THE COLUMBIA
SCIENCE & TECHNOLOGY
LAW REVIEW

VOL. XIII STLR.ORG FALL 2011

ARTICLE

DISPELLING THE MYTH OF PATENTS AS NON-RIVALROUS PROPERTY: PATENTS AS TOOLS FOR ALLOCATING SCARCE LABOR AND RESOURCES[†]

Richard S. Gruner[1]

The view of patents as non-rivalrous property is fundamentally flawed in a key respect that has been largely overlooked in the legal literature. Past scholarship has focused on downstream rivalry regarding the use of patented ideas, while neglecting upstream rivalry regarding the inputs to those ideas in many modern research settings, i.e., the efforts of inventors and the substantial research resources that support them.

By reexamining the impacts of patents on allocations of scarce resources, this Article helps to clarify two important roles of patents in modern, large-budget innovation: First, patent-influenced rewards help to attract scarce resources to innovation projects that would otherwise be devoted to alternative ends. Second, patent-influenced rewards provide prioritizing information to persons allocating scarce resources, establishing a basis to compare the relative value of commitments of resources among innovation projects.

As innovation projects assume ever larger and more central functions in the United States economy, patents in the areas addressed by this Article will only increase in importance. The function of patents in influencing the allocation of resources to invention production has received remarkably little attention in law review analyses to date. This Article aims to rectify this imbalance and highlight the important

1. Professor of Law; Director, Center for Intellectual Property Law, John Marshall Law School. The author would like to thank Joshua D. Sarnoff and David L. Schwartz for thoughtful comments on earlier drafts of this Article and Erin M. McKibben for research assistance in connection with this Article.

functions that patents play in producing innovations valued by the public.

Patents are often mistakenly described as non-rivalrous property.[2] This description is not so much purely incorrect as it is incomplete. Patent rights govern non-rivalrous actions of parties using patented inventions.[3] However, patent rights also regulate highly rivalrous allocations of scarce resources to the production of

---

2. Patents are seen by many analysts as injecting artificial (and arguably undesirable) scarcity into situations where ideas about useful advances are freely available and there is no need to regulate rivalrous conduct to ensure the highest use of scarce resources. This point was made as early as 1934 by Arnold Plant:

> [P]roperty rights in patents . . . do not arise out of the scarcity of the objects which become apportioned. . . . [W]hereas in general the institution of private property makes for the preservation of scarce goods, tending (as we might somewhat loosely say) to lead us 'to make the most of them,' property rights in patents . . . make possible the creation of a scarcity of the products appropriated which could not otherwise be maintained.

Arnold Plant, *The Economic Theory Concerning Patents for Inventions*, 1 Economica 30, 31 (1934).

patented inventions,[4] as well as further rivalrous allocations of scarce resources to the implementation of patented inventions in useful products and the commercialization of those products.[5] Hence, patents influence many rivalrous activities and deserve consideration in policy analyses as means to allocate scarce labor and resources among highly rivalrous demands.

Patents constrain the use of ideas about how to construct and employ useful items or how to undertake useful processes.[6] The use of these sorts of ideas is non-rivalrous of itself in that the use of an

---

3. Some clarification of nomenclature used here is probably in order. This Article will discuss patents, inventions, and patented items at various points. It is important to remember that patents are distinct from the inventions described in the patents and these inventions are in turn distinct from the items that embody the inventions.

An invention is an idea. An invention is created when one or more persons have a mental image of the essential elements of a useful item or process. *See Hybritech Inc. v. Monoclonal Antibodies, Inc.*, 802 F.2d 1367, 1376 (Fed. Cir. 1986) (citation omitted). The design idea or conception of an invention is typically comprised of a combination of physical elements, static interrelationships between the positioning of these elements, and dynamic sequences of changes in the interrelationships over time as the invention operates.

A patent is a document that describes an invention. *See* 35 U.S.C. § 112 (2006). It describes the essential features of the invention in patent claims (so named because they describe the invention for which the patent holder claims protection). The patent also provides background information on how to make and use the invention and how the invention differs from prior items or processes in the same field. Patent rights attach to the invention as defined in the patent claims. These rights prevent persons other than the patent holder (or parties receiving the patent holder's permission) from making, using, selling, or importing the patented invention. *See* 35 U.S.C. § 271 (2006).

Physical items can embody an invention. Many different types of objects may embody a single invention, provided that each contains the essential elements of the invention (often, in addition to other elements). If an object embodies a patented invention during the life of a patent and without the permission of the patent holder, the object infringes the patent and the patent holder can obtain damages for past making, using, or selling of the invention and injunctive relief barring future activities of this type. *See* 35 U.S.C. §§ 271, 283–284 (2006).

The references to patents as non-rivalrous property in the title and text of this Article refer to the view that patent rights regulate non-rivalrous use of patented inventions. This Article argues that, while patents may regulate non-rivalrous use of inventions, they also regulate highly rivalrous allocations and uses of scarce assets as invention inputs.

4. Harold Demsetz has interpreted patent restrictions on the use of inventive ideas as a means to beneficially regulate the use of scarce resources in producing inventions. Demsetz focuses on the potential role of patents in placing a value on inventions as public goods and thereby attracting scarce resources to the production of these public goods at socially optimal levels. For Demsetz, patent rights are useful means to regulate the use of scarce resources as inputs to the production of patented ideas, thereby providing a public goods production theory of patent rights that stresses the importance of patent rights in regulating the use of scarce resources upstream (that is, prior to) inventive processes. *See* Harold

idea by one party does not diminish the usefulness of the same idea by another.[7] This stems from the fact that—unlike real or personal property—the use of a patented idea does not consume the idea or otherwise limit the usefulness of the patented idea to others.[8] In this sense, the use of patented ideas is "non-rivalrous"—that is, we do not need to worry about the impacts of rivals for the use of the same patented ideas interfering with further use.[9]

In these characteristics, patents differ from most types of property and there is consequently little need for patent laws to mediate the potential overuse of patented ideas or to ensure that patented ideas are only used in their best or most highly valued applications. Analysts have argued that this fundamental distinction between patents and physical property justifies relaxing property law rules and controls substantially for patents[10] or, in a more extreme version, excluding patents from property laws altogether and substitut-

---

Demsetz, *The Private Production of Public Goods*, 13 J. L. & Econ. 293, 295–300 (1970).

5. A number of analysts have argued that, while patent laws are not needed to regulate rivalry and potential overuse of patented ideas for useful inventions, there are other reasons to impose patent rights to allocate scarce resources to tasks related to the implementation or distribution of products and procedures based on patented designs.

Edmund W. Kitch, for example, has concluded that there is little reason to apply patent law rules based on property notions to restrict use of design ideas defining patented advances since "the property rights literature has viewed the central problem as one of scarcity, while information has appeared to be an example of something that can be used without limit." Kitch has argued that the proper basis for imposing patent rights lies in the need for those rights as a means to encourage parties to search or "prospect" for applications of patented advances and to allocate scarce resources to these tasks. Edmund W. Kitch, *The Nature and Function of the Patent System*, 20 J. L. & Econ. 265, 275–76 (1977). This "prospecting theory" explains patent laws as beneficial means to regulate the use of scarce resources in actions downstream of (that is, subsequent to) inventive processes. *See id.* at 284–85.

Another explanation of patent laws focusing on the allocation of scarce resources downstream of inventive processes is offered by F. Scott Kieff. He argues that patent rights are needed to encourage parties to take steps to popularize products that implement newly patented advances and thereby ensure that these advances are delivered to consumers. Kieff's "commercialization theory" explains patent laws as means to regulate the allocation of scarce resources to the commercialization of patented advances amidst competing business pressures that may encourage the allocation of the same resources to other business tasks. *See* F. Scott Kieff, *Property Rights and Property Rules for Commercializing Inventions*, 85 Minn. L. Rev. 697, 717–36 (2001).

6. 35 U.S.C. § 271(a) (2006) ("whoever 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 during the term of the patent therefor, infringes the patent.").

ing other reward mechanisms for promoting the creation of inventions without limiting the use of the inventions.[11]

This Article argues that the characterization of patented inventions as non-rivalrous is fundamentally flawed. It is mistaken because it focuses only on downstream rivalry regarding the use of patented ideas, not on upstream rivalry regarding the inputs to those ideas. The primary inputs to patented ideas are the efforts of inventors (often highly talented individuals with rare knowledge and skills) and the substantial research resources that support potential inventors in many modern research settings. These inputs are subject to strong rivalries regarding their use. Both inventors and their resources will typically have substantial alternative projects tugging for their attention and application. These second choices and the rewards they imply establish ongoing rivalries for the application of inventors' labor and the allocation of the enor-

---

7. No less figure than Thomas Jefferson stated this point eloquently:

> [T]he moment [an idea] is divulged, it forces itself into the possession of every one, and the receiver cannot dispossess himself of it. Its peculiar character, too, is that no one possesses the less, because every other possesses the whole of it. He who receives an idea from me, receives instruction himself without lessening mine; as he who lights his taper at mine, receives light without darkening me.

Letter from Thomas Jefferson to Isaac McPherson (Aug. 13, 1813) in 13 The Writings of Thomas Jefferson 326, 334–35 (Andrew A. Lipscomb ed. 1903) (1813). For thoughtful descriptions of how these views on the dissemination of ideas influenced Jefferson's thinking about patent laws (and of how Jefferson's views fit into the intellectual context of his time), see Adam Mossoff, *Who Cares What Thomas Jefferson Thought About Patents? Reevaluating the Patent "Privilege" in Historical Context*, 92 Cornell L. Rev. 953, 960–1009 (2007).

8. The lack of consumption of intellectual ideas such as designs for patentable inventions occurs because ideas are shared, not consumed. This point was made in the context of literary works by Tom G. Palmer. He observed that the non-rivalrous nature of the consumption of works of art stems from the fact that "that there is one Othello for all of us, rather than one Othello for each of us, or even one for each of our separate readings or viewings of the play." Tom G. Palmer, *Are Patents and Copyrights Morally Justified? The Philosophy of Property Rights and Ideal Objects*, 13 Harv. J. L. & Pub. Pol'y 817, 846 (1990).

9. *See* Peter S. Menell, *The Property Rights Movement's Embrace of Intellectual Property: True Love or Doomed Relationship?*, 34 Ecology L. Q. 713, 726 (2007) ("Unlike tangible goods, knowledge and creative works are public goods in the sense that their use is nonrivalrous. One agent's use does not limit another agent's use.").

10. *See, e.g.,* Brett M. Frischmann & Mark A. Lemley, *Spillovers*. 107 Colum. L. Rev. 257 (2007).

11. *See* Friedrich A. von Hayek, The Fatal Conceit: The Errors of Socialism 36 (1988) (noting that "once [technological inventions] have come into existence, they can be indefinitely multiplied and can be made scarce only by law in order to create an inducement to produce such ideas. Yet it is not obvious that such forced scarcity is the most effective way to stimulate the human creative process.").

mous resources now needed to produce many types of patented inventions. The lure of rewards for useful inventions ensures that the public interest in practical advances having substantial utility is a strong influence on how inventors and the companies, universities, and investors that back them make decisions about how to spend their time and apply their resources. In short, patents influence choices that are highly rivalrous in that patents mediate how decisions about the use of scarce innovation resources (including the time of inventors) are made.

I. RECONNECTING PATENT POLICIES TO PROPERTY LAW POLICIES INFLUENCING ASSET PRODUCTION AND RESOURCE ALLOCATION

A. Lessons for Patent Law from Property Rules Governing Asset Production

Recognizing the rivalrous nature of resource allocation decisions made in the production of patented ideas puts these ideas and patents themselves back into the mainstream of property law theory.[12] Property rules are applied not only to ensure efficient use of property once the property is already in existence. These rules are also applied to ensure the production of useful property at socially desirable levels. Property rules reassure parties considering the production of new property that they will be able to put that new property to its most rewarding use. In the context of real property, for example, this ensures that land and the other inputs to the development of new buildings can be put to their best use among available alternatives through building use choices made by building developers (or by successors to the developers such as later building owners). A piece of bare land may be bought by a party who knows that the land can be developed as the site for a hospital if this seems like the land's most profitable projected use rather than being limited to being developed as a store or kept as bare land. These sorts of abilities to plan and commit scarce resources to their projected highest use (as seen by the property owner with planning reassurances backed up by projected property controls over the ultimate

12. Property law rules are typically devices for controlling and limiting the use of scarce resources. Property laws serve two related purposes concerning scarce resources. First, they protect against overuse by excluding users from access to the property absent the permission of the owner. The property owner will tend to refuse access to and use of property so as to maximize the use of the property and the value of that use. Second, property laws allow owners to offer access to assets to only the persons who will pay the most for such access, thereby tending to limit use of the property to its highest, most valued use.

use of the property) are critically important in drawing resources into complex property development projects.

Property law controls—and the choices such controls give a property owner about how to allow or limit access to the final product of a development project—are important in inducing parties with scarce resources to commit the resources to projects producing new assets. Absent control over how the new assets will be used and opportunities to gain commercial returns from such uses, parties might rather allocate resources to other types of real estate projects (for example, speculation on the value of existing properties) or to different types of investments outside of the real estate field.[13] The development of a parcel of real property into a hospital or some other complex building will only be a property owner's first choice of action and trump alternative choices for the commitment of resources if the owner can be sure—based on property law controls—that he or she will have extensive control over the ultimate use of the developed property. With this control, a developer can count on an opportunity to realize his or her planned use and returns concerning the developed property.

The same concept applies to the development of patented innovations. At the outset of a complex innovation project, both potential inventors and parties committing resources to support the project will often have attractive alternatives regarding how they can spend their time and resources. Many potential inventors of patent-eligible advances are highly skilled scientists and engineers with substantial demands for their time in other projects with high salaries or reputational rewards. These alternative ways to spend their scarce time and talents tug constantly as available conduct choices, and are likely to be persuasively attractive if plans for the pursuit of patented advances do not trump these alternatives by offering the promise of even greater rewards.

---

13. Property laws shape the expectations of both property owners and potential users about who will control subsequent choices about the use of particular assets. This reassuring and planning promoting feature of property laws was recognized by F. A. Hayek. *See* 1 F. A. Hayek, Law, Legislation and Liberty: Rules and Order 106–10 (1973); Henry E. Smith, *Intellectual Property as Property: Delineating Entitlements in Information,* 116 Yale L. J. 1742, 1777 n.114 (2007) (describing "F.A. Hayek's argument that property, by establishing boundaries over things over which decision-makers would be free to take action and prevent interference by others, was the best and only workable method to achieve a coincidence of expectations among members of society.").

B. Rivalrous Resource Allocations at the Heart of Invention Production

The allocation of inventor time between the pursuit of patent-eligible innovations and other potential endeavors is highly rivalrous, particularly given that many of the best innovators fall within a very small set of parties at the top of their respective fields. The time and talents of these key innovators are very scarce resources. Given the very small number of parties who may have advanced knowledge in rapidly changing fields and who may be the only ones able to produce useful technological advances in those fields, it is in society's interest that their time and talents should be allocated particularly carefully. Attaching patent rewards that are scaled to the scope and value of societal benefits achieved by patented innovations helps to ensure that the allocation of these scarce talents is made in accordance with society's interests and the total utility of various potential inventions.[14]

Likewise, the allocation of research resources of companies and universities and the financial resources of investors as they consider the backing of research projects or other profitable ventures is beneficially mediated by the promise of patent rewards. Companies and universities have many ways to use their resources that will promote their overall missions. In order to lure them to make what are often enormous resource commitments to the pursuit of patentable innovations in the face of many other demands for use of the same resources, these organizations must be presented with the promise of substantial patent-influenced rewards.

C. How Patent Rights Mediate Resource Allocation Decisions

Ideally, patent-mediated rewards should be scaled to the size of societal benefits that will come from particular patented advances and the projects that produce them. By allowing patent holders to manage the later use of patented inventions through property controls over these inventions, we ensure that successful inventors (or the organizations that will frequently control the resulting patents) are able to collect patent rewards that approximate (for the dura-

14. *See* Harold Demsetz, *The Exchange and Enforcement of Property Rights*, 7 J. L. & Econ. 11, 19–20 (1964) ("if the cost of policing the benefits derived from the use of [public goods such as new inventions] is low, there is an excellent reason for excluding those who do not pay from using these goods. By such exclusion we, or the market, can estimate accurately the value of diverting resources from other uses to the production of the public good."); Harold Demsetz, *The Private Production of Public Goods,* 13 J. L. & Econ. 293, 295–300 (1970) (describing the significance of property controls in attracting the allocation of scarce resources to the production of public goods).

tion of the patents) a large fraction of the incremental societal benefits flowing from the patented advances. This patent-based collection system means that rewards to inventors can roughly track the size of invention benefits. This in turn means that allocations of invention inputs such as the scarce time of key inventors and the scarce innovation resources of corporations will be responsive to and in accordance with society's most valued applications and highest needs for new innovations.

In short, patent rewards granted through property controls on the use and commercialization of patented inventions help to ensure that resource allocation choices made in the early stages of the development of patented inventions are made with the projected scope and later value of the patented advances in mind. The promise through patent laws and rights of downstream patent rewards and payments to inventors for valuable inventions serves to influence upstream decisions about the allocation of resources as inputs to inventions.

Resource allocations modulated by patents in this way are not only highly rivalrous, they are choices in which the country has an enormous stake. Allocations of the attention of our best minds and of extensive research resources to our most pressing societal needs and problems are encouraged by attaching significant patent-mediated rewards to successful responses to these needs and problems. The promise of patent controls and rewards tends to focus critical labor and resource allocation decisions in accordance with the needs of the public. Patents encourage decisions in favor of projects to address the public's greatest needs, with the greatest needs signaled by the promise of the greatest patent-influenced commercialization controls and rewards.

D. Aims of This Article

This Article has three aims. First, it describes why the production of patent-eligible advances in many of our most important technology areas presently involves highly rivalrous allocations of scarce resources, both personal and material. Second, it argues that patent rights should be shaped to create incentives to encourage individual inventors and the organizations that sponsor and support their research to allocate scarce resources to the types of large-scale technology development projects that are increasingly dominating modern science and engineering. Third, the article presents and analyzes ten case studies illustrating how patents have influenced the recent development of several highly valuable technologies and how patent standards can encourage both individuals and organizations to allocate scarce resources to the development of similarly valuable technologies in the future.

The analyses here focus on two features of resource allocations affecting the development of advanced technologies today: (1) sources of scarcity in expertise and supporting resources that are necessary inputs to the production of patent-eligible advances in advanced fields and (2) organizational mechanisms that promote careful consideration of allocations of resources to innovation and other alternative activities, thereby ensuring that decisions about whether to devote resources to innovation are frequently made in highly rivalrous environments amidst strongly articulated demands for other uses of the same resources.

Overall, this discussion clarifies the decision-making environments in which the patent system operates. Properly seen, these environments are often highly rivalrous realms in which work on patent-eligible advances (and the realization of solutions to societal problems that these advances can provide) competes with many other resource uses. Work on patent-eligible advances will often only proceed if patent rewards are set high enough to win the attention of individuals and organizations that control scarce innovation resources. The patent system must win this attention amidst organizational decision-making mechanisms that ensure alternative uses for the same resources are carefully articulated, strongly advocated, and intensely considered, potentially drawing the resources away from innovation projects.

Understanding this highly rivalrous world of resource allocations in which the patent system operates will help to inform future considerations of patent policy. Such understanding will clarify the need for strong patent controls and rewards in technological areas of substantial public interest. With these controls and rewards, patents can serve as means to overcome rivalrous resource demands and to bring critically needed resources to the service of important innovation projects.

II. THE NEED FOR INCREASED ATTENTION TO RESOURCE ALLOCATIONS IN PATENT ANALYSES

A. Risks in Overemphasizing Patent System Costs

Many recent critiques of the patent system have focused excessively on patent system costs—mostly as measured from the patent-influenced costs of using patented advances.[15] Patents, the critiques

15. *See, e.g.*, Nat'l Research Council of the Nat'l. Acads., A Patent System for the 21st Century 10 (Stephen A. Merrill et al. eds., 2004), *available at* http://www.nap.edu/html/patentsystem/0309089107.pdf; Federal Trade

assert, limit the downstream use of patented inventions either by consumers or by parties seeking to use the patented inventions as bases for further improved or derived advances. Cheap access to patented advances would promote more productive activities and the development of more subsequent advances. Hence, these arguments conclude, we should be leery about the enforcement of patent rights, either rejecting patents altogether (as some parties have argued should be the case for software[16] and business methods[17]), allowing uncompensated uses of patent-restricted inventions in special circumstances (as some parties have advocated for infrastructural applications[18]), or limiting the controls and remedies associated with patent rights to reduce the costs that these remedies impose on invention users.[19]

These arguments (admittedly highly simplified here) are doubtlessly correct—if we assume that the inventions involved would exist absent patent rights. Basic economic principles dictate that lower prices for an item (usually ensured by allowing free competition to produce the item for sale at a price at or just above the marginal cost of producing the item) will encourage the broadest use of the item.[20] Antitrust laws are premised on the view that free competition—and the lower prices and market information that result from free competition—are generally in the public interest and should be protected. Antitrust laws generally prohibit efforts to control product supply activities in ways that limit competition and competitive product pricing or to elevate prices to levels different than competition would produce. In short, the basic theme underlying antitrust laws is that competition and competition dictated pricing of products is economically preferred and publicly valuable.

Patent-influenced prices are a contradiction of this basic economic norm and antitrust theme. From the perspective of a competition-preferring economic system, patent rights exert monopoly-like restrictions on the use of patented inventions and should be

---

Comm'n, To Promote Innovation: The Proper Balance of Competition and Patent Law and Policy 5–7 (2003), *available at* http://www.ftc.gov/os/2003/10/innovationrpt.pdf.

16. *See generally* League for Programming Freedom, http://www.progfree.org/ (last visited Mar. 23, 2011); Foundation for a Free Information Infrastructure, http://www.ffii.org/ (last visited Mar. 23, 2011).

17. *See, e.g.*, Rochelle Cooper Dreyfuss, *Are Business Method Patents Bad for Business?*, 16 Santa Clara Computer & High Tech. L. J. 263, 278 (2000).

18. *See generally* Brett M. Frischmann & Mark A. Lemley, *Spillovers*, 107 Colum. L. Rev. 257 (2006); Brett M. Frischmann, *An Economic Theory of Infrastructure and Commons Management*, 89 Minn. L. Rev. 917, 967 (2005).

19. *See, e.g.*, David W. Opderbeck, *Patent Damages Reform and the Shape of Patent Law,* 89 B.U. L. Rev. 127, 129 (2009).

20. *See, e.g.*, Donald Philip Green, *The Price Elasticity of Mass Preferences,* 86 Am. Pol. Sci. Rev. 128 (1992).

avoided by limiting patent rights.[21] In short, the presumption underlying most views of economic competition and the basis for our antitrust laws is that competition is presumptively good and that patent rights are presumptively bad because they are anticompetitive and tend to limit valuable social activities, at least by elevating prices for patented inventions and reducing the range of consumer access to these inventions.

Of course, the policy view underlying patent law is not that the patent system is illegitimate due to its anticompetitive effects, but rather that the patent system serves a special purpose which distinguishes it from the normal commercial world governed by unfettered competition and protected by antitrust law. Patent law is presumed to serve a special purpose which justifies its potential limiting effects on competition. The higher (or at least distinct) purpose of the patent system is to promote advances in the useful arts—that is, to encourage the discovery and public dissemination of new and useful items and processes. This purpose of enhancing the useful arts was deemed highly important by the founders of our country, as evidenced by the founders' inclusion of this purpose for the patent system within the relatively few governmental functions mentioned explicitly in the Constitution.[22] When considering the patent system and why (and when) it is valuable, our first consideration should be the same one emphasized in the Constitution—the production of new inventions and the consequent advancement of the useful arts.

This is not to say that we should ignore patent costs due to the limiting effects of patents on competition.[23] However, these costs are

---

21. Peter Menell has noted several types of social harms that may result from patent controls limiting the use of information about designs for useful inventions:

> Such control . . . reduces social welfare in several ways. First, monopoly exploitation results in deadweight loss to consumers. Two other defects are that it may inhibit the use of scientific or technological knowledge for further research, and, from an ex ante point of view, there is no guarantee that the research effort will be delegated efficiently to the most efficient firms, or even to the right number of firms.

Peter S. Menell, *The Property Rights Movement's Embrace of Intellectual Property: True Love or Doomed Relationship?*, 34 Ecology L. Q. 713, 726–27 (2007).

22. *See* U.S. Const. art. I, § 8, cl. 8. The portions of this constitutional provision related to patents authorize Congress to pass legislation "[t]o promote the Progress of . . . useful Arts, by securing for limited Times to . . . Inventors the exclusive Right to their respective . . . Discoveries." *Id.*

23. There are two types of costs at issue, which are important for the patent system for different reasons (and which may be minimized in different ways). First, some costs are related to patent-elevated amounts that consumers pay for access to inventions that would have been made anyway even in the absence of special patent incentives. These costs can be minimized by ensuring that the

to a certain extent necessary prices to be paid for the incentivization and reward of efforts to take technology development chances and to devote scarce resources to the production of technical advances. We need to understand how the patent system—particularly the rewards given to inventors and their supporting organizations through the enforcement of patent rights—encourages the production of patent-eligible inventions. Once we understand this, we can consider what costs must be paid by consumers of inventions to support the production processes we desire. Starting patent policy analyses with discussions of patent costs elevates the incidental cost portions of patent policy analyses over the core topic of invention production. Criticisms of the patent system based on the costs it imposes on patented invention users are overly simplistic and only the starting point for complete assessments of the merit of various patent standards. What we need to know is whether and how much patent rewards are producing incremental inventions and associated incremental public benefits. That is, are the costs of the patent system useful investments in the future of technology and money well spent?

Access to patented advances certainly costs more than would be the case if the same items were manufactured and sold with complete competition. But this is a desirable system feature, not a flaw. The patent system is supposed to work this way, charging users of patented advances for access to the new functionality of the advances and transferring most of the charges to inventors (or their successors in patent ownership) as rewards for inventive efforts and for risk taking in technological development. Absent confidence that these patent-derived payments will be made, many parties with the inputs to the production of advances will not devote the time and effort to produce them. If we want more, we need to pay more. Where we want more technology most strongly because our needs are particularly important, we should be prepared to pay the most for patent-influenced advances. Of course, we should still be sensi-

patent system is not extended to types of advances that will be produced through normal commercial processes and competition absent any patent-influenced increment of rewards. The second set of costs are those imposed for inventions that are probably products of the patent system in that they were unlikely to have been made absent the special rewards of the patent system. Even as to these advances which are the primary targets of the patent system, costs paid for use of the inventions that are beyond the incentives needed to promote the creation of the inventions are still excessive costs. These are excessive in that they do not need to be paid (even within the patent system) to ensure that the patent-eligible advances involved are made. In these settings, we might seek to reduce patent costs by allowing certain types of uses of patented advances (such as uses in infrastructural contexts) to go forward without the payment of patent-related use fees if we can agree that withholding these sorts of patent-influenced payments will not substantially shift the innovation decisions influenced by patent rewards.

tive to who is paying for access to new technology and to whether they will be denied such access absent special help (and to associated questions such as whether government programs should, for example, increase the ability of AIDS patients to pay for patented drugs for which they have desperate needs but no ability to pay). But these are not the fundamental considerations that govern the production of patentable inventions and we should be hesitant to curtail patent incentives on these grounds as we consider how patents should influence the production of our most important new technologies in the future.

What will govern the production of patent-eligible inventions are the incentives (financial and otherwise) that attract persons and institutions with scarce skills, knowledge, and resources to the production of patent-eligible advances. What we need to understand are these incentive processes, how potential patent rights influence these processes, and whether there are ways to adjust the costs of patent enforcement to avoid imposing unnecessary costs on invention users. The adjustment of these costs will be a secondary consideration, however, to be undertaken only where cost reductions will not undercut the size and certainty of patent rewards in the eyes of the decision makers controlling the innovation projects that we are trying to influence through the patent system.

B. Towards a Balanced View of Patent Policy: Giving Greater Emphasis to Upstream (Supply Side) Impacts of Patent Rights on Invention Production

A patent policy analysis that emphasizes patent costs without completely considering patent benefits in the allocation of resources to invention projects risks misdirecting (and overly weakening) the patent system for several reasons.

First, we need a complete analysis of patent benefits and costs to determine where to strengthen and extend the patent system. Because elevated costs to invention users are inherent in the patent system for the reasons described in the last subsection, costs will always loom large in any analysis of net patent benefits in a particular field or context. Patent enforcement will only look attractive overall if we have a view of patent benefits that is commensurate with that of patent enforcement costs. An analysis that overemphasizes patent costs risks conclusions that the patent system has no net worth and should be avoided or weakened in settings where it would, upon a complete analysis, be seen as having substantial net advantages over time in advancing technologies of great benefit to society.[24]

Second, a focus on patent benefits and the impacts of patents in drawing scarce inventors and resources into innovation projects is important because it forces us to confront and consider the highly rivalrous environment in which patent-eligible advances are produced. It is easy to mistakenly see patents as governing non-rivalrous public goods. Patented designs are indeed non-rivalrous public goods in that the use of a patented design by one party does not diminish the quantity or usefulness of the same design for use by another. However, while the downstream use of patented designs is non-rivalrous, the upstream production of patented designs often involves inputs (contributed both by inventors with scarce skills and knowledge and by organizations such as corporations and universities with scarce resources needed to support resources) that are highly rivalrous. The resources available for the pursuit of patent-eligible advances are often scarce, the resources required for successful research are often substantial, and the alternative uses for the same resources are often many and well rewarded. In this world of few resources with many competing demands, decision making and action are often highly rivalrous and patent rewards must be strong to attract resources towards work on patent-eligible advances.

Third, while the under-application of the patent system is a major concern for the reasons just described, we also need a complete view of patent benefits and costs to ensure that we do not overextend the patent system. For example, analyses of patent-eligible subject matters assume (perhaps based more on faith rather than on empiric evidence) that patent rewards produce beneficial results in expanding innovation in fields as diverse as biotechnology, software development, and business methods. If the needs for patent incentives in particular fields are less (or the net impacts of offering those incentives are likely to be different) because the

24. The greater measurability of patent costs over patent benefits will tend to guarantee an overly weak or curtailed patent system because of the tendency of differentially measured features of an item or process to produce a "lemons equilibrium." Where several features of a given item can be measured with differing accuracy or measurement cost, the merit of the item will tend to be assessed primarily in terms of the more easily assessed features, with quality in other respects more systematically ignored. The result is a "lemons equilibrium" where the most successful versions of the item in question may incorporate defective features that are difficult to assess and are therefore overlooked in many acquisition decisions.

The counterpart consideration in the context of the patent system is that, as decisions about patent reform are made, the costs of patent enforcement may loom large and receive considerable attention, but the more subtle advantages of patent protections in various contexts may be overlooked and undervalued.

mechanisms or circumstances of innovation are different, this may provide reasons to withhold patent protections from those fields (remembering that these protections will always tend to impose some costs on invention users).

Fourth, in fields where patents are generally available, a better understanding of when patent incentives are needed to spur additional levels of innovative effort may help us to apply context-specific standards for determining whether patents should apply to particular inventions. For example, in settings where invention inputs are not scarce because many parties hold the requisite skills to solve a particular type of engineering problem, patent rights may not be needed to specially attract innovation inputs (such as the time of inventors) and to bring scarce resources to the solution of the problem.[25] A better analysis of how patent incentives can influence the work of scarce inventors will help us consider when these incentives are not needed and, therefore, whether patent incentives should be withheld under invention-specific tests such as nonobviousness standards.

Fifth, a better understanding of how patent incentives can promote work on patent-eligible advances will also help us to shape the scope of patent rights and remedies. Types of uses of inventions that can be reasonably foreseen by innovators (and the range of foreseeable uses and commercial gains that innovators might expect from a patented invention at the time that resources are committed to the development of the invention) may help to define the range of actionable patent infringement and the scope of proper remedies for infringement. Under this view, unforeseeable applications of patented advances might be held outside of infringement tests and have no patent rewards because the developers of the advances could not have anticipated and been influenced by such rewards. Similarly, where inventors could not foresee quantities of invention use and related patent-influenced profits or royalties, the increment of profits and royalties resulting from unexpected demand might be excluded from patent damage recoveries. This type of reduction of recoverable damages to include just foreseeable revenues rather than all revenues might be justified because the increment of unforeseeable revenues could not have influenced the work of the parties who discovered the patented advances.

---

25. This is exactly the result that present nonobviousness tests will tend to produce. Under these tests, patents are not available for advances which would have been obvious to persons having ordinary skill in the field (who presumably form a fairly numerous group). *See* 35 U.S.C. § 103 (2006).

III. The Scarcity of Invention Inputs

There are several reasons why inputs to patent-eligible inventions tend to be scarce, leading to a particularly great need for patent-influenced rewards to attract these scarce inputs to the production of patent-eligible advances. In considering the impacts of scarcity on the production of patent-eligible advances, we need to examine both the individuals who are potential inventors and the supporting resources (including research assistants, research equipment, and supporting staffs and facilities) that are needed to pursue effective development of patent-eligible inventions. While additional sources of scarcity may apply in particular industries and research settings, this section addresses three sources of scarcity that apply across numerous domains. These include legal requirements that restrict the range of persons who are likely to produce patent-eligible advances, specialization effects that influence the nature of cutting-edge knowledge in science and engineering fields and limit the number of parties who possess that knowledge in any given field, and research scale demands that limit the number of parties with sufficiently large resources to support the minimum research efforts needed to produce successful results in certain scientific and engineering fields.

A. Legal Scarcity Due to Patent Law Requirements

United States patent laws—particularly the requirement that patent-eligible advances be nonobvious extensions of prior public knowledge in their technical fields—implicitly limit the number of parties who are likely to produce patent-eligible advances and tend to ensure that such advances are produced under conditions of labor scarcity. In order to qualify for a patent, an invention must not only be new relative to the publicly known scientific and engineering knowledge at the time of the invention (commonly known as the "prior art"), the invention must further reflect a nonobvious extension of that prior art. [26] Whether or not the degree of extension of an advance over the prior art would have been obvious at the time the advance was discovered is measured by whether a person of average skill in the art would have been likely to have been able to produce the same advance.[27]

26. 35 U.S.C. § 103 (2006). An invention must also be novel in order to qualify for a patent, meaning that the invention must not have been previously revealed to the public by being described anywhere in a printed publication or issued patent or used or known in a publicly available way in the United States. *See* 35 U.S.C. § 102(a) (2006).

27. *See* 35 U.S.C. § 103 (2006); *Graham v. John Deere Co.*, 383 U.S. 1, 17–18 (1966).

This nonobviousness standard implicitly divides potential inventors into four categories: (1) parties outside of the field of technology of the inventions (and, hence, with no special knowledge or skills in that field) and three categories of specialists in that field, including those with (2) below average, (3) approximately average, and (4) above average knowledge and skills in that field. Although the nonobviousness standard speaks to actions of parties in the third category—indicating that inventions are not patentable if they could be produced by parties within this category—the standard implicitly addresses inventions by parties in categories (1) and (2) since inventions that these less qualified persons could produce are ones that the more qualified parties in category (3) could also produce and therefore obvious and unpatentable. By elimination, this means that the only persons who will generally produce nonobvious advances that are legally sufficient for patents are persons with expertise or skills that are significantly above the average levels in their fields.[28] Put another way, a nonobvious advance is one that a person with average or less than average knowledge and skills in the same technological field generally cannot produce (setting aside the rare case of accidental discovery).[29]

Given these legal restrictions, the number of potential producers of patent-eligible advances may be relatively small. The persons with the needed type of design knowledge will be a minority of the overall number of persons with design knowledge in the same technological field (as a mathematical consequence of the need for these persons to have skills above the average for their field). Hence, patent-eligible advances may tend to be made by relatively few researchers who are scarce resources because they have distinctive skills or knowledge diverging from the normal and widely held knowledge and techniques of other researchers with about average or less than average knowledge in the same fields.

There are a number of reasons why persons capable of producing nonobvious, patent-eligible advances may possess rare knowl-

28. Accidental discoveries are exceptions to this analysis. Accidental discoveries may sometimes be made by persons without extraordinary knowledge or skills in the field of the discoveries. Occasionally, a person of average or lesser skill may stumble upon a new design that would have required nonobvious insights to have been consciously designed. A patent will still be awarded for such an invention to encourage the individual who discovered such an unusual advance by accident to bring it to public attention rather than letting it be lost and ignored. These sorts of discoveries by accident are presumably rare and are unlikely to be influenced by patent rewards, although the disclosure and public dissemination of such accidental discoveries may still be promoted in desirable ways by patent rewards.

29. *See* 35 U.S.C § 103 (2006); *Graham v. John Deere Co.*, 383 U.S. 1, 17–18 (1966).

edge or skills. An inventor may produce such advances because the inventor has superior knowledge about features of some aspect of technology and its capabilities. Or an inventor may understand the functional needs of potential innovation users particularly well, allowing the inventor to see the relevance of a known technology to solve a problem in an application field even though most designers in that field would not make the connection. Or an innovator may have unusual knowledge based on prior research results achieved in secret and not yet shared by others in his field.

Even if the knowledge of an inventor only relates to a narrow area of technology or consumer needs, this means that he or she is a scarce inventor for purposes of using that distinctive knowledge. This distinctive knowledge (however small and narrowly focused) will give the inventor the ability to discover and describe a corresponding range of new invention designs that are not obvious to others in her field and that will meet the patent law requirement of nonobviousness.

Because the requirement restricts patents to inventions involving distinctive knowledge leading to nonobvious invention design insights, the patent law requirement of nonobviousness ensures that most patent-eligible inventions (excluding those few that are accidentally discovered) will be produced by a small (and therefore scarce) set of highly knowledgeable and talented individuals with distinctive understandings of their technological fields or related consumer needs or both.

B. Expertise Scarcity Due to Specialization in Training and Research Knowledge

The increasing complexity and specialization in many scientific and engineering fields also tends to increase the scarcity of researchers at the cutting edge of many fields. The cutting edge knowledge in many technical fields is so complex, diverse, and extensive that no one person can master and apply more than a fraction of it. Where a specific research task or problem requires extensive knowledge about a specific cutting edge theory, research environment, or analytic technique, only a portion of the specialists in a given field will be likely to have mastered the relevant expertise and thus be in a position to produce patent-eligible advances.

Trends towards specialization in advanced scientific and engineering knowledge are direct consequences of growths in the scope of such knowledge, coupled with limits on human cognition. This combination tends to cause particular individuals to master only a portion of the current knowledge in a given field, thereby becoming a specialist in his or her subdomain of focus. One observer described the impact of knowledge expansion on the specialization of individuals as follows:

> As more and more knowledge is produced on a global scale, the scope of knowledge that is possessed by individuals becomes increasingly narrower. Individuals strive to hold in-depth knowledge in a very limited number of fields and subjects, or, in other words, they specialize. Specialization is an involuntary phenomenon, and follows from human cognitive limitations and, most importantly, *time* limitations. In the information era, those who do not specialize tend to become less competitive, because they do not have the *time* to acquire the knowledge and skills needed to compete with others in specific fields of knowledge.[30]

The need for large amounts of specific, specialized knowledge to conduct research in particular scientific and engineering domains means, in turn, that advanced training in many science and engineering fields involves gaining large amounts of knowledge about narrow, specialized topics that are at the cutting edge of the field at the time of the training. Gaining an adequate base of knowledge at a level sufficient to do original research may involve many years of training related to only a small portion of the relevant field. Advanced training will produce fairly small numbers of highly trained parties, each a master of his or her small subdomain, but with very few parties in each subdomain and few, if any, parties who can cross over between areas of specialization.

The implications of this type of specialization for the production of patent-eligible innovations and the patent system have been overlooked. The specialization of persons with advanced educations in many scientific and educational fields means that fields are being divided into more and more subdomains, with fewer and fewer persons who are fully trained and effective researchers in each subdomain.[31] The result is a "balkanization" of the knowledge

30. Ned Kock, *The Effects of Collaborative Technologies*, Collaborative Information Technologies 63, 63 (Mehdi Khosrow-Pour ed., 2002).

31. This analysis assumes that the overall numbers of persons with advanced training in particular fields has stayed about the same as the fields have divided into more and more specialized subdomains. This process has left smaller and smaller groups per subdomain. Given that, in the United States, science and engineering training has not seen a surge in recent years—and may actually be being pursued by fewer students—the assumption of little or no growth in the overall numbers of persons receiving science and engineering training seems reasonable. *See, e.g.,* Susan T. Hill, *S&E Doctorates Hit All-time High in 2005*, Nat'l Sci. Found. Infobrief (Nat'l Sci. Found., Arlington, Va.), Nov. 2006, at 1, *available at* http://www.nsf.gov/statistics/infbrief/nsf07301/nsf07301.pdf (noting that between 1996 and 2005 the number of doctorate degrees awarded in the United States in science and engineering fields stayed relatively constant,

gained by graduates of university programs providing advanced science and engineering training (and presumably a parallel impact on knowledge gained by persons in industry obtaining their advanced knowledge from corporate research or other extra-university sources). This balkanization of expertise means that decreasing numbers of qualified researchers in each subdomain work under conditions of increasing scarcity as they consider and pursue inventive projects in their subdomains.

To see the impact of specialization on the scarcity of highly qualified researchers in particular fields, imagine an area of science or engineering that is ripe for advances, perhaps because theories or research equipment in that field have recently opened up new insights or analytic capabilities. In the period after the development of the new theories or equipment, educational programs will tend to generate only a few persons with extensive knowledge about the new theories or equipment. These graduates will be scarce resources, being among the few parties with sufficient cutting edge knowledge to understand the potential of the new theories or equipment and to capitalize on this potential by producing the types of nonobvious advances that fall within the patent system.

In short, changes increasing the complexity and specialization of scientific and engineering knowledge and altering related patterns of training and research activities have ensured that only small groups of equally specialized researchers are capable of moving forward in many advanced research fields to produce nonobvious advances that will qualify for patents. In this way, the specialization of researchers in learning about and applying increasingly complex scientific and engineering knowledge further increases the scarcity of potential producers of patent-eligible advances.

C. Combinational Scarcity Due to Difficulties in Joining Multiple Specialists in Particular Projects

Projects to produce patent-eligible advances through group efforts may be scarce for additional reasons related to the need combine the work of multiple specialists in these sorts of projects. Such projects may be limited by the scarcity of the scarcest type of needed expert, as well as by the difficulty of bringing groups of experts together in ways that allow them to work together effectively.[32]

Effective workgroups in complex design fields may be hard to form and administer. The experts needed to produce new inven-

---

although the fraction of these awarded to United States citizens declined somewhat in the latter portion of this period).

32. I am indebted to David Schwartz for this insight.

tions that serve public needs may include inventors with several different types of engineering or scientific expertise, as well as specialists in areas like consumer preferences, resource management, project financing, and staff management who all make contributions to the successful completion of a complex design project (although they may perform their tasks without actually being inventors named in any resulting patents). Effective contributions from all of these specialists may be needed to complete a complex invention development project. Absent a competent person in any one of these roles, a complex project may founder or be misdirected towards new technical information of little importance to the public. Hence, scarcity in any one of the personnel areas needed for a given type of project to go forward effectively will produce scarcity in that type of project. Each of the component specialties—and the scarcity of competent parties in these contributing fields—is a source of potentially limiting scarcity in the whole. Put another way, projects that depend on a combination of talents for completion are limited in scarcity by their component expert that is most scarce.

An innovation project that turns on integrating the work of multiple contributing specialists also depends on the success of project managers or executives who can foresee the needed types of specialists, bring these diverse specialists together, keep the specialists working together effectively to produce group results, and link the partial contributions of the multiple specialists to produce completed invention designs. This type of project management capability is an important type of expertise in and of itself. In projects that are sufficiently complex or extensive that single individuals acting alone cannot complete the projects, the need for integrating managers who can bring together and administer effective workgroups are essential, yet scarce innovation resources.

In sum, the rarity of component participants of innovation workgroups makes the combinations needed for effective innovation even rarer. Furthermore, even if combinations of experts needed for innovation projects are available, the parties who are capable of integrating the work of the component experts may be few. These sources of potential scarcity in the combinations of expertise and successful group management that are needed for effective group innovation suggest that effective workgroups may be even scarcer as sources of patent-eligible advances than effective individual inventors.

D. Institutional Scarcity Due to the Enormous Resources Needed to Support Discoveries of Patent-Eligible Advances

Effective research activities in many fields now require researchers to be backed by enormous supporting resources. The size of these necessary resources—and the small number of corporations and other institutions like universities that can provide research resources at the necessary levels—add a further institutional dimension to the scarcity within which patent-eligible advances are developed in many fields.

Innovators in many fields must now have a wide variety of expensive supporting resources in order to be effective in pursuing patent-eligible advances. Supporting resources can include equipment needed to conduct engineering studies, research staffs needed to complete complex research tasks, additional administrative staffs needed to acquire, organize, and administer the resources utilized by researchers, and additional product specialists familiar with consumer needs, manufacturing capabilities, distribution problems, and marketing concerns who can provide important project-targeting information to research teams.[33] Even the most highly trained potential innovators cannot be effective working alone in fields where these sorts of extensive resources are essential research tools and facilitators. Hence, these supporting resources (and the involvement in research projects of the institutions capable of providing the resources) are necessary inputs to the production of patent-eligible innovations in certain fields.

There are a number of reasons for scarcity in light of the nature of these supporting resources. The supporting resources needed for effective research in some fields can be staggeringly costly, meaning that only a few companies or university organizations have the caliber of financial backing needed. Even businesses or organizations with sufficient financial resources must make careful choices about which projects to support and will only be able to support a few projects requiring large resource commitments. Hence, the new companies or universities that are potential suppliers of supporting resources in a given field are those with (1) strong business or academic interests in that field, (2) sufficient funds and other resources to support effective innovation efforts in the field, and (3) the flexibility to make further resource commitments to new research in the field because the entity's resources are not yet committed to other projects.

33. This type of information can be used by innovators in identifying the needed characteristics of a "successful" advance in the context of its projected use.

There may be other reasons why key supporting resources are limited to only a few entities or research groups. Some resources needed for particular types of further research may be controlled by a specific firm or organization. For example, employees of a corporation may have trade secret knowledge accumulated over time that assists persons within the corporation in producing particular types of new patent-eligible advances. This sort of proprietary information provides a capability for further innovation to that firm that will not be available to other parties that might wish to pursue the same type of innovation. This makes the trade secret information a source of scarcity in the production of patent-eligible advances related to the information. In a similar fashion, the possession of specialized physical resources (like certain research tools or testing facilities) that are physically or legally controlled by one company may make that company much more effective in producing successful patent-eligible advances that other competing companies. Exclusive control over these sorts of innovation-facilitating assets is an additional source of scarcity in the production of some patent-eligible inventions.

IV. DECISION-MAKING STRUCTURES GOVERNING ALLOCATIONS OF SCARCE RESEARCH RESOURCES AND THE PRODUCTION OF PATENT-ELIGIBLE INNOVATIONS

The scarcity of resources used as inputs to the production of patent-eligible advances has caused some companies and organizations to implement decision-making mechanisms to ensure full consideration of alternative uses for the same resources before these resources are committed to large and risky innovation projects. The goal of these mechanisms is to project the probable returns from various uses of corporate assets and to allocate available resources to their best use in light of the projected returns. Patent rewards will only increase the allocation of scarce resources to the production of patent-eligible advances if the rewards are large enough to exceed the potential gains available from other uses of the same scarce resources and if the decision-making processes in which these gains are assessed identify the patent rewards as superior.

A. The Importance of Considering Patent Incentives and Resource Allocations at Both Organizational and Individual Levels

In analyzing the forces surrounding the potential impacts of patent rewards on research decisions and the production of patent-eligible advances, it is important to recognize that the decision-making processes, values, and goals of organizational decision makers are highly important and very different from the related decision-making processes, values, and goals of individual inventors who actually make patent-eligible discoveries. The desirability of dual assessments of patent influences at both organizational and individual levels is examined in this subsection.

1. Organizational Innovators

While the romantic image of the lone inventor working in his garage may still control how the public views inventive processes,[34] most modern innovation is conducted in organizational environments with organizations being the primary stakeholders. Corporate and university organizations produce most patented inventions, particularly in technology areas such as pharmaceutical drugs and integrated circuits where large amounts of equipment and other resources are needed to conduct cutting edge research.[35]

a. The Predominance of Corporate Innovators

In most cases, the organizations developing patent-eligible innovations are business corporations of various sizes, with their stakes in the resulting innovations reflected in patent assignment agreements. The patent assignment obligations of corporate employees—typically agreed to by the individuals upon the initiation of their corporate employment—give their corporations ongoing rights to ensure that individual inventors assign their patent rights to the corporate entities. The individual innovators subject to these sorts of patent assignment agreements are usually employees of the corporations working on projects that they planned with managers of their companies. These projects were planned to use substantial corporate resources, to serve corporate commercial

34. Recently, two heroic tales of lone inventors have gained considerable public attention. The widely viewed movie "Touched by Genius" told the story of an individual inventor who developed a design for variable speed windshield wipers and then fought for years to enforce his patents against the automobile companies. *See* Stephen Holden, *An Everyman Inventor Fights the Detroit Goliaths*, N.Y. Times, October 3, 2008, at E14, *available at* http://movies.nytimes.com/2008/10/03/movies/03geni.html. On Broadway, "The Farnsworth Invention", a play written by Oscar and Emmy winner Aaron Sorkin, chronicled the work of a lone inventor who developed the screen scanning technique used in modern television systems and then struggled to enforce his patents against RCA and others. *See* Ben Brantley, *A Farm Boy and a Mogul, and How They Changed the World,* N.Y. Times, December 4, 2007, *available at* http://theater.nytimes.com/2007/12/04/theater/reviews/04farn.html.

35. *See generally* Richard S. Gruner, *Corporate Patents: Optimizing Organizational Responses to Innovation Opportunities and Invention Discoveries,* 10 Marq. Intell. Prop. L. Rev. 1 (2006).

goals, and to result in patent rights for the corporations. In short, innovation in these environments is typically a corporate process from the outset, and is understood to be so by the individual inventors and others who are involved.

These types of corporate processes account for almost all of the inventions covered by United States patents. In 2000, corporations —both domestic and foreign—received 87% of all United States utility patents.[36] These were split about evenly between United States corporations and corporations from the rest of the world. Only 13% of utility patents were received by individual inventors acting on their own behalf.[37]

The dominance of corporate research and patenting is even more complete in certain technology areas. In some fields, corporations account for an extremely high percentage of all patents, with many of the patents held by a very few corporations. This pattern of corporate patenting among a narrow set of firms suggests that only a few companies possess the accumulated expertise or supporting resources needed to be effective in pursuing cutting edge research and producing patent-eligible advances in their fields. In a study of patents issued in the five years from 1997 to 2001, fields in which corporate patenting concentrated in a few firms predominated included research regarding semiconductor device manufacturing processes, electrical connectors, telecommunications, cleaning compounds, and software development, installation, and management.[38]

A somewhat different pattern of corporate research and patenting was present in a few other fields. These fields involved a high percentage of patents issued to corporations in the years from 1997 to 2001, but a substantial number of different corporations were involved.[39] This pattern suggests that corporate fund raising and other corporate processes supporting research were needed for effective research in these fields, but that many corporations were up to these tasks and effective as sources of patent-eligible advances. While this suggests that corporate funding was available to a wide range of researchers, it does not mean that all sources of inventive scarcity were eliminated since the relevant experts with the training and skills needed to produce patent-eligible inventions in particular domains might still have been few. This type of patenting pattern spread across many corporate entities may correspond to the patenting outputs of startup companies or medium sized firms pursuing early stage commercialization of successful innova-

36. *Id.* at 6–7.
37. *Id.*
38. *Id.* at 19.
39. *Id.* at 17.

tions in their fields. This pattern of predominantly corporate patenting spread across many corporations was found in widely divergent technological areas, including the development of refrigeration equipment, bodies and tops of land vehicles, and artificial intelligence.[40]

While the reasons for corporate dominance of innovation in particular fields will vary, there are several generally applicable features of corporate innovators that distinguish them from individual innovators and that give them a potential edge in producing patent-eligible inventions. These include:

> (1) Well established legal and managerial techniques that give corporate organizations abilities to gather, organize, and apply resources to innovation efforts on a superhuman scale;
>
> (2) Securities and financing systems that aid in the funding of corporate innovation projects through investments and loans;
>
> (3) Methods of group knowledge gathering and accumulation in corporate organizations whereby corporations can acquire and develop intellectual property and capital from the efforts of multiple innovators working on numerous projects over time and then use the accumulated bodies of knowledge and intellectual capital as resources to produce additional technological advances;
>
> (4) Established bodies of management expertise (from both inside and outside technology development processes) that can help corporations to organize, conduct, and measure group activities in the pursuit of technological discoveries and the formulation of designs for new products;
>
> (5) Corporate marketing feedback and consumer preference studies that help corporate innovators to understand the needs and desires of users of potential innovations, thereby aiding corporate managers in selecting innovation efforts and in defining innovation project goals; and
>
> (6) Corporate experience derived from past product manufacturing, distribution, and marketing efforts that helps corporate analysts to identify the characteristics of commercially viable products and to better target innovation projects.[41]

40. *Id.*
41. *Id.* at 23–24.

A full account of the dynamics of corporate innovation and the reasons why corporate environments produce so many patented inventions is beyond the scope of this Article. For present purposes, it is sufficient to recognize that most patented inventions emerge from corporate settings. This implies that promised patent rewards, if they are to bring forward more desirable inventions and related public benefits, probably must appeal to and influence the decisions of corporate leaders like those who presently authorize most of the successful efforts to produce patent-eligible inventions and the allocation of corporate personnel and resources to support these efforts.

b. Additional Organizational Innovations from University Sources

University organizations are another important organizational source of patent-eligible advances. Large research universities, like large corporate organizations, are the real parties of interest in most patents emerging from university environments. This is the case because the professors, graduate students, or university employees who are inventors of patented advances in university settings typically are required by the terms of patent assignment agreements they entered into when associating with the universities to assign their patent rights to their universities. While the number of United States utility patents emerging from universities is not large—in recent years, university-owned patents constituted only two percent of all newly-issued United States patents[42]—the advances covered by patents from universities are often particularly important advances derived from breakthroughs in new scientific areas being pursued by university researchers. As a consequence, some university-originated patents control field-defining inventions with particularly significant social and commercial implications. Hence, university-originated patents have significance beyond their numbers. The few patented inventions emerging from university environments are particularly important and the impacts of patents on the directions and scope of university research are correspondingly important.

The project planning and resource allocation processes determining the directions of research projects are somewhat different in university and corporate organizations and the role of patents in these settings may also be different. Top researchers in university environments tend to pick their research directions based on academic interests and the potential of research projects to produce new scientific discoveries. However, prospects for patenting research results may still affect the support that these university

42. *See id.* at 6–7.

researchers receive. In university settings, top researchers benefit from research surroundings that include other highly-trained colleagues, state-of-the-art research facilities, supporting researchers (often involving graduate students working under the primary researchers), and administrative support staffs to organize resources and research processes. These substantial university resources tend to be allocated carefully among research groups and projects. The social utility and commercial potential of practical applications of various types of pure scientific research are common considerations in the allocation of scarce university resources such as staff, equipment, laboratory space, and funds. The commercial potential of research offshoots may also reshape research targets to include more practical applications or cause researchers initially interested in pure science research to extend their results to include additional practical discoveries suitable for patenting. In some settings, funding partnerships between universities and major corporations make the universities direct stakeholders in commercially-targeted research, with an increase in the importance of commerce-facilitating patents accordingly.

Former boundaries and decision-making differences between corporate and university research environments have been breaking down in recent years. University researchers—recognizing the enormous demands of conducting research in certain domains requiring expensive equipment or research programs—have focused their research on areas with clear commercial potential and formed partnerships with private firms to support that type of research. One simple way to accomplish this has been to include university scientists as co-owners and managers of businesses that pick and fund research to be performed in university environments. This was the business structure used by Genentech and Biogen, two biotechnology companies that funded and then commercially benefitted from university research in early stages of recombinant DNA research. Looking backwards at 20 years of Biogen activities, Kenneth Murray, one of the company's founders and a key researcher who produced some of the company's most valuable patents, described the perceived coherence of academic interests and business objectives underlying Biogen's activities:

> A combination of synergistic discoveries in basic biological science over the preceding few years had opened up a range of new possibilities, . . . which were so intrinsically exciting that they would have been pursued enthusiastically in our academic departments anyway. That they were of interest as potential projects for commercial development was an added bonus which did not generate conflicts between Bio-

> gen's interests and our academic activities, but gave impetus to our research by bringing together academic groups that might otherwise have been competitors.[43]

2. Individual Innovators

While incentives for organizations to pursue innovation are probably the most important influences on patent-eligible advances, the incentives motivating individual inventors to pursue such inventions are highly important as well. In order for patents to increase the production of patent-eligible advances, individual scientists and engineers must be motivated to engage in research with a sufficiently practical focus to produce patent-eligible innovations. They must be further motivated to file for patents on these inventions since, under United States patent laws, only an individual inventor (or a group of individuals working on the same invention) can apply for a patent.[44] Corporate interests in patents must be acquired by assignments from individual inventors once the individuals have received their rights, although a commitment to make such an assignment may be made by contract before the rights are actually in existence.[45]

Since corporations are the primary stake holders in patents arising out of corporate research (due to the employment terms and patent assignment agreements already discussed in this Article), companies have strong interests in obtaining enforceable patents concerning successful research results produced through corporate resources and personnel. The same can be said for university organizations regarding innovations produced by professors and other university employees. However, these organizational goals can only be achieved if the organizations pass down incentives to their employees both to produce patent-eligible advances and to follow through with the patent applications needed to obtain patents. Hence, corporate and university organizations have reasons to create pass-down incentives for key innovators that will encourage the innovators to pursue patent-eligible advances.

These incentives from corporations or universities to their researchers are typically specified in patent policies for the organizations. The incentives will vary from organization to organization and sometimes from researcher to researcher. The objective of

---

43. Peter Hans Hofschneider & Kenneth Murray, *Combining Science and Business: From Recombinant DNA to Vaccines Against Hepatitis B Virus*, *in* Recombinant Protein Drugs 43, 60 (P. Buckel ed., 2001).

44. *See* 35 U.S.C. § 116 (2006).

45. 35 U.S.C. § 261 (2006) ("Applications for patent, patents, or any interest therein, shall be assignable in law by an instrument in writing.").

these tailored incentives passed down to individual innovators is to encourage the researchers to devote diligent efforts towards the discovery of patent-eligible advances, while retaining to the organizations involved the bulk of the commercial advantages associated with the resulting advances and patents.

Corporations and universities achieve various patent-influenced rewards for their employees through contract-based bonus and profit sharing arrangements that give innovators and their corporate employers shared interests in the commercial success of patented inventions. The nature of the contract-based bonuses and arrangements can be matched to the desires and risk preferences of different employees, potentially resulting in a wide spectrum of reward systems inside corporations and universities regarding patent-eligible advances. These reward systems are not, strictly speaking, established by patent laws, but are instead derived from those laws and the advantages that the organizations can achieve through patent rewards. Corporate and university organizations—the primary reward recipients under present innovation and patent assignment processes—carve up their rewards and share them under various reward structures with their constituent researchers.

Gordon Matthews, chief patent officer at Forgent Networks, has described how that company linked patent rights and incentives for key employees. As part of the Forgent's "strategic patent program" (which included licensing efforts forcing Sony Corporation to pay millions of dollars in royalties), Forgent offered bonuses to employees for ideas they could patent. According to Matthews:

> For us, the [strategic patent program] is not just a way to create a portfolio of meaningful patents. It's also a way to attract and retain world-class employees. If employees know there will be a payoff later for ideas they come up with today, they're likely to stay around.[46]

This type of reward sharing and restructuring for employees can create highly complex and effective combinations of rewards at the individual level encouraging the production of patent-eligible innovations by teams of diverse types of workers, while at the same time shielding individuals from bearing the full risks of project failures. Corporations commit the supporting resources (including researchers' salaries) and thereby bear the full risks of project failures while providing the individuals with salaries and other constant forms of compensation that do not depend fully on the suc-

46. Mark Hachman, *Update: Forgent Claims Rights To JPEG Patent*, ExtremeTech (July 18, 2002, 6:17 PM), http://www.extremetech.com/extreme/51590-update-forgent-claims-rights-to-jpeg-patent.

cess of the projects they work on. These sorts of compensation schemes (involving blends of constant salaries and success-related bonuses) can match the compensation and incentive schemes presented to individual innovators to the risk and reward preferences of those individuals, achieving attractive inducements for participation in innovation efforts by even the most risk adverse innovators.

B. Organizational Mechanisms for Allocating Scarce Resources: Internal Substitutes for External Investment Markets

As part of broader developments in corporate performance management and budgeting systems,[47] many large companies have adopted budgeting and financial monitoring practices that place tight controls on spending and asset commitments of the scale needed for many modern technology development projects. The aim of many of these mechanisms is to create internal equivalents of external capital markets. External capital markets provide potential investors with choices about how to invest funds and with information aiding investors in making decisions about where to invest funds. Corporate internal institutions that serve as counterparts to external markets help business managers to structure and inform resource allocation decisions. These internal institutions are used to allocate investments of resources within companies to alternative projects and future courses of conduct with varying types of corporate risks and potential returns.[48] As George G. Triantis has noted:

> Internal capital markets permit capital to move between projects; in the language of real options, they enhance the value of "switching options," or the ability to delay a capital allocation decision until more information becomes available. The distinction between external and internal capital markets is that capital moves between projects by contract in the former case and by authority or fiat in the latter.[49]
>
> . . .
>
> An internal capital market permits the reallocation of capital between projects at a lower cost than through external capital markets because project managers possess expertise

47. *See generally* Kenneth A. Merchant, *The Design of the Corporate Budgeting System: Influences on Managerial Behavior,* 56 Accounting Review 813 (October 1981) (investigating corporate-level budgeting systems).

48. *See generally* George G. Triantis, *Organizations as Internal Capital Markets: The Legal Boundaries of Firms, Collateral, and Trusts in Commercial and Charitable Enterprises,* 117 Harv. L. Rev. 1102, 1103 (2004) (describing how corporations set up internal budgeting and management practices that establish internal equivalents of external capital markets).

49. *Id.* at 1105.

> and private information that cannot be efficiently communicated to outside investors.[50]

These sorts of internal capital markets can be particularly effective in managing new technology development projects. Because they have private information about the capabilities of corporate operating units and the potential value of new innovations when used or produced in the context of existing corporate activities, corporate managers allocating resources to innovative activities through internal capital allocation mechanisms can often produce much more efficient targeting than external investment processes or other financing mechanisms.

As they make decisions about whether to develop new technologies and how many resources to devote to particular projects, corporations can marshal considerable amounts of internal information to tailor the scope and timing of backing for innovation efforts. Information aiding in these decisions will include proprietary information collected over time through technological development and product marketing efforts in the same field, as well as new information generated through preliminary project and marketing assessments conducted specifically to inform decisions about whether new projects will be worthwhile and have superior projected returns to other potential corporate uses of the same project resources.

Decisions about how to allocate corporate resources do not simply involve choices between one research project and another, but rather between many different ways that a company may use its available resources to produce profits and advance corporate interests. Often, non-innovative activities will be strong competitors to the possibility of pursuing new innovation projects. As several commentators (including this author) have noted elsewhere:

> Internal capital markets can be means for firms to allocate resources between innovative and non-innovative profit-making activities. For example, a corporation may choose to allocate $1,000,000 to the development of new products or to the enhancement of marketing efforts for existing products, whichever is predicted to produce the most additional corporate profits per dollar spent. Similarly, within the range of available innovation efforts, corporate decision processes implementing internal capital markets can evaluate backing for alternative innovation efforts based on their perceived profit potential.[51]

---

50. *Id.* at 1109.

51. Richard S. Gruner, Shubha Ghosh & Jay Kesan, Intellectual Property in Business Organizations: Cases and Materials 790 (2005).

In these profitability assessments, the availability and effectiveness of intellectual property protections for discoveries will be central considerations in projecting potential corporate returns from innovation projects. Absent intellectual property protections for new technologies—particularly patent rights—companies will worry that new technology development projects will simply aid competitors who will be free to adopt any resulting technologies without being forced to share in the development costs. The technology originator will need to match the prices of competitors once the latter are in the market, potentially driving the prices of products based on the new technology to just over the marginal cost of producing units of the products, thereby leaving the technology originator with few if any means to recoup its technology development costs. This sort of estimation of profits in the absence of patent rights will suggest that new technology innovation will not be substantially profitable and few new projects would be likely in the face of these dismal economics.

Patent rights (and the patent-influenced product prices they enable) change the economics of these sorts of situations. Patents give innovators means to charge more for patented advances and to reap greater returns on innovation investments accordingly. However, even with the greater returns implied by the availability of patents, the patent-influenced profits projected for the results of an innovation project must still exceed the returns that corporate managers expect from other possible uses of resources in order for the innovation project to appear most desirable and to win the allocation of corporate resources in closely administered decision processes.

The institution of carefully conducted corporate processes for considering resource allocation alternatives and for allocating resources based on corporate profitability projections ensures that patent rights and their commercial implications are central concerns in the allocation of major resources to many corporate innovation projects. The frequent availability of other corporate uses for resources needed for innovation (and the often strong advocacy of those alternative uses by persons with stakes in expanding non-innovative corporate activities such as product marketing) mean that patent rights and other sources of commercial gains from innovation projects must present a highly compelling case for the initiation and continuation of such projects in the face of strong internal competition for the same resources.

Increasing resource demands for research in particular fields like biotechnology and drug development suggest that rivalrous contention for the necessary resources will only grow more intense. As the needs for resources to be effective researchers grows in these fields, management processes and fact finding efforts that support decisions about resource allocations are also likely to become more elaborate and demanding.

Hence, in the corporate settings that generate most patent-eligible advances, patents are highly important factors in intensely rivalrous resource allocations. Patents and the project values they imply shape decision alternatives amidst the continuous internal management processes where patent-eligible invention development projects must compete for funding with other corporate projects of merit.

C. Implications of Tight Organizational Management of Resource Allocations for the Production of Patent-Eligible Advances

Confronted with resource allocation choices between the pursuit of patent-eligible inventions or some other profit-producing activity, what sorts of factors will organizational managers and innovators tend to consider in deciding whether to initiate or continue projects aimed at patent-eligible advances? And how will patent rewards influence these considerations? Some of the most important of the probable considerations are summarized in this subsection. For simplicity, the more common case of corporate decision making about innovation projects is considered here; similar considerations will apply to parallel decision making in university settings, although non-economic factors such as academic reputations and other non-monetary career rewards will doubtless alter some of the decision dynamics in university settings.

1. Recovering Development Costs During the Life of a Patent

An organization considering a project to develop a patentable advance will wish, at minimum, to recover its costs of development so that the project has at least some projected net positive returns. Once a patent issues, the period during which a party can recover all development costs through patent-influenced rewards may be very brief. The path to obtaining substantial patent-influenced profits or royalties is a long one. That path includes a patent application being drafted, submitted, and fully examined, a patent being issued, a patent-protected product being brought into production, and sales of the product reaching substantial levels. Therefore, by the time patent-influenced profits or royalties are first obtained in substantial amounts, most or all of the 20 year duration of patent rights (as measured from the date of filing of the relevant patent application) may have passed.[52] The window for obtaining patent-influenced profits from an invention may only be a few years.

Later profits from a product after a patent expires may not contribute much to the recovery of development costs. Once a patent expires and anyone can produce the formerly patent-protected product, the price for the product is likely to drop significantly under conditions of full competition to a price just over the marginal production cost for each unit of the product. Competing producers—who did not share the invention development costs and who can therefore obtain net profits at much lower price levels than the original innovator—will tend to price their competing products at just above the marginal production cost of each product sold. While the former patent holder may be able to drop its price as well to meet this competition and obtain a small profit on each unit sold, this profit will be very small due to the pressures of competitors who can profitably sell the product at a price just over the amount of production costs.

Such low profits will probably not contribute much to the recovery of the original technology development costs and first-time product commercialization costs that only the product developer and introducer will bear. Hence, the patent-enforcement period in which the patent holder is the sole legitimate producer of the patented item (or controls who is a legitimate producer through patent licensing) is the period in which most of the development costs must be recovered and the primary return on the patented advance must be achieved. Substantial patent rewards collected during this limited period may be needed to cover the often considerable development costs of a given innovation.

2. Offsetting Reward Discounting for Projected Invention Failures

Another reason why high levels of patent rewards are sought by corporate managers for those few projects that produce commercially successful inventions is that these rewards must be large enough to persuade innovators to proceed with particular projects aimed at patent-eligible inventions despite the probability that many such projects will fail. A project aimed at developing patent-eligible inventions may fail for many reasons, causing the project to not produce any useful discoveries or to produce only discoveries that do not translate into commercially successful products. Corporate managers contemplating the initiation or continuation of a

52. Under current patent law standards, patent rights normally continue for 20 years after the date of filing of a patent application that leads to an issued patent. *See* 35 U.S.C. § 154(a)(2) (2000).

particular project will be influenced by both the size of potential patent-influenced rewards for a successful outcome and the likelihood of obtaining those rewards. The managers will tend to discount the patent-influenced revenues projected for a commercially successful innovation to reflect the substantial risk that the project will be a technological or commercial failure and that no gains will result at all. Analysts will take the possibility of failure into account by multiplying the projected commercial gains from a successful project by the fractional probability of success (which will equal one minus the probability of failure), thereby discounting or reducing the estimated value of the projected rewards.

While precise probabilities of failure will not be available for technology development projects in rapidly changing fields, some roughly accurate estimates of chances of failures and associated discounting of project payoffs will doubtless still influence project payoff projections and diminish the perceived rewards from patent protections. Even after this discounting and reduction of projected patent rewards, these projected rewards must attract the attention of corporate managers and persuade the managers that patent-eligible invention development is the best organizational course in order for patent rights to have a significant impact on the magnitude and focus of corporate research. Absent this level of patent rewards, such rewards are unlikely to direct organization actions towards projects potentially producing patent-eligible advances given the availability of other attractive corporate uses of the same project resources.

An innovation project may fail due to a variety of technological or business problems at various project stages that bar the development and sale of commercially successful products. Resources and labor invested in the pursuit of a patented innovation may be lost because no useful technology is found. Alternatively, a useful technology may be found, but no patent may be obtained because others have disclosed a similar innovation previously. Or a patent may be obtained, but no commercially successful product may result from the patented technology due to problems in designing, manufacturing, or marketing a successful product. These several types of project failures correspond to different sources of uncertainty that all reduce the likelihood and value of projected patent rewards.

3. Offsetting Further Reward Discounting for Collection Delays

Anticipated delays between outlays for invention development and collections of potential patent rewards will cause the projected rewards to be further discounted due to the time value of money.

While the costs of innovation contemplated by a potential innovator are concrete and immediate, the potential rewards from patent-mediated commercial transactions must wait for the introduction of related products and the achievement of market success or wait for the payment of licensing royalties over the life of a licensing agreement. Patent rewards must be large enough to encourage innovation despite this dichotomy of immediate, relatively certain costs and distant, uncertain rewards.

The potential impacts of product research and perfection costs, coupled with delays in obtaining related profits, were described in the context of the development of hepatitis B vaccines as follows:

> Biogen's research on [the hepatitis B vaccine] HBV began in 1978, and that of others around the same time, and it was almost ten years later that vaccines based upon recombinant DNA technology were introduced to the market. The very extensive and thorough clinical trial [needed to market these vaccines], which represents a late stage in the drug development process, provides a good illustration of significant components of the development time and costs, in addition to production facilities. For a newly formed organization such a development prospect is formidable, but the long time lag between the initial fees of a licensing agreement and the beginning of a royalty income stream can also generate severe problems, sometimes putting the survival of the company at risk.[53]

Hence, even when the prospects of future patent rewards are good, delays in receiving the rewards will create serious gaps in corporate funding and will reduce the value of the rewards due to the time value of money.

The time value of money will be a factor in additionally discounting the present value of patent rewards because these rewards will typically be realized through patent-influenced income gained over time.[54] The time value of money in this context is essentially the return that the company involved forgoes by not putting its invention development resources to other uses. To be attractive and draw corporate support for the development of patent-eligible inventions, patent rewards must assure companies that they are

53. Hofschneider, *supra* note 43, at 55.

54. The gains associated with patents will be realized well after the point when invention development costs are incurred, often in the last few years that a patent remains enforceable. This tends to be the case because it takes this long to produce commercially important products covered by the patent. The net present value of a future income stream related to patent rights will be reduced by the time value of money, even if the income stream is assumed to be certain to be received.

likely to receive superior economic rewards from the development of such inventions despite the often substantial gap between project expenditures and associated patent-mediated rewards and the discounting of the rewards due to the time value of money during this delay.

4. Trumping Gains from Alternative Projects

Finally—and perhaps most importantly—anticipated patent rewards (discounted in the ways discussed above) must still trump the anticipated gains from other uses of the same resources if the rewards are to influence corporate decisions and to draw corporate resources towards projects aimed at producing patent-eligible innovations. Patent rewards must ensure projects aimed at patent-eligible innovations are not only attractive, but compellingly attractive relative to the next best alternative. To do this, innovation projects must have projected patent rewards that are not just positive (after the subtraction of invention costs and discounting for the factors mentioned in this section), but that trump the gains that innovators could produce from their second best alternatives.

Of course, if the returns anticipated on an innovation project are at least somewhat positive—that is, the gains appear greater to potential innovators than the anticipated costs of the project—there is a chance that some innovator might eventually find the net projected gains to be attractive and choose to pursue the project. This logic might suggest that all we need to do to ensure adequate innovation is to provide patent rewards at sufficient levels to offset and slightly exceed the costs of innovation projects (perhaps as increased further to account for the costs of failed projects). Several commentators have suggested that patent rewards would be sufficiently high to encourage the development of patent-eligible innovations if the patent system simply ensured that a party producing a patentable innovation was able to recoup his or her innovation development costs.[55]

This analysis assumes, however, the availability of a large number of potential innovators who have few alternative projects potentially leading to positive returns for their investments of time and resources. Marginally profitable patent rewards would only draw innovators and resources to work on patent-eligible inventions if there were numerous capable parties waiting to take on such work in exchange for the small profits that this weakly rewarding version of the patent system would provide. This ignores the fact that the

55. *See, e.g.,* Mark A. Lemley, *Property, Intellectual Property, and Free Riding*, 83 Tex. L. Rev. 1031, 1033–46 (2005) (arguing that the patent system need not allow inventors to capture the full social value of their inventions).

patent system operates in conditions of scarcity. The nature of patent-eligible inventions implies that there are often only a few persons and institutions that are capable of the insights and endeavors that will lead to patent-eligible inventions. Since innovations qualifying for patents must reflect nonobvious design insights not held by most parties working in the fields of the innovations,[56] innovators with the rare insights needed to produce patentable innovations will be few in number by definition. If these rare persons with the right capabilities to produce patent-eligible advances find better things to do with their time and resources than to just recoup the costs of their development expenses and a small profit upon the production of a successful innovation, the activities of these essential and rare parties and entities are likely to be diverted away from work on patent-eligible advances. This means that weak patent rewards sufficient only to recoup invention development costs risk a substantial reduction in work on patent-eligible advances, resulting in lower numbers of realized advances and reduced benefits to the public.

V. The Desirability of Patent Rewards Approximating and Signaling Consumer Values and Preferences for Innovations

Patent rewards that reflect the value to consumers of various inventions can be valuable means to attract and prioritize the attention of rare innovators and institutions with exceptional, nonobvious design insights and research resources and to encourage them to devote time and resources to the production of patentable innovations of high value to the public. If the patent-influenced gains anticipated by innovators are linked to the utility gains that users realize from inventions, the innovations with the most value to invention users will also tend to be seen by corporate managers as the most valuable targets of innovation projects. These sorts of projects will top the interest rankings and corporate work agendas of those few innovators capable of producing atypical, nonobvious innovations in their fields. Absent patent rewards tracking consumer preferences and utility gains, these key innovators might be assigned by their companies to pursue other activities of greater profit to their companies, but less substantial benefit to the public. By diverging the private rewards and public benefits associated with innovations, a patent reward scheme providing for patent rewards that are substantially less than consumer utility gains from inventions risks the possibility that projects having major benefits to the public will never be the most attractive options for the few par-

56. *See* 103 U.S.C. § 103 (2006).

ties who are capable of pursuing the advances and will therefore never be undertaken.

This discussion treats patent rewards as a means of signaling the nature and importance of consumer preferences for new innovations to potential innovators. Projected patent rewards will be large enough to achieve this signaling if a potential organization considering whether to pursue a project aimed at the development of a patent-eligible invention is promised patent rewards for a successful invention that are roughly equal to the new value for users achieved by the advance. This new value will equal the increased value from the use of the advance relative to the value of using other existing devices or processes that serve the same purposes. I refer to this level of patent rewards measured from invention user utility as "full utility rewards" in this Article.[57]

Full utility patent rewards are an ideal that will not be fully realized for a number of reasons. It is clear that rewards to patent holders will diverge downward from full utility rewards due to a

57. Patent holders' means for gaining these rewards will depend on how they utilize their patent rights. In particular, the sources of rewards will depend on whether a patent holder makes and sells a patented innovation, licenses others to do so, or just sues defendants for patent infringement. However, regardless of the means patent holders use to control their patented inventions, returns to patent holders from commercializing inventions will tend to be limited to gains at or below the increased utility perceived by users of those inventions over the utility associated with non-patented substitutes that can be adopted by consumers without compensation to patent holders.

For a patent holder that makes and sells a patented innovation, the incremental price that the seller can charge for the patented innovation over the prices charged for non-patented substitutes will be limited by the incremental utility achieved by the patented version. Rational buyers will not pay more for the patented item over the prices for the non-patented substitutes than the buyers will gain in increased utility.

Likewise, royalties that parties will pay to make and sell the patented innovation will be limited by the amounts that these parties can realize from such sales, which will in turn be limited by the increased utility of the patented innovation as perceived by users.

Finally, the damages paid by infringers will often be measured by a "reasonable royalty" formula that takes into account the same limits on royalties that shape actual royalty negotiations. This will be the case because courts have tended to consider a reasonable royalty to be the royalty amount that would have resulted from a hypothetical negotiation between a willing licensor and licensee. *See Hanson v. Alpine Valley Ski Area, Inc*., 718 F.2d 1075, 1078 (Fed. Cir. 1983) ("If actual damages cannot be ascertained, then a reasonable royalty must be determined"; a reasonable royalty should be based on an established royalty rate, if there is one, or upon the projected result of a hypothetical negotiation between the plaintiff and defendant acting as a willing licensor and licensee). The outcome of this type of hypothetical negotiation would presumably be influenced by the unwillingness of a reasonable licensee to pay more in royalties than the value of the incremental utility the licensee could ultimately hope to recoup though use or sales of the patented item.

number of unavoidable problems in administering full utility patent rewards. Reasons why patent holders will typically not be compensated for the full incremental utility created by their works (even during the term of their patents) include difficulties in locating all users of a patented invention, characterizing the value of the increased utility being realized by each user, and ensuring that payments are made to a patent holder in an amount roughly equal to the value of an invention user's enhanced utility. The administrative costs and inefficiencies of steps like these ensure some measure of undercompensation to patent holders. Consequently, the payment of full utility level patent rewards is an aspirational goal that will never be fully realized.

Furthermore, patent holders themselves usually wish to forego collecting some measure of the full utility gained by users of their inventions to ensure that the users of the inventions see some advantages in discontinuing their old practices and adopting the new inventions. Absent this type of sharing of new utility benefits from inventions, potential users of new inventions would see little reason to incur the learning and transition costs of shifting from older, non-patented devices to new patented ones. The gains of making this change must be partially shared with the users to give them a stake in making the change, which means that patent holders cannot expect to collect full utility patent rewards if they want their inventions to be adopted.

Even if a patent holder captures most of the incremental utility associated with a patented invention during the life of a patent, the limited duration of the patent holder's recoveries at these levels guarantees that society will, over time, see a net gain from the patented invention. Should full utility patent rewards to innovators cause users of patented inventions to realize only a few net gains during the life of a patent,[58] users will still typically realize additional gains from the patented invention when the invention goes off patent and is freely available. Hence, as patent rewards encourage increased numbers and types of inventions, long-term net gains to users from these inventions will be assured by the expiration of patents on those innovations and the free availability of the innovations at that time. Even if most of the gains from the new inventions go to the inventors prior to this point, all of the gains will go to users of the inventions after this point.

58. Of course, if they are given no net gains during the life of the patent, potential users of the patented innovation are unlikely to adopt it. Hence, even during the life of the patent and patent controls over the patented innovation, the gains realized through use of the patented innovation will probably need to be split between users and the patent holder in order for the patented innovation to gain meaningful adoptions and for the patent holder to gain anything.

For simplicity, this Article uses the term "full utility patent rewards" to refer to practically implemented patent rewards targeted at or near full utility levels, taking into account the transaction costs and inefficiencies of administering such a system and the further marketing forces that may cause patent holders to voluntarily forego some amount of such rewards to ensure invention acceptance and adoption. The cautionary point that full utility patent rewards include patent-influenced payoffs to patent holders at levels approximating utility gains by invention users, but limited and reduced by transaction costs and the scope of reasonable patent enforcement measures is not repeated in this Article every time the term "full utility patent rewards" is used, but should be presumed by the reader.

Rewards that reflect as near as possible the full added utility of a new invention to its users will structure the decisions of key innovators about where to spend their time in accordance with the relative utility and importance of innovations to the public. Hence, invention ranking and consumer interest signaling through full utility patent rewards can implement an innovation system economizing on the rare, yet essential skills and efforts of those few innovators and companies that are capable of producing nonobvious, patent-eligible innovations.

VI. ILLUSTRATING THE POTENTIAL PRIORITIZING IMPACTS OF PATENT REWARDS IN CORPORATE ORGANIZATIONS: SOME TYPICAL ACTIVITY CHOICES FACING HIGHLY TALENTED INNOVATORS AND THEIR BACKING ORGANIZATIONS

A. Corporate Allocations of Innovation Resources in the Face of Potential Patent Rewards

An example of an organization's typical alternatives in deciding how to allocate the time and efforts of a key researcher and how to apply related funding will illustrate the importance of structuring these sorts of decisions under the influence of patent rewards. The shifts in organizational value placed on various alternatives with the addition of substantial patent rewards provide concrete indications of the potential resource allocation advantages of patent rewards set at or near full utility levels.

If patent rewards at full utility levels are not attainable and actual patent rewards perceived by companies are significantly lower, the insights reached in the following discussion will only be strengthened, not diminished in importance. The following discussion illustrates why key innovators may be directed away from the pursuit of patent-eligible advances even in the face of patent rewards at full utility levels. If this extreme case does not hold and actual patent rewards are at rates below full utility levels, then key innovators will be even less likely to be directed by corporate managers towards the pursuit of patent-eligible advances.

The activities and projected values presented here involve hypothetical situations, but nonetheless reflect typical activities in corporate environments. The resource allocation decisions analyzed here are representative (in simplified form) of the types of activity choices and implications facing corporate managers who control the work activities of highly talented engineers and scientists and the allocation of corporate resources to support these individuals. For simplicity, it is assumed that the individual innovator discussed here is employed by a large corporation and that this individual has rare knowledge and innovative ability making him capable of realizing nonobvious innovations that may be patentable. This means that the decisions by corporate managers about the work activities to be pursued by this innovator will be influenced in part by the patent-eligible advances and patent rights that activities of the innovator may produce.

Imagine a researcher who is well versed in the latest electronic communications technologies used in cell phone applications and who works for a company that supplies cell phone equipment. The researcher and managers of his corporate employer who determine where the researcher will focus his work are considering the following alternatives for his next round of efforts.

(1) *Non-Innovative Activity:* One potentially productive use of this individual's time is to not innovate at all, but rather to apply his efforts to non-innovative activities that will enhance the value of his past innovations. He can, for example, spend time aiding in the commercialization of his past work (perhaps by working with a marketing team to better describe or demonstrate products based on his past designs). Such efforts will have fairly predictable gains to his employer since they will involve no new technological risks and will entail repetitions of marketing processes that are familiar to the employer. Let us assume that these activities are seen as having a high likelihood (80%) of success and that they will, if successful, add about $500,000 to the company's profits. The projected value of these efforts by the researcher is about $500,000 times .80 or $400,000.

(2) *Innovative Activity with Largely Unprotectable Results:* A second type of project that the researcher could work on involves efforts to make product design improvements to previous product designs. This type of reengineering project will, if successful, produce design elements that will increase the marketability of the company's

products, but that will be unpatentable and freely copyable by other providers of similar cell phone equipment. Hence, it is expected that any gains that the company realizes from this project in increased product sales and revenues will probably be temporary. The project involves fairly well known engineering principles leading to a high likelihood of success. The company estimates that the project has an 80% likelihood of producing new product features which will gain the company new sales revenues. However, since these heightened revenues are expected to last only for a short time until other companies can copy the same product features, the enhance revenues are estimated at only $1 million, giving the project an overall projected estimated value of $800,000.

(3) *New Design Activities Building on Patented Advances Without Further Protectable Innovations:* The same individual can also work on new product designs that will incorporate his prior patented designs into additional products to be marketed by the company. The new product designs are unlikely to include newly patentable product features. However, the new products are valuable to the company in expanding its product line (and in fully realizing the commercial value of the individual's prior, patented designs). The new products will incorporate the prior patented design features and, while not newly patentable themselves, will not be freely copyable by competitors for the remaining life of the earlier patents, which implies at least a few years of market exclusivity. The design efforts envisioned in this project have some likelihood of engineering failures and the resulting products may not succeed in the marketplace. Taking these both into account, the efforts are seen as having a 30% chance of adding $10 million to the company's profits. This means that this course of action has a projected value of about $3 million.

(4) *New Design Activities Likely to Produce Patentable Advances With Modest User Utility:* The individual in question could also begin work on a new design project which utilizes electronic communication design approaches that are not widely shared in the industry and that are likely to produce nonobvious, patentable advances if successful designs can be formulated. The new designs, if successful, will only be appropriate for products used in a small market segment corresponding to a small total amount of increased user utility. Even if full utility rewards from patent controls are assumed, the limited market for the goods related to this innovation project implies that the company could, with a successful new design, at most realize $50 million from the products related to this project (assuming that there are no impediments to producing the new products, such as unlicensed patents of other parties). The project still involves some speculative steps in developing the targeted new

designs, leading to substantial technical uncertainty about the likelihood of success of the project. These sources of risks of technological failure, when coupled with the marketing uncertainty of introducing a new product based on the projected new technology, implies that there is only a 5% chance that the company will be able to achieve the types of incremental revenues mentioned above. This implies that the projected value of this type of innovation project is only about $2.5 million.

(5) *New Design Activities Likely to Produce Patentable Advances With Extensive User Utility:* Finally, the individual in question has the opportunity to develop a second type of new technology based on exceptional, nonobvious design insights that are, if successful, projected to have widespread consumer applications and extensive invention user utility beyond non-patented substitutes. Because of the high amounts that each user will probably be willing to pay for access to products based on this new and functionally distinctive technology and the large number of users who will probably be willing to pay these amounts, the company projects that products based on the new technology will highly profitable. The company estimates that these products will generate $100 million for the company if offered for sale under patent controls (again assuming that there are no impediments to producing the new products such as unlicensed patents of others). However, these sorts of revenues will only be realized if the projected technology can be successfully developed and related products brought to market. There are still significant technological challenges in developing useful products of this sort and commercializing them, such that the company only sees a five percent chance of producing profitable products from this project. This means that the project has an expected value of $5 million to the company, largely because of the substantial consumer value associated with the products incorporating the anticipated technology and the ability of the company to capture most of this consumer value through patent rights.

B. Impacts of Full Utility Patent Rewards in Shaping Innovator Activity Choices

These comparative views of the importance of patent controls in structuring the private value of project alternatives illustrates why full utility patent rewards are desirable influences on corporate decisions about resource allocation alternatives. The promise of these rewards will capture the attention of potential innovators (or the attention of company executives, who in effect set the activity agendas of employee innovators) in several desirable ways.

Full utility patent rewards may be needed in some circumstances to draw innovators with key design insights towards the production of nonobvious, patentable designs rather than toward work on minimally innovative projects such as extensions of prior designs or products. Designers of innovations and their companies will have other profitable courses of conduct available, with compensation for the alternative activities that competes with rewards from desirable innovations. Absent full utility patent rewards—if, for example, patent rewards were set at levels at or just above innovation development costs—invention alternatives like those in scenarios (4) and (5) leading to socially desirable innovations might receive little attention from parties deciding how to devote limited innovation talent and resources. Attempts to pursue risky projects like these might be seen as less profitable and attractive than surer bets on increased marketing of existing products or modest but predictably successful extensions of existing products.

Full utility patent rewards can also serve a valuable role in mediating choices between projects where two or more projects seem likely to lead to patentable innovations. The projects with the greatest usefulness to consumers will also be seen as the ones with the greatest private rewards to innovators. The choice between alternatives (4) and (5) above is heavily influenced by the size of the aggregate consumer value attributed to the two types of advances at issue, as signaled to individual innovators and corporate managers by the promise of full utility patent rewards. In short, this type of patent reward ensures that individual or corporate decision makers see the value and desirability of technology innovation choices with the same relative merit that consumers do, leading to decisions by the innovators that will generally track consumer value preferences.

VII. CONCRETE ILLUSTRATIONS: FOUR EXAMPLES OF PATENTS AT WORK IN ALLOCATING SCARCE RESOURCES TO VALUABLE INNOVATION PROJECTS

This section profiles several examples of how the promise of patent protection has influenced project initiation and resource allocation decisions in projects leading to some of our most significant inventions in recent decades. The four projects profiled each represent categories of research that are common sources of important inventions. These include (1) an established corporation with research aimed at augmenting existing products and technology strengths (Monsanto), (2) a newer but still well-established company aimed at exploring and commercializing a promising new type of technology (Cetus), (3) a university research lab augmented by commercially targeted research funding (Sir Kenneth Murray's lab at the University of Edinburgh, conducting research funded in part by Biogen), and (4) a lone inventor augmented by a startup company (Julio Palmaz). The scarcity of the personnel and supporting resources involved in these projects, as well as the roles that patents played in assembling and allocating these resources, are profiled in this section.

A. The Projects Profiled

The projects profiled here all led to patents identified by IP Worldwide magazine as among "10 Patents that Changed the World."[59] The patents reflect recent advances[60] with major social impacts. According to the magazine, "[i]nstead of picking patents that have made big bucks, the editors [of IP Worldwide] picked patents that have made a big difference—shaking up society for better or worse."[61] These are, in short, examples of patents and associated research projects with major social impacts.

All of the research in these diverse projects was fundamentally influenced and redirected by patents and the commercial opportunities that patents implied. The influences of patents were felt at different stages of these projects, in some instances helping researchers to target what they would work on, in other instances justifying continuing projects despite early stage failures, and in further instances providing the funding for critical steps in product perfection and testing. These influences are briefly profiled here to illustrate several typical ways that patents can influence research commitments and decisions.

Taken together, the technology development processes described here illustrate why patent influences are important (and perhaps essential) tools in promoting and completing work on many types of socially important advances. While the research results achieved by these projects are definitely not typical—these are among the most significant technological advances of our time—the technology development processes that led to these advances and the impacts of patents on these processes are typical and serve to illustrate why we need to view patent-influenced environments as highly rivalrous settings.

It is hard to imagine any of the important advances described here resulting without the lure of patent-influenced commercial

59. Alan Cohen, *10 Patents That Changed the World*, Intell. Prop. Worldwide, Aug. 2002, at 27 (describing the ten patents as covering inventions "that have made a big difference—shaking up society for better or worse").

60. All of the patents selected by IP Worldwide were issued between 1985 and 2001 and reflected inventions made in the 1980s and 1990s. *Id.*

61. *Id.*

rewards, for reasons that are described in the project profiles that follow. These are, simply, cases where patents mattered and where patents brought critically needed resources to the service of highly valuable technology development. The loss of advances like these is the price we would pay for a weaker patent system and lesser patent rewards.

B. Analyzing Patent Influences at Individual and Organizational Levels

The accounts that follow focus on the scarcity of research resources at both individual and organizational levels and the probable impacts of patents in drawing these resources together in the projects leading to the patented advances under scrutiny.

For the individuals involved in these accounts, the probable scarcity of their knowledge and skills can be roughly gauged from their extensive educational backgrounds and their abilities to realize scarcely achieved accomplishments and achievements in the remainder of their careers. Patents may not have influenced these individuals directly as most worked in organizational environments where the terms of their employment called for them to assign their patent rights to their organizational employers. Hence, these individuals would have known that they would have no ownership stakes in the patents resulting from their work.

Yet, these individuals would have felt a number of real (albeit indirect) influences from patents. Their work incentives, conditions, and rewards were derived from patent considerations. These researchers were given salaries over extended periods, research labs, and the benefit of talented nearby colleagues, all of which reflected the commercial potential of the projects that they were working on and the potential for patenting of their research results as means to ensure commercial returns from their work. In short, patents explain why the organizations involved in these projects were willing to take risks on highly costly research efforts by these individuals and to support these research endeavors with major resource commitments over extended periods and in the face of sometimes disappointing results. The individuals involved here, while not the primary beneficiaries of the patents described, were secondary beneficiaries in the research work, socially significant results, and reputational gains that they were able to realize through organizational backing and research projects that would not have existed without the patent rights flowing from their projects.

For the organizations participating in these projects, the implications of patents were both more direct and more fundamental.

Patents (and the periods of market exclusivity that patents implied) were means to ensure that the organizations could gain substantial returns on investments of large amounts of research resources. Patent rights were the linchpins for technology development risk taking. With patents available, large commitments of salaries, equipment, and supporting staffs to new technology development made economic sense. Patents would ensure that the innovating companies would reap the gains resulting from commercially successful products emerging from the new research, at least for the life of the patents. Without patents, money spent on developing new technology might just benefit the competitors of these innovating companies, which could adopt any newly developed technology for free and then use it against the innovating companies in the market place. Few new technology development efforts of any magnitude would be funded in the face of these adverse implications. Hence, the quest for patents (and the redirecting of resources towards research that made obtaining commercially valuable patents more likely) was a fundamentally significant part of the research efforts pursued by the organizations profiled here.

C. The Patents and Inventions

1. Genetically Engineered Crops

Genetically engineered crops are traditional crops modified to insert genes that produce new plant characteristics.[62] For instance, genetically engineered crops have been produced to create plants that are more likely to survive and thrive in the settings where the plants will be grown by fighting off certain insects or by tolerating herbicides that kill weeds.[63] Other crops have been modified in ways that increase the nutritional content of resulting foods or that increase crop yields or growth rates. Genetically altered crops are dominant in some agricultural settings. For example, as early as 2002, altered crops accounted for 74% of soybean production and 32% of corn production.[64]

The first genetically engineered plants were developed by Monsanto researchers.[65] The company assembled a team of highly skilled researchers and set them out to use recently developed genetic engineering techniques to produce new discoveries and

62. *See generally* Daniel Charles, Lords of the Harvest: Biotech, Big Money, and the Future of Food (2001).

63. Cohen, *supra* note 59, at 27; Robert Lengreth, *High Tech Harvest,* Popular Science, Dec. 1992, at 104, 108, 122.

64. Cohen, *supra* note 59, at 27.

65. For a description of the history of these efforts and their industry surroundings, *see* Charles, *supra* note 62.

products that complemented Monsanto's prior weed killer products. The results were plants and engineering techniques that were both tailored to Monsanto's commercial goals and major scientific breakthroughs with much broader implications.

The research leading to the patent of interest here was completed by a highly talented group of Monsanto employees that included inventors Steve Rogers, Robert Farley, Robert Horsch, and Dilip M. Shah. They developed several new, genetically engineered plant varieties that were resistant to Roundup, a widely-used weed killer marketed by Monsanto. The Monsanto research team obtained a patent on the Roundup-resistant plants that they had newly engineered.[66] Roundup resistant plants eventually included specially created versions of soybean, cotton, alfalfa, canola, flax, tomato, sugar beet, sunflower, potato, tobacco, corn, wheat, rice, and lettuce plants. Farmers growing these modified crops were able to use Roundup to kill weeds while not killing the nearby crops. The agricultural advantages of this practice were highly valuable and seeds for the Roundup-resistant plants were big sellers. Monsanto was not only able to gain considerable commercial success as the sole seller of Roundup-resistant plants during the life of its patent, it saw its sales of Roundup rise as well as this weed killer was increasingly used with the new Roundup-resistant plants.

The research team assembled by Monsanto to work on this project was a highly qualified group with rare technical knowledge and project management skills. The exceptional (and scarce) attributes of the inventors in this project were evidenced by the recognition they received for their work on genetically engineered plant research, as well as their selection for a number of technical and managerial leadership positions in the remainder of their careers. Their knowledge and skills were particularly rare and in demand at the time of their work on Roundup-resistant plants. In this period, the genetic engineering revolution was just underway and many universities and corporations were interested in recruiting persons with high level training in genetic chemistry and related areas, but few persons with training in these areas had yet been educated by leading graduate schools.

The Monsanto research team included the following individuals with exceptional skills in genetic science, related experimental techniques, and high technology project management.

Robert T. Fraley: Fraley earned both his B.S. and Ph.D. degrees from the University of Illinois.[67] When hired by Monsanto, Fraley was a postdoctoral fellow at the University of California at San

66. U.S. Patent No. 4,940,835 (filed July 7, 1986).

67. *Dr. Robert T. Fraley, Biographical Profile*, Monsanto, http://www.monsanto.-com/who_we_are/leadership/fraley_web_bio.asp (last visited on July 22, 2010).

Francisco and a pioneer in techniques for transferring DNA into plants.

In a long career with Monsanto, Fraley held numerous engineering, engineering management, and business management posts. "Fraley's real skill proved to be organizing teams of scientists and driving them towards a common goal."[68] Another researcher noted that Fraley had "a big wide stripe of leadership right up the middle of him."[69] Over his career, Fraley held numerous research management positions at Monsanto, ultimately rising to be the Executive Vice President and Chief Technology Officer of Monsanto, overseeing all of Monsanto's crop and seed agribusiness technology research and facilities for conducting this type of research around the world.

Fraley was also a distinguished researcher and developer of commercially significant advances. He authored more than 100 publications and patent applications relating to technical advances in agricultural biotechnology. In 1999, Fraley was awarded the National Medal of Technology for his pioneering contributions to the genetic engineering of crops.

Robert B. Horsch: Horsch received his Ph.D. in genetics from the University of California, Riverside, in 1979[70] and completed post-doctoral work in plant physiology at the University of Saskatchewan. During his career, Horsch led a number of Monsanto's research projects involving plant tissue cultures and plant transformation efforts. In 1996, Horsch became Vice President and General Manager of the Agracetus Campus of Monsanto Company's Agricultural Sector in Middleton, Wisconsin, serving in that capacity until the end of 1999. Dr. Horsch also held the position of Vice President, Product and Technology Cooperation, at Monsanto. In this position, he was responsible for public-private partnerships that helped farmers in developing countries gain access to better agricultural products and technologies.

Horsch served on the editorial boards of several leading journals in the plant sciences and also as an advisor to the National Science Foundation and the Department of Energy. He published more than 50 articles on plant biology and plant biotechnology. In 1999 he was awarded the National Medal of Technology by President Clinton for contributions to the development of agricultural biotechnology.

Stephen G. Rogers: Rogers earned his M.A. and Ph.D. degrees in biology from the Johns Hopkins University.[71] When hired by Monsanto, Rogers was a newly appointed assistant professor at the Indi-

68. Charles, *supra* note 62, at 14.
69. *Id.*
70. 3 Am. Men & Women of Sci. 899 (26th ed. 2009).

ana University School of Medicine. Rogers led a group at Monsanto that developed new techniques for producing proteins in plants. These techniques remain standard and widely-used research techniques in this field. Rogers eventually served as director of biotechnology projects for Europe at Monsanto's Cereals Technology Center in Cambridge, England. In 1998, Rogers was awarded the National Medal of Technology for his contributions to genetic engineering and crop development.[72]

Dilip M. Shah: Shah received his undergraduate education in India and his M.S. and Ph.D. degrees in genetics from North Carolina State University.[73] From 1976 to 1982, he held various academic research positions with the National Institute of Environmental Health Services, the University of Chicago, and the University of Georgia. He joined Monsanto in 1982 and later served as the Research and Development Director for Monsanto's agricultural research in India.[74] He subsequently joined the Donald Danforth Plant Science Center (a public service research center in Saint Louis) as a Research Scientist and Principal Investigator.[75]

In addition to assembling and compensating this highly qualified team of researchers, Monsanto needed to support the team's research with extensive equipment and staff. The unexpected costs and duration of the needed research were enough to force many other firms out of similar technology development efforts. As recounted by one observer:

> Monsanto would outrace the large companies and outspend the small ones [in mastering the genetic manipulation of plants during the 1980s]. The trio of names [of three Monsanto researchers]—Steve Rogers, Robert Fraley, and Robert Horsch—would become a familiar incantation, linked forever on a steady stream of scientific papers, and

---

71. Michael E. Gorman, et. al., *Monsanto and the Development of Genetically Modified Seeds*, *available at* http://papers.ssrn.com/sol3/papers.cfm?abstract_id=908734 (last visited Oct. 24, 2010) (unpublished manuscript).

72. Marquis Who's Who in Science and Engineering: 2000–2001, at 1125 (1999).

73. Nominations to the FIFRA Scientific Advisory Panel; Request for Comments, 74 Fed. Reg. 40,584, 40588 (Aug. 12, 2009), *available at* http://edocket.access.gpo.gov/2009/E9–19313.htm (last visited Oct. 18, 2010) (including biographical information on Dilip M. Shah).

74. Dilip M. Shah Resume, http://web.archive.org/web/20100311231707/http://www.danforthcenter.org/shah/bio.asp (last visited Nov. 11, 2011).

75. Nominations to the FIFRA Scientific Advisory Panel; Request for Comments, 74 Fed. Reg. at 40588 (including biographical information on Dilip M. Shah).

> on patents giving Monsanto exclusive rights to new tools of genetic engineering and plants with unprecedented powers.
>
> The ultimate fate of this research would remain uncertain throughout the 1980s. There would be no products to sell for more than a decade. Most of the "nervous money" would run out of patience, sell out, and move on. But a small cadre at Monsanto would stick with their bet, and double it. In their own eyes, they had successfully caught a monster wave of technological innovation. . . .[76]

The size of Monsanto's ultimate resource commitment was enormous. The specific commercial targeting of the research—aimed at creating Roundup-resistant plants—made successful results hard to achieve. Determining the genes needed to create Roundup resistance and identifying means to successfully inject these genes into plants both turned out to be highly difficult tasks. Successful results in both areas were developed only after numerous setbacks and extensive efforts. In the end, Monsanto researchers devoted 700,000 hours of researcher time and approximately $80 million dollars to the development of Roundup-resistant plants.[77]

The company's dedication to this research was clearly the product of patent influences. Shortly before the initiation of the project that led to Roundup-resistant plants, Monsanto's top executives had committed the company to an increased focus on commercially-targeted products and research, with a particular focus on the development of patentable discoveries. Richard Mahoney, CEO of the company, noted at the time that: "We are not in the business of the pursuit of knowledge; we are in the business of the pursuit of products."[78] At Monsanto, "[t]he end had come for lavishly funded research on tinkering with petunias, and the aim was now clear: to create transgenic plants that brought in money."[79] Patent-influenced marketing opportunities and associated patent rewards were understood to be the means to realize company gains from new transgenic plants. Hence, patent incentives at the corporate level played a fundamentally important role in encouraging and targeting the research efforts and corporate risk taking that produced the patented discovery of Roundup-resistant plants.

---

76. Charles, *supra* note 62, at 8.
77. Marie-Monique Robin, The World According to Monsanto 140 (2010).
78. *Id.* at 138 (quoting Richard Mahoney).
79. *Id.*

2. DNA Copying via Polymerase Chain Reaction (PCR)

The polymerase chain reaction (PCR) method is a widely used process for producing large quantities of genetically identical material.[80] It allows parties starting with a very small amount of genetic material to multiply the amount of the material by millions of times in just a few hours.[81] The method has been fundamentally important as a tool in genetic research and medical testing processes.[82] PCR has aided scientists in producing advances in drug research and medical diagnostics by allowing researchers to find faulty genes and to identify viruses. PCR was also used extensively by scientists in mapping the human genome and in perfecting cloning technologies.

PCR was invented by Kary Mullis as an offshoot of other research he was performing for the Cetus Corporation. Cetus was engaged in a variety of research concerning biotechnology techniques and discoveries made possible by new knowledge regarding genetics and related chemistry. Mullis was one of many researchers engaged by Cetus as part of the company's exploration of the commercial potential of this new technology area.

Mullis was a highly trained researcher, with a Ph.D. in biochemistry from the University of California, Berkeley and two years of postdoctoral work in pharmaceutical chemistry at the University of California, San Francisco.[83] He initially worked as a biochemist at a medical school in Kansas City and served as a DNA chemist at Cetus for four years prior to his discovery of PCR.

Mullis conceived of the basic idea for PCR while trying to solve a research procedure problem. His research required replication of DNA, which was possible but highly laborious with techniques used prior to PCR. Mullis sought an easier means to produce copies of DNA material in substantial quantities. The PCR procedure was his proposed solution, but the original version of the process he proposed lacked many practical details.[84]

Working out the practical details turned out to be a considerable undertaking.[85] Many of Mullis' coworkers felt that the process was unworkable. As one coworker described:

---

80. *See* Cohen, *supra* note 59, at 27.

81. U.S. Patent No. 4,683,202 (filed Oct. 25, 1985).

82. *See* Wikipedia, *Kary Mullis*, http://en.wikipedia.org/wiki/Kary_Mullis (last visited June 6, 2010).

83. *Id.*

84. Mullis described his discovery of PCR and the process of making PCR workable in his autobiography. *See* Kary Mullis, Dancing Naked in the Mind Field 3–14 (1998).

85. Paul Rabinow, Making PCR 93 (1996).

> When Mullis first presented [the idea behind PCR] to people on paper everyone was looking at it and trying to figure out why it wouldn't work. It was so simple it didn't take a lot of explanation. Once they understood it they thought there must be some reason that it didn't work.[86]

Indeed, many of the details in the process were critical and Mullis himself was unable to make it work for a considerable period. Corporate managers at Cetus were patient, however. Apparently recognizing the scientific and commercial significance of the PCR process if Mullis could perfect it, Cetus' managers committed Mullis' time to work on PCR. They relieved Mullis of other research duties and supported his full-time work on the PCR project. Finally, after over a year of additional research beyond his initial idea about how PCR might work, Mullis was able to complete a version of the process that reproduced DNA material in substantial quantities.[87] He patented this process and the resulting patent was assigned to Cetus.

Mullis left Cetus in 1986 and later served for two years as Director of Molecular Biology for Xytronyx, Inc., in San Diego.[88] His discovery of PCR was subsequently recognized as one of the great advances in the developing field of biotechnology. In 1993, Mullis received the Nobel Prize in Chemistry for his discovery of PCR.[89]

Patents were a key part of the business strategy underlying Cetus' contributions to the development of PCR. The company's business model was built on an expectation of commercialization of new advances in the developing field of biotechnology through the securing of patents on these discoveries and the subsequent use of the patents to obtain commercial rewards. Unlike the research at Monsanto to produce Roundup-resistant plants—which was undertaken in part to compliment the company's preexisting commercial products and interests—Cetus' research was more technology-driven, with an aim of exploring the new advances and commercial products made possible by a particular type of new scientific knowledge. Cetus was targeting research and development of commercial products incorporating new biotechnology advances made possible by new understanding of DNA and related body chemistry. The company was a hotbed of research in this field, with

86. *Id.* at 98.

87. *Id.* at 99–104.

88. Wikipedia, *Kary Mullis*, *supra* note 82.

89. Wikipedia, *History of polymerase chain reaction, http://en.wikipedia.org/wiki/History_of_polymerase_chain_reaction* (last visited June 20, 2010).

a clear commercial focus.[90] Cetus' managers considered patent rights to be their preferred means to ensure commercial returns on the company's research successes.[91]

Cetus accounted for two important features of the development of PCR. First, it created a research environment that attracted and gave collegial and technical support to top researchers such as Mullis. Mullis described the attractions of working at Cetus as follows:

> [It] was an exciting time at Cetus. . . . They had just gotten enough money to start hiring a lot of people and doing a lot of things. It was the heyday of biotechnology. There were all kinds of bold ideas floating around all the time about what we were going to make, and there was absolutely no restraint in terms of imagination.[92]

Second, the company supported Mullis' work financially despite his early failures and the long period it took to make PCR work. The company expended the resources needed for this long program of research because of its willingness to back high-risk research with clear commercial potential. Henry Erlich, a researcher at Cetus when Mullis worked there, described the alignment of scientific and commercial interests at Cetus concerning research like Mullis' work on PCR:

> I didn't really know what Cetus was like—I didn't know what directions they were taking. I thought about the fact that it could conceivably be very exciting to try to do biological research that lead to practical, useful things. . . . If you find a project that is of real fundamental passionate interest to you, and if it also has the possibility for having some real practical commercial outcomes. Then you have the prospect of a company project that really satisfies a scientist.[93]

Cetus' bet on Mullis' research paid off handsomely. Mullis applied for a patent on the PCR process and the resulting patent was assigned to Cetus.[94] Mullis received a cash bonus of $10,000 for his invention, the largest bonus Cetus had paid for an invention to

---

90. *See* Rabinow, *supra* note 85, at 79 (describing an "imperative to develop commercial products at Cetus" imposed by company management at the time of Mullis' work on PCR).

91. *Id.* at 119–122 (describing the views of Cetus' management as to the benefits of obtaining patents on PCR over a trade secret strategy (advocated by Mullis) for protecting and commercializing PCR).

92. *Id.* at 90.

93. *Id.* at 79–80.

94. U.S. Patent No. 4,683,202 (filed Oct. 25, 1985).

that time and an exception to the company's normal refusal to pay bonuses to scientists for inventions.[95] However, this bonus paid to Mullis was far less than Cetus' profits from PCR. In 1991, Cetus assigned its rights to its PCR patents to Hoffman-La Roche for $300 million.[96]

This extraordinary profit, secured through the exclusive rights afforded by patents and the ability of Cetus to transfer those rights to a large medical products supplier like Hoffman-La Roche, reflected the payoff for Cetus' research investment and risk taking. The payoff was a patent-influenced reward for the company's success in building an exceptional research enterprise and for the company's risk taking in backing Mullis' unusual project over its rocky path to completion. The results achieved by Cetus are indicative of how patents can encourage firms to make large research bets on developing new technologies with the expectation that successful results can be translated into high profits through patent rights.

Patent rights can not only ensure that a company like Cetus gains the commercial returns on its research investment, these rights can also facilitate specialization in the development of new technologies and products.[97] In the case of PCR, Cetus was able to focus on research and gain much of the commercial value of PCR without actually developing all of the manufacturing and marketing capabilities needed to fully realize this commercial value. Cetus was able to gain a payment for its research results by transferring its rights to Hoffman-La Roche. The latter was able to take over in further commercialization steps and realize the full commercial value of PCR through extensions of that company's existing manufacturing and marketing activities. In this way, each company specialized in what it did best—Cetus in the support of research and Hoffman-La Roche in the development of commercial products, in the production of those products, and in the marketing of the products through existing distribution chains.

Patent rights served as the bridge between these specialized activities because these rights allowed Cetus to pass on an exclusive commercial opportunity to Hoffman-La Roche. Cetus was compensated in its patent assignment for the commercial value of its research results and for the specialized contributions that it made to the ultimate commercialization of PCR. The exclusive marketing opportunity it received in the patent assignment encouraged Hoffman-La Roche to add its specialized resources and capabilities to the research results produced by Cetus. This opportunity induced

95. Rabinow, *supra* note 85, at 133.

96. *Id.*

97. *See* Jonathan Barnett, *Intellectual Property as a Law of Organization*, 84 S. Cal. L. Rev. (forthcoming 2011), *available at* http://ssrn.com/abstract=1623565.

Hoffman-La Roche to devote additional resources to the commercialization of PCR. Hoffman-La Roche could look to the market for PCR-related products and tailor its resource commitments to manufacturing and marketing of these projects accordingly. In this way, patent rights concerning PCR (when held by Hoffman-La Roche) attracted the allocation of Hoffman-La Roche's scarce resources to the development, production, and marketing of PCR-based products and assisted in these steps of bringing PCR into widespread use for public benefit.

3. Hepatitis Vaccine

Hepatitis B disease is a worldwide killer that claimed as many as one million victims each year, as of 2002.[98] Since the late 1980s, effective vaccines for the disease have been available, due largely to research led Kenneth Murray of the University of Edinburgh. Murray identified "intermediates" for hepatitis B—that is, molecules that aid in the production of hepatitis B virus antigens in the human body. Exposure to the intermediates in advance of exposure to the hepatitis B virus helps the body fight off hepatitis infections. Understanding of the relevant intermediates and their potential roles in preventing hepatitis led to the creation and widespread administration of several types of hepatitis B vaccines in the United States during the last two decades. As a result, deaths due to hepatitis B in the United States have dropped to a few thousand each year. The substantial numbers of hepatitis B deaths that still occur in the rest of the world are largely the result of limitations on the administration of hepatitis B vaccines.

Murray was a highly trained researcher and a leader in both academic and commercial enterprises that produced important discoveries in biotechnology. He was born in England and obtained his undergraduate and Ph.D. degrees from Birmingham University. In 1967, he took a faculty position at the University of Edinburgh in what was then the only Department of Molecular Biology in the United Kingdom. Murray subsequently led that department to a highly regarded reputation in its field. Murray—and his wife, who worked as a fellow researcher with him[99]—pioneered the development of methods for DNA sequencing.[100]

---

98. *See* Cohen, *supra* note 59, at 27.

99. *See Edinburgh University's Professorial Husband and Wife*, The Times Higher Education Supplement, (Apr. 28, 1995) *available at* http://www.timeshighereducation.co.uk/story.asp?storyCode=97759&sectioncode=26 (last visited July 6, 2010); Wikipedia, *Noreen Murray*, http://en.wikipedia.org/wiki/Noreen_Murray (last visited July 6, 2010).

100. *See* David Boxer, *Laureation Address on Professor Sir Kenneth Murray*, University of Dundee, http://www.dundee.ac.uk/pressoffice/grad2000/postgrad/mur-

The Murrays were among the first researchers to use genetic engineering techniques to study the mechanisms for diseases like hepatitis and to develop related medical advances. By 1978, they had successfully produced hepatitis antigens in their laboratory. This work led to Kenneth Murray's later discoveries of hepatitis intermediaries. Murray obtained a patent that claimed protection for several hepatitis B intermediate molecules. The patent also claimed protection for cellular hosts modified by the addition of the specified intermediates, chemicals resulting from the introduction of the intermediates, and methods of making and using the intermediates, hosts, and resulting chemicals.[101] Because of the breadth these claims, most subsequent hepatitis B vaccines have fallen within the scope of Murray's patent, thereby generating enormous revenues for Biogen, the assignee of the patent. As a co-founder and co-owner of Biogen, Murray reaped significant gains from the widespread use of his invention, as well as from other advances commercialized by Biogen. He used some of the wealth generated by his partial ownership of Biogen to establish the Darwin Trust, which supports educational and research activities in natural science. For his own discoveries and his further backing of scientific research, Murray was knighted by the British government in 1993.[102]

Biogen was a major commercial contributor to Murray's research. Murray played a dual role as a co-founder of Biogen and as a beneficiary of the company's funding decisions in carrying out supported research at the University of Edinburgh. Murray's dual role accounts for the extensive commercial considerations underlying the funding of his research. Patents lay at the heart of Biogen's funding contributions and the decisions that led to Murray's research.

Biogen was founded with a heavy involvement of scientists in the targeting of research funding as well as in the research itself. Patents played a remarkably clear role in decisions about research directions meriting Biogen's support. In particular, these considerations were at the heart of the decisions leading to Biogen's funding of Murray's work on hepatitis B intermediaries. This funding choice resulted from analyses by Biogen company leaders of the business potential and scientific promise of various research alternatives. The background of Murray's decision to pursue research concerning hepatitis B intermediaries was explained by him as follows:

---

ray.htm (last visited Nov. 11, 2011).

101. U.S. Patent No. 4,710,463 (filed Mar. 31, 1982).

102. Boxer, *supra* note 100.

> Our involvement in research on hepatitis B virus (HBV) really began at a Microbiology Conference in Geneva in February, 1978. For the small group of academics involved this was not at all the sort of conference to which we were accustomed. It was an intensive discussion, convened by Dr. Raymond Schaeffer and Mr. Dan Adams of the venture capital group of the International Nickel Company of Canada (INCO), of the prospects for formation of a European biotechnology company and a review of research projects and products that such a company might pursue. The role model was Genentech Inc., a company that had been formed two years previously and in which INCO had been a significant and well satisfied corporate investor.[103]

Murray's decision to go forward with hepatitis B research, as well as the impact of commercial interests and patent objectives on this decision, is well documented in a line of opinions contesting the validity of a British patent stemming from Murray's research. In an opinion of the Lords of Appeal of the House of Lords in *Biogen Inc. v. Medeva PLC*, Lord Hoffman gave the following account of the actions leading to Murray's work on hepatitis B intermediaries:

> In February 1978 Professor Murray and a number of other molecular biologists of international repute, together with financial backers, met in Geneva and decided to found Biogen Inc, the patentee company ("Biogen"), for the purpose of exploiting the technology for commercial purposes. One of the first projects upon which they agreed was to try to make the antigens of [hepatitis B virus (HBV)]. Professor Murray began work in the spring of that year and in November reported that he had produced two of the known HBV antigens in colonies of cultured bacteria.[104]

This project reflected Biogen's typical mode of operation. Biogen's normal business approach was to fund and support projects under the direction of a member of its Scientific Board, who was usually the scientist who proposed the project. The actual research work was typically carried out in the proposing scientist's university laboratory.[105]

Writing at a distance of 20 years from the founding of Biogen, Murray noted that when the company was formed, its combination of scientific expertise and venture capital funding represented "a

103. Hofschneider, *supra* note 43, at 43.
104. *Biogen Inc. v. Medeva Plc,* [1997] R.P.C. 1, 33 (H.L. 1996) (appeal taken from Eng.), *available at* http://www.bailii.org/uk/cases/UKHL/1996/18.html.
105. Hofschneider, *supra* note 43, at 45.

new avenue for funding research."[106] Changes in the needs of scientists over this 20 year period made these types of partnerships between scientists and business persons more common, according to Murray. He noted that:

> The recent advances in technologies and automation of many routine operations which have so effectively opened new opportunities in many areas of biological research and catalysed the growth of the biotechnology industry, have also brought escalating costs that are changing the patterns of funding for basic research. Academics are now strongly encouraged to pursue the commercial exploitation of their discoveries, sometimes to the extent that potential for application is a high impact factor that can compete with evaluation of basic scientific importance in the competition for research grant support.[107]

In short, Murray's work, though undertaken in academic surroundings, was directly influenced by the commercially-driven analyses of his business associates at Biogen. These assessments were, no doubt, strongly affected by the potential for discovering patent-eligible advances stemming from Murray's work. Patents based on Murray's findings were needed to fully realize the commercial potential of the discoveries. Commercial potential was a basic consideration in prioritizing Biogen's funding choices and in leading it to giving top funding priority to Murray's research. Biogen's funding was, in turn, critically important in supporting that research and in producing a prompt solution to the problem of hepatitis B infections and deaths. Hence, the organizational importance of patents for Biogen (and the derivative importance of Biogen's patent-influenced funding decisions for the University of Edinburgh) accounted for Murray's research and the societal gains that it produced. In addition, due to his ownership stake in Biogen, Murray had personal, patent-influenced reasons to devote his attentions to hepatitis B research and to produce successful results. Thus, at the individual as well as the organizational levels, patents appear to have been significant influences in the allocation of scarce resources to the development of hepatitis B vaccines and related disease prevention.

---

106. *Id.* at 60.
107. *Id.*

4. Cardiac Stents

Cardiac stents are small devices used to repair clogged arteries.[108] The stents are inserted inside arteries when blockages are cleared and serve to prevent renewed blockages. At one time, the preferred procedure to repair clogged arteries was open-heart surgery, a practice that saved many lives, but that also involved substantial risks of infection and long recovery times. Surgical procedures to repair arterial blockages with stents, by contrast, involve only small incisions and are typically completed on an outpatient basis, with small risks of infection and much less cost than comparable open heart surgeries.[109]

The first heart stent design was developed and patented by Julio Palmaz, a physician working on heart stents as a solo inventor. He began to work on stent designs following a medical lecture describing an angioplasty procedure performed without a stent.[110] In the basic angioplasty procedure described in the lecture, a catheter attached to a small balloon is inserted into an artery far enough to position the balloon at the point of a blockage. The balloon is then expanded, thereby compressing and moving accumulated plaque out of the way and increasing blood movement. The balloon is then deflated and the catheter removed. While this procedure was often initially successful in reducing blockages, almost 50% of patients receiving this treatment suffered recurrences of arterial clogging when the balloon was removed.

Palmaz concluded that a rigid structure which was left behind following this type of balloon procedure might assist in preventing renewed blockages. He designed a new stent that would provide this rigid structure, built an initial version, and tested it in animals. Palmaz's stent design involved a narrow cage-like element made of metal that enclosed a balloon catheter. In surgical use, the balloon and cage structure were both initially collapsed in a narrow form. The combined unit was threaded through an artery until it was positioned at the site of a blockage. The balloon was then inflated, causing the outer cage to expand. Once expanded, the cage was constructed so that it did not contract again when the balloon was deflated and the catheter removed. The expanded cage both pushed out the plaque at the site of the blockage and held the artery open at that point.

---

108. *See* Cohen, *supra* note 59, at 27.

109. *See id.*

110. Palmaz's work in developing his stent designs is described in L.A. Lorek, *The inventor of a groundbreaking stent fought a long battle for . . . A purpose of heart*, San Ant. Express News, Feb. 27, 2005, at 1L.

Palmaz's stents proved to be highly effective in surgical use and have transformed cardiac treatment. Within four years of their FDA approval, balloon-expandable stents of the type covered by Palmaz's patent were used in over 80% of medical procedures concerning coronary blockages, a virtually unparalleled medical success.[111] More than one million stents of this type are implanted annually worldwide. Palmaz's designs have also led to many additional stent design improvements (some with features that are covered by additional patents). Palmaz's initial stents are now part of the medical collection of the Smithsonian Institution in Washington, DC.

Palmaz's work on heart stents was initially a personal sideline to his primary career as a physician and medical researcher. His extensive training was not in cardiac care, but rather in radiology. Palmaz received his MD degree from the National University of La Plata in Argentina in 1971 and practiced vascular radiology at the San Martin University Hospital in La Plata beginning in 1974.[112] He later received three additional years of radiology training at the University of California at Davis' Martinez Veterans Administration Medical Center. Palmaz was appointed Chief of Angiography and Special Procedures in the radiology department at the University of Texas Health and Science Center at San Antonio in 1983. Palmaz is currently the Ashbel Smith Professor at the Science Center.

Palmaz's story as an immigrant who achieved highly extraordinary scientific and financial success has a heroic quality. As noted by a colleague who served as a mentor to Palmaz early in Palmaz's career:

> Here's a young man who came to the United States in the early '70s, hardly speaking any English, and through a great deal of determination and imagination, he has created one of the better medical devices for helping people and has done well in the process. . . . It's an amazing story.[113]

Palmaz indeed did well financially by virtue of the success of his stent designs. The patent that he obtained was the source of considerable personal income. While he has continued his medical research, Palmaz is also very wealthy. He operates a large vineyard and winery in Napa Valley, California that includes a 100,000-

---

111. *See* Wikipedia, *Julio Palmaz*, http://en.wikipedia.org/wiki/Julio_Palmaz (Oct. 16, 2011, 18:00 EST).

112. *Id.*

113. Lorek, *supra* note 110, (quoting Dr. Stewart Reuter, emeritus professor of radiology at the University of Texas Health and Science Center at San Antonio).

square-foot wine cave, which is equivalent in size to an 18-story underground building. The wine cave includes an 8,000-square-foot car museum that contains Palmaz's collection of 17 rare racing Porsches.[114]

Aside from his financial success, Palmaz has achieved considerable success as a medical researcher and entrepreneur. He is named on more than 25 United States patents issued since the patent on his stent design. These additional patents cover several types of medical device designs, materials, methods of manufacturing, and methods of use. Palmaz has also participated in the founding of several other business enterprises aimed at medical technology development. Palmaz formed Advanced Bio Prosthetic Surfaces (ABPS) in 1999, a private R&D enterprise to develop biomaterials suitable for implantable medical devices. In early 2008, Palmaz formed Palmaz Scientific to design, manufacture, and sell implantable bio prosthetic devices.

Unlike the research projects profiled in the case studies to this point, Palmaz's work on his stent designs was not initially motivated by expectations of patents and patent rewards. Palmaz seems to have started his project out of scientific curiosity and a desire to help patients. He conducted some of his initial design efforts in his garage and was able to come up with some tentative designs without great expense.[115]

However, in order to conduct testing and to refine his stent designs to make them workable in surgical procedures, Palmaz needed help. At several stages in obtaining this help and in producing workable stent designs, patent rights played key roles.

Palmaz made initial inquiries to medical device companies about his stent designs, but received little interest. To continue his project, he formed a new business entity called the Expandable Graft Partnership with Phil Romano (founder of several restaurant chains including Fuddruckers and The Macaroni Grill) and Dr. Richard Schatz (a cardiologist at Brooke Army Medical Center). Romano invested $250,000 in the partnership while Schatz contributed to the refinement of the stent designs from the perspective of a cardiologist who was familiar with the demands of heart surgery and treatment. The aims of the partnership were both to bring the stent designs to more finished states and to pursue commercial gains from the new stents.

114. *See id.*

115. "Palmaz went to Radio Shack and bought some copper wire, a solder gun and other materials and began to tinker at a workbench in his garage. He came upon the inspiration for the stent's design from leftover construction material—a piece of wire mesh with a diamond-like pattern. Using that as his guide, he built the first stent prototype." *Id.*

Given the commercial goals of the partnership, a patent on Palmaz' discovery was a critical business feature. Romano, the experienced business person among the partners, immediately pressed Palmaz to obtain a patent on his stent designs. Romano noted that the lack of a patent would reduce the commercial value of Palmaz's invention. Palmaz then applied for and obtained a patent that claimed protection for several versions of his stent designs and the procedures for using the stents.[116] The patent was assigned to the partnership upon issuance, indicating that the partnership was the real party in interest.

Following additional work on the stent designs, the partnership was very successful in using its patent to attract the interest of a medical products company and in gaining favorable terms for a transfer of the technology to the company.[117] It also got the company to provide extensive funding for the final testing and FDA approval processes that were needed to transform Palmaz's designs into medical products available for use on humans. The partnership initially licensed the patented stent designs exclusively to Johnson & Johnson for $10 million plus royalties. Johnson & Johnson invested an additional $100 million in the development of the stents—again in reliance on the commercial potential of the designs as protected in part by the Palmaz patent. The company gained FDA approval for use of the stents in peripheral arteries in 1991 and for use in coronary arteries in 1994. Once the stents were approved for widespread use, Johnson & Johnson captured 90% of the early market for stents. The company bought out the stake in the patent held by Palmaz, Schatz, and Romano in 1998. Overall,

116. U.S. Patent No. 4,739,762 (filed Nov. 3, 1986).

117. *See* Lorek, *supra* note 110. The "steady hand" in guiding the commercialization of Palmaz's designs was Romano, who was experienced with high stakes negotiations and large commercial transactions. In the negations between the partnership and Johnson & Johnson over a possible license for the designs, Romano's business experience and cool headedness played critical roles:

> In one meeting, Johnson & Johnson put $5 million on the table. It was more money than either Palmaz or Schatz had ever dreamed about, but not Romano.
>
> "I said no," Romano said. "And Julio and Richard [(the other Extendable Grafts partners)] were just about to take it. They were sweating bullets. We just kept going. We ended up at twice as much as they first offered."
>
> Johnson & Johnson agreed to pay $10 million to license the stent technology and 7% to 9% royalties on top of that.

"We would have given this away for nothing," Palmaz said. "That's why having Philip [Romano] as the businessman helped us greatly."

Id.

payments for the patent transfer plus royalties netted the three partners $500 million.[118]

Although an expectation of patent protection was not a motivating force behind Palmaz's initial innovation efforts leading to his stent designs, his patent played several key roles in advancing his stent designs to completion and in bringing fully functional stents to the public. Palmaz's patent reassured various participants in the stent project of the commercial potential of his designs. This encouraged additional investments of resources in his project, first by members of the Expandable Graft Partnership and later by Johnson & Johnson. Palmaz's patent was a central commercial consideration to members of the Expandable Graft Partnership. The patent helping to draw the interest of the partners and to encourage them to provide the additional funding and research assistance that Palmaz needed to move his innovation project forward and to bring his stent designs to sufficiently complete states for effective presentation to Johnson & Johnson as candidates for large scale production. Palmaz's patent also provided the promise of market exclusivity and profit potential that Johnson & Johnson (as exclusive licensee of the patent) relied on in investing considerable additional sums to complete product perfection, testing, and regulatory approval steps needed to bring Palmaz's stents to market and into active surgical use. Hence, while an afterthought to Palmaz personally, his patent was a central consideration to other participants in the stent project and was probably essential in gaining the technical and financial backing needed to finalize the stent designs, to obtain FDA approval for the stents, to initiate large scale production of the stents, and to bring the stents into widespread public use.

In using patents to fund and gain technical assistance for product development and testing steps, Palmaz was following a common approach for entrepreneurs in startup companies: an initial founder, bringing a new but commercially unproven technology to the startup enterprise, seeks initial assistance from a few associates who are willing to take high risks by investing money or labor in the future of the new technology. The initial funding generated in this manner is used to partially perfect the technology and to take steps needed to gain further funding to back the final commercialization of the technology. The promise of exclusive business opportunities as the result of patent rights is often a central requirement of this startup business model. Absent this promise of exclusivity, early stage investors will be unlikely to provide significant amounts of financing, particularly where all of this funding may be lost if another party can freely copy the technology and reap most of the

118. *Id.*

commercial rewards from the new technology. Hence, Palmaz's and his associates' use of his patent illustrates how patent rights can draw scarce resources to the development and popularization of a new technology after the point when that new technology is first invented in its raw form. Absent these sorts of attractions for commitments of scarce resources after the point of invention, new advances such as Palmaz's stent designs might be just missed opportunities, known to a few researchers but stalled in the product development process and never made available to the public.

VIII. CONCLUSION

The four patents examined here all have had significant societal impacts and are doubtless "Patents That Changed the World" as contended by the commentator who selected the patents.[119] The advances underlying these patents were produced by highly trained and talented individuals, with the aid of some of our largest, most well-supported corporate and university research organizations. These organizations supported work on the advances with substantial commitments of scarce resources, commitments that were directly influenced by potential patent rewards.

The work of the researchers themselves was both a critically important resource and a scarce one because of the exceptional training and capabilities of the individuals involved. These individuals include some of our most talented scientists and engineers with the rarest of expertise. The overall accomplishments of these individuals provide evidence of their talents, the range of alternative actions for which they would have appeared suited had they not worked on the advances scrutinized here, and the number of other organizations and employers that would have competed for their time were they not working at the tasks leading to these advances.

The researchers who accounted for the four advances examined here are a remarkable group. They include a Nobel Prize winner (Mullis), a knight of the British Empire (Murray), and several winners of the National Medal of Technology (Fraley, Horsch, and Rogers). A very distinguished group to say the least. These highly talented individuals—with many choices of action corresponding to their recognized talents—are the sorts of parties that patent rewards must attract (at least through the intermediaries of corporations and universities that fund and conduct research) if patents are to influence state-of-the-art research.

The organizations involved in the advances studied here also contributed other scarce resources beyond the time and efforts of highly talented researchers. Many modern types of research require

119. Cohen, *supra* note 59, at 27.

vast amounts of supporting resources, meaning that the organizations large enough to have these resources and capable of participating effectively in this research are scarce. Only a few large corporations or university organizations have the funds or physical resources to support the types of research seen in many of these project studies. And these large organizations can only support a few large projects, given that the organizations are typically the focus of many competing demands for their resources.

Amidst this contentious world of scarce organizational resources (at least at the levels needed for effective research) and scarce individuals capable of working at the frontiers of rapidly advancing and increasingly specialized fields, patents must often offer rewards that are very high to trump the attraction of alternative activities and alternative resource allocations and to draw the relevant individuals and organizational resources to work on the types of practical items and processes that the public seeks. The need for patent rights to attract personnel and resources in this way will be greatest where the other rewards for action by the same talented individuals and their organizations do not encourage sufficient attention to the full range of practical advances valued by the public.

The discussions here indicate why patent-influenced rewards need to be large in many instances and why these rewards should increase in accordance with the amounts of enhanced utility that invention users gain from new advances. The pull of alternative resource allocations for the individuals and organizations capable of producing patent-eligible advances is often very great. Patent rewards are important means to mediate decisions about whether to pursue patent-eligible advances or to instead direct the same resources towards less distinctive and safer sources of commercial rewards. To the extent that the public would gain greatly from a new type of advance, the patent rewards promised for successfully producing that advance should be equally large. This type of linkage between public gains and inventor rewards will help to ensure that invention projects have the right priority and attention amidst the contentious allocation of scarce resources between innovation efforts and other resource uses.

The influence of substantial patent rights and rewards has the potential to bring the interest of more highly talented individuals and the organizations that can support them effectively into alignment with the public's values for new inventions. Because the inventions involved can be highly valuable—as evidenced by the advances assessed in this study—the public has a significant stake in ensuring that our most talented individuals and largest organizations continue to pursue patent-eligible advances with gusto and that patents continue their valuable role as key mediators of decisions about how to devote scarce resources to innovation projects.