saved by centralization to, the subject matter most critical to achieving a subsequent innovation. Put most plainly, prospect theory holds that as compared to a decentralized system that allows for a more free competition in the use of closely related rights—and thus, perhaps a greater likelihood of duplicative work—centralization should result in more innovation per innovation dollar expended.

Such a laudatory view of the merits of either monopoly, oligopoly, or other form of centralization is not universal. Notwithstanding the possible waste associated with

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64. It is not necessary that a patent confer a monopoly, and the majority of patents are unlikely to do so. See Kitch, supra note 52, at 1729-34 (explaining that a general conflation of intellectual property rights with the concept of monopoly is improper because it erroneously divorces the economic significance of property rights from an analysis of whether property rights confer a monopoly). However, as later discussed, due to the nature of innovation in the life sciences, patent rights may permit the rights holder to be the sole seller of a particular kind or class of product or service. For these goods, effective non-infringing substitutes may be rare. Thus, monopoly or near-monopoly conditions may sometimes exist.


66. Id.

67. This proposition provides a contrast to trade secrecy. Id. at 275, 277-78. Although few would argue with this contention, removed from comparison to trade secrecy, however, the notion that patent rights are well noticed may be optimistic. See Lee Petherbridge, Positive Examination, 46 IDEA 173, 191-212 (2006) (arguing that meaningful patent system reform should focus heavily on improving the notice function of patents).

68. Kitch, supra note 65, at 276.

69. Id. at 277-78.
duplicating work, scholars Robert Merges and Richard Nelson contend that competition may be a more efficient way to get improvement.\textsuperscript{70} First, and perhaps foremost according to this view, the monopolist is encouraged only by the "carrot."\textsuperscript{71} Rivalrous competition adds the "stick" to the formula; a penalty for inaction.\textsuperscript{72} In addition, there is reason to question the attraction of the carrot. In situations where the products of innovation would cannibalize a monopolist's existing sales and where those sales would be unaffected in the absence of the monopolist's innovations, the monopolist may not be well-motivated to take on the expenditures of innovation.\textsuperscript{73}

In addition, the benefits of centralization flow in significant degree from the fact that broad upstream rights holders have some reliable conception of which subsequent innovations are valuable, and perhaps even a conception of the embodiments of the subsequent innovations. Endowing rights holders with the omniscience to know both which improvements are valuable and how to most efficiently organize research and development to achieve such improvements may be overly optimistic.\textsuperscript{74} If the upstream rights holder erroneously organizes around an approach that cannot work or is otherwise intractable because, e.g., it relies on erroneous information or a limited complementary technology, innovation can be delayed or halted. In such circumstances, innovation could become very expensive.

The duplicative work associated with races to innovate may not be as wasteful as it at first might appear. Competition generates better consumer products at lower prices.\textsuperscript{75} Moreover, competitors with diverse goals and purposes may be important for making valuable improvements to a broad upstream innovation. Because competitors will often, if not invariably, take different approaches, apply different tools, and make different logical connections in view of the resources (e.g., money, tools, and information) they possess, different approaches may prove to have independent social value.\textsuperscript{76}

Regardless of whether a centralized or diverse approach to innovation is best suited to provide efficient innovation, the use of exclusive property rights raises the specter of monopoly. Where a patent does confer a monopoly or near monopoly on its holder, it has the potential to add costs to a system of sequential or cumulative innovation.\textsuperscript{77} The lower output, higher demand, and higher price realized in a

\textsuperscript{71} Id. at 872.
\textsuperscript{72} But see SCHUMPETER, supra note 57, at 87-106 (arguing, in effect, that the stick is "ever-present").
\textsuperscript{73} See KENNETH J. ARROW, Economic Welfare and the Allocation of Resources for Innovation, in THE RATE AND DIRECTION OF INVENTIVE ACTIVITY 609, 619-22 (National Bureau of Economic Reserve ed., 1962) (arguing that "the incentive to invent is less under monopolistic than under competitive conditions").
\textsuperscript{74} Merges & Nelson, supra note 70, at 873-77.
\textsuperscript{75} Kenneth W. Dam, The Economic Underpinnings of Patent Law, 23 J. LEGAL STUD. 247, 263 (1994) (arguing that benefits of diversity flowing from a competitive approach to innovation may outweigh the waste of duplicative efforts; and to the extent there is waste, it is not the sort with which public policy should be concerned).
\textsuperscript{76} Fostering Cumulative Innovation, supra note 56, at 825.
\textsuperscript{77} One important way that monopolies may add costs to innovation is by the commonly known feature of dead weight loss. Under general principles of supply and demand, as the price of a good declines the amount of demand for the good will increase. A firm maximizes profits by selling at a point where marginal
monopoly situation works to raise the cost of access to patented subject matter. Where multiple rights must be acquired, as may typically be the case in situations of complex and/or sequential innovation, the cost of the acquisition of rights may quickly increase beyond the cost that would have been paid in a competitive environment. The more rights that need to be acquired, the greater the premium that must be paid to engage in innovation. As the premium increases, the more it eats into the profits expected to result from engaging in innovation. Hypothetically, there comes a point at which the costs involved may suppress altogether the economic motivations to pursue an innovation.

2. Additional Innovation Suppressive Costs

Inherent in the use of property rights are another set of innovation suppressive costs—the transactional costs of information and negotiation. In general terms, to transact in property rights parties must form an understanding of the legal relationships between one another as well as an understanding of the subject matter—the thing—that is the nexus of the relationship between the parties. In addition, the parties must form an accurate understanding of the respective value of the rights, avoiding exorbitant holdout rents and, where relevant, free riding. Inefficiencies in these tasks add costs to the transaction and make the movement of property rights from lower valued to higher valued uses less efficient.

In an influential article, Michael Heller describes a tangible property scenario where transaction costs attending the bundling of various rights are sufficiently high that ordinary market mechanisms have difficulty aligning rights so that property is put to its best use. By contrast to the catastrophic overuse that characterizes communal revenue, i.e., the amount a firm earns from the sale of an additional unit, equals its marginal cost, i.e., the cost incurred in producing the additional unit. Thus, where marginal revenue is greater than marginal cost, a firm should produce more output. Conversely, where the marginal cost is greater than the marginal revenue a firm has lost money by overproducing the good.

In a competitive environment, the presence of multiple sellers fixes marginal revenue at the price set in the market. In the absence of competition or the availability of equivalent or substitute goods, however, marginal costs may remain the same, but the point at which marginal revenue equals marginal cost (and profits are therefore maximized) is at a level of output less than what would be produced in a competitive market. Consequently, a profit maximizing firm that has a monopoly or near monopoly will sell fewer goods at a higher price. The dead weight loss is seen through the loss of output. Those who would have purchased the additional goods at lower prices cannot do so and some profit that could have been realized by the monopolist is not realized. See generally DONALD S. CHISUM ET AL., PRINCIPLES OF PATENT LAW 57-62 (3d ed. 2004).

78. See discussion supra note 55.


80. Long, supra note 79, at 472-73.

ownership in the tragedy of the commons, a tragedy of underuse, a "tragedy of the anticommons," might arise when enough multiple owners have the right to exclude others from a scarce resource.

More recent works have hypothesized that a growing number of property rights in the form of patents is causing an accretion of transaction costs that may be attenuating innovation in the life sciences. In this view, legislative and university policies create an environment of highly fragmented rights, which in the life sciences combine with a practical requirement of complex sequential innovation to coalesce into a perfect storm of innovation destroying transaction costs. Thus, legislative policy choices given force by the passage of the Bayh-Dole Act and the Federal Courts Improvement Act of 1982 (creating the Federal Circuit) contribute to the tragedy by encouraging the formal propertization of publicly funded invention and discovery.

Thus, for example, if a large and diverse population of property owners through patents directed to nucleic acid sequence fragments each had the right to exclude others from the use of part of a gene for a receptor important in the study of a disease pathology and treatment, it might be very costly to gather all of the licenses necessary for one or a small number of entities to engage subsequent innovation. To the extent that subsequent research and development, marketing approval, and manufacturing and sales is very expensive, pursuing subsequent innovation may be too risky for firms that cannot obtain all the necessary permissions. A risk enhanced by the knowledge that there is rarely, if ever, a guarantee that subsequent research and investment will produce a commercially marketable product.

The cost of innovation in such an environment may be further enhanced by the strategic behavior of upstream entities. By encouraging patenting at this level, the thinking goes, innovation policy inserts large numbers of broad upstream rights far removed from widely demanded commercial products. Because universities and

82. See Garret Hardin, The Tragedy of the Commons, 162 SCIENCE 1243 (1968).
84. See Rai & Eisenberg, supra note 83, at 296 (arguing that legislative innovation policies neglected to take into account distinctions between upstream inventions directed to basic research or fundamental discoveries that enable future scientific investigation and downstream inventions, which lead more directly to commercial products).
85. A result that, if true, is especially perverse considering the purpose of these policy initiatives was to promote the use of inventions and discoveries produced with public funding for the public good. See 35 U.S.C. § 200 (2000) (stating that the purpose of the Bayh-Dole Act is “to promote the utilization of inventions arising from federally supported research or development”); Rai & Eisenberg, supra note 83, at 290 (“The sponsors of the legislation believed that grantee ownership of patent rights . . . was necessary to motivate private investors to pick up where the government sponsors left off and transform new discoveries into commercial products.”).
86. See Heller & Eisenberg, supra note 83, at 699, for a very similar example.
87. See Rai, supra note 7, at 135-36 (explaining that this has had a “dis-integrati[ng]" effect on innovation in the life sciences; where once pharmaceutical firms were vertically integrated houses of innovation, managing rights from early in the innovation process, the economic change wrought by legislation has dis-integrated this older innovation process).
smaller firms are less likely to produce therapeutic end products, they typically seek to appropriate the benefits of their rights by seeking some portion of the revenue expected if others successfully innovate from their upstream inventions and discoveries to downstream commercial products. This task is typically accomplished by licensing. In an atmosphere of uncertainty concerning the feasibility of any commercial therapeutic (or other widely demanded product) these licensing transactions can be very costly.\footnote{Heller & Eisenberg, supra note 83, at 700 (making this point). This uncertainty can be exacerbated where negotiators have limited time, skills, and/or business acumen. See also Lorelei Ritchie de Larena, \textit{The Price of Progress: Are Universities Adding to the Cost?}, 44 Hous. L. Rev. (forthcoming) (at 44 of draft on file with author). ("It is understandable difficult for technology transfer offices to have resources to support the high-level knowledge of both law and business that is now necessary to responsibly administer the university's intellectual property obligations ... ").} Thus, at least hypothetically, problems of information, strategic behavior, and the erroneous prediction of the value of downstream products can increase costs, thereby suppressing innovation and reducing its attendant social benefits.\footnote{Both empirical and theoretical disputes exist concerning the impact of transaction costs on innovation in the life sciences. A recent report by the National Research Council finds that an increase in patenting activity generally has not been linked to a loss of social benefits. \textit{See National Research Council of the National Academies, A Patent System for the 21st Century} 29, 46-63 (Stephen A. Merrill, Richard C. Levin, & Mark B. Myers eds., The National Academies Press 2004) [hereinafter A Patent System for the 21st Century]. \textit{Other reports also suggest that in most cases patents may not be significantly impeding research and development in the life sciences. See John P. Walsh, Charlene Cho, & Wesley M. Cohen, \textit{View from the Bench: Patents and Material Transfers}, 309 Science, 2002, 2003 (2005) (concluding that the results of a survey of academic biomedical researchers offered "little empirical basis for claims that restricted access to IP is currently impeding biomedical research"); John P. Walsh, Ashish Arora, & Wesley M. Cohen, \textit{Effects of Research Tool Patents and Licensing on Biomedical Innovation}, in \textit{Patents in the Knowledge-Based Economy} 285, 331-36 (Wesley M. Cohen and Stephen A. Merrill, eds., National Academies Press 2003) (finding, \textit{inter alia} that upstream rights do not generally inhibit drug development). A theoretical basis for understanding these results is suggested by R. Polk Wagner in \textit{Information Wants to Be Free: Intellectual Property and the Mythologies of Control}, 103 Colum. L. Rev. 995, 1001-16 (2003), in which he describes an expanding information commons. The empirical data is not, however, all one-sided. See Eric G. Campbell et al., \textit{Data Withholding in Academic Genetics: Data from a National Survey}, 287 JAMA 473, 476-78 (2002) (reporting some level of data withholding in life sciences research).} The following example(s) will help to illustrate how myriad rights could affect innovation. Suppose an investigator at University X molecularly clones a complimentary DNA ("cDNA") containing a portion of a gene encoding a receptor important in an intracellular signaling pathway that has been linked to aberrant cell growth, e.g., cancer. Assuming sufficient utility,\footnote{The utility requirement is still properly understood as very low and generally presents a low bar to patentability. \textit{See generally In re Fisher, 421 F.3d 1365, 1369-78 (Fed. Cir. 2005) (stating the standard for utility and applying it to a patent application directed to expressed sequence tags (ESTs) or gene fragments).} \textit{See Parke-Davis & Co. v. H. K. Mulford Co., 189 F. 95, 102-14 (S.D.N.Y. 1911), aff'd \textit{in part}, 196 F. 496, 498 (2d Cir. 1912).}} novelty, and nonobviousness, the cDNA would be patentable under the principles announced in \textit{Parke-Davis}.\footnote{See Parke-Davis & Co. v. H. K. Mulford Co., 189 F. 95, 102-14 (S.D.N.Y. 1911), \textit{aff'd \textit{in part}}, 196 F. 496, 498 (2d Cir. 1912).} Suppose a separate investigator at University Y isolates the genomic clone of the same, or a highly homologous, gene, which contains the coding sequences missing from the cDNA. In view of the law of written description and obviousness as applied to
molecular technologies and products, this too is likely to be patentable. Finally, imagine that an investigator at start-up Z purifies the polypeptide comprising the receptor. This also is patentable subject matter and could be independently patented by the start-up.

At this point, a commercially viable therapy to treat cancer is far off. Already, however, each of these patentees respectively has the right to block all possible uses of each of the sequences of the cDNA, the genomic DNA, and the purified polypeptide. A pharmaceutical firm that wants to test its library of small molecule compounds might have to negotiate three licenses: two for access to the DNA necessary to synthesize the protein, and a third to work with the protein. In each case, the license must be negotiated in an environment of relatively poor information about whether there even exists a chemical or small molecule in their library that antagonizes or agonizes the receptor. And even if such a molecule is found, there is no guarantee that it would have the desired effect on cell growth. Moreover, if a molecule that suppresses aberrant cell growth is found, it would still have to pass through animal, and later human, testing to meet the marketing approval requirements of the FDA.

In the event that a blockbuster is not identified by the foregoing approach, future research would need to be conducted. This would require permissions for each of the entities that would perform the research. These agreements, too, would be negotiated in an environment where little is known about the likelihood of success and the potential benefits. This research might discover additional molecules in the signaling pathway, which would themselves be patented. Other receptors that interact with the first receptor may be discovered, as may be genes and gene products that are activated when the receptor is agonized. Each gene and polypeptide could be patented in whole or in part by the various participants in the research. As with the earlier patents, each of these patentees has the right to block all possible uses of the patented subject matter.

Still later research might involve the creation of cell lines or transgenic animals missing or expressing altered forms or the various components of the signaling pathway. Each line and animal, as well as the techniques for making them, is protected by the property rules of the patent system. Where the therapy ultimately consists of complicated recombinant vectors, e.g., gene therapy, rights in the DNA sequences comprising the coding, regulatory, and other elements of the vectors may have to be collected. Where the therapy is complex macromolecule, such as a biologic, the methods of expression, construction, and/or purification, as well as those of administration can all be expected to be subject to patent protection.

III. A THEORY OF OPEN LIFE SCIENCE

Relatively few would argue with the contention that there is value, both economic and moral, in addressing the healthcare needs of the economically disenfranchised groups discussed previously. Most would probably also agree that intellectual property laws are not the sole cause of the lack of access, distribution, and allocation

93. See discussion supra Part I.
of healthcare resources to the groups described above. However, to the extent that the economics of the current framework of innovation is not producing drugs and therapies directed to important and devastating diseases—particularly if the lack of production flows from a disproportionately small investment in comparison to the impact of the diseases—it is worth considering other possible frameworks for innovation.94

Moreover, the significance of patents in the life sciences does not appear to be on the wane. Indeed, common sense dictates that patents will likely continue to increase in prominence as a tool for organizing research and development in the field. Acknowledging the significance of patents also means acknowledging that innovation suppressive costs are unavoidable, which in turn, presents the question whether these costs might be reduced. As a preliminary matter, one could ask whether the benefits of a property-based legal infrastructure outweigh the costs inherent in such an approach. This question has not been decisively answered, but at present it is probably enough to say that there seems to be little evidence that the general application of a property-based approach to innovation is incorrect as compared to a property-less approach. If the established proprietary framework is not broadly incompetent, then

94. Others have confronted either this particular question or the more general question of whether innovation on the whole might be improved with legal change or private reorganization. See, e.g., Stephen M. Maurer et. al., Finding Cures for Tropical Diseases: Is Open Source an Answer, 1 PLOS MED. 183, 183-85 (2004) (discussing the application of open source); Yochei Benkler, Commons-Based Strategies and the Problem of Patents, 305 SCIENCE 1110, 1110 (2004); Amy Kapczynski et. al., Addressing Global Health Inequities: An Open Licensing Approach for University Innovations, 20 BERKELEY TECH. L.J. 1031, 1091-1108 (2005) (describing equitable access licensing); David W. Oderbeck, The Penguin's Genome, or Coase and Open Source Biotechnology, 18 HARV. J. L. & TECH. 167, 224-26 (2004) (proposing a National Biotechnology Database to force transparency of the licensing market to lower transaction costs and move closer to a Coasian ideal); J.H. Reichman & Paul F. Uhlir, A Contractually Reconstructed Research Commons for Scientific Data in a Highly Protectionist Intellectual Property Environment, 66 LAW & CONTEMP. PROBS. 315, 427-30 (2003) (describing the parameters of a contractually reconstructed research data commons); see also, e.g., Alliance for Cell Signaling, supra note 7, at 706; The Synaptic Leap, http://www.thesynaptic leap.org/ (last visited Jan. 22, 2007) (providing an environment for online research communities to connect and enabling open source biomedical research); International HapMap Project, http://www.hapmap.org/datareleasepolicy.html.en (last visited Jan. 22, 2007) (providing a haplotype map of the human genome, this project seeks to make information produced by the project freely available by requiring that “users must agree not to reduce others’ access to the data, and to share the data only with others who have made the same agreement.”); BiOS, http://www.bios.net/daisy/bios/about/3.html (last visited Jan. 22, 2007) (employing an open source approach to foster innovation on biotechnology); Bioinformatics.org, 2002 Organization Plan (2002), http://bioinformatics.org/about/plan-20020920.pdf at 5-19 (providing an open access/source resource for bioinformatics); Open Bioinformatics Foundation, www.open-bio.org/wiki/main_page (last visited Feb. 4, 2007) (providing support for open source bioinformatics). An additional example is reflected in the Brief of Twenty-Four Intellectual Property Law Professors as Amicus Curiae, supporting KSR's petition for writ of certiorari in KSR International Co. v. Telegex, Inc., No. 04-1350, (U.S. May 12, 2005) (arguing for a change in the standard for patentability). Legislative means have also been proposed. See, e.g., Genomic Research and Accessibility Act, H.R. 977, 110th Cong. (2007) (directed to prohibiting the patentability of nucleotide sequences). Many of the suggestions and proposals in the cited references have merit, and it is not the plan of this Article to dissect and discuss them all. As is evident in later sections of the Article, to the extent the Article reflects a preference it is likely in the direction of private ordering because it permits particularized arrangements that offer a precision that is sometimes difficult to capture with legislative interference or other top-down legal change.
the application of a principle of reasonable precaution argues that any modifications or additions to the current innovation paradigm be tailored to not unreasonably disrupt the basic proprietary framework. At this level of resolution, the question becomes what, if anything, can be done to refine the current innovation infrastructure in a way that complements the current use of property rights, but also creates the possibility that certain types of innovation will be more likely to occur and makes more widespread access to innovation that does occur.

One refinement might come from reconsidering the way in which property rights are deployed. Instead of conceptualizing property as, primarily, a tool of exclusion, property could sometimes be deployed as a tool of inclusion. As discussed below, the liberal access to rights that might follow can in some cases be expected to encourage innovation.

A. Open Science

At the outset, some explanation of the term "open science" is appropriate. As used here, it refers to a framework for innovation directed to providing liberal, low-cost access to intangible (patented) property for the purpose of the creation and accretion of new and useful information and materials that meaningfully advance the state of knowledge and skill in a relevant technological area. In general terms, open science is meant to reflect a socially sensible approach to innovation by recognizing that in some cases the grant of liberal rights to use certain property is a superior approach to innovation than an approach that vests an exclusive right in a single firm. As discussed in more detail below, the use of the term here is not meant to suggest that anyone and everyone should always have the right to use all relevant property in every situation. Rather, an open science approach is properly tailored based on a consideration of the facts and circumstances.

As described, open science depends on relatively liberal, low-cost access to property rights. That being the case, as a preliminary matter it is important to consider the question whether such liberal, low-cost access is harmful to innovation. The general answer is almost certainly that it depends. Surely some innovation will happen in the absence of patents, so removing the possibility of a patent would at worst slow down the pace of innovation. Thus, the detriment would presumably be mostly concentrated on those who needed the advances sooner. However, the animating concern here is directing innovation to seemingly underserved markets. In cases where relatively little work is being done, we might conclude that the contemporary framework has not encouraged the desired level of productivity. Thus, liberalizing access, at a minimum, might be expected to be no worse than the current state of affairs.

The next question to consider is whether liberalizing access could promote innovation. This answer, too, is almost certainly that it depends. Reducing the cost of access to rights could be expected to lower the cost of innovation—potentially encouraging innovators who might have been sitting on the sidelines due to concerns over the access to rights. Thus, alternative means of funding the work might become more feasible, e.g., not-for-profit pharmaceutical companies, government, or United Nations funded research might be performed on a contractual basis. Moreover, where
upstream rights are involved, potential returns might not be prohibitively diminished, especially where patents remained available for end products or therapies.

Creating a framework of liberal access to property rights may have additional innovation-enhancing benefits in the life sciences. As described in more detail below, some benefits may flow from general features of innovation in the life sciences, while others may flow from the ability to achieve at least some innovative advances through the use of large, loosely organized peer research collaborations.

There are several features of innovation in the life sciences, which suggest that an open science approach may sometimes be appropriate. First, innovation in the life sciences can be highly cumulative. Upstream inventions may feature prominently in downstream innovation. In situations where considerable work remains to be done to connect a new discovery with a broadly useful product or therapeutic, it can make sense to provide liberal access to the use of the discovery. Moreover, in cases involving upstream inventions that are of broad technological importance, rights attaching to such inventions could operate as powerful tools to organize downstream innovation.

Second, innovation in the life sciences is characterized by significant platform susceptibility. There are a broad variety of platform technologies that are capable of serving as common research resources. Many of these platform technologies are capable of providing both a structural and functional context for research and for the production of a wide variety of important innovation outputs. Some examples include molecular systems, e.g., cloning vectors, molecular libraries, expression cloning systems, two-hybrid systems, and inducible expression systems. Other examples include cell lines, which provide an irritable structural and functional environment for the reproduction and examination of any number of cellular processes and molecular interactions. Yet other examples include transgenic animals, which can be precisely tailored to express vel non a particular gene, to screen for genes important to particular functions, to serve as broadly applicable disease models, and/or to serve as bio-reactors for the production of important substances. The broad platform susceptibility of innovation in the life sciences suggests that there will be cases in which innovation can be improved by providing liberal, low-cost access to certain technologies.

Third, many of these platforms easily evolve in the hands of ordinarily skilled (or less) individuals to serve important research goals. For example, cloning vectors may play host to a wide variety of molecular clones. Expression cloning systems are generally customizable to probe for clones across a wide range of species, tissues, and states of cellular or organismal differentiation. Cell lines and transgenic animals can be modified using ordinary techniques of gene introduction, ablation, and/or cellular cloning to express exogenous genes, ablate endogenous genes, introduce dominant

95. This makes sense whether or not one adheres to the view that centralization is the superior form of organization. In some cases, it can make sense for a property owner to make liberal grants of the right to use a patent, and perhaps even to include others in ownership.

96. The example of the receptor, discussed supra Part II.B.2, provides at least one example. There are numerous other examples, and new possibilities are ever arising.


98. Notice of this common practice has reached even lay legal audiences. See Univ. of Rochester v.
negative mutations, and express chimeric molecules.\textsuperscript{99} Inducible expression systems can be customized to express a massive array of genes, gene fragments, mutants, or chimeric genes in a number of cellular and animal environments. The same is true for transgenic animals, which can be customized to express \textit{vel non} genes, mutations, and chimeric molecules, in a constitutive or tissue-specific fashion. The fact that platform technologies may be easily customized to serve a diverse array of research and innovation interests suggests the desirability of providing liberal, low-cost access. This may be particularly true where the range of uses is so broad that a rights holder may not be aware of the breadth of uses, or even interested in other uses for purposes beyond obtaining rents.

A fourth feature of innovation in the life sciences that makes an open approach appealing is the historical presence of punctuating technologies. Some notable examples include the microscope, the advent of molecular cloning technologies in the 1970s, the advent of Polymerase Chain Reaction in the 1980s, and the advent of knock-out and knock-in technologies in the 1990s. The broad application of these mostly discrete inventions has produced revolutionary advances in invention and innovation in the life sciences. It may be particularly important that punctuating technologies be made liberally available, because their application to a diverse set of problems can be expected to produce across the board advances in information and understanding.

Finally, there are problems in the life sciences that are both very large and very complex. For example, a fundamental question in the life sciences is: What is the network of interactions involved in intracellular signaling?\textsuperscript{100} It is likely an understatement of the complexity of this problem to analogize it to an attempt to understand the complete workings of the infrastructure of New York City by looking down at the city from the moon. The cost of resolving such complex and detailed relationships may be beyond the reasonable temporal capabilities of any single firm, even a large sophisticated pharmaceutical firm. Liberal sharing of access to information and materials may be a reasonable (or perhaps even necessary) approach to resolving questions of such high complexity.

\textbf{B. To Open Science from Open Source}

The idea of open source, and particularly the idea of using property rights to leverage liberal access to materials and information that are typically legally protected...
as “property,” is most often discussed in the context of software and software innovation. Of the merits proffered in support of open source approaches, two are particularly relevant to innovation in the life sciences: (1) the potential for reducing innovation suppressive costs, and (2) the potential for efficiency gains available because open source allows for a greater number of innovators working collaboratively in a relatively decentralized environment.

In an eye-opening work, Yochai Benkler suggests that commons-based peer production may be usefully deployed in not only software and distributed computing contexts, but perhaps in other production contexts as well. What matters, according to Benkler, are the surrounding environmental conditions. The article distills environmental conditions that, if present, may support larger scale collaborative efforts. These conditions include: (1) a pool of sufficiently skilled peer workers who could be motivated to contribute to a project in which many are unlikely to appropriate substantial monetary rewards; (2) a project that can be sufficiently modularized so that its parts are sufficiently independent and discrete as to be performable independently and flexibly by peer participants in accordance with their availability and motivation; (3) a project in which modules can be sufficiently granularized, because, generally speaking, the smaller the cost of participation to individual peer contributors, the broader the pool of peer contributors can be; and (4) modules capable of being integrated at a relatively low cost. Of particular importance here is the avoidance of spurious or incompetent contributions and the avoidance of unilateral appropriation of rights in the peer-produced subject matter.

The array of approaches to invention and innovation in the life sciences can be quite diverse. In general terms, however, innovation in the life sciences differs in several important ways from the software or distributive computing situations that largely animate the model in Benkler’s piece. These are discussed in more detail below, but include the following: first, innovation in the life sciences has at least some

101. A number of articles and additional resources are available to the reader who would like more information concerning open source in the context of software and other copyright-grounded contexts. There are so many, that it is unreasonable to list them all. One beginning resource is the Free Software Foundation, which supports the General Public License (GPL) versions of the archetypical “copyleft” licenses. The Free Software Foundation, http://www.fsf.org, (last visited Feb. 5, 2007). Another resource that addresses access to copyrightable materials is Creative Commons. Creative Commons has a number of licenses, and its “Share Alike” licensing provisions appear to implement a “copyleft” approach to licensing. Creative Commons, http://creativecommons.org (last visited Feb. 5, 2007).

102. For this seminal article on peer production, see Yochai Benkler, Coase’s Penguin, or, Linux and The Nature of the Firm, 112 YALE L.J. 369, 369 (2002).

103. I have recast Benkler’s argument just slightly. The last three conditions I describe independently, whereas Benkler presents these conditions collectively as significant to solving the problem of motivation. Id. at 378-79.

104. Id. at 423-34.

105. Id. at 435.

106. Id.

107. Id. at 436.


109. Recall that this discussion intentionally sets aside computer-driven approaches to innovation in the life sciences, particularly those that rely on software development.
high fixed costs including the cost of integration of materials; second, there may be a relatively smaller number of peer participants; third, some innovation tasks in the life sciences can exhibit problems of imperfect modularity and can sometimes be large granule; and finally, at least until recently, innovation in the life sciences was more subject to being appropriated by late comers than was innovation in the software field.  

1. Addressing Fixed Costs

Innovation in the life sciences can be characterized as having generally higher physical costs than innovation in the software or distributed computing arenas. The consequence of higher physical costs are primarily to limit the distribution of resources available for research and development. As discussed in more detail below, this need not be fatal to the application of an open science approach because first, not all work has a high physical cost, and second, even where it may, the costs are frequently sunk costs making lower cost sharing, or "piggybacking" possible in many circumstances. Thus, while someone without access to a laboratory might not be able to perform some of the "hands-on" work involved in experimentation, those with access to a lab may readily, for example, set up in parallel to regular work additional sequencing or ligation reactions. Excess reagents may be used, or alternatively, reagents at or near their expiration date. Adding completed reactions to lanes on a gel that would otherwise have gone unused takes little in terms of extra resources. Indeed, it may be better viewed as an exercise in the conservation of resources. In connection with the ligation reactions, it may be true that extra competent cells would have to be used, but these too expire in usefulness and the amounts used would ordinarily be minimal. There would be little additional "hands-on" work as these cloning steps could be carried on in parallel to the primary experiments that are the main focus of the researcher's day-to-day work. So too, for the minipreparations or other techniques, e.g., PCR, that might be used to identify the clones.

Other examples of low (additional) physical cost work include setting up (in parallel or otherwise) additional amplification reactions for use in the unused wells of a PCR run. Primers are cheap, on the order of $20 or less for many PCR usable primers, and can be easily shared between investigators. Moreover they can be used in connection with PCR to achieve a dazzling and broad array of useful work. Again, older or less trusted aliquots of polymerase enzyme may be available. In addition, if the conditions for amplification are different for the primary work and the open, collaborative work the runs for the latter experiments could be done overnight or at

110. If there has been a change, it is an increase in software patents and the apparent refutation of a view held by some that software either was not or should not be patentable subject matter. Thus, software-related inventions are as appropriable by later improvers as patented inventions.

111. PCR refers to Polymerase Chain Reaction, a technique for amplifying nucleic acid sequences. See Kary Mullis & F.A. Faloona, Specific Synthesis of DNA in Vitro Via a Polymerase-Catalyzed Chain Reaction, 155 METHODS ENZYMATIC 335 (1987); Saiki et al., Primer-Directed Enzymatic Amplification of DNA with a Thermotable DNA Polymerase, 239 SCI. 487 (1988).

other times when the PCR machine would otherwise be idle. The resources used are, again, relatively small; some overhead for power consumption (that is probably already fixed), and a minimum amount of wear and tear accounted for in many cases by the fact that most investigators or institutions have already sunk the cost of purchasing service contracts from the vendor of the machines.

The above-mentioned techniques can be used to make constructs and libraries, perform other cloning experiments, load constructs into expression systems, and prepare vectors for introduction into cell lines and transgenic animals. Thus, these foundational tools of molecular biology can be employed at relatively low cost; a cost made lower in an environment of liberal, low-cost access to reagents.

With more complex reagents, such as cell lines, costs may rise. In many cases, the cost of incubators and hoods, and perhaps even the cost of one or more well-trained technicians will be sunk costs (e.g., in common resource areas and core labs). In some cases, extra plates of cell lines can be plated in parallel with regular work. Introducing recombinant constructs or applying available chemical or biological reagents can be accomplished at relatively little extra cost. In other cases, perhaps involving primary cells, or cell lines that are difficult to grow, the cost of obtaining and maintaining extra plates can be higher. Also, where experiments involve very costly reagents, or hard to obtain hormones, like RU-486, or powerful radioactive reagents, the cost of experiments may increase.

Another example of complex reagents includes the broad array of possible transgenic animals. Perhaps surprisingly, the cost of the production of transgenic animals need not be prohibitively high, although their maintenance almost surely will be. Many of the techniques already described, for example, molecular cloning, sequencing, PCR, and cell culture, can be used to create and confirm the constructs used to make transgenic animals. Moreover, many institutions have already sunk the cost of the equipment rooms, injection apparatuses, and expertise, including dedicated core scientists and/or technicians, to produce transgenic animals on a regular assembly line basis. Thus, the opportunity for low-cost "piggybacking" exists in connection with transgenic animals. However, even where the animals are produced, the cost of maintaining the animals can be high. The animals need to be housed, fed, bred, and culled. And while this often takes place in dedicated animal facilities (so the infrastructure costs are sunk), the cost to any individual investigator can be relatively high.

In university labs in particular, some level of collateral experimentation can often exist comfortably within the confines of a primary investigator’s budget. In other cases, grant budgets or funds provided by the institution contain some level of discretionary funding that could be used to support open science projects. In other cases, one or more institutions could agree to cooperate on an open, collaborative project and diffuse costs across several well-funded institutions.

In an open science approach, the integration of results to further the progress of innovation will depend on at least two parameters. The first is the integration of information, and the second is the integration of materials. Depending on the metalevel organization of the peer workers, the cost of integrating information may be reasonable. For example, sequence data, images of gels, reports in the form of tables, graphs, figures, and schematics, could be made available at a website dedicated to the
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project. The website could be a place where data is maintained. Peer workers could then check in to see the status of the project, contribute to the analysis of recently posted results, share ideas for future directions, pick up future "assignments," or organize loose collaborations to complete a next step. Indeed, as discussed below, the relatively high skill level of potential peer volunteers, combined with relatively small incremental inputs, may make for fairly easy integration of information. In addition, such a web-based collaboration may evolve to have "leaders" who exercise more influence over the direction of the research than might be seen in a purely decentralized regime. This could be a positive development, in that this group could guard against spurious or erroneous contributions, refine future tasks for less knowledgeable contributors, and avoid some inefficiencies by limiting duplicative work.

The cost of integrating materials may be higher, but in many cases not insurmountable. For example, in some cases, it may be enough for a peer collaborator to know the sequence information. The cost of having oligomeric primers or other length sequences synthesized may be sufficiently trivial that it can be absorbed by a peer collaborator. But even where it is not, the physical necessities of the transfer of genetic information are very small. DNA can be transferred on a piece of paper, which means that theoretically, it can be transferred nearly anywhere for the cost of a letter. Moreover, if DNA in that form is undesirable, it is trivial to precipitate significant quantities of DNA with a salt. Again, the act of transferring these materials take nothing more than sending a letter or small package; a cost easily borne by a motivated collaborator. Transferring other sorts of reagents can be more difficult, but only in extreme cases should the problem be cost prohibitive. For example, investigators regularly attend meetings. It would not take too much effort to bring along a cooler with a frozen aliquot of a cell line, or a breeding pair of animals. Another way to efficiently transfer material is to make a deposit of, e.g., cells or clone-containing bacteria, at the American Type Culture Collection. In the case of transgenic mice at least some could be deposited at The Jackson Laboratory.

113. Sequence data is already often made available through websites maintained by the National Institutes of Health.
114. Note that this statement is not absolute. There may of course be difficulty on the fringes, where the use of a particular reagent or the reproducibility of a particular experiment is particularly "handsensitive." This refers to a phenomenon sometimes observed on the ground in the life sciences in which a particular experiment or reagent appears to be capable of being reliably used by only a small number of individuals. Usually, this phenomenon is temporary and due to a poorly understood sensitivity parameter in the technique that is discovered and corrected over time.
115. Naturally, there are logistical considerations, including laws regulating the transfer of certain materials, which in some cases would have to be taken into account.
116. The American Type Culture Collection ("ATCC") stores and distributes biological materials such as cell lines, bacteria, animal and plant viruses, and antisera. ATCC Mission, http://www.atcc.org/About/AboutATCC.cfm (last visited Jan. 22, 2007). ATCC, a global nonprofit bioresource center, provides "biological products, technical services and educational programs to private industry, government and academic organizations around the world." Id. Its stated mission is "to acquire, authenticate, preserve, develop and distribute biological materials, information, technology, intellectual property and standards for the advancement, validation and application of scientific knowledge." Id.
117. The Jackson Laboratory, located in Bar Harbor, Maine, is a non-profit biomedical research center renowned for its collections of mutant and transgenic mice. See Facts About the Jackson Laboratory, a Non-Profit Institution, http://www.jax.org/about/jax_facts.html (last visited Feb. 4, 2007).
Yet another way of integrating materials (and information) in an open science environment is to establish cooperative projects in geographic areas with high concentrations of peer workers. A prototypical example could be the Texas Medical Center ("TMC"). At a minimum, the TMC boasts three nationally renowned institutions that are home to very large multi-department research and development communities, Baylor College of Medicine, the M.D. Anderson Cancer Center, and the University of Texas Medical School. Together, the three institutions support (or are supported by) many hundreds of primary investigators, many hundreds of post-doctoral fellows, hundreds of graduate students, hundreds of medical students, and large numbers of technicians. Each institution is literally a stone's-throw or two from the other. The transfer of all sorts of materials in this environment would take quite literally no more than fifteen minutes—the amount of time it takes to cross the street. Informal meetings, follow up questions on the nuances of techniques, or additional information on results is easily conveyed over lunch, or at workshops directed to a particular project. Moreover, these three major institutions are complemented by two other institutions that do significant amounts of biological and biomedical research. Texas A&M University with its research resources is approximately an hour-and-a-half away by car, and the University of Texas Medical Branch at Galveston is an hour's drive. It would be a small task for a motivated peer worker to drive to or from College Station or Galveston to obtain materials useful to the collaborative project. Thus, to the extent the integration of research tools and materials would be difficult when open collaborations take place over large distances, they might...

118. This conservative view ignores all of the research talent at the several hospitals in the medical center, such as Texas Children’s Hospital.
119. See About Baylor College of Medicine, http://www.bcm.edu/about/ (noting that in 2007, BCM was ranked first in the country for research expenditures in biological science by the National Science Foundation and thirteenth in National Institutes of Health funding) (last visited Jan. 22, 2007).
120. The M. D. Anderson Cancer Center is one of the nation’s top two cancer centers, and has a faculty of over 1,200 who have attained the degree of either M.D. or Ph.D. The University of Texas M. D. Anderson Cancer Center Profile, http://www.mdanderson.org/About_MDA/Who_We_Are/display.cfm?id=29E3FCE1-2828-11D5-811100508B603A14&method=displayFull.
122. One throw from Baylor College of Medicine to each of the others. To get from the University of Texas Medical School to the M.D. Anderson Cancer Center, one probably needs two throws. To the extent it would take more, it is because of intervening structures, not distance.
123. This would provide a nice complement to web-based integration of information by creating additional channels to sharpen the information generally made available on the site.
125. See http://www.tamu.edu/ (College Station, Texas).
126. See UTMB Facts and Figures, http://www.utmb.edu/ia/facts.asp (reporting that "UTMB is a major academic health center dedicated to health science education, patient care, research, and community service") (last visited Jan. 22, 2007).
be better organized when connected to geographic areas that contain a larger pool of potential peer workers.  

Finally, while this article largely eschews computational aspects of research and innovation in the life sciences, it is worth noting that as computational biology begins to make more significant contributions, at least that aspect of research and development may begin to take on the more traditional attributes of the peer production environment described by Benkler.

2. Peer Worker Potential

Another way in which innovation in the life sciences may differ from the production of new software and a distributed computation model is that the pool of peer workers may be smaller. This may be compensated for by at least three aspects of research and innovation in the life sciences, which set it apart from some other forms of innovation. First, the pool of peer workers in the life sciences is characterized by a high level of skill; both technical skill and breadth of knowledge. Nearly all of the peer workers will have college degrees, and many will either have or be working towards degrees as advanced as an M.D. or even a Ph.D. Many of these workers will keep up with current cutting edge advances in the life sciences as a function of their day jobs—being biomedical researchers. Thus, the knowledge and skill characteristics of this peer group may result in better auto-organization and better quality contributions.

Second, the pool of peer workers can be characterized as relatively stable. As suggested above, these peer workers will not usually be hobbyists, rather, a description of their "day job" includes constantly working toward being a smart contributor to life sciences projects. Thus, the same skills they are paid to hone are the skills they can bring to an open science collaboration. The stability provided by the income they receive for being life sciences researchers will allow them to be long-term contributors in an open science project. As their time with the project increases, the intellectual memory and infrastructure they provide can enhance the quality of the work done in pursuit of the project's goals.

A third reason to believe that a smaller pool of more highly skilled peer producers can operate in a life sciences theater is that this group may be especially motivated to work on the project. In many cases, these individuals are life sciences researchers because they view the work as being of high social and moral significance. The norms of the field tend to include a belief that participants have committed themselves to lower paying jobs in order to pursue what they view as socially and

127. While the Texas Medical Center presents perhaps the ideal geographic arrangement in the U.S., there may be other geographic locations where open projects could be based. For example, the San Francisco area of California is home to several significant biomedical research institutions, as is the Boston area of eastern Massachusetts. Other possible areas include New York City or Washington, D.C./Bethesda, Maryland.

128. See Benkler, supra note 94, at 1110-11.

129. That the pool of peer workers on a life sciences project will be smaller than the pool of peer workers participating in software or distributed computing contexts is an assumption, not a known (to the author) fact. It may be that relatively large collaborations to solve important scientific and medical problems bring together larger numbers of collaborators than at least some traditional (computational) open source projects.
morally important work. To the extent these norms control,\textsuperscript{130} they enhance stability in participation, might provide for a net average greater contribution per peer worker, and in any event may provide for less fickle peer workers than in other areas of research.\textsuperscript{131}

3. Issues of Modularity and Granularity

Some innovation tasks in the life sciences can exhibit problems of imperfect modularity and can sometimes be of large granule size.\textsuperscript{132} While there is an element of modularity in many innovation projects in the life sciences, heterogeneity exists. Sometimes, certain tasks may need to be completed before later tasks, however, modularizable, can be completed. Described most generally, a wide variety of modules are capable of being worked on by any number of peer workers, but in some cases, “earlier” modules must be completed before work can commence on “later” modules.\textsuperscript{133}

Returning to our earlier examples, while any number of peer workers can independently labor on the task of building an expression vector containing the gene of interest, at least one expression vector must be completed before it can be introduced to a cell line or an animal. While any number of peer workers could conceivably then work on creating a transgenic animal, the animal must be successfully produced and bred before it can be made widely available as, for example, a disease model. Once the disease model is widely distributed, it can be used by a large number of peer workers to test a range of chemical and biological therapies. Thus, in terms of the production of innovation, the temporal relevance of some tasks, i.e., that they must be completed before other tasks, can impact modularity. Naturally, this need not be fatal to an open science innovation model as the creation of a molecular library, or an expression vector, or a transgenic animal may constitute significant advances in and of themselves. Instead, different states of modularity can be taken into account when

\textsuperscript{130} But cf. Oderbeck, supra note 94, at 186-200.

\textsuperscript{131} This is not to say that there is no social conscience in other areas of technology and innovation. Of course there is. However, the traditional norms of life sciences research actually emphasize the social good of the work as a reason for participation and (whether factually true or not) as justifying less monetary remuneration in general.

\textsuperscript{132} Modularity refers to the divisibility of the tasks of a project, and the extent to which they can be performed independently and asynchronously. See Benkler, supra note 102, at 379. Granularity refers to the size of the modules and how well the size of the modules corresponds to the motivations and capabilities of the peer workers. Id.

\textsuperscript{133} I reiterate the qualification that modularity here is a matter of degree. A range of states of modularity can exist in life sciences innovation. One criterion to determining the degree of modularity is the extent to which there are multiple ways of reaching the ultimate advance. In cases where there are a number of independent approaches to getting to the same innovative output, there may be fewer bottlenecks; the result being that more of the larger problem can be worked on asynchronously. Thus, the model described in the text has a sequential aspect that limits modularity somewhat depending on how one defines the innovation output. However, other approaches, for example, rational drug design or synthetic biology, may, at some point in the course of innovation, operate to improve the modularity of work involved in the innovation by allowing different peer workers to work on different aspects of the problem, aspects less accessible in the absence of a wholly different technical approach or model system.
deciding whether an open science approach is likely to be a good idea, and if it is how to tailor the approach to be most efficient.

The size of granules in life sciences innovation is varied. Sequencing a gene, cloning, setting up a PCR reaction, writing a paragraph of analysis of a figure, and designing a set of primers are all fairly small-grain pieces of work. Sequence database searches, translating data into web-publishable figures or graphs, scanning figures, and performing some immunofluorescence or immunohistochemistry are also fairly small-grain pieces of work for those with access and the relevant skill set. On the other hand, the work of organizing and supervising an animal or clinical trial may be of much larger granule size. In the life sciences, a rough rule of thumb might be stated: tasks involving higher physical costs (especially where piggybacking is not possible) or significant regulatory supervision are likely to have the characteristic of larger granule size. Finer granule sized tasks are characterized by lower physical costs because they are inexpensive to begin with, because cheap “piggybacking” on existing infrastructure is possible, or because such tasks are not subject to significant formal regulation.

4. Subsequent (Mis)appropriation

Taken together, the variety of possibilities revealed by the considerations of physical cost, peer worker qualities, and details of modularity/granularity suggest that any decision to use vel non an open science approach should depend on the facts and circumstances. Up to this point, however, the discussion has proceeded on the theoretical possibilities, and largely ignored the impact of the legal framework used in connection with innovation in the life sciences. As noted earlier, that legal framework is one of property rights. And it is property rights that present both problem and promise for any particular implementation of an open science approach. On the one hand, the right to exclude conferred by the legal rules allows later comers to appropriate investment made and innovation produced by others. This may have the effect of discouraging volunteer innovation and participation in an open science project. On the other hand, the legal rules create rights that have the potential of creating an innovative momentum that could thwart unreasonable rent-seeking by latecomers.

IV. TOWARD A PATENT-BASED OPEN SCIENCE FRAMEWORK

Part II presented a framework of innovation in which private, commercially directed science stands to a significant extent on the shoulders of publicly funded basic research performed by universities and research-oriented medical schools, and to some extent by the federal government in the embodiment of, inter alia, the National

134. According to Benkler, varied granule size should not be generally fatal to peer production. Benkler, supra note 102, at 379.
135. See discussion supra Part II.B (discussing the legal infrastructure of innovation).
136. See discussion of blocking patents contained in supra Part II.B. To the extent that innovation in the life sciences is highly punctuated and reflects the broad application of important platform technologies, this problem could be particularly acute. See discussion supra Part III.A (discussing punctuated nature of innovation and platform technologies).
137. See Benkler, supra note 102, at 379.
Institutes of Health. This framework prominently features the use of property rights as a means of integrating public and private scientific research, and as a means of encouraging the production of new and useful information and materials. As Part II concludes, the ubiquitous use of property rights, while likely helpful, logically has an impact on the path and progress of innovation.

In keeping with the animating concern of this Article, namely, whether, and if so, how, innovation might be directed to seemingly underserved markets in the context of a ubiquitous property rights-based framework, Part III explored whether research advances might be made in the life sciences in an “open science” framework. What was notable about the described open science framework was the attenuation of barriers of access to rights. The immediate concern was whether research advances could still be made in the life sciences in situations where the right not to be excluded is liberally granted. Part III concluded that some research in the life sciences would continue, and perhaps even flourish, in an environment where liberal access was promoted.

The conclusions reached in Parts II and III serve as important signposts when it comes to addressing the practical questions of: How might a patentee, particularly a university or research-oriented medical school that wants to encourage broad use of patented subject matter to promote certain types of innovation, do so? Is there a legal framework that could be used to support an open science approach to innovation?

In view of Parts II and III, a legal framework useful for imposing open science should have certain features. First, it should be concerned with attenuating innovation suppressive costs, but remain alert to preserving as much as possible private incentives to innovate. In the prototypical cases of innovation directed to markets that are perceived as having low near-term commercial value, the concern that incentives to produce innovation will be attenuated in a practically significant way by promoting liberal access to rights and materials is probably not that significant. Nonetheless, the legal means used to impose liberal access to patented subject matter should seek to preserve as much as possible market incentives to produce innovation.

Second, the legal framework should be concerned with promoting efficiency gains. In prototypical cases, where the market-based incentives to produce innovation seem already relatively low, reducing innovation suppressive costs may, in and of itself produce efficiency gains. However, as discussed above, very liberal access could also promote positive efficiency gains through the use of large, loosely organized collaborations.

Third, the legal framework used should “understand its place” in an otherwise ubiquitous property rights-based framework. That is, it should complement, and to the extent it is an imperfect complement, it should at least “fit in.” Thus, the legal framework should strive to limit unpredictable, and potentially innovation-harmful, externalities from its use.138

138. Indeed, this concern presents a potentially significant hurdle for a pure “patentleft” approach, i.e., leveraging patent rights to force the immediate and perpetual donation to the public of all innovation that derives from the use of a particular property. Specifically, the concern is that unpredictable externalities may ripple well beyond the boundaries of the subject matter over which the framework was initially imposed to the detriment of innovation in other subject matter. See Kapczynski et al., supra note 94 (describing an elaborate cross-licensing arrangement as a prophylactic to this effect); Sara Boettinger &
Finally, the framework should be relatively easy to impose and operate. It should be relatively clear, predictable, and certain. And, while one size may not fit all, the legal framework should be tailored to deemphasize costly, complex, and sophisticated licensing agreements that may be difficult to develop, understand, and enforce broadly, in favor of a more "wait-and-see" approach to the appropriation of commercial value from innovation.

As set forth in more detail below, the above-described features of an open science legal framework may be usefully imposed through a servitude. The use of a servitude draws on a "prospect" theory of innovation, but complements it with open access principles to alleviate the cost difficulties associated with having a single (and perhaps particularly unskilled entity) exercising an unnecessary controlling influence on the methods and approaches to downstream innovation.

While the form of private ordering described below may be surprising at first glance, it is based on familiar principles of property law. Its novelty comes from its combination of existing elements, which to the author’s knowledge have yet to be tested in a real world context. Thus, what follows is necessarily a broad initial sketch that will need to be further evaluated and particularized before widespread implementation.

A. Establishing a Patent Servitude

By statute, patents are defined as having the attributes of personal property, albeit with a strong emphasis on the rights of exclusion and alienation. Thus, a "patent servitude" presumably falls into the formalistic category of personal property servitudes. Historically, recognized personal property servitudes seem to be relatively rare, and an in-depth discussion concerning the general nature and enforceability of personal property servitudes is beyond the scope of this Article. What is worth pointing out, however, is that while the property rights conferred by a patent may be different from some other forms of property, the rights that attend patents should, like other property rights, be crafted and justified by exogenous public policy concerns. Thus, the formalistic label is not decisively helpful in understanding whether a certain property right should be part of the bundle owned by any particular patentee. The answer to that question turns on economic realities, current economic sensibilities, and relevant policies. To the extent there has been some historical hostility to personal

Dan Burk, Open Source Patenting, 1 J. INT’L BIOTECH. L. 221 (2004) (attenuating this concern in part by making improvements that fall outside the scope of the licensed patent subject to private appropriation while improvements falling within the claims retain their open access character).

141. See Epstein, supra note 140 (explaining that interference with the right to alienate is disruptive of the efficient allocation of intellectual property rights).
142. However, they may be increasing in prominence. See Glen O. Robinson, Personal Property Servitudes, 71 U. CHI. L. REV. 1449, 1455-58 (2004).
143. However, for an interesting discussion, see id., Zechariah Chafee, Jr., Equitable Servitudes on Chattels, 41 HARV. L. REV. 945, 945 (1928), and Zechariah Chafee, Jr., The Music Goes Round and Round: Equitable Servitudes and Chattels, 69 HARV. L. REV. 1250, 1250 (1955-1956).
property servitudes, the complaints appear to have been grounded in policies against restraints on alienation or restraints on trade, and have been in the context of the resale of tangible goods (sometimes goods that were ostensibly covered by some form of intellectual property). As such, these historical objections may not bear contemporary scrutiny in the patent context.  

There are at least two ways to frame the question of whether a patent servitude is permissible. The first way proceeds from a sort of “property first” position: that strong property rights generally attach unless public policy requires otherwise. From that perspective, once any policy objections to patent servitudes are removed, making a restricted grant of patent rights should be generally permitted. The second way asks the question in a somewhat more positive fashion: whether on balance there is good reason to allow a patent owner to make a restricted grant of patent rights.

As noted above, this Article is not an exegesis on the general nature and enforceability of personal property servitudes. Nor does it present a complete discussion on the nature and enforceability of equitable servitudes on patents. Thus, although this Article does not assume a formal “property first” position, it does assume that the public policies which support the property rights conferred by patent in the United States and abroad are sufficiently defensible to justify the several centuries-long history of recognizing what are surprisingly strong property rights. Accordingly, whether the law should recognize a restriction on the right to not be excluded, or a restriction in connection with the transfer of a patent turns on whether the restriction offends the policies that justify making property of patents or offends some other important public policy. Because restrictions should then stand or fall on their particulars, this question is better addressed after further consideration of the patent servitude.

B. Patent Servitudes in Operation

The purpose of the servitude is to create a common plan to advance research and development around the subject matter of a particular patent or patents. A servitude requires (1) the intent to bind successors to a restriction concerning property, (2) notice of the restriction, and (3) that the restriction either touch and concern, or, depending on the view, that it not violate public policy.

For patents, the important elements of intent and notice of the restriction will in many cases be fairly easily met. At the outset, it is worth noting that in many cases, the
acts which normally communicate notice in a tangible property case, e.g., writings between a grantor and a grantee or lessee, will often be sufficient to communicate notice in the case of patent servitudes.

In addition, the Patent Office acts as a recording office for ownership interests in patents or patent applications. Assignment of all or part of a right, title, or interest in a patent or application can be recorded, as may other documents affecting title. Thus, unless the director was to object, a patentee or prospective patentee may record at the patent office a "master deed" reflecting the restrictions placed on the patent. Accordingly, any party seeking a grant of rights from the patentee would naturally be expected to examine the ownership of the patent and should thereby have constructive notice of any restrictions.

There are other ways in which notice of the restrictions could be conveyed. For example, the restrictions could be placed in the written description of the patent itself, or could be added to an issued patent by the use of a terminal disclaimer. Moreover, where a university commits a patent to an open science strategy, notice of the restriction on the patent and the common plan or scheme could be made well known by its advertisement in connection with the mission of the institution, on frequently visited websites, materials produced by the technology transfer office, or through news stories generated by the institution's public relations department. In another form, notice could be provided by referencing the patent and its restrictions in scientific publications pertaining to the patent's subject matter, as well as on posters and slides for talks presented at relevant scientific conferences. Also, materials, information sheets, protocols, sequence deposits, and the like could all be marked with the patent and corresponding restrictions.

Obviously, it remains a concern that someone who would use a patent might not realize that he or she is using it, and hence, may not learn of the restriction. Thus, this is a problem of understanding the full scope of the thing to which the restriction attaches. One suspects that there could be situations where this presents a problem. However, patent law has a number of doctrines that are directed to clarifying the boundaries of the property. Plus, in the case of scientific research in the life sciences, notice of the boundaries of the property will be readily apparent in at least some significant set of cases, e.g., nucleic acid and amino acid sequences and other chemical compositions.

Accepting that in life sciences research a patent user is likely to recognize that it is using patented subject matter, there are several reasons why notice of a common plan for the development of patented subject matter might be implied for issued patents.

149. 37 C.F.R. § 3.11 (2006).
150. 37 C.F.R. § 1.321 (2006). It is worth noting that this is a bit of a novel use of a terminal disclaimer. Traditionally, a terminal disclaimer is used to disclaim a claim or to dedicate to the public some part of the term of a patent. However, depending on the nature of the restriction, it may be properly characterized as dedicating to the public some part of the property rights conferred by a patent. Alternatively, to the extent that one purpose of terminal disclaimers is to provide notice of a change in the default rights associated with a patent, making the restriction public through this means appears to make sense.
151. This would be easy enough to apply in the context of a major university, medical school, or center for research. See, e.g., supra notes 118-27 and accompanying text (discussing the Texas Medical Center).
directly connected to a line of research. First, the institutional players, like universities and firms, are a patent savvy group. Second, scientists and the firms that employ them are actively engaged in scouring publications to identify and incorporate advances that complement their own research goals. Given the documented increase in patenting in the life sciences, it should be nearly a default understanding in the industry that significant advances and discoveries are likely be patented. The interconnectedness of the tools and information used with a particular line of research makes it unlikely that patents of any significance will be missed by the relevant parties. Finally, even if it were possible for a firm to argue that it was unaware of a particular patent or a restriction on a patent, that lack of knowledge is easily remedied by a letter from general counsel.

The next issue that must be approached concerns the nature of the servitude. Given the contractual qualities of servitudes, there are a wide variety of choices in both scope and term. In keeping with the premise that these covenants should be simple, having only a few different forms may be superior in terms of clarity and predictability. I describe below some general approaches.

Broadly speaking, the ideas for “open” restrictions described below vary in either term or scope. Variations in term range from limited to the life of the underlying patent, i.e., whatever remains of the patent term, to indefinite in duration. The use of a property owners association is also possible. In such cases, a vote of the requisite number of owners might be sufficient to terminate the servitude. Moreover, in any event, the term of a restriction may come to an end for any of the common law reasons for terminating a servitude, e.g., merger, release, abandonment, changed conditions, etc.

Variations on scope deal with the degree of openness of the restriction. As described below, they range from promising not to exclude grantees or successors from the practice of the underlying patented subject matter to—along the lines of more

153. See supra note 21 and accompanying text (setting out the increase in TTOs and university patenting).

154. For example, if a major medical school were to make it publicly known that all of some number of its patents directed to aspects of skin development and differentiation were going to be made openly accessible, it is hard to imagine that any private research firms engaged in the study of skin cells would long remain ignorant of that information.

155. While a contract approach might be thought of as generally providing more precision in the allocation of rights, a property-based framework can provide a clarity, a breadth of enforceability, and a predictability that can lack in contract. The advantages of these features of a property-based approach may be particularly pronounced where the future is uncertain. For example, the long evolutionary period of the law of servitudes has through the selective pressures of the common law process (e.g., efficiency, morals, justice, precedent) refined a set of default parameters for the construct. The parameters include guidance concerning what circumstances are necessary and appropriate for a restriction on the use of property to be lifted. There are a number of ways in which servitudes can be terminated. A nonexclusive list includes: merger, release, abandonment, laches, changed conditions, and relative hardship. Another way a servitude may be terminated is by a release or recission process implemented by a property owner or property owners association with the power to enforce the covenant. Many of the listed theories of termination allow for the constant reevaluation of the benefits and burdens of the servitude, and the termination of the servitude should the facts and circumstances so demand. Moreover, a restriction bound to and dependent on property expires with the property, tying the term of the servitude nicely to the legislatively determined optimal duration of the property.
traditional open source licensing—promising not to exclude grantees or successors from practicing the underlying patented subject matter plus all improvements developed through the use of the underlying patented subject matter.

To illustrate the ideas further, it is useful to consider their depiction in some examples. In each of the following examples, the servitudes are created in connection with the transfer of rights in a patent or patents and the transfer could take the form of including a grantee in some significant right of ownership. Thus, the patentee might convey a joint undivided right to exclude. In another variation, the patentee-grantor may wish to convey the joint undivided right not to be excluded, including the power to let others into the right.

In some cases, the patentee-grantor might want to be sure to either retain the right to exclude, or transfer it to a central entity, e.g., a property owners association. The reason for retaining the right to exclude or transferring it to a central entity is purely formal; the joinder doctrine of the patent law makes enforcement against infringers difficult where many own the right to exclude. 156 There will surely be cases where dispersing this right too will make sense. In each of the following examples, the “conveyed property” refers to that defined by the scope of the claims.

Example 1

Not surviving the expiration of the conveyed property, the rights conveyed are subject to the restriction that no grantee or successor in interest will exclude any other grantee or successor in interest from the use of the conveyed property, or the making, using, or selling of any tangible embodiment substantially comprising the conveyed property.

Example 2

Not surviving the expiration of the conveyed property, the rights conveyed are subject to the restrictions that no grantee or successor in interest will exclude any other grantee or successor in interest from the use of the conveyed property and any improvements built thereon, or the making, using, or selling of any tangible embodiment of the conveyed or improved property.

Example 3

The rights conveyed are subject to the restriction that no grantee or successor in interest will at any time exclude any other grantee or successor in interest from the use of the conveyed property, or the making, using, or selling of any tangible embodiment substantially comprising the conveyed property.

Example 4

The rights conveyed are subject to the restriction that no grantee or successor in interest will at any time exclude any other grantee or successor in interest from the use

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156. Thereafter, the right could be transferred. The potential problem with making the right to exclude commonly owned is that the patent laws have been construed to require the agreement of each owner of that right in order to enforce the patent in an infringement litigation. See Ethicon v. U.S. Surgical Corp., 135 F.3d 1456, 1472 (Fed. Cir. 1998) (Newman, J., dissenting) (noting the court’s holding that joint inventors own an undivided interest in a patent as tenants in common).
of the conveyed property and any improvements built thereon, or the making, using, or selling of any tangible embodiment of the conveyed or improved property.

In Example 1, the restriction is temporally limited to the term of the patent. Thus, in the event that the restriction does not terminate for any of the default reasons during the life of the patent, it will still end when the patent ends. The consequence of this restriction is to create a period of open access that will be something less than twenty years. By extracting a promise from grantees that they will not exclude other grantees from practicing the claimed subject matter, the patentee has created liberal access not only to the claimed subject matter, but also to that class of improvements that directly employ the claimed subject matter. 157

By way of illustration, assume that a researcher at university X clones a gene important in the life cycle of a species of worm responsible for lymphatic filariasis. The gene might, *inter alia*, be useful for expressing an antigen for a vaccine or for incorporation in a gene therapy vector. The restriction of Example 1, allows institutions and researchers who become grantees to use the gene (and assuming it is claimed the gene product) for a significant period of time, with a greatly reduced concern that their use will be enjoined and their disposition of resources wasted. Thus, to the extent that a vaccine or a gene therapy flows through the gene or gene product, it may be pursued competitively by both public and private scientists (who become grantees). Moreover, where something of therapeutic value is generated before the restriction expires, if it uses the gene or gene product it can be manufactured and sold by any grantee during the life of the original patent.

Importantly, however, assuming that advances—improvements—made during this period met the statutory requirements, they would remain patentable. This allows grantee improvers some expectation of appropriation. First, against those who are not grantees, 158 and after the restriction ends against all infringers. Thus, in Example 1, after the property that is the basis for the restriction ends the restriction too will end and improvement patents can be asserted against former grantees.

Some would presumably question the judgment of allowing those who were at one time free to practice the patent, to later be held liable as infringers. There are a few reasons, however, why this need not be a great concern. First, if, during the period of the restriction, a competitor was competitive, it should have made advances and should have been able to obtain patents. Thus, a competitive grantee should have some leverage when dealing with other grantees after the restriction expires. Second, because there will be plenty of notice that the restriction will end, grantees should have ample time to organize their affairs through agreements, mergers, etc. Third, some grantees might be willing to make improvements available using the restriction; this keeps certain subject matter open. This could be a particularly competitive strategy for universities or peer collaborations that may be highly motivated to maintain access

157. In other words, the grantees all have permissions—or licenses—to use this particular type of improvement.

158. Note that it should be relatively easy to become a grantee, especially if the right to include others in ownership is liberally granted. While this will suppress appropriation during the grant, it is a convenient mechanism of autoenforcement. Those faced with a claim of infringement can probably get someone to include them in ownership and thereby avoid a suit for infringement. To be included in ownership, the competitor will become subject to the servitude.
to fundamental technologies. Finally, if a grantee is so noncompetitive that they cannot obtain patents on improvements or make a technical or business contribution sufficient to maintain access to rights after the restriction expires, perhaps the right thing is for that firm to direct its resources toward other projects.

The restriction in Example 2 builds on the restriction in Example 1 as follows: If the restricted property is "used" in the practice of an improvement, it is made liberal by the restriction in both Examples 1 and 2. If the restricted property is "used to get to" an improvement, but the improvement does not also employ the restricted subject matter in its operation then the improvement would be made open only by the restriction of Example 2. The restriction reflected in Example 2 is, like that of Example 1, limited in duration to the term of the patent.

To illustrate, consider our earlier example with a slight specification. Assume also that the cloned and patented gene encoded a receptor. There might be agonists or antagonists for the receptor that could serve as a chemotherapeutic to suppress the growth of the parasite. Alternatively, study of the receptor might reveal a significant signaling pathway and molecules important to the growth and development of the parasite. Both sets of molecules present potentially useful targets for future research and various forms of treatment.

Assuming the scope of the claims of the patent to the gene and gene product did not go beyond the molecules, rights in grantee improvements in the form of agonists, antagonists, or other signaling molecules, etc., would not be made liberal by the restriction of Example 1. However, assuming that the claimed subject matter was used in experiments to discover and purify the agonists, etc., the restriction reflected in Example 2 would make rights in such improvements liberal. Again, only for the term of the patent. Thus, once the patent expires, the points discussed in connection with Example 1 pertain here as well.

Examples 3 and 4 reflect restrictions similar to those reflected in Examples 1 and 2, respectively. The modification is one of term. The restrictions reflected in Examples 3 and 4 are facially unlimited in duration although they could always terminate by any of the default reasons for termination, or, if one were used, by the decision of a property owners association. What is particularly notable about the restriction reflected by Example 3 is that it provides for something of a perpetual "practicing the prior art defense" against grantees and successors—one that is not available in the background patent law.159 While it would not include later (after patent expiration) entrants, the advantage of earlier (restricted) access might give grantees a protective competitive advantage over later entrants, which could compensate for its lack of prophylactic effect. The restriction reflected in Example 4 is the most extreme presented in terms of forced access, but is of questionable forward depth depending on how "built thereon" is interpreted.

As mentioned at the outset, to establish a servitude the restriction must, depending on the view, either touch and concern or not be illegal, unconstitutional, or violative of public policy. As discussed in more detail, there are reasons to think that the above-described restrictions touch and concern either the patent, tangible embodiments of the

159. See Tate Access Floors, Inc. v. Interface Architectural Res., Inc., 279 F.3d 1357, 1363 (Fed. Cir. 2002) ("There is no practicing the prior art defense.").
patented subject matter, or the business or R&D concerns of the grantees. In addition,
the arguments that such servitudes might violate public policy may not be strong.

There is some debate over whether the touch and concern requirement still exists
in connection with servitudes, and if so, whether it applies to a servitude attached to
chattel. Even assuming that the touch and concern requirement has breath, it may not
be particularly problematic in connection with chattels. While there may be
conflicting formulations of the touch and concern requirement, it can generally be said
that for a covenant to touch and concern it must affect the use of the property, or, as
one case put it, “the promise must exercise direct influence on the occupation, use or
enjoyment of the premises.” Thus, an imposed servitude that affects externalities
created in connection with the use of a particular property is likely to touch and
concern that property. This likely captures most servitudes that are not completely
arbitrary and unreasonable.

Here, the servitudes seem to clearly touch and concern either the patent or tangible
embodiments of the patented subject matter. It is, after all, the patent and
embodiments of the patented subject matter that must be used by any grantee in much
the same way that a grantee of a parcel of land would use or improve a parcel of land
in which she owns a life estate or term of years. Without a desire to use the patent,
there is little point in becoming a grantee.

Moreover, the servitudes discussed clearly touch and concern the business of
being a university or other institution that is engaged in research and development. To
the extent universities are in the business of doing research, they have a significant
interest in maintaining access to cutting edge research and development. It is access
that makes them competitive in terms of public grants, publications, reputation, hiring,
and patenting. Goodwill flows from making and publicizing discoveries that promise
to impact health and well-being. Moreover, there is goodwill to be gained by an
institution taking proper steps or creating the perception that proper socially
responsible steps have been taken to ensure that the public has reasonable access to the
products of its publicly funded work. The goodwill that flows from being a successful
research university might lead to tax advantages, favorable land deals from local
authorities, committed employees, gifts from private donors for endowed chairs, new
departments and buildings, or new equipment and infrastructure improvements.

Under the Restatement’s approach, one should consider whether a patent servitude
is illegal, unconstitutional, or violative of public policy. The first two objections set
forth in the Restatement seem (at least generally) facially inapplicable. As noted
previously, there is no general prohibition on personal property servitudes. One
commentator has concluded that even the application of patent left open source
licensing provisions would not be anticompetitive under the antitrust rule of reason or

160. See Robinson, supra note 142, at 1455.
162. There is no requirement that a servitude do a particularly good job of adjusting the capture of
externalities. If it does a poor job, one might expect that the burden of the servitude would create a
competitive disadvantage—a natural selection against whatever the restriction on use happened to be.
164. See supra note 144 (discussing the work of Feldman and Robinson).
be inconsistent with patent policy. The more limited footprint of the servitudes described here seem to place them even more comfortably within the contemporary innovation framework.

C. Additional Considerations

In overview, the use of patent servitudes can be employed as a sort of “open-prospect” approach to innovation. The prospector retains some control over the organization of the downstream work (i.e., by exercising some level of judgment over the grantees that would be allowed a “plot” in the subdivision). But because the “profit” the prospector seeks, while pecuniary, is not in the form of direct near-term licensing revenue, but rather in the form of (indirect) goodwill as a going concern, competitive advantage in hiring, and grant dollars, the prospector should have a pretty liberal view of who can be a grantee. Moreover, the prospector is happy to let much of the R&D happen through self-ordering among the grantees, thereby avoiding one of the more common criticisms of the prospect approach.

The restricted co-ownership approach reflected by the use of a servitude has several positive features. One is that it is consistent with the policy of patent law that encourages the use of patents. Co-owners can generally make grants of rights, or license others to practice the subject matter of a patent. These rights protect successors in interest from suits for infringement. For a number of reasons, universities should be motivated to make restricted grants of some of their patents. By granting the right to alienate, to the extent of the grantee’s restricted property, universities can make it easier for others to become grantees or to at least get use permissions. The greater the number of grantees, the greater the supply of grants or permissions. The increase in supply could have a corresponding affect on the cost of access. Thus, when faced with litigation, the path of least resistance for a potential infringer may be to obtain a restricted grant or restricted license from a university or other grantee.

Assuming liberal granting by universities and a corresponding reduction in the cost of access, a reduction of the innovation suppressive costs of monopoly and transaction could be realized. Also, to the extent that positive gains may be possible

165. See also Feldman, supra note 144, at 167 (concluding that open source biotechnology licensing “should not constitute [patent] misuse”); cf. Boettinger & Burk, supra note 138 (providing additional discussion of misuse in connection with biotechnology licensing strategies).
166. See, e.g., Ethicon, Inc. v. U.S. Surgical Corp., 135 F.3d 1456, 1460 (Fed. Cir. 1998) (describing some of the aspects of co-ownership of a patent). Naturally this statement assumes some judgment on the part of the patentee that imposes the servitude. In particular, that it not be done in situations that will cause everyone to shun using the technology controlled by the patent.
167. Id. at 1471-72.
168. Id.
169. See discussion supra at Part III.B.
170. Patents for which there is a high demand, and for which significant licensing revenue is available, might be better deployed in a traditional licensing or exclusive assignment fashion. Whether the restricted grants discussed here should be used ought to reflect some balancing of the revenue available through licensing, the nature of the subject matter, and the mission of the institution. For example, inventions directed to high profile, underserved markets might be better deployed through restricted grants.
through the application of peer production, these too could be realized. Moreover, if the patented subject matter is important, e.g., a punctuating advance or subject matter the use of which is required for a particular stage of innovation, there may be a selective advantage to the servitude approach that could enhance compliance. Presumably some number of innovators who receive grants will invest in a path of innovation that relies on the rights granted. As more do so, the less sense it might make for any particular innovator to wait and litigate access. To do so might place the recalcitrant innovator at a selective disadvantage—particularly if innovation in the field is fast-paced.

The temporal qualities of Covenants 1 and 2, and perhaps the reach of Covenant 3 mitigate significantly the indefinite viral spread that follows from a traditional GPL-like approach. This can be viewed as a positive consequence because if there is no substantial advance on an open project in ten to twenty years, then perhaps the open approach to the project should be scrapped. Generally speaking, however, there is the expected trade off; the proposed innovation framework is not contemplated to be indefinite in duration or ever expanding in scope, so there will be times when rights need to be sorted out.

For example, innovation could take longer than the term of a patent. In that case, it is possible that innovators will have to reorganize in view of the property landscape when the restriction terminates. Second, a patentable, commercializable therapeutic may have been developed during the period of the restriction. If so, when it ends some rights connected with the making of the therapeutic may become enforceable against the joint owners of the former property. Naturally, there would have to be negotiations—with their attendant costs. But as opposed to forcing negotiations in view of very poor information concerning profits, negotiations over rights in view of reasonably expected profits (dividing up a pot of money) could be easier for sophisticated parties.

The servitudes provide flexibility in termination that has been honed over centuries in the common law. Plus, as noted above, the irritable organism that is a property owners association can also abandon the restriction. If, for example, it becomes clear that an important therapeutic is at hand, the owners of the different "plots" will have a much better idea of the potential benefits involved. Because there would be more information available than before R&D began, it would be easier for sophisticated parties to divide up what would likely be more discrete benefits than to divide up, ante, what would likely be more speculative ones. This could permit a framework for collective appropriation, which could help to enhance the productivity of the approach. Thus, if a POA were used, a strategic approach could "pay off" a

171. While possible, a grant need not be given to each peer worker. Grants could be given to firms or institutions whose relationships with employees are governed by employment contracts or state laws.
172. A similar result should be expected if the open approach actually accelerates innovation.
173. Covenant 4 is not well-tailored to avoid this effect.
174. However, there is no guarantee that this must be so. For example, if the approach is working well, other technologies may be granted to owners in the subdivision on the same terms, thus keeping the open approach alive.
175. See Benkler, supra note 102, at 443 (discussing collective appropriation in connection with peer production). Each joint owner would be bought out in a manner similar to a partition by sale.
sufficient percentage of members to secure a release. Alternatively, members’ consent could be purchased based on the extent of their contribution, e.g., payments for access to later developed complementary rights, or other measures of contribution.

An additional strength of the co-ownership regime is that it would generally protect a “right to practice.” Because in many scenarios the servitude will not need to be terminated for a co-owner to practice an improvement, the right to practice retained by other grantees will encourage cooperation, and therefore valuable collective appropriation, or lead to competition in production that should move pricing closer to marginal cost.

When the restrictions end before the patent term, because the grantees are all joint owners of the patent, they retain the rights of ownership, including the right to license others. This maintains some of the open character of the patent but eliminates the promise by other grantees that they will not enforce patents they have obtained on improvements. Although this might at first appear to be problematic, it need not be for reasons already discussed. Other technologies may be granted to owners in the subdivision on the same terms, thus keeping the open approach alive. Even where that does not happen there will be notice of termination, allowing competitive grantees to arrange their affairs. If after ten, fifteen, or twenty years, the open approach has not produced results, the ending of the servitude and a general reorganization might be desirable.

Finally, and more broadly speaking, the servitudes are directed to a recognized public good: encouraging innovation. To the extent that there is little interest in licensing a patent, the objection to making restricted grants such as those described here should not be too great. How well they work will depend on how well they are created and applied to particular circumstances. If successful they could produce a social benefit, but if they fail, relatively little should be lost. No less one suspects, than what would be lost from ignorance or incompetent licensing. Neither of which seem protected against by law. And, like the roots of a tree moving toward water, the progress of innovation can be expected to continue along some path regardless.

V. CONCLUDING REMARKS

While the approach described by this Article could be implemented by any patent applicant or patentee, as a systematic approach it is expected to be most useful when applied by universities and research-oriented medical schools. Exclusive licensing provides one framework by which a university can realize a return on investment. But as a general matter, most universities and medical schools are not profiting from this approach. Moreover, at least some patent case law appears unfavorable to the prospect of universities appropriating the value of their patents through licensing,176 while other patent case law holds that universities are fair game in suits for patent infringement, no matter how attenuated their potential reward from the development of patented subject

176. See, e.g., Univ. of Rochester v. G.D. Searle and Co., 358 F.3d 916 (Fed. Cir. 2004); Regents of the Univ. of Cal. v. Eli Lilly, 119 F.3d 1559, 1562-64, 1566-69 (Fed. Cir. 1997).
Finally, there appears to be a growing normative sentiment that patents are threatening basic science. To the extent this state of affairs is a sign of things to come, universities may have to look elsewhere for a return on their investment in research and development.

The approach described here presents a different, yet perhaps still useful, way for universities to get a return on their research and development investment. While patents that promise immediate royalty revenue can still be licensed, patents that do not can be deployed differently: To enhance the reputation of the institution; to encourage donors and hire and retain skilled employees; as a prophylactic against suits for infringement; to maintain access to substrates and reagents important for the institution’s well being; to gain advantage in grant acquisition; and to gain advantage in the race that is innovation. Beyond return on investment, as a shepherd of so much public money the NIH and their grantees may bear some responsibility for the efficiency with which that money is spent and some social responsibility in ensuring that some of the benefits of that spending reach the public. This or similar approaches could be helpful in fulfilling that responsibility.

Universities are in an excellent position to implement this approach. The scope of basic research in which they engage is broad compared to private companies. Public researchers work in a comparatively wide array of model systems, employ a great diversity of approaches, and generate a great amount and diversity of discovery. They are also more likely to be first in time to important upstream discoveries. To the extent that pharmaceutical and biotechnology companies play a more dependent role, a patent-based open science approach may provide an evolutionary advantage in innovation; one that would therefore be guarded by the approach.

By spreading appropriability to multiple firms, the described approach is properly concerned with ensuring that the incentive to innovate is not destroyed. Several of its features operate to permit some appropriability. As described elsewhere, there are means, e.g., virtual or nonprofit pharmaceutical firms, NGOs, and contract research organizations that can help to fund or perform research, or produce therapeutics. Moreover, administrative processes and the technical difficulties involved in reproducing some potential therapeutics may give sufficient exclusivity to encourage their production by for-profit firms.

Finally, in applying this approach, prudence should be the guide. It would be helpful to test this approach, so that empirical data might be generated on how well it works and what unexpected drawbacks, if any, are revealed. Accordingly, to learn

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179. A large amount of research funding at public institutions comes from taxpayers and is distributed by the NIH. In 2005, the NIH gave out over $22 billion in research dollars to “universities, medical schools and other research institutions.” See http://www.nih.gov/about/NIHoverview.html.
180. See Maurer et al., supra note 94, at 183.
181. See id.
182. For example, biologics and complex macromolecules are difficult, if not impossible, to precisely reproduce. Moreover, it might be difficult to know whether one company has used another company’s process in making a biologic, at least to the extent required to satisfy the Hatch-Waxman Act. See 21 U.S.C. § 355 (2000) (providing for abbreviated new drug applications).
more about the patent-based open science approach described here, a study is advisable. One or more significant (but perhaps underworked) patents addressing innovation markets that are currently underserved should be made subject to a servitude applying the general principles described here. Subsequent interest in their use, and their actual use, could be monitored, measured, and reported upon periodically.