Are Intellectual Property Rights Evolving Towards the Enclosure of the 'Intangible Commons'?

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21 August 2010

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ABSTRACT
Advancements in the areas of Information Technologies (IT) and the New Life Sciences (NLS) are helping redefine the boundaries of Intellectual Property Rights (IPRs). Although the fast growth of these technological areas may very well be fueled by the existence of the IPR system itself, in recent years there has been a shift in the IPR systems moving "upstream" in the research cycle, a movement which may actually discourage future research and innovation. This document addresses some of the most recent public policy issues surrounding IPRs and delves into the case of biotechnology (biotech) to provide examples of how advancements in this area are helping redefine concepts like ownership, property, and rights over things and ideas. Lastly, it presents arguments to suggest that in an era where information has become the most valuable asset, alternative forms of IPR protection in which numerous proprietors share rights simultaneously could help better promote a steady expansion of scientific activity and artistic expression.

Among legal and economics scholars there is an increasing concern about the effects the current expansion of the boundaries of property rights will have on the future of research and development activities.[2] Evidence suggests that recent advancements in science and technology have prompted property rights — mostly in the form of Intellectual Property Rights (IPRs) — to move "upstream" in the research cycle towards areas where their allocation is less conventional, both fueling these concerns and calling for a faster evolution of the policies and institutions associated with these rights.[3] This expansion has introduced property rights over information and subject matter — such as traditionally available knowledge or gene sequences information — that were previously believed to be ‘uncommodifiable’ or part of the common heritage of mankind.[4] To find more evidence of how technological change is helping reshape the general property system and the public policies that derive from it, this document first identifies a series of elements deemed central to any property allocation system and the dimensions in which each of these operate. The article then addresses some of the most recent public policy issues surrounding IPRs in general and further delves into the case of modern biotechnology to provide examples of how advancements in this area are helping redefine concepts like ownership, property, and rights over things and ideas.[5] Lastly, it presents arguments to suggest that in an era where information has become the most valuable asset, alternative forms of IPR protection in which numerous proprietors share rights simultaneously could help better promote a steady expansion of scientific activity and artistic expression.

Property: Five Dimensions

Property rights exist where law, economics, and society intersect. These rights stem from policies that provide rules to guide decisions on the limits of what can be appropriable, who can possess such rights, how to allocate such rights, and the difference between these rules when applied to either tangible or intangible things. These policies, the principles behind them, and the frameworks they help establish have remained in constant evolution; within earlier frameworks 'righteous' proprietors could claim uncontested dominion over anything imaginable in a quest to exclude others from trying to exert any control over the things deemed as "property."[6] Later these rights were justified by claiming that the allocation of private property "saved lives" by reducing overuse and underinvestment and inducing greater efficiency and innovation, highlighting the weight that collective views had over their scope and reach.[7] Today, innovation and scientific advancements are contesting the limits of what is appropriable, forcing a re-evaluation of the fundamentals of the property rights systems and the policies that define them.

Identifying the central elements composed within a property allocation system further explains how property rights are defined, granted, exchanged, used, and policed. According to Carruthers & Ariovich a property system should display the following five elements: i) the objects of property (stating what can be owned); ii) the subjects of property (addressing who can claim ownership); iii) the uses of property (establishing what can be done with it); iv) the enforcement of rights (defining how property rules are maintained); and v) the transfer of property (setting the guidelines on how property rights are exchanged).[8] Each element is essential to guarantee the enforcement and fair allocation of such rights and to ensure that any exchange mechanisms defined within these systems function appropriately and within legally. Yet each also requires a degree of flexibility to cope with a continuously expanding frontier of the appropriable, facilitate the free circulation of rights within these systems, and allow for collective views to help define social objectives.

Intellectual Property: Where to Draw the Line?

Intellectual property introduces a new dimension to the already complex property system; it not only stresses the notion of intangibility but also opens the door to the possibility of obtaining rights over anything that can be produced by the human mind. This way, ideas and concepts — as long as they comply with certain principles and standards — can be enclosed and protected from external use by the property rights enforcement system. This has induced a boom in the appropriation of the intangible, creating new areas of human development where, through the use of IPR schemes such as copyrights, trade secrets and patents, specific rights are granted over ideas, processes or discoveries. Though intellectual property protection is not a new concept, the rate of scientific discovery in the past three centuries has required its fundamentals to adapt at a much faster pace.[9] There has been an even greater necessity to do so in recent years due to the Information Technologies revolution and constant advancements in areas of the New Life Sciences, like genome sequencing and genetic engineering.

Although the fast growth of these technological areas may very well be fueled by the existence of the IPR system itself, there are voices suggesting that such IP expansion is just the reflection of the political, economic, legal, and cultural processes through which property rules in capitalist economies are extended into new realms. These suggestions clearly criticize the way in which rights operate to provide a temporary monopoly over information and ideas and promote the advancement of science and technology.[10] Yet it cannot be denied that scientific development has recently witnessed a more systematic "enclosure" of the less tangible or a more systematic "enclosure of the intangible commons of the mind"[11] as well as a movement of IPR that can be considered as going too far "upstream" in the research cycle.[12] This shift from bounding the rights of the tangible to those of the intangible is partially rooted in a deeper public policy rationale, one that altered the intellectual property protection regimen "to spur innovation and speed the translation of basic science into marketable products," and encourage policymakers to design policies that facilitate the commoditization of knowledge, build links between academia and industry, and expand the scope of intellectual property protection."[13] [14]

As the epitome of the IT revolution, the Internet came to be an innovative information-exchange system that not only played a pivotal role in the expansion of technologies derived from the NLS, but also defined the pace at which the IPR system evolves to keep up with the rate of information production. From this particular advancement in information exchange processes, IP has witnessed two key efficiency-inducing paradigm shifts; information can now be rapidly exchanged and replicated almost ad-infinitum, both at nearly zero transaction costs.[15] Due to these shifts, information has become the prime subject of IPR protection and subsequently, one of the motors behind these changes. This technological advancement and the efficiencies derived from it have also induced a faster pace in the search for original and more widely wider patentable information derived from basic resources (especially biological resources), turning it into a race for attaining the competitive advantages provided by the temporal monopolies that IPR offered, a race that resembles the North American Frontier expansion.[16]

These advancements, however, also come with drawbacks. On the one hand, efficiency-inducing advantages are the source of the information exchange system's biggest weakness by making information (now mostly available in electronic format) extremely difficult to protect. This flaw has numerous legislative and IT experts working overtime on ways to better protect information — either within the system (codifying) or through external regulatory measures (policing) — in order to continue reaping the benefits of low transaction and replication costs. On the other hand, property rules operating within this system are making more evident the fact that having property rights over information (or tangible things like some biological resources) is becoming more like having a segment of a "thicket of rights" that is collectively shared by multiple righteous owners, similar to how a single company stock is shared among multiple stockholders.

Policies appear to be designed to ease the commoditization of knowledge, build links between academia and industry, and expand the scope of intellectual property protection to encourage innovation and speed the translation of basic science into marketable products. The mainstream scientific advancement model is designed to promote knowledge and its derivative technologies through incentive-based IPR systems.[17] As previously mentioned, it appears as if the new property system promotes property rights to "move up the stream" of scientific and technical development, providing consent for the allocation of property rights over things that traditionally are, have been, or may be considered as in the public domain. This movement towards appropriation of the less tangible also denotes that these rules are aimed at turning things that clearly display both public good characteristics of non-rivalry and non-exclusivity into appropriable commodities, without considering that the allocation of property rights over these will be extremely hard, if not impossible, to enforce. Furthermore, this movement has made some of these now appropriable things (such as living, genetically modified organisms and genetic sequences) behave in the real world in a manner that is similar to unprotected information within the information exchange system represented by the Internet.

IPR in Biotech

An example of how IPR protection is enforced over intangibles in these innovation areas can provide a better view of the similarities and differences between conventional and intellectual property rights protection and how these are evolving. Consider the following: As the head of a research team at one of the top New Life Sciences research centers within the umbrella of a large multinational corporation, you are working on the development of a genetically modified pest-resistant, high-sugar corn that can provide the company an edge in the thriving biofuel market. For the past four years, you and your team have been working on the multimillion-dollar project on the introduction of specific characteristics of a ubiquitous species of bacteria, *Bacillus thuringiensis* (or Bt), found in nearly any sample of crop soil around the world, into a particular variety of sweet corn (*Zea mays*). Meticulous note taking and experimenting produces the final genetically modified corn, ensuring that you — as head of the team — provide a confirmation that states that the experiments described were performed in the date, time, and fashion described. In addition, over this period you also made sure that all procedures and results used for the gene sequencing and trait insertion processes were saved in electronic files and the computer simulations were also properly stored. An essential part of the project relies on the software that developers in India helped design. This software and IT expert group that operates it, with whom you exchanged information on a daily basis, also aided in the codification of the programs used and the management of the information produced throughout the research. After all this work you are finally witnessing the success of the experiment in the form of a living, genetically transformed corn. The new plant variety produces higher levels of ethanol-generating sugars than any competing product available. It is also projected that in the upcoming years its seeds will be exported to nations where agricultural costs (and IPRs protection) are fewer than those in the United States.

An analysis of what it is that the company has property rights over, and how these rights are allocated, will answer multiple questions. For instance, will the company have property rights over the entire population of high-sugar, pest-resistant corn that will soon be available? Not really. The company will only be granted property rights over the new genetic sequence conformed by the corn and the bacterial genes that allow the new variety of corn to develop pest resistance against certain pests susceptible to the Bt's toxins. From this statement, it would be easy to think that now the company "owns" the genes of both a ubiquitous bacteria and a common corn. Yet this is also false. The gene sequence contained within the new corn — and that taken from the bacteria — do not belong to the company; through the allocation of property rights the company has a right to exclude others from using the combination of bacteria and plant genes in the newly arranged sequence that produces the particular pest-resistant trait in that type of corn. In other words, if another individual or entity uses exactly the same genes but in a different order (a different new sequence) to express completely different traits in corn or bacteria it would not be infringing any property rights held by the company. More than the genes or their sequence in the new DNA chain, what the company has rights over is information about the genes' (partial) behavior and that of the newly created sequence they helped create, the processes of manipulating and transferring them; and the instruments to do so, including computer software designed for sequencing genes and the algorithms composing such programs, as well as the information these produce during the research processes.

Property rights appear to be a collectively held "thicket of rights" over something, in this case, mostly information. The types of IPR that can be accessed here diverge into three types: patents, copyrights, and trade secrets. In this example, copyrights are filed for all information attained and processes used, patents are filed over the new genetic sequence, and trade secrets over information are kept secluded from other competitors. From earlier examples it is easy to picture how property rights can be enforced over the copyrighted material. This is not an easy task as you, the team leader, will have to rely on numerous electronic and legal instruments to avoid any "spillovers" of the knowledge produced and attained by the participant scientists.[18] Now the question that arises is how property rights over the genetic sequence contained in each corn will be protected? This is an unknown that takes us back to the two main downsides of the current information-exchange system: Although the 'space' in which the corn carrying the new genetic information is an open one (the natural environment where this type of corn can grow) as opposed to that of the Internet (considered a closed information-exchange system), many instruments allow the information contained within the corn's DNA to be effortlessly exchanged and replicated. Moreover, as corn is a living organism that relies on air currents and other organisms for its pollination, guaranteeing a natural environment where the possibility of such an exchange is eliminated is a complex, if not impossible task. Through cross-pollination the information contained within the genetic sequence of the new corn variety could transfer to non-genetically modified varieties of itself or to other corn varieties. This gene exchange could occur with other plants through cross-variety pollination. This intellectual property loss process or "spillover" is almost perfectly analogous to the loss facing unprotected information within the new information-exchange systems, leading to pose questions like: why should the company invest resources in research when property rights enforcement is so complex in areas like biotech?

Again, answers to this type of question will come from the capacity to develop adequate systems and regulation adjustments, some beyond the scope of IPR. In this case, protecting the information produced throughout the research process would require adjustments similar to those previously suggested, such as more intricate codification and tighter data encryption. In the case of the modified corn as product, these adjustments to protect information might require the design and inclusion of specific genetic traits (like induced seed sterility), as well as changes to the environment (such as designated zones for harvesting these types of products). In addition, trying to provide a clean-cut answer to the latter question would also require addressing whether scientific research should be promoted through government subsidies that compensate for such losses and whether science and knowledge itself can be considered as a quasi-public good that is difficult to protect. All these questions can provide for the development of an entire new document beyond this one. One obvious downside of trying to follow these prescriptive solutions 'by the book,' especially under the auspices of advancing property rights protection, is the possibility of turning the information-exchange systems (particularly the Internet) into a "black box" that only a privileged few would have access. This would have repercussions beyond scientific development, altering the way many ideas and forms of artistic expression are created and made available today and in days to come.

Some Policy Implications of Intellectual Property Protection for Biotech

Biotech is at the forefront of technological advancement, helping to redefine the limits of basic and applied research and enabling the innovations that challenge the boundaries of property. As a scientific process that both produces and heavily relies on information, biotech has encouraged the design of guidelines emphasizing that property in this area of scientific research should be defined as having a segment of a collectively held 'thicket of rights' over information. As a technological sector, it has exerted further pressure on the IPR system by inducing adjustments to the rules that apply over more tangible resources, promoting an expansion of the boundaries of the appropriable in a quest to maintain the validity of the 'incentives for research.' Further, it has been associated with a series of contentious patent-related issues, all of which are redefining other policy areas beyond the IPR system.

As the previous example suggests, developing a new product through the use of biotech can be an extremely complex and resource-consuming endeavor. The average product that reaches full development from the university or private lab to the marketplace averages stratospheric costs and requires years for regulatory approval.[19] The liberal state theory suggests that without the use of quasi-monopolistic powers that the patent holder exerts, there would be hardly any connection between basic research and development in this or any information-intensive research area. This may or may not be the case. Maintaining this market-driven incentive has been one of the central premises behind the design of policies that enable IPRs to move up the stream of scientific and technical development. Inevitably, keeping these incentives as the central motor of biotech requires addressing issues on whether the fruits of biotech are patentable (more than answering how suitable these economic incentives are for promoting the advancement of science), whether such products are new (as opposed to those found in nature), and whether or not patents should be granted over living organisms. Answers to some of these issues, as well as more evidence to assert that biotech is truly advancing at a faster pace than the policies and institutions affecting it, are found within some of the decisions amending IP law associated to it.

Earlier in the development of the US pharmaceutical industry, the decision in the case *Parke Davis & Co. v. H.K. Mulford & Co.* (196 F. 496 (2d Cir. 1912)) made it possible for patents to be granted over methods for isolating and purifying "natural" substances into useful, isolated, and pure forms not found in nature.[20] The case provided the grounds to justify why a substance found in nature that has been subject to specific alterations, and the process to induce such transformations, can be subject to IPR protection. This decision, made almost 100 years ago, also provided grounds to support granting IPR over certain biological products obtained or generated through the use of biotech, enabling it to move forward during its initial development stage.

Biotech found itself one step ahead of IP regulation for the first time in 1980, when Ananda Chakrabarty used cell fusion techniques to transform a living organism into a previously non-existent one believed to be capable of breaking down components of crude oil spills. In a move that altered 35 USC §101, the Supreme Court, in a 5-4 ruling, maintained that the Patent Act protected Chakrabarty.[21] The section, which defines what inventions are patentable, allowed for patents to be filled for certain living organisms. *Diamond v. Chakrabarty* (447 US 303 (1980)) not only changed the outlook of the biotech industry but also helped establish other associated areas of great significance for its development, mainly those associated with the safety assessment and management of living GM organisms.[22] Chakrabarty, however, happens to be only the beginning of such patent regulation revision.

Rapid advancements in biotech research allowed for genetic modifications of multi-cellular higher organisms and for further alterations to 35 USC §101. The United States Patent and Trademark Office (USPTO) later ruled in *In Re Allen* (2 USPQ 2d 1425, Bd. Pat. App. 1985) that non-human multi-cell organisms could also be patented. Yet it did not issue clear specifications for those organisms that contained human DNA or any derivatives of it. Scientific development in biotech proved to be one step ahead of the IP system once more when Philip Leder at Harvard University filed for a patent for a higher organism in the form of a transgenic mouse expressing a human oncogene (a cancer-related variant of a gene involved in cell growth and replication). Again, the ruling of the USPTO was favorable, allowing the claim to the mouse (US Pat. 4,736,866) and soon after issuing another for the process for making transgenic mammals (US Pat. 4,873,191). These decisions, however, were not fully embraced by the international community, becoming the first in a long line of discrepancies associated with biotech between the United States and other countries.

Contrasting with these decisions, the European Union's (EU's) position regarding the patentability of animals displayed a more cautionary approach as long as these were not limited to one species. The EU also allowed claims to methods using genetically modified (GM) animals, subject to the limitation that the method must be applicable to more than one species. Yet it would not allow patents over "species," and established the authority to deny claims when these processes appear to cause the animal suffering without any substantial medical benefit to humans or the animal.[23] In a similar tone, the Canadian Supreme Court ultimately decided that genetically engineered animals were not patentable subject matter, thus negating patents over the "oncomouse" and its associated processes.

Advancements in biotech research have also shown the limitations of individual ownership when the boundaries between tangible and intangible become blurry. This, at least for the time being, happens to be evident in the case of filing patents for gene sequences. Under § 101, a patentable invention must be useful, the applicant must set forth a use of the invention, and this use has to be substantial, specific, and credible.[24] Substantial utility is a requirement that guarantees that the applicant has knowledge beforehand of a true application for her invention. In the era of biotech and genomics, the sequencing of the genes is done on a mechanical rather than a target-driven basis, turning the utility requirement into a hurdle for patent filing.[25] This discrepancy exposes the fact that privately funded efforts to sequence genes and then file for patent protection over their sequence are often futile due to the complexity of determining beforehand the relationship between the gene sequence and the gene product's function.[26] This undefined relation between gene sequence and gene product's function has had enormous consequences over the scope of IPR.

A clear implication of the effects of this undefined relationship is that — due to the fact that genes within DNA are generally involved in several protein processes simultaneously — complying with the requirements of "substantial" and "specific" utility in filing a patent may result in having to issue "overlapping" or "simultaneous" rights over particular gene sequences to multiple entities. This means that multiple individuals filing for property rights over the same gene sequence, each claiming a different (and equally valid) substantial, specific, and credible utility over these, might end up having to share the entitlements that compose the full bundle of rights that apply over such sequences. Therefore, making evident the almost-public good nature (non-rivalry with partial excludability) of these tangibles and helping support the assertion that biotech is helping define property for certain types of information and biological resources that is closer in essence to having a segment of a collectively held "thicket of rights."

Another palpable example is the clear reduction of resource investment for basic research in the area of genomics stemming from the fact that processes for mapping a chromosome, or assessing whether an individual has a variant of a particular gene, are the only certain applications suitable for IPR protection.[27] Additionally, these particular activities (chromosome mapping and gene identification) have triggered debates over the management of private information adding further stress to the subject's future prospects.

This undefined relationship between sequence and function has also added thrust to the practice of scientific advisors shaping new policy, which Sheila Jasanoff defines as the "fifth branch."[28] This is the result of relying on experts to determine whether or not new gene sequencing patents credibly uphold their claimed utility, thereby establishing the limits of IPR. This will also affect future policies associated to human capital formation, as the demand for individuals with more technical and scientific sophistication increases with each biotech breakthrough, demanding changes to the IPRs system.

In addition to issues associated to the limits of property, the speed at which IPR evolves, and those issues stemming from some of the patent filing requirements, biotech has been subject to many other patent-related issues with substantial policy implications. Issues of equitable ownership of products derived from human tissue, issues related to inventions that draw on traditional knowledge of indigenous peoples, the patenting of animals (especially farm animals), and broad claims to "disease pathways" are controversial and substantial enough to develop papers to address each individually.

Final Thoughts

As mentioned throughout this paper, property has traditionally been conceived as having complete and individual ownership over specific tangible or intangible things. Carrying this notion into an era where the exchange and replication of goods and technology is extremely easy adds complexity to the discussions of what should or should not be the object of such rights. The recent Information Technology revolution has, once again, called for a review of the policies behind property allocation, making a shift towards establishing a definition of property that is closer in essence to owning a segment of a 'bundle of rights' rather than individual, absolute, irrefutable, and unrestricted ownership. In many cases the entitlements composing these 'bundles of rights' can be distributed among various individuals or entities, similar to the way that company stock can be shared among various stockholders. Furthermore, advancements in scientific research may allow in the not-so-distant future, for some of these segments to be 'owned' by multiple 'righteous proprietors' simultaneously. Property, in this sense, more than establishing an artificially constructed relationship between people and things, like the Blackstonian definition suggests, is moving toward highlighting the establishment of relationships between people as sharing information and biological resources. Furthermore, the scope and value of these rights as commodities are also developing from such social interactions.

Additionally, the proposition that a property rights system should consider five essential elements addressing particular issues — what can be owned, who can own, what can be done with it, what rules for the enforcement of rights of property, and how property moves between different owners — facilitates understanding of the paradigm change that the system is currently experiencing. This analytical framework clarifies how technological advancement, particularly in Information Technologies and the New Life Sciences, is shifting the concept of what the object of property rights can be as well as the mechanisms to enforce property rights over particular things. Technological advancement has allowed information to become the essential input of what can be considered a property rights allocation system in continuous evolution. Furthermore, this shift has helped considerably reduce the transaction costs of replicating and exchanging information, allowing higher levels of efficiency to be displayed by these information exchange systems. Nevertheless, these changes keep undermining the current scheme by adding more stress to its current property rights enforcement framework, exposing the fact that these — the physical information exchange systems and the guidelines that define and enforce property — are not evolving at the same pace as technology. This dissonance appears to have special repercussions on the previously mentioned areas of knowledge — IT and biotech — and in areas of artistic expressions also covered by IPR making them both benefit and suffer from the newly attained low transaction costs that simple replication and exchange provide. There will be a need to further design policies and instruments that can help accelerate the pace at which these systems adapt to change. It will also be necessary to promote research that allows a better understanding of the concept of property rights and its limitations to keep the current IPR protection system from becoming obsolete. These new guidelines should be flexible enough to embrace the essence of existing rules based on traditional private property theory, allow for a permanent dialog about the limits of the boundaries of property rights, and preserve the incentives nature of IPRs to continue promoting the advancement of technology and culture in an era where information and genes are the most valuable commodities.

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Endnotes

1 The inspiration for this title comes from James Boyle's paper "The Second Enclosure Movement and the Construction of the Public Domain," *Law & Contemporary Problems*, no. 66, (Winter/Spring 2003) 33-74.
2 In recent years, law review articles have described an information arms race from various perspectives, with multiple sides battling for larger shares of the global knowledge pool. Charlotte Hess and Elinor Ostrom, "Ideas, Artifacts, and Facilities: Information as a Common-Pool Source," *Law and Contemporary Problems*, vol. 66 (Winter/Spring 2003) 111.
3 James Boyle, "The Second Enclosure Movement And The Construction Of The Public Domain," *Law & Contemporary Problems* no.33 (Winter/Spring 2003) 33-74; James Boyle, "Enclosing the Genome: What the Squabbles over Genetic Patents Could Teach Us," *Perspectives on Properties of the Human Genome Project*, ed. F. Scott Kieff (San Diego, Calif.: Elsevier Academic Press, 2003b), 97-118; Bruce G. Carruthers and Laura Ariovich, "The Sociology of Property Rights," *Annual Review of Sociology* 30 (2004) 23–46; Sheila Jasanoff, "Designs on Nature: Science and Democracy in Europe and the United States." (Princeton University Press, 2006), 13-38; and Keith E. Maskus and Jerome H. Reichman, "The Globalization of Private Knowledge and the Privatization of Global Public Goods," *Journal of Economic Law* 7 no.2 (2004) 279-320.
4 Although views are mixed on the possible outcomes of this property rights expansion many authors suggest there are parallels between this movement

and the process of fencing off common land and turning it into private property known as the English enclosure movement. James Boyle, "Fencing Off Ideas," *DAEDALUS* 13 (Spring 2002), 14.
5 The Cartagena Protocol on Biosafety defines Modern Biotechnology as: "The application of: a) In vitro nucleic acid techniques, including recombinant deoxyribonucleic acid (DNA) and direct injection of nucleic acid into cells or organelles, or b) Fusion of cells beyond the taxonomic family, that overcome natural physiological reproductive or recombination barriers and that are not techniques used in traditional breeding and selection." UNEP, Cartagena Protocol on Biosafety (Secretariat of the Convention on Biological Diversity, 2002), Art. 3 (i).
6 In the Eighteen Century Sir William Blackstone defined property as: "That sole and despotic dominion which one man claims and exercises over the external things of the world, in total exclusion of the right of any other individual in the universe" (Sir William Blackstone, *Commentaries on the Laws of England*, vol. 2. (Chicago: Univ. Chicago Press, 1979), 2.
7 In the view of enclosure defenders, the strong private property rights and single entity control that were introduced during the English enclosure of the common lands avoided the "tragedy of the commons" by reducing overuse and underinvestment. Boyle, "Second," 36.
8 Carruthers and Ariovich, "Sociology," 24-31.
9 The enactment of the first IPRs Law took place in Venice, Italy in 1474. Ibid. 37.
10 Ibid. 37.
11 Boyle, "Second," 37.
12 Boyle, "Enclosing," 105.
13 Steven Hilgartner, "Acceptable Intellectual Property," *Journal of Molecular Biology* 319 no.4 (2002), 944.
14 Of course this principle also affects areas beyond scientific development — such as the creative arts — making them vulnerable to market forces and heavy property right protection. Lawrence Lessig, *Free Culture: How Big Media Uses Technology and Law to Lock Down Culture and Control Creativity* (New York, Penguin Press, 2004), 188-207.
5 This virtually transforms information into a public good by allowing it to be: 1) partially excludable (as opposed to non-excludable), and 2) non-rival.
16 Boyle, "Second," 41.
17 Ibid. 42.
8 Other IPR instruments that could apply for this example are licenses and material transfer agreements. USPTO Online, "Patents," Laws, Regulations, Policies & Procedures, <http://www.uspto.gov/patents/law/index.jsp> (accessed on November 12, 2010).
9 If it requires authorization by the FDA for clinical trials and good manufacturing practices, the process can reach levels of more than $800 million for a single product. Robert A. Bohrer, *A Guide to Biotechnology Law and Business* (Carolina Academic Press, 2007), 71.
20 Bohrer, "Guide," 72.
21 Chakrabarty was not the only case of this type helping define property over genetically modified (GM) organisms; In re Bergy is considered its companion case involving an antibiotic producing microbial strain. Bohrer, "Guide," 79.
22 The most relevant is biosafety of GM organisms, which helped establish new management rules for these types pf organisms, especially those that

were able to reproduce.
23 Although the oncomouse patent was allowed by the European Patent Office (Eur. Pat. Off. V 0006-92), it was only after a long discussion on whether or not the suffering of the resultant mice could be justified in terms of the overall need for experimentation and the reduction in the actual number of these type of mice needed when compared to conventional rodent cancer studies. Bohrer, "Guide," 78.
24 USPTO, "Laws," § 101.
25 Bohrer, "Guide," 80.
26 Furthermore, the results of these efforts could end up entirely in the public domain if similar endeavors over specific genes are conducted simultaneously or in tandem with public enterprises required to make their results available for public access.
27 In an effort that could be described using the term "catch-all kitchen sink" the course taken by some sequencers has been to file an application with as much of a specific function of the gene as could be determined from the homology to other genes and the type of tissue expressing the gene, while hoping that experimentation during the year allowed for amendment after provisionally filing for examination will provide enough data to support credibility of at least one of the claimed utilities. Bohrer, "Guide," 81.
28 Sheila Jasanoff, *The Fifth Branch: Science Advisers as Policymakers* (Cambridge Mass.: Harvard University Press, 1990), 3.